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STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

Crimean Series
Map Sheet Group
L-36-XXVIII (Evpatoriya), L-36-XXXIV (Sevastopol)

EXPLANATORY NOTES

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In the work, the geological data are summarized based on results of extended geological studies in the western part of Plain Crimea in the scale 1:200 000 conducted over 1982-1985, and deep geological mapping in the western part of Mountain Crimea in the scale 1:50 000 carried out in 1978-1984.

The Explanatory Notes contain description of "Geological map and map of mineral resources of pre-Quaternary units", "Geological map and map of mineral resources of Quaternary sediments" in the scale 1:200 000, geomorphologic, tectonic, and geological-ecological schemes in the scale 1:500 000. Description is given for entire stratigraphic column of the area from Paleozoic to Holocene sediments, intrusive rocks, tectonics, geomorphologic and hydrogeological features, and ecological-geological situation of environment. The list of mineral deposits and occurrences and list of geological landmarks are provided in the annexes.

The work is devoted to the wide range of specialists involved in the field of geological sciences and nature studies. The set of maps can be used in the planning of geological exploration works in the south-western part of Crimean peninsula.

CONTENTS

Abbreviations used in the text

BCI - bulk contamination indicator
BST - Branch Standard
CMRW - Complex Method of Reflected Waves
CMTS - Complex Magnetic Telluric Sounding
Derzhgeolkarta-200 - the State Geological Map in the scale 1:200 000
DH - drill-hole
DSS - Deep Seismic Sounding
EGP - exogenic geological processes
EGSF-200 - Extended Geological Study of the Fields in the scale 1:200 000
EGSF-50 - same one in the scale 1:200 000
GE - Geological Enterprise
GEE - Geological Exploration Expedition
GM-50 - Geological Mapping in the scale 1:50 000
IP - Induced Polarization
LOC - light organic compounds
LTZ - Litho-Tectonic Zone
MCDP - Method of Common Deep Point
MPS - Method of Polarized Sounding
MRW - Method of Reflected Waves
MTS - Magnetic Telluric Sounding
NASU - National Academy of Sciences of Ukraine
NSC - National Stratigraphic Committee of Ukraine
OGA - Oil-Gas-Bearing Area
SBST - State Branch Standard
SEC - Scientific-Editorial Council
SGA - structure-geomorphologic area
SGE - State Geological Enterprise
SE - State Enterprise
SSU - the State Standard of Ukraine
TAC - top admissible concentration
TAL - top admissible level
TC - Technical Conditions
UISC - Ukrainian Inter-Ministry Stratigraphic Committee
UNAS - National Academy of Sciences of Ukraine
VES - Vertical Electric Sounding
VSS - Vertical Side Sounding

INTRODUCTION

The map sheet territory L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) is limited by coordinates 44°20'-45°20' N latitude and 33°00'-34°00' E longitude. In administrative respect it is included into Crimean Autonomous Republic encompassing Sakskiy, Simferolopskiy, Bakhchysarayskiy areas, as well as the lands subordinated to Sevastopolska and Yaltynska city councils.

The territory relief is fairly variable. The southern part includes western slopes of the Main and Fore-Mountain ridges of Crimean Mountains, narrow band of the Crimean Southern Coast, and Gerakleyske plateau. The central part comprises low plain gently inclined to the north-west and cut by river valleys and gullies; the northern part encompasses margin of Tarkhankutska height in slightly-inclined to the south Evpatoriyske plateau.

The Crimean Southern Coast includes lower coastal band of the Main Ridge slope from cape Aya to cape Kishka, 1-3 km wide and up to 450 m high. In some places the coals gets narrower and somewhere it is complicated by rocky capes extended to the sea (Aya, Sarych, Gagry-Burnu, Kishka) composed of displaced limestone massifs or dome-shaped igneous rock outcrops. Small harbors (Megalo-Yalo, Batylyman, Laspi) are located between the numerous capes. In this area the relief expresses erosion-hilly appearance with narrow wavy watersheds and deeply-cut valleys complicated by numerous slides. The coast patterns are abrasive-harbor with sand-gravel-pebble beaches. Reserve mode is established over most part of this territory with destined assignment of the coastal band.

The Main Ridge of Crimean Mountains is extended from Balaklava town in the west to Simeiz town in the east. Its western part (up to Baydarskiy pass) consists of some ridges 500-700 m high separated by flat-bottom inter-mountain dimples (Varnautska, Khaytu, Baydarska). Going eastward, the Main Ridge is substituted by the hilly highland – Ay-Petrynska Yayla with some top altitudes 1000-1200 m (At-Besh mountain) where karst forms (funnels, wells, shafts, caves) are widely developed. From the south this highland is broken by the steep precipices up to 600 m high. From the north the Main Ridge is surrounded by the External and Fore-Mountain cuesta ridges with altitudes 300 and 600 m, respectively, separated by the longwise valley. Cuesta southern edges are steep while the northern ones are flat (up to 10-15°), screened.

The relief of Gerakleyskiy peninsula is similar to the plain-Crimea one. Its northern coast is complicated by numerous harbors extended into the gullies. Some hill top altitudes attain 200-250 m.

Most part of Plain Crimea comprises the plain which is gradually descended in the north-western direction, towards the sea, and is cut by numerous river and gully valleys. The northern part is included into Tarkhankutska height with altitudes 50-60 m in Evpatoriyske plateau. The coast of wide Kalamitska bay, from Evpatoriya town to the Alma River mouth, is accompanied by abrasion bench from 60 m high in the south to 2 m in the north. The waterline is strait, without major harbors and bays.

Hydrographic network of the territory is variable enough. The rivers of southern and north-western slopes of Mountain Crimea are distinguished. In the southern slope of Main Ridge the rivers are very short, considerably inclined, with small water-collecting areas, high-speed streams, frequent rapids and waterfalls. Their hydrologic regime is unstable with short spring high water. The rivers in north-western slope of Main Ridge (Chorna, Belbek, Kacha, Alma, West Bulganak) are relatively more extended and do have wider water-collecting areas with lower inclination. The river cross-profile is variable: these are either relatively wide precipices where water-reservoirs are normally created, or narrow chasms (Chornoritskiy canyon, Albatski gates). The annual level and discharge regime of these rivers is unstable, water outflow is highest, normally regulated. In the northern part the gullies are developed which are filled up with water seasonally, in the periods of rains or rainfalls and in the springtime. In the gully mouths the salt lakes are developed separated from the sea by sand banks. This relief diversity causes different heating and cooling conditions of the surface and near-surface air masses. Black Sea also comprises strong heat-regulator but its smoothing influence on the climate is only being imposed over narrow coast band bounded by the mountains from the north.

The distinct climate, resulted from vertical zonation, is characteristic for Mountain Crimea. The lower zone is one with Mediterranean sub-tropic climate, warm and wet winter (February average temperature + 3.5°C), hot dry summer (July average temperature +23.5°C) and annual amount of precipitates from 400 to 700 mm; the upper zone is one with moderate warm wet continental climate. In the western part, under influence of Black Sea, the climate is marine-steppe, moderate warm in the south and moderate-cold in the north; in the north-eastern part the climate is continental.

The soil-plant cover of the territory is quite variable and directly depends on the geology, relief and climate. In the Plain Crimea turf-grain dry steppes (wormwood and feather-grass) with southern black soils and dark-chestnut soils have formerly prevailed. Nowadays primary steppe landscape in Crimea has lost its natural appearance under influence of economic developments and irrigation works. It is almost completely ploughed and occupied by the irrigating plant farming, gardening, vegetable-growing and wine-growing.

In the flora of Mountain Crimea the vertical zonation is clearly expressed. Yayla surface is covered by meadow-steppe grass while the slopes are overgrown with pine-beech and oak-hornbeam forests. Plants in the Southern Coast are fairly variable with xerophitic features and Mediterranean forms predomination, as well as varieties typical for Minor Asia, Balkans and Caucasus with abundant endemics. Lack of widespread plants (maple, fir, alder, heather) and abundant endemics apparently suggest for the island mode of the flora formation in Crimea.

In the Crimean fauna endemics are also clearly expressed: endemics constitute more than third of surface molluscs while less than half of mammals, amphibians, reptiles, insects and birds widely developed in Europe are known in Crimea. This also suggest for biota development under island country conditions which has been periodically connected with neighboring areas (Dobrudja, Minor Asia, Caucasus).

The territory under description constitutes a part of the common economic complex of Crimean Autonomous Republic and Ukraine. Degree of territory development is high with industrial and agriculture branches as well as essential available natural and labor resources. The industry is in leading positions, especially chemical (Saky town), metal-processing, shipyard and machinery (Sevastopol city), mining (Balaklava, Evpatoriya, Saky, Bakhchysaray towns), and food ones. Market gardening, vegetable and wine-growing, poultry farming are widely developed. In the coastal zone resort building is permanently growing up.

The dense communication network is developed in the territory. Major transport lines include railroads – Simferopil-Evpatoriya, Simferopil-Sevastopol, and motor-ways – Simferopil-Sevastopol, Sevastopol-Evpatoriya, Sevastopol-Yalta. Paved and dirt road network is also broad. Major inhabited localities – Sevastopol, Evpatoriya, Yalta towns.

Conditions for geological works significantly differ in various parts of the territory. Most part of the territory is classified to be closed areas. Best exposure is observed in the Fore-Mountain ridge, Yayla and its southern slope. Both lower, Mesozoic, and upper, Cenozoic, tectonic floors are well exposed over there. The Plain Crimea territory is almost completely covered by Pliocene-Quaternary sediments, which overlie all older rocks, and this is why geology in this area is only being studied by drill-holes.

The studied area in geological respect encompasses two regional tectonic structures: the northern (most part) is located in epi-Paleozoic Scythian plate, and southern one belongs to Mountain Crimea (see "Tectonic scheme in the scale 1:500 000").

In the course of map set design the following materials were used, received over last years by SGE "Krymgeologiya":

"Regional stratigraphic schemes of Ukraine for the maps of new generation" (1993);

"Regional stratigraphic schemes of Crimea" (S.V.Biletskiy (1999), M.V.Vanina et al [32], B.P.Chaykovskiy (2000));

"State Geological Map of Ukraine (Sevastopolska map sheet group) in the scale 1:50 000" compiled by authors from SGE "Krymgeologiya" in 1992 [5];

Set of geological maps compiled in the course of deep geological mapping in Baydarska valley in the scale 1:50 000 in 1980 [40];

Set of geological maps compiled in the course of deep geological mapping in Gerakleyske plateau in the scale 1:50 000 in 1984 [63];

Set of geological maps compiled in the course of extended geological study of the field in the western part of Plain Crimea in the scale 1:200 000 in 1990 [38];

Besides that, in the geological map design both older data of geological mapping in some areas were used and results of specialized geological studies of deep Mesozoic and Paleozoic horizons for oil and gas, groundwaters, and near-surface Miocene horizons for construction materials. It should be noted that a set of maps, presented by the authors, is designed on the ground of traditional thoughts on the Crimean geology. Mobilistic trend in Crimean geology is recently being enthusiastically developed by V.V.Yudin [23-28] and V.M.Rybakov (SE "Pivdenekogeotsentr") but these materials are not properly supported so far by factual material and are not followed by majority of geologists. Created diverse models of Crimean geology contain a number of contradictions, not completely adjusted, and therefore for the time being they cannot be taken for the ground of the State Geological Map. In the course of geological map design the airborne and satellite image deciphering has been carried out as well as adjusting field works were undertaken.

The set of maps and explanatory notes are compiled in the Crimean geological mapping group of SE "Pivdenekogeotsentr" by the authors' team including B.P.Chaykovskiy (responsible executive), S.V.Biletskiy, O.S.Demyan, S.I.Krasnorudska, V.B.Deev. The set of map is edited by S.V.Biletskiy, editor of the Crimean Series of Derzhgeolkarta-200, and V.M.Semenenko, Doctor of Geological-Mineralogical Sciences, Academician of NASU.

1. STUDY DEGREE

The history of geological studies over Crimean Peninsula, including map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol), is extended as far back as two centuries. Distinct geographic position, accessibility for direct geological observations, variability of geological processes and structures, had caused enhanced interest of all generations of Crimean geology investigators. Regardless prevailing geological concepts, study of Crimean geology has always produced new data providing further adjustments to these concepts, either fixist or mobilist. Nowadays, because of widely accepted neo-mobilistic ideas, Crimean geology attracts researchers' interests again to the reconstruction of geodynamic environments of geological past. In general, four stages are distinguished in the history of geological studies in Crimea.

The first (pre-revolution) stage, encompassing late XIX and early XX centuries, has established the study object and incipient information about. This stage is related to the activity of "Geolkom" and works on design the 10-verst (1 = 3500 ft.) geological map of Crimea.

The second (pre-war) stage encompasses the Soviet period from 1918 to 1941. Over that time, detailed and regional geological studies were conducted in Crimea, resulted in great amount of new data provided, in turn, the ground for the insights on Crimean geology and a range of stratigraphic schemes.

The third (post-war) stage encompasses second part of Soviet time from 1945 to 1990 with detailed mapping, specialized geochemical, geophysical and hydrogeological studies.

The fourth stage of the geological studies in the territory coincides in time with the works in Ukraine as independent state. This stage is going on under influence of mobilist ideas on the Earth's crust evolution spreading over practice of geological works, and this, in turn, assumes radical re-building of geological thoughts and adjustment of contradictions between fixism ideas, based on significant knowledge, and modern insights, which are currently mainly grounded on theoretic acceptance of mobilistic constructions.

On the ground of work results obtained in the first half of the third period, the Crimean Series of the State Geological Map of USSR in the scale 1:200 000 has been published in 1973 under edition of M.V.Muratov [2, 3]. The maps, designed under leadership of M.V.Muratov, for the time of their publishing had comprised fundamental edition, which elaborated main issues of stratigraphy, tectonics and history of geological development in the area. Geological ideas of that time on the area geology and achieved level of the column stratigraphic subdivision and mineral-resource base have been expressed on these maps.

The Mountain Crimea is considered as the northern limb and core portion of the large mega-anticlinorium which most part is buried beneath the Black Sea waters. Relatively simple fold are distinguished, which were formed through differentiated vertical motions, and the role of block dislocations was actually ignored.

The Plain Crimea is considered as the fragment of epi-Paleozoic Scythian plate complicated by the higher-order tectonic elements.

Concerning minerals, the authors had focused on the construction materials while metallogenic zonation and complex assessment of the territory for other minerals had not been conducted. The maps presented were not conditional and comprised geological base to further studies.

In view of the country economy, research and operating organization needs in more detailed geological base and emerged necessity in complex territory assessment for all possible minerals, in the period after Derzhgeolkarta-200 publishing Krymska GEE of SE "Krymgeologiya" has conducted detailed geological mapping in the scale 1:25 000 [31], deep geological mapping in the scale 1:50 000 [40, 63], and extended geological study in the scale 1:200 000 over some fields of map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol). As a result of these works, general geology of Crimea and stratigraphic subdivision of geological column had been essentially adjusted. In the major structure formation, the major role is assigned to the fault tectonics, and the block structure of the region has been accepted.

The second half of the third stage in the studies over given territory differs in the complex geological and specialized works aiming data upgrading on the geology, composition and minerals in the area, as well as the state, natural and anthropogenic changes in environment, required for the efficient decisions with regard to the rational use of natural resources.

Specifically, in 1974-1976 in the south-western part of Mountain Crimea (map sheet L-36-XXXIV) has been conducted geological, hydrogeological and engineering-geological mapping in the scale 1:25 000. Designed geological map has expressed fault-block structure of the region and on this ground the micro-seismic zonation of the territory has been carried out. As a result of these works hydrogeological and engineering-geological conditions also have been studied in the Southern Coast of Crimea [31].

In the period 1978-1984 the deep geological mapping in the scale 1:50 000 has been conducted aiming deep structure study in the western part of Mountain Crimea. As a result, in Baydarska valley structures have been distinguished suitable for potable groundwater prospecting in Upper Jurassic sediments, and mineral waters – in Upper Jurassic sediments; besides that, the zones have been distinguished prospective for poly-metallic mineralization [40].

In Gerakleyske plateau the same-named volcano-tectonic unit is distinguished and studied. Three sequential phases of volcanism are defined and their features, relationships and distribution in space and column are described. Assessment of the field for gold-polymetallic mineralization has been conducted [63].

Actually at the same time (1982-1985) in the south-western part of Plain Crimea (map sheet L-36-XXVIII (Evpatoriya)) extended geological study in the scale 1:200 000 has been conducted [38]. As a result, a set of geological, hydrogeological and engineering-geological maps has been designed. Major tectonic elements of the folded superimposed Early-Kimmerian and Herzinian basement were defined which govern tectonic patterns of the Neogene-Quaternary cover. Subdivision of pre-Quaternary rocks is performed in compliance with the stratigraphic scheme effective for that time while Quaternary sediments were subdivided up to the section and horizon. Perspective sites for various construction materials are defined and general assessment of intensity and types of exogenic processes has been given.

Over aforementioned period a number of hydrogeological studies were also conducted including: complex hydrogeological and engineering-geological mapping; monitoring of exogenic processes [42]; special hydrogeological studies in seismo-active zone of Crimea aiming earthquake precursor searching and zonation on their prognostic seismic activity [61]; regional study of groundwater regime; prospecting and exploration of potable groundwater resources [69], and thermal mineral waters [60, 47].

This period has also included major studies in geological-ecological assessment of technogenic impact on environment of Crimea and its natural complexes, including influence of North-Crimean channel irrigation system on changes in hydrogeological and engineering-geological conditions. Special attention has been paid to the technogenic factors and dynamics of regional groundwater contamination, study of pesticide regime and products of their dissolution. The integral toxic charge on the territory is appraised in 1976-1982, as well as composition of contaminating substances in the air of industrial towns and assessment is made to the possible vertical migrations of contaminants [42, 45, 61]. The territory zonation is established by ecological-geological processes and recommendations are issued concerning stabilization to some of these processes.

At the final stage of geological mapping works in this period detailed stratigraphic studies have been carried out and as a result geologists of Krymska GEE (M.V.Vanina and others) in cooperation with scientists from Institute of Geological Sciences of NASU the regional stratigraphic scheme for Mesozoic sediments in South-Ukrainian oil-gas-bearing region has been developed [4, 32].

In the 90^{th} of last century Krymska GEE had conducted more extended study of Mesozoic sediments stratigraphy with re-examination of basic sections and approval of new stratigraphic scheme for Jurassic rocks [18, 19]. In parallel to geological mapping metallogenic studies have been conducted. Metallogenic and geochemical maps in the scale 1:200 000 and 1:500 000 were designed. M.V.Vanina [33] had prepared prognostic-mineragenic map in the scale 1:200 000 which reflects mineragenic zonation of the territory performed on the structure-formation basis, and authors have also provided prognostic assessment of the territory for diverse mineral resources. Results of these studies were used as background for the mineragenic map in the scale 1:500 000 prepared by the State Institute of Mineral Resources.

In the same period M.V.Vanina and others had prepared to publishing the Sevastopolska group of map sheets of the State Geological Map of Ukraine in the scale 1:50 000 [5].

In 1992 in Krymska hydrogeological expedition of SGE "Krymgeologiya" has been prepared and published the handbook "Mineral-resource base of construction materials industry of Ukraine. Crimean Autonomous Republic" [23], where information is summarized on geological study of construction materials mineral-resource base, rate of its industrial development and further perspectives were defined.

Together with partly outdated geosyncline theory, which is based on vertical movement predomination (V.M.Muratov, V.M.Tseysler, E.O.Uspenska and others), using Crimean data also had been developed:

- fault-block concept which respects both vertical and horizontal rock mass movements (it is realized in geological maps designed in 1970-1980 by Crimean geologists L.S.Borysenko, S.V.Pyvovarov, V.I.Ivanov, B.P.Chaykovskiy) [31, 40, 63];
- neo-mobilistic concept of V.V.Yudin and O.M.Gerasymov, where structure of Crimea is resulted from some odd-aged suture zones – from Paleozoic to Cenozoic, diverse mélanges and olistoplakes, caused by exotectonics and large-scale horizontal displacements from the south [25-28];
- thrust-nappe concept of S.S.Kruglov, who considered tectonic development of Mountain Crimea by analogy with Carpathians (Kruglov, 1999);

- thrust-nappe concept of Yu.V.Kazantsev, who considered tectonic development of Mountain Crimea by analogy with Urals and displacements from the north [11, 12].

Normally all geological works have been accompanied by the complex of aerial geophysical works – electric, magnetic, gravity and seismic surveys and borehole logging. Geophysical works in 1970-1980 have confirmed block structure of some sites in the region and thickness of some stratigraphic subdivisions is adjusted. Using results of magnetic surveys the map of isodynams for Mountain Crimea and integrated map of magnetic and gravity field in the scale 1:200 000 are designed, as well as basement structure of Mountain Crimea has been studied. By DSS profiles, the scheme of Earth crust is designed and deep-seated fault zones are defined. The seismic sections unequivocally suggest for leading role of fault-block structures at almost complete lacking of thrust-nappe elements.

In the 90th of last century neo-mobilistic thoughts on Crimean geology have been spread out. These ideas have been followed by Crimean geologists V.V.Yudin, E.M.Gerasymov, V.M.Rybakov, Lviv geologists S.S.Kruglov, S.S.Smyrnov and V.P.Popadyuk, as well as Moscow geologists V.S.Myleev, M.V.Koronovskiy and others, but the common model of Crimean geology from the plate tectonics point of view is not developed so far. Moreover, tectonophysics studies, conducted in Mountain Crimea in 2001 by O.B.Gintov and A.N.Aronskiy [67, 39], suggest for the common kinematics of all Upper Jurassic sediments of Mountain Crimea while this would be not possible at their displacement over significant distances; structures are not encountered which might support idea on large-scale movement of Upper Jurassic rocks and their thrusting over Lower Cretaceous sediments. Just horizontal shears by sub-vertical planes and normal-fault deformations are only confidently noted. Thrusts and reverse faults, as the integrated part of mountain-forming processes, cannot account for priority motions of Earth crust in the Crimean region. Besides that, in most columns the normal stratigraphic contacts (through basal conglomerates) with underlaying Middle Jurassic sediments are observed. Neo-mobilistic reconstructions are based on re-interpretation of CMRW and DSS data, resulted in conclusions, which completely differ from previous developments and designed “speed” model of the Earth crust.

The first attempt to introduce the neo-mobilistic ideas in the practice of geological studies in Crimea has been applied in the course of prognostic-geodynamic mapping in the scale 1:500 000 [64]. In this work, formational analysis of litho-tectonic complexes has been performed, including complexes – indicators of geodynamic conditions, and attempt is made to examine the evolution of geodynamic conditions that control formation of these complexes and cause their further transformations and displacement in space. The major role in the region structure formation is assigned to the lateral displacements and collision interaction of litho-tectonic complexes, which have been formed under different geodynamic conditions, and then with flat nappes have been thrusted over autochthonous and para-autochthonous basement. Displacement plane is approximately equated to the zone of rock dilatation, identified at the depth 10 km in average. However, geological complexes, accessible for direct observation and study, do not actually exhibit any evidences for such large-scale displacements.

Geodynamic works, conducted at the border of XX and XXI centuries using Crimean data, contain considerable internal contradictions and ignore all achievements and results of traditional geology in stratigraphy, paleontology and tectonics. At present they cannot be accepted as the base for the State Geological Map in the scale 1:200 000 which re-edition is vitally required.

In the course of preparation to the publishing of Derzhgeolkarta-200, the NSC has published in 1993 the “Stratigraphic scheme of Ukraine for the maps of new generation”, where zonation of entire Crimean territory and studied map sheets, in particular, is given for some slices of stratified Phanerozoic units. Pliocene and Quaternary sediments are grouped and subdivided under climatic-stratigraphic principle.

Among marine Pliocene sediments just the subdivisions of regional scale have been defined (horizons, sub-horizons) while Miocene part of the column was not considered.

In the course of preparation to the publishing of Derzhgeolkarta-200, the authors have designed and approved in NSC the “Regional stratigraphic scheme of Neogene sediments in Plain Crimea” (S.V.Biletskiy, 1996), and “Correlation stratigraphic scheme of Riphean-Paleozoic rocks in Crimea” (B.P.Chaykovskiy, 2000). In these schemes, using results of previous works, Upper Riphean – Paleozoic rocks are divided into Nyzhnyogirska Series and Zuyska and Novoselivska suites (NSC protocol No. 4 of 17.07.2000), and stratification of Neogene sub-aerial and marine sediments is made up to suite, sub-suite and sequence (SEC protocols No. 98 of 01.03.2000 and No. 134 of 01.10.2003).

Thus, the history of geological studies reflects considerable interest of investigators to the Crimean geology. The stages are noted in the tasks elaboration, as well as evolution of scientific ideas concerning history of the complex geological structure development in the region.

2. STRATIFIED UNITS

The studied territory is located in the south-western part of Crimean Peninsula.

In the map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) geological structures are composed of the rock complexes separated by major discontinuities. The first complex (metamorphic) consists of Paleozoic rocks, which are partly extended into the studied map sheets from Simferopilske and Novoselivske uplifts, described in the adjacent map sheet L-36-XXI (Chornomorske). The second complex (sedimentary-volcanogenic) constitutes major structures in the internal part of Mountain Crimea. It is composed of Upper Triassic, Lower and Middle Jurassic flysch sandstone-argillite and volcanogenic rocks. The third complex (sedimentary) includes Upper Jurassic and Lower Cretaceous carbonate and terrigenous-clayey sediments. The fourth complex, which forms the northern limb of Mountain Crimea and Plain Crimea, consists of Upper Cretaceous, Paleogene and Neogene carbonate-marl sediments.

Stratigraphic subdivision of sedimentary complexes is performed in compliance with the "Stratigraphic code of Ukraine" (1997), "Stratigraphic scheme of Ukraine for the maps of new generation" (1993), "Correlation stratigraphic scheme of Riphean-Paleozoic rocks in Crimea" (2000), "Regional stratigraphic scheme of Neogene sediments in Plain Crimea" (1996), and "Basic legends to the Crimean Series of Derzhgeolkarta-200" (1996) approved by SEC.

In the course of works over stratigraphy of mentioned sheets of Crimean Series some contradictions, specifically, the names of "Novoselivska" and "Zuyska" series (Lower-Middle Carboniferous) are changed to the same-named suites in accordance with approved new "Correlation stratigraphic scheme of Riphean-Paleozoic rocks in Crimea" (NSC protocol No. 4 of 17.07.2000).

In the territory of map sheets, in compliance with the "Scheme of litho-tectonic zonation" (see "Legend to geological map and map of mineral resources of pre-Quaternary units") the authors have defined litho-tectonic zones (LTZ) and sub-zones; their boundaries vary under influence of tectonic processes which governed sedimentation conditions over particular time.

In general, in accordance with mentioned scheme the stratigraphic subdivision looks as follows.

PHANEROZOIC
Paleozoic
Carboniferous System – *Simferopilska LTZ, Novoselivska LTZ*

Mesozoic
Triassic, Jurassic – *Pivnichnokrymska LTZ, Evpatoriyska LTZ, Alminska LTZ, Bitatska LTZ, Sukhoritsko-Baydarska LTZ, Ay-Petri-Babuganska LTZ, Kachynsko-Salgyrska LTZ, Pivdenna LTZ;*
Cretaceous – *Pivnichnokrymska LTZ, Tsentralnokrymska LTZ, Zakhidna LTZ (Chornoritsko-Baydarska sub-zone, Belbetska sub-zone);*

Cenozoic
Paleogene – *Tarkhankutska LTZ, Syvaska LTZ, Pivdennozakhidna LTZ;*
Neogene – *Tsentralna LTZ, Alminska LTZ, Pivdennozakhidna LTZ.*

INTEGRATED STRATIGRAPHIC COLUMN OF PHANEROZOIC ROCKS IN THE AREA

PHANEROZOIC ACROTHEME
Cenozoic eratheme
Quaternary System
Holocene division (H)

tH – technogenic sediments
eH – eluvial sediments
apH – alluvial-proluvial sediments
lH – lake sediments
lm,mHčm – Chornomosrskiy horizon. Estuary and marine sediments
m,mHčm – Chornomosrskiy horizon. Marine sediments

Neo-Pleistocene – Holocene (P_{III}-H)
Upper branch, Prychornomorskiy climatolith and Holocene undivided

a^1P_{III}pč-H – alluvial sediments of the first over-flood terrace
ap^1P_{III}pč-H – alluvial-proluvial sediments of the first over-flood terrace
pP_{III}pč-H – proluvial sediments
pdP_{III}pč-H – proluvial-deluvial sediments
dpP_{III}pč-H – deluvial-proluvial sediments
zP_{III}pč-H – slide sediments
cP_{III}pč-H – coluvial sediments
dP_{III}pč-H – deluvial sediments
lP_{III}pč-H – lake sediments

Pleistocene Division
Neo-Pleistocene /P/
Upper branch, undivided sediments /P_{III}/

pdP_{III} – proluvial-deluvial sediments
dP_{III} – deluvial sediments
vd,edP_{III} – aeolian-deluvial and eluvial-deluvial sediments

Upper branch /P_{III}/

amP_{III}nv – Novoevksynskiy horizon. Alluvial-marine sediments

Dofinivskiy and Prychornomorskiy climatoliths combined

edP_{III}df+pč – eluvial-deluvial sediments
ed,vdP_{III}df+pč – eluvial-deluvial and aeolian-deluvial sediments

Buzkiy and Dofinivskiy climatoliths undivided

a^2P_{III}bg-df – alluvial sediments of the second over-flood terrace
dpP_{III}bg-df – deluvial-proluvial sediments

Udayskiy and Vytachivskiy climatoliths undivided

a^3P_{III}ud-vt – alluvial sediments of the third over-flood terrace
ap^3P_{III}ud-vt – alluvial-proluvial sediments of the third over-flood terrace
pP_{III}ud-vt – proluvial sediments
dpP_{III}ud-vt – deluvial-proluvial sediments
zP_{III}ud-vt – slide sediments
cP_{III}ud-vt – coluvial sediments

Prylutskiy, Udayskiy and Vytachivskiy climatoliths combined

ed,vdP_{III}pl+vt – eluvial-deluvial and aeolian-deluvial sediments

Middle and upper branches undivided /P_{II-III}/

Tyasminskiy and Prylutskiy climatoliths undivided

a^4P_{II-III}ts-pl – alluvial sediments of the fourth over-flood terrace

Middle branch /P_{II}/

cdP_{II} – coluvial-deluvial sediments
cdP_{II}kd-ts – Kaydatskiy and Tyasminskiy climatoliths undivided. Coluvial sediments

Karangatskiy horizon

amP$_{II}$kg– alluvial-marine sediments
mP$_{II}$kg – marine sediments
a^{5}P$_{II}$dn-kd – Dniprovskiy and Kaydatskiy climatoliths undivided. Alluvial sediments of the fifth over-flood terrace

Dniprovskiy, Kaydatskiy and Tyasminskiy climatoliths undivided

pP$_{II}$dn-ts – proluvial sediments
dpP$_{II}$dn-ts – deluvial-proluvial sediments
dP$_{II}$dn-ts – deluvial sediments
vd,edP$_{II}$dn+ts – Dniprovskiy, Kaydatskiy and Tyasminskiy climatoliths combined. Aeolian-deluvial, eluvial-deluvial sediments
ed,vdP$_{II}$zv+kd – Zavadivskiy, Dniprovskiy and Kaydatskiy climatoliths combined. Aeolian-deluvial and aeolian-deluvial sediments

Lower and Middle branches undivided /P$_{I-II}$/

a^{6}P$_{I-II}$tl-zv – Tyligulskiy and Zavadivskiy climatoliths undivided. Alluvial sediments of the sixth over-flood terrace
amP$_{I-II}$e – Evksynskiy super-horizon. Alluvial-marine sediments

Lower branch /P$_I$/

cdP$_I$ – coluvial-deluvial sediments

Lubenskiy and Tyligulskiy climatoliths undivided

pP$_I$lb-tl – proluvial sediments
dpP$_I$lb-tl – deluvial-proluvial sediments
zP$_I$lb-tl – slide sediments
cP$_I$lb-tl – coluvialsediments
a^{7}P$_I$sl-lb – Sulskiy and Lubenskiy climatoliths undivided. Alluvial sediments of the seventh over-flood terrace
dpP$_I$mr-lb – Martonoskiy, Sulskiy and Lubenskiy climatoliths undivided. Deluvial-proluvial sediments
ed,vdP$_I$mr+lb – Martonoskiy, Sulskiy and Lubenskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments
a^{8}P$_I$pr-mr – Pryazovskiy and Martonoskiy climatoliths undivided. Alluvial sediments of the eighth over-flood terrace
vd,edP$_I$sh+sl – Shyrokynskiy, Pryazovskiy, Martonoskiy, Lubenskiy and Sulskiy climatoliths combined. Aeolian-deluvial and eluvial-deluvial sediments
amP$_I$čd – Chaudynskiy super-horizon. Alluvial-marine sediments

Shyrokynskiy and Pryazovskiy climatoliths undivided

lpP$_I$sh-pr – lake-proluvial sediments
dpP$_I$sh-pr – deluvial-proluvial sediments
pdP$_I$sh-pr – proluvial-deluvial sediments
ed,vdP$_I$sh+pr – Shyrokynskiy and Pryazovskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments
edP$_I$sh – Shyrokynskiy climatolith. Aeolian-deluvial sediments

Eo-Pleistocene – Holocene undivided /E-H/

st/E-H/ – sub-teral sediments
ek/E-H/ – eluvial-karst sediments

Eo-Pleistocene /E/

Upper branch /E_{II}/

Kryzhanivskiy climatolith

pdE_{II}kr – proluvial-deluvial sediments
edE_{II}kr – eluvial-deluvial sediments

Lower and Upper branches undivided

ap^{10+9}Ebr-il – Berezanskiy, Kryzhanivskiy and Illichivskiy climatoliths undivided. Alluvial-proluvial sediments of the tenth and ninth over-flood terraces
vd,edEbr+il – Berezanskiy, Kryzhanivskiy and Illichivskiy climatoliths combined. Aeolian-deluvial and eluvial-deluvial sediments

Neogene System (Upper Pliocene) and Quaternary System (Eo-Pleistocene) undivided (N_2-E)

ecN_2-E*ms* – Masandrivska Suite. Eluvial-coluvial sediments

Neogene System
Pliocene (N_2)
Upper Pliocene
Akchagylian regio-stage

Alminska LTZ	*Tsentralna LTZ*
N_2*tv* – Tavrska Suite **N_2*tv*$_2$** – Upper Tavrska (Andriivska) sub-suite	**N_2*ng*** – Nogayska Suite **N_2*ng*$_2$** – Upper sub-suite **N_2*ng*$_1$** – Lower sub-suite

Lower Pliocene
Kimmerian regio-stage
Kamysh-Burunskiy horizon

N_2*tv* – Tavrska Suite **N_2*tv*$_1$** – Lower Tavrska (Uchkuivska) sub-suite	**N_2*bgr*** – Bagrationivska sequence

Azovskiy horizon

	N_2*čt* – Chatyrlytska sequence

Miocene (N_1)
Upper Miocene
Meotychniy regio-stage (upper sub-regio-stage) and Pontychniy regio-stage
Alminska and Tsentralna LTZs

N_1*kz* – Kazankivska sequence

Pontychniy regio-stage
Lower sub-regio-stage
Novorosiyskiy horizon
Alminska LTZ

N_1*bl* – Burulchynska sequence

Alminska and Tsentralna LTZs

N_1*od* – Odeski layers
N_1*ev* – Evpatoriyski layers

Meotychniy regio-stage
Lower sub-regio-stage
Bagerovskiy horizon

Alminska LTZ and Tsentralna LTZs
N_1*ak* – Akmanayska Suite
N_1*dz* – Dozinievi layers

Tsentralna LTZ
N_1*bg-ak* – Bagerovska and Akmanayska suites undivided
N_1*bg* – Bagerovska Suite

Sarmatskiy regio-stage
Upper sub-regio-stage
Khersonskiy horizon
Alminska and Tsentralna LTZs

N_1*hr* – Khersonska Suite

Middle sub-regio-stage
Besarabskiy horizon
Alminska and Tsentralna LTZs

N_1*bs* – Besarabska Suite

Lower sub-regio-stage
Volynskiy horizon

N_1*kp* – Krasnoperekopska Suite

Alminska and Tsentralna LTZs
N_1*er* – Ervilievi layers

Alminska and Pivdennozakhidna LTZs
N_1*vl* – Volynska Suite

Middle Miocene

N_1*br+vs* – Brykivski, Spaniodontelovi, Sartaganski and Veselyanski layers

N_1*mkz* – Mekenziivska sequence

Karaganskiy regio-stage

Alminska and Tsentralna LTZs

Alminska and Pivdennozakhidna LTZs
N_1*ps* – sandstone sequence

Chokrakskiy regio-stage

Alminska and Tsentralna LTZs
N_1*br* – Brykivski layers

Alminska and Pivdennozakhidna LTZs

Lower Miocene
Tarkhanskiy regio-stage
Upper and Middle sub-regio-stages
Tsentralna and Alminska LTZs

N_1*mč+jr* – Mayachkynska Suite and Yurakivski layers combined

Paleogene System
Oligocene (₽$_3$)
Maykopska Series
Chattian stage
Sirogozkiy regio-stage
Syvaska and Pivdennozakhidna LTZs

P$_3$*g* – batch of grey clays

Rupelian stage
Molochanskiy regio-stage
Syvaska and Pivdennozakhidna LTZs

₽$_3$*ml* – Molochanska Suite

Planorbeloviy regio-stage

Syvaska, Pivdennozakhidna and Tarkhankutska LTZs

₽$_3$*pl* – Planorbelova Suite
- **₽$_3$*pl*$_2$** – Upper sub-suite
- **₽$_3$*pl*$_1$** – Lower sub-suite

Bakhchysarayska and Tarkhankutska LTZs

₽$_3$*zb* – Subakynska sequence
₽$_3$*kd* – Kyzyldzharska sequence

Eocene (₽$_2$)
Middle and Upper Eocene
Bartonian and Priabonian stages
Novopavlivskiy, Kumskiy and Alminskiy regio-stages
Syvaska and Pivdennozakhidna LTZs

₽$_2$*np+al* – Novopavlivska, Kumska and Alminska suites combined

Middle Eocene
Kumskiy regio-stage
Tarkhankutska LTZ

₽$_2$*ma* – sequence of marls and aleurolites

Simferopilskiy and Novopavlivskiy regio-stages
Tarkhankutska LTZ

₽$_2$*rd* – Rodnikovska sequence

Lower and Middle Eocene
Ypresian and Lutetian stages
Bakhchysarayskiy and Simferopilskiy regio-stages combined
Pivdennozakhidna LTZ

₽$_2$*bh+sm* – Bakhchysarayska and Simferopilska suites combined

Lower Eocene
Ypresian stage
Bakhchysarayskiy regio-stage

Tarkhankutska LTZ

₽$_2$*ok* – Okunivska Suite

Syvaska LTZ

₽$_2$*g* – sequence of clays

Paleocene (₽$_1$)
Upper Paleocene
Thanetian stage
Kachynskiy regio-stage

Pivdennozakhidna LTZ	*Tarkhankutska LTZ*	*Syvaska LTZ*
₽$_1$*kč* – Kachynska Suite	**₽$_1$*lz*** – Lazurnenska Suite	**₽$_1$*mv*** – sequence of marls and clayey limestones

Lower Paleocene
Danian and Montian stages
Bilokamyanskiy regio-stage

₽$_1$*bk* – Bilokamyanska Suite **₽$_1$*bk*$_2$** – Upper sub-suite **₽$_1$*bk*$_1$** – Lower sub-suite	**₽$_1$*grm*** – Gromivska Suite **₽$_1$*grm*$_2$** – Upper sub-suite **₽$_1$*grm*$_1$** – Lower sub-suite	**₽$_1$*bg*** – Bogachivska Suite

M e s o z o i c e r a t h e m e
Cretaceous System
Upper division (K$_2$)
Maastrichtian stage
Zakhidna LTZ

K$_2$*ss* – Starosilska Suite

Campanian stage (upper sub-stage) – Maastrichtian stage
Pivnichnokrymska and Tsentralnokrymska LTZs

K$_2$*dž* – Dzhankoyska Suite
K$_2$*dž*$_2$ – Upper sub-suite
K$_2$*dž*$_1$ – Lower sub-suite

Campanian stage
Zakhidna LTZ

K$_2$*bk* – Beshkoska Suite

Santonian stage – Campanian stage (lower sub-stage)

Zakhidna LTZ	*Pivnichnokrymska and Tsentralnokrymska LTZs*
K$_2$*kd* – Kudrynska Suite	**K$_2$*pl*** – Pavlivska sequence

Santonian stage (lower sub-stage)

	K$_2$*kc* – Koltsovska sequence

Turonian and Coniacian stages

	K$_2$*nt* – Natashynska Suite

Turonian stage (upper sub-stage) – Coniacian stage

K$_2$*pr* – Prokhladnenska Suite	

Turonian stage
Lower sub-stage

K_2*md* – Menderska Suite

Cenomanian stage

K_2*bl* – Bilogirska Suite

Lower and Upper divisions (K_{1-2})
Albian stage (upper sub-stage) – Cenomanian stage undivided
Tsentralnokrymska and Pivnichnokrymska LTZs

K_{1-2}*kp* – Krasnopolyanska Suite

Middle and upper sub-stages
Tsentralnokrymska and Pivnichnokrymska LTZs

K_{1-2}*kp* – Krasnopolyanska Suite
- **K_{1-2}*kp*$_3$** – Upper sub-suite
- **K_{1-2}*kp*$_2$** – Middle sub-suite
- **K_{1-2}*kp*$_1$** – Lower sub-suite

Lower sub-stage
Pivnichnokrymska LTZ

K_{1-2}*pv* – Pryvolnenska Suite
- **K_{1-2}*pv*$_2$** – Upper sub-suite
- **K_{1-2}*pv*$_1$** – Lower sub-suite

Lower division (K_1)
Albian stage
Upper sub-stage
Kovylnenskiy horizon

Zakhidna LTZ Chornoritsko-Baydarska sub-zone	*Tsentralnokrymska & Pivnichnokrymska LTZs*	*Pivnichnokrymska LTZ*	*Zakhidna LTZ Kachynsko-Salgyrska sub-zone*
K_1*kn* – Kanarynska sequence	**K_{1-2}*kv*$_2$** – Kovylnenska Suite, upper sub-suite	**K_{1-2}*kv*$_1$** – Kovylnenska Suite, lower sub-suite	**K_1*trn*** – Ternivska sequence

Pivnichnokrymska and Tsentralnokrymska LTZs	*Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)*
K_1*ev* – Evpatoriyska sequence	**K_1*mn*** – Manguska sequence

Middle and Upper sub-stages

Pivnichnokrymska and Tsentralnokrymska LTZs	*Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)*
K_1*el* – Elyzavetynska sequence	**K_1*čr*** – Chorgunska sequence

Middle sub-stage
Tarkhankutskiy horizon
Pivnichnokrymska LTZ

K_1*tr* – Tarkhankutska Suite

Lower sub-stage
Ryleevskiy horizon
Pivnichnokrymska and Tsentralnokrymska LTZs

K_1*rl* – Ryleevska Suite

Aptian stage
Middle and Upper sub-stages
Tayganskiy horizon

Pivnichnokrymska and Tsentralnokrymska LTZs	*Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)*
K_1*kš* – Kashtanivska Suite	**K_1*mr*** – Maryinska sequence

Middle sub-stage
Zakhidna LTZ (Chornoritsko-Baydarska sub-zone)

K_1*bl* – Balaklavska sequence

Lower and Middle sub-stages
Pivnichnokrymska and Tsentralnokrymska LTZs

K_1*dn* – Donuzlavska Suite

Barremian (upper sub-stage) – Aptian stage (lower sub-stage)
Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)

K_1*bs* – Biasalynska Suite

Hauterivian (upper sub-stage) – Barremian stage
Pivnichnokrymska and Tsentralnokrymska LTZs

K_1*kl* – Kalininska Suite

Barremian stage
Upper sub-stage
Zakhidna LTZ (Chornoritsko-Baydarska sub-zone)

K_1*šr* – Shyrokivska sequence

Hauterivian stage (upper sub-stage) – Barremian stage (lower sub-stage) combined
Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)

K_1*vr+br* – Verkhoritska and Burulchynska sequences combined

Hauterivian stage
Upper sub-stage
Zakhidna LTZ
Belbetska and Chornoritsko-Baydarska sub-zone

K_1*gl* – Golubynska sequence

Lower sub-stage

Zakhidna LTZ (Belbetska sub-zone)	*Zakhidna LTZ (Kachynsko-Salgyrska sub-zone)*
K_1*krt* – Karaltyska sequence	**K_1*rz*** – Rizanska Suite

Valanginian stage – Hauterivian stage (lower sub-stage)
Zakhidna LTZ (Chornoritsko-Baydarska sub-zone)

K_1***nb*** – Novobobrivska sequence

Valanginian stage
Zakhidna LTZ (Belbetska sub-zone)

K_1***kt*** – Kayatepynska sequence

Lower sub-stage
Zakhidna LTZ (Belbetska sub-zone)

K_1***kč*** – Kuchkynska sequence

Berriasian stage
Upper sub-stage
Zakhidna LTZ (Belbetska sub-zone)

K_1***ss*** – Sonyachnosilska sequence

Lower and upper stages undivided
Zakhidna LTZ (Chornoritsko-Baydarska sub-zone)

K_1***bč*** – Bechku Suite

Lower sub-stage
Zakhidna LTZ (Belbetska sub-zone)

K_1***gs*** – Girska sequence

Jurassic System
Upper division (J_3)
Tithonian stage
Upper sub-stage
Bedenekyrskiy horizon

Sukhoritsko-Baydarska LTZ
J_3***bd*** – Baydarska Suite
J_3***dd*** – Deymen-Derynska Suite
J_3***dd***$_2$ – Upper sub-suite
J_3***kl*** – Kalafatlarska Suite

Ay-Petri-Babuganska LTZ
J_3***bd*** – Baydarska Suite
J_3***bk*** – Bedenekyrska Suite

Middle and Lower sub-stages
Yaltynskiy horizon

Sukhoritsko-Baydarska LTZ
J_3***dd*** – Deymen-Derynska Suite
J_3***dd***$_1$ – Lower sub-suite

Sukhoritsko-Baydarska and Ay-Petri-Babuganska LTZs
J_3***jl*** – Yaltynska Suite

Oxfordian stage (middle and upper sub-stages) – Kimmeridgian stage
Yaylynskiy horizon

Sukhoritsko-Baydarska LTZ
J_3***sr*** – Sukhoritska Suite
J_3***jj*** – Yaylynska Suite

Ay-Petri-Babuganska LTZ
J_3***jj*** – Yaylynska Suite

Middle and Upper divisions (J_{2-3})
Callovian stage (middle and upper sub-stages) – Oxfordian stage (lower sub-stage)
Sudatskiy horizon
Sukhoritsko-Baydarska LTZ

J_{2-3}*gr* – Gurzufska Suite

Middle division (J_2)
Bathonian stage (middle and upper sub-stages) – Callovian stage (lower sub-stage)
Kopselskiy horizon
Sukhoritsko-Baydarska and Ay-Petri-Babuganska LTZs

J_2*av* – Ayvasylska Suite

Bajocian stage (upper sub-stage) – Bathonian stage (lower sub-stage)
Karadazkiy horizon

Sukhoritsko-Baydarska LTZ
J_2*kd* – Karadazka Suite
J_2*ml* – Melaska Suite

Ay-Petri-Babuganska LTZ
J_2*kd* – Karadazka Suite
J_2*bl* – Belbetska Suite

Lower and Middle divisions (J_{1-2})
Toarcian and Aalenian stages – Bajocian stage (lower sub-stage)
Bitatskiy horizon

Alminska and Bitatska LTZs
J_{1-2}*ur* – Urguliyska Suite
J_{1-2}*bt* – Bitatska Suite

Ay-Petri-Babuganska LTZ
J_{1-2}*vd* – Vidradnenska Suite
J_{1-2}*bš* – Beshuyska Suite

Triassic System (Upper division) – Jurassic System (Lower division)
Krymskiy and Eskiordynskiy horizons
Pivdenna LTZ (Kachynsko-Salgyrska sub-zone)

T_3-J_1*tv* – Tavriyska Series

Triassic System
Upper division (T_3)
Carnian stage
Krymskiy horizon

Evpatoriyska and Pivnichnokrymska LTZs
T_3*ma* – sequence of marls and argillites

Alminska LTZ
T_3*a* – sequence of argillites

Lower and Middle divisions (T_{1-2})
Evpatoriyska LTZ

T_{1-2}*v* – sequence of limestones

Lower division (T_1)
Induan stage
Evpatoriyska LTZ

T_1*p* – sequence of quartzite-like sandstones
T_1*bg* – sequence of breccia and gravelites

P a l e o z o i c   e r a t h e m e
Carboniferous System
Middle division (C_2)
Simferopilska and Novoselivska LTZs

C_2*ns* – Novoselivska Suite

Lower division (C_1)
Novoselivska LTZ

C_1*zj* – Zuyska Suite

Description of stratified units, indicated in geological maps, is given below, from older to younger ones.

PHANEROZOIC

It includes geological formations of Paleozoic, Mesozoic and Cenozoic erathemes. Of these, accessibility and study degree increases from the older to younger ones.

Paleozoic Eratheme

Paleozoic rocks in the studied map sheets are conventionally distinguished in Plain Crimea – in Novoselivska and Simferopilska LTZs, which are only partly extended into the map sheets from the east and north and are mainly traced by geophysical surveys. Paleozoic rocks are only intersected by drill-holes in the southern slope of Novoselivske uplift, where Carboniferous sediments are developed (Fig. 2.1, Tarasivska field), as well as by drill-holes in the neighboring map sheets.

Carboniferous System

Carboniferous System is encountered in Novoselivska and Simferopilska LTZs where it includes lower and middle divisions.

Lower Division (C_1)

Zuyska Suite (C_1*zj*) is developed in the northern part of map sheets and is intersected by drill-holes in adjacent map sheets in the southern part of Novoselivska LTZ, where at the depth 1500-800 m it is "exposed" at pre-Cretaceous surface, and in the northern part of Alminska depression (nearby Saky town), where it is found beneath Middle Carboniferous sediments.

The stratotype is defined outside the map sheet area, in Zuyske uplift, DH Melnychna-1 (depth 2029-826 m) [4]. The Suite is composed of thin intercalation of schistose phillite-like argillites and carbonaceous-mica-carbonate, graphite-mica-carbonaceous and mica-quartz schists. Graphitized schists are dark-grey to black, thin-flaky, composed of fine-flaky sericite, fibrous-flaky graphite with quartz grain and fine-grained calcite admixture. The rocks are penetrated by numerous milky-white quartz veinlets. Underlaying rocks are not identified. Everywhere Zuyska Suite, without interruption signs, is overlain by Novoselivska Suite, or unconformably – by Jurassic and Cretaceous sediments. Intersected thickness of the Suite is 10-500 m, and in the stratotype it attains 1000 m. To the north from DH Novoselivska-3 [4] (depth 2464-2348 m) M.M.Zharkova has determined spores *Trilobozonotriletes trivialis* (W a l t z) I s c h . , *Leioletes sp., Euryzonotriletes sulcatus* (W a l t z) I s c h . , *Trematozonotriletes cf. variabilis* (W a l t z)., *Calamospora sp.,* and on this ground the Suite age is defined to be Early Carboniferous.

Middle Division (C_2)

Novoselivska Suite (C_2*ns*) is developed in the northern part of studied map sheets and is intersected by drill-holes in the southern slope of Novoselivske uplift and in the north of Alminska depression nearby Saky town. The stratotype is defined in Novoselivska LTZ, DH Krasnovska-1 [4] (depth 1920-1170 m). The Suite is composed of flyschoid sequence of thin intercalation of carbonaceous-mica-carbonate and quartz-sericite-carbonate schists, which in fact comprise highly schistose sandy limestones alternating in thin layers (1-10 mm) with other schist types. Numerous milky-white quartz veinlets are observed. The schists are metamorphosed under greenschist facies conditions and are arranged in folds. Underlaying rocks belong to Zuyska Suite. Novoselivska Suite is unconformably overlain by Jurassic and Cretaceous sediments. The intersected thickness is about 350 m attaining 900 m in the stratotype area. The Suite is correlated with Karapelitska Suite of Dobrudja and is Middle Carboniferous in age.

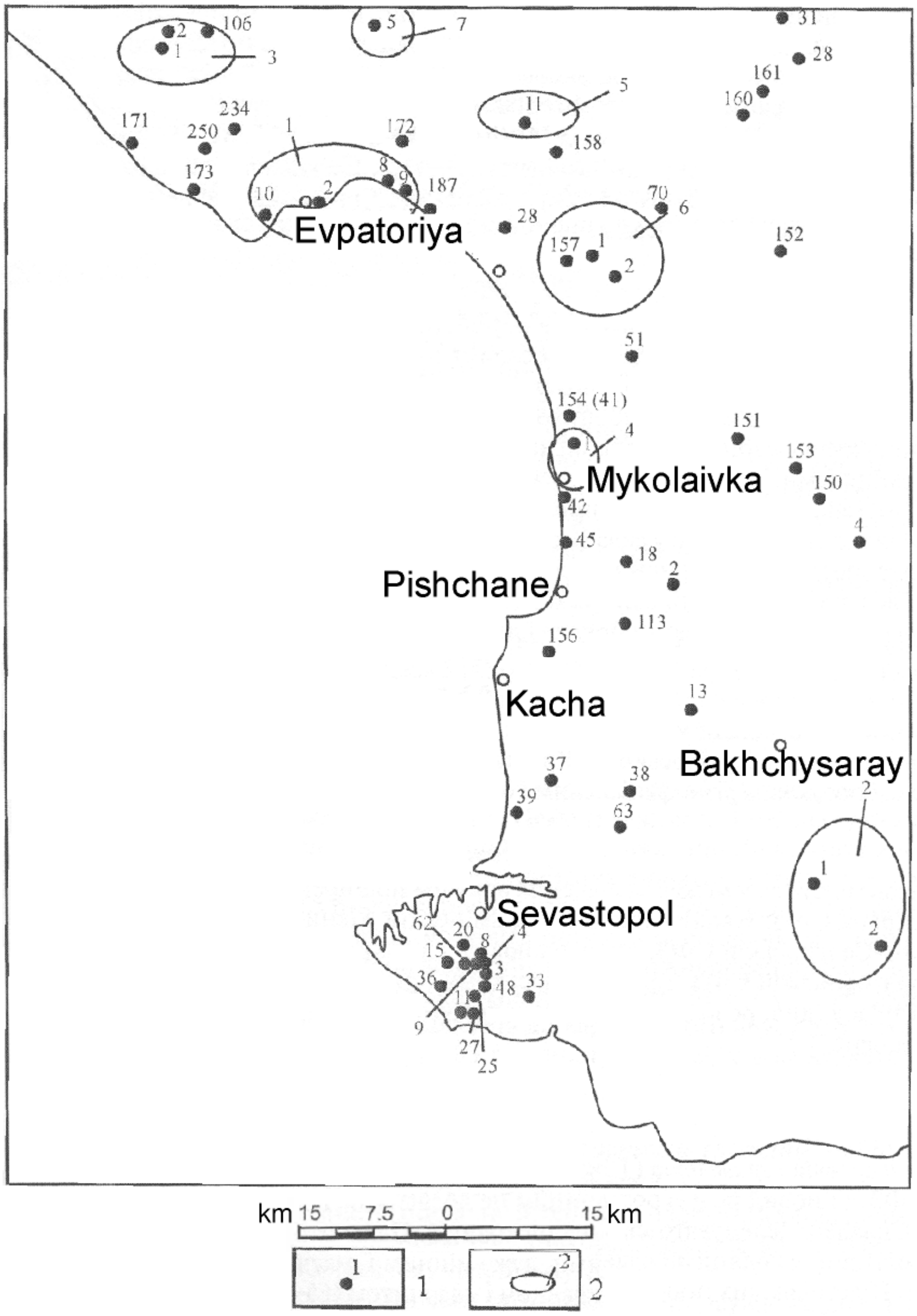

Fig. 2.1. Location scheme of oil and gas prospecting fields with basic boreholes.

1 – drill-holes and their numbers; 2 – oil and gas prospecting fields and their numbers: 1 – Evpatoriyska (DH 2, 9, 10); 2 – Kachynska (DH 1, 2); 3 – Krylovska (DH 1, 2); 4 – Mykolaivska (DH 1); 5 – Okhotnykovska (DH 11); 6 – Sakska (DH 1, 2); 7 – Tarasivska (DH 5).

Mesozoic Eratheme

Mesozoic sediments in the map sheets L-36-XXVIII, L-36-XXXIV are widespread both in Plain Crimea and Mountain Crimea. They include Triassic, Jurassic and Cretaceous units arranged in the thick diverse-facies complex of sedimentary and extrusive-pyroclastic rocks.

Triassic System

Triassic System in the mentioned map sheets is developed wide enough. The rocks are distinguished in four LTZs: Evpatoriyska and Alminska of Plain Crimea, and in Pivdenna and Kachynsko-Salgyrska LTZs which encompass Mountain Crimea. Most complete Triassic columns are intersected in Evpatoriyska LTZ, while in Mountain Crimea the Upper Triassic sediments are confidently defined (see cross-section A_1-A_5 to "Geological map and map of mineral resources of pre-Quaternary units").

Lower division (T_1)

Induan stage

Sequence of breccia and gravelites (T_1*bg*) is locally developed in the north-western part of Evpatoriyska LTZ. The typical column is intersected by DH Krylovska-2 [4, 38] (depth 2547-2385 m) (see Fig. 2.1). It is composed of greenish-grey breccia and gravelites. Clastic material includes aleurolites, mica schists, and brown porphyries. The intersected thickness is 120-130 m. Underlaying rocks are not approached by drilling. Sequence of breccia and gravelites is conformably overlain by the sequence of quartzite-like sandstones. Paleontological remnants are not found and sediments are conventionally ascribed to Induan stage.

Sequence of quartzite-like sandstones (T_1*p*) is locally developed in the north of Evpatoriyska LTZ. The typical column is intersected by DH Krylovska-2 [4, 38] (depth 2385-1588 m). It is composed of light-grey and pink, quartzite-like, very strong, massive and coarse-banded sandstones. Clastic material consists of quartz and quartzite (65-90%), feldspars, muscovite, siliceous rocks, rhyolites, quartz-mica and mica schists. Cement is siliceous and cementation type is contact or porous. Somewhere fine coalified detritus is observed. Intersected thickness attains 560-600 m. The sequence conformably lies over sequence of breccia and gravelites and is unconformably overlain by the sequence of limestones. Paleontological remnants are not found while by position in the column these rocks are conventionally ascribed to Induan stage.

Lower and Middle divisions (T_{1-2})

Sequence of limestones (T_{1-2}*v*) is locally developed in Evpatoriyska LTZ. The typical columns are intersected by DH Evpatoriyska-10 [4, 18, 38] (depth 1375-980 m) and Evpatoriyska-8, 9 [4]. It is composed of grey, pink, black, breccia-like re-crystallized limestones. At the bottom dolomitized limestones predominate and often dolomites with relic organogenic texture. The intersected thickness attains 220 m. It unconformably lies over the sequence of quartzite-like sandstones and is conformably overlain by the sequence of marls and argillites. Of paleontological remnants conodonts *Neospathodus triangularis* (Bender), *Parachirognathus raridenticulatus* (Muller), *P. symmetricus* (Staesche), *Hadrodontina adunca* Staesche and foraminifera – *Glomospirella elbusorum* Broen., *Ammobaculites corpulentus* Efim, *Earlandia cf. tintinniformis* (Misik), *Meandrospira pusilla* (Ho), *Nodosaria hoae skyphica* Efim. and others are determined [4]. The given fauna complex suggests for Olenekian age of the sequence.

Upper division (T_3)

Carnian stage

Sequence of marls and argillites (T_3*ma*) is developed in Evpatoriyska LTZ to the south from Saky town. The typical column is intersected by DH Fedorivka-12 [4, 38] (depth 966-944 m). It is composed of dark-grey carbonate argillites with thin aleurolites, limestone and marl interbeds. The sequence dips steep enough (20-80^o) and is almost free of secondary processes. The intersected thickness is 15-25 m. The sequence conformably lies over the sequence of breccia-like limestones and with erosion is overlain by Lower Cretaceous Elyzavetynska sequence. In argillites E.V.Krasnov [4] has determined *Halobia bittneri* M o i s s., *H. septentrianalis* S m i t h., *H. austriaca* K i t t l l. , *Daonella sp.,* allowing these rocks ascription to Carnian stage of Upper Triassic.

In Kachynsko-Salgyrska and Pivdenna LTZs (Mountain Crimea) this sequence is correlated to Tavriyska Series.

Sequence of argillites (T_3a) is relatively locally developed in Alminska LTZ. The typical column is intersected outside the studied area by DH Tetyanivska-3 [4] (depth 4856-4751 m). It is composed of argillites alternating with aleurolites, sandstones, and the batch of sandstones with shale interbeds occur at the bottom.

Sandstones are grey, dark-grey, dense, diverse-grained, quartz and feldspar. The clastic material includes feldspar (5-30%), muscovite (5%), coaliferous-clayey shales and quartzites, tourmaline and zircon grains. Cement is clayey-carbonate and carbonate, in places siliceous. The type of cementation is basal, somewhere porous or contact.

Argillites are dark-grey, coaliferous-clayey and clayey-carbonate, dense, downward they are replaced by schistose quartz aleurolites with thin black graphitized argillite interbeds. Phosphorite concretions are observed somewhere. The intersected thickness attains 400 m. The sequence unconformably lies over Paleozoic rocks and also unconformably is overlain by Lower Cretaceous sediments. Of paleontological remnants molluscs *Halobia bittneri* M o i s s., *H. septentrianalis* S m i t h . [4] are found allowing argillite sequence ascription to Carnian stage of Upper Triassic.

In Kachynsko-Salgyrska and Pivdenna LTZs Upper Triassic sediments are included into Tavriyska Series.

Triassic System (upper division) – Jurassic System (lower division)

Krymskiy and Eskiordynskiy horizons

Tavriyska Series (T_3-J_1tv) is exposed in the cores of major block-anticline structures in the Crimean Southern Coast (Pivdenna LTZ), in the upper courses of Belbek and Bodrak rivers, as well as along Sukha Richka River (Kachynsko-Salgyrska LTZ).

Nowhere, because of significant dislocation and extensive sliding along the Crimean Southern Coast, more or less complete representative column is known. Just the fragments of individual separated columns are observed consisting of partly correlated portions of Upper Triassic and Lower Jurassic sequences which are not being mapped in the map scale.

In the integrated column of the given straton for specific blocks, where single paleontological findings are noted, it is possible to distinguish two suites – Upper Triassic Krymska, and Lower Jurassic Eskiordynska ones.

Krymska Suite is composed of flyschoid intercalation of sandstones, aleurolites and argillites with siderite concretions, silicified lenses of quartzite-like and coarse-grained quartz sandstones, lenses of fine-pebble conglomerates, and argillite pile with lenses of bun-shaped ironiferous siderites.

Main litho-petrographic types of Krymska Suite include sandstones, aleurolites, argillites and siderites.

S a n d s t o n e s are fine-medium-grained, quartz and polymictic, massive. The clastic material includes quartz (50-60%), silicides (20%), plagioclase (5%), chloritized volcanic rocks (10%), and muscovite (5%). Single siderite, calcite, apatite, ore mineral, zircon grains and sulphide and quartz intergrowths are observed. Cement is contact-porous, quartz-calcite.

A l e u r o l i t e s are grey and dark-grey, fine-medium-aleuritic, quartz and polymictic, unclear-banded, in places oblique-banded. The clastic fraction is composed of rounded quartz (50-60%), siliceous rocks (25%), plagioclases (3-5%). Cement is quartz-calcite, cementation type is porous.

A r g i l l i t e s are dark-grey and black, dense, slightly-aleuritic, with pelite and aleuro-pelite texture. Aleuritic fraction is distributed irregularly or spotty. Autigenic minerals include dust-like pyrite and collomorphic iron-hydroxide aggregates. After difractometry data, argillites are composed of di-octahedron hydromica, mica-smectite mixed-banded units, kaolinite and chlorite [67].

Distribution of femaphilic and felsiphilic micro-elements is characteristically almost equal in Krymska Suite rocks with concentrations close to Clark values in average. With respect to granulometric composition, vanadium only exhibits regular distribution and its content increases in argillites being apparently related to the enriched organic material in these sediments.

Total iron and magnesium contents are also characteristically increased in the Suite rocks. Relatively low ratio of two- and three-valent iron and anomalously high iron content are caused by abundant limonite, intergrowths of sulphides with quartz and calcite, and increased content of autigenic siderite. Geochemistry of Suite sandstones, in comparison to the typical varieties in classifications of Dott and Pettijohn, allows their ascription to the arkose greywackes, in some cases – to litite arenites [67].

Paleontological figure of the Suite is poor enough. In the Crimean Southern Coast, in the areas of Foros-Tesseli, Mukholatka, Mshatka, Goluba Zatoka, and in the basins of Belbek and Bodrak rivers (in Kachynskiy block), Late Triassic bivalve molluscs *Monotis caucasica* W i t t ., *Halobia fluxa* M o i s s ., *H. celtica* M o i s s ., and cephalopoda *Arcestes intuslabiatus* M o i s s ., *Megaphyllites insectus* M o i s s . are found [1, 4, 67].

In general, on the ground of studied organic remnants Krymska Suite is divided (upward) into the layers with *Halobia septentrianalis* (Carnian) and with *Monotis salinaria salinaria* (Norian).

Eskiordynska Suite, which comprises upper member of Tavriyska Series, in turn, is divided in two sub-suites. The lower sub-suite is composed of flysch rocks, very similar to the underlaying rocks of Krymska Suite, as well as argillites with grey and pink limestone lenses with Early Jurassic organic remnants found in the area of Foros-Tesseli, upper courses of Belbek and Bodrak rivers, in Sukha Richka, specifically: *Schlotheimia angulata* (S c h l.) – Late Hettangian, *Arietites bucklandi* (S o w.) – Early Sinemurian, *Angulaticeras dumortieri* F u c, *An. rumpens* (O p p.) – Late Sinemurian, *Phylloceras frondosum* R e y n. – Early Pliensbachian, *Grammoceras penenudum* M o n. – Late Pliensbachian [4, 7, 67].

The upper sub-suite is locally developed in the Bodrak River basin and is composed of light-grey and yellowish quartzite-like and arkose sandstones, polymictic conglomerates with argillite and aleurolites interbeds and limestone lenses.

Sandstones, the main litho-petrographic rock type, are light-grey, yellowish-grey, quartzite-like, diverse-grained, from fine-to medium-, with admixture of coarse-grained ones and fine gravel. Clastic material is composed of well-rounded quartz (70%), plagioclase (5-20%), quartzite and micro-quartzite (5%), weathered chloritized rocks (10-15%), silicides (2-3%), as well as single hydromica, ilmenite, epidote, sphene, magnetite, apatite grains, and coalified phyto-detritus. Cement is carbonate, cementation type is basal and contact. Autigenic assemblage includes calcite, siderite, pyrite, limonite, psylomelane, and chlorite.

Being compared with Krymska Suite sandstones, Eskiordynska rocks, after X-ray fluorescent analysis, contain several times less litho-, chalco- and siderophile elements (except strontium and copper). These features are related to essentially quartz rock composition and high silica content. With regard to granulometric composition, nickel, chromium, vanadium and gallium are regularly distributed and their content is several times higher in argillites in comparison to sandstones, while zinc content in sandstones is higher than in argillites. In comparison to Krymska Suite, Eskiordynska Suite sandstones contain less aluminium, titanium, total iron, manganese, alkalis and phosphorus coupled with the highest silica content. These data, taking into account clastic material composition, in comparison with typical varieties in Dott and Pettijohn classifications, allow studied sandstones ascription to quartz arenites and arkose greywackes [67]. Upper sub-suite carries Early Toarcian bivalve and cephalopoda complex: *Lima punctata* (S o w.), *Mytiloides dubius* (S o w.), *Dactylioceras tenuicostatum* J. et B., *Coeloceras crassum* P h i l l [1, 4, 67].

Stratigraphic boundaries of the Suite are not clear because of long-term and multi-phase tectonic deformations. All Suite boundaries, accessible for observation, are tectonic, both in the given and adjacent areas.

Relationships of Tavriyska Series with underlaying rocks and its thickness are not known confidently. In DH Kachynska-1 [4], drilled to the depth 4032 m in the area of Kuybyshevo village, and in DH Kachynska-2 [4], drilled to the depth 2294 m in the area of Golubynka village, the older rocks are not intersected. Taking into account extensive folding imposed onto flysch sequences of Tavriyska Series its thickness does not exceed 1000 m (conventionally). On the ground of paleontological remnants, the age of Tavriyska Series encompasses Late Triassic (Carnian time) – Early Jurassic (Early Toarcian *Dactylioceras tenuicostatum*). Outside the studied area Middle Triassic bivalvia location is known [7] but elsewhere confident Middle Triassic fauna is not identified.

Jurassic System

Jurassic rocks in the studied map sheets are distributed irregularly. Widespread sites and most complete Jurassic columns are known in Mountain Crimea. Over there, all main Jurassic biostratigraphic subdivisions are distinguished in sediments: stages, sub-stages, horizons, as well as local litho-stratigraphic subdivisions – suites and sub-suites. By facies features two LTZs are distinguished: Sukhoritsko-Baydarska and Ay-Petri-Babuganska. In Plain Crimea Jurassic sediments are intersected by some drill-holes in the northern part of Alminska depression where incomplete columns are encountered (mainly Upper Leiacian and Lower Doggerian). Stratification and age of these sediments are weakly grounded paleontologically and mainly based on micro-fauna and micro-flora determinations, which in general are not confident enough.

Lower and Middle divisions (J_{1-2})

Toarcian and Aalenian stages – Bajocian stage (lower sub-stage)
Bitatskiy horizon

In Bitatskiy horizon, Vidradnenska, Bitatska, Guliyska and Beshuyska suites are correlated, which in the map sheet area replace one another by lateral.

Vidradnenska Suite ($J_{1-2}vd$) is developed in Ay-Petri-Babuganska LTZ of Mountain Crimea (Belbek River basin in Kachynskiy block). The stratotype is defined in Belbek River basin nearby Vidradne village. The Suite is divided into three sub-suites; by technical reasons they are not being mapped in the given map scale.

Lower sub-suite includes greenish-grey massive sandstones with gravelite lenses; thickness is up to 200 m; it contains Toarcian remnants: *Astarte lotharingica* B e n., *Mytiloides cinctus* (G o l d f.), *Oxytoma toarciensis* P c e l [19, 66].

Middle sub-suite includes flysch-like alternating aleurolites and sandstones of 125 m thickness and carries Aalenian remnants: *Tancredia incurva* B e n., *Astarte aalensis* B e n., *A. voltzi* R o e m [19, 66].

The upper sub-suite is composed of sandstones with batches of multiple intercalating sandstone-aleurolite layers of 240 m total thickness. Early Bajocian forms *Witchellia cf. laeviscula* (S o w.), *Mylilus Unci* S e s., *Nucula variabilis* (S o w.), *Astarte cf. orbicularis* Sow are determined in the rocks [19, 66]. Total thickness of the Suite is 565 m.

Main litho-petrographic rock types of Vidradnenska Suite include sandstones, aleurolites and argillites.

Sandstones are greenish-grey, fine-medium-grained, clayey, with prevailing fraction particle size from 0.1 to 0.5 mm. Clastic material consists 80% of the rock volume. It is composed of quartz (60%), plagioclases (10%), diverse sedimentary rocks (25%) with insufficient admixture of biotite, chlorite, magnetite, ilmenite, leucoxene, rutile, zircon, and single garnet, epidote, tourmaline, amphibole, pyroxene, apatite, anatase, corundum, chromium spinels, and muassonite grains. Cement is clayey of contact type.

Aleurolites are grey, medium-dense, coarse-aleuritic, with prevailing fraction particle size from 0.03 to 0.06 mm. Clastic material attains 70-80% of the rock volume and include quartz (65%), plagioclases (20%), sedimentary rocks and minor magnetite, ilmenite, leucoxene, pyroxenes, chlorite, and muscovite. Cement is clayey-carbonate, cementation type is porous and contact.

Argillites are dark-grey, aleuritic, with aleurolites lenses. Allothigene components of aleuritic fraction, which attains 20% of the rock volume, include quartz (80%), plagioclases (10%), rock fragments (7%), chlorite, and calcite. Cement is clayey, cementation type is contact-porous.

Vidradnenska Suite unconformably lies over Tavriyska Series and is conformably overlain by Belbetska Suite. Stratigraphic boundaries of the Suite are notable enough. The lower one is set by the sharp change of moderate deep-water flyschoid sediments of Tavriyska Series. The upper boundary is less prominent and is set by the batch footwall of alternating sandstones, aleurolites and clays of Belbetska Suite. Lateral boundaries are well expressed in the area because of the facial substitution of the mentioned Suite by coal-bearing sediments of Beshuyska Suite and conglomerates of Bitatska Suite. By age, the Suite is ascribed to Early Toarcian (zone *Dactylioceras commune*) – Early Bajocian.

Beshuyska Suite ($J_{1-2}b\check{s}$) had got its name from Beshuyski coal mines. It is developed in Ay-Petri-Babuganska LTZ in the western Mountain Crimea; the stratotype is defined in Chuin-Ilga River (outside map sheet area). In the studied area the Suite is developed at Goluba Zatoka in the Crimean Southern Coast (Pivdenna LTZ) and is composed of alternating sandstones, argillites and aleurolites with minute coal and gravelite interbeds, up to 300 m of total thickness. Over considerable part of the territory Beshuyska Suite is overlain by Quaternary collapse-slide sediments.

In the separated surface outcrops the Suite is composed of greenish-grey sandstones, diverse-grained, with psammite texture. Clastic material consists of quartz, biotite and plagioclase. Cement is composed of montmorillonite, gibbsite, alophane and sericite. Cementation type is porous.

Aleurolites are grey, mainly quartz, with single feldspar grains and siliceous rock fragments. Cementation type is regeneration, hydro-mica, with siliceous material admixture.

Argillites are composed of thin kaoline and sericite flakes with fine-disperse clayey material admixture; in places quartz, plagioclase and carbonate fragments and muscovite flakes are observed. By age, the Suite is ascribed to Early Toarcian – Early Bajocian, according to the fauna complex *Mytiloides cinctus* (G o l d f.), *Astarte opalina* Q u e n . , *A. orbicularis* S o w [4, 19, 66]. The Suite unconformably lies over Tavriyska Series and also unconformably is overlain by Karadazka Suite rocks.

Facially, the Suite is replaced by Vidradnenska, Bitatska and Urguliyska suites.

Bitatska Suite ($J_{1-2}bt$) in the studied area is not exposed and is not intersected by drill-holes. The Suite development in geological structures of map sheet L-36-XXVIII is only induced from geophysical data and by drilling data in the territory directly adjacent from the east. In general, the Suite is composed of conglomerates, gravelites and sandstones, and in at the top – of the flysch-like intercalation of greenish-grey aleurolites, argillites and sandstones [4, 19, 66]. Thickness of the Suite is up to 650 m. It unconformably lies over Tavriyska Series and is unconformably overlain by Lower Cretaceous sediments. By age the Suite is ascribed to Early Toarcian (zone *Dactylioceras commune*) – Early Bajocian.

Urguliyska Suite ($J_{1-2}ur$) is locally developed in Ay-Petri-Babuganska LTZ of Mountain Crimea (in the Bodrak River basin) and is intersected by drill-holes (DH Mykolaivska-1) [17] in Plain Crimea (Alminska LTZ). The stratotype is defined nearby Trudolyubivka village in the Bodrak River valley. The Suite is composed of alternating argillites and aleurolites with sandstone interbeds; thickness is up to 400 m.

Main litho-petrographic rock types include argillites, aleurolites, sandstones. Argillites are dark-grey to black, phillite-like.

Aleurolites are grey, dark-grey, mica-quartz, dense, with clayey-siliceous cement.

Sandstones are dark-grey, quartzite-like, fine-grained, polymictic, with quartz cement.

Urguliyska Suite unconformably lies over Tavriyska Series and is unconformably overlain by Karadazka Suite or Lower Cretaceous sediments.

The Suite carries numerous organic remnants of cephalopoda, bivalvia and gastropoda molluscs and foraminifera: *Dactylioceras commune* (S o w.), *Grammoceras thouarsense* (O r b .), *Witchellia sp., Mesoteuthis rhenana* (O r b .), *Astarte opalina* Q u e n., *A. aalensis* B e n., A. *voltzi* R o e m . , *Anisocardia nuculiformis* (R o e m .), *Lenticulina perlucida* (A n t.) and others suggesting for the Suite Early Toarcian – Early Bajocian age.

In Alminska LTZ Urguliyska Suite is composed of argillites alternating with thin aleurolites, sandstone and gravelite layers. Over there, in DH Mykolaivska-1 [18] (depth 3200-1145 m), from bottom to top four sequences are distinguished:

1) sequence of sandstones with argillite, gravelite and thin aleurolites interbeds; it dips under angles 40-80^{o} and visible intersected thickness is 579 m;

2) sequence of argillites with single sandstone and aleurolites interbeds; dipping angles vary from 40-50^{o} to 80-90^{o}; visible thickness is 532 m;

3) sequence of argillites with aleurolite interbeds; dipping angles – 50-75^{o}, visible thickness – 454 m;

4) sequence of argillites with aleurolite interbeds; dipping angles – 15-35^{o}, visible thickness – 490 m.

Main litho-petrographic rock types include argillites, sandstones, aleurolites and gravelites.

Argillites are dark-grey to black, phillite-like, thin-flaky, non-carbonate, cataclazed with breccia-like structure.

Sandstones are grey, dark-grey, diverse-grained, polymictic, feldspar-quartz, dense, quartzite-like, in places micaceous, massive, metamorphosed, with numerous quartz and calcite veinlets (up to 2 mm) and pyrite pods. Cement is siliceous, cementation type is contact and porous.

Aleurolites are grey, dark-grey, feldspar-mica-quartz, massive, quartzite-like in some beds, very strong, with chlorite-siliceous cement of corrosion type.

Gravelites are black, composed of metamorphosed aleuritic and clayey rock gravel. Cement is clayey, re-crystallized, with coalified organic matter and single, poorly-preserved remnants of spore and pollen grains of broad age interval. In the black gravelites from the depth 262 m, G.O.Orlova-Turchyna has determined spores *Selaginella sp., Colamosporia sp., Equisetites sp., Osmunda sp., Coniopteris sp., Hausmannia sp., Dictyophllidites sp., Pecopteris sp., Portina bulbifera* M a l., *Camptotriletes sp.* and pollen *Cycas sp., Podocarpus off. patula* B o l c h . , *Protopicea sp.,* suggesting for Toarcian-Aalenian age of sediments [4, 18].

In Ay-Petri-Babuganska LTZ, Beshuyska and Vidradnenska suites comprise analogues to Urguliyska Suite.

Middle division (J_2)

Bajocian stage (upper sub-stage) – Bathonian stage (lower sub-stage)
Karadazkiy horizon

In Karadazkiy horizon, Karadazka, Melaska and Belbetska suites are correlated, which in the map sheet area replace one another by lateral.

Karadazka Suite (J_2kd) is developed in Sukhoritsko-Baydarska and Ay-Petri-Babuganska LTZs, in the Crimean Southern Coast, from Tesseli cape to Goluba Zatoka. It is exposed in the coastal cliffs at Fiolent cape, constituting also entire Gerakleyskiy peninsula, and is also known in some outcrops in the Bodrak River basin.

In the stratotype of Drakon ridge (Melas area) the Suite is divided into three sub-suites which are not being mapped in the scale of the given map.

The lower sub-suite is composed of andesite-basalt and andesite lavas with their tuff interbeds; thickness is 125-240 m.

The middle sub-suite is composed of argillites and aleurolites with siderite concretions; thickness of middle sub-suite is 120 m.

The upper sub-suite is composed of litho-clastic andesite tuffs with tuffite and sandstone interbeds; thickness is 315 m.

The total thickness of the Suite in the stratotype is 675 m. Similar three-fold Suite column is intersected by drill-holes in Gerakleyskiy peninsula. In the Bodrak River basin the Suite includes middle and upper sub-suites only.

In lithologic-petrographic respect, Karadazka Suite is composed of extrusive, explosive and sedimentary rocks. Extrusive range includes andesite-basalt lava-breccia, andesite and micro-diabase porphyry lavas.

Andesite-basalts are dark-grey, porphyry-like, with minor plagioclase and pyroxene phenocrysts. Plagioclase is idiomorphic, coarse-tabular and short-prismatic in habitus, with volcanic glass micro-inclusions; in places crystals are zoned: the central part is composed of bytownite and periphery – of andesine. Augite is short-prismatic in habitus with ilmenite micro-inclusions. The groundmass is composed of plagioclase (45%), pyroxene (15%), chlorite (20%), quartz (5%), epidote (3%), carbonate (2%), and volcanic glass (7%) laths and microlites. Chemical analyses suggest for significant variations in silica content caused by secondary quartz filling up vesicles.

Micro-diabase porphyries are greenish-grey, with micro-diabase or intercertal groundmass, vesicular structure and plagioclase (30%), augite (10%) and ore mineral (3%) grains. The rock contains abundant vesicles filled with calcite and chalcedony.

Andesites are greenish-grey, with porphyry texture, massive structure; groundmass texture is microlitic. Phenocrysts are composed of plagioclase. Mineral composition is as follows (%): plagioclase – 42, chlorite – 15, calcite – 15, kaolinite – 10, sericite – 5, epidote – 5, muscovite – 4, ore minerals – 3, biotite – 2, quartz – 1. Plagioclase in porphyry inclusions is of calcium composition, prismatic and tabular, with single and polysynthetic wedge- and fan-shaped twins. Secondary alteration is expressed in calcitization, chloritization and epidotization. Chlorite is observed in fine-flaky aggregates after volcanic glass and pyroxenes. Calcite does form fine-grained irregularly-shaped accumulations with aggregate extinction and coarse isometric crystals; it is developed after plagioclase and fills up fractures. Epidote is developed in assemblage with calcite after plagioclase, both in groundmass and phenocrysts.

Pyroclastic rock range includes tuffs of andesitic composition, and volcanogenic-sedimentary and sedimentary rocks – tuff-sandstones, sandstones, aleurolites and argillites.

The tuffs are greenish-grey, brownish-grey, litho-clastic, andesitic, composed of andesite and andesite porphyry bombs and lapillies cemented by mica-carbonate material. Texture is litho-clastic, crystal-clastic, lapilli, cementation type is contact; fragment groundmass texture is pilotaxitic, structure is vesicular, porous.

Andesites in fragments are composed of elongated plagioclase laths with minute fine quartz grains, with wavy extinction and monocline pyroxene relic grains. The fragment periphery is brownish because of ore mineral grain concentrations.

Andesitic porphyries are of porphyry texture (plagioclase-andesine phenocrysts constitute 25%).

Agglomerate tuff of andesitic composition are brownish-greenish-grey, composed of volcanic bombs (more than 50% of rock volume) cemented by coarse-clastic crystal-litho-clastic tuffs. The bombs are rounded or ellipse-like; along periphery the chilling rims, concentric-zoned pores and vesicles are observed which size regularly decreases from periphery to the core. In composition, the bombs are andesitic, with microlitic and pilotaxitic groundmass texture and plagioclase phenocrysts with simple and polysynthetic twins. Secondary minerals include chlorite, albite, sericite, calcite; accessories – ore mineral.

Tuff-sandstones are greenish-grey, with psammitic texture, massive structure, composed of andesite porphyry, plagioclase, quartz, mica-quartz schist fragments cemented by mica-carbonate material. Fragment to cement ratio is 4:1, tuffogenic material admixture attains 30%; mica-carbonate cement is composed of fine-flaky aggregate of sericite and calcite. Volcanic glass is brownish-greenish, rounded and crescent-shaped.

Sandstones are dark-grey, with aleuro-psammitic texture, composed of quartz, plagioclase, biotite, muscovite, chlorite and ore mineral grains. Clayey-carbonate cement constitutes 50% of the rock volume; cementation type is porous and basal.

Aleurolites are dark-grey, dense, thin-platy, with psammitic-aleuritic texture. Clastic material constitute 55% of the rock volume and includes quartz, biotite, muscovite, chlorite are ore mineral grains (from 0.012 to 0.057 mm across). Cement is carbonate-clayey, cementation type is basal, in places porous.

Argillites are dark-grey, dense, thin-platy, with aleuro-pelitic texture and layered structure caused by alternating politic, aleuro-pelitic or aleuritic varieties. Mineral composition (%): quartz – 15, calcite – 15, iron hydroxides – 2, quartz-mica cement aggregate – 68.

Geochemical features of extrusive and pyroclastic rocks are defined by the processes of magmatic differentiation, resulted in separation of siderophile and chalcophile elements, and low-temperature hydrothermal metasomatism, caused removal of lithophile elements and slight enrichment in vanadium and chromium.

Most extrusives are depleted in magnesium and alkalis in comparison to the average values (after Daly). Sodium and potassium oxide ratio strongly depends on albitization degree of primary plagioclase. Tight relation between sodium and iron oxides suggests for oxidizing spilitization with sodium input and almost without potassium removal [66].

From the lower sub-suite *Spiroceras bifurcatum* (Q u e n .) is determined [19, 66] characteristic for the lower zone of Upper Bajocian. The middle sub-suite carries cephalopoda molluscs *Garasantiana garantiana* (O r b .), *Sphaeroceras brongniarti* (S o w.), *Erystomiceraspolyhelicum* (B o c k h.), *Parkinsonia parkinsoni* (S o w .) [19, 66]. Upper sub-suite contains Late Bajocian *Parkinsonia parkinsoni* (S o w .), *P. orbigniana* W e l z . , *P. bigoti* N i k . , and Early Bathonian *Simiradzkia aurigera* (O p p.), *Nannolitoceras stremouchoffi* P c e l . , *Leda lacryma* (S o w .), *Opis pukhella* O r b . [19, 66]

The lower sub-suite age is ascribed to the first half of Late Bajocian (up to zone *Garantiana garantiana*), by location in the column above the fauna-characterized Early Bajocian sediments at Chuin-Ilga River (outside map area). The middle sub-suite age is set after the lower zone *Parkinsonia parkinsoni*. The upper sub-suite age is ascribed to the second half of Late Bajocian (zone *Parkinsonia parkinsoni*) – Early Bathonian.

By lateral, Karadazka Suite is facially replaced by flyschoid sediments of Melaska Suite in the Southern Coast block, and Belbetska Suite in Kachynskiy block. In the Crimean Southern Coast Karadazka Suite unconformably lies over Tavriyska Series and is conformably overlain by clays of Ayvasylska Suite. In Gerakleyskiy peninsula underlaying rocks are not intersected while the Suite is unconformably overlain by Cretaceous and Neogene sediments.

Melaska Suite (J_2*ml*) is developed in Sukhoritsko-Baydarska LTZ in the Crimean Southern Coast where it comprises facial analogue of Karadazka Suite which replaces it outward the paleo-volcanic extrusive centers. In the stratotype, to the east from Drakon (Melas) ridge, it is divided into three sub-suites which are not being mapped in the given map scale.

The lower, 110 m thick, sub-suite includes grey fine-grained sandstones, carbonate aleurolites and thin-platy argillites.

The middle, 115 m thick, sub-suite is composed of greenish-grey aleurolites with siderite lenses and concretions and batches of alternating aleurolites and sandstones. Late Bajocian ammonites *Garantiana garantiana* (O r b.), *G. humilis* Z a l., *Eurystomiceras polychelictum* (B o c k h .) and bivalvia *Protocardia* sp., *Bositra buchi* R o e n are identified over there [19, 66].

The upper, 110 m thick, sub-suite is composed of alternating sandstone-aleurolite and argillite layers with tuff batches. It is characterized by bivalvia molluscs *Gerviellia waltoni* L y s . , *Pinna buchi* K o c h . e t D u n k [19, 66]. The total thickness of Melaska Suite is 335 m.

Main litho-petrographic rock types include argillites, aleurolites, sandstones, tuffs and siderites.

Argillites are dark-grey, aleuritic, dense, with politic and aleuro-pelitic texture. Aleuritic fraction (10%) is uniformly distributed in the rock and composed of medium aleurolite consisting of feldspar and quartz as well as mica and chlorite flakes. The clayey fraction, by X-ray data, consists of hydro-mica, chlorite, smectite and calcite.

Aleurolites are dark-grey, dense, micro-layered, with fine-aleuritic texture. Clastic material, from 0.023 to 0.15 mm in size, is weakly-sorted, constitutes 60% of the rock volume and is composed of quartz, plagioclase, mica and chlorite. Cement is chlorite-carbonate, cementation type is porous and basal.

Sandstones are dark-grey, greenish-grey, with psammitic texture. Clastic material, from 0.06 to 1.25 mm in size, is weakly-sorted, constitutes 65% of the rock volume, composed of quartz (30-50%), feldspar (5%), biotite, muscovite, chlorite, ore minerals. Cement comprises brownish- and dark-grey politic mass, cementation type is porous and basal. By geochemical characteristics argillites of Melaska Suite are similar to argillites of Karadazka Suite.

By analogy with the column of Karadazka Suite, due to direct correlation of sub-suites, the age of lower sub-suite is Late Bajocian (up to zone *Garantiana garantiana*), and age of upper sub-suite is Late Bajocian – Late Bathonian.

Stratigraphic boundaries of the Suite, especially upper sub-suite, are clear enough because of both lithological composition and rhythmic structure. The prominent marker feature is the horizon of washed siderite and limestone-marl concretions at the bottom of upper sub-suite. Melaska Suite unconformably lies over Tavriyska Series and is conformably overlain by Ayvasylska Suite.

In Ay-Petri-Babuganska LTZ it is facially replaced by Karadazka and Belbetska suites.

Belbetska Suite (J_2bl) is developed in Ay-Petri-Babuganska LTZ, in the western area of Mountain Crimea. The stratotype is located in 2 km to the north-west from Plotynne village. The Suite, up to 425 m thick, is composed of flysch-like alternating sandstones, aleurolites and argillites with single sandstone batches.

Main litho-petrographic rock types include sandstones, aleurolites and clays.

Sandstones are grey, fine-grained, feldspar-quartz. Clastic material constitutes 70% of the rock and includes semi-rounded and non-rounded quartz grains (50%), feldspar tables (40-50%), muscovite and biotite flakes and single ore mineral grains. Clastic material size is from 0.05 mm to 0.25 mm across, no sorting is observed. Autigenic minerals, constituting cement, include calcite (60-70%) and hydro-mica. Texture of sandstone is psammitic, fine-grained. Cementation type is porous, in places – basal.

Aleurolites are greenish-grey, with coarse-aleuritic texture, unclear-layered structure. Allotigenic material constitutes 70-80% of the rock volume and includes coarse aleurite (50-70% of all grains) with irregular admixture of fine-sandy material (3-10%). Grain size is from 0.025 mm to 0.14 mm. Grains are not rounded and not sorted either by size or by composition. Mineral composition of clastic material: quartz (60-65%), feldspar (20-25%), single grains of quartzite, mica flakes and magnetite, ilmenite, garnet, leucoxene, zircon, rutile and anatase, as well as tourmaline, pyroxene, amphibole, corundum, muassonite and chromium spinel grains. Autigenic minerals, constituting cement, include hydro-mica and chlorite, in places collomorphic iron hydroxides are observed. Cementation type is contact or film.

Clay is argillite-like, grey, dense, aleuritic, with politic and aleuro-pelitic texture. At the sites of extensive secondary carbonatization the groundmass is composed of carbonate-clayey material and micro-grained calcite. Organic matter is uniformly distributed over entire rock in fine-disperse particles and collomorphic clots. Aleuritic fraction of clays constitutes 3% of the rock volume and includes quartz (60-70%), feldspars (30%) and single mica and chlorite flakes. Autigenic minerals (except mica) include dust-like pyrite clots and brown collomorphic iron hydroxides.

Belbetska Suite carries sufficient but relatively uniform complex of bivalvia and cephalopoda: *Nucula subovalis* G o l d f.*, N. eudorae* O r b.*, Astarte pulla* R o e m .*, A. subcircularis* S c h m.*, A. minima* R o l l .*, Oxytoma scarburgensis* R o l l .*, Entolium spatulatum* (R o e m .)*, Pinna buchi* K o c h e t D u k .*, Garantiana cf. humilis* Z a l.*, Erystomiceras polyhelicum* (B o c k h.) [19, 66], as well as numerous Middle Jurassic plant remnants.

Belbetska Suite conformably lies over Vidradnenska Suite and is also conformably overlain by Ayvasylska Suite. By lateral it is facially replaced by Karadazka and Melaska suites.

Bathonian stage (middle, upper sub-stage) – Callovian stage (lower sub-stage)
Kopselskiy horizon

In the studied map sheets Kopselskiy horizon includes Ayvasylska Suite.

Ayvasylska Suite (J_2av) is developed in Sukhoritsko-Baydarska and Ay-Petri-Babuganska LTZs, it is exposed in two bands along the northern and southern slopes of the Main ridge of Crimean Mountains. The northern band is extended in Kachynskiy block from Putylivka village to Plotynne village and further to the east outside the area. The southern band is observed from Balaklava town to Simeiz town and further to the east outside the studied area. The Suite neo-stratotype is located in the studied map sheets (in the area of Putylivka and Bagata Ushchelyna villages).

Ayvasylska Suite is divided into three sub-suites but in the given scale is mapped as undivided.

Lower sub-suite includes polymictic sandstones with gravelite lenses and batches of flysch-like alternating sandstones, aleurolites and clays, siderite concretions. Thickness is 145 m. It contains Middle Bathonian ammonites *Oppelia fusca* (Q u e n .), *O. subdiscus* (O r b.) [4, 19, 66].

Middle sub-suite comprises flysch-like intercalation of sandstones, clays with siderite concretions and clayey limestones. Thickness is 90 m. It contains Late Bathonian ammonites *Oxycerites aspidoides* (O p p.), *O. serrigera* (W a g.), *Clidoniceras discus* (S o w.), *Sowerbiceras neymayeri* P. e t R [4, 19, 66].

Upper sub-suite includes gypsumized clays with single batches of sandstone-argillite flysch, with siderite concretions. Thickness of this sub-suite is 80 m. It carries Early Callovian ammonites *Macrocephalites macrocephalus* (S c h l.), *Grossouvria curvicosta* (O r b.) [4, 19, 66]. Total thickness of the Suite is 315 m.

Main litho-petrographic types of Ayvasylska Suite include clays, aleurolites, sandstones and siderites.

Clays are dark-grey, unclear-layered, aleuritic, with quartz (up to 0.04 mm) and muscovite grains. Cement is composed of carbonate-mica material. Clayey fraction composition by difractometry data: hydro-mica, smectite, calcite.

Aleurolites are grey, dark-grey, micro-layered, with aleuritic texture. Clastic material attains 40% of the rock volume and in mainly composed of quartz. Cement is mica-clayey-carbonate.

Sandstones are grey, greenish-grey, quartz, layered, with psammitic texture. Clastic material attains 90% of the rock volume and is mainly composed of quartz and plagioclases. Cement is calcite-clayey, cementation type is porous and contact.

In paleontologic respect, Ayvasylska Suite carries rich complex of bivalvia and cephalopoda molluscs. The Suite formation age encompasses the time from Middle Bathonian (zone *Oppelia fused*) to Early Callovian (zone *Macrocephalites macrocephalus*). Ayvasylska Suite conformably lies over Karadazka, Melaska and Belbetska suites and is unconformably overlain by Gurzufska Suite, in places – by Yaylinska or Sukhoritska suites.

Middle and Upper divisions undivided (J_{2-3})

Callovian stage (middle and upper sub-stages) – Oxfordian stage (lower sub-stage)
Sudakskiy horizon

Gurzufska Suite (J_{2-3}*gr*) is locally developed in Sukhoritsko-Baydarska LTZ in the western area of Mountain Crimea where it is exposed in Batylimanska harbor. In the stratotype, at Gurzufske "saddle", the Suite is divided in two sub-suites. In the studied area the Suite is mapped as undivided. It is composed of grey algae limestones, massive-layered and sandy, with *Heliocoenia costulata* K o b y., *Creniceras renggeri* (O p p.) i *Plagiocidaris elegans* M u n [4, 19, 66]; thickness is up to 50 m. Mentioned organic remnants suggest for Late Callovian – Eraly Oxfordian age of Gurzufska Suite.

Gurzufska Suite unconformably lies over Ayvasylska Suite and is conformably overlain by Sukhoritska or Yaylinska suites.

Upper division (J_3)

Upper Jurassic sediments constitute entire south-western part of the Main ridge of Crimean Mountains while in Plain Crimea they are not identified. These include Oxfordian, Early Kimmeridgian and Tithonian rocks. Upper Jurassic rock complex unconformably lies over underlaying rocks because of the regional interruption in sedimentation coincided with Middle and partly Late Callovian. The rock complex exhibits facial variability at different stratigraphic levels: from the coastal sediments to the rocks of open shallow-water shelf. Sedimentation conditions changes are expressed in the litho-stratigraphic complexes, suites and sequences. In total, three stratigraphic levels are distinguished which correspond to the regional horizons: Yaylinskiy, Yaltynskiy and Bedenekyrskiy.

Oxfordian stage (middle and upper sub-stages) – Kimmeridgian stage (lower sub-stage)
Yaylynskiy horizon

In the studied map sheets Yaylynskiy horizon is correlated with Yaylynska and Sukhoritska suites.

Yaylynska Suite (J_3*jj*) is developed in the western area of Mountain Crimea, mainly in Ay-Petri-Babuganska LTZ and, partly, in Sukhoritsko-Baydarska LTZ. The stratotype is defined outside the studied area, in Iograf ridge, nearby Yalta. In geological map Yaylynska Suite is shown as undivided into sub-suites although in the stratotype it is divided in two sub-suites.

Lower sub-suite is composed of brownish-grey, layered, algae limestones with aleuritic limestone interbeds, sandstone and aleurolites lenses; in the area thickness varies from 150 to 450 m.

Upper sub-suite consists of brownish-grey, massive, pelitomorphic and algae limestones with batches of sandy and clayey platy limestones and marls; thickness is up to 185 m.

The total thickness of Yaylynska Suite in the studied area attains 500 m.

By petrographic features, reefogenic, organogenic-detritus, pelitomorphic, oncolitic and clayey limestones are distinguished in the Suite.

Reefogenic limestones exhibit organogenic, clotty irregular-grained textures. Organic remnants are composed of corals replaced by coarse-grained calcite and re-crystallized sponge and algae remnants.

Organogenic-detritus limestones are massive with organogenic-detritus texture. Clastic material is composed of pelitomorphic limestone, quartz, organic remnants (foraminifera shells, molluscs detritus, echinodermata shells, algae clots and pseudo-oolitic newly-formed aggregates cemented by crystalline calcite). The clastic material attains 75% of the rock volume.

Pelitomorphic limestones are composed of thin-fibrous calcite aggregate with rounded or irregular bunches of grained calcite (particle size from 0.0114 to 0.17 mm across). Rock texture is pelitomorphic with fragments of clastic and crystal-grained, structure is fan-like, banded.

Oncolitic limestones are composed of blue-green algae arranged in nodules up to 10 mm in size and cemented by fine-grained and cryptic-crystalline calcite.

Yaylynska Suite carries rich and variable complex of organic remnants: *Perisphinctes plicatilis* (S o w .), *P. linci* C h o l f., *Taramelliceras episcopalis* L o r . , *Epipeltoceras bimammatum* (O p p.), *Idoceras planula* Z i e t, *Taramelliceras flexuosa* (M u n.) (lower sub-suite), and *Streblites tenuilobatus* (O p p.), *S. oxypictus* (Q u e n .), *Lithacoceras lictor* (F o n t .) and others (upper sub-suite) [4, 19, 32, 66].

The given ammonite complex outlines Yaylynska Suite age to be Middle Oxfordian – Early Kimmeridgian. The lower sub-suite is ascribed to Middle-Upper Oxfordian, and upper one – to Lower Kimmeridgian. Yaylynska Suite conformably lies over Gurzufska Suite, somewhere unconformably over Ayvasylska Suite, and is unconformably overlain by Yaltynska or Deymen-Derynska suites.

In Sukhoritsko-Baydarska LTZ Yaylynska Suite is facially replaced by Sukhoritska Suite.

Sukhoritska Suite (J_3sr) is developed in Sukhoritsko-Baydarska LTZ, in the western area of Mountan Crimea. In general, it is composed of conglomerates with coarse-grained and organogenic limestone lenses. The Suite stratotype is located at Balaklava town outskirt.

Major Suite lithotype comprises grey, yellowish-grey, diverse-pebble, coarse-layered conglomerate. Layering is caused by intercalation of dense conglomerates with carbonate cement and less dense ones with clayey cement. Layer thickness varies from 40-80 cm to 2-3 m. In the clastic material grey and dark-grey medium-coarse-grained sandstones predominate. In addition, up to 5-20% of extrusive rocks, tuffs and intrusive rocks, 5-20% of quartz and quartzites, up to 10% of argillites, and up to 5% of limestones occur in the fragments. Pebble size is from 1-3 to 10-15 cm, some boulders up to 1 m in size are known. Cement constitutes 30-40%. Bioherm bodies in Yaylynska Suite are composed of grey, organogenic and detritus-organogenic, dense, re-crystallized, 0.7-1.5 m thick limestones.

The total thickness of Sukhoritska Suite attains 500 m. In limestones and in cement of Sukhoritska Suite conglomerates increased titanium and decreased manganese contents are noted. The Suite carries *Thamnasteria dendroidea* (L a m.), *Axosmilia corallina* (E t a l .), *Stylina lobata* (G o l d f.), *Paracidaris florigemme* P h i l l., *Plagiocidaris elegans* (M u n.), *Mesodiceras enissalense* P c e l [4, 19, 32, 66]. This complex of organic remnants defines Sukhoritska Suite age to be Middle Oxfordian – Early Kimmeridgian.

Sukhoritska Suite unconformably lies over Ayvasylska Suite, and with interruption is overlain by Baydarska or Kalafatlarska suites.

Tithonian stage
Lower and Middle sub-stages
Yaltynskiy horizon

In the studied are Yaltynskiy horizon is correlated with Yaltynska Suite and lower sub-suite of Deymen-Derynska Suite.

Yaltynska Suite (J_3jl) is developed in the western area of Mountain Crimea, mainly in Ay-Petri-Babuganska LTZ and, in lesser extent, in Sukhoritsko-Baydarska LTZ. In all locations it is constituted of various limestone types linked with facial transitions. The stratotype is located in Yaltynska Yayla, to the east from the studied area. In the map Yaltynska Suite is shown as undivided although in the stratotype it is divided in two sub-suites.

Lower sub-suite is composed of brownish-grey, oolitic, micro-phytolitic, spirocycline, massive limestones with interbeds of pelitomorphic and clayey varieties; thickness attains 265 m.

Upper sub-suite is composed of brownish-grey, massive, pelitomorphic, algae limestones with sandy and clayey limestone interbeds; thickness is from 125 to 1075 m.

The total thickness of Yaltynska Suite attains 1340 m.

By petrographic features, coral-algae, oolitic and micro-grained aleuritic limestones are distinguished in the Suite.

Coral-algae limestones are massive, composed of corallites and algae clots constituting 80% of the rock volume, cemented by cryptic-crystalline calcite; cementation type is porous.

Oolitic limestones are composed of partly re-crystallized calcite mass which contains oolites (up to 50% of the rock volume). Oolites are rounded and oval, with core normally composed of shell fragment or quartz grain.

Micro-grained aleuritic limestones are composed of calcite with up to 15% admixture of terrigenous material – quartz, limestone, calcite, mica, 0.003-0.05 mm in size.

Yaltynska Suite is characterized by rich and diverse complex of organic remnants: *Kossmatia richteri* (Z i t t.), *Lithacoceras ulmensis* (O p p .), *Haploceras cristifer* (O p p .), *Aulacosphinctes occultefurcatus*

(W a a g) (lower sub-suite) and *Semiformiceras semiforme* (O p p .), *Oppelia strambergensis* B l a s h , *Haploceras staszyi* (Z e i s s .) and others (upper sub-suite) [4, 19, 66].

This ammonite complex defines Early – Middle Tithonian Suite age; the lower sub-suite is ascribed to Early Tithonian and upper one – to Middle Tithonian.

Yaltynska Suite unconformably lies over Yaylynska Suite and, in turn, is conformably overlain by Baydarska and Bedenekyrska suites, and unconformably – by Kalafatlarska Suite.

In Sukhoritsko-Baydarska LTZ it is facially replaced by the lower sub-suite of Deymen-Derynska Suite.

Deymen-Derynska Suite (J_3dd) is developed in Sukhoritsko-Baydarska LTZ in the western area of Mountain Crimea. In all locations the Suite is constituted of flyschoid intercalation of clays, aleurolites and limestones. The Suite stratotype is located in Deymen-Dere ravine in Baydarska valley. The Suite is divided in two sub-suites.

Lower sub-suite (J_2dd_1) comprises flysch-like intercalation of grey aleuritic clays and brownish-grey detritus limestones with minor, thicker, batches of detritus limestones. Thickness of this sub-suite is 800 m. It carries rich and diverse complex of organic remnants including ammonites *Lithacoceras ulmensis* (O p p.), *L. zeissi* S a p u n., *Kossmatia richteri* (O p p.), *Aspidoceras rogoznicensis* (Z e u s c h.), *Perisphinctes virgulatus* (Q u e n .), *Virgatosphinctes saheraensis* (S p a t h), *V. geron* (Z i t t.) [4, 19, 66], suggesting for its Early-Middle Tithonian age.

Upper sub-suite (J_3dd_2) is composed of grey aleuritic clays with siderite concretions and detritus limestone interbeds; thickness is up to 275 m. It contains rich and variable complex of organic remnants including ammonites: *Protetragonites cf. quadrisulcatum* (O r b.), *Haploceras titonius* (O p p.) [4, 19, 66], suggesting for its Late Tithonian age.

Main Suite lithotypes include argillite-like clays, aleurolites and limestones.

Clays are dark-grey, thin-layered. Aleuritic fraction does not exceed 5% and includes acute semi-rounded quartz grains, elongated chlorite flakes, and isometric ore mineral grains. Texture of the rock is politic or aleuro-pelitic.

Aleurolites are brownish- and greenish-grey, layered. Clastic material is composed of irregular or rounded quartz grains, single polysynthetically twinned feldspar grains, muscovite, biotite and chlorite tables and flakes. Cement is of basal type of contact carbonate-clayey. Texture of the rock is pelite-aleuropelitic.

Of limestones, detritus, pelitomorphic and micro-grained varieties are distinguished. Detritus limestones are composed of dark-grey pelitomorphic limestone fragments (80-60% of the rock volume), and single quartz, polysynthetically-twinned feldspar and isometric ore mineral grains. The fragments are cemented by crystal-grained (up to 17 mm) and micro-grained calcite; cementation type is porous.

Ammonite complex from the lower sub-suite suggests for its Early-Middle Tithonian age while upper sub-suite is Late Tithonian in age. Deymen-Derynska Suite unconformably lies over Yaylynska Suite and is conformably overlain by Baydarska Suite. By lateral, the lower sub-suite is facially replaced by Yaltynska Suite, and upper sub-suite – by Baydarska or Kalafatlarska suites.

Upper sub-stage
Bedenekyrskiy horizon

Bedenekyrskiy horizon in the studied map sheet correlates Baydarska, Bedenekyrska and Kalafatlarska suites and upper sub-suite of Deymen-Derynska Suite.

Baydarska Suite (J_3bd) is developed in the western area of Mountain Crimea, mainly in Sukhoritsko-Baydarska LTZ and, partly, in Ay-Petri-Babuganska LTZ. In all locations Baydarska Suite constitutes of various limestone types: breccia-like, pelitomorphic, organogenic, coral, linked one to another by facial transitions. The stratotype of Baydarska Suite is located in the southern slopes of Kyzyl-Kaya and Eli mountains (Baydarska valley area). In lithologic-petrographic respect, Baydarska Suite is composed of reddish and pink-grey limestone varieties: organogenic-detritus, pelitomorphic, micro-grained, micro-phytolitic, oncolitic, coral-algae. Their structure is mainly massive, coarse-layered, breccia-like.

Organogenic-detritus limestones are composed of cryptic-crystalline or micro-grained calcite which contains pelitomorphic and sandy limestone fragments, oolites, shell fragments, algae remnants, and quartz grains. Limestones are often re-crystallized when coarse-medium-grained calcite is superimposed onto rock groundmass and fills up to 1.6 mm wide micro-fractures.

Pelitomorphic limestones are of cryptic-crystalline texture, in places porphyry-blastic. Slight banding is observed somewhere in the cryptic-crystalline carbonate groundmass caused by admixture of the oriented quartz, plagioclase and feldspar fragments.

Coral limestones are composed of numerous oval corallites with radial-fibrous structure, up to 0.8 mm across; corallites are cemented by micro-grained calcite.

Micro-phytolitic limestones are completely composed of calcite. Micro-phytolites are expressed in microscopic separated and grouped nodules (clots and clods), 0.01-0.1 mm in size, with distinct micro-texture. The following units are distinguished: rounded-oval, brownish-grey fine nodules with clot micro-texture, close to nubecularises; lens-like nodules with dark-grey rim and spherolitic core; worm-shaped nodules; two types of so called "protuberance pellets" which differ in the core structure (clots and clods versus micro-grained calcite); micro-phytolites of vesicularitis type; pitonelic inclusions. Cement is calcite in composition, of contact-porous type; it occupies up to 30% of the rock volume. Foraminifera (nodosarides, globigerines, textularias or calpionelides) are often observed in cement. Thickness of Baydarska Suite is up to 855 m.

In paleontologic respect, Baydarska Suite is characterized by abundant complex of organic remnants. Determined ammonites *Haploceras tithonius* (O p p.), *H. elimatum* (O p p.), *Euphylloceras serum* (O p p.), *Ptychophylloceras ptychoicum* (O r b.), *Lytoceras sutile* (O p p.) [4, 19, 66] suggest for Late Tithonian age.

Baydarska Suite conformably lies over Yaltynska Suite or over lower sub-suite of Deymen-Derynska Suite, and also conformably is overlain by Lower Cretaceous sediments (Bechku Suite).

By lateral, in the western part of Sukhoritsko-Baydarska LTZ, it is facially replaced by Kalafatlarska and upper sub-suite of Deymen-Derynska Suite, and in Ay-Petri-Babuganska LTZ – by Bedenekyrska Suite.

Kalafatlarska Suite (J_3*kl*) is developed in Sukhoritsko-Baydarska LTZ in the western area of Mountain Crimea. The stratotype is located in the slope of Megalo-Yalo harbor, on Kalafatlar Mountain. Kalafatlarska Suite is composed of brownish, parti-colored, medium- and fine-pebble, polymictic, layered conglomerates with Yaylynska Suite limestone boulders. The fragments constitute up to 70% of the rock volume, cement – 10%, gravel-sand matrix – 20%. The fragments up to 5 cm in size are well-rounded and sorted, composed of greenish-grey and brownish quartz-mica and carbonate sandstones (50%), brownish-grey siderites (20%), white quartz (20%), light-grey quartz gravelite (5%), and reddish-brown, pink, brownish-grey pelitomorphic and micro-grained limestones. Cement is clayey-carbonate, cementation type is basal or porous. Thickness of the Suite is 180 m.

In paleontological respect, the Suite is poorly characterized: bivalvia and cephalopoda mollusc remnants are noted in conglomerate cement, and corals of Oxfordian age are known from the washed fragments. By the stratigraphic position and direct correlation with Baydarska Suite "pudding" limestones, Kalafatlarska Suite is ascribed to Upper Tithonian. The Suite with angular and azimuth unconformity lies over Sukhoritska Suite and is conformably overlain by Lower Cretaceous sediments.

In Ay-Petri-Babuganska LTZ the Suite is facially replaced by Bedenekyrska Suite.

Bedenekyrska Suite (J_3*bk*) is developed in Ay-Petri-Babuganska LTZ in the western area of Mountain Crimea. The stratotype is located on Bedenekyr Mountain, to the north from Ay-Petri pass. By technical reasons, in the map Bedenekyrska Suite is shown as undivided into sub-suites although in the stratotype it is divided in two sub-suites.

Lower sub-suite includes cream-grey, sandy and clayey, platy limestones with massive pelitomorphic and organogenic-detritus limestone, marl, aleurolites and clay interbeds. Thickness of lower sub-suite is 640 m.

Upper sub-suite is composed of yellowish-grey, organogenic-detritus, algae, breccia-like, coarse-layered limestones up to 180 m thick.

Main lithologic-petrographic rock types of the Suite include oncolitic, oolitic, clayey, coral-algae limestones and aleurolites.

Oncolitic limestones are pink-grey, composed of ellipse-shaped concentric oncolites which occupy 70% of the rock volume. Micro-grained calcite of oncolites is cemented by cryptic-crystalline calcite.

Oolitic limestones are pink-grey and grey, with prominent oolitic texture. Oolites are rounded or ellipse-shaped, 0.5-1.0 mm in size, with concentric-zoned structure. Oolite core is composed of quartz or pelitomorphic limestone fragments, and cementing mass, occupying up to 40-70% of the rock volume, is composed of micro-grained calcite.

Clayey limestones are composed of calcite groundmass of micro-grained texture with up to 20% admixture of aleuro-pelitic terrigenous material and radiolarian, foraminifera, tyntinida fragments.

Coral and coral-algae limestones are composed of micro-grained calcite corallites cemented by cryptic-crystalline non-banded calcite.

Aleurolites are grey and dark-grey, carbonate, with psammo-aleuritic texture and layered structure. The fragments are composed of quartz and limestone from 0.03 to 0.1 mm in size and occupy 60% of the rock volume. Cement is carbonate-clayey, often with yellowish-brown iron-enriched limestone oolite inclusions, as well as foraminifera and radiolarian fragments.

Bedenekyrska Suite contains rich and diverse complex of organic remnants including ammonites: *Haploceras elimatum* (O p p .), *Streblites zonarius* (O p p.) (lower sub-suite) and *Ptychophylloceras ptychoicum* Q u e n . , *Lytoceras liebigi* (O p p .), *Berriasella* (P i c t e t I c e r a s) (upper sub-suite) [4, 19,66]. This ammonite complex defines Bedenekyrska Suite age to be Late Tithonian, in the zone *Paraulacosphinctes transitorius*.

Bedenekyrska Suite conformably lies over Yaltynska Suite and is conformably overlain by Lower Cretaceous sediments. By lateral, in Sukhoritsko-Baydarska LTZ, it is facially replaced by Baydarska and Kalafatlarska suites and upper sub-suite of Deymen-Derynska Suite.

Cretaceous System

Cretaceous System plays very important role in the geology of Fore-Mountain and Plain Crimea. It includes rock of both divisions. Most complete columns are encountered in the Fore-Mountain area while lower parts of Cretaceous System in Plain Crimea are lacking.

By facial features three litho-tectonic zones are distinguished: Pivnichnokrymska, Tsentralnokrymska and Zakhidna (Northern-Crimean, Central-Crimean and Western, respectively[1]).

Lower Division (K_1)

In the studied area Lower Cretaceous sediments are exposed in Crimean Fore-Mountains from Sevastopol city in the west to the eastern map sheet border, in places being extended into the area of Main ridge of mountain land where they fill up erosion-tectonic inter-mountain dimples. Small outcrops are known in the western slopes of Yaltynske highland where they constitute the column fragments preserved from erosion (Machu Mountain, Ay-Dymytriy ravine). In Plain Crimea Lower Cretaceous sediments are intersected in the course of drilling works for oil and gas. Over there, Lower Cretaceous footwall becomes as younger as Hauterivian and plunges in the northern direction from 500 to 1000 m (Fig. 2.2, 2.3).

A number of stratigraphic subdivisions are indicated in the geological map. It is because of both strong facial variability of sediments and different degree of their study, especially in Plain Crimea where these units are encountered by single drill-holes. By lithology and geological setting Lower Cretaceous sediments are distinguished in Zakhidna, Tsentralnokrymska and Pivnichnokrymska LTZs. Zakhidna LTZ, which encompasses Crimean Fore-Mountain land, is divided into three litho-tectonic sub-zones: Chornoritsko-Baydarska, Belbetska and Kachynsko-Salgyrska.

Chornoritsko-Baydarska sub-zone encompasses the area of Lower Cretaceous sediments from Sevastopol city to the Chorna and Belbek inter-river area. Over there, both clayey deep-water sediments, which fill up inter-mountain gorges like Varnautska and Baydarska, and shallow-water sediments in the northern rim of Baydarska valley are developed. Total thickness of sediments attains 1800 m. These include Bechku Suite, Kuchkynska, Novobobrivska, Shyrokynska, Balaklavska, Chorgunska and Kanarynska sequences. Belbetska sub-zone in the studied area encompasses the eastern part of Lower Cretaceous sediments area, from the Chorna and Belbek inter-river area to the Belbek and Kacha inter-river area. Over there, mainly shallow-water terrigenous sediments are developed which transgressively lie over the northern limb of Kachynskiy block. The columns are incomplete and their total thickness attains 335 m. These include Girska, Sonyachnosilska, Kuchkynska, Kayatepynska, Karatlykhska, Golubynska and Ternivska sequences.

Kachynsko-Salgyrska sub-zone encompasses limited eastern part of Lower Cretaceous sediments are in the Crimean Fore-Mountain land in the Kacha and Salgyr inter-river area. Over there, shallow-water terrigenous sediments up to 425 m of total thickness are developed. These include Rizanska, Biasalynska suites and Virkhoritska, Burulchynska, Maryinska, Manguska and Ternivska sequences.

Tsentralna LTZ encompasses most part of Plain Crimea in the studied area. Kalininska, Donuzlavska, Kashtanivska, Ryleevska, Elyzavetynska, Kovylnenska, Krasnopolyanska suites and Evpatoriyska sequence, up to 1170 m thick, are distinguished over there.

Pivnichnokrymska LTZ in the studied area is locally developed. Kalininska, Donuzlavska, Kashtanivska, Ryleevska, Elyzavetynska, Tarkhankutska, Kovylnenska, Pryvolnenska, Krasnopolyanska suites and Evpatoriyska sequence, up to 2760 m thick, are distinguished over there.

[1] Although in this particular case the names can be easily transmitted into English equivalents, Ukrainian-driven spelling is retained to follow general approach in the volume.

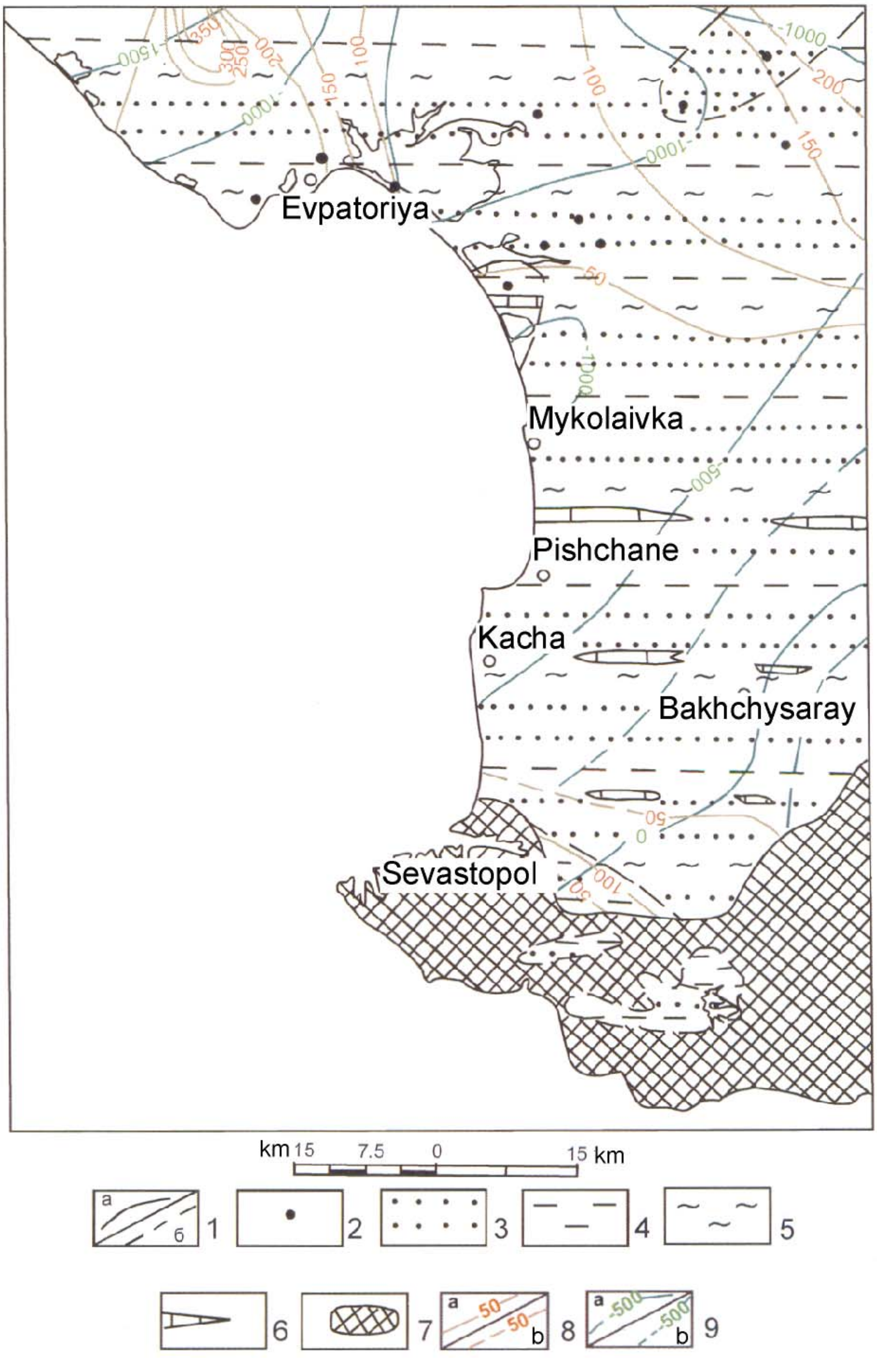

Fig. 2.2. Lithologic sketch of Valanginian-Barremian sediments.
1 – lithologic boundaries: a – proven, b – probable; 2 – drill-holes; 3 – sandstones, aleurolites; 4 – argillites; 5 – clays; 6 – limestone lenses; 7 – fields of Valanginian-Barremian sediments complete erosion; 8 – isopachs: a – proven, b – probable; 9 – depth contour lines of Valanginian-Barremian sediments footwall: a – proven, b – probable.

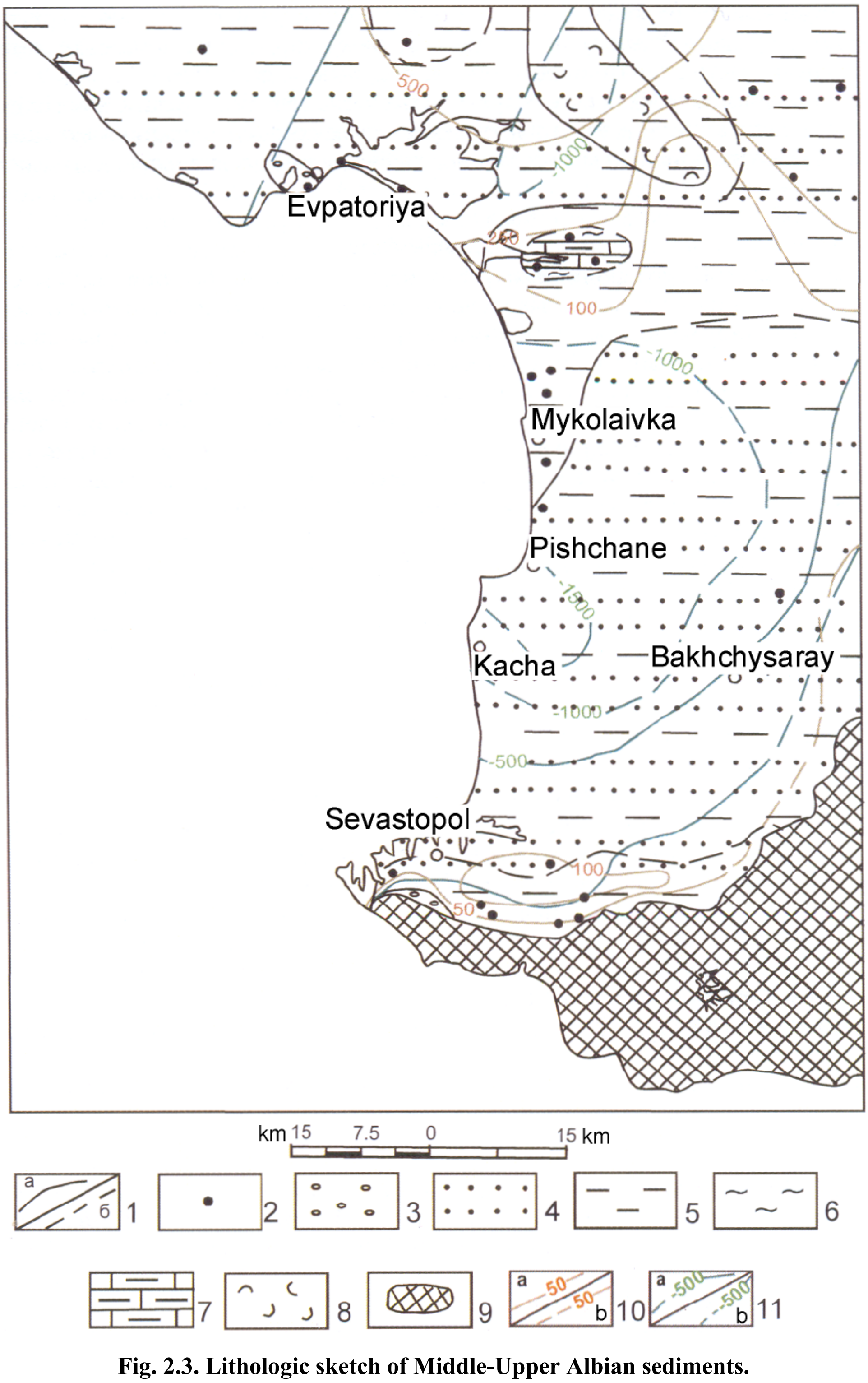

Fig. 2.3. Lithologic sketch of Middle-Upper Albian sediments.

1 – lithologic boundaries: a – proven, b – probable; 2 – drill-holes; 3 – conglomerates; 4- sandstones; 5 – argillites; 6 – clays; 7 – marls; 8 – tuffs; 9 – fields of Middle-Upper Albian sediments complete erosion; 10 – isopachs: a – proven, b – probable; 11 – depth contour lines of Middle-Upper Albian sediments footwall: a – proven, b – probable.

Berriasian stage
Lower sub-stage

Girska sequence (K_1grs) is developed in Belbetska sub-zone of Zakhidna LTZ, in the middle course of Belbek River, from Suatkan gorge in the west to Khoru valley on the east. The typical column is studied at Girske village outskirt. The Sequence is persistent in composition and is composed of diverse-pebble conglomerates with sandstone and aleurolite interbeds and lenses. Thickness is variable, from 8 to 40 m. Conglomerates are parti-coloured, from grey to reddish-brown, polymictic. Clastic material is semi-rounded, weakly-sorted, from 3 to 10 cm in size, composed of milky-white quartz (50%), dark-grey and greenish-grey, medium-grained, polymictic sandstones (30%), quartz-carbonate aleurolites (20%), and siliceous shales (10%). Clastic material occupies 50-80% of the rock volume. Cement is sandy-clayey, friable, in places carbonate, strong, cementation type is basal. The Sequence is poor in paleontologic remnants. It contains bivalvia molluscs *Myophorella laewinson — lesingi* (R e n n.) та *Gervillia cf. extenuata* E i c h w. [1, 4] characteristic for Berriasian. Since Girska sequence is unconformably overlain by well-grounded Upper Berriasian sediments, most authors consider sequence is Early Berriasian in age.

Girska sequence unconformably lies over Tavriyska Series and Ayvasylska Suite and is unconformably overlain by Sonyachnosilska sequence. In Chornoritsko-Baydarska sub-zone it is facially replaced by the lower part of Bechku Suite.

Lower and upper sub-stages undivided

Bechku Suite ($K_1b\check{c}$) is widely developed in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, in the northern slope of Baydarska valley and in the southern slope of Varnautska valley, and it is also intersected by many drill-holes in the central parts of both mentioned valleys.

The Suite stratotype is located in the southern slopes of Bechku Mountain. In the valley banks the Suite comprises intercalation of sandstones, limestones, clays with conglomerate and gravelite lenses. Clays with clastic limestone, sandstone interbeds and siderite concretions predominate in the columns of the central valley parts. Thickness of the Suite is up to 100 m.

Main lithologic-petrographic rock types include conglomerate-gravelites, sandstones, clays, limestones.

Conglomerate-gravelites are grey, medium-strength, diverse-pebble, contain up to 0.2 m thick carbonate sandstone and aleuritic clay lenses and interbeds.

Sandstones are grey, polymictic, diverse-grained, occur in up to 1.0 m thick interbeds.

Clays are dark-grey, greenish-grey, unclear-layered, calcareous, occur in interbeds from 0.2 to 3.0 m thick.

Organogenic-detritus, micro-grained, phytolitic, and sandy limestone varieties are observed in the interbeds from 0.2 to 1.0 m thick and batches up to 10-15 m thick.

Bechku Suite is characterized by abundant and diverse complex of organic remnants: *Contortella recta* P c e l . , *Valanginella plana* P c e l . , *V. acuta* P c e l . , *Ervilia anceps* D e s h., *Neithea simplex* M o r d., *Discorbis crimicus* S c h 1., *Belorusiella taurica* G o r b., *Trocholina molesta* G o r b., *Cidaris pretiosa* D e s o v . , *Apionocrinus valanginensis* L o r., as well as *Berriasella boissieri* P i c t., *B. privasensis* P i c t., *Phylloceras callipso* O r b., *Spiticeras negrelli* M a t h. [1, 4, 32, 40], suggesting for its Berriasian age.

Bechku Suite conformably lies over Upper Jurassic Baydarska or Kalafatlarska suites, and in the central valley parts is conformably overlain by Novobobrivska sequence, while in the valley banks – by Kuchkynska sequence.

In Belbetska sub-zone Girska and Sonyachnosilska sequences comprise the facial analogues to Behcku Suite.

Upper sub-stage

Sonyachnosilska sequence (K_1ss) is developed in Belbetska sub-zone of Zakhidna LTZ in the middle course of Belbek River, from Suatkan gorge in the west to Khoru valley on the east. The stratotype is located at the Sonyachnosillya and Girske village outskirts. The Sequence comprises intercalation of sandstones, aleurolites and aleuritic clays with horizons of bioherm limestones. Thickness is not persistent, from 45 to 60 m. In the Kacha River valleys the Sequence is completely pinched out.

Main lithologic-petrographic rock types include sandstones, aleurolites, clays and limestones.

Sandstones are dark-grey, brownish-grey, greenish-grey, medium-coarse-grained, polymictic, dense and friable, with inclusions of individual pebbles and marcasite concretions. Texture is aleuro-psammitic with grain size from 0.05 to 0.7 mm. Clastic material is composed of quartz grains (70%), plagioclases (5%) and volcanic and siliceous rocks. Fragments are semi-rounded. Cement is clayey-carbonate, cementation type is corrosion and basal. Iron hydroxides and leucoxenization cause brownish colour of some cement sites. In addition, cement contains coalified organic remnants.

Aleurolites are dark-grey, greenish-grey, brownish-grey, fine-medium-aleuritic, slightly-clayey, with aleuritic texture, layered structure, and in composition are similar to sandstones, contains numerous coalified organic remnants.

Clays are brownish-grey, aleuritic, with aleuro-pelitic texture, friable.

Limestones are brownish, organogenic-detritus and phytolitic, occur in bioherm bodies. Phytolites, occupying up to 90% of the rock volume, are brownish, rounded-ellipsoidal in shape and from 0.5 to 7 mm in size. Aggregates of individual corallites and broken bivalvia mollusc and echinodermata shells, individual quartz pebbles are often observed in the clastic material. The Suite sediments are characterized by abundant and variable complex of organic remnants including bivalvia, gastropoda, brachyopoda, cephalopoda, single and colony corals, irregular sea lilies and foraminifera. Late Berriasian age of the Suite is defined after *Protetragonites tauricus* K i l - V o r., *Dalmasiceras crassicostatum* D j a n., *D. dalmasi* P i c t., *Killianicerasjanini* D r u z ., *Goniomia anceps* P i c t., *Panopeneocomiensis* L e u m., *Gervillia anceps* D e s h., *Lopha rectangularis* R o e m ., [1, 4, 32, 40].

The Suite unconformably lies over Girska sequence and is conformably overlain by Kuchkynska sequence.

In Chornoritsko-Baydarska sub-zone it is facially replaced by the upper part of Bechku Suite.

Valanginian sub-stage
Lower sub-stage

Kuchkynska sequence ($K_1k\check{c}$) is developed both in Belbetska sub-zone of Zakhidna LTZ (middle course of Belbek River), and in Chornoritsko-Baydarska sub-zone where it is extended from the northern bank of Baydarska valley to the mouth of Chornoritskiy canyon. The stratotype is located at Kuchky village outskirt. The Sequence is persistent in composition and comprises intercalation of various types limestones and polymictic sandstones up to 2 m thick with some bioherm bodies, of irregular, fan-like or lens shape, from 10-15 to 300 m in size by strike. Thickness of the Sequence is from 25 to 60 m.

Main lithologic-petrographic rock types include limestones and sandstones.

Limestones are yellowish-grey, reddish-brown, light-grey, micro-phytolitic, organogenic-detritus, oncolitic, sandy, from massive to layered. In micro-phytolitic limestones micro-phytolites comprise nodules of *Osagia* group. At the column bottom coarse (0.5-1.5 mm) mainly simple rounded nodules predominate which upward are replaced by the finer (0.04-0.12 mm) ones, and at the top coarse (2-5 mm) complex nodules predominate. Composite nodules are of concentric-layered structure with core inclusions composed of quartz grains or shell fragments. Algae colonies, surrounding terrigenous particles, are composed of cryptic-crystalline calcite with organic matter and iron hydroxide admixtures.

Bioherm limestones are light-grey, dense, massive, composed of scleractinia colonies rimmed by stromatopora and blue-green algae colonies.

Organogenic-detritus (bio-clastic) limestones are grey, with organogenic-detritus texture, massive structure, composed of pelitomorphic, cryptic-crystalline and bio-clastic limestone fragments (up to 90%), quartz grains, foraminifera, cephalopoda and crinoidea shell fragments. The fragments are weakly sorted, their size varies from 0.05 mm to 1-2 mm. Cement is composed of cryptic-crystalline calcite with clayey minerals admixture.

Sandstones are grey, brownish-grey, quartz-carbonate, with psammitic, medium-grained texture, massive structure, composed of quartz (70%) and plagioclase (5%) grains and quartzite and other rock fragments (25%). Cement constitutes 40% of the rock volume, it is clayey-carbonate, in places iron-enriched, cementation type is basal. Bio-clasts of colonial corals, bivalvia and cephalopoda are noted in cement. The Sequence is characterized by numerous and variable organic remnants: bivalvia, brachyopoda, single and six-ray corals, sea lilies, rudistes, and others including *Killianella roubaudiana* O r b., *Neithea atava* R o e m., *Exogyra minor* C o d ., *Belbekella airgulensis* M o i s., *Stylina pachystylina* K o b y., *Montlivaltia pwnila* T r a u b ., *Sphaera corrugata* S o w., *Protetragonites rotundus* O r b., [32, 40], *Dalmasiceras belbekense* B o g d a n o v a e t A r k a d i e v , *Prohinnites renevieri* (C o g u a n d.) [4] and others. These forms define Early Valanginian age of the Sequence. It conformably lies over underlaying Bechku Suite or Sonyachnosilska sequence and is unconformably overlain by Kayatepynska or Ternivska sequences.

In Chornoritsko-Baydarska sub-zone, in the inter-mountain dimples, it is facially replaced by the lower part of Novobobrivska Suite.

Upper sub-stage

Kayatepynska sequence (K_1*kt*) is developed in Belbetska sub-zone of Zakhidna LTZ, in the Belbek River basin from Suatkan gorge in the west to Vysoke village in the east. The typical column is located in Kaya-Tepe Mountain, in the right bank of Belbek River valley. The Sequence is persistent in composition and consists of conglomerates with sandstone and clay 0.5-1.5 m thick lenses and interbeds. Thickness of the Sequence is from 3 to 100 m.

Main lithologic-petrographic rock types include conglomerates, sandstones and clays.

Conglomerates are grey, brownish-grey, weakly-cemented. The clastic material is almost completely composed of well-rounded quartz pebbles from 2 to 5 cm in size. Cement is clayey-carbonate, iron-enriched.

Sandstones are greenish-grey, irregularly-grained, quartz-feldspar, oblique-banded, weakly-cemented, friable, with coalified organic remnant inclusions.

Clays are greenish-grey and brownish-grey, sandy, occur in thin (0.3-1.0 m) lenses. Paleontologically Kayatepynska sequence is not characterized. Its Late Valanginian age is defined by the setting between paleontologically characterized Kuchkynska and Karatlyska sequences. The Sequence unconformably lies over Kuchkynska sequence and is unconformably overlain by Karatlyska sequence.

In Chornoritsko-Baydarska sub-zone it is facially replaced by the middle part of Novobobrivska Suite.

Valanginian stage – Hauterivian stage (lower sub-stage)

Novobobrivska Suite (K_1*nb*) is developed in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, in the central portions of inter-mountain dimples – Varnautska, Baydarska, Khaytu, Uzundzha. Typical column is located nearby Novobobrivske village, in the east of Baydarska valley. The Sequence is composed of unclear-banded aleuritic clays with limestone interbeds and numerous siderite concretions, as well as single sandstone, conglomerate and aleurolites interbeds. Thickness of the Sequence is up to 250 m.

Main lithologic-petrographic rock types include clays, sandstones, limestones, siderites.

Clays are grey, greenish-grey to dark-grey, in places argillite-like, mica-carbonate, from aleuritic to sandy, layered. Layering is caused by sandstone and aleurolites interbeds up to 20 cm thick.

Sandstones are grey, medium-grained, quartz-carbonate, massive. Clastic material constitutes 70-80% of the rock volume and is composed of quartz (50%), limestone (30%), quartzite. Some glauconite grains are observed. Cement is carbonate, cementation type is porous and contact.

Limestones are grey, cream-grey, detritus, oncolitic, breccia-like, with psammitic-organogenic texture and breccia-like structure. The rock is composed of various-type limestone fragments, from 0.2 to 1 mm in size, as well as acute semi-rounded quartz, feldspar and clayey rock grains. Novobobrivska sequence is characterized by abundant but uniform complex of organic remnants, mainly foraminifera: *Spirillina italica* D i e n i e t M a s s ., *Neobullimina inversa* A n t ., *Pseudolamarckina reussi* (A n t .), *Bigenerina clavellata* B a r t B r a n d ., *Gaudryina neocomica* C h a l., *Saracenaria italica* D e f., *Citrarina rudocostata* B a r t B r a n d . [4, 32, 40], which define its Valanginian – Early Hauterivian age.

Novobobrivska sequence conformably lies over Bechku Suite, and in places – unconformably over Baydarska Suite. It is unconformably overlain by Shyrokynska sequence.

In Belbetska litho-tectonic sub-zone it is facially replaced by Kuchkynska, Kayatepynska and Karatlyska sequences.

Hauterivian stage
Lower sub-stage

Karatlyska sequences (K_1*krt*) is developed in Belbetska sub-zone of Zakhidna LTZ, in the Belbek River basin, in its right bank side from Golubynka village to Vysoke village. The typical column is located on Karatlykh Mountain. The Sequence consists of layered sandy limestones and high-carbonate coarse-grained sandstones with aleurolites and gravelite lenses. Sandstones and limestones are rich in reddish-brown pebble of quartz in "ironiferous rim", as well as numerous ironiferous oolites. Thickness of Karatlyska sequence is from 10 to 60 m.

Main lithologic-petrographic rock types include sandstones and limestones.

Limestones are yellowish-grey, organogenic-detritus, sandy and clayey.

Sandstones are grey, greenish-grey, diverse-grained, carbonate, in places replaced by gravelites or aleurolites. Paleontologically the Sequence is well-characterized including pelecypoda, bivalvia, brachyopoda, and others. Early Hauterivian age is defined after *Amphydonta subsinuata* (L e u m .), *Pterotrigonia caudata*

A g . , *Lyticoceras ambligonius* N e u m e t U h l . , *Zeilleria baksanensis* T. S m., *Duvalia poligonalis* B l., *D. binervia* R a s p [4, 32, 40]. The Sequence unconformably lies over Kayatepynska sequence and is also unconformably overlain by Golubynska or Ternivska sequences.

In Baydarska litho-tectonic sub-zone it is facially replaced by the upper part of Novobobrivska Suite, and in Tsentralna LTZ – by Kalininska Suite.

Rizanska Suite (K_1*rz*) is developed in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, in the area between Kacha and Alma rivers. The stratotype is located on Rizana Mountain, at Verkhorichchya village outskirt. The Suite comprises intercalation of sandstones and clays, with "pudding" conglomerates at the bottom. Thickness of the Suite is up to 120 m.

Main lithologic-petrographic rock types include sandstones, aleurolites and conglomerates.

Sandstones are grey, brownish-grey, polymictic and clayey, medium-fine-grained, oblique-banded.

Aleurolites are grey, brownish-greenish-grey, clayey, thin-layered.

Conglomerates are brownish-grey, polymictic, diverse-pebble, with carbonate-clayey cement. The Suite carries abundant and diverse complex of organic remnants including *Leopoldia leopoldiana* O r b . , *Crioceratites duvali* L e v . [1,4], indicating Early Hauterivian age. The Suite conformably lies over Ayvasylska Suite or Tavriyska Series, and is conformably overlain by Verkhoritska sequence.

In Belbetska sub-zone the Suite is facially replaced by the similar in composition Karatlyska sequence, and in Tsentralna LTZ – by lower part of Kalininska Suite.

Upper sub-stage

Golubynska sequence (K_1*gl*) is locally developed in Belbetska sub-zone of Zakhidna LTZ. Some outcrops are preserved from erosion in the south-western slope of Karatlykh Mountain, in the Blbek River right-bank side. Typical column is located over there. The Sequence is persistent in composition and composed of grey, dark-grey, slightly-carbonate, thin-platy, splinter clays, replaced at the bottom by the iron-enriched aleurolites with fine quartz pebble. Thickness of the Sequence is up to 15 m.

Main lithologic-petrographic rock types include clays and aleurolites.

Clays are dark-grey, carbonate, composed of halloysite and calcite, often aleuritic and sandy, with inclusions of acute limestone and sandstone fragments.

Aleurolites are yellowish-brown, polymictic, with carbonate cement, iron-enriched, with abundant quartz gravel. The Sequence is characterized by rich and diverse complex of organic remnants – bivalvia, brachyopoda, cephalopoda and foraminifera including *Lamellaptuchus angulicostatum* P i c t e t L o r . , *L. diday* C o g . , *Duvalia dilatata* B l., *Phyllocrinus malbosianus* O r b . , *Ph.janini* A r e n d . , *Phyllopachyceras infondibulum* O r b . , *P. Eichwaldi* K a r . , *P. prendeli* K a r . , *P. stuckenbergi* K a r . , *Cruralina belbekensis* T. S m . , *Gavelinella sigmoicosta* D a m . , *Globorotalites sigmoicosta* D a m . , *Trochogaudryina subglobosa* A n t [4, 32, 40]. This complex of organic remnants defines Late Hauterivian age of Golubynska sequence. It unconformably lies over Karatlyska sequence and unconformably overlain by Ternivska sequence.

In Tsentralna LTZ the Suite is facially replaced by Kalininska Suite.

Hauterivian stage (upper sub-stage) – Barremian stage (lower sub-stage) combined

Verkhoritska and Burulchynska sequences combined (K_1*vr+br*) are developed in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, in Kacha River basin. Typical columns are located nearby Verkhorichchya village.

Verkhoritska sequence (K_1*vr*) is composed of brown sandy clays and aleurolites with limestone interbeds and phosphorite nodules. Thickness of the sequence is up to 20 m. It contains foraminifera complex *Globorotalites sigmoicosta* D a m . , *Lenticulina nodosa* (R s s.) [4, 32], indicating its Late Hauterivian age.

The Sequence conformably lies over Rizanska Suite and is unconformably overlain by Burulchynska sequence.

In Belbetska sub-zone the Sequence is facially replaced by Golubynska sequence, and in Tsentralna LTZ – by lower part of Kalininska Suite.

Burulchynska sequence (K_1*br*) consists of red-brown, organogenic and organogenic-detritus, layered and sandy limestones up to 20 m thick. The Sequence contains abundant complex of organic remnants – bivalvia, cephalopoda, brachyopoda, echinodermata, coelenterata, including *Holcodiscus caillaudianus* O r b . , *Curthohibolites trubatschensis* S t . V e r g . , [4, 32] indicating its Early Barremian age.

Burulchynska sequence unconformably lies over Verkhoritska sequence and is unconformably overlain by Biasalynska Suite.

In Tsentralna LTZ the Sequence is facially replaced by the upper part of Kalininska Suite.

Total thickness of above combined sequences attains 40 m.

Barremian stage
Upper sub-stage

Shyrokynska sequence (K_1*šr*) is developed in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, in the central parts of inter-mountain dimples – Varnautska, Baydarska, Sukha Richka, Khaytu, Balaklavska. Typical column is located nearby Shyroke village in Baydarska valley. The Sequence is composed of greenish-grey, unclear-banded, greasy clays with siderite, limestone, aleurolites, sandstone interbeds, from 2 to 10 cm thick. Thickness of the Sequence is from 100 to 300 m.

Main lithologic-petrographic rock types include clays, siderite, limestones and aleurolites.

Clays are grey, dark-grey, lumpy, with glass cut, unclear-banded.

Siderites are greenish-brown, dense, massive or concentric-zoned, shelly.

Limestones are dense, detritus, often re-crystallized. Fragments are composed of pelitomorphic limestones, light-grey quartz grains from 0.2 to 1 mm in size.

Aleurolites are greenish-grey, dense, mica.

Sandstones are grey, polymictic, quartz-glauconite, medium-fine-grained with carbonate cement of contact and porous cementation types.

The Sequence is characterized by abundant complex of foraminifera: *Discorbis barremiana* M j a l l., *Clavihedbergella sigali* M o u l., *C. tuschepsensis* A n t., *C. priniarae* K r e t c h ., *Gavelinella barremiana* B e l l ., *Globorotalites burtensteini* B e l l ., and belemnites: *Mesohibolites moderatus* S c h w., *M. cf. minaret* R a s p ., *M. fallauxi* U h l., *Neohibolites inflectus* S t e l l [4, 32, 66]. This organic remnant complex indicates Late Barremian age of Shyrokynska sequence.

The Sequence unconformably lies over Novobobrivska sequence and is unconformably overlain by Balaklavska, Chorgunska, Kanarynska or Ternivska sequences.

In Kachynsko-Salgyrska sub-zone Shyrokynska sequence is correlated with lower part of Biasalynska Suite, and in Tsentralna LTZ it is facially replaced by Kalininska Suite sediments.

Hauterivian stage (upper sub-stage) – Barremian stage

Kalininska Suite (K_1*kl*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studies area in DH Tetyanivska-5 (depth 4605-4518 m) [4]. In Pivnichnokrymska LTZ the Suite is most completely intersected by DH Krylovska-1 [4] (depth 1610-1590 m). It consists of continental diverse-grained, grey, brownish-grey, oligomictic sandstones and aleurolites with coaliferous inclusions, up to 100 m thick. In Tsentralnokrymska LTZ the Suite thickness decreases in the southern direction to 20-60 m. In lithological respect, from the north to south amount of coarse-terrigenous rocks decreases. In DH Sakska-1 [4, 17] (depth 882.0-820.0 m) the Suite consists of light-grey, fine-grained sands, sandstones and aleurolites alternating with dark-grey sandy clays and siderites. In Mykolaivska field in DH 45 (depth 1260.0-1170.0 m) [38] the Suite is composed of grey fine-grained sandstones and dark-grey to black mica aleurolites in the lower part, and dark-grey carbonate clays in the upper part. Hauterivian-Barremian age is supported by palinological data. From the lower part of Kalininska Suite abundant pollen *Classopolis* (62%), and in the upper part the schizean spores (23%) *Cicatricosisporites, Pilosisporites, Trilobosporites, Anemia, Pelletieria* are determined [4]. In addition, ceathean, dixonean, sellaginellan and others are noted. The Suite unconformably lies over older sediments and is conformably overlain by Donuzlavska Suite.

In Chornoritsko-Baydarska sub-zone of Zakhidna LTZ Kalininska Suite is facially replaced by Shyrokynska sequence, and in Kachynsko-Salgyrska sub-zone – by Verkhoritska and Burulchynska sequences and Biasalynska Suite.

Barremian stage (upper sub-stage) – Aptian stage (lower sub-stage)

Biasalynska Suite (K_1*bs*) is locally developed in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, in the Khor valley and Kacha River basin. The Suite stratotype is located in the area of Biasala (Verkhorichchya) village. The Suite is composed of clays with numerous siderite interbeds and coalified organic remnant inclusions. Thickness of the Suite is up to 100 m.

Grey, brownish- and yellowish-grey, greasy, ductile, carbonate clays comprise the main lithological-petrographic rock type. The Suite contains abundant complex of organic remnants – cephalopoda and foraminifera including *Barremites strettostoma* U h l ., *Silezites seranonis* U h l ., *Globorotalites bartensteini* B e l l ., *Gaudryinella elongata* P a i r ., *Deshayesites deshayesi* L e u m ., *Aconeceras nisum* O r b., [4, 32] which indicate Late Barremian – Early Aptian age. The Suite unconformably lies over Karatlyska, Golubynska and Verkhoritska sequences and is unconformably overlain by Maryinska sequence.

In Chornoritsko-Baydarska sub-zone Biasalynska Suite is facially replaced by Shyrokynska sequence, and in Tsentralna LTZ – by Kalininska Suite.

Aptian stage (lower and middle sub-stages)

Donuzlavska Suite (K_1*dn*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studies area in DH Zakhidnooktyabrska-31 (depth 3191-3167 m) [4]. In Pivnichnokrymska LTZ the typical column is intersected by DH Evpatoriyska-9 (depth 1048.0-1008.0 m) [4, 17]. The Suite is composed of marine, coastal-marine, carbonate and sandy aleurolites with thin clay or limestone interbeds. Sandstones are aleuritic, diverse-grained, in places replaced by gravelites. In Tsentralnokrymska LTZ, DH Sakska-1 (depth 820.0-705.0 m) [4, 17] amount of clays increases in the column. Thickness of the Suite attains 200 m. The Suite is well-characterized paleontologically: in carbonate sandstones foraminifera *Chofatella decipiens* S c h u m b., *Palorbitolina sp.* and others are determined [4], typical for Mediterranean Urgonian facies of Barremian-Aptian sediments, and in argillites and aleurolites *Gavelinella ex gr. suluralis* (M j a l l.), *Hedbergela aptica* (A g a l.) are noted [4], characteristic for Aptian time. In general, the Suite age is Late Barremian – Middle Aptian. The Suite conformably lies over Kalininska Suite and is conformably overlain by Kashtanivska Suite.

Donuzlavska Suite is facially replaced by Biasalynska Suite in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, and in Chornoritsko-Baydarska sub-zone the lower part of Donuzlavska Suite is correlated with the upper part of Shyrokynska sequence.

Aptian stage
Middle sub-stage

Balaklavska sequence (K_1*bl*) is developed in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, in Balaklavska valley, from Balaklava town to Alsu (Morozivka) village. The typical column is located nearby Balaklava town, in one of the clay quarries. The best columns are intersected by drill-holes. The Sequence is lithologically similar to the underlaying rocks of Shyrokynska sequence and only differs in some details of structure and in the complex of organic remnants. It consists of greenish-grey, dense, mica argillite-like clays with numerous brown siderite concretions. In places gravelite and sandstone lens-like interbeds are observed. Thickness of the Sequence is from 25 to 100 m.

Balaklavska sequence is poorly characterized by organic remnants – belemnites and foraminifera, including

This complex indicates Middle Aptian age of the Sequence. It unconformably lies over Shyrokynska sequence and is unconformably overlain by Chorgunska, Kanarynska or Ternivska sequences.

In Kachynsko-Salgyrska sub-zone of Zakhidna LTZ Balaklavska sequence is replaced by the lower part of Maryinska sequence, and in Tsentralnokrymska LTZ Kashtanivska Suite comprises its facial analogue.

Aptian stage
Middle and upper sub-stages
Tayganskiy horizon

Kashtanivska Suite (K_1*kš*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studies area in DH Kashtanivska-31 (depth 3130-2830 m) [4, 17]. The typical column is intersected in Pivnichnokrymska LTZ by DH Evpatoriyska-9 (depth 1008.0-888.0 m) [4, 17]. The Suite consists of dark-grey argillites with interbeds and lenses of polymictic and oligomictic aleurolites, in places fine-grained sandstones and clayey siderites. In Tsentralnokrymska LTZ amount of coarse-terrigenous rocks decreases. Thickness of the Suite varies from 40 to 150 m, in places it attains 200 m. Molluscs findings *Hypacanthoplites nolaniformis* (N a t z k.) G l a s., *H. jacobi* C o l l., *Neohibolites sp., Aucellina cf. caucasica* B u c h. [4, 17] support Middle-Late Aptian age of Kashtanivska Suite. It conformably lies over Donuzlavska Suite and is also conformably overlain by Ryleevska Suite.

In Chornoritsko-Baydarska sub-zone of Zakhidna LTZ the lower part of Kashtanivska Suite is facially replaced by Balaklavska Suite, and in Kachynsko-Salgyrska sub-zone Maryinska sequence comprises its facial analogue.

Maryinska sequence (K_1*mr*) is developed in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, from Khor valley to the east up to Kacha River basin. Typical column is located outside the studied area at Simferopil city outskirt. The Sequence comprises intercalation of clays containing siderite and barite concretions and thin interbeds of clayey sandstones and fine-grained quartz-glauconite sands. Thickness of the Sequence is from 40 to 60 m.

Main lithologic-petrographic rock types include clays, sandstones and siderites.

Clays are grey, greenish-grey, dense, ductile, often aleuritic, mica, in places carbonate (calcite content up to 35%). High carbonate content is caused by skeletal coccolitephoride elements concentration.

Sandstones are grey, brownish-grey, quartz-glauconite, clayey, with aleuro-psammitic texture and layered structure.

Siderites are brownish, elongated-ellipsoidal, 0.2-0.3 m in size, concentric-layered.

The Sequence contains rich complex of cephalopoda and foraminifera organic remnants including *Acanthohoplites ex gr. aschiltaensis* A n t . , *Parahoplites multicostatus* S i n z., *Hedbergella optica* A g a l., *Globigerinelloides ferreolensis* M o u l. [4, 32, 66], which suggest for its Middle-Late Aptian age. The Sequence unconformably lies over Biasalynska Suite and is unconformably overlain by Ternivska sequence.

In Chornoritsko-Baydarska sub-zone it is facially replaced by Balaklavska Suite, and in Tsentralna LTZ – by Kashtanivska Suite.

Albian stage
Lower sub-stage
Ryleevskiy horizon

Ryleevska Suite (K_1rl) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studies area in DH Ryleevska-1 (depth 4200.0-4077.0 m) [4, 17]. The typical column in the area is intersected by DH Evpatoriyska-9 (depth 888.0-693.0 m) [4, 17]. The Suite is composed of dark-grey, layered, sandy aleurolites with glauconite and abundant pyritized plant remnants, as well as aleuritic, slightly-carbonate argillites with fine-disseminated pyrite and light-grey diverse-grained sandstone interbeds. Thickness of the Suite varies from 100 to 170 m. In Tsentralnokrymska LTZ the Suite is intersected by DH Sakska-1 (depth 680.0-610.0 m) [4, 17]. Foraminifera *Haplophraqmoides rosaceus* S u b b., *H. nonioninoides* R s s., *Hedbergella trocoidea* G a n d., ammonites *Hamites attenuatus* S o w., and bivalve molluscs *Grammatodon carinatus* S o w., and *Inoceramus sp.* [4, 17] indicate Early Albian age of the Suite.

Ryleevska Suite conformably lies over Kashtanivska Suite and is conformably overlain by Tarkhankutska Suite in Pivnichnokrymska LTZ, and unconformably – by Evpatoriyska sequence in Tsentralnokrymska LTZ.

Middle sub-stage
Tarkhankutskiy horizon

Tarkhankutska Suite (K_1tr) is developed in Pivnichnokrymska LTZ. The stratotype is defined outside the map sheet area. In the given territory the Suite is intersected by DH Krylovska-1 (depth 1279.0-1210.0 m) [4, 17]. The rocks include dark-grey to black aleuritic argillites and dark-grey fine-aleuritic aleurolites. Thin dacite-andesite and hornblende-plagioclase porphyry tuff, tuff-lava and tuff-lava-breccia layers are often observed. This is caused by volcanic activity over there. Thickness of the Suite is 500 m. It conformably lies over Ryleevska Suite and is also conformably overlain by the lower sub-suite of Kovylnenska Suite. Ammonites *Hoplites dentatus* S o w . , *Kossmatella agassiziana* P i c t., *Neohibolites minimus* L i s t . , *Inoceramus anglicus* W o o d s. [4, 17] are known form the Suite sediments indicating its Middle Albian age and corresponds to Tarkhankutskiy horizon. The lower parts of Chorgunska sequence comprises the Suite facial analogue in Chornoritsko-Baydarska LTZ. In Tsentralnokrymska LTZ the Suite is facially replaced by the lower part of Elyzavetynska sequence.

Middle and upper sub-stages

Chorgunska sequence ($K_1\check{c}r$) is developed in the north-western part of Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, from Flotske village to Chornorichchya village, and is intersected by drill-holes in Gerakleyske plateau. The typical column is located at Chornorichchya village outskirt. The Sequence includes sandstones and gravelites in basal conglomerate at the bottom and rhythmic intercalation of dense, fine-grained, yellowish-brown, with carbonate cement, 0.15-0.45 m thick sandstones, and friable, coarse-medium-grained, brownish-grey, with carbonate cement, from 0.7 to 2.5 m thick at the top, sandstones. The total thickness of the Sequence is up to 250 m.

Main lithologic-petrographic rock types include conglomerates, gravelites and sandstones.

Conglomerates are grey, greenish-grey, pudding. The fragments from 0.3 to 1 cm in size are composed of quartz (70%) and dark-grey fine-grained sandstone (30%). They are well-rounded and sorted. Cement is carbonate with sandy filler. Sandstones are yellowish-brownish-grey, diverse-grained, polymictic and quartz-carbonate, dense and friable, with carbonate or carbonate-clayey cement. The Sequence is characterized by variable complex of organic remnants including *Latidorsella latidorsata* M i c h ., *Hoplites ex gr. splendeus* S o w ., *Inoceramus concentricus* P a r k . [4, 32, 66], which define its Middle-Late Albian age. Chorgunska sequence unconformably lies over Balaklavska sequence and Baydarska Suite and is unconformably overlain by Kanarynska sequence.

In Tsentralnokrymska LTZ, Evpatoriyska sequence comprises the facial analogues of the Suite, in Pivnichnokrymska LTZ – Kovylnenska Suite, and in Belbetska and Kachynsko-Salgyrska sub-zones of Zakhidna zone – lower part of Ternivska sequence.

Elyzavetynska sequence (K_1*el*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the map sheet territory by DH Elyzavetynska-2 (depth 950-735 m) [4, 17]. The typical column is intersected by DH Krylovska-1 (depth 1210-995 m) [4, 17]. The Sequence is composed of carbonate argillites with aleurolites interbeds; thickness is up to 500 m.

After ammonite *Hoplites dentatus* S o w., and foraminifer *Hedbergella aff. infracretacea* (G l a e s s n.) *Pseudolamarckina cf. woodi* K h a n . [4, 17] findings the Middle-Late Albian age of Elyzavetynska sequence is defined.

Sediments of the Sequence conformably lie over Ryleevska Suite and also conformably are overlain by Upper Kovylnenska Suite rocks.

In Pivnichnokrymska LTZ, in the north-eastern direction, with volcanic rocks appearance the Sequence is facially replaced by Tarkhankutska Suite or lower sub-suite of Kovylnenska Suite. In Tsentralnokrymska LTZ, in the southern direction Elyzavetynska sequence is facially replaced by Evpatoriyska sequence.

Upper sub-stage
Kovylnenskiy horizon

Evpatoriyska sequence (K_1*ev*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The typical column is intersected by DH Evpatoriyska-9 (depth 693.0-549.0 m) [4, 17]. The Sequence is composed of quartz medium-grained sandstones, argillites and siliceous rocks. Thickness of the Sequence is 100 m. It unconformably lies over Ryleevska Suite and is conformably overlain by upper sub-suite of Kovylnenska Suite. After foraminifera *Ticinella off breggiensis* (G a n d.) and others [4, 17] findings, the Sequence age corresponds to the early and middle phases of Late Albian.

In Pivnichnokrymska LTZ the Sequence is facially replaced by lower sub-suite of Kovylnenska Suite, in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ – by Chorgunska sequence, in Kachynsko-Salgyrska sub-zone – partly by Manguska sequence, and in Belbetska sub-zone – by the lower part of Ternivska sequence.

Manguska sequence (K_1*mn*) is developed in Kachynsko-Salgyrska sub-zone of Zakhidna LTZ, in the Kacha and Alma river basins. The typical column is located nearby Prokhladne village. The Sequence is composed of clays with sandstone and conglomerate basal horizon. Thickness of the Sequence is up to 85 m.

Main lithologic-petrographic rock types include clays, sandstones and conglomerates.

Clays are greenish-grey, aleuritic.

Sandstones are grey, greenish-grey, diverse-grained, quartz-carbonate, oblique-banded.

Conglomerates are grey, brownish-grey, polymictic, diverse-pebble. The Sequence contains variable enough complex of organic remnants including *Hysteroceras orbignui* S p a t h ., *H. varricosum* S o w . [4, 32, 38] indicating Late Albian age (its first half – zone *Hysteroceras orbignui*). The Sequence unconformably lies over Maryinska sequence or older stratons and is unconformably overlain by Ternivska sequence.

In Chornoritsko-Baydarska sub-zone it is facially replaced by Chorgunska sequence, in Belbetska sub-zone – by the lower part of Ternivska sequence, in Tsentralna LTZ – by Evpatoriyska sequence, and in Pivnichnokrymska LTZ – by the lower sub-suite of Kovylnenska Suite.

Kovylnenska Suite (K_1*kv*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studied area by DH Serebryanska-8 (depth 4184-3200 m [4, 17]. The Sequence is composed of terrigenous-volcanomictic rocks and two sub-suites are distinguished herein.

Lower sub-suite (K_1kv_1) is developed in Pivnichnokrymska LTZ. It is composed of argillites, volcanomictic and polymictic sandstones, gravelites, in places volcanogenic siliceous rocks; thickness is up to 1600 m. Ammonites and foraminifera *Pervinquieria subiflata* (P i c t.), *Hamites cf. attenuatus* S o w . and others are found in the rocks [4, 17] suggesting for the early and middle Late Albian age. Lower sub-suite of Kovylnenska Suite conformably lies over Tarkhankutska Suite and is conformably overlain by the upper sub-suite of Kovylnenska Suite.

Upper sub-suite (K_1kv_2) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The typical column is intersected by DH Evpatoriyska-9 (depth 549-420 m) [4]. In Pivnichnokrymska LTZ it is composed of argillites, marls and volcanomictic rocks up to 300 m thick which conformably lie over lower sub-suite of Kovylnenska Suite and are also conformably overlain by the lower sub-suite of Pryvolnenska Suite. In Tsentralnokrymska LTZ the given sub-suite is up to 170 m thick and composed of argillites with sandstone interbeds. It conformably lies over Evpatoriyska sequence and is also conformably overlain by the lower sub-suite of Krasnopolyanska Suite. Early Albian age (early and middle phases) is supported by foraminifera *Praeglobotruncana delrioensis* (P l u m m .) and others findings [4, 17].

Kanarynska sequence comprises facial analogue of Kovylnenska Suite in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, Manguska sequence – in Kachynsko-Salgyrska sub-zone, and Ternivska sequence – in Belbetska sub-zone.

Kanarynska sequence (K_1kn) is developed in Chornoritsko-Baydarska sub-zone of Zakhidna LTZ, in Balaklavska valley, and is intersected by drill-holes in Gerakleyske plateau. The typical column is located nearby Kanary (Oboronne) village in the railroad cut. Most complete columns are intersected by drill-holes in Gerakleyske plateau and in Balaklavska valley. The Sequence consists of alternating litho-crystal-clastic and vitric-crystal-clastic tuffs, tuffites and tuff-sandstones with sandstone, aleurolites and clay interbeds. Thickness of the Sequence is up to 350 m.

Main lithologic-petrographic rock types include tuffs, tuffites and tuff-sandstones.

Tuffs are greenish-grey, fine-clastic, litho-crystal-clastic and vitric-crystal-clastic, augite-hornblende-plagioclase, composed of plagioclase, augite, green and brown hornblende fragments and crystals, as well as augite-hornblende andesite and volcanic glass fragments and lapilli from 0.1 to 0.3 mm in size.

Tuffites are light-grey and greenish-grey, fine-clastic. Pyroclastic material from 0.05 to 0.3 mm in size is mainly composed of plagioclase crystal fragments and single augite and basaltic hornblende grains. Cement is composed of calcite and partly of mica which is developed in flakes on the surface of pyroclastic particles.

Tuff-sandstones are grey, greenish-grey, fine-medium-grained. Clastic material is composed of andesite fragments, plagioclase, augite, green and brown hornblende crystals, from 0.1 to 0.7 mm in size. Cement is porous carbonate.

The Sequence is characterized by abundant and variable complex of organic remnants, specifically *Mortoniceras inflatum* S o w . , *Hoplites sp., Parahibolites pseudoduvalia* S i n s . , *Neohibolites subtilis* K r i m., *Inoceramus anglicus* W o o d s . , *Aucellina gryphaeoides* S o w . [66] indicating Late Albian age.

Kanarynska sequence unconformably lies over Karadazka and Ayvasylska suites (Gerakleyske plateau and western part of Balaklavska valley), over Baydarska and Chorgunska sequences (southern part of Balaklavska valley), and is conformably overlain by Bilogorska Suite.

In Belbetska sub-zone it is facially replaced by Ternivska sequence, and in Pivdennokrymska and Tsentralnokrymska LTZs – by the upper sub-suite of Kovylnenska Suite and lower sub-suites of Krasnopolyanska and Pryvolnenska suites.

Ternivska sequence (K_1trn) is mainly developed in Belbetska sub-zone, partly enters Chornoritsko-Baydarska and Kachynsko-Salgyrska sub-zones of Zakhidna LTZ, where it is extended in the broad band from the Chorna River valley to the Bodrak River basin. The typical column of the Sequence is located in the area of Ternivka village. The Sequence is composed of two batches: glauconite sandstone batch at the top, and carbonate sandstone batch at the bottom; in places up to 3 m thick basal horizon composed of fine-pebble quartz conglomerate is observed at the footwall. Thickness of the Sequence is variable and attains 40 m.

Main lithologic-petrographic rock types include carbonate and glauconite sandstones, aleurolites, conglomerates.

Sandstones are grey, dark-grey, fine- and medium-grained, polymictic, in places with up to 15% glauconite admixture, friable, often clayey, with dense, fine-grained quartz-carbonate sandstone interbeds. Texture is psammitic, irregularly-grained, structure is spotty and massive, cementation type is contact and basal. The clastic material includes medium-rounded quartz (50%), quartzite (20-27%), potassium feldspar (7%) and plagioclase (5%) fragments. Secondary minerals include calcite and siderite. Inclusions of shell and coalified plant remnant fragments are characteristic.

Aleurolites are grey, dark-grey, dense, quartz-carbonate, with psammo-aleuritic texture and massive structure.

Conglomerates are quartz with carbonate cement. Clastic material occupies 80% of the rock volume and is composed of milky-white quartz (80%), re-crystallized limestone (10%) and quartz sandstone (10%) fragments. Cement is carbonate. Cementation type is basal and porous.

The Sequence contains abundant and variable complex of organic remnants including cephalopoda, bivalvia, gastropoda and foraminifera *Inoceramus concentricus* P a r k . , *I. anglicus* W o o d s . , *Nucula cf. albensis* O r b . , *Kossmatella cf. agassiziana* P i c t., *Metacerithium cf. trimonile* (O r b .), *Neohibolites stylioides*

R e n n g . , *Neohibolites subtilis* K r i m h . , *Hoplites dentatus* S o w . , *Gavelinella slavutichi* K o p t . [66], *Hedbergella globigerinellinoides* S u b l., characteristic for Middle-Late Albian.

The Sequence unconformably lies over various levels of Lower Cretaceous sediments, in places over Upper Jurassic Baydarska Suite, and is conformably overlain by Bilogorska Suite.

In Chornoritsko-Baydarska sub-zone of Zakhidna LTZ it is facially replaced by Kanarynska sequence, in Kachynsko-Salgyrska sub-zone – by Manguska sequence, in Tsentralnokrymska LTZ – by upper sub-suite of Kovylnenska Suite and Evpatoriyska sequence, in Pivnichnokrymska LTZ – by Tarkhankutska, Kovylnenska and lower part of Pryvolnenska suites.

Lower and Upper divisions

Albian stage (upper sub-stage) – Cenomanian stage undivided

Pryvolnenska Suite ($K_{1\text{-}2}pv$) is developed in Pivnichnokrymska LTZ. The stratotype is defined outside the studied area by DH Dzhankoyska-3 (depth 3176-2971 m) [4]. Two sub-suites are distinguished therein.

Lower sub-suite ($K_{1\text{-}2}pv_1$) is composed of clayey marls, siliceous sandstones and volcanics up to 60 m thick. Late Albian age (time end) is supported by foraminifera *Rotalipora ticinensis* (G a n d.) and other findings [4].

Upper sub-suite ($K_{1\text{-}2}pv_2$) is composed of dacite-andesite lavas, lava-breccia and their tuffs up to 300 m thick. Early Cenomanian age is supported by bivalvia mollusc and foraminifera *Inoceramus crippsi* M a n t., *Rotalipora appeninhica* (R e n z.) [4] findings. Pryvolnenska Suite conformably lies over Kovylnenska Suite and is conformably overlain by upper sub-suite of Krasnopolyanska Suite.

In Chornoritsko-Baydarska sub-zone of Zakhidna LTZ Kanarynska sequence comprises its facial analogue, and in Kachynsko-Salgyrska sub-zone – Ternivska sequence.

Krasnopolyanska Suite ($K_{1\text{-}2}kp$) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the studied area by DH Karlavska-10 (depth 3977-3452 m) [4]. The Suite is divided into three sub-suites. It is developed in full outside the map sheet territory while in the studied area just its upper sub-suite is distinguished. In Pivnichnokrymska LTZ it is intersected by DH Evpatoriyska-2 (depth 600-420 m) [4, 38], and in Tsentralnokrymska LTZ – by DH 42 (depth 1270-1150 m) [38].

Lower sub-suite ($K_{1\text{-}2}kp_1$) is composed of alternating clayey marls and limestones up to 900 m thick. Late Albian age is supported by foraminifera *Rotalipora ticinensis* (G a n d.) findings [4, 17].

Middle sub-suite ($K_{1\text{-}2}kp_2$) is composed of dark-grey clayey marls with dark-grey to black limestone interbeds, up to 300 m thick. Early Cenomanian age is supported by *Rotalipora appeninnica* (R e n z.) findings [4, 17].

Upper sub-suite ($K_{1\text{-}2}kp_3$) is composed of dark-grey to black clayey limestones with pyrite inclusions, up to 300 m thick. Middle-Late Cenomanian age is supported by foraminifera *Rotalipora cushmani* M o r n findings [4, 17].

Krasnopolyanska Suite conformably lies over upper sub-suite of Kovylnenska Suite and is also conformably overlain by Natashynska Suite. In Pivnichnokrymska LTZ the lower and middle sub-suites are facially replaced by coeval sediments of Pryvolnenska Suite. In Chornoritsko-Baydarska sub-zone of Zakhidna LTZ the upper parts of Kanarynska sequence comprise the facial analogues of the lower and middle sub-suites. The middle and upper sub-suites in Zakhidna LTZ are facially replaced by Bilogirska Suite.

Upper division (K_2)

Upper Cretaceous sediments are widely developed both in Crimean Fore-Mountains and in Plain Crimea. Insufficient outcrops are known in the western slopes of Yaylinske Highland (Machu Mountain). In the studied area, in Crimean Fore-Mountains, these sediments are distinguished in Zakhidna LTZ extended from Sevastopol city in the west to the Alma River basin in the east. In Plain Crimea Upper Cretaceous sediments are distinguished in Pivnichnokrymska and Tsentralnokrymska LTZs where they are intersected by drill-holes at the depths 700-2300 m (Fig. 2.4).

Upper Cretaceous sediments are mainly composed of marl-limestone rocks of variable thickness; all stages of the general stratigraphic scale are distinguished.

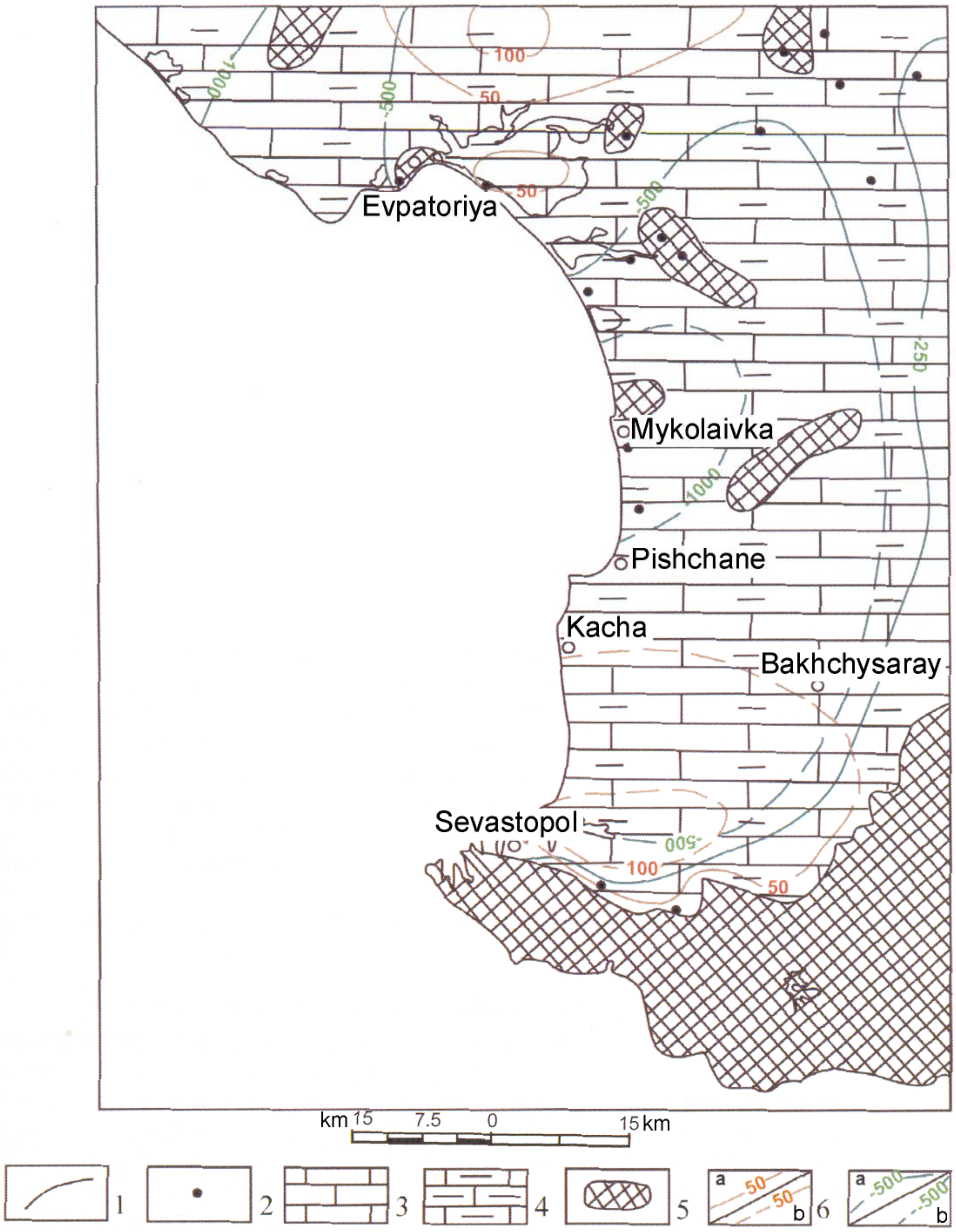

Fig. 2.4. Lithological scheme of Cenomanian sediments.
1 – lithological boundaries; 2 – drill-holes; 3 – limestones; 4 – marls; 5 – areas of complete Middle-Upper Albian sediments erosion; 6 – isopachs: a – proven, b – probable; 7 – depth contour lines of Cenomatian sediments footwall.

Cenomanian stage

Bilogirska Suite (K_2*bl*) is developed in Zakhidna LTZ. The stratotype is located outside the studied area, at the Bilogirsk town outskirt. The Suite consists of marls, limestones, carbonate sandstones with clay interbeds and flint nodules which in some columns (Selbukhra Mountain) are arranged in separate batches. Thickness of the Suite is up to 200 m.

Main lithologic-petrographic rock types include marls, limestones, sandstones, clays, flint.

Marls are grey, dark-grey, dense, with politic texture, spotty, bedded texture and thin-platy jointing. Up to 15% of the rock volume is composed of the foraminifera remnants 0.02-0.1 mm in size, and up to 5% – of the fine-aleuritic fraction clastic material consisting of quartz, feldspar, mica and glauconite.

Sandstones are grey, irregularly-grained, polymictic, dense, layered. The calstic material consists of quartz, feldspar, glauconite; it is weakly rounded and sorted. Cement is carbonate, clayey-carbonate. Cementation type is porous. Glauconite sandstones are greenish-grey, friable. The clastic material constitutes 80% of the rock volume and includes glauconite (60-70%), feldspar (10%) and quartz (20%). Besides that, they contain inclusions of coalified organic remnants and newly-formed pyrite. Cement is clayey, cementation type is porous and contact.

Clays are dark-grey, mica, with aleuro-pelitic texture, inclusions of coalified plant remnants, fish flakes and newly-formed pyrite.

Flint is grey, brownish-grey; it occurs in lens-shaped concretions, composed of uniform micro-grained chalcedony-quartz mass.

The Suite is characterized by abundant complex of organic remnants – bivalvia, cephalopoda, foraminifera, specifically: *Inoceramuscrippsi* M a n t . , *I. scalprum* B o e h m., *Neohibolites ultimus* O r b., *Mantelliceras mantelli* (S o w.), *Puzosia planulata* S o w., *Schloenbachia varians* (S o w.), *Turrilites cosiatus* L a m . , *Scaphites aequalis, Rotalipora appeninhica* R e n z . , *Gavelinella cenomanica* B r o t z . [4, 32, 66], indicating Cenomanian age of the Suite. It conformably lies over Lower Cretaceous sediments and is also conformably overlain by Menderska Suite.

In Tsentralnokrymska LTZ the middle and upper sub-suites of Krasnopolyanska Suite comprise analogue of Bilogirska Suite, and in Pivnichnokrymska LTZ the lower part of Bilogirska Suite is facially replaced by the upper sub-suite of Pryvolnenska Suite.

Turonian stage
Lower sub-stage

Menderska Suite (K_2*md*) is developed in Zakhidna LTZ. The stratotype is located on Mender Mountain nearby Trudolyubivka village. The Suite is composed of light-grey and white chalk-like marls and chalk with grey and black flint inclusions. Thickness of the Suite is up to 50 m.

Main lithologic-petrographic rock types include marls and chalk.

Marls are light-grey and white, with politic texture, composed of pelitomorphic clayey-carbonate mass with numerous fine-grained calcite lenses and veinlets; up to 20% of the rock volume is composed of organic remnant fragments.

Chalk is white, with pelitomorphic texture, consisting by almost 100% of skeletal coccolitephoride remnants. In the area of Kudryno village (Aksu-Dare gorge) dark-grey to black bituminous marls with fish remnants are encountered at the Suite footwall.

Menderska Suite contains abundant complex of organic remnants, specifically, cephalopoda, bivalvia, foraminifera including *Inoceramus labiatus* S c h l o t h., *I. hercynicus* P e r t . , *Praeglobotruncana helvetica* (B o l l i) [4, 32, 66], indicating Early Turonian age. The Suite conformably lies over Bilogirska Suite and is also conformably overlain by Prokhladnenska Suite.

In Plain Crimea (Pivnichnokrymska and Tsentralnokrymska LTZs) the lower part of Natashynska Suite comprises the facial analogue of Menderska Suite.

Turonian stage (upper sub-stage) – Coniacian stage

Prokhladnenska Suite (K_2*pr*) is developed in Zakhidna LTZ. The stratotype is located nearby Prokhladne village of Bakhchysarayskiy area. The Suite consists of light-grey limestones and marls with flint interbeds and concretions. Thickness of the Suite is up to 40 m.

Main lithologic-petrographic rock types include limestones, marls, sandstones, flints.

Limestones are light-grey, yellowish-white, re-crystallized, consisting of pelitomorphic and micro-grained calcite with up to 25% inclusions of bivalvia molluscs, brachyopoda and foraminifera shell remnants.

Marls are light-grey, white, with pelitomorphic texture, composed of pelitomorphic clayey-carbonate mass.

Sandstones are light-grey, fine-grained, carbonate, thin-layered.

Flints are grey, dark-grey to black, composed of micro-grained chalcedony-quartz mass.

The Suite contains abundant but uniform fauna complex including *Inoceramus wandereri* A n t . , *I. lamarcki* P e r t . , *I. lapparenti* R o e m . , *I. deformis* M a n t., *I. inconstans* W o o d s . , *Najdinothyris becksi*

R o e m . , *Cyclothyris venthplanata* (S c h l.), *Globotruncana primitiva* D a l v , *G. lapparenti* B r o t z. [4, 32, 66], suggesting for Late Turonian – Coniacian age.

The Suite conformably lies over Menderska Suite and is also conformably overlain by Kudrynska Suite.

In Plain Crimea the upper part of Natashynska Suite comprises the facial analogue of Prokhladnenska Suite.

Turonian – Coniacian stages

Natashynska Suite (K_2*nt*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs of Plain Crimea. The stratotype is defined outside the map sheet area in DH Elyzavetynska-505 (depth 1053-995 m) [4]. In Pivnichnokrymska LTZ the Suite is intersected by DH Evpatoriyska-9 (depth 420-327 m) [4], and in Tsentralnokrymska LTZ – by DH Mykolaivska-1 (depth 1100-1025 m) [4]. It is composed of grayish-white and white, clayey, organogenic-detritus limestones with sutures and stilolites and marl and clay, in places sandstone interbeds. Thickness of the Suite attains 200 m. Foraminifera *Gavelinella ammonoides* (R s s.) findings at the bottom and *Stensioeina emscherica* B a r y s h n . [4] and others – at the top support Turonian-Coniacian age of the Suite.

The Suite conformably lies over Krasnopolyanska Suite and is unconformably overlain by Koltsovska sequence. In Zakhidna LTZ, Menderska and Prokhladnenska suites comprise the facial analogues of Natashynska Suite.

Santonian stage
Lower sub-stage

Koltsovska sequence (K_2*kc*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The typical column is distinguished outside the studied area by DH Strilkovska-1 (depth 1905-1848 m) [4]. In Pivnichnokrymska LTZ the Sequence is intersected by DH Evpatoriyska-9 (depth 347-316 m) [4], and in Tsentralnokrymska LTZ – by DH Sakska-1 (depth 524-500 m) [4]. Koltsovska sequence is composed of grey dense marls and light-grey clayey pelitomorphic limestones up to 120 m thick. It unconformably lies over Natashynska Suite and is also unconformably overlain by Pavlivska sequence. After foraminifera *Pseudovalvulineria infrasantonica* (B a l a k h m.) findings [4] the Sequence is ascribed to Early Santonian.

In Zakhidna LTZ the lower part of Kudrynska Suite comprises the facial analogues of the Sequence.

Santonian stage – Campanian stage (lower sub-stage)

Kudrynska Suite (K_2*kd*) is developed in Zakhidna LTZ. The stratotype is located at the outskirt of Kudryno village, Bakhchysarayskiy area. In the lower part, the Suite consists of light-grey marls with grey and bluish-grey marl interbeds, with flint lenses and concretions; in the upper part it includes alternating grey and greenish-grey marls with dark-grey and greenish-grey carbonate clays. Thickness of the Suite attains 400 m.

Main lithologic-petrographic rock types include marls and clays.

Marls are grey, light-grey, greenish-grey, with politic texture, massive or layered structure; in places marls are spotty with lens-shaped inclusions of clayey marls. They are composed of clayey-carbonate cryptic-crystalline mass with numerous inclusions of fine-grained calcite and organic remnant fragments.

Clays are dark-grey and greenish-grey, carbonate, dense, aleuritic, with aleuropelitic texture and layered structure. The Suite contains abundant and variable complex of organic remnants – bivalvia, cephalopoda, brachyopoda, echinodermata, foraminifera, including *Gaudryuceras varagurense* K o s s m., *Hauericeras pseudogardeni* S c h l u t., *Inoceramus cardissoides* G o l d f., *I. azerbaydjanensis* A l i e v., *Orbirhynchia pisiformis* P e l l i t., *Actinocamax verus* M i l l . , *Marsupites testudinarius* S c h l o t h., *Micraster schroederi* S t o l l . , *Pseudovalvulineria infrasantonica* (B a l a k h.), *Globotruncana concavata* B r o t z., G. *fornicata* P l u m m . , *G. area* Cush m., *Gavelinella stelliqera* (M a r i e), *Cibicidoides temirensis* (V a s s.) [4], suggesting for Santonian – Early Campanian age. The Suite conformably lies over Prokhladnenska Suite and is also conformably overlain by Beshkoska Suite.

In Pivnichnokrymska and Tsentralnokrymska LTZs of Plain Crimea Koltsovska and Pavlivska sequences comprise the facial analogue of the Suite.

Pavlivska sequences (K_2*pl*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The typical column is distinguished outside the map sheet area by DH Dzhankoyska-3 (depth 2299-2105 m) [4]. In Pivnichnokrymska LTZ the Sequence is intersected by DH Evpatoriyska-9 (depth 316-272 m) [4], and in Tsentralnokrymska LTZ – by DH Sakska-1 (depth 500-404 m) [4]. The Sequence is composed of light-grey to white clayey limestones with marl and clay interbeds. To the south the column is changed a bit, specifically, amount of limestones decreases. Thickness of the Sequence is 170 m. It unconformably lies over Koltsovska sequence and is unconformably overlain by Dzhankoyska Suite. After foraminifera *Gavelinella stelligera* (M a r i e) and *Cibicidoides temirensis* (V a s s .) findings [4] the Sequence is ascribed to Late Santonian and Early Campanian.

In Zakhidna LTZ, the upper part of Kudrynska Suite comprises the facial analogue of Pavlivska sequence.

Campanian stage
Upper sub-stage

Beshkoska Suite (K_2*bk*) is developed in Zakhidna LTZ. The stratotype is located on Besh-Kosh Mountain in Bakhchysarayskiy area. The Suite is composed of white and grayish-white chalk-like marls with flint concretions, up to 120 m thick.

Marls are chalk-like, composed of cryptic-crystalline clayey-carbonate mass with organic remnant and coccolitephoride skeleton fragments (up to 20% of the rock volume).

The Suite contains abundant and variable complex of organic remnants – bivalvia, cephalopoda, brachyopoda, echinodermata, sponge, foraminifera, including: *Inoceramus barabini* M o r t., *I. balticus* B o e h n . , *I. tauricus* M o r t., *I. convexus* H a l l e t M e e k . , *Limatula decussata* (M u n.), *Area granulato-radiata* A l t h., *Leda producta* (N i l s s .), *Pseudokossmaticeras cf. galicianum* F a v., *Anapachydicus witteniudi* (S c h l i i t.), *Haploscaphites cf. roemeri* (S c h l.), *Belemnitella mucronata senior* N o w . , *B. mucronata minor* J e l e t s k . , *Vernenilina munsteri* R e u s s . [4, 66] indicating Late Campanian age. The Suite conformably lies over Kudrynska Suite and is also conformably overlain by Starosilska Suite.

In Pivnichnokrymska and Tsentralnokrymska LTZs, the lower sub-suite of Dzhankoyska Suite comprises the facial analogue of the Suite.

Campanian stage (upper sub-stage) – Maastrichtian stage

Dzhankoyska Suite (K_2*dž*) is developed in Pivnichnokrymska and Tsentralnokrymska LTZs. The stratotype is defined outside the map sheet area by DH Dzhankoyska-3 (depth 2106-1810 m) [4]. Two sub-suites are distinguished.

Lower sub-suite ($K_2dž_1$) is composed of grey clayey limestones with greenish marl interbeds, up to 450 m thick.

Upper sub-suite ($K_2dž_2$) is composed of light-grey marls with limestone interbeds, in places siliceous rock and spongolite lenses, up to 900 m thick.

In Pivnichnokrymska LTZ the Suite is intersected by DH 172 (depth 185.0-174.5 m) [38] where it is composed of light-grey to white, chalk-like, dense, greenish-grey, clayey marls and greyish-green clayey limestones. In the full volume it is intersected by DH Krylovska-1 (depth 710-170 m) [4]. In Tsentralnokrymska LTZ the Suite is intersected by DH Sakska-1 (depth 404-310 m) [4] where it is composed of grey marls with limestone interbeds. Late Campanian age of lower sub-suite is supported by *Globotruncana coarctata* (B o l l i), *G. morozovae* V a s s. findings. The upper sub-suite after *Bolivina incrassata* (R s s.), *Pseudotextularia varians* R z e h. and other findings is ascribed to Masstrichtian.

The Suite sediments unconformably lie over Pavlivska sequence or the older rocks and is conformably overlain by Gromivska Suite in Tarkhankutska LTZ, and Bogachivska Suite in Syvaska LTZ.

In Zakhidna LTZ, Beshkoska Suite comprises facial analogue of the lower sub-suite, and Starosilska Suite – that of the upper one of Dzhankoyska Suite.

Maastrichtian stage

Starosilska Suite (K_2*ss*) is developed in Zakhidna LTZ. The stratotype is located in Starosillya village, at Bakhchysaray town outskirt. The Suite is composed of sandy and aleuritic marls with marcasite concretions. Upward in the column sand content in marls increases and they are gradually changed by bluish-grey sandstones with oyster shells. Thickness of the Suite attains 140 m.

Main lithologic-petrographic rock types include marls and sandstones.

Marls are bluish-grey, sandy and aleuritic, massive to coarse-layered. They are composed of cryptic-crystalline clayey-carbonate mass with clastic material admixture – fine-grained sand and aleurite from 20 to 50%, consisting of glauconite, quartz, micas, fish flakes, organic remnant fragments and arthropoda imprints filled with fine-crystalline marcasite.

Sandstones are grey, yellowish-bluish-grey, glauconite, carbonate and clayey-carbonate, fine-grained, coarse-layered and massive, with fragments and solid shells of bivalvia molluscs.

The Suite contains abundant and variable complex of organic remnants – bivalvia, cephalopoda, coelenterate, echinodermata. In the lower column part *Inoceramus impressus* Orb., *Spondylus dutempleanus* Orb., *Smilotrochus galeriformis* Kner., *Chlamys acuteplicatus* Alth., *Ch. cretosa zeiszneri* (Alth.), *Pseydocossmaticeras cf. galicianum* Fav., *Pachydiscus neubergicus* (Hauer). are determined. In the upper column part *Echinocoris vulgaris* Leshe., *Chlamys trisulea* (Hag.), *Cibicidoides bembix* (Marss.), *Baculites vertebralis* Lam., *Belemnella arkhangelskii* Najd., *Bolivinoides draco* Marss. [4, 32, 66] are characteristic. Mentioned complex of organic remnants supports Maastrichtian age of the Suite. It conformably lies over Kudrynska Suite and is unconformably overlain by Bilokamyanskla Suite.

In Tsentralnokrymska LTZ, the upper sub-suite of Dzhankoyska Suite comprises facial analogue of the Suite.

Cenozoic Eratheme

Cenozoic sediments in the studied map sheets do form the upper sedimentary cover. They include Paleogene, Neogene and Quaternary systems.

Paleogene System

Paleogene sediments play considerable role in the geology of studied area. At the surface they are exposed in Crimean Fore-Mountains, being extended with continuous band in sub-latitudinal direction from Sevastopol city to Skaliste village, and constitute Pivdennozakhidna and Bakhchysarayska LTZs. Over most part of territory Paleogene sediments are overlain by Neogene rocks and are intersected by numerous drill-holes. Distinct sedimentation conditions have caused facial variability of Paleogene sediments in Plain Crimea allowing their subdivision in two litho-tectonic zones – Tarkhankutska and Syvaska (see "Scheme of litho-tectonic zonation" and legend to the "Map of pre-Quaternary units").

Tarkhankutska LTZ enters the area with its southern part only while Syvaska LTZ encompasses most part of Alminska depression.

Pivdennozakhidna LTZ encompasses the south-western part of the Paleogene rocks distribution area, from Sevastopol city in the west to the eastern map sheet border. These rocks are exposed in the Fore-Mountain cuesta ridge of Crimean Mountains.

Paleogene System includes all three divisions and is divided into Bilokamyanska, Bogachivska, Gromivska, Kachynska, Lazurnenska, Bakhchysarayska, Okunivska, Simferopilska, Novopavlivska, Planorbellova, Molochanska suites, the sequences of marls and aleurolites, clays, marls and clayey limestones argillites of Kyzyldzharska and Zubakynska sequences, as well as grey clay batch. Bakhchysarayskiy area is taken as the stratotypic for the south of CIS.

Paleocene (₽$_1$)

Danian and Montian stages
Bilokamyanskiy regio-stage

Bilokamyanska Suite (₽$_1$*bk*) is developed throughout and constitutes the cliffs of Fore-Mountain cuesta; it is also intersected by numerous drill-holes beneath younger sediments (DH Mykolaivska-1 [4], DH 42 [38] and others). The stratotype is located in the area of Bilokamyansk town where the Suite is divided in two sub-suites.

Lower sub-suite (₽$_1$*bk*$_1$) consists of light-grey aleuritic limestones which are gradually replaced by white, pearlwort, crinoidea-pearlwort, serpula limestones. At the footwall the basal horizon is composed of grey-green, glauconite-quartz, carbonate, medium-grained sandstones with phosphorite nodules. Thickness of the lower sub-suite is up to 50 m.

Upper sub-suite (₽$_1$*bk*$_2$) consists of light-grey, oncolitic, detritus-organogenic, foraminifera limestones, often re-crystallized and cavernous, up to 25 m thick. Total thickness of Bilokamyanska Suite is up to 75 m.

Main lithologic-petrographic rock types include limestones and sandstones. The Suite is characterized by abundant and variable complex of organic remnants – brachyopoda, cephalopoda, bivalvia, pearlworts, echinodermata. The lower sub-suite contains *Crania tuberculata* Nilss., C. *austriaca* Traub., *C. almensis* Zelinsk., *Nautilus danicus* Schl., *Gruphaea similis* Pusch., *Pycnodonte simile* (Risch.), *Ostrea* *praemontensis* Gorb., *Natica corneti* (C o s s m .), *Hercoglossa danica* (S c h l o t h.), *Tylocidaris rosenkrantzi* B r o t z . , *Echinocorys obliquus* R a o n . , *E. sulcatus* G o l d f., *Globigerina pseudobulloides* P l u m m., *Reussella minuta* (M a r s s .), indicating its Danian age. The upper sub-suite contains *Ostrea montensis* C o s s m . , *Fimbria montensis* (C o s s m), *Turritella montensis* B r z e t C o r n . , *Corbis montensis* C o s s m . , *Area montensis* C o s s m . , *Cuculaea crassatina Lam, Epistomaria bundensis* (B e l l .), *E. taurica* (S c h u t z.) [4], suggesting for its Early Paleocene age.

The Suite mainly unconformably lies over Staroselska Suite (Upper Cretaceous) and is unconformably overlain by Upper Paleocene Kachynska Suite.

Gromivska Suite comprises facial analogue of Bilokamyanska Suite in Tarkhankutska LTZ, and Bogachivska Suite – in Syvaska LTZ.

Gromivska Suite (₽$_1$*grm*) is developed in Tarkhankutska LTZ. The stratotype is defined outside the studied area by DH Zakhidnooktyabrska-30 (depth 577-237 m) [4] where it is divided in two sub-suites and is composed of grey dense marls and limestones up to 440 m thick.

Lower sub-suite (₽$_1$*grm*$_1$) is composed of grey and greenish-grey, dense marls with limestone interbeds, up to 200 m thick. Danian age is supported by *Stensioina caucasica* (S u b b .), *Anomalinoides danicus* (B r o t z .), *Globigerina taurica* M o r . , *G. varianta* S u b b . and other findings [4].

Upper sub-suite (₽$_1$*grm*$_2$) is composed of grey organogenic-detritus and foraminifera limestones with dense marl interbeds, up to 240 m thick. Montian age is supported by *Heterostomella gigantica* S u b b., *Anomalinoides danicus* (B r o t z .), *Globorotalia angulata* W h i t e . , *Reussella paleocenica* B r o t z . and other findings [4].

Gromivska Suite conformably lies over Dzhankoyska Suite (Upper Cretaceous) and is also conformably overlain by Upper Paleocene Lazurnenska Suite.

In Syvaska LTZ the Suite is facially replaced by Bogachivska Suite. Bilokamyanska Suite comprises facial analogue of the Suite in Pivdennozakhidna LTZ.

Bogachivska Suite (₽$_1$*bg*) is developed in Syvaska LTZ. The stratotype is defined outside the studied area by DH 6 (depth 1700-1597 m) [4] in Balashivska field of Prysyvashshya. The Suite is composed of grey organogenic-detritus limestones, somewhere sandy, re-crystallized, flinted, in places with clay interbeds, up to 120 m thick. Danian-Montian age is supported by foraminifera complex *Arenobulimina dubia* W o l o s c h., *Elphidiella prima* D a m., *Anomalinoides danicus* (B r o t z.), *Karreria fallax* R z e h a k. and others [4].

The Suite unconformably lies over Dzhankoyska Suite (Upper Cretaceous) and with interruption is overlain by Upper Paleocene sequence of marls and limestones.

In Tarkhankutska LTZ the Suite is facially replaced by Gromivska Suite, and Bilokamyanska Suite comprises its facial analogue in Pivdennozakhidna LTZ.

Thanetian stage
Kachynskiy regio-stage

Kachynska Suite (P$_1$*kč*) is developed in Pivdennozakhidna LTZ and constitutes lower sites in between Danian and Simferopilska cuestas. The stratotype is located in the left bank of Belbek River nearby Tankove village. The Suite is composed of alternating aleuritic and clayey marls with sandstone horizon at the bottom. Thickness of the Suite is irregular and attains 40 m.

Main lithologic-petrographic rock types include marls and sandstones.

Marls are grey, greenish-grey, aleuritic, dense, layered, being composed of coarse-crystalline clayey-carbonate material with glauconite and organic remnant fragments admixture.

Sandstones are greenish-grey, glauconite, fine-grained, carbonate and clayey, layered.

The Suite is characterized by abundant and variable complex of organic remnants – bivalvia, cephalopoda, sponge, foraminifera, including *Niltha volginica* N e t h s c h . , *Tellina briarti* C o s s m . , *Cucullaea volgensis* B a r b . d e M a r n . , *Chlamys prestwichi* (M o r r .), *Turritella Kamyschinensis* N e t h s c h . , *Ostrea reussi* N e t h s c h . , *Globigerina pseudobulloides* P l u m m., *Globorotalia crassata* C u s c h m . , *Acarinina tadjikistanensis djanensis* S c h u t z., *A. acarinata* S u b b . , *A. subsphaerica* S u b b . [4], indicating its Late Paleocene (Thanetian) age.

The Suite unconformably lies over Lower Paleocene Bilokamyanska Suite and is unconformably overlain by Eocene Bakhchysarayska Suite.

Lazurnenska Suite comprises facial analogue of Kachynska Suite in Tarkhankutska LTZ, and sequence of marls and limestones – in Syvaska LTZ.

Lazurnenska Suite (₽$_1$*lz*) is developed in Tarkhankutska LTZ. The stratotype is defined outside the map sheet area by DH Zakhidnooktyabrska-30 (depth 237-112 m) [4]. In the studied area the typical Suite column is intersected by DH Krylovska-1 (depth 170-110 m) [4]. The Suite is composed of greenish-grey marls with clayey limestone and clay interbeds, up to 260 m thick. It contains rich foraminifera complex *Heterostomella gigantica* Subb., *Anomalinoides fera* (Schutz.), *Acarinina acarinata* Subb. and others [4] suggesting for its Late Paleocene (Thanetian) age.

The Suite sediments conformably lie over Gromivska Suite (Paleocene) and are also conformably overlain by Lower Eocene Okunivska Suite.

In Syvaska LTZ the Suite is facially replaced by the sequence of marls and limestones, and Kachynska Suite comprises its facial analogue in Pivdennozakhidna LTZ.

Sequence of marls and limestones (₽$_1$*mv*) is developed in Syvaska LTZ. Most complete columns are intersected by DH 28, DH 31 [38] in the north-east of the area; in places the Seqeunce is completely eroded. It is composed of grey and dark-grey marls and light-grey and grey clayey limestones, up to 100 m thick. Numerous foraminifera *Stensioina caucasica* (Subb.), *Globigerina nana* Chal., *Reussella paleocenica* (Brotz.) and others are indentified in the Sequence [4] suggesting for its Late Paleocene (Thanetian) age.

The Sequence with erosion contact lies over Lower Paleocene Bogachivska Suite, and is unconformably overlain by the sequence of clays (Upper Paleocene).

In Tarkhankutska LTZ it is facially replaced by Lazurnenska Suite, and Kachynska Suite comprises its facial analogue in Pivdennozakhidna LTZ.

Eocene (₽$_2$)

Lower Eocene
Ypresian stage
Bakhchysarayskiy regio-stage

Okunivska Suite (₽$_2$*ok*) is developed in Tarkhankutska LTZ. The stratotype is defined outside the map sheet area by DH Zakhidnooktyabrska-30 (depth 113-43 m) [4]. The Suite is composed of light- and dark-grey carbonate clays, in places greenish-grey clayey marls, up to 100 m thick. Early Eocene (Ypresian) Suite age is supported by the complex of ostracoda, radiolaria, sea urchins and foraminifera: *Marginulina eofragaria* Balakhm., *Globorotalia subbotinae* Mor., *G. marginodentata* Subb., *G. aequa* Cushm., *Pseudoparrella culler* (Park. et Jon.) and others [4].

It conformably lies over Upper Paleocene Lazurnenska Suite and is also conformably overlain by Middle Eocene Rodnikovska sequence.

Sequence of clays (₽$_2$*g*) is developed in Syvaska LTZ. The typical column is defined outside the studied area by DH Krasnoperekopska-4 (depth 1760-1710 m) [4]. In the map sheet area it is intersected by drill-holes No. 28, 31 [38] in the northern part only.

The Sequence is composed of grey carbonate and aleuritic clays with thin marl interbeds, up to 50 m thick. The rocks are characterized by *Acarinina camerata* Chal., *A. subbotinae* Mor. [4], as well as fine nummulites suggesting for its Early-Middle Eocene age.

The Sequence unconformably lies over Upper Paleocene sequence of marls and limestones and is conformably overlain by Middle Eocene Rodnikovska sequence.

In Tarkhankutska LTZ the Sequence is facially replaced by Okunivska Suite and lower parts of Rodnikovska sequence, and Bakhchysarayska and Simferopilska suites comprise its facial analogues in Pivdennozakhidna LTZ.

In Syvaska LTZ Okunivska Suite is facially replaced by the sequence of clays, and Bakhchysarayska Suite comprises its facial analogue in Pivdennozakhidna LTZ.

Lower and Middle Eocene

Ypresian and Lutetian stages
Bakhchysarayskiy and Simferopilskiy regio-stages

Bakhchysarayska and Simferopilska suites combined (₽$_2$*bh+sm*) are developed in Pivdennozakhidna LTZ and constitute the steep foothill and cliffs of Simferopilska cuesta, and are also intersected by numerous drill-holes beneath younger sediments (DH Mykolaivska-1 [18], DH 41 [38]). The suites' stratotypes are located in Bakhchysarayskiy stratotypical area.

Bakhchysarayska Suite (₽$_2$*bh*) consists of dark-grey with bluish shade clays, with pyrite and marcasite bunches, from 10 to 30% glauconite admixture, as well as light-grey sandy marls, up to 65 m thick.

Main lithologic-petrographic rock types include clays and marls.

Clays are greenish-grey, sandy, carbonate, glauconite, dense, in places contain up to 30% by rock volume of nummulite detritus and solid bivalvia mollusc shells.

Early Eocene Suite age is supported by numerous organic remnants: *Spondilus cf. demissus* Desh., *Exodyra oversa* (Mall.), *Chlamys orcina* Vass. In addition, foraminifera complex *Operculina semiinvoluta* Nemk., *O. pavva* Dohv., *Nummulites globulus* Leum. is identified at the Suite bottom, while in the middle part *Nummulites crimensis* Nem et Barkh., *Piscocyclina archiaci* (Schlumb.), *Assilina placentula* (Desh.), *Nummulites planulatus* (Lam.), *Operculinagigantea* (Majer.) predominate [4]. The Suite unconformably lies over Upper Paleocene Kachynska Suite and is conformably overlain by Simferopilska Suite.

Simferopilska Suite (Ꝑ$_2$*sm*) consists of nummulitic limestones with marl, sandstone and somewhere clay interbeds.

In the surface relief the Suite is expressed in the cliffs of “Numulitova” cuesta, and in places it constitutes distinct-shaped weathering remnants and comprises reliable marker horizon. Thickness of the Suite is up to 80 m. Thickness of combined Bakhchysarayska and Simferopilska suites attains 250 m.

Nummulitic limestones comprise main lithologic-petrographic rock types. They are almost by 100% composed of nummulite remnants cemented by cryptic-crystalline calcite. Somewhere the rock contains up to 5% of quartz and glauconite grains. The Suite contains rich but uniform complex of organic remnants, mainly foraminifera: *Nummulites nemkovi* Schaub. are mainly developed at the Suite bottom, *Nummulites distans* Desh. are characteristic for the middle column parts, and *Nummulites polygyratus* Desh. are developed at the top. The Suite is also characterized by the complex of minor foraminifera including *Acarinina pentacamerata* Subb., *A. bullbrooki* (Bolli), *Brotzenella acuta acuta* (Plumm.), *Rotalia armata* (Orb.) and others [4].

The Suite conformably lies over Bakhchysarayska Suite and is also conformably overlain by combined Upper Eocene sediments.

Okunivska Suite and lower part of Rodnikovska sequence comprise the facial analogues of the Suite in Tarkhankutska LTZ, and sequence of clays – in Syvaska LTZ.

Simferopilskiy and Novopavlivskiy regio-stages

Rodnikovska sequence (Ꝑ$_2$*rd*) is developed in Tarkhankutska LTZ. The typical column is defined outside the map sheet area by DH Rodnikovska-222 (depth 370-90 m) [38]. In the studied area, the Sequence is intersected by DH 20, 106 [38]. It is composed of light-grey and greenish-grey clayey marls with thin limestone and carbonate clay interbeds, up to 300 m thick. Middle Eocene Sequence age is supported by rich foraminifera complex: *Globigerapsis subconglabatus* Chal., *Acarinina bullbrooki* (Bolli.), *Valvulineria intenta* N. Byk., *Anomalina affinis* Hantk. and others [4]. Often radiolaria and ostracoda are observed.

The Sequence conformably lies over Okunivska Suite and is also conformably overlain by the sequence of marls and aleurolites.

Simferopilska and Novopavlivska suites comprise the Sequence facial analogues in Pivdennozakhidna LTZ, and upper parts of the sequence of clays – in Syvaska LTZ.

Middle Eocene

Kumskiy regio-stage

Sequence of marls and aleurolites (Ꝑ$_2$*ma*) is developed in the south of Tarkhankutska LTZ. The typical column is defined outside the studied area by DH Golitsynska-1 (depth 1939.0-1676.0 m) [4]. In the map sheet area it is intersected by drill-holes in Krylovska and Tarasivska fields (see Fig. 2.1). The Sequence is composed of greenish-grey marls with brownish aleurolites and grey clay interbeds; the batch of grayish-brown marls is observed at the bottom; thickness is up to 260 m. The Sequence sediments are poor in foraminifera *Globigerina subtriloculinoides* Chal., *G. inflata* Orb., *Brizalina binaensis* Chal., *Globigerina turkmenica* Chal. [4] suggesting for Middle Eocene age.

The layers with *Globigerina turkmenica* comprise the facial analogue of the Sequence in Pivdennozakhidna LTZ.

Middle and Upper Eocene

Bartonian and Priabonian stage
Novopavlivskiy, Kumskiy and Alminskiy regio-stages

Novopavlivska Suite, layers with Globigerina turkmenica, layers with fine Bolivina and Globigerina, and Alminska Suite combined (Ꝑ$_2$*np+al*) are developed in Pivdennozakhidna LTZ where they constitute the northern slopes of “Numulitova” cuesta and the foothill of the external, third ridge of Crimean Mountains. The stratitypes of these suites are located in Bakhchysarayskiy stratotypical area. Over there, *Novopavlivska Suite* (Ꝑ$_2$*np*) is divided into Kuberlynski and Kerestynski layers composed of chalk-like marls and limestones, in places clayey, up to 75 m thick. The total thickness of Novopavlivska Suite attains 120 m. Novopavlivska Suite contains rich and variable complex of organic remnants – bivalvia, ostracoda, pearlworts, echinodermata, crabs, foraminifera, including *Acarinina rotundimarginata* Subb., *Globigerapsis subconglobatus micva* (Shutz.), *Hantkenina alabanensis* Cushm., *Lirolepis caucasica* Rom., *Operculina alpina* H. Douv., *Nummulites atacicus* Leum. [4] suggesting for the middle part of Middle Eocene.

The Suite conformably lies over Simferopilska Suite and is also conformably overlain by the layers with *Globigerina turkmenica*. In the Kumskiy horizon stratotype the sequence of marls and clays is exposed where upward the layers with *Globigerina turkmenica* are distinguished, up to 135 m thick, composed of brownish-grey, sheeted marls, which besides the index-type, also contain *Globigerina azerbaydjanica* Chal., *Acarinina rugosoaculeata* Subb. [4], and also layers with fine *Bolivina* and *Globigerina*, up to 30 m thick. The latter are composed of grey marls with dark-grey clay interbeds. Mentioned layers contain poor foraminifera complex: *Bolivina budensis* (Hantk.), *B. pseudointermedia* Chal., *Globigerina bulloides bulloides* (Orb.) [4], and numerous fish remnants, characteristic for Late Eocene. In the studied area the total thickness of the layers with *Globigerina turkmenica*, and layers with fine *Bolivina* and *Globigerina*, does not exceed 150 m.

The rocks of mentioned layers conformably lie over Novopavlivska Suite and are overlain by Alminska Suite with evidences for intra-formation erosion.

Alminska Suite (Ꝑ$_2$*al*) consists of light-grey, greenish-grey marls and carbonate clays, up to 150 m thick. The typical column is intersected by DH Kochergino-2 (depth 340-194.3 m) [4]. The Suite contains rich complex of bivalvia, foraminifera and nano-plankton, including *Variamussium fallax* Korob., *Ostrea prona* Wood., *Globigerapsis tropica lis* (Blow et Banner.), *G. index* Finl., *Bolivina antegressa* Subb. [4], which indicate Late Eocene age.

The Suite conformably lies over the layers with *Globigerina turkmenica*, and layers with fine *Bolivina* and *Globigerina*, and is unconformably overlain by Oligocene Planorbellova Suite or Neogene sediments.

The upper parts of Rodnikovska sequence and sequence of marls and aleurolites comprise the facial analogues of this combined complex in Tarkhankutska LTZ.

Oligocene (Ꝑ$_3$)

Oligocene sediments are throughout developed and include *Maykopska Series* (Ꝑ$_3$*mk*) (Fig. 2.5). In comparison to other areas of Maykopskiy trough of the Eastern Para-Tethys, in the map sheet area Maykopska Series columns are reduced (incomplete), mainly at the expenses of its upper (Miocene) horizons. Over here, Maykopska Series includes Planorbelloviy, Molochanskiy and Sirogozkiy horizons. In Syvaska and Pivdennozakhidna LTZs, Planorbellova and Molochanska suites as well as sequence of clays are distinguished. In Bakhchysarayska LTZ, in addition, Kyzyldzharska and Zubakynska sequences are distinguished.

Planorbelloviy regio-stage

Planorbellova Suite (Ꝑ$_3$*pl*) is developed almost everywhere except Bakhchysarayska LTZ. The stratotype is defined outside the studied area, in Eastern Prychornomorya (Kerchenskiy peninsula), where it is divided in two sub-suites.

Lower sub-suite (Ꝑ$_3$*pl*$_1$) is composed of grey, dark-grey, aleuritic, often carbonate clays, up to 80 m thick. In these sediments foraminifera *Haplophragmoides fidelis* Ter-Grig., *H. deformabilis* Subb., *Ammomarginulina foliaceus* (Brady), *Gaudryina gracilis* Cushm., *Lenticulina herrmanni* (Andr.), *Heterolepa oligocenica* (Saml.) are identified [4].

Upper sub-suite (Ꝑ$_3$*pl*$_2$) is composed of grey aleuritic and brownish-grey carbonate clays, up to 200 m thick. These rocks contain foraminifera *Textularia carinata oligocenica* (J. Nik), *Cyclammina constrictimargo* Stew. et Stew., *Neogyroidina memoranda* Subb., *Uvigerinella majcopica* Krajeva [4]. The given foraminifera complex indicates Early-Middle Oligocene Suite age and its affinity to the same-named Lower Oligocene horizon.

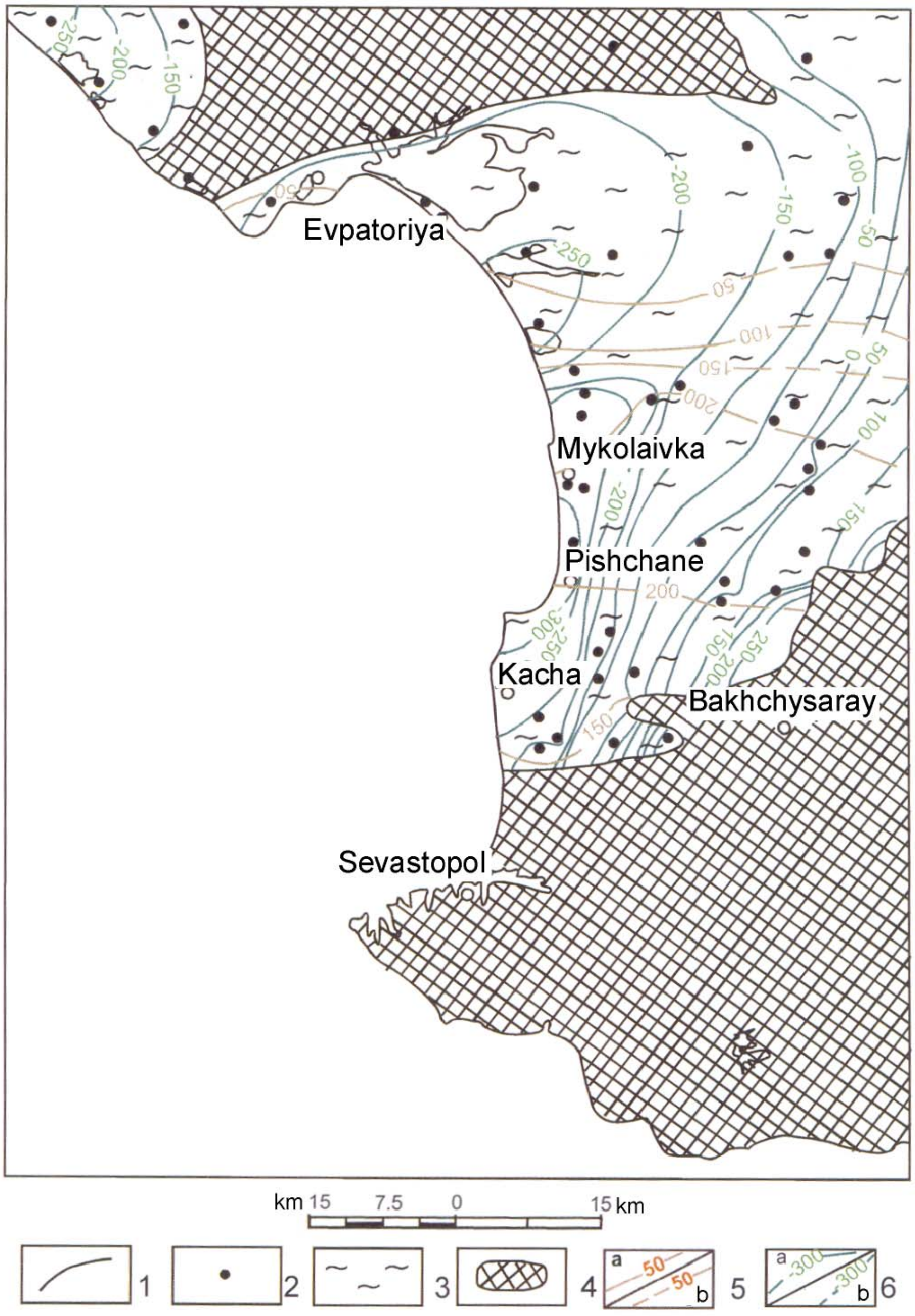

Fig. 2.5. Lithological sketch of Maykopska Series.
1 – lithological boundaries; 2 – drill-holes; 3 – clays; 4 – areas of complete erosion of Maykopski sediments; 5 – isopachs: a – proven, b – probable; 6 – depth contour lines of Maykopski sediments footwall: a – proven, b – probable.

Planorbellova Suite unconformably lies over Alminska Suite in the combined complex of Upper Eocene sediments, and is conformably overlain by Molochanska Suite. In Bakhchysarayska LTZ, Kyzyldzharska sequence comprises the lower sub-suite, and Zubakynska sequence – the upper sub-suite facial analogues.

Kyzyldzharska sequence (₽$_3$*kd*) is locally developed in Bakhchysarayska LTZ. The typical column is defined on Kyzyl-Dzhar Mountain in Bakhchysarayskiy area. Most complete columns are exposed in the Alma and Bulganak river valleys.

The Sequence consists of two batches. The lower one, up to 7 m thick, includes greenish-grey aleurites with numerous ball-shaped radiolaria and sponge spicules. The upper batch, up to 13 m thick, is composed of alternating greenish-grey carbonate clays and aleurites. The brownish-red clay interbeds and gypsum lenses are often observed in greenish-grey clays. The total thickness of the Sequence is 20 m. Clays and aleurites contain bivalvia molluscs and foraminifera, specifically, *Nucula comta* G o l d f., *Cardita kickxi* N y s t., *Heterolepa almaensis,* (S a m l) *Lenticulina herrmanni* (A n d r .) [4] indicating Early-Middle Oligocene age.

The Sequence conformably lies over Alminska Suite and is also conformably overlain by Zubakynska sequence.

Outside Bakhchysarayska LTZ this Sequence is facially replaced by the lower sub-suite of Planorbellova Suite.

Zubakynska sequence (₽$_3$*zb*) is locally developed in Bakhchysarayska LTZ. The typical column is defined nearby Kochergine village of Bakhchysarayskiy area by DH 2 (depth 59.2-160.5 m) [4].

The Sequence is exposed in the Alma and Belbek river valleys. It is composed of light-grey, greenish-grey aleuritic clays up to 100 m thick.

The Sequence conformably lies over Oligocene Kyzyldzharska sequence, and is conformably overlain by Molochanska Suite or unconformably – by Brykivski layers (Miocene). The Early-Middle Oligocene age is supported by *Corbula conglobata* K o e n., *Textularia (Spiroplectammina) carinata oligocaenica* (I. N i k.), *Lucina batalpaschinica* K o r o b determined over there [4].

Outside Bakhchysarayska LTZ these sediments are facially replaced by the upper sub-suite of Planorbellova Suite.

Rupelian stage
Molochanskiy regio-stage

Molochanska Suite (₽$_3$*ml*) is developed in Syvaska and Pivdennozakhidna LTZs. The stratotype is located outside the studied area, in the Eastern Prychornomorya. The Suite is composed of light-grey carbonate clays and aleurolites, up to 560 m thick. Findings of *Lentidium (Janschivlella) vinogrodskii* M e r k l., *L. garetzkii* M e r k l., *Cardium serogosicum cimlanicum* Z h i z h., ostracoda *Cytherella beyrichi* (R e u s s .), *Candona candidula* L n k l., *Disopontocypris oligocaenica* (Z a l.), and coccolitophorides *Sphenolitus predistentus* (B r a m l. e t W i l c o x) and *Sph. distentus* (M a r t i n i) suggest for Middle Oligocene age and Suite affinity to the same-named Molochanskiy horizon of the Lower Oligocene upper part.

The Suite conformably lies over Planorbellova Suite and is also conformably overlain by the clay batch of Sirogozkiy horizon.

Chattian stage
Sirogozkiy regio-stage

Batch of grey clays (₽$_3$*g*) is developed in Syvaska and Pivdennozakhidna LTZs, in Alminska depression. The typical column is intersected by DH 4 (depth 133-120 m) [4].

The batch is composed of grey, carbonate and yellowish-brown, argillite-like, slightly sandy, carbonate clays with aleurolites interbeds, up to 40 m thick. Organic remnants are not identified. The batch conformably lies over Molochanska Suite and is unconformably overlain by Neogene sediments.

By position in the stratigraphic column, that is, above Molochanska Suite, the batch of grey clays is ascribed to Late Oligocene Sirogozkiy regio-stage.

Neogene System

Neogene sediments in the studied area are distributed widely enough. The rocks are distinguished in three LTZs: Tsentralna, Alminska and Pivdennozakhidna. The boundary between Tsentralna and Alminska LTZs is set in the latitudinal direction from Sasyk Lake in the west to Nyzynne village and further to the east up to Salgyr River. The boundary between Alminska and Pivdennozakhidna LTZs follows the southern slope of Alma River (see "Scheme of litho-tectonic zonation").

Neogene sediments include Miocene and Pliocene rocks.

Miocene (N_1)

Miocene sediments are exposed at the surface and pre-Quaternary surface over most part of the map sheet territory, and in the south they constitute the ledge and the surface of the external ridge of Crimean Mountains. They include Lower, Middle and Upper Miocene rocks.

Lower Miocene
Tarkhanskiy regio-stage

In the area it only includes middle and upper sub-regio-stages. These sediments fill up negative paleo-relief forms (depressions) over eroded surface of Maykopska Series.

Mayachkynska Suite and Yurakivski layers combined (N_1*mč+jr*) are developed in Tsentralna LTZ and in the north of Alminska LTZ. The stratotypes are located outside the studied area. In the map sheet territory these sediments, intersected by single drill-holes and composed of marls and clays of irregular thickness, do have similar composition of organic remnants and irregular thickness.

Mayachkynska Suite (N_1*mč*) is intersected by DH 153 (depth 186.4-172.0 m) [38] where it consists of greenish-grey, sandy, iron-enriched clays, up to 14 m thick, containing foraminifera complex *Elphidium macellum* (F. e t M.), *Nonion cf. granosus parous* B o g d., *Eponides cf. vialovi* V e n g e., *Globigerina cf Pseudoedita* S u b b. [4, 38] suggesting for Early Miocene (Middle Tarkhanskiy) age. The highest thickness of the layers is confined to the axial part of Alminska depression where it attains 28 m.

The Suite unconformably lies over Maykopska Series and is also unconformably overlain by limestones of Middle Miocene Karaganskiy regio-stage.

Yurakivski layers (N_1*jr*) are most completely characterized by DH Mykolaivska-1 (depth 295-283 m) [38], where the following rocks are observed from bottom to top:

1. Green, aleuritic, iron-enriched clay, up to 2 m thick.
2. Greenish-grey marl, up to 10 m thick.

The intersected thickness of Yurakivski layers attains 12 m. The rich foraminifera complex is determined in clays: *Globigerina tarchanensis* S u b b. e t C h u t z., *G. aff. bulloides* O r b ., *Globigerinoides sp., Textularia tarchanensis* B o g d ., *Virgulina tarchanensis* B o g d ., *Nonion parvus* B o g d ., and foraminifera and ostracoda *Florilus bouenus* (O r b .), *F. communis* O r b ., *Discorbis tschokrakensis* B o g d ., *Bytocythere cristata* S c h n ., *Eucythere aff. tamanica* S c h n ., *Pontocypris vitrea* S u z i n., *P. suzini* S c h n . [4, 38] are found in marls, suggesting for Early Miocene (Late Tarkhanskiy) age.

Yurakivski layers unconformably lie over Maykopska Series or conformably – over Mayachkynska Suite, and are also unconformably overlain by Brykivski layers.

The total thickness of the Tarkhanskiy complex of sediments attains 40 m.

Middle Miocene
Karaganskiy regio-stage

It includes sandstone sequence and Spaniodontelovi layers. The rocks fill up most subsided part of Alminska depression where their surface is at the depth with altitude -222 m. From the central part of depression towards its limbs the hanging-wall altitude of Karaganskiy horizon ascends to +85 m.

Sandstone sequence (N_1*ps*) is developed in Tsentralna LTZ and in the northern part of Alminska LTZ and is irregular in term of lithology.

In Tsentralna LTZ the Sequence is composed of sands with limestone and clay interbeds, up to 33 m thick (DH 160, 172 and others [38]). The typical column is intersected by DH 161 where the following rocks are observed from bottom to top:

1. depth 165.6-164.8 m – grey, organogenic-detritus limestone;
2. depth 164.8-152.5 m – grey, greenish-grey, fine-grained sand;
3. depth 152.5-151.0 m – clay with limestone fragments.

Sands are fine-grained, mainly quartz, in places carbonate-quartz. Clays are hydromica-montmorillonite. Chemical and granulometric composition of terrigenous rocks in sandstone sequence are set forth in tables 2.1 and 2.2. From sands, V.G.Kulichenko has determined molluscs *Spaniodontella opistodon* A n d r u s., *Mohrensternia sp.*, and L.A.Digas has studied foraminifera *Ammonia cf beccarii* (L), *Nonion cf. punctatus* (O r b.), *Elphidium cf listen* (O r b.), *Quinquelloculina sp.* [4, 38] indicating Middle Miocene age.

Sandstone sequence unconformably lies over Brykivski layers or older sediments and is also unconformably overlain by Sartaganski layers.

In Alminska LTZ sandstone sequence is facially replaced by Spaniodontelovi layers.

Chokrakskiy, Karaganskiy and Konkskiy regio-stages

Brykivski, Spaniodentellovi, Sartaganski and Veselyanski layers combined (N_1*br+vs*) are developed in Tsentralna LTZ where their thickness attains 47 m (DH 187) [38], and in Alminska LTZ where their thickness increases up to 57 m (DH 154) [38].

Brykivski layers (N_1*br*) are developed in Tsentralna and Alminska LTZs. The stratotype is located outside the map sheet area, in Kerchenskiy peninsula. Lithological composition is not persistent. In the western part of Tsentralna LTZ the clays, while in the eastern part the sands predominate. In Alminska LTZ Brykivski layers are composed of alternating sandstones, clays and limestones. Hanging-wall altitudes of the Layers vary from 74 m in the east to 195 m in the north. In the central part of Alminska depression the hanging-wall altitude of the Layers is -195 m. Thickness of the Layers attains 26 m.

Main lithological-petrographic rock types include clays, limestones and sands. Clays are mainly hydromica-montmorillonite with glauconite grain inclusions. Limestones are organogenic-detritus, re-crystallized. Sands are fine-grained, quartz-carbonate.

From clays of Tsentralna LTZ, in DH 173 (depth 179.0-174.0 m) [38] L.A.Digas has determined foraminifera *Elphidium rugosum* (O r b.), *Nonion cf. granosus* (O r b.), *Porosononion cf. martcobi* (B o g d.) and others. From limestones and clays of Brykivski layers in Alminska LTZ, in DH 157 (depth 232.2-196.0 m) [38] and DH 154 (depth 262.8-255.0 m) [38] V.M.Semenenko has determined molluscs *Spaniodontella intermedia* A n d r u s., *Gibbula pictiformis* A n d r u s., *Sandbergeria ex gr. praeroxolanica* Z h i z h and others [4, 38]. Mentioned complex of organic remnants supports Middle Miocene (Late Chokrakskiy) age.

Brykivski layers unconformably lie over Yurakivski layers or older sediments, and are also unconformably overlain by Spaniodontelovi layers.

In Crimean Fore-Mountains (Pivdennozakhidna LTZ) they are facially replaced by the lower part of Mekenziivska sequence.

Spaniodontelovi layers (N_1*sp*) are developed in Alminska LTZ exclusively where they are exposed in the Fore-Mountain cuesta cliff and fill up the central part of Alminska depression. The Layers hanging-wall altitudes vary from +85 m to -222 m.

Spaniodontelovi layers are composed of clays, limestones, sandstones and sands up to 22 m thick.

Chemical composition of limestones and clays is given in Tables 2.1 and 2.3. Granulometric composition of clays from the Layers is set forth in Table 2.2. The rocks of Layers contain rich fauna complex: *Spaniodontella pulchella* B a i l u, *S. gentilis* (E i c h w.), *S. opistodon* A n d r u s . , *Mohrensternia grandis* A n d r u s . , *Sandbergeria cf. sokolovi* A n d r u s . and others [4, 38] indicating Middle Miocene (Karaganskiy) age.

Mentioned sediments unconformably lie over Brykivski layers and are also unconformably overlain by Sartaganski layers.

In the northern direction Spaniodontelovi layers are facially replaced by sandstone sequence, and Crimean Fore-Mountains (Pivdennozakhidna LTZ) – by the middle part of Mekenziivska sequence (Middle Miocene).

Sartaganski layers (N_1*sr*) are developed in Tsentralna and Alminska LTZs where they constitute lower part of Konkskiy regio-stage. They are composed of carbonate-terrigenous rocks up to 14 m thick. Hanging-wall altitudes vary from -200 m in the centre of Alminska depression up to +100 m in its limbs and in Tsentralna LTZ.

In Tsentralna LTZ the Layers are intersected by DH 173 (depth 154.2-150.1 m) [38], and in Alminska depression – by DH 150 (depth 107.0-95.1 m) [38], where they are composed of light-grey with greenish shade, medium-fine-grained, dense sandstones. From DH 150 (depth 107.0-95.1 m) [38] I.D.Konenkova has determined foraminifera complex: *Elphidium macellum* (F. et M.), *Guttulina commonusOrb., Polymorphina* *ovata* O r b., *Triloculina pyrula* (K a r r.), and from DH 151, 154, 155, 157, 159 [38] V.M.Semenenko has studied molluscs *Ervilia trigonula* S o k., *Mactra konkensis* S o k., *Spaniodontelb ex gr. sokolovi* S i n z. [4, 38] and others.

Mentioned complex of organic remnants in Sartaganski layers suggests for Middle Miocene (Early Konkskiy) age. Chemical composition of Middle and Upper Miocene limestones is given in the Table 2.3.

Table 2.1. Chemical composition of Miocene terrigenous rocks
(Alminska and Tsentralna LTZs)

Sample location and rock name	Contents, %													
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3	H_2O	Σ
Burulchynska sequence (N_1*bl*)														
Alminska LTZ; DH 152; depth 69.2-76.8 m; clay	61.9	12.12	4.34	0.38	0.48	0.073	6.69	1.17	0.02	1.92	0.32	0.05	2.92	99.9
Bagerovska Suite (N_1*bg*)														
Alminska LTZ; DH 152; depth 80.0-84.4 m; clay	59.49	11.03	3.20	0.66	0.49	0.026	9.32	1.26	0.02	1.81	0.21	0.02	3.29	99.98
Khersonska Suite (N_1*hr*)														
Alminska LTZ; DH 153; depth 84.9-85.4 m; clay	22.25	0.60	0.69	-	0.01	0.071	41.88	0.33	-	0.29	0.08	-	0.28	99.99
Besarabska Suite (N_1*bs*)														
Alminska LTZ; DH 151; depth 141.3-144.3 m; clay	41.85	11.97	3.98	-	0.56	-	19.81	2.49	-	2.41	1.28	0.19	-	100.6
Krasnoperekopska Suite (N_1*kr*)														
Alminska LTZ; DH 152; depth 115.6-121.5 m; clay	38.02	7.66	1.23	0.94	0.34	0.02	23.63	2.63	0.02	1.30	0.52	0.41	2.03	101.8
Spaniodontelovi layers (N_1*sp*)														
Tsentralna LTZ; DH 161; depth 151.0-152.5 m; clay	33.40	6.25	3.81	3.62	0.27	0.005	27.47	2.11	-	0.82	0.24	0.09	1.75	99.7

Table 2.1. Continued.

Sample location and rock name	Contents, %													
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3	H_2O	Σ
Sandstone sequence (N_1*ps*)														
Tsentralna LTZ; DH 160; depth 169.0-184.0 m; clay	80.16	5.48	2.18	0.86	0.58	0.021	4.36	0.75	-	1.39	0.60	0.05	0.70	101.3
Mayachkynska Suite (N_1*mč*)														
Alminska LTZ; DH 152; depth 223.0-224.0 m; clay	61.06	9.71	4.31	0.84	0.47	0.029	7.90	1.97	0.02	2.25	0.73	0.03	2.29	99.9
Tsentralna LTZ; DH 174; depth 208.7-213.0 m; clay	58.43	14.12	3.98	0.80	0.81	-	7.16	0.39	0.04	2.21	1.12	0.04	2.11	101.0

Sartaganski layers unconformably lie over Spaniodontelovi layers and sandstone sequence. In Crimean Fore-Mountains (Pivdennozakhidna LTZ) they are facially replaced by the middle part of Mekenziivska sequence and are conformably overlain by Veselyanski layers.

Veselyanski layers (N_1*vs*) are developed in Tsentralna and Alminska LTZs. The stratotype is located outside the map sheet area, in Kerchenskiy peninsula.

In Tsentralna LTZ, the most complete column is studied in DH 173 (depth 150.1-137.8 m) [38] where it looks as follows (upward):

1. depth 150.1-144.9 m – grey, shelly-detritus limestone;
2. depth 144.9-141.5 m – greenish-grey, argillite-like clay;
3. depth 141.5-137.8 m – grey. organogenic-detritus limestone.

From the depth 141.5-137.8 m V.M.Semenenko has determined *Ervilia trigonula* S o k., *Corbulagibba* (O l.), *Cerastoderma cf.andrussovi* Sok., *Donaxsp.*, and from the depth 150.1-144.9 m – *Paphia vitaliana* (O r b.) [4, 38].

In Alminska LTZ the Layers are intersected by DH 150 (depth 107.0-82.9 m) [38], where they are composed of grey, light-brown with greenish shade, dense, in places pelitomorphic and dolomitized limestones and green argillite-like clays.

Thickness of Veselyanski layers in the studied area attains 33 m.

Chemical composition of limestones from the Layers is given in Table 2.3.

Mentioned complex of organic remnants from the Layers suggests for their Middle Miocene (Late Konkskiy) age. These sediments conformably lie over Sartaganski layers and are also conformably overlain by Ervilievi layers in the north, and by Krasnoperekopska Suite in the east.

In Pivdennozakhidna LTZ of Crimean Fore-Mountains the Layers are facially replaced by the upper part of Mekenziivska sequence (Middle Miocene).

Table 2.2. Granulometric composition of Miocene terrigenous rocks
(Alminska and Tsentralna LTZs)

Sample location and rock name	Fraction size/content (%)				
	>0.6	0.6-0.01	0.01-0.005	0.005-0.001	<0.001
Burulchynska sequence (N_1*bl*)					
Alminska LTZ; DH 152; depth 69.2-76.8 m; sandy clay	24.36	18.09	3.0	14.35	40.20
Kazankivska sequence (N_1*kz*)					
Alminska LTZ; DH 151; depth 50-51 m; aleuritic clay	4.17	17.14	11.21	19.21	48.27
Alminska LTZ; DH 159; depth 70 m; fine-grained sandstone	7.12	11.83	18.12	25.13	37.80
Bagerovska Suite (N_1*bg*)					
Alminska LTZ; DH 153; depth 75.0-78.3 m; clay	3.94	10.11	8.05	16.50	61.40
Besarabska Suite (N_1*bs*)					
Tsentralna LTZ; DH 172; depth 46-52 m; clay	19.99	14.51	3.10	14.45	48.95
Krasnoperekopska Suite (N_1*kr*)					
Tsentralna LTZ; DH 160; depth 143-145 m; clay	5.59	16.12	9.48	20.17	48.64
Alminska LTZ; DH 152; depth 115.6-121.5 m; clay	4.34	16.66	11.02	24.56	43.42
Spaniodontelovi layers (N_1*sp*)					
Alminska LTZ; DH 152; depth 219-220 m; clay	4.19	19.94	22.11	17.19	39.57
Sandstone sequence (N_1*ps*)					
Alminska LTZ; DH 154; depth 240.0-243.7 m; clayey sand	0.7	90.3	3.3	5.6	0.1
Mayachkynska Suite (N_1*mč*)					
Tsentralna LTZ; DH 174; depth 208.7-213.0 m; sandy clay	20.84	13.36	6.45	11.50	41.85

Table 2.3. Chemical composition of Middle and Upper Miocene limestones
(Alminska and Tsentralna LTZs)

Limestone sample location	Contents, %													
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3	H_2O	Σ
Akmanayska Suite (N_1*ak*)														
Tsentralna LTZ; DH 174; depth 30.1-34.5 m	0.70	0.12	0.05	-	0.05	0.03	54.58	0.83	-	0.05	0.17	0.05	0.10	100.3
Bagerovska Suite (N_1*bg*)														
Tsentralna LTZ; DH 174; depth 34.7-37.8 m	1.85	0.34	0.20	-	0.05	0.01	52.40	1.24	-	1.07	0.20	0.05	0.10	100.4

Table 2.3. Continued.

Sample location and rock name	Contents, %													
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3	H_2O	Σ
Dozinievski layers (N_1*dz*)														
Alminska LTZ; DH 152; depth 84.4-86.0 m	26.64	3.31	1.15	-	0.16	0.03	36.89	0.62	-	0.54	0.12	-	0.28	100.2
Khersonska Suite (N_1*hr*)														
Tsentralna LTZ; DH 174; depth 38.4-48.0 m	1.26	0.20	0.16	-	0.05	0.02	49.12	3.78	-	0.07	0.38	0.05	0.12	99.7
Alminska LTZ; DH 152; depth 94.0-99.0 m	4.57	0.73	0.40	-	0.02	0.05	52.13	0.27	-	0.17	0.06	-	0.02	99.6
Besarabska Suite (N_1*bs*)														
Tsentralna LTZ; DH 174; depth 143.0-148.2 m	24.94	0.90	1.25	-	0.14	0.03	35.56	3.50	-	0.30	0.25	0.08	0.05	99.9
Alminska LTZ; DH 152; depth 105.5-111.0 m	5.43	1.19	0.81	-	0.01	0.04	46.02	4.40	-	0.32	0.09	-	0.10	99.8
Veselyanski layers (N_1*vs*)														
Tsentralna LTZ; DH 173; depth 146.0-150.0 m	0.94	0.27	0.61	-	0.02	0.14	35.15	16.50	-	0.03	0.03	0.18	0.04	99.4
Alminska LTZ; DH 152; depth 185.0-188.0 m	2.88	0.15	0.24	-	0.01	0.36	53.18	0.67	-	0.07	0.06	-	0.04	99.58
Spaniodontelovi layers (N_1*sp*)														
Alminska LTZ; DH 152; depth 192.0-193.8 m	6.83	0.22	0.30	-	0.01	0.09	51.07	0.64	-	0.12	0.06	-	0.06	99.8

Mekenziivska sequence (N_1*mkz*) is developed in Pivdennozakhidna LTZ where it constitutes the cliff of the Crimean Mountains External ridge. It is exposed in the coastal cliffs in Gerakleyskiy peninsula, and further its outcrops in continuous band are extended in the north-eastern direction through Sapun-Gora, Inkermanski heights and Mekenziivski mountains.

The Sequence is composed of terrigenous-carbonate sediments: carbonate sandstones, gravelites, clays and limestones, up to 58 m thick.

Most typical column of the Sequence southern distribution area is intersected by DH 11-B (depth 42.0-21.9 m) [31], where it includes light-grey, dense, "pudding" limestones, white, light-grey, quartz gravelites, and greenish-grey clays, 20.1 m thick.

In the north-eastern direction from DH 11-B [31] the Sequence contains more deep-water facies (DH 33, depth 69.1-0.3 m [40]) and is composed of greenish-grey carbonate clays with iron-enrichment spots, and grey clayey limestones with clay interbeds, 57.5 m thick.

In the north-eastern part of Gerakleyske plateau, in the left bank of Kamenolomniy gorge, the Sequence consists of conglomerates, light-grey quartz sandstones, and yellowish-white or light-grey limestones, 36.3 m thick.

The Sequence contains rich complex of organic remnants, including *Ervilia thgonula* S o k ., *Obsoletiforma impar* Z h i z h., *Spaniodontella intermedia* A n d r u s ., *Pholas sp., Leda fragilis* C h e m n., *Ostrea digitalina* D u b ., and others [4, 40], indicating Middle Miocene age.

Mekenziivska sequence unconformably lies over diverse rocks from Middle Jurassic to Paleogene and is conformably overlain by Volynska or Krasnoperekopska suites, and unconformably – by Besarabska Suite.

In Alminska LTZ it is facially replaced by Brykivski, Spaniodontelovi, Sartaganski and Veselyanski layers, and in Tsentralna LTZ – by sandstone sequence.

Upper Miocene
Sarmatian regio-stage

The regio-stage is developed over entire map sheet territory and includes Ervilievi layers, Volynska, Krasnoperekopska, Besarabska and Khersonska suites. The rocks are exposed at the pre-Quaternary surface in all LTZs, and constitute the upper part and surface of the Crimean Mountain External ridge.

Lower sub-regio-stage
Volynskiy horizon

Volynska Suite (N_1*vl*) is intersected by single drill-holes in Tsentralna and Alminska LTZs, and is studied in the cliff of the Crimean Mountain External ridge. It is mainly composed of light-grey limestones with grey clay interbeds, up to 10 m thick.

The Suite contains characteristic complex of Early Sarmatian molluscs: *Ervilia dissita* E i c h w ., *Cerastoderma praeplicatum* (H i l b), *Paphia vitaliana* O r b [4].

Volynska Suite unconformably lies over Middle Miocene sediments and is conformably overlain by clays and limestones of Besarabska Suite.

In the eastern and northern directions of Tsentralna LTZ the Suite is facially replaced by clays of the lower part of Krasnoperekopska Suite, and in the northern part of Alminska LTZ – by Lower Sarmatian Ervilievi layers.

Ervilievi layers (N_1*er*) are developed in the north-eastern part of Alminska LTZ and in Evpatoriyske plateau of Tsentralna LTZ.

These include organogenic limestones composed of *Ervilia dissita* E i c h w. [4], up to 8 m thick. The Layers constitute shallow-water banks of Early Sarmatian sea.

Ervilievi layers conformably lie over Veselyanski layers and are also conformably overlain by Besarabska Suite. The Layers are facially replaced by Volynska and Krasnoperekopska suites.

Krasnoperekopska Suite (N_1*kp*) is throughout developed in Plain Crimea where it comprises regional water-proof. The stratotype is located outside the map sheet area, in the north Crimean Peninsula. The Suite hanging-wall altitudes vary from +200 m in the south to -200 in the north. The typical column in the map sheet area is studied in DH 152 (depth 175.0-114.5 m) [38].

The Suite is composed of grey, dark-grey to black, layered, platy clays, with dust at the layering surfaces, and in the lower column part – of alternating clays and limestones. Thickness of the Suite sediments is up to 90 m.

In the southern slope of Alminska depression, in DH 150 (depth 82.9-63.4 m), light-grey and yellow, weakly-cemented sandstones appear in the column.

Rock chemical and granulometric composition is given in Tables 2.1 and 2.2.

From clays in DH 152 [4, 38] L.A.Digas has determined foraminifera and ostracoda *Elplidium crispum* (L), *E. macellum* (F. e t M.) *E.jukovi* S e r o v a., *Porosononion subgranosus umboelata* G e r k e ., *P. subgranosus hualinus* B o g d ., *Nonion punctatus* (O r b.), *N. granosus* (O r b.), *Articulina sp.* and others, and in DH 150 [38] I.D.Kononenkova has additionally determined *Elphidium echinum* S e r, *Nonion bogdanowiczi* V a l ., *Protelphidium subgranosus* (E g g.) and others. Besides that, V.G.Kulichenko has found broad variety complex of *Cerastoderma* mollusc family, as well as *Abra reflexa* (E i c h w.), *Ervilia dissita* (E i c h w.) [4] suggesting for Early-Middle Sarmatian age of the Suite.

In Tsentralna LTZ the Suite conformably, in places unconformably, lies over Veselyanski layers. In Alminska LTZ it unconformably lies over Veselyanski layers and conformably – over Volynska Suite, and in Pivdennozakhidna LTZ of Crimean Fore-Mountains it conformably lies over Volynska Suite, in places – unconformably over Mekenziivska sequence. The sediments are everywhere conformably overlain by the upper part of Besarabska Suite.

In Tsentralna LTZ Krasnoperekopska Suite is facially replaced by Volynska Suite and throughout – by the lower part of Besarabska Suite.

Middle sub-regio-stage
Besarabskiy horizon

Besarabska Suite (N_1*bs*) is developed in all LTZs where it is intersected by numerous drill-holes. At the surface the Suite is only exposed in the southern part of Alminska LTZ and in Pivdennozakhidna LTZ where it constitutes the Fore-Mountain cuesta cliff of Crimean Mountains External ridge.

At the surface the Suite rocks dip monoclinally (dipping azimuth 320-335^o, angle 4-8^o), in Alminska depression rock dipping changes to azimuth 250-280^o, angle 3-5^o. The hanging-wall altitudes vary from -80 m at Alminska depression axis to +100 m in its northern and +150 m – its eastern limbs.

The Suite lithology is variable. In Tsentralna LTZ it is studied in DH 174 (depth 148.2-57.2 m) [38] where cream-grey, grey, organogenic-detritus, in places clayey pelitomorphic and sandy limestones are intersected with grey detritus sand interbeds at the top, up to 90 m thick. Chemical composition of limestones is given in Table 2.3. From limestones V.G.Kulichenko has determined bivalvia molluscs *Gibbula picta* (E i c h w .), *Paphia vitaliana* (O r b .), *Cerastoderma fittoni* (O r b .), *C. ingratum* (K o l e s .), *Mactra vitaliana* (E i c h w .), *M. fabreana* (O r b .), *Modiolus sp.* and others [4]. L.A.Digas in DH 172 (depth 59.0-46.0 m) [38] has determined foraminifera *Elphidium cf. macellum* (F. e t M.), *E. aculeatum* (O r b.), *Ammonia cf. beccarii* (L i n n e .), *Nonion ex gr. tauricus* K r a s c h e n [4].

In Alminska LTZ the Suite lithology is a bit different: in general, amount of clayey rocks increases, and in the southern part, besides that, light-grey sandstones appear. Characteristic column is intersected by DH 151 (depth 148.5-95.0 m) [38] where it consists of more or less regular intercalation of grey and light-grey, clayey and pelitomorphic, in places organogenic-detritus limestones and dark-grey and grey-green clays. The latter are hydromica-montmorillonite in composition, and sandstones are mainly carbonate, in places quartz-carbonate. Thickness of the Suite in the given LTZ attains 60 m.

The chemical and granulometric composition of the Suite clays is given in Tables 2.1, 2.2 and 2.3.

From DH 151 [38] V.M.Semenenko has determined *Cerastoderma desperatum* (K o l e s .), *C. fittoni* O r b . , *C. ex gr. praeplicatum* H i l b., *C. ex gr. oblignobsoletum* K o l e s . , *Mactra fabreana* O r b . , *Buccinum duplicatum* S o v. [4, 38], supporting Middle Sarmatian (Besarabskiy) age.

The Suite conformably lies over Krasnoperekopska and Volynska suites and Ervilievi layers, and is also conformably overlain by Khersonska Suite.

In Alminska LTZ the Suite lower part is facially replaced by the upper part of Krasnoperekopska Suite.

Upper sub-regio-stage
Khersonskiy horizon

Khersonska Suite (N_1*hr*) is developed almost in all LTZs. Over most part of its distribution area the Suite lies below modern erosion basis, and only in the western part of Tsentralna LTZ as well as in the southern and eastern margins of Alminska LTZ and Pivdennozakhidna LTZ of Crimean Fore-Mountains the Suite rocks are exposed at the pre-Quaternary surface.

In the western part of Tsentralna LTZ the Suite constitutes most elevated portion of Evpatoriyske plateau where it lies almost horizontally. Over there, the hanging-wall altitudes vary from +40 m in the west to -10 m in the east. In the same direction, the Suite lithology changes from pure limestone to terrigenous-carbonate.

Most complete Suite column is intersected by DH 187 (depth 103.0-41.3 m) [38] where it includes detritus, shell limestones, in places with clay and sand interbeds. Thickness of the Suite in this LTZ attains 62 m.

Chemical composition of limestones is given in the Table 2.3.

From limestones V.M.Semenenko has determined *Mactra caspia* E i c h w., *M. bulgarica* T o u l a., and in clays L.A.Digas has noted *Ammonia cf. beccarii* (L i n n e), *Guigueloculina sp.* [4, 38].

In Alminska LTZ the Suite lithology is more variable. The hanging-wall altitudes increase in the southern and south-eastern directions from 0 m to +200 m. Most complete Suite column is studied in DH 152 (depth 95.0-78.5 m) [38] where yellow, fine-oolitic-detritus limestones are intersected, in places dolomitized, at the top – oolitic.

In the north-western direction, from DH 152 [38], the Suite is of sandy-clayey-carbonate (DH 158) [38], and in the south-eastern direction – of clayey-carbonate composition. Clays are mainly grey, grey-green, of montmorillonite composition, with kaolinite and hydromica admixture. Chemical composition of clays is given in the Table 2.1.

Aforementioned organic remnants support Late Sarmatian (Khersonskiy) Suite age.

The Suite conformably lies over Besarabska Suite and over most part of map sheet area it is conformably overlain by Bagerivska Suite or Dozinievi layers, and unconformably – by the younger rocks.

Meotychniy regio-stage

Meotic sediments are developed in Tsentralna LTZ where they are exposed at the pre-Quaternary surface surrounding Sarmatian rock outcrops in Evpatoriyske plateau, and are exposed in the narrow bands and "windows" in the gully thalwegs. In Alminska LTZ they are overlain by the younger sediments and are only exposed at the surface along Bulganak and Alma rivers and in Skvortsovska gully. Regio-stage includes lower sub-regio-stage, which corresponds to Bagerovskiy horizon, and upper strato-regio-stage, which corresponds to Akmanayskiy horizon.

Lower sub-regio-stage
Bagerovskiy horizon

In Tsentralna LTZ it is comprised of Bagerovska Suite, and in Alminska LTZ – of Dozinievi layers.

Bagerovska Suite (N_1bg) is developed in Tsentralna LTZ. The stratotype is defined outside the studied area, in Kerchenskiy peninsula.

The Suite is intersected by numerous drill-holes. At the pre-Quaternary surface it is encountered along the southern rim of Evpatoriyske plateau, where carbonate rocks predominate in the column while in the eastern direction carbonate facies are partly replaced by clayey ones. The hanging-wall altitudes plunge down from the center to the east from +30 m to 0 m.

Most typical column is studied in DH 172 (depth 15.5-8.4 m) [38], where yellowish-grey, light-grey, shell-detritus, marleous limestones are intersected with grey-green carbonate clay interbeds, up to 1.0 m thick. Thickness of the Suite in Tsentralna LTZ attains 40 m.

Clays are poly-mineralic in composition; clay fraction is composed of montmorillonite, hydromica and kaolinite with chlorite admixture. Coarse-grained fraction includes quartz grains (90%), iron hydroxide, calcite and chlorite aggregates, as well as opaque mineral grains.

Limestones are composed of fine-crystalline calcite (90%) with quartz (5-10%) and clayey mineral admixture.

The chemical and granulometric composition of the rocks is given in Tables 2.1, 2.2 and 2.3.

From the sediments V.G.Kulichenko has determined bivalvia molluscs *Pirenella disjuncta disjunctoides* (S i n z), *Cerastoderma arcella mithridatis* (A n d r u s .), *Loripes psendonivens* (A n d r u s .), *Valvata aff. piscinatis* (M i l l.); V.M.Semenenko has studied *Dosinia maeotica* (A n d r u s .), *Ervillia minuta* S i n z., and L.A.Digas from clays has determined foraminifera *Elplidium ex gr. angulatum* (E g g e r.), *Ammonia* beccarii (L i n n e) [4, 38]. The given complex of organic remnants supports Early Meothychniy (Bagerovskiy) Suite age.

The Suite conformably lies over Upper Sarmatian sediments and is also conformably overlain by Akmanayska Suite. In the east of LTZ the rocks are facially replaced by Dozinievi layers.

Dozinievi layers (N_1dz) are developed in Alminska LTZ. They are exposed by erosion in the banks of Bulganak and Alma rivers, and by denudation – at the Alma-Kacha river watershed where they dip under azimuth 330-335^o and angle 3-5^o. The most complete column is intersected by DH 18 (depth 84.0-43.5 m) [38] nearby Viline village.

The Layers are composed of greenish-grey clays, with iron-enrichment spots, and with light-grey, fine-grained limestones. Maximum thickness is up to 70 m (7-46 m in average).

In clays V.M.Semenenko has determined *Dosinia maeotica* A n d r u s . , in places cores of *Pirenella iisjuncta disjunctoides* S i n z. [4], indicating Early Meotychniy age of the Layers.

The Layers conformably lie over Upper Sarmatian rocks or with erosion over older Miocene rocks, and are conformably overlain by Akmanayska Suite. In the northern and central parts of this LTZ the rocks with erosion are overlain by Evpatoriyski layers, in the south – by Burulchynska sequence, Novorosiyskiy regio-stage of Pontychniy stage, and in the east – by Upper Miocene Kazankivska sequence.

In Tsentralna LTZ Dozinievi layers are facially replaced by Bagerovska Suite.

Akmanayska Suite (N_1*ak*) is developed in Tsentralna and Alminska LTZs. The stratotype is defined outside the map sheet area, in Kerchenskiy peninsula. In Tsentralna LTZ the Suite is exposed by denudation or is overlain by thin Upper Quaternary cover. In Alminska LTZ the rocks are exposed in the north only, and in the southern direction they are either removed by erosion or facially replaced by coarse-clastic rocks from the lower part of Kazankivska sequence.

The Suite is composed of limestones with clay, aleurolite, somewhere sandstone interbeds, up to 13 m thick. Chemical composition of limestones is given in the Table 2.3.

In Tsentralna LTZ the Suite is intersected over entire thickness by numerous drill-holes where it consists of grey-yellow, yellow, fine-oolitic and grained limestones. Cell weathering forms filled with red-brown clay are observed. From limestones V.M.Semenenko has determined *Congeria panticapaea* A n d r u s . , *Cerastoderma arcella mithiridatis* (A n d r u s .), *Mytilaster minor* (A n d r u s .), and others [4], indicating Late Meotychniy (Akmanayskiy) age.

The Suite conformably lies over Dozinievi layers and is unconformably overlain by Evpatoriyski layers in the northern and central parts of LTZ, by Burulchynska sequence – in the south, and by Kazankivska sequence – in the east.

In the southern part of Alminska LTZ Akmanayska Suite is facially replaced by the lower part of Kazankivska sequence.

Bagerovska and Akmanayska suites undivided (N_1*bg-ak*) are distinguished in Tsentralna LTZ.

Most complete columns are intersected in Evpatoriyske plateau by DH 172 [38]. They include yellow and yellowish-grey limestones, marls and greenish-grey clays, up to 60 m thick; they contain *Congeria sp., Musculus minor* (A n d r u s .), *Dosinia maeotica* A n d r u s . , *Pirenella sp.* [4], indicating Meotychniy age.

Undivided Bagerovska and Akmanayska suites conformably lie over Khersonska Suite and are unconformably overlain by Evpatoriyski or Odeski layers. In Alminska LTZ they are facially replaced by the lower part of Kazankivska sequence.

Pontychniy regio-stage

It is developed in the south of map sheets L-36-XXVIII and L-36-XXXIV and includes lower sub-regio-stage only which sediments are distributed over most part of the territory.

Lower sub-regio-stage
Novorosiyskiy horizon

It is developed in the south of Alminska LTZ and in the western part of Peredgirna LTZ where it is comprised of Burulchynska sequence. Over remaining map sheet territory in the horizon Evpatoriyski layers are distinguished at the bottom and Odeski layers – at the top.

Evpatoriyski layers (N_1*ev*) are developed in Tsentralna LTZ where they are exposed at the pre-Quaternary surface nearby Evpatoriya town and are exposed by technogenic activities in the quarries. In the north of Alminska LTZ they are overlain by the younger sediments and are exposed by the Bulganak River erosion.

The Layers unconformably lie over Akmanayska Suite of Meotychniy regio-stage. With azimuth unconformity they are overlain by limestones of Odeski layers or with erosion by the younger rocks.

In Tsentralna LTZ the Layers are exposed at the surface under sub-horizontal dipping, and in Alminska LTZ they are gently inclined to the north-west (azimuth 315-320^o, angle 2-3^o).

Evpatoriyski layers are composed of yellow, grey-yellow, oolitic limestones with cell-shaped weathering patterns, in places with clay interbeds at the bottom. Thickness of the Layers is not regular and does not exceed 5 m.

Over their full thickness the Layers are intersected by numerous drill-holes. In the southern direction they are facially replaced by the lower part of Burulchynska sequence, and in the western direction – by the middle part of Kazankivska sequence.

From limestones in DH 152 (depth 65.9-63.2 m) [38] V.M.Semenenko has determined *Congeria novorossica* S i n z., *Prosodacna littoralis* (E i c h w.) [4], indicating Early Pontychniy age which corresponds to the lower part of Novorosiyskiy horizon.

Odeski layers (N_1od) are developed in Tsentralna LTZ and in the north of Alminska LTZ. In Tsentralna LTZ they constitute pre-Quaternary surface in Evpatoriyske plateau; the rocks conformably lie over Evpatoriyski layers and are unconformably overlain by thin Quaternary cover.

The Layers are composed of shell, organogenic and detritus limestones of various density and re-crystallization degree.

In the east of Tsentralna LTZ, with stratigraphic interruption or erosion, they are overlain by the rocks of Chatyrlytska and Bagrationivska sequences. Thickness of the Layers attains 12 m.

In the southern direction, in Alminska LTZ, the reddish-brown clay interbeds appear in the column up to complete replacement of the Layers, approximately at the latitude of Uglove-Kolchugino villages, by the upper part of Burulchynska sequence. In the west Odeski layers are replaced by the coarse-terrigenous rocks of the upper part of Kazankivska sequence or are completely eroded.

The Layers contain rich complex of Early Pontychna fauna of Novorosiyskiy sub-regio-stage: *Monodacna pseudocatillus* B a r b ., *Limnocardium cf. odessovi* (B a r b .), *Dreissensia rostriformis* D e s h., *D., simplex* B a r b . [4], and others, as well as micro-fauna: *Loxocancha eichwaldi* L i v., *Cuprideis punctillata var. pliocenica* R o z. [4], indicating their affinity to the upper part of Novorosiyskiy horizon.

Burulchynska sequence (N_1brl) is developed in the Fore-Mountains and in the south of Alminska LTZ, where it is intersected by drill-holes and Kacha and Belbek river erosion. The Sequence is composed of estuary, aqueous and sub-aerial sediment complex arranged in four climatoliths. It unconformably lies over Meotychniy regio-stage and is also unconformably overlain by Pliocene rocks (Tavrska Suite). In the northern direction the Sequence is facially replaced by marine sediments of Evpatoriyski and Odeski layers.

The basic column of the Sequence is defined nearby Lyubymivka village (Fig. 2.6) where beneath Uchkuivska Suite the following rocks are observed:

1. Oskolskiy climatolith. Yellow-brown, grayish, sandy clays with aleurolites, gravelite, pebble-stone, shell and sandy limestone interbeds. Thickness is up to 20 m.
2. Lyubymivskiy climatolith. Alternating paleo-soil horizons of red and cherry-red clays with brown clays and aleurites. Thickness is up to 7 m.
3. Salgyrskiy climatolith. Yellow-brown, greenish-grey, sandy clays. Thickness is 32-5 m.
4. Belbetskiy climatolith. Clays and carbonate yellow-grey sandstones. Thickness is up to 2 m.

In limestones and sandstones L.A.Nevesska and V.M.Semenenko have determined *Prosodacna littoralis* (E i c h w.), *Pseudocatillus cf. pseudocatilus* (B a r b .), *Limnocardium sp., Monodacna ex gr. novossica* S i n z., *Theodoxus sp., Viviparus sp.* [4, 38].

Most complete column of the Sequence is studied in DH 156 [38] nearby Uglove village, where the following rocks unconformably lie above Meotychni sediments, from bottom to top:

1) depth 78.3-69.7 m – yellow-brown, greenish clay with carbonate aggregates;

2) depth 69.7-69.1 m – grey sandy limestone with quartz gravel inclusions and shell limestone interbeds, where V.M.Semenenko has determined *Prosodacna littoralis* (E i c h w.) [38];

3) depth 69.1-65.5 m – brown clay with ocher and greenish-grey spots and gravelite lenses;

4) depth 65.5-62.5 m – brown clay with gravelite interbeds and fossilized remnants in re-crystallized limestones, where V.M.Semenenko has determined *Prosodacna littoralis* (E i c h w.) [38].

Middle Pliocene clays lie above. Maximum thickness of the Sequence attains 40 m.

Clay chemical and granulometric composition is given in Tables 2.1 and 2.2.

By position in the column and complex of organic remnants, Burulchynska sequence is ascribed to lower sub-stage of Pontychniy regio-stage.

Meotychniy (upper sub-regio-stage) and Pontychniy regio-stages undivided

Kazankivska sequence (N_1kz) is developed in Alminska LTZ where it fills up negative forms of Late Miocene relief in the area of Bogayly gully – Salgyr River, or is preserved in “caps” on the watershed cuestas of Belbek, Kacha, Alma and Bulganak rivers. The Sequence with erosion lies over Lower Meotychni marine Bagerovski sediments and with stratigraphic interruption – over the rocks of Sarmatian regio-stage. It is unconformably overlain by Pliocene and Pleistocene sub-aerial and sub-aqueous sediments.

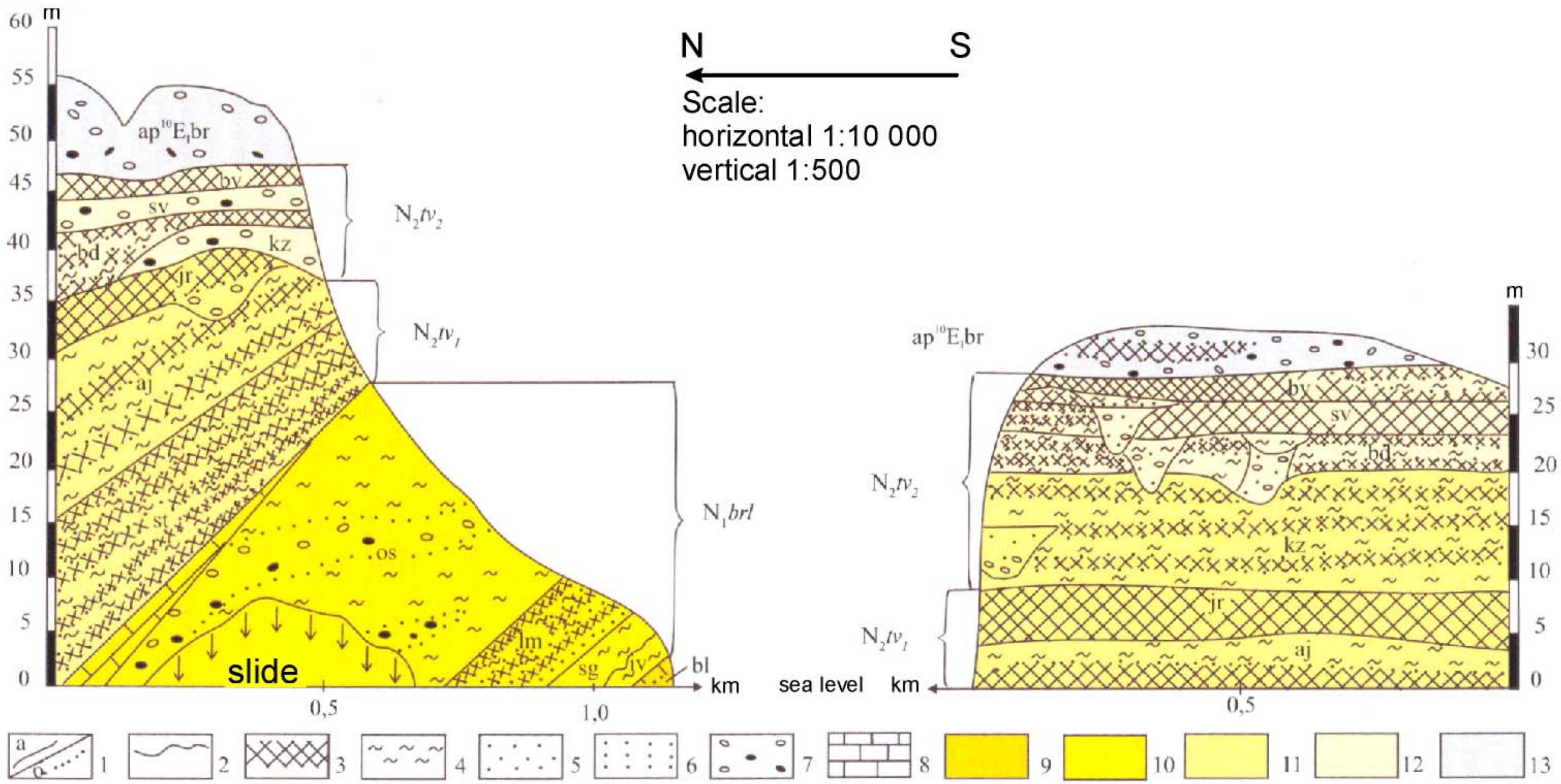

Fig. 2.6. Stratotypic column of Pliocene sub-aerial sediments nearby Lyubymivka village

Fig. 2.7. Basic column of Upper Plioecene and Eo-Pleistocene sediments nearby Beregove village

1 – geological boundaries between: a – climatoliths, b – stadials; 2 – erosion boundaries; 3 – paleo-soils; 4 – clays; 5 – sands; 6 – sandstones; 7 – gravel-pebble sediments; 8 – limestones; 9 – Belbetskiy climatolith (*bl*); 10 – Burulchynska sequence (N_1brl) including Ivankivskiy (iv), Salgyrskiy (sg), Lyubymivskiy (lm), and Oskolskiy (os) climatoliths; 11- Lower Tavrska (Uchkuivska) sub-suite (N_1tv_1) including Sevastopolskiy (st), Aydarskiy (aj) and Yarkivskiy (jr) climatoliths; 12 – Upper Tavrska (Andriivska) sub-suite (N_1tv_2) including Kyzylyarskiy (kz), Bogdanivskiy (bg), Siverskiy (sv), and Beregivskiy (bv) climatoliths; 13 – Eo-Pleistocene Berezanskiy climatolith (N_2br).

Kazankivska sequence is composed of coarse-terrigenous rock complex with limestone and clay interbeds. In the north-western direction it is facially replaced by Akmanayska Suite and Burulchynska sequence.

The basic column is defined on Kyzyl-Dzhar Mountain nearby Kazanky village, where the sequence of gravel-pebble-stones with clayey-sandy filler and sandy clay and sand lenses lies over Early Meotychna surface. In the zone of facial replacement, in the Sequence column in the west the former soil interbeds appear, and further to the north – limestones with fauna of Pontychniy regio-stage. Thickness of the Sequence in the basic column attains 22 m. Pebble-stones are coarse-pebble with clayey-sandy filler. Pebble composition: limestone – up to 80%, coarse-grained hematitized sandstone – up to 15%, flint, quartz, volcanic rocks and argillites – up to 5%. Granulometric composition of clays is given in the Table 2.2.

The lower age boundary of the Sequence is set at the rock exposures by paleo-geomorphologic features, and in other areas – by position in the column; it corresponds to Upper Meotis.

The upper age boundary is set by fauna remnants of Pontychniy type with limestone interbeds, and by position in the column below the younger fauna-characterized Pliocene sediments. In general, the Sequence age is accepted to be Late Meotychniy – Early Pontychniy.

Pliocene (N_2)

In the studied map sheets Pliocene includes Kimmerian and Akchagylian regio-stages developed in Tsentralna and Alminska LTZ of Plain Crimea.

Lower Pliocene
Kimmerian regio-stage

The rocks are divided into the lower – Azovskiy, middle – Kamysh-Burunskiy, and upper – Pantrykapeyskiy horizons.

Azovskiy horizon

In Tsentralna LTZ it is comprised of Chatyrlytska sequence, and in Alminska LTZ – of the lower part of Uchkuivska sub-suite of Tavrska Suite.

Chatyrlytska sequence (N_2*čt*) is developed in Tsentralna LTZ, where in the north of map sheet L-36-XXVIII, like the “caps”, with erosion, it lies over limestones of Pontychniy regio-stage. The Sequence is unconformably overlain by red-color rocks of Middle Kimmerian Bagrationivska sequence or by Quaternary sediments.

Most complete columns of the Sequence are located outside the studied territory. In the map sheet area the Sequence is intersected by numerous drill-holes and is composed of pink-grey and reddish re-crystallized limestones, it is so called “stone cap” with evidences for “desert tan”. In the upper column part intercalation of limestones, marls and chocolate clays predominate. Thickness is variable by strike and does not exceed 6 m.

In Alminska LTZ coeval sediments are developed in the lower part of Uchkuivska Suite. Somewhere in the Sequence weakly-preserved remnants of bivalvia molluscs *Dreissensia angusta* R o u s s., *Dr. rostriformis* D e s h . , *Didacna sp.* are observed [4].

By position in the column and fauna remnants Chatyrlytska sequence is ascribed to the lower sub-stage of Kimmerian regio-stage.

Kamysh-Burunskiy horizon

In Tsentralna LTZ it is comprised of Bagrationivska sequence, and in Alminska LTZ – of the middle part of Uchkuivska sub-suite of Tavrska Suite.

Bagrationivska sequence (N_2*bgr*) constitutes pre-Quaternary surface in the north-east of map sheet L-36-XXVIII of Tsentralna LTZ. It is confined to the southern plunge of Tarkhankut-Novoselivske uplift.

The Sequence, with stratigraphic interruption, in laterite-like paleo-soil complex, lies over Chatyrlytska sequence or the older Upper Miocene rocks, and is unconformably, or with partial discontinuity, overlain by sub-aerial Quaternary rocks or by Nogayska Suite. In Alminska LTZ the Sequence corresponds to the middle part of Uchkuivska sub-suite of Tavrska Suite. The typical column is located outside the studied area, where the Sequence at the bottom is composed of cherry, brown-red clays of Sevastopolskiy climatolith, and reddish-orange, yellowish clays of Aydarskiy climatolith at the top. The Sequence is intersected by numerous drill-holes.

Most complete column in the studied area is intersected by DH 160 [38], where above limestones of Pontychniy regio-stage, at the depth 25.0-19.2 m, brown-red, dense, slightly-ductile clays are observed, in places with manganese hydroxide spots and dendrites. Single fossilized foraminifera *Quinqueloculina sp.* cores are found in the Sequence [4]. Thickness of the Sequence in the studied map sheets does not exceed 6 m.

By position in the column the Sequence is ascribed to Kamysh-Burunskiy horizon of Kimmerian (Neogene).

Kimmerian and Akchagylian regio-stages

These regio-stages in the L-36-XXVIII and L-36-XXXIV map sheet area are composed of continental sediments (Tavrska and Nogayska suites).

Tavrska Suite (N_2tv) is developed in Alminska LTZ; the rocks are distinguished late in XIX century by K.Vogt in the volume of Tertiary System. According to the stratigraphic scheme, it is divided in two sub-suites: Lower Tavrska (Uchkuivska) and Upper Tavrska (Andriivska).

Lower Tavrska (Uchkuivska) sub-suite (N_2tv_1) is developed in Alminska LTZ where it constitutes pre-Quaternary surface in the most elevated part of external cuesta or is exposed by erosion along Bulganak, Alma, Kacha and Belbek rivers.

Sub-suite, with stratigraphic interruption, lies over Miocene rocks or, with partial discontinuity, over Burulchynska sequence (in the stratotypic area nearby Lyubymivka village). It is composed of the red-brown and grey-color continental rock complex divided into three climatoliths. It is unconformably overlain by Andriivska sub-suite of Tavrska Suite and unconformably – by Quaternary sediments.

In the stratotypic area nearby Lyubymivka village, above Pontychni continental rocks of Burulchynska sequence, the following rocks are exposed by abrasion (see Fig. 2.6), from bottom to top:

1. Sevastopolskiy climatolith – intercalation of paleo-soil horizons of cherry-red, dense clays with manganese and iron hydroxide spots, and brown, grey-brown, aleuritic clays. Thickness of some horizons is up to 2 m, and total thickness of climatolith is up to 12 m. Somewhere at the bottom light-grey, pelitomorphic limestone lenses are observed.

2. Aydarskiy climatolith – alternating horizons of brown, reddish-brown paleo-soil clays and yellowish-grey, brownish-grey, aleuritic clays and aleurites. Thickness of some horizons is up to 2.5-3.0 m, and climatolith in total – 8-12 m.

3. Yarkivskiy climatolith is composed of paleo-soil horizon of red, orange-red clays. At the bottom the paleo-cut “pocket” of gravel-pebble rocks up to 3 m deep is observed. Thickness of climatolith is up to 8 m, and thickness of entire column is 32 m.

Lower Tavrska (Uchkuivska) sub-suite is overlain, with erosion, by Kyzylyarskiy and Bogdanivskiy climatoliths of Andriivska sub-suite. In Tsentralna LTZ it corresponds to Chatyrlytska and Bagrationivska sequences and the lower part of Lower Nogayska sub-suite.

In the northern direction some pebble, gravel and sand interbeds and lenses are observed among inter-soil horizons of Uchkuivska sub-suite. Thickness of sub-suite attains 37 m. According to A.V.Kozhevnikov and N.M.Naydina, in the coastal cliff to the south from Kacha River valley sub-suite rocks contain ostracoda *Pontoniella loezui* (Z a l.), *Candona sp.* (J u v.), *Dorwinula stevensoni* (B. e t R.) [4].

In the stratotype, the spore-pollen complex in the column varies in term of arboreal and herbaceous plant contents. Arboreal pollen amount decreases upward from 48-60% in Sevastopolskiy climatolith to 10-33% in Aydarskiy one; amount of herbaceous plants increases in the same direction from 24-46% to 60-75%.

No pollen and spores are found in Yarkivskiy climatolith.

Paleo-magnetic data for soil horizons suggest for the fast change in the magnetization vector polarity. Sevastopolski paleo-soils in the lower part do exhibit reverse, and in the middle and upper parts – direct paleo-magnetization.

Aydarskiy climatolith in the lower and middle column parts exhibit reverse paleo-magnetization, and in the upper part – direct one with the single anomalous episode.

Yarkivski paleo-soils exhibit direct paleo-magnetization with the single episode of anomalous magnetization in the middle column part.

By position in the column and the complex of supplementary evidences Lower Tavrska (Uchkuivska) sub-suite is ascribed to Pliocene Kimmerian regio-stage.

Upper Tavrska (Andriivska) sub-suite (N_2tv_2) is developed over most part of Alminska LTZ. It conformably or with partial discontinuity lies over Uchkuivska sub-suite, and in places, with stratigraphic interruption – over Upper and Middle Miocene sediments. Sub-suite with erosion is overlain by Eo-Pleistocene or younger Quaternary sediments.

The stratotypic area for Upper Pliocene continental sediments is established in the coastal cliff nearby Beregove village (Fig. 2.7) where the basic column is studied at Skvortsove village (Fig. 2.8).

At Beregove village, above paleo-soils of Yarkivskiy climatolith, the following rocks are observed from bottom to top:

1. Kyzylyarskiy climatolith – intercalation of three yellowish-brown paleo-soil clay horizons with pale-yellow aleurites and sandy clays. Gravel-pebble-stone lenses are known. Thickness of climatolith is 11 m.

2. Bogdanivskiy climatolith – intercalation of dark-brown paleo-soil clay horizon with brownish-yellow aleuritic and sandy clays. In the clays of climatolith, over entire their thickness, the paleo-valleys are developed filled with gravel-pebble-stones and grey clays. Thickness of climatolith is 3-4 m.

3. Siverskiy climatolith – intercalation of light-brownish paleo-soil clays and yellow-grey aleurites with gravel-pebble-stone and sand “pockets”. Thickness of climatolith is up to 3 m.

4. Beregivskiy climatolith – paleo-soil horizons of reddish-brown clays with aleurite interbeds. Thickness of climatolith is 1-3 m.

Upper Tavrska (Andriivska) sub-suite is overlain by Eo-Pleistocene gravel-pebble rocks. Total thickness of sub-suite attains 28 m. In the coastal cliff nearby Kacha village A.V.Kozhevnikov and N.M.Naydina have determined from sub-suite ostracoda *Pontoniella loezyi* (Z a l .), *Advenocypris sp., Candona sp.* Close to Andriivka village (Fig. 2.9) and Tebek Mountain *Aglaiocupris chutzievae* (S u z.), *Cyprideis torosa* J o n e s , *Loxoconcha sp., Iliocypris bradyi* S a r s are found [4].

Spore-pollen complex of these sediments contains up to 63% of the steppe herbaceous pollen and in Beregivskiy climatolith only, in paleo-valley sediments, the arboreal pollen (up to 30-35%) is encountered.

In paleo-magnetic respect, Kyzylyarskiy climatolith exhibits gentle profile with direct paleo-magnetization in the lower part, and two short-term events of reverse field magnetization. The upper column part displays anomalous and reverse magnetization.

Bogdanivski sediments exhibit complex paleo-magnetic patterns (by 7 episodes of reverse and direct magnetization).

Siverski rocks display three episodes of reverse, four episodes of direct, and one – of anomalous magnetization.

Beregivski paleo-soils in the lower part exhibit direct, and in the upper one – reverse magnetization.

According to magnetic-stratigraphic scale, sub-suite is ascribed to the Gauss zone, and by position in the column and complex of evidences sub-suite belongs to the Upper Kimmerian-Akchagylian.

Nogayska Suite (N_2ng) is developed in Tsentralna LTZ, in the western limb of Simferopilske uplift. The Suite is divided in two sub-suites and is mainly composed of sub-aerial and continental rock complexes. In the western direction the Suite is facially replaced by the middle and upper parts of Tavrska Suite.

Lower sub-suite (N_2ng_1) is not exposed at the surface and is intersected by numerous drill-holes. Yarkivskiy, Kyzylyarskiy and Bodganivskiy climatoliths are distinguished.

Sub-suite conformably or with partial discontinuity lies over Bagrationivska sequence and is overlain by the upper sub-suite. In the western direction this sub-suite is facially replaced by the lower part of Tavrska Suite.

The stratotype for lower sub-suite is located outside the studied area. Most complete column is intersected by DH 63 [38], where above Bagrationivska sequence the following rocks are observed from bottom to top:

1. depth 47.2-41.9 m – Yarkivskiy climatolith. Brown clay, in the lower part dark-brown, dense, ductile, with carbonate concretions up to 2 cm across (up to 1-2% by rock volume);

2. depth 41.9-34.6 m – Kyzyldzharskiy climatolith. Light-brown, dense, aleuritic clay with single carbonate concretions and spots, manganese spots;

3. depth 34.6-33.2 m – Bogdanivskiy climatolith. Brown, dense clay with numerous manganese hydroxide spots and dendrites.

Higher in the column the upper sub-suite of Nogayska Suite occurs, up to 15 m thick.

In Alminska LTZ it corresponds to the upper part of Uchkuivska and lower part of Andriivska sub-suites of Tavrska Suite.

By position in the column sub-suite is ascribed to Kimmerian Pantykapeyskiy horizon.

Upper sub-suite (N_2ng_2) is developed in Tsentralna LTZ where it constitutes pre-Quaternary surface. Two climatoliths are distinguished: the lower Siverskiy and the upper Beregivskiy ones.

The upper sub-suite conformably or with partial erosion lies over the lower sub-suite rocks and is overlain by Quaternary sediments. In complete columns Siverskiy climatolith is composed of light-brown, brown-pale clays, rarely aleurites with pebble-stone interbeds. Beregivskiy climatolith is mainly composed of paleo-soil reddish-brown and brown dense clays. Thickness of sub-suite varies from 3 to 6.5 m by strike. In Alminska LTZ it corresponds to the upper part of Andriivska sub-suite of Tavrska Suite.

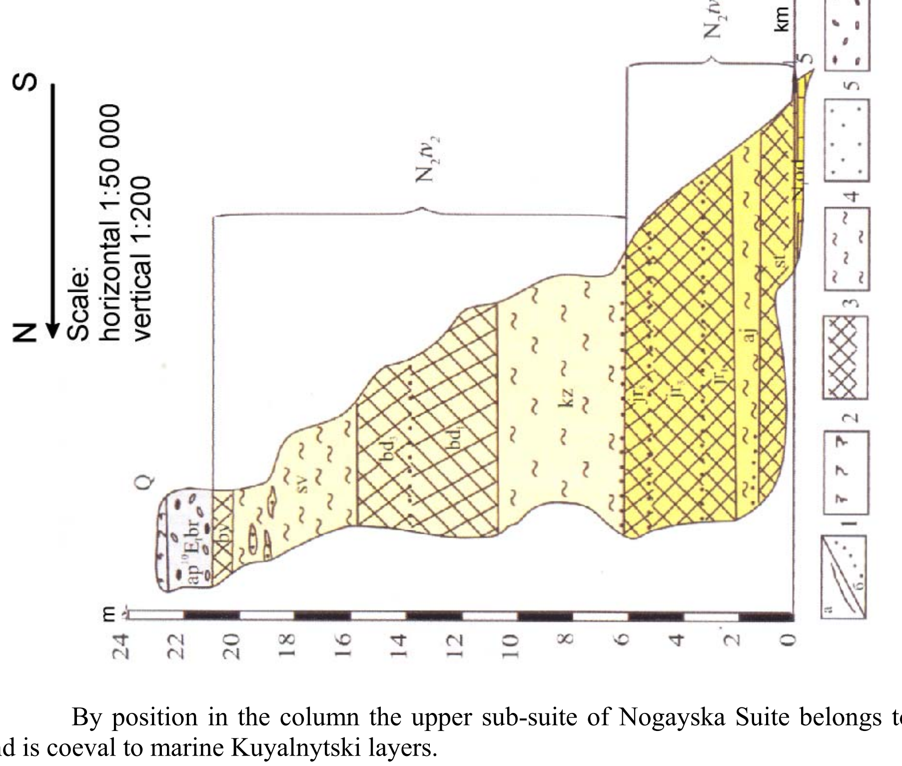

Fig. 2.8. Basic column of Pliocene sediments nearby Skvortsove village.

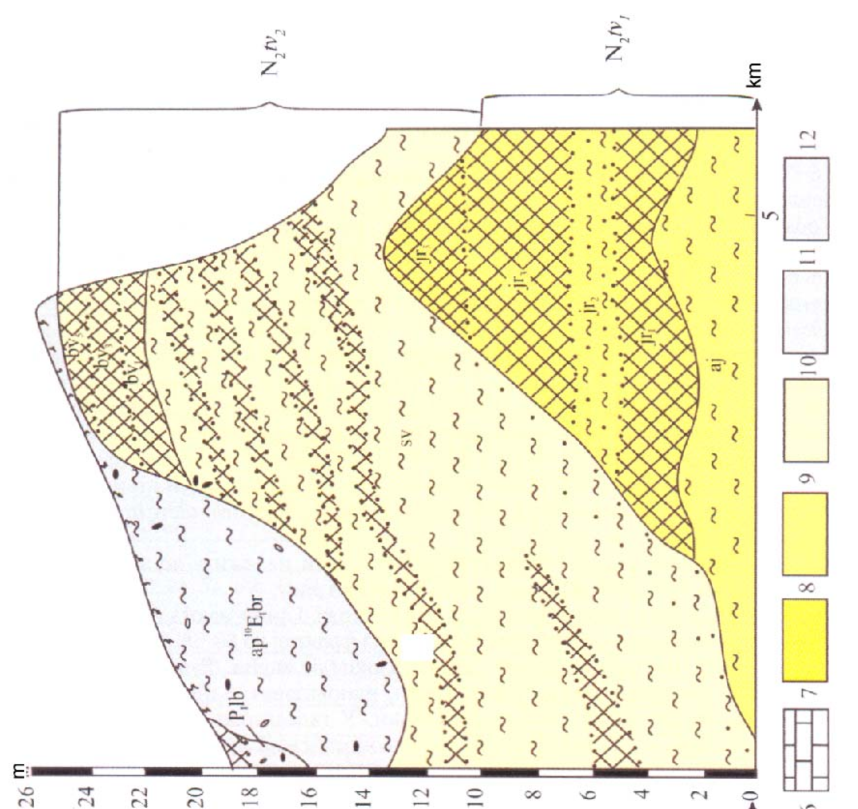

Fig. 2.9. Basic column of Upper Pliocene - Eo-Pleistocene sediments nearby Andriivka village.

1 – geological boundaries between: a – climatoliths, b – stadials; 2 – soils; 3 – paleo-soils; 4 – clays; 5 –sands; 6 – gravel-pebble sediments; 7 – limestones; 8 – Odeskiy horizon; 9 – Lower Tavrska (Uchkuivska) sub-suite (N_1tv_1) including Sevastopolskiy (st), Aydarskiy (aj) and Yarkivskiy (jr) climatoliths; 10 – Upper Tavrska (Andriivska) sub-suite (N_1tv_2) including Bogdanivskiy (bg), Siverskiy (sv), Beregivskiy (bv), and Kyzylyarskiy (kz) climatoliths; 11 – alluvial-proluvial sediments of Berezanskiy climatolith ($ap^{10}E_1br$); 12 – Quaternary sediments of Lubenskiy climatolith (P_1lb).

By position in the column the upper sub-suite of Nogayska Suite belongs to Akchagylian regio-stage and is coeval to marine Kuyalnytski layers.

Pliocene rocks are very similar in composition. Clays are polymineral kaolinite-hydromica-montmorillonite composition. Sand fraction by 80-90% is composed of quartz with calcite, feldspars, mica and iron hydroxide admixture. Pebble-stones are medium-coarse-pebble with various degrees of pebble rounding, filler is sandy-clayey. In pebble-stones of Uchkuivska sub-suite carbonate pebble predominate while in Andriivska and Upper Nogayska sub-suites quartz pebble is more common.

Chemical and granulometric composition of Pliocene clays is given in Tables 2.4 and 2.5.

Table 2.4. Granulometric composition of Pliocene terrigenous rocks

Sample location and rock name	Fraction size/content (%)				
	>0.6	0.6-0.01	0.01-0.005	0.005-0.001	<0.001
Tavrska Suite Upper Tavrska sub-suite (N_2tv_2) Beregivskiy climatolith					
Alminska LTZ; DH 53; depth 16.7-21.7 m; paleo-soil clay	5.95	21.60	7.10	20.85	44.50
Bogdanivskiy climatolith					
Alminska LTZ; DH 53; depth 28.7-31.9 m; paleo-soil clay	2.8	11.9	35.8	15.0	33.7
Kyzylyarskiy climatolith					
Alminska LTZ; DH 53; depth 31.9-33.9 m; brown-pale clay	3.3	21.7	39.7	11.9	23.4
Lower Tavrska (Uchkuivska) sub-suite (N_2tv_1) Yarkivskiy climatolith					
Alminska LTZ; DH 53; depth 37.6-9.9 m; paleo-soil clay	14.3	22.6	35.4	11.1	17.5
Aydarskiy climatolith					
Alminska LTZ; DH 53; depth 48.6-49.9 m; pale clay	20.4	15.5	39.9	10.2	14.0
Sevastopolskiy climatolith					
Alminska LTZ; DH 53; depth 49.9-51.9 m; paleo-soil clay	8.6	29.1	39.8	8.1	14.4
Chatyrlytska sequence					
Tsentralna LTZ, observation point 1146, outcrop 1; aleurite	12.04	63.76	3.15	4.35	16.70

Neogene and Quaternary systems

Upper Pliocene – Eo-Pleistocene undivided (N_2-E)

Undivided Upper Pliocene – Eo-Pleistocene sediments are developed in the Crimean Southern Coast and sporadically in the northern slope of the Crimean Mountains Main ridge. They are included into Masandrivska Suite.

Masandrivska Suite (ecN_2-E*ms*) is developed in the Crimean Southern Coast from Laspi harbor in the west to Kishka cape in the east of studied area. Continental sediments of the Suite fill up ancient relief dimples. Because of relatively higher resistance to denudation processes, in the modern relief these sediments are confined to the local watersheds. Normally, the Suite constitutes flattened or gently inclined to the south surfaces at the Crimean Yayla foothills, occurring in the bands up to 1 km wide. Multiple slides, occurred after formation of these bands, had resulted in their redistribution over the slopes of Southern Coast. By geomorphologic location, these surfaces are correlated with X-IX denudation levels with altitudes 600-800 m.

Often Masandrivska Suite fills up subsided valleys with the bottom occurring 10-30 m below the modern cut as it is observed in the area of Opolzneve village.

Masandrivska Suite sediments include eluvial-coluvial, proluvial and slide formations.

Three main lithological varieties of sediments are distinguished: boulders and gravel with heavy loam and clay filler; breccia composed of diverse-grained limestones with calcite cement; displaced hard rock blocks composed of Upper Jurassic limestones and conglomerates, from first tens of meters to 1 km in size.

The boulders and gravel with variable amount of reddish-brown carbonate loamy filler are most developed. Boulder material is not rounded and sorted while dimension of individual boulders attains tens of meters. Secondary alteration of Masandrivska Suite includes manganese enrichment, particularly, manganese hydroxide dendrites by cracks in clays, and carbonatization expressed in dirty-white and yellowish-white calcite films.

Table 2.5. Chemical composition of Pliocene clays

Sample location and rock name	Contents, %													
	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	MnO	CaO	MgO	P_2O_5	K_2O	Na_2O	SO_3	H_2O	Σ
Tavrska Suite Upper Tavrska (Andriivska) sub-suite (N_2tv_2) Beregivskiy climatolith														
Alminska LTZ; DH 53; depth 24.7-26.7 m; paleo-soil clay	47.89	11.11	4.56	-	0.68	0.07	15.38	1.10	-	1.42	0.32	0.06	2.50	100.0
Kyzylyarskiy climatolith														
Alminska LTZ; DH 53; depth 35.9-37.6 m; brown-pale clay	43.9	13.27	5.16	-	0.7	0.07	14.36	1.11	-	1.52	0.26	0.05	3.24	100.4
Lower Tavrska (Uchkuivska) sub-suite (N_2tv_1) Yarkivskiy climatolith														
Alminska LTZ; DH 53; depth 39.9-41.9 m; paleo-soil clay	49.29	14.13	5.80	-	0.72	0.08	10.91	1.06	-	1.70	0.34	0.06	2.56	100.0
Aydarskiy climatolith														
Alminska LTZ; DH 53; depth 48.6-49.9 m; pale clay	54.46	10.38	4.43	-	0.5	0.07	12.79	0.98	-	1.37	0.11	0.05	3.11	101.0
Sevastopolskiy climatolith														
Alminska LTZ; DH 53; depth 49.9-51.9 m; paleo-soil clay	50.76	10.75	4.41	-	0.3	0.07	14.94	0.89	-	1.37	0.13	0.06	2.45	100.0

Boulder surface is normally eroded, in places sinter formations are observed. Fine-clastic material surfaces are more smoothed, rather because of leaching processes and then mechanic detrition. With respect of lithology, clastic material is composed of grey pelitomorphic Upper Jurassic limestones, rarely andesite porphyries (Opolzneve village). Breccias with calcite crustification cement are locally developed, with various degrees of calcite crystallization (from amorphous mass to coarse-crystalline aggregates). Debris breccias with weakly-expressed sorting of clastic material are also observed.

Displaced hard rock blocks are also ascribed to the slide formations. In the map sheet L-36-XXXIV, the geomorphologic position of these blocks on the slopes of Southern Coast is quite variable. Individual displaced massifs differ in the hard rock preservation degree. Somewhere blocks displacement had occurred without their breaking and with preservation of Yayla surface elements. In other cases displacement had been accompanied by block splitting up to the boulder rock falls. Thickness of the Suite attains 100 m.

The Suite age is defined after its relative position in the column and geomorphologic data.

Quaternary System

In the studied map sheet Quaternary sediments are widely developed. In the north of map sheet L-36-XXXIV (Sevastopol) and in the southern and central parts of map sheet L-36-XXVIII (Evpatoriya) sub-aqueous and sub-aerial facies are distributed of most complete columns and thickness up to 20 m, attaining 45 m in the Chorna River mouth. In the north of map sheet L-36-XXVIII, in the area of neo-tectonic uplifts in Tarkhankutskiy peninsula, and over most part of map sheet L-36-XXXIV, in the are of neo-tectonic uplifts in Mountain Crimea, Quaternary sediments are mainly developed in sub-aerial facies, up to 5-10 m thick, and in places are lacking at all.

By geology of Quaternary cover, its thickness, column completeness and genetic type sets, Quaternary sediments are grouped into: Plain Crimea sub-area (C-II-16) of Southern-Ukrainian area (C-II), Western Fore-Mountain sub-area (B-II-1) of Crimean Fore-Mountain area (B-II), Central Mountain (B-I-1) and Southern Coastal (B-I-2) sub-areas of Mountain area (B-I) (see “Zonation scheme of Quaternary sediments”).

In the Plain Crimea sub-area two morphostructure-geomorphologic areas (SGA) are distinguished: Tarkhankut-Novoselivskiy (C-II-16-b) and Alminskiy (C-II-16-a); in the Western Fore-Mountain sub-area (B-II-1) – Sevastopolsko-Bakhchysarayskiy (B-II-1-b) and Chornoritsko-Belbetskiy (B-II-1-a); in the Central Mountain sub-area (B-I-1) – Balaklavsko-Ay-Petrynskiy (B-I-1-a); in Southern Coastal (B-I-2) – Batyliman-Simeizkiy (B-I-2-a) SGAs.

Stratigraphic subdivision of Quaternary sediments is performed up to climatoliths and in some cases combined or undivided climatolith complexes are distinguished. It is either because of weakly studied such the complexes or technical possibilities to show these complexes in the map.

In the legend to the “Map of Quaternary sediments” the regional “Correlation scheme of Quaternary sediments” is included where climatoliths are linked to the horizons of marine range and ledges of continental range of Quaternary sediments. It is meaningful in order to highlight, first of all, the difference between alluvium structure over platform areas of Ukraine, where mentioned ledges were actually distinguished, and the folded structure of Mountain Crimean and adjoining territory of Plain Crimea. Alluvium structure under platform regime is mainly related to the climate changes on the background of tectonic motions and World Ocean level changes. This causes formation of erosion cut within warm stages and its filling with alluvial sediments and loess paleo-soils within cold stages.

In Crimea, alluvium is being formed on the background of neo-tectonic activation of the folded Mountain Crimea expressed in permanent growth of Crimean Mountains. Erosion cut is being formed at the erosion basis descend within cold stages when surface waters are concentrated in the glacier-snow mountain caps. Then, with warm stage coming, thick alluvial and alluvial-proluvial sediments with former soil horizons are being formed.

Eo-Pleistocene /E/

In the studied map sheet Eo-Pleistocene sediments are widely developed. In Crimean Fore-Mountains and in Mountain Crimea they are weakly studied. Over there, in Sevastopolsko-Bakhchysarayskiy and Chornoritsko-Belbetskiy SGAs, Eo-Pleistocene includes socle terraces of some table heights like Sheludyva, Dovga, the fragment of proluvial terrace in the area of Opolzneve village in Batyliman-Simeizkiy SGA, as well as eluvial-karst and sub-terric units in Balaklavsko-Ay-Petrynskiy SGA.

In Plain Crimea mentioned sediments are developed in all SGAs and include diverse genetic complexes.

Lower and upper branches undivided

Berezanskiy, Kryzhanivskiy and Illichivskiy climatoliths combined. Aeolian-deluvial and eluvial-deluvial sediments /vd,edEbr+il/ are developed in some areas of Tarkhankutsko-Novoselivskiy and Alminskiy SGAs where they are intersected by a range of drill-holes and composed of paleo-soil clays and banded loams. Often the rocks unconformably lie over Miocene-Pliocene sediments and are also unconformably overlain by sub-aerial Neo-Pleistocene rocks. Most complete column is studied in Alminskiy SGA by DH 70 (depth 20-14 m) [38]. Over here, mentioned sediments include brown, light-brown clays with disseminated manganese hydroxide pods. Thickness of the climatolith complex attains 8.5 m.

The time of sediments formation is defined by their position in the column and the complex of supplementary evidences.

Berezanskiy, Kryzhanivskiy and Illichivskiy climatoliths undivided. Alluvial-proluvial sediments of X and IX over-flood terraces /ap^{10+9}Ebr-il/ are exposed at the surface in the central part of Alminskiy SGA and on the Kacha, Alma and Belbek river watersheds of Sevastopolsko-Bakhchysarayskiy SGA. The sediments include pebble-stones, gravels, sandstones, sands with loamy and clayey filler. The basic column is studied in the coastal cliff nearby Beregove village (see Fig. 2.7).

Thickness of sediments varies from 7.9 m (DH 159) [38] to 10.6 m (DH 153) [38]. Most complete column is intersected by DH 153 (depth 16.0-5.4 m) [38]. Over there, the rocks include pebble-stones with sandy-clayey filler and coarse-grained sands with gravel, up to 30% of the rock volume. In the east of Alminskiy SGA mentioned sediments are overlain by Neo-Pleistocene sub-aerial clays.

The time of rocks formation is defined by their position in the column and geomorphologic data.

In Chornoritsko-Belbetskiy SGA Eo-Pleistocene alluvial-proluvial sediments are known from DH 18 [40] drilled in the mouth portion of Chorna River. Over there, at the depth 30.0-20.7 m, in the subsided Chorna River valley, cemented pebble-stones are intersected. The pebble from 0.7 to 3.0 cm in size is well rounded, composed of limestones, marls, flint, igneous rocks, and constitutes up to 70% by rock volume. Cement is carbonate of basal or porous type. Thickness attains 10.6 m.

Being compared with terraces and denudation levels, these pebble-stones are correlated with X (Kyzyldzharskiy) terrace level. Mentioned sediments lie over pebble-stones of Upper Pliocene Siversko-Beregovskiy horizon and are overlain by alluvial-marine sediments of Chaudinskiy horizon.

The time of rocks formation is defined by their position in the column and geomorphologic data.

Upper branch /E_{II}/

Kryzhanivskiy climatolith. Eluvial-deluvial sediments /edE_{II}kr/ are preserved in the limbs of neo-tectonic uplifts where they are exposed at the surface in the south-eastern part of Alminskiy SGA in the area of Novoselivka and Klyuchi villages. In DH 70 (depth 14.0-8.2 m) [38] the rocks include brown clays with limestone fragment inclusions, and in DH 63 (depth 27.0-22.9 m) [38] – light-brown aleuritic clays. Intersected thickness varies from 1.0 m (DH 51) [38] to 5.8 m (DH 70) [38]. The rocks are overlain by Lower and Middle Neo-Pleistocene aeolian-deluvial and eluvial-deluvial sediments.

The time of rocks formation is defined by their position in the column and denudation level.

Proluvial-deluvial sediments /pdE_{II}kr/ are developed in Alminskiy and Sevastopolsko-Bakhchysarayskiy SGAs. Over entire thickness they are intersected by DH 156 (depth 5.5-10.5 m) [38] where the rocks include yellowish-brown loams with limestone fragments constituting up to 30% of the rock volume; thickness of the sediments attains 5 m.

The time of rocks formation is defined by their position in the column and geomorphologic data.

Eo-Pleistocene – Holocene undivided /E-H/

These sediments are only developed in Mountain Crimea where they include sub-terric and eluvial-karst rocks.

Eluvial-karst sediments /ekE-H/ are developed in Mountain Crimea in Ay-Petri plateau and Balaklavsko-Ay-Petrynskiy SGA only. They do cover the bottom of large karst funnels and valley-shaped dimples which are not involved in the modern river network. The rocks include red and reddish-brown clays of "Terra Rossa" type comprising the final product of limestone weathering, as well as limestone debris. Clays are thin-layered, uniform, in places knotty.

According to the seismic survey data, thickness of eluvial-karst sediments in Ay-Petrinska Yayla attains 8.5 m.

The time of rocks formation is related to the beginning of karst development in Eo-Pleistocene and continues up to now.

Sub-terric sediments /stE-H/ are developed in Balaklavsko-Ay-Petrynskiy SGA, in the Main ridge of Crimean Mountains, in the area of karst hollows development in Upper Jurassic limestones. The rocks are poly-genetic and do have complex structure. Rock-fall, water-mechanic, clayey and water chemogenic sediments are most developed.

Of the rock-fall sediments, four genetic types are distinguished:

- thermo-gravitation – being deposited just at the entrance to the case under influence of the sharp daily and season temperature variations: debris and gruss from organogenic and pelitomorphic, marble-like, karsted limestones;
- gravitation rock-fall – being deposited throughout the karst cave length , especially in the zones of tectonic breaks and extensive tectonic fracturing: debris, gruss, little boulders falling from the roof;
- collapse-gravitation – do form deposition fans, clearly localized and suggest for the funnel bottom collapse above karst hollow or inter-floor pillars: limestone boulders, debris, gruss;

– seismic-gravitation – being formed during earthquakes: chaotic accumulations of limestone boulders and blocks up to 100 tons weight.

Water-mechanic sediments, sand and pebble, are developed at the bottom of underground rivers or galleries. Clayey sediments comprise the final weathering and leaching product of limestones with admixture of sponges, corallites, algae, bivalvia mollusc shell fragments.

Water chemogenic sediments combine surface sinter and underwater sub-aqueous calcite rocks. Calcite sinter forms are being formed in the air environments and include stalagmites, stalactites, helictites and corallites. Sub-aqueous calcite forms are characteristic for underground lakes and pools including thin calcite films, "cave lace" and "cave pearl".

In the studied area, in Skelska cave (see "Scheme of geological landmarks"), the integrated column of sub-terric sediments, from bottom to top is as follows:

1) rock-fall sediments – boulders of grey, reddish-grey, organogenic and pelitomorphic, breccia-like, karsted limestones – 5 m;
2) water-mechanic sediments – alternating limestone sands with pebble and gravel inclusions, and carbonate brownish clays – 0.5 m;
3) water chemogenic sediments – stalagmitic crust composed of marble onyx and white and brownish coarse-grained calcite, with banded structure – 0.2 m;
4) water-mechanic sediments – yellowish-grey, brownish, diverse-grained, limestone sand with pebble lenses and limestone pebble-gravel interbeds – 0.2 m;
5) brownish-yellow sandy clay with organogenic remnants – corallites, algae nodules, etc. – 0.05 m.

The time of sub-terric rocks formation is tightly related to the cave age which is defined by the time of buried organic remnants, from Late Pliocene to Holocene.

Neo-Pleistocene /P/

Lower branch /P_I/

In Plain Crimea mentioned sediments are developed in all GSAs and include diverse genetic complexes. In Crimean Fore-Mountains and in Mountain Crimea Lower Neo-Pleistocene sediments are developed widely enough, specifically, in Chornoritsko-Belbetskiy SGA – in the Chorna River mouth, in Batyliman-Simeizkiy SGA – at the Main ridge foothill, and in Balaklavsko-Ay-Petrynskiy SGA – on the watershed surface gently inclined to the south, with altitudes from 500 to 800 m. Relative elevation above the modern cut is 100-125 m. In the area of Opolzneve village Lower Neo-Pleistocene sediments fill up paleo-valleys subsided relatively to the modern cut by 50 m. In Lower Neo-Pleistocene sediments the following genetic types are distinguished: coluvial, coluvial-deluvial, deluvial-proluvial, lake-proluvial, alluvial and alluvial-marine, slide, aeolian- and eluvial-deluvial.

Shyrokynskiy climatolith. Eluvial-deluvial sediments /ed$P_I$sh/ are exposed at the surface in the south of Alminskiy SGA. In Tarkhankut-Novoselivskiy SGA they are encountered at some sites only. The rocks include light-brown and brownish-red clays with manganese hydroxide pods and debris admixture. The sediments unconformably lie over Neogene, and conformably – over Eo-Pleistocene sediments, and are overlain by Neo-Pleistocene sub-aerial rocks. Intersected thickness attains 3.5 m (DH 150) [38].

The time of sediments formation is defined by their position in the column and the complex of supplementary evidences in the full columns.

Shyrokynskiy and Pryazovskiy climatoliths combined. Eluvial-deluvial, aeolian-deluvial sediments /ed,vd$P_I$sh+pr/ are developed in Tarkhankut-Novoselivskiy SGA where they constitute the lower part of Neo-Pleistocene sub-aerial cover. The rocks include brownish-red and dark-brown paleo-soil clays with loess-like loam and aleurite interbeds. This complex is not exposed at the surface. It unconformably lies over Eo-Pleistocene sub-aerial sediments or the older rocks, and is conformably overlain by the younger rocks. Maximum thickness is 7.8 m (DH 160) [38].

The time of sediments formation is defined by their position in the column.

Shyrokynskiy and Pryazovskiy climatoliths undivided. Proluvial-deluvial sediments /pd$P_I$sh-pr/ are developed in Alminskiy SGA. At the surface this complex is exposed in the south, in the area between Bulganak and Alma rivers. Most complete column is intersected by DH 153 [38], in 2.5 km from Novoselivka village. Over there, at the depth 0.6-5.4 m the rocks include brownish-red loams and clays with limestone debris and gruss. Thickness of sediments varies from 0.8 m (DH 49) [38] to 4.8 m (DH 153) [38]. The rocks conformably lie over Eo-Pleistocene sub-aqueous sediments and are also conformably overlain by the younger Neo-Pleistocene rocks.

The time of rocks formation is defined by their position in the column and geomorphologic data.

Deluvial-proluvial sediments /dp$P_I$sh-pr/ are developed in Tarkhankut-Novoselivskiy SGA where they constitute the blanket bodies on the uplift slopes. The rocks include reddish-brown and brown clays, in places loams with limestone gruss and debris (up to 30%). The sediments unconformably lie over Miocene limestones and are overlain by Upper Neo-Pleistocene sub-aerial and sub-aqueous rocks. Thickness of these sediments attains 2.2 m.

The time of sediments formation is defined by their position in the column and the complex of supplementary evidences.

Lake-proluvial sediments /lp$P_I$sh-pr/ are developed in Alminskiy SGA, nearby Sasyk Lake, where they are intersected by drill-holes and composed of mud-like sandy clays and loams. The rocks are arranged into lens-shaped bodies up to 2.0 m thick laying with slight erosion mainly over Eo-Pleistocene sub-aqueous sediments.

The time of sediments formation is defined by their composition, position in the column and correlation with adjacent columns.

Chaudynskiy super-horizon. Alluvial-marine sediments /amP_Ičd/ are locally developed in Chornoritsko-Belbetskiy SGA. They are intersected by DH 18 [40] in the mouth part of subsided Chorna River valley, nearby Inkerman town. At the depth 20.7-17.0 m, above Eo-Pleistocene pebble-stones lie dark-grey, dense, ductile clays with up to 15% admixture of shell fragments, quartz and limestone gravel, coalified plant remnants. Thickness of sediments is 2.3 m.

The time of sediments formation is defined by their composition, structure and settings in the column, as well as after single solid shell *Didacna baericrassa* P a t n f e r v l. and *Dreissena tschaudae* A n d r u s findings [4].

Shyrokynskiy, Pryazovskiy, Martonoskiy and Sulskiy climatoliths combined. Aeolian-deluvial and eluvial-deluvial sediments /vd,ed$P_I$sh+sl/ are developed in Alminskiy SGA. Most complete column is intersected in the southern part of Tarkhankut-Novoselivskiy SGA (DH 70) [38] where thickness of the complex attains 3.6 m. It is composed of brownish-red, dense, ductile clays with manganese hydroxide pods and fine carbonate concretions. This complex lies over clays of Kryzhanivskiy climatolith and is overlain by Upper Neo-Pleistocene sediments.

Spores and pollen are not identified. The time of sediments formation is defined by their position in the column and the complex of supplementary evidences.

Pryazovskiy and Martonoskiy climatoliths undivided. Alluvial sediments of VIII over-flood terrace /a^8P_Ipr-mr/ are developed in Alminskiy SGA of Plain Crimea where known as “Bulganatska terrace”, as well as in Chornoritsko-Belbetskiy and Sevastopolsko-Bakhchysarayskiy SGAs of Crimean Fore-Mountains. At the surface they are exposed in the right-bank side of Bulganak River and in the area between Kacha and Alma rivers. Terrace surface is gently inclined to the sea, elevation above the river course line attains 60 m (Kamyshynka village) at altitude 240 m, and descends to the west to 15-9 m. The rocks under description are well expressed in all columns and are intersected at the depth up to 4.5 m. Alluvial sediments are composed of pebble-stones, gravels with sands and sandy loams. With interruption they lie over Miocene-Pliocene sediments, in places over Eo-Pleistocene sub-aqueous sediments, and are overlain by proluvial-deluvial loams of Neo-Pleistocene upper branch. Thickness of climatolith complex varies from 1.2 m (DH 156) [38] to 13.0 m (DH 388) [38].

In Chornoritsko-Belbetskiy SGA of Crimean Fore-Mountains these sediments are locally developed. They are known in the Belbek River valley, in the area of Golubynka village, where they lie over eroded surface of Middle Jurassic flysch in the terrace fragments 50 by 15 m in size. The rocks include pebble-stones and gravels with layered sand lenses. Pebble-stones are reddish-brown, diverse-clast. Clastic material is well rounded, weakly sorted, and constitutes up to 40% of the rock volume. It consists of pelitomorphic and organogenic-detritus limestones, fine-medium-grained polymictic sandstones and medium-grained gabbro-diabases and diorites. Thickness of sediments does not exceed 1.5 m.

The time of sediments formation is defined by their composition, structure and terrace level setting.

Martonoskiy, Sulskiy and Lubenskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments /ed,vd$P_I$mr+lb/ are developed in Tarkhankut-Novoselivskiy SGA and on watershed surfaces of Early Pleistocene paleo-relief in Alminskiy SGA. In the column the rocks of warm development stages are well expressed while Sulskiy cold stage is almost lacking. Sediments include reddish-brown ductile clays with manganese hydroxide spots, in places brown loams with carbonate concretions, as well as aleurites and aleuritic clays. The complex rocks lie over Miocene limestones (DH 161) [38], in places over Upper Eo-Pleistocene sediments (DH 63) [38]. Thickness of the climatoliths complex varies from 2.3 to 5.0 m.

The time of sediments formation is defined by their position in the column and the complex of supplementary evidences.

Martonoskiy, Sulskiy and Lubenskiy climatoliths undivided. Deluvial-proluvial sediments /dp$P_I$mr-lb/ are developed in Tarkhankut-Novoselivskiy SGA where they are composed of clays, loams, with debris and gruss, up to 15.0 m thick. The rocks lie over Neogene sediments and are overlain by the younger Neo-Pleistocene rocks.

The time of rocks formation is defined by correlation with adjacent columns and geomorphologic data.

Sulskiy and Lubenskiy climatoliths undivided. Alluvial sediments of VII over-flood terrace /a^7P_Isl-lb/ are only developed in the southern part of Alminskiy SGA where respective terrace is called “Novovasylivska” from Novovasylivka village, in the Alma River right bank. They are exposed at the surface where constitute the ledge with surface altitude up to 75 m. The rocks include gravel-pebble-stones with loamy filler which lie over Lower Neo-Pleistocene proluvial-deluvial sediments.

Terrace surface is slightly inclined to the sea and gradually descends to 10-14 m. Thickness of alluvial sediments attains 9.6 m.

The time of sediments formation is defined by their composition, structure and terrace level setting.

Lubenskiy and Tyligulskiy climatoliths undivided. Coluvial sediments /cP_Ilb-tl/ are locally developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. They are known at the Yayla foothill in the area of Kastropol-Simeiz villages where they lie over eroded surface of Middle Jurassic flysch or overlie Masandrivska Suite at the altitudes 400-700 m with elevations 125-150 m above the modern cut level. Often these sediments fill up the limbs of ancient valleys by periphery of “Masandrivski” limestone boulders, debris and gruss with grey-yellowish loamy filler constituting up to 30% of the rock volume. Clastic material from 0.5 cm to 50 cm in size is rounded without visible orientation and sorting. Average coluvium thickness is 3-7 m, maximum thickness is intersected by DH 87 [31] and attains 75 m.

The time of sediments formation is defined by their composition, structure and position in the column.

Slide sediments /zP_Ilb-tl/ are developed in Batyliman-Simeizkiy SGA where they are especially typical for the area of Opolzneve-Kastropol villages and mainly confined to the upper slope parts with altitudes from 600 to 100 m and relative elevation up to 150-100 m over modern cut. Displacement basis of Lower Pleistocene slides is not related with the system of modern erosion cuts.

Slide sediments are observed in the well expressed hard rock blocks within friable Quaternary slope sediments. Lithology of displaced massifs is variable and includes blocks of massive grey pelitomorphic limestones, as well as Tavriyska Series or Middle Jurassic aleurolites and argillites in monocline dipping. Thickness of sediments attains 50 m.

The time of sediments formation is defined by their composition, structure and position in the column.

Deluvial-proluvial sediments /dpP_Ilb-tl/ are locally developed in Batyliman-Simeizkiy SGA of Crimean Southern Coast. They are known in the area of Opolzneve village where lie over eroded surface of Middle Jurassic flysch.

Sediments are composed of yellowish debris material with boulder inclusions and loamy filler. Clastic material is semi-rounded, from 0.2 to 0.8 cm in size, mainly composed of limestones. Thickness of sediments is 10 m.

The time of sediments formation is defined by their composition, structure and position in the column.

Proluvial sediments /pP_Ilb-tl/ are locally developed in Mountain Crimea, in Batyliman-Simeizkiy SGA. They are known in the area of Opolzneve village where lie over eroded surface of Middle Jurassic flysch filling up buried valleys which bottom occurs 50-60 m below the modern cut level. The sediments are composed of reddish-brown debris-gruss material with clayey-carbonate cement. Clastic material is semi-rounded, from 0.2 to 1.0 m in size, mainly composed of limestones. Thickness of sediments attains 60 m.

The time of sediments formation is defined by their composition, structure and position in the column.

Lower branch /P_I/

Coluvial-deluvial sediments /cdP_I/ are locally developed in Batyliman-Simeizkiy SGA of Crimean Southern Coast, in the area of Opolzneve-Kastropol villages. They constitute 30-40^o steep slopes and in places approach right against the foothill of Yayla gorges. By relative elevation above the modern cut level they are correlated with Bulganatsko-Novovasylivskiy and partly Mandzhylskiy terrace levels. They include diverse-size Upper Jurassic (Yaylynska and Yaltynska suites) boulders and debris with yellowish-brown, grey-yellow loamy filler. In places limestone breccia boulders are observed cemented by carbonate tuff or crystalline calcite. Thickness of sediments is 25-30 m.

The time of sediments formation is defined by their composition, structure and position in the column.

Lower and Middle branches undivided /P_{I-II}/

These rocks are locally developed in Mountain Crimea. Just alluvial-marine and alluvial facies are reliable known.

Evksynskiy super-horizon. Alluvial-marine sediments /amP_{I-II}ev/ are encountered in Chornoritsko-Baydarskiy SGA of Crimean Fore-Mountains, in the mouth portion of Chorna River subsided valley, in DH 18 (depth 7.7-17.0 m) [40]. The rocks include dark-grey, dense, ductile clays, with up to 25% by rock volume admixture of marine bivalvia solid shells and minute quartz and limestone gravel. They lie over clays of Chaudynskiy super-horizon and with sharp contact are overlain by alluvial-marine sediments of Karangatskiy horizon. Intersected thickness of sediments attains 9.3 m.

The time of sediments formation is defined by their position in the column and *Didacna parvula* N a b findings [4].

Tyligulskiy and Zavadivskiy climatoliths undivided. Alluvial sediments of VI over-flood terrace /a6P_{I-II}tl-zv/ are distinguished in Chornoritsko-Baydarskiy SGA of Crimean Fore-Mountains under the name "Mandzhylska terrace". These sediments are developed in Baydarska inter-mountain dimple, in the Belbek and Kokozka river valleys, where they constitute terrace fragments at altitudes 350-380 m, corresponding to Kyzyldzharskiy terrace level. Elevation over river cuts varies down the river stream from 80 to 40 m.

Alluvial sediments include pebble-stones and gravel-stones with lenses of oblique-banded, irregularly-grained, polymictic sandstones. They unconformably lie over irregular, with dimples and ledges, sub-horizontal surface of Jurassic and Cretaceous sediments, and are overlain by Upper Neo-Pleistocene – Holocene eluvial-deluvial sediments. Thickness of alluvial sediments is 0.5-5.0 m.

The time of rocks formation is defined by their composition, structure and structure-geomorphologic level.

Middle branch /P_{II}/

Middle Neo-Pleistocene sediments are developed both in Plain Crimea and Crimean Fore-Mountains, as well as in Crimean Mountains (Fig. 2.10).

In Plain Crimea eluvial-deluvial, aeolian-deluvial and alluvial sediments are most developed.

In Crimean Mountains and Crimean Fore-Mountains aforementioned rocks are locally developed. They constitute minor fragments of watershed surfaces, not related to the modern erosion network. Altitudes of these surfaces vary in the range 500-600 m, and elevations above the modern cut are 80-100 m. In the band of Crimean Southern Coast these surfaces are inclined in the southern direction under the angles from 4-8^o to 8-12^o.

Besides mentioned Middle Neo-Pleistocene sediments, the following genetic types are distinguished: coluvial, coluvial-deluvial, deluvial, deluvial-proluvial, proluvial, alluvial, alluvial-marine, and marine. Alluvial sediments are developed in the northern slope of the Main ridge where the river valleys are more mature.

Zavadivskiy, Dniprovskiy and Kaydatskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments /ed,vdP_{II}zv+kd/ are developed in Tarkhankut-Novoselivskiy SGA. Normally, aeolian-deluvial sediments predominate in the columns. The complex conformably lies over Lower Neo-Pleistocene sub-aerial sediments and is overlain by genetically-similar Upper Neo-Pleistocene rocks. Most complete column is intersected by DH 63 (depth 17.9-13.0 m) [38] and DH 161 (depth 13.5-8.4 m) [38], where these sediments include brown dense clays with dusty carbonate inclusions, manganese hydroxide dendrites and gruss admixture (up to 10%). Thickness of the climatoliths complex varies from 1.6 m (DH 160) [38] to 5.5 m (DH 161) [38].

The time of sediments formation is defined by their composition, structure and position in the column.

Dniprovskiy, Kaydatskiy and Tyasminskiy climatoliths combined. Aeolian-deluvial and eluvial-deluvial sediments /vd,edP_{II}dn+ts/ are distinguished in Tarkhankut-Novoselivskiy and Alminskiy SGAs. They are composed of loess-like loams, loams and paleo-soil clays. Most complete column is intersected by DH 160 (depth 9.8-5.3 m) [38]. The rocks include brownish-pale loams 4.5 m thick. This complex lies over Middle Neo-Pleistocene sub-aerial sediments and is overlain by Upper Neo-Pleistocene loams.

The time of sediments formation is defined by their composition, structure, position in the column, and the complex of supplementary evidences.

Dniprovskiy, Kaydatskiy and Tyasminskiy climatoliths undivided. Deluvial sediments /dP_{II}dn-ts/ are widely developed in the Crimean Southern Coast band, in Batyliman-Simeizkiy SGA. The rocks are observed in the blankets covering upper and middle 5-25^o steep slopes. They are composed of medium and light, brownish and yellowish-grey loams with inclusions of argillite, sandstone, limestone and igneous rock debris and gruss. Amount of clastic material attains 40-50% by the rock volume. The fragments, from 2 to 10 cm in size, are not rounded, with prominent sorting. In the upper column part the fragments are characteristically penetrated by the secondary iron and manganese hydroxides. Thickness of sediments is up to 5 m.

The time of sediments formation is defined by their composition, structure, position in the column, and the complex of supplementary evidences.

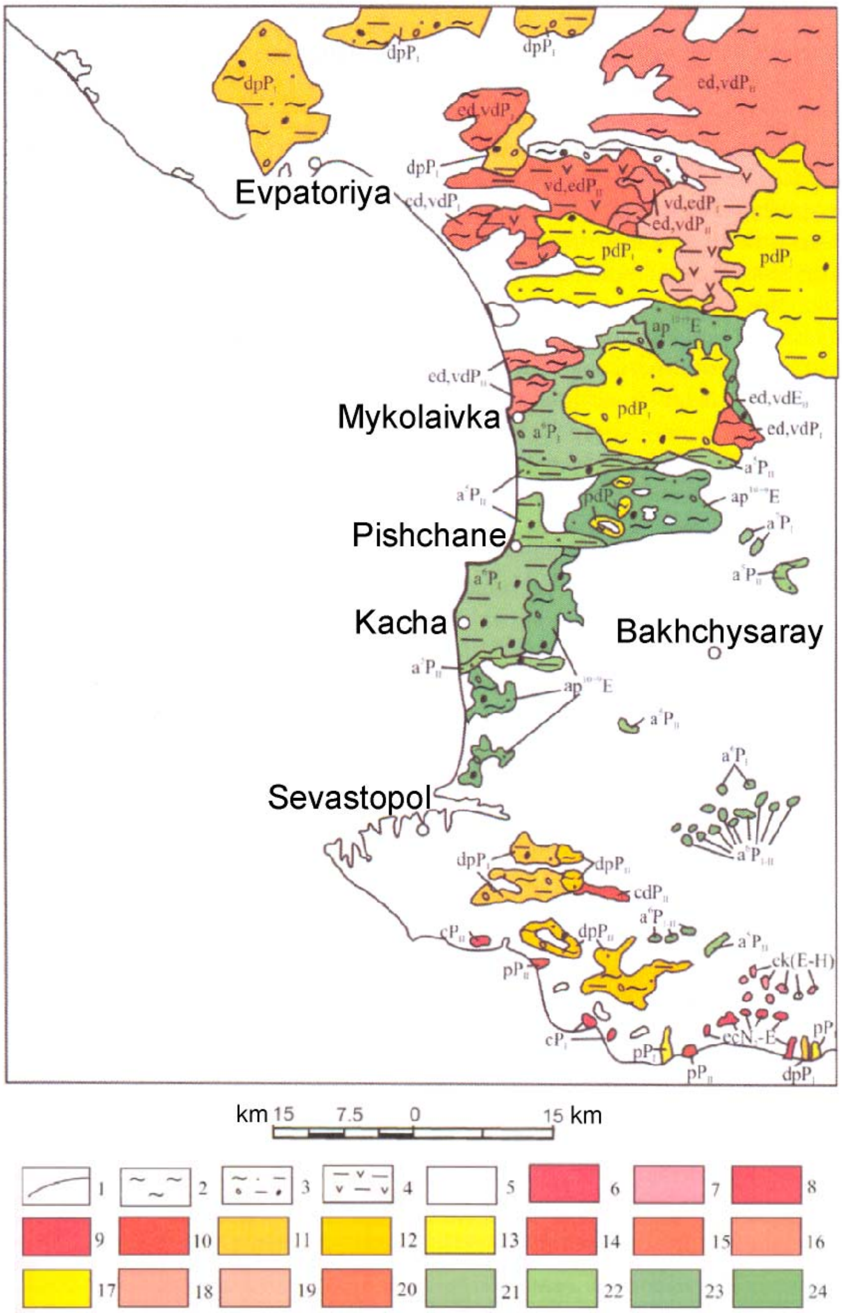

Fig. 2.10. Geological sketch of pre-Upper Quaternary surface.

1 – lithological boundaries; 2 – clays; 3- clays, loams with limestone gravel and gruss; 4 – loess loams; 5 – areas of lacking Upper Quaternary sediments; 6 – Pliocene – Eo-Pleistocene eluvial-coluvial sediments (ecN_2-E); 7 – Eo-Pleistocene – Holocene eluvial-karst sediments (ekE-H); 8-9 – coluvial sediments: 8 – Lower Neo-Pleistocene (cP_I), 9 – Middle Neo-Pleistocene (cP_{II}); 10 – Middle Neo-Pleistocene coluvial-eluvial sediments (cdP_{II}); 11-12 – deluvial-proluvial sediments: 11 – Lower Neo-Pleistocene (dpP_I), 12 – Middle Neo-Pleistocene (dpP_{II}); 13-14 – proluvial sediments: 13 – Lower Neo-Pleistocene (pP_I), 14 – Middle Neo-Pleistocene (pP_{II}); 15-16 – eluvial-deluvial and aeolian-deluvial sediments: 15 – Lower Neo-Pleistocene (ed,vdP_I), 16 – Middle Neo-Pleistocene (ed,vdP_{II}); 17 – Lower Neo-Pleistocene proluvial-deluvial sediments (pdP_I); 18 – Lower Eo-Pleistocene eluvial-deluvial and aeolian-deluvial sediments (ev,vdE_{II}); 19-20 – aeolian-deluvial and eluvial-deluvial sediments: 19 – Lower Neo-Pleistocene (ed,vdP_I), 20 – Middle Neo-Pleistocene (ed,vdP_{II}); 21-23 – alluvial sediments: 21 – Lower Neo-Pleistocene (aP_I), 22 – Middle Neo-Pleistocene (aP_{II}). 23 – Lower-Middle Neo-Pleistocene ($aP_{I\text{-}II}$); 24 – Eo-Pleistocene alluvial-proluvial sediments (apE).

Deluvial-proluvial sediments /dpP_{II}dn-ts/ are widely developed in the Crimean Southern Coast band, in Batyliman-Simeizkiy SGA. Over there, the rocks are distinguished in Opolzneve village area, where they fill up the dimple separating Kishka Mountain and Khyr massif with Isar cliff. Over there, slope altitudes attain 800 m and the slope is 10-15^o steep. Mentioned sediments lie over eroded surface of Middle Jurassic flysch. They include alternating gruss and debris with loamy filler, boulders and debris, light loams, and parti-colored brownish-yellow, yellow, grey-yellow and greenish-grey clays. Fragments are weakly rounded, grey-yellow and greenish-grey, weakly sorted. They are mainly composed of grey limestones although sandstones, aleurolites and igneous rocks are also known. Thickness of sediments is up to 10 m.

The time of sediments formation is defined by their composition and setting in the column.

Proluvial sediments /pP_{II}dn-ts/ are locally developed in the Crimean Southern Coast band, in Batyliman-Simeizkiy SGA. They are known in vicinity of Opolzneve village where include boulder-debris sediments with loamy filler and medium loams with yellowish-grey gruss admixture. Thickness of these sediments is 11 m.

The time of sediments formation is defined by their setting in the column.

Dniprovskiy and Kaydatskiy climatoliths undivided. Alluvial sediments of V over-flood terrace /a$^5P_{II}$dn-kd/ are developed in Alminskiy and Sevastopolsko-Bakhchysarayskiy SGAs, where the given terrace is called "Novopavlivska". It is most clearly expressed in the lower courses of Bulganak, Alma and Kacha rivers, where the terrace is preserved from erosion in the right-bank side narrow bands. Terrace width varies from 300 m (Novopavlivka village) to 1250 m in the Bulganak River mouth part. Terrace is composed of sands, gravel, pebble with sandy-loamy filler. Thickness of sediments attains 6.8 m (DH 389) [38].

The time of sediments formation is defined by their setting in the column between Middle Neo-Pleistocene Zavadivskiy and Tyasminskiy climatoliths.

Karangatskiy climatolith. Marine sediments /mP_{II}kg/ are quite locally developed in Mountain Crimea in Batyliman-Simeizkiy SGA.

In the studied map sheets these sediments are encountered in Triyka cape. Over there, in 13 m above sea line the flat horizontal plate is described where the trench has intersected the column composed of detritus sands and clays with admixture of well rounded pebble and oyster *Cardium edule* L., *Ostrea edulis* L. remnants [4]. Thickness of sediments is up to 1 m; they lie over limestone breccia of Lower Neo-Pleistocene deluvial-proluvial sediments.

The time of sediments formation is defined by their composition, structure, terrace hypsometric level and paleontological remnants.

Alluvial-marine sediments /amP_{II}kg/ are locally enough developed in Chornoritsko-Belbetskiy SGA. They are intersected by DH 18 [40] in the mouth part of the Chorna River subsided valley. At the depth 7.7-3.5 m, above clays of Evksynskiy super-horizon lie dark-grey to black, dense, ductile clays with up to 10% by rock volume pebble and gravel admixture. In places up to 3 cm thick gravel lenses are observed. Clastic material is composed of limestones and igneous rocks up to 2 cm in size. Bivalvia mollusc *Ostrea edulis* L. shells are often observed [4]. Thickness of sediments is 4.2 m.

The time of sediments formation is defined by their composition, structure, setting in the column and paleontological remnants.

Kaydatskiy and Tyasminskiy climatoliths undivided. Coluvial sediments /cP_{II}kd-ts/ are developed in the Crimean Southern Coast in Batyliman-Simeizkiy SGA. Over there, they constitute rock-fall fans and tongues in the vicinity of Yayla cliff foothills. Clastic material is composed of limestone boulders and debris with gruss-loamy filler which occupies up to 15% of the rock volume. Dimension of individual boulders is 1-5 m. Thickness of sediments is up to 15 m. They lie over the surface of older coluvium and are overlain by the younger coluvium.

The time of sediments formation is defined by their composition, structure, and setting in the column.

Coluvial-deluvial sediments /cdP_{II}/ are locally developed in the Crimean Southern Coast in Batyliman-Simeizkiy SGA where they occur on the slopes up to 30^o steep. The sediments are composed of diverse-size Upper Jurassic limestone boulders and debris with yellowish-grey loamy filler, up to 20 m thick (in the "Scheme of internal structure of Quaternary sediments" only).

The time of sediments formation is defined by their composition, structure, and setting in the column.

Middle and upper branches undivided /P_{II-III}/

Tyasminskiy and Prylutskiy climatoliths undivided. Alluvial sediments of the IV over-flood terrace /a$^4P_{II-III}$ts-pl/ are encountered in Fore-Mountain Crimea in Chornoritsko-Belbetskiy SGA. In the eastern part of Mountain Crimea this terrace is distinguished by local geologist as "Sudatska" one.

The rocks constitute minor remnants in the Belbek River valley and in Ustrochyer ridge in Baydarska valley. In Kokozka valley such remnants are as high as 80-90 m above the modern river cut. Down Belbek River stream this level descends and in the Tankove village area the IV terrace remnant is elevated above the modern river cut by 40 m. The sediments are composed of pebble-stones. Clastic material is well rounded and includes limestones, sandstones and quartz, from 2 to 8 cm in size. Irregularly-grained sand interbeds and lenses are often observed. In the upper alluvium column part the clastic material dimension decreases while amount of sand increases and somewhere it is replaced by sandy clay. Thickness of alluvium attains 5 m.

The time of rocks formation is defined by their composition, structure, and geomorphologic data.

Upper branch /P_{III}/

Prylutskiy, Udayskiy and Vytachivskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments /ed,vdP_{III}pl+vt/ are developed in Plain Crimea. In Tarkhankut-Novoselivskiy SGA they are confined to the elevated sites of Pleistocene relief. The sediments exhibit characteristic columns of warm climatoliths (Prylutskiy and Vytachivskiy) and less expressed Udayskiy. They are composed of light-brown clays with inclusions of fine, regularly disseminated gypsum crystals, and paleo-soil loams. The contact with underlaying rocks is gradual. Thickness of the complex attains 4.9 m (DH 234) [38].

The time of sediments formation is defined by their composition, structure, and setting in the column.

Udayskiy and Vytachivskiy climatoliths undivided. Coluvial sediments /cP_{III}ud+vt/ are developed in Mountain Crimea, in Batyliman-Simeizkiy SGA of the Crimean Southern Coast, and in Fore-Mountain Crimea in Chornoritsko-Belbetskiy SGA. In Opolzneve village area of Batyliman-Simeizkiy SGA these sediments lie over the surface of Upper Jurassic flysch on the slopes 15-25^o steep, at the foothill of Yayla cliffs or steep slopes of displaced massifs of Upper Jurassic limestones. Altitudes of coluvial sediment bodies are 450-800 m. The sediments include boulder-debris material with yellowish and brownish loamy filler occupying up to 35-40% of the rock volume. Thickness of the sediments is up to 25 m.

The time of sediments formation is defined by their setting in the column.

Slide sediments /zP_{III}ud-vt/ are widely developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. In the Verkhniy Kastropol village area individual slide bodies are arranged in the systems which almost completely encompass the watersheds of Kastropolskiy and Kuchuk-Koyskiy gorges. In geomorphologic respect, the slide sediments are confined to the slopes with altitudes 200-400 m. Relative elevation of slide terraces above the modern cut is 20-60 m. Often the footwall of slide sediments is located below the modern cut level. Slide bodies are circum-shaped in the plane, often they are smoothed by superimposed processes of complex denudation. The sediments include loams with argillite, aleurolite, sandstone, siderite and limestone fragments. Some argillite and argillite flysch batches of Tavriyska Series and Melaska Suite are often involved in the sliding motions. Thickness of slide sediments attains 50 m.

The time of sediments formation is defined by their setting in the column.

Deluvial-proluvial sediments /dpP_{III}ud-vt/ in Tarkhankut-Novoselivskiy SGA are preserved in the fan and tongue remnants in the Bulganak River valley (Trudolyubivka village). In Chornoritsko-Belbetskiy SGA these sediments are known from the upper gully courses on the northern slope of the Internal ridge (Glybokiy Yar village). In the Crimean Southern Coast they are developed in the Glyboka Zatoka area, where they lie on the slope with altitudes about 300 m and elevations 60-70 m above the modern cut. The sediments include grayish-pale loams with limestone, quartz, sandstone gruss, debris and gravel admixture, and gravel-pebble material with loamy filler. The sediments lie over Pliocene or Middle Jurassic hard rocks. Maximum thickness attains 6 m. The rocks are overlain by the Upper Neo-Pleistocene sub-aerial soil-loess sediments.

The time of sediments formation is defined by their setting in the column.

Proluvial sediments /pP_{III}ud-vt/ are locally developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. They conformably lie over eroded surface of Middle Jurassic flysch, filling the buried valleys. Sediments are composed of coarse-clastic material with yellowish-grey loamy filler. In subsided gully valleys these sediments are composed of loams with fine-clastic aggregates and loamy filler. Thickness of proluvial sediments is up to 6 m.

The time of sediments formation is defined by their composition, structure, and setting in the column.

Alluvial-proluvial sediments of the III over-flood terrace /ap^3P_{III}ud-vt/ are developed in Plain Crimean, Fore-Mountains and Mountain Crimea. In Alminskiy SGA they are defined in the Bulganak River valley (Kolchugine village) and in the gully upper courses (Kyzyl-Yarska). The sediments are composed of brown loams with limestone, quartz, sandstone gruss and debris admixture, in places – of gravel-pebble material with sandy-loamy filler. Thickness of sediments is 1-3 m. In DH 51 (depth 3.0-1.3 m) [38] are found brown clays with gravel, dusty carbonates and manganese hydroxide pods. The complex rocks unconformably lie over sub-aqueous Eo-Pleistocene sediments and are overlain by Upper Neo-Pleistocene loams. In Mountain Crimea these sediments are encountered in Baydarska valley, and in Chornoritsko-Belbetskiy SGA they are intersected by DH 18 [40] in the mouth part of Chorna River. Over there, at the depth 3.0-3.5 m, above Karangatskiy horizon clays lie yellow-brown dense clays with inclusion up to 50% by the rock volume of marble-like limestone fragments. The fragments 0.3-4.0 cm in size are irregularly rounded.

The time of sediments formation is defined by their composition, structure, and setting in the column.

Alluvial sediments of the III over-flood terrace /a^3P_{III}ud-vt/ are developed in Alminskiy, Sevastopolsko-Bakhchysarayskiy and Chornoritsko-Belbetskiy SGAs, as well as in the inter-mountain dimples of Mountain Crimea (Baydarska, Khaytu valleys). These sediments are preserved in the Alma, Bulganak, Kacha, Belbek and Chorna river valleys. In morphologic respect, these sediments constitute 300-400 m wide terrace gently inclined to the river courses (Poshtove, Novopavlivka villages). Over there, terrace surface altitudes are 160-165 m at the elevation above the modern river cut by 15 m. Down the river courses terrace height descends to 12 m (Vidradne village) at altitudes 50-55 m. In Mountain Crimea and Fore-Mountains terrace width does not exceed 20-30 m. In the Chorna River mouth part alluvium of Udaysko-Vytachivskiy climatoliths plunges down beneath the younger sediments.

The sediments are composed of pebble-stones, gravel-stones, sands and clays. Clastic material is well rounded and consists of limestones, sandstones, aleurolites and quartz. In the Kacha River right-bank side (Suvorove village) alluvium contains loams with gravel-pebble material interbeds. Thickness of the sediments attains 5 m.

The time of sediments formation is defined by their composition, structure, and terrace geomorphologic level.

Buzkiy and Dofinivskiy climatoliths undivided. Deluvial-proluvial sediments /dpP_{III}bg-df/ are widely developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. They lie over the surface of Upper Jurassic flysch or the older Quaternary sediments, constituting watershed surfaces gently inclined to the south. Altitudes of the flattened and extended along the slope terraced surfaces vary from 400-500 to 700 m. Relative elevations over the modern cut are 30-70 m. Terrace surface dipping under are from 4-5^o to 12^o. Deluvial-proluvial sediments are composed of clays and loams with debris. Clastic material is not rounded and composed of grey and grayish-brown limestones, aleurolites and sandstones. Maximum thickness of mentioned sediments attains 27 m.

The time of sediments formation is defined by their composition, structure, and geomorphologic level.

Alluvial sediments of the II over-flood terrace /a^2P_{III}bg-df/ are developed in Chornoritsko-Baydarskiy SGA of Crimean Fore-Mountains. They are known if the Belbek, Chorna, Kokozka river valleys and are correlated with Otuzka terrace in the eastern Crimea. The second over-flood terrace of Belbek River is mainly of socle type. In the river upper courses its elevation above the river water line is 5-7 m, and down the river stream the elevation descends to 3-4 m. In the Corna River mouth part alluvium is overlain by the younger alluvial sediments. Alluvium is composed of limestone pebbles, in places quartz and sandstone pebbles, often sand and clays appear in the column. Down the river courses the pebbles gradually decrease in size and amount while the sands become more ubiquitous and further, in the Chorna River mouth part, they are replaced by clays with pebble-stone and sandstone lenses. Thickness of sediments in Baydarska valley attains 8-10 m (DH 48, 49) [38].

The time of sediments formation is defined by their composition, structure, and terrace geomorphologic level.

Dofinivskiy and Prychornomorskiy climatoliths combined. Eluvial-deluvial and aeolian-deluvial sediments /ed,vdP_{III}df-pč/ are throughout developed and constitute pre-Holocene surface of the watershed areas. The rocks are encountered in Tarkhankut-Novoselivskiy, Alminskiy SGAs and in Crimean Fore-Mountains. The columns are of persistent two-fold structure: paleo-soils of Dofinivskiy climatolith are observed at the bottom being composed of brown, dark-brown, lumpy loams with inclusions of fine-crystalline gypsum, and loess-like loams of Prychornomorskiy climatolith with numerous inclusions of dust-like carbonates are developed at the top. Total thickness of the complex attains 2.8 m (DH 250) [38]. The rocks mainly unconformably lie over older Neo-Pleistocene sediments.

The time of sediments formation is defined by their position in the column and the complex of supplementary evidences.

Eluvial-deluvial sediments /edP_{III}df-pč/ are developed in Sevastopolsko-Bakhchysarayskiy SGA, in the northern slope of External ridge and flattened sites of river valleys and gullies. They are composed of gruss-debris material with loamy filler. Normally the sediments lie over pre-Quaternary rocks. Thickness of the complex varies from 2 to 5 m.

The time of sediments formation is defined by their composition, structure, position in the column, and the complex of supplementary evidences.

Novoevksynskiy horizon. Alluvial-marine sediments /amP_{III}nv) are quite locally developed in Chornoritsko-Baydarskiy SGA of Crimean Fore-Mountains. They are intersected by DH 18 [40] in the mouth part of buried Chorna River valley. At the depth 2.8-3.0 m, above clays of Karangatskiy horizon, lie dark-grey, greenish-grey, brown-grey, aleuritic clays with friable structure, detritus admixture and *Dreissena polymorpha* P a l l. remnants. Thickness of sediments is 0.7 m.

The time of sediments formation is defined by their composition, structure, setting in the column and paleontological remnants.

Upper branch, undivided sediments /P_{III}/

Aeolian-deluvial and eluvial-deluvial sediments /vd,edP_{III}/ are developed in Tarkhankut-Novoselivskiy and Alminskiy SGAs where they are exposed at the surface nearby Romashkyne and Krymske villages. They are composed of light-brown medium loams with inclusions of dusty carbonates and manganese hydroxides, and brown clays with inclusions of fine-crystalline gypsum. Upper Neo-Pleistocene sediments conformably lie over genetically similar Lower and Middle Neo-Pleistocene rocks. Thickness varies from 1.5 m (DH 37) [38] to 12.1 m (DH 63) [38].

The time of sediments formation is defined by their composition, structure, and setting in the column.

Deluvial sediments /dP_{III}/ are widely developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. They are most completely expressed in the area of Opolzneve – Goluba Zatoka villages where constitute the tongues in the slopes from 8^o to 16^o steep with elevation above the modern cut from 5 to 35 m. In some cases they fill up pre-Upper Neo-Pleistocene dimples and are also observed close to the slope watershed parts. Lithology of deluvial sediments is irregular – loams and sandy loams, clays with sandstone, aleurolites, siderite, limestone and igneous rock fragments. Clastic material is not rounded, with weak evidences for the fragment long axis orientation along the slopes, partly sorted. Brown shades characteristically predominate, as well as widespread secondary carbonates and less prominent iron and manganese hydroxides. Thickness of these sediments is up to 5.0 m.

The time of sediments formation is defined by their setting in the column.

Proluvial-deluvial sediments /pdP_{III}/ are developed in Alminskiy SGA where they are exposed at the surface. The rocks include pale-brown and brown loams with inclusions of carbonate concretions and limestone gruss. Thickness of the complex varies from 1.6 (DH 43) [38] to 6.4 m (DH 47) [38]. The sediments lie over alluvial and alluvial-proluvial rocks of Lower Neo-Pleistocene over-flood terraces.

The time of sediments formation is defined by their setting in the column.

Neo-Pleistocene - Holocene /P_{III}-H/

Prychornomorskiy climatolith – Holocene undivided

These sediments are most developed in Mountain Crimea and Crimean Fore-Mountains, as well as in Alminskiy SGA, and are locally known in Tarkhankut-Novoselivskiy SGA.

Diverse genetic types are distinguished among mentioned sediments. Fluvial sediments are most developed in Crimean Fore-Mountains with more complete profile of the river and gully valleys. Coluvial sediments are most characteristic for Batyliman-Simeizkiy SGA of the Crimean Southern Coast where the relief energy is much higher. Over there, they lie at the upper slope parts occurring under the active influence of gravitation processes. In these cases, mentioned rocks overlie the older sediments of the gravitation group. For the lower slope parts of the Crimean Southern Coast the sediments of deluvial and fluvial groups as well as slide facies of coluvial sediments are more characteristic.

Lake sediments /lP_{III}pč-H/ are distinguished in Alminskiy SGA. They are encountered at the bottom of Sakske, Sasykske, Kyzyl-Yarske lakes and are composed of aleurites, loams and aleuritic clays with *Cardium edule* L., *C. exiquum* L. shell remnants [4]. Thickness of these sediments attains 5.0 m.

The time of sediments formation is defined by their composition, structure, setting in the column and paleontological remnants.

Deluvial sediments /dP_{III}pč-H/ are widely developed in Mountain Crimea where over entire territory constitute the tongues and blankets at the slope foothills just above the first over-flood terrace. These sediments are widespread in Batyliman-Simeizkiy SGA of the Crimean Southern Coast. Most complete columns are known in the area of Opolzneve – Goluba Zatoka villages where deluvial sediments are confined to the lower and middle parts of the slopes from 10^o to 20^o steep. They are composed of debris and loams with equal amounts of the fragments and brown filler.

The fragments consist of sandstones, aleurolites and limestones from Upper Jurassic sequences and andesitic porphyries of Karadazka Suite. They are not rounded, in places weakly rounded, fragment sorting is weakly expressed; with flat fragment predomination, their plane orientation along the slope is noted. Fragment size is from 2 to 9 cm. Thickness of deluvial sediments is 3-5 m.

The time of sediments formation is defined by their setting in the column.

Coluvial sediments /cP_{III}pč-H/ are widely developed in Mountain Crimea, in Batyliman-Simeizkiy SGA of the Crimean Southern Coast, and in Crimean Fore-Mountains, where these rocks are observed at the foothills of the southern steep, cliffy Yayla slopes. Altitudes of these areas vary from 600 to 900 m. Rock-fall fans and tongues are most widespread.

Clastic material includes boulders and debris with gruss-loamy filler which occupies insufficient (up to 10-20%) rock volume. Some limestone boulders are as much as 20-30 m in size. Cobble and debris sediments are developed in the upper slope part. These sediments mainly lie over the older coluvium surface. Their thickness is 10-12 m in average, attaining 25-30 m in some cases.

The time of sediments formation is defined by their setting in the column.

Slide sediments /zP_{III}pč-H/ are developed in Batyliman-Simeizkiy SGA of the Crimean Southern Coast and in lesser extent in Alminskiy and Sevastopolsko-Bakhchysarayskiy SGAs. In Batyliman-Simeizkiy SGA these sediments constitute circum-like and glacier-like in the plane bodies located in the lower parts of erosion slopes where the modern cut provides displacement basis. Most commonly slide sediments are being formed on the slopes 10-35^o steep.

In the displacement processes flyschoid rock of Tavriyska and Melaska suites are commonly involved. The bedrocks become broken, fractured and contain few loamy filler in the upper column part. Mainly argillite flysch sets off distinct slide forms with smoothed hilly relief (Chorna Gora (Black Hill) slide nearby Opolzneve village). Under more solid flysch displacement (three-fold or aleurolitic) the block bodies are being formed with prominent slide terrace, normally turned to the slope. Significant bedrock folding does not occur and dipping angles only become steeper. And when displacement follows the bedrock layering, the dipping patterns remain unchanged at all. Average thickness of slide sediments is from 5-7 m to 20-30 m, often up to 100 m.

In Alminskiy SGA of Plain Crimea and Crimean Fore-Mountains slide sediments are confined to the Bulganak, Alma, Kacha and Belbek river valley slopes, at the sites of the External ridge breakthrough by these rivers. Lithology of sediments depends on the rocks involved in the slide processes.

In Bulganak River valley, nearby Kamyshynka village, Maykopska Series clays and Lower Miocene limestone boulders are displaced over the area 2 km^2 in size. Thickness of slide sediments is 10-20 m over there.

In Zavitne village area (Alma River basin) limestones and sandstones of Khersonska and Besarabska suites and clays of Maykopska Series are displaced over the territory up to 6 km^2 in size; over there, thickness of slide sediments attains 30 m.

In the Kacha and Belbek river basins displaced units are composed of Khersonska and Besarabska suites clays and limestone, sandstone and clay blocks, their thickness is 10-30 m.

The time of sediments formation is defined by their setting in the column.

Deluvial-proluvial sediments /dpP_{III}pč-H/ are widely developed in all SGAs of Plain and Mountain Crimea and Crimean Fore-Mountains. They are confined to the river valley slopes and are common for the territories where relief energy is lower and river valleys and most developed. Over there, they are based on the flood-land or first over-flood terrace and constitute the tongues up to 200 m wide extended along the valleys and inclined towards their bottom under the angles 5-12^o. The rocks are composed of debris and gruss with grey and brownish-grey loamy filler. The fragments are normally 3-4 cm in size and they are not rounded, without visible sorting and orientation. In Batyliman-Simeizkiy SGA these sediments lie over Middle Jurassic flysch, and in Crimean Fore-Mountains, in the northern slopes of Main ridge – over wide range of Mesozoic sediments.

In all areas of Plain Crimea deluvial-proluvial sediments fill up gully, ravine and stream bottoms. In the Alma River right bank, in the area of Frontove-Pyrogovka villages, these sediments include light-grey, carbonate clays with sandstone and limestone gravel admixture, up to 6-8 m thick. In Kurd-Dzhylga and Kara-Agach gullies the column is composed of gravel-pebble material with sandy and sandy loam filler. Thickness of mentioned sediments in the gullies is 3.5 m, in the mouth part – 11 m. Thickness of these sediments in Mountain Crimea and Crimean Fore-Mountains is up to 5 m.

The time of sediments formation is defined by their setting in the column.

Proluvial-deluvial sediments /pdP_{III}pč-H/ are encountered in Tarkhankut-Novoselivskiy, Alminskiy and Sevastopolsko-Bakhchysarayskiy SGAs. They constitute gully bottoms in vicinity of Shtormove, Skvortsove, Okhotnykove villages. The rocks of this complex include brownish-grey medium loams with gravel and pebble interbeds, up to 8 m thick.

The time of sediments formation is defined by their setting in the column.

Proluvial sediments /pP_{III}pč-H/ are developed in all areas except Tarkhankut-Novoselivskiy and north of Alminskiy SGAs, where they fill up gully bottoms and fans of temporary water streams based on flood-land sediments.

Lithology of sediments is fairly variable depending on the bedrock lithology, river course inclination and other factors. The relief contrast affects proluvial sediments composition in most extent. In the Crimean Southern Coast band proluvium is mainly composed of coarse-clastic material with minor loamy filler. When gully bottom are V-shaped, proluvial sediments are composed of boulders and debris with minor loamy filler amount. With relief contrast decreasing, the clastic material size is regularly decreased and, under slightly-cut relief, proluvium is mainly composed of brownish-grey medium and light loams with gruss and fine debris admixture up to 10%.

In Alminskiy SGA proluvial sediments are also confined to the gully bottoms and fans where they are composed of loams, sandy loams, with admixture of gruss, debris and individual boulders.

Characteristic secondary alteration of proluvial sediments includes iron enrichment in ocher films on the fragment surface. Thickness of proluvial sediments varies from 50 cm in the gully upper courses up to 12 m in the fans.

The time of sediments formation is defined by their setting in the column.

Alluvial-proluvial sediments of the Ist over-flood terrace /$ap^{1}P_{III}$pč-H/ are widely developed in all areas of Plain Crimea, Mountain Crimea and Crimean Fore-Mountains. In Mountain Crimea and Crimean Fore-Mountains alluvial-proluvial sediments are confined to the river valley upper courses where they constitute flood-land and first over-flood terrace. They are composed of gruss-debris or gravel-pebble material with average grey loamy filler occupying up to 50% of the rock volume. The clastic material, because of short water stream length, is not rounded or weakly rounded, irregularly-shaped, with prominent sorting by size and well expressed fragment orientation by the long axis in the water stream direction. In Plain Crimea these sediments constitute gully and ravine bottoms and are composed of loams, gravel and pebble with loamy filler. Thickness of alluvial-proluvial sediments in Mountain Crimea is from 3 to 13 m, in Plain Crimea – up to 3 m.

The time of sediments formation is defined by their setting in the column.

Alluvial sediments of the Ist over-flood terrace /$a^{1}P_{III}$pč-H/ are widely developed in Alminskiy SGA of Plain Crimea and in Crimean Fore-Mountains. In the latter, alluvial sediments are widespread enough in the northern slope of the Main ridge, where river valleys are most developed. They are distinguished in the river and their main branch valleys, where they constitute the columns of the river course flood-land and first over-flood terrace sediments. The over-flood terrace surface is elevated by 1-15 m in Belbek and Chorna river valleys. Alluvium is composed of the boulders, pebble and gravel with grey, brownish-grey loamy filler, as well as loams and sandy loams with gruss and debris of variable rounding. The clastic material is well sorted by size while the layers pinch out by strike in the lens fashion.

Normally alluvium constitutes accumulative terrace which lies over the surface of the older sediments. Average thickness of alluvial sediments is 5-7 m, maximum up to 12 m.

The gullies in Gerakleyskiy peninsula and in the Chorna River mouth part are subsided and do form the harbors similar in outlines to marine bays.

Alluvial sediments of the first over-flood terrace are well expressed in the valleys of all major rivers in Plain Crimea. Terrace width varies in the broad range from 25-50 m (Bulganak River) to 500 m in Alma River valley. Elevation of this terrace above the modern cut is 7 m nearby Novopavlivka village (Alma River) and 1-12 m in Bashtanivka village area (Kacha River). Down the river course, terrace elevation decreases to 1.6-1.8 m nearby Bryanske village (Alma River), and to 1.0 m (Belbek River). The first over-flood terrace is composed of gravel-pebble material with sandy loam filler, as well as loams, sandy loams with gruss and pebble. Maximum thickness of alluvium attains 12 m.

The time of sediments formation is defined by their setting in the column and their upper part transition into Novochornomorska marine terrace.

Holocene /H/

Marine sediments of Chornomorskiy horizon /mHčm/ are developed in the narrow band along entire Black Sea coast. They are exposed in separated outcrops 20-30 m long. Of these sediments, the old Chornomorski sediments, quite rarely preserved just at the coastal cliffs, and young Chornomorski sediments, which correspond to the wave-cut sediments, are distinguished. Old Chornomorski sediments are distinguished in Batyliman-Simeizkiy SGA, in the middle part of Laspinska and Lemenska harbors, below the slide sediments, 4-5 m above the modern sea line. They are composed of alternating sand and gravel, with admixture of sandstone pebble and oyster fragments, up to 2.5 m thick. These sediments lie over the slide accumulations of grey loams and clays with fragments and debris of various rocks.

Novochornomorski (young Chornomorski) sediments are confined to the wave-cut zone and are distinguished in many small-size beach accumulations. They are exposed in some sites along the steep enough coasts in Gerakleyskiy peninsula, Khersones, Fiolent, Aya capes, and nearby Balaklavska and Megalo-Yalo harbors. These beaches are composed of pebble-stones with individual boulders, friable sands and shell-stones. Clastic material of pebble-stones and boulders includes well rounded limestone, sandstone, quartz and extrusive rock pebbles, up to 5-6 cm across. Thickness of marine gravel-pebble or boulder-pebble beach sediments attains 5 m.

In Plain Crimea Holocene marine sediments are observed in the narrow band along the coast from the Belbek River mouth in the south to Evpatoriya town in the north. They constitute modern beaches, in places spits. Beach width varies from 2-10 m to 20-26 m. The sediments include clays with sand, gravel and pebble, as well as pebble-stone and shell-stone interbeds, up to 5 m thick.

The time of sediments formation is defined by their setting in the column and paleontological data – modern mollusc *Cardium edule* L., *Ostrea edulis* L. remnants [4].

Estuary and marine sediments of Chornomorskiy horizon /lm,mHčm/ are developed in Tarkhankut-Novoselivskiy and north of Alminskiy SGAs. Over there, they are encountered along the coast of Karkinitska Bay in partly or completely separated bays and lakes (Donuzlav Lake). The rocks include muds and muddy sands, as well as aleurites with shell-stone interbeds, 3.5-5.0 m thick.

The time of sediments formation is defined by their setting in the column and correlation with Chornomorskiy horizon.

Lake sediments /lH/ are developed in Alminskiy and Tarkhankut-Novoselivskiy SGAs. They are tightly related to the lakes in the coast of Karkinitska Bay. In geomorphologic respect, the modern lake sediments constitute the first lake terrace up to 0.8 m high above the water line. Width of this terrace attains 800 m (Zaozerne village). Lake sediments consist of dark-grey, greenish, politic, viscous mud with detritus of modern molluscs, in places aleurites. Thickness of the complex is up to 3.5 m.

The time of sediments formation is defined by their setting in the column, paleontological data and correlation with Chornomorskiy horizon sediments.

Alluvial-proluvial sediments /apH/ are developed in Tarkhankut-Novoselivskiy, Alminskiy and Sevastopolsko-Bakhchysarayskiy SGAs. They constitute river and gully flood-lands. By geological setting, either enclosed or adjoined (to the older ones) sediments are distinguished. Flood-land width varies from 20 to 550 m. The sediments include brown and dark-brown, heavy loams and sandy loams, with up to 40% admixture of clastic material – debris, gruss, pebble, gravel and sand, in places aleurolites with gravel and pebble interbeds. Maximum thickness of Holocene alluvial-proluvial sediments attains 1.5 m.

The time of sediments formation is defined by their composition, structure, setting in the column, and correlation with Chornomorskiy horizon sediments.

Eluvial sediments /eH/ are throughout developed both in Plain Crimea and Mountain Crimea and Crimean Fore-Mountains. They are especially widespread in the flattened relief forms in the External ridge of Crimean Mountains, as well as in Alminska depression. Lithology of eluvium depends on the bedrock composition, primary in relation to the eluvium. The turf, turf-carbonate, black-soil, chestnut brown and reddish-grey steppe modern soils, composed of various loams, often humused, up to 2.0 m thick.

The time of sediments formation is defined by their setting in the column.

Technogenic sediments /tH/ are developed in all areas of the studied territory. In Plain Crimea they constitute the dumps in quarries for construction materials, the heaps along North-Crimean Channel, spits and dams. They are composed of friable rocks and limestone fragments, up to 20 m thick. The sediments are most developed in the Crimean Fore-Mountains, where they are confined to the numerous limestone quarries for construction materials industry (Inkermanska and Bodrak-Alminska groups of dimension limestones) and metallurgy (Balaklavska group of deposits). The area, occupied by technogenic sediments, depends on the quarry size. Over there, the sediments consist of stripping rocks – clays of Bakhchysarayskiy horizon, marls and sandstones of Kachynskiy horizon, as well as of non-conditional waste from exploited Bilokamyanskiy or Simferopilskiy horizons. In Balaklavska group of deposits the technogenic dumps are composed of stripping rocks – clays of Albian stage, as well as of non-conditional waste from exploited horizon – Baydarska Suite limestone boulders. Thickness of technogenic sediments attains 10-20 m. Technogenic rocks in the Crimean Southern Coast include spits along the shore resulted from the beach constructions.

The distinct and limited in size technogenic units include the hand-made water reservoir dams in the area of Ozerne, Tylove, Orlyne villages, the arcs along Chorna River close to Inkerman station and along the eastern bank of Belbek River between Kuybysheve and Tankove villages, as well as solid household waste disposal and arched petroleum workshop nearby Inkerman town.

3. NON-STRATIFIED INTRUSIVE AND SUBVOLCANIC UNITS

In the map sheet area intrusive and subvolcanic rocks have been directly studied in Mountain Crimea only where they are exposed at the surface or occur at low depth. Deep basement position in Alminska depression of Plain Crimea and insufficient sedimentary cover perspectives for mineral discoveries, reflected in few deep boreholes in map sheet L-36-XXVIII (Evpatoriya), had precluded intersection of intrusive complexes over there. In view of insufficient Mountain Crimea erosion at present cut, these rocks represent less than 10% of the total igneous amount and include minor intrusive bodies exclusively. Although they are studied in details, there is no generally accepted idea concerning their origin. V.I.Luchytskiy had thought they are derived from two magmas – basalt and granite [14]. V.I.Lebedynskiy [15, 16] has pointed out they are derived from the single basalt magma and defined Crimean igneous rocks to be subvolcanic bodies. Other authors (V.V.Yudin [28]) consider Mountain Crimea intrusive rocks "rootless", included in the allochthons or mixtites, and support the idea that these rocks are autochthonous and include both minor intrusions and subvolcanic complexes. It is expressed in geological setting, structure-texture patterns, and characteristic aureoles of exocontact metamorphism.

Two complexes are distinguished in the area: Gerakleyskiy subvolcanic complex and Bodratskiy complex of minor intrusions. They are of Late Bajocian – Early Bathonian age and included in the lower tectonic floor composed of flyschoid and volcanogenic Triassic-Jurassic rocks (Tavriyska Series, Karadazka, Melaska and Belbetska suites). Rock exposures are located in Gerakleyskiy peninsula, in the Crimean Southern Coast, from Foros to Goluba Zatoka, as well as in the northern slope of Crimean Mountain Main ridge, in the Belbek and Bodrak river basins. In tectonic respect, the minor intrusions are confined to Gerakleyska volcano-tectonic structure, Pivdennoberezhne and Kachynske uplifts. Besides that, in the map sheet area the gravity and magnetic anomalies are observed related to the "blind" intrusive massifs. Some of the latter are already intersected by drill-holes in Gerakleyske plateau (depths 50-100 m) [63] and in the Alma River basin (Poshtova anomaly, DH 18, depth 700-900 m [64]). The distinct group of intrusive rocks is comprised of Balaklavski granitoids in allochthonous position which upgrade the spectrum of intrusive magmatism in the area. The intrusive rocks of Middle-Late Albian magmatic phase are weakly studied so far.

Gerakleyskiy subvolcanic complex ($\lambda{-}\omega\beta J_2 gr$)

This complex is distinguished by S.V.Pyvovarov [63]. It is developed in Gerakleyska volcano-tectonic structure, assigned to subvolcanic facies and arranged in the single magmatic complex together with volcanogenic rocks of Karadazka Suite. This conclusion is supported by the tight spatial relations between intrusive and extrusive rocks, similarity in composition and major chemical features. The rhyolite dykes, perhaps, provide the only exception. In Gerakleyskiy complex is mainly composed of subvolcanic, stock- and dome-shaped bodies, as well as veined dyke-like forms, not related to the paleo-volcano neck.

Four emplacement phases are distinguished in Gerakleyskiy subvolcanic complex. The earliest one includes dyke-like picrite and picrite-basalt bodies of the first phase. The second phase includes stock- and dome-shaped bodies of mafic composition. The third phase is composed of dyke-like andesite, andesite-dacite and rhyodacite bodies. At the final phase the rhyolite dykes were emplaced which somewhat differ from the previous rocks in chemical composition. Because of negligible body size, in the geological map in the scale 1:200 000 the rocks of specific phases are not mapped and the complex is shown undivided.

The first-phase rocks (picrites, picrite-basalts) are intersected by DH 27 (depth 52-126 m) [63] in the central part of Gerakleyske plateau. Macroscopically these are greenish rocks, medium-grained, with intersertal or hypidiomorphic texture, and uniform structure. Mineral composition: augite (30%), olivine (up to 30%), plagioclase (20%), biotite (1-2%). Most of olivine and pyroxene is replaced by serpentine pseudomorphs. Accessories include magnetite, ilmenite, chrome-spinellides, garnet. Secondary alteration is expressed in auto-metasomatic and post-magmatic chloritization, serpentinization and albitization, overprinted by the late carbonatization and pyritization. After chemical analysis (Table 3.1), picrites and picrite-basalts are enriched in alkalies. Because of the body small size, their expression in the gravity and magnetic fields is not confidently defined. Their magnetic properties are one of the highest among Crieman intrusive rocks: magnetic susceptibility – $1000\text{-}4000\times4\pi\times10^{-3}$ A/m, magnetization $360\text{-}3500\times4\pi\times10^{-3}$ A/m, rock density – 2.40-2.62 g/cm^3.

The time span is defined from the observations that the rocks are emplaced into Late Bajocian – Early Bathonian extrusive sequence of Karadazka Suite, and are cut by the dyke of the second emplacement phase.

The second-phase rocks (diabase porphyrites, gabbro-porhyrites) constitute subvolcanic intrusions, either ones exposed in the coastal cliffs, or the "blind" ones in Gerakleyske plateau, intersected by DH 2, 3, 8, 9, 15, 27 [63]. They include single-phase simple bodies formed within the single magma injection. Nevertheless, petrographic zonation is observed, expressed in diverse rock crystallization degree at the contacts on onward. The typical intrusion in Gekakleyske plateau is known in the area of Fiolent lighthouse (map sheet L-36-XXXIV (Sevastopol)), where the body occurs under the cutting contacts with the hosting Karadazka Suite andesite-basalts and tuffs. Steeply-dipping sidewalls and flat roof make the intrusion dome-shaped. From the east the contact is tectonic and exocontact alteration is expressed in mechanical deformation, andesite-basalt brecciation, calcite and epidote veinlets appearing; the endocontact alteration includes thin (20 cm) chilling zone where the rock becomes fine-grained. In gravity field the diabase porphyrite bodies are expressed in isometric or similar up to 1.6 mGl positive anomalies Δga. In magnetic field diabases are expressed in extensive magnetic anomalies up to 500 nTl. Grouping of these anomalies into elongated chains suggest for intrusion emplacement control by tectonic breaks. In the intrusion roof part diabase porphyrites are greenish-grey, uniform, fine-grained, with incomplete-crystalline groundmass. Micro-texture is ophitic. Phenocrysts consist of tabular, partly albitized calcium plagioclase (15%) and prismatic monoclinic pyroxene almost completely replaced by fibrous light-green amphibole (10%). The groundmass of hyalopilitic texture is composed of plagioclase microliths and chloritized matrix with abundant magnetite and titanomagnetite. The deeper subvolcanic intrusion horizons are studied by drilling data and suggest for significant role of crystallization differentiation. Diabase porphyrites in the zones, away enough from the contact, comprise the grey-green rock with porphyry texture and massive, uniform structure. Their phenocrysts include plagioclase-labrador in tabular, poly-synthetically twinned crystals up to 1 mm in size (15-20%), and pyroxene-augite in short-prismatic crystals up to 1.5 mm in size (10%).

Table 3.1. Chemical composition and numeric indicators after A.M.Zavaritskiy [9a] of picrite-basalts and mafic rocks of Gerakleyskiy complex

No.	Chemical composition (%) and numeric indicators	Sample location and depth, rock name				
		DH 27, depth 52 m; diabase	DH 27, depth 78 m; diabase porphyrite	DH 27, depth 100 m; diabase porphyrite	DH 27, depth 126 m; picrite	Sample 5/14 [63]; gabbro-porphyrite
1	SiO_2	43.50	48.10	48.02	41.62	52.38
2	TiO_2	1.06	1.24	-	0.79	0.78
3	Al_2O_3	15.17	15.85	16.16	10.89	15.21
4	Fe_2O_3	8.24	4.60	3.15	4.29	3.36
5	FeO	0.05	3.92	4.88	6.14	4.62
6	MnO	0.134	0.108	0.134	0.185	0.15
7	MgO	10.54	10.04	0.91	19.06	5.42
8	CaO	3.76	6.45	6.81	5.37	7.00
9	Na_2O	1.42	2.64	3.42	0.98	3.60
10	K_2O	0.50	0.24	0.84	0.30	0.70
11	P_2O_5	0.115	0.167	0.124	0.094	0.117
12	LOI	14.56	6.40	5.10	10.22	6.35
13	a*	4.6	6.9	9.2	2.7	9.83
14	c	5.4	8.3	7.0	6.3	6.27
15	b	30.6	23.2	24.6	40.4	17.80
16	s	59.4	61.7	59.3	50.5	66.10
17	a'	28.2	-	-	-	-
18	f'	30.0	36.2	31.2	24.3	44.61
19	m'	68.9	81.2	73.0	84.0	56.66
20	c'	-	1.6	7.7	1.4	17.34
21	n	80.7	34.5	87.3	84.2	88.66
22	φ	26.4	18.3	11.3	9.2	17.73
23	t	1.8	1.9	1.8	1.4	1.11
24	Q	4.2	1.2	0.1	10.6	6.27
25	Σ	-	-	-	-	99.68

* hereafter see [9a] for the "Classification scheme of chemical composition on the features determined from the numeric indicators".

By chemical composition (see Table 3.1) the rocks correspond to diabase with sodium alkali predomination which is also characteristic for the diabases from extrusive flows. In the contact varieties silica content slightly increases while calcium and magnesium contents decrease. Most metallic element contents in subvolcanic diabases, except chromium, zirconium, titanium, are below Clarke values for respective rock types. In comparison to extrusive diabase varieties, increasing in lead, cobalt, nickel, chromium and gallium contents is observed.

Intrusive diabases exhibit high density (2.64 g/cm^3) and residual magnetization (300-3000×4π×10^{-3} A/m), resulted from enrichment in magnetic minerals during crystallization under oxygen-undersaturated conditions. Magnetic susceptibility is 1150-3600×4π×10^{-3} A/m,

The time interval of subvolcanic stocks relatively to other igneous rocks is defined from the observations that the stocks are emplaced into the extrusive sequence of Karadazka Suite, they cut picrite dykes, and are, in turn, cut by andesite porphyrite, andesite and andesite-dacite dykes.

The third-phase rocks (andesites, andesite-dacites) constitute linear dykes, widely developed in the major break zones in Gerakleyska volcano-tectonic structure, and partly are exposed in the coastal cliffs or intersected by drill-holes beneath Neogene sequence. Although their composition varies considerably (from andesites to quartz rhyolites), they are developed together, exhibit similar chemistry, and often observed in gradual transitions with transitional varieties. The host rocks include andesite-basalts and felsic tuffs of Karadazka Suite. Main rocks types are andesites and andesite-dacites.

Andesites are greenish-grey, massive rocks with porphyry texture. Porphyry inclusions are composed of plagioclase from oligoclase-andesine range (# 35-38) up to 1 mm in size (15-20% by the rock volume). Simple twins, spot albitization by cleavage are characteristic. The groundmass of hyalopilitic texture is composed of fine, random albite-oligoclase microliths, often embedded in chloritized volcanic glass.

Andesite-dacites are yellow-grey and light-grey aphanitic rocks. Under microscope they look like felsic groundmass with coarser drop-like quartz grains and albite microliths. Somewhere in the felsic groundmass fine (0.3 mm) porphyry albite, quartz and biotite grains are observed. Secondary alteration includes propilitization, chloritization and carbonatization. By chemistry (see Table 3.2), the rocks correspond to the sodium andesite-dacites, dacites, rhyodacites, rhyolites, in places potassium dacites are noted. In the heavy mineral fraction magnetite, ilmenite, zircon and epidote are permanently observed.

Geochemical features indicate that average cobalt, zinc, chromium, manganese and vanadium contents do correspond to the respective rock type Clarkes, while copper, lead, nickel, zirconium and gallium contents are several times less of Clarke ones, and titanium content exceeds Clarke by the factor of one and more.

Magnetic properties are the lowest of all igneous rocks (magnetic susceptibility is 1150-3600×4π×10^{-3} A/m); in the maps of magnetic anomalies the fields of intermediate and felsic rocks are expressed in the negative anomalies.

The fourth-phase rocks (rhyolites) comprise the latest, enriched in volatile components differentiates of magmatic complex. They are encountered in the east of Gerakleyska structure and are intersected by drill-holes No. 4, 25 [63] and 48, 62 [68]. The host rocks include andesite-basalts from the lower part of Karadazka Suite and subvolcanic diabases. The contacts are cutting, complicated by post-intrusive breaks.

The rock is light-grey, with porphyry texture and massive structure. Porphyry inclusions are composed of biotite, plagioclase, potassium feldspar and quartz. Somewhere inclusions are arranged into glomeroporphyritic intergrowths in the following succession: biotite-K-feldspar-plagioclase-quartz. Groundmass is felsic, micro-granoblastic (because of devitrification) and composed of feldspar microliths and biotite flakes. Accessories include ilmenite, apatite, zircon, rutile, sphene, orhtite. Secondary alteration is expressed in sericitization, pelitization, and pyritization. In addition, potassium feldspar rim is observed around porphyry quartz inclusions and even potassium feldspar spherolites appear in quartz veinlet selvages, suggesting for potassium metasomatism. By chemical composition (see Table 3.2) the rock is similar to rhyolite with increased K_2O content. With their cenotypal appearance and chemistry the rhyolites differ from the range of essentially sodium igneous rocks not only of Gerakleyskiy complex but also entire Crimea. Geochemical features of rhyolites are caused by high titanium and tin contents; direct correlation is characteristic between these elements concentration and gallium, vanadium and lead contents. Rhyolite density is 2.30 g/cm^3, magnetic susceptibility – 18×4π×10^{-3} A/m, magnetization – 2×4π×10^{-3} A/m [63], that is, the rock is relatively high-density and actually non-magnetic.

Main varieties of intrusive rocks in Gerakleyskiy complex are conjugated with the extrusive mafic rocks, including diabases with sodium predomination in alkalies (n=80-95^{o}). More stable, in comparison with lavas, crystallization conditions in subvolcanic bodies had caused crystallization differentiation processes. In this case, more leucocratic residual melt, corresponding to adnesite-basalt, is accumulated in the roof portions of subvolcanic intrusions, while the inner intrusion parts are enriched in pyroxenes and olivine. By chemistry these rocks are similar to picrites, although they should be considered as differentiates of the common basalt magma with retained general sodium affinity.

Table 3.2. Chemical composition and numeric indicators after A.M.Zavaritskiy [9a] for felsic intrusions of Gerakleyskiy complex [63]

#	Chemical composition (%) and numeric indicators	Sample location and depth, rock name								
		DH 20-g, depth 296.0 m; andesite	DH 36, depth 121.2 m; andesite	DH 20-g, depth 300.0 m; rhyo-dacite	DH 36-9, depth 15.1 m; rhyo-dacite	DH 39, depth 56.0 m; rhyo-dacite	DH 39-k, depth 72.0 m; rhyolite	DH 25, depth 149 m; rhyo-dacite	DH 25, depth 45.7 m; rhyolite	DH 48, sample 2; rhyo-dacite
1	SiO_2	56.58	59.58	71.24	72.80	72.40	74.08	71.94	75.60	72.16
2	TiO_2	0.02	0.50	0.71	0.38	0.22	0.28	0.20	0.26	0.17
3	Al_2O_3	12.80	16.95	11.75	12.22	13.02	12.90	13.53	11.78	13.86
4	Fe_2O_3	2.69	0.93	1.76	0.74	0.30	0.53	0.67	0.79	1.34
5	FeO	5.23	3.65	2.75	1.84	1.64	1.24	1.07	1.99	0.73
6	MnO	0.32	0.11	0.23	0.06	0.05	0.05	0.02	0.058	-
7	MgO	10.0	6.97	2.19	4.52	4.52	3.87	0.26	0.77	0.50
8	CaO	2.87	1.64	1.08	0.72	0.84	0.72	2.87	1.25	0.61
9	Na_2O	3.05	3.75	2.71	2.20	0.85	1.94	2.66	2.20	2.24
10	K_2O	0.33	0.28	2.30	0.30	1.56	1.16	5.20	4.32	6.70
11	P_2O_5	0.10	0.076	0.212	0.051	0.058	0.06	0.073	0.048	-
12	LOI	5.42	5.28	2.64	3.84	4.16	3.04	1.58	0.78	-
13	a	6.95	8.38	9.07	4.81	3.82	5.59	-	10.7	14.1
14	c	3.54	1.9	1.33	0.82	0.95	0.82	-	1.5	0.73
15	b	24.8	24.41	10.0	17.39	18.91	15.78	-	4.7	4.90
16	s	64.71	65.31	79.6	8.00	76.31	77.81	-	83.0	30.10
17	a’	12.09	36.68	37.33	50.18	55.09	54.58	-	35.2	-
18	f’	30.22	17.16	42.67	12.36	9.94	9.44	-	53.5	-
19	m’	68.13	46.65	68.13	40.73	37.46	38.65	-	26.7	-
20	c’	-	-	-	-	-	-	-	-	-
21	n	66.66	95.31	66.66	92.11	45.29	70.79	-	43.5	-
22	φ	9.34	3.22	9.34	2.91	1.26	2.39	-	14.0	-
23	t	0.84	0.60	0.84	0.41	0.23	0.32	-	0.2	-
24	Q	11.98	11.96	11.98	43.52	44.04	43.62	-	43.2	31.44
25	Σ	100.0	99.73	100.0	99.67	99.65	99.86	100.1	-	-

Differentiation processes are also characteristic for subvolcanic felsic rocks, where transitions from andesite-dacites to dacites are observed within the single body. The rock chemical composition in the fault zones is essentially affected by accompanied metasomatism processes. The distinct metasomatic processes developed in Gerakleyskiy complex include:

- sodium metasomatism is expressed in albitization which had occurred in post-magmatic stage and encompassed all rocks, except rhyolite dyke, whose emplacement bounds the upper time boundary of sodium metasomatism;
- silica metasomatism and related propilitization, encompassing subvolcanic bodies and host rocks in fault zones. Mineralogically this process is expressed in extensive silicification, pyritization, chloritization, sericitization and epidotization; chemically – in silica and sulfur content increasing and partial magnesium removal;
- potassium metasomatism is superimposed onto previous processes; potassium source comprises potassium rhyolites of Gerakleyskiy complex (metasomatic, but not primary-magmatic nature of potassium enrichment is evidenced by the spotty distribution patterns of potassium-enriched rocks within volcanics, newly-formed potassium feldspar in quartz vein selvages, potassium enrichment of both vein and host rocks).

Potassium metasomatism determination and tracing in Gerakleyska structure is of practical value since it is developed together with sulphide mineralization (ore mineralization is confined to quartz-feldspar veinlets).

Gerakleyskiy complex is ascribed to gabbro-diabase formation. Some emplacement phases include several petrochemical series – tholeiitic (IV phase), alkaline-earth (III-II phases) and transitional to shoshonitic (I phase). In a whole, the complex belongs to the island-arc association with multi-phase (completed) formation mode, prominent differentiation processes and wide range of associations on silica basis. This causes its mineralization potential. To date, gold-polymetal specialization of the final (IV) emplacement phase is confidently defined – potassium rhyolite dykes and concomitant potassium metasomatism over the rocks of earlier phases.

The complex is formed at shallow depth and consists of hypabyssal bodies. General geological environment (location of intrusive roof zones), mineral composition, structure-texture features and geochemical parameters suggest for low erosion cut degree. Late Bajocian – Early Bathonian age of the complex is revealed from the observations that intrusive bodies are emplaced into the extrusive sequence of Karadazka Suite and are overlain by Middle Bathonian – Early Callovian clayey Ayvasylska Suite.

Rock age after K-Ar radio-chronology is estimated to 135-170 Ma [21, 63].

Bodratskiy subvolcanic complex ($\alpha\beta J_2$*bd*)

In tectonic respect, this complex is confined to Kachynskiy and Pivdennoberezhne uplifts and includes some groups of minor mafic and intermediate subvolcanic intrusions: Bodratska and Sokolynska in the north-western limb of Kachynske uplift, and Foroska, Melaska, Kastropolska and Limenska in Pivdennoberezhne uplift. Intrusions are single-phase or multi-phase, composed of hypabyssal diabase and diorite porphyrites, and confined to weakened zones related to the north-west-trending breaks or junction nodes of variously-oriented faults.

The setting of individual massifs in the complex are similar enough, specifically, intrusions are positioned both in the flysch Tavriyska Series and in volcanogenic Karadazka Suite. The contacts with host rocks are cutting, steeply-dipping. In physical fields the rocks of this complex are well expressed because of their physical properties: density – 2.52-2.78 g/cm^3, magnetic susceptibility – 31-1683×4π×10^{-3} A/m, longitudinal wave speed in sample rocks is 4800-5500 m/s, electric resistance – 6.7×10^{-4}-2.3×10^{-6} Ohm, and dielectric permeability – 11.7-23.8 mD [13].

The body shape and size vary in the wide range: stock-like bodies are oval in the plane and from 20 to 300 m across, and dyke-like bodies are from 10 to 600 m long and 1-2 m wide. Sheeted bodies are mainly oriented in the north-eastern direction while the dyke orientation is often north-western and latitudinal. Since the host rocks are mainly composed of flysch sediments, the contact morphology and contact alteration are quite uniform: the exocontacts are expressed in “whitening” zones, without newly-formed minerals, from 5 to 30 cm wide, and the endocontacts exhibit changes in rock texture and vesicular structure appearance. Most of massifs are single-phase and composed of diabase porphyrites, augite diabases. The facial changes are often observed because of structure-texture diversity of rocks in the roof and inner massif parts. Bigger massifs are zoned, two-phase, where periphery is composed of diabase porphyrites and the central part consists of diorite porphyrites.

In Bodratska group of intrusions this complex includes four emplacement phases [21, 22] of similar geological and isotopic age but due to insufficient dimensions of individual intrusives the complex is mapped as undivided into the phases (see “Geological cross-section by line A_1-A_5”).

The first-phase rocks include sill-like and lens-shaped bodies, in places dykes of north-east and sub-latitudinal strike with dipping to the north, composed of two-pyroxene, olivine-hypersthene dolerites, dolerite porphyrites, basalts. Body thickness is up to 55 m, length – up to 400 m. The typical body in the studied area comprises Koronovskogo sill located at the Trudolyubivka village outskirt, in the left slope of Shara gorge, in 400 m from the mouth. The sill is extended in the north-eastern direction and dips to the north-west under the angle 40^o. It is cut by sub-vertical dyke of second-phase olivine basalts (extension azimuth 310^o) and dyke of third-phase hypersthene basalts of Bodratskiy subvolcanic complex. Depending on the body size, two or more facies are distinguished. The roof portion is composed of basalts, dolerite-basalts, dolerite porphyrites. The central portion is composed of fine-medium-grained dolerites. The contact alteration is expressed in the narrow (up to 1 m) aureoles of dehydrated and roasted rocks. Metasomatic and hydrothermal alteration is insufficient. Post-intrusion deformations are expressed in several fracture systems. Most widespread are the rock petrotypes of the first emplacement phase – micro-gabbro-porphyrites and dolerite-basalts, rarely dolerites and dolerite-porphyrites.

Dolerites are dark-grey with greenish shade, fine-grained, with doleritic and taxitic micro-textures. Phenocrysts occupy 10-20% of the rock volume and are composed of coarse (6-8 mm) augite and plagioclase crystals, rarely hypersthene and olivine. Groundmass texture is doleritic or ophitic and composed of plagioclase, augite and hypersthene laths. Accessories include titanomagnetite, chrome-spinellides, ilmenite. Changes in structure-texture and mineral composition cause such rocks distinguishing as dolerite-basalts, dolerite porphyrites, micro-gabbro-porphyrites. After chemical analysis data (Table 3.3), the rocks are enriched in magnesium and calcium with sodium predomination over potassium, depleted in titanium, phosphorus, alkalies, characteristic for tholeiitic or similar basaltoids. The time interval of the first emplacement phase is defined from observations that sills and lens-shaped bodies are confined to volcanogenic rocks of Late Bajocian – Early Bathonian Karadazka Suite, and are cut by two-pyroxene olivine basalt dykes of the second emplacement phase. The second-phase rocks include elongated stocks (typical body – Bodratskiy massif) and steeply-dipping dykes up to 500 m long and from 0.5 to 7.0 m thick. They are widespread in the Trudolyubivka village outskirts, in the Bodrak River basin. The bodies are composed of melanocratic olivine-augite, two-pyroxene-olivine basalts, dolerite-basalts, dolerites and dolerite porphyrites, which cut dolerite rocks of the first phase. The contact alteration is expressed in the narrow aureoles of roasted rocks. Metasomatic and hydrothermal alteration is insufficient.

Table 3.3. Chemical composition (%) of the first-phase rocks of Bodratskiy complex [21, 22]

No.	Chemical composition	Sample location and rock name			
		Koronovskogo sill, Shara gorge; olivine-hypersthene dolerite	Dyke, Bodrak River; olivine-augite dolerite	Dyke, Trudolyubivka village; dolerite-basalt	Bodrak River; dolerite dyke
1	SiO_2	48.5	48.45	46.00	49.00
2	TiO_2	0.65	0.65	0.81	0.78
3	Al_2O_3	15.33	14.45	17.12	17.48
4	$FeO+Fe_2O_3$	12.03	13.05	9.05	9.08
5	MnO	0.24	0.28	0.36	0.20
6	MgO	8.43	7.10	3.79	3.72
7	CaO	9.54	10.12	12.86	7.8
8	Na_2O	1.37	1.18	2.15	2.33
9	K_2O	0.30	0.17	0.20	0.09
10	P_2O_5	0.04	0.06	0.07	-
11	LOI	3.11	5.02	7.09	9.76
12	Σ	99.63	99.53	99.50	100.04

Table 3.4. Chemical composition (%) of the second-phase rocks of Jurassic Bodratskiy complex [21, 22]

No.	Chemical composition	Sample location and rock name		
		Shara gorge; olivine-augite dolerite dyke	Dyke at the junction of Mender and Shara gorges; dolerite porphyrite	Trudolyubivskiy stock; olivine-augite dolerite
1	SiO_2	45.15	46.65	47.82
2	TiO_2	3	4	5
3	Al_2O_3	0.63	0.56	0.66
4	$FeO+Fe_2O_3$	14.50	13.65	14.52
5	MnO	11.45	10.63	11.28
6	MgO	0.15	0.28	0.22
7	CaO	9.25	11.18	10.60
8	Na_2O	12.50	11.92	10.23
9	K_2O	1.40	1.17	1.57
10	P_2O_5	0.27	0.14	0.29
11	LOI	0.04	0.04	0.06
12	Σ	3.16	3.30	2.14

Olivine dolerites comprise the most widespread petrotype of the second emplacement phase. These are dark-grey to greenish, massive, fine-medium-grained rocks with abundant phenocrysts of zoned augite and fine olivine pods. Numerous vesicles, composed of calcite and chlorite, are characteristic. Micro-texture is micro-doleritic. Groundmass is composed of plagioclase laths and mafic minerals. Accessories include chrome-spinellides, ilmenite, pyrrhotite, chalcopyrite, titanomagnetite, cubanite, pentlandite.

By chemical composition the second-phase rocks do correspond to the tholeiitic melano-basalts; they are depleted in aluminium, titanium, potassium, phosphorus, and enriched in calcium and magnesium (Table 3.4).

Table 3.5. Chemical composition (%) of the third-phase rocks of Jurassic Bodratskiy complex [21, 22]

No.	Chemical composition	Sample location and rock name		
		Olivine-hypersthene basalt from dyke; Shara gorge	Augite-hypersthene dolerite-basalts; Trudolyubivka village	Hypersthene-augite dolerite-basalts; Dzhydair gorge
1	SiO_2	45.05	49.52	48.15
2	TiO_2	0.64	0.73	0.61
3	Al_2O_3	14.82	16.68	15.72
4	$FeO+Fe_2O_3$	11.51	11.32	10.05
5	MnO	0.14	0.17	0.22
6	MgO	8.81	7.24	6.32
7	CaO	10.25	9.60	9.72
8	Na_2O	1.90	2.75	2.15
9	K_2O	0.02	0.37	0.04
10	P_2O_5	0.04	0.04	0.04
11	LOI	6.35	1.12	6.49
12	Σ	99.53	99.84	99.50

Table 3.6. Chemical composition (%) of the fourth-phase rocks of Jurassic Bodratskiy complex [21, 22]

No.	Chemical composition	Sample location and rock name		
		Dolerite-basalts; Dzhydair gorge	Hornblende andesite-basalt; dykes in the right bank of Dzhydair gorge	Andesite; dykes in the Bodrak and Dzhydair gorges watershed
1	SiO_2	49.34	53.48	57.60
2	TiO_2	0.94	0.70	0.68
3	Al_2O_3	17.00	16.47	16.74
4	$FeO+Fe_2O_3$	9.81	8.45	7.96
5	MnO	0.20	0.18	0.16
6	MgO	5.22	3.17	2.94
7	CaO	7.93	7.93	3.85
8	Na_2O	3.05	4.25	4.5
9	K_2O	0.51	1.58	1.87
10	P_2O_5	0.24	0.30	0.68
11	LOI	5.27	5.56	2.95
12	Σ	99.51	99.47	99.50

By the chemistry and mineral composition, the second-phase dolerites of Bodratskiy complex are intermediate between typical island-arc melanocratic basalts (picritic basalts) and boninite series rocks, expressed in their low alkali and phosphorus contents. The time interval of two-pyroxene olivine basalts is defined from the observations that they cut micro-gabbro-porphyrites and dolerites of the first phase and are cut by the leucocratic basalt dykes of the third phase.

The third-phase rocks include steeply-dipping latitudinal or north-west-trending dykes and sill-like bodies composed of leucocratic augite-hypersthene, hypersthene-augite, hypersthene basalts and dolerites, dolerite-basalts and dolerite porphyrites.

The contact alteration is expressed in slight aureoles of dehydrated and roasted rocks. Metasomatic and hydrothermal alteration is insufficient. Post-intrusive deformations are expressed in several fracture systems. Leucocratic two-pyroxene dolerites comprise most widespread petrotype of the third emplacement phase of Bodratskiy complex. These are dark-grey fine-medium-grained massive rocks with abundant plagioclase and low-ferric hypersthene phenocrysts. Numerous vesicles composed of chalcedony (agate) and zeolites are characteristic. Groundmass of micro-doleritic texture is composed of plagioclase laths, hepersthene and accessory minerals. The latter include ilmenite, pyrrhotite, rarely – chrome- and titanomagnetite. The third-phase rocks by chemical composition do correspond to the basalts of tholeiitic and alkaline-earth series (Table 3.5).

The time interval of the third-phase leucocratic basalts of Bodratskiy complex is defined from the observations that they cut two-pyroxene olivine basalt stocks of the second-phase and are cut by andesite and similar rock dykes of the fourth phase.

The fourth-phase rocks include stock-like bodies and steeply-dipping thin dykes of the north-western and north-eastern extension composed of andesite-basalts, andesites, andesite-dacites, and dacites. The typical massif, Shkilniy, is located outside the studied map sheets. At the Bidratskiy and Dzhydairskiy gorges watershed thin dykes are encountered. The contact alteration is expressed in insufficient hornfelsitization aureoles, and metasomatic and hydrothermal alteration – in propilitization. Andesite-basalt comprises the most widespread in the studied area petrotype. The rock is greenish-grey, massive, fine-grained, porphyry-like, with plagioclase and opacitized hornblende phenocrysts. Micro-texture is incomplete-crystalline, microlitic, intersertal, in places micro-dolerite. Rock groundmass is composed of plagioclase microliths and pyroxene and amphibole grains. Accessories are comprised of titanomagnetite. The fourth-phase rocks by chemical composition are relatively high-alumina, moderate-ferric, poor if phosphorus (Table 3.6) and are ascribed to alkaline-earth series.

The time interval of the andesites and andesite-basalts is defined from the observations that they cut the third-phase leucocratic basalts and similar rocks, and are overlain by the flysch rocks of Middle-Late Bathonian Ayvasylska Suite.

In *Sokolynska group of intrusions* at the modern erosion cut two massifs are observed – stock-like and laccolite-like; besides that, intrusive bodies are intersected by drill-holes (Kachynska-1, 2) at the depth 2-3.5 km and weakly studied. The laccolite-like intrusion is crescent-shaped in the plane, extended over 140 m being 25 m thick. The contacts with Tavriyska Series host rocks are cutting and conformable. Intrusion is zoned: its periphery is composed of diabases, and central part – of diorite porphyrites and diorites.

The stock-like intrusion is up to 120 m across. The contacts with host rocks are cutting. Exocontact aureole is 1-2 m wide and includes rock whitening, hornfelsitization, calcitization. Endocontact alteration is expressed in rock crystallization degree. Intrusion is also zoned: its periphery is composed of diabases and diabase porphyrites, and the core – of diorite porphyrites and diorites.

Main rock types include diabases, diabase porphyrites, diorite porphyrites, diorites.

Diabases are greenish-grey, fine-grained rocks with diabase, in places porphyry-like micro-texture, composed of plagioclase laths – andesine-labrador (45-60%), augite phenocrysts (15-20%), chlorite (20%) and ore mineral (3%) grains. Diabase porphyrites are greenish rocks with apo-intersertal, in places porphyry-like texture, narrow plagioclase laths (50%), and fine augite (10-15%) and ore mineral (2-3%) grains, embedded in chlorite mesostasis (25-30%). Somewhere albitization is widely developed – albite (up to 15%) replaces andesine-labrador or does form individual idio-blasts in chlorite mesostasis.

Diorite porphyrites are grey, greenish-grey rocks with porphyry-like texture and hypidiomorphic fine-crystalline groundmass. The phenocrysts up to 1.5-3.0 mm in size are composed of andesine (20-25%). Groundmass consists of andesine (40%), augite (15-20%), as well as secondary chlorite (15%) and albite (3-10%).

Diorites are grey rocks with medium-grained diorite texture, composed of andesine (55-60%), augite (15%), chlorite (15-20%). Accessories: magnetite (2%) and leucoxene (1-3%). Secondary minerals include chlorite, developing after pyroxene and plagioclase, and albite (up to 15%), calcite (3%) and quartz (1-5%). Rock chemical composition of Sokolynska group of intrusions is given in Table 3.7.

Foroska group of intrusions includes about 50 minor points of sheeted bodies located in Tavriyska Series rocks. At the modern erosion cut they are not exposed well enough yet and almost not expressed in the relief. By composition, these are diabase and diorite porphyrites of massive and vesicular texture. Exocontacts are expressed in the thin zone of host rocks hornfelsitization.

Melaska group of intrusions is comprised of the stock-like body up to 40 m across, and some minor bodies. They are located in Karadazka Suite and Tavriyska Series and composed of diabase porphyrites. Exocontact alteration is insufficient and expressed in whitening, silicification and hornfelsitization of the host sandstones and argillites.

Kastropolska group of intrusions consists of six minor stock-like and dome-shaped massifs from 10 to 100 m in size located in Karadazka Suite and Tavriyska Series. Intrusions are well exposed, especially

Mukholatskiy dome, and expressed in the relief having relative elevation from 10 to 50 m. They are composed of diabase and micro-diabase porphyrites. Exocontact zone, expressed in silicification and hornfelsitization, is up to 3-4 m thick. Rock chemical composition of Kastropolska group of intrusions is given in Table 3.7.

Limenska group of intrusions include couple of bodies, of which the biggest one – “Verblyud” (Camel) massif, at the modern cut is 100 m thick. The bodies are located in Karadazka Suite and composed of albitized diabase porphyrites. Exocontact alteration is expressed in silicification and calcitization. Sulphide mineralization (galena, sphalerite, pyrite) is confined to the contact metasomatites.

Bodratskiy subvolcanic complex is ascribed to gabbro-diabase formation. Individual emplacement phases belong to several petrochemical series – tholeiitic, alkaline-earth and one close to boninitic. By the complex of evidences, the rocks represent the island-arc association. By chemistry the rocks are similar to Karadazka Suite volcanics in Kachynske uplift. The rocks of subvolcanic bodies, in general, are more melanocratic in comparison to volcanics. In the complex formation the fractional crystallization processes had played important role. Sulphide and mercury mineralization findings indicate mercury-polymetal specialization of the complex although in general the ore-bearing features of the complex are weakly studied. The complex has been formed at considerable depth. General geological setting (preserved intrusion roofs), mineral composition, structure-texture patterns, and geochemistry suggest for low erosion cut.

Table 3.7. Chemical composition and numeric indicators after A.M.Zavaritskiy [9a] of mafic rocks of Bodratskiy complex [40, 14-16]

No.	Chemical composition (%) and numeric indicators	Sample location							
		Sokolynska group of intrusions			Kastropolska group of intrusions			Limenska group of intrusions (Pylyaky Mountain)	
		Diabase porphyrite	Diabase	Diabase porphyrite	Diabase	Diabase porphyrite	Diabase porphyrite	Albitized diabase porphyrite	Albitized diabase porphyrite
1	SiO_2	47.24	46.65	47.31	44.05	48.34	48.65	50.13	51.55
2	TiO_2	0.46	0.44	0.48	0.48	0.46	0.45	0.71	0.83
3	Al_2O_3	18.52	15.80	15.80	14.75	15.89	15.77	16.35	16.51
4	Fe_2O_3	1.93	0.96	3.06	1.48	3.21	2.86	2.68	3.02
5	FeO	7.00	6.82	5.83	6.37	5.30	5.56	7.90	7.90
6	MnO	0.13	0.11	0.10	0.20	0.12	0.11	0.14	0.14
7	MgO	5.64	6.75	8.72	4.64	9.88	9.07	4.79	4.96
8	CaO	4.35	11.07	6.59	12.83	5.05	5.05	5.05	4.63
9	Na_2O	5.38	2.01	3.69	2.07	3.83	3.95	6.49	6.37
10	K_2O	0.84	0.27	0.46	0.14	0.43	0.48	0.11	0.11
11	P_2O_5	0.20	0.22	0.23	0.20	0.13	0.17	0.13	0.13
12	LOI	3.75	3.61	3.97	4.98	2.80	3.44	2.33	2.35
13	a	14.4	5.20	9.4	5.5	9.4	10.1	15.0	14.4
14	c	5.8	9.10	6.6	8.7	6.5	6.2	3.9	4.1
15	b	20.5	26.6	26.4	27.2	25.9	24.8	21.3	20.8
16	s	59.3	59.01	57.6	58.6	58.2	58.9	59.8	60.7
17	a’	50	48	59	-	-	-	-	-
18	f’	5	-	-	32	32	33	49	50
19	m’	45	31	33	34	68	66	39	42
20	c’	-	21	8	34	-	1	12	8
21	n	91	93	93	96	94	93	99	97
22	Q	-16.0	-1.3	-10.2	-2.5	-8.6	-8.6	-14.3	-11.6
23	Σ	99.49	100.65	99.49	100.66	99.72	99.56	100.15	100.14

The complex age is Late Bajocian – Early Bathonian, defined by emplacement of intrusive bodies into extrusive pile of Karadazka Suite and their overlaying by Middle Bathonian – Early Callovian clayey Ayvasylska Suite. Absolute age, determined by K-Ar method, is 138-145 Ma [21].

In the map sheets L-36-XXVIII and L-36-XXXIV, in the field of Paleogene rocks, some magnetic anomalies are known, which can be thought are "blind" intrusive massifs. The biggest one, up to 700 nTl Poshtovska magnetic anomaly is located to the north-west from Bodratska group of minor intrusions. It is split in two local maximums with the same parameters, of which one is located outside the studied area. In the map sheet territory this anomaly intersected by DH 18 [64]. Beneath Paleogene and Cretaceous rocks, at the depth 973.6-816.6 m, the intrusive body is intersected with main petrographic rock types including diabase porphyrites, gabbro-diorites, diorites.

Diabase porphyrites are greenish-grey with porphyry-like texture. Groundmass is cryptic-crystalline to fine-grained, composed of fine plagioclase (labrador) laths, carbonatized, it occupies up to 85% of the rock volume. Phenocrysts (15%) include tabular, zoned plagioclase (bytownite) crystals 0.3-1.0 mm in size, and prismatic augite grains 0.3 mm in size.

Gabbro-diorites are dark-grey to black, fractured. Texture is gabbro-diabasic, comprised of idiomorphic plagioclase and augite crystals. Secondary processes are expressed in silicification, calcitization, alushtitization and chloritization.

Diorites are grey with greenish shade, full-crystalline, with dioritic and hypidiomorphic texture, composed of idiomorphic plagioclase (andesine), augite and quartz crystals. Ore minerals include pyrite and chalcopyrite micro-grains. Secondary alteration includes alushtitization and chloritization. Absolute age of intersected rocks is not defined yet but on the ground of available evidences they can be ascribed to Bodratskiy complex.

Talking about intrusive rocks in Mountain Crimea, it is worthy to remind on the boulders of granitoids at Balaklava town outskirt and in Oboronne village. They are composed of plagioclase granitoids, quartz diorites and plagioclase granites. Macroscopically these are grey, coarse-grained, massive rocks. Macro-texture is hypidiomorphic and poikilitic. Main minerals include quartz (31-41%), feldspars (38-54%), green hornblende (4-12%), biotite (6-10%). Accessories (1-1.5%) include apatite, zircon, magnetite. Post-magmatic processes are expressed in biotite chloritization, and plagioclase epidotization and sericitization. By chemical composition (Table 3.8) these are sodium-range rocks, similar to the rocks of felsic dome-shaped intrusions of the Crimean Southern Coast. Granitoid boulders are confined to the northern limb of Crimean Mountains and it is most likely they are brought down over there by the mudflows from the ancient southern mountains. The source region location in the south (in the sea) is evidenced by the lacking of similar granitoids in the northern plain. Their absolute age is 210-281 Ma [16, 24], that is, Late Paleozoic – Triassic.

Table 3.8. Chemical composition (%) of Balaklavski granitoids [21, 22, 14-16]

No.	Chemical composition	Sample location and rock name		
		Plagioclase granite; Balaklava town outskirt	Plagioclase granodiorite; Balaklava town outskirt	Quartz diorite; Balaklava town outskirt
1	SiO_2	68.28	65.02	54.34
2	TiO_2	0.43	0.56	-
3	Al_2O_3	14.52	14.05	18.01
4	Fe_2O_3	0.74	1.83	1.10
5	FeO	3.65	4.46	4.40
6	MnO	0.06	0.04	-
7	MgO	1.2	2.66	2.60
8	CaO	4.83	5.16	6.59
9	Na_2O	3.21	3.17	4.56
10	K_2O	0.40	1.73	2.27
11	P_2O_5	0.11	0.15	-
12	CO_2	1.69	0.18	-
13	SO_3	-	-	-
14	Σ	99.51	100.74	99.32

Intrusive magmatism in the western part of Mountain Crimea, in general, is tholeiitic and alkaline-earth in composition with transitions to shoshonite and boninite series. Erosion cut of intrusives is low and they are weakly exposed respectively. In shape, the intrusives are dome-, stock- and dyke-like. By the forming time, these are mainly Middle Jurassic rocks with absolute age, after K-Ar method, in the range 135-170 Ma [21]. The distinct features of Crimean "minor intrusions" include high alkali content with subordinates potassium role (n=80), except the fourth phase of Gerakleyskiy complex, and relatively low alumina content, Fe_2O_3 predomination over FeO, high MgO and moderate TiO_2 contents, high level of crystallization water and CO_2. Losses on ignition at the level of 6% suggest for extensive post-magmatic processes and high level of vapor and other volatiles in magma. The gold-polymetal and mercury-polymetal specialization of intrusive complexes is identified.

4. TECTONICS

Geotectonic layout of the map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) includes fragments of two major structures: Scythian plate in the north and Mountain Crimea in the south (see “Tectonic scheme in the scale 1:500 000”).

In the Scythian plate the first-order (I) structure is distinguished – Tsentralnokrymske uplift. Mountain Crimea in the map sheet area is only comprised of its south-western part.

In tectonic respect, in the area geology by composition, metamorphic degree and rock dipping two tectonic levels are distinguished: the lower, basement of pre-Alpine consolidation (C_3-J_3), and upper, Alpine platform complex (K_1-Q).

The lower tectonic level includes Herzinian (C_{1-2}) and Kimmerian (T_3-J_3) tectonic floors, and upper level – lower- (K_1-N_1^1) and Upper Alpine (N_1^2-Q) tectonic floors.

In both the Kimmerian and Upper Alpine tectonic floors two sub-floors are distinguished.

The first-order structures of various tectonic floors and sub-floors the higher-order structures are distinguished.

Lower (pre-Alpine) tectonic level (C_1-J_3)

Herzinian tectonic floor (C_{1-2})

Herzinian tectonic floor problematically constitutes the lower part of structures in Tsentralnokrymske uplift, where in the studied map sheets they include Novoselivske and Simferopilske uplifts.

Litho-tectonic complexes of the given floor are encountered in the course of drilling for oil and gas (in adjacent map sheets L-36-XXI, L-36-XXII), as well as by mapping drill-holes under DGM-50 and EGSF-200 [38].

In Novoselivske uplift (in the mentioned map sheets) the intersected portion of Herzinian tectonic floor is composed of Novoselivska Suite of Upper Carboniferous green-schist complex. The hanging-wall depth varies from 800 m (to the north from the studied area) to 155 m.

In Simferopilske uplift this floor is composed of Carboniferous Zuyska Suite of black coaliferous shales and Novoselivska Suite of green schists. Maximum thickness of the floor exceeds 3000 m (DH Melnychna-1 in adjacent map sheet L-36-XXIX).

In the given floor magnetic field is reduced along sub-latitudinal zones while regional gravity field is increased indicating deep crustal structure and general sub-latitudinal strike changes. Isometric magnetic field anomalies, caused by igneous rocks, are also characteristic.

Herzinian tectonic floor is accompanied by Novoselivskiy subvolcanic complex and Zuyskiy complex of minor intrusions comprised of diabase porphyrite, gabbro-diorite and granodiorite sills and dykes.

However, in the studied area aforementioned complexes are not intersected by drill-holes and, consequently, not studied so far.

The fault tectonics is weakly studied yet. Formation of Herzinian litho-tectonic complex has been accompanied by emerging deep-seated zones along sub-latitudinal and diagonal tectonic breaks up to some kilometers in amplitude. Deep-seated faults, developed in Baikalian and Early Kimmerian times, do play control functions in Herzinian tectonic floor over studied map sheets. Of the first ones, two deep-seated faults are distinguished, specifically, Salgyro-Oktyabrskiy fault which bounds Simferopilske uplift from the west and in the south joins suture junction zone of Scythian plate and Mountain Crimea structures, and Evpatoriysko-Skadovskiy fault, which is extended from Prychornomorska depression into the most subsided area of Alminska depression.

In the second group of Herzinian fault structures, Evpatoriysko-Krasnogvardiyskiy deep-seated fault which bounds Novoselivske uplift from the south, and Kalynivskiy fault which bounds Simferopilske uplift from the north-west are most important.

Other deep-seated faults either complicate the internal (stair-like) structure of Herzinian basement or had appeared at the late stage of the young Scythian platform formation.

Kimmerian tectonic floor (T_3-J_3)

Two sub-floors are distinguished in this floor. The lower sub-floor is throughout developed while the upper one is only distinguished in the Mountain Crimea.

Lower sub-floor (T_3-J_2k)

In Tsentralnokrymske uplift it is developed in Novoselivske uplift and in Alminska depression. In Mountain Crimea it is throughout developed.

The lower tectonic sub-floor consists of Upper Triassic – Lower Jurassic flyschoid formation and Lower-Middle Jurassic terrigenous-volcanogenic formation. The rocks are arranged in the system of tight, fault-complicated, often over-turned folds.

Tsentralnokrymske uplift

In Novoselivske uplift the lower sub-floor is intersected by drill-holes for oil and gas located outside the studied map sheets (L-36-XXI, L-36-XXII). It is composed of clayey shales, aleurolites, marls containing limestone and dolomite interbeds and porphyrite layers. Sub-floor hanging-wall depth is 800-2000 m and its thickness attains 850 m.

In Alminska depression sub-floor is encountered by drilling for thermal waters in Sakska structure, as well as in vicinity of Mykolaivka village [18].

In *Sakska anticline zone* (Sakskiy tectonic ledge) the Middle Jurassic rocks hanging-wall depth is up to 740 m, and in adjacent areas of Alminska depression it attains 1000-1200 m.

Sub-floor is composed of terrigenous, slightly-metamorphosed but highly dislocated Upper Triassic, Lower and Middle Jurassic rocks up to 1000 m thick.

According to geophysical data, the fragment of up to 700 nTl Poshtovska magnetic anomaly is clearly distinguished. In the studied map sheets the anomaly is drilled by DH 18 [64] where below Paleogene and Cretaceous sediments, at the depth 973.6-816.6 m the intrusive body of Bodratskiy subvolcanic complex is intersected composed of diabase porphyrites, gabbro-diorites and diorites [64].

Mountain Crimea

In the studied area, the south-western part of the east-north-east-trending structure is located. The core and northern limb are distinguished. The core is exposed in the Main ridge of Crimean Mountains, and in that part which is preserved in the land, it is composed of Triassic and Jurassic sediments. The southern core part and western core closure are subsided beneath the Black Sea water line.

The Mountain Crimea has been set on the Baikalian folded base and was inheritedly developing over Kimmerian and Alpine stages. The fold-block structure of Mountain Crimea consists of orthogonal and diagonal systems of trans-crustal and crustal deep-seated faults. It is evidenced by entire complex of tectonic, litho-facial, mineralogical, paleo-geographic, geophysical and hydrogeological records, as well as tectonic position, morphology and geochemistry of igneous rocks in the area. The latter constitute the western tectono-magmatic block with characteristic central-type morpho-structures defining position of specific paleo-volcanic ring structures within the single paleo-volcanic arc [24]. Tectonic position of paleo-volcanic centers is defined by the zones of deep-seated faults (Krymskiy and Pivdennokrymskiy).

In the Mountain Crimea Kimmerian tectonic floor constitutes Kachynskiy, Sukhoritskiy and Pivdennoberezhniy blocks, as well as Gerakleyskiy volcano-tectonic block.

Tavriyska Series comprises the basement of all tectonic elements: in the cores of block uplifts it is exposed at the surface, while in depressions it is subsided and overlain by Middle and Upper Jurassic and Lower Cretaceous. The Series rocks are arranged in the fine folds, in places highly deformed, and Jurassic and Cretaceous rocks in the central depression parts are almost horizontal dipping, and in the south only they are pulled-up and dip steeply enough.

In the studied area the south-western peripheral part of *Kachynskiy block* is located. It is composed of Middle Jurassic Tavriyska Series, Vidradnenska, Karadazka and Ayvasylska suites. The internal structure of the block is intricate and is not completely deciphered. Tavriyska Series is deformed into numerous folds and complicated by the thrusts. Middle Jurassic sediments are arranged into brachy-form fold structures and their dipping is more flat. Drill-hole KCH-2 [40] in the Belbek River valley, nearby Aromat village, in the field of

Tavriyska Series rocks, drilled to the depth more than 4000 m, did not get underlaying sediments. The column over there includes Tavriyska Series flysch with numerous dykes and hypabyssal bodies of Bodratskiy complex.

In the studied area the western part of *Pivdennoberezhniy block* is located being extended along Black Sea coast from Megalo-Yalo harbor in the west to Simeiz town in the east; this block comprises the northern limb of structure buried beneath Black Sea line. The Block is composed of Tavriyska Series flyschoid sediments as well as Lower and Middle Jurassic terrigenous and volcanogenic rocks. In the Block fold structure some higher-order structures are distinguished: Laspinska, Foroska anticlines, separated by tight overturned synclines. In addition, Melasko-Limenska volcano-tectonic zone is distinguished in the Block, being composed of the basalt and andesite-basalt flows and dykes, as well as micro-gabbro-porphyrite dykes of Bodratskiy subvolcanic complex.

Thickness of the lower sub-floor in the Block exceeds 2500 m.

Sukhoritskiy block comprises minor uplift (block-anticline) in the Sukha Richka gully mouth composed of Upper Triassic and Lower and Middle Jurassic rocks, from north-east to sub-latitudinal strike.

In the core the Upper Triassic and Lower Jurassic rocks are exposed which are overlain by Bathonian-Callovian sediments in the limbs. Structure axis plunges in the north-eastern direction where its core is overlain by Upper Jurassic limestones of highly reduced thickness. The rock dipping angles in the fold limbs attain 20-40^o.

Gerakleyskiy volcano-tectonic block does spatially occupy the same-named peninsula. It is composed of mafic and intermediate lava flows, cut by gabbro-porphyrite, andesite-basalt, andesite, rhyolite and rhyodacite stocks, dykes, extrusions and sills of Middle Jurassic Gerakleyskiy subvolcanic complex.

The lower sub-floor of Kimmerian floor is overlain by the rocks of Alpine tectonic floor. The lower sub-floor is intersected by a number of mapping and some parametric drill-holes. The hanging-wall depth in the south does not exceed 40 m and in the northern direction it plunges down to the depths 600-800 m.

Fault tectonics in the Mountain Crimea does play important role in the geology of the lower sub-floor of Kimmerian tectonic floor. The deep-seated Krymskiy fault, which is the junction zone of young Scythian plate and Mountain Crimea, comprises the major break structure in the area. This fault is traced by DSS over all seismic horizons and is well expressed in the magnetic field map. This is about 10 km wide band of north-eastern strike accompanied by magmatism and hydrothermal activity.

Displacement plane of this structure is also complicated and expressed in the system of contiguous sub-parallel high-order faults, which go down in the stair-like fashion to the south-east and accompanied by physical field anomalies, magmatic activity, secondary mineralization and extensive rock deformations.

The fault under consideration is long-lived which played important role both in the beginning stages of Crimean development and in Middle Jurassic times, as well as in the period of neo-tectonic activation. It is evidenced by the late-seated fault taking up in suture zone and even deep-seated faults like Chornoritskiy.

The second-order faults are structure-forming deep-seated faults; they are lesser in the scale but more localized: Georgiivskiy, Sukhoritskiy, Batylimanskiy.

G e o r g i i v s k i y r e v e r s e f a u l t comprises the south-eastern suture of Krymskiy deep-seated fault. It is well expressed from Marmurova gully to Bilokamyansk town and further to Simferopil city. The fault is accompanied by volcanism and hydrothermal processes.

The fault controls development of litho-tectonic complexes in the north-west and north of Mountain Crimea; the best example is complete pinching out of Upper Jurassic sediments away from the fault.

S u k h o r i t s k i y r e v e r s e - n o r m a l f a u l t is of north-eastern direction, with some hundred of meters amplitude, and subsided southern limb. The fault is accompanied by the crushing and hydrothermal alteration zone (it is part of Demerdzhiyskiy-Baydarskiy fault which bounds Sukhoritskiy block).

B a t y l i m a n s k i y n o r m a l f a u l t is one with some hundred of meters amplitude and subsided northern limb. It is accompanied by the crushing and folding zones in Deymen-Derynska Suite as well as hydrothermal alteration.

The local faults are most confidently studied. Of these, diagonal faults are best expressed, both longwise (north-eastern) and crosswise (north-western).

Of the longwise faults, reverse and reverse-shear faults predominate with pisplacing plane dipping to the north-west under the angles 50-70^o and displacement amplitudes up to 100 m (Khersoneskiy normal fault, Zakhidniy normal fault, Sevastopolskiy reverse-normal fault, Fiolentskiy reverse fault, as well as Kuchuk-Muskaminskiy, Kokiya-Belskiy, Limenskiy normal faults and others).

Crosswise breaks of north-western strike include normal faults, reverse faults, shears and reverse-shear faults with vertical and steeply-dipping shears (Monastyrskiy reverse-shear, Flotskiy reverse fault, Karantynniy reverse fault, Foroskiy normal-reverse fault, Kuchuk-Kairskiy and Kuchuk-Koyskiy normal faults).

The inter-block breaks in Pivdennoberezhniy block also cut the rocks of Pivdennozakhidna block-monocline where they are best expressed. The time of their setting is not later than Middle Jurassic but their activation was multi-phase and appeared at various times.

All these faults are expressed at the surface in crushing zones with kaolinization and silicification in Tavriyska Series rocks, and the zones of marbling in Upper Jurassic and Lower Cretaceous limestones.

The thrusting structures do not play considerable role in the area geology and are of relatively low (up to 1 km) horizontal displacement amplitude.

The certain role in the geology of Gerakleyska tectono-volcanic zone is played by the faults related to tectono-magmatic structures appeared during emplacement of intrusive bodies (radial faults). These are the dykes and subvolcanic intrusions that are confined to the radial and ring faults.

Besides inter-block faults, some minor breaks of intra-block type are distinguished. By morphology, these are normal and normal-shear faults with amplitude 10-40 m. These are the faults which are best expressed – they are accompanied by crushing zones, friction planes, and hydrothermal alteration (calcitization, iron-enrichment).

In general, the faults exhibit inherited development and displacement along the faults from Middle Jurassic to Quaternary time are identified.

Upper sub-floor (J_3o-J_3tt)

This sub-floor constitutes Pivdennozakhidna monocline of Mountain Crimea. By the setting and tectonic features three major blocks are distinguished: Balaklavskiy, Varnautsko-Baydarskiy and Ay-Petrinskiy.

The upper tectonic sub-floor is composed of Upper Jurassic marine carbonate and molassa formations. Litho-facial conditions and tectonic features allow two tectonic horizons distinguishing separated by the Late Kimmeridgian interruption in sedimentation. The upper sub-floor rocks, in comparison to the lower sub-floor ones, constitute more gentle and large fold structures complicated by the breaks. From the lower tectonic sub-floor they are separated by the Middle Callovian interruption in sedimentation and sharp angular unconformity.

Upper (Alpine) tectonic level (K1-Q)

In the studied map sheet area it is throughout developed. The upper (Alpine) tectonic level includes Lower Cretaceous terrigenous-clayey and volcanogenic-terrigenous formations, Upper Cretaceous – Eocene terrigenous-carbonate formation, Oligocene – Lower Miocene clayey formation, Miocene carbonate-terrigenous formation, and Pliocene – Anthropogenic molassoid red-color formation. The upper level rocks gently dip and are less affected by the faults. In tectonic respect the upper level is divided in two tectonic floors: Lower Alpine and Upper Alpine.

Lower Alpine tectonic floor

It is developed over most part of the territory in Tsentralnokrymske uplift and Mountain Crimea.

Tsentralnokrymske uplift

By geological setting and composition the II-order structures are distinguished: antiform – fragments of Novoselivske and Simferopilske uplifts, and synform – Kalynivskiy trough and Alminska depression.

Novoselivske uplift in the studied area is comprised of its south-western margin. Its most elevated part is located to the north in adjacent map sheet L-36-XXII. From the south-east uplift is bounded by Kalynivskiy trough and Vynogradivska syncline zone is located at the border. In the north-western direction the uplift plunges down in the stair-like fashion into Donuzlavska syncline zone.

The surface altitudes of the given tectonic floor vary from -250 m to -100 m. Most elevated portion of structure is constituted of the frontal part of two north-east-trending reverse faults and is separately distinguished as Novoselivska anticline zone where Krylovska structure is defined. In the Novoselivska anticline zone the Upper Cretaceous and Paleogene sediments are partly missed from the given tectonic floor.

In general, over there the floor is composed of carbonate-terrigenous, in places volcanogenic rocks from 1000 to 1700 m thick.

Kalynivskiy graben separates Novoselivske and Simferopilske uplifts. Structure is of the north-eastern strike and in the same direction outside the map sheet area followed by Gvardiyskiy trough. In the south-east the graben is separated from Alminska depression by Kalynivskiy normal fault up to 400 m amplitude. In

Kalynivskiy graben the footwall of mentioned tectonic floor plunges to the depth 1200 m while in adjacent structures the footwall lies at the depth 800-1000 m. Upward in the section the graben is replaced by the trough. It is filled with the full complex of Mesozoic-Cenozoic, mainly terrigenous sediments from 800 to 1000 m thick.

Simferopilske uplift in the studied area is comprised of its western margin. In the north it is bounded by Kalynivskiy trough and in the west and south-west it adjoins Alminska depression. In the south, away from the map sheet area, Simferopilske uplift is joined with Mountain Crimea along suture zone.

The western uplift slope is flat, the footwall depth in the north-western and western directions varies from 0 to 500 m over the distance of 40 km. Upper Cretaceous – Eocene columns are reduced in the uplift.

The surface altitudes of Lower Alpine tectonic floor vary from -100 m in the north-west to +100 m in the far eastern part of map sheet L-36-XXVIII.

In general, the floor composition is terrigenous in the lower part and essentially carbonate in the upper one.

In the junction zone with Mountain Crimea the Eocene-Oligocene sediments are partly missed from the column.

Alminska depression encompasses the central part of the studied map sheets. In the north and east it adjoins Kalynivskiy trough and Simferopilske uplift. In the south it adjoins Mountain Crimea by suture zone.

In the depression, by drilling data, the surface of tectonic floor lies at the depth from -300 m to +260 m. Most subsided part is located in Kalamitska bay of Black Sea with subsiding axis along the line Mykolaivka village – Novoselivka village (see "Tectonic scheme in the scale 1:500 000").

In the northern part of depression, in the course of drilling for thermal waters, the Sakska anticline zone is distinguished comprising the distinct basement tectonic ledge. Reduced clayey-carbonate columns of the given floor are characteristic over there.

Mountain Crimea

Mountain Crimea is composed of terrigenous and carbonate rocks of the given tectonic floor and is exposed at the surface in Sevastopolsko-Simferopilska monocline in the north and in Pivdennozakhidniy trough in the south.

Sevastopolsko-Simferopilska monocline. The floor rocks constitute the lower part of the monocline in the External ridge of Mountain Crimea.

From the north and north-west the monocline is bounded by suture junction zone where the floor rocks plunge down in the north-western direction under the angles 4-23^{o}. In the south and south-east the Mesozoic-Cenozoic complex of the monocline with structure and stratigraphic unconformity lies over Kimmerian tectonic floor or by the faults adjoins tectonic structures of Pivdennozakhidniy trough.

By drilling data, in the suture zone the surface of tectonic floor monoclinally plunges to the north-west from +400 m to -100 m nearby Sevastopol city and +200 m in vicinity of Novopavlivka village [1].

Pivdennozakhidniy trough is filled with Lower Cretaceous complex of Lower Alpine tectonic floor. By tectonic features, composition and location in the trough Kanarynska volcano-tectonic zone, Varnautska and Baydarska erosion-tectonic zones.

K a n a r y n s k a v o l c a n o - t e c t o n i c z o n e is located in the north-western part of the trough. The rocks are intersected by numerous mapping drill-holes [31, 40]. Volcanic unit, by geophysical data, is confined to the junction suture zone of Mountain Crimea and Scythian platform and is located in Black Sea [24, 63]. Kanarynska volcano-tectonic zone is composed of mafic tuffs, tuffites and tuff-sedimentary rocks at least 350 m thick.

V a r n a u t s k a a n d B a y d a r s k a e r o s i o n - t e c t o n i c z o n e s are located in the central part of Lower Cretaceous Pivdennozakhidniy trough, in Varnautsko-Baydarskiy block. They comprise isometric erosion depression on the surface of Upper Kimmerian sub-floor and filled with Lower Cretaceous terrigenous complex up to 600 m thick (Fig. 4.1). All boundaries are tectonic and comprise the series of normal and reverse faults with amplitude up to 1000 m.

Fault tectonics has played important role in the formation and structure of the given tectonic floor.

In tectonic respect, the deep-seated and deep faults are of structure-forming value and their activation at the Early Alpine stage has caused differentiation of the I-order structures into the minor ones.

In Tsentralnokrymske uplift, at the border of Novoselivske uplift and Alminska despression, Kalynivskiy graben had emerged along Evpatoriysko-Krasnogvardiyskiy, Sasykskiy and Kalynivskiy faults. In the east, apparently under participation of Salgyro-Oktyabrskiy fault, ascending of the Simferopilske uplift basement had occurred.

The junction suture zone of Tsentralnokrymske uplift in Scythian platform and Mountain Crimea, known as Krymskiy fault (Peredgirniy or Crimean-Caucasus) is of particular geo-structure value.

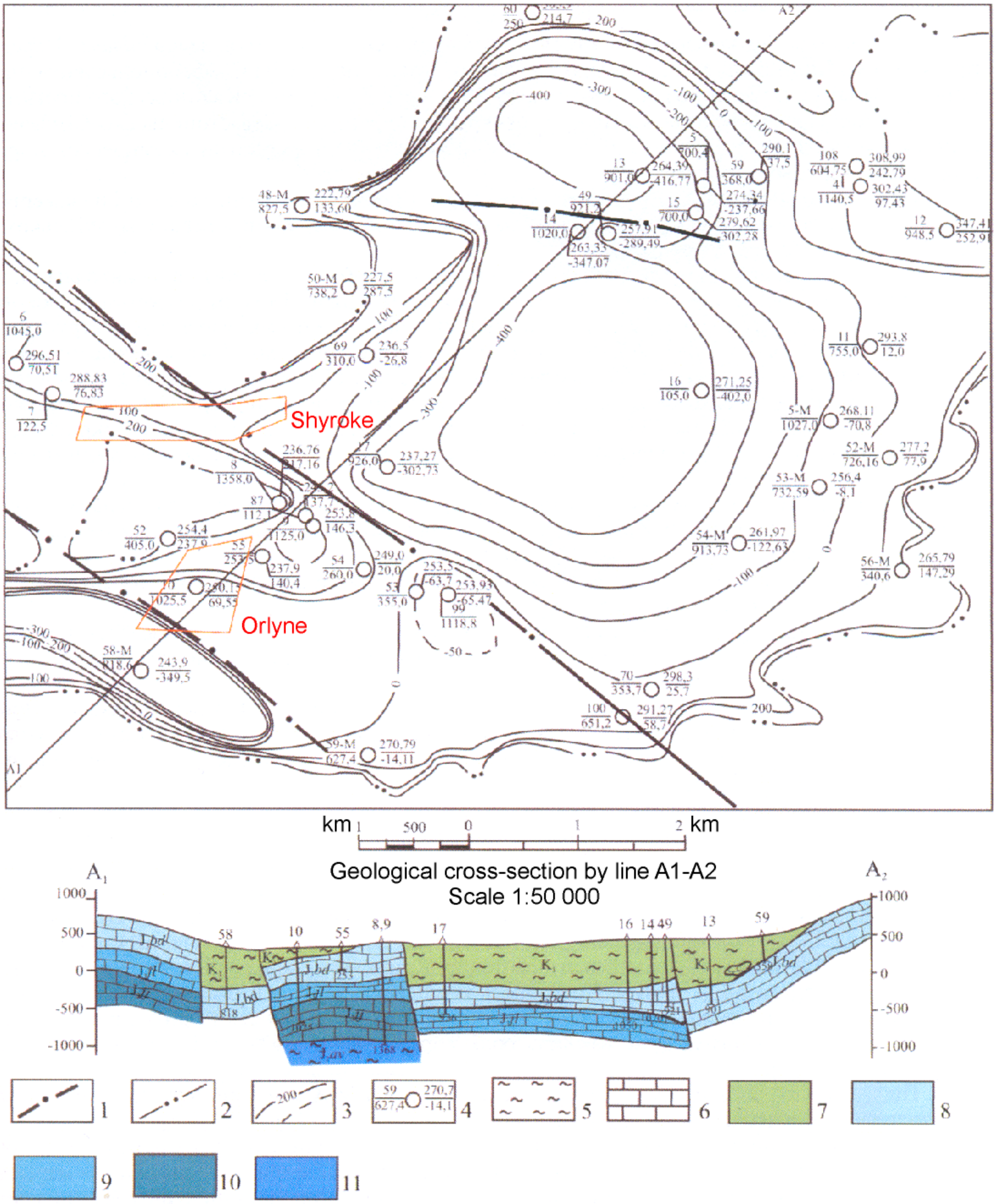

Fig. 4.1. Geology of Baydarska depression (compiled by B.P.Chaykovskiy).
1 – faults; 2 – boundaries of Lower Cretaceous and Upper Jurassic sediments; 3 – hanging-wall contour lines of Upper Jurassic sediments and intermediate contour lines; 4 – drill-holes [40] intersected Upper Jurassic sediments: to the left – drill-hole number in numerator, depth in denominator; to the rights – drill-hole collar altitude in numerator, Upper Jurassic sediments hanging-wall in denominator; 5 – clays; 6 – limestones; 7 – Lower Cretaceous sediments (K_1); 8-11 – Jurassic sediments: Baydarska Suite (J_3*bd*); 9 – Yaltynska Suite (J_3*jl*); 10 – Yaylynska Suite (J_3*jj*); 11 – Ayvasylska Suite (J_3*av*).

In the studied map sheets suture zone is up to 10 km wide and extended from Sevastopol city in the west to the Simferopil city outskirts in the east and controls the steepest portion of monocline plunging under the angles 12-28°. Tectonic activity of the zone has been expressed over entire Apline stage of the territory development. In the Lower Alpine tectonic floor it is expressed in the stratigraphic unconformities with Upper Cretaceous and Paleogene partial or complete missing from the column.

In the geophysical fields suture zone is expressed in the sharp changes of Δg_{tot} from negative in Alminska depression to positive ones characteristic for Sevastopolsko-Simferopilska monocline.

The higher-order breaks in the II-order structures of Tsentralnokrymske uplift had been expressed later in time. In Mountain Crimea these breaks are inter-block and intra-block. The inter-block breaks have mainly affected formation of the Lower Alpine tectonic floor. These breaks had been set in Kimmerian stage of Mountain Crimea development and in the Early Alpine stage they have caused formation of inter-mountain depressions separating the latter within Mountain Crimea.

By the prevailing direction, sub-latitudinal and crosswise diagonal breaks are distinguished.

The first-type breaks in the northern margin of Pivdennozakhidniy trough are reverse faults with the displacement plane dipping to the north. In the southern trough margin the breaks are mainly normal faults. Displacement amplitudes do attain 1200 m.

The second group of breaks includes normal faults and normal-shear faults set up somewhat later of the sub-latitudinal ones. The vertical displacement amplitudes along these breaks do not exceed first hundreds of meters, and horizontal displacement – 1000 m.

Upper Alpine tectonic floor (N_1^2-Q)

This floor completes the general tectonic history in the area. By the internal structure patterns it is divided into lower and upper sub-floors.

Lower sub-floor (N_1^2- N_1^3)

It is widely developed in Tsentralnokrymske uplift where constitutes Fore-Mountain ridge of Crimean Mountains, the surface of Tarkhankut-Novoselivske and Simferopilske uplifts, and the middle part of Cenozoic column in Alminska depression and Kalynivskiy trough.

In Mountain Crimea the given sub-floor is developed in the suture zone of Sevastopolsko-Simferopilska monocline. It is composed of Middle and Upper Miocene terrigenous-carbonate rock complex.

In Tsentralnokrymske uplift II-order structures, which had been set up on Kimmerian stage and completely developed on Early Alpine stage, are only partly modified on Upper Alpine stage.

Kalynivskiy trough was developing under compensated mode, that is, was filling with Lower Alpine rock complex up to 260 m thick between Sakskiy and Kalynivskiy deep faults.

Lower Alpine rock complex constitutes Novoselivske uplift at the surface. It is intersected by the river erosion in Alminska depression and surrounds the latter from the south-east in Peredgirske cuesta ridge, capping the column of Sevastopolsko-Simferopilska monocline of Mountain Crimea at the same time. Sub-floor hanging-wall altitudes in both uplifts and their periphery towards the central part of Alminska depression vary from +200 m to -40 m.

The lower sub-floor of Upper Alpine tectonic floor with regional interruption and angular unconformity in the central part of Alminska depression and in Simferopilske uplift is overlain by the friable rocks of upper sub-floor.

The *fault tectonics* is reflected in neo-tectonic motions in the beginning and at the end of sub-floor formation.

The first activation had occurred in Late Oligocene – Early Chokrakskiy time and confined to the deep fault zones and suture zone where displacement amplitudes had attained first hundreds of meters.

The second activation is related to Middle-Late Pontychniy time. It had developed under impulse mode in the conditions of compression-extension resulted in low-amplitude reverse faults sub-parallel to the suture zone strike, Evpatoriysko-Krasnogvardiyskiy and Kalynivskiy deep faults.

Upper sub-floor (N_2-Q)

Sub-floor has been formed in structures, composed of the lower tectonic floor, overlaying the latter with regional stratigraphic unconformity over entire studied area. It is comprised of Late Cenozoic terrigenous complex and constitutes the modern surface of Tsentralnokrymske uplift and the northern part of Mountain

Crimea. The given tectonic sub-floor does correspond to the phase of the latest orogenesis in Mountain Crimea and neo-tectonic activation of the territory in a whole. The rock complex thickness in uplifts and Mountain Crimea does not exceed first tens of meters and in Alminska depression it attains 70 m.

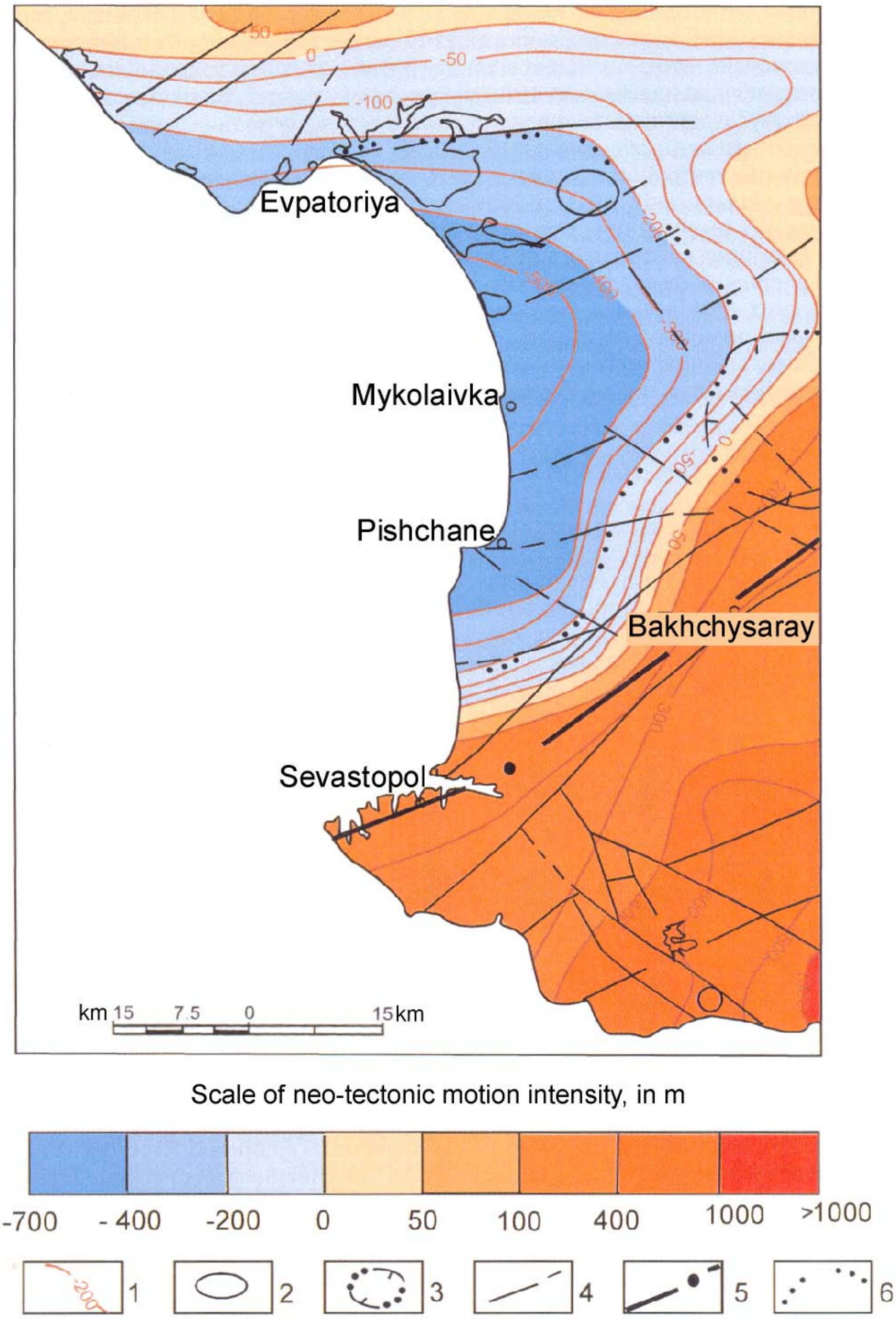

Fig. 4.2. Scheme of neo-tectonic and contemporary motions (after V.P.Palienko [12]).
I – isobases of bulk amplitudes of neo-tectonic movements of Earth crust (m); 2 – neo-tectonically-active local structures; 3 – ring anomalies distinguished after satellite images; 4 - neo-tectonically-active breaks.
Geological boundaries: 5 – platform and orogenic structures; 6 – Alminska depression.

Neo-tectonics does play important role in the sub-floor formation and the modern surface in the studied map sheets.

Reverse faults, set up at the end of Late Miocene, have been quite active over Pliocene-Quaternary time.

Most considerable reverse faults are encountered in pre-Quaternary surface of Alminska depression. The modern river network has been developed along these faults in Quaternary time. These breaks include Bogaylykskiy, Bulganatskiy, Alminskiy and Kachynskiy reverse faults and Evpatoriyskiy normal fault.

Aforementioned reverse faults differ in the time of neo-tectonic activation.

Analysis of thickness, paleontological remnants and column structure of the upper tectonic sub-floor indicates that under compression conditions Bogaylykskiy reverse fault in the margin of Sakska anticline zone was the earliest. Further in the southern direction the reverse faults were set up following accumulated tangential stress (horizontal tectonic movements).

The activation moment of Alminskiy reverse fault has apparently coincided with the Evpatoriyskiy normal fault deformation resulted in the III-order structure – Pivnichnoalminskiy Pliocene-Quaternary trough. Over there, the full rock column of sub-floor is developed and erosion cut of the relief is moderate or low. Subsidence amplitude over Pliocene-Quaternary time is 50 m at least, and over entire neo-tectonic period is attains 500 m (Fig. 4.2).

Further to the south Pivdennoalminska monocline is distinguished comprising the northern extension of Sevastopolska monocline. Over there, amplitudes of Pliocene-Quaternary motions vary from 0 to +200 m, and over entire neo-tectonic time – from -400 to +200 m.

Activation of reverse faults had occurred at the Pliocene – Eo-Pleistocene boundary and later. It is indicated by the lack of Neo-Pleistocene sediments at the monocline surface. Amplitude of reverse-fault motions is from 10-12 m to 45-60 m.

The contemporary tectonic motions include crosswise north-west-trending normal faults in Alminska depression and activation of deep Chornoritskiy fault. As a result, Alminsko-Kachynska depression has been separated in Pivdennoalminska monocline, and Gerakleyskiy ledge – in Sevastopolsko-Simferopilska monocline. In Alminsko-Kachynska depression subsidence amplitudes in relation to adjacent sites are 30 m. In Gerakleyskiy ledge the rocks of upper tectonic sub-floor are completely eroded.

All the higher-order tectonic breaks are of intra-block nature and displacement amplitudes along these faults do not exceed first tens of meters.

5. HISTORY OF GEOLOGICAL DEVELOPMENT

In the history of the studied area development four major periods are distinguished: Baikalian, Herzinian, Kimmerian and Alpine, which differ in geotectonic regimes and related geological processes.

For the reconstruction of geological development in Baikalian period the present knowledge base is not sufficient. In the map sheet area the litho-tectonic complexes of this period are not accessible so far (data are lacking) for direct observation and study. Perhaps, over that time Paleo-Crimea had comprised the margin of ensimatic island arc in Proto-Tethys, which in Late Precambrian has been located between Eastern-European, African and Arabian plates [26, 28]. Material evidences for this period can be considered the zircon in sandstones of Tavriyska Series and zircon in granite pebbles from the Middle Jurassic conglomerates.

Terrigenous-mineralogical studies have revealed the zircons with estimated age 0.8-1.2 Ga confidently indicating Riphean-Vendian age and development of Precambrian metamorphic, ultra-metamorphic and migmatite rocks over there.

As a result of Late Riphean tectogenesis (Chornomorskiy event, as analogue to Dalslandian orogeny in Scandinavia), the primary complexes have been consolidated and formed the crystalline basement of the young Scythian plate.

More factual information is gathered on the Herzinian period in the area geological development.

In Late Paleozoic (Carboniferous period), in the north of the region, over Baikalian basement of the young Scythian plate, within Paleo-Tethys ocean, sub-latitudinal Novoselivsko-Simferopilskiy trough has been formed, where thick sediments of Zuyska and Novoselivska suites were depositing composed of phillite-like quartz-carbonate-mica, quartz-chlorite and actinolite-epidote-chlorite schists. Herzinian tectogenesis has been accompanied by the green-schist metamorphism and emplacement, in adjacent territories, of subvolcanic complexes: Novoselivskiy – in Novoselivske uplift, and Zuyskiy – in Simferopilske uplift. As a result of Herzinian tectogenesis the mountain unit has been formed, which further on has been peneplenized and subsided below the sea level, while its remnants have only existed later on as the islands. Sedimentation has occurred under conditions of passive continental margin and resulted in the sub-platform sediments, including carbonate ones intersected by drill-holes nearby Evpatoriya town.

One may suppose on the litho-tectonic complexes of that time also after so called “exotic boulders” known in Triassic – Lower Jurassic sediments in the Marta River basin and further to the east from the map sheet area, in the Salgyr River basin. “Exotic boulders” in the studied area include pelitomorphic limestones of Carboniferous Serpukhovian and Bashkyrian stages (Trudolyubivska boulder) or Upper Permian Murgabian stage (boulder in the Marta River basin).

In Plain Crimea in the Early – Middle Triassic the platform sandstone and limestone sequences were depositing.

More reliably Kimmerian period in the south of the territory can be deduced. The oldest Upper Triassic – Lower Jurassic rocks in the lower tectonic level of Mountain Crimea are distinguished in Tavriyska Series.

Late Triassic – Early Jurassic litho-tectonic complexes, involved in Tavriyska Series, were depositing in various paleo-geographic environments. In formation respect, the flysch association has been formed over that time, which in geodynamic respect corresponds to the passive margin litho-dynamic complex, existed in Meso-Tethys ocean to the south from Eastern-European platform.

Litho-tectonic complexes, tectonic patterns, organic remnants, as well as analogies with modern sedimentation at the passive margins, allow the forming conditions reconstruction for the Tavriyska flysch formation. In general, the mode of sediments, their mineralogical-petrographic composition, and organic remnants suggest for sedimentation in the open sea basin with normal salinity (indicated by ammonites) at various bathymetric levels: shelf, continental slope and its foothill. Sedimentation basin is characterized by:

- significant water hydrodynamic activity expressed in numerous flow and wave signs;
- unstable sediments: gravity instability has been provided by the elevation differences between the shelf and continental slope foothill, resulted in both simple slope down-sliding and numerous mud avalanches that gave rise to the flysch and olistostrome sequences;
- under conditions of sedimentation basin over-saturation with clastic material, the terrigenous sediment type predominated while carbonate sedimentation was not possible;
- hydro-chemical water regime during diagenesis has facilitated abundant siderite and iron sulphide formation and caused unfavorable conditions for the life reflected in the scarce organic remnants in Tavriyska Series.

Thus, the full facial profile terrigenous sediments had been deposited on the passive continental margin, from the shelf association (open shallow-water shelf and bar zone, major water-flow fore-deltaic areas) to the association of continental slope (underwater canyon and fan-valley sediments) and association of the continental slope foothill (distal flysch).

Paleo-geographic aspects of Tavriyska Series were elaborated using detailed terrigenous-mineralogical studies and petro-fund reconstructions on the ground of zircon studies which carries most complete information on the composition and age of primary rocks in the source regions. It is established, that from Late Triassic to the end of Lias sedimentation basin of the Series has been supplied by terrigenous material from at least two source regions – "proximal", tens of kilometers apart, and "distal", hundreds of kilometers apart from sedimentation basin. The "proximal" province has played prevailing role providing non-rounded zircons, while the role of "proximal" province with rounded zircons was minor.

The "proximal" province is more variable in the constituting age and petrochemical rock types – the zircons with estimated 1.5 Ga (Proterozoic), 1.2-0.8 Ga (Riphean-Vendian), and 0.7-0.6 Ga (Paleozoic) age are identified. The role of "intermediate" and mafic magmatism increased with its maximum on the Paleozoic stage. Obviously, Herzinian igneous rocks predominated in the "proximal" province (gabbroids, diorites, granodiorites), and the "proximal" source regions can be ascribed to the zone of Herzinides in the basement of Scythian plate.

In the "distal" supplying province Precambrian rocks with estimated age > 1.4 Ga had predominated. The age "spectrum" of respective rounded zircons is similar to the "spectrum" designed after zircon isotopic dating of Ukrainian Shield. Reconstructed petrochemical rock types do also coincide. Just the young rounded zircons (with estimated age 1.3 Ga) do not have their analogues in Ukrainian Shield. Thus, the "distal" supplying province can be associated with Ukrainian Shield and Baikalide belt in the north of Crimea (Bakalska Series), and relation can be also assumed with the medial massif in the south [67].

By the time of the modern Mountain Crimea involvement into the stage of active margin (Late Bajocian – Early Bathonian), the flysch and flyschoid sediments, deposited in Late Triassic and Early Jurassic times, in the subduction zone of Meso-Tethys ocean had constituted the external (frontal) part of volcanic island arc comprised the typical accretion prism. The full facial profile sediments deposited at the passive margin stage, in the "subduction" zone have been "detached" from subducting plate in the deep-water trough due to "bulldozer" effect, and in the batches of deformed sediments have been attached to the trough margin.

In the course of Chornomorska platre subduction in the south, started from the end of Late Jurassic, and in contrast to that, the riftogenic structures have been set up in Alminska depression of Plain Crimea. Flyschoid and sandy-clayey sequences of Urguliyska Suite ($J_{1\text{-}2}$*ur*) (DH Mykolaivska-1) [18] are deposited ever since Early Toarcian to Early Bajocian. In Fore-Mountain and partly Mountain Crimea (in local troughs) flyschoid (Vidradnenska and Urguliyska suites), coarse-clastic (Bitatska Suite) and sandy-clayey coal-bearing (Beshuyska Suite) formations are deposited.

On the stage of active margin, on the continental slope of ensimatic island arc, under conditions of extensive thrusting, the island arc formation of sodium basalt-liparites is formed, distinguished in Mountain Crimea as Karadazka Suite. At the same time, emplacement of Gerakleyskiy and Bodratskiy subvolcanic complexes had occurred including gabbro-porphyrite, andesite-basalt, rhyodacite and rhyolite sills, stocks and dykes.

Volcanism rejuvenation in Late Bajocian – Early Bathonian is related to both subduction along Pivdennoberezhniy fault and activation of Peredgirskiy (Crimean-Caucasus) fault, which supplied material for subvolcanic intrusions, mafic and intermediate lava flows and pyroclastic rocks deposition in the final stage of Middle Jurassic magmatism. Fissure-type volcanic eruptions had occurred by the system of the north-eastern and north-western faults (Fiolent, Melas) under coastal-marine conditions. At Khyr-Pylaky massif the central-type volcanic unit existed providing mafic magma and pyroclastic material eruptions.

Volcanic activity continued over Early Bathonian and then from Middle Bathonian to Early Callovian in the sea basin exclusively the thick and facially-variable sequences of Ayvasylska Suite are deposited composed of terrigenous flyschoid formation.

The short break in sedimentation had occurred in Middle Callovian when the sea escaped from entire studied territory and it comprised slightly cut plain. This regional interruption apparently can be related to the next compression phase in the subduction zone of Chornomorska micro-plate and folding processes where Bajocian-Bathonian sediments have participated. These processes have accompanied by thrusting and associated shearing, completely obscuring stratigraphic relations between individual stratons. In addition, the rock complexes from various facial belts have been spatially mixed and the modern fold-thrust structure of Tavriyska Series is formed where individual piles constitute tectonic wedges of various stratigraphic volumes.

Middle Jurassic complexes have covered the intricate, extensively folded internal structure of Tavriyska Series. Their internal structure is much simpler reflecting relatively stable stage in the region development.

The map sheet territory was involved in marine-type sedimentation basin with slight bathymetric variations and prevailing shallow water sea. Over entire subsequent development Middle Jurassic basin got run inherited and underwent just a few regional transformations reflected in two short (as long as sub-stage) stratigraphic interruptions in Middle Callovian and Late Kimmeridgian. The open, relatively shallow-water shelf condition, proximity of the land and numerous islands had supplied the basin with the local terrigenous material reflected in the coarse-clastic facies.

The multi-phase transgression and regression epoch commenced which had occurred under conditions of unstable tectonic regime but without major cataclysms. All transgressions of that time have been expanded from the south and, with time, the sea coast has progressively moved to the north, towards the land. Respectively, some sedimentation cycles were formed consisting of transgressive and regressive sub-cycles.

At the end of Late Callovian time marine sedimentation is restored in the modern Mountain Crimea after Middle Callovian regression. The area of Gerakleyske plateau remains most hilly land and the northern land of Tsentralnokrymske uplift also remains elevated.

In Late Jurassic time the southern part of map sheet area comprises shallow-water sea with hilly volcanic island archipelago where since Late Callovian time the reef massifs, surrounded by the coarse-clastic rock band have been developed. The area of Fiolent volcano is the best example, where Sukhoritska Suite conglomerates are developed to the east and further eastward they are replaced by Yaylynska Suite of coral-algae limestones. During Late Oxfordian and Early Kimmeridgian times the thick terrigenous-carbonate formation is deposited. Thickness of reef sequences attains 500 m and increases further to the east.

The reef island archipelago is formed providing the Major Crimean barrier reef extended over entire modern Mountain Crimea. It consisted of individual large reef massifs connected with horizons of layered pelitomorphic and organogenic-detritus limestones into the common reef structure. To the north, in front of the northern land, the narrow shelf was located and then the coastal plain. Oxfordian – Early Kimmeridgian sea transgression was so broad that sea has even captured volcano island archipelago (Melas, Khyr-Pylyaky). To the south from the barrier reef the continental slope is located with subduction zone underwent the stage of relative stability.

New short activation of subduction zone had occurred in the Late Kimmeridgian time. This caused regional interruption in sedimentation that even had not accompanied by the change in lithology and angular unconformity.

Tithonian time differs in widespread carbonate-terrigenous sedimentation in shallow-water shelf and reef sediments at the external shelf margin. In Mountain Crimea the external margin of Tithonian shelf is expressed in the band of Tithonian reefs constituting Baydarska Suite (reefs of Kyzyl-Kaya, Eli and other mountains), and the continental slope – in the thick sequence of Deymen-Derynska Suite carbonate-clayey flysch. In the western part of this territory the open shelf was relatively narrow under influence of volcanic archipelago in Gerakleyske plateau; in this direction limestones first became “pudding” and then have been replaced by conglomerates of Kalafatlarska Suite composed of the local-origin fragments.

The area of carbonate sedimentation comprised shallow-water shelf where under hot climate conditions massive reef units had formed, which underwent from time to time the periodic destruction because of the active sea hydrodynamics (storms, tsunamis). This is why Baydarska Suite, except some reef massifs (Kyzyl-Kaya Mountain), is composed of red-color limestone breccia and conglomerate-breccia, tightly related in their genesis to the reef formation and not related to the olistostrome sequences, which indicate significant horizontal displacements.

The modern Plain Crimea, to the north from Fore-Mountain (Krymskiy) deep-seated fault, had comprised the continental area where parti-coloured formation was depositing; later on, because of the broad Early Cretaceous transgression, this formation has been completely eroded.

Upper Tithonian Bedenekyrska Suite marks the closed-shelf sites (lagoons) where layered limestones and marls were depositing under the stable conditions with abundant complex of marine foraminifera and calpionelida.

In general, Pivdennozakhidna block-monocline is formed in Late Kimmerian stage within the modern Mountain Crimea structure, where Sukhotsko-Baydarska and Ay-Petri-Babuganska litho-tectonic zones are distinguished.

With Cretaceous period beginning the territory is entered into Alpine development period consisting of two major stages – Early Alpine (K_1-N_1^1) and Late Alpine (N_2^1-Q). Sedimentation cycling analysis allows specific phases distinguishing in these stages: Early Cretaceous – Cenomanian, Turonian – Early Paleocene, Late Paleocene – Eocene, Oligocene – Early Miocene, Middle-Late Miocene, and Pliocene-Pleistocene.

Early Cretaceous transgression run from the south-east to north-west and caused poly-facial composition of sediments from relatively deep- to shallow-water. Transition from Late Tithonian to Berriasian is almost gradual: in the central basin parts the stratigraphic unconformities and interruptions are lacking, while in some marginal basin sites, at uplifts, these interruptions are identified and Lower Cretaceous basal horizons are composed of conglomerates (Girska sequence). In most cases, however, Early Cretaceous sediments include clayey sediments alternating with sandstone and aleuroites, with siderite concretions. In the lower column part of Lower Cretaceous sediments carbonates are also often developed, and in the upper part volcanogenic rocks are characteristic. Early Cretaceous transgression was expanding with time and Lower Cretaceous basalt horizons become younger in the northern direction. Specifically, the oldest rocks of Early Cretaceous epoch (Berriasian-Valanginian) are only defined in the area of modern Fore-Mountains and in the Main ridge of Mountain Crimea. Further to the north these sediments pinch out, and the lower units are missed from the column with time: Berriasian first, then Valanginian and Hauterivian. In the same direction the basal layers do move indicating northward migration of the Early Cretaceous coast line. Thus, in Berriasian time in the Fore-Mountains and in the Main ridge of Mountain Crimea the Early Cretaceous trough has been formed where diverse-facies sediments were depositing.

Since Barremian time the central trough part has been opened to the north and the sea covered almost entire studied area including the modern Mountain and Plain Crimea. From Middle Albian the sea had also took up most elevated volcanic archipelago of Gerakleyske plateau (over there, Upper Bajocian – Lower Bathonian Karadazka Suite is overlain by Chorgunska and Kanarynska sequences composed of volcanomictic rocks resulted from erosion of volcanic islands).

Thus, all Early Cretaceous transgressions have been expanded from Meso-Tethys ocean. The territory of Mountain Crimea Main ridge was covered by the sea whose margins periodically spread out to the north, towards modern Plain Crimea which was most elevated area by that time. The partly elevated area was also modern Fore-Mountains where a range of volcanic islands existed (Gerakleyskiy peninsula, DH 18 [64] area, Bodrak-Alminske inter-river area), separating the open sea of Mountain Crimea from shallow-water Plain Crimea. Erosion flows were directed from the north to south. Inclusion of modern territory of Mountain Crimea into the Early Cretaceous sea basin is evidenced by the fragments of deep-water sediments: marleous clays with foraminifera and belemnites from Berriasian to Aptian (Ay-Dymytriy gorge, Balaklava), Albian and Cenomanian (northern slope of Baydarska valley, area of Balaklavski heights). In the mentioned areas of Crimean Yayla and Ai-Petrinska Yayla these sediments are preserved from erosion and lie over Upper Jurassic limestones. Outside the studied area the fragments of Lower Cretaceous deep-sea sediments are also preserved in Chatyr-Dag Mountain.

Over Early Cretaceous time sedimentation basin was developing under pulsation mode when on the background of general transgression some short-time regressions had occurred resulted in several transgressive and regressive half-cycles of the complete sedimentation cycle. The sea regressions are identified in the Hauterivian – Lower Barremian and Lower Albian sediments. Analysis of Lower Cretaceous sediments composition and setting in the Fore-Mountains and Mountain Crimea allows distinguishing the sub-zones in Zakhidna litho-tectonic zone. In the Plain Crimea territory Pivnichnokrymska and Tsentralnokrymska LTZs had existed in the Early Cretaceous epoch.

In the Early Cretaceous stage, on the background of the ancient continental margin general subsidence, in the shelf province both local uplifts and their erosion, and local block subsidence had occurred. As a result, the inter-mountain Baydarska and Varnautska erosion-tectonic zones have been set up composed of Berriasian-Valanginian sediments, and Kanarynska volcano-tectonic zone where Aptian-Albian sediments are also developed, including Upper Albian volcanogenic rocks. In Plain Crimea these structures include Tsentralnokrymske uplift consisting of Novoselivske and Simferopilske uplifts and separating Alminska depression and Kalynivskiy trough.

In the Late Albian time tectonic activity has increased accompanied by extensive volcanic activity and andesite formation which completes Mesozoic stage of magmatism. Volcanic activity had caused a range of volcanic islands formation to the north of the studied area, while in Kanarynska volcano-tectonic zone the thick pyroclastic Upper Albian Kanarynska sequence was depositing, apparently in relation to the activity of Kanarynskiy volcano.

In the Late Cretaceous stage the broad sea basin transgression continued. The Sea has occupied entire territory of the modern Crimea. Volcanic island archipelago also has been taken up by the sea and over entire continental margin, under conditions of gentle hydrodynamic regime, the chalk formation (chalk-like limestones and marls) was depositing at various depths of the warm-water marine basin. In some places, under abiotic conditions, dark-grey to black bituminous marls were depositing with numerous fish remnants in Menderska Suite in the Aksu-Dare gorge branch (at the Cenomanian and Turonian boundary).

Development of Late Cretaceous sea over entire territory of modern Crimean Mountains is also evidenced by the preserved from erosion fragments of Bilogirska Suite, which together with Albian sediments lie over Neocomian and Jurassic rocks in the western slopes of Mountain Crimea Main ridge (Machu Mountain). In addition, during the studies of Black Sea shelf to the south-west form the map sheet area, recently marine geologists had got from the sea bottom the same Upper Cretaceous marls which are widely exposed in the Fore-Mountains.

In the next development stage, apparently at the boundary of Mesozoic and Cenozoic, in relation with tectonic stress activation and progressive compression in subduction zone, which continued to develop to the south from the modern Mountain Crimea since the beginning of Middle Jurassic, the Mountain Crimea uplifting had commenced as well as oceanic basin closure. Erosion of Upper Cretaceous carbonate sediments had started and clastic material have been brought to Paleogene basin of Plain Crimea and Fore-Mountains. Over there, Paloecene-Eocene siliceous-carbonate formation was developing on the shelf, composed of chalk-like marls, organogenic pearlwort and nummulite limestones, sandstones and clays with flints and phosphorites. Due to subsequent uplifting in subduction zone, the territory of modern Mountain Crimea ascends above sea level and the island archipelago emerges where extensive erosion commences. These are the flint concretions from Cenomanian-Turonian sediments from which the sponge horizons had probably been formed in Pliocene-Eocene with silica sedimentation peak in the region. Thus, over Paleocene-Eocene epoch, under directed Mountain Crimea ascend, entire Upper Cretaceous sequence in Mountain Crimea has been completely removed by denudation.

Late in Eocene-Oligocene tectonic movements have been activated even more both in subduction zone and continental margin: subduction of Chornomorska micro-plate becomes more active and at the same time extensive subsidence synchronously increases in Plain Crimea. In parallel, in the band of Mountain Crimea uplift, the broad Indolo-Kubanskiy (Maykopskiy) trough has emerged in the east of Crimea, which to the west, in the studied area, is replaced by Alminska depression with inherited development ever since Kimmerian stage. Over there, bituminous-clayey formation was depositing comprised of Maykopska Series composed of thick clayey sequence: dark-grey to black bituminous clays with fine-grained sandstone and aleurolites interbeds and lenses. Terrigenous composition of Oligocene sediments in the studied area indirectly indicates that the source region for Oligocene sedimentation basin was the area of Mountain Crimea, eroded by that time up to the Lower Cretaceous sediments.

Maykopskiy trough over Oligocene and Early Miocene was developing under conditions of progressive tension stress at the Mountain Crimea continental margin.

At the border of Early and Middle Miocene tectonic layout of Alpides has been drastically re-arranged. The southern slope of Alminska depression is involved in contrasted rising in direction from the south-west to north-east along the Plain and Mountain Crimea junction zone. Maykopski sediments deposited in the trough have been partly eroded.

In the Early Chokrakskiy time the sea completely escapes from the map sheet area. This is the time interval in the geological history when the first cycle of neo-tectonic activity has appeared. Sub-latitudinal zones of reverse and reverse-thrust types were set up and developed in Fore-Mountains and Mountain Crimea.

In Tsentralnokrymske uplift, within Novoselivske and Simferopilske uplifts, slight rising had occurred that time.

As a result of mentioned tectonic motions, the upper part of Lower Alpine rock complex has been partly eroded, and flat Kalynivskiy trough, located at the modern Sasyk Lake place, was closed from the north-east.

Tension stress elimination in Late Chokrakskiy time has restored marine regime actually over entire territory of Tsentralnokrymske uplift. Miocene sea shoreline did roughly coincide with the southern boundary of the I-order structures junction zone. Sedimentation basin was characterized by the shallow upper shelf and sporadic low-amplitude sea level oscillations.

Over entire Middle Miocene mainly terrigenous and carbonate-terrigenous rock complex was depositing with the clastic material supplying from the Lower Alpine and partly Kimmerian tectonic floors.

Further geological development in the area had followed the Early Alpine stage with the only difference that over entire Miocene the sea basin boundaries have remained almost unchanged.

In the beginning of Sarmatian time tectonic regime of increasing tension stress has been restored again not only at the external continent margin but also in the adjacent sea basin. With Mountain Crimea rising the deepening of Alminska depression had occurred. Relatively deep-water sequence of Lower-Middle Sarmatian clays of Krasnoperekopska Suite was depositing.

In the Middle-Late Sarmatian time relatively stable shelf sedimentation conditions have remained with carbonate rocks deposition.

At the end of Late Miocene the second cycle of neo-tectonic activity has appeared. The Mountain Crimea rising has been accelerated and its south-western part becomes most elevated. It is related to the activation of Salgyro-Oktyabrskiy deep-seated fault, along which Kachynskiy and Pivdennoberezhniy Early Kimmerian blocks have been uplifted first, and then, along the parallel breaks – other structures of the lower tectonic floor.

The inter-mountain depression, and from the Late Meotis also Pra-Salgyr valley has been set up along this fault.

Simultaneously, the elevated blocks become the objects of extensive denudation and terrigenous material removal into the Fore-Mountain and Alminska depressions where fore-deltaic sediments of Kazankivska sequence were depositing.

Later on, compression activation has been resulted in the series of reverse faults in Alminska depression.

The activation peak coincides with the Middle-Late Pontychniy time, when the sea basin has almost completely escaped from the map sheet area. Shallow-water lagoons and lakes have remained in the place of Alminska depression where Pliocene sub-aqueous sediments were depositing.

Thus, in Neogene-Quaternary times the final arrangement of major tectonic elements in Crimea had occurred – Crimean island arc with shallow-water shelf joins the shelf of continental margin and then Crimean Island adjoins the northern continent. Grey- and red-color sandy-clayey molassoid marine and continental formations have been established.

In Late Pliocene – Eo-Pleistocene especially active rising of Crimean Mountains had occurred with the thick fan sediments band on their northern slopes. At the same time, in the Crimean Southern Coast the rockfall-slide formation composed of Masandrivska Suite is developed.

Upper Jurassic limestones of Upper Kimmerian tectonic sub-floor become the denudation area. It is evidenced by the composition of coarse-clastic material in Pliocene – Eo-Pleistocene sediments (Fig. 5.1).

Further rising of Crimean Mountains causes Yayla relief formation, similar to the modern one. Erosion processes in Upper Jurassic carbonate sequence have led to the extensive karst processes.

In the Early Neo-Pleistocene time the Mountain Crimea rising and synchronous subsidence in Alminska depression had continued with river valleys in the Crimean Mountains northern slope shifting to the west and their capturing by sub-latitudinal valleys set up along the reverse fault zones. The side erosion becomes predominate with accumulation of pebble material at Bulganatskiy and Novovasylivskiy terrace levels, as well as aeolian-deluvial and eluvial-deluvial sediments formation.

In the Chorna River mouth part alluvial-marine sediments of Chaudynskiy super-horizon were depositing, and in Sasyk Lake the lake-alluvial sediments have been formed.

In the Middle Neo-Pleistocene time both Novoselivske and Simferopilske uplifts, as well as Mountain Crimea area, including Gerakleyskiy ledge and Sevastopolsko-Simferopilska monocline, had continued to rise. Subsidence continued in Alminska depression where Pivnichnoalminskiy trough and Pivdennoalminska monocline were separated. Aeolian-deluvial loams are formed at the watersheds, and alluvial and alluvial-proluvial sands and pebble-stones of Novopavlivskiy and Sudatskiy terrace levels were depositing in the gullies and rivers. In the Crimean Southern Coast the complex of rock-fall and slide sediments have been formed. The karst processes in Upper Jurassic limestones continued in the Crimean Yaylas.

In the Crimean Southern Coast and in the Chorna River mouth part alluvial-marine sediments of Evksynskiy super-horizon and Karangatskiy horizon were depositing.

In the Late Neo-Pleistocene time the main features of the previous development stage remains unchanged while tectonic activity is somewhat accelerated and considerable erosion cuts are formed. Sedimentation of Quaternary loams continued at the watersheds.

In the Chorna River mouth part alluvial-proluvial sediments, in Sasyk Lake – lake sediments, and in the gullies and rivers – sands and pebble-stones of Sudatskiy terrace level have been formed. In the northern and southern slopes of Mountain Crimea the thick complex of rock-fall and slide sediments continued to develop.

In Holocene the relief continued to develop under influence of tectonic and denudation processes. Holocene sedimentation includes coluvial, deluvial-proluvial, aeolian- and eluvial-deluvial, alluvial-proluvial, alluvial, as well as marine, estuarian, lake and technogenic rock types.

In Pleistocene multiple periodic climate changes have occurred. Each warm stage had accompanied by the former soil horizons formation, and the cold one – by loess-like loams deposition. All Quaternary sediments were forming in the back-glacier zone.

Over Neogene-Quaternary tectonic activation of the given territory, related to the accelerated tension in the subduction zone of Chornomorska micro-plate, the amplitudes of vertical displacement in the southern margin of Mountain Crimea attained 2000 m, and the rock dipping angles in the south of map sheets, in Upper Jurassic limestones, attains 30^o.

Under tectonic instability conditions, reinforced by seismic motions, the Crimean Yaylas massifs were involved into the exo-tectonic breaking, specifically, under influence of gravitation, seismic activity and strong wetting because of karst waters in the basement composed of Middle Jurassic clayey sequences they have started to slide northward. Amplitudes of exo-tectonic horizontal displacement are estimated to the first hundreds of meters but unlikely tens of kilometers as it is reported in publications [25-28].

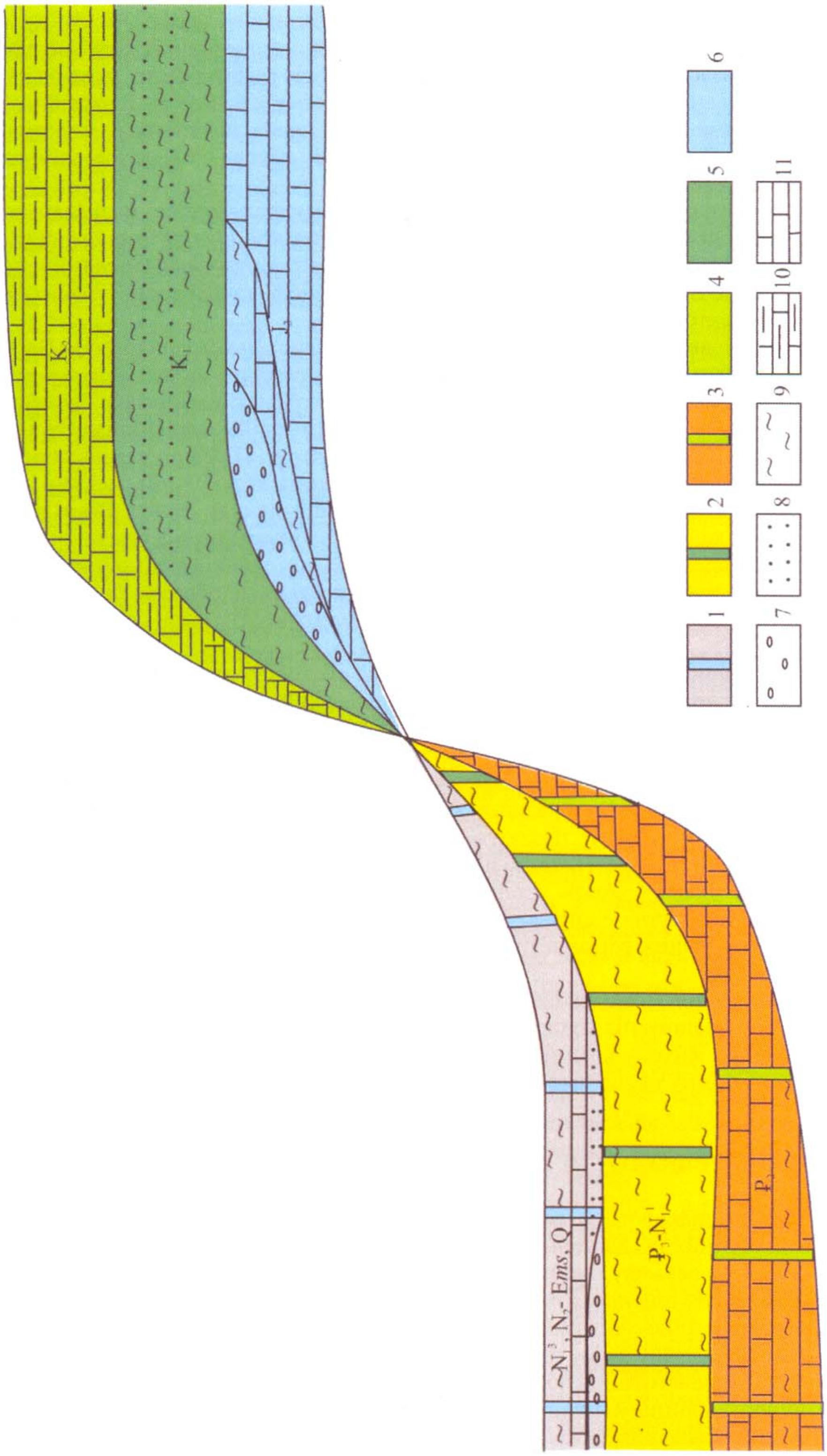

Fig. 5.1. Generalized sketch of relationships between denudation and sedimentation processes in the map sheets L-36-XXVIII and L-36-XXXIV in Cenozoic (after B.P.Chaykovskiy).

Sedimentation basin consists of: 1 – Upper Miocene – Quaternary sediments (N_1^3, N_2-E); 2 – Oligocene – Lower Miocene sediments (Maykopska Series), Ꝑ$_3$-N_1; 3 – Eocene sediments (Ꝑ$_2$).

Denudation area includes sediments: 4 – Upper Cretaceous (K_2); 5 – Lower Cretaceous (K_1); 6 – Upper Jurassic (J_3); 7 – conglomerates; 8 – sandstones; 9 – clays; 10 – marls; 11 – limestones.

The modern geodynamic environment in the region is defined by the subduction zone of the Eurasian plate fragment and Chornomorska micro-plate, located to the south from the Crimean Southern Coast, with most contrasted gravity anomalies and high seismicity [9, 20, 24, 27]. To seismic-focal zones are distinguished in this subduction zone where tectonic stress is being discharged.

Eurasian and Arabian plates come one to another in sub-longitudinal direction. And the wedge of Arabian plate spreads out micro-plates in between to the west and east providing Chornomorska micro-plate moving in the north-western direction. Emerging compression stress causes tangent (horizontal movement) stress of the north-western and north-eastern directions. This stress, in turn, causes respective system of sinistral and dextral normal and reverse shears. These breaks are being mapped everywhere in the Mesozoic-Cenozoic complexes of Mountain and Plain Crimea.

Geodynamic environment of Mountain Crimea is not distinct but typical for the continent-sea junction areas, and it, like miniature, reflects much bigger structure of this type emerged at the sea and continent border, like Andean coast in Latin America.

Over there, the analogue of Chornomorska micro-plate apparently comprises the oceanic Nasca plate which in the subduction zone goes down beneath continent with Brazilian Shield in the core, being the analogue of Ukrainian Shield.

The similarities and the continent internal structure details are also impressive: at the boundary with subduction zone the Andes continues to rise up which also displays the parallel orientation relatively to the subduction zone strike and includes three cordillera separated by the longwise valleys, as the analogues to three Crimean ridges. Between Brazilian Shield and Andean Mountains, the Amazonian lowland and La-Plata valley are distinguished over there, as the analogues to Syvaska depression, which balances Crimean Mountains uplifting.

The system Pacific Ocean – Andes in its present state does inheritedly develop ever since Mesozoic. By analogy, it could be the case for Crimea as well. In view of these ideas on the history of geological development for various regions, some disputable questions of Crimean geology can be solved quite simply and logically. Specifically, Upper Jurassic limestones, which reflect the barrier reef, are in the autochthonous position and there is no need to find their southern block buried beneath Black Sea; the latter one comprises residual basin existing ever since the boundary of Mesozoic and Cenozoic at least, when Mountain Crimea uplifting and simultaneous erosion of Upper Cretaceous sediments inside had commenced.

6. GEOMORPHOLOGY AND RELIEF-FORMING PROCESSES

In the studied area two geomorphologic provinces are distinguished – Mountain and Plain Crimea. Combination of endogenous and exogenic relief-forming processes had caused diverse relief types in the tight relationships with geological structure and specific features of the modern tectonic motions. Erosion-tectonic, structure-denudation, erosion-denudation, erosion-accumulative and accumulative relief types are widely developed (see "Geomorphologic scheme in the scale 1:500 000").

Geomorphologic zonation by previous authors [38] is performed on the ground of historic-morphogenetic principle when the modern relief is being considered as several age-different smoothening surfaces. Their relationships, combination of common morphogenetic features, similar history of the relief formation have allowed definition in the mentioned provinces, in the map sheets L-36-XXVIII and L-36-XXXIV, of respective sub-provinces and areas.

Mountain Crimea province

In the studied map sheets it includes the western part of Mountain Crimea mega-anticlinorium, from At-Bash Mountain in the east to Fiolent Cape in the west. Three sub-provinces are distinguished in this province – Crimean Mountains Main ridge, Crimean Fore-Mountains, and Gerakleyska height.

Crimean Mountains Main ridge sub-province (II-order morphostructure) is the highest part of Crimean Mountains. From the east to west the Main ridge, composed of Triassic-Jurassic and Lower Cretaceous sediments – limestones, sandstones, conglomerates, clays, progressively descends. The sediments facial diversity has caused different rate of denudation processes, which had caused significant horizontal (2.8-3.7 km/km^2) and sharp vertical (1000 m) cut of the Crimean Mountains Main ridge and development of erosion-denudation relief in this zone with short acute-top or smoothed ridges and inter-mountain troughs of erosion-tectonic origin. Combination of common morphogenetic features had caused definition of three geomorphologic areas – Yaylynske highland, Southern coast, and Northern slope.

Yaylynske highland (III-order morphostructure) constitutes the highest part of the Crimean Mountains Main ridge and in the map sheet area encompasses the western part of Ay-Petrinska Yayla – the westernmost one of the table massifs. Ay-Petrinska Yayla does correspond to the lower level of the table massifs – relicts of the ancient erosion-denudation peneplains. This is lightly-hilly forest-less surface composed of Upper Jurassic limestones. The highest point in the territory is At-Bash Mountain (altitude 1207.3 m). From the east to west progressive Yayla descending is observed and in Balaklava town area it is 215 m high. The width attains 12 km and the length is up to 40 km. The massifs of Yaylynske highland include narrow flat-top ridges separated by the flat descended interims or by deep erosion-tectonic valleys (Baydarska, Varnautska, Uzundzhynska). In the western part erosion-denudation relief type is characteristic with young deep canyons and gorges of the upper river valleys (Chorna River canyon, Deymen-Dere gorge and others). In the eastern part, with its plain plateau, composed of Upper Jurassic limestones, the karst landscape predominates in the relief. Six karst areas are distinguished: Nyzhnyosukhoritskiy, Varnautskiy, Baydarskiy, Prymorskiy, Zakhidnoaypetrinskiy and Tsentralnoaypetrinskiy [40].

Tsentralnoaypetrinskiy area is most representative, where both surface and underground karst relief forms are widely developed – funnels, wells, caves, which in places are grouped in the systems – Besh-Tekne karst field. In total, 218 karst hollows are identified, of which Kryshtaleva (113 m deep, 110 m long), Skelska (570 m long, 60 m deep) and Uzundzha (1500 m long) caves are most interesting. The karst relief forms are fairly important in the water resources distribution in the area. In general, primary smoothing surface of the highland is of abrasion origin, it is related to the Sarmatian transgression and its age corresponds to Early Miocene. The younger smoothing surfaces are also known in the highland but by technical reasons they cannot be shown in the small-scale geomorphologic map [40].

M i d d l e P l i o c e n e s m o o t h i n g s u r f a c e is distinguished in Velykiy Babugan gorge, in Trapan-Bair, Kokiya-Bel, Kurtler-Bogaz, Orboka, Biyuktyuz mountains. This surface altitudes decrease from the east to west from 950 m to 530 m and relative elevation above the river valleys respectively decreases from 650 to 450 m.

E o - P l e i s t o c e n e s m o o t h i n g s u r f a c e is observed in Maliy Babugan gorge, in Sarpakha, Villya-Burun, Kokiya-Bel, Syuyur-Tepe mountains.

E a r l y Q u a t e r n a r y d e n u d a t i o n s u r f a c e is related to the water flow valleys – Uzundzha River upper courses in the south-western slope of Baydarska valley, in the northern slope of Kokiya-Bel ridge.

M i d d l e Q u a t e r n a r y d e n u d a t i o n s u r f a c e is known to the south from Pidgirne, Pavlovka, Tylove villages, on the slopes of Kutur-Kaya and Biyuk-Kol-Burun mountains, nearby Novo-Bobrivske and Peredove villages. In the Main ridge the surface altitudes vary from 320 to 500 m and only to the north from Peredove village they descend to 70-200 m.

Structure-denudation relief type in the area was forming during selective denudation and separation of denudation-resistant rocks with the slope surface formation overlain by the monoclinally-dipping Upper Jurassic or Lower Cretaceous limestone layers. This relief type is characteristic for the southern and northern margins of Baydarska and northern margin of Varnautska valleys and the area of Balaklava town.

Coastal area (III-order morphostructure) encompasses the land from 0.5 to 5 km wide extended along the Main ridge foothill from Aya cape in the west to Kishka Mountain in the east and comprises medium-hill, extensively cut, steep-slope relief type. From the foot of cliffs with altitudes from 1100 m in the east (Pylyaky ridge) to 50-100 m in the west, towards the sea over relatively short interval the sharp relief descending is observed with steep surface inclinations. Formation of this relief is especially affected by erosion processes which form the blocks of Yaylynski limestones. The complex erosion-hill relief is also developed below the Yayla cliffs in Middle Jurassic and Tavriyska Series clayey rocks. But gravitation processes are the main relief-forming factor over there providing such relief forms in the upper part of the southern slope as boulder accumulations, "chaos", rock-fall fans, slides, developed everywhere. In the lower slope part the narrow wavy watersheds are developed, separated by the deep-cut trough-like valleys with steep slopes. In addition, significant space over there is occupied by slides: both older, temporarily stabilized, and modern, active ones. The slide processes mode and scale are tightly related to tectonics and neo-tectonics. Thickness of the old slides attains 70-100 m, modern ones – up to 25-50 m. The base of older slides is normally located in 50-60 m below the sea level, while the modern ones – at the sea level or in 5-7 m below. Numerous slide relief forms are distinguished – slide-flow, circum slide depression with stair profile, slide detachment slopes, and others. The area micro-relief becomes especially impressing when the isolated cliff-detachments are displaced over the slope from the Main ridge foothill downward, somewhere just to the shoreline or even dropped into the sea and standing above the water in the chimerical cliffs (Blakytna bay, Laspi harbor and others). The mixed gravitation-fluvial relief forms are formed by the old fans and mudflows (mud-stone) which constitute Masandrivska Suite (ecN_2-E*ms*). Certain contribution to the coastal relief formation is put by the sea abrasion providing curvilinear shoreline, coastal cliffs and beaches. The rock structure and lithology are important in these cases since most distinct positive relief forms are related to the eroded intrusions. Because of the high energy of relief-forming factors, the relief in the coastal area is permanently renewed and the age of its major geomorphologic elements is defined as Quaternary.

Northern slope of Main ridge (III-order morphostructure) is characterized by medium- and low-mountain, extensively cut, flat-slope relief. In the map sheet territory this area is located between Belbek-Kokozka river valleys in the east and Chorna-Aytodorka river valleys in the west. The southern boundary follows the northern foothill of the Main ridge and the northern one – the cuesta foothill of the Internal ridge. The area is characterized by the dense and deep-cut river and gully network which makes the relief outlines similar to the system of separated medium-low-mountain slopes with altitudes up to 750 m and relative elevations up to 300 m. To the west the slope surfaces progressively descend, getting smoother, and then is gradually replaced by the slightly-hilly plain. The narrow, wavy watersheds are cut by the steep-slope valleys. The valley bottoms are water-free, filled with debris material, with fans in the mouths. Main relief-forming processes include erosion and accumulation. Erosion-accumulative relief type combines genetically uniform surfaces resulted from sedimentation. Of these, alluvial terrace, proluvial-deluvial fan, gully and temporary water flow bottom surfaces are distinguished, as well as the surfaces of coluvial-deluvial and technogenic accumulations. Of the ten terrace levels, distinguished in Crimea, five ones are known in the studied area, which correspond to the over-flood terraces. The eighth terrace level, specifically, Budatsko-Donetska terrace is only preserved in the Belbek River valley. Terrace elevation above the cut attains 80-90 m descending downward the Belbek River course to 40-50 m. The sixth terrace level constitutes Krukenytsko-Khadzhybeyska terrace developed in the Belbek, Kokozka, Chorna, Uzundzha, Sukha Richka, Aytodorka, Baydarka river valleys. In the upper course it is of socle mode, and down the stream it becomes accumulative. Its elevation above the water lien attains 25-40 m, and width is 70-170 m. The fourth terrace level constitutes Cherkasko-Trubizka terrace developed in Belbek, Kokozka, Chorna, Uzundzha, Sukha Richka, and other river valleys, its elevation above the stream line is 18-20 m, width – up to 150 m. The second terrace level corresponds to Late Neo-Pleistocene – Holocene Sadova over-flood terrace developed along all river courses attaining 50-250 m width. Its elevation above the water courses is 3-3.5 m. Terrace surface is flat, inclined under the angel 1-2^{o} downstream and towards the course. The flood-land is developed in the middle and lower river courses and is up to 200 m wide. The river course width does not exceed 5-7 m.

The surfaces of Middle Neo-Pleistocene – Holocene deluvial-proluvial fans also constitute terrace-like ledges resulted from the planar erosion and weathering products transport by temporary water flows.

The foothills of denudation cliffs are composed of coluvial and coluvial-deluvial accumulations and developed along the southern area boundary. The slopes are steeply-dipping towards the water flow valleys with chaotic wavy micro-relief formed by accumulation of the boulder-debris material.

The surfaces composed of technogenic sediments are developed in the areas of open mining accompanied by the waste and low-grade ore dumps, in the areas of road construction works, as well as numerous water reservoirs with their thick dams.

Western Fore-Mountains (II-order morphostructure) adjoin the Main ridge northern slopes being separated from the ridge by the 5-7 km wide longwise valley. Structure-denudation cuesta relief is characteristic for the Crimean Fore-Mountains where clayey-marleous piles are overlain by the denudation-resistant monoclinally dipping limestones. In the sub-province the inclined surface of the Late Miocene – Holocene Internal fore-mountain ridge (III-order morphostructure) and the flat hilly surface of the Late Pliocene – Holocene External fore-mountain ridge (III-order morphostructure) are distinguished. Two cuestas are defined in the Internal fore-mountain ridge. The first one is extended over entire area from Skaliste village in the east to Inkerman town in the west. The southern slope is steep, in the upper part – vertical, with elevations up to 150 m. The northern slope is flat (6-8^{o}) and capped by the monoclinally laying limestones of Bilokamyanska Suite (Lower Paleocene). The second cuesta is parallel to the first one and is better expressed from Tankove village in the east to Inkerman town in the west. The southern slope is also steep, in the upper part – vertical, with elevations up to 20 m. The northern slope is flat (3-6^{o}) and capped by nummulitic limestones of Simferopilska Suite (Lower-Middle Eocene). To the both sides from this area the nummulitic cuesta gradually joins the first one. With the system of crosswise, often canyon-like valleys, the individual plateau-like massifs are separated from the cuestas – Tepe-Kermen, Chufut-Kale, Mangup-Kale, and chimerical cliff-remnants – Slon, Sfinks, and others (Bakhchysaray town outskirts). The surface of Internal fore-mountain ridge is gradually replaced by the Late Pleistocene – Holocene slope erosion-denudation surface which constitutes longwise inter-cuesta valley separating Internal and External fore-mountain ridges. The valley, 3-8 km wide, is asymmetric. The bottom surface is wavy, with diverse-aged alluvial terrace remnants. The External fore-mountain ridge cuestas are in general parallel to the cuestas of Internal ridge, and are traced from Novopavlivka village in the east to Inkerman town in the west. The south-eastern slope is steep with elevations up to 40-50 m. The north-western slope is flat and capped by Sarmatian limestones (Khersonska Suite), and overlain by pebble-stones of Kazankivska Suite (Upper Miocene).

Besides structure-denudation, erosion-accumulative relief type is also widely developed in the relicts of over-flood terraces. The heights of over-flood terraces decrease both downstream the river courses (young terraces plunge down beneath Holocene alluvium and become buried) and by strike of fore-mountain ridges: in the west, in the Kacha and Belbek river valleys, terraces are located lower than the same-aged terraces in the eastern areas (Alma and Bulganak river valleys). Of the ten known in Crimean over-flood terraces, seven ones are developed in the map sheet area. The highest position is occupied by the tenth (Kyzyldzharska) terrace of X terrace level. Its height in the Belbek River valley (Syuren village) is 305 m, in the Kacha River valley (Dolynne village) – 210 m, and elevations above the modern river course are 210 and 185 m respectively. The ninth Nogaysko-Budatska terrace of IX terrace level is most developed at the watershed of Alma and Bulganak rivers. Formation of this terrace is related to the migration of ancient Alma River course from the north to south [62]. Its surface elevation above the river course nearby Kyrshavlu-Oba Mountain varies from 80 to 88 m (altitudes from 290 to 180 m). The remnants of eighth Budatsko-Donetska over-flood terrace (VIII terrace level) are well preserved in the Alma River valley (Topoli-Novovasylivka villages) at the heights 285 and 220 m at the elevation above the modern river course 100-105 m. Donetsko-Krukenytska terrace of VII terrace level is best expressed in the right bank of Alma River nearby Novovasylivka village. Terrace top is 75 m high above the river course (altitude 180 m), decreasing downward the stream to 27-14 m (altitude 50 m). Khadzhybey-Cherkaska over-flood terrace of V terrace level is observed in the Alma and Kacha river valleys. In the Alma River basin (Novopavlivka village) terrace height is 190-200 m with elevation above the river course by 35-40 m. In the Kacha River basin (Verkhorichchya village) terrace remnants are preserved at the heights 300-310 m with elevations above the river course by 50 m. Down the river course terrace height sharply decreases and in the area of Dolynne village it is 30 m. Trubizko-Vilshanska over-flood terrace of III terrace level is well expressed in the Alma River valley (Poshtove-Novovasylivka villages). It is extended in the 300-400 m wide band at the height 160-200 m with elevation above the modern river course by 15 m. The first (Sadova) terrace is developed everywhere. In the Alma River valley (Novopavlivka village) its elevation above the modern river course is 4-5 m and decreases to 3.5 m in the area of Poshtove-Novovasylivka villages.

Gerakleyska height (II-order morphostructure) is located in the same-named peninsula and comprises slightly-cut inclined smoothing surface developed over almost horizontally laying Sarmatian limestones

(Khersonska and Besarabska suites). From the three sides the height is surrounded by Black Sea. In the south the coast is abrasive, strait, cliffy, up to 130 m high, with reduced beaches. The southern coast is cut by numerous chimerical harbors. The fragments of abrasive and accumulative sea terraces 4.5-5.0 m high above sea level are known. The surface of the height is hilly and cut by numerous gullies. In the upper courses the gullies are flat, in the middle and lower parts crosswise profile is steep, and in the mouth parts they become the narrow harbors [32].

Plain Crimea province

In the map sheet area the territory encompasses Tarkhankutsko-Novoselivske uplift and Alminska depression and, respectively, is divided in two sub-provinces – sub-province of Tarkhankutsko-Novoselivska structure-denudation height and sub-province of Alminska accumulative plain.

Tarkhankutsko-Novoselivska structure-denudation height (II-order morphostructure) is expressed in the gently inclined to the south plateau which surface throughout corresponds to the hanging-wall of Pontychni limestones [38]. Plateau is cut by few but deep gullies facilitating formation of flat and extended erosion-denudation slopes. Main genetic relief types: structure-denudation, erosion-denudation and erosion-accumulative. For the structure-denudation relief type the smoothing surfaces of various ages are characteristic. In the north-east significant area is occupied by the Late Miocene – Early Pliocene smoothing surface with altitudes 40-80 m. Erosion cutting is insufficient and confined to the margins because of differentiated neo-tectonic subsidence in the area of Sasyk and Kyzyl-Yar lakes. The cover sediments include aeolian-deluvial and deluvial-proluvial loams. In the north-west of territory essential area is encompassed by Middle Neo-Pleistocene – Holocene accumulative-erosion plain composed of aeolian-deluvial and lake-marine sediments. The plain is cut by dense river and gully network with erosion basis at Sasyk Lake and Black Sea. The plain gradually, without clear ledge adjoins sea coast. Sasyk Lake, the ancient sea bay separated from the sea by up to 2 km wide sand spit, comprises the distinct geomorphologic element. The history of Sasyk Lake formation and onward erosion cut distribution suggest for differentiated neo-tectonic motions when subsidence processes in places predominate over the general arc-shaped rising of entire territory.

Alminska accumulative plain (II-order morphostructure) in tectonic respect corresponds to the most subsided portion of Alminska depression.

The plain is gently inclined to the west (2-5^{o}) with altitude 150 m (area of Pozharske and Furmanovka villages). Towards the coast line its relief gradually descends to 35 m (area between Kacha and Alma rivers), and in the coastal band its elevation above sea level is 15-20 m. The plain is cut by the river valleys and gullies and in the watershed slopes the dense ravine network is developed. To the south from Kyzyl-Yar Lake it looks like the broad ancient-terrace watershed with flat surface, erosion of the river valley mouth portions and development of hanging gullies opened directly to the sea. To the north from Kyzyl-Yar Lake the plain coastal band is lower in altitude with abundant spits and salt lakes-estuaries. The main relief type – erosion-accumulative expressed in surfaces created by the river accumulation and temporary flows, as well as surfaces of aeolian-deluvial, marine and estuary-marine sediments. As a result of previous works [62], 10 alluvial terraces of ten terrace levels are distinguished in the area. In the studied area six over-flood terraces are encountered. The highest one – the tenth (Kyzyldzharska) Eo-Pleistocene terrace of X terrace level is widely developed in the areas between Alma-Bulganak, Alma-Kacha, Kacha-Belbek rivers. In the area of Kyzyl-Dzhar Mountain its height is 180 m and in the coast it drops to 30 m. The IX terrace level of Nogaysko-Budatska terrace is developed at the watershed of Bulganak River and Klyucheva gully. Terrace surface is inclined to the north and west and gradually merges with Budatsko-Donetska terrace. Its height varies from 65-70 m to 20 m in the west (altitudes decrease from 267 to 80 m). Few remnants of the ninth terrace are preserved to the north from Plodove and Dorozhne villages at the heights 180-190 m, which by technical reasons are not indicated in the small-scale geomorphologic scheme. In the central plain part significant area is occupied by the eighth Budatsko-Donetska over-flood terrace of VIII terrace level. In the Bulganak River basin it is located in the slope with altitude 240 m and elevation above the river course is 60 m. Down the river stream its height decreases and in the coastal cliff it is 15 m.

At the V terrace level, in the Alma and Bulganak river valleys, Donetsko-Krukenytska over-flood terrace is well expressed. In the Bulganak River valley it is also preserved in the mouth part where its total width is up to 1250 m. The third Trubizko-Vilshanska over-flood terrace at the third terrace level is weakly expressed and slightly differs from adjacent terraces. The relict of Trubizko-Vilshanska terrace is preserved in the Alma River right bank (Vynogradne village area) where its height is 12-14 m above the modern river course. The first (Sadova) over-flood terrace is well expressed in the valleys of all major rivers. Terrace width varies in the wide range from 25-50 m (Bulganak River) to 500 m in the Alma River valley. Elevation of this terrace is from 7 m nearby Novopavlivka village to 1.6-1.8 m in vicinity of Bryanske village. At the coast it is replaced by Holocene Novochornomorska sea terrace.

Significant relief-forming factors include slide processes and abrasion. The slides are developed on the slopes of Alma, Kach, Belbek rivers, especially in places of their course turns and smoothing surface breakthrough. The major slide massifs, which involve entire slope with setting depth up to 60 m, and associated minor higher-order slides with setting depth up to 10 m are distinguished. In the Alma River valley (Pishchane, Plodove villages) the slides are confined to the steep (30^o) slopes. The slide bodies over there are composed of Pliocene sediments while their displacement plane is confined to Middle Pliocene clays. In the Bulganak River valley the slide bodies are composed of Upper Maykopska Series (Oligocene) and Middle Miocene rocks and their displacement plane is located in Maykopski clays.

The shoreline over entire plain coast is bounded by the active cliff suggesting for the active sea invasion to the land. In the area of Evpatoriya town the low (9-10 m) coast cliff is developed in Meotychni and Pontychni limestones and to the south (Lukul cape) the height of cliff, composed of Pliocene continental clays and pebble-stones, increases to 60 m. As a result of abrasion, large rock blocks (from 10-180 m wide and 25-2000 m long) are detached from the coast cliff by steep (70-80^o) fractures and drop down to the sea. In the area of Beregove and Lyubymivka villages these detached and displaced blocks create underwater arcs at the distance of 10-40 m away from the shoreline.

7. HYDROGEOLOGY

According to the "Hydrogeological zonation of Ukraine" (A.E.Babynets, F.A.Rudenko) [1a], the map sheet territory L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) belongs to the Plain Crimea artesian basin (I) and Mountain Crimea hydrogeological area (L). These are first-order hydrogeological regions (Fig. 7.1).

Hydrogeological conditions in these regions are different, especially in Mountain Crimea where fracture-karst and fracture water basins are confined to the tectonic structures and are of sheet-block type. On the ground of previous works the following main water-bearing horizons and complexes are distinguished (see "Distribution scheme of water-bearing horizons and complexes"):

- water-bearing horizon in modern marine sediments (mH);
- water-bearing horizon in Neo-Pleistocene – Holocene coluvial sediments (cP-H);
- water-bearing horizon in Upper Neo-Pleistocen – Holocene slide sediments (zP_{III}-H);
- water-bearing horizon in Neo-Pleistocene – Holocene alluvial sediments (aP-H);
- locally water-bearing horizon in Neo-Pleistocene – Holocene slide and coluvial-deluvial-proluvial sediments (z,cdpP-H);
- water-bearing complex in Pliocene continental and Lower Neo-Pleistocene alluvial sediments (N_2-aP_1);
- water-bearing complex in Pliocene continental and Eo-Pleistocene alluvial-proluvial sediments (N_2-apE);
- water-bearing (a) complex and locally water-bearing (b) horizons in Pliocene continental sediments (N_2);
- water-bearing horizon in Meotychni and Pontychni sediments (N_1m-p);
- water-bearing horizon in Middle-Upper Sarmatian and Meotychni sediments (N_1s_{2+3}-m);
- water-bearing horizon in Middle-Upper Sarmatian sediments (N_1s_{2+3});
- water-bearing horizon in Middle Miocene sediments (N_1^2);
- water-bearing horizon in Eocene sediments (₽$_2$);
- water-bearing horizon in Paleocene sediments (₽$_1$);
- locally water-bearing complex in fracturing zone of Upper Cretaceous sediments (K_2);
- water-bearing complex in Lower Cretaceous sediments (K_1);
- water-bearing complex in Upper Jurassic sediments (J_3);
- locally water-bearing horizon in fracturing zone of Middle Jurassic rocks (J_2);
- locally water-bearing horizons in exogenic fracturing zone of Tavriyska Series rocks (T_3-J_1);
- water-bearing horizon in Lower and Middle Triassic sediments (T_{1-2}).

Water-bearing horizon in modern marine sediments (mH) is developed in the narrow bands along the shoreline and is first from the surface. It is underlain by water-proof loams and clays of various genesis and age. Thickness of water-bearing horizon is 0.6-8.0 m. Water-containing sediments include sands, sandy loams, mud, mud loams and clays. Water content of horizon is low, borehole yield is 0.009-86.4 m^3/d. Filtration coefficient is 0.6-0.8 m/d. Water table depth is 0.1-1.0 m, table altitudes from 0.4 to 0.7 m. Waters in the horizon are chloride sodium salt and very salt with mineralization 6.8-62.6 g/dm^3. Feeding is being done through atmospheric precipitate infiltration, additional feeding – from underlaying water-bearing horizons, as well as in the period of "forcing" winds – from sea and lakes. Discharging is being done into the lakes and sea, partly by evaporation. Horizon is out of practical value.

Water-bearing horizon in Neo-Pleistocene – Holocene coluvial sediments (cP-H) is sporadically developed in the northern slopes of Main ridge at the Yayla cliff foothills. Water-containing rocks include boulder-debris sediments with loamy filler 30-40 m thick. Horizon is groundwater. It is underlain by Middle Jurassic water-proof argillites and sandstones. Main feeding sources include water-rich Upper Jurassic limestones and conglomerates exposed at the surface in the Yayla slope upper part. The waters are being discharged from the horizon through numerous descending springs with yield 34.6-0.69 m^3/d and from the wells. By chemical composition the waters are hydrocarbonate calcium, fresh (0.3-0.6 g/dm^3).

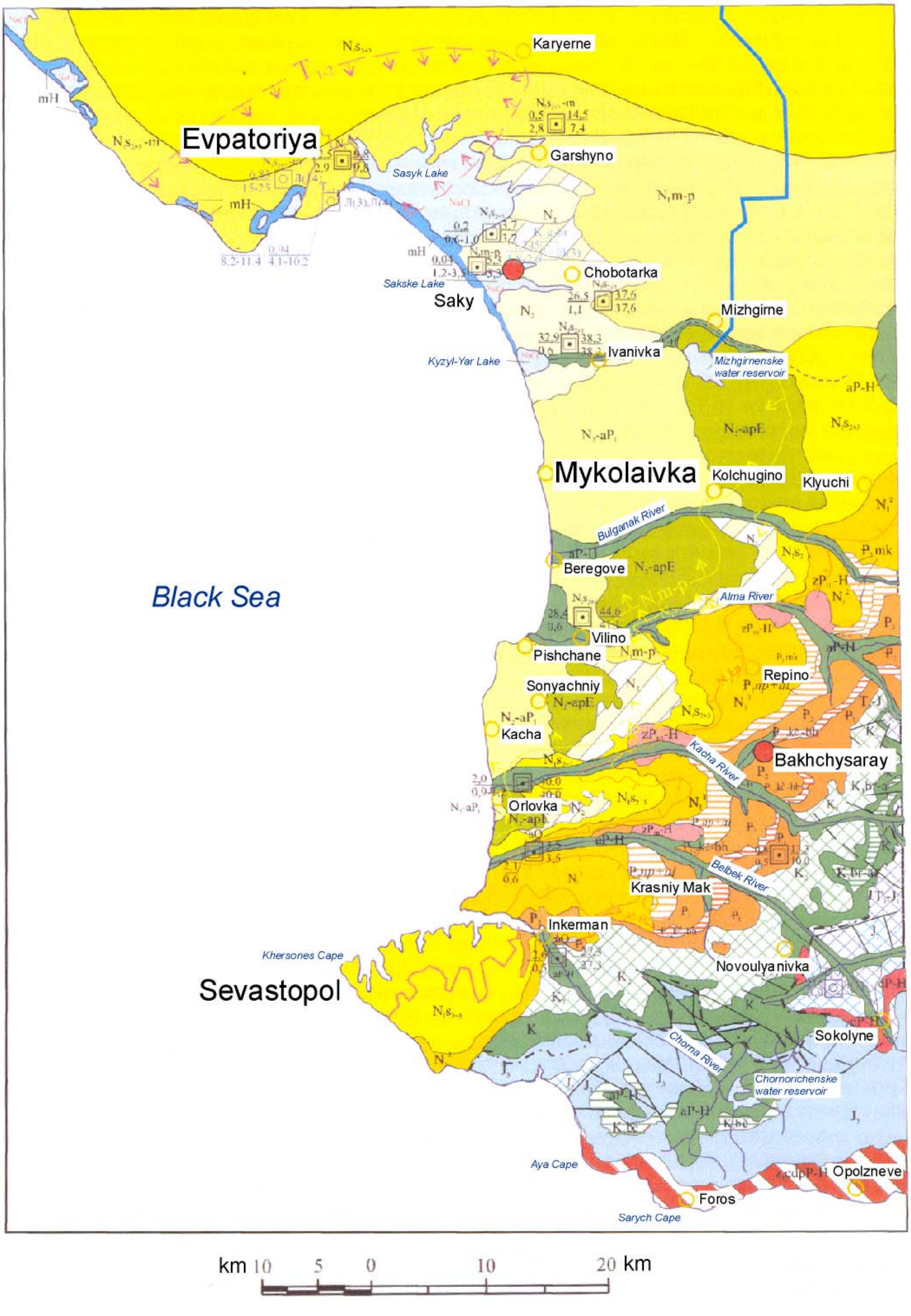

Fig. 7.1. Distribution scheme of water-bearing horizons and complexes.
See next page for legend.

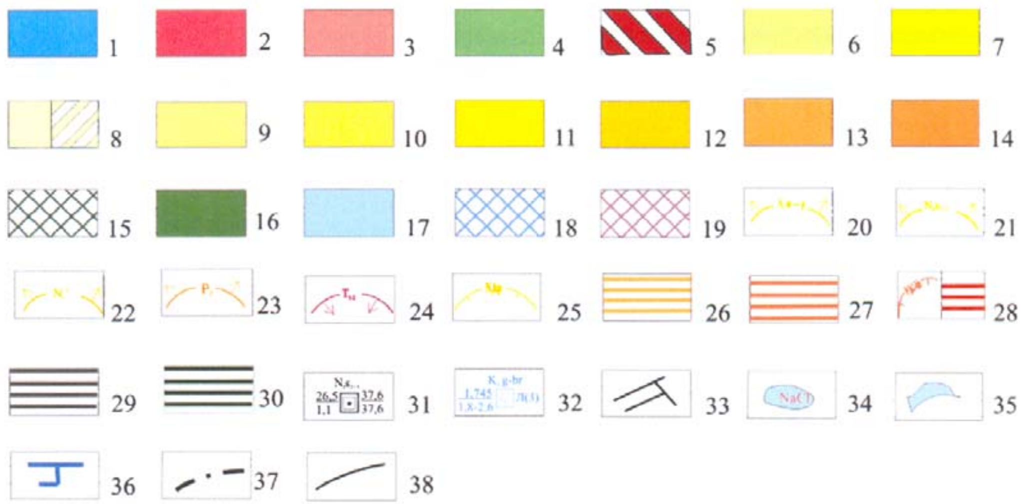

Fig. 7.1. Continued. The legend.

Water-bearing horizons and complexes positioned first from the surface: 1 - water-bearing horizon in modern marine sediments (mH); 2 - water-bearing horizon in Neo-Pleistocene – Holocene coluvial sediments (cP-H); 3 - water-bearing horizon in Upper Neo-Pleistocen – Holocene slide sediments (zP_{III}-H); 4 - water-bearing horizon in Neo-Pleistocene – Holocene alluvial sediments (aP-H); 5 - locally water-bearing horizon in Neo-Pleistocene – Holocene slide and coluvial-deluvial-proluvial sediments (z,cdpP-H); 6 - water-bearing complex in Pliocene continental and Lower Neo-Pleistocene alluvial sediments (N_2-aP_1); 7 - water-bearing complex in Pliocene continental and Eo-Pleistocene alluvial-proluvial sediments (N_2-apE); 8 - water-bearing (a) complex and locally water-bearing (b) horizons in Pliocene continental sediments (N_2); 9 - water-bearing horizon in Meotychni and Pontychni sediments (N_1m-p); 10 - water-bearing horizon in Middle-Upper Sarmatian and Meotychni sediments (N_1s_{2+3}-m); 11 - water-bearing horizon in Middle-Upper Sarmatian sediments (N_1s_{2+3}); 12 - water-bearing horizon in Middle Miocene sediments (N_1^2); 13 - water-bearing horizon in Eocene sediments (Ꝑ$_2$); 14 - water-bearing horizon in Paleocene sediments (Ꝑ$_1$); 15 - locally water-bearing complex in fracturing zone of Upper Cretaceous sediments (K_2); 16 - water-bearing complex in Lower Cretaceous sediments (K_1); 17 - water-bearing complex in Upper Jurassic sediments (J_3); 18 - locally water-bearing horizon in fracturing zone of Middle Jurassic rocks (J_2); 19 - locally water-bearing horizons in exogenic fracturing zone of Tavriyska Series rocks (T_3-J_1);

Water-bearing horizons and complexes positioned second and more from the surface: 20 - water-bearing horizon in Meotychni and Pontychni sediments (N_1m-p); 21 - water-bearing horizon in Middle-Upper Sarmatian sediments (N_1s_{2+3}) 22 - water-bearing horizon in Middle Miocene sediments (N_1^2); 23 - water-bearing horizon in Eocene sediments (Ꝑ$_2$); 24 - water-bearing horizon in Lower and Middle Triassic sediments (T_{1-2});

Water-proof rocks: 25 – clays of Miocene Krasnoperekopska Suite (N_1*kp*); 26 – dense clays of Maykopska Series (Ꝑ$_3$*mk*); 27 – water-proof sediments of Novopavlivska, Kumska and Alminska suites (Ꝑ$_2$*np+al*); 28 – water-proof sediments of Paleocene-Eocene Kachynskiy and Bakhchysarayskiy horizons (Ꝑ$_{1-2}$*kč-bh*); 29 – water-proof Lower Cretaceous Upper Barremian – Aptian sediments (K_1*br-a*); 30 – Lower Cretaceous clays of Bechku Suite (K_1*bč*);

Other symbols: 31 – water-scoop units operating under exploitation groundwater reserves approved by State Commission of Ukraine on Mineral Reserves or its territorial bodies: top – geological index of water-bearing horizon, to the left: numerator – bulk yield, th.m^3/d; denominator – mineralization, g/dm^3; to the right: numerator – reserves, sum of A+B+C_1 categories, th.m^3/d; denominator – reserves of A+B categories, th.m^3/d; 32 – group of water-scooping boreholes: top – geological index of water-bearing horizon; to the left: numerator – bulk yield, th.m^3/d; denominator – mineralization, g/dm^3; to the right: water type index by use; in parentheses – number of water-scooping boreholes in the group; blue-color symbol indicates mineral waters; 33 – geological faults with undefined hydrogeological role; 34 – salt lakes; 35 – water reservoirs; 36 – channels;

Boundaries: 37 – first-order hydrogeological regions: I - Plain Crimean artesian basin, L - Mountain Crimea hydrogeological area; 38 – distribution boundaries of water-bearing sediments from different stratigraphic-genetic subdivisions.

Water-bearing horizon in Upper Neo-Pleistocen – Holocene slide sediments (zP_{III}-H) is locally developed in the Belbek, Kacha, Alma and Bulganak river banks, in places of the external cuesta breakthrough, and always is first from the surface. Water-containing rocks are composed of Eocene, Middle Miocene and Sarmatian limestone boulders slid down over Eocene, Maykopski and Sarmatian clays. The horizon is grounded, water table depth is from 0.1 to 18.5 m. It is fed by atmospheric precipitates and overlaying horizons discharging. Waters are hydrocarbonate and chloride-hydrocarbonate calcium with mineralization 0.4-0.8 g/dm^3. Discharging is being done through springs and evaporation. Local inhabitants use water from the horizon with wells and catchment springs.

Water-bearing horizon in Neo-Pleistocene – Holocene alluvial sediments (aP-H) is confined to the flood-land and first over-flood terraces and is developed in narrow bands in the Belbek, Kacha, Alma, Bulganak, Bodrak, Salgyr river valleys. In the Chorna River basin alluvial waters of this horizon are most developed in Baydarska, Varnautska and Inkermanska valleys. In Mountain and Fore-Mountain Crimea water-containing sediments of the given horizon include pebble-gravel-debris material with sandy loam or loam filler, 5-10 m thick. In the lower river courses the gravel-pebble sediments are replaced by the loam-sandy ones; thickness of the horizon increases to 30-40 m. Water-bearing horizon is first from the surface. Waters are grounded, with free table. Water-bearing horizon is underlain by the rocks of various genesis and age, both water-proof and water-containing; in the latter case hydraulic link is established with underlaying horizons and complexes. The groundwater table depth in alluvial sediments varies from 0.5-2.0 m in the flood-land to 5.5 m in the valley banks. In the Belbek and Chorna river lower courses, because of overlaying water-proof rocks, the waters of alluvial horizon become pressurized, with 2.7-7.5 m of pressure. Filtration coefficients in the rocks of alluvial water-bearing horizon, due to complex and multi-layer column, are variable, both in vertical and horizontal directions, and vary from 0.01 to 60 m/d. In the upper river course the waters of this horizon are hydrocarbonate and sulphate-hydrocarbonate calcium with mineralization 0.4-0.7 g/dm^3. In places, where river valleys cut through marls of Novopavlivskiy and Alminskiy horizons and Maykopski clays, sulphates become predominate in the waters. In the Belbek and Kacha middle and lower river courses water mineralization attains 0.8-1.1 g/dm^3, Alma river course – 1.5-2.3 g/dm^3, Bulganak river course – 2.0-4.5 g/dm^3. Water content of the horizon is normally low but it increases with thickness and sorting of pebble sediments increasing. Water-bearing horizon is fed by atmospheric precipitate infiltration, upgrading – from underlaying water-bearing horizons and complexes. Discharging is done into the rivers and Black Sea, into overlaying water-bearing horizons and complexes, as well as by evaporation. In Alminskiy basin and Crimean Fore-Mountains the waters of alluvial horizon are used for the rural inhabited locations and centralized water supplying of Sevastopol city (Belbetskiy and Inkermanskiy water scoops).

Locally water-bearing horizon in Neo-Pleistocene – Holocene slide and coluvial-deluvial-proluvial sediments (z,cdpP-H) is developed in the Crimean Southern Coast in specific flows at various depth from the surface. Water-containing rocks include gravel-pebble, cobble-debris-gruss sediments with sandy loam and loam filler. The rocks of this horizon are underlain by the water-proof rocks of Tavriyska Series and Middle Jurassic, and in the elevated sites – by Upper Jurassic rocks with karst-sheeted and fractured waters. Thickness of the sediments is from 2-5 to 40 m, rarely 50-100 m, water-saturated zones – from 0.2-3.0 m to 8-16 m, rarely some tens of meters. Water content is low. Specific borehole yields are 0.08-15.6 m^3/d, filtration coefficients vary from 1 to 18.9 m/d, spring yields – from 0.08 to 172.8-258.1 m^3/d. Formation of these waters is done from the fracture-karst waters of Upper Jurassic limestone massifs and atmospheric precipitate infiltration. Water flow is directed towards the sea. The streams and flows are formed under influence of slope sediments lithology and slope surface morphology. Water table depth varies from 1.4 to 20-30 m. The waters are mainly hydrocarbonate calcium with mineralization 0.3-0.6 g/dm^3. Actually all springs are being used for water supplying by sanatoriums and local inhabitants.

Water-bearing complex in Pliocene continental and Lower Neo-Pleistocene alluvial sediments (N_2-aP_1) is developed in the lower courses of Kacha, Alma, Bulganak river watersheds and in Kyzyl-Yar gully. Water-containing rocks include gravels, sandy loams and loams. Because of lacking the persistent water-proof, the waters of these sediments are involved in the single water-bearing complex. The waters are grounded with depth from 1.4 to 9.1 m. Borehole yields are 0.12-129.6 m^3/d. By chemical composition the waters are sulphate, hydrocarbonate-sulphate, along the sea coast – chloride, sulphate-chloride, with mineralization up to 1 g/dm^3. Horizon is fed by atmospheric precipitates and irrigation waters infiltration, and discharged in the springs with low yield in the Black Sea coast. In Andriivka village the waters from the given complex are being used by local inhabitants in household and drinking purposes (scooping from wells).

Water-bearing complex in Pliocene continental and Eo-Pleistocene alluvial-proluvial sediments (N_2-apE) is developed in Eo-Pleistocene terraces and constitutes watersheds in the western part of Alminskiy basin. It lies first from the surface. Water-containing rocks include gravel and pebble with loamy filler. Because of solid water-proof lacking between Eo-Pleistocene and Pliocene sediments, the groundwaters do form the single water-bearing complex with depth up to 18 m. Specific borehole yields vary from 3.46 to 124.42 m^3/d. Filtration coefficients are 1.0-11.0 m/s. The waters are fresh, their mineralization does not exceed 0.3-0.8 g/dm^3 but in the eastern part of the map sheet area it in places increases to 1.0-1.6 g/dm^3. By chemical composition the waters are sulphate-hydrocarbonate and hydrocarbonate calcium. Water-bearing complex is fed through atmospheric precipitates and irrigation waters infiltration. Groundwater flow direction is western and north-western, in compliance with the natural surface inclination. Discharging is being done through springs and partly by evaporation.

Water-bearing and locally water-bearing horizon in Pliocene continental sediments (N_2) is developed at the watershed areas in Alminskiy basin where it lies first or second from the surface. Pliocene column is divided into the lower water-proof and upper slightly-permeable sequences with sand and gravel-pebble interbeds and lenses, where water-bearing or locally water-bearing horizon is being formed at the footwall. The total thickness of water-containing rocks varies from 0.10-3.0 m to 16-18 m, decreasing in the eastern direction, and the number of water-containing interbeds decreases downward the column. Established table depth varies from 1-3 m to 25-30 m. Borehole yields are 0.08-0.17 m^3/d, and in some cases only they attain 8.6-172.8 m^3/d. Filtration coefficients vary from 0.007 to 3-44 m/d. In the Belbek-Alma inter-river area the water mineralization is 0.5-0.8 g/dm^3 and they are chloride-hydrocarbonate, hydrocarbonate and sulphate-chloride, sulphate sodium-calcium in composition. Over remaining territory mineralization varies from 1-3 to 8-12 g/dm^3 and by composition sulphate and hydrocarbonate waters predominate. Water-bearing horizon feeding is being done by atmospheric precipitate infiltration, partly – through filtration losses from Mizhgirnenske water reservoir, and their discharging – in numerous springs in the coastal cliff and on the watershed slopes. Due to low water content and increased mineralization the waters are of very limited use.

Water-bearing horizon in Meotychni and Pontychni sediments (N_1m-p) is developed in Alminskiy basin (except its eastern and south-eastern parts), it lies first from the surface in its northern part and in the narrow bands on the river valley slopes and Kyzyl-Yar gully slope. Over remaining area it is second and more from the surface. Pontychni and Meotychni sediments are similar in lithology, regional water-proof in between them is lacking, thus groundwaters, developed in these sediments, are combined into the single water-bearing horizon with lower water-proof comprised of water-proof clays and marls of Bagerovska Suite and Lower Meotychni Dozinievi layers. Water-containing rocks are interbeds in the sequence of cavernous limestones, gravelites, sandstones and sands 0.5-10.0 m thick. In the elevated limbs of Alminskiy basin the rock dipping angles are high and water-bearing horizon is being formed in some, discontinuous by strike and thickness layers. With sediments plunging in Alminskiy basin, limestone layers in the upper column part become thicker (9-44 m) and continuous with the common piezometric surface of the horizon. Specific borehole yields in peripheral parts vary from 0.086 m^3/d to 371-432 m^3/d, and in the central and north-western parts of Alminskiy basin – 1382.4-8640 m^3/d. Filtration coefficients of limestone, gravelite and sand interbeds, alternating with clays, vary from 0.1 to 270 m/d. Mineralization does not exceed 1 g/dm^3, although closer to the sea in the west and to the lakes in the north-west it increases to 1-32 g/dm^3. By chemical composition the waters are hydrocarbonate-sulphate, hydrocarbonate-chloride calcium-sodium, and along the sea coast and in the area of salt lakes – chloride sodium. Mineralization increasing has been recorded in the first years of the horizon waters exploitation in the coastal area due to sea and salt waters input from the lower horizon layers. In the last years, because of additional feeding by irrigation waters and filtration from Mizhgirnenske water reservoir, mineralization of horizon had significantly decreased to 1.2-1.65 g/dm^3 (in boreholes located in Sakske Lake isthmus). Feeding is being done through atmospheric precipitates and irrigation water infiltration. The given horizon is discharged into Black Sea, partly at the gully slopes through a number of springs confined to the horizon limestones outcrops, as well as into the underlaying water-bearing horizons and complexes. The waters of this horizon are being used in technical purposes by centralized water-scoops at the sites with approved reserves (Sakskiy chemical plant and Okhotnykovskiy water-scoops) and from wells in Kolchugino, Rivnopillya and other villages.

Water-bearing horizon in Middle-Upper Sarmatian and Meotychni sediments (N_1s_{2+3}-m) is developed in the narrow band in the south of Tarkhankutske uplift where it is first from the surface. Meotychni and Sarmatian groundwaters are hydraulically linked and comprise the single water-bearing horizon, without interim water-proof in between. The water-containing rocks include fractured, porous and cavernous limestones. Horizon is underlain by 10-20 m thick Lower Sarmatian clays comprising regional water-proof. Thickness of water-bearing horizon is 100-160 m. Horizon is grounded with water table depth 0.0-3.0 m and altitudes 0.4-4.3 m. Water content of the horizon is irregular over territory and in the column because of various porosity, fracturing and cavernocity degrees, as well as variable rock lithology. Specific borehole yields vary from 86.4 to 7603.2 m^3/d and filtration coefficients are 1-266 m/d. The natural regime is broken under influence of extensive exploitation and irrigation. By chemical composition the waters are chloride-sulphate sodium-magnesium, in the area of salt lakes and shoreline – chloride sodium. The waters are salty and salt up to brines with mineralization from 1-3

g/dm^3 to 3-52 g/dm^3. Feeding of the horizon is being done through atmospheric precipitates and irrigation water infiltration. Discharging of the water-bearing horizon is being done into the underlaying water-bearing horizons, salt lakes and Black Sea, partly – by evaporation. In the area of Evpatoriya town reserves of iodine-bromine chloride sodium mineral waters of "marine" type are approved which are being used in medical bodies in curative purposes and also to fill up the dolphinarium basin.

Water-bearing horizon in Middle-Upper Sarmatian sediments (N_1s_{2+3}) is developed first from the surface in the peripheral elevated parts of Alminskiy basin and in Gerakleyske plateau. Over remaining territory it plunges down towards Black Sea beneath younger water-bearing horizons and complexes and becomes second and more from the surface. In the elevated limbs of Alminskiy basin, at the horizon boundaries, Middle-Upper Sarmatian sediments are composed of coastal facies and in the limestone column the sands, sandstones, clays and conglomerates occur. Total thickness of clays in the column is 5-10 m and entire water-bearing horizon – 10-15 m. With horizon plunging water-containing rocks almost completely consist of limestones and horizon thickness increases to 130 m. Depth of the horizon increases in the western direction from 0.1 to 150 m. Upper water-proof of the horizon consists of Meotychni clays and marls, and lower one – of Lower Sarmatian clays. Specific borehole yields vary in the ranger 0.03-16416.0 m^3/d, filtration coefficients of water-saturated rocks – 0.01-228.0 m/d. Water mineralization over most horizon distribution area is 1.0-1.5 g/dm^3. By composition the waters are hydrocarbonate, hydrocarbonate-sulphate, chloride calcium or calcium-sodium. In the coastal parts mineralization decreases to 10-46.8 g/dm^3 and waters become chloride sodium. Water-saturated sites are confined to the syncline structures. Feeding of the horizon is being done through atmospheric precipitate and irrigation water infiltration, water filtration from Mizhgirnenske water reservoir, inflow from overlaying water-bearing horizons, upgrading from the underlaying water-bearing horizon in Middle Miocene sediments, as well as at the sites of depression funnels where Middle-Upper Sarmatian horizon tables are lower than ones of the Middle Miocene one. Discharging of the waters from horizon is being done into the lakes, Black Sea, underlaying water-bearing horizons, through water-scooping, and in the sites with shallow water tables – by evaporation. The horizon is major exploitation one and its natural regime broken by non-controlled water scooping over many years. In Alminska depression the water-bearing horizon in Middle-Upper Sarmatian sediments is being exploited by a number of centralized water-scoops operating at the sites with approved reserves: Ivanivskiy, Chobotarskiy, Vilenskiy. At the site of Orlovskiy water-scoop, because of significant water scooping above the approved reserves, the salt water input from the sea has commenced, which has actually terminated the water scooping operations. The total Sarmatian horizon groundwater reserves in ALminska depression are estimated to 189.9 th.m^3/d.

Water-bearing horizon in Middle Miocene sediments (N_1^2) is exposed at the surface in the narrow band in Crimean Fore-Mountains while over remaining territory it is interbedded. Upper water-proof consists of Lower Sarmatian clays and the lower one – Maykopska Series clays. The depth is from 0.6 m at the distribution boundaries to 290 m in the centre of Alminska depression; thickness is 50-70 m. Water content of the horizon is variable because of various thickness and rock filtration properties. Mineralization does not exceed 1 g/dm^3; by chemical composition the waters are hydrocarbonate calcium or sodium-calcium. In the limbs of Alminskiy basin, in places where horizon is drained by deep erosion cuts of river valleys and gullies, abundant downstream spring with 25.9-43.2 m^3/d yields are observed. Feeding of the horizon is being performed through atmospheric precipitates, water discharge and inflow from overlaying water-bearing horizons and complexes. Discharging is being done into Black Sea, river valleys in the limbs of Alminskiy basin, and through exploitation water scooping. The waters of this horizon are being used for drinking and housing water supplying by individual boreholes, and under centralized mode – by Evpatoriyskiy and Sakskiy enterprises for water facilities.

Water-bearing horizon in Eocene sediments (₽$_2$) is confined to nummulitic limestones of Simferopilska Suite, which is exposed at the surface in Crimean Fore-Mountains, in the area of Kripke, Kholmovka villages, to the west from Krasniy Mak and Zalisne villages, where the water-bearing horizon table is free. Piezometric levels are established at the depth 148.2-730.4 m from the surface. Plunging to the west and north-west, water-bearing horizon is overlain by water-proof marls of Novopavlivska and Alminska suites, and underlain by clayey-marleous sediments of Kachynska and Bakhchysarayska suites. The waters are hydrocarbonate calcium with mineralization up to 0.5 g/dm^3. Downstream spring yields are low – 8.6-43.2 m^3/d.

Water-bearing horizon in Paleocene sediments (₽$_1$) is confined to the fractured and karsted foraminifera limestones and sandstones of Bilokamyanska Suite. It is developed first from the surface in the narrow band within Internal cuesta ridge. In the north-western direction the horizon sharply plunges and becomes second and more from the surface. Groundwaters of this horizon are developed at the depth from 0.10-3.0 m to 100 m. With plunging, the waters become pressurized with pressure value 1000-1500 m. The lower water-proof is comprised of persistent sequence of Upper Cretaceous marls, the upper one – clays and marls of Kachynska and Bakhchysarayska suites. Water content is highest in the area adjacent to the feeding region where nearby Kripke village borehole yield is 3024.0 m^3/d at the depression by 16.6 m. The water mineralization is 0.4-0.5 g/dm^3, by chemical composition waters are hydrocarbonate calcium. With plunging to the north-west, sodium, chloride and sulphate contents increase in the waters and sulphur hydrogen appears. Feeding is being done through atmospheric precipitates infiltration in the areas where horizon is first from the surface. Discharging is being performed in the erosion cuts through the springs with yields from 43.2 to 172.8 m^3/d, in places up to 259.2 m^3/d, as well as by single boreholes. In Krepkinska site the fresh water reserves are estimated and approved but for the moment centralized water-scoops is almost out of operations.

Locally water-bearing complex in fracturing zone of Upper Cretaceous sediments (K_2) is exposed at the surface in Crimean Fore-Mountains, where Upper Cretaceous sediments include fractured marls, dense, breccia-like limestones, and glauconite sandstones. Water-bearing complex is confined to the zone of exogenic fracturing of these rocks and fractured tectonic breaks. Over there downstream spring yields are 8.64-43.2 m^3/d and borehole yields – 8.64-51.8 m^3/d at the depression by 1-6 m. The water mineralization is 0.4-0.5 g/dm^3, by chemical composition the waters are hydrocarbonate calcium; with plunging mineralization increases up to 10-40 g/dm^3 and chemical type becomes chloride sodium. Feeding is being done through atmospheric precipitate infiltration and with plunging – by water inflow from overlaying water-bearing horizons. Horizon is out of practical use. In the Plain Crimea artesian basin the given water-bearing horizon is intersected by drill-holes in the central part of Alminskiy basin at the depth 887-937 m. Thickness of water-bearing zone is from 17 to 125 m. Static level is defined at the altitudes +12 – +80 m. Water-containing rocks include limestones with low water content from 0.09 to 25.9 m^3/d. Water type is chloride-sodium, mineralization from 2.1 to 80.7 g/dm^3. High-mineralized water contain iodine (5.08 mg/dm^3), bromine (160.8 mg/dm^3), and boron (4.6 mg/dm^3) [60].

Water-bearing complex in Lower Cretaceous sediments (K_1) is exposed at the surface in the northern slope of Crimean Mountain Main ridge. The water-containing rocks include fractured and slightly-fractured Valanginian and Hauterivian sandstones and limestones, pebble-stones and conglomerates (with Lower Jurassic and Tavriyska Series flysch water-proof); Hauterivian and Barremian sands, sandstones and conglomerates within thick sequence of water-proof argillites underlain by Barremian and Aptian water-proof clays. Thickness of Valanginian-Hauterivian water-bearing interbeds is 3-7 m, Hauterivian-Barremian – from 1.0 to 103.6 m, at the total thickness 150-300 m. Thickness of Albian water-bearing rocks is 23-85 m. Mineralization of Lower Cretaceous water-bearing horizons in the northern slopes of Crimean Mountains does not exceed 1 g/dm^3, spring yields vary in the range 0.4-604.8 m^3/d. Waters are hydrocarbonate calcium and sodium. Over remaining territory the water-bearing complex is second and more from the surface, progressively plunging down to the north and north-west. With plunging the waters become pressurized. In the buried part of Alminskiy basin, in the Saky town area, the water-bearing Hauterivian-Barremian gravelites, sandstones and aleurolites with clay interbeds are intersected at the depth 782-1169 m. Thickness of water-bearing zones is from 35 to 175.4 m. The waters are pressurized with static level +70 – +114 m. Mineralization varies from 1.6 to 11.4 g/dm^3 although in most it is 2.2 g/dm^3; borehole yields on outflow are 864-2592 m^3/d. Water temperature at collars varies from 18°C to 58°C. In the Evpatoriya town area, the water-bearing Albian sandstones, argillites and aleurolites of total thickness 35-417 m are intersected at the depth 476-745 m. Static level is defined at altitudes +10 – +87 m. Borehole yields are from 6.48 m^3/d at the depression 110 m to 2851.2 m^3/d at the depression 74 m. In general, water content of the complex is variable, it increases from the south to north, the water types changes to chloride sodium and in mineralization increases the same direction. Feeding of the horizons is performed through atmospheric precipitate where horizons are first from the surface, and water inflow from Upper Jurassic karsted limestones in places where Upper Jurassic and Lower Cretaceous water-bearing horizons and hydraulically connected. Fresh waters are being used for water supplying while mineral thermal waters are used by Saky and Evpatoriya resorts in curative-medical purposes (Saksko-Evpatoriyske deposit of mineral thermal waters, sites 2 and 3).

Water-bearing complex in Upper Jurassic sediments (J_3) is developed in the northern slope of Crimean Mountains Main ridge. Over there, water-bearing horizon is grounded, water-containing rocks include karsted fractured limestones, rarely conglomerates and sandstones. The lower water-proof in the feeding area is comprised of Middle Jurassic flysch, and somewhere in the transitional area – Upper Jurassic clayey limestone interbeds. In Baydarska and Varnautska valleys, where Upper Jurassic sediments are overlain by Lower Cretaceous water-proof rocks, the groundwaters become pressurized. The pressure value varies in Baydarska valley from 32.8 m to 776.5 m, in Varnautska valley – from 184 to 342 m. Over remaining territory the pressure is from 11 to 192 m [40].

Development of some water-containing zones from 18 to 216 m thick is characteristic for the pressurized waters. Specific borehole yields vary from hundredth m3/d to 950.4 m^3/d. In Upper Jurassic sediments the waters are fresh, hydrocarbonate calcium, rarely hydrocarbonate-chloride, chloride-sulphate with mineralization up to 1 g/dm^3 (0.3-0.5 g/dm^3). Feeding is being provided by atmospheric precipitates and discharging – in through numerous springs and by fractures into the Chorna River under-course sediments. Specifically, “Skelske” spring gives rise to Chorna River. For many years its average annual output is 119.23

th.m^3/d [40]. Considerable discharging is performed into Black Sea with submarine springs in the area of Aya cape and in Balaklavska harbor. Fracture-karst and fracture waters in Upper Jurassic sediments comprise the main source of water supplying for inhabited locations in Mountain Crimea.

Locally water-bearing horizon in fracturing zone of Middle Jurassic rocks (J_2) is first from the surface in Mountain Crimea where thin water-bearing horizons are related to weathered and fractured rocks in the upper column part. By chemical composition the waters are hydrocarbonate or sulphate-hydrocarbonate with mineralization 1.0-1.5 g/dm^3. In Plain Crimea the waters in Middle Jurassic sediments are intersected by drill-hole nearby Saky town where they are confined to sandstones and conglomerates at the depth 709-808 m. The waters are pressurized with yield 15.6 m^3/d. The water type is chloride-hydrocarbonate sodium with mineralization 2.65-3.0 g/dm^3. The waters are out of practical value.

Locally water-bearing horizons in exogenic fracturing zone of Tavriyska Series rocks (T_3-J_1). The rocks of Tavriyska Series, exposed at the surface in Kachynske uplift, are almost water-free, and only in the upper weathered zone and in fractured fault zones the local water-bearing horizons are developed. They include gas spring Chorni Vory (Adzhy-Su) and are intersected by drill-holes nearby Sokolyne and Novoulyanivka villages. The waters are chloride sodium-calcium with mineralization 4.06-5.52 g/dm^3. In the water of Adzhy-Su spring the micro-components (mg/dm^3): I – 0.4-1.8; B – 2.6-5.1; Br – 1.6-5.3; F – 0.3-0.7 are determined, as well as increased Li, Al, Mn, Ni contents. In the gas of the spring and in drill-holes: nitrogen, sulfur hydrogen, helium, and in Adzhy-Su spring also radon are determined. For many years average annual yield of Adzhy-Su spring is 13.8 m^3/d; water from this spring is being used in medical purposes in the physio-therapeutic hospital "Chorni Vody". Borehole yield nearby Sokolyne village is 0.13 m^3/d, and boreholes nearby Novoulyanivka village – 0.35-100.22 m^3/d. Prognostic water reserves in Novoulyanivka site are 163 m^3/d. Curative value of these waters is confirmed by Odesa institute of resorts [40, 46, 47, 49].

Water-bearing horizon in Lower and Middle Triassic sediments (T_{1-2}) is weakly studied; three drill-holes, intersected Triassic sediments at the depth 797-944 m, are located in Evpatoriya town. Horizon is confined to the sequence of Lower and Middle Triassic limestones, breccia-like, re-crystallized, fractured, pelitomorphic and oolitic at the bottom. Intersected thickness of the sediments is 143-456 m. Borehole yields on outflow vary from 0.08 to 568 m^3/d. The pressure is +50.0 – +125.8 m. By composition the waters are chloride sodium with mineralization from 8.2 to 11.4 g/dm^3, thermal (41-56^{o}C) [49, 50]. The water from these drill-holes is being used by Evpatoriya town resorts in curative purposes (Saksko-Evpatoriyske deposit of mineral thermal waters, site 1).

8. MINERAL RESOURCES AND REGULARITIES IN THEIR DISTRIBUTION

By the complex of mineragenic features the territory of map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) is included in two tectonic-mineragenic areas: Plain Crimea and Mountain Crimea [33]. In the former one Central Plain Crimean mineragenic zone, and in the latter – Mountain Crimean and Fore-Mountain Crimean tectonic-mineragenic zones are distinguished. Each zone differs in specific number of minerals. In Central Plain Crimean zone Neogene dimension limestones, curative mineral sledge and coastal-lake brines, mineral and thermal waters are of particular value. In Fore-Mountain Crimean zone phosphate-glauconite rocks, bentonite clays, Paleocene dimension limestones, clays for claydite are characteristic. In Mountain Crimean zone flux limestones, decorative and facing stones, as well as manganese and polymetal occurrences are known.

Metallic mineral resources

They include manganese, copper, lead and zinc occurrences.

Ferrous metals

Manganese

In Mountain Crimea Balaklavskiy (V-3-77), Uzundzhynskiy (VI-4-90), and Orlynivskiy (VI-4-89) occurrences are encountered. They are confined to marble-like brecciated limestones of Baydarska Suite and especially to its contact with overlaying Lower Cretaceous sediments. Ore body morphology is sheeted, lens-shaped and bunch-like. The ores are composed of pyrolusite, psilomelane, goethite, hydro-goethite with manganese content from 11.98 to 47.10% and iron oxide 12-30%. Uzundzhynskiy occurrence has been discovered as far back as 1898 by Geolkom, and Balaklavskiy one – in 1984 [63]. These occurrences are ascribed to the type of oxidized manganese ores and are of exclusively mineralogical value. Their description is given in Annex 1.

Regularities in distribution of manganese mineralization are not completely defined because of weakly studied particular occurrences. Some ones in Mountain Crimea are ascribed to manganese terrigenous ore formation which is confined to the bottom of transgressive sedimentary complexes [33].

Other occurrences are related to volcano-tectonic structures and located at various stratigraphic levels (from Middle Jurassic to Lower Cretaceous). Increased concentrations of molybdenum, mercury, silver, arsenic and gold do not exclude polygenic nature of these ores (sedimentary-volcanogenic with hydrothermal).

Non-ferrous and base metals

Copper, lead, zinc

Polymetalic mineralization is observed in sediments of broad age interval, from Triassic to Cretaceous. It is expressed in abundant dissemination aureoles of lead, zinc, copper, silver, heavy concentrate aureoles of galena, sphalerite, cassiterite, native copper, as well as veinlet-pod ore bodies in hard rocks.

In the western part of Mountain Crimea Fiolentskiy (VI-2-84), Monastyrskiy (V-3-76), Gerakleyskiy (V-3-72), Opolznevskiy (VI-4-93) ore occurrences are known and their description is given in Annex 1.

Fiolentskiy occurrence (VI-2-84), located in 5 km to the west from Balaklava town in Fiolent cape, is most studied; it is discovered in 1976 [31] and additionally studied in 1984 [63]. Occurrence is located in Gerakleyska volcano-tectonic structure and Fiolentskiy deep fault and is confined to Late Bajocian – Early Bathonian Karadazka Suite constituting the portion of the central-type volcanic unit. Polymetalic mineralization is related to both rhyolite and andesite-dacite dykes and faults in andesite-basalts. Thickness of the dykes is from 0.2 m to 5.0 m. Sulphide mineralization is veinlet-pod, pod, in the junction zones with crosswise breaks – bunch-like. Main ore mineral include pyrite, galena, sphalerite, chalcopyrite, minor – covellite, bornite, chalcosine, hessite, argyrodite, gold, silver. The highest ore component content is characteristic for andesite-dacites, specifically: copper – 0.16-1.46%, zinc – 0.25-1.4%, lead – 0.53-1.13%, gold – 0.4-1.7 g/t.

Hydrothermal alteration is expressed in calcitization, silicification, kaolinization and dickitization. In silicified spilites gold content is up to 0.5 g/t, silver – 33.7 g/t. General geological setting, mineral composition and geochemical features suggest for low rate of erosion cut. Mineralization age is Kimmerian since post-volcanic processes, accompanied by hydrothermal alteration and sulphide mineralization, did not affect Upper Jurassic and younger sediments. Ore body depth is from 0 to 150 m, total thickness is about 10 m, length – 100-300 m. The stripping rocks include Middle Jurassic tuffs of mafic and intermediate composition, spilites and Neogene terrigenous-carbonate sediments. By composition of mineralization the given occurrence belongs to copper-lead-zinc with increased gold, silver, cadmium and molybdenum contents.

Monastyrskiy (V-3-76) and Gerakleyskiy (V-3-72) occurrences have been formed in the similar geologic-tectonic situation: they are characterized by steep host rock dipping (75^o) to the south-west.

In Opolznevskiy occurrence (VI-4-93) ore mineralization is confined to sub-latitudinal subvolcanic diorite porphyrite body controlled by the fault of the north-eastern extension. The body, dipping to the north, is traced over 550 m with thickness up to 50 m. The host rocks include folded flysch of Tavriyska Series. In the northern block of the body, with less steep dipping, the hydrothermal-metasomatic alteration of both intrusive and host rocks is observed expressed in silicification, carbonatization and sulphidization. Ore mineralization include disseminated chalcopyrite, chalcosine, covellite, in places – bornite; in the oxidation zone limonite, malachite and azurite are developed. Copper content is 0.3-0.65%, zinc – up to 0.31%. Genetic type of occurrence is polymetalic meso-thermal.

Prognostic resources for the sum of metals (zinc, lead, copper, gold) are evaluated in Monastyrskiy and Gerakleyskiy occurrences. The depth of evaluated prognostic resources is 350 m in Monastyrskiy and 500 m in Gerakleyskiy occurrences, Perspectives to the depth are related to the anomalies of VES and IP up to 4.9% at the depth 250-400 m and ore component content increasing from the upper horizons to lower ones.

In the study of polymetalic mineralization distribution regularities the stratigraphic, lithological and tectonic factors are valuable.

Mineralization is almost exclusively confined to Late Bajocian – Early Bathonian Karadazka Suite. Lithological control is fairly prominent since the bodies of dense slightly-permeable felsic rocks provide the screen effect and mineralization in Middle Jurassic complex is confined to andesite-dacites and rhyolites with maximum concentrations at their contacts with mafic rocks.

Localization of mineral zones suggests for para-genetic link between occurrences and potassium rhyolites. Ore bodies in Monastyrskiy and Gerakleyskiy occurrences are located at the junction zones of variously-oriented tectonic breaks where north-west-trending faults are ore-transporting channels and crosswise ones do act the screens for ore-bearing solutions. Sulphides are normally concentrated in the zones of brecciated crushed andesites. In Fiolentskiy occurrence ore mineralization is also confined to the post-dyke faults developed in the dyke footwall block. Metasomatic factor is also expressed well enough and mineralization is accompanied by the rock whitening, silicification and pyritization, in places – propilitization. Second-generation quartz and potassium feldspar, characteristic calcitization, barytization and dickitization are directly related to sulphides. Dimensions of hydrothermally-altered rocks significantly exceed the ones of the ore zones.

In the ore zones prospecting the geophysical factor is important since the ore occurrences are controlled by strongly different magnetic field and mineralization is confined to the high-contrasted intricate negative magnetic anomalies which follow the felsic subvolcanic bodies. Sulphide mineralization exhibits some relations with positive anomalies of residual gravity field and zones of increased polarization.

Non-metallic mineral resources

Non-metallic mineral resources include flux limestones and limestones for soda and sugar industries, natural mineral salts, phosphorites, pigment and bentonite clays, Iceland spar, marble onyx, ornamental flint, decorative-facing stone, construction raw materials.

Non-ore raw materials for metallurgy

Flux raw materials

Limestones

Upper Jurassic limestone deposits of Balaklavska group are explored and being mined in the flux purposes: Kadykivske (V-3-75), Psylerakhske (VI-3-85). Gasfortske (V-3-74) and Karanske (VI-3-86) deposits are in reserve.

By their physico-mechanical properties and chemical composition limestones of these deposits are similar. They are being widely used in metallurgy, as well as in chemical, sugar and construction industries.

The minerals comprise diverse-color yellowish, pink and reddish massive and breccia-like fractured limestones of Baydarska Suite. Physico-mechanical properties of limestones are as follows: density – 2.6-2.81 g/cm^3, compression strength – 60-123.3 MPa, porosity – 0.89-1.31%, water absorption – 0.3-0.4%, Deval drum wearing – 3.5-3.9, softening coefficient – 0.9. Chemical composition of limestones (%): SiO_2 – 1.1-3.03; CaO – 52.6-54.7; MgO – 0.67-0.76; Al_2O_3 – 0.29-0.64; Fe_2O_3 – 0.09-0.58; P – 0.012; S – 0.054.

Description of deposits is given on the example of typical Psylerakhske deposit (VI-3-85) located in 2 km to the west from Balaklava town. Limestone massif constitutes the ridge extended along the Black Sea coast. In tectonic respect deposit is located in sub-latitudinal anticline fold with asymmetric limbs. The northern limb is composed of Lower Thitonian Yaylynska Suite limestones with dipping angles 60-70°, and Baydarska Suite limestones with dipping angles 30-40°. The southern limb is composed of Yaltynska Suite limestones with dipping angles 30-50°. Limestone massif is cut by tectonic breaks of normal type into a range of blocks. Between specific blocks the brecciation zones 15-35 m thick with dipping angles 60-75° are observed. Entire limestone sequence is irregularly-fractured and karsted. The stripping rocks include Quaternary loams, and in the flanks – Lower Cretaceous clays. The depth of exploration is 200 m.

By chemical composition and physico-mechanical properties limestones are suitable for manufacturing of convertor "C-1" and "C-2" grade lime, "M-1" and "M-2" flux grades, "Ch-1" and "Ch-2" blast-furnace grades in compliance with BST-14-64-80 and BST-14-63-80 standards and for calcined soda, and non-conditional limestones – for manufacturing of construction crushed stone under SBST 8267-82 and construction lime under SBST-21-27-76 standards. Deposit is in production since 1958 by Balaklavske mining administration.

Regularities in deposits distribution are caused by their location in Tithonian reef formation of Mountain Crimea (Baydarska Suite). Thickness of producing sequence is about some hundred meters. In tectonic respect all deposits are confined to Balaklavskiy block in South-Western Crimean synclinorium. Aforementioned formation also hosts deposits of Iceland spar, decorative-facing stone and raw materials for lime manufacturing.

Ore-chemical raw materials

Chemical raw materials

Rock salt

Natural mineral salt and brines in the map sheet area are related to salt lakes extended along the western Crimean coast, from Mykolaivka village in the south to Donuzlav Lake in the north.

Sasyk-Syvaske deposit (I-2-106) is confined to the southern part of Sasyk Lake. Deposit square is 41.9 km^2. As a result of geological exploration (preliminary exploration in 1977-1981) the static and dynamic reserves of sodium chloride, magnesium, potassium and bromine are estimated. Concentrations (kg/m^3) are as follows: sodium chloride – 150.49, magnesium – 8.13, potassium – 1.75, and bromine – 0.36.

According to the deposit exploitation exploration, from 1982 to 1998 valuable component concentration in the brine has been decreased in 1.71-1.78 times and becomes (g/dm^3) for sodium chloride – 85.72, magnesium – 4.56, and bromine – 0.21 [30].

Agro-chemical raw materials

Phosphorites

In the Fore-Mountain Crimea, in Paleogene sediments some horizons are encountered which contain nodular phosphorites. During geological exploration phosphorite occurrences are found in the rocks of Bilokamyanska Suite and at the bottom of Kachynska Suite sandstones – Skalystivskiy (IV-4-44), Peredushchelnenskiy (IV-4-54), Malosadoviy (IV-4-59), Inkermanskiy (V-3-64).

Phosphorites are comprised of clayey nodules 3-7 cm in size, disseminated fine pebble, mollusc cores, thin (up to 5-7 cm) phosphatized sandstone lenses (Inkermanskiy occurrence), with P_2O_5 content in nodules up to 13-19%. The host rocks include carbonate-glauconite-sandstone and carbonate-clayey-sandstone sediments.

Chemical composition of phosphorites in Skalystivskiy occurrence is as follows (%): SiO_2 – 17.62-23.16; TiO_2 – 0.06-0.12; Al_2O_3 – 0.31-0.42; Fe_2O_3 – 2.2-2.55; CaO – 39.88-40.3; MgO – 0.44-0.59; K_2O – 0.79-0.95; Na_2O – 0.85-1.16; P_2O_5 – 13.0-19.14; SO_3 – 0.4-0.69; F – 0.37-0.81; SrO – 0.09-0.13; LOI – 13.57-17.69; Total – 99.27-99.29.

All occurrences are weakly studied.

Regularities in the distribution of nodular and grained phosphate and phosphate-glauconite ores are controlled by several mineragenic factors. Phosphate-bearing layers are confined to the transgressive Paleogene lower parts and related to terrigenous-siliceous-carbonate phosphorite-bearing formation [33]. Lithological factor causes phosphorite link with the basal layers composed of glauconite sandstones, marls and clays. Phosphorus pentoxide concentrations are set in phosphorite nodules, in the lesser extents – in sandstone cement, and increase with glauconite content increasing in the rock. Tectonic, paleo-geographic and formational mineragenic factors are regional and define phosphorite-bearing horizons location in the platform con-sedimentation structures, formed in the coastal environments of shallow-water sea and active water dynamics.

Raw materials for mineral pigments

Pigment clay

The clayey paleo-soil, extensively red- and cherry-coloured sediments of Uchkuivska sub-suite, Tavrska Suite, are being widely used in Crimea for the pigments manufacturing.

Previous studies in the map sheet area [43] have revealed Skvortsivskiy (II-4-29), Kolchuginskiy (III-4-35) and Pishchanivskiy (III-3-31) occurrences of the ocher-type pigment clay. In occurrences the horizons are distinguished where clays contain 3.8-11.9% of Fe_2O_3 and can be used for enamel, oil- and glue-paints. Description of mineral pigment occurrences is given in the Annex 1.

Non-metal ore raw materials

Optical and piezo-optical raw materials

Iceland spar

Iceland spar is known from the veins, bunches and lenses in Upper Jurassic limestones of Baydarska, Yaltynska and Yaylynska suites and located in mineralization points and some occurrences.

Most known is Baydarskiy occurrence (VI-4-95) located in vicinity of Baydarski Vorota pass in Chelebi-Yauri-Beli Mountain. The veinlets and pods of milky-white semi-transparent calcite are identified by prospecting-exploration works [41] in limestones of Yaylynska Suite. Veinlet thickness is 0.8-1.0 cm, in places up to 1.5 m, length – 5-6 m. Mining of Iceland spar is not feasible because of low quality of raw material.

Adsorption raw materials

Bentonite clay

Bentonites are widely developed in the western part of Fore-Mountain Crimea where they constitute interbeds and lenses in marls of Kudrynska Suite (K_2*kd*), in places – in limestones of Upper Sarmatian Khersonska Suite (N_1*hr*) (Nekrasivskiy occurrence (IV-3-39)).

In the studied area Chornoritska and Kudrynsko-Bakhchysarayska distribution fields of Upper Cretaceous bentonite clays are distinguished. In Chornoritska field Inkermanske deposit (V-3-68) and Sapun-Gora (V-3-69), Chornorichenskiy (V-3-67) and Kara-Koba (V-3-66) are located. In Kudrynsko-Bakhchysarayska field Kudrynske (IV-4-55) and Menderske (IV-4-52) deposits and Bashtanivskiy (IV-4-58), Bakhchysarayskiy (IV-4-53) and Nekrasivskiy (IV-3-39) occurrences are distinguished.

Typical Kudrynske (IV-4-55) deposit is most studied. It is located in the right slope of Kacha River in between Mashyne and Kudryne villages and explored in 1971-1975. Producing horizon comprises the bed 0.15-0.7 m thick in layered chalk-like marls of Kudrynska Suite. The bed is traced over 1.5 km to the north-east and dips to the north-west under the angle 6-8^o. The depth is from 0.5 to 62.7 m. Clays are greenish-grey and yellowish-green, wax-like, montmorillonite. Colloid-chemical parameters are as follows: expansion – 227.2-423.4%, exchange capacity – 44.6-90.9 mg/equiv./100 g; wetting heat – 56.7-110.7 J/kg, specific surface – 49-96×10^4 m^2/kg, pH – 7.8-8.1. Chemical composition of clays (%): SiO_2 – 42.22-61.66; TiO_2 – 0.1-0.95; Al_2O_3 – 11.28-18.31; FeO – 0.4-1.79; Fe_2O_3 – 2.35-4.46; MnO – 0.14; CaO – 2.19-10.45; MgO – 3.26-4.92; Na_2O – 0.05-0.88; K_2O – 0.71-0.81; P_2O_5 – 0.14; SO_3 – 0.9; H_2O^- - 0.22-0.43; H_2O^+ - 5.29-14.36; CO_2 – 0.1-6.0.

The clays of Kudrynske deposit comply with requirements of BST-18-49-71 "Bentonites in grape-wine industry".

By the results of technological assessment conducted in Odeskiy technological institute and Institute of Mineral Resources, bentonite clays of Kudrynske deposit are composed of magnesium-aluminium montmorillonite of alkali-earth and alkali types, similar in composition and properties to the clay types known in the former Soviet Union (Gumbriyskiy, Sarytsokhskiy, Askangelyu). They are being used for the whitening of wine, fruit-berry juices, vegetable and mineral oils. Deposit is in production sine 1994 by "Bento-Krym" LLP.

Bentonite clays in Upper Sarmatian limestones of Khersonska Suite, known nearby Nekrasivka village, require additional study, and in Chornomorska field the land use conditions are not suitable.

Regularities in distribution of bentonite clays are mainly caused by stratigraphic mineragenic factor. They are confined to the marleous rocks of Kudrynska Suite (Santonian – Lower Campanian) and belong to the marl phosphorite-bearing marine formation [33]. Thin beds of high-quality bentonites have been formed by halmyrolysis, further diagenesis and epigenesis of the fine pyroclastic material from Late Cretaceous volcanoes in the Plain Crimean activated platform. Bentonite-like clays are also known in Upper Sarmatian sediments indicating possible volcanic activity in Neogene as well.

Jewelry-gem raw materials (semi-precious stones)

Marble onyx

In the studied area the gem occurrences are known – marble onyx (Uzundzhynskiy (VI-4-87), Baydarski Vorota (VI-4-94), Besh Tekne (VI-4-91), Lemenskiy (VI-4-114), confined to the highly karsted Upper Jurassic limestones. Onyx is observed in calc sinter forms in karst hollows and fractures. Lemenskiy occurrence is confined to the displaced massifs of Upper Jurassic limestones included in eluvial-coluvial sediments of Masandrivska Suite (N_2-E*ms*). Description of occurrences is given in the Annexes 1 and 2.

Gem raw materials

Ornamental stone

Occurrences of ornamental stones are known in Fore-Mountain Crimea. The host rocks include porcelain-like limestones of Bilogirska, Menderska and Prokhlandenska suites, as well as marls of Beshkoska Suite and sandstones of Ternivska Suite. Limestones and marls are white and grey, layered. The rocks contain lens- and nodule-like flint interbeds from 2-5 cm to 20-25 cm thick.

Most decorative flint varieties are known in Chorgunske occurrence (V-3-71) in the eastern outskirt of Chornorichchya village where they are confined to sandy marls of Bilogirska Suite. Flints are observed in light-grey, dark-grey and cream concretions and nodules. In the clayey marl sequence the ball-shaped, from 5 to 20 cm in diameter flint concretions are observed. Thickness of the batch, containing these concretions, attains 14 m. Concretion content is from 5 to 12% by the rock volume. Higher in the column, in Bilogirska Suite limestones, the lens- and sheet-like, dark-grey and black, 0.5-0.8 m thick flint bodies are observed. Flint-bearing batch is traced over 600 m by strike. Flint coloring is variable, from light-grey to black, often yellow, reddish, white or bluish spots are observed on the black background. The banded varieties are also known. The flints are composed of massive cryptic-crystalline mass of chalcedony-quartz composition. Flint concretions are being well cut and polished. They can be used both in technical purposes (manufacturing of grinding balls, mortars, stampers, polishing devices), and adornments (comply with BST-41.117-76 requirements).

Facing stone raw materials (decorative stone)

Limestones

Resource base of this mineral type in Crimea in general and the studied map sheets is actually unlimited. This base includes pearlwort limestones of Paleocene Bilokamyanska Suite – "Inkermanskiy" stone, and nummulitic limestones of Eocene Simferopilska Suite – "Bodratskiy" stone. High-decorative marble-like Upper Jurassic limestones of Baydarska Suite are being used in somewhat lesser amount in the facing stone manufacturing, often in souvenir ware purposes (office kits, vases, ash-trays, etc.), and marble debris – in mosaic wares, decorative concrete and plaster. Locally, in the Inkerman town area, Middle Miocene spaniodontelovi limestones (Mekenziivska sequence) are being used as facing stones – "Krymbalskiy" stone. Facing stones from Paleogene sediments are produced in the dimension limestone deposits as by-products and are described in respective section. Two deposits of facing stones in Upper Jurassic Baydarska Suite are explored – Sevastopolske (V-3-73) and Morozivske (V-3-70).

Sevastopolske deposit (V-3-73) of Baydarska Suite marble-like facing limestones is located in 12-16 km to the south-east from Sevastopol city and includes three sites – Gasfort, Morozivska and Chornorichenska. In Gasfort Mountain limestones are pink- and red-shaded (thickness 4.0-14.8 m); in Morozivska site limestones are grayish-white with calcite inclusions and pelecypoda fauna (explored thickness 4.9-15.5 m); in Chornorichenska site limestones are breccia-like, light-grey and pink-grey, pudding (explored thickness – 22.2-26.2 m). Limestone strength margin under dry-air state is 93.4-176.8 MPa, water adsorption – 0.11-0.44%, volume mass – 2610-2710 kg/m^3. Chemical composition of limestones (%): CaO – 53.3-54.37; MgO – 0.5-0.9, unsoluble residue – 2.0. Average yield of blocks from 0.2-0.6 to 2.5 m^3 in size in specific sites is as follows: Gasfort – 15.8%, Chornorichenska – 17.8%, Morozivska – 12%. Yield of plates from 1 m^3 of raw block: Morozivska site – 5.61 m^2, Chornorichenska – 15.22 m^2. Limestones in deposit are of high decorative properties, mirror-polished, suitable for facing and floor plates manufacturing, as well as art-decorative wares of general use, marble debris, fine chips for mosaic works, aggregates of “800”-“1200” grades, and the waste – for “A” and “B” class lime manufacturing. Deposit has never been mined since its Gasfort site is included into the reserve estimation contour of Gasfort flux limestone deposit, and Morozivska and Chornorichenska sites are located within sanitary zone of Chornorichenske water reservoir. Reserves are taken off the balance in 1990.

Inkermanske deposit (V-3-63) of “Krymbalskiy” stone is located in 0.5 km to the south-east from Inkerman-II railway station, in Sevastopol city lands. It is preliminary explored in 1971-1972 and composed of Middle Miocene carbonate sediments (Mekenziivska sequence), monoclinally dipping to the north-east under the angle 2-5^o. The raw materials include three varieties in the middle column part:

1. Shell-detritus, spaniodontella, re-crystallized limestones – “Krymbalskiy” stone – 2.2-12.1 m.
2. Fine-detritus limestones at the top of “Krymbalskiy” stone – 0.6-1.3 m.
3. Fine-detritus limestones with fine quartz pebble inclusions, in places they are completely facially replaced by the layer of spaniodontella limestones – 1.8-7.8 m.

Stripping rocks include limestones and sandstones with sand and clay interbeds, from 5-7 m to 45-50 m of total thickness. Physico-mechanical properties of “Krymbalskiy” stone are as follows: strength margin under dry-air state is 5.2-7.0 MPa, water adsorption – 3.67-4.75%, volume mass – 2066-2291 kg/m^3, porosity – 22.7-24.0%, softening coefficient – 0.55-1.0, frost-resistance coefficient – 1.0. Chemical composition (%): CaO – 50.24-50.72; MgO – 0.12-0.23, Fe_2O_3 – 0.13-0.15; Al_2O_3 – 0.19; TiO_2 – 0.02; LOI – 28.99-39.2. Fine-detritus varieties and limestones with fine quartz pebble almost do not differ by quality parameters from “Krymbalskiy” stone. They are being well cut and polished complying with SBST-9479-84 requirements.

Prospecting-exploration works in the map sheet area [44] have revealed three prospective occurrences of marble-like parti-colored limestones of Baydarska Suite: Irytskiy (V-4-81), Peredivskiy (V-4-82) and Azys-Bairskiy (VI-4-88) described in the Annex 1.

Construction raw materials

In the studied area construction raw materials include most widespread types of minerals: cement raw materials, dimension limestones, limestones for lime manufacturing, construction sand and gravel, clays for claydite, brick and tile manufacturing.

Cement raw materials

Marl, carbonate loam

In the map sheet area L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) the strong mineral resources base of cement industry is created. It is supported, first of all, by Bakhchysarayske deposit (IV-4-50) of cement loams and marls collated in 1.2 km to the south-east from Bakhchysaray railway station. Deposit was exploring in 1931, 1937, 1955-1956, 1971-1972 by various organizations of the Ministry of construction raw materials and Ministry of Geology of UkSSR. It is in production since 1960. Deposit is constituted of Paleogene and Quaternary sediments.

Quaternary sediments consist of light-grey, yellowish-grey, brownish-grey, carbonate loams 0.7-14.7 m thick.

Paleogene sediments include grayish-yellow clayey and greenish-bluish-grey carbonate marls with single interbeds of Eocene (Alminska and Novopavlivska suites) glauconite sandstones. Total thickness of marls attains 80 m. Rock dipping is monoclinal (north-west 330^o, angle 3^o). Producing sequence is wetted due to fracture waters of marl sequence (water-bearing horizon depth is 6.4-20.4 m) and Middle Eocene pressurized horizon (depth 100 m) in fractured nummulitic limestones of Simferopilska Suite. Maximum groundwater input into the quarry is 2556 m^3/d.

The first productive horizon is composed of Upper Pleistocene carbonate loams. They are composed of cryptic-crystalline hydromica material with limestone and sand-aleuritic admixture and pelecypoda and foraminifera remnants. Thickness of the horizon is from 0.3 to 14.7 m, average – 3.7 m. Granulometric composition: clay fraction – 28.7-75.0%, dirt particles – 23.8-47.7%, sand particles – 1.3-10.0%. Weighted-average content of the fractions more than 0.2 mm and 0.08-0.2 mm is about 5%. Loams are moderate-ductile, slightly sandy.

The second productive horizon is composed of clayey marls of Alminska and Novopavlivska suites with CaO content from 19.0% to 41.6%. Rock groundmass is pelitomorphic, mica, carbonate, with fine detritus admixture, single autigenic quartz inclusions. Texture is micro-grained, structure – thin-layered. Thickness of horizon is from 1-2 to 78.6 m, average – 26 m.

The third productive horizon is composed of calcareous marls of Novopavlivska Suite with CaO content more than 41.6%. The rock consists of micro-grained clayey-carbonate material with up to 5% detritus admixture and single quartz grains. At the top marl with CaO content 42-45% is observed, up to 20 m thick. By the module composition it is not suitable for direct portland-cement manufacturing. Thickness of the third horizon (within reserve estimation depth to +100 m) is from 25.5 to 71.7 m, average – 54.2 m.

Maximum content of harmful admixtures (manganese oxides, sulfur, phosphorus, alkali metals) in loams and marls is below admissible margins. By chemistry clayey marls and carbonate loams are similar and in equal extent can be used as clayey ingredient in the portland-cement manufacturing. Module values in all three productive horizons vary in the wide range and in the course of mining the raw materials mixture composition should be permanently controlled.

Dimension wall raw materials

Limestones

In the map sheet area, on the ground of Paleocene, Eocene and Neogene sediments, the strong mineral resources base of dimension limestone is created. Pearlwort and foraminifera limestones of Paleocene Bilokamyanska Suite, because of their high strength and productive thickness, are most important in dimension limestone production and being used in the dimension wall block, wall stone and facing stone manufacturing. Nummulitic limestones of Eocene Simferopilska Suite also comprise important object in dimension wall block and wall stone manufacturing. Wall stone is also being produced from thin shell, oolitic and detritus limestones (Upper Sarmatian Khersonska Suite, Bagerovska and Akmanayska suites of Meotycyhniy regio-stage, Evpatoriyski and Odeski layers of Novorosiyskiy horizon).

Major dimension limestone deposits are related to Paleocene and Eocene sediments of Crimean Fore-Mountains. Pearlwort limestones of Bilokamyanska Suite are explored in Bodratskiy-I (IV-4-45), Nykh-Syrt (IV-4-51), Glybokoyarske (IV-4-49), Alminsko-Bodratske (IV-4-47), Bodratsko-Alminske (IV-4-46), Peredushchelnenske (IV-4-56), Skhidnoinkermanske (V-3-61) deposits and Pervomayska site of Inkermanske deposit (V-3-65). Thickness of productive sequence is from 10.1 to 41.0 m, stripping rocks – from 0.2 to 24.1 m. Skhidnoinkermanske deposit has been mined by underground method and at present it is under conservation.

Alminsko-Bodratske deposit (IV-4-47), located in 0.5 km to the south-east from Glybokiy Yar village of Bakhchysarayskiy area, comprises typical example of pearlwort dimension limestones. Productive horizon is composed of pearlwort, fine-pod, re-crystallized limestones, 10.2 m thick in average. Stripping rocks include Quaternary loams 5 m thick in average. Physico-mechanical properties are as follows: compression strength margin under dry-air state is 4.8-12.7 MPa, water adsorption – 10.0-18.1%, volume mass – 1.65-2.06 kg/m^3, softening coefficient – 0.6-0.93, frost-resistance – 15-25 cycles. Chemical composition (%): CaO – 38.6-53.35; MgO – 0.15-0.83, SiO_2 – 2.33-11.5; Fe_2O_3 – 0.24-1.26; Al_2O_3 – 0.16-2.0; TiO_2 – 0.01-0.09; K_2O – 0.042-0.98; Na_2O – 0.02-0.09; P_2O_5 – 0.017-0.136; LOI – 37.7-42.5; unsoluble residue – 3.26-4.96. Limestones are suitable for manufacturing of wall blocks under SBST-15884-79 and “35”-“100” class wall stones under SBST-4001-84 standards, and partly – facing stones. Deposit is in production. Saleable wall block output is 65-77%.

Nummulitic limestones of Eocene Simferopilska Suite are explored in Skalystivske (IV-4-43), Kachynske (IV-4-57), Krasnomakivske (V-3-62) and Chapaivske (IV-4-48) deposits. Average thickness of dimension rock sequence is from 27.9 to 49.7 m, stripping rocks – 1.0-13.5 m.

Skalystivske deposit (IV-4-43), located in 5 km to the south-east from Poshtove village of Bakhchysarayskiy area, comprises typical example of this group of deposits. It is explored in details in 1966-1967 by “Ukrgeolstroym” expedition of the Ministry of construction raw materials of UkSSR. Productive horizon is composed of nummulitic limestones which monoclinally dip to the north-west under the angles 8-10^o and are 32.5 m thick in average. The stripping rocks include loams (0.3 m), greenish-grey marls of Novopavlivska Suite and weathered nummulitic limestones, of 2.45 m total average thickness. Underlaying rocks include highly re-crystallized nummulitic limestones. Physico-mechanical properties are as follows: compression strength margin under dry-air state is 7.5-32.4 MPa, water adsorption – 3.1-12.9%, volume mass – 1.89-2.39 kg/m^3, softening coefficient – 0.48-0.99, frost-resistance – 9-15 cycles. Chemical composition (%): CaO – 50.34-53.3; MgO – 0.22-1.0, SiO_2 – 2.83-6.9; Fe_2O_3 – 0.4-0.62; Al_2O_3+TiO_2 – 0.2-1.08; SO_3 – 0.05-0.2; LOI – 40.45-42.33. Limestones are suitable for manufacturing of wall blocks and "75"-"300" class wall stones under SBST-15884-79, 4001-84 and RSN-116-63 standards, as well as II-class lime and "300"-"400" class construction aggregate under SBST 8267-64 standard. Deposit is in production by Alminskiy plant of construction materials. Saleable wall stone output is 56-70%.

In the studied area 15 deposits of Neogene dimension limestones are explored, mainly with minor reserves. Of these, Sasytske (I-3-13), Mytyaivske (I-3-11) and Naumivske-1 (I-3-7) are the biggest.

Shell and detritus limestones of Upper Sarmatian Khersonska Suite are widely developed in Evpatoriyske plateau where Evpatoriyske (I-2-4) and Mytyaivske (I-3-11) deposits are explored.

In Evpatoriyske deposit (I-2-4) mainly Pontychni, Meotychni and Sarmatian limestones are being mined for construction lime, lime powder, debris and carbonate sand manufacturing and, at the same time, dimension limestones; description of deposit is given in the section "Raw materials for construction lime".

Among the Crimean construction materials significant role is played by Pontychni shell limestones (Evpatoriyski and Odeski layers). They are being easily cut, low heat conduction and high frost-resistance. Meotychni oolitic limestones are of lesser demand. They are of high volume mass, weak porosity that complicates their cutting and loading. Sasytske deposit (I-3-13), located in between Baranivka and Naumivka villages in 16 km to the north-east from Saky railway station, comprises the typical examples of this group of deposits. It is explored by "Ukrgeolnerud" trust in 1955-1956 as the part of Western site. Productive horizon consists of shell and oolitic-detritus limestones of Odeski layers (Pontychniy regio-stage), 5.9 m thick in average, separated by the bed of non-dimension, irregularly re-crystallized clayey limestone 0.5-4.2 m thick. Stripping rocks include Quaternary loams up to 3 m thick and fractured, weathered, irregularly re-crystallized limestones up to 2 m thick. Underlaying rocks include re-crystallized platy limestones up to 5.5 m thick. Physico-mechanical properties of shell and oolitic-detritus limestones are similar: compression strength margin under dry-air state is 0.4-2.4 MPa, water adsorption – 3-32%, volume mass – 0.9-2.0 g/m^3, frost-resistance coefficient – 0.6-0.9. Except the latter parameter, limestones comply with the SBST-4001-84 standard and are thought to be suitable for "4"-"10" class wall stone manufacturing for the south of Ukraine. Non-dimensional varieties and waste can be used in carbonate aggregate and sand manufacturing. Deposit is in production since 1966. Standard wall stone output is 77%.

Regularities in distribution of dimension limestone deposits are caused by their affinity to the carbonate organogenic Paleogene formation of Crimean Fore-Mountains composed of pearlwort limestones of Bilokamyanska Suite and nummulitic limestones of Simferopilska Suite, and to Neogene carbonate formation of Plain Crimea. Limestones of Paleogene formation by their chemistry and physico-mechanical properties do also comply with requirements to the raw materials for cement industry, as well as for lime, facing and construction stone manufacturing.

Raw materials for petrurgy and light concrete fillers

Clays

Claydite raw materials base in Western Crimea is supported by Oligocene clays with high enough bloating properties (Kyzyldzharska and Zubakynska sequences). They are widely developed in Crimean Fore-Mountains and exposed in the Alma and Kacha river valleys. In the studied map sheets three deposits are explored: Alminske (III-4-37), Plodivske (III-4-38), Komyshynske (III-4-36) which comprise the base of Bakhchysarayskiy claydite plant of "Budindustriya" combine.

Plodivske deposit (III-4-38) is located in 3 km to the south from Plodove village of Bakhchysarayskiy area. It is explored in details in 1978-1979 by Crimean branch of "Ukrgeolproekt" institute, and then further explored in 1985-1986 to the depth within the mining allotment contour by Crimean GEE of SE "Krymgeologia"; deposit is in production. Productive horizon consists of two layers of yellowish-brown and dark-grey Oligocene clays (Kyzyldzharska and Zubakynska sequences) of 33.9 m average total thickness (up to the reserve estimate horizon +118 m), which dip monoclinally to the north-west under the angles 5-20^o. Stripping rocks include Quaternary loams and Middle Miocene sandy-clayey sediments of 1.7 m average thickness.

Contents of major admissible chemical components and granulometric composition of clays from upper and lower layers comply with the SBST 25264-82 standard, and final product quality – SBST 9759-83 standard ("Claydite gravel and sand"). Some clay intervals in productive horizon are enriched in sulfur compounds caused by pyrite admixture in clay; most of pyrite is being burned on roasting (content of water-soluble sulphureous and sulfur compounds is less than 0.36%). By mineral composition the clays are montmorillonite-chlorite-hydromica with minor admixture of quartz, feldspar and kaolinite. Volume mass of yellowish-brown clays is 1.7-2.0 g/cm^3, dark-grey – 1.79-1.89 g/cm^3, foundry moisture – 29% and 31% respectively.

By the coarse-grained inclusions content, consisting of iron-enriched clayey material (15 mm across), carbonate (6 mm), gypsum (7 mm) and fine pyrite crystals, the clays from both layers do comply with SBST 25264-82 standard. The clays of upper layer are weakly bloating under natural conditions. To improve their bloating 0.5% of black oil and organic admixture should be added. The bloating interval upon additions is 45-80^o (40% of samples) and 90^o (60% of samples). The clays of lower layer bloat under natural conditions at 120^{o}C. Optimum roasting temperature is 1050-1070^{o}C. Refractoriness of clays is 1260-1320^{o}C. Claydite class is "200"-"350". It is frost-resistant and complies with SBST 9759-83 standard.

Raw materials for construction lime and gypsum

Limestones

In construction lime manufacturing purposes limestones from Jurassic to Neogene age can be used. Under BST 21-27-76 standard, by geological setting and raw materials quality Paleogene and Neogene limestones are most suitable, developed both in Plain and Fore-Mountain Crimea. In addition, non-conditional limestones from the Balaklavska group of deposits of flux raw materials are being used simultaneously.

The main demands in construction lime are supplied from Evpatoriyske (I-2-4) and Inkermanske (V-3-65) complex deposits.

Evpatoriyske deposit (I-2-4) of carbonate raw materials is located in 0.5 km to the south from Kamenolomnya village of Sakskiy area. Geological exploration has been conducted with interruptions since 1955 to 1983.

Geological column in the deposit is as follows (downward):

1. Dark-brown loams with limestone fragments, 2.54 m thick in average – Anthropogenic;
2. Yellowish-grey, oolitic-detritus limestones, cavernous at the bottom; thickness up to 8.4 m, of these dimension varieties – from 0 to 5 m (1.2 m in average) – Evpatoriyski layers (N_1*ev*);
3. Grey and yellowish-grey, shell-detritus limestones with clay interbeds; thickness from 0 to 9.6 m (5.2 m in average) – Akmanayska Suite (N_1*ak*);
4. Parti-coloured, breccia-like limestones with clay interbeds; thickness from 0 to 7.5 m (2.7 m in average) – Bagerovska Suite (N_1*bg*);
5. Grey, shell and shell-detritus, pelitomorphic limestones; thickness from 3.6 to 15.6 m (10.7 m in average), of these dimension varieties – up to 10.8 m (4.2 m in average) – Khersonska Suite (N_1*hr*);
6. Grey, pelitomorphic, wetted limestones, exposed thickness 2.6 m – Khersonska Suite (N_1*hr*).

Productive horizon is composed of shell limestones of second, third and fifth layers of total thickness up to 30 m. Stripping rocks include Anthropogenic loams and breccia-like limestones of the fourth layer (interim stripping) of 2.7 m average thickness.

Limestone complex assessment has been conducted for manufacturing of: construction lime under SBST 9179-77 and BST-21-27-76; carbonate aggregate and sand for construction works under SBST 222-63-76, TC 21 UkSSR 28-76, RST UkSSR 5014-82; limestone powder for acid soil calcinations under SBST 14056-78. Limestones in the deposit belong to the soft rocks with compression strength margin up to 1.0 MPa and suitable for construction lime manufacturing (sub-classes A, B, C under BST 21-27-76).

All limestone varieties comply with TC 21 UkSSR 28-76 and are suitable for "P-25"-"P-200" (by strength) and "800-1000" (by volume mass) class aggregate manufacturing which can be further used as light concrete filler, as well as in the road and municipal building. Limestones of this deposit are simultaneously evaluated as dimension stone. The SBST 4001-84 standard except frost-resistance (Mrz-15) is matched by oolitic-detritus limestones of Evpatoriyski layers and shell limestones of Khersonska Suite. All limestone varieties by harmful component contents (MgO, SO_3, P_2O_5, alkali metals) are suitable for cement industry under conditions of silica addition to Pontychni limestones, and silica and iron addition – to Meotychni and Sarmatian ones. Interim stripping loams and breccia-like limestones are being used for abandoned fields reclamation.

Inkermanske deposit (Pervomayska site, V-3-65) is located in 1 km to the east from Inkerman-II station. Geological exploration has been conducted with interruptions since 1955 to 1983. Productive horizon is composed of pearlwort limestones of Bilokamyanska Suite; total thickness from 23.5 to 59.8 m, average – 47.8 m. Stripping rocks include Quaternary loams up to 22.7 m of total thickness (8.6 m in average), as well as Neogene limestones, conglomerates, sandstones and clays, average thickness 8.8 m. Deposit is confined to the south-eastern limb of Alminska depression. Rock dipping is monoclinal to the north-north-west under angle 5^o.

Productive horizon is not wetted. Limestones are suitable for I and III grade construction lime manufacturing, as well as limestone powder for soils calcinations. Some pearlwort limestone layers are suitable for wall stone mining under TC-21 of Ukraine 315-81. Saleable stone output is 64-76%. Deposit has been mined since 1964 by Inkermanskiy construction materials plant, and recently – by "Inkerstrom" Ltd.

Sand-gravel raw materials

Sand, gravel

Conditional construction sands and sand mixtures are very locally developed in Crimea although a great number of marine, lake and alluvial occurrences are discovered both in Black Sea coast and in the Alma, Kacha and Belbek river valleys. Their age encompasses the time span from Lower Cretaceous to Anthropogenic.

In the studied area Sasytske deposit (II-2-107) is explored, located in 10 km to the west from Saky town, at the spit, separating Sasyk Lake and Kalamitska Bay from Black Sea. Two sites are distinguished in the deposit – Western and Eastern, separated by the sea channel.

Productive horizon is composed of modern and Upper Quaternary sediments comprising intercalation of yellowish-grey and dark-grey sands with lens-like interbeds of sand-gravel material. Gravel is composed of quartz, limestone, shell fragments, from 1.2 to 20%. Total thickness of productive horizon is from 4.3 to 12.8 m, average – 5.57 m. Stripping rocks include soils and humused fine-medium-grained sands from 0.2 to 2.0 m thick. Underlaying rocks are composed of dark-grey clayey fine-grained sands. Productive horizon is wetted – groundwater table varies from 0.2 to 1.4 m. Borehole yield is 10.37-248.83 m^3/d, specific yields – 111.46-4492.8 m^3/d. The waters are mineralized, chloride-sodium, alkaline. Wetting of sand-gravel sediments facilitates mining by suction-tube dredges when fine particles are brought out by water flow into the lower part of washed heap providing sand beneficiation with conditional fractions.

In the granulometric composition of sand-gravel sediments the fractions 5-10 and 10-20 mm predominate. Weighted-average content of 5-40 mm fraction in the deposit is 21.3% in general. Sample partitioning by gravel classes is as follows: Dr-8 – 60.4%, Dr-12 – 24.0%, Dr-16 – 11.4%, Dr-24 – 4.2%. Gravel is almost free of the soft rock grains (their average content is 3.3%), frost-resistance grade – Mrz-15, amortization grade in table drum "Z-1", "Z-2", shot resistance grade in headframe PM – "U-75". Average volume mass is 1.6 t/m^3, density – 2.65 g/cm^3, cavity – 39%, size module – 1.1-3.7, clay and mud particle content – 4.5%.

In the mineral composition of sand fraction (0.14-2.5 mm) quartz (47%), carbonate shell fragments (33%), marble-like limestone (12%) and quartz sandstone (7%) predominate. The gravel fraction contains marble-like limestone fragments (50.6%), quartz (25%), sandstone (23%), fragments and solid shells (1.4%). Gravel-sand mixture complies with SBST 23735-79 and SBST 8736-77 standards and can be used in "200" grade concrete manufacturing. Gravel is not suitable for hydro-technical concrete manufacturing. Deposit is in production since 1964.

Brick-tile raw materials

Clays

In the brick and tile manufacturing the Lower Cretaceous and partly Pliocene clays are being most widely used in Crimea. Lower Cretaceous clays in the studied area are being mined in Balaklavske deposit (V-3-78), and Pliocene ones are explored in Vilinske deposit (III-3-32).

Balaklavske deposit (V-3-78) is located in the north-eastern outskirt of Balaklava town. It was exploring in 1932, 1939-1940, 1948, 1952-1953, 1973-1975.

Deposit is composed of the following rocks (downward):

1. Loess-like loams, thickness from 2.5 to 4.0 m – Upper Quaternary (P_{III}).

2. Yellowish-brown, oxidized, carbonate, ductile clays, 4.2-9.5 m thick (6.0 m in average) – Balaklavska sequence (K_1*bl*).

3. Dark-grey, dense, uniform, argillite-like clays, 27-39 m thick (33.0 m in average) – Balaklavska sequence (K_1*bl*).

4. Light-grey, aleuritic clays, exposed thickness – 25 m – Balaklavska sequence (K_1*bl*).

Productive horizon is composed of yellowish-brown and dark-grey clays of total average thickness 39 m. Minerals are not wetted.

In places frequent, thin, from 0.03 to 0.1 m thick sandstone, gravelite and sphero-siderite interbeds are observed in clays. The latter are hydro-mica-montmorillonite-kaolinite, sheeted, dipping to the north under the angles 12-18°. Ductile number in yellow-brown clays is 11.7-14.7, dark-grey – 15-18. Sintering interval is 1100-1150°C.

The clays comply with SBST 530-71, SBST 8411-74, SBST 9165-75 standards and are suitable for "125"-"200" class brick and drainage pipe 150 mm in diameter manufacturing. Deposit is in production since 1946 by Sevastopolskiy plant of construction materials.

Vilinske deposit (III-3-32) is located in 3 km to the north-east from Viline village of Bakhchysarayskiy area. It is explored in 1989-1992. Productive horizon is composed of Andriivska Suite clays of Pliocene Tavrska Suite which comply with BST 21-78-88 standard except content of carbonate inclusions 0.5-3.0 mm in size. However, the brick produced in semi-plant trials complies with SBST 530-80 standard ("100"-"150" class by strength and Mrz-25 by frost-resistance). The mixture includes 88% of clay and 12% of flotation coal beneficiation waste.

Waters

Groundwaters

The groundwaters include mineral, fresh and thermal ones.

The complex geological structure causes hydrogeological zonation within four regions:

1. The core of Mountain Crimea – region of mainly water-proof flysch sediments of Tavriyska Series and Middle Jurassic. The water-proof sequence of sandstone-clay rocks contains locally developed groundwaters in fractures and crushing zones resulted from extensive tectonic breaking. Discharge of this horizon is being done through the springs in the gully slopes, in coastal cliffs above sea beach. Water content of the horizon is low (spring yields are 17.28 m^3/d), the waters are mineralized.

2. South-western block of Mountain Crimea – region of groundwaters confined to the fractured and karsted Upper Jurassic limestones.

3. Northern limb of Mountain Crimea – region of Lower Cretaceous groundwaters. The waters are confined to Valanginian and Hauterivian limestones, sands and sandstones, as well as Albian sandstones.

4. Plain Crimea artesian basin – region of water-bearing horizons in Lower-Middle Triassic, Lower Cretaceous, Paleogene, Neogene and Anthropogenic sediments. The first ones are low-water, high-mineralized (up to 10-34 g/dm^3) and relatively high-temperature (up to 80°C), defining their curative value and use as the heat-transfer.

Mineral waters

In the map sheet area L-36-XXVIII and L-36-XXXIV Adzhy-Su deposit (V-4-80) and Novoulyanivskiy (V-4-79) and Melas (VI-4-96) occurrences are known.

Mineral waters of Adzhy-Su deposit (V-4-80), located in 2 km to the west from SOkolyne village, are known from the ancient times and have been "artisanally" used long ago to cure rheumatism, polyarthritis, trophic ulcers, neuritis and other illness. Since 1957 the physiotherapeutic hospital "Chorni Vody" operates nearby the spring offering 150 baths per day. The spring is confined to the deep tectonic fault separating the Main and Fore-Mountain ridges of Crimean Mountains and set in Tavriyska Series rocks. The spring has been studied since 1929, prospecting works were conducted in 1965-1969 [49]. Spring yield is 13.8 m^3/d. The water composition is chloride, sodium-calcium, with mineralization 4.06-5.52 g/dm^3. Dissolved gas of methane-nitrogen composition with helium admixture is contained in the water. Chemical composition formula is as follows: $M_{41}\frac{Cl_{98.9}}{Ca_{67.6}Na_{32.3}}$. Content of biologically-active micro-elements (mg/dm^3): iron – 0.317-1.25; lithium – 0.032-2.3; fluorine – 0.1-0.35; silica acid – 6.0-20.0; manganese – 0.038-0.498; dissolved sulfur hydrogen – 0.008-11.8. In the gas, freely discharging from the water, nitrogen content is 63-81%, methane – from 7.12 to 37.4%, and helium – 0.086-0.54%. By composition and curative properties Adzhy-Su waters are included into the same group as Matsestynski and Staroruski ones. Temperature regime in the spring is unstable and varies from 7 to 19°C.

Novoulyanivskiy occurrence (V-4-79), according to conclusion by Odeskiy institute of resorts, can be used to cure chronic gastritis, colitis, thyro toxicosis.

Melas occurrence (VI-4-96) is being used by Melas sanatorium to cure etching organs.

Fresh waters

In the studied map sheets the major fresh water-bearing horizons and complexes include Pontychniy-Meotychniy in the north and Middle-Upper Sarmatian and Middle Miocene – in the central part of the territory. Besides that, in the area of Fruktove village in the Belbek River valley Belbetska site (IV-3-112), and in the area of Shuli village (Chorna River valley) – Inkermanska site (V-3-113) are known, where groundwaters in Anthropogenic alluvial sediments are developed. In the south of territory (Polyana, Rodnykivske, Opolzneve villages) the water-bearing horizon in Upper Jurassic sediments is in use. Significant fresh water reserves are explored in limestones of Bilokamyanska Suite (Krasniy Mak village).

The following fresh water deposits are distinguished in the map sheet area:

Novoselivske – Sakska site (I-3-12);

Alminske, the sites: Evpatoriyska (I-2-5), Alminska-1 (I-3-17), Alminska-2 (II-3-25), Okhotnykivska (I-3-16), Chobotarska (II-3-26), Sakska-1 (II-3-24), Sakska-2 (II-3-23), Ivanivska (II-3-27), Alminska-5 (II-3-28), Alminska-8 (III-3-30), Vilinska-1 (III-3-34), Vilinska-2 (III-3-33), Orlivska (IV-3-41), Suvorovo-Tinysta (IV-3-40), Lyubymivska (IV-3-42), Kripkenska (V-3-60), Belbetska (IV-3-112), Inkermanska (V-3-113);

Zakhidnokrymske, the sites: Polyanska (V-4-83) and Zakhidna (VI-4-92).

Thermal mineral waters

The thermal mineral waters were discovered for the first time in 1956-1959 by the trust "Krymnaftogasrozvidka". In 1959-1964 prospecting-exploration works were conducted for Saky and Evpatoriya resorts [48]. As a result, Saksko-Evpatoriyske deposit has been distinguished which consists of Sakske (II-3-22) and Evpatoriyske (I-2-6) deposits.

In Saky resort Hauterivian-Barremian water-bearing horizon of thermal mineral waters is developed, and in Evpatoriya resort – Triassic and Albian ones.

In Sakske deposit (II-3-22) the Hauterivian-Barremian water-bearing horizon is being exploited by borehole from where curative-potable water "Krymska mineralna" is produced. The water is chlodire-hydrocarbonate-sodium and hydrocarbonate-chloride-sodium with biologically-active components content (mg/dm^3): iodine – 0.2-0.3; bromine – 0.4-3.25; boron – 4.1-19.3. By gas composition the water is methane-nitrogen, temperature in outflow – from 38 to 47^{o}C, mineralization from 1.8 to 17.5 g/dm^3. Borehole yield in outflow is from 6.48 to 2877.12 m^3/d.

The waters of Albian horizon are salt, chloride-sodium with dissolved sulfur hydrogen content from 0.12 to 19.74 mg/dm^3, mineralization up to 35.63 g/dm^3, and temperature in outflow 27-42^{o}C. Outflow yield is 604.8 m^3/d.

Triassic water-bearing horizon is confined to the fractured and dolomitized limestones with dolomite interbeds. Water pressure above borehole collar is 88-100 m, outflow temperature 41-42^{o}C. Mineralization is 9-10 g/dm^3, water type – chloride-sodium slightly alkaline and low-sulphide.

The thermal water-bearing horizons in Novoselivske deposit (I-4-18) are confined to Lower Cretaceous (Hauterivian-Barremian) sediments. For the first time the thermal waters were discovered in the course of drilling for oil and gas in 1953-1968 by "Krymnaftogasrozvidka" trust. In 1981 prospecting works commenced and in 1990 detailed exploration of thermal waters in Novoselivska field has been completed [60].

Novoselivske deposit (I-4-18) occupies large territory in Sakskiy and Pervomayskiy areas. Water-bearing horizon is confined to Hauterivian-Barremian sandstones with gravelite interbeds (Kalininska Suite). Horizon is pressurized, pressure height is 811-1290 m. Outflow yield at minimum pressure 0.2 MPa is 337-484 m^3/d. By composition the water is chloride-sodium, chloride-hydrocarbonate-sodium, with mineralization 5.7-17.3 g/dm^3. Content of biologically-active components (mg/dm^3): iodine – 11.5; bromine – 10-81; boron – 68-117.6. Temperature at borehole collar is 49-65^{o}C. In the north of Novoselivske uplift the hanging-wall of the water-bearing horizon plunges down to the depths 1260-1335 m and water temperature increases to 69-80^o.

Mineral sludge and mud

Curative sludge

Mineral curative sludge in the studied map sheets are related to the Anthropogenic lake-estuary sediments. They are widely developed along the western Crimean coast where they form the lake bottom sediments. The sediments include dark-grey to black mud (glue) with characteristic sulfur hydrogen smelt. Sulfur content per 100 g of dry sludge is 0.049-0.179 g.

In the studied map sheets the following deposits of Evpatoriyska lake group are located: Sakske (II-3-108), Maynatske (I-2-105), Sasyk-Syvaske (I-2-104), Adzhy-Baychy Lake (I-1-98), Airchynske Lake (I-1-99), Galgaske Lake (I-1-100), Konradske Lake (I-1-102), Terekly Lake (I-1-103), Kyzyl-Yarske Lake (II-3-109), Bogayly Lake (II-3-110), as well as occurrences: Oyburzke Lake (I-1-97), Krugle Lake (I-1-101). In the lakes Krugle, Konradske, Sakske detailed exploration is conducted while in the others – just the preliminary studies. By the sludge composition all lakes are ascribed to chloride-magnesium-sodium mineral type. Thickness of curative sludge varies from 0.17 to 1.4 m (0.2-0.3 m in average). Volume mass is 1.4-1.6 g/cm^3, contamination – 0.7-5.0%, organic matter content – 0.5-1.4%, moisture – 42-60%, pH – 5.3-7.2 (6.3-7.0 in average). Sakske deposit only is being exploited.

9. ASSESSMENT OF THE AREA PERSPECTIVES

In the studied map sheets the main perspectives for new deposits discovery are related to non-metallic minerals, mainly flux, cement and facing limestones, diverse construction materials (construction stone, claydite and brick-tile clays, carbonate raw materials for lime manufacturing).

In the course of establishment in Ukraine the own base metal and gold industry the perspectives may be enhanced with regard to the copper, zinc and lead (with gold) occurrences encountered in the south-western Crimea in volcanogenic rocks of Middle Jurassic Karadazka Suite.

Perspectives of discovery the horizons, productive for phosphate-glauconite raw materials, are related to further study of Lower Cretaceous and Paleogene sediments.

In term of green pigment production, 0.5-3.0 m thick glauconite sands of Paleocene Kachynska Suite are perspective; these sediments are included into the stripping rocks in Inkermanske dimension limestone deposit. Upon glauconite magnetic separation (glauconite content in the rock is 50-60%) and milling the light-green pigment is being received suitable for the oil, glue and cement paints manufacturing. Perspective mineral pigments may also include by-product siderite concretions mined in Balaklavske deposit of brick-tile clays.

The modern raw mineral base for construction materials in general meets Crimean demands in wall stone, cement raw materials, claydite and brick-tile clays, carbonate raw materials for lime and aggregate manufacturing.

Significant perspectives for new dimension limestone deposits are related to Neogene and Paleogene sediments in Sakskiy and Bakhchysrayskiy (Krasnomakivska, El-Burun, Chkalivska, Turgenivska sites) areas respectively, as well as reserves upgrade in the flanks of explored deposits [38].

The modern raw material base for claydite is quite enough to meets Crimean demands for long perspective. If necessary, it can be expanded though exploration of the deeper horizons and flanks of Plodivske and Komyshynske deposits, as well as through exploration in the new sites of Oligocene clays encountered in the course of exploration works.

In the course of EGSF-200 [38] some clay occurrences perspective for brick-tile raw materials (Verkhorichenskiy, Orlivskiy, Kashtanivskiy, Varnautskiy and others) are found. According to the laboratory studies, the clays are suitable for brick, cement, tile and coarse ceramics manufacturing. The minerals include Hauterivian-Barremian and Aptian clays, Middle-Upper Pliocene clays and loams, as well as argillites of Tavriyska Series.

A great number of quarries for dimension, flux and construction limestones (aggregate) may ensure extended production of construction lime by using the stripping rock waste on the major deposits (Alminsko-Bodratske, Psylerakhske, Skalystivske and others). There is no need therefore in the special works devoted to the expansion of mineral-resource base of carbonate rocks for construction lime.

At the same time, there is a strong deficit in construction sands, caused by both specific Crimean geology and environment protection aspects – forbidden sand mining in the Black Sea coastal area. The perspectives for raw material base expansion with regard to construction sands and sand-gravel mixtures are actually missed in the given map sheet area (continental part). Reserve upgrade is only possible for the low-quality sands and gravel related to Anthropogenic and Lower Cretaceous sediments. This is why main perspectives for the construction sands raw material base expansion are thought to be related to the development of the off-shore resources in the western part of Black Sea.

Significant role in the resort development is played by the mineral resources of salt lakes (brines and mineral curative sludge) and mineral thermal waters. It is especially the case for the western and southern Crimean coasts where major operating medical-resort objects and new ones under construction are located.

10. ECOLOGICAL-GEOLOGICAL SITUATION

Ecological state of geological environment in the studied map sheets undergoes changes under influence of technogenic loading. These changes become especially prominent over the last fifty years with regard to the growing industry and agriculture in Plain and Fore-Mountain Crimea.

In the preparation works to the given section, materials of the Ministry of Agriculture and Food of Crimea, Vegetable Protection Station, and Sanitary-Epidemiologic Station of Crimea were used. Besides that, in the analysis of ecological state the following factors were accounted: the territory located in the zone of high seismicity – 6-8 of magnitude; groundwaters in Plain Crimea and sheet-block waters in Mountain Crimea are ascribed to the non-protected category; radio-nuclide content over last 10 years did not exceed 0.5 Cu/km^2 on Cs-137 and 0.02 Cu/km^2 on Sr-90.

Collected materials had provided the ground for compiled "Schematic map of ecological state of geological environment" and are expressed in Fig. 10.

Landscape zonation. Taking into account the landscape classes, type and kind, two landscape provinces are distinguished in the map sheet area: A – Plain Crimean steppe, and B – Mountain Crimean.

Plain Crimean steppe province (A) comprises the integral part of the south-steppe landscapes of sheet-accumulative lowland in Prychornomorska depression and is divided in two groups of landscapes:

A-I – sub-province of inclined Tarkhankutska height (within its southern part) – Ca^{2+}, Ca^{2+}-Na^{+} calcium, calcium-sodium landscapes of structure-denudation elevated plain in the uplifted Herzinian folded basement with sub-surface position of Neogene limestones; fescue-feather-grass steppe and motley-grass-fescue-feather-grass steppe on black earth salternous and meadow salterns and agro-landscapes on them.

A-II – sub-province of Alminska accumulative-denudation plain – H^{+}-Ca^{2+}, Ca^{2+} acid-calcium, calcium landscapes of Alminska depression composed of alluvial and alluvial-proluvial terrigenous sediments on the Miocene-Pliocene basement. It includes steppe sites on carbonate debris brown and full-extent black earth soils with feather-grass, motley-grass-fescue, shibliak families and agro-landscapes on them, as well as swamp landscapes of the river flood-lands.

The province B comprises the integral part of the Crimean Mountain landscapes. Over there, extensive migration of technogenic elements is characteristic during soil washing by water and water removal. Two sub-provinces are distinguished:

B-I – sub-province of Crimean Fore-Mountains – Ca^{2+}, H^{+}-Ca^{2+} calcium, acid-calcium fore-mountain landscapes with eluvial-deluvial sediments over Neogene-Paleogene and Cretaceous carbonate rocks, steppe sites on the eluvium of carbonate rocks and partly, agro-landscapes on them;

B-II – sub-province of Crimean middle- and low-mountains – Ca^{2+} calcium mountain-forest landscapes; meadow plants developed over brown mountain and turf-brown-earth debris soils on the eluvium of carbonate karsted rocks; beech-pine forests on the steep slopes with brown and turf-brown-earth debris soils.

Technogenic loading. Major factors of technogenic loading include industrial enterprises, transport, agriculture, water scooping, hydro-technical constructions and mineral mining.

Industry. In the map sheet area L-36-XXVIII and L-36-XXXIV the enterprises and objects are located which are included into the "List of activities and objects providing increased ecological hazard". These include Sakskiy chemical plant, Bakhchysarayskiy "Budindustriya" combine, ammunition stores in the Sevastopol city area, Sevastopol plant for technical and house waste recycling, Sevastopol city landfill (overloaded long ago), and enterprises of "Teplokomunenergo" (municipal heating units) in Evpatoriya and Sevastopol towns. In addition, the enterprises of light, food, metal-working and instrument-making industries are located in Sevastopol, Evpatoriya, Saky and Bakhchysaray. In Evpatoriya town, with 121 thousand of population, about 30 enterprises of light, food, and instrument-making industries are located, as well as sea port and auto-transport enterprises. The enterprises of "Teplokomunenergo" and "Kurortteploenergo" are the most significant contamination sources which annually emit to the air about 2 thousand tons of harmful substances: SO_2, CO, nitrogen compounds, light organic compounds (LOC), soot, Pb and Mn compounds, benzine, toluene, xylene, styrene, phenol, butylacetate, formaldehyde, sulfur hydrogen, and others (hereafter by 1993).

Saky town is the major curative resort, but industrial town from the other hand, where enterprises annually emit to the air about 500 tons of harmful substances: CO, SO_2, NO_x, C_x, H_x, LOC, methyl spirit, HCl, Mn compounds. Industrial waters from Sakskiy chemical plant are being dropped into Sakske Lake almost untreated. They contain ammonia, potassium permanganate, hydrogen peroxide. Gas emissions from these enterprises contain Hg, Cu, Zn, Pb and other heavy metals, and in Garshyno village the solid waste dump from chemical plant is located.

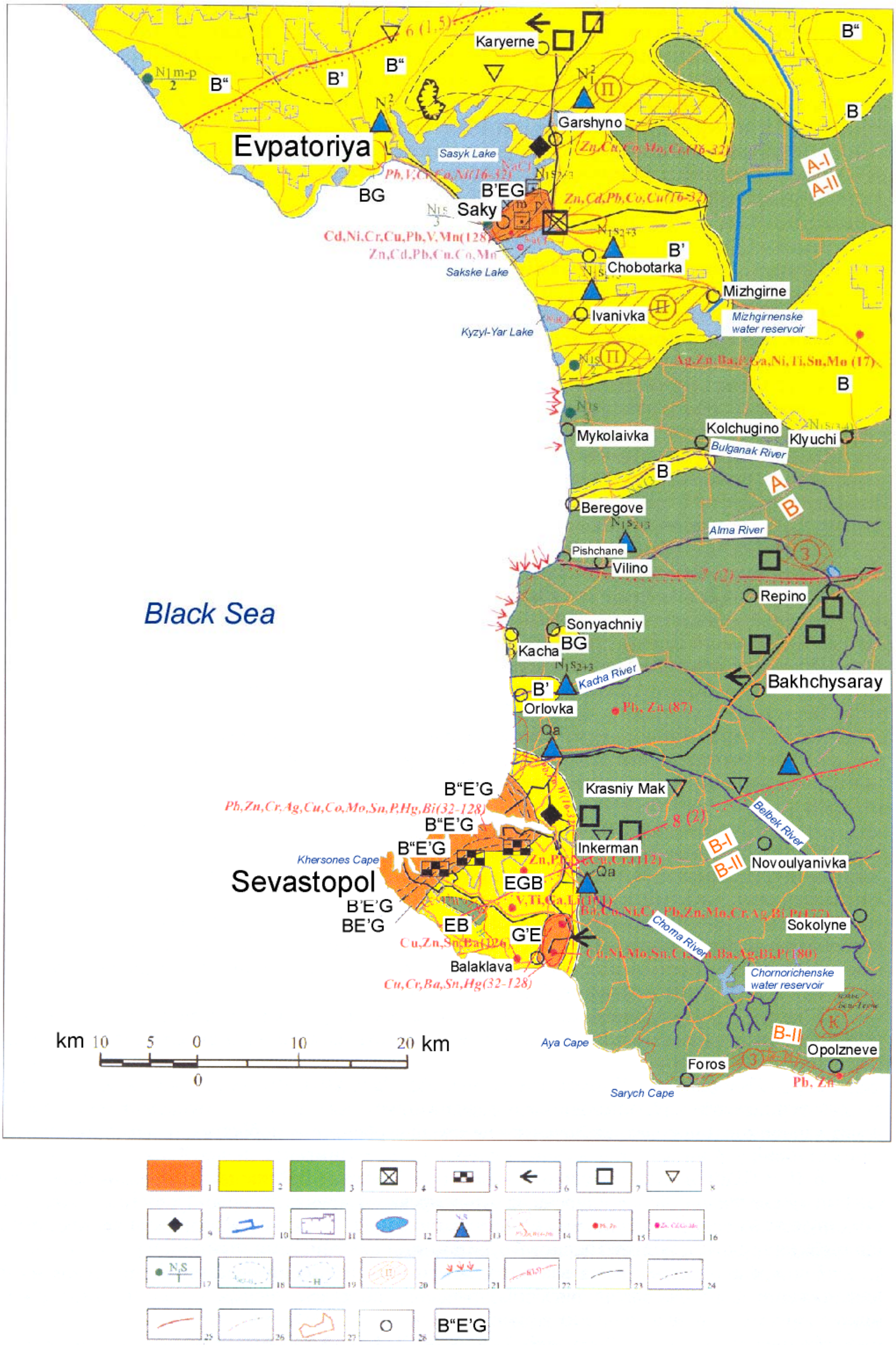

Fig. 10. Schematic map of ecological state of geological environment.
See next page for legend.

Fig. 10. Continued. The legend.

Ecological state of geological environment: 1 – charged; 2 – moderate charged; 3 – appropriate;

Technogenic objects affecting the state of geological environment: 4 – chemical industry; 5 – machinery and metal-working; 6 – construction materials; 7 – non-ore mineral mining; 8 – animal complexes and poultry farms defined as the groundwater contaminants; 9 – industry and house waste store objects; 10 – supplying channel to Mizhgirnenske water reservoir; 11 – irrigation systems; 12 – water reservoirs, lakes; 13 – water scoops operating with exploitation groundwater reserves approved by State Commission of Ukraine on Mineral Reserves; above symbol – index of water-bearing horizon;

Extensive geological environment contamination with toxic chemical elements: 14 – planar soil contamination with heavy metals; in the gaps – chemical elements-contaminants, in parentheses – factors in excess of TAC; 15 – local soil contamination with heavy metals; next to the symbol – elements-contaminants, in parentheses – factors in excess of TAC; 16 – local contamination of bottom sediments with heavy metals; next to the symbol – elements-contaminants; 17 – local groundwater contamination with nitrogen compounds: numerator – index of water-bearing horizon, denominator – factors in excess of TAC; 18 – water-bearing horizon contamination contour with nitrogen compounds, in the contour gap – water-bearing horizon age, in parentheses – factors in excess of TAC; 19 – Middle Miocene water-bearing horizon contamination contour with oil products.

Other symbols: 20 – sites affected by dangerous geological processes in more than 50% of square (S – slides, K – karst, F – under-flooding); 21 – abrasion (more than 5 m^3 per m/year);

Boundaries: 22 – earthquake magnitude zones, in the contour gap – magnitude, in parentheses – technogenic share of magnitude; 23 – territories with different integral assessment of the ecological state of geological environment; 24 – sites with different ecological state of particular elements of geological environment; 25 – landscape provinces (A – Plain Crimean steppe province, B – Mountain Crimean province); 26 – sub-provinces of landscape provinces (A-I - sub-province of inclined Tarkhankutska height, A-II - sub-province of Alminska accumulative-denudation plain, B-I - sub-province of Crimean Fore-Mountains, B-II - sub-province of Crimean middle- and low-mountains, B-III – sub-province of the Crimean Southern Coast); 27 – city boundaries; 28 – other inhabited locations; 29 - Pseudo-formula to assess the state of geological environment.

ASSESSMENT OF GROUNDWATERS CONTAMINATION DEGREE

Pseudo-formula index	Chemical elements and compounds contamination degree	Mineralization, g/dm^3	TAC danger classes		
			I	II	III
B”	Very dangerous	>3			
B’	Dangerous	1.5-3.0	2-3	5-10	
B	Moderate dangerous	1.0-1.5	1-2	1-5	1-10
	Admissible	<1	<1	<1	<1

ASSESSMENT FOR TERRITORY DEFEATING DEGREE BY DANGEROUS EXOGENIC AND ENDOGENOUS PROCESSES AND PHENOMENA

Pseudo-formula index	Territory defeating degree by dangerous EGP and phenomena	Total territory defeating, %	Development of dangerous EGP and phenomena including technogenic activation	Seismicity including technogenic increments, scores
E’	Strong	25-30	Extensive flooding, slides, karst in open and semi-open forms, technogenic activation	5-6 (1.5)
E	Medium	10-25	Karst in open and semi-open forms, gully and planar erosion	5-6 (1)
	Moderate and low	<10	Low and moderate development of some EGP and phenomena	5-6 (0.5)

G – moderate dangerous degree of soil contamination.

Sewage and house drops from Saky and Evpatoriya towns upon treatment are being brought into Kalamitska Bay. In the fore-mountains Sevastopol and Bakhchysaray towns are located. Sevastopol, placed in Gerakleyske plateau, with 378 thousand population, is the navy base and major industrial city where about 40 enterprises of dock, instrument-making, construction, food and light industries are located. Of these, "Sevmorzavod" combine is the biggest. Operating under full capacity, it was emitting in the air about 2 thousand of wastes per year containing SO_2, CO, NO, H_2SO_4, C_3H_8, LOC, benzine, toluene, xylene, acetone, phenol, formaldehyde, HCl, alkaline aerosols, white-spirit, ethanol, phosphorus compounds and other harmful substances. In addition, significant contamination is also imposed by "Sevmistkomuenergo" with emissions 1206.7 t/year, "Pivdenruda" in Balaklava – 1444.3 t/year, construction materials plant – 1096 t/year. "Muson" enterprise has emitted 137 t/year of harmful wastes only but they included cadmium aerosol, heavy metals (Mn, Cu, Pb, Cr), acids (HCl, HNO_3), ammonia and more than 20 other harmful compounds. In general, the enterprises of this agglomeration had annually emitted into the air 8919 t of harmful substances of which 2/3 were gaseous. Liquid wastes are being dropped into Black Sea and Sevastopolska harbor. For instance, in 1990 into the latter 146 mln.m^3 of industrial-house sewages were dropped, of which 45.7 mln.m^3 were treated mechanically, 5.3 mln.m^3 – biologically, and 1.57 mln.m^3 – partly. Together with the mentioned sewages 60 t of oil products were dropped. In Bakhchysaray town the major contamination is still imposed by "Budindustriya" combine which annually emits into the air more than 5 thousand tons of harmful substances including dust, LOC, SO_2, CO, NO_x, formaldehyde, white-spirit. Technical charge module in the towns and adjacent territories was more than 50 th.m^3/km^2/year.

Transport. Almost all inhabited localities are connected with the dense paver-road network. As far back as beginning of 80^{th} the traffic over major lines was about 17 thousand cars per day and had significantly increased in recent years. Automobile emissions include toxic gases: carbon, nitrogen and sulfur oxides, hydrocarbons lead compounds. Under influence of transport emissions the anomalous zones up to 250 m wide had been formed along the roads with increased lead, copper, tin, zinc, lithium contents exceeding the Clarke values by 2-30 times (BCI 16-40). The highest concentrations of heavy metals are identified in the first 10 m away from the road.

Agriculture. Most extensively agriculture is developing in Plain Crimea where the agriculture lands occupy more than 80% of the territory. Over there, the dry farming predominates and gardens and vineyards occupy from 4% to 11.5% of the agriculture lands (by 01.01.2001). In the fore-mountains the agricultural lands shrink in general while the garden and vineyard shares increase. For instance, in Bakhchysarayskiy area the latter occupy 26.1% of all agricultural lands. In the northern macro-slope of the Main mountain ridge agricultural lands occupy 3.5% only of the territory and are mainly concentrated in Baydarska valley. The southern macro-slope is mainly involved into the Yaltynskiy mountain-forest reserve. The limited areas suitable for land workings are mainly used for the gardens and vineyards. Extensive development of agriculture over 1960-1980, with a huge amount of fertilizers input as well as wide range of pesticides has led to the negative changes in soils, surface and groundwaters. Over last 10 years amount of fertilizers and pesticides, used in agriculture, has been decreased by the factor. Pesticide use has been changes not only in quantity but in quality as well. New types of pesticides had appeared, more efficient and with lesser half-disintegration period. Sulfur, copper sulfate, amide salt, and other species are still being used but in the lesser amounts. Thus, the rate of technogenic charge onto agricultural lands is somewhat decreased. Contamination sources include not only pesticides spread out in the fields but also the stores where conditions for their storage are broken.

Forbidden, undefined and unsuitable chemical substances for plant protection in the agricultural agglomerations and enterprises are given in the Table 10.1.

Table 10.1. Stored forbidden, undefined and unsuitable chemical substances.

Area	**Total, kg**	**Group A – forbidden, kg**	**Group B – unsuitable, kg**	**Group C, kg**	**Number of stores**	**Of these under guard**
Bakhchysarayskiy	14827	11627	659	2541	10	10
Simferopilskiy	134754	39035	1911	93808	25	25
Sakskiy	36320	15450	2290	18580	13	10
Sevastopol	13666	12991	375	300	7	7
Total					55	52

The animal farms, poultries and, especially, pig farms, often located in the areas with unprotected groundwaters, are mainly exploited without solid and liquid waste treatment and disposal, thus becoming the sources for surface and groundwater contamination. Sewage mineralization from animal farms is 11 g/dm^3, pig farms – 20 g/dm^3. They contain hydrocarbonates, ammonia, nitrates, nitrites, phosphates, potassium, sodium oxides, saprophyte organisms. In the liquid wastes about 50% of micro-flora consists of pathogenic types, specifically: colibacteriosis, dysentery, typhus, para-typhus, abscess, phlegmon, enteritis, tuberculosis and others. More than 50% of farms by 1985 were not equipped with the treatment units and the rules for waste storage were broken resulted in groundwater contamination over significant areas. Livestock shrinkage over last 10 years has caused improvement of ecological state and reducing technogenic loading on groundwaters.

Water scooping. In the Plain Crimea the surface waters suitable for water supplying are missed and major water supplying source over there comprises the waters of Pontychniy-Meotyhcniy-Sarmatian water-bearing horizon and alluvial waters. In the map sheet L-36-XXVIII the following water scoops are located: Evpatoriyskiy, Ivanivskiy, Chebotarskiy, Vilenskiy, Orlovskiy, Sakskiy-2, Okhotnykovskiy and Sakskiy-1, Belbetskiy and Inkermanskiy. Water scooping amount is from 0.6-0.7 th.m^3/d in Sakskiy and Okhotnykovskiy water scoops to 35.7 m^3/d in Ivanivskiy one.

Hydro-technical construction. In the north-east of the map sheet area the Sakska branch of North Crimean Channel is located which supply Dnipro River water into Mizhgirnenske water reservoir, as well as for the irrigating fields. In addition, so called "minor irrigation" is in use by the groundwaters. By 01.01.2000, the fields occupy 23.98% of agricultural lands in Sakskiy area, 12.67% in Simferopilskiy, 15.74% in Bakhchysarayskiy ones. In Baydarska valley Chornoritske water reservoir is located with 64 mln.m^3 of water capacity and average annual drop of 56.8 mln.m^3.

Mining. Construction raw materials comprise the main mineral type in the area – wall stone, debris, sand, clay. The biggest quarries for limestone mining are located in Sakskiy area where they occupy 1313.2 hectares, and in Bakhchysarayskiy area – 405.7 hectares.

Ecological state of geological environment

Under influence of technogenic loading the litho-geochemical anomalies have been formed which were identified by geological-ecological works of various scales: O.S.Klyuev [45] and Yu.A.Novikov [61] – in the Saky and Evpatoriya town areas; N.M.Kapinos [42] – in Sevastopol city and adjacent territory; M.V.Maltseva [59] – the eastern part of L-36-XXVIII map sheet. Industrial sites of chemical enterprises in Saky town are found contaminated (BCI – 16-128, association of elements Cd, Ni, Cr, Cu, Pb, Mn). Chemical enterprises are situated on the shore of Sakske Lake and use its part, separated with a dam, as the accumulation pool, where with time heavy metals are concentrated in the brine and bottom sediments. Iron content in the pool brine exceeds TAC by 19.5-50.6 times, Mn – 2.2 times, Cu – 118-328 times. Bottom sediments of this pool contain Cu in excess of the background one by 600 times, and also increased amounts of Zn, Cd, Pb, Co, Mn. All toxic elements are concentrated in the first 30 cm of the bottom sediments and Mn only is found from the depth 15-20 cm and below suggesting for its high migration properties in the acidic environment. The water and bottom sediments contamination in Sakske Lake as well as the soils in adjacent territories of the sea coast imposes the danger to the unique medical sludge and Saky resort in a whole. Nowadays the plant, operated with the imported Chiaturska raw materials, is closed but no ecological actions for environment reclamation were undertaken.

The central part of Evpatoriya town is contaminated by Pb, V, Cr, Ni and BCI is 16-32 (G, see Fig. 10).

Location of contaminating sources (enterprises, military objects) in Gerakleyske plateau is mosaic. Coupled with geology and complex plateau relief, these factors affect heavy metal anomalies in soils.

In Sevastopol city and adjacent territories the soil contamination by heavy metals Pb, W, Zn with BCI 16-32 (G) is identified. In the local sites the soil BCI is 32-128 (G'). In the city and adjacent inhabited locations, in ports, docks, industrial zones, along transport routes, the soil contamination by various heavy metal associations and high BCI is identified in some samples. Maximum Cu concentrations are noted in soils at vineyards and adjacent sites, Cu content is also increased in vicinity of landfills, military shops, along auto-routes. Increased Ti content is noted in soils close to military camps, airports, along auto-routes and railways. In vicinity of airports, construction material plants, "Sevmorzavod" increased content of metal association Ni-W-Pb in soils is noted.

The groundwaters are more and more affected by anthropogenic factors, of which groundwater scooping, agro-technical actions, irrigation, industry and technical constructions are most important. In Plain Crimea, groundwater consumption in amounts, significantly exceeding their reserves, had led to the local and regional groundwater resources exhaustion, formation of depressive funnels and mineralization increasing. The situation is very strong in the Evpatoriya and Saky town area where under influence of non-controlled water scooping the groundwater mineralization in Meotychniy-Pontychniy water-bearing horizon does not comply with SBST 2784-82 "Potable water" standard anymore. The first water scoop of Sakskiy chemical plant was completely destroyed and water mineralization attained 8.5 g/dm^3 over there, in Okhotnykovskiy water scoop – 2.2 g/dm^3. Increasing of mineralization occurs by means of salt sea water input and is from 1.0-1.5 g/dm^3 (B), 1.5-3.0 g/dm^3 (B') to ≥3 g/dm^3 (B"). In Sarmatian water-bearing horizon, under influence of water scooping, depression funnel 60 by 30 km in size has been formed with maximum descending in the centre – 4.6 m. After the filling of Mizhgirnenske water reservoir progressive uplifting of Sarmatian water-bearing horizon water table both at the expenses of water-scooping drop and filtration from the reservoir. The total water scooping from Sarmatian water-bearing horizon was as follows over last years: 1994 – 188.35 th.m^3/d; 1995 – 177.88 th.m^3/d. In 1999 the water scooping from Alminske groundwater deposit was 147.98 th.m^3/d. The local depression funnels still remain in Vilenskiy and Orlovskiy water scoops. Water-bearing horizon in Middle Miocene sediments is under exploitation in Alminske deposit and in Sevastopol city. In Alminske deposit depression funnel had appeared with dimensions 46 by 24 km and maximum table descend in summer time to 14.1 m. Mineralization remains stable over there – 0.6-1.1 g/dm^3. Water scooping from water-baring horizon in Lower Miocene sediments progressively drops down from 29.03 th.m^3/d in 1990 to 11.36 th.m^3/d in 1999 and by this reason the table of this water-bearing horizon does gradually rise up. Groundwaters from Quaternary alluvial sediments are under exploitation by Belbetskiy and Inkermanskiy water scoops for the needs of Sevastopol city. Hydrodynamic situation is stable over there. The waters of Upper Jurassic water-bearing horizon are being exploited in Baydarska valleys and used by sanatoriums in Foros and for Sevastopol city water supplying. Water scoop is 5-6 th.m^3/d over there at the approved reserves 85.9 th.m^3/d which does not affect hydrochemical situation considerably. Groundwaters from the major exploitation Sarmatian-Meotychniy-Pontychniy water-bearing horizon of Plain Crimea is not protected in general and in some local sites only they are conventionally protected from the vertical input of contaminating substances. As a result, under influence of extensive agricultural and industrial activities over 1950-1980, the groundwaters become contaminated by pesticides, nitrogen compounds and heavy metals. Strong decreasing in amount of pesticide input into the soils over last years has caused respective decreasing in their content in groundwaters. While in the first half of 80^{th} pesticides were contained in almost 100% of water samples and their content exceeded TAC in most samples, over last years only BI-58 and traces of other pesticides are noted [69, 70]. Nitrogen compounds approach groundwaters from the surface during nitrogen fertilizer input in the fields, and from the waste pools of animal, especially pig farms. Groundwater contamination by nitrogen compounds has been decreased over last years. From 67 boreholes where hydrochemical state of groundwaters is monitored, the nitrogen compounds are found in the half only, and in most samples their contents do not exceed the TAC. Nitrogen compounds in amounts, not exceeding TAC, are found in Sarmatian water-bearing horizon in the Bulganak River basin and watershed areas in around [59]. The persistent contamination of Sarmatian-Meotychniy-Pontychniy water-bearing horizon by nitrogen compounds in the Evpatoriya and Saky town areas is caused by the high ecological loading (dense-populated area with developed industry and extensive agriculture), from the one hand, and because the waters of main exploitation water-bearing horizon over there are not protected, or conventionally protected, from another hand. Groundwater contamination by heavy metals has been observed nearby Sakskiy chemical plant where Pb in amount of 0.027 mg/dm^3 (2.7 TAC), Fe – 0.81 mg/dm^3 (2.7 TAC), and traces of Cd, Zn were indentified. In the area of industrial waste dump of Sakskiy chemical plant in Garshyno village, in the first from the surface water-bearing horizon, the Mn content was fixed in 1997 exceeding TAC in 3.3-4.78 times, while over last two years Mn is not identified in the samples.

Exogenic geological processes. Of the latter, most developed ones include karst, slides, abrasion, rock falls and avalanches, erosion and under-flooding.

Karst. The studied area is located in the western part of Mountain, Fore-Mountain and Plain Crimean karst regions. In Mountain Crimea the natural-historic karst is confined to Lower Cretaceous and Upper Jurassic limestones. Over there, karst is of open and semi-open types. The surface and underground forms include funnels, caves, wells, shafts, etc. The "Besh-Tekne" field is the most prominent example. The deep karst forms are mainly watered. In the Crimean Fore-Mountains surface karst forms are scarce because of monocline dipping of the rocks, involved in karst process, significant ridge cutting by erosion network, as well as occurrence of lenses, interbeds and batches of clays, sands, clayey marls. In the Plain Crimea karst region (in the map sheet L-36-XXVIII) karst is confined to Neogene limestones and includes open, semi-open and closed types. Open karst is developed in gullies going to Sasyk Lake. Irrigation and limestone mining in quarries over large square facilitates karst process activation. In Alminska depression karst is expressed in the overlain deep form. Activation of karst processes over there is facilitated by the changes in hydrochemical processes under influence of water scooping, specifically, changes in groundwater chemical and gas composition, speed and feeding conditions.

Slides are developed in Plain Crimea – over sea coast, in between Bulganak and Belbek river mouths, and in Mountain Crimea – in fore-mountains: in Alma River valley, in Gerakleyske plateau, and in the Main ridge southern macro-slope. The southern macro-slope of Main ridge is most affected by the slides – 7.51%. This is the complex, in the engineering-geological respect, area where slides often constitute the large slide massifs extended from the Main ridge foothill up to the sea coast (Foros-Simeizskiy amphitheatre). They are inherited from pre-Holocene time and governed by the complex forming mechanisms. The factors, that cause slide formation, are mainly of geological nature, while the slide process intensity is governed by the speed, direction and magnitude of modern tectonic processes, eustatic uplift of Black Sea water line, climatic and hydrogeological conditions. Activation of slide processes is mainly caused by climatic processes and varies in the wide range. From 8 to 50% of slides do stay in the active state in various years. Their number increases mainly because of technogenic and natural-technogenic slides. The road construction, active resort and private building in the coastal band without proper engineering-geological support, saving on drainage and shore-protection constructions facilitate appearance of technogenic and technogenically-activated natural slides. For instance, in 1999 the slides had damaged the old Sevastopolske highway, the road between Mukhalatka and Melas – over the distance of 3 km, the road to Baydarskiy pass; in the area of "Zarya" (Foros) cottage the access roads and escalator to the sea are damaged, etc.

Abrasion is the dominating process in the Black Sea coast. Abrasion activity depends on the coast morphology, rock composition and dipping, beach width, sea depth along the coast, neo-tectonic motions, wave energy (storms). In between Donuzlav Lake and Evpatoriya town the shore is low, accumulative, with lakes-lagoons and sand spits in the coastal zone of sea bottom. The shore from Evpatoriya town to Belbek River mouth is of abrasion, abrasion-accumulative and accumulative type. Intensity of abrasion processes is 1 m/year in average, in places 5 and more m/year. In the Southern Coast abrasion shores with "pocket" beaches and boulder heaps at the foothill are characteristic. Most extensive is abrasion of the slide cliffs, in the range 1-2 m^3/m/year, and cliff escape speed is 0.3-1.8 m/year. Over remaining coast areas the cliff escape speed is 0.1-0.2 m/year. Decreasing of solid flow drop by regulated rivers, sand and gravel take off in beaches, spits and in the sea coastal band facilitate the beach band shrinkage and abrasion process activation.

Minor boulder heaps, 2-3 th.m^3 by volume, are observed in the abrasion cliff in the western coast nearby Beregove and Andriivka villages, between Kacha and Belbek river mouths, and in Kermenchyk cape, in case of cliff cutting by the waves. Large landslip, 20 th.m^3 by volume, had happened in 1999 in Fiolent cape. Technogenic heaps are being formed during land workings, slope cutting and road construction. Their risk is considerably enhanced under excess watering. The *rock-falls* from Yayla walls are known in the area of old and new Yalta-Sevastopol highway.

Of the erosion processes, the water erosion is widespread in Mountain Crimea, especially in the southern slope, where it includes course erosion of permanent and temporary water flows and slope (planar) erosion. Horizontal cutting attain 5.8 km/km^2 over there. Slope steepness is 20-40°. Planar erosion rate is 0.5-0.7 mm/year, in the steep slopes – 1.6-1.7 mm/year. Erosion comprises the cause of the slide origin in more than half of the cases. Main reasons for erosion activation include extensive rains, wood cutting, cattle pasture and slope ploughing.

Under-flooding. In around Sasyk, Sakske, Kyzyl-Yar, Bogayly lakes and in the gullies flowing into them, the natural high groundwater level (3 m and more) is observed. Recently, under influence of technogenic reasons – water losses from urban water pipes and sewerage, infiltration from the irrigating fields, and expanding irrigation network, the areas of under-flooding have been considerably increased; Saky town is involved nowadays in the under-flooding zone.

On the ground of analysis of soil, groundwater state and major exogenic processes, the studied area zonation is performed. Criteria for the assessment of ecological state of geological environment are given in the Table 10.2.

Taking into account the changes in quality and quantity indicators of the soil and groundwater composition and influence of technogenic-activated exogenic processes, three categories of the areas with different degree of geological environment defeating:

- territories with charged state of geological environment – negative changes are expressed in all components of geological environment (agriculture-industrial agglomerations of Sevastopol and Saky towns);
- territories with moderate charged state of geological environment – negative changes are found in one or two components of geological environment (most part of Plain Crimea, Gerakleyske plateau, mouth parts of Bulganak and Kacha river valleys, Kacha town);
- territories with appropriate state of geological environment – the latter is similar to the natural state, ecologically safe (remaining territory).

Table 10.2. Criteria for the assessment of ecological state of geological environment (to the “Schematic map of ecological environment”)

Ecological state of geological environment	Natural factors	Technogenic factors				
	Pressurized groundwater protection from vertical input of contaminating components	Territory defeating by EGP, %	Soil conta-mination (BCI), %	Groundwater contamination by chemical elements and their compounds		Module of technogenic loading, th.m^3/km^2/year
				minera-lization	organic compounds (TAC)	
Charged	Non-protected; $H_2<H_1$ and $m_0<10$	25-50	32-128	3 and >3	2-5	50-100
Moderate charged	Conventionally protected; $H_2>H_1$ and $m_0<10$ or $H_1 \leq H_2$ and $m_0>10$	10-25	16.32	1.5	1-2	10-50
Appropriate	Protected; $H_2>H_1$ and $m_0>10$	10	≤16	≤1	≤1	≤1

Notes: H_2 – pressure of underlaying water-bearing horizon;
H_1 – pressure of overlaying water-bearing horizon;
m_0 – water-proof thickness.

Further on, to define criteria of admissible and critical anthropogenic loading on environment, its top admissible changes and identification of exact biosphere reserves, it is necessary:

- to carry out litho-geochemical studies in the scale 1:200 000 (2×2 km) with grid shortening in places of most technogenic loading;
- to increase amount of hydrogeological studies five times (to the state by 01.01.1990) and a number of components to be studied;
- to increase the number of ecologic polygons to improve regime observations, study of regularities and control over exogenic processes and processes, developed in the underground hydrosphere in the areas of most extensive anthropogenic loading;
- to develop the automatic systems for gathering, transfer, recording and processing of regime observation data on the state of exogenic processes, litho- and hydrosphere.

CONCLUSIONS

The works on preparation to publish the new series set of map of Derzhgeolkarta-200 (map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol)) allow adjustment the area geology, to solve some questions of stratigraphy, magmatism, tectonics, history of geological development, and assess the area perspectives for various minerals. Major results of the works are as follows:

1. New series set of map of Derzhgeolkarta-200 is created, which includes geological maps and maps of mineral resources for pre-Quaternary units and Quaternary sediments, where data of previous works are summarized in compliance with the recently approved correlation schemes and instructive materials. In the course of works the authors have designed and approved stratigraphic correlation schemes of Riphean-Paleozoic, Miocene and Pliocene sediments; as a result, the geological maps become more detailed and geological boundaries are more substantiated. The maps are designed according to the litho-stratigraphic principle with local and supplementary subdivisions, sequences and layers definition.

2. Paleozoic sediments are subdivided into Zuyska and Novoselivska suites of Carboniferous System alike adjacent map sheets.

3. On the ground of deep drilling data analysis all mapping objects are harmonized with new correlation stratigraphic schemes and all coeval Mesozoic and Cenozoic diverse-facies complexes are correlated.

4. For the first time in the geological maps of the studied area Upper Tavrska (Andriivska) sub-suite and Lower Tavrska (Uchkuivska) sub-suites (Upper Pliocene) and Tyup-Dzhankoyski layers are distinguished.

5. Quaternary sediments are divided up to climatoliths and the modern structure-geomorphologic zonation of the territory is carried out.

6. The data on the area magmatism are summarized. Two complexes of non-stratified rocks are distinguished – Gerakleyskiy and Bodratskiy.

7. The modern mineral resource base of the territory is described and its upgrading perspectives are assessed, mainly with respect to the traditional minerals: groundwaters and construction materials.

8. Ecological-geological situation is reviewed with definition of technogenic landscapes, distribution of contaminating elements and is defined, as well as the sites of negative technogenic processes, related to exploitation of the North Crimean Channel and Sakskiy chemical plant.

After completion of works with set of map L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol) preparation some questions of geology and history of structure development did not get unequivocal solution and require additional studies. The most important questions include:

1. Adjustment of basement geology in Scythian plate including Paleozoic rocks.

2. Study of the lower column parts (deeper) in Alminska depression.

3. Adjustment of the stratigraphic correlation scheme for Mesozoic subdivisions in Plain and Mountain Crimea and stratigraphic scheme unification.

4. Adjustment of the correlation between marine and continental Pliocene and Eo-Pleistocene sediments aiming stratigraphic scheme improvement.

5. Study and adjustment of basic columns of Quaternary sediments in Mountain Crimea and their correlation with Plain Crimea columns.

6. Adjustment of the region magmatism scheme on the ground of additional isotopic dating, correlation of magmatism in Mountain and Plain Crimean and Lomonosivskiy underwater massif recently discovered in Black Sea shelf, to the south from the studied area [24].

7. It is necessary to continue study of new tectonic models with regard to the structure of Mountain Crimea, specifically:

- suture zones plunging down to the north, established by V.V.Yudin and M.E.Gerasimov [26];
- mélange established by V.V.Yudin [25, 26, 28]. In this respect, the deeper seismic sounding by modern methods (MCDP) is required;
- to continue paleo-magnetic studies which first results require assumption on very significant (up to 1500 km) approaching of Bajocian – Lower Bathonian volcanic arc with Eurasian margin [20];
- further detailed studies of thrusting tectonics.

8. Bio-stratigraphic studies remain quite important and vital. These are the only means which allow solution of the following problems in Mountain Crimea:

- bio-stratigraphic proofs to the thrusting tectonics;
- development of substantiated and properly dated stratigraphic scheme of Tavriyska Series and only on this ground its internal structure can be deciphered and mapped;

- the issue of Lower Cretaceous fauna findings in mélange and below Yaylynski highlands should be once again and completely solved;
- detailed correlation of Upper Jurassic and Lower Cretaceous sediments of Crimean Yaylas on the ground of micro-fauna (foraminifera, calpionelida).

9. Ecological-geological studies and monitoring of geo-ecological situation of environment.

To elaborate aforementioned problems further geological exploration and research studies are required and these investigations can be based on the geological maps prepared and described in the given work.

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ANNEXES

Annex 1. List of deposits and occurrences indicated in the "Geological map and map of mineral resources in pre-Quaternary units" of map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol)

Cell index, number in map	Mineral type, object name and its location	Deposit exploitation state or brief description of occurrence	Geological-economic (genetic) type	Notes (references cited)
1	2	3	4	5
L-36-XXVIII **NON-METALLIC MINERAL RESOURCES** **Ore-chemical raw materials** **Agro-chemical raw materials** **Phosphorites** ***Occurrence***				
IV-4-44	Skalystivskiy; nearby Skalyste village	Phosphorite formation, mineral type – phosphorite-glauconite. Phosphorite nodules and organic remnant shells contain P_2O_5 (13.0-19.1%). Thickness of the layer is 1 m. Host rocks – sandstones in Paleocene footwall and Eocene clayey-sandstone sediments	Nodular	33
IV-4-54	Pered-ushchelnenskiy; nearby Peredushchelne village	Phosphorite formation, mineral type – phosphorite-glauconite. Phosphorite nodules – at the footwall of up to 1 m thick Kachynskiy horizon sandstones	Nodular	33
IV-4-59	Malosadoviy; nearby Male Sadove village	Phosphorite formation. Host rocks – glauconite sandstones at the bottom of Paleocene, with phosphorite nodules and pebble. Sandstone thickness is 5-6 m	Nodular	33
Mineral pigment raw materials **Paint clay** ***Occurrence***				
II-4-29	Skvortsivskiy; Skvortsove village, in 28 km to NW from Simferopil city	Productive horizon – interbeds of bright-red and brown clays occurring in the sequence of yellowish-brown and grayish-yellow clays of Lower Tavrska (Uchkuivska) sub-suite of Tavrska suite (N_2tv_1). Four layers of paint clays are encountered, from 0.5 to 1.7 m thick, at the depth from 2 to 20 m. Iron oxide content is from 4.02 to 11.08% (7.6-7.7% in average). According to laboratory texts, paint clays can be ascribed to the "C" grade group	Sedimentary	10

1	2	3	4	5
III-3-31	Pishchanivskiy; in between Beregove and Viline villages	Encountered in two sites. The first one is located in Black Sea coast nearby Beregove village, in between Alma River and Viline village. Productive horizon – red-brown clays occurring in the sandy-clayey sequence of the Lower Tavrska (Uchkuivska) sub-suite of Tavrska suite (N_2tv_1) continental sediments. From one to three red clay interbeds are found in the first site, from 0.9 to 3.0 m thick. Iron oxide content is from 5.5 to 11.85%. In the second site six red clay interbeds are counted, from 0.2 to 1.5 m thick, at the depth from 0.2 to 12.0 m. Iron oxide content varies from 6.48 to 11.53% over there. By the iron content just the lower interbed of red-brown clays is suitable for class "B" ochre manufacturing	Sedimentary	10
III-4-35	Kolchuginskiy; Kolchugine village, in 28 km to W from Simferopil city	Productive horizon comprises brownish-red and cherry-red clays occurring in the interbeds and lenses within yellowish-brown clays and pebble-stones of the Lower Tavrska (Uchkuivska) sub-suite of Tavrska suite (N_2tv_1) continental sediments. From one to five clay interbeds are counted in the outcrops, from 0.1 to 1.2 m thick, at the depth from 1.3 to 15.7 m. Iron oxide content varies from 3.8 to 11.9%. According to the laboratory tests, the paint of "ochre" type for oil and glue paints and enamels manufacturing can be obtained from the clays.	Sedimentary	10
Non-metallic ore raw materials **Adsorption raw materials** **Bentonite clay** ***Deposit***				
IV-4-52	Menderske; in 2 km to W from Prokhladne village, in the W and NW slope of Mender Mountain	Out of production	Post-volcanic, volcanogenic-sedimentary	56
IV-4-55	Kudrynske; in between Mashyne and Kudrine villages	In production	Post-volcanic, volcanogenic-sedimentary	57

1	2	3	4	5
		Occurrence		
IV-3-39	Nekrasivskiy; in 500 m to E from Nekrasovka village	Productive horizon – keel-like, greenish-grey, yellowish-green, dense, schistose clays. Fraction < 0.001 mm content is 26.39-70.23%, sum of exchangeable cations – 32.93 mg/equiv., swelling – 0.4-1.4, bentonite number – 10-13, colloidity – 20.0-28.1, ductility – 33.3-53.0, pH – 8.85-10.1. Chemical composition (%): SiO_2 – 43.53-53.18; TiO_2 – 0.58-0.83; Al_2O_3 – 20.74-22.70; Fe_2O_3 – 6.25-9.0; MnO – 0.4-0.5; MgO – 2.12.-3.10; CaO – 0.64-1.09; Na_2O – 0.21-0.27; K_2O – 2.49-2.93; P_2O_5 – from traces to 0.13; SO_3 – not detected; H_2O^- - 6.53-6.83; H_2O^+ - 6.53-8.48; LOI – 13.36-16.17; free SiO_2 – 1.2-6.1; Σ – 99.57-100.47. Suitable for drilling liquids and ceramic manufacturing	Post-volcanic, volcanogenic-sedimentary	56
IV-4-53	Bakhchy-sarayskiy; in 8 km to E from Bakhchysaray town	Productive horizon – bentonite clay layer, 0.2-0.3 m thick, at the depth 0.5-17.3 m	Post-volcanic, volcanogenic-sedimentary	56
IV-4-58	Bashtanivskiy; in 2 km to S from Bashtanivka village	Two bentonite clay beds are encountered. The upper bed is 4-10 cm thick, depth up to 27 m. The lower bed is 10-20 cm thick, intersected at the depth 9.9-34.5 m	Post-volcanic, volcanogenic-sedimentary	57
		Construction raw materials **Cement raw materials** **Marl** ***Deposit***		
IV-4-50	Bakhchy-sarayske; in 1.2 km to NE from Bakhchysaray railway station	In production	Sedimentary	23

1	2	3	4	5
I-1-1	Kozatske; in 4 km to N from Shtormove village	In production	Sedimentary	37
I-2-2	Nyvivske; in 1.2 km to SW from Nyva village	In production	Sedimentary	55
I-2-3	Vuzlivske; in 3 km to E from Vuzlove village	In production	Sedimentary	10
I-3-7	Naumivske-1; in 2 km to NW from Naumivka village	In production	Sedimentary	23
I-3-8	Baranivske-II; in 8 km to NE from Karyerne village	In production	Sedimentary	23, 54

1	2	3	4	5
I-3-9	Runnivske; in 2 km to N from Naumivka village	In production	Sedimentary	35
I-3-10	Baranivske-III; in 6 km to E from Karyerne village	In production	Sedimentary	34
I-3-11	Mytyaivske; in 8 km to NNE from Mytyaeve village	In production	Sedimentary	23
I-3-13	Sasytske; in between Karyerne, Naumivka and Lugove villages	In production	Sedimentary	23
I-3-14	Lystove; in 4 km to E from Lystove village	In production	Sedimentary	53
I-3-15	Lyubymivske; in 2 km to SW from Lyubymivka village	Out of production	Sedimentary	23
I-4-19	Zernove; in 4 km to SW from Zernove village	In production	Sedimentary	65
I-4-20	Kraynenske; in 1.5 km to SW from Krayne village	In production	Sedimentary	36
I-4-21	Kraynivske; in between Trudove and Krayne villages	Out of production	Sedimentary	23
IV-4-43	Skalystivske; in 0.5 km to N from Skalyste village	In production	Sedimentary	23
IV-4-45	Bodratske-I' in 2.5 km to SE from Skalyste village	Out of production	Sedimentary	23
IV-4-46	Bodratsko-Alminske; directly adjoins Alminsko-Bodratske deposit from E	Exhausted	Sedimentary	23
IV-4-47	Alminsko-Bodratske; in o.5 km to SE from Glybokiy Yar village	In production	Sedimentary	23
IV-4-48	Chapaivske; in 3 km to SSW from Glybokiy Yar village	Out of production	Sedimentary	23
IV-4-49	Glybokoyarivske; in 0.5 km to SE from Glybokiy Yar village	Out of production by various reasons without conservation certificate	Sedimentary	23

1	2	3	4	5
IV-4-51	Anykh-Syrt; in 0.5 km to SW from Glybokiy Yar village	Out of production	Sedimentary	23
IV-4-56	Pered-ushchelninske; in 0.5 km to SE from Peredushchelne village	Out of production	Sedimentary	23
IV-4-57	Kachynske; in 3 km to E from Siren station	Out of production	Sedimentary	23
Petrurgy and light concrete filler raw materials **Claydite clays** ***Deposit***				
III-4-36	Komyshynske; in 0.3 km to W from Komyshynka village	Out of production	Sedimentary	23
III-4-37	Alminske; in between Zubakine and Novovasylivka villages	Out of production	Sedimentary	23
III-4-38	Plodivske; in 3 km to S from Plodove village	In production	Sedimentary	23
Construction lime and gypsum raw materials **Limestones** ***Deposit***				
I-2-4	Evpatoriyske; in 0.5 km to S from Kamenolomnya village	In production	Sedimentary	23
Brick-tile raw materials **Clays** ***Deposit***				
III-3-32	Vilinske; in 3 km to NNE from Viline village	Out of production	Sedimentary	52
WATERS **Groundwaters** **Fresh waters** ***Deposit***				
I-2-5	Alminske; Evpatoriyska site, Evpatoriya town	In exploitation	Sheeted	70
I-3-12	Novoselivske; Sakska site, Lyubymivka village	In exploitation	Sheeted	70
	Sites of Alminske deposit			
I-3-16	Okhotnykivska; Okhotnykove village	In exploitation	Sheeted	70

1	2	3	4	5
I-3-17	Alminska-I; Okhotnykove village	In exploitation	Sheeted	70
II-3-23	Sakska-2; Saky town	In exploitation	Sheeted	70
II-3-24	Sakska-1; Saky town	In exploitation	Sheeted	70
II-3-25	Alminska-2; Saky town	In exploitation	Sheeted	70
II-3-26	Chobotarska; Chobotarka village	In exploitation	Sheeted	70
II-3-27	Ivanivska; Ivanivka village	In exploitation	Sheeted	70
II-3-28	Alminska-5; Teplivka village	In exploitation	Sheeted	70
III-3-30	Alminska-8; Mykolaivka village	In exploitation	Sheeted	70
III-3-33	Vilinska-2; to NW from Viline village	In exploitation	Sheeted	70
III-3-34	Vilinska-1; Viline, Pishchane villages	In exploitation	Sheeted	70
IV-3-40	Suvorovo-Tinysta; Tinyste village	Out of exploitation	Sheeted	70
IV-3-41	Orlivska; Orlivka village	In exploitation	Sheeted	70
IV-3-42	Lyubymivska; Lyubymivka village	Out of exploitation	Sheeted	70
Thermal mineral waters ***Deposit***				
I-4-18	Novoselivske; Trudove, Zernove, Vodopiyne villages	Out of exploitation	Sheeted	60
I-2-6	Evpatoriyske; Evpatoriya town	In exploitation	Sheeted	48
II-3-22	Sakske; Saky village	Out of exploitation	Sheeted	48

1	2	3	4	5
L-36-XXXIV **METALLIC MINERAL RESOURCES** **Ferrous metals** **Manganese** ***Occurrence***				
V-3-77	Balaklavskiy; in 5 km to WNW from Balaklava town	It is confined to Baydarska Suite (J_3*bd*) sediments consisting of breccia-like re-crystallized limestones, containing calcite veinlets and chalcedony films. Intersected by trench and two shallow shafts. Thickness of iron-manganese mineralization zone is 0.4 m, stripping rocks (loams and breccia-like limestones) – 0.8-1.0 m. Ore body shape is lens-like. Ores are composed of goethite, hydro-goethite, psilomelane. By chemical analyses, Fe_2O_3 content varies from 3.6 to 38.86%, MnO – from 11.89 to 47.12%, P_2O_5 – from 0.188 to 0.3%. By spectral analyses, the ore contains: Zn – up to 0.05%, Ti – up to 0.5%, Ba – up to 0.5%, Zr – up to 0.7%. Determined: Hg, Co, Ga, gold traces (after fine assay analysis), and up to 2 g/t of silver in four samples. Occurrence belongs to the type of oxidized manganese ores and is confined to carbonate formation of the orogenic stage in the region development	Oxidized manganese ores	63
VI-4-89	Orlynivskiy; in 2 km to N from Orlyne village, nearby Azys-Bair hill	It is confined to the contact of Lower Cretaceous clays and marbled limestones of Baydarska Suite (J_3*bd*); stripping rock thickness is up to 5 m. Body type – films and lens-like aggregates, thickness of ore zone is from 0.1 to 0.5 m. Content of MnO_2 – 8.1%, Fe_2O_3 – 37.5%. By spectral analyses, Mo – up to 0.001% and Co – 0.01% are detected.	Oxidized manganese ores	58
VI-4-90	Uzundzhynskiy; in 2 km to NW from Kolkhozne village	It is confined to the massive marble-like limestones of Baydarska Suite (J_3*bd*). Ore body is lens-shaped and sheeted, thickness is up to 0.8 m. Main minerals – pyrolusite, psilomelane, hydro-goethite. Content of MnO_2 – 12.1-38.6%; Fe_2O_3 – 12.39-39.1%. In minor amount Ni, Ba, As, Mo occur.	Oxidized manganese ores	40

1	2	3	4	5
Non-ferrous and base metals **Copper, lead, zinc** ***Occurrence***				
V-3-72	Gerakleyskiy; in 5 km to N from Folent cape	General tectonic setting of occurrence is defined by its location in Gerakleyska volcano-tectonic structure. Geology includes thick (up to 120 m) sequence of felsic tuffs filling erosion-tectonic dimple in diabase-spilites. Depression shape (after magnetic survey) is oval in the plane, elongated in sub-longitudinal direction over 1.5 km being 500-600 m wide. Tuff sequence is cut by numerous dyke bodies of andesite-dacites from 1.5 to 10 m thick. Tuffs are overlain by Upper-Middle Albian volcano-mictic sandstones and gravelites, laying with angular and stratigraphic discontinuity and are from 10 m in the south to 230 m thick in the north of occurrence. Albian rocks are unconformably overlain by Neogene limestones from 86 to 230 m thick. Tectonic regime is highly tensional. In the NW the north-east-trending Sevastopolskiy reverse-fault-shear is located with vertical amplitude about some hundreds of meters. By this reverse fault Middle Jurassic volcanogenic complex sharply plunges down. Sub-latitudinal and north-west-trending breaks are characteristic, as well as numerous satellite faults with crushing zones and friction planes in tuffs and dyke rocks. Ore mineralization is intersected by drill-holes in the north of the site and includes pyrite, chalcopyrite, galena, sphalerite.	Mesothermal polymetallic	63

1	2	3	4	5
V-3-76	Monastyrskiy; in 7 km to NW from Balaklava town	Occurrence is confined to Gerakleyska volcano-tectonic structure related to the deep Fiolentskiy fault. It is composed of highly deformed complex of Middle Jurassic volcanogenic rocks (Karadazka Suite) and belongs to the zone of SW-trending Monastyrskiy reverse-shear. Host rocks include Karadazka Suite spilites and cutting andesite-dacite, dacite, rhyolite and felsite dykes. Dyke swarm width is 300 m, length – 5 km, azimuth strike 320°, dipping is steep (75°) to the south-west. Productive sequence is overlain by Middle Miocene and Middle Sarmatian sediments 39-60 m thick laying with angular and stratigraphic unconformity. Mineralized zones are intersected by drill-holes at the depth 39-148 m. They include extensively crushed, brecciated, pyritized and whitened dacites, rhyolites with disseminated galena, sphalerite, chalcopyrite. In places bornite, covellite, chalcosine are found. Vein minerals include quartz, calcite, dickite, secondary – potassium feldspar (adularia). Wall-rock alteration includes sericitization, kaolinitization, dickitization, K-feldsparization, silicification, hematitization, and limonitization. Below encountered ore zones (at the depth 300-400 m) VES-IP anomaly of 4.9% is observed caused by sulphide mineralization (ore component content increases with depth while thickness of hydrothermally-altered rocks increases)	Mesothermal polymetallic	63

1	2	3	4	5
VI-2-84	Fiolentskiy; in 5 km to W from Balaklava town (Fiolent cape)	It is confined to Gerakleyska volcano-tectonic structure related to the deep Fiolentskiy fault. Is composed of highly deformed complex of Middle Jurassic volcanogenic rocks (Karadazka Suite). Polymetallic mineralization is related both with andesite-dacite dykes and faults. Thickness of the dykes is up to 5 m. Sulphide mineralization is vein-pod and pod, in the junction zones with crosswise faults – bunch-like. Main ore minerals include pyrite, galena, sphalerite, chalcopyrite, in places covellite, bornite, chalcosine, hessite, argyrodite, gold, silver are observed. The highest ore component content is foun d in andesite-dacites. Hydrothermal alteration includes calcitization, silicification, kaolinization, dickitization. General mgeological setting, mineral composition and geochemical feaqtures suggest for considerable erosion depth. Mineralization age is Kimmerian since post-volcanic processes, accompanied by hydrothermal alteration and sulphide mineralization, do not overprint Upper Jurassic and younger sediments. Stripping rocks include Middle Jurassic mafic and felsic tuffs, spilites and Neogene limestones	Mesothermal polymetallic	63
VI-4-93	Opolznevskiy; Pylyaky ridge, in 1280 m to NE from Opolzneve village	It is related to the sub-latitudinal diorite porphyrite dyke dipping to the north, confined to the NE-trending fault. The dyke is traced over 550 m with thickness 50 m. Host rocks include highly deformed argillite-aleurolite flysch of Tavriyska Series (T_3-J_1tv). In the dyke southern (footwall) block the host rocks are extensively crushed and pyritized. In the dyke hanging-wall the rocks are whitened, highly silicified, carbonatized and sulphidized. Ore mineralization include disseminated pyrite, chalcopyrite, chalcosine, covellite; oxidized zone is composed of limonite, malachite, azurite	Mesothermal polymetallic	31
NON-METALLIC MINERAL RESOURCES **Non-ore raw materials for metallurgy and ore-chemical raw materials** **Flux raw materials** **Limestones** ***Deposit***				
V-3-74	Gasfortske; in 6 km to NE from Balaklava town	Out of production	Sedimentary	33
V-3-75	Kadykivske; in 1.5 km to SW from Balaklava town	In production	Sedimentary	33
VI-3-85	Psylerakhske; in 1 km to W from Balaklava town	In production	Sedimentary	33

1	2	3	4	5
VI-3-86	Karanske; adjoins Psylerakhske from the W	Out of production	Sedimentary	33
Ore-chemical raw materials **Agro-chemical raw materials** **Phosphorites** ***Occurrence***				
V-3-64	Inkermanskiy; right slope of Chorna River, north of Sakharna Golivka Mountain	Productive horizons are confined to basal layer of Bilokamyanska Suite and sandstones of Kachynska Suite (Paleogene). Bilokamyanska Suite sandstones 0.2-1.2 m thick contain brownish-grey phosphorite concretions up to 2 cm across with P_2O_5 content up to 9.78%. Kachynska Suite glauconite sandstones contain phosphate grains and phosphorite pebble. Thickness of phosphorite-enriched layer is 1.5 m, P_2O_5 content – 4.28%. Stripping rock thickness is 40 m, surface exposure is limited. Phosphorite bearing of both horizons is related to terrigenous-siliceous-carbonate formation with glauconite and nodular phosphorites. Mineral form is francolite.	Nodular	63
Non-metallic ore raw materials **Optical and piezo-optical raw materials** **Iceland spar** ***Occurrence***				
VI-4-95	Baydarskiy; Chelyabi-Yauri-Beli Mountain, nearby Baydarski Vorota pass	Confined to limestones of Yaylynska Suite (J_3*jj*). Iceland spar is milky-white, semi-transparent and transparent, fractured, occurs in veins, veinlets and bunches from 0.8-1.0 cm to 1.5 m thick. By strike the veins are traced by up to 6 m.	Hydrothermal	33
Adsorption raw materials **Bentonite clay** ***Deposit***				
V-3-68	Inkermanske; in 2 km to SE from Inkerman railway station, in the left slope of Chorna River valley	Out of production	Post-volcanic, sedimentary	56
Occurrence				
V-3-66	Kara-Koba; right slope of Chorna River valley, to SE from Sakharna Golivka Mountain	Host rocks include layered marls of Kudrynska Suite. Productive horizon comprises bentonite clays from 10 to 45 cm thick. Horizon is traced by strike over 750-800 m, by dip – over 1000 m, to the depth 33 m.	Post-volcanic, volcanogenic-sedimentary	56

1	2	3	4	5
V-3-67	Chornorichenskiy; in 2.5 km to NW from Chornorichchya village, in the right slope of Chorna River valley	Geological setting is similar to that of Kudrinske and Inkermanske deposits. Bentonite clay bed is traced over 300-500 m by strike, depth is 0-21.8 m, thickness – 20-25 m	Post-volcanic, sedimentary	56
V-3-69	Sapun-Gora; left slope of Chorna River valley, in 2.5 km to S from Inkerman town	Bentonite clay bed 20-25 m thick lies in chalk-like marls of Kudrynska Suite and is traced over 350 m by strike. The northern flank of occurrence is included into the sanitary zone of Inkermanskiy water scoop	Post-volcanic, volcanogenic-sedimentary	56
Jewelry-gemstone raw materials **Marble onyx** ***Occurrence***				
VI-4-87	Uzundzhiyskiy; in 3 km to SE from Kolkhozne village	Confined to massive reef limestones of Baydarska Suite. Productive horizon comprises limestones with sintered marble onyx up to 6 m^2 in square and up to 0.7 m thick. Onyx is grey-brown with characteristic thin-banded structure and fine-crystalline texture	Infiltration	29
VI-4-91	Besh-Tekne; in 5 km to NE from Pylyaky Mountain	Confined to layered limestones of Yaltynska Suite. Productive horizon comprises limestones with sintered forms, fragments of stalactites and stalagmites, veins, lenses. Onyx exhibits high decorative properties: brown-yellow colour, banded and radiate-fibrous structure, medium-coarse-crystalline texture. Some varieties comply with requirements of BST 41.117-76 standard and ascribed to the first class of Kumyshkanskiy type	Infiltration	29
VI-4-94	Baydarski Vorota; S slope of Chelyabi-Yauri-Beli Mountain (Sevastopol city lands)	Confined to Baydarskiy fault-shear complicated by gravitation slide. Occurrence is related to grey pelitomorphic limestones of Yaylynska Suite. Productive horizon associates with various hollows with sintered marble onyx. Thickness of sinter forms is from 0.5 to 50 cm. Both transparent coarse-crystalline “stalactite”-like varieties and brown and yellowish-white fine-crystalline thin-banded varieties are observed. It is being cut without defect points up to 50×60×100 mm. By decorative properties it belongs to I-III classes by BST 41.117-76 standard	Infiltration	51

1	2	3	4	5
Gemstone raw materials **Figured stone** ***Occurrence***				
V-3-71	Chorgunskiy; Chornorichchya village outskirt	Productive horizon, up to 14 m thick, comprises clayey marls of Bilogirska Suite containing round-shaped flint concretions up to 20 cm in diameter. Flint is micro-grained, diverse-color: chalcedony-quartz, structure is banded and spotty; it complies with BST 42.117-76 standard and is suitable for gemstone works	Chemogenic-sedimentary	29
Facing-stone (decorative stone) raw materials **Limestones** ***Deposit***				
V-3-63	Inkermanske; in 0.5 km to SE from Inkerman-II station	Out of production	Sedimentary	23
V-3-70	Morozivske; in 1 km to NE from Ridne village	Out of production	Sedimentary	23
V-3-73	Sevastopolske; in 12-14 km to SE from Sevastopol city, nearby Morozivka and Chornorichchya villages	Out of production	Sedimentary	23
Occurrence				
V-4-81	Irytskiy; in 2.3 km to SW from Polyana village, in 4 km to NE from Novobobrivske village	Productive horizon comprises limestones of Kuchkynska Suite (K_1*kč*), pink-red, bright-brown, breccia-like, organogenic-detritus, 37.2 m thick. Strength limit under dry compression is from 12.4 to 109.6 (49.4 in average) MPa, volume mass – 2.56-0.51 g/cm^3, water uptake – 0.06-0.76% (mainly 0.13-0.51%), porosity – 0.04-2.4%, softening coefficient – 0.8. Chemical composition (%): CaO – 52.32; MgO – 0.71; SiO_2 – 2.56; Fe_2O_3 – 0.32; MnO – 0.02; TiO_2 – 0.08; Al_2O_3 – 1.1; P_2O_5 – 0.017; LOI – 42.17. Block output – from 10 to 16.4%. Stripping rocks – weathered limestones 2.7 m thick	Sedimentary	44
V-4-82	Peredivskiy; in 2 km to SE from Peredove village (Sevastopol city lands)	Discovered during prospecting-assessment works for marbled facing stones in 1986-1989. Productive horizon comprises marble-like, bright-grey with greenish and pink shade, organogenic-detritus, with inclusions of re-crystallized fauna, up to 25.8 m thick limestones of Kuchkynska Suite. Chemical composition and physico-mechanical properties are similar to limestones of Irytskiy occurrence. Block output is 45.6%. Good decorative properties. Stripping rocks are 3.0 m thick	Sedimentary	44

1	2	3	4	5
VI-4-88	Azys-Bairskiy; to S from Shyroke village	Productive horizon comprises parti-colored, brownish-grey, pink-grey and dark-grey, organogenic-detritus, breccia-like, up to 47.2 thick limestones of Baydarska Suite (J_3*bd*). Limestones comply with SBST 9478-84 standard; strength limit under dry compression is from 10.3 to 107.2 MPa; density – 2.67-2.71 g/cm3; water uptake – 0.06-0.93%; porosity – 0.1-5.3%; frost-resistance coefficient – 0.4-1.0. By chemical composition are similar to limestones of Irytskiy occurrence. Thickness of stripping rocks is 1.0 m	Sedimentary	44
Construction raw materials **Dimension wall raw materials** **Limestones** ***Deposit***				
V-3-61	Skhidno-Inkermanske; in 4 km to NE from Inkerman-II railway station	In conservation	Sedimentary	23
V-3-62	Krasnomakivske (western site); in 5 km to SW from Krasniy Mak village	In production	Sedimentary	23
Construction lime raw materials **Limestones** ***Deposit***				
V-3-65	Inkermanske (Pervomaiska site); to E from Inkerman-II railway station	In production	Sedimentary	21
Brick-tile raw materials **Clays** ***Deposit***				
V-3-78	Balaklavske; NE outskirt of Balaklava town	In production	Sedimentary	21
WATERS **Groundwaters** **Mineral waters** ***Deposit***				
V-4-80	Adzhy-Su (Chorni Vody); to E from Sokolyne village	In exploitation	Veined	49, 47
Occurrence				
V-4-79	Novoulyanovskiy; in 2 km to SW from Novoulyanovka village	Self water outflow from the depth 400 m from drill-hole drilled in 1971 was 69.98 m^3/d. Water is chloride, sodium, iodine-bromine; mineralization – 5.43 g/dm^3. Iodine content is 9.0 mg/dm^3, bromine – 80.0 mg/dm^3.	Fracture-veined	40

1	2	3	4	5
VI-4-96	Melas; Sanatorne village, in "Melas" sanatorium	Yield is 4.32-10.37 m^3/d (depending on atmospheric precipitates), mineralization – 146.88-155.52 g/dm^3. Water is hydrocarbonate-sulphate magnesium-calcium, minor amount of micro-components	Sheeted	50
Fresh waters ***Deposit***				
V-3-60	Alminske; Kripkenska site, Krasniy Mak, Kripke villages	In exploitation	Sheeted	70
	Zakhidno-Krymske deposit, sites:			
V-4-83	Polyanska; Polyana village	In exploitation	Sheeted	70
VI-4-92	Zakhidna; Opolzneve village	In exploitation	Sheeted	70

Annex 2. List of deposits and occurrences indicated in the "Geological map and map of mineral resources of Quaternary sediments" of map sheets L-36-XXVIII (Evpatoriya) and L-36-XXXIV (Sevastopol)

Cell index, number in map	Mineral type, object name and its location	Deposit exploitation state or brief description of occurrence	Geological-economic (genetic) type	Notes (references cited)
1	2	3	4	5
L-36-XXVIII NON-METALLIC MINERAL RESOURCES Ore-chemical raw materials Chemical raw materials Rock salt *Deposit*				
I-2-106	Sasyk-Syvaske; SW part of Sasyk Lake water area	In production	Sedimentary	30
Construction raw materials Cement raw materials Carbonate loams *Deposit*				
IV-4-111	Bakhchysarayske; in 1.2 km to NE from Bakhchysaray railway station	In production	Sedimentary	23
Sand-gravel raw materials Sand, gravel *Deposit*				
II-2-107	Sasykske; in 10 km to W from Saky town	In production	Sedimentary	23
WATERS Groundwaters Fresh waters *Deposit*				
IV-3-112	Alminske; Belbetska site, Fruktove village	In exploitation	Sheeted	70
Mineral sludge and mud Curative sludge *Deposit*				
I-1-98	Adzhy-Baychy Lake; in 17 km to W from Evpatoriya town	Out of exploitation	Sedimentary	33
I-1-99	Airchynske Lake; in 15 km to W from Evpatoriya town	Out of exploitation	Sedimentary	33

1	2	3	4	5
I-1-100	Galgaske Lake; in 14 km to W from Evpatoriya town	Out of exploitation	Sedimentary	33
I-1-102	Konradske Lake; in 12 km to W from Evpatoriya town	Out of exploitation	Sedimentary	33
II-1-103	Terekly Lake; in 1 km to SW from Evpatoriya town	Out of exploitation	Sedimentary	33
I-2-104	Sasyk-Syvaske Lake; in 8 km to E from Evpatoriya town	Out of exploitation	Sedimentary	33
I-2-105	Maynatske Lake; western outskirt of Evpatoriya town	Exhausted	Sedimentary	33
II-3-108	Sakske Lake; in 0.5 km to W from Saky town	In exploitation	Sedimentary	33
II-3-109	Kyzyl-Yar Lake; in 10 km to S from Saky town	Out of exploitation	Sedimentary	33
II-3-110	Bogayly Lake; in 13 km to S from Saky town	Out of exploitation	Sedimentary	33
		Occurrence		
I-1-97	Oyburzke Lake; in 21 km to NW from Evpatoriya town	Average thickness of sludge bodies – 0.3 m, moisture – 50%, volume mass – 1.5 g/cm^3, contamination – 1.5%, organic matter content – 0.9%, pH – 6.8. Ionic composition formula: $M(104-169)\frac{Cl89SO_4 9}{(Na+K)77Mg18}$	Sedimentary	33
I-1-101	Krugle Lake; in 12 km to W from Evpatoriya town	Average thickness of sludge bodies – 0.22 m, moisture – 44%, volume mass – 1.6 g/cm^3, contamination – 1.8%, organic matter content – 0.6%, pH – 5.3. Ionic composition formula: $M(180-366)\frac{Cl79SO_4 20}{Na60Mg38}$	Sedimentary	33

1	2	3	4	5
L-36-XXXIV **NON-METALLIC MINERAL RESOURCES** **Non-metallic ore raw materials** **Jewelry-gem (semi-precious stone) raw materials** **Marble onyx** ***Occurrence***				
VI-4-114	Lemenskiy; in 3 km to NW from Opolzneve village	Related to one of the slides at the foothill of Ay-Petrinske highland and composed of boulder accumulation of Upper Jurassic limestones cemented by loamy-clayey filler – Pliocene-Quaternary Masandrivska Suite. Confined to 150 m wide tectonic zone where karst caves “Medova” and “Druzhna” are located, as well as numerous karst funnels and wells. Boulder and collapse-rockfall units with marble onyx comprise the remnants of destroyed karst hollows like “Medova” cave. Onyx is yellowish-brown, brown, cream, with radiate-fibrous and banded structure. Bright-coloured varieties are well easily polished. Onyx volume mass is 2.5-2.6 g/cm^3 (2.53 in average), water adsorption – 0.74-1.2%, strength limit – 21.2-22.0 MPa. Raw materials comply with BST 41.117-76 (first class) standard	Infiltration	29
WATERS **Groundwaters** **Fresh waters** ***Deposit***				
V-3-113	Alminske; Inkermanska site, Shuli village (Shtormove village), Chorna River valley	In exploitation	Sheeted	70

Annex 3. List of geological and ancient culture landmarks

No.	Number in the map	Name and brief description	Category
1	2	3	4
I. Stratigraphic landmarks natural and artificial outcrops			
1	4	Basic Upper Miocene column	L
2	6	Basic Eo-Pleistocene column nearby Beregove village	L
3	8	Basic Upper Pliocene column nearby Andriivka village	L
4	14	Basic column of Oligocene sediments nearby Poshtove village (313*)	S
5	19	Outcrop of "exotic" Paleozoic limestone boulders nearby Trudolyubivka village	S
6	21	Basic column of Upper Cretaceous sediments nearby Starosillya village (including stratotype of Maastrichtian Starosilska Suite) (334)	L
7	25	Basic column of Upper Cretaceous Cenomanian-Turonian sediments nearby Prokhladne village	S
8	28	Outcrop of Cenomanian-Turonian bituminous sediments with fish remnants in Aksu-Dere gorge – typical example of the event stratigraphy – oxygen-free environment in the sedimentation basin	M
9	29	Outcrop of Upper Eocene sediments in Kachynska valley (342)	S
10	33	Basic column of Lower Cretaceous sediments in Rizana Mountain (344)	S
11	37	"Exotic" Paleozoic limestone boulders at Marta River	L
12	40	Stratotype of Pliocene continental sediments nearby Lyubymivka village	S
13	49	Stratotype of Upper Hauterivian Golubynska sequence	L
14	55	Startotype of Upper Toarcian – Lower Bajocian Vidradnenska Suite in the Belbek River valley	L
15	56	Startotype of Upper Bajocian – Lower Bathonian Belbetska Suite in the Belbek River valley	L
16	60	Lower Valanginian reef nearby Bagata Ushchelyna village	L
17	65	Stratotype of Upper Albian Chorgunska sequence	L
18	67	Stratotype of Lower Valanginian Kuchkynska sequence	L
19	68	Stratotype of Berriasian Bechku Suite	L
20	70	"Exotic" boulders of Proterozoic granites in Balaklavska valley	L
21	71	Stratotype of Baydarska Suite in Kyzyl-Kaya Mountain	L
22	75	Startotype of Middle Aptian Balaklavska sequence	L
23	83	Contact between Oxfordian and Tithonian sediments	L
24	84	Stratotype of Upper Oxfordian – Lower Kimmeridgian Sukhoritska Suite	L
25	85	Para-stratotype of Ayvasylska Suite in Megalo-Yalo harbor	L
26	86	Olistostrome horizon in Baydarska Suite in Sukha Richka river valley	L
27	89	Stratotype of Upper Tithonian Kalafatlarska Suite	L
28	93	Stratotype of Deymen-Derynska Suite in Deymen-Dere gorge in Baydarska valley	L
II. Paleontological landmarks Outcrops with unique or distinct accumulations of animal remnants			
29	3	Finding of mammal remnants nearby Mykolaivka village	L
30	15	Finding of mammal remnants at Lukul cape	L
31	17	Finding of mammal remnants at Kermenchyk cape	L
32	46	Location of abyndant Berriasian-Valanginian fauna	L
33	80	Location of Triassic molluscs	L

1	2	3	4
III. Tectonic landmarks **Faults**			
34	54	Tectonic break zone (deformation, mélange)	L
35	82	Marmurova Balka break	L
36	90	Perovskiy normal fault in the northern bank of Varnautska valley	L
37	98	Baydarskiy normal fault	L
Magmatic structures			
38	62	Outcrop of Sokolynska diabase porphyrite intrusion	L
39	74	Outcrop of diabase porphyrite intrusion in Lermontova cape of Gerakleyskiy peninsula	L
IV. Volcanic landmarks **Location of paleo-volcanoes and their products**			
40	78	Fiolentskiy volcano neck in Gerakleyskiy peninsula	L
41	99	Pylyaky volcanic ridge	L
42	101	Drakon volcanic ridge	L
43	104	Ifigenia volcanic cliff	L
V. Geomorphologic landmarks **Weathering remnants, stone chaos**			
44	20	Sfinks cliffs in Churyuk-Su valley	S
45	73	Orlyniy Zalit cliffs	S
46	103	Kuchuk-Koyskiy stone flow (chaos)	L
VI. Speleologic landmarks **Karst funnels**			
47	87	Besh-Tekne karst field	L
Karst caves			
48	72	“Danylcha-Koba” and “Partyzanska” caves	S
49	77	“Syundyurlyu” cave	S
50	81	Uzundzha cave	S
51	91	“Skelska” cave	S
52	92	“Kryshtaleva” shaft-cave	S
VII. Landscape landmarks **Locations of typical and unique landscapes reflecting results of endogenous and exogenic processes interaction**			
53	31	Kachynski Vorota canyon (343)	S
54	42	Belbetski Vorota canyon	S
55	69	Great Crimean Canyon	S
56	76	Chorna Richka Canyon	S
57	94	Shaytan-Merdven (Devil’s Stairs)	L
VIII. Hydrology-hydrogeological landmarks **Mineral water springs**			
58	59	Curative spring nearby Pidlissya village	L
59	63	Curative spring Adzhy-Su	L
IX. Impressive landmarks **Locations of geological bodies out of particular scientific or lore value but interesting in esthetic respect**			
60	97	Batyliman-Laspinska wall	S
61	100	Baydaro-Kastropolska wall	S
X. Ancient culture landmarks **Archeological landmarks of Antic epoch**			
62	1	Ancient Greek Ercenitida town remnants, VI – IV-III centuries B.C., Scythian fortress remnants, II-I centuries B.C.	S
63	13	Late Scythian Alma-Kermen settlement remnants, IV-III centuries B.C.	S
64	18	Rasnozorinske settlement remnants	S
65	22	Ust-Alminske Late Scythian settlement (V-III centuries B.C.)	S

1	2	3	4
66	35	Kemi-Obynska culture settlement (III – beginning of Ist century B.C.) in Tash-Air gorge (cliff hang)	S
67	50	Antic Khersones town ruins	S
Medieval archeological landmarks			
68	2	Remnants of medieval armed settlements	S
69	24	Uspenskiy cave monastery	S
70	26	Medieval cave town and fortress Chufut-Kale (X century A.D.)	S
71	30	Cave settlement and fortress Tepe-Kermen (VIII-IX centuries B.C.) at the distinct "table" mountain	S
72	32	Medieval fortress Kyz-Kermen (Girls' fortress) remnants, VIII-IX century A.D.)	S
73	34	Ioann Predtecha (John the Baptist) church remnants (XIV century A.D.)	S
74	36	Medieval cave settlement Kachy-Kalyon	S
75	39	Medieval burial ground (VI-VIII century A.D.) nearby Bashtanivka village	S
76	43	Medieval Kermenchyk fortress remnants nearby Pecherne village	S
77	44	Syuyrenska fortress ruins, VIII century A.D.)	S
78	45	Medieval Alamita fortress ruins in Monastyrska Mountain in Inkerman town	S
79	47	Medieval monastery remnants on Zagaytan cliff nearby Inkerman town	S
80	48	Kyz-Kule (Maidenly Tower) fortress and Donatory castle	S
81	51	Eski-Kermen cave town and fortress, VI century A.D.	S
82	52	Mangup-Kale cave town and fortress	S
83	53	Medieval fortress remnants in Pambuk-Kaya Mountain	S
84	57	Chelter cave monastery, VI-IX centuries A.D.	S
85	58	Shuldon-Marmara cave monastery, VIII-XV centuries A.D.	S
86	61	Medieval fortress and temple remnants on Boyko Mountain	S
87	64	Agriculture land remnants of ancient Khersones in Gerakleyskiy peninsula	S
88	66	Chorgunska tower of medieval fortress, XV century A.D.	S
89	79	Chembalo medieval fortress remnants, XIV-XV centuries A.D.	S
90	95	Feudal lord castle remnants in Kokiya-Isar Mountain, X-XIII centuries A.D.	S
91	96	Prophet Illya temple remnants in Ilyas-Kaya Mountain	S
92	102	Necropolis, II-I centuries B.C. and I-II centuries A.D., medieval Genoa fortress remnants, VIII-X century A.D., in Kishka cape	S
Ancient graves, primordial culture settlements			
93	5	Naymen-Oba mound	S
94	7	Ak-Mechet-Oba mound	S
95	9	Yushon-Oba mound	S
96	10	Khosh-Oba mound	S
97	11	Karshavlu-Oba mound	S
98	12	Kara-Oba mound	S
99	16	Orus-Oba mound	S
100	23	Endekli-Oba mound	S
101	27	Shenglyar-Oba mound	S
102	38	Cave settlement "Alymiv Navis" in Alymova gully	S
103	41	Syuyrenski grottos – Paleolite and Mesolite settlement in Belbetska valley	S
104	88	At-Bash Neolitic settlement	S

Note: * - number after the list of geological landmarks in the book "Geological landmarks of Ukraine" [13a].
L – local-rank landmarks;
S – State-rank landmarks

STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

Crimean Series

Map Sheet Group
L-36-XXVIII (Evpatoriya), L-36-XXXIV (Sevastopol)

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