MINISTRY OF ECOLOGY AND NATURAL RESOURCES
STATE GEOLOGICAL SURVEY

UKRAINIAN STATE GEOLOGICAL RESEARCH INSTITUTE
(UkrSGRI)

STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

CENTRAL-UKRAINIAN SERIES
MAP SHEET M-36-XXXI (PERVOMAISK)

EXPLANATORY NOTES

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In the work the previous data are reviewed and generalized. The system description is provided for the stratified and non-stratified units, tectonics of the territory, history of geological development, mineral resources and regularities in their formation. Influence of the deep structure on the formation of near-surface tectonic units and localization of mineral resources are examined. Descriptions of geomorphological structure, hydrogeology and geological environment are given in particular sections.

The set of maps in the scale 1:200 000 – “Geological map and map of mineral resources of pre-Quaternary units”, “Geological map and map of mineral resources in Quaternary sediments”, and “Geological map and map of mineral resources of crystalline basement”, as well as the supplementary explanatory notes are devoted to the wide range of specialists in the fields of geological sciences and nature studies.

Present issue comprises 2007 authorized English translation of the edition originally published in 2004.

CONTENTS

Abbreviations used in the text

ABC – average background concentrations
AC – absorption capacity
CMF – component of missile fuel
COP – chlorine-organic pesticides
Derzhgeolkarta-200 – the State Geological Map 1:200 000 (the State Program)
DGM-200 – Deep Geological Mapping in the scale 1:200 000
DH – drill-hole
DMA – dymetilamine
DMM-200 – Deep Mineragenic Mapping in the scale 1:200 000
EE – ecological emergency
EEZ – ecological emergency zone
IGMOF – Institute of Geochemistry, Mineralogy and Ore Formation of NAS
IGS – Institute of Geological Sciences of NAS
IP – induced polarization
KNU – Kyiv Taras Shevchenko National University
LTZ – Litho-Tectonic Zone
MBC – medium-background concentration
MRW-JDP – method of reflected waves – joint deep point
MSL – missile shaft launcher
MTP – method of transitional processes
NAS – National Academy of Sciences of Ukraine
NDMA – nitrozodymethylamine
REE – rare earth elements
SCMR – the State Commission of Ukraine on Mineral Reserves
SE – the State Enterprise
SGE – the State Geological Enterprise
SRGE – the State Regional Geologic Enterprise
SSPE – the State Scientific-Production Enterprise
TAC – top admissible concentration
TAL – top admissible level
TE – Treasury (fully State-owned) Enterprise
TMZ – Tectono-Metallogenic Zone
VEL – vertical electric logging

Acc – accessories
ap – apatite
Bi – biotite
Cpx – clinopyroxene
Ga – garnet
Hb – amphibole
Mgt – magnetite
Opx – orthopyroxene
Pl – plagioclase
Q – quartz
sdM – sulphides
tr – traces
zr – zircon
æ – volume magnetic susceptibility
σ – density in g/cm^3

INTRODUCTION

The territory of map sheet M-36-XXXI (Pervomaisk) is located in the south-western part of Ukrainian Shield, in the Middle Pobuzhzhya, and is bounded by coordinates $48^0 00'$-$48^0 40'$ N latitude and $30^0 00'$-$31^0 00'$ E longitude. The square of the map sheet is equal to 5,496 km^2.

In administrative respect the territory of map sheet belongs to Gaivoronskiy, Ulyanivskiy, Golovanivskiy, Novoarkhangelskiy, Vilshanskiy, and Dobrovelychkivskiy areas of Kirovogradska Oblast[1]; Savranskiy area of Odeska Oblast; Pervomaiskiy and Kryvoozerskiy areas of Mykolaivska Oblast; Umanskiy area of Cherkaska Oblast; Bershadskiy area of Vynnytska Oblast.

The connection ways are well developed. In the south the map sheet is being crossed by railway Pomoshnya-Pervomaisk-Kotovsk, from north to south – the highway Kyiv-Odesa with branching off nearby Ulyanivka village the new motorway to Golovanivsk-Pervomaisk and further to Simferopol. Almost all inhabited localities are connected by the roads paved with asphalt, stone or gravel, rarely – by enhanced country roads.

By relief conditions the territory comprises flat-hilly plane cut by river valleys and gullies which slopes in turn are cut by local gorges. Absolute heights vary from 247 m in the north-west to 130 m and less in the south-east. The soils are mainly loamy, in the east – clayey, and only in between the Savranka and Southern Boug rivers – sandy. The ground waters along the river valleys and gullies lie at the depth 1-5 m, and at the watersheds – up to 20 m. The rivers belong to the Southern Boug River system which in its middle course intersects the southern part of the map area from west to east over the distance about 110 km. From the north to the Southern Boug River there are inflow Synytsya and Synyukha Rivers with branches Yatran, Sukhiy Tashlyk and Maliy Tashlyk, and from the south – Savranka and Gnylyukha Rivers. Close to the inhabited localities the rivers and gullies are blocked off with the dams providing ponds and water reservoirs higher the courses. Normally the rivers are being frozen in the mid of December (ice thickness 20-30 cm) and are being opened late in the March.

The vegetation is mainly of the steppe type. Some deciduous forests occur. Close to the inhabited localities the gardens and vineyards are located. Forest-strips are also widespread.

Climate conditions are mild. The winter (December-February) is comparatively mild with dully weather and rather frequent fogs, weak frosts (-3…-6^{o}C) alternating with thaws but sometimes the frosts may even attain -36^{o}C. The snow cover (thickness up to 15 cm) is being stored from the second half of December up to the beginning of next March. The soils are being frozen to the depth 15-20 cm. The springtime (March-May) is cool in the first half and warm in the second one, with light morning frosts. The summertime (June – second half of September) is warm and in some years it is hot and droughty with short-time thunder downpours, often dust storms. The autumn (second half of September – November) is warm and dry in the first half, and cool with frequent rains and frogs in the second half.

By economic conditions the territory may be classified as agriculture area. The industry enterprises are mainly of local value and are located in the towns and town-type inhabited localities. Pervomaisk town with the population over 75,000 inhabitants is located in the south-east of the territory. The town-type inhabited localities (population more than 2,000 people) include[2]: Novoarkhangelsk, Golovanivsk, Pobuzke, Ulyanivka, Zavallya, Savran, Vilshanka, Tyshkivka, Pidgorodnya, Ladyzhynka, Kolodyste, Mogylne, Peregonivka, Tryduby, Kuryachi Lozy. In other inhabited localities the population does not exceed 2,000 people. Water supply in the towns and town-type inhabited localities is of pipe-type whereas in the villages there are mainly being exploited up to 10 m deep shafts and the springs. The industry objects include: Pobuzkiy nickel plant, Zavallivskiy graphite quarry, numerous quarries for gravel and quarry-stones, enterprises of light, food and processing industries.

Within the studied map sheet, geology is very intricate, since the map sheet territory actually encompasses three geological regions (geo-blocks): Rosynsko-Tykytskiy, Dnistersko-Buzkiy, and Ingulo-Inguletskiy. Exposure degree by the river and gully slopes and valleys is appropriate but Phanerozoic sediments are being exposed in some places only.

The geological column is subdivided in three-fold way distinguishing Quaternary, thrust and folded complexes.

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[1] In Ukraine, the “Oblast” comprises major territorial administrative unit. In total, Ukraine includes 25 Oblasts plus the Crimean Autonomic Republic. Each Oblast consists of some higher-order administrative units hereafter entitled as “area” (*Translator note*).

[2] In the Annexes 1-3, for simplicity, these town-type inhabited localities are indicated as “villages” (*Translator note*).

By the degree of complexity, the sedimentary cover units are simplest, whereas crystalline basement rocks, according to their geology and geophysical fields, are being subdivided into complicated (10%) and very complicated (90%). The satellite view interpretation is weak (some lineaments only). The territory passableness is appropriate.

In compilation and preparation to publishing in the map series of "State Geological Map 1:200 000" ("Derzhgeolkarta-200"), over the territory of the sheet M-36-XXXI (Pervomaisk) the results of geological mapping, prospecting, geophysical survey, and research works were used. The major ones include:

- Sets of geological maps in the scale 1:200 000, basic sections and documentations of the drill-holes and outcrops, analytical data (V.S.Kostyuchenko, V.V.Zyultsle, 1990);
- Geological and geological-mineragenic map in the scale 1:200 000 (O.P.Storozhuk, 1997);
- Sets of geological maps in the scale 1:50 000, documentations of the drill-holes and outcrops, analytical data (G.G.Vynogradov, 1961, 1963, 1964, 1974, 1976; V.M.Bondarenko, 1990; V.V.Kyslyuk, 1991).
- Set of geophysical and geochemical maps in the scales 1:50 000 – 1:200 000 (A.F.Fedorov, 1984);
- Seismic-gravity models in the scale 1:50 000 (L.M.Shymkiv, V.A.Entin, 1998).
- Set of ecological-geochemical maps in the scale 1:200 000 (V.P.Kolesnichenko, 1996).
- Complex geological-geophysical model of the deep structure of the Earth crust designed by leading specialists of Institute of Geophysics of National Academy of Sciences of Ukraine headed by I.K.Pashkevich, S.S.Krasovskiy, M.I.Orlyuk.
- Tectonofacies sketch designed by leading specialists of Kyiv National University headed by O.I.Lukienko.

The following specialists had participated in preparation to the publishing:

- From Ukrainian State Geological Research Institute (UkrSGRI) – V.M.Klochkov (senior scientist, responsible executive), Ya.P.Bilynska (leading engineer-geologist), Yu.M.Veklych (head of division), Yu.K.Piyar (leading engineer-geologist), O.M.Shevchenko (leading engineer-geologist), I.I.Marakhovska (leading engineer-geologist), S.V.Klochkov (I-category engineer-geologist), I.F.Kiryanova (II-category engineer-geologist), O.M.Pylypchuk (I-category engineer-geologist).
- From Institute of Geophysics of National Academy of Sciences of Ukraine – I.K.Pashkevich (leading scientist), S.S.Krasovskiy (head of division), M.I.Orlyuk (head of division).
- From Kyiv National University – O.I.Lukienko (Professor, head of chair).

The major and supplementary maps are designed based on the electronic database (Geolkarta-200 database) over the territory of map sheet M-36-XXXI (Pervomaisk). Database administrator and responsible for computer forwarding of the works is S.V.Klochkov (I-category engineer-geologist).

Analytical determinations are obtained from the following laboratories:

1. Spectral analysis of crystalline rock samples – Central laboratory of SRGE "Pivnichgeologia".
2. Complete chemical (silicate) analysis of rock samples – laboratory of IGMOF.
3. Rock sample chemical analysis for trace elements – Central laboratory of SRGE "Pivnichgeologia".
4. Paleo-phyto and paleo-fauna researches – paleontologic laboratory of SSPE "Geoinform".
5. Spectral analysis of crumble rock samples – laboratory of TE "Kirovgeologia".
6. Paleomagnetic researches over consolidated crumble rock samples – laboratory of IGS.
7. Thermo-luminescent analysis of crumble rock samples – laboratory of IGS.
8. Preparation of polished thin sections – laboratory of KNU.
9. Petrographic description of thin sections – own specialists.
10. Water extraction from the crumble rock samples – laboratory of IGMOF.
11. Granulometric analysis of rock samples – Central laboratory of SRGE "Pivnichgeologia".

1. STUDY DEGREE

The major results of geological mapping, prospecting works and geophysical surveys are described in this section. In total, the study degree of the map sheet territory complies with the scale 1:200 000 for the crystalline basement rocks, and with the scales 1:100 000 – 1:50 000 for the sedimentary cover.

Medium-scale geological mapping

Review of previous works can be commenced from the first edition of the set "Geological map of USSR in the scale 1:200 000" published in 1959 [9]. It was encountered most of silicate nickel occurrences in the Middle Pobuzhzhya, as well as four major complexes of Lower and Upper "Archeozoic" were distinguished. The complexes of metamorphic, mafic and ultramafic rocks were distinguished as Teterevo-Buzka Series. Buchatskiy, Kyivskiy and Kharkivskiy Stages were distinguished in Paleogene and they were paleontologically characterized. Poltavska and Baltska (Miocene-Pliocene) Suites were distinguished in Neogene. Genetic types of Quaternary sediments were subdivided into four divisions of this System.

In 1984-1990 over the sheet territory V.S.Kostyuchenko and V.V.Zyultsle had conducted the deep geological mapping in the scale 1:200 000 [80]. This work had provided the ground for edition of the new generation of the map set. This report also accounts the models of territory geology that over the various times were suggested by G.G.Vynogradov, A.Ya.Drevin, I.B.Shcherbakov, Yu.K.Piyar, and P.S.Veremyev. In design of the crystalline basement geological map the authors have had distinguished the taxons at the level of rock complexes mapped by determined paragenetic rock associations; this seems to comply in more extent with the term "geological formation". It is verified the stratigraphic position of Cretaceous sediments, Obukhivska and Novopetrivska Suites, as well as it is improved subdivision of the Pliocene sediments. The authors of report have suggested appropriate conclusions concerning prospective evaluation of the territory with regard to the mineral deposits, as well as concerning geochemical specialization of the rock complexes.

It looks equally important another report on results of deep mineragenic mapping in the scale 1:200 000 (DMM-200) compiled in 1995 by O.P.Storozhuk et al [88]. These works were conducted over four map sheets in the scale 1:200 000 within the Central-Ukrainian Lineament Zone which also include the current sheet M-36-XXXI. First of all, it should be noted that in the framework of research under consideration the maps of crystalline basement were essentially re-designed. Although such re-arrangement was performed mainly by compilation method using previous mapping results, mentioned re-design was conducted respecting requirements to the content of the map set under the program "Derzhgeolkarta-200". It was provided the general outline of the geological history based on the new tectonic concepts. It is of especially value the analysis of mineral deposits and findings, primarily, precious and other metals, as well as ideas on regularities in their location coupled with definition of some mineragenic zones.

In 1972 it was published the "Hydro-geological map of USSR" in the scale 1:200 000 including the sheet M-36-XXXI [12]. It were characterized the parameters of major water-supplying horizons. The most important is the water-supplying horizon in the zones of enhanced permeability in the rocks of crystalline basement. The second subsoil horizons related mainly to Paleogene sediments is locally distributed.

In 1996 the Expedition No. 44 of TE "Kirovgeologia" over the territory of the sheet had conducted ecology-geochemical mapping in the scale 1:200 000 [77]. The report contains the numeric characteristics of contamination of the soils, bottom sediments, as well as surface, subsoil and underground waters.

Large-scale geological mapping

During period of 1959-1976 G.G.Vynogradov had performed geological mapping over 14 map sheets in the scale 1:50 000 [55-59]. These scale mapping was completed in 1990 by V.M.Bondarenko simultaneously with the DGM-200. As a result, it were designed in respective scale the major geological maps of pre-Quaternary units, Quaternary sediments, crystalline basement, and mineral deposits. All the reported maps were designed in compliance with the stratigraphic schemes valid for those times while results of G.G.Vynogradov were taken as the ground for such the schemes. For instance, he had suggested subdivision of Buzka Series into four suites which were then used in most of the stratigraphic schemes up to beginning of 90^{th}. Later on Synytsivska Suite was excluded from Buzka Series but this point is under discussion up to recent. At the same time, the granitoid complexes were also subdivided. After mentioned as well as prospecting works, A.Ya.Drevin [69] and

A.Ya.Kanevskiy [73-75] in various years had designed tectonic-geological maps of crystalline basement in Middle Pobuzhzhya in the scale 1:50 000 which seem to be equally important at present time as well. Essential weakness of these works is caused by limited amount and low depth of drilling by crystalline basement. In reports of G.G.Vynogradov it was accounted most of mineral deposits and findings except precious and rare metals due to lack of reliable laboratory base. The main petro-types of metamorphic, ultra-metamorphic, and intrusive rocks defined by mentioned authors, as well as paragenetic associations of respective rocks were used as the ground designing the major maps over the territory of the sheet.

In 1998 V.V.Kyslyuk and V.V.Zyultsle had completed extended geological study of the sub-sheets M-36-133-A,B [76]. It was compiled the set of main geological maps in the scale 1:50 000. Based on stratones defined in Phanerozoic cover the authors had provided the section subdivision. Concerning the geological maps of crystalline basement these maps actually are the maps of geological formations and complexes of such formations. The authors have stressed that in their view the complexes of Dnistersko-Buzka and Buzka Series comprise continuous range of geological formations whose rocks were coevally metamorphosed under granulite facies at the boundary between Archean and Proterozoic. Further Precambrian history, according to the authors, was dominated by the retrograde metamorphic processes. In fact, the authors have suggested new approach to the geological mapping which seems to be not complies with requirements to the design and edition of "Derzhgeolkarta-200".

Prospecting and exploration works

Over period from 1951 to 1984 within the territory of the map sheet it were conducted the prospecting, prospecting-evaluation and exploration works for nickel [60, 61, 65, 74, 75, 92, 94], chromites [69, 93], iron ores [50, 51, 52], graphite [96, 101, 102], corundum [68], sillimanite [64], vermiculite. By these works it were discovered and explored 6 deposits of silicate nickel, one deposit and 13 findings of iron ores, two chromite deposits, some deposits of sillimanite and others.

In 1976-1978 there were performed the works on study the deep geology and metal content in Moldovska and Sekretarska structures [89]. Within both structures graphite and precious metal occurrences were found.

In 1984-1988 there were performed the gold prospecting works in Demovyarska structure [81] and poor gold mineralization was encountered.

In 1984-1999 there were performed prospecting works for sulphide nickel, iron ore, and graphite [62, 70]. In Moldovske deposit it was found that thickness of ore bodies increases with depth while the ores comprise silicate-magnetite (easy beneficiating) and carbonate-magnetite (easy fluxing) varieties. M.N.Duplyak [70] had concluded concerning perspectives for silicate nickel of the linear weathering crust within Derenyukhinskiy, Pushkivskiy, Kapitanivskiy, and Lypovenkivskiy massifs of mafic rocks.

In 1985-1989 within Troyanivska structure it was conducted the apatite prospecting [100]. New apatite-bearing weathering crust fields were not found.

Geophysical and geochemical works

Geophysical works over the map sheet M-36-XXXI (Pervomaisk) are being carried out since 1949.

Before 1960 the whole territory was covered by magnetic survey in the scale 1:50 000 and gravity survey – 1:200 000. In some areas there were also performed the surveys in the scales 1:10 000 and 1:50 000. Below we will outline just the major results and generalizing works of the latest periods that have first-order value.

It seems most informative the report on geophysical and geochemical preparations for the DGM-200 [90]. It was re-interpreted the geophysical surveys of previous periods as well as conducted extended study of some piles (sheet M-36-121-A) though gravity survey in the scale 1:50 000 and magnetic survey – 1:25 000. Over the square 4,306 km^2 there were carried out vertical electric survey, and in places – by induced polarization. There were performed deep geochemical prospecting and reassessment-geochemical studies, designed the maps of physical fields, geology-geochemical, and complex interpretation ones. There were provided conclusions concerning tectonic subdivision and deep structure of the Earth's crust. Finally, there were evaluated the perspectives for gold, tungsten, molybdenum, and diamonds over 15 predictive-prospective areas.

In 1988 [97] it was conducted the seismic survey JDP by the system of regional and detailed profiles. There were designed 2D seismic-gravity models of the upper crust in Golovanivskiy Block to the depth 10 km. The authors had concluded that Tarasivska and Troyanska structures comprise complicated oldest intrusions of deeply eroded central-type volcanoes.

In 1980-1981 in the Middle Pobuzhzhya area there were carried out the geochemical prospecting for sulphide nickel. There were designed predictive maps in the scale 1:50 000, and in the prospective areas (Demiv Yar, Emylivska, Kumarivska, Sekretarska) – 1:5 000. There were concluded concerning recommendation on prospecting-evaluating works. In 1989 during prospecting for sulphide nickel [62] in the areas Kumary, Grushka, Ternovatka, Kamyana Balka, and Savran there were carried out the geochemical works by dissemination aureoles. There were defined the first-order objects for further studies.

In the framework of GMM-200 [88] V.P.Ivanchykov had designed geochemical map in the scale 1:200 000 which was specialized for gold and its satellite trace-elements.

Thus, above brief overview of studied performed over the map sheet territory suggests for background data amount which is quite enough for design the major maps of the set under requirements of "Derzhgeolkarta-200".

2. STRATIFIED ROCKS

In the general stratigraphic column of the map sheet territory there are distinguished the sediments of Cenozoic, Mesozoic erathemes, and the rocks of Paleo-Proterozoic, Neo-Archean and Paleo-Archean eonothemes. Their subdivision is being grounded on the "Legend to the Geological Map of Ukraine in the scale 1:200 000 (series Central-Ukrainian)" and on the valid correlation stratigraphic schemes. Paleontologic characteristic of some Cenozoic stratons is being provided mainly after previous studies. In subdivision of Quaternary sediments and Precambrian metamorphic rocks there were used data on the basic sections compiled as after previous works as via supplementary extended study of the territory performed during preparation under "Derzhgeolkarta-200" the current set of maps for the sheet M-36-XXXI (Pervomaisk).

Phanerozoic sediments comprise the sedimentary cover (cover complex).

Paleo-Proterozoic and Archean rocks in crystalline basement belong to the folded complex consisting of three tectonic levels, each highly deformed and eroded.

Although entire territory of the sheet is covered by the geological mapping in the scale 1:50 000, and over the territory there were also performed the works of DGM-200 in the scale 1:200 000 and somewhere even 1:50 000, the stratigraphy of Precambrian metamorphogenic units is not studied in most details yet despite of significant amount of drilling carried out. Since the drill-holes were done mainly in prospecting purposes for various minerals, there are actually no areas where the drill-hole profile continuously intersect the whole stratigraphic columns as the single suites as, especially, their transition portions displaying their relationships.

It is set forth below the overall characteristic of generalized stratigraphic section from top downward.

PHANEROZOIC

Cenozoic Eratheme

Quaternary System

Holocene Division

Technogenic sediments (tH)

Technogenic-aqueous sediments (tlH)

Alluvial sediments (aH)

Upper Neo-Pleistocene – Holocene Complex

Deluvial and deluvial-aeolian sediments (d,dvP_{III}-H)

Pleistocene Division

Neo-Pleistocene Section

Upper Neo-Pleistocene Branch

Aeolian-deluvial sediments (vdP-$_{III}$)

Deluvial-aeolian sediments (dvP_{III})

Deluvial-aeolian sediments (dvP_{III} bg-pč)

Deluvial-aeolian slope sediments (ddvP_{III})

Aeolian-deluvial and elluvial-deluvial sediments (vd,edP_{III})

Middle-Upper Neo-Pleistocene Complex

Alluvial sediments (aP_{II-III})

Alluvial and deluvial-aeolian sediments (a,dvP_{II-III})

Elluvial-deluvial and aeolian-deluvial sediments (ed,vdP_{II-III})

Aeolian-deluvial and elluvial sediments (vd,eP_{II-III})

Aeolian-deluvial and elluvial-deluvial sediments (vd,edP_{II-III})

Aeolian-deluvial and deluvial-elluvial sediments (vd,deP_{II-III})

Aeolian-deluvial sediments over the alluvial sediments (vd,aP_{II-III})

Lower-Middle Neo-Pleistocene Complex

Alluvial and deluvial-aeolian sediments within IV-VIII (čk-dc) terraces (a,dvP_{I-II})

Elluvial-deluvial sediments (edP_{I-II}^2)

Aeolian-deluvial and alluvial sediments (vd,aP_{I-II})

Elluvial-deluvial sediments (edP_{I-II}^1)

Lower Neo-Pleistocene Branch

Alluvial sediments of VI-VIII (bk-kn) terraces (aP_I)

Elluvial-deluvial sediments (edP_I)

Elluvial-deluvial and aeolian-deluvial sediments (ed,vdP_I)

Aeolian-deluvial and elluvial-deluvial sediments (vd,edP_I)
Aeolian-deluvial sediments (vdP_I)
Eo-Pleistocene – Lower Neo-Pleistocene Complex
Elluvial-deluvial sediments (edE_I-P_I)
Elluvial-deluvial and aeolian-deluvial sediments (ed, vdE_I-P_I)
Pliocene – Eo-Pleistocene Complex
Elluvial-deluvial and aeolian-deluvial sediments (ed,vdN_2^3-E_I)

<u>Neogene System</u>
Pliocene Division
Pile of red-brown clays (N_2*čb*)
Pliocene and Miocene Divisions undivided

Northern litho-tectonic zone		*Southern litho-tectonic zone*
Parti-coloured sandy-clayey pile ($N_{1\text{-}2}$*pg*)	Pile of parti-coloured sands ($N_{1\text{-}2}$*p*)	Baltska Suite ($N_{1\text{-}2}$*bl*)

Miocene Division
Upper Sub-Division
Clayey pile (N_1*g*)
Sandy pile (N_1*p*)
Coaliferous-clayey pile (N_1*vg*)
Sandy-lime pile (N_1*pv*)
Lower and Middle Sub-Divisions undivided
Poltavska Series
Novopetrivska Suite (N_1*np*)

<u>Paleogene System</u>
Oligocene Division
Poltavska Series
Berekska Suite (₽$_3$*br*)
Kharkivska Series
Mezhygirska Suite (₽$_3$*mž*)
Eocene Division
Kharkivska Series
Obukhivska Suite (₽$_2$*ob*)
Kyivska Suite (₽$_2$*kv*)
Buchatska Series (₽$_2$*bč*)

Mesozoic Eratheme
<u>Cretaceous System</u>
Lower Division
Kodymska Suite (K_1*kd*)

PRECAMBRIAN

Proterozoic Acrotheme
<u>Paleo-Proterozoic Eonotheme</u>
Ingulo-Inguletska Series (PR_1*ii*)
Roshchakhivska Suite (PR_1*ršč*)
Upper Sub-Suite (PR_1*ršč$_2$*)
Lower Sub-Suite (PR_1*ršč$_1$*)
Kamyano-Kostovatska Suite (PR_1*kk*)

Archean Acrotheme
<u>Neo-Archean Eonotheme</u>
Rosynsko-Tykytska Series (AR_3*rt*)
Buzka Series (AR_3*bg*)
Khashchuvato-Zavallivska Suite (AR_3*hz*)
Kosharo-Oleksandrivska Suite (AR_3*ko*)

Paleo-Archean Eonotheme

Dnistersko-Buzka Series (AR_1*db*)

Zelenolevadivska Pile (AR_1*zl*)

Pavlivska Pile (AR_1*pv*)

Tyvrivska Pile (AR_1*tv*)

And in the next sub-sections the text provides description of the stratons indicated in the maps of the set. According to the common principles description of the stratigraphic column will be given upward from below.

PRECAMBRIAN

Archean Acrotheme

Paleo-Archean (AR_1)

Dnistersko-Buzka Series (AR_1db). Within the map sheet territory the Paleo-Archean rocks defined as Dnistersko-Buzka Series, according to the valid “Correlation Stratigraphic Scheme of Ukrainian Shield”, there are distinguished three piles (upward): Tyvrivska (AR_1tv), Pavlivska (AR_1pv) and Zelenolevadivska (AR_1zl). Relationships between the piles are not defined consistently due to extensive granitization and studied section discontinuity. The pile stratigraphic succession is mainly induced through the general geologic considerations. Besides that, somewhere the relicts of the Series contain the fragments which internal structure cannot be compared to the known stratotypes and this is why undivided Series is being distinguished in some places (areas of Mogylne, Kamyana Krynytsya villages, etc.).

In the eastern part of the map sheet (areas of Osychky, Martynivka villages) close to Pervomaiska Zone it was attempted to show the generalized section of Dnistersko-Buzka Series which is overlain by aluminous graphite-bearing plagiogneisses, apparently of Kosharo-Oleksandrivska Suite. It is assumed that here the Series comprises three piles but of reduced thickness. It was included into the T y v r i v s k a P i l e about 160 m thick rock sequence composed of orthopyroxene mafic gneisses with interbeds of two-pyroxene mafic gneisses. Metamorphic rocks are extensively granitized and actually orthopyroxene and biotite-orthopyroxene plagiomigmatites predominate in the section. It was included into the P a v l i v s k a P i l e about 320 m thick rock sequence composed mainly two-pyroxene mafic gneisses often with essential (up to 10%) magnetite content; in places the rocks are amphibolized. There occur interbeds of orthopyroxene and magnetite-orthopyroxene mafic gneisses, sometimes orthopyroxene plagiogneisses, in places with garnet, and often thin (first meters) veins of pegmatoid and aplite-pegmatoid granites. Although there are no ferruginous rocks in this pile, its general enrichment in magnetite make it similar to the Pavlivska Pile. The most controversial is the third up to 170 m thick rock sequence which is conventionally defined as Z e l e n o l e v a d i v s k a P i l e . According to V.V.Zyultsle [80], the Pile is mainly composed of metasomatic biotite-garnet-quartz-feldspar rocks after garnet-biotite plagiogneisses which contain interbeds of garnet-orthopyroxene and garnet-cordierite plagiogneisses and orthopyroxene mafic gneisses. The section of this sequence in most details resembles one of Zelenolevadivska Pile.

Some attention should be paid to the kind of granitization imposed on metamorphic rocks of Dnistersko-Buzka Series. While the rocks of Tyvrivska Pile are extensively enderbitized and often essential parts (sometimes up to the half) of its sections are comprised of enderbites, enderbite-migmatites, orthopyroxene and biotite-orthopyroxene plagiogranites of Gaivoronskiy Complex, the metamorphic rocks of Pavlivska and especially Zelenolevadivska Piles are mainly granitized by granitoids of Pobuzkiy Complex.

The upper age boundary of Dnistersko-Buzka Series is taken as 3650 Ma [38].

Tyvrivska Pile (AR_1*tv*) is widespread over entire map sheet territory and occurs in strip-like and irregular-shaped relicts of various sizes within granitoids of Gaivoronskiy and Pobuzkiy Complexes. The rocks of the Pile are enderbitized in various extents up to formation of enderbite-migmatites, often irregularly silicified. Sometimes restite-like garnet and biotite aggregates occur at the enderbite boundaries.

The Pile comprises mainly two-pyroxene, orthopyroxene, hornblende-two-pyroxene, hornblende-orthopyroxene mafic gneisses, and sometimes plagiogneisses of similar composition. Interbeds of gabbro-like, mainly melanocratic mafic gneisses occur, sometimes enriched (up to 3%) in magnetite (areas at Nebelivka, Polonyste, Popivka, Pidvysoke villages) and in places thin (up to 5 m) calciphyre interbeds also occur.

By external appearance all the mafic gneisses are grey, dark-grey, and those with high amphibole content – greenish-grey; fine- to fine-medium-grained, massive or with weakly pronounced thin banding caused by segregate distribution of the light- and dark-coloured minerals. Texture is granoblastic, hetero-granoblastic, mosaic, sometimes with elements of granulated, poikiloblastic, glomeroblastic. Physical properties vary within the following ranges: $\sigma = 2.63 \div 3.11$ g/cm^3; æ = $396 \div 1510 \cdot 4\pi \cdot 10^{-6}$CI.

Table 1 sets forth the mineral composition (in %) of the rocks.

Table 1

Rock name	Pl	Q	Opx	Cpx	Hb	Bi	Mgt	Acc
Two-pyroxene mafic gneisses	50-70	0-7	8-25	10-35	—	—	tr-3	ap, sdM
Amphibole-two-pyroxene mafic gneisses	45-63	—	5-10	10-20	15-25	—	tr-2	- " -
Gabbro-like mafic gneisses	50-65	0-5	10-25	8-15	tr-12	0-12	3-4	- " - zr
Orthopyroxene mafic gneisses	65-80	0-10	5-25	—	—	0-1	1-3	ap, sdM
Amphibole-orthopyroxene mafic gneisses	40-50	0-10	5-30	—	5-40	0-3	2-3	- " -

By set of the rock-forming minerals the plagiogneisses are quite similar to mafic gneisses and differ only in decreased content of opaque minerals, more widespread biotite and much higher (20-25% in average) quartz content. In some places these are just the silicified mafic gneisses. Sometimes besides quartz also garnet appears. And according to [80], in the area at Pidvysoke village the mafic gneisses with garnet grains under granitization are being transformed into plagiogneisses with disequilibrium-faced Ga-Opx-Bi paragenesis and then – into Ga-Bi plagiogneisses with relic orthopyroxene.

Plagioclase composition in mafic gneisses is rather inconstant and varies from 35 to 68% of anorthite. Sometimes dissociation anti-perthites and zoning occur in plagioclase. Iron content of orthopyroxene is 36-40%, diopside 26-30%, and in magnetite-bearing varieties clinopyroxene comprises salite with mafic index 45-50%. I.B.Shcherbakov [47] had noted that orthopyroxenes from gabbro-like mafic gneisses display most clear pleochroism.

Hornblende is brown-green and greenish-brown along Ng. Some grains at the boundaries with plagioclase are rimmed with thin simplectite envelope composed of regular intergrowth of pyroxene and plagioclase. Apparently, this hornblende is in equilibrium with pyroxene but also green and bluish-green hornblende occurs which obviously replaces pyroxene.

The proto-substrate of mafic gneisses is thought to be ultramafic and mafic rocks as it is revealed from the chemical composition[3]. Petrochemical series are tholeiitic and calc-alkaline, range is sub-alkaline. By ratio $Al_2O_3 \times [FeO_{tot} + TiO_2]$ – MgO the rocks are high-Fe and in less extent high-Mg tholeiites and calc-alkaline basalts. Plagiogneisses by chemical composition belong to the calc-alkaline series and sub-alkaline range. In the Le Maitre (1989) classification plot these rocks correspond to andesites and andesite-basalts.

Analysis of geodynamic conditions of the Tyvrivska Pile rock formation provides the ground to consider them as the products of the primitive crust of oceanic type.

Mineral paragenesises suggest for the rocks of the Pile are metamorphosed under granulite-facies conditions, and in the tectonized sites they undergone retrograde alteration under amphibolite-facies conditions. It is difficult to estimate the thickness of the Pile due to extensive enderbitization and lack of fully overlapped sections. According to [80] the total thickness of the Pile in the map sheet area of studies attains first kilometres. Thickness of the studied sections is about 650 m.

In general, the sections encountered in the map sheet territory are close to the stratotype (Budivskiy Profile) but this territory sections differ from the stratotype one in more widespread the rock varieties enriched in magnetite.

Pavlivska Pile (AR_1*pv*) was distinguished by V.V.Zyultsle [71] at Pavlivka village (outside the map sheet area under consideration). Within the map sheet area the Pile, in contrast to Tyvrivska Pile, is not widely distributed. The rocks of the Pile occur mainly in Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ. In Yatranska Sub-Zone they are not known and only close to Pervomaiska Fault Zone nearby Martynivka village

[3] Hereafter the chemical characteristics are referred to the database "Derzhgeolkarta-200. Analytics".

(DH 73g-78g) there is encountered the pile of weakly granitized magnetite-bearing pyroxene mafic gneisses where magnetite content in places attains 10%. The contacts with underlaying Tyvrivska Pile, and overlaying Zelenolevadivska Pile are reliably not established since the respective sections normally are dismembered and do not overlap one another in the space.

Since the Pavlivska Pile contains silicate-magnetite quartzites it is clearly expressed in high-intensity magnetic anomalies. The rocks of the Pile are disclosed by numerous drill-holes in the areas of Lozuvate, Emylivka, Shepylivka villages, Golovanivsk town-type inhabited locality. Most typical section of the Pile within the map sheet is established in the area of Golovanivsk town-type inhabited locality.

The Pile composition is complex. It comprises two-pyroxene, hornblende-two-pyroxene mafic gneisses which often contain magnetite (up to rock-forming mineral quantity), orthopyroxene, biotite plagiogneisses, high-alumina (sillimanite, garnet, and cordierite) gneisses and plagiogneisses, and minor silicate-magnetite quartzites that occur in subordinate amount as 10-15 m thick interbeds.

The upper part of the section in most respect resembles the lower part of Zelenolevadivska Pile. In this upper part in frequent alternating there occur high-alumina gneisses and various mafic gneisses, as well as mesoperthite granites and granite-gneisses. Average thickness of alternating layers varies from first meters to first tens of meters.

By external appearance, texture and mineral composition the mafic gneisses are similar to those of the Tyvrivska Pile. They differ a little from the latter by higher magnetite content and more frequent garnet occurrences especially in the area of Golovanivsk town-type inhabited locality. Most frequent the garnet is in silicified and granitized varieties where it forms coarse porphyryblasts. According to [80], garnet is mainly of reaction nature.

Detailed description of the high-Al rocks is given in DGM-200 report [80]. According to this work, these rocks are quite variable by texture patterns and mineral composition.

Ferruginous quartzites by external appearance are dark-greenish-grey, fine- to medium-grained, coarse-banded and massive. Under microscope texture is heterogranoblastic, nematoblastic.

Mineral composition (%): orthopyroxene 25 (f = 75), clinopyroxene 5-20, hornblende 3-5, quartz 50-70, magnetite 35.

There occur two varieties of quartzites: 1) those with predominating orthopyroxene over clinopyroxene (Golovanivsk town-type), and 2) reverse (Lozuvate village). In some places quartzites gradually transforms into eulizites which form thin (first tens of centimetres) interbeds within quartzites. Under microscope texture of eulizites is heteroblastic, panidioblastic, poikiloblastic, sometimes helicitic. Mineral composition (%): orthopyroxene 25-50 to 90 (f = 93), garnet 5-45 (f ~ 95), hornblende (after pyroxene) 0-3, biotite (after pyroxene) 0-10, quartz 3-15, magnetite – single grains – 5.

Petrochemical composition of mafic gneisses corresponds to the basalt of tholeiitic series of sub-alkaline range. By ratio Al_2O_3×[FeO_{tot}+TiO_2] – MgO the rocks corresponds to high-Fe tholeiites.

As it suggested the mineral paragenesis, the rocks of the Pile are metamorphosed under conditions of granulite facies, and in the sites of extensive granitization the retrograde amphibolite-facies metamorphism occurs. Granitization is mainly caused by the granitoids of Pobuzkiy Complex.

According to [80], the thickness of the Pile may attain 1.5 km. In the area of stratotype (outside the map sheet) its thickness estimated to 755 m, and in the sections disclosed in the area of Golovanivsk town-type inhabited locality and Lozuvate village the thickness is respectively estimated to ~ 550 m and ~350 m.

Zelenolevadivska Pile (AR_1*zl*) at the Precambrian erosion level is distributed in Yatranska, Pobuzka, and Synytsivsko-Savranska Sub-Zones. In most cases these are not large (in average 4 by 1 km in size) lens-like and irregular remnants within granitoids of Pobuzkiy Complex. The section of the Pile is weakly studied yet. In fact, there is no overlapped section where one can consistently characterize the sequence of changes between the rock varieties and estimate the thickness of respective layers.

The rocks of the Pile are disclosed by some drill-holes and they are also known in some outcrops along the Southern Boug River where in the area of Zelena Levada village there was established the stratotype of the Pile. However, even in the area of the stratotype it is difficult to make clear the internal structure of the Pile due to extensive granitization.

In this Pile there predominate garnet-biotite and biotite gneisses (plagiogneisses) mainly of leucocratic appearance where interbeds of orthopyroxene and garnet-orthopyroxene plagiogneisses (thickness up to tens of meters) and orthopyroxene and hornblende-two-pyroxene mafic gneisses occur. Numeric ratio between the biotite and garnet-biotite varieties is not defined and normally they are being intercalated with gradual transitions.

According to E.M.Lazko [25], the contacts of the Pile with the overlaying rocks of Kosharo-Oleksandrivska Suite are sharp and are being fixed by disappearance of biotite and garnet-biotite plagiogneisses from the section.

Description of the rock varieties is being provided after V.S.Kostyuchenko et al [80].

Gneisses are biotite, garnet-biotite, light-grey, greyish-pink, with fine gneiss-like texture, chain-lens-like garnet aggregates 1-3 mm in size, and sometimes also quartz. Micro-texture is granoblastic with elements of poikiloblastic, lepidogranoblastic, in granitized varieties – heterogranoblastic. Mineral composition (%): plagioclase (oligoclase) 30-40, potassium feldspar (orthoclase) 1-10 up to 20-25 (in granitized varieties microcline appears), quartz 30-40, biotite 1-15, garnet 1-15. Accessory minerals: apatite, zircon, monazite, anatase (brucite). Gangue: ilmenite, sometimes magnetite.

Plagiogneisses orthopyroxene and garnet-biotite-orthopyroxene, light-grey, grey, fine-grained, coarse-banded due to irregular distribution of opaque minerals. Band width is 0.5-2 cm. Micro-texture is granoblastic, lepidogranoblastic. Mineral composition of mesocratic bands (%): plagioclase 35-45, quartz 25-30, orthopyroxene 10-15; leucocratic bands: plagioclase 48-55, quartz 35-38, orthopyroxene up to 5, sometimes biotite up to 8, garnet. Accessory minerals: apatite up to 1, monazite, zircon. Gangue: ilmenite up to 1, magnetite up to 2.

Under their granitization there are being formed enderbite-plagiogranites whose plagioclase does not contain anti-perthites, in contrast to the enderbites of Gaivoronskiy Complex.

Mafic gneisses are two-pyroxene, hornblende-two-pyroxene, macroscopically they are black, greenish-black, fine- and medium-grained, massive, sometimes schistose. Micro-texture is granoblastic sometimes with elements of allotriomorphic, and in amphibolized varieties – nematogranoblastic. Mineral composition (%): plagioclase 20-50, pyroxene 3-5 to 30-35 (with strong predomination of clinopyroxene over orthopyroxene), hornblende from 30-50 to 70-75, garnet 3-4. Accessory minerals: apatite up to 1, zircon. Gangue: ilmenite – single grains – 2, magnetite to 1.

Hornblende is of several generations: 1) equilibrated with pyroxenes although aggressive to them – brownish; 2) green of various intensity with slight bluish shade, almost completely replaces pyroxene; 3) sometimes – actinolite rims around diopside grains.

Position of leptite-like gneisses (leptites) in the section is not defined yet. These are mainly thin bodies within leucocratic gneisses of Pobuzkiy Complex. By external appearance these are greyish-light-pink, leucocratic, fine-grained, massive rocks, often with parallel-oriented platy quartz. Micro-texture – glomeroblastic, platy. Mineral composition (%): oligoclase-albite 40-45, quartz 30-35, potassium feldspar 20-25 (with non-arranged and unclear grate texture), biotite up to 3. Accessory minerals: zircon, ilmenite.

By results of petrochemical analysis it is difficult to estimate the proto-composition of metamorphic rocks reliably. In the Le Maitre classification plot described rocks do correspond to dacites and calc-alkaline rhyolites, and after reconstruction using method of A.A.Predovskiy it can be concluded that polymictic rocks had undergone metamorphism.

Thickness of the Pile is also difficult to estimate due to very extensive granitization and lack of overlapped studied sections; however, from the general geologic considerations V.V.Zyultsle [80] had thought that it is less than 1 km whereas E.M.Lazko et al [25] had thought it could be in the range of 2.5-3.0 km.

Mineral paragenesises suggest for metamorphism of the rocks under conditions of granulite facies.

Neo-Archean (AR_3)

Neo-Archean units include Buzka (AR_3*bg*) and Rosynsko-Tykytska (AR_3*rt*) Series. M.O.Yaroshchuk [49] assumes that the rocks of these Series were formed coevally but in a little different geodynamic conditions.

Buzka Series (AR_3bg). On the modern erosion surface the rocks of this Series are mostly distributed within Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ and in Zavallivskiy enclave where they are confined to the synform structures and narrow fault-side monoclines. According to M.O.Yaroshchuk [49] "… in general Neo-Archean gneiss-granulite complex comprises distinct structure-composition mélange ensemble which is characteristic to the suture zones". The metamorphic rocks of the Series form the units, rather distinct by shape, in the Yatranskiy Block (Troyanska and Tarasivska).

The rocks of the Series are being underlain mainly by the rocks of Dnistersko-Buzka Series and enderbites of Gaivoronskiy Complex.

According to the valid "Correlation Stratigraphic Scheme …", two suites are being distinguished in the Series (upward): Kosharo-Oleksandrivska (AR_3*ko*) and Khashchuvato-Zavallivska (AR_3*hz*).

Because of lithologic complexity, layers pinching out by strike, and tectonic breaking some sections are difficult to be correlated with the stratotypes. In such cases undivided units are distinguished.

Kosharo-Oleksandrivska Suite (AR_3*ko*). The rocks of the Suite are being observed almost in all synform and monocline structures (areas of Kosharo-Oleksandrivka, Kapitanivka, Shamraivka, Sekretarka villages) but in places these are not complete sections but only their fragments. The rocks are disclosed by numerous drill-holes and are exposed along Southern Boug River and in Danylova gully (left branch of Synytsya River). Characteristic feature is association of feldspar quartzites and high-alumina rocks.

The stratotype section of the Suite is being observed nearby Kosharo-Oleksandrivka village where above the rocks of Dnistersko-Buzka Series and Gaivoronskiy Complex there lies the thick (up to 100 m) pile of feldspar quartzites with thin (first meters) interbeds of high-alumina and leptite-like gneisses; higher this pile is being changed by frequent intercalation of quartzites, gneiss-quartzites, high-alumina gneisses (often with variable graphite content) and two-pyroxene and orthopyroxene mafic gneisses with garnet, in places amphibolized. Thickness of the interbeds normally is first meters, in places – first tens of meters. In the Suite quartzites predominate in general. Fraction of high-alumina gneisses attains one third of the section. Rarely occur two-pyroxene and orthopyroxene mafic gneisses and leptite-like gneisses are scarce. Transitions between the rock varieties are mainly gradual.

The rocks of the Suite are cut by the veins of aplitoid and aplite-pegmatoid granites which thickness does not exceed first meters; the veins apparently belong to Pobuzkiy Complex.

Thickness of the lower part of the section, where quartzites predominate, is estimated to ~100 m, and upper part - ~255 m. The total thickness in the section ~355 m. G.G.Vynogradov et al [57] had estimated the thickness of the Suite in a range 800-1,200 m, V.V.Zyultsle [80] – 1,100 m, and after E.M.Lazko et al [25] – 450-470 m.

By external appearance q u a r t z i t e s are light-grey to white, sometimes with pink shade, fine-grained and diverse-grained, that is probably caused by re-crystallization processes. There occur parallel grains and lens of quartz and sometimes veinlet-like sillimanite-quartz aggregates. The latter apparently are caused by the processes of acid leaching. Under microscope texture is granoblastic, heterogranoblastic, mosaic. Quartzite composition (%): quartz 80-100, oligoclase 0-15, potassium feldspar 0-15, biotite up to 1, muscovite up to 1, graphite, sillimanite, garnet – single grains; accessories: zircon, rutile, magnetite. Physical properties: $\sigma = 2.4 \div 2.69$ g/cm^3; æ $= 5 \div 200 \cdot 4\pi \cdot 10^{-6}$CI.

In the plot of A.A.Predovskiy quartzites under consideration are being projected into the fields of feldspar quartzites and arcoses.

By geochemical characteristics quartzites display [80] inconstant behaviour of the range of elements that does not clearly correlate to their composition and origin. The most persistent background patterns are characteristic for rare earths, niobium, and tantalum. The most variable features are being displayed by (%): scandium (0.0001-0.0015), barium (0.0035-0.04), nickel (0.002-0.04), and, especially, manganese (0.007-0.2).

H i g h - a l u m i n a g n e i s s e s comprise several varieties including: garnet-sillimanite, biotite-garnet-sillimanite, and garnet-cordierite-sillimanite. Often the rocks do contain graphite. In places garnet-biotite plagiogneiss interbeds occur. The rocks under consideration display high variability of the rock-forming mineral content although by the external appearance the rocks are mainly similar. These are fine- and medium-grained, light- and dark-grey rocks with rather clear directive, banded structure caused by irregular distribution of the rock-forming minerals and parallel arrangement of some minerals. Texture of the rocks is nematogranoblastic, lepidonematogranoblastic, sometimes with elements of fiberblastic, often porphyryblastic. Often superimposed blastoclastic, granular and sometimes cement textures occur. Mineral composition (%): plagioclase and potassium feldspar (their content varies from first units to 50), quartz (from units in mafic gneisses to 70-80 in gneiss-quartzites), sillimanite (5-50), garnet (5-30), biotite (5-8), graphite (1-10); in cordierite varieties – cordierite up to 60. In cordierite fine inclusions of green spinel occur. Accessory minerals: zircon, apatite, rutile, monazite, titanium magnetite, ilmenite, sulphides. It should be noted that quartz, potassium feldspar, garnet, sillimanite and, probably, plagioclase, do occur at least in two generations. For instance, coarse (1.5-50 mm) cordierite grains oversaturated with inclusions of quartz, plagioclase, and sillimanite, are in turn sometimes rimmed with fine-fiber fibrolite.

The works under DGM-200 [80] had provided some corrections to the definitions of the high-alumina rocks, in particular, to the rocks with highly variable composition enriched in sillimanite, garnet, lesser in biotite, cordierite, and graphite, while the ratio of quartz to feldspar is rather far away from that accepted by common nomenclature to the typical gneisses. To these rocks the authors, following K.Mehnert, had suggested the term “kinzigite” or kinzigite gneiss leaving behind the genetic meaning of the term. These rocks comprise high-Al melanosoma in migmatite-like rocks in the central part of the Suite section. Physical properties: $\sigma = 2.7$ g/cm^3, æ $= 700 \cdot 4\pi \cdot 10^{-6}$CI.

In the FAK plot of A.A.Predovskiy the garnet-sillimanite gneisses form the compact group in the field of hydro-mica clays, and some varieties of gneisses are being projected into the fields of greywacke and montmorillonite clays.

The equilibrium temperatures were calculated for the pair garnet-biotite in the range from 730^{o}C to 650^{o}C. The first estimate only does correspond to the conditions of granulite facies whereas lesser values are probably related to the superimposed retrograde metamorphism which also had caused extensive granitization.

Some other factors suggest for the granulite facies: high pyrope minale content (from 25 to 43%) is determined in garnets; in association with cordierite and sillimanite the garnet mafic ratio is about 72% that does correspond to the Aldanska sub-facies of the deep granulite facies.

The age of clastogenic zircon from quartzites is estimated to 2800 Ma, thus, the lower age boundary of the Suite rock formation as well as the Series as a whole cannot be older than this value [44]. From another hand, by zircon collected in Vilshanskiy quarry from biotite-amphibole plagiogneisses of Rosynsko-Tykytska Series it was obtained the radiologic age as 2700 Ma [38]. Therefore, it can be assumed that Buzka Series was formed within the time span 2700-2800 Ma.

Khashchuvato-Zavallivska Suite (AR_3*hz*). The rocks of the Suite are confined to the central portions of most of the synform structures within the map sheet and are disclosed by a number of drill-holes. Its most complete sections and known from Zavallivska (quarry) and Moldovo-Ternuvatska structures. According to V.V.Zyultsle [80], in the southern flank of Zavallivska structure the rocks are conformably overlie the high-alumina gneisses of Kosharo-Oleksandrivska Suite. Within Synytsivsko-Savranska Sub-Zone and in Vradievskiy Transitional Block of Pobuzka Sub-Zone the sections are similar to the Suite under consideration and there they are being overlain by the rocks of Rosynsko-Tykytska Series although in the most cases the contacts are tectonic in nature.

The complex lithology, insufficient knowledge concerning succession of the rock formation, facial variability by strike and thickness changes with regard to specific rock varieties from one structure to another, as well as tectonic breaking make extremely difficult the correlation of particular stratigraphic section parts between the structures. In the Suite, Yu.K.Piyar had distinguished four batches making their consideration as the Sub-Suites (upward): first – Sekretarska, second – Moldovska, third – Zavallivska, fourth – Antonivska; these units do correspond to the three rock associations (formation) distinguished by V.P.Kyrylyuk [22]: iron-gneiss, condalite, and marble-calciphyre.

Sekretarska Sub-Suite comprises mafic gneisses and plagiogneisses two-pyroxene, in places with garnet, garnet-orthopyroxene, that intercalate with leptite-like gneisses. Thickness of the latter is 5-15 m in average. Sometimes thin (up to 5 m) single interbeds of garnet-biotite plagiogneisses and calciphyres occur. Thickness of the entire Sub-Suite is estimated to ~330 m.

Moldovska Sub-Suite is mainly composed of silicate-magnetite quartzites with 2-20 m, sometimes up to 50 m thick interbeds of marbles and calciphyres, often enriched in magnetite, as well as thin (first meters) interbeds of garnet-biotite plagiogneisses. The total thickness of the batch is ~170 m.

Zavallivska Sub-Suite comprises frequent intercalation of graphite-biotite, garnet-biotite, biotite plagiogneisses, calciphyres, skarn-like garnet-clinopyroxene-quartz and garnet-quartz rocks, sometimes with magnetite. In places thin (first meters) interbeds of feldspar quartzites occur. Graphite varieties of gneisses predominate in the lower part of the batch. Thickness of the batch is ~300 m.

Antonivska Sub-Suite is mainly composed of calciphyres and marbles. Thickness is estimated to > 450 m. The contacts between the batches (sub-suites) are gradual.

It should be noted that aforementioned subdivisions are not equally distributed. For instance, in Zavallivska structure iron-silicate rocks are completely absent whereas biotite-graphite and graphite-biotite rocks are widespread. The total thickness of the Suite under consideration is estimated to ~1,250 m; however, taking into account the fact that in the synform structures the rocks are complicated by numerous secondary folding and tectonic breaking, this thickness estimation may be invalid.

The rocks of the Suite are weakly granitized. These are mainly thin (up to 10 m) enclaves of fine- and medium-grained migmatites with biotite and garnet within garnet-biotite plagiogneisses. Besides this, there also occur the veins of aplite-pegmatoid granites with parallel-oriented lens-like quartz; the veins apparently belong to Pobuzkiy Complex. Close to the tectonic zones and in the granitized areas the rocks of the Suite are sometimes undergone retrograde metamorphism under amphibolite-facies conditions but this kind of alteration is irregularly expressed in different synform structures. Retrograde changes are rather sufficient in Moldovska and Sekretarsko-Ternuvatska, Grushkivska and some other structures where through retrograde changes the mafic gneisses are modified into amphibolites.

Below is given the brief characteristics of the major rock varieties in the Suite. Because the Suite is the iron-ore and graphite-bearing and producing unit it was studied by numerous authors [34, 36, 47, 52, 59, 89 and others] who had performed as search-prospecting as the specialized works with detailed characterization not only the rock varieties but also some rock-forming minerals and examination of the rock petrochemical and geochemical features.

According to V.V.Zyultsle [80], the two-pyroxene and garnet-orthopyroxene m a f i c g n e i s s e s a n d p l a g i o g n e i s s e s do differ neither by texture patterns nor by mineral composition from the similar rocks of Dnistersko-Buzka Series. These rocks are also similar in term of their petro- and geochemical features. The rocks are described in most details in the work of I.B.Shcherbakov [47].

G r a p h i t e - b i o t i t e a n d g a r n e t - g r a p h i t e - b i o t i t e p l a g i o g n e i s s e s are being characterized by very variable composition and actually it could be distinguished a wide range of varieties up to the mafic gneisses with gradual transitions between the ones. By external appearance the rocks are grey, dark-grey, fine- to medium-grained, thin- and lens-like-banded, often with thin quartz-feldspar veinlets. Micro-texture is lepidogranoblastic, sometimes with elements of heteroblastic, and in tectonized varieties – coarse-milonite, blasto-cement. Mineral composition (%): plagioclase 30-50, quartz 5-30, biotite 20-25, garnet 0-25, graphite 2-25, sometimes sillimanite 0-5. Accessory minerals: apatite, zircon, monazite, tourmaline. Gangue: magnetite, ilmenite, sulphides.

G a r n e t - b i o t i t e p l a g i o g n e i s s e s are grey, dark-grey rocks with pink shade, fine-grained, with irregularly and sometimes band-like distributed garnet. Micro-texture is lepidogranoblastic with elements of heteroblastic. Mineral composition (%): plagioclase 40-60, quartz 20-35, biotite 5-20, garnet 3-12. Accessory minerals: apatite, zircon, monazite, sulphides.

I r o n - s i l i c a t e r o c k s normally are more or less re-crystallized with re-distribution of the rock-forming minerals and often they become appearance of skarnoids. Their numeric mineral composition is characterized by considerable variations making possible distinguishing the range of varieties from ferruginous quartzites to ferruginous mafic gneisses. The latter in association with skarn-like garnet-(orthopyroxene)-quartz rocks are being observed along the contact zones of the iron-silicate rock layers. Macroscopically these are dark-grey with greenish or pinkish shade depending on the content of garnet, amphibole, and clinopyroxene. Structure is banded. Micro-texture is heterogranoblastic with elements of poikiloblastic, sometimes sideronite. Mineral composition (%): orthopyroxene 15-75 (f = 54-60 and 34-45), clinopyroxene 0-15, sometimes up to 30, hornblende 0-15, rarely up to 40 (in areas of extensive granitization), garnet up to 25, biotite 0-10, magnetite 15-35, quartz 35-50. The latter two minerals are at least of two generations. Accessory minerals: apatite, zircon, sometimes rutile, spinel, ilmenite. Quartzites are metamorphosed under conditions of granulite facies. Association clinopyroxene-garnet suggests for high-pressure metamorphism, that is, one of eclogite affinity.

Paragenesis fayalite-orthopyroxene-clinopyroxene-garnet-quartz-magnetite, as it was pointed out by N.I.Polovko [34] in these rocks of granulite metamorphic facies is absent. In this respect they differ from the similar rocks of Pryazovskiy and Orikhovo-Pavlogradskiy regions. Physical properties: $\sigma = 4.0$ g/cm^3, æ = $5000 \cdot 4\pi\ 10^{-6}$CI.

Finally, it should be noted that in mind of V.F.Bogatyryov [52] the thin-banded, folded ferruginous quartzites often with cummingtonite in Chimerpilska area (DH 15024, 15025) are similar to those of Kryvorizka Series and are metamorphosed under conditions of amphibolite facies.

It can be distinguished two types of carbonate rocks: 1) continuous thick (hundreds of meters) layers with associated metapelites (Antonivska Sub-Suite), and 2) less thick (meters, tens of meters) layers related to iron-silicate rocks (Moldovska Sub-Suite). The first ones are mainly distributed in Khashchuvatska and Zavallivska synform structures, the second ones – in the remaining synform structures where are observed the rocks of Khashchuvato-Zavallivska Suite with iron-silicate rocks (Grushkivska, Moldovska, Sekretarska and other structures). In Troyanska structure the carbonate rocks associate with meta-gabbroides and pyroxene mafic gneisses sometimes enriched in magnetite.

Among the carbonate rocks there are distinguished the marbles, calciphyres, and ophycalcites. The first type includes mainly dolomite marbles that form the layers up to 20 and more meters thick. These are coarse- and medium-grained rocks with granoblastic and heteroblastic mictotextures and simple mineral composition (%): dolomite 80-90, calcite 10-15, sometimes olivine, spinel (light-green), phlogopite. Accessory minerals: magnetite, apatite.

C a l c i p h y r e s of this type are characterized by the banded structures and heterogranoblastic micro-textures with elements of poikilitic ones. Numeric content of the rock-forming minerals does vary rather widely (%): calcite 25-60, dolomite 0-15, forsterite and serpentine 15-40, diopside 0-5. Accessory minerals: spinel, apatite, magnetite, graphite (altogether 1-3).

Carbonate rocks of the second type include more varieties. Dolomite and dolomite-calcite marbles are much less distributed. Commonly these are thin interbeds and lens-like bodies within the thick calciphyre layers. Texture patterns of these rocks however are almost the same as for the rocks of the first group; the Table 2 sets forth the mineral composition of the carbonate rocks.

Transitions between the rock varieties are gradual and often very weakly expressed. Accessory minerals: apatite, zircon, sphene, graphite, magnetite. The latter sometimes occurs in essential amounts, and in the area of Slyusareve village it attains 50-60% in some enclaves which are in fact the ore bodies.

Mineral paragenesises in the rocks under consideration do correspond to the conditions of granulite metamorphic facies but often they are complicated by retrograde metamorphism under conditions of amphibolite facies (evidenced by clinopyroxene rims around olivine grains), and close to the zones of tectonic weakness – even epidote-amphibolite (Shamraivka site). In such zones the rocks sometimes become of breccia-like appearance. By petrophysical features the carbonate rocks are rather irregular due to variable content of iron-magnesium minerals: $\sigma = 2.4 \div 3.2$ g/cm^3, æ = $456 \div 1391 \cdot 4\pi \cdot 10^{-6}$CI [78].

Table 2

Rock name	Minerals, %								
	Dolomite	Calcite	Olivine	Clinohumite	Pargasite	Clinopyroxene	Phlogopite	Spinel	Serpentine
Dolomite marbles	80-95	0-10	1-2	-	-	1-3	0-1	to 1	2-3
Dolomite-calcite marbles	10-20	60-70	1-2	-	-	1-2	0-1	to 1	2-3
Spinel-olivine calciphyres	2-5	57-65	10-25	-	0-1	1-2	0-2	3-7	1-7
Spinel-clinohumite calciphyres	2-3	65-70	-	5-25		-	-	3-7	-
Spinel-clinopyroxene-olivine calciphyres	3-5	30-42	10-25	-	0-5	10-30	1-15	1-6	5-20
Spinel-pargasite-olivine calciphyres	0-7	45-50	20-25	-	15-20	0-2	1-2	13	5-10
Phlogopite-olivine calciphyres	-	50-60	25-30	-	0-2	1-3	10-15	1-3	1-3
Ophycalcites	20-25	35-60	1-3	-	-	0-1	0-10	1-7	25-30

Magnesium and calcareous skarns and skarn-like rocks are related to the carbonate rocks. By particular synform structures they are described in most details in the report of V.S.Kostyuchenko and V.V.Zyultsle [80].

In the plot of A.A.Predovskiy for carbonate rocks the points of calciphyres and marbles are being projected into the fields of dolomites and calcareous dolomites from volcano-sedimentary formations.

According to V.M.Zagnitko [18], the calciphyres from Troyanka village area by their chemical composition differ from the typical carbonate rocks of Middle Pobuzhzhya. These rocks are depleted in manganese and iron, and in places are enriched in apatite.

Isotope composition of carbon and oxygen allows consideration the carbonate rocks of the Suite as the metamorphic products after primary dolomite sediments. V.M.Zagnitko [19] had noted that these sedimentary rocks display very narrow value range of δ^{13}C and δ^{18}O (0.5±0.5% and 20.5±0.5% respectively).

Leptite-like gneisses are being observed mainly in the lower part of the Suite section. These are light-grey and pinkish-grey unclear-banded rocks with granoblastic Micro-texture, in places with elements of heteroblastic one. Mineral composition (%): oligoclase 30-40, microcline-perthite 20-35, quartz 25-30, orthopyroxene 3-4 (is being replaced by hornblende), biotite (f = 37%) 1-2, garnet, apatite, zircon, monazite, sulphides – single grains.

Results of petrochemical calculations with regard to the metavolcanics of Khashchuvato-Zavallivska Suite suggest for the rock points are being projected into the fields of island-arc tholeiites and MORB. However, in the Suite sections there are some evidences for bimodal volcanic association that provides the ground to consider the rocks as the complex of proto-continental rifts. Furthermore, it should be noted that according to V.V.Zyultsle [80], in the area of Grushka village (DH 67g) there are observed the interbeds of ultramafic gneisses with large grains of serpentinized olivine resembling “spinifex” textures. These rocks are similar to those previously were described by O.B.Fomin [42] in the area of Polyanetske village (Polyanetska structure) and which were named by him “komatiites”.

As it was already pointed out above in description of specific rock varieties, the mineral paragenesises suggest for granulite facies metamorphic conditions. After co-existing garnet and biotite temperature of metamorphism is estimated to ~710^{o}C.

Rosynsko-Tykytska Series (AR_3rt) is confined to the western part of the map sheet area and is known within Umanska and Synytsivsko-Savranska Sub-Zones and in the border strip of the latter and Vradievskiy Transitional Block. These are mainly strip-like remnants within granitoids of Umanskiy and Tetiivskiy Complexes. Besides that, these rocks also occur in the cores of synform and on the limbs of higher-orders antiform structures close to the eastern boundary of Khashchuvato-Zavallivskiy enclave (area of Zhovtneve village) and in the southern part of Synytsivsko-Savranska Sub-Zone (area of Chemerpil, Polyanetske and other villages). In these structures the rocks of the Series lie above the complex carbonate-ferruginous-amphibolite sequence which is conventionally defined as Khashchuvato-Zavallivska Suite but by internal features this sequence is more similar to the rocks which are known from Volodarsko-Bilotserkivski magnetic anomalies. It should be noted that this sequence (Polyanetska structure) contains considerable amount of thick (up to hundred meters) [52] amphibolite layers which, in turn, sometimes contain interbeds of melanocratic (ultramafic) amphibolites (by chemistry – peridotite komatiites) and thin bodies of mafic rocks. By internal regularities this sequence somewhat resembles litho-tectonic complexes 1 and 2 distinguished by V.P.Bezvynniy [2] in the Rosynsko-Tykytskiy area. This issue, however, requires further studies and, perhaps, it will be solved during the works which are currently in progress in the territory adjacent to the map sheet one from the north, if there will be obtained reliable stratotype sections of the Series rocks.

The rocks of the Series are disclosed by numerous drill-holes and they are also being exposed in the outcrops along the Synytsya River and its branches, as well as along Yatran River (from Yatranivka village to Tekucha village) and Southern Boug River in front of Synytsya River mouth (Vilshanskiy quarry).

In the most extent the section of the Series is studied in the southern part of Synytsivsko-Savranska Sub-Zone of Odesko-Bilotserkivska LTZ (area of Chemerpil, Polyanetske, Savran villages) where previously were performed the search-prospecting works for gold and ferruginous quartzites. In the generalized column over this area compiled after [52], above ~600 m thick batch of parti-coloured rocks, resembling those of Khashchuvato-Zavallivska Suite, there is encountered another batch of biotite plagiogneisses with thin interbeds of amphibole-biotite plagiogneisses and amphibolites. Thickness of this batch exceeds 30 m. Higher in the section it is changed with the sequence of intercalating amphibolites and amphibole, pyroxene-bearing, mafic gneisses with biotite-amphibole plagiogneisses, and in the lowermost part – single thin (10-25 m) melanocratic ultramafic amphibolites. The rocks are extensively migmatized and often are being changed by plagiomigmatites of Tetiivskiy Complex with small remnants of aforementioned metamorphic rocks. Thickness of this sequence is about 570 m. Further in the section there is observed the sequence of biotite plagiogneisses, in places with minute garnet, cordierite, and sillimanite grains, and in the lowermost part with the single thin (up to 20 m) amphibolite interbeds. Gneisses are migmatized. Besides plagiomigmatites also appear the veins (2-10 m thick) of Umanskiy Complex granites – pink, medium-fine-grained; close to the veins plagiogneisses are migmatized and in microcline appears in the newly formed plagiomigmatites. Thickness of this sequence is estimated to ~200 m but it is obviously uncompleted because of lack the overlaying rocks. The total thickness of the Series in this area is ~800 m.

P l a g i o g n e i s s e s are biotite, grey, light-grey, fine-grained and medium-fine-grained, unclear-banded, sometimes massive. Micro-texture is lepidogranoblastic with elements of heteroblastic (in migmatized varieties), structure sub-parallel. Mineral composition (%): plagioclase 30-55 (oligoclase, andesine), quartz 15-35, biotite 15-25 (rarely up to 30); minor minerals occurring occasionally: garnet 0-5, sillimanite 0-1 (in silicified varieties up to 10), and cordierite – up to 1. Accessory minerals: apatite – up to 1, zircon, tourmaline. Gangue: sulphides, magnetite (up to 3 in silicified varieties). Amphibole-biotite plagiogneisses differ from biotite plagiogneisses by presence of hornblende in amount of 5-10%, lack of aluminous minerals and less content of plagioclase (30-40%) which is more mafic (andesine).

B i o t i t e - a m p h i b o l e m a f i c g n e i s s e s are greenish-dark-grey, fine-grained, unclear-banded, schistose. Micro-texture is granoblastic, lepidonematogranoblastic, sometimes – elements of heteroblastic (in silicified varieties). Mineral composition (%): plagioclase (andesine) 30-75, quartz 1-5 and up to 10-25 (in silicified varieties), hornblende 20-45, biotite 3-5 (in biotitized varieties up to 10-20). Accessory minerals: zircon, apatite. Gangue: ilmenite, sulphides, magnetite (up to 1). Physical properties: $\sigma = 2.73\text{-}2.87$ g/cm^3, æ = $326\text{-}6136 \cdot 4\pi \cdot 10^{-6}$CI.

A m p h i b o l i t e s differ from mafic gneisses in more mafic plagioclase (up to labrador) and its lower content (20-45%) as well as by higher content of hornblende (40-60%) and magnetite (3-5%).

In association with amphibolites and mafic gneisses there are observed melanocratic rocks in composition close to hornblendites (area of Maiske gold deposit) with grano- and nematogranoblastic Micro-textures and the following mineral composition (%): hornblende 70-85, cummingtonite 015-25; sometimes relic minerals: clinopyroxene 10-15, and orthopyroxene up to 1. In biotitized varieties the biotite content is from 1-8 to 10-25. Secondary minerals: serpentine and chlorite ~10, calcite 3-5. Accessory minerals: apatite, sphene; gangue: magnetite up to 1 and sulphides 3-5.

In petrochemical calculations the points of amphibolites and mafic gneisses are being projected into the fields of basalts and andesite-basalts while the points of gneisses – into the fields of dacites and transitional zone of trachyandesite-andesites. By geodynamic conditions [Wood, 1980] they are located in the field of tholeiites of island arcs and continental rifts.

Isotope age by zircon from biotite-amphibole plagiogranites from Vilshanskiy quarry yield about 2700 Ma [38].

Following S.V.Nechaev [31], we suppose that the rocks of the Series are metamorphosed under conditions of progressive amphibolite facies but later on close to the zones of tectonic weakness they undergone the retrograde alteration under conditions of epidote-amphibolite facies.

Proterozoic Acrotheme

Paleo-Proterozoic (PR_1)

Ingulo-Inguletska Series (PR_1ii) are distributed mainly in the Bratska Sub-Zone of Ingulo-Inguletska LTZ and in the zone of influence of the Pervomaiska Fault Zone. Sometimes small bodies occur in Yatranska and Pobuzka Sub-Zones of Odesko-Bilotserkivska LTZ close to Pervomaiska Fault Zone. According to the valid "Correlation Stratigraphic Scheme of Ukrainian Shield" there are distinguished two suites in the Series (upward): Kamyano-Kostovatska (PR_1kk) and Roshchakhivska ($PR_1r\check{s}\check{c}$). The latter is in turn subdivided into two sub-suites (lower and upper ones). The rocks of both suites are extensively granitized by granitoids of Kirovogradskiy Complex. The contacts of metamorphic rocks with granitoids are either gradual or rather sharp with formation of thin reaction strips. Metamorphic rocks of both suites often are oversaturated with the veins of aplitoid and aplite-pegmatoid granites and pegmatites. Granitoids close to the remnants sometimes inherit opaque minerals (garnet, pyroxene, cordierite) of the metamorphic rocks.

Kamyano-Kostovatska Suite (PR_1kk). The rocks of the Suite at the modern erosion level are most widespread in the south-eastern portion of the map sheet area where they are disclosed by some drill-holes and are also exposed along Southern Boug and Chorniy Tashlyk rivers. Data available suggest that most typical section is provided by the cores of DH 83g-85g in the area of Mygiya village. The rocks of the Suite are being observed on the limbs of synform structures and in small remnants within granitoids of Kirovogradskiy Complex. In the Suite, biotite-orthopyroxene plagiogneisses predominate, often with graphite, sometimes with garnet and cordierite grains. Orthopyroxene mafic gneisses and two-pyroxene plagiogneisses occur in thin (2-5 m) interbeds. Aforementioned rocks are overlain by high-alumina plagiogneisses of Roshchakhivska Suite. Thickness of the Suite by profile in the area of Mygiya village is ~250 m but it is not completed because the underlaying rocks are not known.

Biotite-orthopyroxene plagiogneisses macroscopically are grey, fine-grained, massive, banded, sometimes fine-spotty rocks. Micro-texture is granoblastic, lepidogranoblastic, with elements of poikiloblastic. In fine-grained varieties mosaic textures occur. In the fine-grained groundmass there occur characteristic skeletal forms of orthopyroxene grains. Such the forms are not typical for the mafic gneisses and plagiogneisses of Buzka and Dnistersko-Buzka Series [47]. In opinion of I.B.Shcherbakov, such the orthopyroxene forms occur in the transitional zone to amphibolite metamorphic facies. Mineral composition (%): plagioclase (andesine, oligoclase-andesine) 45-50, quartz 23-35, orthopyroxene 5-15, biotite 5-10, graphite 0-5, garnet 0-15. Two-pyroxene varieties are characteristic by the banded structure caused by development of the bands composed purely of either orthopyroxene or clinopyroxene; in the latter case plagioclase is more mafic (#63-82). Accessory minerals: apatite – single grains – 2%, zircon, and in clinopyroxene bands – sphene up to 3-4%. Gangue: magnetite, sulphides. Physical properties: $\sigma = 2.85 \div 2.9$ g/cm^3, æ $= 40 \div 350 \cdot 4\pi \cdot 10^{-6}$CI.

Looking at the mineral paragenesises it can be concluded that the rocks of the Suite are metamorphosed under conditions of granulite facies.

According to the results obtained in the territory adjacent to the east [14], the restored composition of the Suite rocks does correspond to the products of weathering after mafic and ultramafic rocks that belong to tholeiite and calc-alkaline series and sub-alkaline range. Primary tholeiite basalts belong to high-Mg and high-Fe tholeiites. Geodynamic conditions of these rocks formation are thought to be those of island-arc tholeiites of Island type. Apparently, the rocks were formed through weathering and re-deposition the material from the lower tectonic level of the crystalline basement.

Roshchakhivska Suite ($PR_1r\check{s}\check{c}$) at the present erosion level is known much wider than Kamyano-Kostovatska Suite. The central portions of the high-order synform structures are filled with the rocks of the Suite. They occur also in diverse-size remnants within granitoids of Kirovogradskiy Complex. The rocks of the Suite are disclosed by some drill-holes and also are exposed along the left branches of Synyukha and Chorniy

Tashlyk rivers. According to the data available the section of the Suite most typical for the map sheet area is being provided by DH 52g-55g and 17195, 17197, 17198 in the area close to Dobryanka village.

As it is evidenced by profiles in the areas of Mygiya and Dobryanka villages, the rocks of the Suite do lie above the rocks of Kamyano-Kostovatska Suite and are linked to them by gradual transitions.

Lower Sub-Suite (PR_1*ršč₁*) is rather widespread at the eastern border of the map sheet and is composed mainly of biotite, cordierite-biotite and garnet-cordierite-biotite plagiogneisses, often with graphite and interbeds (thickness – first meters) of amphibole-biotite plagiogneisses and boudine-like thin interbeds of amphibole-diopside and diopside plagiogneisses and mafic gneisses. Thickness of the Sub-Suite is ~80 m.

Upper Sub-Suite (PR_1*ršč₂*) is characterized by local development and is known in the central portions of some synform structures. By composition the Sub-Suite is rather uniform. These are mainly intercalation of biotite and graphite-biotite plagiogneisses (thickness of individual layers – first meters – first tens of meters) within which there are observed interbeds of cordierite-biotite, sometimes with garnet, pyroxene-biotite amphibolized plagiogneisses and "boudines" of diopside mafic gneisses. Thickness of the Sub-Suite is ~220 m, and the thickness of entire Suite – ~300 m.

Since specific rocks of both suites do not differ one from another, their characteristics below are being given together.

B i o t i t e   p l a g i o g n e i s s e s are graphite-bearing, sometimes with garnet and cordierite, fine-grained, dark-grey, thin-banded or massive, sometimes fine-spotty. Micro-texture is lepidogranoblastic with elements of heteroblastic, in places granulation. Mineral composition (%): plagioclase (oligoclase) 30-40, quartz 25-30, microcline 0-15, biotite 15-30, graphite 1-8, cordierite 0-15, garnet 0-10 (often skeleton-like grains), sometimes fibrolite (at the boundaries between plagioclase and cordierite grains). Accessory minerals: apatite, zircon, tourmaline. Physical properties: $\sigma = 2.78 \div 2.8$ g/cm^3, æ = 25÷45 · 4π · 10^{-6}CI.

Amphibole-biotite plagiogneisses are dark-greenish-grey, massive, thin-banded, in places fine-spotty. Hornblende is bluish-green, it occurs in grains and glomeroblastic aggregates – from single grains to 5% and up to 20-45%. Besides those accessories mentioned for biotite plagiogneisses, in this case also occur sphene and orthite. Physical properties: $\sigma = 2.74 \div 2.82$ g/cm^3, æ = до 100 · 4π · 10^{-6}CI.

C o r d i e r i t e - b i o t i t e   a n d   g a r n e t - c o r d i e r i t e - b i o t i t e   p l a g i o g n e i s s e s are grey, dark-grey, sometimes with pinkish shade (varieties with garnet), fine-grained, fine-medium-grained (in silicified and granitized varieties), banded. Micro-texture is lepidogranoblastic, heterolepidogranoblastic with elements of poikiloblastic and with coarser sieve-like grains of cordierite and garnet. Mineral composition (%): plagioclase (oligoclase) 20-40, quartz 15-60, cordierite 20-25, garnet up to 10, biotite up to 30. Accessory minerals: apatite, zircon, monazite, sulphides. Microcline is being observed in the granitized varieties. Physical properties: $\sigma = 2.78$ g/cm^3, æ = 28 · 4π · 10^{-6}CI.

D i o p s i d e   p l a g i o g n e i s s e s   a n d   m a f i c   g n e i s s e s are light-greenish-grey, fine-grained, mainly massive. Micro-texture is heterogranoblastic. Mineral composition is quite variable (%): plagioclase (labrador, sometimes bitovnite) 25-50, clinopyroxene 10-30, quartz 5-40, actinolite (after clinopyroxene), scapolite, epidote (after plagioclase). Accessory minerals: apatite, sphene (fairly characteristic for these varieties), zircon.

According to V.M.Klochkov [14], in the territory of adjacent eastern area the rocks of the Suite are metamorphosed under conditions of granulite facies (T = 690-720^{o}C by garnet-biotite geothermometer). Close to the faults and in the extensively granitized areas the rocks undergone the retrograde metamorphism under conditions of amphibolite facies.

Reconstruction of the proto-composition of the Roshchakhivska Suite plagiogneisses by method of A.A.Predovskiy suggests for their sedimentary origin. It were metamorphosed the montmorillonite and hydro-mica clays, greywackes, sometimes polimictic sediments. It should be noted that clinopyroxene plagiogneisses and mafic gneisses were not analyzed in the same manner. It looks likely, however, that these rocks apparently are metamorphosed sandy and clayey marls.

PHANEROZOIC
Mesozoic Eratheme

Cretaceous System (K)

The oldest sedimentary rocks within the territory of map sheet “Pervomaiskiy” are Mesozoic Cretaceous sediments which are encountered by single drill-holes in the southern part of the map sheet. Table 3 sets forth the comparative grid to the stratigraphic subdivision of the Phanerozoic rocks in the territory of map sheet M-36-XXXI (Pervomaisk) between with geological maps issued in 1959 and 1990.

Table 3

<table>
<tr><th>System</th><th>Division</th><th>Sub-Division</th><th>Regio-Stage (horizon)</th><th colspan="3">State Geological Map of Ukraine in the scale 1:200 000. V.M.Klochkov, 2002</th><th colspan="2">Deep Geological Mapping in the scale 1:200 000. V.S.Kostyuchenko, 1990</th><th>Geological Map in the scale 1:200 000. Series Central-Ukrainian, M.T.Vadymov, 1959</th></tr>
<tr><td rowspan="7">Neogene - N</td><td rowspan="2">Pliocene – N_2</td><td>Upper</td><td>Akcha-gylskiy</td><td colspan="3">N_1čb</td><td rowspan="5">Baltska Suite</td><td>N_2^3</td><td rowspan="5">N_{1-2}bl</td></tr>
<tr><td>Lower</td><td>Cimme-rian</td><td rowspan="2">N_{1-2}pg</td><td rowspan="2">N_{1-2}p</td><td rowspan="2">N_{1-2}bl</td><td>N_2^2</td></tr>
<tr><td rowspan="5">Miocene – N_1</td><td rowspan="3">Upper</td><td>Pontian</td><td rowspan="2">N_{1-2}ps</td></tr>
<tr><td>Meotic</td><td colspan="3">N_1g</td></tr>
<tr><td>Sarma-tian</td><td colspan="3">N_1p
N_1vg
N_1pv</td><td>N_1s_2</td></tr>
<tr><td>Middle</td><td rowspan="2">Novo-petriv-skiy</td><td colspan="3" rowspan="2">N_1np</td><td colspan="2">N_1bj</td><td rowspan="2">N_1pl</td></tr>
<tr><td>Lower</td><td colspan="2">N_1np</td></tr>
<tr><td rowspan="5">Paleogene – ₽</td><td rowspan="2">Oligocene - ₽ 3</td><td rowspan="2"></td><td>Berek-skiy</td><td colspan="3">₽$_3$br(?)</td><td colspan="2" rowspan="3">₽$_2$ob</td><td rowspan="2">Pg$_3$hr</td></tr>
<tr><td>Mezhy-girskiy</td><td colspan="3">₽$_3$mž</td></tr>
<tr><td rowspan="3">Eocene - ₽ 2</td><td rowspan="3"></td><td>Obu-khiv-skiy</td><td colspan="3">₽$_2$ob</td><td rowspan="2">Pg$_2$kv</td></tr>
<tr><td>Kyiv-skiy</td><td colspan="3">₽$_2$kv</td><td colspan="2">₽$_2$kv</td></tr>
<tr><td>Buchat-skiy</td><td colspan="3">₽$_2$bč</td><td colspan="2">₽$_2$bč</td><td>Pg$_2$b</td></tr>
<tr><td>Cretaceous - K</td><td>Lower – K_1</td><td></td><td>Irshan-skiy</td><td colspan="3">K_1kd</td><td colspan="2">–</td><td>–</td></tr>
</table>

Lower Division (K$_1$)

For the first time Cretaceous sediments were studied by G.G.Vynogradov in 1969 during geological mapping in the scale 1:50 000 [57] and these rocks were distinguished by him as the Lower Cretaceous (Aptian), and later on by V.V.Kyslyuk [76] had defined these rocks as Kodymska Suite.

Kodymska Suite (K$_1$*кd*). The rocks are known exclusively from the right bank of Southern Boug River with absolute heights of the footwall as 72.0-47.0 m and are related to most buried blocks of crystalline basement (Fig. 2.1). The rocks are disclosed by drill-holes only (DH 792, 1149, 1158, 16816, etc.).

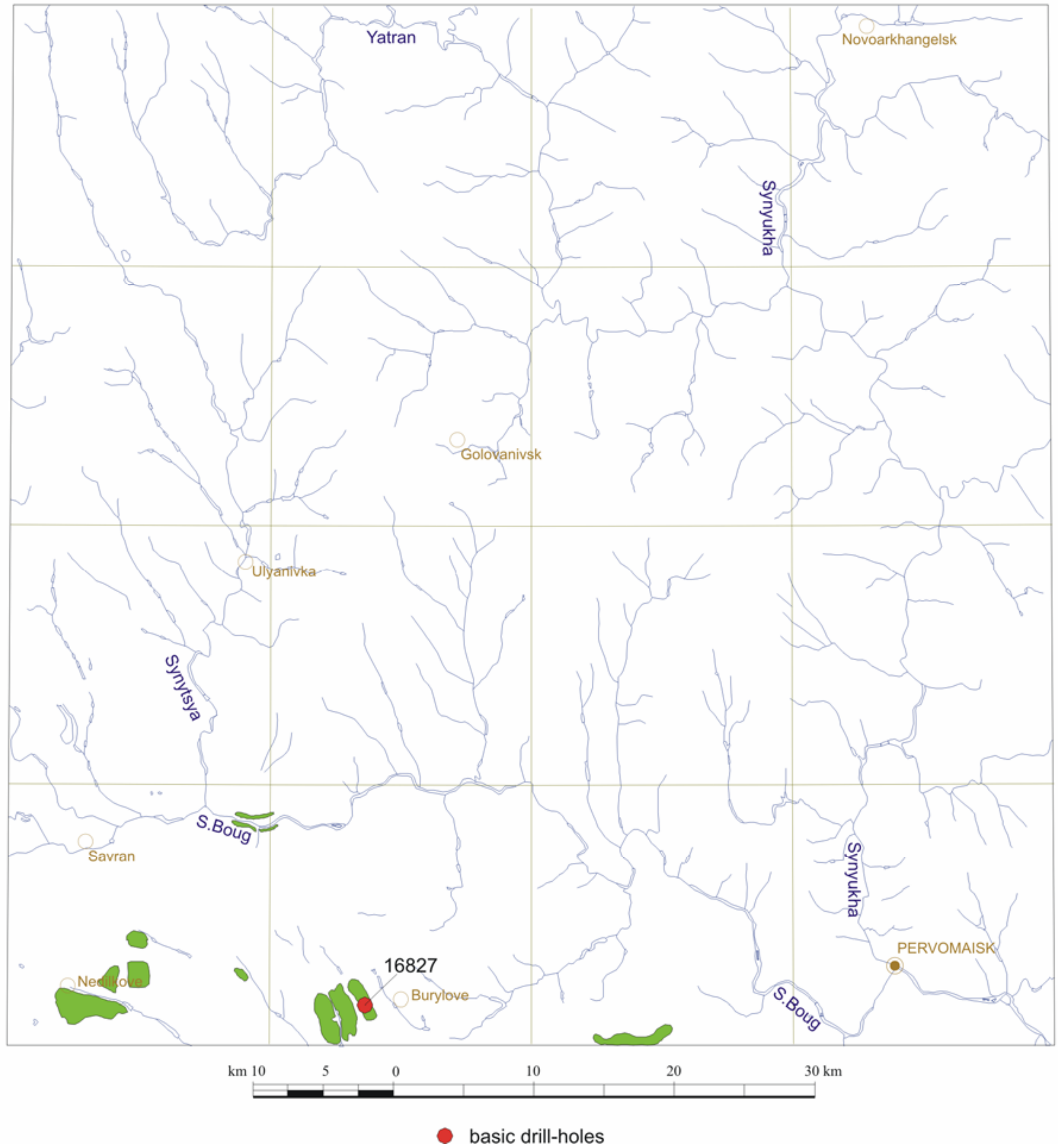

Fig. 2.1. Distribution scheme of Kodymska Suite (K$_1$*kd*) sediments.

Thin continental sediments of Kodymska Suite that are encountered in the areas of Mykolaivka, Burylove, Nedilkove and other villages comprise conglomerate-like rocks, sandstones with flint cement, dark-grey to black clays with remnants of coalified plants, secondary kaoline and fine-grained quartz sands. Thickness of the Suite by separate sections is not sufficient and varies from 0.5 to 8.0 m (DH 16827).

The rocks of Kodymska Suite lie directly on the kaoline weathering crust of crystalline rocks and with stratigraphic discontinuity are being overlain by Paleogene and Neogene sediments.

Cenozoic Eratheme

Paleogene System

The works on geological mapping, search-prospecting works, as well as DGM-200 had revealed that some suites of Paleogene System are rather locally distributed in the map sheet territory caused by tectonic movements of some blocks during their formation and influence of the fault zones on the distribution of the sedimentation sites.

Paleogene sediments do lie on the weathering crust of Precambrian rocks and in less extent – with stratigraphic discontinuity on the Cretaceous rocks. These rocks comprise Eocene and Oligocene sediments. Paleocene sediments are not known in the territory of the map sheet.

Eocene Division (₽$_2$)

This division comprises sediments of Buchatska Series, as well as Kharkivska Series including Kyivska Suite and Obukhivska Suite.

Buchatska Series (₽$_2$*bč*). These rocks are most widespread in the western and north-eastern parts of the map sheet territory. In separated bodies they also occur in other areas (Fig. 2.2). The strike of the available fields of Buchatski sediments varies from north-east in the west to almost sub-longitudinal in the east and it thought to inherit the position of ancient paleo-valleys that do extend along the line of villages Tauzhne-Mechyslavivka-Vel.Troyany in the west of study area, and along the line of villages Pidvysoke-Torgovytsya in the north-east of study area.

The following rock types are found in the section: dark-grey coaliferous sandy clays with interbeds of brown coal; brown coal; fine-medium-grained quartz sand, sometimes coaliferous; secondary kaoline.

In the coaliferous sediments at Kvitka village, located close to the eastern border of the “Pervomaisk” map sheet, A.K.Kolomiytseva [57] had determined the following sporo-pollen set of Middle-Eocene (Buchatskiy) age (%): *Bryales* – 0.5; *Polypodiaceae* – 0.5; *Stenozonotriletes cerebriformis* – 0.5; *Pinus* – 2.0; *Taxodiaceae* – 0.5; *Palmae* – 4.0; *Salicaceae* – 1.5; *Myricaceae* –17.5; type *Carya* – 26.0; *Engelhardtia* – 0.5; *Corylus* – 1.5; *Quercus* – 1.0; *Castanea* – 0.5; *Santalaceae* – 0.5; *Rosaceae* – 1.0; *Rhus* – 1.5; *Ilex* – 1.5; *Aceraceae* – 2.0; *Rhamnaceae* – 1.0; *Begoniaceae* – 3.0; *Myrtaceae* – 6.0; *Sapotaceae* – 1.0; *Ericaceae* – 4.0; *Araliaceae* – 1.0.

By the forming conditions there are distinguished the facies of the course and lake-bioherm type which repeatedly change one another suggesting for their formation under conditions of the coastal marine plains.

In some sections of Buchatska Series there are known up to three interbeds of the brown coal but normally 1-2 of them occur. Thickness of individual coal seams attains 8.5 m (DH 144) and does not exceed 3.0-4.0 m in average. The absolute heights of the Buchatski rock footwall in the northern part of the map sheet are about 175 m, and in the southern part – 123 m. The total thickness of the Series in some drill-holes attains 20.0 m (DH 117). Partly it is overlain by younger Paleogene sediments and almost everywhere – by Neogene rocks. The Series itself lies over the weathering crust of crystalline rocks.

Kharkivska Series. Kyivska Suite (₽$_2$*kv*). These rocks are most widespread in the western (Zhovtneve, Tauzhne, Vel.Troyany villages) and eastern (Mygiya, Tyshkivka, Slavski Khutory villages) parts of the study area where they form relatively small bodies with winding boundaries (Fig. 2.3). In term of lithology the Suite comprises mainly aleuritic greenish-grey clays with lenses and interbeds of fine-medium-grained quartz sands and quartz sandstones with flint cement and with fauna remnants; marls; tripoli-like rocks and sometimes – secondary kaoline.

Early in the studies of the Pervomaiskiy map sheet territory M.T.Vadymov [9] had considered to be sediments of Kyivska Suite those rocks which later on were re-defined by V.Yu.Zosymovych [67] as Obukhivska Suite of Middle Eocene.

In the quartz sandstones (DH 17067, 12896, 18179 and others) B.F.Zernetskiy, K.Y. Nikolaevska and I.E.Piyar [67] had determined the following set of mollusc fauna: *Crassatella fuschi* Slodk., *Glycymeris heberti* Posq., *Pseudamussium corneum* Sow., *Chlamys bellicostatus* Wood *var. orientalis* Sok., *Pecten subtripartita* Arch., *Phacoides aff. bugensis* Klush., *Cardita* (*Venericardia) divergens* Desh. *var. anitestita* Slodk., *Pitar calista ex gr. suberycinoides* Desh., *Spondilus cf. tenuispina* Sand., *Ostrea cf. prona* Wood.

The sediments of Kyivska Suite lie directly on the weathering crust or on the rocks of Buchatska Series, with absolute heights of their footwall from 52.0 m in the south to 170.2 m in the north; this suggests for extensive uplift of some basement blocks in the northern part of map sheet area in the post-Kyivskiy time. Thickness of the Suite sections by individual drill-holes (DH 16719) is 29.0 m whereas average thickness comprises 3.0-5.0 m. The Suite is overlain by Obukhivska Suite as well as Oligocene and Neogene rocks.

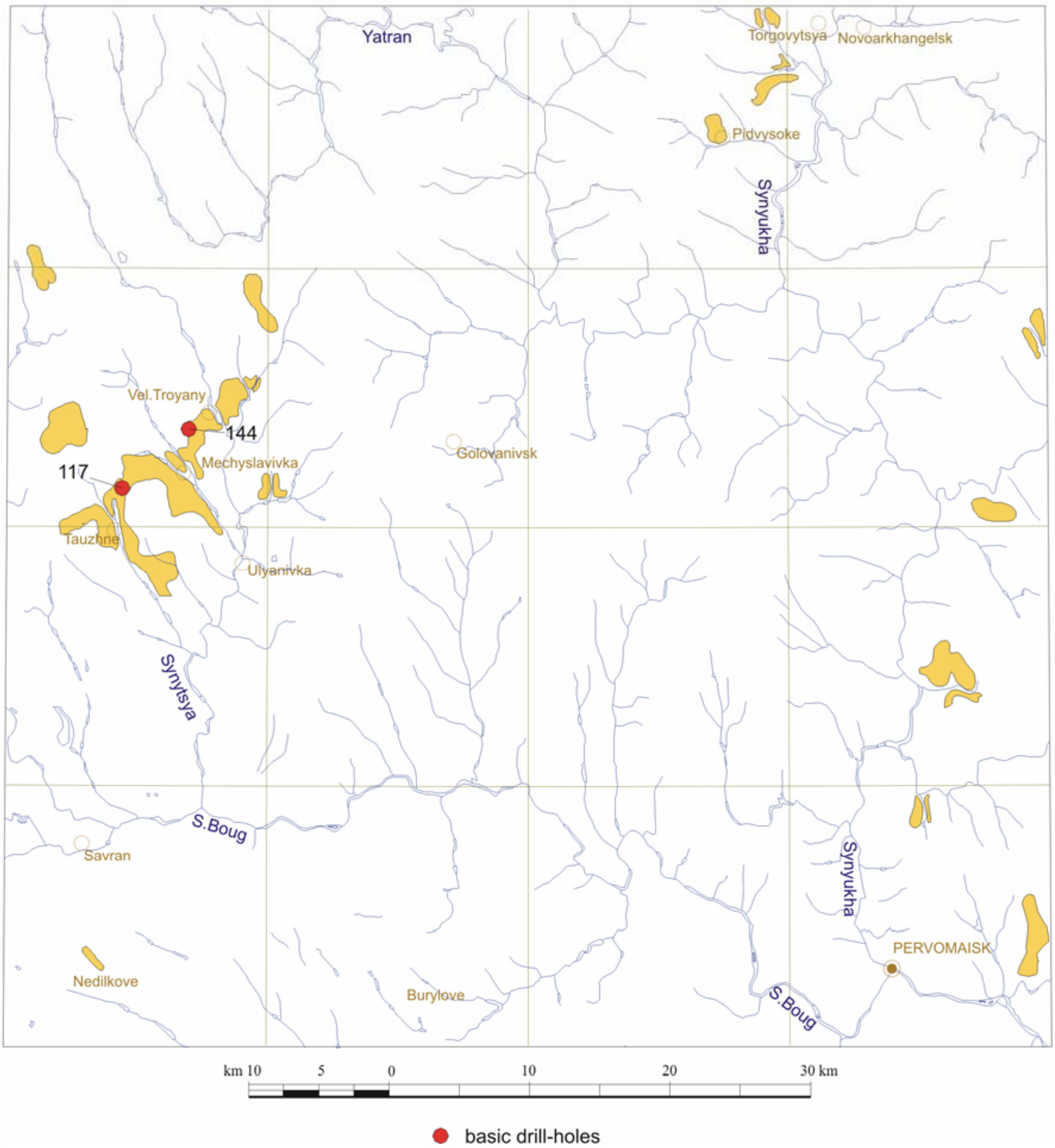

Fig. 2.2. Distribution scheme of Buchatska Series (₽$_2$*bč*) sediments.

Kharkivska Series. Obukhivska Suite (₽$_2$*ob*). The rocks of the Suite are developed in the western and north-eastern parts of the map sheet area. Elsewhere in the territory they are locally distributed and are encountered by single drill-holes as well as identified in the outcrops (Fig. 2.4) highlighting the topmost central and south-eastern portions of the territory. In the section of these rocks by lithology there are distinguished greyish-green quartz-glauconite sands with clayey cement and with interbeds of greenish-grey aleuritic clays; greenish-grey quartz sands, often clayey; silica clays and silica-clay-like sandstones.

In the outcrops # 309 and 310 located in the upper part of the slope of Ternivka River valley, in silica-clay-like sandstones, that form lowermost part of the section, the following set of mollusc fauna (outcrop # 309) is determined by V.Yu.Zosymovych: *Venericardia divergens* Desh. *var. praeculta* Klush., *V. sokolovi* Slodk., *Crassatella desmareschti* Desh., *Pseudamussium corneum* Sow., *Chlamys sokolovi* Klush., *Ch. bellicostatus* Wood *var. orientalis* Sok., *Ch. aturi* Tourn *var. rotundata* Slodk., *Turritella granulosa* Desh.

The sporo-pollen set (outcrop # 310) was studied by T.B.Gubkina (specimens): *Pinus n/p Diploxylon* – 10; *Taxodiaceae* – 1; *Myricaceae* – 1; *Carya sp.* – 2; *Castanea sp.* – 2; and it is characteristic for the Obukhivska Suite of Ukraine.

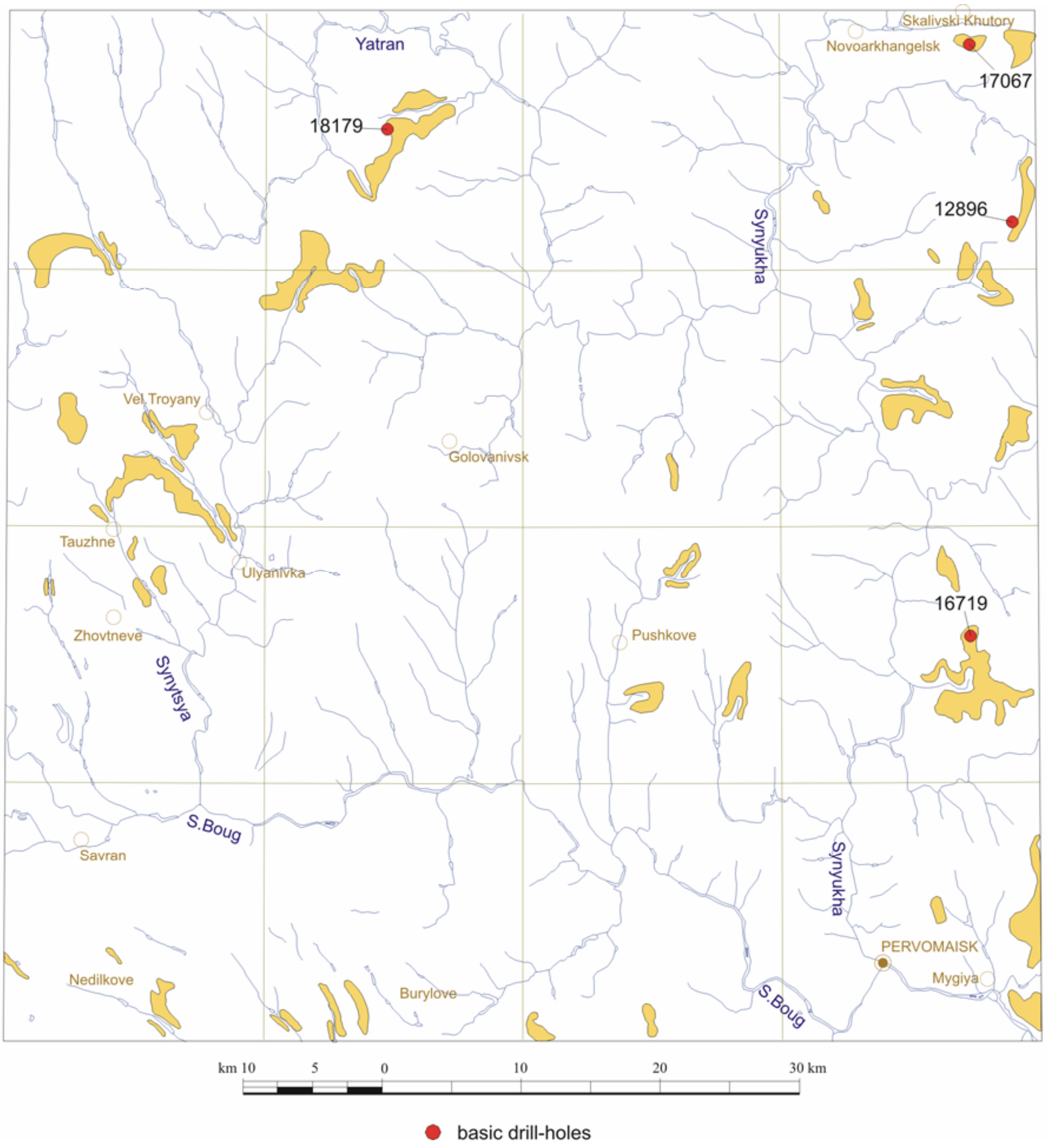

Fig. 2.3. Distribution scheme of Kyivska Suite (₽$_2$*kv*) sediments.

The rocks lie onto the weathering crust, the sediments of Buchatska Series and Kyivska Suite. The absolute heights of their footwall in some sections vary from 58.0 m in the south to 180.0 m in the north. The maximum thickness attains 13.0 m (DH 16966), and the average by the area – 2.5-5.0 m. The rocks are overlain by Oligocene and Miocene sediments.

Oligocene Division (Ᵽ$_3$)

Oligocene sediments in the territory of Pervomaiskiy map sheet, likewise adjacent Novoukrainskiy map sheet, are determined on the ground of correlation analysis of the lithologic succession of sections by single drill-holes (DH 112) and include the rocks of Mezhygirska and Berekska Suites. There are not found yet in the territory of both map sheets the fauna remnants and sporo-pollen sets which could confirm that overlain clayey layers belong to Obukhivska Suite. In the Pervomaskiy map sheet the rocks of Mezhygirska and Berekska Suites are distinguished for the first time and this issue requires further studies.

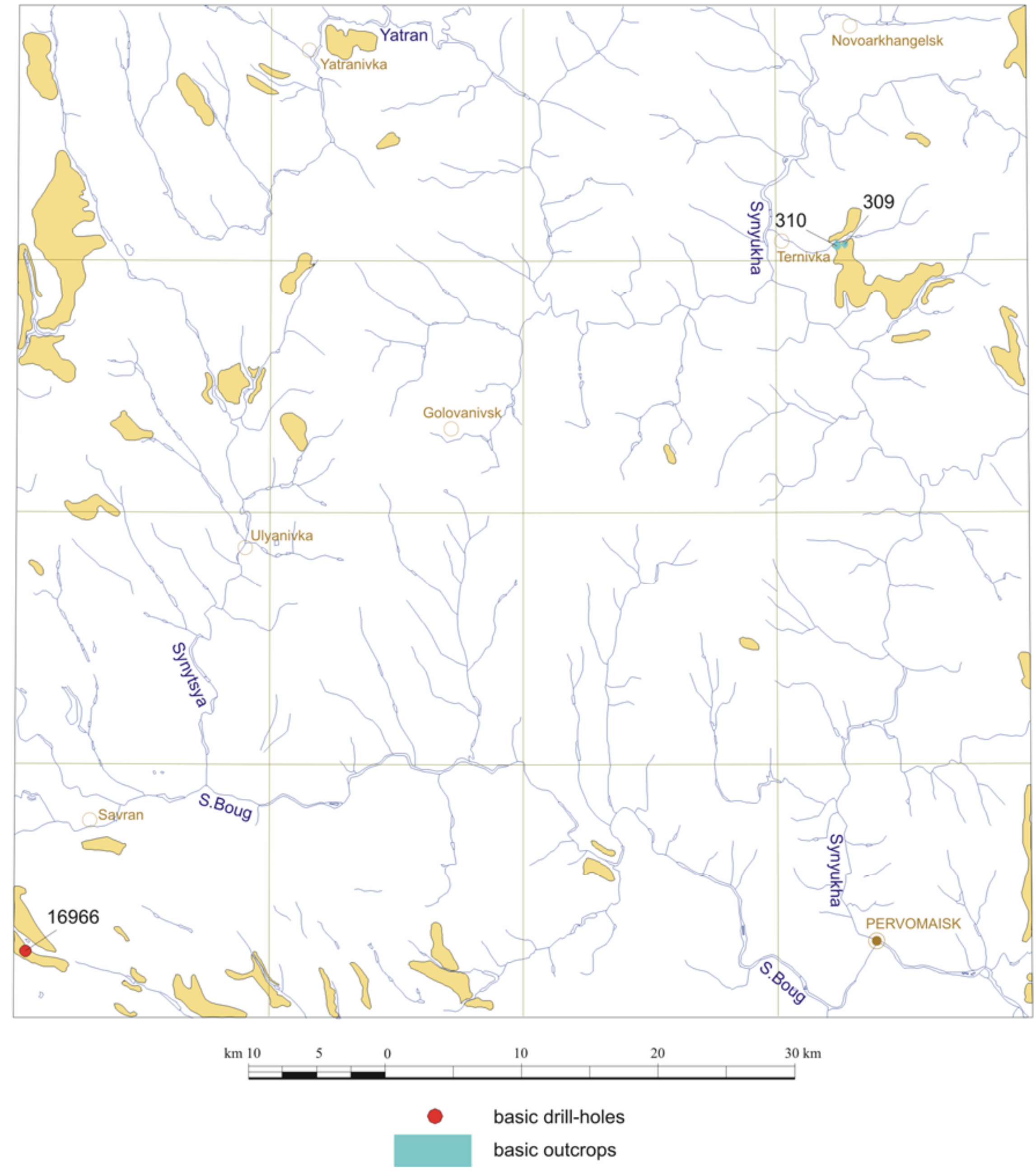

Fig. 2.4. Distribution scheme of Obukhivska Suite (Ᵽ$_2$*ob*) sediments.

Kharkivska Series. Mezhygirska Suite (Ᵽ$_3$*mž*). In the section of Mezhygirska Suite there are distinguished grey, greenish-grey, aleuritic, micaceous, sometimes slightly sandy clays with interbeds of aleurites and fine-grained quartz sands, sometimes with glauconite grains and with montmorillonite.

The rocks of Mezhygirska Suite, likewise underlaying Eocene sediments, are being extended in a narrow strip of the small local bodies in the western part of the map sheet from Savran River in the south to Osytne village in the north (Fig. 2.5). The absolute heights of the rock footwall vary from 65.5 m (DH 31g) to 207.0 m (DH 62). The rocks lie over the weathering crust and Eocene sediments. In turn, they are overlain by the Neogene sediments. Thickness of the Suite is up to 10 m.

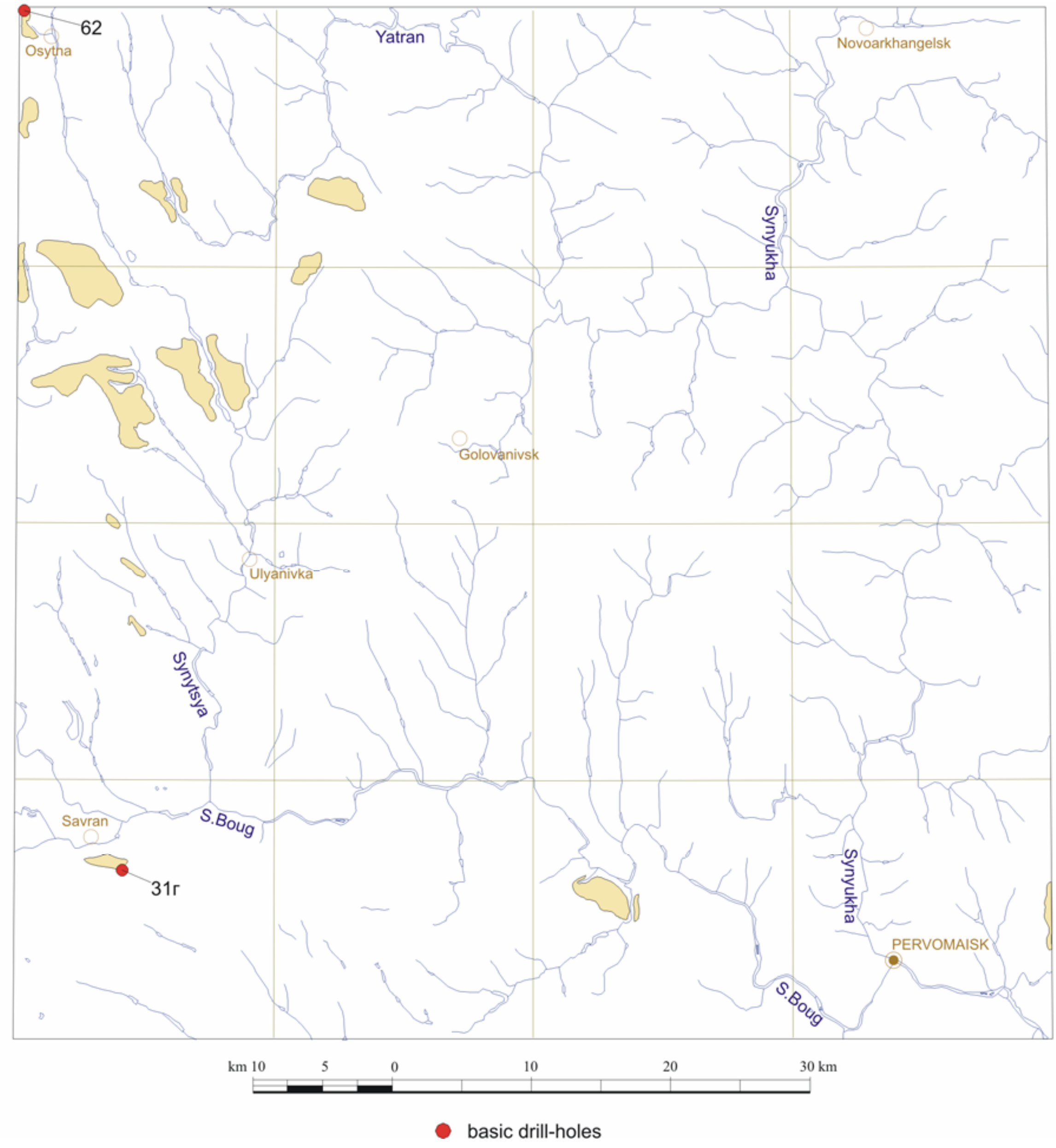

Fig. 2.5. Distribution scheme of Mezhygirska Suite (₽$_3$*mž*) sediments.

Poltavska Series. Berekska Suite (₽$_3$*br*?). It is widespread in the western and north-eastern parts of the map sheet, and in less extent – in the central part, forming relatively small bodies with winding boundaries and predominate north-western strike (Fig. 2.6). Likewise underlaying Paleogene sediments, these rocks are related to the strip along the line of Polyanetske, Kamyana Krynytsya, Kolodyste, Chernovody villages.

By lithology, in the section of Berekska Suite there are distinguished mainly quartz sands, yellowish- and greenish-grey, diverse-grained, in the lower part with glauconite grains. At the bottom often thin interbeds of sandy clays occur with single glauconite grains; this causes gradual transition between Mezhigirska and

Berekska Suites. The rocks are overlain by light-grey quartz sands of Miocene Novopetrivska Suite which are enriched in gangue minerals.

The absolute heights of the Suite footwall vary from 52.2 m (DH 16953) in the south to 183.0 m (DH 189) in the north-west. Thickness of the sands is 0.5-27.5 m (DH 186).

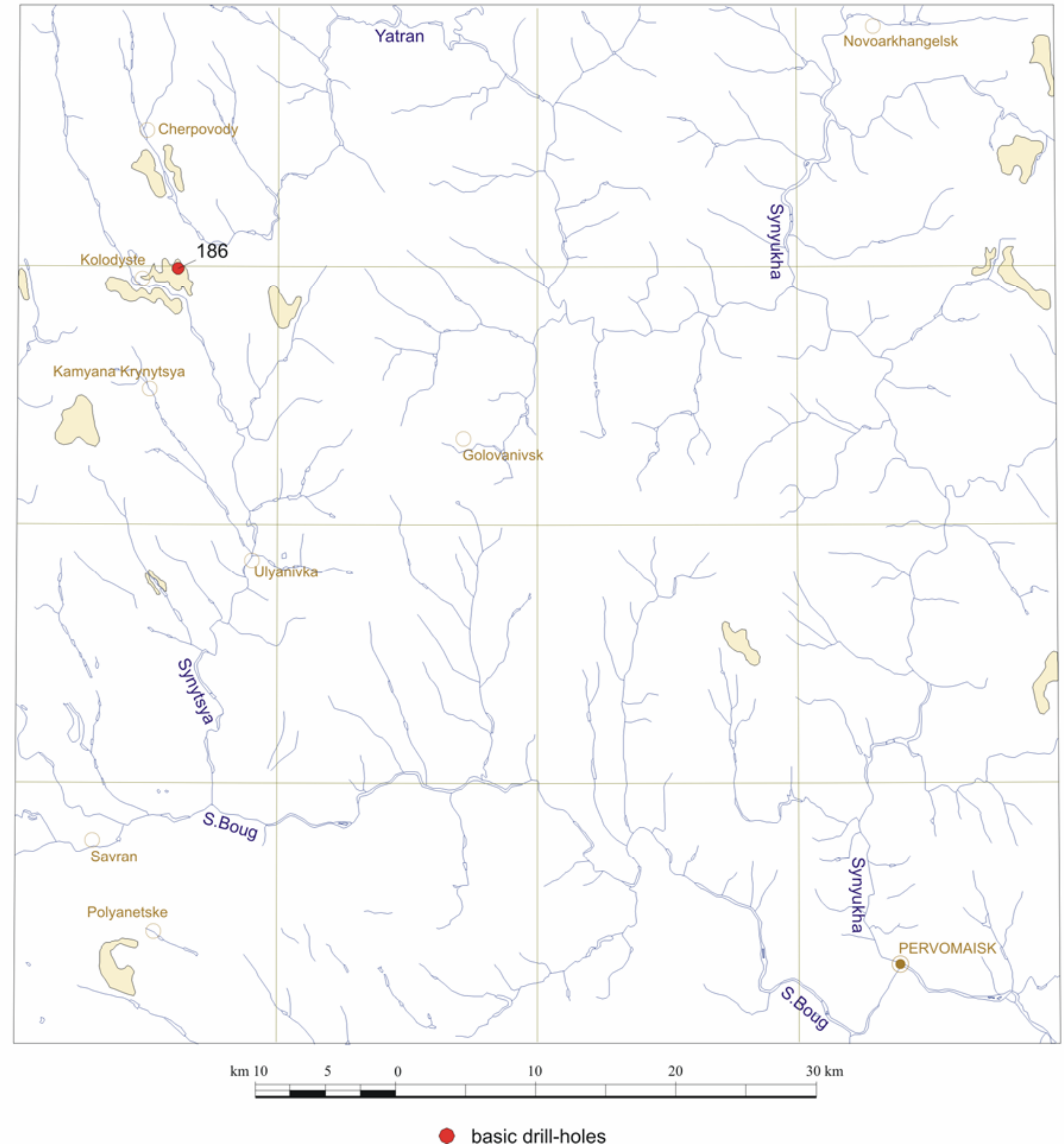

Fig. 2.6. Distribution scheme of Berekska Suite (₽$_3$*br?*) sediments.

The newly-formed glauconite is characteristic to the entire Paleogene section (except continental sediments of Raypilska Pile and the rocks of Buchatska Series) in contrast to the Neogene sections. This is why the quartz sands with glauconite are being mistakenly considered to be the counterparts of Neogene Novopetrivska Suite. Due to lack of paleontologic data and clear relationships with underlaying sediments of Mezhigirska Suite, this sandy pile is being conventionally considered as the Berekska Suite. This issue requires further studies.

Neogene System (N)

The rocks of Neogene System in the territory of "Pervomaiskiy" map sheet comprise two divisions: Miocene and Pliocene; these ones are developed over the whole territory although some stratons are confined to western, northern and eastern areas.

Miocene Division (N_1)

The Lower and Middle Sub-Divisions encompass the rocks of Novopetrivska Suite whereas Upper Sub-Division includes Sandy-Limestone Pile (N_1pv), Coaliferous-Clayey Pile (N_1vg), and Sandy Pile (N_1p) that correspond to the Middle Sarmathian, and Clayey Pile (N_1g) which is being correlated with the Meotic Regio-Stage.

Poltavska Series. Novopetrivska Suite (N_1np). The rocks of Novopetrivska Suite normally with the stratigraphic discontinuity lies over the weathering crust, as well as Cretaceous or Paleogene rocks. The bodies largest by square do have the north-west strike (Fig. 2.7).

The sediments everywhere comprise quartz, fine-medium-grained, yellowish-greyish, whitish-grey, kaolineous sands, with opaque minerals, with interbeds of greenish-grey clays, often "glue", and secondary kaoline.

V.S.Kostyuchenko [80] for the first time had distinguished so called Boyarska Pile, which in term of lithology is composed of montmorillonite clays with interbeds of quartz, light-grey, whitish, yellowish-grey, fine-grained sands. Further analysis of these sediments, however, allows, following T.B.Gubkina [67], to consider this Pile as the layers of Novopetrivska Suite whose total thickness attains 40.0 m. The absolute heights of the Novopetrivska Suite sand footwall vary from 62.0 m (DH 13527) in the south to 207.0 m (DH 63) in the north-west; this suggests for significant movements of some blocks in the post-sedimentation times. Thickness varies in the range 0.5-30.0 m. Organic remnant are not known from the Suite's sediments. The rocks of Novopetrivska Suite lie over the Paleogene sediments and the weathering crust of crystalline rocks.

We have performed subdivision of Paleogene and Lower Miocene sediments in accordance with the valid stratigraphic scheme but positions of the defined subdivisions – volumes of Kharkivska and especially Poltavska Series do require further verification.

Sandy-Limestone Pile (N_1pv). These sediments are rather developed in the south-western part of the map sheet only (Krychunove, Nedilkove, Mazurove, Mykhalkove and other villages) and in the plane form the large areas of north-western strike (Fig. 2.8). In the remaining territory they form small bodies encountered by single drill-holes.

By lithology the Pile comprises grey, quartz sands; shell limestone with fauna of Middle-Sarmathian mollusc (*Cardium fittoni* Orb., *C. plicatofittoni* Orb., *Mactra fabreana* Orb. and other); greenish and yellowish-grey clay, sometimes with interbeds of shell detritus.

Aforementioned rock varieties are often intercalated in the section. Maximum thickness of the Pile attains 20.0 m (DH 16965); its footwall occurs at the level of 63.0 m (DH 16878) in the south, and 209.0 m (DH 41) in the north. The sediments lie over the weathering crust of crystalline rocks, as well as over Cretaceous and Paleogene (in the south-western part of the map sheet) sediments and are overlain by Coaliferous-Clayey Pile and the rocks of Baltska Suite.

Coaliferous-Clayey Pile (N_1vg). This Pile, distinct by lithology, is developed in the western part of the map sheet (Strutynka, Zhovtneve, Kamyana Krynytsya and other villages) where it forms rather large bodies (Fig. 2.9) and comprises dark-grey, coaliferous clays with remnants of coalified plants; grey, dark-grey, quartz, fine-grained sands. It is characteristic to the section the widespread coaliferous substance which in places (DH 9619 and others) becomes the brown coal. In the sandy piles the coaliferous substance is being contained in minor amount while the clays are coalified in most extent.

Thickness of the Pile attains 22.7 m (DH 5354). Described rocks lie at the height level of 44.7 m (DH 9617) in the southern part of the territory, and about 180.0 m (DH 18085) – in the north. The Coaliferous-Clayey Pile is underlain by the Miocene Sandy-Limestone Pile, by the rocks of almost all Paleogene subdivisions, and also by the Lower Cretaceous rocks in the south of the territory.

In the coaliferous clays of the section in the area of Mazurovo village (DH 16834, depth 37.0-48.0 m) K.S.Kostetska [57] had determined the following foraminifera set: *Triloculina clavata* Didk., *T.volhynica* Didk., *T.pseudoukrainica* Didk., *T.pseudoinflata* Didk., *Quinqueloculina fasseta* Didk., *Q.prava* Didk., *Q.oblonga* Didk., *Q.consobrina* Orb., *Q.karreri* Reuss, *Elphidium macellum* (Ficht. et Moll), *Streblus beccarii* (Lin.). In the area of Mykhalkovo village in the grey clay (DH 16815) T.B.Gubkina [57] had studied the following spore-pollen set (%): *Pinus n/p Diploxylon* – 70.0, *P. n/p Haploxylon* – 1.0, *Tsuga sp.* – 0.5, *Sparganiaceae* – 1.5, *Juglans sp.* – 1.0, *Corylus sp.* – 0.5, *Carpinus sp.* – 5.0, *Fagus sp.* – 8.0, *Ulmus sp.* – 6.0, *Rosaceae* – 0.5, *Dipsocaceae* – 0.5, *Chenopodiaceae* – 0.5, *Ericaceae* – 2.0. Spores: *Spagnales* – 0.5, *Polypodiaceae* – 2.0. Both sets suggest for Middle-Sarmathian age of these clays.

Upon analysis of position of aforementioned two Upper Miocene piles in the sections of drill-holes (DH 16817, 16835, 13413, 1135, 775 and others) it was unambiguously concluded about higher stratigraphic attitude of Middle-Sarmathian Coaliferous-Clayey Pile with respect to the Miocene Sandy-Limestone Pile.

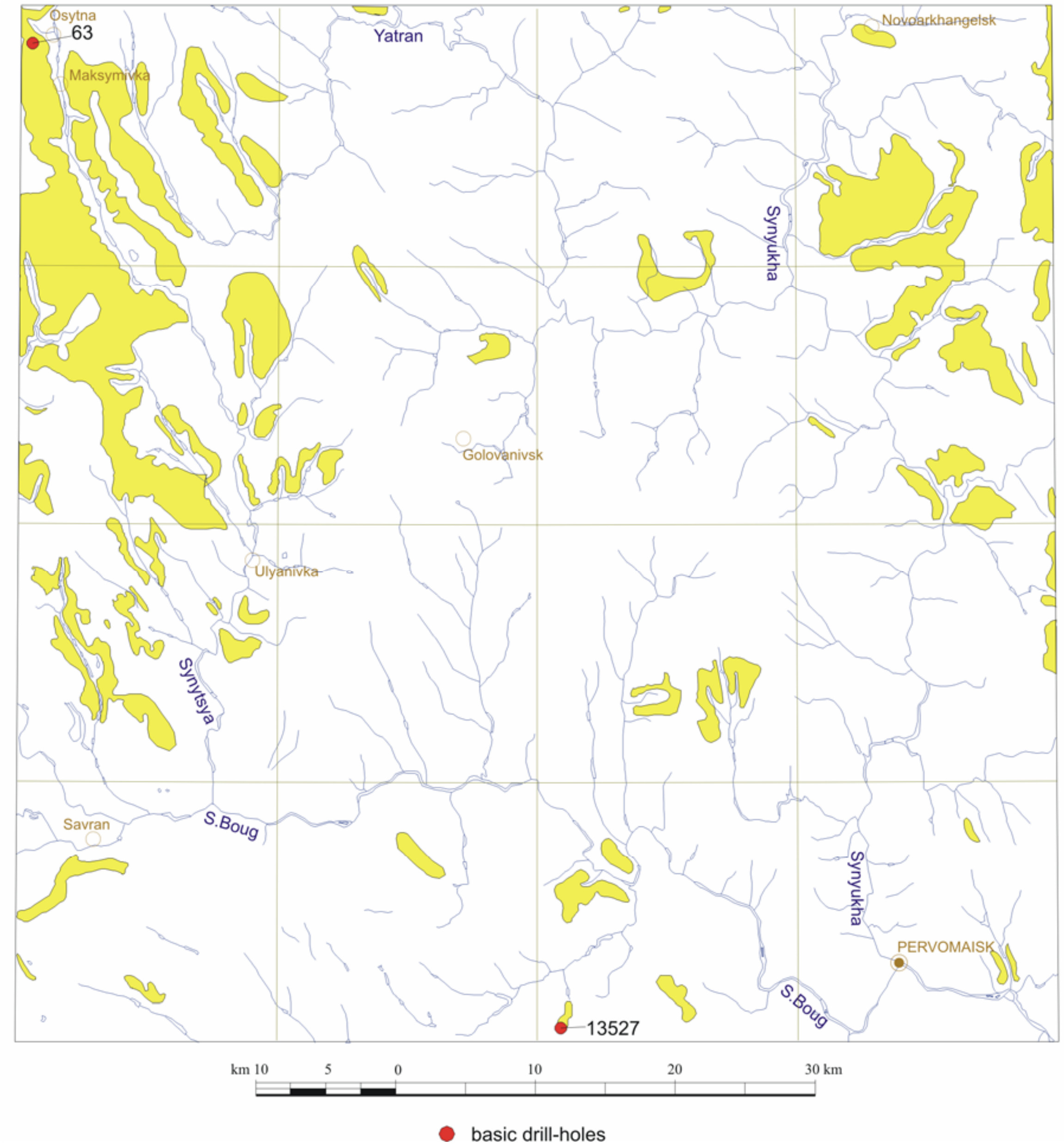

Fig. 2.7. Distribution scheme of Novopetrivska Suite (N_1*np*) sediments.

Sandy Pile (N_1*p*). This Pile in the territory of the map sheet is developed in the eastern, northern and western parts whereas it is almost absent in the central and southern parts (Fig. 2.10). In fact, the squares of its distribution are related to the areas of development of the oldest for the studied territory Neogene and Paleogene sediments; apparently this suggests for inherited patterns of the sedimentation sites and durable deposition processes. The Pile is mainly composed of quartz, grey, greenish- and yellowish-grey, fine-grained and sometimes aleuritic, clayey sands with thin interbeds of yellowish- and bluish-grey, sandy clays. In places the sands contain ilmenite, disthene, rutile, and anatase.

The Sandy Pile caps Middle-Sarmathian sediments. The top of this Pile coincides with the margin of the oxygen regime change during sedimentation. Grey, bluish-grey and greenish-grey shades are characteristic to the lower (Paleogene) part of the pre-Quaternary cover section. Above this margin in Neogene rocks there are predominate more parti-coloured shades – yellowish, ocher, reddish, brown.

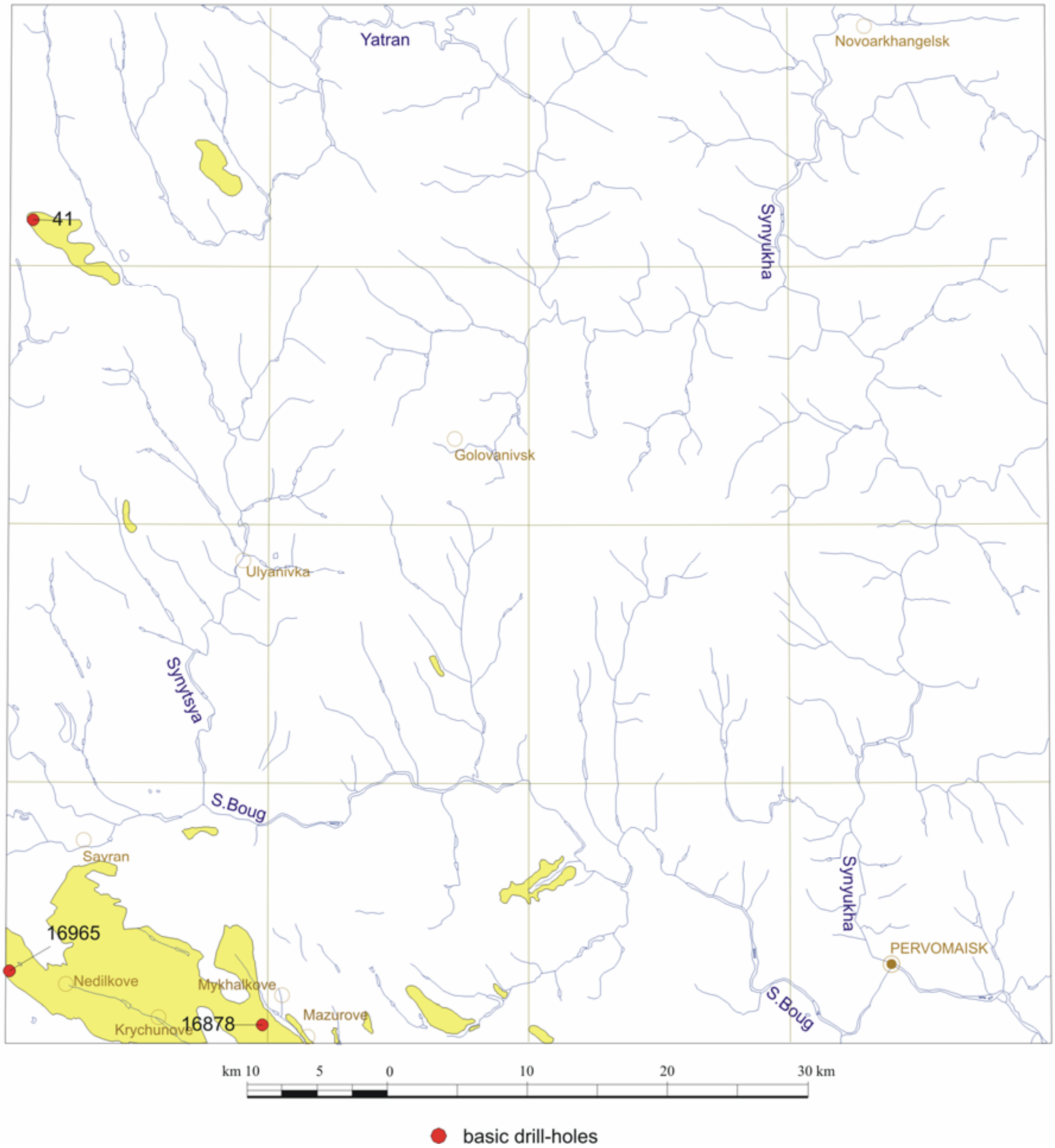

Fig. 2.8. Distribution scheme of Sandy-Limestone Pile (N_1*pv*) sediments.

The absolute heights of the sand footwall in some blocks vary from 66.0 m (DH 16825) in the south, to 215.0 m (DH 38) in the north. Maximum thickness attains 36.5 m (DH 2596). The rocks lie over the Miocene Coaliferous-Clayey Pile, over Paleogene and older sediments and rocks. And the Pile is overlain by Meotic Clayey Pile.

Clayey Pile (N_1*g*). The rocks of the Pile are known mainly from the western (Synytsivka, Tauzhne, Chornovody and other villages) and south-eastern (Mygiya, Stanislavchyk and other villages) part of the "Pervomaisk" map sheet territory (Fig. 2.11). They are distinguished by lithology and position in the section. The plane correlation of sections between the mapping drill-holes had been conducted using computer technologies. The Pile comprises yellowish- and greenish-grey, aleuritic, mainly non-carbonate (very rare with carbonate concretions) clays with interbeds of quartz, micaceous, clayey sands, and in places secondary kaoline. Absolute heights of the clay footwall vary from 74.0 m (DH 15908) in the south-east, to 213.7 (DH 68) in the north. Maximum thickness attains 24.5 m (DH 13407, 2656 and others). The rocks are underlain by the Upper Miocene (Middle Sarmathian) Sandy Pile, and are overlain by sediments of undivided Miocene-Pliocene parti-coloured Sandy-Clayey Pile.

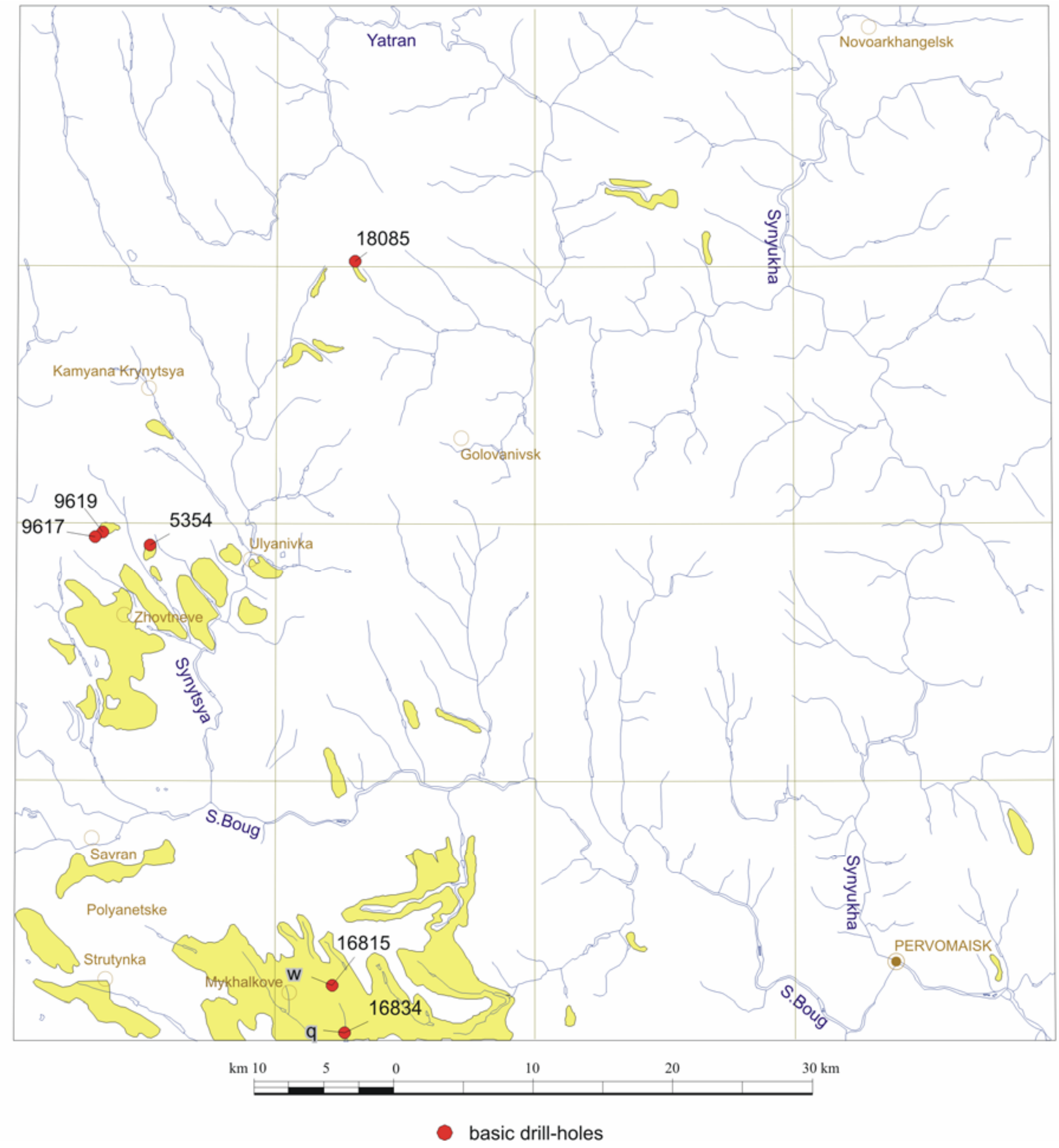

Fig. 2.9. Distribution scheme of Coaliferous-Clayey Pile (N_1vg) sediments.

Miocene and Pliocene Divisions undivided (N_{1-2})

The undivided Miocene-Pliocene sediments are distinguished within two LTZ: Northern (Southern Boug River left-bank) and Southern (Southern Boug River right-bank). The Northern LTZ comprises two piles: Parti-coloured Sandy-Clayey Pile and Parti-coloured Sand Pile; the Southern LTZ – Baltska Suite.

Parti-coloured Sandy-Clayey Pile ($N_{1\text{-}2}pg$). The Pile is widely developed actually over entire territory of the Northern LTZ (Fig. 2.12) and lack in the Southern LTZ where it is replaced by the Baltska Suite sediments. The rocks of the Pile everywhere are confined to the watershed areas and lie directly below red-brown clays at the footwall absolute heights from 222.0 m (DH 36) in the north, to 103.8 m (DH 15943) in the south-east. Thickness of the sediments varies from first meters (DH 18391) to 28.2 m (DH 18409).

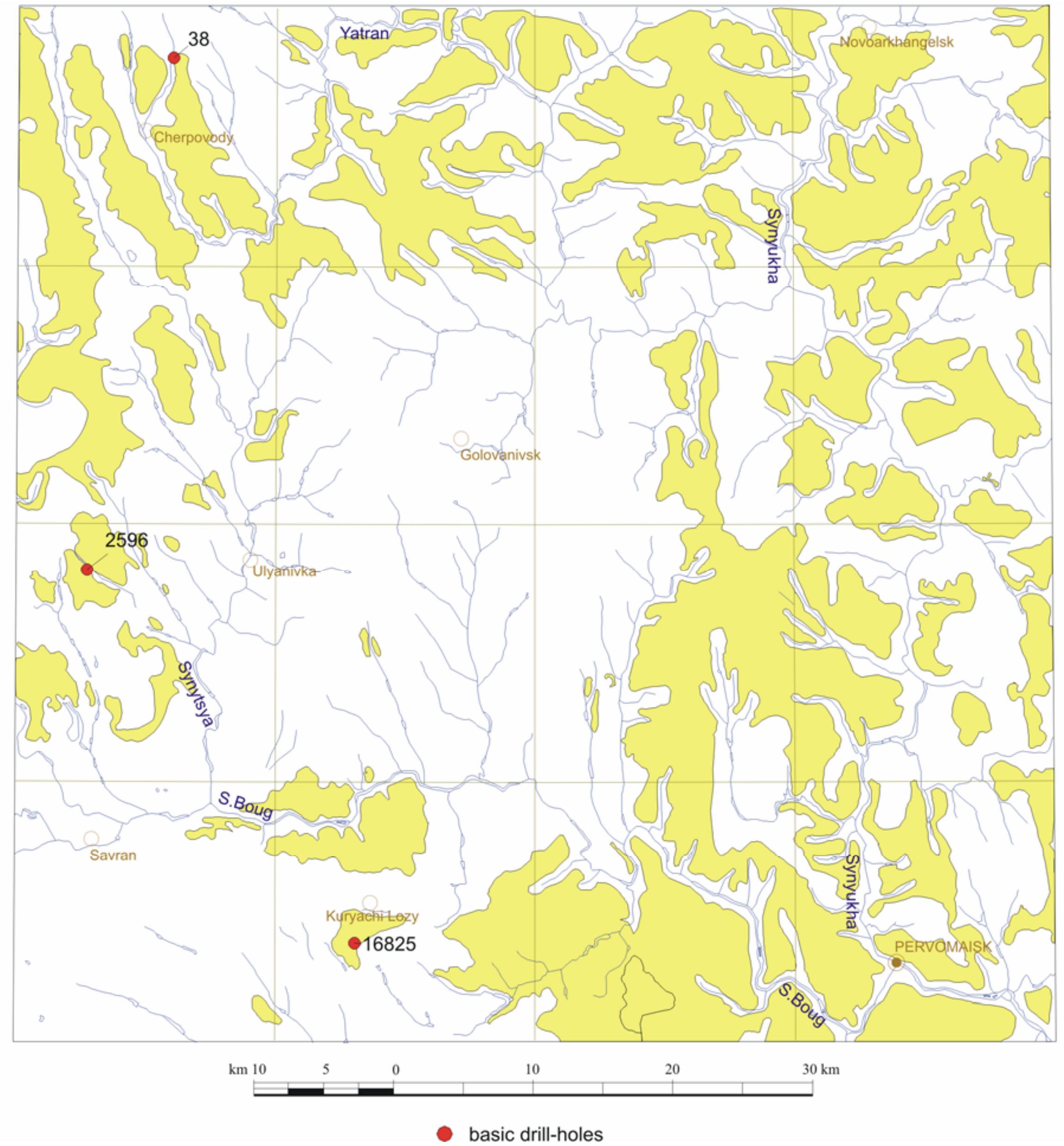

Fig. 2.10. Distribution scheme of Sandy Pile (N_1p) sediments.

By lithology, the rocks comprise mainly brown, brownish-yellow, greyish-yellow, reddish-brown, slightly-sandy clays, with carbonate concretions, with interbeds of quartz, diverse-grained, mainly fine-grained, greyish-brown, yellowish-grey sands, with aggregates of carbonate, iron and manganese hydroxides. Sometimes sandstone interbeds occur. The rocks do not contain any organic remnants and by their position in the section they are distinguished as undivided Miocene-Pliocene ones. They are underlain by Miocene (Sarmathian, Meotic) and Paleogene (Eocene, Oligocene) sediments, and are overlain by the Upper Pliocene red-brown clays.

Parti-coloured Sand Pile ($N_{1\text{-}2}p$). The Pile is distributed in the far south-eastern part of the studied area, in direct proximity to the map sheet "Novoukrainka". The Pile is distinguished by lithology. The absolute heights of the footwall comprise 142.0-151.0 m, and average thickness of the layers – 3.5-5.0 m (Fig. 2.13). The Pile is composed of quartz, diverse-grained, yellowish-grey, yellowish-brown, ocherous, clayey sands, in places kaolineous at the bottom, carbonatized, sometimes with clay interbeds. It is underlain by Middle Sarmathian and Meotic (Clayey Pile) sediments, and is overlain by the Upper Pliocene pile of red-brown clays.

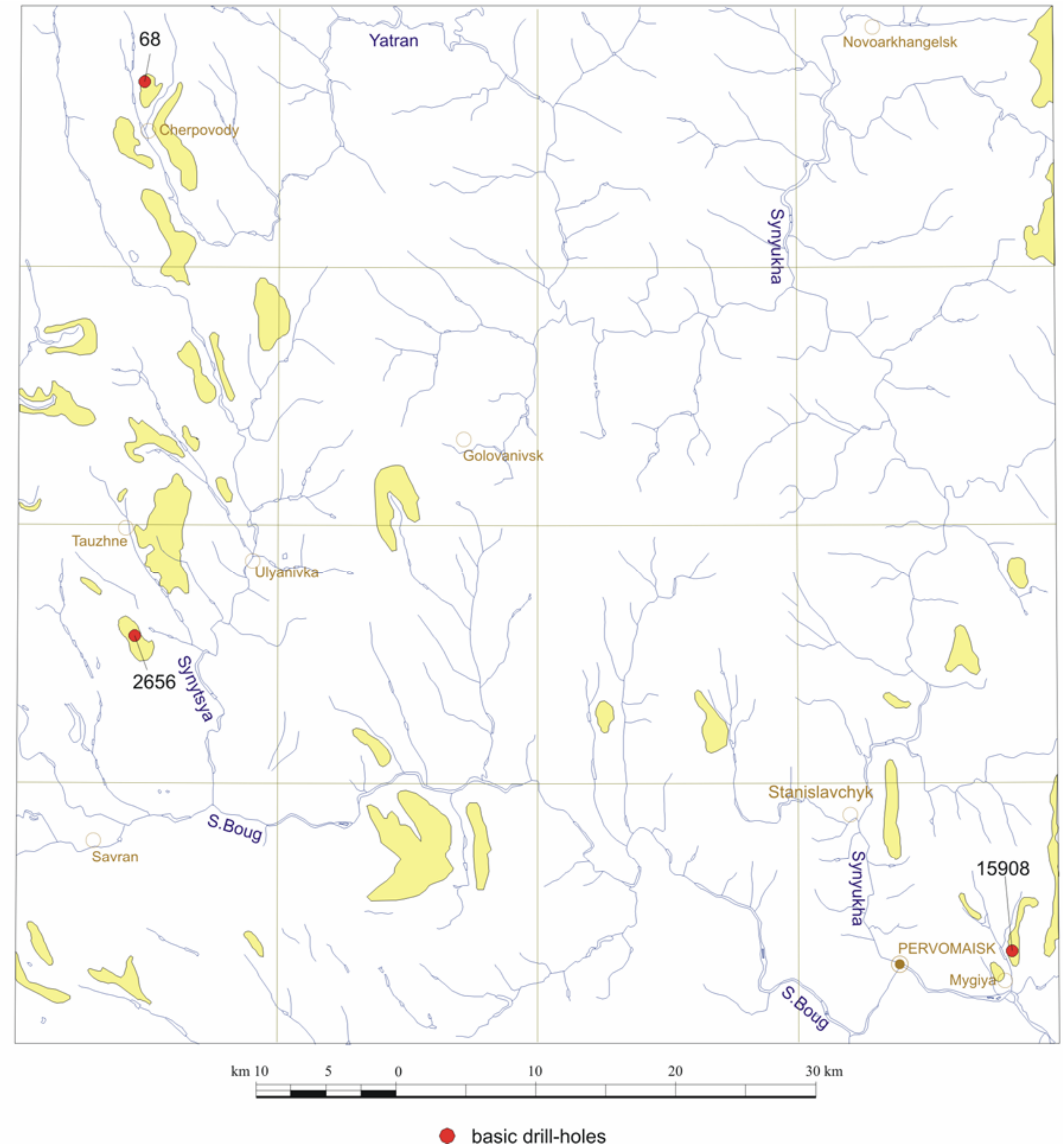

Fig. 2.11. Distribution scheme of Clayey Pile (N_1g) sediments.

Correlation of undivided Miocene-Pliocene sediments (Parti-coloured Sandy-Clayey and Parti-coloured Sand Piles) in the Northern LTZ is performed by analogy with the Baltska Suite rocks in the Southern LTZ.

Baltska Suite ($N_{1-2}bl$). In the territory of "Pervomaisk" map sheet the Baltska Suite rocks are developed exclusively in the Southern LTZ (Zabuzhzhya) (Fig. 2.13). M.T.Vadymov [9] had distinguished the Baltski sediments actually over entire map sheet territory where (after his data) the rocks comprise two-four repeating rock rhythms. V.A.Golubev [63] in the territory of adjoining map sheet "Novoukrainka" had distinguished the Baltski sediments in its far southern part only. V.M.Bondarenko [53] and V.V.Zyultsle [71] had considered the rocks of Baltska Suite as deltaic facies of paleo-valleys.

Correlation of parti-coloured sections over entire territory of the map sheet is very complicated. This is why the name “Baltska Suite” is remained for the parti-coloured rocks in the Southern LTZ without its further subdivision into sub-suites.

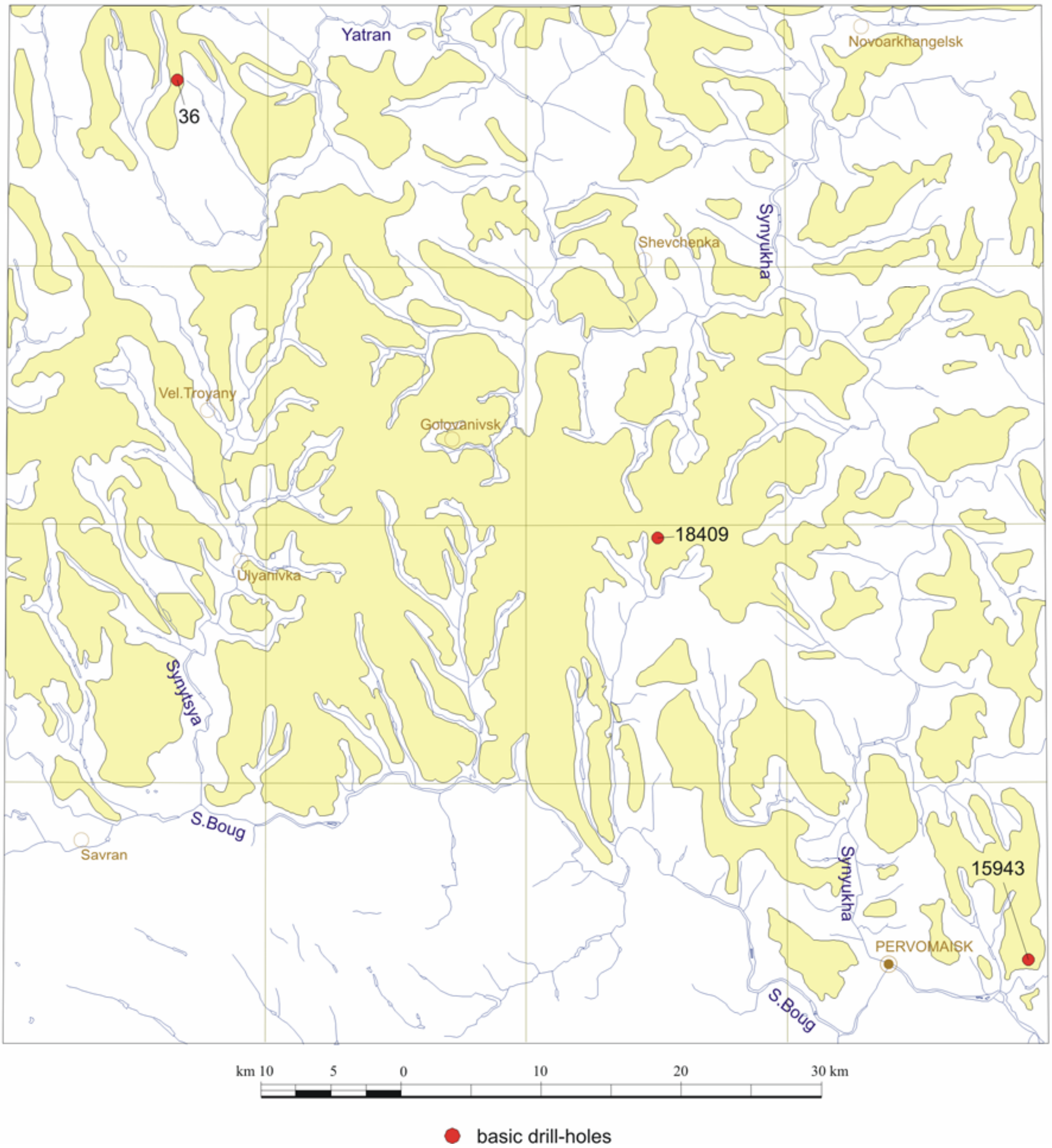

Fig. 2.12. Distribution scheme of Parti-coloured Sandy-Clayey Pile (N_{1-2}*pg*) sediments.

By lithology, in the lower part of Baltska Suite grey, yellowish-grey, non-carbonate clay rocks predominate, with interbeds of quartz, grey, yellowish, fine-grained sands. Higher in the section mainly the sands with minor clayey rocks occur. The sands are quartz, brown, reddish-brown, fine-medium-grained, with clayey cement, in places carbonate and iron hydroxide beans are observed. On approach to the overlaying pile of red-brown clays, the clayey material content increases in the section of Baltska Suite and the transition becomes gradual. This portion of the Baltskiy section by its stratigraphic position and composition is similar to the sections of undivided Miocene-Pliocene Parti-Coloured Sandy-Clayey Pile. The absolute heights of the Suite footwall are from 153.0 m (DH 786) to 80.0 m (DH 16951). Thickness varies from the first meters to 56.0 m (DH 16971). By genesis, the Baltski sediments are being considered as continental formations.

Thus, analysis of data available does not allow subdivision of the Baltski sediments without study and correlation of the sections over the map sheet L-36-I (Kodyma) and this is why we are obliged to show these rocks as undivided.

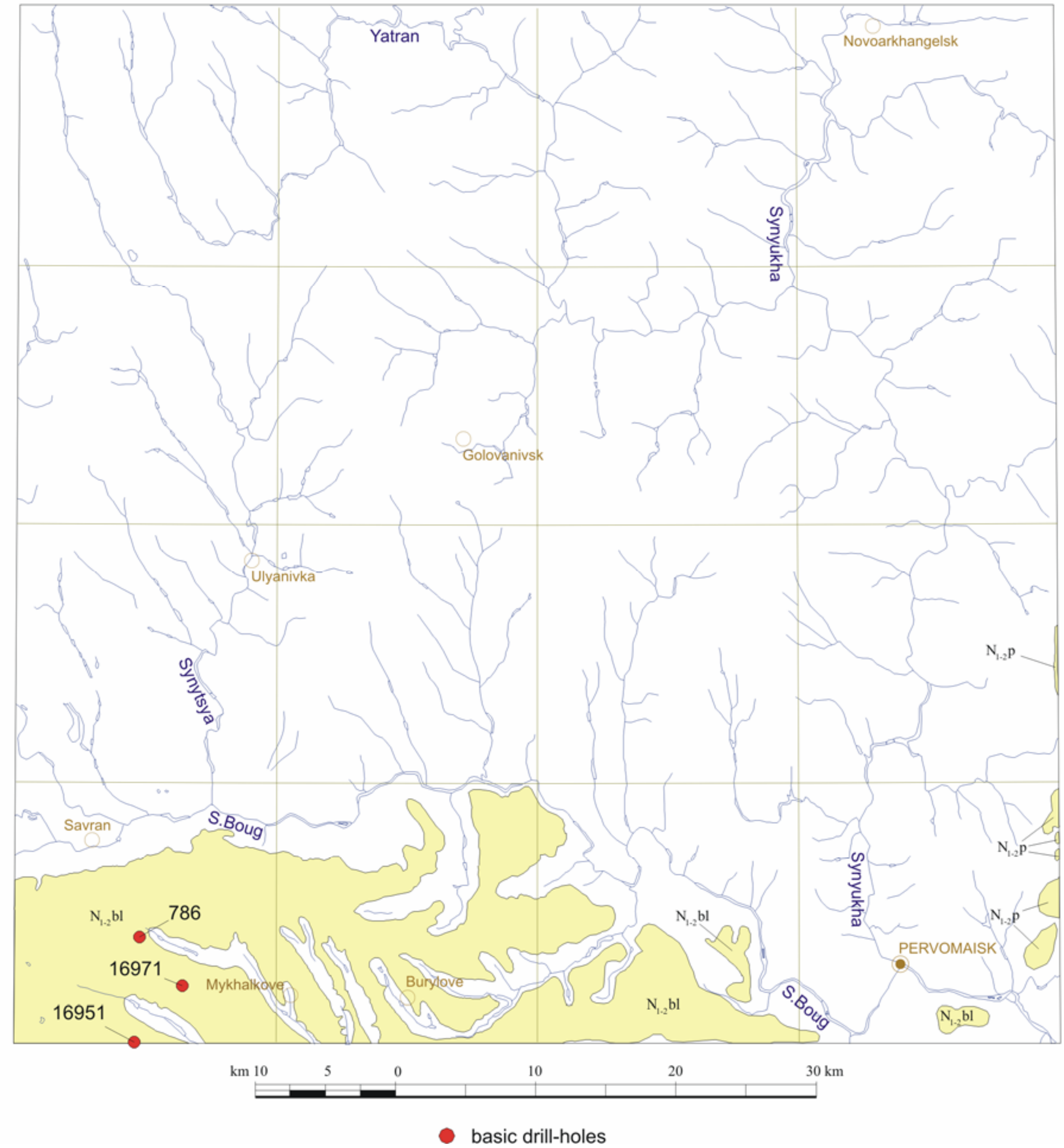

Fig. 2.13. Distribution scheme of Baltska Suite (N_{1-2}*bl*) and Parti-coloured Sand Pile (N_{1-2}*p*) sediments.

Pliocene Division (N_2)

Pile of Red-Brown Clays (N_2*čb*). The sediments are widespread over the map sheet territory and are mainly confined to the watershed areas and in the upper part of the plateau slopes (Fig. 2.14). The footwall level is about 206.0-208.0 m (DH 70, 95) in the north-western part of the map sheet, and 104.0 m (DH 5470) in the southern-east part. Thickness varies in the range 0.2-23.7 m. The Pile is composed of red-brown, viscous, sometimes sandy clays, with rare inclusions of carbonate, single coarse quartz grains, and beans of iron and manganese hydroxides. The rocks are overlain by Quaternary loams, and the rocks lie over Miocene sandy-clayey sediments or over the crystalline rock weathering crust.

The Pile is not characterized in term of paleontology. However, similar sediments were studied in the western part of Novoukrainskiy map sheet, in the area of Lysa Gora village where it was established the spore-pollen sets which includes the pollen of heat-loving pine-tree varieties, grassy plants etc. According to O.A.Sirenko [14], these sets are being correlated with the phyto-remnants of Upper Pliocene and Eo-Pleistocene sediments from Dniprovsko-Donetska Depression. The patterns of these sets suggest for the climate warming.

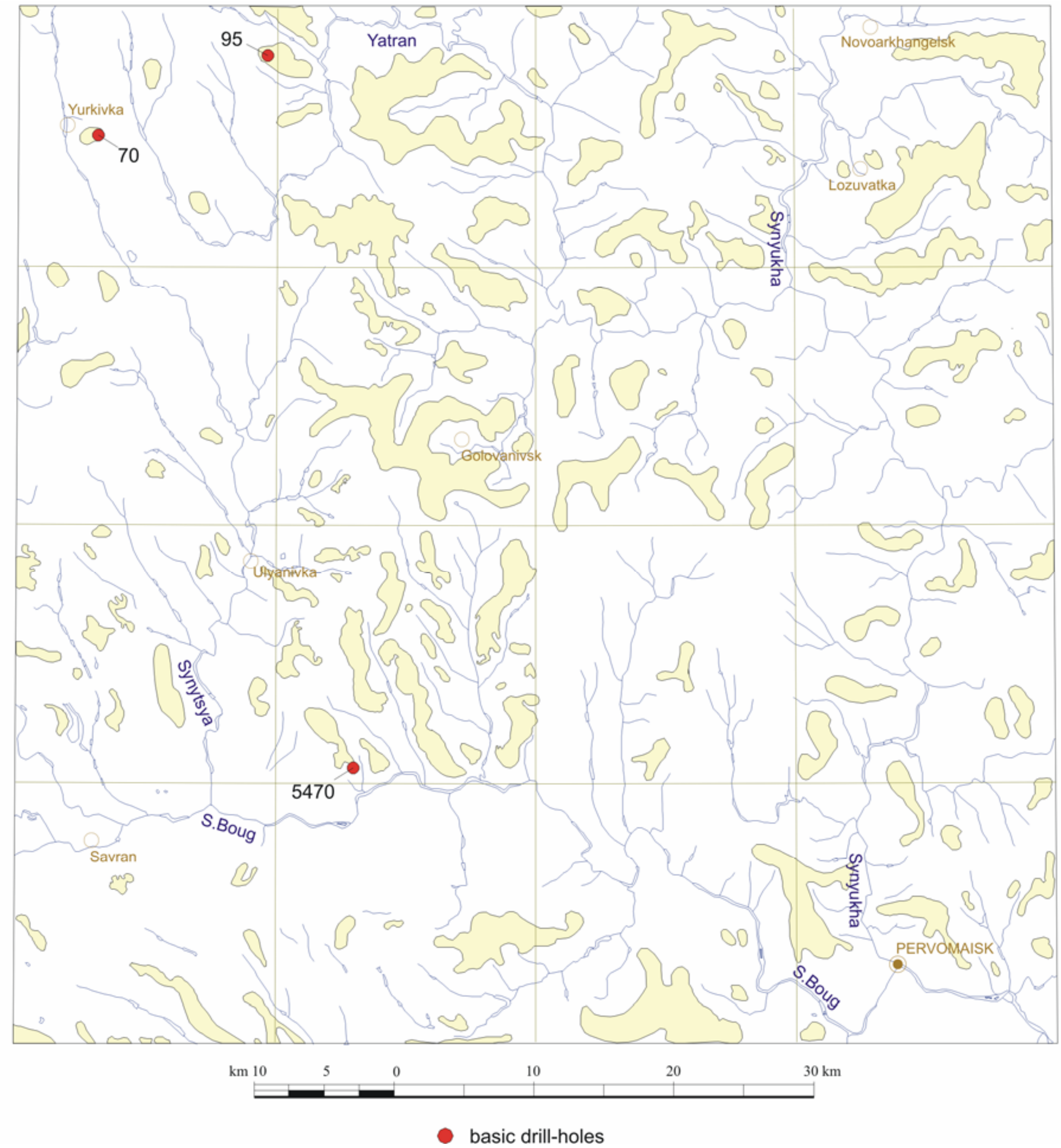

Fig. 2.14. Distribution scheme of the Pile of Red-Brown Clays (N_2*čb*) sediments.

Quaternary System

In the territory of the map sheet the Quaternary sediments are distributed almost completely. They do overlain with rather thick layer as the plates as the slopes. Thickness of the Quaternary sediments attains 22 m. Exceptions include some areas in the lower parts of river valleys and gullies where the hard rocks, mainly of Precambrian basements, are exposed. At the watersheds the Quaternary sediments somewhere overlie Neogene red-brown clays, often without stratigraphic break. At the river valley slopes the rocks overlie older ones, mainly Precambrian hard rocks. The study territory is located within northern loess area of back-glacier zone. By detailed earth-marking scheme [10], the study territory belongs to Inguletskiy area of South-Ukrainian loess sub-region (C-II-13-c). And only small part of the south-western corner of the map sheet partially encompasses Prydnisterskiy area (C-II-13-b) of the same sub-region [10]. Extended study of Quaternary sediments was performed on the ground of reconnaissance routes, investigation of 167 points of the own observations (outcrops and geomorphologic points), and two basic sections of Quaternary sediments, as well as description of core from 3127 drill-holes and of specimens from 120 exposures of previous works. In addition, there were used materials of the basic section for Middle Pobuzhzhya which was previously studied in this territory [6].

Subdivision of the Quaternary sections was performed up to stratons of climatolith rank. Unfortunately, majority (about 70%) of previous drill-holes in the upper part (2-6 m) were drilled without core uplift, and this made essentially harder the mapping of Quaternary cover. Despite of this, it was used the mapping stratons in compliance with the map scale. Each of subdivisions used for the map design is represented in the sections by repetition of the stratons of cold and hot stages, mainly loess and soil formations. Since the stratons of cold and hot stages display considerable lithological and facial differences, description of the major subdivisions is being provided by each straton (climatolith). Straton's characteristic is being provided along with the uniform scheme, mainly on the ground of additional and basic sections. Lithology sets are being added with analytic data obtained in the studies of the basic sections of Zavallya and Pervomaisk (current works), as well as "Aerial basic Quaternary section of Middle Pobuzhzhya" (1993). Besides the standard list of analyses (sporo-pollen, granulometric, bulk-chemical, spectral, water extraction, terrigenous mineralogy) it were also performed thermo-luminescent and paleo-magnetic researches.

Zonation of Quaternary sediments

The territory of Pervomaiskiy map sheet is located within the Inguletskiy area of South-Ukrainian loess sub-region. With its south-western corner the territory adjoins Prydnisterskiy area of the same sub-region.

It is characteristic to the territory predomination of soils over loess in the section of Quaternary sediments. By the patterns of lithology, internal structure and the relief, there are distinguished six major areas: A (north-western) – dome-shaped, high; B (central) – medium-height; C (north-east) – humpy medium-height with heavy-loam cover; D (western) – plane inclined; E (southern) – humpy inclined (in the southern margin); and F (eastern) – south-eastern low-height.

The areas A and E are characterized by relatively thin cover of Quaternary sediments. It is characteristic to the areas F and C more heavy-loam composition of the Quaternary cover. The area E is distinct in term of its non-uniform structure and with its western part the area, probably, partially belongs to the margin of Prydnisterskiy region. Prybuzki parts of all defined areas are characterized by extreme facial variability and attitude of the Quaternary cover; this is caused by wide development of alluvial processes under conditions of essential block differentiation of tectonic activities in the Southern Boug River valley.

Pleistocene Division

There are distinguished Eo-Pleistocene and Neo-Pleistocene Sections in the Pleistocene Division.

Eo-Pleistocene Section (E)

The sediments of Eo-Pleistocene Section form the own set of the facial complexes of which the mapping had revealed the following ones:

Alluvial sediments ($aE_{II}ng$). Alluvium of the IX(kr-il) terrace comprises sands, sandy loams, gravelous in places. These sediments are indicated in the sections only. They are known at the boundaries between Quaternary and Pliocene terraces. Thickness is 2-3 m.

Eluvial and aeolian-deluvial sediments (e,vdE) are rather widespread at the level of Pliocene terraces. In the areas X(bv-br) these sediments are thickest. They are completely absent in the river valleys and in gullies where they are wash off in later stages. Thickness is 1.5-5.0 m. The sediments include Berezanskiy, Kryzhanivskiy and Illichivskiy climatoliths which strongly differ by lithology, facial, paleo-geographic, paleontologic and physical properties. The major counterpart of the Eo-Pleistocene sections is Kryzhanivskiy climatolith. Berezanskiy and Illichivskiy climatoliths (cold stages) often are removed from the section, mainly due to re-working by soil-forming processes. Paleo-magnetic data suggest for mainly direct magnetization of the all Eo-Pleistocene stratons. They have the following characteristics.

Berezanskiy climatolith (E_Ibr) of cold stage is described in the facies v, ed, vd. It is comprised of clayey loess and soils, often with the signs of re-deposition and hydromorphism. Thickness is 0.2-1.0 m (often is absent). By lithology – clay or loam, heavy, often sandy, brown, light-brown, slivery and lumpy, in places with coarse (up to 20 cm) carbonate newly-formed aggregates (predominate in the upper part). It contains single pollen of the pine-tree – *Pinus Diploxylon* (spore-pollen analysis performed by T.B.Gubkina, SSPE "Geoinform"). In the rock does predominate quartz, and also feldspar occur, as well as traces of montmorillonite, hydro-mica, and kaoline; relatively low content of clayey (<0.001 mm) particles – 16.24-16-8%, and high of coarse (1.0-0.063 mm) ones – 41-59%; the ratio SiO_2/R_2O_5 – 9.0-13.6.

Kryzhanivskiy climatolith (E_{II}kr) does correspond to the warm stage; e, ed, comprises soil formations (pedo-complex of 2-3 soils) of sub-tropic type, sometimes with evidences for re-deposition; thickness 1-3 (normally 1.4) m (thickness is indicated mainly by outcrops). By mechanic composition this is the heavy loam or clay, often sandy, red-brown, reddish-brown, slivery, in places with coarse (up to 20 cm) carbonate newly-formed aggregates. Sporo-pollen sets comprise grassy (50-57%) and tree (40-46%) forms, with traces of spore (3-6%), with medium-heat-loving (*Morus, Rhus),* mesophyle grassy and aquatic (*Alismatacea, Sparganiacea*) elements. In the group of ancient rock the pine-tree pollen *Diploxylon* and *Haploxylon* predominates (19.6-23.3%); broad-leaved forms, however, are rather abundant: hornbeam (0.8%), oak (up to 4%), beech (0.8%) and others (hereafter after determinations by T.B.Gubkina, SSPE "Geoinform", and S.I.Turlo, Institute of Geography, Ukrainian National Academy of Science). In the sediments of Kryzhanivskiy paleo-cut (Pervomaiskiy basic section) there are found "in situ" the remnants of large *Bos sp*. In the rock, quartz predominates, also feldspar occurs, as well as traces of montmorillonite, hydro-mica, and kaoline; relatively high content of clayey particles – 50-52%, and coarse-grained ones – 11.9-17.6%; ratios SiO_2/R_2O_5 are relatively low – 4.0-4.8; reaction of the soil solution under water extraction (pH) is alkaline, from 8.4 to 8.8; total capacity of absorbing complex (AC) of exchangeable cations Ca^{2+}, Mg^{2+} Na^+, K^+ and H^+ is one of the highest for Pleistocene rocks – 36.2-38.4. By paleo-magnetic data the rocks display reverse magnetization (Matuyama epoch).

Illichivskiy climatolith (E_{II}il) does correspond to the cold stage; v, ed, vd comprises clayey loess and medium soil formations, often with evidences for re-deposition and hydromorphism; thickness 0.2-0.5 m (often is absent). By mechanic composition – clay or loam heavy, sometimes sandy, brown, light-brown, slivery and lumpy, in places with coarse (up to 12 cm) carbonate newly-formed aggregates, cut by the soil wedges. There is distinguished single pollen of pine-tree *Pinus Diploxylon* and linden *Tilia*. The clayey particles content in the rock is relatively low – 47.1-49.0%, and coarse ones is rather high – 7.6-13.8%; quartz predominates besides calcite and feldspar, with traces of montmorillonite, chlorite, kaoline, and hydro-mica; ratios SiO_2/R_2O_5 are relatively low – 4.4-4.6. The rocks display reverse magnetization (Matuyama epoch).

Eluvial sediments (eE_{II}kr). These ones are composed of Kryzhanivski soils; they are developed in the sites similar to e,vdE, but are characterized by complete lack of the cold-stage rocks. Thickness is 1-3 m. The general description of the rocks eE_{II}kr is provided above.

Eo-Pleistocene Section and Lower Neo-Pleistocene Branch (E-P_I)

Eluvial-deluvial and Aeolian-deluvial sediments (ed,vdE-P_I) are distributed in the areas, similar to the Eo-Pleistocene sediments. The complex is distinguished, specifically, through continuous mode of such stratigraphic combination, as well as due to the low quality of the primary data. It is comprised of soil formations, mainly of Kryzhanivskiy, Shyrokinskiy, Martonoskiy, and Lubenskiy stages, which somewhere are intercalated with thin non-soil rocks of Berezanskiy, Illichivskiy, Pryazovskiy, Sulskiy, and rarely Tyligulskiy climatoliths of cold stages (loess). The soil formations predominate in the sections. Thickness is 3-12 m. Description of individual stratons is being provided in the subdivisions Eo-Pleistocene Section and Lower-Neo-Pleistocene Branch.

Eluvial-deluvial sediments (edE-P_I) are known in the areas similar to those of (ed,vdE-P_1) but are represented exclusively by soil piles (characteristic of individual stratigraphic elements are given in respective sections). Thickness is 3-10 m.

Alluvial sediments (aE-P_I) are distributed over the VI, VII, VIII, IX and X terraces. The rocks include diverse-grained sands and sandy loams, layered, dense; at the bottom – more gravel-contained and less clayey. Thickness of alluvium is from first decimetres (for cut terraces of small rivers) to 10 m and a bit more meters (for superimposed terraces of Southern Boug River nearby Krasnenke village). For the small water flows these complex is defined due to its small size. For the Southerg Boug River this is caused by essential variability in thickness of sub-aerial cover of terraces, small-block (key-type) character of side-valley river parts, as well as buried (superimposed) terraces somewhere that make quite complicated the sediment tracing.

Lower Neo-Pleistocene Branch (P_I)

Lower Neo-Pleistocene Branch includes Shyrokynskiy, Martonoskiy, and Lubenskiy stratons of the warm stages, which are overlain respectively by Pryazovskiy, Sulskiy, and Tyligulskiy climatoliths of the cold stages. Within the map sheet the stratons comprise the single facies and combinations of facies of sub-aerial (loess-soil) and sub-aqueous (mainly alluvial) types. Of the climatoliths and their complexes the following are indicated in the map of Quaternary sediments:

Alluvial sediments (aP_I) are distributed in the upper portions of the steep valley slopes of the water flows. The complex include the sediments of three terraces – VI, VII, VIII, which are combined in the map due to relatively small width (even for Southern Boug River lower Lyushnevate village).

Alluvial and deluvial-aeolian sediments (a,dvP_I) are distributed within Early Quaternary terraces where alluvium is overlain by thin cover of Aeolian sands (loamy cover is absent). They comprise the sands and sandy loams, diverse-grained, layered, grey, brown-grey, and brown; at the top the rocks are non-layered and light-grey.

Eluvial-deluvial and aeolian-deluvial sediments (ed,vdP_I) are widely distributed but often are not exposed and are overlain by the younger rocks. These sediments are absent in the lower part of the steep valley slopes of the water flows and gullies. The rocks comprise former soils which are intercalated with loess, somewhere deluvial. Thickness attains 3.0-19.0 m. Higher the VIII(sh-pr) terrace this complex of stratons lies over Eo-Pleistocene rocks. The stratons that comprise these sediments do have the following characteristics.

Shyrokinskiy climatolith (P_Ish) does correspond to the warm stage; it is described in sub-aerial facies e and ed. It is represented by the soil formations (pedo-complex of 2-3 soils, somewhere the pile of pedo-complexes) of sub-tropic type, brown-colour range, in places with evidences for re-deposition; it is complicated by the soil wedges; thickness 1-7 (normally 1-3.5) m. By mechanic composition the clay or loam heavy, often sandy, reddish-brown to greyish-brown, prismatic, in places with mat sliding "mirrors", somewhere with carbonate newly-formed aggregates up to 10 cm in size. The pollen of trees predominates (60%); among these the pine-tree (*Pinus Diploxylon* – 20%) and broad-leaved (21%) are more abundant. Among the grassy forms, the motley grass pollen predominates; there are spores of the ferns *Polypodiacea* and algae remnants. The clayey particle (<0.001 mm) content in the rocks is relatively high – 48.0-51.7%, as well as coarse ones (1.0-0.063 mm) – 3.8-12.8%. Of minerals, quartz predominates, besides calcite, traces of feldspar, montmorillonite, chlorite, kaoline, and hydro-mica. Ratios SiO_2/R_2O_5 are relatively low – 3.2-4.5; pH is alkaline – 8.8; AC capacity – 36.9. Paleo-magnetic studies have revealed predomination of the reverse magnetization (Matuyama epoch).

Pryazovskiy climatolith (P_Ipr) does correspond to the cold stage v, ed, vd. It comprises loamy loess (the oldest "true loess") and medium soils (confined to the bottom); normally, strongly cut by the soil wedges and oversaturated with carbonate newly-formed aggregates (up to 10 cm in size); thickness 0.2-2.3 (normally 0.3) m; somewhere is absent; often is observed as carbonate interlayer. By lithology – heavy loam, brown-pale, brown, lumpy, slightly-porous. It is determined single pollen of pine-tree *Pinus Diploxylon* and linden *Tilia*. In the rock: clayey particles – 37.6-38.6%, course particles – 3.1-4.8%; quartz predominates over calcite and feldspar, there are traces of montmorillonite, chlorite, kaoline, and hydro-mica; SiO_2/R_2O_5 are relatively low – 4.4-4.6; pH is alkaline – 8.64; AC capacity – 36.2-38.4. The rocks do have reverse magnetization (Matuyama epoch). Thermo-luminescent analysis did not give positive result (out of method's detection limit).

Martonoskiy straton (P_Imr) does correspond to the warm stage; e, ed. It is represented mainly by pedo-complex of 2-3 soils of sub-tropic type, red-brown range, sometimes with evidences for re-deposition; thickness – 0.3-4.5 (normally 1.0-2.2) m. It is composed of heavy loam, reddish-brown to red-brown, prismatic, with carbonate newly-formed aggregates up to 6 cm in size. In the spore-pollen set there predominates the tree varieties pollen (up to 63%), mainly *Pinus Diploxylon* (up to 32%), and broad-leaved ones; bush forms are also known. Among the grassy forms the motley grass pollen predominates (up to 17%), there are found spores of the ferns, moss, horse-tails. There is rather high content of clay particles in the rock – 36.8-49.5%, and low content of coarse ones – 2.1-3.1%. Quartz predominates besides minor calcite, hydro-mica, feldspar, traces of kaoline and chlorite; ratios of SiO_2/R_2O_5 = 3.8-4.4; pH is alkaline – 8.8; AC capacity – 35.6. Paleo-magnetic study had revealed abnormal magnetization (mainly reverse).

Sulskiy climatolith (P_Isl) does correspond to the cold stage; v, ed, vd. It comprises loamy loess with medium soil counterparts (confined to the bottom); thickness 0.2-5.2 (normally 1.2) m. By lithology – heavy loam, brown-pale, dove-pale (loess), greyish-brown (soil), lumpy, weakly-porous, with carbonate newly-formed aggregates up to 2-3 cm in size. The pollen of grassy plants predominates (69%), mainly goosefoot (35%), Compositae up to 8%, nettle and rosane by 1%; sedges and labiate also occur. From the ancient forms the pine-tree predominates (up to 22%), then birch (up to 4%), and pussy-willow (up to 3%); single pollen of oak, elm, and maple occur. Some flora elements (*Pinus silvestris, Betula verrucosa, Alnus incana*) suggest for cold dry almost pre-glacial climate. Clay and coarse particles content is low – 23.6-27.0% and 1.7-6.7% respectively. Of minerals quartz predominates, then calcite, hydro-mica, feldspar, dolomite, traces of kaoline and chlorite; SiO_2/R_2O_5 = 5.1-6.4; pH is alkaline and variable – 7.8-9.1; AC capacity – 23.5-24.6. By thermo-luminescent analysis the age is: 200±20, 210±20 and 240±20 thousand years. It has the abnormal magnetization (transitional zone close to inversion Brunes-Matuyama).

Lubenskiy climatolith ($P_I$lb) does correspond to the warm stage; e, ed. It is represented mainly by pedo-complex of 2-3 soils, medium-sub-tropic, brown-color range, sometimes with evidences for re-deposition; thickness 0.3-3.2 (normally 1.2) m. It is composed of heavy loam, brown to greyish-brown (in arrow facies – brownish-dark-grey), lumpy, with carbonate newly-formed aggregates up to 2-4 cm in size. In the spore-pollen set there predominates the tree-type pollen (up to 54%), mainly *Pinus Diploxylon, P. Haploxylon* (up to 28%), and broad-leaved ones (hornbeam, beech, ash-tree by 0.9% each), among thermophyles – *Morus, Juglans*. The grassy forms include pollen of motley grass (up to 21%). There are found the spores of the ferns, moss, horse-tails. The rock contains the particles <0.001 mm – 37.9-44.9%, coarse ones – 1.9-3.1%. Of minerals quartz predominates, then traces of calcite, montmorillonite, feldspar, hydro-mica, and kaoline; SiO_2/R_2O_5 = 3.9-4.8; pH is alkaline – up to 8.7; AC capacity – 34.5. Paleo-magnetic studies had revealed abnormal magnetization (mainly normal – transitional zone close to inversion Brunes-Matuyama).

Tyligulskiy climatolith ($P_I$tl) does correspond to the cold stage; v, ed, vd. It comprises loamy loess and medium soil formations (confined to the bottom); thickness 0-0.5 m, normally it is absent due to re-working by the younger soil-forming processes. By composition the loam is heavy to medium, brown-pale, lumpy, weakly-porous, with carbonate newly-formed aggregates up to 2 cm in size. The pollen of grassy plants predominates (77%), mainly goosefoot (32%), herbs (up to 15%), Compositae (up to 16%). There are found nettle and buckwheat (by 1.6% each), crucifers and rosane (by 0.8% each). From the ancient (up to 23%) the pine-tree predominates (up to 19.4%), then birch (up to 2.5%), alder-tree and pussy-willow (by 1.6% each), single *Larix*. By spore-pollen set the climate is thought to be cold and dry. Clay particles (<0.001 mm) content is low – up to 11%, coarse one (1.0-0.05 mm) is high – up to 84%. Quartz predominates in the rock; SiO_2/R_2O_5 = 0.4.

Eluvial sediments (eP_I) are developed at the slope-side sites of the valleys and comprise soil piles (loess is absent). Thickness of the rocks is 3-8 m. Hereafter description of specific climatolith is given above in the sequence of the combined Lower-Neo-Pleistocene Branch P_I.

Aeolian-deluvial sediments of Pryazovskiy climatolith (vd$P_I$pr) are described in many sections. Pryazovskiy climatolith (and other particular climatoliths) are normally indicated in the cross-sections.

Eluvial sediments of Martonoskiy climatolith (e$P_I$mr) are widely distributed but are absent below the medium portions of the valley slopes.

Aeolian-deluvial sediments of Sulskiy climatolith (vd$P_I$sl). Are widespread over the territory and are well-prominent in the cross-section.

Eluvial sediments of Lubenskiy climatolith (e$P_I$lb). The rocks are rather widespread. They are formed with pedo-complex of 2-3 soils, dark-brown and dark-grey.

Aeolian-deluvial sediments of Tyligulskiy climatolith (vd$P_I$tl) are known occasionally (in paleo-cuts) in the section of the Lower-Quaternary sediments. Commonly they are completely re-worked by the soil-forming processes in Zavadivskiy stage.

Lower Neo-Pleistocene and Middle Neo-Pleistocene Branches (P_{I-II})

Alluvial sediments (aP_{I-II}) are distributed in the upper portions of the steep slopes of water-flow valleys. The complex includes the sediments of some terraces – III, IV, V, VI, VII, VIII, which comprise mainly the steep-slope portion of the water-flow valleys, or the complex of superimposed-side-wall terraces of Southern Boug River. The rocks include sands, sandy loams, diverse-grained, layered, dense; at the bottom gravel-contained. Alluvium thickness is from first decimeters (incised terraces of small rivers) up to 6-8 m. In the map these sediments are combined due to relatively small total width for the small rivers and even for most places along Southern Boug River, as well as small-block structure of its valley.

Alluvial and deluvial-aeolian sediments (a,dvP_{I-II}) are distributed within Early-Middle-Quaternary terraces where alluvium is overlain by the thin layer of aeolian sands (loamy cover is absent). The rocks include sands, sandy loams, diverse-grained, layered, light-grey, brown-grey and brown; at the top the sands are uniforn, non-layered, light-grey.

Eluvial and Aeolian-deluvial sediments (e,vdP_{I-II}). The rocks are widely distributed except the flood-side sites; somewhere are overlain by the younger cover.

The territory of distribution coincides with the distribution area of aP_{I-II} (except the sites with loamy cover). They are also distinguished in some sites of denudation slopes. Specific of this particular territory comprises continuity of the Lubensko-Zavadivskiy pedo-complex (Tyligulskiy climatolith re-worked) that caused necessity of such the complex introduction. Thickness is 5-14 m. Description of each Middle-Pleistocene straton of this complex is given below.

Middle Neo-Pleistocene Branch (P_{II})

The Middle-Neo-Pleistocene Branch includes Zavadivskiy and Kaydatskiy climatoliths (warm stages) which are overlain respectively by Dniprovskiy and Tyasminskiy climatoliths (cold stages). Within the map sheet they are represented by specific facies and complexes of facies of sub-aqual (mainly alluvial) and sub-aerial (loess-soil) types. In the purposes of mapping the following stratons are distinguished.

Alluvial sediments (aP_{II}, aP_{II}hd, aP_{II}čk) are distributed in the IV and V terraces of the water flows. They include sands, sandy and gravel loams, layered, non-dense. Thickness is 0.2-5.0 m.

Eluvial and aeolien-deluvial sediments of Middle Neo-Pleistocene (e,vdP_{II}) are distributed almost over entire map sheet and often conformably lie over the Lower Neo-Pleistocene rocks described above. The paleo-soils (Zavadivskiy, Kaydatskiy) predominate in the sections over the loess (Dniprovskiy and Tyasminskiy). The climatoliths are composed of loams, medium, light in places. Thickness varies from 2 to 9 m (in paleo-cut). Each climatolith of Middle Neo-Pleistocene Branch displays the own peculiarities described below in details.

Zavadivskiy climatolith (P_{II}zv) of warm stage is described in facies e, ed. It is represented by the compact pedo-complex of medium-sub-tropic type, red-brown-colour range. Somewhere it displays evidences for re-deposition. Thickness is 0.2-2.4 (normally 1.0) m. It is composed of loam, medium to heavy, light-reddish-brown to reddish-brown, lumpy, with carbonate newly-formed aggregates up to 3 cm in size. In the spore-pollen set there predominate the tree-type pollen (up to 57%), mainly *Pinus Diploxylon* and *Haploxylon* (до 21.8%), as well as broad-leaved (oak, hornbeam, beech, elm, maple, linden, ash-tree, mulberry-tree). Among grassy plants the motley grass pollen predominates (up to 17.7%); there also occur spores of fern and moss. The spore-pollen set does characterize the broad-leaved pine-tree landscapes. In the rock content of clay particles (<0.001 mm) comprises 39.6-43.1%, and coarse ones (1.0-0.063 mm) – 3.0-3.7%. Of minerals, quartz predominates, then calcite, feldspar, traces of montmorillonite, hydro-mica, and kaoline; ratios SiO_2/R_2O_5 = 2.0-4.6; pH is alkaline – 8.9; AC capacity – up to 37.8. Paleo-magnetic studies had revealed the normal magnetization.

Dniprovskiy climatoliths (P_{II}dn) does correspond to the cold stage; v, ed, vd. It comprises loamy loess and weakly-prominent soil formations (confined to the bottom); thickness 0.2-4.7 m, rather consistent by strike, somewhere is cut by the modern soil or modern surface. By lithology – medium loam, greyish- and brown-pale, dark-grey-pale (soil), lumpy, porous, with carbonate tubes. The grassy plant pollen predominates (71%), mainly goosefoot (up to 35.2%), Compositae (up to 11.2%), wormwood (up to 15%), herbs (up to 8.4%). From the ancient forms the pine-tree predominates (up to 26%), then birch (up to 4.2%), alder-tree (up to 2.8), pussy-willow (up to 0.9%). These relationships suggest for herd-wormwood-goosefoot steppes under conditions of cold dry pre-glacial climate. Clay particles content is 20.9-28.6%, coarse ones – 3.3-7.8%. Of minerals, quartz predominates, then calcite, traces of hydro-mica, dolomite, kaoline, and chlorite; SiO_2/R_2O_5 = 5.3-6.6; pH is alkaline variable – 8.7-8.9; AC capacity – 25.0-28.8. The age by thermo-luminescent analysis is 105±15 and 110±15 thousand years. It has the normal magnetization.

Kaydatskiy climatolith (P_{II}kd) does correspond to the warm stage; e, ed. It is represented by compact pedo-complex of medium-forest-steppe and steppe soils of brown-color range. Somewhere displays evidences for re-deposition and salinization. In pale-cuts often comprises the lower part of the section. Thickness is 0.3-1.1 (normally 0.6) m. It is composed of loam, medium and light, greyish-brown to brown (arrow soils are dark-grey), lumpy, slightly-prismatic, sometimes with carbonate newly-formed aggregates up to 1.5 cm in size. The pollen of tree-type predominates (up to 64%), mainly *Pinus silvestris* L. (up to 33.6%) and broad-leaved (oak – 4%, hornbeam – 0.6%, elm – up to 2.6%, maple – up to 1.8%, as well as pussy-willow and mulberry-tree). Among the grassy plants the pollen of motley grass (13.9%) and herb (up to 11.2%) predominate; also are abundant sedge, goosefoot, wormwood (by 2.7-3.7%), there are spores of fern, moss, horse-tail. The spore-pollen set does characterize the steppe and forest-steppe warm medium landscapes. In the rock, the clay fraction content is 19.8-30.5%, and coarse one – 4.6-6.4%. Of minerals, quartz predominates, then feldspar, hydro-mica, chlorite, traces of calcite, dolomite, and kaoline; SiO_2/R_2O_5 = 3.0-7.3; pH is alkaline – 8.6; AC capacity – up to 24.0. The age after thermo-luminescent analysis is 78±15 thousand years.

Tyasminskiy climatolith (P_{II}ts) does correspond to the cold stage; v, ed, vd. It comprises loamy loess; thickness 0.1 m, it normally is absent in the section due to re-working by later soils. By lithology – loam medium or lights, greyish- and brownish-pale, dark-grey-pale, lumpy, often porous, with carbonate concretions up to 1 cm in size. Clay fraction content is 27.9%, coarse one – 6.8%. Of minerals, quartz predominates; SiO_2/R_2O_5 = 5.8; pH is alkaline – 8.8; AC capacity – 27.1. The age by thermo-luminescent analysis is 80±10 thousand years.

Aeolian-deluvial sediments of Dniprovskiy and Tyasminskiy climatoliths (vdP_{II}dn and vdP_{II}ts) are distributed almost over entire the map sheet territory except the terraces younger than V(zv-dn) and IV(kd-ts) respectively. The sediments are indicated in the stratigraphic columns and in the scheme of Quaternary sediments subdivision.

Eluvial-deluvial sediments of Prylutskiy, Zavadivskiy and Kaydatskiy climatoliths ($edP_{II}zv$, $edP_{II}kd$) are distributed in the similar mode to $vdP_{II}dn$ and $vdP_{II}ts$.

Middle Neo-Pleistocene and Upper Neo-Pleistocene Branches (P_{II-III})

Alluvial sediments (aP_{II-III}, $aP_{III}tb$, $aP_{III}vl$, $aP_{III}ds$) are distributed within I-V terraces. The rocks include sands and sandy loams, gravelous, layered, non-dense. Thickness is 0.2-5.0 m.

Alluvial and deluvial-aeolian sediments (a,dvP_{II-III}) are distributed within Early-Middle-Quaternary terraces where alluvium is overlain by the thin cover of aeolian sands (loamy cover is absent). They comprise sands, sandy loams, diverse-grained, layered, grey, brown-grey and brown; at the top the sands are uniform, non-layered, light-grey.

Eluvial and aeolian-deluvial sediments (e,vdP_{II-III}) are distributed in the central and southern parts of the study area. They comprise mainly former soils and in less extent the loess of total thickness from 3 to 10 m. Description of particular climatoliths are given in the paragraphs of Middle- and Upper Neo-Pleistocene Branches.

Eluvial-deluvial sediments (edP_{II-III}) are distributed over the study area by the gully slopes, in pale-cuts, and in the river valleys. They comprise paleo-soil piles (loess is absent). Thickness of sediments varies from 2 to 6 m. Description of the counterparts is given in respective paragraphs.

Deluvial-aeolian sediments (dvP_{III}) comprise deflation facies distributed at the watershed sites in the right bank of Southern Boug River and in the left bank of Synytsya River. They are composed of sand and sandy loams, fine- and medium-grained, sorted, often re-worked by the modern soils (of sandy loam composition). Thickness is 0.1-0.5 m.

Upper Neo-Pleistocene Branch (P_{III})

This Branch includes Prylutskiy (pl), Udayskiy (ud), Vytachivskiy (vt), Buzkiy (bg), and Prychornomorskiy (pč) climatoliths.

Alluvial sediments ($aP_{III}tb$, $aP_{III}vl$, $aP_{III}ds$) are distributed within I-IV terraces. They are composed of sands, sandy loams, loams, layered, non-dense. Thickness is 0.2-5.0 m.

Eluvial-deluvial and aeolian-deluvial sediments (ed,vdP_{III}). Of these sediments the soil formations predominate. They are represented mainly by the former soils (loess is thin). Thickness of the complex varies from 0.4 to 4.5 m. Most widespread in the sections are Prylutski and Vytachivski former soils.

Prylutskiy climatolith ($P_{III}pl$) of the warm stage is described in the facies e, ed. It is represented by the compact pedo-complex of medium steppe soils of brown-color range. Somewhere it displays evidences for re-deposition and salinization. In the young paleo-cuts often comprises the middle portion of the section. Thickness varies from 0.1 to 2.7 m, normally – 0.3 m. It is composed of light loam, brownish-grey to dark-grey, lumpy, sometimes with carbonate newly-formed aggregates up to 1.5 cm in size. The spores and pollen comprise single elements of the pine-tree. The clay fraction (<0.001 mm) in the rock is 27.1-34.4%, coarse one (1.0-0.063) – 9.4-15.1%. Of minerals, quartz predominates, then feldspar, traces of hydro-mica, calcite, montmorillonite; ratio SiO_2/R_2O_5 = 4.6-5.7; pH is alkaline – 8.5-8.7; AC capacity – up to 33.3.

Udayskiy climatolith ($P_{III}ud$) does correspond to the cold stage; v, ed, vd. It comprises loamy loess; thickness 0.1 m, it often is absent in the section due to re-working by later soils. By lithology – light loam, greyish- and brownish-pale, lumpy, porous, with carbonate concretions 0.5-1.0 cm in size. It contains single pollen of the pine-tree, goosefoot, orach. Clay fraction content is 28.5-30.1%, coarse one – 7.0-11.9%. Of minerals, quartz predominates, then calcite, feldspar, hydro-mica, traces of kaoline; SiO_2/R_2O_5 = 4.7-6.6; pH is alkaline – 8.5; AC capacity – 32.0.

Vytachivskiy climatolith ($P_{III}vt$) does correspond to the warm stage; e, ed. It comprises the compact pedo-complex of medium steppe soils of brown-colour range. Somewhere it displays evidences for re-deposition and salinization. In paleo-cuts it is confined to the upper part of the section. Thickness varies from 0.1 to 1.6 m (in paleo-cuts), normally 0.4 m. It is composed of loams, light, brownish-grey to dark-grey, lumpy, sometimes with carbonate newly-formed aggregates up to 1.5 cm in size. The spores and pollen include single pine-tree elements. The spore-pollen set does characterize steppe warm medium landscapes. Content of the clay particles in the rock is 27.1-34.4%, coarse ones – 9.4-15.1%. Of minerals, quartz predominates, then feldspar, traces of hydro-mica, calcite, montmorillonite; SiO_2/R_2O_5 = 4.6-5.7; pH is alkaline – 8.5-8.7; AC capacity – up to 33.3. The age by thermo-luminescent analysis is 70±10 thousand years.

Buzkiy climatolith (P_{III}bg) does correspond to the cold stage; v, ed, vd. It comprises loamy loess; thickness from 0.1 to 1.5 m, it often is absent in the section due to re-working by the soil-forming processes of the subsequent paleo-stages; it is thick at II(vt-bg)-VI(kd-ts) terraces nearby Savran town. By lithology it is light loam, somewhere sandy (at young terraces), pale, lumpy, porous. It contains single pollen of the pine-tree and goosefoot. Clay particles content is 32.9-33.1%, coarse ones – 5.5-7.3%. Of minerals, quartz predominates, then calcite, feldspar, traces of montmorillonite, hydro-mica, and kaoline; SiO_2/R_2O_5 = 4.7; pH is alkaline – 8.5; AC capacity – 33.1 (description corresponds to the watershed sites).

Dofinivskiy climatolith (P_{III}df) does correspond to the medium-warm stage; e, ed. It is represented by pedo-complex of medium-cold steppe soils. At the watershed sites it is often absent (re-worked by the modern soil) or does occur in thin soil below the Holocene pedo-complex. Thickness is 0.1-0.3 m. It is composed of light loam, brownish-grey to light-grey, lumpy, with carbonate newly-formed aggregates up to 0.2 and 1.5 cm in size. The spores and pollen comprise single elements of pine-tree and goosefoot. The clay particles content is 32-36%, coarse ones – 5-6%. Of minerals, quartz predominates, then calcite, feldspar, traces of montmorillonite, hydro-mica, and kaoline; SiO_2/R_2O_5 = 4.7; pH is alkaline – 8.5; AC capacity – up to 33.0.

Prychornomorskiy climatolith (P_{III}pč) does correspond to the cold stage; v, ed, vd. It is represented by loess. Thickness is up to 0.2 m (commonly it is completely re-worked by the modern soil). It is composed by light loam, grey-pale, light-grey, lumpy, porous.

Aeolian-deluvial and eluvial-deluvial sediments (vd,edP_{III}). The Buzki loess predominates in the section. The sediments are locally distributed within the low-land terraces of Southern Boug River at Savran town. Thickness is 1.0-3.5 m.

Aeolian-deluvial sediments of Tyasminskiy, Udayskiy, Buzkiy, and Prychornomorskiy climatoliths (vdP_{III}ud, vdP_{III}bg and vdP_{III}pč). There are indicated in the stratigraphic columns and in the scheme of Quaternary sediment subdivision; the rocks are described above.

Eluvial-deluvial sediments of Prylutskiy, Vytachivskiy, and Dofinivskiy climatoliths (edP_{III}pl, edP_{III}vt, and vdP_{III}df) are indicated in some cross-sections. The rocks description is given above.

Upper Neo-Pleistocene Branch and Holocene Division (P_{III}-H)

Alluvial-deluvial sediments (adP_{III}-H) are distinguished for mapping the gully bottoms, and it was defined as the uniform (in facial and space respects) complex. It is represented by loams downward changing to sandy loams and sands. Thickness is 1-6 m.

Holocene Division (H)

Alluvial sediments (aH) are known in the flood-land of the water flows (could be indicated mainly out of scale). They comprise loams, sandy loams and sands, diverse-grained, at the footwall gravelous; total thickness 1-10 m.

Technogenic sediments (tH) are found in some places of the study territory. These are accumulative objects of artificial origin – the dumps of quarries, shafts, filtration fields, dams etc.

Tehcnogenic-aqual (lake-pond technogenic-caused) sediments (tlH). These include the sediments of the modern artificial water reservoirs (just the water reservoirs and ponds). They are represented by silt and mud of loamy and sandy loamy composition. Thickness is 0.5-6.0 m.

Eluvial sediments (eH) does correspond to the warm stage; e, ed. They are indicated in the cross-sections. The sediments are widely distributed forming almost consistent cover but are absent in the water reservoirs, at hard-rock outcrops, and at technogenic relief forms. They are represented mainly by black earth, deep, low- and medium-humus, light-, medium-, and heavy-loam composition. Thickness is 0.3-1.7 (normally 0.7) m. It is composed of light loam, grey to dark-grey, grained, nutty, somewhere with non-dense carbonate newly-formed aggregates up to 1.5 cm in size. The rock contains the pollen of grassy pants, goosefoot, wormwood, carnation. The clay particles (<0.001) content is 39.9%, coarse ones (1.0-0.063 mm) – 7.3%. Of minerals, quartz predominates, then feldspar, traces of montmorillonite, hydro-mica, and kaoline; ratio SiO_2/R_2O_5 = 4.7; pH is alkaline – 7.8; AC capacity – up to 31.6.

3. NON-STRATIFIED UNITS

These units comprise intrusive, ultra-metamorphic and metasomatic rocks. The ultra-metamorphic rocks are most widespread whereas metasomatic rocks occur in very limited amount. In general, the formation age boundaries of intrusive and ultra-metamorphic rock complexes are being grounded on the isotope dating results [38, 44] as well as studies of their relationships with the hosting stratigraphic subdivisions.

Intrusive units (AR_1)

In accordance with the valid "Correlation Stratigraphic Scheme of Ukrainian Shield" there are distinguished:

Proterozoic Acron
- Paleo-Proterozoic (PR_1)
  - Novoukrainskiy Complex (PR_1*nu*)
  - Raypilskiy Complex (PR_1*rp*)

Archean Acron
- Neo-Archean (AR_3)
  - Kapitanivskiy Complex (AR_3*kp*)
  - Derenyukhinskiy Complex (AR_3*dr*)
- Paleo-Archean (AR_1)
  - Sabarivskiy Complex (AR_1*sb*)

In the map sheet territory the massifs of mafic and ultramafic rocks are confined to the synform structures or to the zones of tectonic weakness.

Archean Acron

Paleo-Archean (AR_1)

Sabarivskiy Complex (ν-υAR_1*sb*) is actually not studied due to insufficient but in fact lack of the vigorous primary data. It was distinguished taking into account the tight association of mafic-ultramafic rocks mainly with the rocks of Tyvrivska Pile. The rocks of the Complex are being observed in small bodies and comprise gabbro-norites and pyroxenites. The mineral composition of the latter (%): orthopyroxene 70-75, clinopyroxene 5-7, actinolite 5-10, plagioclase 1-2, phlogopite 10-20. Accessory minerals: apatite, sphene, magnetite.

Neo-Archean (AR_3)

This age group includes mafic-ultramafic massifs combined into two complexes: Kapitanivskiy chromite-bearing (dunite-harzburgite formation) and Derenyukhinskiy (dunite-peridotite-gabbro-norite formation). The rocks of these complexes were studied in details by many authors [20, 40, 41, 42 and others].

According to O.B.Fomin [42], by geochemical characteristics the ultramafic rocks of these complexes can be considered as the oceanic ultramafic rocks.

Radiogenic age of the rocks is not determined yet.

Kapitanivskiy Complex (ν-σAR_3*kp*). The rocks of the Complex are mainly confined to Emylivska thrust zone which from the north-east is bounded by Emilivskiy Fault, and from south-west – by Kapitanivskiy Fault. The rocks of the Complex lie within the host units of Buzka Series and granitoids of Pobuzkiy Complex and occur as sheet-like and isometric bodies. The contacts with the host rocks are often tectonic.

According to [80], within serpentinized peridotites close to gneisses or granitoids there are often observed from first meters to 20 m thick orthopyroxene "zones" which on approach to granitoids are being changed by mica-rich bodies from some centimeters to 5 m thick. The maximum length of sheet0like bodies is up to 2,500 m, width – up to 300 m; isometric bodies are about 200 by 300 m in size. Most of the bodies steeply dip to the north-east. The rocks of the Complex form some massifs (Kapitanivskiy, Zavodskiy, Lypovenkovskiy, Lypnyagivskiy, Burtnyanskiy and others), of which, in turn, it can be distinguished a range of smaller intrusions, for instance, Lypovenkivskiy massif, bodies: Zakhidne, Skhidne, Pivnichno-Zakhidne, Pivdenno-Skhidne, Poshtove. It is characteristic to the massifs that they are chromite-bearing. And as a result of prospecting for chromite ores the rocks of the Complex are disclosed by a number of drill-holes. It was established that the rocks include dunites, harzburgites, in place lherzolites, olivine pyroxenites, vebsterites, and chromite bodies. Most of the rocks are in more or less extent serpentinized often up to formation of serpentinites.

Visually dunites and their serpentinized varieties are the massive, fine-medium-grained. Microtexture is panidiomorphic, in serpentinized varieties – fibrous, eyelet, platy. The rocks are composed of (%): olivine up to 90, orthopyroxene (enstatite) up to 5, chromite up to 8 (and up to 90 in the ore), serpentine, carbonate, magnetite (in grains and as magnetite dust), sulphides, spinel. According to [40], olivine mafic index is 7%.

Peridotites commonly in more or less extent are altered and serpentinized, amphibolized. As a result, their mineral composition varies widely (%): olivine 40-60 (f = 10), orthopyroxene (bronzite) 10-40 (f = 12), clinopyroxene (diopside) 0-30 (f = 7), serpentine 0-90, tremolite, pargasite, actinolite 0-6, carbonate, phlogopite, iddingsite, chromite up to 10, spinel ~ 5, sulphides. By external appearance these are fine- and medium-grained rocks, massive, dark-greenish-grey. Under microscope texture is hypidiomorphic (relic) with superimposed eyelet, platy.

Orthopyroxenites are known locally. These are greenish-grey, medium-fine-grained massive rocks. Mineral composition (%): bronzite (f = 10-12%) – 90, in altered varieties – 30, olivine 0-10, amphibole (tremolite-actinolite range, sometimes anthophyllite) 1-5 up to 50, phlogopite 0-15, serpentine 1-25, chlorite 0-8, carbonate 0-10, spinel – grains up to 25, chromium spinel 0-1 (and up to 50 in the ores), magnetite – grains up to 8, sulphides – grains up to 3. Orthopyroxene is mainly fresh and somewhere is replaced by serpentine and amphibole. Taking into account high content of SiO_2 (55-56%) and low content of Al_2O_3 (1.6-2.2%) in orthopyroxene, V.V.Zyultsle [80] had concluded that bronzite was formed under high pressure which, in view of ratio Al^{V1}/Al^{1V} = 0.66, had attained 15 Kbar (Lypovenky area, DH 1618), and from the ratio Ca/Ca+Mg = 0.5-0.9 temperature of its crystallization is estimated at least to 1000°C (DH 17g). These estimations indirectly suggest for the protrusive origin of the rocks.

By petrochemical data, apo-dunite and apo-harzburgite serpentinites belong to sub-alkaline series of the alkaline range, they are characterized by increased magnesium content and in the classification plot their point are being projected into the fields of lherzolites-harzburgites, rarely meimechites (apo-harzburgites) and dunite-olivinites, as well as in the transitional zone between dunites and harzburgites (apo-dunites).

Orthopyroxenites and vebsterites belong to sub-alkaline series of the alkaline range and in the classification plot are being projected into the fields of verhlites and vebsterites, while part of point falls into transitional zone between mentioned varieties.

By the forming conditions the rocks of Kapitanivskiy Complex belong to the mantle fractions of plate-margin collisions formed in the mixed geodynamic environments of middle-oceanic ridges, island arcs and continental rifts.

On the metallogenic plot MgO – [Fe_2O_3 + FeO] – CaO + Na_2O + K_2O (contours of chromite-bearing, nickel-bearing and titanium-bearing mafic-ultramafic complexes are shown after A.I.Bogachov, 1968) the points of dunites, harzburgites and their replacing serpentinites are tightly grouped in the field of chromite-bearing rocks and nearby this field. Pyroxenites and vebsterites fall into the field of nickel-bearing rocks and adjacent to this field although the points are not tightly spaced but are disseminated.

Derenyukhinskiy Complex (ν-υAR_3*dr*). The rocks of the Complex are disclosed by a number of drill-holes and are rather widely distributed within the map sheet forming relatively large massifs (Derenyukhinskiy, Demovyarskiy, Grushkivskiy, Kamyanobalkivskiy, Lyushnevatskiy) which attain the length up to 7 km and width 0.4-1.5 km [40]. Besides the mentioned massifs, in Pobuzka, Yatranska and Synytsivsko-Savranska sub-zones of Odesko-Bilotserkivska LTZ also occur a number of mush smaller massifs in the areas of Tarasivka, Troyanka, Sukhiy Tashlyk, Osychky, Chausove, Synyushniy Brid and other villages. Due to their small size some of these massifs are not shown in the map.

The rocks of the Complex in most cases lie as inter-layer bodies within the rocks of Buzka Series. Sometimes they also occur within granitoids of mainly Pobuzkiy Complex. According to O.B.Fomin [41], the gabbro-peridotite bodies of some massifs (Ternuvatskiy, Demovyarskiy) contain up to 50 m thick xenoliths of mafic gneisses and plagiogneisses.

In contrast to the ultramafic rocks of dunite-harzburgite formation (Kapitanivskiy Complex), the massifs of dunite-peridotite-gabbro-norite formation are being characterized by significant differentiation. Quantitative relations between the rock varieties are not consistent from one massif to another. Gabbroid rocks (gabbro-norites, norites, often amphibolized in various extents) are most widespread whereas peridotites (verhlites, lherzolites, harzburgites) are less developed. Dunites are subordinate and their content in the massifs does not exceed 10%. Among pyroxenites I.S.Usenko [40] had distinguished hypersthenites, bronzitites, vebsterites, and diallagites. Of these varieties, hypersthenites are most widespread. The contacts of gabbroid rocks with peridotites are mainly sharp, and with pyroxenites are often gradual. According to Yu.K.Piyar [86], at the contact of mafic-ultramafic rocks with gabbroid rocks there are observed 5 m and sometimes 10 m thick sulphides mineralization zones.

The rocks of the Complex are extensively altered; mainly these are already apo-dunite and apo-peridotite serpentinites, gabbro-amphibolites, amphibolites. Degree of rock alteration depends on the body size, their position and tectonic breaking. The small bodies and marginal parts of the massifs are commonly more altered.

According to Yu.K.Piyar [86], unaltered dunites are observed in Ternuvatskiy, Skhidno-Lyushnevatskiy, and Grushkivskiy massifs where these rocks occur in the central and bottom parts within serpentinized peridotites. These are dark-grey almost black rocks, medium-fine-grained, with panidiomorphic micro-texture. They are composed of (%): olivine (f = 8-13%) ~95, orthopyroxene ~3; secondary minerals: serpentine, actinolite, carbonate, brucite. Accessory minerals: apatite, spinel. Gangue: chromite, magnetite, chromium spinels, pyrrhotite, chalcopyrite, pyrite, pentlandite, millerite.

Of peridotites, the harzburgites are most widespread and in much less extents – lherzolites. Both rock varieties are altered in various extents. Mineral composition (%): olivine (f = 10-14%) up to 70, orthopyroxene (f = 12-22%) up to 45, clinopyroxene (f = 10-18%) up to 65, spinel up to 12, magnetite up to 8, sulphides. Secondary minerals: serpentine, hornblende, actinolite, sometimes tremolite, iddingsite, chlorite, carbonate. Under extensive serpentinization the rock transforms into apo-peridotite serpentinites with sheeted, eyelet-like, fibrous micro-textures.

Pyroxenites form the marginal part of the massifs are observed as vein-like bodies [41]. These are dark-grey almost black rocks, medium- and coarse-grained, with hypidiomorphic micro-texture, sometimes with elements of poikilitic. Mineral composition is rather variable (%): olivine up to 35, orthopyroxene up to 80, clinopyroxene up to 80, spinel up to 10, hornblende and actinolite up to 40, serpentine up to 10, biotite, chlorite, carbonate; gangue minerals.

The mafic rocks are mainly norites and gabbro-norites. Somewhere vein-like bodies of anorthosites occur. Visibly the gabbroids are dark-grey with greenish shade rocks, medium-coarse-grained, massive, banded, spotty, sometimes unclear schistose. Micro-texture is gabbroid, often with elements of granular. It is characteristic considerable variations of the rock-forming mineral content (%): plagioclase (mainly labrador) 40-95, orthopyroxene (hypersthene, f = 28-49%) – grains up to 50, clinopyroxene (diopside, f = 41%), hornblende (almost always with brownish shade) 0-55. Accessory minerals: apatite, zircon, sphene. Gangue: magnetite, titanium magnetite, sulphides.

By petrochemical characteristics, the apo-harzburgite and apo-verhlite serpentinites belong to sub-alkaline and calc-alkaline series of the alkaline range; pyroxenites and gabbroids – to the tholeiite and sub-alkaline series of sub-alkaline range. Apo-harzburgite serpentinites in the Le Maitre plot partially fall into komatiite field.

By the forming conditions, the rocks under consideration belong to the mantle fractions of plate-margin collisions formed in the mixed geodynamic environments of island arcs and continental rifts. In the metallogenic plot the points of pyroxenites are being placed in the field of nickel-bearing rocks; the points of apo-peridotite serpentinites and peridotites – in the fields as of chromite-bearing as of nickel-bearing rocks, and the point of dunites – in the field of chromite-bearing rocks.

Proterozoic Acron

Paleo-Proterozoic (PR_1)

Raypilskiy Complex (vPR_1rp). The rocks of the Complex are very locally distributed. They are observed in the areas of Bogdanivka and Kalmazovo villages (outcrops 188, 130) as thin (1-5 m) dyke-like bodies and remnants within granitoids of Kirovogradskiy Complex. Commonly these rocks are tectonized in various extents. Within the map sheet the rocks of the Complex include gabbro, gabbro-norites, partly amphibolized, often with the zones of mica development (biotite, phlogopite). Somewhere blastesis is observed (nest-like aggregates of plagioclase-pyroxene composition. In outcrop # 130 in some footwall places of the dyke-like body the rocks are extensively carbonatized and silicified. Macroscopically gabbroids are fine-grained, sometimes irregularly-grained, dark-grey, massive. Under microscope texture is gabbroid, blastic-gabbroid. Mineral composition (%): plagioclase (andesine, labrador) 45-55, orthopyroxene (partly replaced by amphibole) 1-15, clinopyroxene (also partly replaced by amphibole) 15-30, hornblende 5-10, biotite (mainly by mica zones) up to 20. Secondary minerals: calcite, sericite, saussurite. Accessory minerals: apatite 1-3, zircon. Gangue: magnetite, sulphides, hematite 2-5. Physical properties: $\sigma = 2.92 \div 3.17$ g/cm^3, æ = $764 \div 12827 \cdot 4\pi \cdot 10^{-6}$CI.

The age boundaries of the rocks of this Complex are not determined yet.

Novoukrainskiy Complex (PR_1*nu*). In the south-eastern corner of the map sheet (Bratska Sub-Zone of Ingulo-Inguletska LTZ) there is observed small portion of the granite massif. The rocks are sub-alkaline, leucocratic, trachytoid, with minor content of biotite, orthopyroxene and garnet (γ_3PR_1*nu*). By analogy with the territory neighbouring from the east where alkaline granites are more widespread, the rocks are defined as representatives of Novoukrainskiy Complex.

Ultra-metamorphic units

In accordance to the valid "Correlation Stratigraphic Scheme of Ukrainian Shield", the general age layout looks as follows:

Proterozoic Acron
- Paleo-Proterozoic Aeon (PR_1)
  - Kirovogradskiy Complex (PR_1*kg*)
  - Umanskiy Complex (PR_1*um*)
  - Pobuzkiy Complex (PR_1*pb*)

Archean Acron
- Neo-Archean Aeon (AR_3)
  - Tetiivskiy Complex (AR_3*tt*)
  - Litynskiy Complex (AR_3*lt*)
- Paleo-Archean Aeon (AR_1)
  - Gaivoronskiy Complex (AR_1*gv*)

And below is given the description of the ultra-metamorphic complexes (upward).

Archean Acron

Paleo-Archean (AR_1)

Gaivoronskiy Complex (AR_1*gv)*. The rocks of the Complex are distributed over almost entire study territory. They are lacking in the Umanska Sub-Zone only. The rocks are disclosed by drill-holes and also are exposed along the rivers Yatran, Southern Boug, and Synyukha. The rock distribution coincides with the mosaic medium-intensity magnetic field. Commonly the rocks are being observed in strip-like remnants with irregular boundaries, and very often in association with mafic gneisses of Dnistersko-Buzka Series (mainly Tyvrivska Pile which is being replaced by these rocks) within granitoids of Pobuzkiy Complex. In some places enderbites had undergone high-temperature potassium metasomatism, apparently, related to the influence of mentioned granitoids of Pobuzkiy Complex, and by composition are close to charnockites. In zones of extensive tectonism and re-crystallization the enderbites gets granulite-like appearance. Enderbites strongly predominate in the Complex, with minor diorite-enderbites, plagiogranites with pyroxene and garnet grains, migmatite-enderbites. Visually the varieties are similar and differ one from another by the rock-forming mineral content only, mainly quartz and opaques. These are greenish-grey, irregularly-grained (mainly medium-grained), banded, gneiss-like rocks. Micro-texture is hypidiomorphic, heterogranoblastic (in altered varieties). Mineral composition (%): plagioclase (andesine, oligoclase-andesine, with frequent anti-perthites) 40-70, potassium feldspar 0-10, quartz 10-30, orthopyroxene (f = 34-52%) 5-20, diopside (f = 32-34%) 0-10, hornblende (f = 44-48%), after pyroxene) 0-5, biotite (with titanium content up to 5%) 0-5, garnet 0-5. Accessory minerals: zircon, apatite, monazite (in K-feldspatized varieties). Gangue: ilmenite, sulphide, sometimes magnetite. According to I.M.Lisna [26] and I.B.Shcherbakov [98], in the enderbites under consideration there are defined four zircon varieties, in contrast to the enderbites of Litynskiy Complex where two only are found. Physical properties: $\sigma = 2.56 \div 2.75$ g/cm^3, æ = $3209 \div 5432 \cdot 4\pi \cdot 10^{-6}$CI.

By petrochemical composition the enderbites of this Complex belong to the calc-alkaline series of sub-alkaline range. In the $Na_2O+K_2O–SiO_2$ plot the points are widely disseminated and encompass the fields of from quartz diorites, quartz monzonites, tonalites to granites (few points). By the relation K_2O-SiO_2 the enderbites in most cases belong to medium-potassium, sometimes – low-potassium.

By content of the trace elements, the enderbites of this Complex somewhat differ from the similar rocks of Litynskiy Complex (see below). They contain (in g/t): rubidium 43, lithium 22, niobium 6, zirconium 76, strontium 541. By the REE spectrum and some element ratios (Eu/Eu^* = 1.1-1.8, La/Yb = 2-6) they do not differ from the Gaivoronskiy Complex enderbite petrotype.

In the territory adjoining from the west, the rocks of the Complex yield geochronology dating to 3400 Ma [46].

Neo-Archean (AR_3)

Litynskiy Complex (AR_3*lt*). I.B.Shcherbakov et al in 1987 had separated this Complex from Berdychivskiy Complex. In the territory of the map sheet these rocks are locally distributed and are disclosed by few drill-holes as well as studied in some outcrops along Southern Boug River in the area of Kosharo-Oleksandrivka village. The rocks are confined to the Lupolivska antiform structure. In the marginal parts of the latter are observed gneiss-like two-pyroxene enderbites which further to the centre of structure are changed by massive rather uniform orthopyroxene enderbites with granite texture. These latter rocks are being considered to be the locatype (local petrotype) of the Complex.

The rock substrate of this Complex was mainly enderbites of Gaivoronskiy Complex, and, in much lesser extent, metamorphic rocks of Dnistersko-Buzka Series which are observed in diverse-size remnants within enderbites of Litynskiy Complex. The contacts are normally unclear, gradual, with a range of transitional varieties. By physical properties the rocks do not differ from the enderbites of Gaivoronskiy Complex.

Enderbites of Litynskiy Complex comprise massive, sometimes gneiss-like, medium-grained, grey and greenish-grey rocks with granite and blastic-granite texture. Mineral composition (%): plagioclase (andesine) 75-78, quartz 10-15, pyroxene (ortho- and clino-) 5-7, and in massive enderbites orthopyroxene only 2-10, sometimes biotite up to 1, garnet up to 5. Accessory minerals: apatite up to 1%, monazite – single grains, zircon – single grains, zoned, elongated-prismatic. Gangue: magnetite, ilmenite – up to 1%. Mafic index of orthopyroxene 50-54%, biotite – 50-52%; plagioclase grains are saturated with anti-perthites.

In the Middlemost plot ($Na_2O+K_2O–SiO_2$) the enderbite points of this Complex fall into the fields of quartz diorites and in transitional zone of quartz diorite-tonalite, and in the Le Maitre plot the rocks belong to the low-potassium rocks, in contrast to the rocks of Gaivoronskiy Complex where medium-potassium rocks predominate.

Geochemical characteristics of Litynski enderbites differ from those of Gaivoronskiy Complex enderbites [86] by content of zirconium (149 g/t), strontium (236 g/t), lithium (16 g/t), niobium (12 g/t), and lead (20 g/t).

In REE distribution there is observed clear enrichment in light REE on the background of prominent positive europium anomaly.

From the enderbites of this Complex (outcrop 342) by U-Pb zircon isochrone there is obtained the dating to 2838 Ma that corresponds to Neo-Archean [38].

Tetiivskiy Complex (AR_3*tt*). At the present erosion level the granitoids of the Complex are distributed in Umanska, Yatranska, and Synytsivsko-Savranska Sub-Zones of Odesko-Bilotserkivska LTZ. In Pobuzka Sub-Zone they are almost completely lacking and are observed only in Vradievskiy Transitional Block where these rocks are known in the remnants of irregular shape and insufficient size being preserved from extensive potassium granitization related to the granitoids of Pobuzkiy Complex.

The granitoids of Umanskiy and Pobuzkiy Complexes reomorphically replace the plagiogranitoids and the contacts between the rocks are gradual. Similar relationships are found with the enderbites which undergone influence of Tetiivskiy Complex plagiogranites. In turn, in plagiogranites there are observed the remnants of biotite and amphibole-biotite plagiogneisses and amphibolies, and the contacts in this case are mainly sharp, sometimes with reaction rims around the remnants.

In the Yatranska Sub-Zone plagiogranites are thought to be retrograde whereas in Synytsivsko-Savranska Sub-Zone and in Vradievskiy Block these are progressive formations which do granitize the rocks of Rosynsko-Tykytska Series except semi-isomorphic massif located in the far south-western corner of the map sheet.

The rocks of the Complex comprise plagiogranites and plagiomigmatites and migmatites of diorite composition.

Plagiogranites and plagiomigmatites are biotite, sometimes with amphibole or garnet (pγmAR_3*tt*). The varieties with garnet are known mainly from the Yatranska Sub-Zone. Visually the rocks are grey, light-grey, in K-feldspatized varieties with pink shade, fine-, medium-, and sometimes coarse-grained, massive and coarse-banded, in places with single porphyry-like plagioclase tables. Micro-texture is granite (in granites), lepidoheterogranoblastic, heterogranoblastic with elements of cataclastic. Mineral composition (%): plagioclase (oligoclase, oligoclase-andesine) 45-55 (in migmatites) and 60-70 (in plagiogranites), quartz 25-40, potassium feldspar 0-10, biotite 3-8 (in plagiogranites) and 15-20 (in plagiomigmatites), hornblende up to 1. Accessory minerals: apatite, zircon, in places tourmaline (in metasomatically altered rocks in the area of Maiske gold deposit), garnet up to 3. Gangue: magnetite up to 1, ilmenite, sulphides up to 2. Secondary minerals: carbonate, chlorite, muscovite. Physical properties: $\sigma = 2.65 \div 2.71$ g/cm^3, æ = $20 \div 730 \cdot 4\pi \cdot 10^{-6}$CI.

Plagiomigmatites of diorite composition (δmAR*tt*) differ from granitoids described above by much lower (3-5%) quartz content and relatively high (10-20%) hornblende content.

It is characteristic to the rocks of this Complex the lacking of ore geochemical anomalies while the trace-element content is close to the clarke (background) one.

In the Debon Le Forta plot the Complex granitoids points are rather tightly being projected into the fields of tonalites and adamellites and only some point fall into the field of quartz monzonites.

Radiogenic age of the Complex granitoids is about 2600 Ma (The Legend of Central-Ukrainian Series of Derzhgeolkarta-200, 1996).

Proterozoic Acron

Paleo-Proterozoic (PR_1)

Pobuzkiy Complex (PR_1*pb*) is widely distributed and is absent in the Umanska Sub-Zone only. Most widespread the rocks are in the Pobuzka Sub-Zone where they comprise almost 60% of the territory and form distinct “matrix” where metamorphic rocks of Dnistersko-Buzka Series as well as ultramafic and granitoid rocks of the older complexes are observed. In other sub-zones these are irregular, sometimes dome-shaped and strip-like bodies with quite unequal (bay-like) boundaries. Granitoids of the Complex are disclosed by numerous drill-holes and are also studied in outcrops along Southern Boug and Yatran Rivers as well as branches of Synyukha River. The rocks are tightly associated with metamorphic rocks of Zelenolevadivska and Pavlivska Piles, in lesser extents – with the rocks of Buzka Series which are in various extents being granitized by them (depending on the composition).

The major counterparts of the rock association in the Complex are a p l i t e - l i k e l e u c o g r a n i t e s a n d m i g m a t i t e s (ίργmPR$_1$*pb*), which by some evidences can be considered as para-autochthonous members of the Complex. Less developed are banded and shadow l e u c o g r a n i t e s a n d m i g m a t i t e s (γmPR$_1$*pb*), which are controlled by magnetic anomalies with amplitudes up to 100-200 gamm, are clearly prominent in the potential fields and display some evidences of the autochthonous counterparts. By periphery of enderbite massifs there are known single c h a r n o c k i t e bodies (čPR$_1$*pb*), which are considered to be retrograde granitoids formed in the enderbites of Litynskiy and Gaivoronskiy Complexes.

Leucogranites and their migmatites are in general characterized by strong variations in quantitative relations of the rock-forming minerals (in addition, they are often of several morphologic types), texture diversity and, in most cases, gneiss-like obscured parallel-banded structures. The latter are caused by thin (2-5 mm in average) commonly lens-like, parallel, essentially quartz and feldspar bands. Granitoids of the Complex are subdivided into two rock groups: 1) aplite-like and aplite-pegmatoid leucogranites and migmatites comprising all varieties of leucogranites, and 2) charnockites.

A p l i t e - l i k e a n d a p l i t e - p e g m a t o i d l e u c o g r a n i t e s a n d m i g m a t i t e s (ίργ, ίργm, γmPR$_1$*pb*) visually are pinkish-light-grey, greyish-pink, pink, sometimes with red shade, fine-medium-grained, in places up to coarse-grained pegmatoid. Micro-texture is quite irregular and actually comprises combination of various textures: granite and aplite-like, granite and granoblastic, sometimes heteroblastic. Often granular and pegmatoid textures are observed. Sometime single potassium feldspar porphyryblasts occur. Mineral composition (%): plagioclase (oligoclase, albite) 15-30, sometimes up to 50, and in varieties with meso-perthite it comprises 3-5, potassium feldspar (orthoclase, meso-perthite with unclear twin lattice by grain boundaries, microcline) 5-50, quartz 30-45, orthopyroxene 0-3, sometimes 7-10, biotite – single plates up to 3, garnet and sillimanite 0-10 (mainly in varieties with meso-perthite). Accessory minerals: apatite, zircon, spinel (in intergrowth with magnetite), anatase – up to 1 (in varieties with meso-perthite only), ilmenite, sulphides. Sometimes in granite varieties with meso-perthite there are observed cordierite grains. Physical properties: $\sigma = 2.54 \div 2.75$ g/cm^3, æ = $1 \div 277 \cdot 4\pi \cdot 10^{-6}$CI.

In the Na_2O+K_2O-SiO_2 plot the points of granites under consideration fall into the field of granites and the border zone of granites – alkaline granites, the points of banded migmatites – into granite field, and their single points – into the fields of monzonites and granodiorites.

By geochemical features the leucocratic granites are characterized by higher-clarke values (exceed the clarke value in g/t respectively by factor of): scandium – 1.4, zirconium – 1.6, lead – 1.5, copper – 1.1.

C h a r n o c k i t e s (čPR$_1$*pb*) are being observed mainly at the boundaries between leucogranites and enderbites and form the lens-like and irregularly-shaped bodies with unequal borders, 1 by 0.5 by 0.8 km in size in average. Much smaller bodies also occur but they cannot be indicated in the map of defined scale. Most widespread charnockites are in Pobuzka Sub-Zone (area of Danylova Balka, Svirneve, Goloskovo, Novosilka and other villages). The contacts with the rocks they do replace are normally gradual.

Macroscopically charnockites are grey, pinkish-grey, sometimes greenish-grey, medium- and coarse-grained, massive, sometimes with elements of banding getting migmatite-like appearance. Under microscope texture is heteroblastic, granite, and hypidiomorphic (area of Pidvysoke, Troyanka and other villages). Mineral composition (%): plagioclase 30-50 (oligoclase-andesine, andesine often with anti-perthites of dissociation and replacement), potassium feldspar 10-20 (besides non-regulated, sometimes granulated grains also microcline with clear twin lattice occurs), quartz 15-25, orthopyroxene (f = 34-40%), clinopyroxene (f = 18-22%) – sometimes occurs in Yatranska Sub-Zone, biotite up to 15, garnet. Accessory minerals: apatite, zircon, monazite, ilmenite. Physical properties: $\sigma = 2.69$ g/cm^3, æ = 1981 · 4π · 10^{-6}CI.

In the $Na_2O+K_2O–SiO_2$ plot the charnockites are placed in the field of granites, sometimes in the border zone of quartz syenites – quartz monzonites. According to V.V.Zyultsle [80], by geochemical characteristics the average content of all elements in charnockites does not spread out the variability boundaries of the same elements average content in the enderbites.

The age of Pobuzki Complex granitoids based on the marking U-Pb isotope dating by zircon is 2510 Ma (The Legend of Central-Ukrainian Series of Derzhgeolkarta-200, 1996). According to L.M.Stepanyuk [38], the age of Pobuzkiy Complex is 2380 Ma.

Umanskiy Complex (PR_1*um*) is widespread in the Umanska Sub-Zone where it comprises the south-eastern part of Umanskiy Massif; in Synytsivsko-Savranska Sub-Zone (especially in its southern part) and in Pobuzka Sub-Zone (in Vradievskiy Transitional Block only); relatively small (up to 2 by 0.5 km) bodies are also observed in Yatranska Sub-Zone. Granitoids are disclosed by drill-holes and studied in outcrops along Yatran (Yatranivka, Ladyzhenka villages) and Synytsya Rivers and their branches. There are distinguished in the Complex porphyry-like granites and migmatites (γ_2,γ_2mPR_1*um*), medium-fine-grained thin-banded granites and migmatites (γ_1,γ_1mPR_1*um*), and pegmatoid and aplite-pegmatoid varieties (ίργPR_1*um*). The latter form veinlet-like, nest-like, and irregular thin (from first centimeters to some meters) bodies with gradual transition to the hosting granitoids. Saturation with aplite-pegmatoid granites is non-uniform. In places the saturation is so extensive that the bodies are closer to the small (first kilometers) massifs.

The remnants in granitoids of the Complex comprise biotite and amphibole-biotite plagiogneisses, plagiogranites of Tetiivskiy Complex, and sometimes amphibolites. The contacts are mainly gradual.

Porphyry-like granites and migmatites are visually pinkish-grey, greyish-pink, pink, medium-grained, with variable content (10-25%) of tabular porphyryblasts of microcline up to 2 cm long. Micro-texture is porphyry-like, and groundmass – granite, in places with elements of myrmekite, and in tectonized varieties cataclastic one appears. Mineral composition (%): plagioclase (oligoclase) 25-30 (in pegmatoid varieties often of relic appearance within microcline), microcline 30-35 (clearly lattice, in porphyryblasts with single twins), quartz 2-30, biotite 3-5 (often zoned), hornblende – sometimes single grains. Accessory minerals: zircon, sphene, orthite, titanium magnetite, sulphides. Secondary minerals: sericite, muscovite, epidote, chlorite, carbonates. Physical properties: $\sigma = 2.58 \div 2.64$ g/cm^3, æ =3÷513 · 4π · 10^{-6}CI.

Biotite, medium-fine-grained granites and migmatites are developed mainly in Pobuzka Sub-Zone in Vradievskiy Block, and in Synytsivsko-Savranska Sub-Zone. In most cases the granitoids are tectonized, probably, re-crystallized. Visually the rocks are greyish-pink, reddish-pink to pink-red, banded (to shadow), fine-grained, fine-medium-grained, in places (outcrop 73) they do transform into coarse-grained, unclear porphyryblastic to pegmatoid varieties, with “remnants” of fine-grained, thin-banded rocks. In migmatites melanosome comprises biotite plagiogneisses, and leucosome – aplite-like granites. Micro-texture is mainly granoblastic, heterogranoblastic with elements of lepidoblastic, in places – blastogranite. Mineral composition (%): plagioclase (oligoclase) 23-25, microcline 30-35 (of two generations: spotty-lattice with numerous dissociation perthites and finer clear lattice grains without perthites), quartz 30-35, biotite 8-10 (often zoned). Accessory minerals: apatite, monazite, zircon, sometimes orthite. Gangue: magnetite up to 0.5%, sulphide. Secondary minerals: epidote, muscovite.

According to O.B.Bobrov [4], granite formation in Synytsivsko-Savranska Sub-Zone is close to formation of the Umanskiy granitoid massif. Granites of Synytsivska Zone are close to granitoids of Umanskiy type, especially to their varieties in endo-contacts of large bodies, or to small bodies in around such the large bodies, not only by time of formation but also by composition and texture patterns. Being completely agreed with these ideas, we have to emphasize, that granites of Umanskiy massif and single granite massifs of Synytsivsko-Savranska Sub-Zone only can be considered as allochthonous counterparts of the Complex (ίργ,γ_1, $\gamma_2$$PR_1$*um*), while other rocks varieties (γ_1m,γ_2mPR_1*um*) of the Complex display evidences for para-autochthonous and autochthonous origin.

In the plot $Na_2O+K_2O–SiO_2$ the Complex rock points fall into the field of granites, leucogranites, sometimes into the border zone of granites-granodiorites. By geodynamic forming conditions these rocks belong to the collision granites.

According to V.V.Zyultsle [80], all the Complex rock varieties display the uniform geochemical background. Some variations of the average content are observed (%) for copper (0.0006-0.0015), lanthanum (0.003-0.006), chromium (0.0005-0.002), and manganese (0.003-0.03).

The age of Umanskiy Complex granites, according to M.P.Shcherbak [21] is 2200-2010 Ma (U-Pb dating by monazite). According to V.P.Bezvynniy [1], the time of Umanskiy Complex granite formation is limited by the age boundaries as 2060-2000 Ma.

Kirovogradskiy Complex (PR_1*kg*). Granitoids of this Complex are developed mainly in Bratska Sub-Zone of Ingulo-Inguletska LTZ where at the modern erosion level they occupy significant squares but do not form individual massifs. The western limit of their distribution is the zone of Pervomaiskiy Fault – in the north and in the central part of Bratska Sub-Zone, and in the south – frontal Emylivskiy Thrust. Outside the Sub-Zone, the granitoids of this Complex are being observed in single bodies of irregular shape. The rocks are disclosed by numerous drill-holes and are studied in outcrops along Synyukha (area of Synyushyn Brid, Vilshanka villages), Chorniy Tashlyk (Novooleksandrivka village), Sukhiy Tashlyk (Troyany, Dobryanka villages), and Southern Boug (Pervomaisk town, Mygiya village) rivers. Granitoids of the Complex contain the remnants of Ingulo-Inguletska Series plagiogneisses and Pobuzkiy Complex granitoids. In the contacts with the first ones sometimes small transitional sites are observed comprised of plagiogranites, and in the contact zone with Pobuzkiy Complex granites the hybrid rocks appear enriched in schlieren-like aggregates of garnet and biotite (outcrop 55). At the contact with charnockites the leucocharnockites with pyroxene and garnet as well as biotite aggregates appear, the rocks get the coarse-spotty structure and gradually change into porphyryblastic granites (outcrop 47). In fault zones and close to them in porphyryblastic granites numerous pegmatite and aplite-pegmatoid granite veins of various thicknesses occur; sometimes (Dobryanka village) enriched in large tourmaline crystals. In the Complex, biotite and garnet-biotite granites and migmatites predominate, coarse- and medium-grained, porphyryblastic (γ_2mPR_1*kg*), pinkish-grey, grey-pink, in places with reddish shade. Porphyryblasts comprise about 15-40% in average and are composed of microcline, clearly lattice, often with Carlsbad twins. Their size is 0.5 by 1.0 by 2.0 cm. In places porphyryblasts are parallel-oriented. Massive structure is characteristic for granites, and banded, shadowed one – for migmatites. Micro-texture is porphyryblastic, and of groundmass – granoblastic with elements of lepidoblastic (in migmatites), blasto-granite, sometimes granite; in tectonized varieties – blastic-cement. Mineral composition (%): plagioclase (oligoclase) 25-35, microcline 30-50, quartz 20-30, biotite 5-7 (in migmatites up to 20), garnet 0-5, sometimes up to 15 (irregularly distributed), relic single grains of orthopyroxene and cordierite. Accessory minerals: zircon, monazite, ilmenite, sometime rutile, tourmaline, sillimanite. Physical properties: $\sigma = 2.65 \div 2.8$ g/cm^3, æ = $10 \div 18 \cdot 4\pi \cdot 10^{-6}$CI.

B i o t i t e m e d i u m - g r a i n e d g r a n i t e s a n d m i g m a t i t e s (γ_1mPR_1*kg*) at the Precambrian erosion level are distributed much less than porhyryblastic ones. Commonly they are observed in the northern part of Bratska Sub-Zone and outside the Pervomaiskiy Fault. The contacts with porhyryblastic granitoids are gradual. Macroscopically these are pinkish-grey, greyish-pink rocks of massive (in granites), banded and shadowed (in migmatites) structure, sometimes with garnet grains or grain aggregates. Micro-texture is granite, blasto-granite, granoblastic. Mineral composition (%): plagioclase (oligoclase, albite-oligoclase) 25-45, microcline 25-35, quartz 20-30, biotite 5-7 (in migmatites up to 20), garnet 0-5. Accessory minerals: apatite, zircon, monazite, ilmenite, magnetite, pyrite. Physical properties: $\sigma = 2.59 \div 2.71$ g/cm^3, æ = $2 \div 4 \cdot 4\pi \cdot 10^{-6}$CI.

According to the petrochemical calculations, the Complex granitoids belong to the calc-alkaline series, sub-alkaline range of potassium branch. In the $Na_2O+K_2O–SiO_2$ plot the points are mainly placed in the field of granites and sometimes in the field of granodiorites, close to the border with granites. In the plot of geodynamic environments they fall into collision granite field. Major indicator petrochemical characteristics of granites are closer to the crustal S-type granites.

V.S.Kostyuchenko, V.V.Zyultsle et al [80] had noted that datasets compiled for these granites display the consistent patterns of the average trace-element background content for the entire Complex. The absolute values of the contents are actually coincides with those of the Umanskiy Complex granitoids. The nickel content only is little bit less. According to K.Yu.Esipchuk [84], Kirovogradskiy Complex granitoids are characterized by negative europium anomaly (Eu/Eu^*) – 0.4-0.5.

Metasomatic and retrograde-metamorphic rocks

Distribution of these types of rocks complies with the major dislocation structures of the map sheet territory. Some of them are of regional extension within specific tectonic levels of Precambrian basement while others are locally prominent. Most likely, the squares of their distribution do correspond to the distribution of tectono-facies of the major types of dislocation tectonics (Fig. 4.3).

The major types of metasomatically altered rocks are the skarns and skarn-like rocks. Their wide distribution within the middle tectonic bench of the lower tectonic level is related to the marble-calciphyre formation occurring in the respective sections of Buzka Series. Much rarely they are known in the sections of the lower tectonic bench (calciphyre-mafic gneiss formation of Dnistersko-Buzka Series). And in the upper tectonic bench they are found at all levels of Roshchakhivska Suite of Ingulo-Inguletska Series.

The skarn-forming phenomena are most widespread in the areas of Khashchuvato-Zavallivska Suite of Buzka Series [17] where they occur mainly at the contacts of calciphyres and ferruginous quartzites (itabirites), as well as at the contacts of calciphyres with granitoids, metamorphic rocks and ultra-metamorphic rocks. Most common are magnetite-bearing skarns which genetically control deposits and findings of carbonate-magnetite ores as well as skarn-like rocks. By mineralogical composition they are subdivided into: magnetite-salite, in places with garnet; scapolite-magnetite-amphibole-salite; hornblende-magnetite-pyroxene with spinel and sometimes with garnet; cummingtonite-magnetite-olivine. Another type of skarnoids, which is mainly known from the contact zones of calciphyres and silicate rocks, was studied by S.V.Nechaev in Zavallivskiy quarry. These are mainly olivine-diopside rocks with garnet, pyroxene-garnet and essentially garnet skarns and skarn-like rocks.

In itabirites there are widespread the phenomena of metasomatic re-crystallization with formation of coarse-grained skarn-like sites composed of ferro-hypersthene, salite, and garnet, as well as formation of garnet-quartz and quartz-feldspar metasomatites.

The skarn-like rocks also include diopside gneisses and mafic gneisses known mainly from the sections of Roshchakhivska Suite of Ingulo-Inguletska Series where they form lens-like interbeds associated with scheelite mineralization. Metasomatic rocks described above are also known (in much less amounts) from the sections of Dnistersko-Buzka Series and are related to the rocks of calciphyre-mafic gneiss formation. The information concerning the composition of metasomatically altered rocks is given in the section “Stratified units”.

The ultramafic rocks of Derenyukhinskiy and Kapitanivskiy Complexes are essentially serpentinized, in places with formation of serpentinites where primary rocks are actually not preserved. Deposits and findings of silicate nickel are related to the weathering crust after serpentinized ultramafic rocks.

In the studied area are also widespread the poly-facial retrograde metamorphic phenomena related to the tectono-thermal activization. This was caused by retrograde metamorphism under amphibolite, epidote-amphibolite and greenschist facies the early formed rock complexes of crystalline basement.

The retrograde metamorphism under amphibolite facies had regional patterns and it is more characteristic for the Paleo-Archean complexes (lower tectonic level of crystalline basement). The process is marked by newly-formed hornblende and biotite. The most characteristic is replacement of hypersthene and garnet by biotite, clinopyroxene – by hornblende, greenish-brown hornblende – by green and blue-green hornblende, reddish-brown biotite – by brownish-green biotite.

Retrograde metamorphism under epidote-amphibolite and greenschist facies is quite locally distributed, mainly by zones of cataclasm and cleavage flow of brittle-ductile faults. Greenschist retrograde metamorphism is known in some lens-like sites only within Synytsivsko-Savranska and Serednyo-Buzka bands. Newly-formed epidote, chlorite, tremolite, and secondary carbonate are characteristic for the greenschist retrograde metamorphism. Permanent paragenesis of sulphides mineralization with secondary minerals formed due to retrograde greenschist metamorphism, confirms conclusions of A.F.Ryabokon concerning link of secondary sulphides mineralization with the phenomena of epigenetic hydrothermal re-working of primary mafic and ultramafic rocks containing poor sulphides mineralization, and possibility of enriched sulphide ore formation outside the massifs of mafic and ultramafic rocks in the host gneiss sequences. In our view, similar conclusions can be attributed also to the secondary redistribution of gold mineralization within Savranske ore camp and Derenyukhinske ore field.

In Synytsivsko-Savranska Sub-Zone there are observed the signs of hydrothermal-metasomatic processes in tectonically weakened zones. Normally, these local points are confined to the zones of volumetric cataclasm formed at the junctions of the major sub-longitudinal faults with sub-latitudinal ones. These evidences are known from the areas of Savran, Zavallya, Grushka and other inhabited locations. Most widespread are silicification, alkaline, silica-alkaline, carbonate-alkaline metasomatism and acid leaching. Thickness of these processes location zones does not exceed first meters.

In the sites of carbonate-alkaline metasomatism there are developed processes of hematitization, carbonatization, sericitization, chloritization, argillization. They are accompanied by fine-disseminated sulphidization (pyrite, molybdenite, chalcopyrite, galena etc.) and contain uranium mineralization. The newly-formed albite, microcline, as well as sulphidization are characteristic for the sites of alkaline metasomatism. These sites commonly contain the complex gold-bismuth-uranium mineralization.

The hydrothermal-metasomatic zones are weakly studied by depth and not studied at all by strike. The information concerning their minerageny, composition and host rocks are given in the cadastre of metal mineral deposits and findings (Database "Derzhgeolkarta-200" of the map sheet M-36-XXXI (Pervomaisk)).

Finally, it should be noted the following: while in Pobuzka Sub-Zone within the square bounded from the east by Emylivskiy, and from the west by Vradievskiy Faults, the retrograde metamorphism under amphibolite facies conditions is observed almost over the entire territory (with diverse intensity), in Yatranska and Bratska Sub-Zones these processes are developed quite locally.

Dynamo-metamorphic rocks (tectonites - t)

Linear zones of dynamo-metamorphic rocks (undivided tectonites) are developed along all faults in the earth crust. While along the minor faults thickness of these rocks does not exceed first tens of metres, in the tectonic sutures and zones of Deep-Seated Faults their thickness attains some kilometres. Ceasing of deformations is clearly seen away from the major planes of tectonic rock displacement. Normally the rocks altered by dynamo-metamorphic processes are arranged into continuous ranges milonite (blastomilonite) - cataclasite (blastocataclasite) - zone of increased fracturing. Five types of tectonites are widespread.

Mixtites (tectonic mixture) are developed in the over-thrust zones or in the hanging-wall portions of thick listric reverse faults. Normally these are the varieties of tectonic melange of lens-shaped-like or boulder-layered macro-structure. Mixtites are widespread mainly in Zhuravlynsko-Yatranska and Emylivsko-Pervomaiska tectonic zones.

Blastocataclasites and blastomilonites exhibit augen-schistose and schistose fluidal structures, that is, evidences for brittle tectonic flow. They are observed together and are characteristic for all high-pressure zones subordinated to the zones of Deep-Seated Faults. Primary minerals and their assemblages are almost completely destroyed. Ovaloids of porphyryblasts are commonly composed of microcline, much rarely of plagioclase. Blastesis and tectonic shearing cease away from the major tectonic sutures, and in parallel the blastocataclasites are being replaced by cataclasites and highly-fractured rocks.

Cataclasites are developed in the back portions of the large tectonic zones where dynamo-metamorphic processes gradually cease. These rocks accompany almost all major and minor faults.

At the junction sites of the faults with different morpho-kinematical features the zones of bulk-volume cataclasis are normally being developed which are favourable for localization of ore components. Commonly cataclasites exhibit partial and total breaking both whole rock and individual minerals as well as mineral aggregates.

Pseudo-conglomerates are encountered in Subotsko-Moshorynska and Emylivsko-Pervomaiska tectonic zones.

From conglomerates these rocks differ only in the same composition of the matrix and olistolites; tectonic schearing is characteristic for the former. Olistolites, irrespective of the tectonic stress degree, change their shape (across) from rhombic to ellipse-like. In the latter case olistolites contain residual edges. Another feature, which makes olistolites different from the conglomerate pebbles, comprises considerable (by the order) excess of the long axis in comparison to the short one. Actually, olistolites are pencil-shaped.

Mealy milonites accompany only the youngest tectonic breaks, mainly in Pervomaiska tectonic zone. The rocks are being formed only in the tectono-facies of the secondary epi-zone dislocation structures. Normally they are "dry" and in texture respect comprise the weakly-cemented mealy mass.

The zones of tectonite development are highly-permeable and by this reason are favourable for the circulation of fluid solutions. This is resulted in the units of overprinting metasomatism described above.

Weathering crust of Precambrian rocks (PZ-KZ)kv

The weathering crust of Precambrian crystalline rocks is developed almost over entire territory of the map sheet (Fig. 3.1). It is lacking in the zones of modern erosion (valleys of Southern Boug, Synyukha, Yatran and other rivers).

The weathering crust was formed over the long geologic time encompassing Paleozoic, Mesozoic and Cenozoic, under conditions of wet and warm climate.

Despite of variability of Precambrian rocks, four zones can be clearly distinguished in the profile of weathering crust (upward):

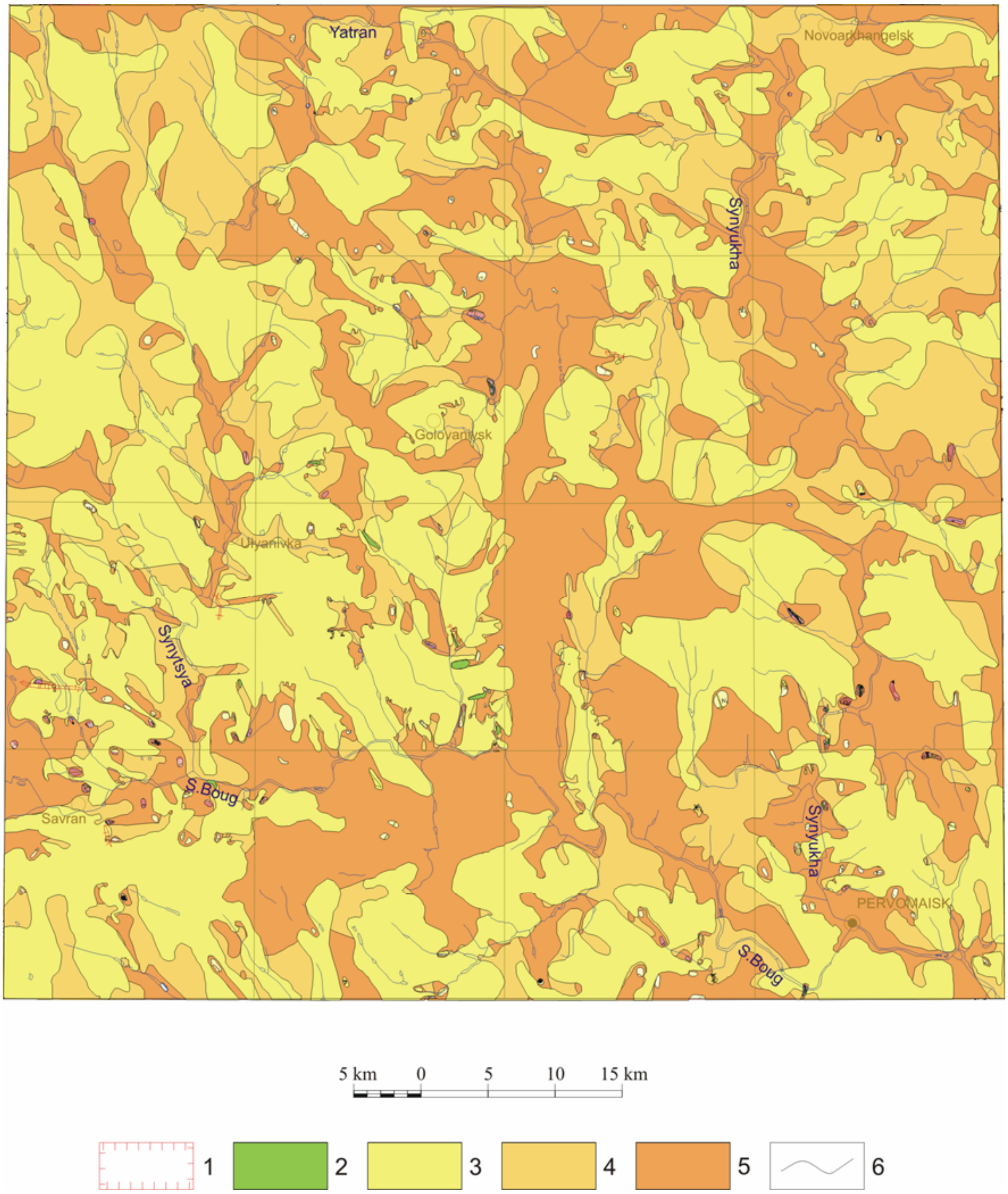

Fig. 3.1. The map of weathering crust.
1 – linear; 2 –laterite; 3 – kaolinite; 4 – montmorillonite (hydro-mica); 5 – grussy (hydro-mica-sericite); 6 – distribution boundary of weathering crusts.

1) Disintegration zone with characteristic sericitization, slight kaolinization, chloritization, micro-fracturing with extensive iron oxidation. Thickness of disintegration zone is not sufficient and rarely attains first meters.

2) Hydro-mica zone everywhere is accompanied by replacement of biotite by hydro-biotite, and chlorite – by hydro-chlorite; partially by development of kaolinization, beidellitization, montmorillonitization, nontronitization, iron oxidation.

3) Kaolinite, montmorillonite, nontronite and mixed zone. Depending on the composition of primary rocks it displays specific patterns. For instance, after gneisses, plagiogneisses, granites, and migmatites the kaolinite weathering crust is being formed.

After gabbro and gabbro-norites, mafic gneisses, amphibolites and amphibole-pyroxene plagiogneisses it is being formed beidellite-montmorillonite weathering crust, and after serpentinites, pyroxenites, and peridotites – the nontronite weathering crust.

4) Brown iron-ore, ocher and secondary quartzite zone appears due to complete leaching of the newly-formed minerals of the weathering crust. Resistant counterparts include brown iron-ore, clastogenic quartz, and supergene silica compounds.

Analysis of the weathering crust profile over the studied territory had shown that regardless composition of the primary rocks, succession of crust formation was identical; absence of the third zone at some watersheds and almost throughout lacking of the fourth zone suggests for partial erosion of the upper portion of the weathering crust in pre-Paleogene and later times.

Depending on mineralogical composition and genetic features of primary rocks, the following types of weathering crust are distinguished: kaolinite, montmorillonite, nontronite, and mixed.

1) Kaolinite type is developed after felsic rocks (granites, migmatites and gneisses). Depending on the primary rock composition, the thickness and composition of the weathering crust in some bodies essentially change but kaolinite predominates everywhere. Thickness of weathering crust after granites rarely exceeds 10-15 m, and normally attains 5-7 m. The crust is mainly composed of slightly iron-oxidized, almost white kaoline with variable content of the relic quartz. In kaolinite crust developed after diverse gneisses, content of such clastic minerals as graphite, sillimanite and garnet essentially changes. Colour of these minerals is brown, rusty due to excess of iron hydroxides formed over entire period of the crust development. Texture and structure properties of the gneiss rocks as well as tectonic movements cause significant thickness (more than 70 m – Zavallya area) of kaolinite and other weathering crusts.

2) Beidellite-montmorillonite type is developed after amphibolites and amphibole-pyroxene mafic gneisses (amphibole-pyroxene-plagioclase amphibolites), gabbro-norites, crystalline limestones. Mineralogical composition and quantitative relations between individual minerals of this crust type are not consistent and depend on the composition of primary rock. The clastic minerals in beidellite-montmorillonite crust include: garnet, magnetite, pyrite, whose content does not exceed first per cents.

In the crusts formed after bended mafic gneisses and amphibolites the primary rock banding is strongly preserved being caused by alternating kaolinite and montmorillonite.

In the weathering crust of crystalline limestones with very complicated primary structure (high variability of composition and grain size of primary rocks), pyrolusite aggregates are observed besides formation of kaolinite and montmorillonite (Khashchuvate village).

3) Kaolinite-nontronite type of weathering crust in the Middle Pobuzhzhya is studied in details by M.T.Vadymov and I.Y.Shevchyshyn during search-prospecting works for silicate nickel [9, 94]. In all identified deposits (Kapitanivske, Lypovenkivske, Grushkivske and others) it is clearly observed the vertical zoning of the crust formed after serpentinized pyroxenites, peridotites and dunites.

Both lower zones (disintegration and hydro-mica) are thin and are being changed upward by kaolinite-nontronite zone which is accompanied by major nickel concentrations. The following newly-formed minerals are distinguished in this upper zone: kaolinite, beidellite, montmorillonite, nontronite. Jefferysite, vermiculite and chlorite are more characteristic to the hydro-mica zone. The type of weathering crust after altered ultramafic rocks is capped by brown iron-ores, cemented by opal, and crumble ochre. This part of sections is lacking or almost lacking in most profiles which suggest for its later erosion.

Performed thermal investigations of nontronites and serpentine (chrysotile) indicate two clear thermal stops: one at $T = 640^oC$, which can be considered as temperature of pyroxenites and peridotites metamorphism, and second one at $T = 140^oC$ which corresponds to the supergene formation of not only nontronite but of entire crust; this allows consideration the weathering crust formation as the supergene low-temperature process.

4) Mixed type of crust is being formed after ferruginous skarns and ferruginous quartzites when besides kaolinite and montmorillonite in the crust also increased magnetite and hematite content is observed; this, in turn, causes formation of the poor iron ores (Sekretarske, Khashchuvate, Grushka and other deposits).

Linear types of weathering crust are known in the zones of tectonic breaking where their thickness attains 100 m and higher (Zavallya, Grushka and other villages). In contrast to the aerial weathering crusts, the linear ones often do not display succession of the zone formatrion. For instance, below kaolinite zone disintegration zone may occur.

4. TECTONICS

In the cross-section of upper Earth's crust within the studied territory there are clear distinguished two tectonic levels: upper one, composed of the cover sediments, and lower one, represented by the folded complex. Tectonic levels are separated by the regional sub-horizontal surface of stratigraphic and structure discontinuities.

The upper tectonic level is composed of Phanerozoic sediments. Any processes of tectono-magmatic activization within this complex are not reliably supported yet. In this respect, the ideas about such processes in the upper level are grounded on the interpretation of geology-geophysical data and are subjected to discussions. At the same time, major tectonic patterns of the lower Precambrian level are clearly mirrored as in the Phanerozoic cover as in the modern geomorphology of the territory. The map sheet belongs to the single geo-structure unit – Ukrainian Shield, and this is why tectonic subdivision of the Phanerozoic cover is not provided.

Structure of the folded complex in the lower tectonic level, composed of Precambrian rocks, is fairly complicate; this is because most of the map sheet territory belongs to the Golovanivska Suture Zone which separates Volyno-Podilskiy Micro-Continent in the west and Kirovogradskiy Orogen in the east. Most of litho-tectonic complexes display evidences for sub-horizontal movements, that is, they occur in the para-autochthon and allochthon laying. Tectonic subdivision of the Precambrian units was performed following the principle of litho-tectonic zones definition. By the complex of evidences, the studied territory encompasses two LTZ: Odesko-Bilotserkivska in the west and Ingulo-Inguletska in the east.

In the vertical cross-section of the lower tectonic level there are distinguished three tectonic benches which do correspond to the tectono-magmatic cycles by the scale of associated magmatism and tectogenesis. Due to multi-phase tectono-thermal re-working, the boundaries between tectonic benches are gradual, at the first glance.

Lower tectonic level

It is composed of crystalline basement Precambrian rocks. Three tectonic benches are distinguished inside: lower (Paleo-Archean), middle (Neo-Archean), and upper (Paleo-Proterozoic). Due to numerous tectono-magmatic activizations, especially of the lower bench, their structure planes had undergone essential changes which were most extensive in the epoch of the late collision at 2000 Ma. This is why the structure planes in the lower and middle tectonic benches are of superimposed nature complicated by fault-side folding.

Lower tectonic bench is composed of extensively dislocated rocks of Dnistersko-Buzka Series and granitoids of Gaivoronskiy Complex and, probably, Tashlytskiy Complex (in deep horizons of Bratska Sub-Zone). In some places these units are essentially re-worked (due to Neo-Archean and Paleo-Proterozoic activization) with formation of reomorphic (in this case) granitoids of Litynskiy and Pobuzkiy Complexes respectively. The rocks of the lower tectonic bench are being exposed at the erosion surface in the cores of dome structures complicated by the linear folding in subsequent periods. In this respect, it is characteristic the steep isocline folding of the higher orders with the limb inclination 75^{o}-85^{o}. It should be noted that in the Pervomaiska Tectonic Zone under conditions of tectonic squeezing along the Deep-Seated Faults the rocks of lower tectonic bench are uplifted to the heights of the upper bench and almost completely re-worked. By average composition and physical properties the complexes of given bench do correspond to the analogues of the conventional diorite layer of the Earth's crust.

Middle tectonic bench is composed of extensively dislocated rocks of Buzka and Rosynsko-Tykytska Series and granitoids of Tetiivskiy and Pobuzkiy Complexes. In places they are re-worked due to activization with formation of Umanskiy Complex granitoids, first of all within Synytsivsko-Savranska Sub-Zone of Odesko-Bilotserkivska LTZ. The rocks of the middle tectonic bench, except of Ingulo-Inguletska LTZ, are exposed at the erosion surface in the cores of linear mainly synform structures, and within the Umanskiy granitoids massif – in erosion windows. They are characterized by the normal often asymmetric folding with the limb dipping angles from 50^{o} to 75^{o}; in the zones of major steeply-dipping faults the mentioned folding may be complicated by superimposed isocline folding of higher orders.

In the Bratska Sub-Zone of Ingulo-Inguletska LTZ the rocks under consideration, together with the rocks of the upper tectonic bench, stair-wise bury down beneath the sediments of the upper tectonic level up to the depth of 8 km, and are overlain by the upper tectonic level rock complexes.

Litho-tectonic complexes of the middle tectonic bench are essentially reduced and display evidences for tectonic multiplication in the single vertical cross-section due to thrust movements. In general, the rocks of middle tectonic bench do correspond to the analogues of conventional granite and diorite layers of the Earth's crust or transitional zone between them.

Upper tectonic bench is composed of dislocated (with evidences for tectonic multiplication) rocks of Ingulo-Inguletska Series and granitoids of Kirovogradskiy and Novoukrainskiy Complexes. Metamorphic and ultra-metamorphic rocks are arranged in mainly linear often asymmetric folds of north-west strike with limb dipping to north-east under the angles from 40^o to 70^o. In Pervomaiska Tectonic Zone their strike changes to sub-longitudinal. Litho-tectonic complexes of the upper bench are mapped in the Ingulo-Inguletska LTZ and in the eastern part of Yatranska Sub-Zone of Odesko-Bilotserkivska LTZ. In the west, their distribution is bounded by Pervomaiska Tectonic Zone. Probably, their western boundary coincides with Emilivska Thrust Zone but occurrence of the Ingulo-Inguletska Series metamorphic rocks to the west from Pervomaiska Tectonic Zone is not proven yet.

In general, the rocks of given bench do correspond to the conventional granite layer of the Earth's crust which thickness attains 8-10 km.

Spatial tectonic subdivision is expressed in the tectonic map supplemented to the geological map of crystalline basement (see also Fig. 4.1 and Fig. 4.2 in the text below). Assuming three-fold structure of Precambrian crystalline basement, the spatial tectonic subdivision can be considered at the three age levels: Paleo-Archean, Neo-Archean, and Paleo-Proterozoic.

At the Paleo-Archean level the studied territory is fully belongs to the granulite basement (granitized Dnistersko-Buzka Series); by complex of evidences these rocks are defined as undivided litho-tectonic complexes of proto-continental crust (UG.AR_1) [7] in the internal parts of the plates.

At the Neo-Archean level, in the Middle Pobuzhzhya can be distinguished litho-tectonic complexes of continental rifts (CR.AR_3) and island arcs (IA.AR_3), and respectively – Buzka and Rosynsko-Tykytska Series. Granitized complexes – indicators of these environments – are known in Odesko-Bilotserkivska LTZ but primary contours of this LTZ were different being compared to the present ones.

At the Paleo-Proterozoic level in the territory of map sheet two LTZ rather clear are distinguished: Odesko-Bilotserkivska and Ingulo-Inguletska. Such subdivision does not contradict to the geologic subdivision but make it more precise and extended. In the Yatranska Sub-Zone of Odesko-Bilotserkivska LTZ (eastward from Pervomaiska Tectonic Zone) there are distinguished the complexes of continental shelf (CS.PR_1) that lie over Archean complexes with the signs of stratigraphic and angular discontinuities and are composed of granitized metamorphic rocks of Ingulo-Inguletska Series. For entire Ingulo-Inguletska LTZ, within the territory of map sheet, it is characteristic development of the complexes from paleo-zone of the external arcs – accretion prisms (AP·PR_1). Collision complexes of early (CC.$PR^1{}_1$) and late (CC.$PR^2{}_1$) collisions and orogenesis (Kirovogradskiy and Umanskiy Complexes) are developed as in Odesko-Bilotserkivska as in Ingulo-Inguletska LTZ.

Odesko-Bilotserkivska LTZ extends in sub-longitudinal direction and is characterized by development of the rift (Buzka Series) and island-arc (Rosynsko-Tykytska Series) complexes which overlie the granulite basement. At the Pale-Proterozoic level it is considered as secondary, heterogeneous. Deep-crust structure evidences that almost all litho-tectonic complexes occur in the allochthonous or para-autochthonous laying suggesting for under-thrusting of Volyno-Podilskiy Proto-Continent beneath Kirovogradskiy Orogen, or the over-thrusting of the latter over the former one along the gentle-inclined to the north-east crustal and mantle faults.

In the east, the litho-tectonic complexes of Odesko-Bilotserkivska LTZ are overlain by the supra-crustal rocks of Igulo-Inguletska LTZ along the system of listric reverse fault-shears of Pervomaiska Tectonic Zone. In the north, west and south its boundaries extend out the map sheet. In general, at the level of sub-soil and deep structure of the Earth's crust, Odesko-Bilotserkivska LTZ is composed of the set of tectonic nappes bounded by the listric reverse faults and shears plunging north, north-east and eastward; this allows the LTZ subdivision by four Sub-Zones: Umanska, Synytsivsko-Savranska, Pobuzka, and Yatranska.

Umanska Sub-Zone is bounded in the east by Talnivska, and in the south – by Obodivska tectonic zones. At the sub-soil level it is composed of allochthonous granites of Umanskiy Complex. In the erosion windows there are exposed autochthonous plagiogranitoids of Tetiivskiy Complex. Granitoids of Tetiivskiy and Umanskiy Complexes contain numerous xenoliths and remnants of gneisses, mafic gneisses and amphibolites of Rosynsko-Tykytska Series. The vertical section of the deep structure, in contrast to Synytsivsko-Savranska Sub-Zone, is characterized by up to 4 km thick granite layer only.

Synytsivsko-Savranska Sub-Zone is bounded in the east by Talnivska, and in the north – by Obodivska Tectonic Zones. From Pobuzka Sub-Zone it is separated by tectonic sheet of transitional structure which gently plunges north-eastward and spatially coincides with Vradievskiy Block of III-rd order (Fig. 4.2). In places of non-deep laying of the granulite basement the Sub-Zone is characterized by isometric folding complicated by linear folding; in other case the folding is linear of north and north-west strike. In the cores of synform structures there are exposed mainly rocks of Buzka and Rosynsko-Tykytska Series, and of antiform structures – granitoids of Umanskiy, Pobuzkiy, Tetiivskiy, and Gaivoronskiy Complexes. According to the deep-structure modelling results the Sub-zone is characterized by tectonically layered Earth's crust of abnormal thickness ~55-65 km. Tectonic layering is being found in the most of geological cross-sections and after modelling results (Fig. 4.2) it is developed over entire crustal thickness. This Sub-Zone is also characterized by the abnormal thickness of diorite layer – from 20 km in the south up to 25 km in the north, as well as development of the up to 10 km thick crust-mantle mixture at the bottom of the Earth's crust.

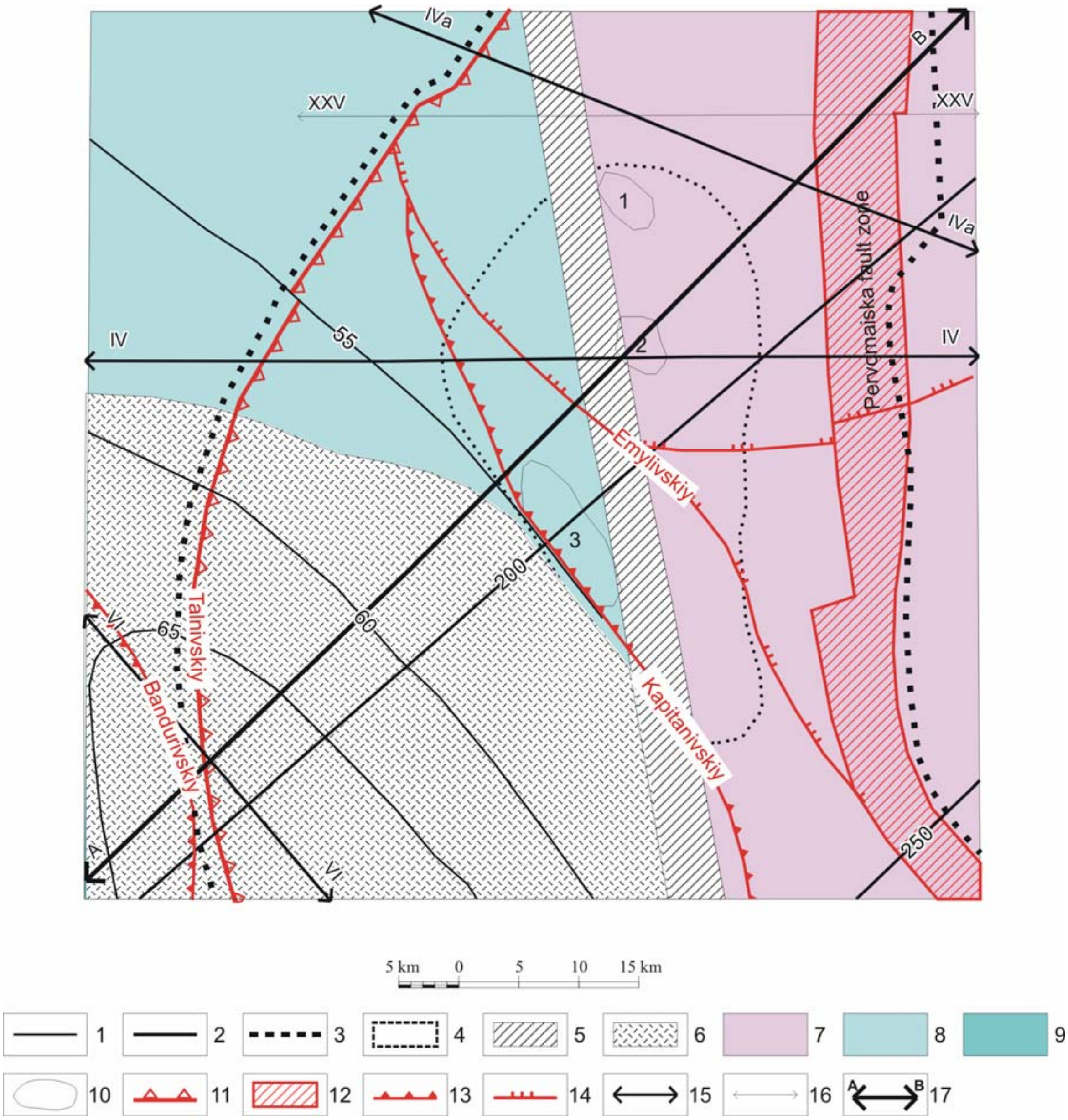

Fig. 4.1. Deep structure of the earth crust.

1 – contour lines of M surface; 2 – contour lines of lithosphere footwall, km; 3 – area of Golovanivskiy gravity maximum; 4 – area of Pushkivskiy gravity maximum within Golovanivskiy gravity maximum; 5 – M surface ledge projected over the surface of Precambrian basement; 6 – crust-mantle mixture projected over the surface of Precambrian basement. **Crustal types by composition and thickness**: 7 – granite-diorite, thickness 40-45 km; 8 – leuco-basalt, thickness over 50 km; 9 – normal basalt, thickness over 50 km; 10 – structures composed of mafic-ultramafic rocks (1 – Tarasivska, 2 – Troyanska, 3 – Lypovenky-Kapitanka (chromium-bearing)). **Faults**: 11 – Talnivskiy, 12 – Pervomaiska fault zone. **Other symbols**: 13 – reverse faults; 14 – thrusts; 15 – geotrasects; 16 – deep-seismic sounding profiles; 17 – cross-section line in the block-diagram (Fig. 4.2).

Pobuzka Sub-Zone is bounded in the east by Pervomaiska, and in the west – by Talnivska Tectonic Zones, and in the north – by Zhuravlynskiy Thrust. The Sub-Zone is characterized by mainly linear folding. In the cores of synfrom structures there are mainly developed the rocks of Buzka and Dnistersko-Buzka Series, and in the antiform ones – granitoids of Gaivoronskiy, Litynskiy, and Pobuzkiy Complexes. The disconformity of folded structures, mainly overturned, is observed in Pobuzka Sub-Zone: far from the listric faults the limbs of the fold structures plunge south-westward whereas in direct proximity to the major listric faults these limbs plunge north-eastward. This suggests for superposition of the tectonic processes: the first direction does correspond to the folding which could be formed at the closure stage of spreading zone development (continental rifting), while the second one is thought to be related to the formation of Kirovogradskiy Orogen and forland (marginal part of Volyno-Podilskiy Proto-Continent) under-thrusting beneath this orogen.

In general, given Sub-Zone deep structure is defined by the set of tectonic sheets plunging north-eastward and separated by the listric reverse fault-shears – Emylivska, Ternuvatska, and Vradievska. The Sub-Zone also differs in tectonic layering of the crust especially within the diorite layer. Thickness of the Earth's crust within Sub-Zone does not exceed 40-42 km to the east from the large Moho Surface Ledge (Fig. 4.2), and 50 km to the west from the latter. Thickness of diorite layer (at the latitude of Geo-Transect IV) does not exceed 10-12 km and only at the southern margin of the map sheet it attains 20 km. Thickness of the basalt layer varies from 40 km in the west to 20-25 km in the east. Granite layer is almost lacking.

Yatranska Sub-Zone is bounded in the west by Talnivska Tectonic Zone, in the south – by Zhuravlynska, and in the east – Vodyano-Tymofiivska Thrust Zones. It is characterized by mainly isometric folding which is overprinted by the linear folding along the thrust tectonic zones. In the cores of antiform structures there are exposed the granitoids of Gaivoronskiy, Pobuzkiy, Umanskiy, and Kirovogradskiy Complexes which contain the rock remnants of Dnistersko-Buzka Series, and in synform structures – mainly gneisses and mafic gneisses of Dnistersko-Buzka Series. The rocks of Buzka Series are found within Tarasivska and Troyanska synforms only which some researchers [80, 90] do consider as volcano-tectonic structures. In the eastern flank, in the influence zone of Ternivska Tectonic Zone, Archean complexes are overlain, with evidences for structure discontinuity, by the rocks of Ingulo-Inguletska Series.

According to modelling results (Fig. 4.2), the deep structure of the Earth's crust in the Sub-Zone does not differ from Pobuzka Sub-Zone but displays some distinctions. Along the sub-latitudinal tectonic breaks of the Central-Ukrainian Lineament Zone there is observed stair-wise thickness increase of the crustal diorite layer from 10 km in the southern flank up to 25 km in the north. In the upper part of the Earth's crust there is observed tectonic displacement of crustal granite and diorite layers that confirms the allochthon nature of Yatranskiy Block due to thrust movements from north to the south. Thickness of allochthon attains 10 km.

Ingulo-Inguletska LTZ does spatially coincide with the same-named geological region; it extends in sub-longitudinal direction and by spatial tectonic subdivision belongs to the Kirovogradskiy Orogenic Belt. Within the map sheet, the western part of Bratska Sub-Zone is located only which is separated from Odesko-Bilotserkivska LTZ by Pervomaiska Tectonic Zone in the west, and Zhuravlynska and Vodyano-Tymofiivska Thrust Zones – in the north. Litho-tectonic complexes of the accretion prism, within Bratska Sub-Zone, lie over granulite basements (lower tectonic bench) as the batch of tectonic sheets bounded by the listric reverse fault-shears. The surface of tectonic discontinuity which separates the upper and lower tectonic levels, does conventionally coincide with the eastward gently-inclined distribution boundary of granitoids of Kirovogradskiy and Pobuzkiy Complexes; it is supposed that this boundary during formation of Kirovogradskiy Orogen was reduced by superimposed linear folding. Pobuzkiy granitoid complex in Bratska Sub-Zone was formed after the rocks of granulite basement as a result of early collision phenomena. In general, the Sub-Zone is characterized by the linear folding of north-west strike which is changed to sub-longitudinal in the influence zone of the Pervomaiska Fault System. In the cores of synform structures there are exposed mainly metamorphic rocks of Ingulo-Inguletska Series, and of antiform ones – collision granitoids of Kirovogradskiy Complex.

According to modelling results (Fig. 4.2), the Sub-Zone is characterized by tectonic layering over entire crustal thickness and from adjoining Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ – by increase of granite layer thickness up to 10 km at the expense of diorite layer thickness decrease up to 10-15 km.

Major elements of block structure display clear inherited patterns and are subordinated to the spatial subdivisions at the level of LTZ and Sub-Zones. It is known that Golovanivska Suture Zone, which does spatially coincides with Odesko-Bilotserkovska LTZ we have defined, separates Volyno-Podilskiy and Centralno-Ukrainskiy Geo-Blocks. The Geo-Block subdivision into the blocks of the first, second and third orders is not widely accepted and is most argued (for the given territory) in the report on DMM-200 [88]. However, we suppose that according to the new data we had obtained and analyzed, the eastern margin of Volyno-Podilskiy Geo-Block (proto-continent) is defined by the Bershadskiy reverse fault located in the map sheet adjoining from the west the given one. In other words, the eastern parts of II-nd order Gaisynskiy and Chechelnytskiy Blocks, I-st order Podilskiy Block, and Volyno-Podilskiy Geo-Block (respectively, III-rd order

Umanskiy and Bandurivskiy Blocks) should be included into the Golovanivska Suture Zone, which, in turn, due to its heterogeneity, is being subdivided into the blocks. In this case the Golovanivska Suture Zone spatially does fully coincide with Odesko-Bilotserkivska LTZ and can be considered as the zone of gradual under-thrusting of granulite rocks of Volyno-Podilskiy Geo-Block (Proto-Continent) beneath the western part of Centralno-Ukrainskiy Geo-Block, that is, beneath I-st order Kirovogradskiy Block (Orogen). To avoid confusion through the block names and until solution of this question by the Tectonic Committee, we retain the old names to all the blocks. The territory subdivision by blocks is expressed in the block-diagram of the territory deep crustal structure (see Fig. 4.2).

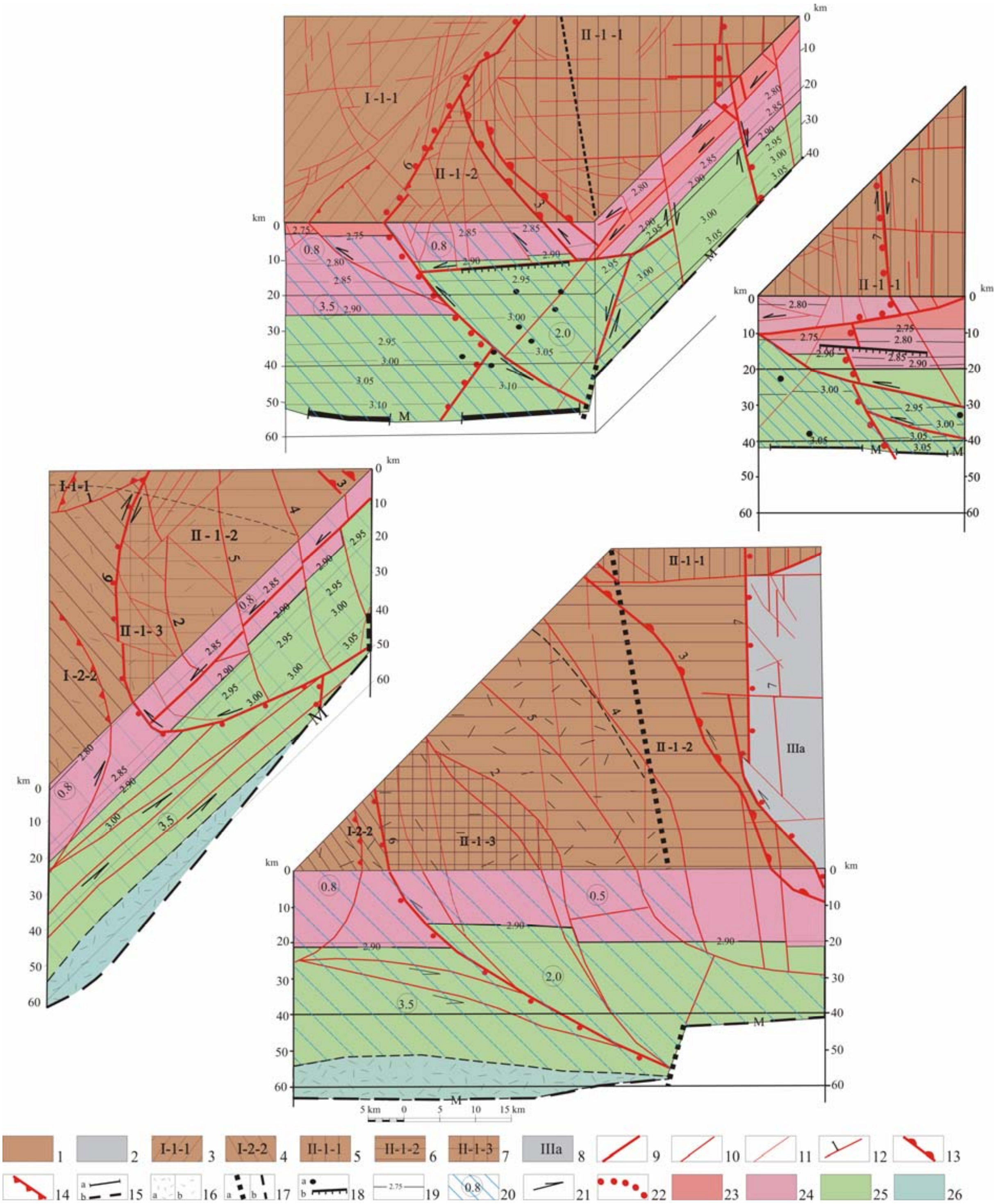

Fig. 4.2. Block-diagram of the deep crustal structure.

Fig. 4.2. Continued. Captures.
Tectonic zonation: 1 – Odesko-Bilotserkivska LTZ; 2 – Ingulo-Inguletska LTZ. **III-order blocks within I-order Podilskiy block**: 3 – Umanskiy within II-order Gaysynskiy block; 4 – Bandurivskiy within II-order Chechelnytskiy block. **III-order blocks within II-order Golovanivskiy block of the I-order Serednyobuzkiy block**: 5 – Yatranskiy; 6 – Pobuzkiy; 7 – Vradievskiy. **II-order blocks within I-order Kirovogradskiy block**: 8 – Bratskiy. **Faults**: 9 – first-order (deep-seated); 10 – second-order (major); 11 – higher-order including complicating ones (minor); 12 – **major faults** (1 – Obodivskiy reverse fault, 2 – Vradievskiy reverse fault, 3 – Emylivska reverse-fault-thrust zone, 4 – Kapitanivska reverse-fault-thrust zone, 5 – Ternuvatska reverse-fault-thrust zone, 6 – Talnivskiy fault, 7 – Pervomaiska fault zone); **other indications**: 13 – thrusts; 14 – reverse faults. **Legend to cross-sections**: 15 – M surface (a – defined by deep-seismic sounding data along profiles, b – interpolated in between profiles); 16 – crust-mantle mixture with $Vp > 7.2$ km/s, $\rho > 3.18$ g/cm^3 (a), and its projection over basement surface (b); 17 – zone of large M surface ledges (a), and its projections over basement surface (b); 18 – diffraction point (a), reflecting bars K_2; 19 – density contour lines by gravity modelling data; 20 – deep magnetic blocks and their magnetization (A/m); 21 – directions of inferred inner-crust block displacement; 22 – source contour of the Golovanivskiy gravity maximum. **Conventionally delineated crustal layers**: 23 – granite; 24 – diorite; 25 – basalt; 26 – crust-mantle mixture.

Thus, the map sheet territory belongs mainly to the Golovanivska Suture Zone and only its eastern part – to the I-order Kirovogradskiy Block of Centralno-Ukrainskiy Geo-Block.

In the Golovanivska Suture Zone, within the map sheet territory, it is distinguished the eastern part of Podilskiyh and Serednyo-Buzkiy I-st order Blocks, respectively, to the west and to the east from Talnivska Tectonic Zone. They differ, first of all, in deep crustal structure.

Podilskiy I-order Block (within the studied territory) is characterized by abnormal crustal thickness which attains 55-60 km while within Serednyo-Buzkiy I-order Block it does not exceed 40 km. Obodivskiy reverse fault separates the eastern part of Podilskiy Block into Gaisynskiy (in the north) and Chechelnytskiy (in the south) II-nd order Blocks.

The eastern parts of the aforementioned blocks are located within the studied territory, respectively, Umanskiy and Bandurivskiy III-rd order Blocks. The Umanskiy Block spatially coincides with Umanska, and Bandurivskiy Block – with Synytsivsko-Savranska Sub-Zones of Odesko-Bilotserkivska LTZ, hence, their definition does not require additional discussion.

Within the map sheet the only II-order Golovanivskiy Block is located which is the part of Serednyo-Buzkiy I-order Block and spatially coincides with Pobuzka and Yatranska Sub-Zones of Odesko-Bilotserkivska LTZ. It is characterized by abnormal density of the Earth's crust that causes respective Golovanivskiy gravity maximum. At the deep structure level, the Golovanivskiy Block in most extent corresponds to the model that comprises the set of north-east and northward-plunging tectonic sheets; respectively, it is subdivided into the III-order Blocks: Yatranskiy, Pobuzkiy, and Vradievskiy. Yatranskiy Block spatially coincides with Yatranska Sub-Zone; Pobuzkiy and Vradievskiy Blocks – with Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ. Vradievskiy III-order Block looks like transitional buffer zone which separates Pobuzka Sub-Zone of "thin" crust from Synytsivsko-Savranska Sub-Zone of "thick" crust, and as transitional zone it spatially coincides with the zone of large stair on the Moho surface at depth.

Within the I-order Kirovogradskiy Block from west to east there are distinguished the following tectonic elements: Bratskiy Synclinorium, Korsun-Novoukrainske Crestal-Block Uplift, Pryingulskiy Synclinorium, and Inguletskiy Anticlinorium. In the territory of map sheet there is located only western part of Bratskiy Synclinorium which by the rank does correspond to the II-nd order block. Spatially it coincides with Bratska Sub-Zone of Ingulo-Inguletska LTZ, and, therefore, its definition does not require additional discussion.

Tectonic breaks. These units in the accepted classification are divided into superimposed zones of tectonic activization, Deep-Seated Faults (tectonic sutures), frontal thrusts of tectonic nappes (deep-seated thrusts), major and minor faults. Apparently, this gradation in most extent corresponds to the fault distribution by depth, length and importance in the geological structure of entire territory. Definition of tectonic breaks and their classification was performed by the authors on the ground of morpho-kinematical analysis and additional results of tectono-facial analysis over the territory which was carried out for some years at the general geology chair in KNU [82]. The morpho-kinematics of tectonic breaks, their spatial position and structure paragenesises are made precise essentially through the field works using as own approaches as methods offered by P.S.Veremyev and T.P.Shevchenko. It was established the thrust movements but only those are indicated in the map which were supported by direct geological observations.

Superimposed zones of tectonic activization are characteristic as for Kirovogradskiy Orogen as for Golovanivska Suture Zone although in the latter metasomatic processes much less expressed. These zones are defined by complex of geological-geophysical evidences and they are characterized by extensive development of tectonites.

The territory of the map sheet is located within Centralno-Ukrainska Lineament Zone [86] which is considered by some authors as mega-zone of activization. The latter is expressed by the variable-density network of sub-latitudinal lineaments comprising 2 to 6-8 km thick alternating zones of compression and extension. These zones include the systems of sub-vertically dipping shear fractures with brittle deformations, milonitization, cataclasm and sheeting, sometimes with formation of pseudo-conglomerates. Considerable thicken of sub-latitudinal lineaments is observed in the north of map sheet territory, in its central part and in the south; based on kinematical patterns this makes possible distinguishing of Subotsko-Moshorynska, Tauzhnyansko-Vivsyanykivska and Lyuboivanivska Zones of sub-latitudinal lineaments thicken up to 10 km wide.

In Subotsko-Moshorynska Zone there are observed mainly normal faults complicated by dextral shifts. In general, this is extension zone. In Tauzhnyansko-Vivsyanykivska Zone there are observed mainly reverse faults with diverse-oriented shift deformations that allows its definition as compression zone. In Lyuboivanivska Zone are observed mainly normal faults with sinistral shifts; this makes possible its definition as extension zone with predominate sinistral horizontal shifts.

Any lineament in Centralno-Ukrainska Zone displays evidences for the batches of en echelon elementary shears with sub-vertical and sub-horizontal micro-displacements which total magnitude varies from first hundreds of meters to first kilometres. Majority of lineaments in the Zone are intra-crustal and tend to be pinched off within hypothetical "basalt layer". By these reasons they cannot be considered as the ore-forming transit channels although the site of their jointing with the Deep-Seated Faults are thought to be favourable for the zones of volumetric cataclasm which can play as structure traps and, therefore, very often are ore-containing.

Deep-seated faults (tectonic sutures), according to the results of deep modelling, do have mantle and lower-crustal roots. They are distinguished by complex of geological-geophysical evidences and are characterized by zones of cataclasm, blastesis, milonites, somewhere mélange zones from first hundreds of meters to some kilometres thick. In this category are classified Talnivska (Odesko-Talnivska) and Pervomaiska Tectonic Zones; in fact, these Zones always are accompanied by thin bodies of mafic and ultramafic rocks.

Talnivska Fault Zone is sub-longitudinal strike at the moderate (from 60^o to 80^o at the sub-soil level) eastward dipping; the strike of the Zone does change to north-eastward in the area of Ulyanivka village. The Zone separates Umanska and Synytsivsko-Savranska Sub-Zones of Odesko-Bilotserkivska LTZ from Pobuzka Sub-Zone, and also divides Podilskiy and Serednyo-Buzkiy I-st order Blocks. According to the deep modelling results, this Zone belongs to the type of listric reverse faults complicated by mainly dextral shifts. It is thought that at the final stages of development this Zone had served the functions of drainage systems. The Zone hosts Maiske gold deposit and a range of gold prospect of which Chemerpilskiy prospect is most important.

Pervomaiska Tectonic Zone separates Odesko-Bilotserkivska and Ingulo-Inguletska LTZ and displays clear linear sub-longitudinal strike (about 350^o) and eastward dipping under the angles of 60-80^o. According to the deep modelling results supported by the field observations, the Zone belongs to the type of deep reverse fault complicated by the sinistral shifts. In the plane the Zone looks like the beam of rays which from Mygiya village disperse northward. By these reasons the Zone width in this direction increases from 1-2 to 8-10 km and more. In general, the Pervomaiska Fault Zone also can be defined as drainage system. In the hanging-wall of the Zone Dobryankivskiy gold prospect is located. The Zone is expressed by the thick zones of blasto-cataclasites and milonites. Within the Zone, Kirovogradski granites get the trachytoid structure.

According to the deep modelling results confirmed by the field observations, Emylivska, Zhuravlynska, and Vodyano-Tymofiivska Zones are classified as frontal thrusts of tectonic nappes (deep thrusts). Notably, Vodyano-Tymofiivskiy thrust is the north-eastern extension of Zhuravlynska Thrust Zone. These two Zones bound Yatranskiy Allochthon from the south, west and east, and are divided into two arcs by Pervomaiska Tectonic Zone.

Motion of Yatranskiy Allochthon to the south was accompanied by extensive destruction of its frontal part with formation of Zhuravlynsko-Yatranska Zone of over-thrust mélange which contains boulders and blocks of the autochthon rocks, divided and split into tectonic sheets – "digitations" that gently plunge to the north. At the meridian of Zavitne village the over-thrust mélange zone width attains 10-12 km and further to the north from Krutenke village it getting narrower up to 2-4 km. From the south it is bounded by Zhuravlynskiy (frontal), and from the north – by Yatranskiy thrusts. In the north-west the zone of over-thrust mélange is cut by Talnivskiy reverse fault and in the east it is broken by Pervomaiska Tectonic Zone. The over-thrust mélange zone, which bounds Yatranskiy Allochthon from below, does dip northward under the angles 10-30^o.

Another zone of over-thrust mélange – Emylivsko-Pervomaiska is being traced from western outskirt of Pervomaisk town in the south to Emylivka village in the north and further joins the western flank of Zhuravlynsko-Yatranska Zone of over-thrust mélange and partially is cut by this Zone. This Zone is quite important for understanding the geology of the region and according to the deep modelling it can be defined as deep thrust. It is composed of boulders and blocks of the autochthon rocks with the signs of ductile flow due to complication by sinistral horizontal shifts. Thickness of the Zone varies from 2-4 km in the south to 8-10 km in the north. From the north-east it is bounded by Emylivskiy frontal thrust, and in the south-west – by Kapitanivskiy thrust-reverse fault. The sliding (detachment) surfaces plunge north-eastward under the angles from 20^o in the north to 45^o in the south. This Zone of over-thrust mélange bounds from the north-east the distinct transitional zone which divides Odesko-Bilotserkivska and Ingulo-Inguletska LTZ.

In our mind, formation of the over-thrust mélange zones is related to the Neo-Archean approach and collision of Lysnyanska Island Arc with Volyno-Podilskiy Proto-Continent and obduction of the former onto the complexes of the latter; later in Paleo-Proterozoic the situation was complicated by orogenic movements in relation to formation of Kirovogradskiy Orogenic Belt. There are some evidences for assumption that Emylivsko-Pervomaiska Zone of over-thrust mélange comprises the root zone of tectonic nappe which western margin is located outside the map sheet and its fragments are retained at the erosion level in tectonic detached masses (thrust clips). Of them, most prominent is Khashchuvato-Zavallivskiy Clip bounded (within map sheet) from below by Zavallivskiy thrust.

The root portions of the over-thrust mélange zone, which definition is argued above, had played as drainage systems favorable for migration of the ore-bearing fluids; in presence of ophiolite complex rocks these root portions are thought to be favourable for location of gold mineralization. In this respect most prospective are the zones of thrust zone junction with the sub-latitudinal extension systems. It first of all concerns Emylivsko-Pervomaiska Zone.

Major and minor mainly intra-crustal faults are being defined by complex geological-geophysical evidences and supported by field observations. They are characterized by zones of cataclasm and milonitization of various thicknesses that does not exceed first tens of meters, sometimes attaining first kilometres. The major faults and fault zones somewhere are accompanied by up to 1.5 km thick mélange zones (Obodivskiy reverse fault-shift) and normally separate sub-zones or individual tectonic sheets (digitations) inside LTZ. In the scheme of the spatial tectonic subdivision and in the geological map these faults are shown in limited amount which only highlights the major tectonic patterns of the territory.

Some fault of Subotsko-Moshorynska, Tauzhnyansko-Vivsyanykivska and Lyuboivanivska Zones of sub-latitudinal lineament thicken are defined as major ones. Normally, these faults intersect the Earth's crust over full its thickness up to the Moho boundary. The major faults of north-western and north-eastern strike commonly pinch off within the basalt layer of the Earth's crust at the depth 20-30 km. The most important major faults are as follows: Obodivskiy, Kolodystivskiy, Vradievskiy, Strutynskiy, and Ternivskiy reverse faults; Ternuvatskiy and Kapitanivskiy reverse fault-shifts; Yatranskiy thrust. These faults commonly are complicated by dextral and sinistral shifts and in their majority are ore-controlling and ore-containing. It should be specially noted that Obodivskiy fault, which at Ladyzhynka village joins Talnivska Tectonic Zone, bounded from the south the Korostenskiy tectono-centre established by O.B.Gintov.

Folded structures within the map sheet are significantly reduced and broken by faults. Most of these structures are lens-shaped and do not exceed 4-8 km (rarely 10-15 km) by the long axis and 2-4 km (rarely 5-6 km) by the short axis with the limb dipping under the angles from 50^o to 85^o. The fold bends plunge under the same angles. The synform structures are mainly envelope folds. This pattern of the fold structure in the studied territory is fairly similar to the lens-layered mélange, for instance, in Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ. On approach to the deep-seated and major faults there is observed overprinting of the simple folded forms by isocline folding of higher orders and formations of disharmonic folding in compression zones.

Major positive structures within the studied territory include Ocheretyanska, Lupolivska, Roznoshynska, and Velykomechetnyanska antiforms. They are located within Pobuzka Sub-Zone of Odesko-Bilotserkivska LTZ; by strike they are traced over 20-25 km and are up to 5-6 km wide. Lupolivska antiform is weakly studied and it could be monocline. All the forms are mainly composed of granitoids of Gaivoronskiy and Pobuzkiy Complexes.

Major negative structures include Khashchuvato-Zavallivska, Polyanetska, Grushkivska, Kosharo-Oleksandrivska, Rozdolynska, Moldovska, Ternuvatska (Sekretarska), Derenyukhinska, Kapitanivska, Sukhotashlytska, Chausivska, Troyanska, Tarasivska, Chemerpilska, and other synform structures which size is not sufficient (except the first one). By strike they are traced over the distance from 4-5 to 10-15 km and their width does not exceeds 2-4 km. Some researchers consider Troyanska, Tarasivska, and Chemerpilska synforms as the root structures of the deeply eroded paleo-volcanoes but most reliable to do so with regard to Chemerpilska structure. It is of semi-isometric shape and its central part is associated with gravity and magnetic maximums surrounded by the ring gravity and magnetic minimum. Thickness of the major synform structures does not exceed 4-5 km.

Massifs of intrusive rocks are widely distributed. In the territory of map sheet they are composed of the rocks of Kapitanivskiy, Derenyukhinskiy, Raypilskiy, and Sabarivskiy Complexes. The ultra-metamorphic rocks commonly do not form the individualized massifs ue to their regional distribution.

Mafic and ultramafic rocks are observed as the small intrusions in zones of deep-seated and major faults or in the zones of these fault influence. Most of these massifs are spatially linked with synform structures, they are of small (up to first kilometres) size and form mainly folded inter-layering bodies with thickness up to first hundreds of meters. Some of these bodies confined to the deep thrusts display the signs of serpentinite mélange and can be considered as ductile protrusions, for instance, in Emylivska Zone (Kapitanivskiy Complex).

Ultra-metamorphic granitoids form three separate groups depending on their relations to different tectonic levels and formations.

The first group includes granitoids of tonalite-enderbite formation (Gaivoronskiy Complex) of the lower tectonic bench. They probably formed in the zones of primary crustal consolidation [7] and display the signs of "I" granites. These rocks are related to the oldest enderbite-gneiss domes of the lower tectonic bench which are essentially affected by superimposed linear folding. At the surface of crystalline basement these rocks are always exposed in the cores of antiform structures.

The second group includes massifs and distribution fields of collision "S" granites of early collision (Pobuzkiy Complex). They are composed of leucogranulite formation (mainly of the middle tectonic bench) and are known from both positive and negative folded forms. In Synytsivsko-Savranska Sub-Zone their autochthon and para-autochthon varieties somewhere form individual small massifs like granite-migmatite domes (area of Maiske gold deposit).

The third group includes massifs and distribution fields of "S-type" granites (Kirovogradskiy and Umanskiy Complexes) formed within the crustal granite layer in relation to granitization processes caused by the late collision and formation of Kirovogradskiy Orogenic Belt. They commonly formed in the cores of antiform folded structures where granitization processes have had maximum attitude. Their thickness by geophysical data attains 2.5-3.0 km and rarely exceeds 3.5-4.0 km. Transitions to the host gneiss-granite sequences are gradual. Mainly these are autochthon and para-autochthon granitoids. Just the Umanskiy massif is considered to be allochthonous.

Umanskiy granite massif is located in the far north-western part of the studied territory which belongs to Rosynsko-Tykytskiy geologic region and spatially coincides with Umanska Sub-Zone of Odesko-Bilotserkivska LTZ. The depth of lowermost massif's boundary does not exceed 2.5-3.0 km and drops to zero within the erosion windows where plagiogranitoids of Tetiivskiy Complex are exposed.

Upper tectonic level

It includes the sediments of the cover complex. It is composed of Phanerozoic (Cretaceous, Paleogene and Neogene) and Quaternary sediments; the rocks lie horizontally, their thickness varies from 0 to 150 m (35-40 m in average). Tectonic breaks are small-amplitude and are caused by irregular oscillatory epeirogenic motions of some crustal blocks under platform environments. The block size varies from the first hundreds of meters up to tens of kilometers. The plicate breaks are absent but there are some evidences to assume that within tectonic zones kaoline and clay diapirs can be found. The depth of substrate re-working in zones of tectonic breaks is low, normally initial, and does correspond to the clay tectonites and breccia while commonly it comprises jointing and shear fracture formation. The breaks which sometimes are observed in Quaternary sediments at the sub-soil level are commonly expressed by the system of contiguous frost-imposed fractures.

The oscillatory motions in the sedimentary cover are caused by low-amplitude movements along tectonic breaks in Precambrian basement including those not indicated in the geological map of crystalline basement due to their insufficient influence on the Precambrian structure. Most of tectonic breaks in Phanerozoic cover are sub-vertical and are classified as normal and reverse faults.

The vertical movements of some blocks depending on the age of their appearance have had variable direction as well as compensatory mode: sinking of one block had accompanied by adjacent block uplift and reverse. Tectonic breaks in sedimentary cover are quite rarely observed in outcrops but this fact is caused by very low exposure of Phanerozoic sediments. Commonly the break are being found during morpho-structure analysis of the basic geological sections through oscillations in the level of some horizons, their thickness, some horizon pinch-off in some intervals of the sections, as well as by the sharp change of thickness and litho-facial composition of the stratons in sedimentary cover. In some cases straton thickness decrease and straton pinch-off can be also explained by erosion at the local uplifts but, in turn, formation of such positive structures is thought to be the consequence of the vertical oscillatory motions of some blocks.

By the age of maximum expression of tectonic processes in the territory of the map sheet the only Alpine epoch of tectogenesis can be distinguished more or less reliably and this is also caused by activization of

Precambrian basement faults. There are found no evidences for older epochs of tectonic activization although there are enough evidences to assume that in the country between Kodyma and Southern Boug Rivers in Cimmerian epoch of tectogenesis was formed the graben-like structure which at the end of Pliocene only had been transformed into neo-tectonic uplift.

Alpine tectogenesis is expressed over entire map sheet territory with oscillatory tectonic motions of some crustal blocks due to activization of tectonic breaks in Precambrian basement as at sub-soil as probably at the deep levels. It first of all concerns the faults of north, north-west and sub-latitudinal strike likewise in the territory of adjacent map sheet M-36-XXXII (Novoukrainka) [14]. The cover faults that control distribution of Phanerozoic sediments and bound some blocks, do spatially coincide with the faults distinguished in Precambrian basement and sometime are parallel to them. They are expressed in "piano-key" system of diverse-level blocks or they form linear structures, horsts and grabens of macro- and micro-levels which are from some tens of meters up to 3-10 km wide. Linear neo-tectonic structures are most characteristic for Subotsko-Moshorynska, Tauzhnyansko-Vivsyanykivska and Lyuboivanivska Zones of sub-latitudinal lineament thicken. And above the sub-latitudinal lineaments in extension zones sometimes are found micro-horsts, for instance, at south-eastern outskirt of Polyanetske village. The age of most extensive oscillatory tectonic motions of Alpine tectogenesis epoch likewise adjacent Novoukrainskiy map sheet does correspond to Eocene-Miocene.

Neo-tectonic, including modern, motions are rather clear expressed; they form the modern relief and are described in the section "Geomorphology". The general features of neo-tectonic characteristics include: 1) the studied territory belongs to the areas with inherited geodynamic regime and mainly single-directed positive crustal motions and unstable block uplifts; 2) tectonic pre-determination of the modern relief is supported by the spatial coincidence of the watersheds with lineament zones which, in turn, completely or partly spatially coincide with the zones of tectonic activization in Precambrian basement described above.

Crustal deep structure and the link between surface and deep structures

Most of the M-36-XXXI map sheet territory encompasses Golovanivska Suture Zone located between Volyno-Podilskiy and Centralno-Ukrainskiy Geo-Blocks of Ukrainian Shield. This determines considerable difficulties as in design the geophysical models as in transition from these models to the crustal tectonic and composition elements in the region and in geological-geophysical interpretation of obtained results. From another hand, detailed analysis of geological-geophysical data allows receiving the unique information concerning structure and composition of diverse litho-tectonic complexes from the upper and lower Earth's crust and on this ground to define both the crustal regions with different types of magmatic processes and the individual bodies of mafic-ultramafic composition, as well as to determine tectonic breaks and movements of specific crustal parts and blocks.

The scheme of crustal structure (see Fig. 4.1) and block-diagram showing relations between spatial tectonic subdivision and deep crustal structure (see Fig. 4.2) are designed on the ground of generalization and re-interpretation of available geophysical data [27, 32, 39, 43], results of 3D gravity and magnetic modelling, and their combined analysis coupled with geological materials.

The territory of map sheet is located in the area unique for Ukrainian Shield by its complicated deep crustal structure. In sub-longitudinal direction with prominent ledge over the Moho Surface it is split into the eastern and western portions which differ by crustal thickness and composition. At the sub-soil level and in the crustal vertical section the Moho Ledge is expressed in the III-rd order wedge-shaped Vradievskiy Transitional Block bounded by Talnivskiy and Vradievskiy Deep-Seated Faults. Talnivskiy Fault is associated with the same-named ore-bearing zone where Savranske Gold-Ore Field is located. In the eastern part the Moho Surface relief is actually flat and its depth is 40-43 km. The crustal composition that reflects thickness relationships of conventional Granite, Diorite and Basalt Layers, in the eastern part is close to Diorite Layer. The western part of the territory is characterized by abnormal crustal thickness (from 50 to 68 km) but the structure plan of the Moho Surface does not comply with the general trend of Golovanivska Suture Zone while the Moho Surface bend extends in north-west direction. Crustal composition in this part of the map sheet is leuco-basaltic and in the north-western part – normal basaltic. The distinct characteristic of the crust in this area is development of the crust-mantle mixture extending outside the map sheet. And over both sides from the Moho Ledge there is observed the change in distribution of magnetic units as in the upper as in the lower crustal portions. In the western part the entire crustal section is characterized by mainly high-magnetization values. Eastward from the Ledge the average magnetization in the upper crust does not exceed 0.5 A/m and higher-magnetic rocks are confined to the lower half of the Basalt Layer (see Fig. 4.2). In contrast, in the north-east of the eastern part of the territory the crust is actually non-magnetic.

Aforementioned features of the deep crustal structure in the eastern and western parts of the territory are reflected at the sub-soil level of Precambrian basement. Particularly, the section of Neo-Archean (Middle

Tectonic Bench) to the west from Vradievskiy Deep-Seated Fault is more typical for Rosynsko-Tykytskiy geological region and differs from Neo-Archean sections of Pobuzka Sub-Zone as by composition as by metamorphic degree. It should be noted, that the metamorphic facies distribution is also controlled by the Moho Ledge, that is, to the west from the Ledge (specifically, to the west from Talnivskiy Deep-Seated Fault) the rocks of the Middle Tectonic Bench are mainly metamorphosed under amphibolite facies whereas to the east from the Ledge – under granulite facies.

The strike of the Moho Ledge being projected onto the surface of Precambrian basement is sub-parallel to the Pervomaiska Fault Zone and to the series of sub-longitudinal faults. It probably causes S-shaped morphology of the major faults in Pobuzkiy Block (Emylivskiy, Kapitanivskiy, Vradievskiy).

Thickness of the lithosphere decreases from the south-east to the north-west – from 250 km to less than 200 km [37]. By this feature V.B.Sollogub had distinguished lineament "G" of north-east strike (see Fig. 4.1). The zone of its junction with the Moho Ledge is observed in the central part of Golovanivska Suture Zone. The latter, as it is known, is marked by Golovanivskiy Gravity Maximum (see Fig. 4.1). According to gravity modelling results, this Maximum is caused by cumulative effect of the Moho Ledge and abnormally dense rocks in the upper crust, mainly in the western part of the Maximum. There in the most of territory Granite Layer is absent and Diorite Layer is of minimum thickness. In the central part the Golovanivskiy Maximum is complicated by Pushkivskiy Maximum with the relative intensity more than 10 mgl. It is located just above the Moho Ledge and in the junction point of the Ledge with the "G" lineament projection onto the surface of Precambrian basement. Within Pushkivskiy Maximum are located Tarasivska and Troyanska structures as well as a number of mafic and ultramafic massifs which are the indicators of the upper crust abnormal saturation with mafic and ultramafic magmas.

The junction point of the Moho Ledge and asthenosphere lineament "G" on the surface of Precambrian basement is the locus of Pobuzkiy Ore Camp, and Derenyukhinskiy Ore Field does spatially coincide with the Pushkivskiy Gravity Maximum which complicates the Golovanivskiy Maximum. In general, there are enough arguments to conclude that most of the metal prospects (in the territory of the map sheet) are concentrated in the influence zone of the asthenosphere lineament "G".

Looking at the block structure of the territory in relation to the deep crustal structure it can be emphasized the following specific features.

- The spatial tectonic subdivision of the territory at the level of LTZ and sub-zones is being grounded on the patterns of the crustal deep structure within specific blocks.
- Along Talnivskiy Fault there is expressed the change of crustal section from the east to the west with actual thickness doubling of Diorite Layer and Granite Layer appearance in the Synytsivsko-Savranska Sub-Zone. In this case, according to the tectonic interpretation of geophysical modeling results, structure relations between Granite and Diorite Layers can be attributed to the reverse fault upthrow along Bandurivskiy Fault.
- Occurrence of the crust-mantle mixture developed in the Moho Ledge beneath Talnivskiy Fault as well as density distribution in the Basalt Layer allow prediction the gradual under-thrust movements of the deep horizons in Synytsivsko-Savranska Sub-Zone underneath the Talnivskiy Fault.
- Pervomaiska Zone comprises series of major faults which in their deep portions are cut by intra-crustal breaks at various levels. In the lower crust such movements are determined in the density model (see Fig. 4.2). In general, to the west from Pervomaiska Zone up to Talnivskiy Fault the crustal density in Diorite and Basalt Layers is increased. Discontinuity in the lower crust beneath Pervomaiskiy Fault can be considered as the deep extension of the Emylivsko-Pervomaiska Mélange Zone.

Special attention should be paid to the density-increased crustal portion beneath Talnivskiy Fault in direct proximity to the Moho Ledge. Coupled with density-increased and magnetized "sheet" in the lower crust to the west from the Ledge, aforementioned crustal portion can be considered as a result of the abnormal mafic-ultramafic magmatism in the zone of sharp changes in the crustal thickness and composition.

The distinct crustal structure is determined in Yatranskiy Block. As can be seen (see Fig 4.2) this Block is underlain by irregular and broken crustal section. The surface of Basalt Layer stair-wise does plunge northward by latitudinal faults whereas Diorite and Granite Layers are displaced from the north to the south in the nappe mode over-thrusting one another. At the same time and direction it is observed decreasing of the Granite Layer thickness. In general, Yatranskiy Block comprises large allochthon over-thrusted southward and broken by latitudinal normal faults.

Analysis of structure relations between the upper and lower crustal horizons allows assumption that 1) the major feeding channel of mafic-ultramafic magmas was the zone of sharp changes in crustal thickness in connection with numerous linked one to another flat faults inside the crust, and that 2) the zone of the maximum crustal re-working is the area to the west from the Moho Ledge, that is, Synytsivsko-Savranska Sub-Zone of Odesko-Bilotserkivska LTZ. The Pushkivskiy Gravity Maximum directly above the Moho Ledge and in the junction with lineament "G" provides the interest with regard to development of chromite-bearing intrusions within the Maximum in the area Lypovenki-Kapitanivka. The special attention should be paid to the area of "thick" Earth's crust underlain by the horizon of crust-mantle mixture and determined in the south-western part of the territory. There on the Precambrian basement surface in around Bandurivskiy Dome (outside the studies territory and in Zavallivskiy Graphite Quarry) occurrences of lamproite magmatism are found [49]. It is most likely that Tarasivska and Troyanivska structures are "root-off", displaced together with Yatranskiy Allochthon.

Thus, tectonic interpretation of the density and magnetic crustal models designed on the ground of seismic data does confirm the complicated history of development and multi-phase magmatic activization of the region.

Tectono-facies in major rheological types of dislocation tectonics

The theoretic ground for definition of tectono-facies is tectono-facial analysis. In this respect the staff of Kyiv Taras Shevchenko National University under leadership of Prof. O.I.Lukienko had carried out research works [82].

Tectono-facial scheme (Fig. 4.3) commonly uses some tectonic base from the geological map of crystalline basement which reflects succession of the crustal formation. The major supplement to the tectono-facial scheme is a structure-age scale (Table 4). The field works had revealed that in the map sheet territory are developed the dislocation structures and respective tectono-facies of the Lower and Upper Catazone, Sub-Catazone, Local Mesozone, and Secondary Epizone.

Structure-age scale of dislocation tectonics in Middle Pobuzhzhya discloses relative age of defined rheological types of dislocation tectonics. Such the scale provides the system to evaluate the time succession of changes in the rheological state of geological medium (and respective P-T conditions) and rheological mechanisms of dislocation processes.

Tectono-facial structure (see Fig. 4.3) comprise the integrated sum of tectono-facies and respective dislocation structures of all mentioned (see Table 4) stages of dislocation transformations on the background of continuous retrograde changes of P-T conditions and changes in retrograde rheologic properties of the medium.

Lower Catazone dislocation tectonics that corresponds to the stages D_1 and D_2 is preserved fragmentary. But even information available suggest for low-intensity dislocation tectonics (large enderbite massifs do not display any internal deformations) which were close to the brittle type.

The strongest and most ductile deformations in the given area are related to the Upper Catazone stage D_3 which had coincided in time with amphibolite retrograde metamorphism and quite extensive migmatization and granitization of Archean granulite complexes. This stage is characterized by ductile-fault tectonics of suture type which by realization intensity and rank of tectono-facies does correspond to the typical geosyncline folding.

In the given area aforementioned stage is determined exclusively of Pobuzka Sub-Zone and comprises series of schistose-gneissose ductile faults of north-west sub-longitudinal strike which by their spatial position do coincide with later brittle faults including, for instance, Talnivskiy, Vradievskiy, Ternuvatskiy, Kapitanivskiy, Sykhotashlytskiy, and Emylivskiy. Width of these fault zones varies from 1 to 5 kilometres.

Mentioned faults spatially are tightly linked and actually form ductile-fault zone of suture type which display the shape of bud opens in the central part of the studied area (between Southern Boug River and latitudinal part of Yatran River) and joins together in the north of the area. Perhaps, it is worthy to call this zone as Golovanivska Ductile-Fault Zone.

This Ductile-Fault Zone is sharply cut by the brittle Talnivskiy and Emylivskiy Faults and "eat up" by granitoids of Kirovogradskiy and Umanskiy Complexes.

Taking into account the dipping of schistosity and gneissosity surfaces and other planar elements, the dipping of entire Golovanivska Ductile-Fault Zone is thought to be mainly steep and varies from 60^o to 90^o being directed westward (Talnivskiy and Vradievskiy Ductile Faults), eastward (Sukhotashlytskiy and Emylivskiy Ductile Faults), or semi-vertical (Ternuvatskiy Ductile Fault). Linearity spatial orientation data suggest that displacement by such zone is of shift-upthrown type (upthrown counterpart predominates) in the site of maximum zone opening, and upthrown-shift type (horizontal shift counterpart predominates) in the fault junction site.

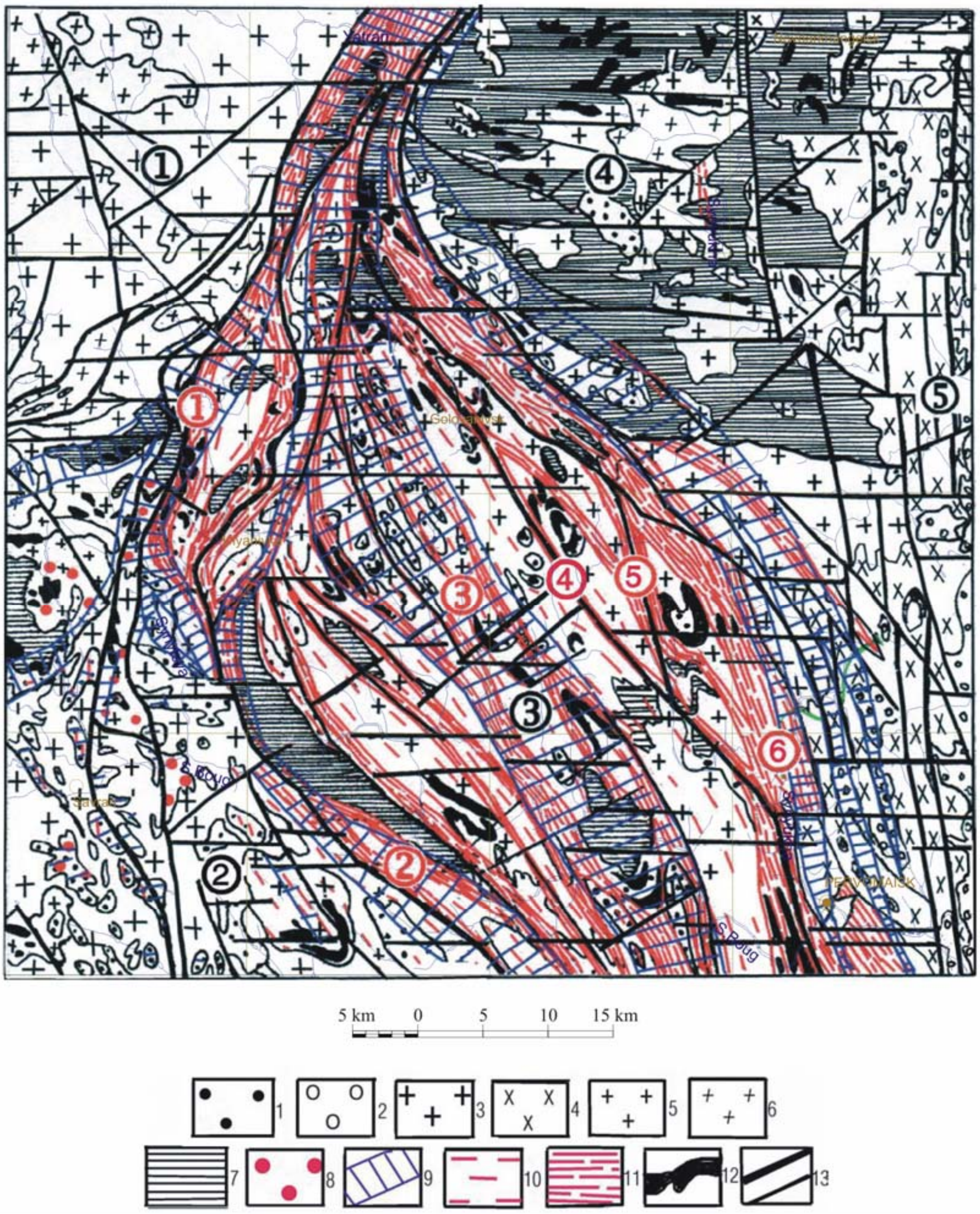

Fig. 4.3. Tectono-facies scheme.

1-7 – background (I-IV) tectono-facies of Dnistersko-Buzka and Buzka series (1), Ingulo-Inguletska Series (2), granitoids of Umanskiy (3), Kirovogradskiy (4), Pobuzkiy (5), Tetiivskiy (6) complexes and enderbites of Gayvoronskiy Complex (7); 8 – areas of non-linear viscous flow of Pobuzkiy Complex migmatite-granites (tectono-facies I-VII); 9 – viscous cleavage faults in lower meso-zone (tectonofacies V-X); 10-11 – viscous schistose and gneissose faults in upper cata-zone (10 – tectonofacies V-VII, 11 – VII-X); 12 – lens-like bodies of Archean granulites; 13 – brittle faults of all types. **Numbers in red circles – LTZ**: 1-4 – Odesko-Bilotserkivska including its sub-zones (1 – Umanska, 2 – Synytsovo-Savranska (Talnovska), 3 – Pobuzka (Golovanivska), 4 –Yatranska); 5 – Ingulo-Inguletska. **Numbers in black circles – viscous faults** (1 – Talnovskiy, 2 – Vradievskiy, 3 – Tarnovatskiy, 4 – Kapitanivskiy, 5 – Sukhotashlykskiy, 6 – Emylivskiy).

Table 4

<table>
<tr><th>Stage index</th><th>Structure-rheologic environ-ments</th><th>Major rheologic mechanism</th><th>Major dislocation structures</th><th>Tectono-facies</th><th>Tectonic level where dislocation structures occur</th><th>Age of dislocation transformations</th></tr>
<tr><td>D_1</td><td>Lower Catazone-1</td><td>Ductile crystallization-schistose and non-schistose flow</td><td>Weakly expressed ductile schistose faults and zones of disharmonic folding</td><td>I-VII</td><td>Lower</td><td>Early- and, probably, Middle-Archean</td></tr>
<tr><td rowspan="3">D_2</td><td rowspan="3">Lower Catazone-2</td><td>Ductile non-schistose turbulent and laminar-turbulent flow</td><td>Non-linear zones of disharmonic folding</td><td>I-VII</td><td rowspan="3">Lower and Middle</td><td rowspan="3">Late-Archean, pre-Pobuzkiy</td></tr>
<tr><td>Crystallization-schistose flow</td><td>Weakly-expressed ductile schistose faults</td><td>I-VII</td></tr>
<tr><td>Milonitization +ductile flow and partial melting</td><td>Zones of pseudo-tachylytes and ultra-milonites like brittle faults</td><td>IX-X</td></tr>
<tr><td rowspan="2">D_3</td><td rowspan="2">Upper Catazone</td><td>Migmatite turbulent and laminar-turbulent flow</td><td>Non-linear zones</td><td>I-VII</td><td>Lower and Middle</td><td>Early Proterozoic, syn- and post-Pobuzkiy – pre-Kirovogradskiy</td></tr>
<tr><td>Crystallization and translation-schistose, gneissose</td><td>Ductile faults of several phases</td><td>V-X</td><td>Middle Tectonic Bench</td><td>Early Proterozoic, syn- and post-Pobuzkiy – pre-Kirovogradskiy</td></tr>
<tr><td>D_4</td><td>Lower Mesozone</td><td>Cleavage flow</td><td>Ductile cleavage faults</td><td>V-X</td><td>All tectonic benches</td><td>Early Proterozoic, post (and probably also syn-) Kirovogradskiy – pre-Umanskiy</td></tr>
<tr><td>D_5</td><td></td><td>Ultra-milonitization +ductile flow of ultra-milonite mass</td><td>Sutures like brittle faults</td><td>IX-X</td><td>All tectonic benches</td><td>Proterozoic, syn-pegmatoid of regional vein phase</td></tr>
<tr><td>D_6</td><td>Local Mesozone</td><td>Mechanic-cleavage</td><td>Lens-like sites</td><td>V-X (background I-IV)</td><td>All tectonic benches</td><td>Apparently, Late Proterozoic, syn-middle-temperature-metasomatic and, probably, syn-gold-ore</td></tr>
<tr><td rowspan="3">D_7</td><td rowspan="3">Secondary Epizone</td><td>Brittle-cleavage</td><td>Ductile-like amplitude-off faults</td><td></td><td rowspan="3">All tectonic benches</td><td rowspan="2">Probably, Late Proterozoic</td></tr>
<tr><td>Brecciation and cataclasm</td><td>Brittle-ductile faults</td><td></td></tr>
<tr><td>Floury milonitization</td><td>Brittle faults</td><td></td><td>Phanerozoic</td></tr>
</table>

Given zone in the site of its maximum opening leads to tectonic boudinage of granitized and retrograde-metamorphozed rocks of the Lower and Middle Tectonic Benches, as well as to the slide-fold (distinct fault-side crumpling when ductile faults is displacer) crumpling of layered bodies of mentioned tectonic benches.

Lower Mesozone cleavage ductile-fault tectonics of the stage D_4 also essentially contributes to enhancement of the aforementioned ductile schistosity. Spatially it almost fully coincides with the previous ductile one, overprints it and partially encompasses the spaces between the two. Besides this, it is more widely distributed as compared to the Upper Catazone. Particularly, their branches are known in Synytsivsko-Savranska and Yatranska Sub-Zones. Cleavage faults affect all tectonic benches as well as granitoids of Kirovogradskiy Complex. But they are not known in Umanski granitoids and there are some reasons to consider them as pre-Umanski.

This type fault dipping is mainly steep and displacement by these faults is roughly similar to those by schistose-gneissose faults.

Ultra-milonite tectonics of the stage D_5 by morphological features is brittle-fault and leads to formation of the block structures. Apparently, this kind of tectonics commences the stage of active crustal block formation in the studied territory (as well as other portions of Ukrainian Shield).

In the tectono-facial scheme given above this kind of tectonics is not defined separately.

Dislocation structures of the Local Mesozone stage D6 are not considerably distributed over the studied territory and by this reason are not indicated in the tectono-facial scheme.

Dislocation tectonics of the Secondary Epizone stage D7 in the studied territory is represented by brittle-ductile and brittle faults as well as fault-side (brittle-ductile fault-related) folds of gneissed and cleavaged metamorphic bodies and granitoids. This it typical block tectonics that detach all previous structures and does form the regmatic networks.

In tectono-facial scheme above this tectonics together with ultra-milonite one is defined as uniform subdivision concerning brittle faults of all types.

Thus, above discussion suggests that most important dislocation style in the studied part of Middle Pobuzhzhya is the ductile schistose-gneissose and cleavage ductile-fault tectonics which leads to essential Earth's crust boudinage at the given site and apparently traces most mobile and permeable crustal zones in Early Proterozoic. Brittle tectonics appears in the stages of sharp thermal gradient decrease (in conjunction to regional crustal uplift) and crustal consolidation under low-temperature conditions, that is, in Epizone regime. The part of such tectonics inherits directions of the ductile tectonics and causes block arrangement of the LTZ.

As to the Pervomaiska Fault Zone, which is being considered to be the boundary between Odesko-Bilotserkivska and Ingulo-Inguletska LTZ, in term of dislocation it is expressed weakly enough and formally is distinguished by single relatively young floury-milonite brittle faults of longitudinal strike. Perhaps, the principal boundary structure between these LTZ comprises the Golovanivska Ductile-Fault Zone which at the final orogenic stage had been transformed into Serednyo-Buzka Mélange Zone bounded by Talnivskiy and Emylivskiy faults.

5. HISTORY OF GEOLOGICAL DEVELOPMENT

In the geological history of the studied territory likewise entire Ukrainian Shield there are rather clear distinguished two stages: Precambrian and Phanerozoic ones. They differ in tectonic regimes and patterns of all geological processes. It is characteristic for Cryptozoic the frequent changes in tectonic regimes and widespread magmatic processes. Deposition of relatively thin Phanerozoic sedimentary piles was occurred under conditions of the platform oscillatory motions.

Precambrian stage

It encompasses Archean and Proterozoic Acrons over which pulsation transformations of the Earth's crust from oceanic into transitional one and from transitional to continental crust occurred. Crustal evolution is thought to have had released in progressive-cyclical mode: periods of high tectono-magmatic activity did alternate with the periods of relative stability when the crust was in the quasi-cratonic state [45].

There are distinguished six epochs of tectogenesis in the crustal Precambrian history of Ukrainian Shield: Dnisterska, Azovska, Dniprovska, Buzka, Saksaganska, and Volynska. By their meaning these epochs do correspond to the tectono-magmatic cycles; some of them can be considered as completed and some – as uncompleted. And some only are directly expressed in the studied territory but nevertheless the echoes of respective events outside the territory are expressed through activization of previously consolidated crustal portions. The age boundaries indicated after [44] unless these are supported in the map sheet territory by isotope dating.

Paleo-Archean (Dnistrovian). Dnisterska Tectogenesis Epoch, according to the data of L.M.Stepanyuk [38], encompasses the time span of 3900-3400 Ma. It was the epoch of primary crustal consolidation. Apparently, prior to 3650 Ma occurred deposition of the thick volcano-sedimentary sequences of Dnistersko-Buzka Series in paleo-zones of proto-continental crust (Lower Tectonic Bench). At the time border of 3650 Ma these units were intruded by the oldest ultramafic rocks of Sabarivskiy Complex. And at the time border of 3400 Ma Dnisterska Tectogenesis Epoch was terminated with tonalite-enderbite Gaivoronskiy Complex.

It is characteristic that Dnisterskiy Tectono-Magmatic Cycle is not completed. Crustal cratonization was terminated at the stage of transitional crust formation. Taking into account conclusions of L.M.Stepanyuk [38], it can be supposed that within the given territory the "Dnistrides" underwent 5 phases of tectono-thermal transformations under activization regime, which had accompanied by re-building of isotopic geochemical systems.

- The first phase was released in the time span 3.2-3.1 Ga and is related to the echo from opening of Dniprovsko-Sumskiy paleo-oceanic basin.
- The second phase was released in the time span 2.8-2.7 Ga and is related to the echo from closure of above paleo-oceanic basin.
- The third phase was released in the time span 2.4-2.3 Ga (according to L.M.Stepanyuk) and most probably – 2.5-2.3 Ga, and is related to collision of Paleo-Archean Volyno-Podilskiy Proto-Continent (Geo-Block) with Neo-Archean Lysyanska Island Arc and closure of Ingulskiy Back-Arc Basin and forland collision.
- The fourth phase was released in the time span 2.08-2.0 Ga and is related to formation of Kirovogradskiy Orogenic Belt.
- The fifth phase was released in the time span 1.96-1.93 Ga and is related to post-orogenic hydrothermal-metasomatic processes. Formation of large-reserve uranium and gold deposits in the studied and adjacent territories is related to this phase.

Meso-Archean (Azovian). The signs of Azovian Tectogenesis Epoch are not found in the map sheet territory and it can be concluded that in the time span 3400-3200 Ma this part of Ukrainian Shield occurred in the quasi-cratonic state.

Neo-Archean (Dniprovian). It includes Dniprovska and Buzka Tectogenesis Epochs separated by the isochrone 2800 Ma.

Dniprovska Tectogenesis Epoch in the studied area is expressed in palingenetic-metasomatic re-building of Early-Archean granulite and enderbite complexes of the Lower Tectonic Bench and, as a result, formation of Litynskiy Complex of reomorhic granitoids, as well as re-building of isotope systems at the border of 2800 Ma.

Buzka Tectogenesis Epoch in the studied area occurred in the time span 2800-2600 Ma [38]. Beginning of the Epoch is marked with the opening of Golovanivska Paleo-Oceanic Zone [7] with formation of the thick rifting and oceanic complexes of Buzka and Rosynsko-Tykytska Series. The peak of volcanic activity probably took place in the time span 2750-2720 Ma (L.M.Stepanyuk had supposed that intrusive mafic-ultramafic magmatism in Zavallivskiy Block took place prior to 2720 Ma [38]). The end of Buzka Tectogenesis Epoch was defined by closure of Golovanivska Paleo-Oceanic Zone and its subduction beneath Sarmatskiy Aeo-Craton [7]. The end-indicator of Buzka Tectogenesis Epoch is tonalite-plagiogranite Tetiivskiy Complex (2600 Ma) widely distributed in Odesko-Bilotserkivska LTZ. According to L.M.Stepanyuk [38], "Buzides" underwent three phases of tectono-thermal transformations under activization regime: first one in the time span 2.5-2.3 Ga, second – 2.08-2.0 Ga, and third – 1.96-1.93 Ga.

Paleo-Proterozoic (Kryvorizhian). Kryvorizkiy Tectono-Magmatic Cycle in the full extent occurred in the Ingulo-Inguletska LTZ in the time span 2600-2000 Ma and corresponds to Saksaganska Tectogenesis Epoch [38]. Voclanic-sedimentary rocks of Ingulo-Inguletska Series, according to V.G.Pastukhov, formed in the Ingulskiy Back-Arc (residual flischoid) Basin.

At the time border ~2500 Ma, as a result of collision the back-arc basin and then same-placed residual flischoid basin were ceased due to subduction and formation of Bratska Accretion Prism. Apparently, this process had changed by progressive under-thrusting of Volyno-Podilskiy Proto-Continent beneath Kirovogradska Micro-Plate and Sarmatskiy Aeo-Craton under conditions of continental "A" subduction paleo-zone and had terminated at the time border ~2300 Ma. The process was accompanied by gold deposition in the contrasted formations of under-thrust zone. And coeval to this process, in paleo-zone of deep squeezing at the forland "S" granites of early collision were formed.

Significant under-thrusting of Proto-Continent granulite and enderbite complexes beneath Kirovogradska Micro-Plate at the time border of 2100 Ma caused partial melting and formation of monzo-diorite magma intrusions to the east from the studied territory (Novoukrainskiy Complex) under conditions of active-margin geodynamic regime.

Further collision growth caused formation of Kirovogradskiy Orogenic Belt (within Ingulo-Inguletska LTZ) and obduction of early formed litho-tectonic complexes of Golovanivskiy Paleo-Basin onto Volyno-Podilskiy Proto-Continent along the flat eastward inclined sub-mantle shears. These processes in the map sheet territory were accompanied by formation of the deep thrusts (Emylivsko-Pervomaiska and Zhuravlynsko-Yatranska Nappe Zones). Collision peak and orogenesis were posted to 2050-2000 Ma and ended with formation of ultra-metamorphic granitoids of Kirovogradskiy (at hinterland) and Umanskiy (in forland collision zone) Complexes. This allows consideration the Golovanivska Suture Zone as one transitional from Kirovogradskiy Orogen to Volyno-Podilskiy Proto-Continental Massif. Gold deposition associated with above processes did include ore-bearing fluid re-mobilization and push out to the periphery of dome-centred structures as well as fluid migration to the upper crust mainly by zones of the deep thrust served as the strong drainage systems.

It is supposed and confirmed by the thermo-isochrone determinations [85], that post-orogenic processes had ceased gradually up to the time border 1800 Ma.

Meso-Proterozoic (Klesovian). In the Klesivska Tectogenesis Epoch the territory of map sheet was involved into the epi-cratonic regime and more or less active tectonic processes occurred just in the zones of tectonic activization; some of them are characterized by silica-alkaline metasomatism. It was the fifth phase of tectono-thermal transformation of previously formed litho-tectonic complexes which was released in the time span 1.96-1.93 Ga [38] mainly in Talnivska Tectonic Zone. Perhaps, this is most productive epoch of deposition and reomorphic enrichment of gold mineralization. At the end of Klesivskiy Tectono-Magmatic Cycle of 1.75 Ga it was formed composite Korsun-Novomyrgorodskiy Pluton (in the territory adjoining studied one from the north-east). Since that time the platform regime had been established in the map sheet territory and further Earth's crust development followed cratonic conditions.

Phanerozoic stage

It encompasses Pelozoic, Mesozoic and Cenozoic Eras during which on the background of low-intensity epeirogenic oscillatory motions of crystalline basement surface took place formation of weathering crusts, deposition of Cretaceous, Paleogene, Neogene and Antropogene sediments. In contrast to adjoining territory (in the east), activization related to Herzinian tectogenesis is not found in the studied territory. In Paleozoic and Mesozoic Eras the map sheet territory was the land where occurred processes of crystalline basement denudation and weathering with formation of weathering crust profiles. These processes were peaked in Mesozoic under conditions of arid climate. However, in Early Cretaceous Epoch most of the map sheet territory becomes covered by the sea [58]. The remnants of Cretaceous sediments are found at the latitude of Zavallivskiy graphite quarry

[86]. And maximum subsidence beneath the sea level is observed to the south from Southern Boug River in Kodymskiy Block.

In Paleocene Epoch the map sheet territory was uplifted again above the sea level to the erosion basis and as a result Cretaceous sediments were almost completely destroyed except ones in Kodymskiy Block. In Buchatskiy Time begins new subsidence of the territory leading to the deposition of Buchatska Series lake-swamp and river sediments in the wide swampy river paleo-valleys; brown coal interbeds are also deposited. In Kyivskiy Time the territory sunk beneath sea level again. Coastal-marine sedimentation regime retains up to Berekskiy Time. Then Paleogene sea recedes with formation of lagoons and lakes separated by the low-land areas. In the lagoons and lakes of the coastal-marine plains took place deposition of sandy and sandy-clayey piles of Novopetrivskiy and Sarmathian Times.

In the Pontian and Cimmerian Times the territory to the north from Southern Boug River was the uplift where erosion processes predominated, whereas to the south under conditions of coastal-marine alluvial plains deposited sediments of Baltska Suite. And in Cimmerian Time occurred general territory uplift being most extensive in Kodymskiy Block. In that time over the flat watersheds the rocks of parti-coloured sandy-clayey pile were deposited, and in rather wide paleo-valleys – parti-coloured sand pile. Uplift of Kodymskiy Block caused the distinct event – catching the sub-longitudinal river valleys of Pra-Synytsya and Pra-Synyukha by sub-latitudinal Souther Boug River valley. At the end of Cimmerian Time uplifted plain is formed completely where under sub-aerial conditions the red-brown clay pile deposited, and under sub-aqual conditions – the dark-grey clay pile.

Over period from Late Cretaceous Epoch up to Late Pliocene Time the map sheet territory was involved into extensive low-amplitude oscillatory motions under conditions of small-block tectonics peaked up in Paleogene and Miocene and sharply ceased at the end of Pliocene. This allows consideration of mentioned activization period as appearance of Alpine Tectogenesis Epoch.

Tectonic motions in Quaternary Time were more or less uniform, erosion activity and other processes occurred that formed the modern relief on the background of persistent gradual uplift of the erosion basis.

It is interesting to note that the modern watersheds and river valleys in general are subordinated to the strike of major Precambrian fault-block tectonic elements and south-eastern spurs of Prydniprovska Height – to the strike of lineament "G", in which zone of influence the studied territory is located. This suggests for neo-tectonic activization of the major crustal faults in the map sheet territory both at the sub-soil and the deep levels.

6. GEOMORPHOLOGY AND RELIEF-FORMING PROCESSES

The territory of Pervomaiskiy map sheet in morpho-structure respect comprises a part of Eastern-European Platform and belongs to the elevated socle plains of Ukrainian Shield, particularly, its Volyno-Podilskiy and Centralniy geomorphologic levels [33].

According to the scheme of morpho-structure zonation of Ukraine, the map sheet territory is completely located within the I-st order Centralnoukrainska Plain-Platform Morpho-Structure. By zonation of the II-order morpho-structures, the western (larger) part of the map sheet belongs to Zakhidno-Prydniprovska, and the eastern part – to Kirovogradska Morpho-Structures. After more detailed zonation, the eastern part of the map sheet (the II-order Kirovogradska Morpho-Structure) belongs to the III-order Korsun-Novoukrainska Morpho-Structure. Eastern-Prydniprovska Morpho-Structure within the map sheet in divided into larger Vynnytska and smaller Dnistersko-Pivdennobuzka (south-western corner of the sheet) III-order Morpho-Structures [33].

By zonation of the modern relief-forming regimes and environments, the larger south-western part belongs to the area of mainly single-directed non-persistent block uplifts separated by periods of tectonic motion stabilization and relative subsidence. The south-western margin passes to the territories with extensive interrupting processes coupled with tectonic extremes and exo-tectonic phenomena. In the east these processes ceased to the slight ones [33].

By the total amplitudes of neo-tectonic subsidence, the northern (larger) part of the territory belongs to the areas underwent interrupting relative subsidences or slight uplifts in Miocene and Early Pliocene. Right bank and partially the valley of Southern Boug River are characterized by interrupting-permanent subsidence in Middle Miocene. The values of isobases of the total neo-tectonic uplifts vary from zero in the central and northern parts to 60 m in the south-western margin of the map sheet [33].

By neo-tectonic zonation, the territory is mainly defined as the sub-area of moderate (15-200 m) inherited-interrupting uplifts of the Eastern-European Platform. In the southern part of the map sheet it is characteristic slight (100 m) uplifts took place mainly in Miocene [33].

The territory displays clear structure-block patterns traced in geology and reflected in the modern relief. Configuration of the river network is characterized by numerous straighten intervals of diverse orientation – sub-latitudinal, sub-longitudinal, and some types of diagonal. Strait-line lineaments are being traced not only after the elements of gully-river network but also by the tops and borders of the watersheds, modern soil cover configuration and so forth. The studies suggest for correspondence of the most lineaments to the faults that separate the crustal blocks with different modes of tectonic motions. Often tectonic regime of adjacent blocks essentially differs causing different configuration of the terrace relief for the opposite valley slopes. Such the phenomena quite widely occurs over the map sheet territory both in the valleys of major rivers – Southern Boug, Synytsya, Synyukha, Yatran, Chorniy and Sukhiy Tashlyk, and in specific valleys of the small water flows and gullies. Large water flows and watershed areas do mainly have sub-latitudinal and sub-longitudinal orientation.

In the north-western and south-eastern portions of the map sheet, configuration of the river network and other elements of the relief do form in the plane the ring- and arc-shaped lineament-like units. Diameter of such ring- and arc-shaped objects varies from 3 to 20 km and more. And presence of these ring-shaped forms is supported by the results of satellite image processing.

Some complexes of linear forms of the same orientation are well-correlated with tectonic zones defined on the ground of geological and geophysical data. Particularly, Synyukha River valley in general is correlated to Pervomaiska, and some intervals of Synytsya River coincide with Talnivska Zone of Deep-Seated Faults. In the south of map sheet area the course of Southern Boug River is confined to Lyuboivanivska Zone of sub-latitudinal lineaments, and straighten sub-latitudinal intervals of Yatran and Pargovytsya Rivers coincide with Subotsko-Moshorynska Zone of sub-latitudinal lineament concentration.

By the macro-relief of watershed areas and geological structure the map sheet territory is being rather clear subdivided into six large parts: A – dome-shaped high (in the north-west), B – central medium-height, C – humpy medium-height (in the north-east), D – inclined (in the far south-west), E – humpy inclined (in the southern margin), and F – low-height with heavy-loam Quaternary cover.

The areas A, B and C are widely distributed and are also traced outside the map sheet. Most of the areas by the patterns of the watershed meso-relief are not uniform and are further divided into 2-3 geomorphologic structures of the lower rank. Particularly, the area D by geology of Upper Cenozoic cover and the relief patterns is subdivided into the northern moderately cut elevated plain (D1) and the southern slightly-cut low-land (D2). The area E by relief patterns is clearly subdivided into three portions – the western humpy deeply-cut height (E1), the central moderately-cut elevated plain (E2), and the eastern slightly-cut low-land (E3). Most of the defined morpho-structure elements are prominently inclined southward and/or eastward and are extended outside the map sheet.

By morpho-sculpture patterns and history of development the territory belongs to the loess plains of back-glacier terrain within Pravoberezhna Height. The complex of accumulative relief forms at the surface comprises soil-loess cover of eluvial-deluvial and aeolian-deluvial origin; this cover surface is cut by erosion processes which often involve the crystalline basement rocks.

Terraces and terrace relief. The network of permanent and temporary water flows had created rather prominent erosion relief represented by alluvial and gully terrace relief. The time span of terrace relief is from recent (flood plain) to Middle Miocene (for the area A, probably, Paleogene). The general patterns of the fluvial erosion relief depend on the water flows when the voluminous water flows do generate the wider and deeper terrace relief.

Pliocene-Quaternary terrace relief does form continuous slopes of water flow valleys. The older terraces are preserved mainly fragmentary and not always are conformable to the present river network. Quaternary terraces of the small and medium rivers and, especially, gullies are smoothed by accumulative-denudation processes and morphologically are expressed as the series of straighten slope intervals but not the stairs with horizontal pads. Each one differs in the inclination angle and often is separated from the neighbouring ones with the convex or concave bend. Expressiveness and configuration of the terrace relief bends often are distorted by different thickness of the soil-loess cover. By total square, the Quaternary terrace relief only attains 20-25% of the total map sheet square. Pliocene terraces are flat and normally are separated from the steep-slope Quaternary terraces by the sharp bend. In the geomorphologic map-scheme for the most of territory defined steep-slope areas reflect just the Quaternary terrace relief.

Exposed sections of Quaternary terraces are rather common mainly in the local quarries developed at the steep-slope valley parts. Pliocene terraces do rarely expose, for instance, in the field works it was described single section only X(bv-br) of the Late Pliocene terrace (Synyukha River nearby Dobryanka village).

Configuration of the steep-slope Quaternary terrace relief in different areas does get two types – convex cliffy (up to canyon-like) and straighten (almost without valley slope bends). For example, in the area of Mygiya (some portions of gully and Southern Boug River), Paronivka and Goloskovo-Lyushnevate villages (Southern Boug River) the Quaternary terrace complex creates canyon-like cliffs; their edges is located approximately in the first third of the slope (from below) between the thalweg and Pliocene-Quaternary bend of terrace relief. The starting time of canyon-like cliffs formation defined by series of sections does correspond to Lubenskiy Stage. The areas with other configuration of Quaternary terrace relief (straighten or slightly-concave) in the given territory are more widespread (Ternivka village, Synyukha River; Gannivka village, Kagarlyk River; Korzhova village, Yatran River, etc.) than convex one.

Besides aforementioned configurations of the water flow valley slopes, in the map sheet territory are also known the areas with quite different types of slopes (terrace relief). Particularly, the north-western area (A) is characterized by the valleys with relatively steeply inclined terrace slopes of both Quaternary and Pliocene times. The boundary between these time-different slope parts is not clear. There, Pliocene terrace relief on approach to the watershed does gradually pass into directly older one – Sarmathian and further, apparently, even of older formation time (perhaps, after formation of Kyivska Suite). Transition between the Pliocene and directly pre-Pliocene terrace relief is also gradual, with unexpressed bend. These features as well as lacking of the terrace remnants on the slopes suggest for continuous tectonic uplifts and incise-terrace morphogenesis over Sarmathian-Pliocene-Quaternary time span of the geological history of the elevated North-Western Morpho-Structure.

Terraces of Southern Boug River. During the territory development in Quaternary Period, Pliocene Epoch, and pre-Pliocene Time the Southern Boug River had created fairly evolved ranges of alluvial terraces. Within the map sheet territory the Southern Boug River terraces display a number of distinctions of which the following should be specially noted: 1) configuration and relations of the heights and width of terrace range elements essentially differ along and across the valley suggesting for “piano-key” structure and irregular tectonic regime of the “keys”; 2) at various sites in the valley there are found both buried and incised terraces; 3) structure and thickness of sub-aerial Quaternary cover are quite variable due to frequent lateral changes of aeolian sedimentation regime; 4) in the Late Cenozoic alluvium (especially of Pliocene terraces) appears so called “Carpathian pebble” which is characteristic for the Dnister River alluvium.

By the patterns of terrace relief the Southern Boug River valley is clearly divided in two parts. Lower the downstream from Krasnenke village the valley is similar to the Dnister River valley in its mid-stream – Pliocene terraces are wide and slightly inclined whereas Quaternary terraces are steep and narrow. In most cases the bend between the Pliocene and Quaternary terraces is rather prominent. In some cases (in the areas of Lyushnevate-Goloskove and Mygiya-Grushivka villages) there are observed canyon-like valley slope cross profiles. The principal difference of Southern Boug River terraces from the Dnister River terraces comprises morphologic inexpressiveness and erosion of the terrace stairs which there look like a range of variously-inclined valley slope sites but not the stairs exactly.

Higher the upstream from Krasnenke village (Krasnenke, Dubynove and Olshanka villages) the Southern Boug River valley becomes mainly concave – the Quaternary terraces create the flat slope which in 1.5-3.5 km from the river course passes with rather clear concave bend into the steep denudation slope (probably, of Pliocene terraces). Somewhere (Dubynove village) this bend is accompanied by depression like terrace-side down-slope. It is characteristic for the Quaternary terraces in this relief that it includes both buried and superimposed terraces. In the structure of this type terraces there is observed superposition of two alluvial cycles (two pairs of the stages "warm-cold") that is traces over a range of outcrops. In some outcrops there is found superposition of Lubenskiy alluvium onto Martonoskiy one (Osychky village), and in others – Zavadivskiy alluvium onto Lubenskiy one (Savran town) or Martonoskiy onto Shyrokynskiy (Krasnenke village); this clearly suggests for the difference in tectonic regimes of these sites. Often on such terraces the sub-areial loess-soil cover is absent and at the surface terraces do comprise sandy and often layered Early Quaternary (rarely Middle Quaternary) alluvial sediments somewhere overlain by thin cover of aeolian sands.

In the mouth-side area between Southern Boug and Savran Rivers (northward from Savran town) it is also described along-terrace relief type formed due to migration of the Savran – Southern Boug Rivers junction further downstream and which is joint for both rivers.

The Southern Boug River valley is very irregular also in term of structure of the loess-soil cover. For example, between Dubynove and Savran inhabited locations there is observed the alternation of the sites with thick (from 12 to 24 m) loamy (soil-loess) cover and the sites where such cover is lacking and Holocene sandy soil lies just on the alluvial sediments. These features are noted both on the right (Krasnenke and Dubynovo villages) and left (southward Zavallya village) banks of Southern Boug River. The cases when lacking of loess-soil cover in one side of the Southern Boug River valley is accompanied by this cover presence in the opposite side are rather common. The sites with the sandy sub-soils (without loess-soil cover from the surface) somewhere do extend outside the Quaternary and Pliocene terraces up to the watershed areas. It is also determined that some sites with loess-soil cover do have essentially distinct stratigraphy. In some places beneath Holocene soil there is observed the Buzkiy loess (mouth-side right bank of Savran River westward from Chemerpil village) but in other ones – Dniprovskiy or Dniprovsko-Vytachivskiy Complex (Lupolove village, Pervomaisk town).

The speckle patterns and configuration of the terrace ranges of Southern Boug River and its branches as well as geology of the loess-soil cover suggest for significant territory breaking into the block which underwent quite different tectonic motions. Left- and right-bank terrace relief here is also often different. This suggests for "piano-key" (narrow-block) structure of Southern Boug River valley where the blocks with different tectonic regime alternate along the valley, and dynamics of the left-bank blocks often differs from the dynamics of the right-bank blocks. The field observations and results of satellite image analysis coupled with detailed analysis of topographic maps suggest in most case for very short (from 5 to 50 m) distance of transition between the sites with a given configuration of terrace relief to some different one.

Significant breaking and irregularity of tectonic motions over the territory considerably complicate the studies of terrace relief; by these reasons the key parameters (the time span, elevation and terrace width) can be described in generalized mode. For the sites with steep-slope Quaternary terrace relief (downstream the Krasnenke village) the Quaternary terraces do have the elevations 50-60 m and width from first tens of meters to first hundreds of meters. The border of their distribution is marked by clear convex bend which reflects transition from Quaternary terraces to Pliocene ones (normally terraces IX(kr-il) or X(bv-br)). The elevation of Late Miocene – Pliocene terraces (with Carpathian pebble in alluvium) attains 120-130 m above the Southern Boug River water line, and their width attains first kilometres measured from the course. The oldest alluvial terrace of the modern valley with characteristic Southern Boug River alluvium and relief was formed on Znamyanskiy Paleo-Geographic Stage (as evidenced by data from adjoining territories). Prior to this, perhaps, there was existed the river network of different type and configuration. Terrace relief further upstream from Krasnenke village is sharply changed – there Quaternary terraces are much lower (elevations about 40 m) and wider (the external edge attains 3.5 km from the river course).

In the geological studies of Quaternary and Pliocene sediments in Pobuzhzhya within the Pervomaiskiy map sheet it is important to define the origin of "Carpathian" pebble in the Pliocene-Quaternary alluvium since this pebble is lacking in these terrace alluvium further upstream and in the older terraces. The pebble includes brown-coloured jasperoids, sards and other rocks exotic for the given territory; its origin is being considered in view of possible temporary connection of the Southern Boug River system with Dnister River system where such pebble is the compulsory element of alluvium. Occurrence of a range of Pliocene terraces with abundant "Carpathian" pebble (Southern Boug River valley in the area of Ternuvate-Goloskove villages), sharp decrease of this pebble content in Quaternary terraces and lacking of alluvium with such pebble at Miocene levels allows conclusion about joint Dnister – Southern Boug River system over Late Miocene – Late Pliocene times (apparently, from Znamyanskiy to Beregivskiy Stages). Lacking of "Carpathian" pebble a bit further upstream from Zavallya village suggest for location of the Dnister River – Southern Boug River junction just in the area of Zavallya-Savran villages.

The valley of Southern Boug River and the valleys of most other rivers do have some sites characterized by asymmetry of the opposite valley slopes. This is normally caused by the following factors: 1) migration of the river course to the right or to the left in Quaternary time (Chorniy Tashlyk River, Novooleksandrivka village area); 2) different thickness of the clayey-loamy cover (Sukhiy Tashlyk River, Troyanka and Dobryany villages area); 3) different intensity of tectonic uplift in the opposite sides of the water flow valley (Southern Boug River, Krasnenke and Goloskove villages area).

Terrace remnants in the map sheet territory are rather widespread. It was established several generations of such remnants and found that different morpho-structures are characterized by the remnants of diverse time spectrum. In some sites – Tyshkivka and Ternivka villages (Ternivka River valley), Novooleksandrivka village (Chorniy Tashlyk River valley), Kalmazove village (Southern Boug River valley), Synyukhyn Brid village (Synyukha River valley), etc. – there are found terrace remnants which age is determined as Beregivskiy or Bogdanivskiy (Late-Middle Pliocene). To the north-east from Mygiya village in the right bank of Southern Boug River there are described two small (1.5-3 m) height-different socle terrace remnants; their age by geomorphologic data is estimated to Late Pliocene (Beregivskiy Stage) and Early Quaternary (Lubenskiy Stage). In between Rossokhovatets and Pokotylove villages there is observed small remnant hill which by its position relative to the river is the terrace remnant of probably Sarmathian Time. The remnant similar in age and origin is also observed in the right bank of Yatran River and in the left bank of Synyukha River.

The flood-lands of most rivers (valleys with steep-slope Quaternary terrace relief) are wide and low-lying; by these reasons the valleys somewhere get the trough shape. In the upper course of Southern Boug River (Lupolove village) the flood-land is clearly of concave mode – the surface of course-side flood-land part often is hypsometrically higher than the edge-side flood-land part. The primary patterns of water flow flood-lands (unchanged by present or let out ponds) are quite variable – from rapid ones (Southern Boug River, area of inhabited localities Mygiya, Pervomaisk, Lyushnevate, etc; Synyukha River, area of Synyukhyn Brid, Kalmazove villages; Synytsya River, Kamyaniy Brid village area, etc.) to swampy (some sites of Gnylyukha River and western-southern water flows in the right bank of Southern Boug River).

In some sites of big river valleys (Southern Boug, Synyukha, Synytsya, Chorniy Tashlyk and Sykhiy Tashlyk Rivers) are widely distributed the cliffs formed as a result of river course meandering; the highest cliffs (Mygiya, Grushivka villages) attain 10 m height. Most of ravines, scours and coastal cliffs are from 1 to 4-6 m deep, the deepest ones attain 10 m (Gannivka village). Ravines and coastal cliffs are irregularly distributed and do form concentration zones mainly confined to the valleys of the large water flows. It should be noted that degree of the valley incise by ravines or coastal cliffs does not correlate with the height of morpho-structures. The highest morpho-structures – North-Western and South-Western – do have relatively few running erosion relief forms whereas relatively low sites in the Central Morpho-Structure are rather deeply and densely incised by ravines and cliffs. Besides the common by spatial configuration ravines (bush-like) there are also known their hyrtope-like and tree-circus-like varieties (Manuilivka, Vivsyanykivka villages).

In the map sheet territory there are known the stone remnants that comprise large relatively separated blocks of crystalline rocks (Mygiya village). They are mainly located on the sides of the large water flow valleys – Southern Boug River (Mygiya, Grushivka villages), Synyukha (Synyukhyn Brid village), Yatran (Polonyste village). The biggest one (Mygiya village) attains 10 m.

Re-building of the river network within the map sheet occurred twice at least – at the end of Miocene (Znamyanskiy Stage) and, probably, at Early Sarmathian Stage. Substantiation of the first re-building is grounded on appearance of the distinct "Carpathian" pebble in alluvium. The signs of the earlier re-building have been established by V.M.Klochkov through analysis of crystalline basement surface (Fig. 6.1); according to these results, the valleys of Synytsya River and some other small sub-parallel water flows do have their extensions in the right bank of Southern Boug River and are expressed by valley-like depression of the crystalline basement surface. This feature can be used to prove the river system re-building, that is, catching by Southern Boug River the system of Synytsya River and other sub-longitudinal water flows which previously flowed down further to the south. Occurrence of Middle Sarmathian alluvial sediments of superimposed-terrace (accumulative) type above the buried erosion pra-valley of Synytsya River at the watershed sites in the right bank of Southern Boug River may suggest for its catching of Synytsya River and other sub-longitudinal river systems in pre-Middle Sarmathian, apparently, in Early Sarmathian Time.

Significant relief-forming role were played by aeolian-accumulative and deflation processes which caused differentiation of thickness and stratigraphy of Quaternary loess-soil cover. In the valleys of most water flows there is observed thick (3-8 m) cover (so called terrace cover relief) on the one slope and its full lacking on the opposite slope (socle terrace relief). Besides aforementioned examples of loamy cover lacking for the terraces of the Southern Boug River valley, the same phenomena is described for Synyukha River (Dobryanka village and northward from Vilshanka village) where the valley slopes are composed of the sand (alluvial, somewhere aeolian) facies of Late Quaternary Time. Sometimes essential change of loess-soil cover thickness in adjoining sites is accompanied by the change in configuration of the cross-profiles in socle valley slopes that suggests for heterogeneity of both tectonic and aeolian (aflation-deflation) regimes simultaneously. In single cases the lacking of clayey-loamy cover generates 10-30 m thick bands which may transect the valleys of water flows, gullies and terrace remnants at various angles (that excludes their erosion genesis). Often within different blocks there is observed stratigraphic heterogeneity of the soil Pliocene and Eo-Pleistocene piles as well. These and other evidences suggest for relationships between intensity of loess-soil cover deposition and deflation processes with the blocks (of different tectonic regime) and faults that separate the blocks.

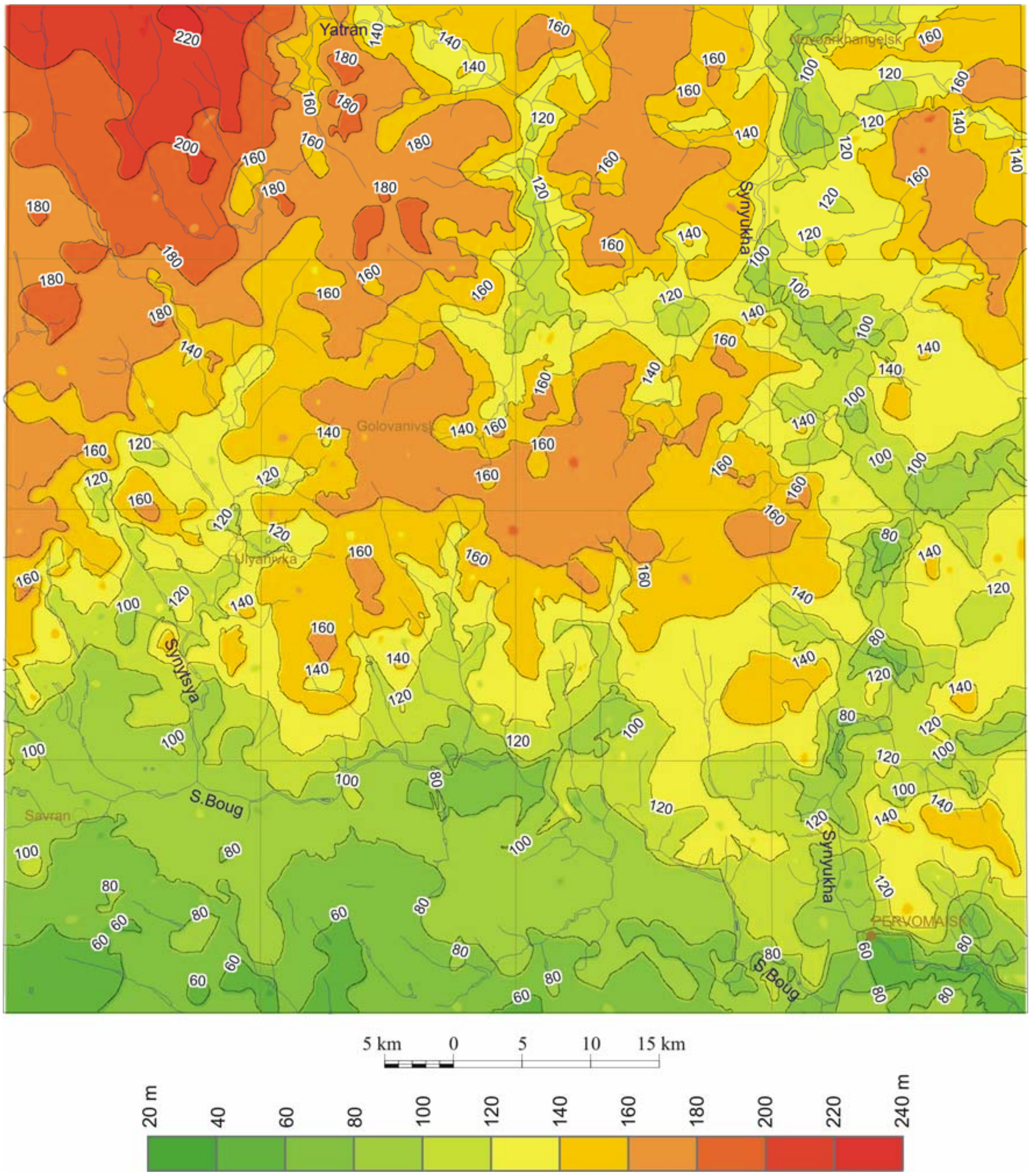

Fig. 6.1. The map of Precambrian basement surface relief.

Traditional aeolian accumulative relief forms (sand dunes and so forth) are limited in their distribution regardless significant sites with sand and sandy loam background (upper part of the Southern Boug River course and slopes of Synytsya River valley nearby Chorniy Tasklyk River mouth). Field works of the sand hill in the Southern Boug River valley (Olshanka, Savran inhabited locations) suggest for their remnant-erosion origin due to erosion of Pleistocene terrace alluvium by the dense gully network; here terrace alluvium is not overlain by the loess-soil cover.

Technogenic and technogenic-caused relief forms in the map sheet territory are rather widespread. Commonly they are related to big and small quarries. Big quarries (Zavallya, Pervomaisk inhabited locations) comprise the complex of accumulative (dumps) and technogenic-erosion (quarries themselves) relief forms. Small quarries created mainly during construction of the dams and ponds. In the pond water areas rather thick (up to 10 m) sub-aqueous sediments occur which are indicated in the geological map of Quaternary sediments by sites of technogenic-caused modern formations. In geomorphologic respect the water areas of the modern ponds comprise erosion-accumulative surfaces which are also defined as technogenic-caused relief forms. The wide distribution of the technogenic-caused sediments of pond terraces formed due to the pond mudification is characteristic valley feature of most water flows in the territory of Pervomaiskiy map sheet. In the watershed areas there are observed the barrows as well as mounds and grooves which are defined as technogenic relief forms because they were created during the road and channel construction.

By neo-tectonic relief-forming regimes and environments the map sheet territory is being considered in the framework of inherited geodynamic environments in the areas of mainly single-directed crustal motions and non-persistent block uplifts interrupted by periods of stabilization of tectonic motions. By neo-tectonic zonation this territory comprises counterpart of the area of inherited moderate (150-200 m) interrupting uplifts of Ukrainian Shield [33]. Neo-tectonic regime of the defined morpho-structures essentially differs. According to geologic and geomorphologic data, morpho-structure A underwent tectonic uplift in Paleogene, relative subsidence in Neogene, uplift in Pleistocene and slight relative and absolute subsidence in Holocene. Plateau-like morpho-structures B, C and E have had similar tectonic regime – there predominated alternating tectonic motions with mainly subsidence in Paleogene and Neogene, uplift in Pleistocene and then relative subsidence in Holocene. The low hill-like morpho-structure D underwent alternating tectonic motions with predomination of slight subsidence in Paleogene, interrupting subsidence in Neogene, uplift in Pleistocene, and relative subsidence in Holocene. The high hill-like morpho-structure F is characterized by rather extensive interrupting tectonic uplift in Paleogene and Neogene, suspended uplift in Pleistocene, and further uplift in Holocene.

Neo-tectonic motions of plateau-like high morpho-structure B and hill-like high morpho-structure F were in the anti-phase. At some stages the morpho-structure B underwent tectonic subsidence evidenced by Sarmathian and Novopetrivski sediments of mainly hydro-morphic and sub-aqueous facies. The morpho-structure F in that time was uplifted which is evidenced by just pre-Pliocene geomorphologic denudation levels. And the morpho-structures C, E and in some extent F by the same features are similar to the morpho-structure B but differ in the intensity and amplitude of tectonic motions.

Clear difference in the inclination of Pliocene and Quaternary parts of terrace relief slope (water flow valley slopes) suggests also for diverse intensity of tectonic uplifts in Pliocene and Quaternary Times. Particularly, the cliffs of the aforementioned water flow canyon-like valleys formed as a result of relatively extensive tectonic uplift of these areas in Lubensko-Buzkiy Time. In the other areas, which in that time underwent the relative subsidence, such the cliffs are lacking and the same-aged terrace relief is replaced by the straighten profile of the water flow valley slopes.

Analysis of the terrace surface elevations concerning Quaternary and Pliocene terrace relief of the diverse-volume water flows and its configuration suggests for the following major trends in the Late Cenozoic tectonic regime. Within the morpho-structures B, C, E, and F the relative subsidence (or slight uplift) in Pliocene had then changed by uplift (extensive uplift) in Pleistocene evidenced by the convex kind of terrace relief – slightly inclined Pliocene terrace relief passes into the steep-slope Quaternary one. Tectonic motions of the morpho-structures A and partially D and E were in the anti-phase to the aforementioned ones – their relative uplift in Pliocene had then changed by relative subsidence in Pleistocene (at the general extensive uplift over both stages). It is evidenced by predomination of the strait-slope (concave) Pliocene-Quaternary terrace relief. In general, in the map sheet territory the first type of tectonic regime predominates.

The flood-lands, which comprise the sensible indicator of tectonic motions in Holocene Time, do suggest for the fairly different tectonic regime of Holocene as compared to Pleistocene one. Extensive uplift in Pleistocene, which predominated over the most part of the map sheet territory (evidenced by the steep inclination of the Quaternary terrace relief of the water flow valleys), normally had changed by relative subsidence in Holocene. This is evidenced by the wide low-lands or swampy flood-lands which somewhere overlie Late Pleistocene terraces. Some geologic and geomorphologic data suggest for a bit older time than Early Holocene when the last neo-tectonic inversion in tectonic regime appeared and it was related to the beginning of Dofinivskiy (previous warm) Stage.

7. HYDROGEOLOGY

According to previous researchers [12], the map sheet territory is characterized by the complicated hydrogeological conditions defined by the relief, lithological composition, the water-containing rocks collector and filtration properties, tectonics and climate conditions. In the hydrogeological respect the territory is clearly divided in two areas with the border positioned by Southern Boug River: Left-Bank and Right-Bank. The first one belongs to the fracture water area of Ukrainian Shield, and the second one – to the Prychornomorskiy artesian basin.

The Left-Bank area is characterized by the shallow position of crystalline basement overlain by Paleogene, Neogene and Quaternary sediments which thickness in the watershed attains 50-60 m, and in the river and gully valleys varies from 0 to 15 m. For the Right-Bank area it is characteristic the crystalline basement plunging toward Prychornomorska Depression, and sedimentary cover thickness increasing from 50-60 m in the north to 160 m in the south. The most of the sediments here belongs to Neogene System and in the lowermost part somewhere Cretaceous sediments occur.

The waterproof horizons are distributed mainly locally. First of all, this is 10-25 m thick horizon of Pliocene red-brown clays occurring mainly in the watersheds. Secondly, these are 15-20 m thick kaoline weathering crusts of crystalline basement. The contours of the first waterproof horizon spatially coincide with the distribution boundaries of the second water-bearing horizon. The second waterproof is distributed even more locally and does not play as regional one. Mezhygirski, Obukhivski, Buchatski and Kodymski sediments comprised mainly of clays, tripoli-like rocks and secondary kaoline do play the role of the local waterproofs only. Analysis of waterproof horizon distribution allows conclusion that the water-bearing horizons do have direct or indirect hydraulic connection and by this reason over the most territory they are not protected or are conventionally protected, perhaps, except the seventh and eighth horizons only. In the Right-Bank area (southward from Southern Boug River) the water-bearing horizons 5-8 can be considered as protected. The patterns of underground water contamination with the harmful substance and elements are discussed in the section “Ecological-geological environments”.

By the patterns of hydrogeological conditions in the map sheet territory there are distinguished eight water-bearing horizons and complexes which differ by the host rock composition and degree of their water saturation, conditions of feeding and discharge, as well as quality and quantity composition of related underground waters.

1. *Water-bearing horizon in the modern alluvial sediments (aH)* is distributed in the river and gully flood-lands. Water-bearing rocks – diverse-grained sands, sandy loams, loams, muds, sometimes with the rock fragments. Thickness of these rocks does not exceed 10 m. In most cases this horizon lies directly on the inundated fractured rocks of crystalline basement, much rarely (mainly in the Right-Bank area) – over water-bearing Neogene rocks, somewhere over primary kaoline of weathering crusts or over re-deposited Eocene kaoline. In most cases there is direct hydraulic connection between this water-bearing horizon and those horizons laying below. The horizon does have free mirror of sub-soil waters which level varies from 0 to 4 m, or in the absolute heights from 90 to 200 m. This water-bearing horizon [12] contains transparent and ice-color waters which by chemical composition belong to hydrocarbonate, rarely hydrocarbonate-sulphate and hydrocarbonate-chloride types with rather mottled cation composition [12]. Mineralization [12] varies in the range 300-900 mg/dm^3, it rarely attains 1 000-1,200 mg/dm^3. The total hardness varies in the range 4.8-10.6 mg-equiv/dm^3. Reaction of waters is neutral or slightly-alkaline (pH = 7-7.5). It is observed essential content of nitrate and nitrite ions.

The shaft yield [12] attains 0.4-0.6 dm^3/sec, well yield (water scoop in Dovga Prystan village) – 0.3-2.0 dm^3/sec at the specific yield 0.08-0.8 dm^3/sec. Feeding of the water-bearing horizon is being performed through the surface water infiltration. The water discharge occurs in the low period into the rivers and water-bearing horizons laying below (on lacking of waterproof rocks). The water-bearing horizon is being used for local water supply mainly through the shafts, and in Pobuzke town only this horizon is used as the base the centralized water supply.

2. *Water-bearing horizon of the first and second over-flood-land terraces* ($aP_{III}vl$, $aP_{III}ds$) is distributed mainly in the valleys of Southern Boug and Savranka Rivers. In alluvial sediments of other rivers (Synyukha, Yatran) this horizon is almost lacking due to terrace sites dismembering and insufficient thickness of the host rocks. Water-bearing rocks – diverse-grained sands, sandy loams, clays, somewhere with gravel and pebble-stone interbeds. Thickness of the rocks varies from 10-15 to 40 m. The horizon is underlain by Neogene sediments or Precambrian crystalline rocks and products of their weathering, and is overlain by aeolian-deluvial sediments. The horizon is free-flow. The depth of the level depends on relief and varies from 5 to 17 m, absolute

heights – from 8 to 100 m. By physical properties waters are ice-coloured, transparent, taste- and smell-free. Their chemical composition is carbonate, rarely hydrocarbonate-sulphate and sulphate-hydrocarbonate; cation composition is mottled with calcium and magnesium predomination. Mineralization changes from 400 to 1 000 mg/dm^3. Total hardness in average – 6-8 mg-equiv/dm^3 and does not exceed 10 mg-equiv/dm^3. The pH value varies in the range 6.8-7.5. The waters of this horizon are not protected and this is why increased content of nitrogen and micro-components occurs (in % of dry residue weight): barium up to 0.006, molybdenum up to 0.0003, copper up to 0.001, zinc up to 0.01, nickel up to 0.01, strontium up to 0.1, chromium up to 0.004, vanadium up to 0.0002, titanium – up to 0.02. The yield comprises [12] 0.4-0.6 dm^3/sec at the level decreasing respectively to 1.0 and 0.4 m (for shafts) and 1.1 dm^3/sec at depression to 5.7 m (for wells). The horizon feeding is being performed through atmospheric water infiltration, underground water pouring from horizons of aeolian-deluvial and Neogene sediments, as well as crystalline basement pressure water inflow by disintegration zones. Discharge occurs toward the river flood-lands. The water-bearing horizon of over-flood-land terraces due to insufficient water saturation cannot be recommended for essential centralized water supply but it is being widely used (through the shafts) for housing-drinking water supply of Zavallya, Savran, Pobuzke, Vilshanka, Dubynove, Krasnenke inhabited locations located in the Southern Boug River valley.

3. Water-bearing horizon of aeolian-deluvial and eluvial-deluvial sediments (vd,edP$_I$) is widely distributed over the studied territory and are mainly abundant in the watershed plateau and its slopes. Occurrence of the horizon is caused by development of red-brown clays and products of their re-deposition at the bottom; the clayey rocks play as the lower waterproof. The water-containing rocks – mainly loess-like loams; in their granulometric composition [12] predominate the fractions: 0.05-0.01 (up to 45%) and <0.01 (up to 84%). Filtration coefficients in most cases comprise the hundredth and thousandth of meters per day. The permanent water-bearing horizon does form in the lower part of the loams and its thickness varies from 1 to 10 m (5-6 m in average). Somewhere in the local waterproofs in the upper part of loess-like loam horizons do form temporary water-bearing horizons (vadose waters). The horizon under consideration contains typical sub-soil waters; the mirror depth varies from 4 (Tryduby village) to 2 m (Tauzhne village). Sub-soil water mirrors are included toward the water flow valleys which replicate the modern relief.

By chemical composition [12] sob-soil waters of this horizon belong to hydrocarbonate-calcium-magnesium and magnesium types. In the central and southern parts of the map sheet sulphate and chloride content increases, and the type of sub-soil waters changes to hydrocarbonate-sulphate and hydrocarbonate-chloride ones.

All types of waters do have the variable cation composition. According to [12], in general the mineralization does not exceeds 1 000 mg/dm^3 somewhere increasing to 1,600 mg/dm^3, but according to the year 1996 data [12] over 30 year it increased by a factor of 2.5. This is explained first of all by occurrence of nitrates, nitrites and ammonia in the sub-soil waters due to surficial contamination of the horizon. The waters are hard and very hard (total hardness from 6 to 15.5 mg-equiv/dm^3), reaction is slightly-alkaline and close to the neutral. Oxidation is 0.5-8 mg/dm^3. The dry residue is equal to 600-1500 mg/dm^3 and in its composition [12] the following micro-components are determined (in % of dry residue weight): gallium up to 0.0003, barium up to 0.01, molybdenum up to 0.0001, lithium up to 0.003, copper up to 0.001, ytterbium up to 0.0001, lanthanum up to 0.0006, zinc up to 0.01, nickel up to 0.03, zirconium up to 0.001, cobalt up to 0.0001, strontium up to 0.2, chromium up to 0.04, vanadium up to 0.0006, titanium up to 0.03.

Water saturation of the horizon is not sufficient and it can be exploited by the shaft only with the maximum yield 0.1-0.3 dm^3/sec; the day scoop in most cases will not exceed 2 m^3. Feeding of the horizon is being performed through atmospheric precipitate infiltration. The annual amplitude of the water level mirror does not exceed 0.5-0.8 m and somewhere (shallow laying) it attains 1-1.5 m.

The waters of the horizon are being widely used in the countryside by shafts but due to the areal contamination by nitrates, nitrites and pesticides as well as weak water saturation it is not recommended for the centralized drinking supply.

4. *Water-bearing complex in Miocene-Pliocene sediments* ($N_{1\text{-}2}pg$, $N_{1\text{-}2}p$, $N_{1\text{-}2}bl$) is distributed almost over entire studied territory except its north-western part (plateau-like ledge of the crystalline basement surface) and big rivers and gully valleys. The water-bearing rocks – coarse-, medium- and fine-grained sands, sometimes gravelous. The sand as interbeds and lenses lie within the clays which play as the local waterproofs. Somewhere upper waterproof comprises red-brown clay horizon. In case of lacking the weakly-permeable rocks the complex does have hydraulic connection with overlaying and underlaying water-bearing horizons. The lithologic heterogeneity both in vertical section and by strike, as well as the alternation of water-bearing and waterproof rocks cause formation of several thin water-bearing horizons which are hydraulically-connected and do form the single water-bearing complex. The sand granulometric composition [12] is as follows: content of particles from 3 to 1 mm in size up to 15%; 1.0-0.5 mm – up to 2.3-28.8%; 0.5-0.25 mm – 6.6-24%; 0.25-0.1 mm – 14-47.1%;

0.1-0.05 mm – 4.9-14.5%; 0.05-0.001 mm – up to 5%; less than 0.001 mm – 16.8-52.4%. Respectively, filtration coefficient varies from 0.6 to 1.48 m/day.

Thickness of water-bearing rocks varies in the range 18-24 m in the left bank and 25-60 m in the right bank of Southern Boug River. In most cases these rocks lie over crystalline rocks and their weathering crust, much rarely – over Miocene and Eocene sediments. The horizon does have free underground water mirror and in places only (Lypovenki village and right bank of Southern Boug River) it gets the local pressure attaining 6-12 m. The depth of water-bearing complex varies in the range 2-24 m. Hypsometric position of the underground water mirror replicates the modern relief and, beside this, it is observed its gradual plunging southward from 80 m to 216 m.

By chemical composition [12] the waters of this complex belong to hydrocarbonate with calcium and magnesium ions predomination. In the central and south-eastern parts of the territory sulphate-ion content increases in the waters and they become hydrocarbonate-sulphate and sulphate-carbonate; chlorine content rarely increases. The mineralization is moderate: in wells and springs it does not exceed 1 000 mg/dm^3 (TAC level), in shafts it increases to 1,500 mg/dm^3. In general, the mineralization increases southward. The total hardness does not exceed 7-10 mg-equiv/dm^3 and somewhere only attains 15-21.2 mg-equiv/dm^3. The hard waters are mainlt of hydrocarbonate-sulphate type with increased mineralization which causes calcium and magnesium sulphate salt content increase. Reaction of the waters is neutral and weakly alkaline, pH varies in the range 6.9-8.5. The high nitrate content in the waters of some shafts as well as increased mineralization suggest for the complex susceptibility to contamination. The following micro-component composition is observed (in % of dry residue weight which varies in the range 400-1700 mg/dm^3): barium up to 0-0.02, zinc – 0.003-0.04, nickel – 0.006-0.08, zirconium up to 0.004, cobalt up to 0.0002, strontium – 0.06-0.006, chromium – 0.001-0.06, vanadium up to 0.0003, titanium – 0.006-0.06.

The yield [12] in wells which exploit waters of this complex varies from 0.03 (Left-Bank area) to 0.9 dm^3/sec (Right-Bank of Southern Boug River) at respective depression – 12.4 and 4.6 m. Specific yields varies from 0.003 (Lypovenki village) to 0.2 dm^3/sec (Slyusarevo village). Daily water scoop from the shaft comprises respectively 0.3 m^3 (Ostrivka village) and 2 m^3 (Mala Mechetnya village). Yield of the springs is mainly 0.08 dm^3/sec (Pidvysoke village). Feeding of the water-bearing complex is being performed through atmospheric precipitates, and in case of given sediments laying in crystalline basement depression – through water inflow from fracturing zone of Precambrian basement. Movement of underground waters is directed toward the river valleys and gullies where water-bearing complex discharge through the springs occurs. In the sites where the lower waterproofs are lacking this water-bearing complex feeds the underlaying water-bearing horizons through direct infiltration. The annual level variations comprise 1-1.5 m.

The waters of this water-bearing complex are rather widely used for drinking supply by means of single wells and the shafts but due to the low water saturation it cannot be used for the large-scale centralized water supply.

5. *Water-bearing horizon in Middle Sarmathin sediments* (N_1p, N_1vg, N_1pv) is developed mainly in the right bank of Southern Boug River. The water-bearing rocks – sands, sandstones alternating in the section with clays and argillites and are of variable thickness. The rocks overlie Paleogene sediments, crystalline basement rocks, and somewhere the sands of Poltavska Series.

The water are pressurized [12], the pressure degree attains 15-18 m. The depth of water piezometric level varies in the range 78-107 m from the Earth's surface. By chemical composition the waters are neutral, hydrocarbonate, calcium-magnesium, with mineralization 510-700 mg/dm^3. The total hardness, which can be reduced, varies from 5 to 8.6 mg-equiv/dm^3.

The water saturation of this horizon is weakly studied. Yields varies from 1 to 4.4 dm^3/sec, specific yield – 0.06-0.1 dm^3/sec (Kovbasna Polyana, Polyanetske, Nedilkove villages). Due to lacking of the consistent waterproofs this water-bearing horizon in Sarmathian sediments is hydraulically connected with both the water-bearing complex laying above (in Miocene-Pliocene rocks) and with underlaying fracture waters of crystalline basement. Feeding of the horizon is being performed from the overlaying horizons and from the pressurized fracture waters of the crystalline basement rocks. The water discharge occurs further to the south outside the map sheet.

The water-bearing horizon in Sarmathian sediments in view of its relatively high water saturation and slight contamination by harmful substances can be exploited by single hydrogeological wells for the needs of small agriculture enterprises.

6. *Water-bearing horizon in Miocene-Oligocene sediments of Poltavska Series* (N_1np, ₽$_3br?$) is distributed both in the left and right banks of Southern Boug River but water-bearing sediments of Poltavska Series are developed within separated enclaves. The water-bearing rocks (thickness from 3 to 30 m) comprise the sands, rarely sandstones, fine-grained, with thin clay interbeds. The total thickness of the water-bearing horizon rarely exceeds 10 m. The role of upper waterproof in places is played by clayey sediments of Mezhygirska Suite,

and lower one – clayey sediments of Kyivska Suite and Buchatska Series, as well as kaoline weathering crust of crystalline basement. However, the water-proof horizons are developed locally and as a result the Miocene-Oligocene water-bearing horizon does have hydraulic connection with underlaying and overlaying horizons.

The water-bearing horizon is free-flow in the Left-Bank area, and in the Right-Bank area it is not studied; here it can be pressurized and protected from contamination by harmful substances and elements. By physical properties the waters are ice-coloured, transparent, out of taste and smell. By chemical composition [12] they are hydrocarbonate sodium-calcium, calcium-sodium. The mineralization varies from 400 to 900 mg/dm^3. They do have moderate hardness which can be eliminated. The total hardness is equal to 4.7-6.9 mg-equiv/dm^3, pH value is 7.2-7.4. According to spectral analysis, the waters contain the following micro-elements (in % of dry residue weight which varies in the range 500-800 mg/dm^3): gallium up to 0.0004, barium – 0.006-0.02, molybdenum up to 0.0001, lithium up to 0.006, copper – 0.001-0.003, yttrium up to 0.001, zinc – 0.003-0.006, nickel – 0.02-0.04, zirconium – 0.002-0.006, cobalt up to 0.0001, strontium – 0.06-0.1, chromium – 0.03-0.04, vanadium up to 0.001, titanium – 0.04-0.1.

The waters of this horizon due to enclave-type distribution of hosting sediments and their low water saturation are being used very rare and do not have any practical value for the centralized water supply. The daily water scoop from the shafts does not exceed 1-1.5 m^3. Feeding of the water-bearing horizon is being performed through the water infiltration from the overlaying water-bearing horizons as well as atmospheric precipitates.

7. *Water-bearing horizon in Eocene sediments* (₽$_2$) is not studied due to its limited distribution. The water-bearing rocks – fine-grained sands, tripoli-like sandstones, clays, aleurolites, marls included into Obukhivska, Kyivska Suites and Buchatska Series of Upper-Middle Eocene; thickness 10-20 m (somewhere up to 35 m). The water-bearing rocks lie at the depth from 20 to 40 m in the left bank, and 60-120 m – in the right bank of Southern Boug River. Upper waterproofs are mainly composed of Middle Sarmatian and Mezhygirska Suite clays, lower ones – clays of Middle Eocene Kyivska Suite, Lower Cretaceous Kodymska Suite, and kaolinite weathering crusts of Precambrian basement. The complex consists of several hydraulically-connected water-bearing horizons separated by clay and sandstone lenses.

According to the data obtained for adjoining territory (map sheet L-36-1), the waters of this complex are fresh with mineralization up to 1,000 mg/dm^3, hydrocarbonate-sulphate, magnesium-sodium or sodium-magnesium, total hardness from 2 to 13 mg-equiv/dm^3. Water saturation of the complex is irregular. Yields of the wells that tap Eocene water-bearing complex in adjoining (from the south) territory vary in the range 1-2 dm^3/sec (at depression 12 and 31 m). Due to limited enclave-like Eocene sediments distribution the water-bearing complex do not have any practical value for the water supply issues.

8. *Water-bearing complex of fracturing zones in Precambrian crystalline rocks and products of their weathering* in the map sheet territory is throughout distributed. Most favorable for the water saturation are fractured metamorphic rocks and migmatites as well as grussy weathering crusts. The clayey rocks of sedimentary cover and kaolinite zone of the weathering crust profile do play the role of upper waterproof. The lower boundary of the fracturing zones is not defined. The waters of crystalline basement and products of their weathering are hydraulically-connected and form the uniform water-bearing complex.

The depth position of the fracturing waters is caused by the surface relief and hypsometry of crystalline rock surface. In the river valleys and in the gullies the waters lie at the depth from 1-5 to 25 m and are tapped by the shaft; they sometimes are being drained by descending springs. In the watersheds they lie at the depth from 30 to 77 m in the Left-Bank area, and 50-160 m – in the Right-Bank area. From the watershed plateau (absolute heights of basement relief 150-230 m) located in the area of Tomashivka-Ropotukha-Yatranivka-Ladyzhenka-Golovanivsk inhabited locations and plateau-like heights in the area of Nebelivka-Nerubayka-Kopenkuvate and Skalevski Khutory-Tyshkivka villages the surface of crystalline basement plunges toward the valleys of major water flows: Yatran, Synyukha, Southern Boug Rivers and southward in general. There, in the right bank of Southern Boug River absolute heights of crystalline basement surface do not exceed 50-90 m, and in the far south – 30-50 m. These are directions where this complex artesian waters discharge occurs.

Fracturing waters in most cases are pressurized. The pressure value comprises 10-30 m in general and sometimes it attains 50 m (Golovanivsk town). The pressure is caused by relatively high position of the feeding areas (in watershed plateaus) and occurrence of upper waterproofs at the top of crystalline rocks (kaoline weathering crusts and clayey rocks at the bottom of Phanerozoic sediments). The absolute heights of piesometric levels vary from 80 m (Yatranivka village) to 240 m (Gromy village).

By chemical composition [12], there is observed some zonation in fracturing waters of this complex. In the northern and central parts of the studied territory the waters are hydrocarbonate calcium-magnesium with mineralization up to 500 mg/dm^3. In the south-eastern direction the waters gradually become hydrocarbonate-sulphate with mineralization 500-1 000 mg/dm^3 and sulphate-hydrocarbonate or sulphate-chloride with enhanced mineralization (up to 2 000 mg/dm^3). Cations of calcium and magnesium predominate in the waters. Total hardness of the basement fracturing waters varies in the range 2.7-19.3 mg-equiv/dm^3; the highest hardness is observed in the waters with mineralization in excess of 1 000 mg/dm^3. The waters are hard and medium-hard. Reaction is neutral and sub-alkaline, pH varies from 6.9 to 7.7 (mainly 7.3-7.5). According to the spectral analysis, the following micro-components are contained in the fracturing waters (in % of dry residue weight which varies in the range 400-800 mg/dm^3): lead up to 0.0006, gallium up to 0.0002, barium up to 0.002, molybdenum up to 0.0003, lithium up to 0.003, copper up to 0.0015, zinc – 0.004-0.04, nickel – 0.008-0.08, zirconium up to 0.003, cobalt up to 0.003, titanium up to 0.035. The waters, enriched in nickel and chromium, do mainly occur in the central and south-eastern parts of the territory. In some places increased radon content is observed in the waters (area of Zavallya, Ulyanivka, Vilshanka, Golovanivsk, Pervomaisk, Tyshkivka inhabited localities) which varies from the unity to 50-100 emans.

The water saturation depends both from the fracturing degree and the rock types. The highest water saturation is observed in migmatites: well yields from 0.75 to 12.55 dm^3/sec at level depression 56 and 16 m respectively. Specific yield – 0.004-0.8 dm^3/sec (maximum – 3.5 dm^3/sec); spring yield attains 2.5 dm^3/sec (Yurkivka village). The least water-saturated are enderbites and charnockites: well yields do not exceed 0.09 dm^3/sec at the depression level of 45.7 m, specific yield does not exceed 0.08 dm^3/sec, and in most cases the wells are actually water-free.

Reserve replenishment of fracturing waters in basement rocks and their weathering crusts is being performed through infiltration of atmospheric precipitates within the local feeding areas (plateau-like watersheds of the map sheet northern part). The flow of underground waters is directed to the south-east and south with partial drainage into the river and gully valleys, and in the slopes of local basement surface depressions – into the sedimentary cover rocks. Amount of the season variations in the level of water mirror – 0.6-1.5 m; in the watershed the season level variations are actually lacking.

The waters of the fracturing zones in the basement crystalline rocks and their weathering crusts (grussy zone) are actually not contaminated, do have good properties and are being widely used (besides surficial water scoops) for housing-drinking centralized water supply. In the map sheet territory reserves of underground waters are estimated for 5 deposits: Zavallivske, Golovanivske, Ulyanivske, Yatranske, and Novoarkhangelske. The first two ones are being exploited and three other are put into reserve. The local inhabitants use the waters of this complex for individual supply by means of wells, shafts and captured springs. In view of the sharp (by a factor of 2.5 over last 30 years) increase of contamination the sub-soil waters of the first from the surface water-bearing horizons with nitrates, pesticides and other harmful substances and elements [12, 77] it is recommended to release the gradual switch of all inhabited locations to the centralized water supply using surficial and artesian water scoops. The latter, first of all, can use the underground waters from the fracturing zones of Precambrian basement rocks and their weathering crusts.

8. MINERAL RESOURCES AND REGULARITIES IN THEIR LOCALIZATION

Most of mineral deposits and prospects in Middle Pobuzhzhya, which do have economic value, are related to the rocks of Precambrian crystalline basement and their weathering crusts; much less economic objects are discovered in Phanerozoic and Quaternary sediments.

Metallogenic zonation

The grounds for metallogenic zonation include the scheme of tectonic zonation, defined regularities in location of mineral resources, geological structure and position of the studied territory in metallogenic zonation of the territory of Ukraine. According to [24], in the studied area there is observed the junction of two regional metallogenic taxons of Ukrainian Shield: Kirovogradska and Dnistersko-Buzka Sub-Provinces; the border between the two is drawn by the western flank of Pervomaiska Deep-Seated Fault Zone.

Dnistersko-Buzka Sub-Province includes Bilotserkivska (I) and Golovanivska (II) TMZ (Fig. 8.1); specific Sub-Zones of Odesko-Bilotserkivska LTZ do correspond to these TMZ (see Tectonic Scheme). Bilotserkivska TMZ encompasses the far western and north-western parts of the map sheet territory. Golovanivska TMZ occupies most part of the studied territory and in the east it borders upon Zvenygorodsko-Annivska TMZ (III) which comprises the counterpart of Kirovogradska Sub-Province.

Metallogenic patterns of the territory are mainly defined by specialization of Golovanivska TMZ which is characterized by extremely complicated geological structure. Inside this Zone some Sub-Zones are distinguished (see Scheme of Tectonic Zonation); each one does have its own metallogenic features. In general, metallogenic patterns of Golovanivska TMZ are defined by occurrences of deposits and prospects of chromite, iron, gold, and graphite ores which time of formation falls into Neo-Archean and Paleo-Proterozoic Epochs, as well as silicate cobalt-nickel ores in Mesozoic weathering crusts after ultramafic rocks.

Zvenygorodsko-Annivska TMZ does have uranium-gold-rare-metal specialization. Bilotserkivska TMZ within the map sheet is characterized by prospects of ferruginous quartzite within volcano-sedimentary formations, rare-earths in weathering crusts, iron-manganese occurrences in weathering crust of carbonate rocks, gold mineralization in tectono-metasomatic zones, and graphite ores in gneisses and their weathering crusts.

Depending on confining the ore objects with certain economic type of mineralization to specific structures and complexes, within aforementioned TMZ there are distinguished ore camps, zones, nodes, and fields (see Fig. 8.1, Table 5). The regularities in localization of ore mineralization are being given under description of particular types of mineral resources; it should be noted, however, that the general and characteristic feature of ore object localization in the shield areas, highlighted by some researchers [3], comprises integrity of lithological and tectonic factors, first of all, Deep-Seated Faults. The studied area is not exclusion from this principle. Discussion concerns asthenosphere lineament “G” distinguished by V.B.Sollogub [37] as a zone of asthenosphere thickness drop. Projection of this lineament onto the surface of Precambrian basement (see Fig. 4.2) is being traced as the north-east trending zone of contiguous faults which cut the map sheet almost by diagonal. This zone plays the outstanding role in control over localization of ore objects despite of their confining to the different metallogenic taxones (litho-tectonic sub-zones). At the sites of junction between north-east-trending faults (within projection of lineament “G”) and deep-seated zones of north-west-trending and sub-longitudinal faults – Talnivska, Ternuvatska, Kapinativska, Vradievska and other – there is observed concentration of deposits and prospects (including direct prospecting signs) which are being joined into the known ore fields and locations prospective for further studies. Among the latter, in our mind, the most attractive is the site confined to the junction of asthenosphere lineament with Pervomaiska Fault Zone (Dobryankivska site) which is thought to be prospective for gold and rare-metal mineralization. Taking into account occurrence of Zhyravlynsko-Yatranska Thrust Zone which provides excellent screening surface for the ore-beating solutions, the perspectives of this site is even more.

In general, within the map sheet in crystalline basement are discovered 199 mineral deposits and prospects (Annex 3), which by their genetic type belong to residual (weathering crust), metamorphic, magmatic, hydrothermal-metasomatic (somewhere up to skarn) and pegmatite groups. Of mineral resources, the most important for the economy of the region, in particular, and the country as a whole, are deposits of silicate cobalt-nickel, chromite, and graphite ores, in less extent deposits and prospects of iron, manganese, gold, and construction materials. Within the map sheet 37 deposits and prospects are related to the sediments of platform cover (Annexes 1 and 2). These are mainly construction materials of which the principal are deposits of clays and loams for brick-tile raw materials of local value. Characteristics of ore-bearing facies and regularities in localization of mineralization in the rocks of sedimentary cover are given below under description of particular types of mineral resources.

Table 5

Metallogenic zonation

Metallogenic taxons (known and those predicted(*)), their number, age and specialization			
Tectono-metallogenic zones	*Ore camps, metallogenic sub-zones*	*Ore zones and nodes*	*Ore fields*
I Bilotserkivska AR_3-PR_1 U,Au,Fe	I.1 Ananiivska AR_3 gp,Fe,Mn/TR,Au (U)		I.1.0.1 Vilkhovetske* AR_3-PR_2 Au
			I.1.0.2 Khashchuvatske AR_3-MZ Mn,TR (Au)
			I.1.0.3 Zavallivske AR_3-MZ gp/Au,U (di)
		I.1.1 Talnivska* AR_3-PR_2 Au/Bi,Ni,Co (W,U)	I.1.1.1 Savranske AR_3-PR_2 Au/Bi,Ni,As (W,U,Mo,Te)
			I.1.1.2 Polyanetske* AR_3-PR_2 Au,Fe
II Golovanivska AR_3-PR_2 Ni,Cr,Fe/Au,Co,gp (Pt,Mo,Mn)			II.0.0.1 Troyanske* AR_3-PR_2 Au,ap/Cu,Ti
	II.1 Pobuzkiy AR_3-MZ Ni,Co,Fe,Cr,Au/gp, (Pt,Mo,Mn)		II.1.0.1 Grushkivske AR_3-MZ Fe,Ni,Co/Mn (U)
			II.1.0.2 Golovanivske* AR_3-PR_2 Au,Bi/U,TR,Zr
			II.1.0.3 Shamraivske* AR_3-MZ Au,Fe/gf,Bi (U)
		II.1.1 Derenyukhynskiy AR_3-MZ Ni,Co,Fe,Cr/Au,Cu (Pt,Mo,Mn)	II.1.1.1 Moldovske AR_3 Fe/Ni,Co,Au (Pt,Mo)
			II.1.1.2 Kapitanivske AR_3-MZ Ni,Co,Cr,Au/Fe,Mo, (Cu,Pt)
			II.1.1.3 Ternuvatske AR_3-MZ Ni,Cu,Au/Co,Mg,Fe (Pt,gp)
III Zvenygorodsko-Annivska PR_{1-2} U,Li,Ta,Nb,TR	III.1 Bratskiy PR_{1-2} Li,U,Au/Ta,Nb		III.1.0.1 Dobryankivske* PR_{1-2} Au,Ta,Nb/Sn,Be
		III.1.1 Bandurskiy* PR_{1-2} U,TR/Th,Zr (Au)	
		III.1.2 Mygiyska* PR_2? Cu,Au/W (Hg)	

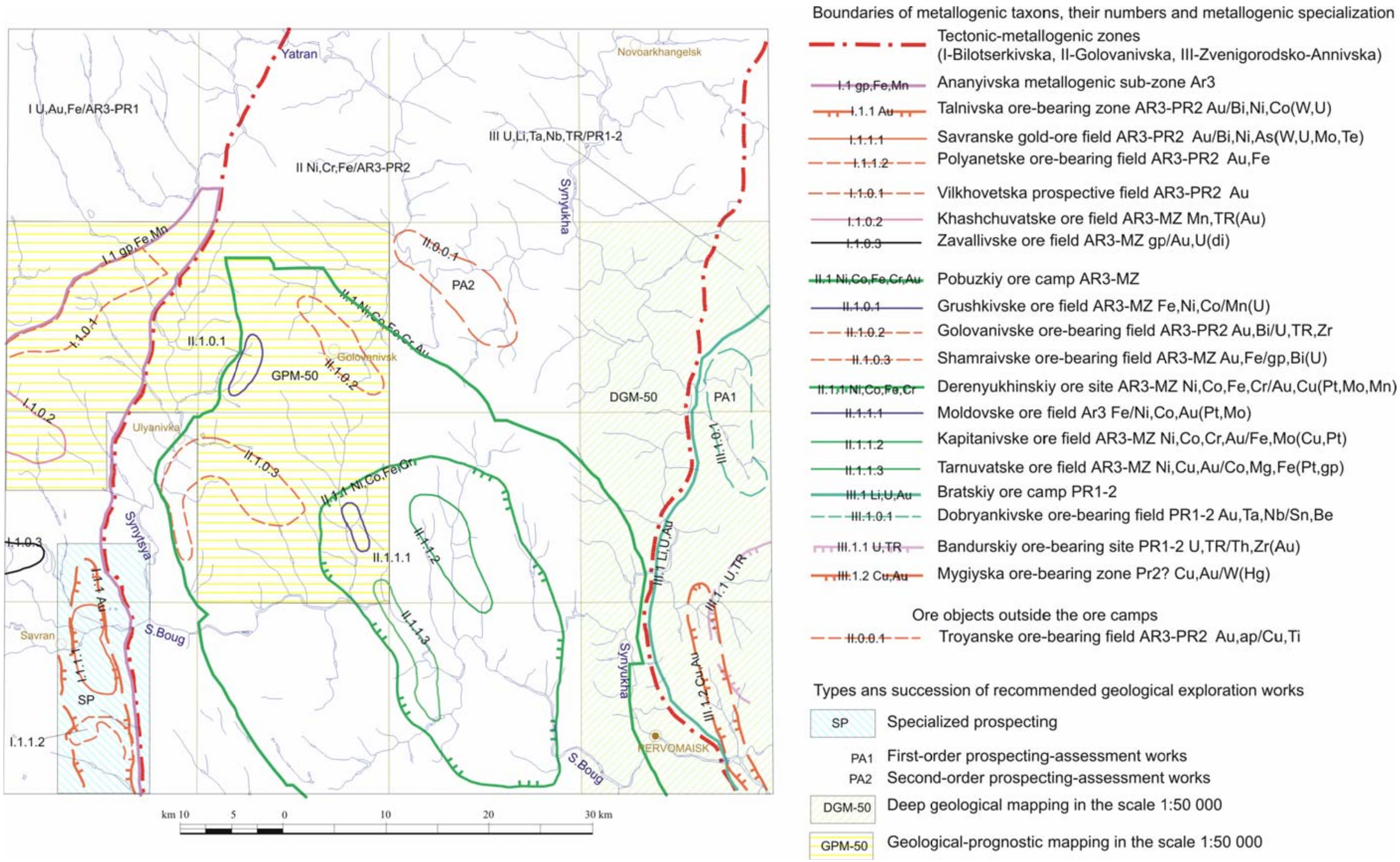

Fig. 8.1. Scheme of the metallogenic zonation and prognosis.

Combustible minerals

Solid combustible minerals

Brown coal

Resources of brown coal are related to the continental coal-bearing sediments of Buchatska Series confined to the buried ancient paleo-valleys. The only brown coal prospect (Velyko-Troyanivsko-Tauzhnyanskiy II-I-16) is known in the map sheet territory. It is located in the north-western part of the studied area where most widespread are the sediments of Buchatska Series composed of sands, kaoline clays and secondary kaoline. The brown coal layer is split into three bodies by strike due to non-conditional parameters of its thickness in places of paleo-valley contraction. The coal body is of rather simple structure and lies sub-horizontally. Average thickness comprises 4.1 m, depth – about 49 m. The ash content varies from 11.5 to 40% (29.3% in average). There are estimated resources by category P_2. At present time this prospect is out of economic value.

Metal mineral resources

Ferrous metals

Iron

Iron deposits and prospects and confined to Golovanivska and Bilotserkivska TMZ. Within the map sheet territory are known 2 iron deposits (Moldovske and Grushkivske) and 14 prospects where have been performed prospecting works and carried out evaluation of their predictive resources mainly by category P_2; in Moldavske deposit (III-2-174) there are estimated ore reserves by category C_2 and resources by category P_1.

Ferruginous rocks are included into so called ferruginous-silica-metabasite-carbonate formation [17] which is distinct in term of rock sequence in the section – metamorphosed mafic rocks (metabasites) are changed by ferruginous-silica layers and the latter are overlain by calciphyres. And the latter are enriched in magnetite and form carbonate-magnetite ores which can be used in metallurgy without preliminary beneficiation.

By genetic type, mineral composition of ores and morphology of ore bodies the iron-ore deposits and prospects are divided in two groups – metamorphic with magnetite-quartz and pyroxene-magnetite-quartz mineralization, and skarn with carbonate-magnetite ores. In some objects there are observed two types of mineralization and somewhere brown iron ores occur in weathering crust. The iron content, both magnetite and total, is higher a bit in carbonate-magnetite ores. The iron-ore deposits of Middle Pobuzhzhya belong to medium and poor iron ores which require preliminary beneficiation (except the ores in calciphyres).

The leading role in distribution and localization of the ferruginous rocks do play tectonic and stratigraphic factors. All known iron-ore deposits and prospects are confined to Khashchuvato-Zavallivska Suite of Buzka Series and in much less extent – to Pavlivska Pile of Dnistersko-Buzka Series. These rocks are preserved within the fields of granites and migmatites in synform structures of the second and higher orders which are observed in the linear overturned isocline folds. The general strike of structure is north-western, sometimes sub-longitudinal and sub-latitudinal with virgation in the eastern points.

The iron ore bodies are characterized by variable iron content, sheet-like, lens-like and somewhere column-like shape, insufficient thickness and rather high length with common pinch out over the distance 0.5-5 km (sometimes up to 10 km). Thickness of silicate-magnetite ore bodies (ferruginous quartzites) varies from 10 to 110 m (normally 30-60 m), carbonate-magnetite ores (calciphyre ores) – from 10 to 70 m. Average total iron content in the former ores varies in the range 25-33%, in calciphyres – 33-39%, and magnetite iron content, respectively, varies as 16-25% and 27-32%.

The depth of ore mineralization, according to surface geophysical survey, attains 1,500 m; by drill-holes the ore bodies are traced up to the depth 1,200-1,300 m (in Moldovske deposit). Thickness of the overburden rocks varies from 40 to 120 m. All the prospects are characterized by magnetite type of mineralization (75-80% of magnetite is more than 0.1 mm in size), and increased contents of Ti, Cr, Mn, P_2O_5. In some prospects there is observed anomalous gold content at the level 0.1-0.3 g/t, and tungsten – 0.01-0.1%.

Ferruginous quartzites and ore calciphyres of Middle Pobuzhzhya are rather well studied. Their mineral composition and structure-texture features are described in details in the reports on iron-ore prospecting over the map sheet territory and in the monograph [17]. It should be noted that both in ferruginous quartzites (in less extent) and in magnetite-bearing calciphyres (always) there is observed iron metasomatic re-distribution with formations of secondary magnetite.

In the prospects the ore mineralization is accompanied by skarning, silicification, and sulphidization. Somewhere sulphide mineralization does form bunches and interbeds of massive ores composed of pyrrhotite, pyrite and sometimes chalcopyrite.

Extraction of ferruginous quartzites economically is less profitable than ore calciphyres but taking into account their common joint laying, there is a possibility for their complex development and, therefore, the ferruginous quartzites also provide some economic value. According to some opinions [17], the estimated reserves of iron ores in the studied area are quite enough for the activities of a large mining enterprise.

Moldovske deposit (III-2-174) is the most studied and prospective iron-ore object in Middle Pobuzhzhya. It is located at the northern outskirt of Moldovka village, Golovanivskiy area, Kirovogradska Oblast. The ore mineralization is confined to the western limb and partially to the northern closure of Moldovo-Ternuvatska syncline structure of north-western strike which is extensively compressed and overturned westward. The rocks of the structure are located in the field of Pobuzkiy Complex biotite granites and steeply dip under the angles 78-82^{o}. Two sheets of ferruginous quartzites are conformably alternate with pyroxene-plagioclase mafic gneisses, amphibolites, garnet-biotite gneisses, calciphyres, and skarnoids of Buzka Series. Thickness of the ferruginous quartzite ore bodies varies from 5 to 140 m; the length attains 2.4 km; the ore bodies are often cut by up to 2 m thick veins of quartz-feldspar metasomatites. Most widespread are ferro-hypersthene ands two-pyroxene ferruginous quartzites; in the rocks is observed extensive metasomatic re-crystallization with formation of coarse-grained rocks and separation of the rich magnetite ore bunches. Magnetite-bearing (ore) calciphyres are tightly spatially related to the ferruginous quartzites. The rich carbonate-magnetite ores are confined to the central part of the deposit where they form about 90 m thick column-like body traced to the depth of 1,200 m. The weathering crust after ore-bearing rocks comprises brown iron ores and ochres with average thickness 77 m and total iron content at the level of 40%. The total iron content in carbonate-magnetite rocks is 38%, in quartzites – 27%. The skarn-like rocks display increased contents of tungsten (up to 0.007%), and weathering crust of the ferruginous rocks – of gold (up to 0.5 g/t). By genetic type the ores in deposit are divided into skarn, metamorphic and brown-ore in weathering crust.

The standard prospecting-evaluation works are carried-out in the deposit with reserve estimation over specific ore types by category C_2 and are also approved the prospective resources by category P_1. Up to now deposit was not exploited yet.

Grushkivske deposit (II-2-155) is confined to the same-named synform structure of north-eastern strike overturned to the north-west. The syncline is composed of metamorphosed extrusive-skarn rocks (ferruginous quartzites, calciphyres, amphibolites, aluminous gneisses) of Buzka Series, ultramafic rocks of Derenyukhynskiy Complex, and biotite migmatites of Pobuzkiy Complex.

The ferruginous quartzites include ferro-hypersthene and two-pyroxene varieties and in the eastern limb of the fold they form a range of big ore bodies which are traced one by one over the distance of 5 km. Thickness of ore-bearing pile varies from 10 to 300 m (75 m in average); the pile normally contains some ferruginous quartzite layers, first tens of meters thick, separated by thin (2-15 m) interbeds of calciphyres, amphibolites and hypersthene-cordierite-biotite gneisses. In ferruginous quartzites, at the contacts with calciphyres up to 1-2 m thick skarn pockets of diverse composition often are observed; in calciphyres the skarnoids are more numerous and their thickness attains 10 m. The calciphyres often contain the magnetite dissemination and in such sites do contain the rich iron ores. The average total iron content by entire deposit is 28.83%, and magnetite iron – 17.21%. By genetic type the ores in deposit can be divided into metamorphic and skarn ones. Based on the performed prospecting works in the deposit the prognostic resources are evaluated by category P_2 to the depth 1,000 m.

All other iron-ore findings in Middle Pobuzhzhya by their geology, structure position, morphology and composition of ore bodies are close or analogues to Moldovske deposit. Their list is given in the Annex No.3.

Iron, manganese

The iron-manganese hydroxide sheet-like ores are known both in Golovanivska TMZ and Bilotserkivska TMZ where their distribution is controlled by the sites of weathering crust after carbonate rocks (calciphyres) and skarnoids of Khashchuvato-Zavallivska Suite of Buzka Series. Within the map sheet territory there are known 7 findings of iron-manganese ores of residual type which are similar by the forming conditions, mineral composition and morphology of ore bodies, localization specifics and structure. Stratigraphy and lithology are the major control factors in these findings (occurrence of carbonate rocks and related skarnoids within Khashchuvato-Zavallivska Suite), as well as the preservation degree of the laterite profile in weathering crust. The Deep-Seated Fault zones control the linear weathering crusts where increase of thickness and length of ore bodies occur.

Discovered prospects include mainly small sheet-like ore bodies, bunches and lenses which thickness varies in the range 0.1-2-3 m, sometimes exceeds 10 m. These are composed of limonite-pyrolusite with hematite, goethite and hydro-goethite scattered, earthy mass, somewhere with fine-concretion or bean structure. Manganese oxide content varies from 3.0 to 32.6%, total iron – from 19.5 to 42.0%. In general, the findings of hydroxide iron-manganese ores are weakly studied. And only some were involved in the general prospecting with prognostic resource evaluation by category P_3.

One of the prospective objects is Savranskiy prospect (IV-1-210) located in the same-named ore field and confined to the linear weathering crust controlled by Talnivska Deep-Seated Fault Zone. The ore body is traced in the 50 m wide band over the distance about 10 km at the thickness up to 20 m. Mineralization is related to the weathering crust of carbonate and skarn-wall rocks. The ores comprise crumbly earthy, sometimes fine-concretion rock of limonite-pyrolusite with goethite, in places hydro-goethite composition. Manganese content attains 6.0%, the total iron – 42.0% in average. Increased content of P_2O_5 (0.1-0.9%) is observed in the ores. According to R.M.Dovgan, confining of mineralization to the tectonic zone is caused by metasomatic processes that facilitate inflow of manganese- and iron-enriched solution and their concentration in carbonate rocks – distinct geochemical barrier. In the prospect the general works were carried out with resources evaluation by category P_3.

Manganese

Besides the hydroxide iron-manganese ores, within the map sheet there are known 2 findings of the dense manganese ores in crystalline rocks (Ternuvatskiy IV-3-74 and Tarasivskiy 1-3-3) represented by gondites.

Manganese-bearing gondites in Tarasivskiy prospect are confined to the south-eastern closure of the same-named structure located within Yatranska Sub-Zone (see Scheme of Tectonic Zonation). Gondites are composed of spessartite, rhodonite, manganese-bearing pyroxene, amphibole and mica (biotite-phlogopite-manganophillite), as well as plagiocale, quartz, and potassium feldspar. In the section the ores associate with two-pyroxene and hypersthene mafic gneisses of Buzka Series. Accessory minerals of gondites (magnetite, ilmenite, sphene, pyrite) also carry increased manganese content. The ore bodies comprise the interbeds and lenses; thickness varies from 0.1 to 2.5-3.0 m and decreases by depth. The ore MnO content in the upper part of the section attains 31.6% and decreases by depth to 0.3-11.18%. Studies of REE distribution in manganese rocks of Tarasivska structure had shown their similarity to gondites from India in the field of heavy and medium REE [80]. The prospect is weakly studied.

Ternuvatskiy finding of gondite-like rocks is discovered by the single drill-hole in the south-western limb of the same-named structure within mafic-ultramafic rocks. Gondite-like rocks are composed of garnet (of spessartite range) – up to 50%, carbonate (18-20%), mica, magnetite and clinopyroxene. Metallic manganese content varies in the range 6.0-9.0%, the column thickness of ore-bearing rocks – 7.6 m.

Chromium

In the map sheet territory there are known 2 deposits (Kapitanivske and Lypovenkivske) and 8 studied prospects of chromite ores which are concentrated within Derenyukhynskiy ore node and are one of the most important mineral commodity types in Middle Pobuzhzhya. Without exclusions all these objects are related to the massifs of ultramafic rocks of Kapitanivskiy Complex whose distribution is mainly controlled by the deep-seated factors. The ultramafic rocks of the Complex are confined to Pushkivskiy gravity maximum; nature of this unit is apparently caused by the upper crust saturation with the deep rocks of mafic-ultramafic composition and its confining to the Kapinativska Deep-Seated Fault Zone. The latter by geological-geophysical data is thought to be the frontal part of Emylivsko-Pervomaiska Thrust Zone. In this respect, the known small ultramafic bodies of Kapitanivskiy Complex are being considered as tectonic seizures and actually comprise the macro-boudines.

By the forming conditions and geology chromite objects are rather similar and belong to the typical late-magmatic formations located in serpentinized dunites and peridotites. The ore bodies comprise mainly lenses or sub-parallel, often bifurcating thin (from 0.1 to 10.0 m, sometimes more) veins from first meters to first hundreds meters long. Somewhere the twitches are observes up to full pinch out both by strike and dip. The ore body dipping is mainly vertical or sub-vertical. The scale of mineralization by depth in some places only exceeds 100 m and more. Amount of ore bodies in a single object varies from 1 to 6. By texture, there are known the solid and densely-disseminated ores where major minerals are chrome-spinellides. Content of the latter varies in the range 80-94% in the solid ores and 50-80% in the densely-disseminated ores. Non-ore minerals include chrysotile, antigorite, chlorite, chrome-diopside, etc. Sometimes are observed magnetite, pentlandite, pyrite, and chalcopyrite. The ore bodies comprise the alternation of solid and densely-disseminated ores. The latter occur in minor amount. Content of Cr_2O_3 varies from 30 to 45% in the solid ores and from 6 to 28% in the densely-disseminated ores. In some findings (particularly, in Kapitanivske deposit III-2-194) there is determined the anomalous content of platinum (up to 2.0 g/t) and platinoids (Pd – 0.01 g/t) in ultramafic rocks but their distribution is weakly studied. Besides this, in the weathering crust after ultramafic massifs of Kapitanivskiy Complex there are found the sites of silicate cobalt-nickel sometimes with iron ores with economic or non-economic parameters.

At present, in two deposits there are estimated and approved reserves by category C_1, and for other objects, depending on study degree, there are evaluated the prospective resources by categories P_1, P_2, and prognostic – P_3.

Economic value is attributed to Kapitanivske (III-3-194) and Lypovenkivske (III-3-187) deposits, and Zavodskiy prospect (III-3-200). Other chromite findings in view of their ore body parameters and Cr_2O_3 content are not economic. According to the results of technological trials, the solid chromite ores can be directly used for alloy production in electrowins or in production of the ferro-nickel with increased chromium content by technology adopted in Pobuzkiy Nickel Plant.

The most prominent example of chromite mineralization is Kapitanivske deposit (III-3-194) explored and studied by I.Y.Shevchyshyn [93] late in 50th. Mineralization is related to the same-named serpentinite massif of Kapitanivskiy Complex. Almost all ore bodies are confined to the weakened western contact of the massif with the host rocks. Majority of ore bodies is concentrated in the southern part of intrusion and comprises the system of contiguous sub-parallel, somewhere bifurcated veins with swells, twitches, sometimes with complete pinch out both by dip and strike. Thickness of the bodies is from 0.1 to 16.0 m (up to 40 m in swells), length – from first tens to 600 meters. The scale of mineralization to the depth exceeds 300 m. The dipping of ore bodies is vertical and sub-vertical. The ores are composed of chrome-spinellides contained in amount of 80-94% in the solid and 50-80% in densely-disseminated ores. Non-ore minerals and sulphides comprise assemblage indicated above. The crumbly ores in the linear weathering crust zone contain opal, chalcedony, calcite, minerals of limonite group, oxides of manganese and nickel, nontronite. Cr_2O_3 content varies in the range 32.0-48.7% and about 29.14% in the solid and densely-disseminated ores respectively.

Deposit is explored. Reserves by category C_1 are approved in the State Commission on Reserves of USSR in 1959 [93]. Deposit was never exploited.

Non-ferrous metals

Copper

Two copper objects are discovered within Bratskiy ore camp of Zvenigorodsko-Bratska TMZ – Pidgorodnyanskiy (IV-4-234) and Mygiyskiy (IV-4-96); these two can be defined as hydrothermal type of copper mineralization in crushing zones. The vein-disseminated chalcosine-chalcopyrite mineralization of these objects is confined to the cataclasm zones within Pervomaiskiy Deep-Seated Fault and is accompanied by silicification and retrograde metamorphism of the host rocks. According to the spectral analysis results, the copper content varies from 0.23 to 1.0%. Mineralization zones are accompanied by geochemical and soil anomalies of tin, zinc, silver, lead, mercury, and gold. Prospective rate is not defined.

Nickel, cobalt, copper

By the forming conditions and localization the nickel deposits and prospects known in Middle Pobuzhzhya are subdivided into some genetic types: silicate cobalt-nickel ores of weathering crusts (residual), magmatic sulphide copper-nickel, and cobalt-nickel sulphide-arsenide vein-type. Two latter types are represented by single objects only whereas silicate cobalt-nickel ores are of great economic value for the region and a whole country.

All known silicate nickel ore objects (8 deposits and more than 10 prospects) are concentrated within Pobuzkiy ore camp where most of objects are confined to Derenyukhynskiy ore bunch. Studies, exploration and evaluation of the cobalt-nickel findings started in 50th and finished late in 80th – beginning of 90th. In 6 deposits (Lypovenkivske (III-3-188), Derenyukhynske (IV-3-71), Kapitanivske (III-3-193), Pushkinske (III-3-183), Grushkivske (II-2-154), Ternuvatske (IV-3-223)) reserves by categories B and C_1 are approved in the State Commission on Reserves of USSR, and in Kamyanobalkinske (IV-3-228) and Lashchivske (IV-3-222) deposits detailed exploration was performed with reserves estimation by categories $B+C_1$ (not approved yet). Based on these deposits up to recent times Pobuzkiy Nickel Plant was operating with the annual capacity 950 thousand tons of ore [80]. Upon some years of suspension the Plant had recently restored its activities.

All deposits and findings of silicate nickel are related to the laterite weathering crust after serpentinized ultramafic rocks of Kapitanivskiy and Derenyukhynskiy Complexes, and their economic value is defined by size of ultramafic massifs and preservation degree of weathering crust. In turn, localization of mafic-ultramafic rock massifs is controlled by both deep-seated factors (Kapitanivskiy Complex) and tectonic ones.

Almost in all known objects the nickel ores contain economic or sub-economic grades of cobalt and somewhere also iron, and in this respect they can be considered as complex ores. In all nickel deposits reserves of cobalt as by-product are estimated. Geology of the objects is similar. The contours of ore bodies with conditional parameters are being defined by sampling. Normally these are sheet- and lens-like ore bodies irregularly-shaped in the plane. They occupy the space from hundreds to tens of thousands square kilometres. Thickness of nickel-bearing weathering crust varies from 1 to 50 m; in case of economic ores thickness normally does not exceeds first meters. In general, the nickel-bearing weathering crust profile is subdivided into 4 zones (downward): 1) brown iron ore and ochre; 2) nontronite; 3) nontronitized serpentinite; 4) carbonatized serpentinite. Major nickel reserves are concentrated in second zone and much less – in the lowermost portion of ocher zone and uppermost portion of nontronitized serpentinites. The first zone is accompanied by iron-ore bodies with iron content in the range 21-28%. They are composed of iron hydroxides and contain valuable impurities of nickel and cobalt.

The nontronite ores comprise the solid crumbly (friable) mass and contain 0.9-1.0% of nickel irregularly distributed in the ore body. Increased cobalt grade in general coincides with economic horizons of nickel ores where it is concentrated in manganese hydroxides which occur in small bunches, veinlets, and irregularly-shaped aggregates. The ration of cobalt to nickel is about 1:20 at the average cobalt grade 0.0360.064%. Besides this, in some prospect the anomalous gold grade (up to some g/t) is determined in the nickel-bearing weathering crusts. In Ternuvatska site there were performed special studies with regard to use the ultramafic rocks as the raw magnesium commodity. The depth of silicate cobalt-nickel ores varies from first meters to first tens of meters. Deposits are being exploited by open-cast method. At present Derenyukhynske deposit (IV-3-71) is fully exhausted, and Lypovenkivske deposit (III-3-188) is conserved. Other deposits are not exploited.

Kapitanivske deposit (III-3-193) provides the best example of residual-type nickel ores. It was explored in 1958 [92] and extended exploration was performed in 1989 [70]. Deposit is related to the same-named massif of serpentinized mafic-ultramafic rocks; the latter rocks comprise about 95% of intrusion by volume. The massif lies within gneisses of Buzka Series and migmatites of Pobuzkiy Complex. Major reserves of nickel ores are concentrated in the nontronite zone of weathering crust after serpentinites. Nickel content in the ores varies from 0.3 to 3.5%, cobalt – 0.02-0.16%. The iron oxide content in the ochre zone is 26.6% in average. The nickel-bearing weathering crust is characterized by increased manganese content – 0.49-8.55% (average – 3.0%).

The north-west trending ore bodies of irregular, lens-like shape are extended over about 0.9 km at average width 8.39 m. Sedimentary cover thickness varies in the range 2-60 m. In the linear weathering crusts in the northern part of massif there is discovered gold mineralization (0.1-9.4 g/t) encountered both in the nickel-bearing rocks and outside them. There are estimated reserves of gold which is considered as by-product of nickel deposit. In weathering crust of serpentinites the diamond finding is encountered (see “Precious stones”).

Demovyarskiy prospect (III-2-46) of sulphide copper-nickel ores is discovered within Ternuvatske ore field where zones of sulphide-disseminated chalcopyrite-pyrrhotite with pentlandite mineralization are encountered in the south-eastern closure of Moldovska synform structure. The internal part of structure is composed of gneisses of Khashchuvato-Zavallivska Suite which contain the bodies of mafic-ultramafic rocks of Derenyukhynskiy Complex. The latter form two small massifs in the north-eastern limb and underwent extensive silicification (especially gabbro-amphibolites) with formation of up to 140 m thick silicified zones which, in turn, contain mono-mineral quartz veins with disseminated sulphides (up to 3-5%). Somewhere sulphide content attains 30-40% (pyrrhotite, chalcopyrite, pyrite, arsenopyrite), silicified rocks and quartz veins contain gold mineralization (0.01-19.9 g/t).

Copper-nickel ores in zones of sulphide vein-disseminated mineralization and sulphide bodies are confined to the endo- and sometimes exo-contacts of peridotite and pyroxenite interbeds with gabbro-amphibolite bodies. Ore bodies do have thickness from 0.1-0.5 to11.0 m and are traced over the distance about 2 km. The scale of mineralization by depth exceeds 500 m. The metal content in the ores varies as follows (%): nickel – 0.27-0.44; copper – 0.07-0.736; cobalt – 0.01-0.02. The ores contain anomalous grade of gold (up to 0.03 g/t), silver (up to 0.5 g/t), molybdenum, arsenic. In the northern part of the area there are encountered metacomatic minerals of cobalt and nickel comprised of arsenides and sulpho-arsenides and confined to the skarn-like rocks at the contact of gabbro-amphibolites and ultramafic rocks.

Sulphidization zones are accompanied by graphitization, carbonatization and skarnization of the host rocks which are also sheared and brecciated. In the object there are performed prospecting works with evaluation of prognostic resources by category P_3 to the depth of 200 m [61].

Savranskiy prospect (IV-1-208) of sulphide-arsenide cobalt-nickel ores is discovered within the same-named ore field where it is confined to apo-pyroxenite metasomatites formed within Talnivskiy Dee-Seated Fault Zone after the rocks of Buzka Series. Mineralization zone in metasomatites is confined to extensively cataclazed and milonitized rocks of Khashchuvato-Zavallivska Suite. The zone is traced in the northern direction over the distance of more than 500 m. Within mineralization zone there is defined a series of veinlet-type 0.5 m thick ore bodies with composite mineral paragenesis. The ore assemblages include diverse sulphides, arsenides, native elements, of which the leading are arsenopyrite, nikeline, gersdorffite, and loellingite. The maximum nickel content attains 1.58% at the average content over the ore yone 0.4%, and cobalt – 0.037%. The ores are characterized by relatively low copper content – not more than 0.03%, and increased contents of antimony (up to 0.05%), gold (up to 0.95 g/t), and high (up to some pre cents) arsenic content. The hanging-wall and foot-wall of ore zones are characterized by geochemical anomalies of bismuth content – up to 2 g/t. The object can get economic value in case of its complex exploitation together with gold ores known there.

Titanium

Titanium findings are represented by two types: residual (eluvial) in weathering crusts of crystalline rocks and titanomagnetite-ilmenite mineralization related to metasomatically re-worked skarn-like rocks within mafic and ultramafic rocks. The latter are weakly studied and their genetic affinity and ore formation are not defined completely. In general, localization of titanium objects in weathering crust is predetermined by distribution of crystalline rocks containing abnormal amounts of accessory ilmenite. Among numerous findings of this type known in the map sheet territory two ones only are worthy of attention. Other findings of the ilmenite-bearing weathering crusts are not shown in the map due to insufficient parameters of ore bodies, low titanium content, and weak study degree.

Troyanskiy Prospect (II-3-156) is discovered in the central and northern parts of the same-named structures. Economic concentrations of ilmenite in the range from 17.0 to 28.8 kg/t are confined to the clay-hydro-mica horizons of weathering crust after pyroxene mafic gneisses and form ore bodies 300 by 900 m in size. Upon further extended studied the ilmenite concentrate can be extracted together with apatite (see section "Agrochemical raw commodities".

Grushkivskiy prospect (II-2-153) is confined to the ilmenite-bearing kaolinite-halloysite weathering crust after migmatites of Pubuzkiy Complex. Ilmenite content is 43.0 kg/t.

Tarasivskiy prospect (I-3-5) is confined to the southern closure of the same-named structure (Yatranska Sub-Zone). Mineralization is related to the contact skarn-like rocks of titanomagnetite-garnet-pyroxene composition which occur within metamorphosed mafic rocks of Derenyukhynskiy Complex and mafic metamorphic rocks of Buzka Series intruded by leuco-granites of Pobuzkiy Complex. The ore bodies are of the first meters thick and some tens of meters long, lens-like and ball-like shape, contain from 4.6 to 7.15% TiO_2 as well as anomalous concentrations of (%) yttrium – 0.2, gallium – 0.008, copper – 0.02, antimony – 0.005, and gold – 0.03-0.07 g/t. The mafic rocks, that contain skarnoids, are characterized by increased scandium content in the range 0.003-0.02%. At present study degree the prospect does not have economic value.

Rare metals, trace and rare-earth metals

Bismuth

In the map sheet territory there are known 4 bismuth prospects in crystalline rocks which are being considered as by-product bismuthine mineralization in the composite gold-ore objects. Native bismuth and bismuthine mineralization in association with iron, lead and arsenic sulphides is observed in the gold-ore bodies of Savranske, Chemerpilske, Shamraivske, and Golovanivske prospects. In two latter besides gold it is also encountered uranium mineralization. The ore mineralization is controlled by tectonic weakness zones with the signs of alkaline-silica metasomatism (albitization, silicification, sericitization) and spatially and paragenetically is related to the vein bodies of leucocratic aplite-pegmatoid granites. Granites normally display evidences for metasomatic modification and often are sillimanite-, garnet-, cordierite-, and tourmaline-bearing. Bismuth content in gold-bearing rocks varies from 0.01 to 0.45%.

Geochemical prospecting directly for bismuth mineralization is performed in Golovanivskiy (II-2-18) prospect only where the ore mineralization is encountered in the vein bodies of leucocratic sillimanite-garnet with cordierite granites (alkaline metasomatites after garnet-biotite gneisses). Spatially it is located in the limb of

Golovanivska synform fold. Ore intervals from 0.4 to 2.0 m thick contain dissemination of native bismuth, bismuthine, uraninite, urano-thorite, orangite, and molybdenite, and are characterized by bismuth content in the range 0.01-0.13%, uranium – up to 0.02%, and anomalous Au, Ag, Mo, Pb, Cu content. Bismuth-uranium mineralization in this prospect is spatially disconnected a bit from the gold-ores but the latter are characterized by anomalous bismuth content. Prognostic resources by category P_3 are evaluated in the prospect. The ore formation is not defined yet; genetic type of mineralization – hydrothermal, probably – metasomatic-hydrothermal.

Tungsten

The tungsten prospects (IV-1-211, IV-3-226) are confined to magnesium skarns and skarn-like rocks formed mainly after high-calcium rocks of Khashchuvato-Zavallivska Suite at the contacts with the bodies of aplite-pegmatoid granites. Besides lithological factor, localization of scheelite-bearing skarns is controlled by tectonic factor – normally all skarnoids are confined to the fracturing zones with the signs of metasomatic modification of the host rocks. Scheelite mineralization often is supplementary in the gold and iron prospects.

Savranskiy prospect (IV-1-211) is located within the same-named ore field and is confined to the skarns and skarn-like rocks controlled by the zone of sub-longitudinal fault. The same zone also controls gold, bismuth, and arsenic-nickel mineralization forming polygenic complex ore mineralization. Sulphide content in metasomatic spotty and banded clinopyroxene skarnoids varies in the range 3-4%, sometime sup to 10%. In the ore interval scheelite is associated with arsenopyrite, chalcopyrite, pyrite, galena, molybdenite, bismuthine, native bismuth, gold, and other minerals. The ore zone is saturated with sub-conformable bodies of aplite-pegmatoid granites. The tungsten anomaly is traced over the distance of 5 km by strike at the width of 100 m. Tungsten content varies from 0.01 to 0.15%. Economically tungsten is of interest as by-product in connection to the gold mineralization which scales increase northward.

Sekretarskiy prospect (IV-3-226) like previous one is related to garnet-magnetite-pyroxene skarns formed after calciphyres of Khashchuvato-Zavallivska Suite and occur as interbeds within mafic gneisses in the south-western closure of Ternuvatska structure. Tungsten content varies in the range 0.001-0.1%. The skarn rocks are characterized by anomalous gold content – up to 0.03-0.04 g/t.

Favourable geologic factors and direct prospecting evidences for tungsten mineralization allow assumption on discovery of economic objects in Middle Pobuzhzhya. Besides these, the skarn tungsten deposits are normally complex ones.

Molybdenum

Previous researchers had discovered two molybdenum prospects which by their localization features can be defined as disseminated ores of hydrothermal type. Spatially and paragenetically the molybdenum mineralization is related to the bodies of aplite-pegmatoid granites and its localization is controlled by tectonic breaks. The host rocks are metasomatically altered.

Lypovenkivskiy prospect (III-3-189) is encountered in the northern part of the same-named massif of mafic-ultramafic rocks where is observed extensive rock biotitization and in lesser extent carbonatization, silicification, chloritization, tourmalinization controlled by the zone of steeply-dipping tectonic breaks. The zone is saturated with thin veins of aplite-pegmatoid granites. Quartz-molybdenite fine-disseminated ores in veins and veinlets up to 5 cm thick apparently form the stockwork body 350 by 50 m in size within altered serpentinites. Molybdenum distribution is quite irregular – from thousandth of per cent up to 0.093% (0.04% in average). The ores contain anomalous amounts of copper (0.15-0.2%). Prognostic resources by categories P_2+P_3 are evaluated to the depth of 250 m.

Molybdenite mineralization of *Tarasivskiy prospect* (I-3-6) is confined to north-eastern part of the same-named structure (Yatranska Sub-Zone). Pyrite-chalcopyrite-molybdenite mineralization in bunches 1-2 cm in size, dense dissemination by mass, and single fractures is localized in highly-fractured zone within two-pyroxene and magnetite-pyroxene mafic gneisses of Buzka Series. Within the latter are observed the conformable dyke-like bodies of pink aplitoid granites as well as lenses of skarned calciphyres with anomalous scheelite (up to 200 g/t) and apatite (up to 9.46 kg/t) contents. In the ore intervals molybdenum content is not consistent and is 0.86% in average; elements-satellites – copper (0.3%), tungsten (up to 0.041% in skarns). Mineralization is weakly studied.

Rare earths, zirconium

Increased contents of rare earths and zirconium in the map sheet territory are known both from weathering crust of leucocratic, mainly pegmatoid granites, and directly from the vein aplite-pegmatoid granites with anomalous radioactivity. Somewhere rare-earth mineralization is related to the alkaline metasomatites located within the zones of tectonic weakness with the signs of local silica-alkaline metasomatism. In the studied territory there are known about 10 findings of zirconium-rare-earth mineralization which are almost unstudied and undefined economically. Major minerals-concentrators are zircon and monazite which content in the ore intervals varies from 0.5 to 6.5 kg/t and from 0.1 to 19.7 kg/t respectively. In rare-earth pegmatites zircon-monazite mineralization is observed as irregular fine dissemination. According to the spectral analysis, zirconium content is about 0.5%, rare earths – at the level of first tenth of per cent.

One of the prospective prospects is *Dovgoprystanskiy* (IV-3-76) one where fine-disseminated zircon-monazite mineralization is observed in veins of pegmatites and aplite-pegmatoid granites which intrude enderbites of Gaivoronskiy Complex. Thickness of ore bodies is 0.1-2.0 m, monazite content – 9.0-14.6 kg/t, zircon – 2.24-6.5 kg/t.

Precious metals

Gold

Geological position of gold-ore objects known in the map sheet territory is rather variable that caused occurrence of the prospect of diverse genetic types with certain mineral composition of the ores. Localization of gold mineralization with semi-economic parameters is controlled by several factors of which, according to O.P.Storozhuk [88] the major ones include tectonic, magmatic, and lithology-petrographic. In all endogenous findings the major ore-controlling factor is the systems of tectonic zones of fracturing and cataclasm which play the role of drainage systems for ore-bearing solutions. The group of local factors (trapping properties of the host rocks, their mineral composition, tectonic traps, geochemical barriers, screening surfaces) controls localization of ore fields with certain genetic type of mineralization. It is established the spatial and paragenetic link of gold mineralization with the zones of hydrothermal-metasomatic modifications (silicification, micatization, albitization, carbonatization, sulphidization, and skarning) which width can attain 1 km at the length up to some kilometres. In these zones of tectono-metasomatic modifications there are distinguished the linear, often sub-parallel, sub-zones of tectonic breaks with the signs of more extensive hydrothermal-metasomatic changes. Thickness of these zones does not exceed 100 m at the length up to first kilometres. Mentioned sub-zones often contain small bodies of aplite-pegmatoid granites, and somewhere mafic and ultramafic rocks.

The favourable rocks, playing as locators of gold mineralization, include biotite gneisses, mafic gneisses, amphibolites, serpentinites, flint interbeds in ferruginous quartzites, skarnoids, that is, the rocks with excess iron content. Concerning stratigraphic control of gold ores it should be noted that at least within Savranske ore field the gold mineralization is tightly related to the amphibolite-gneiss complex which is not resulted from retrograde metamorphism of Buzka Series granulites but is the analogue of Rosynsko-Tykytska Series [31]. The authors completely agree with opinion of S.V.Nechaev concerning development here the fragments of Rosynsko-Tykytska Series. The grounds for such conclusions come from the detailed studies of the sections in Maiske deposit and over Savranska group of prospects kindly provided by geologists of TE “Kirovgeologia”. Distribution of amphibolite-gneiss rocks of Rosynsko-Tykytska Series to the north allows assumption on the gold prospective over entire Savransko-Synytsivska Sub-Zone, especially within Talnivska Deep-Seated Fault Zone.

Besides above, the favourable tectonic traps for gold mineralization include the sites of ore-bearing drainage tectono-metasomatic zones overlapped by the thrusts. Gold-ore lodes of this type can be found first of all in the frontal part of Zhuravlynsko-Yatranska Thrust Zone where are already known the areas with extensively expressed direct prospecting evidences.

In the map sheet territory there are known about 20 gold prospect one of which (Maiske IV-2-213) is defined as deposit. By their formational affinity the gold mineralization points are subdivided into hydrothermal gold-quartz and gold-sulphide-quartz with vein-disseminated ore type, gold-skarn, and residual in weathering crusts. In the endogenous objects often is observed joining of some formations as well as development of gold-ore formations on the background of gold-bearing formations suggesting for the complicated (multi-phase) patterns of gold mineralization.

Majority of gold-ore prospects are weakly studied an din some only prospecting or even preliminary exploration works have been performed. The ore-bearing sites are characterized by complicated geology. Cross-sections comprise the layered sequences composed of gneisses and granitoids with remnants of amphibolites and calciphyres, and in synform structures – with the bodies of metamorphosed mafic and ultramafic rocks, as well as silica-ferruginous, high-aluminous and carbon-bearing formations. In the zones of tectogenesis there are developed multi-phase hydrothermal-metasomatic rock modifications resulted in diverse metasomatites and skarnoids. The gold mineralization, developed on the background of these modifications is confined directly to the sites of sulphidization, micatization and silicification. Fracture-side biotitization and silicification is quite characteristic.

Ore bodies of gold-quartz and gold-sulphide-quartz formations comprise veinlet zones of mineralization and quartz veins in crushing zones. Thickness varies from some centimeters to first meters, length – from hundreds of meters to 1-2 km. Besides free gold the ores contain arsenopyrite, pyrite, pyrrhotite, chalcopyrite, sphalerite, often native bismuth and bismuthine, some other minerals. In skarns, additionally, scheelite throughout occurs. Gold-bearing rocks are accompanied by geochemical anomalies of silver, bismuth, arsenic, tungsten, sometimes copper, molybdenum, etc. Gold grade in the ores varies from tenth to first g/t and in places if attains tens of g/t.

One of the most studies and prospective gold-ore objects is *Maiske deposit* (IV-1-213) located within Talnivska ore zone where some additional prospective targets are known. The gold mineralization is controlled by regional sub-longitudinal zone of dynamo-metamorphism and metasomatism and is confined to the junction of north-eastern and north-western zones of ore-bearing dislocations in the exo-contact part of leucocratic granite massif. The gold mineralization is located in five major north-west-trending zones where 11 sub-parallel steeply-dipping ore zones are distinguished. The host rocks comprise biotite, biotite-amphibole plagiogneisses and amphibolites of Rosynsko-Tykytska Series, as well as migmatites of the same composition. The ore-bearing band is saturated with numerous veins and veinlets of aplite-pegmatoid granites. The rocks are extensively silicified; it is observed their biotitization, tourmalinization. The ore-bearing zone about 400 m wide is traced over the distance over 2 km. Within the ore zone the vein-disseminated 0.5-5.5 m thick ore bodies are located within quartz-biotite, somewhere quartz-amphibole metasomatites, and contain up to 1-2% of sulphides including pyrite, marcasite, pyrrhotite, chalcopyrite, sphalerite, molybdenite as well as nickel sulphides and arsenides. Scheelite mainly occurs in the hanging-wall of the main gold-ore zone where its anomalous concentrations are confined to the skarned amphibolites. The ore type is mainly gold-quartz and gold-sulphide-quartz with tellurides. Average gold grade is 5.65 g/t. Bonanzas are confined to the junctions of north-east and north-west-trending fracturing systems where vein-disseminated mineralization type is changed by disseminated-stockwork one.

Primary geochemical aureoles that accompany the gold-ore bodies are characterized by the contrast Cr and Ni anomalies and less intensive Ti, Bi, Cu, Te, Pb, Zn, Mo, Co, V anomalies which are typomorphic for the ultramafic association [88]. The ore formation is gold-quartz. There are distinguished several generations of quartz with associated native gold at the negligible role of sulphides and other ore minerals. S.V.Nechaev [29, 30] had distinguished three gold-ore associations: gold-silver-telluride, gold-telluride and gold itself that reflect multi-phase nature of gold mineralization. Gold fineness is 877-992. At present in the deposit are continued the mine-drilling works of preliminary exploration stage.

Somewhat different geological position of mineralization is observed in *Kapitanivskiy prospect* (III-3-52) where gold mineralization is related to magnesium skarns, quartz, garnet-quartz, carbonate-quartz, and serpentine-phlogopite metasomatites in the endo- and exo-contacts of ultramafic rocks in the same named massif. The skarns and metasomatites often contain sulphide (pyrite, pyrrhotite, chalcopyrite, sometimes arsenopyrite) and hematite-magnetite mineralization in amount from 1 to 10%, sometimes 20%. Gold is determined in the band from 40 to 250 m wide and about 2.5 km long along entire massif but economic concentrations are observed in the northern and southern flanks where high gold grades are known both in weathering crust and in crystalline rocks. Endogenous gold mineralization is confined to the north-west-trending tectonic zone in the western contact of the massif which controls location of chromite ores and gold-bearing magnesium skarns and metasomatites of diverse composition. The highest gold content is observed in biotite-pyroxene-plagioclase metasomatites and plagioclasites which are spatially associated with the vein bodies of aplite-pegmatoid granites, as well as in junction sites of the main tectonic break with fracturing zones of north-east strike. On the background of intervals from first meters to 100 m with gold grade 0.1-1.0 g/t there are encountered the local intervals (0.5-2.5 m) with gold grade from 1.0 to 79.0 g/t. The average grade over entire prospect is 2.8 g/t. Gold is represented by electrum, coarse (0.05-0.5 mm), occurs in dendrites and irregular grains. Gold fineness is 670-750. Zones of metasomatites and skarnoids are characterized by anomalous concentrations of scheelite (wolframite content – up to 0.048%); gold-bearing rocks contain silver (somewhere up to 45 g/t). The prospect like entire ore field is characterized by relatively high background content of Cr, Ni, Ti, V, Cu in the rocks at subordinate anomalies of W, Mo, Pb, Bi. In the northern part of ore zone the local arsenic anomalies (up to 1.0%) are observed.

The supergene gold mineralization is most widespread in the northern part of Kapitanivskiy massif where it is located in the weathering crust of metasomatically altered mafic and ultramafic rocks. Here is observed the highest gold grade about 7 g/t and silver – 30 g/t over the thickness 2.0 m. Ore body is sheet-like and lie at the depth from 0.5 to 13.0 m. Gold in the weathering crust is being considered to be the by-product in Kapitanivske deposit of silicate cobalt-nickel ores. In supergene prospect are estimated reserves and resources by categories C_2 and P_1.

Prospect is thought to be representative of gold-skarn ore formation. Prognostic resources by categories P_2 and P_3 are approved in the prospect.

Gold mineralization of *Chemerpilskiy prospect* (IV-1-61; IV-1-206) is controlled by tectono-metasomatic zone of apparently north-west strike and is confined to the same-named "ring" structure located in the northern part of Savranske ore field. Gold-sulphide vein-disseminated mineralization comprises native gold, arsenopyrite, bismuthine, pyrite, pyrrhotite, molybdenite, chalcopyrite, galena, in places loellingite, niccolite, gersdorffite, and scheelite occur. The host rocks underwent silicification, albitization, chloritization, tourmalinization, sulphidization, and skarning. Sulphide content varies from 3 to 30%. Ore intervals are confined to the contact parts of albitized tourmaline pegmatoid granites with biotite and pyroxene-biotite plagiogneisses where occur the interbeds of ferruginous quartzites, skarnoids, amphibolites, and calciphyres. Gold grade in ore bodies varies from 0.14 to 7.54 g/t. Content of associated elements is as follows (%): arsenic – 0.1-8.1; tungsten – up to 0.08; bismuth – 0.05-0.1; and silver – up to 3 g/t. Genetic type of mineralization is hydrothermal, ore formation – gold-sulphide-quartz which is, probably, superimposed on the skarns. Prospecting works performed by geologists of Pravoberezhna Geologic Expedition allowed reserve estimation by categories P_1+C_2 in weathering crust. At present the works are being continued.

Other gold prospects are weakly studied but taking into account research works performed in the map sheet territory [88] Middle Pobuzhzhya belongs to the prospective areas of Ukrainian Shield for discovery of economic gold objects both in crystalline rocks and in their weathering crust.

Silver

Increased silver content are found in some gold, nickel, copper or uranium prospects and are of subordinate value being by-product. Solver grade in ores of these prospects varies from some g/t to 420 g/t (Demovyarskiy (III-2-45) gold prospect). Silver distribution is irregular and weakly studied. Anomalous silver concentrations are also known from some graphite ore prospects where its grade varies in the range 0.5-5 g/t.

Platinum, palladium

Economic objects of platinum mineralization are not found yet but platinum group elements are determined in all rock varieties of gabbro-peridotite formation in Middle Pobuzhzhya [41, 42]. According to assay analysis, the highest concentrations of these elements are observed in dunites of Ternuvatskiy massif – platinum up to 0.3 g/t, palladium – 0.19 g/t, as well as mafic-ultramafic rocks of Pivnichno-Ternuvatska and Kapitanivska intrusions. In the latter, the highest grades are 2.0 g/t of platinum and 0.01 g/t of palladium.

Radioactive metals

Uranium, thorium

In the studied area there are known 7 prospects of radioactive metals represented by hydrothermal and hydrothermal-metasomatic uranium prospects and radioactive rare-earth pegmatites with zircon-monazite fine-disseminated mineralization. Uranium mineralization is related to the products of carbonate-alkaline metasomatism formed in tectonically-weakened zones both after metamorphic rocks and small dyke-like intrusions of aplite-pegmatoid granites. In the first case uranium mineralization comprised of uraninite, uranium black, somewhere coffinite and pitchblende, is accompanied by fine-disseminated sulphidization (pyrite, molybdenite, chalcopyrite, galena and some others). This type includes *Zavallivskiy* (III-1-40), *Grushkivskiy* (II-2-151), and *Savranskiy* (IV-2-212) prospects where ore bodies from 0.09 to 5.2 m thick are not studied by depth and strike. Uranium content in ores varies from 0.013 to 2.1%. In the second case formed alkaline metasomatites with complex gold-bismuth-uranium ores (Golovanivskiy II-2-18 and Shamraivskiy III-1-33 prospects) comprised of dissemination of native bismuth, bismuthine, uraninite, urano-thorite, orangite, molybdenite, pyrite, galena, arsenopyrite and other sulphides. Thickness of ore bodies with uranium mineralization varies in the range 0.4-1.8 m. By dip and strike they are not studied. Uranium content in ore bodies varies from 0.02 to

0.04%, bismuth – 0.01-0.45%, gold – 0.03-0.3 g/t. In term of economic development these object is worthy to consider as complex ones.

Rare-earth pegmatites of *Nalyvaykivskiy* (II-3-25) and *Ternivskiy* (I-4-11) prospects are characterized by anomalous thorium content at the level 0.12-0.15% and uranium – 0.0015-0.0017% and do not have economic value.

Non-metallic mineral commodities

Raw materials for metallurgy

Refractory raw materials

Secondary kaolines

According to previous researches [58, 74], in the map sheet territory is discovered *Tarasivskiy prospect* (I-3-7) of high-quality secondary kaolines comprised of the ore body from 1.2 to 10.0 m thick; its distribution square is about 3 km^2. Kaolines are overlain by red-brown clays and loams of total thickness from 10.0 to 24.6 m, and underlain by fine-grained quartz sands. Kaolines do have refractory properties that match the industry requirements.

Quartzites

In the map sheet territory there are known two prospects of the feldspar quartzites: *Kosharo-Oleksandrivskiy* (IV-2-67) and *Shamraivskiy* (III-1-165); both are represented by steeply-dipping sheet-like bodies within gneissic sequences of Kosharo-Oleksandrivska Suite. By technological properties quartzites can be used as fillers of ZD-87 mark and in limited amount as silica refractory [91]. Thickness of the layers attains 100 m but mono-mineral dense quartzites suitable for production of refractory raw materials are very limited distribution; they form 2-3 m, sometimes 9 m, thick interbeds and lenses within feldspar varieties. In the prospects there were performed prospecting works and evaluated prognostic resources by categories P_1+P_2 to the depth of 100 m.

Sillimanite

In some sites within the map sheet there are performed prospecting of high-aluminous raw materials with the tests of the rock technological properties [64]. As a result, just *Kosharo-Oleksandrivskiy* (IV-2-65) prospect is discovered where 8 local ore bodies of sillimanite gneisses from 5 to 180 m thick were distinguished within the rocks of Kosharo-Oleksandrivska Suite, mainly feldspar quartzites. Sillimanite content is quite irregular and varies from 1-11 kg/t (ore bodies 2, 4) to 54 kg/t (ore body 7), comprising 25-30 kg/t in average. Ore bodies are traced over the distance from 400 to 3,500 m by strike. Prospect is thought to be out of economic value due to low content of the raw minerals and insufficient reserves. Genetic type is metamorphic.

Chemical raw mineral commodities

Agrochemical raw minerals

Apatite

Troyanskiy apatite prospect (II-3-157) is discovered within the same-named structure which is considered by some researchers as concentric-zoned volcano-tectonic structure. It is composed of the rocks of Buzka Series and mafic rocks of Derenyukhynskiy Complex. Two ore bodies of apatite-bearing calciphyres in the north-western part of structure are of economic value; average thickness of each body is about 100 m.

Irregular apatite dissemination in calciphyres at about 2-3% in some sites of skarning and metasomatism, in fracturing zones and at the contacts with granite veins does form the concentrations up to 3-5% and somewhere much higher. P_2O_5 content in the ores varies from 2.31 to 3.86%. The weathering crust of ore-bearing calciphyres in enriched in apatite (average content 9.3%). And P_2O_5 content in the crumbly ores rises somewhere up to 18% and in average comprises 7% for the 25-30 m thick ore body. Apatite of ore-bearing calciphyres by 99% is metasomatic [35]. Meta-gabbroid rocks in the sites of metasomatism are also characterized by increased apatite content, and in general they display anomalous scandium content (0.003-0.02%). Prospect requires extended studies. Prospecting works allowed evaluation of prognostic resources by category P_2 to the depth 300 m.

Non-metal ore mineral commodities

Abrasive mineral commodities

The garnet concentrate as abrasive mineral commodities is being mined from garnet-bearing rocks of Zavallivske graphite deposit.

Electric- radio-technical mineral commodities

Graphite

Graphite ores comprise one of the most valuable mineral commodities in Middle Pobuzhzhya. In the map sheet territory there are known 2 deposits (unique *Zavallivske* III-1-37 and *Shamraivske* III-1-34) and 18 graphite prospects located in both Bilotserkivska and Golovanivska TMZ.

Without exceptions, all graphite prospects are confined to the rocks of Khashchuvato-Zavallivska Suite and their location in controlled by the sites of the latter rock distribution which, in turn, together with metamorphic rocks of other suites of Buzka and Dnistersko-Buzka Series are observed in linearly elongated mainly synform structures within granitoids of Pobuzkiy and enderbites of Gaivoronskiy Complexes. Graphite ore are related mainly to graphite-biotite and in less extent to other graphite-bearing gneisses and their weathering crusts. The sheet-like and lens-like ore bodies are being traced over the distance from first tens to first thousands of meters at the thickness from some to tens of meters. Mineralization scale over the depth exceeds first hundreds of meters. Graphite distribution in the ores is irregular and average content in the ores varies from 3.5 to 10.0%. Graphite ores often (at the level of mineralization points) are characterized by anomalous concentrations of copper, silver, zinc, and gold. Almost in all objects the major reserves are confined to the weathering crust that increases their economic value. In the most prospect there were performed prospecting works resulted in reserve estimation and resource evaluation. Formation of graphite ores is thought to be related to regional metamorphism of the rocks piles contained sedimentary bituminous substance. It was also supposed (V.I.Yatsenko, Candidate of Sciences Theses "Structure-Morphological and Genetic Types of Graphite on the Example of Deposits in Ukrainian Shield") that economic graphite concentration are caused by its crystallization from the fluid phase at the retrograde metamorphic stage and is controlled by superimposed tectonic zones with associated metasomatic alteration of the host rocks.

Zavallivske deposit (III-1-37) is one of the most outstanding objects. It was explored in details in 1971-1982 [101, 102]. Reserves by categories B+C_1 were approved in the State Commission on Reserves of USSR. It is being exploited by Zavallivskiy graphite plant since 1930; the plant produces 11 types of graphite: crucible, elementary, casting, etc.

Deposit is confined to the southern limb of Zavallivska synform structure of sub-latitude strike. Within deposit there are clearly distinguished two ore zones (northern and southern) composed of biotite-graphite and garnet-biotite-graphite gneisses with skarnoid interbeds which are separated by the carbonate core. Within the ore zones there are explored 5 blocks. Total length of the ore zones is 7-8 km, thickness from 6- to 425 m. In the explored blocks there are distinguished from1 to 14 ore bodies of rather complicated morphology. Thickness of ore bodies varies from the first meters to 30-50 m, and their length – from tens of meters to 3.5 km. Graphite distribution in the ore is irregular and its content varies from 2 to 32% (6.86% in average). After the ore zones the linear weathering crust is developed (up to the depth 100-200 m). In the deposit construction stones are also being mined (quarrystone, aggregate; reserves by category C_1 are approved) and abrasive mineral commodities (garnet-bearing rocks). At present the mining in deposit is almost suspended due to the changes in the market conditions.

Jewellery raw commodities (precious stones)

Diamond

Direct prospecting evidences for diamond-bearing crystalline rocks in Middle Pobuzhzhya were found by various researchers since 1952. Discussion concerns first of all the findings of crystals and fine diamonds in the alluvial sediments of Yatran and Synyukha River courses, as well as the diamond grains encountered in the weathering crust of crystalline rocks using exclusively auger and hard-alloy drilling (first of all in the northern part of Kapitanivskiy ultramafic massif). It is not excluded that some of diamonds are of technogenic origin. Besides that, in Yatran River valley there are known soil (heavy concentrate) pyrope aureoles. According to M.O.Yaroshchuk, R.M.Dovgan [49], the revision drilling in around Bandurivskiy Gravity Maximum (the site that directly adjoins the map sheet from the south-west) within Zavallivskit Deep-Seated Fault which bounds this structure from the south-east, within calciphyres there are encountered some tens of contiguous (cluster) of lamproite bodies which have clear magmatic contacts with the host rocks. There are also known the findings of distinct "fluidisite" breccias within calciphyres in Zavallivskiy quarry [49, 88] that fill up small bodies similar by shape to the "explosive pipes" from 5 to 20 m in diameter and whose nature is not defined up to now.

It should be noted that for the map sheet territory, where are encountered 6 diamond prospects in weathering crust and about 15 findings in alluvial sediments, are characteristic yellow-green fine diamonds (0.07-0.5 mm); the fragments predominate over unbroken crystals. The biggest diamond of 40.1 mg weight is found in the Synyukha River course alluvium nearby Synyukhyn Brid village (IV-4-126). Among the prospects in weathering crust it is of interest Kapitanivskiy one (III-3-50) where about 20 diamond grains and fragments were found and whose origin is still subjected to discussion. In the same site there are encountered chrome-spinellides, unfortunately, out of high-chromium varieties [80].

The question on possible nature of the diamond source regions – lamproites-kimberlites, paragneisses and conglomerates, eclogites and supplementary rocks, ultramafic rocks, impactites, or others, remains open. According to opinion of V.S.Kostychenko [80], the sources of Yatranski diamonds can be eclogite formations in distinct mélange zones resulted from tectonic movement of upper mantle material into the sub-soil crustal horizons. It is not excluded accessory diamonds occurrence in the mafic-ultramafic complexes. Finally, it should not be refused the possibility of diamond-bearing lamproite discovery, first of all, in south-western part of the studied territory where Earth's crust attains maximum thickness (55-65 km), and at its bottom, according to modelling results (see Fig. 4.1), there is observed the crust-mantle mixture layer.

Construction materials

Glass and porcelain-faience raw materials

Primary kaoline

Primary kaolines as the raw materials for ceramic and refractory wares as well as other industry use in the map sheet territory are rather widespread but, according to [80], up to now only two deposits with explored reserves are known (*Konetspilske* IV-4-92 and *Verbivske* IV-4-235). Other objects (about 30) where the raw material properties were studied, are weakly prospected and are out of interest for the local consumers. Productive horizons of the deposits comprise white and light-grey kaolines laying at the depth up to 16 m and are 12-14 m thick. Economic-quality kaolines are developed over leucocratic granitoids. Deposits are not being mined.

Quarry-stone materials

There are known 28 deposits of construction stone with approved reserves in the map sheet territory [15], as well as a number of small prospects without approves reserves. The biggest deposits are being mined by large mechanized quarries (*Boleslavchytske* IV-4-85, *Vilshanske* IV-1-63, *Chausivske* IV-4-90, *Mygiyske* IV-4-95 and others). The quarry rocks include charnockites, enderbites, granites, migmatites, and calciphyres which are being mined for high-quality crushed stones. Reserves are almost unlimited.

Claydite raw materials

Comprise just *Bogopilske deposit* (IV-4-128) of Quaternary loams (paleo-soils) of Eo-Pleistocene and Early Pleistocene Stages; the layer is of 8.0 m average thickness and lie at the depth 0.4-0.9 m. Deposit is explored in details but is not scheduled yet for mining.

Raw materials for silicate wares

Vilshanske deposit (IV-1-124) is represented by the layer of Quaternary quartz sand with average thickness 11.5 m, distributed over the square 0.4 by 1.1 km.

Construction sands

According to the State Cadastre data [15], in the map sheet territory there are explored *5 deposits* (I-4-110; III-4-121; IV-4-84; IV-4-87; IV-4-94) of diverse-age construction sands – Upper Miocene, Lower Pliocene, and Quaternary System which by their technologic properties can be used as fillers of construction solutions and concrete aggregates. Thickness of productive horizons varies from 3.7 to 13.3 m. Deposits are not being mined.

Brick-tile raw materials

The most widespread and suitable type of raw materials for brick-tile ware manufacturing are Quaternary loams and clays (loess and paleo-soils) of mainly Early-Middle Pleistocene Stage (ed, vdP_{I-II}), which lie directly below the soil-plant layer as the solid layer. In the map sheet territory there are known numerous deposits of these raw materials explored in details (*Kamyanokrynychanske* II-1-111, *Novoarkhangelske* I-4-109, *Kapitanivske* III-3-120, *Peregonivske* I-3-103 and others) with approved reserves. Small brick plants are based on some of these deposits (Peregonivka, Kapitanivka villages). Productive pile comprises light-yellow, pale-brown, yellow- brown and brown loess-like loams which thickness in average varies in the range 2.2-11.2 m.

Waters

Underground waters

Mineral waters

Previous researchers had discovered 2 prospects of mineral underground waters (*Kapitanivskiy* III-3-53, *Vilshanskiy* III-4-56) which can be used in medical purposes. Prospects are confined to the fracturing zones in crystalline basement. Hydrogen sulphide waters of Kapitanivskiy prospect do have sulphate-chloride-magnesium-sodium mineralization at the level 1.0-1.3 g/dm^3, and radon waters of Vilshanskiy prospect are characterized by hydrocarbonate-calcium to sulphate-chloride-sodium specialization with mineralization 0.8-1.2 g/dm^3. Yield in self-discharge is 7 m^3/day, and in trial pumping – 22.3 m^3/day with level decrease by 1.4 m.

Drinking waters

There are known *5 deposits* (I-2-2; III-1-38; I-4-135; II-2-146; III-1-164) of underground drinking waters of fracture-vein type which by their chemical properties are suitable for exploitation in purposes of local inhabitant water supply. Two of them (Zavallivske III-1-38 and Golovanivske II-2-146) at present are being exploited. Water-bearing horizons are located in fractured crystalline rocks comprised of granites, gneisses, and migmatites. Daily-average water scoop is about 0.4-1.9 thousand m^3/day. In deposits the balance reserves by categories $A+B+C_1$ are estimated.

10. ECOLOGO-GEOLOGICAL ENVIRONMENT

The map sheet territory belongs to the areas that are characterized by appropriate and slightly loaded ecological conditions and only in some places – by strained (over some parameters) ecological state of geological environment (Fig. 10.1). Ecological-geochemical mapping of the territory in the scale 1:200 000 had been performed by Expedition 49 of TE "Kirovgeologia" in 1992-1996 [77]. Eco-geological observations in Boleslavchytskiy polygon are being continued. All the information is presented based on these sources. Definition of the ecological loading levels is grounded on the evaluation criteria developed and recommended by UkrSGRI researchers V.I.Pochtarenko, I.V.Sanina, and colleagues.

Evaluation criteria for contamination state of geological environment comprise accumulation degree of harmful substances and elements in the three counterparts: soils, surface, and underground waters. For the soils, contaminating items include radio-nuclides, chlorine-organic pesticides (COP) and toxic elements; for the underground and surface waters – micro-components of chemical composition to be normalized, as well as associations of toxic elements (Li, Ba, Be, Sr, Mn, Ni, Pb, Zn).

In the map sheet territory there are distinguished 5 major classes of geochemical landscapes:

- black-earth high-humus alkaline soils (HCO_3^-, Ca^{2+}, pH = 8,0) with hydrocarbonate-calcium natural waters;
- black-earth leached, limed, degraded medium-humus, neutral and slightly-alkaline soils (HCO_3^-, CA^{2+}, pH = 7,5) with hydrocarbonate-calcium natural waters;
- grey loess slightly-acid soils (H^+, Ca^{2+}, pH = 6,5) with hydrocarbonate-calcium natural waters;
- alluvial neutral and slightly-acid soils (H^+, pH = 6,0) with hydrocarbonate-calcium waters;
- technogenically-contaminated (inhabited localities).

General evaluation of ecological state of the geological environment counterparts

The soils are being evaluated as slightly-contaminated with radio-nuclides, mainly by cesium-137. The aureoles with contamination density in excess of 1 Curie/km^2 are located in the areas of Yatranivka-Gromy-Ropotukha, Slusareve-Dubynove, Lupolove-Shevchenko, Chausove villages. The highest-contaminated are the soils within forest massifs to the south-east from Slusareve village (3.2 Curie/km^2) and to the north from Golovanivsk town (2.3 Curie/km^2).

The chlorine-organic pesticides (COP) are found in the soils at all observation points in amounts from $n\times10^{-4}$ to $n\times10^{-1}$ mg/kg. Contamination is of aerial mode in the western, northern and central parts of the territory, and spotty-like – in the remaining sites. The highest concentrations in the contaminated areas do not exceed 1-5 TAC, and in some places only, in the forest massifs, do exceed 5-8 TAC.

In the lesser extent the soils are contaminated with metals and other toxic elements. The wide contamination aureoles are not found but most of the map sheet territory displays the lead content in soils at the level 0.5 TAC (in 15 points there are observed concentrations > 2.0 TAC). The background zinc content attains 59 mg/kg (>2 TAC), anomalous – up to 6.0 TAC. Other metals and elements are determined in concentrations that do not exceed 1 and sometimes 2 TAC.

Contamination of the bottom sediments is relatively low. In most extent they are contaminated with lead and phosphorus – in the range that does not exceed 2-5 TAC. Normally the bottom sediments are contaminated within the inhabited localities (Pervomaisk, Golovanivsk, Vilshanka towns, Ladyzhynka, Dovga Prystan villages).

The surface waters, in contrast to the soil ones, are least contaminated. From the toxic element group there are determined only barium, manganese, lead, and cadmium in concentrations that attain the TAC. Nitrate content in some places only does exceed the TAC.

Contamination of the soil waters is rather consistent. Their depth varies from 1 to 16 m. The aeration zone rocks in the watersheds comprise mainly loess-like loams with filtration coefficient 0.01-0.1 m/day, and in the valleys – alluvial, mainly sandy sediments with filtration coefficient 1-10 m/day. The aeration zone rocks are permeable and do not protect the soil waters from contamination.

These waters which are mainly used for the housing and drinking supply can be considered as contaminated: by nitrates – MBC exceed 3 TAC (over last 30 years they arose in 2.5 times), barium (MBC > 1 TAC) lithium (MBC > 0.3 TAC), titanium (MBC > 0.8 TAC); in less extent – sulphides, fluorine, and lead. In some places concentrations of beryllium, manganese, zinc, nickel, and strontium also exceed TAC. This situation is complicated by essential total hardness and anomalous value of the dry remainder which exceeds TAC in 1.5-4 times especially in the southern part of the territory.

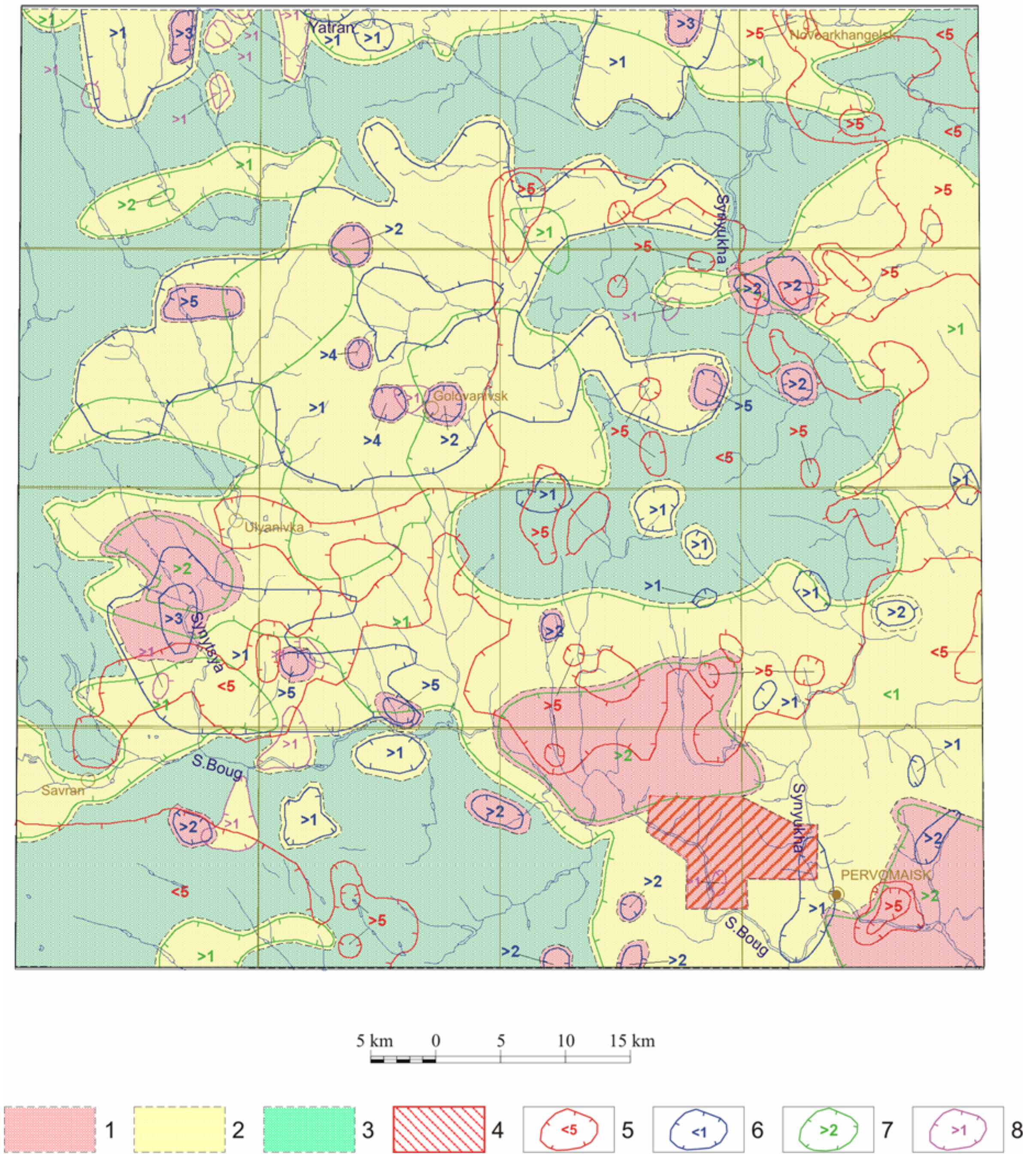

Fig. 10.1. Schematic ecologo-geologic map.

I – ecological state of geological environment*: 1 – charged; 2 – moderately charged; 3 – admissible; 4 – zone of extraordinary ecological situation. II – fields of anomalous contamination by harmful substances: 5 – soil contamination by toxic elements (** <5 – bulk soil contamination parameter); 6 – bulk soil contamination by pesticides; 7 – field of anomalous total mineralization of ground waters; 8 – soil contamination by caesium-137 (>1 – concentration in Curie/km^2).
* – by nitrates and barium content in ground waters the map sheet territory is ranked to the charged state;
** – number within anomaly contour does correspond to the contamination parameter in TAC.

Contamination of the fracturing waters in crystalline basement is not sufficient over the most studies territory and only in some places the weight of the normalized components does exceed the TAC. This is observed mainly in the southern and south-eastern areas. The macro-elements defined in the soil waters tend to accumulate in the fracturing waters as well. Most widespread is slight contamination with barium, titanium, manganese, and in much lesser extent – lithium, lead, zinc, and beryllium. Increased natural radioactivity is observed in the area of Zavallya town (Rn – 4,183 Bk/dm^3, Ra – 3.3×10^{-9} g/dm^3), Ulyanivka town (Rn – 2,086 Bk/dm^3, Ra-5.7×10^{-11} g/dm^3), and Vilshanka town (Kirovogradska Oblast) where radon content attains 1715 Bk/dm^3, and radium – 5.7×10^{-11} g/dm^3.

Zone of ecological emergency

The distinct state of ecological emergency zone (EEZ) in the inhabitant localities Boleslavchik, Chausove-1, Chausove-2, Michurine, and Pidgirya was introduced by the Decree of President of Ukraine of August 31, 2000 No. 1039 with regard to the mass health deterioration of inhabitants in June, 2000. The square of EE zone comprises about 80 km^2.

Under specialized study of the territory [83], potential sources of environment contamination and deterioration of its ecological parameters were attributed both to the agrarian agglomerations and some technogenic objects, as well as the shaft launchers and the sites of deposition and non-arranged utilization of their wastes. Taking into account the complicated and dynamic patters of the mass sickness of the EEZ, the Government Commission had considered 7 versions of the sharp health deterioration of inhabitants. In the complex of studies and environment monitoring it was accounted ability of environment to accumulate and re-distribute the technogenic contaminations over the up-surficial air, water-saturated upper soil layer and soil waters, as well as to change its hydro-meteorological and eco-geophysical parameters.

In laboratory studies performed by SE “Eco-center-43” in the environment counterparts (soils, up-surficial air, soil waters) there were determined content of heptyl and its derivatives (nitrozodymethylamine (NDMA) and dymethylamine (DMA)), which origin in most extent can be related to the components of missile fuel (CMF). In Boleslavchyk village it was defined relatively persistent soil contamination by the remnants of DMA: from 0.7 of top admissible level (TAL) to 26.8 TAL. There were found no unknown toxic substances in the samples. NDMA and DMA occurrence in the water samples from the Boleslavchyk village shafts, according to evaluations of SE “Eco-center-43”, could be related to the CMF content in the water shafts. DMA is determined in 9 of 33 studied shafts. ”Contamination of water and soils by heptyl derivatives is caused by their limited air transfer and fast condensation due to low vaporization temperatures (30-70^{o}C). This can be linked with the version of these substances ejection from possible contamination source (bury site of CMF fragment remnants in Boleslavchyk village, open burn down the cable production remnants, burn out the paraffin, transformer lubricant, etc.) and their irregular spotty distribution in the air and over the soil surface” [83, page 18].

Performed analysis of the space-time distribution of deteriorations in EEZ and quasi-stationary state of environment ecological parameters allows high-probability conclusion on the local source of the toxic substance and its rather clear positioning to the influence zone of dismantled shaft launcher that was located in the western outskirt of Boleslavchyk village. It was determined the persistent decreasing trend in parameters of technogenic contamination by heptyl and its derivatives [83]. At the same time, it should be noted, that geochemical parameters of soils, soil and surficial waters, as well as fracturing zones of crystalline basement actually do not differ from surrounding areas and could not cause mass deteriorations in EEZ. For example, in all villages of EEZ there is observed the persistent contamination of the full set of environment counterparts with nitrates (2-3 TAC in average at maximum from 4.2 to 12.5 TAC) but in case of the same contamination parameters (and not only by nitrates) outside the EEZ, the similar mass inhabitant deteriorations were not observed.

Zonation by ecological state of geological environment

Taking into account the major criteria of geological environment ecological state evaluation, in the map sheet territory there are distinguished four levels (zones) of ecological state: ecological emergency, strained, moderate-strained, and appropriate. By toxic element content in soils the map sheet territory belongs to the appropriate level zone, and by nitrate content in soil waters – to the strained contamination level zone.

Ecological emergency state (EES) is characterized by occurrence of relatively persistent soil contamination with the remnants of DMA from 0.7 to 26.8 TAL (Boleslavchyk village) on the background of general environmental distribution of harmful substances and elements.

Zones of strained environmental ecological level do have spotty and “dotty” contamination patterns. They were distinguished in case of soil waters total mineralization in the range 1.5-3.0 g/dm^3, and soil contamination with pesticides in the range 2-5 TAC.

Zones of moderate-strained environmental ecological level do have the aerial patterns. They are characterized by soil waters total mineralization (over dry remainder) at the level 1-1.5 g/dm^3, soil contamination with pesticides in the range 2-5 TAC, and cesium-137 – 1-5 Curie/km^2.

Zones of appropriate ecological state do have the aerial patterns. They were distinguished in case of soil waters total mineralization less than 1 g/dm^3, soil contamination with pesticides less than 1 TAC, and cesium-137 – less than 1 Curie/km^2.

The soil waters over entire map sheet territory are not protected. The territory defeating by supergene geological processes does not exceed 10-15%. These processes are most widespread in the right-bank of Southern Boug River in relation to neo-tectonic uplift of Baltska plain. There is observed the modern growth of ravines and gullies, and in the northern slope of the watershed there are distributed the landslides of Quaternary loams over the top of re-brown clay horizon. Some land-sliding are also observed in the slopes of Synyukha River. Seismic activity does not exceed 2-3 marks.

Performed zonation of the territory allows definition of the environmental ecological level as appropriate and moderate-strained, in some place only – strained one. The sites with appropriate ecological state, according to previous evaluations [77], can be recommended for manufacturing of the clean agriculture production for the children food, and in the moderate-strained sites – the clean production for the mass consumers.

With regard to the aerial soil water nitrate contamination (especially in the area of Synyukhyn Brid, Kamyaniy Brid, Ryzhavka an others) it should be developed as soon as possible the activities concerning transfer of inhabited localities to the centralized water supply from reservoirs or wells equipped by the systems of water scoop protection and cleaning of drinking waters.

In the area of EES it seems to be expedient establishment of environment monitoring over short-medium-term hydro-meteorological cycles from 3-4 to 8-12 years. It is also required additional study of high-dangerous technogenic objects – dismantled missile shaft launchers and “sites of accumulation and non-arranged utilization of their wastes” [77] aiming prevention of their unauthorized disclosure in the future.

CONCLUSIONS

The main results of performed works have both scientific and practical value. It is designed the set of maps "Derzhgeolkarta-200" over the territory of map sheet M-36-XXXI (Pervomaisk) with explanatory notes and supplementary annexes, which content completely complies with requirements to the new-generation maps "Derzhgeolkarta-200" of Ukraine. These results make a synthesis almost all achievements of previous territory researchers that were received during geological, geophysical, prospecting and research works over the last almost 45 years since the first edition of "Gosgeolkarta SSSR" in the scale 1:200 000 of the sheet M-36-XXXI (Pervomaisk).

According to the valid stratigraphic schemes and the legend of Centralno-Ukrainska Series, there were revised ideas on geological structure of the territory and regularities in formation and localization of mineral deposits on the ground of modern tectonic concepts and new data on the crustal geological structure within the studied territory. As a result, it is suggested tectonic zonation on the basis of definition the litho-tectonic zones (LTZ) and sub-zones which is connected with traditional views on the block structure of Ukrainian Shield and consented with performers of similar works in adjoining territories. Definition of Odesko-Bilotserkivska LTZ and its elements is substantiated both by occurrence of heterogeneities in the deep crustal sections and by the patterns of basic sections of stratified supercrustal formations. For the first time over given territory it is proved occurrence to the south from Obodivska tectonic Zone the analogues of Rosynsko-Tykytska Series which in the general section of metamorphic rocks are positioned instead of the former Synytsivska Suite of Buzka Series which is lacking in the valid correlation stratigraphic scheme. These rocks, distributed mainly within Savransko-Synytsivska Sub-Zone of Odesko-Bilotserkivska LTZ, grow up the sections of Buzka Series but do have mainly tectonic contacts with the latter.

It is outlined the geological structure of Centralno-Ukrainska Lineament Zone and for the first time over given territory it is shown abundant over- and under-thrust movements of some blocks and tectonic sheets over entire crustal section and presented the morpho-kinematical characteristics of tectonic breaks. It is designed the complex geological-geophysical model of the deep crust consented with the sub-soil structures and morpho-kinematical scheme of major tectonic breaks. It is established that mineral deposits and prospects display clear tectonic confinement and regularities in their localization depend on the deep crustal structure.

Geological maps of the set are designed in the electronic mode on the ground of the map sheet database "Derzhgeolkarta-200" (Pervomaisk) which in the final version contains the graphic supplements, information on geology of the territory and its analytical coverage. The works in database "Derzhgeolkarta-200" creation as well as compilation and pre-printing preparation of the maps under accepted methods were actually research-methodical. By these reasons the works were accompanied by improvement efforts and development the rational methods for this particular kind of works aiming their subsequent implementation in the practice of geological mapping. Discussion concerns methodical and technical basics to the complete turn to the computer technologies in design of geological maps using electronic databases of the factual material. In the future this will allow provision of permanent updating the "Derzhgeolkarta-200" of Ukraine as often as new geological information accumulates.

Complexity of geological-prognostic researches is ensured by modelling of the deep geological processes and determination of their links to sob-soil structures; implementation of new computer technologies, morpho-kinematical and elements of geodynamic analysis; identification of the litho-tectonic complexes at the petrochemical and geochemical levels of their study allowing in most cases consideration the genetic condition of their formation.

In the mapping and stratigraphic subdivision of Phanerozoic sediments, in our mind, it was succeeded definition of stratons in accordance with the valid stratigraphic scheme which are reliably identified. Subdivision is performed mainly on the litho-stratigraphic ground since most of distinguished stratons are dumb in paleontological respect.

The list of major problematic, disputable and non-solved questions likewise adjoining map sheet M-36-XXXII (Novoukrainka) can be opened with the problem of trans-lithosphere lineament "G" impact on the regional-metallogenic zonation. Within influence range of this lithosphere permeability-increased zone there is located almost entire central and south-eastern parts of the map sheet territory which are characterized by localization of the majority of metal deposits and prospects. If conclusions concerning metallogenic zonation in the lineament "G" zone are correct [14] then the Pervomaiskiy map sheet territory is not perspective in term of uranium-rare-earth mineralization but is specialized for gold and base metal mineralization. As it was shown in respective sections the most attractive are thought to be bunches of lineament "G" intersections by the Deep-Seated Faults and their zones.

Generalized section of supercrustal Neo-Archean rocks compiled by us for Synytsivsko-Savranska Sub-Zone of Odesko-Bilotserkivska LTZ does coincides with the section of Rosynsko-Tykytska Series suggested by V.P.Bezvynniy [2] including (upward): Mezynivska, Volodarsko-Bilotserkivska and Lysyanska Sequences. At the same time, Volodarsko-Bilotserkivska Sequence is correlated with Khashchuvato-Zavallivska Suite of Buzka Series. From the one hand, this allows direct and rather reliable correlation of both Series, and from another hand – to raise a question on subsequent combining the Teterivska, Rosynsko-Tykytska and Buzka Series into the single Teterivsko-Buzka Series that was formerly distinguished by the founders of Ukrainian Precambrian geology. Discussion, therefore, concerns the turn toward the past based on the qualitatively new study level.

Evidences for bimodal (rhyolite-tholeiite) volcanic rock association in the uppermost Dnistersko-Buzka Series (Zelenolevadivska Pile) and in Buzka Series sections, firstly, do open the way for these rocks correlation with similar complexes encountered in the dome structures of Western-Inguletska Tectonic Zone, and, secondly, raise a question concerning the arguments for Zelenolevadivska Pile subdivision as a part of Dnistersko-Buzka Series. Such a question seems to be quite justifiable in view of Lviv-school geologists' approach to consider these rock complexes (and including leucogranites formed after them) within the single Leucogranulite Formation.

In our view, distinguishing the two same-aged complexes of mafic and ultramafic rocks in Middle Pobuzhzhya is not substantiated strong enough. Even their petrotypes within Kapitanivskiy and Derenyukhynskiy massifs do not differ by petrochemical features and all the differences concern the various degrees of magmatic differentiation.

New data obtained on geology of territory further allow considerable detalization in the position of a zone which separates Odesko-Bilotserkivska and Ingulo-Inguletska LTZ. In our view, supported by results of tectono-facial analysis performed by O.I.Lukienko [82], the border between the two LTZ comprises zone of ductile and brittle faults bounded by Vradievskiy reverse fault in the west and by Emylivsko-Pervomaiska thrust-reverse-fault zone in the east. In the first approximation, by degree of saturation with ultramafic rocks this zone corresponds to the term "Alpine Line", and can be called Serednyobuzka Mélange Zone. In this case the territory to the east from Emylivsko-Pervomaiskiy Deep Thrust including Yatranskiy Block should be transferred into Ingulo-Inguletska LTZ.

The hard questions also arise in stratigraphic subdivision of the Phanerozoic covers sediments as well as tectonic break identification and mapping inside this complex. It is caused by the weakness of current stratigraphic schemes (Pliocene first of all) and lacking of acceptable methods for mapping of tectonic breaks within the sedimentary cover.

First of all, this is a problem in definition the volume, distribution borders and clear "typomorphic" signs of Baltska Suite sediments. Some researchers put into this Suite also clayey Meotic pile and in geological map of pre-Quaternary formations [80] its upper border is drawn by the top of red-brown clay pile. We have established that Baltska Suite (sub-aqueous sedimentation) is overlain by red-brown clays and parti-coloured sandy-clayey pile comprises its stratigraphic analogue (sub-aerial sedimentation). The lower border of this Suite cannot be considered as fully defined.

Problematic questions also include subdivision of Upper Oligocene Berekska Suite because in the given territory these sediments are not supported paleontologically. Therefore, this Suite occurrence also cannot be considered as fully defined.

The most complicated question arise under the mapping and ranking of tectonic breaks in the cover complex, establishing their links with both lineament zones expressed in Quaternary sediments and tectonic breaks in crystalline basement. This issue is vital not only for the studied territory and it requires further development both at methodical and practical levels.

Aforementioned problematic and non-solved questions are, in authors' mind, of both scientific and practical value and require solution in subsequent extended geological studies of a given territory in the framework of specialized works. It is of especial importance the problem of mapping the Rosynsko-Tykytska Series analogues within Synytsivsko-Savranska Sub-Zone and Vradievskiy Block of Pobuzka Sub-Zone because the most prospective gold prospects are confined to the contact zone of Rosynsko-Tykytska and Buzka Series in structures whose sections are saturated with mafic and ultramafic rocks.

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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

Cell index, number in map	Mineral type, object name and its location	Deposit exploitation state or brief description of occurrence	Geological-economic type	Notes (references cited)
1	2	3	4	5
Combustible minerals Solid Brown coal				
II-1-16	Occurrence Velyko-Troyanivsko-Tauzhnyanskiy	Prospected	Sedimentary	54, 90
Metallic mineral resources Ferrous metals Iron, manganese				
II-2-21	Occurrence Grushkivskiy; 1.8 km to NE from Grushka village	Increased manganese content encountered in hydro-mica weathering crust; perspectives are not defined	Iron-manganese weathering crusts	55, 80
III-1-36	Occurrence Zavallivskiy, nearby E outskirt of Zavallya village	Bunches and lenses within weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	80, 90
III-2-42	Occurrence Novoselytskiy; SW outskirt of Novoselytsya village	In weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	55, 80
Manganese				
I-3-3	Occurrence Tarasivskiy; 2.5 km to NE from Shevchenko village	Gondite interbeds and lenses with MnO content up to 31.62%; not studies	Not defined	59, 80
IV-3-74	Occurrence Ternovatskiy; 3 km to NW from Ternovate village	Gondite-like rock interbeds and lenses with MnO content up to 46.25%; not studied	Not defined	62, 80
Chromium				
III-3-49	Occurrence Pushkivskiy; Pushkove village	Out of economic value	Chromite in ultramafic rocks	80, 92
III-3-51	Occurrence Burtnyanskiy; Kapitanka village, E outskirt	Prospected	Chromite in ultramafic rocks	69, 73

1	2	3	4	5
Non-ferrous metals Copper				
IV-4-96	Occurrence Mygiyskiy; 2.2 km to SE from Mygiya village	Requires extended study during DGM-50	Hydrothermal	80, 88
Nickel, copper				
III-2-46	Occurrence Demovyarskiy-1; 2-3 km to E from Lyushnevate village	Prospected	Sulphide copper-nickel ores	61, 80
Nickel, cobalt				
III-2-48	Occurrence Demovyarskiy-2; 2-3 km to E from Lyushnevate village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	55
III-4-57	Occurrence Stantsiyniy; to NW from Synyukha railway station	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	57, 74
III-4-60	Occurrence Synyukhobrodskiy; N outskirt of Synyukhin Brid village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	57, 61
IV-2-68	Occurrence Lyushnevatskiy Skhidniy; 3 km to SE from Lyushnevate village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 94
IV-3-71	Derenyukhinske deposit; 3 km to SW from Kapitanka village	Exhausted	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
IV-3-77	Occurrence Pidgoryivskiy; 2 km to S from Pidgorye village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	94, 60
Titanium				
I-3-5	Occurrence Tarasivskiy; 2 km to E from Shevchenko village	Mineralization is related to the contact skarn-like rocks of titanomagnetite-garnet-pyroxene composition; perspective are not defined	Not defined	58, 80

1	2	3	4	5
Rare metals Bismuth				
II-2-18	Occurrence Golovanivskiy; 2 km to N from Golovanivsk town	Deep geochemical prospecting is conducted	Hydrothermal-metasomatic	80
Molybdenum				
I-3-6	Occurrence Tarasivskiy; at NW outskirt of Tarasivka village	Weakly studied; perspectives are not defined	Hydrothermal	80
Zirconium				
II-2-19	Occurrence Golovanivskiy-2; W part of Golovanivsk town	Not studied; perspectives are not defined	Residual	90
IV-3-75	Occurrence Bridskiy; 1.4 km to NE from Brid village	Not studied; extended studies are required during DGM-50	Residual	80
Precious metals Gold				
II-2-20	Occurrence Golovanivskiy; Golovanivsk village	Prospected by series of the complex geological mapping drill-holes over the area 12.5×4 km in size	Hydrothermal	80, 90
II-3-29	Occurrence Zakhidno-Troyanskiy; at W outskirt of Troyanka village	Weakly studied; promising for prospecting and required extended studies	Residual	80
II-4-30	Occurrence Dobryankivskiy; to NE from Dobryanka village	Weakly studied, is promising for prospecting and required extended studies aiming possible discovery of complex gold-rare-metal mineralization	Hydrothermal	59, 80
III-1-33	Occurrence Shamraivskiy; S outskirt of Ulyanivka village	Weakly studied, requires further studies aiming possible discovery of complex ores (Bi, Au, U)	Hydrothermal	80, 95
III-1-39	Occurrence Zavallivskiy; Zavallya village	Weakly studied, requires further studies	Hydrothermal	88, 102
III-2-45	Occurrence Demovyarskiy; 2.2 km to E from Lyushnevate village	General prospecting; requires further studies	Polygenic	61, 81, 80, 90
III-3-52	Occurrence Kapitanivskiy; Kapitanivka village	Reserves and perspective resources are estimated by categories C_2 and P_1	Residual, skarn	79, 80, 70
III-3-54	Occurrence Pobuzkiy; to W from Pobuzke village	Is of prospecting interest	Residual	70, 80
IV-1-61	Occurrence Chemerpilskiy-2; to S from W outskirt of Chemerpil village	Prospecting-evaluation works underway; promising	Hydrothermal	52, 76, 80

1	2	3	4	5
IV-1-64	Occurrence Savranskiy-1; SE outskirt of Savran village	Deep geochemical prospecting is conducted; promising	Residual	62, 76, 80
Rare-earth metals				
II-3-27	Occurrence Tabanivskiy; 200 m lower of khutor Tabanivskiy, Tsyurupa gully	Not studied; perspectives not defined	Not defined	80
IV-3-73	Occurrence Lashchivskiy; 0.5 km to E from Lashchivka village	Not studied; perspectives not defined	Pegmatite	80
IV-3-76	Occurrence Dovgoprystanskiy; 1.4 km to SW from Dovga Prystan village	Occurrence requires further studies during DGM-50	Pegmatite	80
IV-4-93	Occurrence Konetspilskiy; at NW outskirt of Konetspil village	Occurrence requires further studies during DGM-50	Pegmatite	57
Radioactive metals Thorium				
I-4-11	Occurrence Ternivskiy; SW part of Ternivka village	Out of economic interest; prospecting evidence	Pegmatite	80
II-3-25	Occurrence Nalyvaykivskiy; to N from Nalyvayka village	Out of economic interest; prospecting evidence	Pegmatite	80
Uranium				
III-1-40	Occurrence Zavallivskiy; Zavallya village	Not studied by strike and dip; prospecting evidence	Hydrothermal	24
Non-metallic mineral resources Non-ore raw materials for metallurgy Refractory raw materials Secondary kaoline				
I-3-7	Occurrence Tarasivskiy; N outskirt of Tarasivka village	Not studied	Sedimentary	58, 74
Quartzites				
IV-2-67	Occurrence Kosharo-Oleksandrivskiy; Kosharo-Oleksandrivka village	Prospected with prognostic resources estimation by categories P_1+P_2	Metamorphic	91
Sillimanite				
IV-2-65	Occurrence Kosharo-Oleksandrivskiy; Kosharo-Oleksandrivka village	Prospected; recognized as low-perspective	Metamorphic	64

1	2	3	4	5
Non-metal ore commodities Electric- and radiotechnical raw materials Graphite				
II-1-13	Occurrence Mechyslavskiy; 1.5 km to NW from Mechyslavka village	General prospecting, requires further studies	Graphite ores in gneisses and their weathering crusts	54, 80
II-2-17	Occurrence Synkivskiy; 1.3 km to SE from Synki village	Requires further studies, perspectives not defined	Graphite ores in gneisses and their weathering crusts	80
II-3-28	Occurrence Troyanskiy; 3 km to NW from Troyanka village	Prospected, prognostic resources evaluated by category P_3	Graphite ores in gneisses and their weathering crusts	80
III-1-34	Shamraivske deposit; 1.0 km to S from Shamraivka village	Prospecting-evaluation works conducted. Never been mined	Graphite ores in gneisses and their weathering crusts	84, 95, 96
III-1-37	Zavallivske deposit; Zavallya village	Explored in details. In production	Graphite ores in gneisses and their weathering crusts	101
III-1-41	Occurrence Synytsivskiy; to E and SE from Synytsivka village	General prospecting conducted. Further prospecting is not recommended	Graphite ores in gneisses and their weathering crusts	95
III-2-44	Occurrence Kosharo-Oleksandrivskiy; to W from Kosharo-Oleksandrivka village	General prospecting. Low-perspective in view of insufficient reserves	Graphite ores in gneisses and their weathering crusts	84
III-2-47	Occurrence Demovyarskiy; to E from Lyushnevate village	Detailed prospecting. Resources and reserves are estimated	Graphite ores in gneisses and their weathering crusts	55, 95
IV-1-62	Occurrence Vilshanskiy; 0.6 km to N from W outskirt	General prospecting. Low-perspective in view of insufficient graphite content	Graphite ores in gneisses and their weathering crusts	84
IV-2-69	Occurrence Dubynivskiy; 0.3 km to W from Dubynove village	Detailed prospecting. Promising	Graphite ores in gneisses and their weathering crusts	56, 95
Jewelry raw materials (precious stones) Diamond				
I-3-4	Occurrence Tarasivskiy; N outskirt of Tarasivka village	Green-coloured diamond fragment 0.17×0.12 mm in size is encountered in clayey weathering crust	Not defined	80
III-1-32	Occurrence Mogylnyanskiy; NE outskirt of Mogylne village	Diamond fragment 0.35×0.3 mm in size is found in weathering crust after calciphyres	Not defined	80
III-3-50	Occurrence Kapitanivskiy; N part of Kapitanka village	20 diamond crystals and fragment are found both in bedrock and in clayey weathering crust	Not defined	80

1	2	3	4	5
IV-3-78	Occurrence Chausivskiy; NE outskirt of Chausove village	Yellowish-grey diamond table 0.26×0.18×0.05 mm in size is found in clayey weathering crust	Not defined	80
Construction raw materials Glass and porcelain-faience raw materials Primary kaoline				
III-1-35	Occurrence Kamyanobridskiy, Kamyaniy Brid village	Not studied, perspectives not defined	Residual	59
III-2-43	Occurrence Svirnevskiy; SE outskirt of Svirnevo village	Not studied, perspectives not defined	Residual	55
III-4-55	Occurrence Berezovo-Balkivskiy-2; 1.5 km to SE from Berezova Balka village	Prognostic resources are estimated by category P_3	Residual	57
IV-4-92	Konetspilske deposit; 4.5 km to NW from Konetspil village	Explored in details. In reserve	Residual	15
Quarry-stone raw materials				
I-1-1	Antonivske deposit; Antonivka village	Explored in details. Out of production	Ultra-metamorphic	15
I-3-8	Peregonivske deposit; 1 km to S from Peregonivka village	Explored in details, In production	Ultra-metamorphic	15
I-4-9	Torgovytske deposit; 1 km to S from Torgovytsya village	Explored in details, In production	Ultra-metamorphic	15
I-4-10	Sabovske deposit; 1 km to SW from Sabove village	Explored in details. Out of production	Ultra-metamorphic	15
II-1-12	Kolodyste deposit; 3 km to E from Kolodyste village	Explored in details. Out of production	Ultra-metamorphic	15
II-1-14	Velykotroyanske deposit; 0.4 km to SW from Velyki Troyany village	Explored in details. Out of production	Ultra-metamorphic	15
II-1-15	Yosypivkse deposit; 2 km to N from Yosypivka village	Explored in details. In development	Ultra-metamorphic	15
II-3-22	Lebedynske deposit; 1.2 km to NE from Lebedynka village	Explored in details. Out of production	Ultra-metamorphic	15
II-3-23	Krasnopilske deposit; 1 km to NE from Krasnopillya village	Explored in details. Out of production	Ultra-metamorphic	15
II-3-24	Tabanivske deposit; 1 km to W from Tabanovo village	Explored in details. In conservation	Ultra-metamorphic	15
II-3-26	Orlovske deposit; 3 km to S from Orlova village	Explored in details. In conservation	Ultra-metamorphic	15

1	2	3	4	5
III-1-31	Shamraivske deposit; at S outskirt of Shamraivka village	Explored in details. Out of production	Ultra-metamorphic	15
III-4-58	Tarasivske deposit; 1 km to SW from Synyukha railway station	Explored in details. Out of production	Ultra-metamorphic	15
III-4-59	Vilshanske (Kalmazove) deposit; 5 km to S from Vilshanka area centre	Explored in details, In production	Ultra-metamorphic	15
IV-1-63	Vilshanske deposit; 1.5 km to E from Vilshanka village	Explored in details, In production	Ultra-metamorphic	15
IV-2-66	Lupolovske deposit; 2.5 km to NE from Lupolovo village	Explored in details. In conservation	Ultra-metamorphic	15
IV-3-72	Boleslavchytske-2 deposit; 4 km to NW from Boleslavchyk village	Explored in details. In reserve	Ultra-metamorphic	15
IV-3-80	Chausivske-2 deposit; at NW outskirt of Chausovo village	Explored in details. In reserve	Ultra-metamorphic	15
IV-3-81	Kamyanobalkivske deposit; 1 km to SE from Kamyana Balka village	Explored in details. In development	Ultra-metamorphic	15
IV-4-82	Chornotashlytske deposit; 1.5 km to SW from Novo-oleksandrivka village	Explored in details. Out of production	Ultra-metamorphic	15
IV-4-83	Novooleksandrivske deposit; 1 km to SW from Novo-oleksandrivka village	Explored in details. Out of production	Ultra-metamorphic	15
IV-4-85	Boleslavchytske deposit; 3 km to S from Stanislavchyk village	Explored in details, In production	Ultra-metamorphic	15
IV-4-86	Pidgorodnyanske deposit; 8 km to NW from Pervomaisk town	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-88	Synyukhinske deposit	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-89	Pervomaiske deposit; at N outskirt of Pervomaisk town	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-90	Chausivske deposit; 3 km to SE from Chausove village	Explored in details, In production	Ultra-metamorphic	15
IV-4-91	Konetspilske deposit; 4.5 km to NW from Konetspil village	Explored in details, In production	Ultra-metamorphic	15

1	2	3	4	5
IV-4-95	Mygiyske deposit; 3 km to SE from Mygiya village	Explored in details. Out of production	Ultra-metamorphic	15
Sand-gravel raw materials Sand				
IV-4-84	Stanislavchytske deposit; Stanislavchyk village	Explored in details. Never been mined	Sedimentary	15
IV-4-87	Pidgorodnyanske deposit; Pidgorodnya village	Explored in details. Not planned to be mined	Sedimentary	15
IV-4-94	Pervomaiske deposit; Pervomaisk town	Explored in details. Out of production	Sedimentary	15
Waters Underground waters Fresh				
I-2-2	Yatranske deposit; Yatranivka village	Not being used	Fractured	15
III-1-38	Zavallivske deposit; Zavallya village	Are being used	Fractured	15
Mineral				
III-3-53	Occurrence Kapitanivskiy; Kapitanka village	Not being used	Fractured	80
III-4-56	Occurrence Vilshanskiy; at N of Vilshanka village	Not being used	Fractured	77

Annex 2. List of deposits and occurrences indicated in the geological map and map of mineral resources in Quaternary sediments

Cell index, number in map	Mineral type, object name and its location	Deposit exploitation state or brief description of occurrence	Geological-economic type	Notes (references cited)
1	2	3	4	5
Non-metallic mineral resources Jewelry raw materials Diamond*				
I-2-97	Occurrence Stepkivskiyl central part of Stepkivka village	Alluvial bedrock-side sediments; 1 diamond grain found	Alluvial	90
I-2-98	Occurrence Zayachkivskiy; NE outskirt of Zayachkivka village	Alluvial bedrock-side sediments; 1 diamond grain 0.07 mm in size found	Alluvial	90
I-3-99	Occurrence Nebelivskiy, NW outskirt of Nebelivka village	Alluvial bedrock-side sediments; fragment 0.2×0.1×0.1 mm in size	Alluvial	80
I-3-100	Occurrence Nerubaykivskiy; E outskirt of Nerubayka village	Alluvial bedrock-side sediments; octahedral grain 0.13×0.11 mm in size	Alluvial	80
I-3-101	Occurrence Rogivskiy; northern part of Rogova village	Alluvial bedrock-side sediments; 2 grains 0.1 mm in size	Alluvial	90
I-3-102	Occurrence Peregonivskiy-3; 0.2 km to N from Peregonivka village	Alluvial bedrock-side sediments; light-green diamond 0.1 mm in size	Alluvial	90
I-3-105	Occurrence Peregonivskiy-4; centre of Peregonivka village	Alluvial bedrock-side sediments; fragment 1.3×1.1×0.4 mm in size and 0.9 mg of weight	Alluvial	58, 80
I-3-106	Occurrence Peregonivskiy-2; S part of Peregonivka village	Alluvial bedrock-side sediments; transparent diamond grain 0.25 mm in size	Alluvial	90
I-3-107	Occurrence Peregonivskiy-2; in front of khutor Peregonivka	Alluvial bedrock-side sediments; diamond 0.1 mm in size	Alluvial	90
II-2-112	Occurrence Synkivskiy; S part of Synki village	Alluvial bedrock-side sediments; yellowish-greenish grain of cube-octahedral habit, 0.2 mm in size	Alluvial	80

1	2	3	4	5
II-3-114	Occurrence Polonystenskiy; Polonyste village	Alluvial bedrock-side sediments; diamond grain 0.1 mm in size	Alluvial	90
II-3-115	Occurrence Davydivskiy; W outskirt of Davydivka village	Alluvial bedrock-side sediments; greyish-green cubic crystal 0.1 mm in size	Alluvial	90
II-3-116	Occurrence Pokotylivskiy; SE outskirt of Pokotylove village	Alluvial bedrock-side sediments; cubic crystal fragment 0.15×0.1 mm in size	Alluvial	90
II-3-117	Occurrence Kogutivskiy; N outskirt of Kogutivka village	Alluvial bedrock-side sediments; light-green diamond grain 0.1 mm in size	Alluvial	90
IV-4-125	Occurrence Novooleksandrivskiy; 1.0 km to W from Novooleksandrivka village	Alluvial bedrock-side sediments; irregularly-shaped fragment 0.2 mm in size	Alluvial	80
IV-4-126	Occurrence Synyukhobridskiy; Synyukhyn Brid village	Alluvial bedrock-side sediments; diamond crystal 40.1 mg of weight comprised of complex intergrowth of platy octahedrons	Alluvial	80
Construction raw materials Brick and tile raw materials Clay, loam				
I-3-103	Peregonivske (Pivnichne) deposit; N outskirt of Peregonivka village	Explored in details. In production	Sedimentary	15
I-3-104	Pidvysotske deposit; NE part of Pidvysoke village	Explored in details. Out of production	Sedimentary	15
I-3-108	Peregonivske (Pivdenne) deposit; S outskirt of Peregonivka village	Explored in details. Out of production	Sedimentary	15
I-4-109	Novoarkhangelske deposit; E outskirt of Novoarkhangelsk village	Explored in details. In reserve	Sedimentary	15
II-1-111	Kamyanokryny-chanske deposit; S outskirt of Kamyana Krynytsya village	Explored in details. In reserve	Sedimentary	15
II-2-113	Golovanivske deposit; SW part of Golovanivsk village	Explored in details. Out of production	Sedimentary	15
III-1-118	Ulyanivske-2 deposit; NE outskirt of Ulyanivka village	Explored in details. In production	Sedimentary	15
III-2-119	Lozuvatske deposit; N outskirt of Lozuvatka village	Explored in details. In reserve	Sedimentary	15

1	2	3	4	5
III-3-120	Kapitanivske deposit; Kapitanivka village	Explored in details. In conservation	Sedimentary	15
III-4-122	Vilshanske-2 deposit; S outskirt of Vilshanka village	Explored in details. In production	Sedimentary	15
III-4-123	Vilshanske-1 deposit; SE outskirt of Vilshanka village	Explored in details. Out of production	Sedimentary	15
IV-4-127	Pervomaiske deposit; NW outskirt of Pervomaisk town	Explored in details. In production	Sedimentary	15
Claydite raw materials				
IV-4-128	Bogopilske deposit; W outskirt of Pervomaisk town	Explored in details. Not planned for development	Sedimentary	15
Sand and gravel raw materials Sand				
I-4-110	Komyshevske deposit; W outskirt of Komysheve village	Explored in details. In reserve	Sedimentary	15
III-4-121	Osychkivske deposit; N part of Osychky village	Explored in details. Out of production	Sedimentary	15
IV-1-124	Vilshanske deposit; SE outskirt of Vilshanka village, Odeska Oblast	Explored in details. In reserve	Sedimentary	15

* Note: origin of diamond grains is not completely defined and technogenic nature of some these grains is not excluded

Annex 3. List of deposits and occurrences indicated in the geological map and map of mineral resources of crystalline basement

Cell index, number in map	Mineral type, object name and its location	Deposit exploitation state or brief description of occurrence	Geological-economic type	Notes (references cited)
1	2	3	4	5
Metallic mineral resources Ferrous metals Iron				
II-2-148	Occurrence Golovanivskiy; N outskirt of Golovanivsk village	Prospected	Ferruginous quartzites	52, 80
II-2-155	Grushkivske deposit; Grushka village	Prospected. Never been mined	Brown iron-stones in weathering crust; ferruginous quartzites	17, 51, 80
II-3-160	Occurrence Shepilivskiy; in 3 km to SE from Shepilovo village	Prospected	Ferruginous quartzites	52, 80
III-1-168	Occurrence Bogdanivskiy; in between Bogdanovo and Synytsivka villages	Prospected	Ferruginous quartzites	52, 80
III-2-170	Occurrence Shamraivskiy; left bank of Synytsya River, in between Shamraivka and Novoselytsya villages	Prospected	Ferruginous quartzites	50, 80
III-2-172	Occurrence Novoselytskiy; nearby Novoselytsya village	Prospected	Ferruginous quartzites	74, 80
III-2-174	Moldovske deposit; SE outskirt of Moldovka village	Prospecting-evaluation works conducted. Never been mined	Ferruginous quartzites and high-grade iron ores (dolomite-magnetite)	17, 72, 50, 51, 52
III-3-176	Occurrence Emylivskiy; in between Emylivka and Marynopol villages	Prospected	Ferruginous quartzites	17, 50, 80
III-4-202	Occurrence Dobryankivskiy; in 1 km to S Dobryanka village	Prospected	Skarn	57, 74

1	2	3	4	5
IV-1-205	Occurrence Chemerpilskiy; at W outskirt of Chemerpil village	Prospected	Ferruginous quartzites	52, 80
IV-1-215	Occurrence Slyusarivskiy; nearby Slyusareve village	Prospected	Ferruginous quartzites and high-grade iron ores (dolomite-magnetite)	51, 80
IV-1-216	Occurrence Bakshynskiy; 1.5 km to E from Baksha village	Prospected	Ferruginous quartzites	52, 80
IV-1-218	Occurrence Polyanetskiy; in between Polyanetske and Strutynka villages	Prospected	Ferruginous quartzites	52, 80
IV-3-221	Occurrence Lashivskiy; 1.5-2.0 km to W from Lashivka village	Prospected	Ferruginous quartzites	52, 80
IV-3-225	Occurrence Ternuvatskiy; on right bank of Southern Boug River	Prospected	Ferruginous quartzites	74
IV-3-227	Occurrence Sekretarskiy; in between Sekretarka and Velyka Mechetnya villages	Prospected	Ferruginous quartzites	17, 50, 80
Iron, manganese				
II-2-21	Occurrence Grushkivskiy; 1.8 km to NE from Grushka village	Increased manganese content encountered in hydro-mica weathering crust; perspectives are not defined	Iron-manganese weathering crusts	55, 80
III-1-36	Occurrence Zavallivskiy, nearby E outskirt of Zavallya village	Bunches and lenses within weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	80, 90
III-2-42	Occurrence Novoselytskiy; SW outskirt of Novoselytsya village	In weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	55, 80
IV-2-70	Occurrence Sekretarskiy; 3 km to SW from Sekretarka village	In weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	57
III-1-163	Occurrence Skhidno-Khashchuvatskiy; at NW outskirt of Mogylne village	Iron-manganese ores are related to weathering crust after calciphyres. General prospecting	Iron-manganese weathering crusts	80, 90
IV-1-210	Occurrence Savranskiy; in between Savran and Polyanetske villages	Occurrence is related to weathering crust after carbonate and skarn-side rocks. General prospecting is conducted	Iron-manganese weathering crusts	80, 90

1	2	3	4	5
IV-2-220	Occurrence Burylivskiy; 0.4 km to E from Burylove village	In weathering crust after calciphyres; not studied	Iron-manganese weathering crusts	57
		Manganese		
I-3-3	Occurrence Tarasivskiy; 2.5 km to NE from Shevchenko village	Gondite interbeds and lenses with MnO content up to 31.62%; not studies	Not defined	59, 80
IV-3-74	Occurrence Ternovatskiy; 3 km to NW from Ternovate village	Gondite-like rock interbeds and lenses with MnO content up to 46.25%; not studied	Not defined	62, 80
		Chromium		
III-3-49	Occurrence Pushkivskiy; Pushkove village	Out of economic value	Chromite in ultramafic rocks	80, 92
III-3-51	Occurrence Burtnyanskiy; Kapitanka village, E outskirt	Prospected	Chromite in ultramafic rocks	69, 73
III-3-177	Occurrence Lypnyagivskiy Pivnichniy; 2.6 km to N from Lypnyagy village	Prospected	Chromite in ultramafic rocks	73
III-3-180	Occurrence Lypnyagivskiy-1; 2 km to W from Lypnyagy village	Prospected	Chromite in ultramafic rocks	69, 80
III-3-184	Occurrence Lypnyagivskiy-2; 3 km to W from Lypnyagy village	Prospected	Chromite in ultramafic rocks	69, 80
III-3-187	Lypovenkivske deposit; Lypovenkv village	Explored; never been mined	Chromite in ultramafic rocks	80, 92
III-3-190	Occurrence Lypovenkivskiy Skhidniy; E part of Lypovenky village	Prospected	Chromite in ultramafic rocks	74
III-3-194	Kapitanivske deposit; Kapitanivka village	Explored; never been mined	Chromite in ultramafic rocks	70, 80, 92
III-3-196	Occurrence Pervomaiskiy; 3 km to E from Kapitanka village	Prospected	Chromite in ultramafic rocks	69, 73
III-3-200	Occurrence Zavodskiy; at S outskirt of Kapitanka village	Prospected	Chromite in ultramafic rocks	69, 70

1	2	3	4	5
Non-ferrous metals Copper				
IV-4-96	Occurrence Mygiyskiy; 2.2 km to SE from Mygiya village	Requires extended study during DGM-50	Hydrothermal	80, 88
IV-4-234	Occurrence Pidgorodnyanskiy; 4 km to NE from Mygiya village	Requires extended study during DGM-50	Hydrothermal	80
Nickel, copper				
III-2-46	Occurrence Demovyarskiy-1; 2-3 km to E from Lyushnevate village	Prospected	Sulphide copper-nickel ores	61, 80
Nickel, cobalt				
III-2-48	Occurrence Demovyarskiy-2; 2-3 km to E from Lyushnevate village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	55
III-4-57	Occurrence Stantsiyniy; to NW from Synyukha railway station	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	57, 74
III-4-60	Occurrence Synyukhobrodskiy; N outskirt of Synyukhin Brid village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	57, 61
IV-2-68	Occurrence Lyushnevatskiy Skhidniy; 3 km to SE from Lyushnevate village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 94
IV-3-71	Derenyukhinske deposit; 3 km to SW from Kapitanka village	Exhausted	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
IV-3-77	Occurrence Pidgoryivskiy; 2 km to S from Pidgorye village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	94, 60

1	2	3	4	5
II-2-154	Grushkivske deposit; 1 km to NE from Grushka village	Explored in details. Never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
III-3-178	Occurrence Lypnyagivskiy Pivnichniy; 2 km to N from Lypnyagy village	Explored in details.	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 73
III-3-181	Occurrence Lypnyagivskiy (in the village centre)	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	94
III-3-182	Occurrence Lypovenkivskiy; 2 km to NW from Lypovenky village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 94
III-3-183	Occurrence Pushkovske; 0.5 km to SE from Pushkove village	Explored; never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
III-3-185	Occurrence Evgenivskiy; 2 km to W from Lypnyagy village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 73
III-3-188	Lypovenkivske deposit; 0.6 km to W from Lypovenky village	Explored in details. In conservation	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
III-3-191	Occurrence Lypovenkivskiy Skhidniy; to E from Lypovenky village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
III-3-192	Occurrence Lypovenkivskiy Pivdenno-Skhidniy; at SE outskirt of Lypovenky village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 94

1	2	3	4	5
III-3-193	Kapitanivske deposit; Kapitanivka village	Explored; never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	70, 92
III-3-197	Occurrence Pervomaiskiy; 3 km to E from Kapitanka village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	60, 94
III-3-201	Occurrence Zavodskiy; to SE from Kapitanka village	Prospected	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	73, 80
IV-1-208	Occurrence Savranskiy; 1.4 km to S from Savran village	Prospected	Hydrothermal-metasomatic	80
IV-3-222	Lashivske deposit; 0.6 km to S from Lashivka village	Explored in details. Never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	73, 75
IV-3-223	Ternuvatske deposit; to W from Ternuvate village	Explored in details. Never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	92
IV-3-228	Kamyanobalkivske deposit; at S outskirt of Kamyana Balka village	Explored in details. Never been mined	Silicate cobalt-nickel ores in weathering crusts after mafic and ultramafic rocks	73, 75
Titanium				
I-3-5	Occurrence Tarasivskiy; 2 km to E from Shevchenko village	Mineralization is related to the contact skarn-like rocks of titanomagnetite-garnet-pyroxene composition; perspective are not defined	Not defined	58, 80
II-2-153	Occurrence Grushkivskiy; Grushka village	Weathering crust contains up to 43 kg/t of ilmenite. Not studied	Residual	55
II-3-156	Occurrence Troyanskiy; 3 km to NW from Troyanka village	Weathering crust contains up to 28.8 kg/t of ilmenite. Not studied	Residual	80

1	2	3	4	5
III-3-195	Occurrence Kapitanivskiy; Kapitanka village	Economic ilmenite concentrations are encountered in metasomatically-altered ultramafic rocks and in skarn-like clinopyroxene rocks. Not studied	Not defined	70, 80
Rare metals **Bismuth**				
II-2-18	Occurrence Golovanivskiy; 2 km to N from Golovanivsk town	Deep geochemical prospecting is conducted	Hydrothermal-metasomatic	80
Tungsten				
IV-1-211	Occurrence Savranskiy; 1.4 km to S from Savran village	General prospecting	Skarn	80
IV-3-226	Occurrence Sekretarskiy; (promising mineralization point); 2 km to N from Sekretarka village	Not studied. Evaluation is recommended during DGM-50	Skarn	50, 80
Molybdenum				
I-3-6	Occurrence Tarasivskiy; at NW outskirt of Tarasivka village	Weakly studied; perspectives are not defined	Hydrothermal	80
III-3-189	Occurrence Lypovenkivskiy; Lypovenky village	Weakly studied. Prognostic resources evaluated by categories P_2+P_3	Hydrothermal	70, 80
Zirconium				
II-2-19	Occurrence Golovanivskiy-2; W part of Golovanivsk town	Not studied; perspectives are not defined	Residual	90
IV-3-75	Occurrence Bridskiy; 1.4 km to NE from Brid village	Not studied; extended studies are required during DGM-50	Residual	80
II-2-152	Occurrence Golovanivskiy-1; SW outskirt of Golovanivsk village	Not studied; prospecting evidence	Residual	90
Precious metals **Gold**				
II-2-20	Occurrence Golovanivskiy; Golovanivsk village	Prospected by series of the complex geological mapping drill-holes over the area 12.5×4 km in size	Hydrothermal	80, 90
II-3-29	Occurrence Zakhidno-Troyanskiy; at W outskirt of Troyanka village	Weakly studied; promising for prospecting and required extended studies	Residual	80

1	2	3	4	5
II-4-30	Occurrence Dobryankivskiy; to NE from Dobryanka village	Weakly studied, is promising for prospecting and required extended studies aiming possible discovery of complex gold-rare-metal mineralization	Hydrothermal	59, 80
III-1-33	Occurrence Shamraivskiy; S outskirt of Ulyanivka village	Weakly studied, requires further studies aiming possible discovery of complex ores (Bi, Au, U)	Hydrothermal	80, 95
III-1-39	Occurrence Zavallivskiy; Zavallya village	Weakly studied, requires further studies	Hydrothermal	88, 102
III-2-45	Occurrence Demovyarskiy; 2.2 km to E from Lyushnevate village	General prospecting; requires further studies	Polygenic	61, 81, 80, 90
III-3-52	Occurrence Kapitanivskiy; Kapitanivka village	Reserves and perspective resources are estimated by categories C_2 and P_1	Residual, skarn	79, 80, 70
III-3-54	Occurrence Pobuzkiy; to W from Pobuzke village	Is of prospecting interest	Residual	70, 80
IV-1-61	Occurrence Chemerpilskiy-2; to S from W outskirt of Chemerpil village	Prospecting-evaluation works underway; promising	Hydrothermal	52, 76, 80
IV-1-64	Occurrence Savranskiy-1; SE outskirt of Savran village	Deep geochemical prospecting is conducted; promising	Residual	62, 76, 80
II-1-141	Occurrence Viknenskiy; 5 km to N from Viknena village	Weathering crust after granites contains up to 1.0 g/t of gold. Not studied	Residual	80
II-3-159	Occurrence Troyanskiy; 3 km to NW from Troyanka village	Weakly studied, further works are required	Hydrothermal	100, 80
III-1-169	Occurrence Bogdanivskiy; to W from Bogdanivka village	Weakly studied, promising in prospecting respect	Hydrothermal	52, 80
III-2-171	Occurrence Danylovo-Balkivskiy; 1.5 km to S from Novoselytsya village	Weakly studied, promising in prospecting respect	Hydrothermal	SE “Kirov-geologia”
III-3-186	Occurrence Lypovenkivskiy; 1 km to W from Lypovenky village	Weakly studied, promising in prospecting respect	Hydrothermal	70, 80
III-3-199	Occurrence Zavodskiy; to SE from Kapitanka village	Requires further studies aiming reserve growth in Kapitanivske deposit	Skarn	70, 80
IV-1-206	Occurrence Chemerpilskiy-1; to WSW from Chemerpil village	Prospecting-evaluation works underway	Residual	52, 80, 90

1	2	3	4	5
IV-1-209	Occurrence Savranskiy-2; 1 km to S from Savran village	Geochemical prospecting. Drilling within ore field	Hydrothermal	62, 76, 80
IV-1-213	Maiske deposit; 1 km to SW from Savran village	Preliminary exploration stage drilling works underway	Vein gold-quartz and gold-quartz-sulphide ores	SE "Kirov-geologia" 87, 4, 30
IV-1-219	Occurrence Polyanetskiy; in between Polyanetske and Strutynka villages	Not studied. Requires study. Promising	Not defined	50, 62, 80
		Rare-earth metals		
II-3-27	Occurrence Tabanivskiy; 200 m lower of khutor Tabanivskiy, Tsyurupa gully	Not studied; perspectives not defined	Not defined	80
IV-3-73	Occurrence Lashchivskiy; 0.5 km to E from Lashchivka village	Not studied; perspectives not defined	Pegmatite	80
IV-3-76	Occurrence Dovgoprystanskiy; 1.4 km to SW from Dovga Prystan village	Occurrence requires further studies during DGM-50	Pegmatite	80
IV-4-93	Occurrence Konetspilskiy; at NW outskirt of Konetspil village	Occurrence requires further studies during DGM-50	Pegmatite	57
II-2-147	Occurrence Golovanivskiy; 2.2 km to NW from Golovanivsk village	Kaolinite weathering crust contains up to 19.7 kg/t of monazite. Not studied	Residual	55
III-1-162	Occurrence Moshchenskiy; 1.75 km to NW from Moshchene village	Increased content of yttrium-group rare-earths is encountered in gruss-clayey weathering crust. Not studied	Residual	80
III-3-198	Occurrence Kapitanivskiy; Kapitanka village	Apo-gneiss metasomatites contain up to 10.9 kg/t of monazite. Not studied	Not defined	70
		Radioactive metals Thorium		
I-4-11	Occurrence Ternivskiy; SW part of Ternivka village	Out of economic interest; prospecting evidence	Pegmatite	80
II-3-25	Occurrence Nalyvaykivskiy; to N from Nalyvayka village	Out of economic interest; prospecting evidence	Pegmatite	80
		Uranium		
III-1-40	Occurrence Zavallivskiy; Zavallya village	Not studied by strike and dip; prospecting evidence	Hydrothermal	24

1	2	3	4	5
II-2-151	Occurrence Grushkivskiy; 2.6 km to N from Grushky village	Not studied	Hydrothermal-metasomatic	80
IV-1-212	Occurrence Savranskiy; to S from Savran village	Occurrence is promising and requires further studies aiming complex ore mining at Savranska site	Hydrothermal	80
Non-metallic mineral resources Non-ore raw materials for metallurgy Refractory raw materials Quartzites				
IV-2-67	Occurrence Kosharo-Oleksandrivskiy; Kosharo-Oleksandrivka village	Prospected with prognostic resources estimation by categories P_1+P_2	Metamorphic	91
III-1-165	Occurrence Shamraivskiy; S outskirt of Ulyanivka village	Prospected with prognostic resources estimation by categories P_1+P_2	Metamorphic	91
Sillimanite				
IV-2-65	Occurrence Kosharo-Oleksandrivskiy; Kosharo-Oleksandrivka village	Prospected; recognized as low-perspective	Metamorphic	64
Chemical ore mineral commodities Agrochemical raw materials Apatite				
II-3-157	Occurrence Troyanskiy; 3 km to NW from Troyanka village	General prospecting	Metasomatic	35, 80
Non-metal ore commodities Electric- and radiotechnical raw materials Graphite				
II-1-13	Occurrence Mechyslavskiy; 1.5 km to NW from Mechyslavka village	General prospecting, requires further studies	Graphite ores in gneisses and their weathering crusts	54, 80
II-2-17	Occurrence Synkivskiy; 1.3 km to SE from Synki village	Requires further studies, perspectives not defined	Graphite ores in gneisses and their weathering crusts	80
II-3-28	Occurrence Troyanskiy; 3 km to NW from Troyanka village	Prospected, prognostic resources evaluated by category P_3	Graphite ores in gneisses and their weathering crusts	80
III-1-34	Shamraivske deposit; 1.0 km to S from Shamraivka village	Prospecting-evaluation works conducted. Never been mined	Graphite ores in gneisses and their weathering crusts	84, 95, 96

1	2	3	4	5
III-1-37	Zavallivske deposit; Zavallya village	Explored in details. In production	Graphite ores in gneisses and their weathering crusts	101
III-1-41	Occurrence Synytsivskiy; to E and SE from Synytsivka village	General prospecting conducted. Further prospecting is not recommended	Graphite ores in gneisses and their weathering crusts	95
III-2-44	Occurrence Kosharo-Oleksandrivskiy; to W from Kosharo-Oleksandrivka village	General prospecting. Low-perspective in view of insufficient reserves	Graphite ores in gneisses and their weathering crusts	84
III-2-47	Occurrence Demovyarskiy; to E from Lyushnevate village	Detailed prospecting. Resources and reserves are estimated	Graphite ores in gneisses and their weathering crusts	55, 95
IV-1-62	Occurrence Vilshanskiy; 0.6 km to N from W outskirt	General prospecting. Low-perspective in view of insufficient graphite content	Graphite ores in gneisses and their weathering crusts	84
IV-2-69	Occurrence Dubynivskiy; 0.3 km to W from Dubynove village	Detailed prospecting. Promising	Graphite ores in gneisses and their weathering crusts	56, 95
IV-3-79	Occurrence Sekretarskiy; at SW outskirt of Sekretarka village	General prospecting. Requires further studies	Graphite ores in gneisses and their weathering crusts	57
I-3-131	Occurrence Rogivskiy; to W and SW from Rogova village	General prospecting	Graphite ores in gneisses and their weathering crusts	58, 90
I-3-133	Occurrence Pidvysokskiy; nearby Pidvysoke village	General prospecting	Graphite ores in gneisses and their weathering crusts	90
III-2-175	Occurrence Bogdanivskiy; 1km to E from Bogdanove village	General prospecting	Graphite ores in gneisses and their weathering crusts	84
III-3-179	Occurrence Sukhotashlytskiy; 1 km to NW from Sukhiy Tashlyk	General prospecting	Graphite ores in gneisses and their weathering crusts	56, 80, 90
IV-1-214	Occurrence Skhidno-Savranskiy; SE outskirt of Savran village	General prospecting	Graphite ores in gneisses and their weathering crusts	84
IV-1-217	Occurrence Polyanetskiy; area of Kalynivka and Polyanetske villages	Not studied	Graphite ores in gneisses and their weathering crusts	51, 90
IV-3-224	Occurrence Velyko-mechetnyanskiy; 1.4 km to W from Velyka Mechetnya village	Not studied	Graphite ores in gneisses and their weathering crusts	80

1	2	3	4	5
Jewelry raw materials (precious stones) Diamond*				
I-3-4	Occurrence Tarasivskiy; N outskirt of Tarasivka village	Green-coloured diamond fragment 0.17×0.12 mm in size is encountered in clayey weathering crust	Not defined	80
III-1-32	Occurrence Mogylnyanskiy; NE outskirt of Mogylne village	Diamond fragment 0.35×0.3 mm in size is found in weathering crust after calciphyres	Not defined	80
III-3-50	Occurrence Kapitanivskiy; N part of Kapitanka village	20 diamond crystals and fragment are found both in bedrock and in clayey weathering crust	Not defined	80
IV-3-78	Occurrence Chausivskiy; NE outskirt of Chausove village	Yellowish-grey diamond table 0.26×0.18×0.05 mm in size is found in clayey weathering crust	Not defined	80
I-2-130	Occurrence Korzhevoslobodskiy; 1 km to SE from Korzhova Sloboda village	Diamond fragment is found in amphibole-pyroxene schist	Not defined	80
IV-1-207	Occurrence Chemerpilskiy; 1.9 km to W from Chemerpil village	Fragment of green crystal 0.17×0.12 mm in size is found in montmorillonite weathering crust	Not defined	80
Construction raw materials Glass and porcelain-faience raw materials Primary kaoline				
III-1-35	Occurrence Kamyanobridskiy, Kamyaniy Brid village	Not studied, perspectives not defined	Residual	59
III-2-43	Occurrence Svirnevskiy; SE outskirt of Svirnevo village	Not studied, perspectives not defined	Residual	55
III-4-55	Occurrence Berezovo-Balkivskiy-2; 1.5 km to SE from Berezova Balka village	Prognostic resources are estimated by category P_3	Residual	57
IV-4-92	Konetspilske deposit; 4.5 km to NW from Konetspil village	Explored in details. In reserve	Residual	15
I-1-129	Occurrence Zatyshkivskiy; outskirt of Zatyshok village	Prognostic resources are estimated by category P_3	Residual	54
I-3-132	Occurrence Nerubaykivskiy; 1.0 km to SW from Nerubayka village	Technological properties are studied	Residual	58
I-3-134	Occurrence Pidvysokskiy; in between Pidvysoke and Levkovka villages, on the right bank of Synyukha River	Prognostic resources are estimated by category P_2	Residual	58

1	2	3	4	5
I-4-136	Occurrence Kamyshivskiy; at SE outskirt of Kamyshivo village	Prognostic resources are estimated by category P_2	Residual	59
I-4-137	Occurrence Churivskiy; 1.7 km to NW from Churivka village	Technological properties are studied	Residual	59
I-4-138	Occurrence Kostyantynivskiy; 2 km to N from Kostyantynivka village	Technological properties are studied	Residual	59
I-4-139	Occurrence Obroshkivskiy; to NW from Tyshkivka village	Technological properties are studied	Residual	59
I-4-140	Occurrence Tyshkivskiy; 1.0 km to NW from Tyshkivka village	Prognostic resources are estimated by category P_2	Residual	59
II-1-142	Occurrence Viknenskiy; to S from Vikneno village	Prognostic resources are estimated by category P_2	Residual	54
II-1-143	Occurrence Kamya-nokrynychanskiy; S part of Kamyana Krynytsya village	Prognostic resources are estimated by category P_2	Residual	54
II-1-144	Occurrence Zakhidno-Tauzhnyanskiy; 1.0-1.5 km to NW from Tauzhne village	Prognostic resources are estimated by category P_2	Residual	54
II-2-145	Occurrence Grushkivskiy; 1.0 km from Grushky village	Prognostic resources are estimated by category P_3	Residual	55
II-2-149	Occurrence Zakhidno-Stanislavchykskiy; to W from Stanislavove village	Technological properties are studied	Residual	80
II-2-150	Occurrence Pivdenno-Stanislavchykskiy; S outskirt of Stanislavove village	Technological properties are studied	Residual	80
II-3-158	Occurrence Troyanskiy; 3.1 km to NW from Troyanka village	Technological properties are studied	Residual	80
II-4-161	Occurrence Andriivskiy; to NE from Andriivka village	Prognostic resources are estimated by category P_2	Residual	59
III-1-166	Occurrence Mogylnyanskiy; 1.1 km to SW from Mogylne village	Technological properties are studied	Residual	80

1	2	3	4	5
III-1-167	Occurrence Zhakchynskiy; 3.4 km to W from Zhakchyk village	Technological properties are studied	Residual	55
III-2-173	Occurrence Lozuvatskiy; 1.0 km to W from Lozuvata village	Prognostic resources are estimated by category P_3	Residual	62
III-4-203	Occurrence Berezovo-Balkivskiy-1; W outskirt of Berezova Balka village	Technological properties are studied	Residual	57
III-4-204	Occurrence Ermolaivskiy; 3.0 km to N from Ermolaivka village	Technological properties are studied	Residual	57
IV-4-229	Occurrence Anatoliivskiy-1; nearby Anatoliivka village	Technological properties are studied	Residual	57
IV-4-230	Occurrence Synyukhobridskiy-1; 2.4 km to NE from Synyukhin Brid village	Technological properties are studied	Residual	57
IV-4-231	Occurrence Pidgorodnyanskiy; 2.8 km to N from Pidgorodnya railway station	Technological properties are studied	Residual	57
IV-4-232	Occurrence Synyukhobridskiy-2; 2.4 km to E from Synyukhin Brid village	Prognostic resources are estimated by category P_2	Residual	57
IV-4-233	Occurrence Anatoliivskiy-2; 5.5 km to SE from khutor Anatoliivskiy	Technological properties are studied	Residual	57
IV-4-235	Verbivske deposit; 4 km to N from Mygiya village	Explored in details. In reserve	Residual	15
IV-4-236	Occurrence Mygiyskiy; at W outskirt of Mygiya village	Technological properties are studied	Residual	57
Quarry-stone raw materials				
I-1-1	Antonivske deposit; Antonivka village	Explored in details. Out of production	Ultra-metamorphic	15
I-3-8	Peregonivske deposit; 1 km to S from Peregonivka village	Explored in details, In production	Ultra-metamorphic	15
I-4-9	Torgovytske deposit; 1 km to S from Torgovytsya village	Explored in details, In production	Ultra-metamorphic	15
I-4-10	Sabovske deposit; 1 km to SW from Sabove village	Explored in details. Out of production	Ultra-metamorphic	15

1	2	3	4	5
II-1-12	Kolodyste deposit; 3 km to E from Kolodyste village	Explored in details. Out of production	Ultra-metamorphic	15
II-1-14	Velykotroyanske deposit; 0.4 km to SW from Velyki Troyany village	Explored in details. Out of production	Ultra-metamorphic	15
II-1-15	Yosypivkse deposit; 2 km to N from Yosypivka village	Explored in details. In development	Ultra-metamorphic	15
II-3-22	Lebedynske deposit; 1.2 km to NE from Lebedynka village	Explored in details. Out of production	Ultra-metamorphic	15
II-3-23	Krasnopilske deposit; 1 km to NE from Krasnopillya village	Explored in details. Out of production	Ultra-metamorphic	15
II-3-24	Tabanivske deposit; 1 km to W from Tabanovo village	Explored in details. In conservation	Ultra-metamorphic	15
II-3-26	Orlovske deposit; 3 km to S from Orlova village	Explored in details. In conservation	Ultra-metamorphic	15
III-1-31	Shamraivske deposit; at S outskirt of Shamraivka village	Explored in details. Out of production	Ultra-metamorphic	15
III-4-58	Tarasivske deposit; 1 km to SW from Synyukha railway station	Explored in details. Out of production	Ultra-metamorphic	15
III-4-59	Vilshanske (Kalmazove) deposit; 5 km to S from Vilshanka area centre	Explored in details, In production	Ultra-metamorphic	15
IV-1-63	Vilshanske deposit; 1.5 km to E from Vilshanka village	Explored in details, In production	Ultra-metamorphic	15
IV-2-66	Lupolovske deposit; 2.5 km to NE from Lupolovo village	Explored in details. In conservation	Ultra-metamorphic	15
IV-3-72	Boleslavchytske-2 deposit; 4 km to NW from Boleslavchyk village	Explored in details. In reserve	Ultra-metamorphic	15
IV-3-80	Chausivske-2 deposit; at NW outskirt of Chausovo village	Explored in details. In reserve	Ultra-metamorphic	15
IV-3-81	Kamyanobalkivske deposit; 1 km to SE from Kamyana Balka village	Explored in details. In development	Ultra-metamorphic	15
IV-4-82	Chornotashlytske deposit; 1.5 km to SW from Novo-oleksandrivka village	Explored in details. Out of production	Ultra-metamorphic	15

1	2	3	4	5
IV-4-83	Novooleksandrivske deposit; 1 km to SW from Novo-oleksandrivka village	Explored in details. Out of production	Ultra-metamorphic	15
IV-4-85	Boleslavchytske deposit; 3 km to S from Stanislavchyk village	Explored in details, In production	Ultra-metamorphic	15
IV-4-86	Pidgorodnyanske deposit; 8 km to NW from Pervomaisk town	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-88	Synyukhinske deposit	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-89	Pervomaiske deposit; at N outskirt of Pervomaisk town	Explored in details. In reserve	Ultra-metamorphic	15
IV-4-90	Chausivske deposit; 3 km to SE from Chausove village	Explored in details, In production	Ultra-metamorphic	15
IV-4-91	Konetspilske deposit; 4.5 km to NW from Konetspil village	Explored in details, In production	Ultra-metamorphic	15
IV-4-95	Mygiyske deposit; 3 km to SE from Mygiya village	Explored in details. Out of production	Ultra-metamorphic	15
Waters Underground waters Fresh				
I-2-2	Yatranske deposit; Yatranivka village	Not being used	Fractured	15
III-1-38	Zavallivske deposit; Zavallya village	Are being used	Fractured	15
I-4-135	Novoarkhangelske deposit; Novoarkhangelsk village	Explored. Not being used	Fractured	15
II-2-146	Golovanivske deposit; Golovanivsk village	Explored. Are being used	Fractured	15
III-1-164	Ulyanivske deposit; S part of Ulyanivka village	Explored. Not being used	Fractured	15
Mineral				
III-3-53	Occurrence Kapitanivskiy; Kapitanka village	Not being used	Fractured	80
III-4-56	Occurrence Vilshanskiy; at N of Vilshanka village	Not being used	Fractured	77

* Note: origin of diamond grains is not completely defined and technogenic nature of some these grains is not excluded

STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200,000

Central-Ukrainian Series
Map Sheet M-36-XXXI (Pervomaisk)

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