STATE COMMITTEE ON NATURAL RESOURCES OF UKRAINE

SE "PIVDENUKRGEOLOGIYA"
DNIPROPETROVSKA GEE
UKRAINIAN STATE GEOLOGICAL RESEARCH INSTITUTE
"UkrSGRI"

STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

Central-Ukrainian Series
Map Sheet Group
L-36-VI (Zaporizhzhya) and L-37-I (Pology)

EXPLANATORY NOTES

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English Translation (2010): B.I.Malyuk

Kyiv - 2004 (2010)

UDC 550.8:528.(0.84.ZM200)(477.63+477.64)

The State Geological Map of Ukraine in the scale 1:200 000, map sheets L-36-VI (Zaporizhzhya), L-37-I (Pology). Central-Ukrainian Series. Explanatory Notes. Kyiv: State Committee on Natural Resources of Ukraine. State Enterprise "Pivdenukrgeologiya", 2004. - K.: UkrSGRI, 2009 (2010). ___ p. 11 figures, 119 references, 7 annexes.

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The work summarizes geological material based on results of extended geological study over map sheets L-36-VI (Zaporizhzhya), L-37-I (Pology) in the scale 1:200 000 conducted in 1990-2000. The Explanatory Notes contain description of the "Geological map and map of mineral resources in pre-Quaternary units", "Geological map and map of mineral resources in Quaternary sediments", "Geological map and map of mineral resources in crystalline basement". Description of stratigraphic column over the studied area from Precambrian to modern sediments is provided.

Tectonic structure, mineral resources and regularities in their distribution, geomorphology, hydrogeology and ecologo-geological environment are reviewed and the list of mineral deposits and occurrences is compiled.

The set of maps in the scale 1:200 000 and supplementary Explanatory Notes are devoted to the broad range of specialists familiar in the field of geological sciences and nature researches and also can be used in the planning of geological exploration works.

CONTENTS

Abbreviations used in the text

BCN – bulk concentration number
CSF – conventionally-safe factor
DDD – Dniprovsko-Donetska Depression
Derzhgeolkarta-200 – the State Geological Map in the scale 1:200 000
DGM-50 – Deep Geological Mapping in the scale 1:50,000
DH – drill-hole
DSS – Deep Seismic Sounding
EGP – Exogenic Geological Processes
EGSF-200/50 – Extended Geological Study of the Fields in the scale 1:200 000/1:50 000
GEE – Geological Exploration Expedition
GMG – Geological-Mapping Group
GPM-200 – Geological-Prognostic Mapping in the scale 1:200 000
IP – Induced Polarization
IUA – Industry-Urban Agglomeration
LTC – Litho-Tectonic Complex
LTZ – Litho-Tectonic Zone
MBP – Mining-Beneficiation Plant
MSDP – Method of Shared Deep Point
MTS – Magneto-Telluric Sounding
NSC – National Stratigraphic Committee of Ukraine
OP LTZ – Orikhovo-Pavlogradska Litho-Tectonic Zone
OPSZ – Orikhovo-Pavlogradska Suture Zone
PCD – Prychornomorska Depression
PCM – Pryazovskiy Crystalline Massif
SGE – State Geological Enterprise
TAC – top admissible concentration
TAL – top admissible level
TIC – Territorial-Industrial Ccomplex
TMZ – Tectono-Metallogenic Zone
UkS – Ukrainian Shield
VES – Vertical Electric Sounding

INTRODUCTION

The territory of map sheets L-36-VI (Zaporizhzhya) and L-37-I (Pology) is bounded by geographic coordinates 35°00'-37°00' E longitude and 47°20'-48°00' N latitude. In the administrative layout of Ukraine it is included in Zaporizka Oblast completely or partly encompassing Vasylivskiy, Vilnyanskiy, Gulyajpilskiy, Zaporizkiy, Kuybyshevskiy, Mykhaylivskiy, Novomykolaivskiy, Orikhivskiy, Pologivskiy and Tomkatskiy areas. The minor part (15%) of the territory is situated in Dnipropetrovska (Pokrovskiy area) and Donetska (Velykonovoselivskiy area) Oblasts. The square of both map sheets is 10 443 km^2 net of the area of Kakhovske water reservoir (597 km^2).

The map sheet territory is located within the southern part of Eastern-European Platform and in geotectonic respect it belongs to the south-eastern part of Ukrainian Shield, northern part of Prychornomorska Depression and, partially, south-western part of Dniprovsko-Donetska Depression.

The region comprises steppe zone of the eastern Ukraine – the flat-hilly plain (altitudes 16-285 m) cut by wide (1-2 km) and shallow (30-50 m) valleys with gentle slopes (up to 3-5°); it is situated within Azovo-Prydniprovska and, partially, Donetska Heights and Prychornomorska Lowland.

The map sheet territory is crossed by Dnipro, Konka, Vovcha, Gaychur and Mokri Yaly rivers. In the south-western part of the map sheet Kakhovske water reservoir is located.

Climate in the area is moderate-continental. The winter is mild, low-snowy (-5…-8°C). In some hard winters the frost may attain -30…-40°C. The summer is dry and hot. Maximum temperature is 37-40°C. Average annual amount of atmospheric precipitates is 350-470 mm. Prevailing wind direction is eastern and north-eastern.

In economic respect the region is industrial-agricultural. The industry is concentrated in Zaporizhzhya city. Ferrous and non-ferrous metallurgy is developed as well as machinery construction, metal-processing, mining and construction materials industry. The food industry enterprises and brick-tile plants are located in the area centres. In agriculture sector the cattle breeding and grain growing are mainly developed.

The major inhabited localities include Zaporizhzhya, Orikhiv, Pology, Gulyajpole and Kuybysheve towns. These are interconnected by the road and railway networks.

According to the accepted zonation, the map sheets territory belongs to the two-floor closed type. The basement exposure extent does not exceed 3% (325 km^2), cross-country ability is appropriate (80%) and weak (20%). The basement complexity degree is high (15%, 1566 km^2) and very high (5%, 522 km^2), and sedimentary cover – simple (50%, 5222 km^2) and moderate (30%, 3133 km^2).

Degree of satellite image deciphering is weak (100%).

In the course of map sheets preparation the results of regional geological mapping were used: in the scale 1:200 000 – E.G.Lapytskiy, V.M.Kinshakov, A.A.Petrenko; in the scale 1:50000 – O.I.Andreev, B.Z.Berzenin, O.M.Bestuzhev, V.M.Dralov, V.F.Kiktenko, V.M.Kinshakov, V.M.Kichurchak, Yu.V.Kovalenko, A.G.Kutko, M.I.Lebedev, M.A.Leiye, Zh.Z.Shamonov, Yu.D.Shkovyra, V.M.Shypilov and other geologists. Results of research works of Yu.G.Yermakov, O.T.Ageev, A.D.Shevchyk, G.V.Pasichniy, B.Z.Berzenin on stratigraphy, tectonics, mineral resources, metallogeny and geochemistry of the studied area are used. The work quality complies with the modern requirements to the geological information (see "Scheme of geological mapping materials used").

The information of geological exploration for various minerals is also used in the work. In particular, the exploration results of I.I.Mogilevits, V.N.Krylov, L.V.Isakov, E.M.Koval for iron ores and rare metals should be noted.

The preparation works were fulfilled by A.A.Petrenko, V.O.Shpylchak and A.I.Nekryach. The drawing works were conducted by V.Yu.Petrenko. The electronic version of the set "Derzhgeolkarta-200" is created by Yu.V.Antykhovych, E.V.Semenikhin, N.V.Stakhova, L.O.Filkova, V.O.Shpylchak and others.

1. GEOLOGICAL STUDY DEGREE OF THE AREA

On the ground of the works conducted by A.A.Goyzhevskiy in 1956 and E.V.Repina in 1957 the reports were prepared [51, 107]. In 1960 the "Geological Map of USSR in the scale 1:200 000", Central-Ukrainian Series, map sheet L-37-I (Pology), and in 1962 – the "Geological Map of USSR in the scale 1:200 000", map sheet L-36-VI (Zaporizhzhya).

Since that time the scheduled by-sheet geological mapping in the scale 1:50 000 was performing over the map sheet territory. In the map sheet L-36-VI in 1961-1986 it was conducted by V.F.Kiktenko, Yu.D.Shkovyra and V.Yu.Kovalenko. In the map sheet L-37-I in 1961-1981 the geological mapping is carried out by M.I.Lebedev, G.G.Konkov, O.I.Andreev, M.A.Leiye, Yu.D.Shkovyra, V.M.Shypilov and Zh.Z.Shamonov.

Since the mid 70th up to 1994 the deep geological mapping (DGM) in the scale 1:50 000 and 1:200 000 was performing in the map sheet territory.

Most perspective fields are subject to the mapping. Mokromoskovskiy (B.Z.Berzenin, 1976) and Shcherbakivskiy (V.F.Kiktenko, 1982) granite massifs are mapped as well as most part of Orikhovo-Pavlogradska LTZ (E.G.Lapytskiy, 1994; V.F.Kiktenko, 1978, 1982), Gaychurska and Kosivtsivska greenstone structures (V.M.Kinshakov, 1991), Shevchenkivska and Fedorivska structures (V.M.Kichurchak, 1990), Novopavlivska structure (V.F.Kiktenko, 1982), the northern slope of Prychornomorska Depression (V.M.Kinshakov, 1977). At present the DGM of Konkska greenstone structure and its envelope is underway; the works are on approach to the finish. The field materials are used in the course of geological map design (O.M.Bestuzhev).

The map sheet L-37-I (Pology) is completely covered by the medium-scale geological mapping (V.F.Kiktenko, 1987); S.I.Pereverzev in 1992 and E.G.Lapytskiy in 1994 have conducted the DGM in the north-western and south-eastern parts of the map sheet L-36-VI (Zaporizhzhya) respectively (see "Scheme of geological mapping materials used").

On the ground of the geological mapping results the new generation set of maps is created for the sedimentary cover and crystalline basement. Detailed subdivision of Phanerozoic sediments and crystalline rocks is carried out. The distribution boundaries for defined subdivisions are adjusted. Regulations in mineral deposits location are studied. The new data on tectonics and neo-tectonics are received. The geological history of the region is considered from the new points of view.

Since 1961 the numerous prospecting and exploration works for iron ores (E.I.Kochanov, 1973; I.I.Mogilevits, 1977), bauxites (A.V.Dyukov, 1973), diamonds (A.V.Dyukov, 1985), apatite (E.G.Lapytskiy, 1973), rare metals (L.V.Isakov, 1986), radioactive elements (D.I.Plotnichenko, 1961; A.N.Bragin, 1976), ilmenite and zircon placers (M.I.Solovey, 1970), and non-metallic minerals were performed.

In parallel, a broad complex of research and targeted works is conducted. In 1964 Yu.G.Ermakov had compiled the "Complex Geological Map of Prychornomorska Depression" which became the counterpart of the "State Geological Map of Uk.S.S.R in the scale 1:500 000". O.T.Ageev had designed in 1966 the prognostic-metallogenic map.

The method of regional litho- and hydrochemical prospecting conducted in 1964-1967 by A.D.Shevchyk is used in the common works.

Based on lithologo-stratigraphic method M.I.Lebedev had stratified the metamorphic rocks of Precambrian up to sub-suites and designed the "Geological Map of Middle-Dniprean Region (1975).

In 1975 M.V.Mitkeev had compiled the prognostic map for iron ores over the Big Kryvyj Rig, and O.A.Gonchar – for apatite-bearing in Pryazovya and Middle-Dniprean regions.

Review of mineral resources in Dnipropetrovska Oblast is performed by E.O.Yartseva (1990), and in Zaporizka Oblast – V.S.Yunak (1988).

In 1984 the litho-tectonic analysis of rock associations developed by researches of Lvivskiy State University A.O.Sivoronov and V.D.Koliy is introduced in the working practice.

E.O.Yartseva in 1984 had designed the map of landscape-geochemical zonation for the territory of SGE "Pivdenukrgeologiya" activities. This work is in use up to now in view of regional ecological studies over the territory of Ukraine.

In 1992-1999 S.Z.Gendrikhovskiy in the map sheets L-36-VI (Zaporizhzhya) and L-37-I (Pology) had performed the geological-ecological studies. It is designed the set of maps for ecological state of geological

environment in the scale 1:200 000. Yu.N.Volokhov in 1997 had conducted the ecological mapping in the scale 1:50 000 for Zaporizka urban agglomeration in the map sheets L-36-11-A,C.

K.Yu.Bilostotska in 1973 had designed the "Hydrogeological Map of USSR for the spread population water supplying over special period" in the scale 1:200 000 for Zaporizka Oblast.

Under edition of N.G.Butenko the "Hydrogeological Map of Uk.S.S.R" in the scale 1:200 000 of the map sheet L-36-VI (Zaporizhzhya) is published.

The complex hydrogeological and engineering-geological mapping in the scale 1:50 000 over the map sheets L-36-11-A,C,D is conducted in 1966-1968 by N.M.Strilkova and Yu.F.Marchenko.

V.D.Nesmiyko in 1992 had completed the works on the complex hydrogeological and engineering-geological mapping in the scale 1:50 000 in the irrigation purposes for Donetska Oblast. The works were performed over the map sheets L-37-2-B, -3-A,B. The same work was performed by M.S.Ryabtsev over the map sheets L-36-11-B,D; L-36-12-A,C in 1987-1992.

A great number of prospecting-exploration works is performed over the territory aiming water supplying the inhabited localities and agricultural objects in Zaporizka, Donetska and Dnipropetrovska Oblasts. Of these the most important include the works of V.G.Polishko (1975-1977) for water supplying of Orikhiv and Pology towns, L.V.Dorozhnina (1978) for Kushugum and Malokaterynivka villages. B.A.Neklyudov (1983-1992) was dealt with the water supplying of inhabited localities in Velykonovoselivskiy area of Donetska Oblast. Detailed exploration of underground waters for the centralized water supplying of Gulyajpole town is conducted by M.L.Mudriy in 1969. Prospecting and preliminary exploration of underground waters in Konksko-Yalynska Depression within Zaporizka Oblast is performed by V.G.Polishko in 1986-1988. G.T.Tyazhlov and M.T.Ulinska (1983) had conducted detailed prospecting of underground waters for temporary housing-drinking supplying of the objects at Tavriyskiy MBP.

G e o p h y s i c a l s t u d i e s . The territory is completely covered by the medium-scale magnetic and gravity surveys except the water area of Dnipro River and adjacent territories beneath the inhabited localities.

Electric surveys are conducted by the VES method in the scale 1:500 000-1:200 000 over entire map sheets, and in the scale 1:50 000-1:100 000 for 60% of the territory only. Seismic works performed by the profile of DSS and MSDP. The territory is crossed by the 8th DSS Profile (Geotraverse IV) and 02-88 MSDP.

In the design of integrated magnetic map the surveys in the scale 1:25 000 were used. They were performed by-sheet basis in 1964-1980 by the grid 200 by 50 m. To cover some territories adjacent to Dnipro River and beneath the towns the surveys in the scale 1:50 000 were used performed in 50th by the grid 500 by 200 m, 400 by 100 m, as well as airborne surveys in the scale 1:50 000 – 1:100 000. Aiming support of prospecting works, mainly for iron ores, the surveys in the scale 1:5 000 – 1:10 000 by the grids 50 by 25 m and 100 by 50 m were conducted. Magnetic surveys were carried out by SGE "Dniprogeofizika" staff V.M.Popov, V.P.Sakovtsev, V.B.Mittelman, M.Ya.Shlain, A.V.Metlytskiy, I.G.Klyuev and others. Gravity surveys performed in the scale 1:50 000 by the grid 500 by 500 m, 400 by 200 m. These surveys cover 90% of the studied map sheets. Only in the territory adjacent to Dnipro River (map sheets L-36-11-A,C; -23-B) the surveys done in the scale 1:200 000. In prospecting purposes the surveys in the scale 1:10 000 by grid 200 by 100 m are conducted. The integrated map of observed gravity field over the map sheets L-36-VI and L-37-I is composed under Bouguer reduction (δ_{of} = 2.3 g/cm^3) from the fact maps and iso-anomals Δga.

Electric surveys are performed under VES modification, partially by dipole sounding. The VES points are located by the grid mesh 1×1 km and rarely 2×2 km, 4×2 km. About 70% of the map sheet L-37-I and 25% of the map sheet L-36-VI are covered by dense network. Fracturing zones (faults) are distinguished on the ground of electric sounding.

Magneto-telluric sounding is performed in the map sheet territory in 37 observation points. These works allowed receiving the geo-electric section up to the depth of 100 km. These data are used for the deep structure studies over the Zaporizko-Pologivski map sheets.

The seismic works by deep seismic sounding (DSS) and shared deep point (MSDP) are conducted by the single profiles. These works encompasses the crustal depth from first kilometers to 60 km (and more in places) and are used in the deep tectonic considerations.

2. STRATIFIED UNITS

In tectonic respect the territory of map sheets L-36-VI (Zaporizhzhya) and L-37-I (Pology) is located in the Ukrainian Shield, Prychornomorska Depression and Dniprovsko-Donetska Depression (DDD). Geology of the studied map sheets is defined by the Precambrian crystalline rocks and the thick sedimentary sequence (see "Geological Cross-Sections" to the map of pre-Quaternary sediments).

The stratigraphic subdivision is performed in compliance with the "Stratigraphic Code of Ukraine" approved by the NSC of Ukraine on April 2, 1997, the Correlation stratigraphic schemes approved by the Ukrainian Inter-Ministry Stratigraphic Committee and "Correlation Stratigraphic Scheme of Precambrian Units in Ukrainian Shield" approved by NSC of Ukraine on July 1, 2002.

The studied area displays two-level structure. The lower tectonic level comprises the highly-dislocated crystalline basement of Ukrainian Shield composed of Archean and Proterozoic metamorphic and intrusive rocks. The upper tectonic level comprises the platform cover composed of Phanerozoic rocks of Paleozoic, Mesozoic and Cenozoic age.

According to the scheme of geological zonation in the lower tectonic floor (Ukrainian Shield), the territory is located in the Middle-Dniprean and Pryazovian areas separated by Orikhovo-Pavlogradskiy deep-seated fault. The first area comprises the classic granite-greenstone terrain, and the second one – granulite-greenstone terrain. Genetic features of the areas reflected in their titles define the major features of their geology. The two areas are similar in term of their second tectonic level – sedimentary-volcanogenic greenstone complex which constitutes the superimposed greenstone structures (belts). And the two areas differ in the lower tectonic level. In the Middle-Dniprean area it is composed of stratified-granitoid complexes whereas in the Pryazovian area – mainly of granitoid-gneiss complexes underwent modifications under PT-conditions of amphibolite and granulite metamorphic facies respectively (see "Scheme of Geological Zonation" to the "Geological Maps of Crystalline Basement").

In Pryazovskiy area three litho-tectonic zones (LTZ) are distinguished: Orikhovo-Pavlogradska (OP LTZ), Zakhidnopryazovska (ZP LTZ) and Tsentralnopryazovska (TS LTZ). Their boundaries coincide with the margins of tectonic blocks or major plicative structures. The first LTZ coincides with the same-named synclinorium while the second one is distinguished within Gulyajpolsko-Saltychanskiy (Zakhidnopryazovskiy) block which is similar in geology to the granite-greenstone terrains. The western edge of Tsentralnopryazovska LTZ comprised of the same-named synclinorium is extended along the eastern and southern limits of the map sheet L-37-I. The Middle-Dniprean area is bounded by the map sheet L-36-VI limits and includes Konksko-Bilozerska LTZ.

The upper tectonic floor, which includes three tectonic levels – Paleozoic, Meso-Cenozoic and Pliocene-Quaternary, was forming repeatedly in the various LTZ whose boundaries changed under influence of tectonic processes that define sedimentation environments for specific time. Three sub-levels are distinguished in the Meso-Cenozoic level – Cretaceous, Paleogene and Miocene.

Paleozoic sediments include the Lower Carboniferous rocks in Kalmius-Nesvetayska LTZ. They constitute the north-eastern part of the studied area (Kalmiuska Plate) in the junction zone of DDD and Ukrainian Shield (map sheet L-37-I) monoclinally dipping at the angle 2-3^{o} to the south-east.

Cretaceous sediments are widely developed over the studied area. The full column of the sequence is restricted to the Konksko-Yalynska and Elanchyksko-Vovchanska LTZs where the rocks gently plunge toward Prychornomorska Depression under the angle up to 2^{o} (see "Tectonic Scheme" to the "Geological Map of Pre-Quaternary Sediments).

Paleogene and Neogene sediments lie over the crystalline basement and Cretaceous rocks with the slight inclination in the southern and south-western directions. Vasylivska and Plogivska LTZs are distinguished in the map sheet areas.

The loess formation blankets the rocks of various ages – from Archean to Pliocene inclusive. It occupies the back-glacier zone within the southern loess areas and includes various genetic rock types.

The schemes of stratigraphic zonation are given in the geological maps.

The scheme of stratigraphic subdivision for the rocks in the column is given below.

PHANEROZOIC
Cenozoic Eratheme
Quaternary System
Holocene Division (H)

aH – alluvial sediments of the low flood-land
tH – technogenic type
tfH – covering
taH – washing
tbH – construction and buildings
eH – eluvial type

Pleistocene and Holocene divisions undivided (P-H)

ad, P_{III}pc-H – alluvial-deluvial sediments
dP_{III}-H – deluvial sediments
vP_{III}pc-H – aeolian sediments

Pleistocene Division
Neo-Pleistocene Sub-Division (P)
Upper Branch (P_{III})

a^1P_{III}ds – Desnyanskiy ledge. Alluvial sediments of the first terrace
a^2P_{III}vl – Vilshanskiy ledge. Alluvial sediments of the second terrace
a^3P_{III}tb – Trubizkiy ledge. Alluvial sediments of the third terrace
vd,eP_{III}bg-pc – aeolian-deluvial, eluvial sediments
vdP_{III}pc – Prychornomorskiy climatolith, aeolian-deluvial sediments
eP_{III}df – Dofinivskiy climatolith, eluvial sediments
vdP_{III}bg – Buzkiy climatolith, aeolian-deluvial sediments
e,vdP_{III}pl-vt – eluvial, aeolian-deluvial sediments
eP_{III}vt – Vytachivskiy climatolith, eluvial sediments
vdP_{III}ud – Udayskiy climatolith, aeolian-deluvial sediments
eP_{III}pl – Prylutskiy climatolith, eluvial sediments

Lower and Middle branches undivided

e,vdP_{I+II} – eluvial, aeolian-deluvial sediments

Middle Branch (P_{II})

a^4P_{II}cr – Cherkaskiy ledge. Alluvial sediments of the fourth terrace
a^5P_{II}hd – Khadzhybeyskiy ledge. Alluvial sediments of the fifth terrace
vdP_{II}ts – Tyasminskiy climatolith, aeolian-deluvial sediments
eP_{II}kd – Kaydatskiy climatolith, eluvial sediments
vdP_{II}dn – Dniprovskiy climatolith, aeolian-deluvial sediments
eP_{II}zv – Zavadivskiy climatolith, eluvial sediments
e,vdP_{II} – eluvial, aeolian-deluvial sediments
e,vd,lP_{II} – complex genetic type. Eluvial, aeolian-deluvial and lake (pod) sediments undivided

Lower Branch (P_I)

e,vdP_I – eluvial, aeolian-deluvial sediments undivided
e,vd,lP_I – complex genetic type. Eluvial, aeolian-deluvial and lake (pod) sediments
a^6P_Ikn – Krukenytskiy ledge. Aluvial sediments of the sixth terrace
a^7P_Idc – Donetskiy ledge. Aluvial sediments of the seventh terrace
a^8P_Ibk – Budatskiy ledge. Aluvial sediments of the eighth terrace
vd$P_I$tl – Tyligulskiy climatolith, aeolian-deluvial sediments

eP_1lb – Lubenskiy climatolith, eluvial sediments
vdP_1sl – Sulskiy climatolith, aeolian-deluvial sediments
eP_1mr – Martonoskiy climatolith, eluvial sediments
vdP_1pr – Pryazovskiy climatolith, aeolian-deluvial sediments
eP_1sh – Shyrokinskiy climatolith, eluvial sediments

Eo-Pleistocene Division and Lower Branch of Neo-Pleistocene Sub-Division of Pleistocene Division undivided

$e,vdE+P_1$ – eluvial, aeolian-deluvial sediments

Eo-Pleistocene Sub-Division (E)

e,vdE – eluvial, aeolian-deluvial sediments undivided

Upper Branch (E_{II})

$a^9E_{II}ng$ – Nogayskiy ledge. Alluvial sediments of the ninth terrace
$vdE_{II}il$ – Illichivskiy climatolith, aeolian-deluvial sediments
$eE_{II}kr$ – Kryzhanivskiy climatolith, eluvial sediments

Lower Branch (E_I)

vdE_Ibr – Berezanskiy climatolith, aeolian-deluvial sediments
$a^{10}N_2$-E_1kh – Kyzyldzharskiy ledge. Alluvial sediments of the tenth terrace

Neogene System

Pliocene Division (N_2)

N_2cp – sequence of red-brown clays

Vasylivska LTZ	*Pologivska LTZ*

Miocene Division (N_1)

Upper Sub-Division

Pontychniy regio-stage

N_1sg – sequence of parti-coloured clays **N_1pv** – sequence of sands and limestones	**N_1sg** – sequence of parti-coloured clays

Meotychniy regio-stage

N_1ak – Akmanayski Layers

Sarmatian regio-stage

Upper sub-regio-stage

N_1gl – Geliksovi Layers	**N_1gl** – Geliksovi Layers

Middle sub-regio-stage

N_1nm-vs – Novomoskovski and Vasylivski Layers undivided	**N_1nm** – Novomoskovski Layers

Lower sub-regio-stage

N_1kh-zb – Kuzhorski and Zbruchski layers undivided

Middle Sub-Division

Konkskiy regio-stage
N_1sr-kn – Sartaganski and Konkski layers undivided

Karaganskiy regio-stage
N_1kr – Kartvelski Layers

Chokrakskiy regio-stage
N_1uk – Chokrakski Layers

Tarkhanskiy regio-stage
N_1tm – Tomakivski Layers

Novopetrovskiy regio-stage
N_1pl – Poltavska Series
N_1np – Novopetrivska Suite
N_1np_3 – upper sub-suite

N_1np_2 – middle sub-suite

Paleogene System
Oligocene Division (P_3)
Upper Sub-Division
Chattian Stage

Vasylivska LTZ

Askaniyskiy regio-stage
Maykopska Series
P_3as – Askaniyska Suite

Sirogozskiy Horizon
Maykopska Series
P_3sr – Sirogozska Suite

Pologivska LTZ

Lower Sub-Division
Rupelian Stage

Molochanskiy regio-stage
Maykopska Series
P_3ml – Molochanska Suite

Planorbelloviy regio-stage
Maykopska Series
P_3bs – Borysfenska Suite

Mezhygirskiy regio-stage
Kharkivska Series
P_3jl – Yalynska sequence

Eocene Division (P_2)
Upper Sub-Division
Priabonian Stage

Alminskiy regio-stage

P_2al – Alminska Suite

Obukhivskiy regio-stage
Kharkivska Series
P_2rl – Reshetylivska sequence

Middle Sub-Division
Bartonian Stage

Kumskiy regio-stage
P_2hd – Khadzhybeyska Suite

Simferopolskiy regio-stage
P_2pg – sequence of sands and clays

Kyivskiy regio-stage
P_2kv – Kyivska Suite

Buchatskiy regio-stage
P_2bu – Buchatska Series

Lower Sub-Division
Ypresian Stage

Bakhchysarayskiy regio-stage	**Kanivskiy regio-stage**
P_2p – batch of green sands	**P_2kn** – Kanivska Series

Mesozoic Eratheme
Cretaceous System
Upper Division (K_2)

Konksko-Yalynska LTZ	*Elanchyksko-Vovchanska LTZ*
Upper Campanian sub-stage and Maastrichtian Stage undivided	
K_2ol – Oleksandrivska Suite	**K_2ol** – Oleksandrivska Suite
Santonian stage and Lower Campanian sub-stage undivided	
K_2st – Staromlynivska Suite	**K_2st** – Staromlynivska Suite
Turonian and Coniacian stages undivided	
K_2bd – Berdyanska Suite	**K_2kz** – Kozeletska Suite
Cenomanian stage	
K_2gn – Genicheska Suite	**K_2gn** – Genicheska Suite
Lower-Upper divisions undivided (K_{1-2})	
	$K_{1-2}ls$ – Lysogorska sequence
Lower Division (K_1)	
Albian stage	
K_1ln – Lunacharska Suite	
Aptian stage	
K_1gp – clayey-sandy pile	**K_1pk –** Pokrovo-Kyreivska sequence

Paleozoic Eratheme
Carboniferous System
Lower Division (C_1)
Visean stage

Konksko-Yalynska LTZ	*Kalmius-Nesvetayska LTZ*
	Olenivskiy Horizon
	C_1^2(B) – Mezhevska Suite
Tournaisian and Visean stages undivided	
Bugaivskiy and Efremivskiy horizons undivided	
	C_1^1(A) – Mokrovolnovakhska Suite

PRECAMBRIAN

Proterozoic Acrotheme

Paleo-Proterozoic Eonotheme (Kryvorozhiy) - PR_1

Middle-Dniprean area	*Pryazovian area* *Zakhidnopryazovska and Tsentralnopryazovska LTZs*
	PR_1gp – Gulyajpilska Suite PR_1gp_3 – Upper Sub-Suite PR_1gp_2 – Middle Sub-Suite PR_1gp_1 – Lower Sub-Suite

Archean Acrotheme

Neo-Archean Eonotheme (Dniproviy) - AR_3

Middle-Dniprean area	*Pryazovian area*	
Konksko-Bilozerska LTZ	*Orikhovo-Pavlogradska LTZ*	*Zakhidnopryazovska and Tsentralnopryazovska LTZs*
AR_3bl – Bilozerska Series **AR_3zz** – Zaporizka Suite **AR_3zz_2** – Upper Sub-Suite **AR_3zz_1** – Lower Sub-Suite **AR_3mh** – Mykhaylivska Suite		
AR_3kn – Konkska Series **AR_3sr** – Surska Suite **AR_3sr_1** – Lower Sub-Suite **$AR_3sr_1^5$** – fifth batch **$AR_3sr_1^4$** – fourth batch **$AR_3sr_1^3$** – third batch **$AR_3sr_1^2$** – second batch **$AR_3sr_1^1$** – first batch	**AR_3ng** – Novogorivska Sequence	

Meso-Archean Eonotheme (Azoviy) - AR_2

Konksko-Bilozerska LTZ	*Orikhovo-Pavlogradska and Zakhidnopryazovska LTZ*
AR_2bz – Bazavlutska Sequence	**AR_2tr** – Ternovatska Sequence **AR_2tr_2** – Upper Sub-Sequence **$AR_2tr_2^2$** – upper batch **$AR_2tr_2^1$** – lower batch **AR_2tr_1** – Lower Sub-Sequence **AR_2ks** – Kosivtsivska Sequence **AR_2ks_2** – Upper Sub-Sequence **AR_2ks_1** – Lower Sub-Sequence

Paleo-Archean Eonotheme (Dnistroviy) - AR_1

Konksko-Bilozerska LTZ	*Orikhovo-Pavlogradska LTZ*	*Zakhidnopryazovska and Tsentralnopryazovska LTZs*
AR_1al – Aulska Series	**AR_1vv** – Vovchanska Sequence	**AR_1dr** – Dragunska Sequence
AR_1sl(?) – Slavgorodska Sequence	**AR_1np** – Novopavlivska Sequence	**AR_1zp** – Zakhidnopryazovska Series **AR_1knk** – Kainkulatska Sequence **AR_1vt** – Verkhnyotokmatska Sequence **AR_1np** – Novopavlivska Sequence

PRECAMBRIAN

Archean Acrotheme

Paleo-Archean Eonotheme (Dnistroviy) - AR_1

Paleo-Archean stratified metamorphic rocks and products of their ultra-metamorphic transformations are most widespread Precambrian complexes over the studied map sheets, especially in the Pryazovskiy area, where the large fields of their development are mapped. In the Middle-Dniprean area they are comprised of the Aulska Series rocks occurring in the separated skialites within granitoid fields. In the Pryazovskiy area Dnistrovian rocks constitute the pre-greenstone granulite-gneiss tectonic level, which, in turn, is divided in two tectonic sub-levels – lower granulite-basite and upper quartzite-gneiss (leuco-granulite). The central part (almost entire territory of the map sheet L-37-I (Pology)) of the Pryazovskiy area – Gaychurskiy Block, defined by the authors as Zakhidnopryazovska LTZ, is composed of the rocks of lower tectonic sub-level only which correspond to Zakhidnopryazovska Series including Verkhnyotokmakska and Kainkulatska sequences. The envelope of Gaychurskiy Block is mainly composed of the upper tectonic sub-level rock associations which overlie the rocks of the lower one. The western (eastern part of the map sheet L-36-VI (Zaporizhzhya)) and northern Block envelopes are known as Orikhovo-Pavlogradskiy synclinorium or the same-named LTZ, and the south-eastern envelope corresponds to the western margin of Tsentralnopryazovskiy synclinorium or the same-named LTZ. In the first LTZ the rocks of Vovchanska Sequence are being mapped, and in the second one – the same-aged rocks of Dragunska Sequence (see "Geological Map of Crystalline Basement" and associated "Schemes of Stratigraphic Zonation").

Konksko-Bilozerska LTZ

Aulska Series (AR_1al)

In the studied area the Series includes the rocks conventionally ascribed to Slavgorodska Sequence. Their tectonic setting in the cores of granitoid domes and single isotopic dating of Dnipropetrovskiy Complex granitoids and Konkska Series meta-volcanics in the area of Bilozerska greenstone structure suggest for Paleo-Archean age of the Sequence. However, the mapped rock association does not strictly correspond to the stratotype columns of Slavgorodska Sequence by composition and metamorphic degree. Taking into account that Tomakivska Sequence of this Series also display considerable differences and mainly constitutes brachy-syncline structures, the correlation of mentioned rocks with Slavgorodska Sequence seems to be more reliable.

Slavgorodska Sequence ($AR_1sl(?)$)

The Sequence metamorphic rocks are observed in various by shape and size skialites within granitoids of the Middle-Dniprean area. The biggest ones are being mapped in the linearly elongated bodies up to 6-20 km long and up to 1-3 km wide in the envelope of Skelkskiy massif in the south-western part of the map sheet L-36-VI (Zaporizhzhya). The Sequence is composed of biotite, amphibole-biotite and amphibole gneisses, rarely amphibolites. The latter are found in the thin remnants within granitoids and in the interbeds within gneisses.

The rocks throughout are extensively granitized and form substratum in plagiomigmatites of Dnipropetrovskiy Complex being often connected to them with gradual transitions. Altogether they comprise the consolidated base (proto-crust) on top of which incipient development of greenstone belts occurred.

Amphibolites and allied amphibole gneisses seemingly are derived from the mafic and intermediate volcanics metamorphosed under PT-conditions of amphibolite facies, evidenced by their chemical composition [67, 68, 76]. The primary nature of biotite gneisses is not clear although in places they are tightly associated with amphibolites and apparently they comprise the strongly granitized varieties of the latter.

The Slavgorodska Sequence rocks display increased density (gneisses – 2.72-2.8 g/cm^3, amphibolites – 2.85-3.0 g/cm^3) and often magnetic susceptibility providing contrasted expression in the physical fields with anomalies up to 0.5-1.0 mGal and 200-400 nTl.

Orikhovo-Pavlogradska and Zakhidnopryazovska LTZs

Zakhidnopryazovska Series (AR_1zp)

Metamorphic rocks of the Series are encountered in Orikhovo-Pavlogradska and Zakhidnopryazovska LTZs of the Pryazovskiy area. In the latter LTZ they are developed in Gaychurskiy Block (IIIrd order Gulyajpilskiy and Remivskiy blocks). The first one does correspond to the syncline (Pologivska) and the second one – the same-named anticline structures. In Orikhovo-Pavlogradska LTZ the Series rock paragenesises constitute Novopavlivska anticline (block) structure and the cores of higher-order anticlines.

Three sequences are distinguished in Zakhidnopryazovska Series (upward): Novopavlivska, Verkhnyotokmatska and Kainkulatska. The first one is known in OP LTZ only while two others are developed to the east in ZP LTZ. The contacts between the first and two other sequences are not encountered. In Konksko-Yalynska depression, where the Series rocks are overlain by the thick (up to 550 m) sedimentary sequence, it is weakly studied and not subdivided.

The rocks of Zakhidnopryazovska Series are strongly granitized, especially the gneiss piles included.

Novopavlivska Sequence (AR_1np)

The Sequence is defined in the same-named block of Orikhovo-Pavlogradskiy Synclinorium (OPS) (Meeting of NSC, Ternopil, 1991). Later large fields of this Sequence were mapped to the south and recently also to the north and north-east from Novopavlivskiy Block [88, 104, 116] (see "Geological Map of Crystalline Basement).

The major rock types of the Sequence include two-pyroxene (often with garnet) amphibolites; pyroxene-amphibole mafic gneisses; biotite, garnet-biotite, sillimanite-garnet-biotite, amphibole, pyroxene-amphibole, two-pyroxene, hypersthene, garnet-amphibole-pyroxene gneisses; minor interbeds of pyroxene-magnetite quartzites, ironiferous-magnesium rocks or "skarnoids" and actinolitites. In the eastern part of OP LTZ amphibole-biotite and biotite gneisses predominate with interbeds of garnet-bearing amphibolites. In the western part the column is more variable. The rocks of mafic composition alternate with the aluminous gneisses and schists over there.

The Sequence rocks are being mapped in the remnants of the north-eastern extension in the plagiomigmatite fields. Thickness of the biggest ones does not exceed 2000 m and length – 20 km. In all directions they plunge underneath the rocks of Vovchanska Sequence; in the west they are overlain by the meta-mafic rocks of Novogorivska Sequence and are bounded by the Orikhovo-Pavlogradskiy Fault. In the east Novopavlivska Sequence through the migmatite fields is in contact with the meta-mafic rocks of Kosivtsivska Sequence and meta-sediments of Ternovatska Sequence, as well as the rocks of Verkhnyotokmatska and Kainkulatska sequences. It is not excluded that in the north-east by lateral they are changed by undivided rocks of Zakhidnopryazovska Series in Remivskiy Block. The rock dipping is mainly to the east at the angles from 80 to 45^o; in Vovchanskiy Block – diverse-oriented and more flat.

Because of the rock high density (2.8-3.18 g/cm^3 of meta-basites and up to 2.88 g/cm^3 of gneisses) and magnetic susceptibility (up to 22000 χ ($4\pi\times10^{-6}$ CI units)) the Sequence is expressed by the linear positive gravity anomalies up to 0.4-3.5 mGal and anomalous magnetic field from 100 to 3000 nTl (see "Map of Anomalous Magnetic Field" and "Map of Residual Gravity Anomalies" in the scale 1:500 000).

The author A.I.Nekryach has encountered the regular alternation of the Sequence rocks at the outskirt of Vasylkivka village (Bila Skelya gully). It consists of two- and three-component rhythms. Normally the rhythm base is composed of amphibolite, often garnet- and pyroxene-bearing, rarely amphibole-biotite or pyroxene-amphibole-biotite gneiss, and much rarely of garnet-sillimanite-biotite gneiss with high (up to 50%) quartz content – actually quartzite-schist. Upper components include biotite and garnet-biotite gneisses. In the three-component rhythms the second and third members are comprised of garnet-biotite and biotite gneisses respectively.

The boundaries between the petrographic rock varieties not always are clear and often the rocks are connected by gradual transitions and differ one from another in mineral content only. In the geological map these rocks are mainly shown as undivided units.

The ferruginous rocks of volcanogenic-metasomatic origin are observed in the lens-like and sheet bodies of various thickness (0.4-40 m) and length (up to 3 km). In places the series of contiguous layers up to 100 m thick and more occur. Mineral composition of the rock varieties is fairly variable; the varieties from distinct magnetite-pyroxene-amphibole-garnet schists or "skarnoids" to the typical pyroxene-magnetite quartzites are distinguished. Often quartzites are gradually changes by "skarnoids" and amphibolites.

Further subdivision of the Sequence into more detailed units is precluded by strong enough tectonic fabric in OP LTZ. The stratotype section of the Sequence is taken rather unsuitably since it is located in the zone of extensive tectonic influence of Orikhovo-Pavlogradskiy deep-seated fault where tectonic overprinting between the Sequence rocks and high-alumina rocks of Vovchanska Sequence and mafic-ultramafic rocks of Novopavlivskiy Complex is often observed.

The rocks of Novopavlivska Sequence initially were metamorphosed under granulite facies PT-conditions of regional metamorphism (mineral assemblage – ferrohypersthene-quartz-labrador-bitovnite) and later essentially retrograded under PT-conditions of amphibolite and epidote-amphibolite facies.

The upper age boundary of the Sequence (3650 Ma) is set after the age of mafic-ultramafic rocks from Novopavlivskiy Complex which are associated with the Sequence rocks and often cut them [41]. It is supported by the age of enderbites from Novopavlivskiy granitoid complex – 3470-3370 Ma (Shcherbak, Esypchuk, 1993) and tonalites from Bila Skelya gully (Artemenko, 2001) formed through the granulite ultra-metamorphism of the Sequence rocks and the same-named mafic-ultramafic complex. The mafic rocks in the Sequence and in the Complex are comagmatic [67, 70]. The lower age boundary, according to some authors, attains 3800 Ma.

Verkhnyotokmatska Sequence (AR_1vt)

The Sequence rocks in the map sheet L-37-I (Pology) are confidently distinguished in the southern part of Gaychurkiy Block, in the zone of Prakonkskiy regional fault. The stratotype is described in the upper course of Tokmak River (in 6 km to the south of the map sheet margin) and is accessible for observation.

In the southern part of Remivskiy Block (map sheet L-37-I, square IV-4) the Sequence is mainly composed of biotite-amphibole, pyroxene-amphibole, rarely biotite gneisses and amphibolite interbeds. To the west the rocks are substituted by biotite-amphibole diorite-like migmatites of Novopavlivskiy Complex, and in the east and south they are unconformably overlain by the rocks of Late Paleo-Archean Dragunska Sequence. The rock strike is normally sub-longitudinal with minor deviations to the east and west. To the north of Konkskiy Fault the Sequence rocks are traced in magnetic field by linear anomalies up to 600-700 nTl as the undivided rocks of Zakhidnopryazovska Series. The rock dipping is steep – 70-90^o (rarely 40-50^o).

The internal structure of the Sequence is complex enough. The frequent alternation of the rocks both in vertical and lateral directions is observed. The layer boundaries are either sharp or gradual often obscured by granitization processes. By mineral composition and numeric relations of mineral the Sequence rocks can be conventionally subdivided into three groups.

The first group includes amphibolites and pyroxene-amphibole-plagioclase, amphibole-two-pyroxene and two-pyroxene-amphibole-plagioclase mafic gneisses. The second group includes the rocks of intermediate composition – pyroxene-amphibole and amphibole gneisses and mafic gneisses which only differ in quartz content and pyroxene replacement degree. The rocks often contain amphibolite interbeds with the gradual contacts. Part of these rocks had formed through ultra-metamorphism of meta-basites or comprises gneissosed diorites, enderbites or tonalites with the contact relationships similar to above. The third group consists of biotite plagiogneisses which predominate in the column. Most of these rocks transformed into gneissose plagiogranitoids through ultra-metamorphism.

The granulite mineral assemblages in the rocks and their association with enderbites, diorites and tonalites of Novopavlivskiy Complex provide the characteristic features.

Petrochemical features of the rocks and reconstruction of their primary composition [47-49, 58, 71] suggest for the igneous nature of most amphibolites and mafic gneisses, and mixed (sedimentary-magmatogenic) origin of the intermediate and felsic rocks.

The limited distribution scale, spatial discontinuity and extensive granitization complicate the studies of Sequence column. In general, it is characteristic the gradual upward increasing of the gneiss amounts and, respectively, sedimentary rocks.

Paleo-Archean age of the Sequence is determined on the ground of its relationships with the rocks of Meso-Archean Kosivtsivska and Ternovatska sequences and Dobropilskiy Complex, as well as compositional correlation of granulite paragenesises with other Early-Archean complexes [29].

In Gulyajpilskiy Block the rocks of Verkhnyotokmatska Sequence, which constitute the south-western closure and the north-eastern limb of Pologivska syncline (the core and south-western limb are almost completely replaced by plagiogranitoids of Shevchenkivskiy and Novopavlivskiy complexes), display appearance somewhat different from its known granulite petrotype. These include amphibolites, actinolitites, tremolitites, biotite-amphibole and biotite gneisses as well as sheets and lenses of amphibole-magnetite quartzites with the mineral assemblages of amphibolite metamorphic facies.

Despite of the authors' opinion differences [48-50, 58, 71, 73, 113, 115] concerning the stratigraphic position of the Sequence, all the authors consider the Sequence as the counterpart of Zakhidnopryazovska Series. Its ascription to Verkhnyotokmatska Sequence logically follows its tectonic setting (in the limbs of Pologivska syncline), high mafic coefficient of the column (mafic and ultramafic rocks comprise from 32 to 42% by volume in total, and together with the rocks of intermediate composition – up to 60% [73]), radiological age of the Dobropilskiy Complex diorites (3280-3310 Ma [71, 73]) which occur in the cutting relations with the Sequence rocks, the higher degree of its secondary modifications by ultra-metamorphic processes in comparison to the almost unaltered meta-volcanics of the overlaying Kosivtsivska Sequence. The petrographic differences of the Sequence rocks from the Verkhnyotokmatska Sequence stratotype are explained by the rock extensive dynamic metamorphism in the Dobropilsko-Sorokynska fault zone with subsequent metamorphism and ultra-metamorphism under amphibolite facies PT-conditions in the time of Kosivtsivska and Gaychurska structures development (see "Geological maps of crystalline basement" for the studied map sheets).

The Sequence rocks are being mapped in comparatively large extensively granitized linear remnants within plagiogranitoids. Their strike changes from the north-western to north-eastern. In the horizontal projection they are observed in the arch with the north-westward oriented convex. Rock dipping is steep (60-80^{o}), centriclinal.

Petrophysical properties of the Sequence rocks are almost the same of the rocks from Novopavlivska Sequence although the rocks of Verkhnyotokmatska Sequence are a bit more magnetic in comparison to the latter; this is expressed in the physical fields where the Sequence is clearly expressed by the linear contrasted magnetic anomalies up to 300-500 nTl, and above the ferruginous quartzite beds – up to 10 000 nTl, and by residual gravity anomalies 0.2-0.9 mGal.

V.M.Kinshakov divides the Sequence into the lower and upper sub-sequences. In the first one the gneisses predominate while in the second one – the amphibolites. Thickness of the lower sub-sequence is 2650 m, upper one – 2800 m, and the total thickness – 5450 m. The visible thickness of the north-eastern syncline limb composed of the Sequence rocks attains 10-11 km. According to the author [73], in the studied basic Sequence column (by drill-hole cores) by the line Zatyshok-Staroukrainka villages the section twinning is observed due to isocline folding of the rocks.

Detailed studies of the Sequence layering had revealed the rhythmic alternation of essentially ultramafic-mafic batches, from 200, rarely 500, to 750 m thick, and essentially gneiss ones – from 270 to 800 m thick. In total, five such "rhythms" are observed [50]. At the bottom the felsic batches are encountered. In case of the normal layering (without folding) from 10 to 11 such "rhythms" are observed across the strike and then the Sequence thickness rises to 11 km. Higher in the column (toward the core of Pologivska syncline) it is supposed its stacking with essentially gneiss rocks (probably, those of Kainkulatska Sequence (?)) replaced by plagiogranitoids.

As it is revealed from the petrochemical analysis [71, 73], the mafic Sequence members are of unequivocally igneous origin and are treated to be basalts, tholeiites, spilites and websterites of komatiite-tholeiite trend; plagiogneisses – dacite-andesite extrusives and tuffs and sedimentary rocks. In general, volcanics predominate in the Sequence. Geochemical features of biotite gneisses and amphibolites are similar and suggest for their formation from the single magma source. Actinolitites display similarity with ultramafic rocks of Kosivtsivska Sequence in Gaychurska structure. According to S.I.Pereverzev, petrochemical features of the

Sequence rocks are similar to the respective rocks of Novopavlivskiy mafic-ultramafic complex. All mentioned above suggest for the formation of most meta-basites in the area from the single long-lived igneous source.

In general, the Pologivska syncline can be considered as the oldest in Ukrainian Shield Paleo-Archean "primary greenstone belt". It is also supported by the rock association affinity which corresponds to the granitized dacite-andesite-tholeiite and jaspilite-komatiite-tholeiite rock associations [73]. In view of location the Kosivtsivska, Gaychurska and Gulyajpilska structures over there, Gulyajpilskiy Block comprises long-lived (Paleo-Archean – Paleo-Proterozoic) Zakhidnopryazovska granite-greenstone terrain. The similar rocks (with the age 3600-3500 Ma) underlie the Meso- and Neo-Archean greenstone sequences in South Africa (Swaziland) and Western Australia (Kalgoorlie) and are interpreted to be the oldest greenstone belts [28].

Kainkulatska Sequence (AR_1knk)

The Sequence rocks are mapped in the south-western part of Gulyajpilskiy Block. From the west they are bounded by Korsatskiy, and from the north – by Pologivskiy regional faults. In the east they are replaced by granitoids of Novopavlivskiy and Shevchenkivskiy complexes. The Sequence rocks are in tectonic relationships with meta-volcanic rocks of Verkhnyotokmatska Sequence in Pologivska syncline. As noted above, the Sequence rocks are extensively migmatized and are only preserved in separated lenses and sheet bodies within granitoids of Novopavlivskiy, Remivskiy and Shevchenkivskiy complexes. The strike of these remnants is close to sub-longitudinal. The dipping is steep (60-90^o) and mainly to the east. Thickness of the Sequence is estimated to 4 km [40].

In contrast to Verkhnyotokmatska Sequence, Kainkulatska Sequence is essentially gneiss in composition; it is expressed by the negative field values in gravimagnetic maps or displays the slight linear anomalies in the magnetic field. The remnants are mainly composed of biotite, amphibole-, rarely pyroxene- and garnet-biotite plagiogneisses with rare thin interbeds of amphibolites and ferruginous quartzites. The rocks are metamorphosed under granulite facies PT-conditions, and retrograded under amphibolite facies.

Petrochemical and geochemical data [48, 58, 71] allow conclusion for the sedimentary origin of the most Sequence rocks with minor volcanics.

Paleo-Archean (3650 Ma) age of the Kainkulatska Sequence rocks is estimated by the authors on the ground of the same facts considered for the Verkhnyotokmatska Sequence. Direct age determinations on zircon from metamorphic rocks yield 2660-2940 Ma values suggesting for their granitization in the Late Archean time.

Zakhidnopryazovska Series undivided

Undivided rocks of Zakhidnopryazovska Series are being mapped in Remivskiy Block by the single drill-holes over the remnants within Novopavlivskiy Complex granitoids and together with the latter they constitute the Novopavlivska and Morkoyalynska anticlines and Krutoyarivska syncline. The remnants strike is mainly sub-longitudinal and is well enough expressed in magnetic field which in the north of the Block turns to the north-western up to sub-latitudinal. In the axial central part of the Block the linear magnetic anomalies are arranged in the oval structures where magnetic field magnitude is decreased apparently due to the development of more felsic gneiss complexes. Biotite and rarely amphibole- and garnet-biotite gneisses are intersected by drill-holes over there which is characteristic for the column of Kainkulatska Sequence and affirms the tectonic assumptions (definition of Krutoyarivska syncline). The rock dipping is variable, from sub-vertical to flat (20-30^o) in the fold cores. Besides the mentioned gneisses, the Series in the Block also includes pyroxene-amphibole, pyroxene-biotite gneisses and amphibolites.

In the east of the Block the mentioned rocks are overlain by Dragunska Sequence. In the north they are in tectonic contact with the rocks of Novopavlivska Sequence. In the area of Uspenivska brachy-syncline (square II-2) the tectonic and stratigraphic unconformable laying of Vovchanska Sequence over the Series rocks is mapped. In the western and north-eastern parts of the Block the undivided Series rocks are unconformably overlain by the rocks of Meso-Archean Kosivtsivska and Ternovatska sequences. In the junction zone of Remivskiy and Gulyajpilskiy blocks the Series rocks are intruded by diorites and tonalites of Dobropilskiy Complex with the age of 3310-3140 Ma supporting their Paleo-Archean age.

Orikhovo-Pavlogradska LTZ

Vovchanska Sequence (AR_1vv)

The Sequence rocks are encountered in Orikhovo-Pavlogradska LTZ of Pryazovian Mega-Block where, together with Novopavlivska Sequence granulite complexes of Zakhidnopryazovska Series, they constitute the

same-named synclinorium extended in the sub-longitudinal direction along the same-named deep-seated fault, and two IIIrd order blocks adjacent to this fault: Vovchanskiy in the north and Korsatskiy in the south.

In spite of the long enough period of studies in Orikhovo-Pavlogradska LTZ, the actual study degree of this zone, except some areas (Novopavlivska, Vasynivska, Pivnichnotersyanska and Pivdennotersyanska), remains fairly weak precluding the detailed column of the Sequence design and its subdivision. Previously offered subdivision versions (B.Z.Berzenin, V.F.Kiktenko, A.I.Nekryach) are imperfect and do not allow the mapping of the offered subdivisions. At the best of present knowledge just the quantitative prevailing of some petrographic varieties over various column parts can be stated confidently. The subdivision is strongly complicated by the complex internal structure of the OP LTZ which is not deciphered yet.

The Sequence rocks constitute the central and northern parts of the territory and in the continuous 14-28 km wide band are extended along the eastern margin of the L-36-VI map sheet. In the north of L-37-I map sheet the rocks are split into the western and eastern batches. The first one enters the north-western corner and gets sub-longitudinal strike. The second one, upon flexure turn, gradually changing its strike to sub-latitudinal one, surrounds Zakhidnopryazovskiy Block from the north and constitutes the southern part of Vovchanskiy Block, where diverse-oriented and chaotic strike of the beds is observed.

The rock dipping is also variable in different areas. It is steep (60-80^{o}), mainly eastern in Orikhovo-Pavlogradskiy synclinorium. In Vovchanskiy Block the flat brachial folding and respective rock dipping is observed. In general, Vovchanskiy rock complex comprising the upper portion (sub-level) of the Paleo-Archean granulite-gneiss complex, gently plunges to the north where it almost completely overlies the lower Zakhidnopryazovskiy sub-level. In the southern part of the studied area it is preserved from erosion only in the cores of the narrow linear syncline folds separated by the granitoids of Novopavlivskiy Complex with the remnants of Zakhidnopryazovska Series. By geophysical data, the total thickness of these rocks is 2-3 km in the area of Orikhiv town. In the north it gradually increases to 4500 m and in Vovchanskiy Block is 0.5-1.5 km. The true thickness of Vovchanska Sequence in the area of Vasylkivka village, by the data of the same-named drill-hole profile and exposures along Vovcha River [99], is 600 m. In the studied area the Sequence thickness is estimated to 2000 m.

Relationships of the Vovchanskiy rock complex with the overlaying and underlaying units are being defined only by the indirect data, except Uspenivska syncline where stratigraphic and tectonic unconformable contact with the underlaying Zakhidnopryazovskiy complex is encountered by drill-holes. Throughout the rocks are separated by tectonic breaks and granitoid fields. However, tectonic relationships suggest for the clear discontinuity with the lower complex. Commonly Vovchanskiy and Zakhidnopryazovskiy (Novopavlivskiy) complexes are tectonically conformable.

The rock composition of Vovchanska Sequence is fairly variable. The garnet-, sillimanite- and graphite-bearing biotite gneisses predominate in the column. The “barren” and ferruginous quartzites constitutes considerable fraction of the column. Association of the latter rocks with aluminous gneisses provides the distinct petrotype of the Sequence. Amphibolites, pyroxene-amphibole and amphibole-biotite gneisses are less characteristic. On the ground of the lateral facial variability analysis the differences in the Sequence structure in Orikhovo-Pavlogradskiy synclinorium and Vovchanskiy Block can be confidently argued. In the latter case the biotite gneisses predominate while amphibole- and garnet-biotite varieties are subordinate. In the far southern Block part amount of pyroxene- and garnet-bearing amphibolites and amphibole schists increases. The column “diversity”, thickness and amount of high-alumina gneisses and quartzites gradually increase in the western direction where the column gets the petrotype appearance (to the west of Chaplynskiy Fault). The similar relations are observed in Orikhovo-Pavlogradskiy synclinorium (eastern part of L-36-VI map sheet). Taking into account that the latter contains the core section and the eastern limb only, and that Vovchanskiy Block comprises the fragment of the synclinorium eastern flat limb, it is supposed that the rocks developed in the eastern limb of synclinorium and in Vovchanskiy Block comprise the lower portion of Vovchanska Sequence, and the rocks developed in the synclinorium core – the upper portion.

The Sequence column displays the internal regularity. In the outcrops along Vovcha River, nearby Vasylkivka village, V.F.Kiktenko [69] notes the rhythmic structure of the gneiss sequence. The first-order rhythms are 45-50 cm thick. Their base is composed of roughly-grained meta-sandstones with inclusions of quartz gravel and the central part of the rhythms – of coarse-grained meta-sandstones. The rhythms are completed by the layers of biotite gneisses (meta-pelites). The higher-order rhythms 80-100 m thick are also encountered.

According to A.I.Nekryach [99], the variable portion of Vovchanska Sequence is composed of two- and (mainly) three-component rhythms. At the rhythm base the feldspar and ferruginous quartzites, garnet-, sillimanite- and magnetite-bearing quartzite-schists and mafic gneisses, rarely garnet-sillimanite-biotite and sillimanite-biotite gneisses are observed. The middle members of three-component rhythms commonly include garnet-sillimanite gneisses or mafic gneisses. The upper ones in the both rhythm types are composed of garnet-

biotite and garnet-bearing biotite gneisses, often highly granitized; in single cases the rhythm is stacked up with amphibolites or mafic gneisses. A.I.Nekryach counts nine first-order rhythms from part of meters to first tens of meters thick.

Petrographic, petrochemical and geochemical characteristics of the Sequence rocks are given in the numerous reports [45, 49, 50, 67-71, 99] and publications [30, 31]. The primary nature of the rocks is reconstructed on this ground. Most of these rocks are thought to be meta-sedimentary. Amphibolites and gneisses of mafic and partly intermediate composition apparently are developed after meta-volcanics while amphibolites within clearly meta-sedimentary rhythms comprise the para-rocks (marls). Petrophysical properties of the rocks: density varies from 2.69 (biotite gneisses), 2.71 (barren quartzites) to 2.85 (garnet-biotite, garnet-sillimanite gneisses); 2.94-3.01 (high-alumina gneisses and amphibolites) and 3.34 g/cm^3 (magnetite quartzites). Magnetic susceptibility: from 86 (garnet-sillimanite gneisses) to 41900 χ ($4\pi\times10^{-6}$ CI units) (magnetite quartzites).

Mineral assemblages in the rocks of Vovchanska Sequence suggest for two-stage metamorphism: prograde under granulite facies PT-conditions and further retrograde – under amphibolite facies conditions. Development of the Sequence was accompanied by granulite ultra-metamorphism resulted in formation of enderbites, diorites, tonalites and garnet- and sillimanite-bearing plagiomigmatites. At least two further stages of ultra-metamorphism are supposed and almost throughout the Sequence rocks were transformed into granitoids, especially the lower batch in Vovchanskiy Block. In Orikhovo-Pavlogradskiy synclinorium the sites composed of the upper "complex" batch rocks are more preserved.

Paleo-Archean age of the Vovchanska Sequence rocks is defined on the ground of isotopic studies of ultramafic rocks and granitoids of Novopavlivskiy Complex (3470-3370 Ma) (Artemenko, 2001 [70]) which cut the alumina-quartzite complex or are developed after it. Received values provide the upper time boundary of the Sequence.

It is supported by the unconformable laying of Kosivtsivska Sequence meta-volcanics and Ternovatska Sequence meta-sediments in relation to the aluminous rocks of Vovchanska Sequence (Chystopilska riftogenic greenstone structure).

The Sequence rock composition is confidently correlated with leuco-granulite (high-alumina-quartzite and khondalite) Paleo-Archean rock associations of Dragunska Sequence in Central Pryazovya.

Tsentralnopryazovska LTZ

Dragunska Sequence (AR_1dr)

Metamorphic rocks of Dragunska Sequence are encountered in the far eastern and in the southern parts of map sheet L-37-I (Pology) in the narrow band 2-8 km wide. In tectonic respect they constitute the lower portion of Tsentralnopryazovska LTZ (synclinorium) and Bilotserkivska syncline (second-order structure of Tsentralnopryazovska LTZ) (see "Scheme of tectonic zonation" to the "Map of crystalline basement").

It is composed of high-alumina rocks (garnet, garnet-biotite, sillimanite with corundum, graphite) and biotite, amphibole-biotite plagiogneisses with interbeds of diopside-amphibole and two-pyroxene gneisses and garnet-bearing mafic gneisses, single 2-3 m thick amphibolite lenses.

In the south the Sequence rocks with clear tectonic and angular discontinuity lie over the rocks of Zakhidnopryazovska Series. In the east, where the rocks are intersected by some drill-holes and are mapped mainly by geophysical data, the conformable laying is observed. Further to the east the rocks are overlain by meta-sediments of Neo-Archean Tsentralnopryazovska Series. In the south-eastern corner of the map sheet L-37-I the facial transition is anticipated between the rocks of Dragunska and Vovchanska sequences buried beneath the rocks of Ternovatska Sequence and intruded by granites of Yanvarska association. In term of rock association, the Sequence rocks alike Vovchanska ones do correspond to leuco-granulite and khondalite rock associations [19, 20, 50]. In contrast to the Vovchanskiy rock complex, Dragunska Sequence rocks are much less retrograded. In the mineral assemblages of the aluminous batch spinel and corundum are encountered. In some places corundum content attains economic grades.

In general, the column of Dragunska Sequence is similar to the lower gneiss batch of Vovchanska Sequence.

Meso-Archean Eonotheme (Azoviy) (AR_2)

Meso-Archean rocks in the studied area comprise the early greenstone tectonic sub-level in the folded crystalline basement and include Bazavlutska Sequence in the Middle-Dniprean area and Kosivtsivska and Tarnovatska sequences in the Pryazovskiy area. In contrast to the Paleo-Archean level, the Meso-Archean rocks

are developed in the local superimposed structures confined to the major tectonic breaks and often are located at the LTZ boundaries (Fedorivska brachy-syncline, north-western part of Gaychurska structure – Ternovatska monocline) or blocks – Kosivtsivska monocline.

Konksko-Bilozerska LTZ

Bazavlutska Sequence (AR_2bz)

The Sequence rocks are encountered mainly in the east, rarely to the east of Konkska greenstone structure. The minor (from 3-5 to 10 km^2) sites of amphibolite development within Dnipropetrovskiy Complex plagiogranitoids predominate. Of these the biggest ones are being mapped in the southern part of Kupriyanivskiy Dome (northern part of the first-order Kamyshuvakhskiy Dome) to the north from Shcherbakivskiy massif. Amphibole, biotite-amphibole and biotite gneisses predominate in the remnants over the marginal parts of the field (in the west and east) and in the thin interbeds in amphibolites.

The Sequence relationships with the underlaying stratified complexes are not defined. And tectonic discontinuity with meta-volcanics of Konkska Series is observed along Vasylivsko-Kamyshuvakhskiy Fault.

In petrophysical respect the Sequence mafic rocks are non-magnetic or slightly-magnetic high-density rocks – 2.9-3.2 g/cm^3 (amphibolites). In magnetic field they are commonly "transparent" and in the gravity field they are expressed by contrasted residual anomalies up to 3-5 mGal (see "Map of anomalous magnetic field" to the "Geological map of crystalline basement" and "Map of gravity field residual anomalies").

The rock metamorphic degree corresponds to the amphibolite facies PT-conditions.

In the marginal parts of the development field the rocks are extensively migmatized by plagiogranitoids of Meso-Archean Dnipropetrovskiy Complex, and the field itself is intruded by granites of Neo-Archean Mokromoskovskiy and Tokivskiy complexes (see Section 3 "Non-Stratified Units"). These relationships provide the ground for the Sequence Meso-Archean age considerations.

Thickness of the Sequence is 2000 m roughly.

Orikhovo-Pavlogradska and Zakhidnopryazovska LTZs

Kosivtsivska Sequence (AR_2ks)

The Sequence rocks in the studied area are encountered in Orikhovo-Pavlogradska LTZ and in Zakhidnopryazovskiy (Gulyajpilsko-Saltychanskiy) Block where these rocks constitute Chystopilska, Kosivtsivska and Gaychurska fault-side monoclines.

The Sequence column is most studied in the north-western part of Kosivtsivska greenstone structure [73] where the lower and upper sub-sequences are distinguished. In other structures the Sequence meta-volcanics are being mapped undivided. Kosivtsivska greenstone structure is extended in the north-western direction and is confined to the north-eastern edge of Gaychursko-Sorokynska fault zone comprising the inter-block monocline. The Sequence rocks dip at the angle 65-70° to the south-west, beneath the fault. The north-western flank of structure is sharply cut by Andriivskiy Fault. To the south, from the junction point of Andriivskiy and Gaychurskiy faults, the minor area is mapped of upper sub-sequence meta-tholeiites which unconformably overlie the rocks of Verkhnyotokmatska Sequence. Apparent dipping in this site is north-eastern.

The column of upper Kosivtsivska sub-sequence is fairly uniform, mainly amphibolite (meta-basalt) with minor actinolitite interbeds. The lower sub-sequence is mainly composed of meta-komatiites (serpentinites, actinolitites and tremolitites). Rarely meta-basalt (amphibolite) interbeds are observed.

The Sequence rock composition and structure-texture patterns suggest for their affinity to the meta-komatiite-tholeiite rock association characteristic for the early greenstone stages of Precambrian evolution [18].

The *lower meta-komatiite sub-sequence* conformably (DH 751 [73]) lies over the Remivskiy Complex plagiomigmatites (by geophysical data, to the north-east from this drill-hole relationships become sharply cutting) and is also conformably overlain by meta-tholeiites of the upper sub-sequence but is in tectonic contact with the rocks of Ternovatska Sequence. The intersected thickness of the sub-sequence is 210 m.

Meta-komatiites are extensively serpentinized, actinolitized, tremolitized, carbonatized, chloritized and phlogopitized, grey and dark-grey coloured with greenish shade, fine- and medium-grained. Structure is massive, spotty, gneissose-schistose, porphyry, loopy. Olivine and pyroxene are idiomorphically replaced by the secondary minerals and are preserved partly only. The primary spinifex-textures (platy, radial and needle spinifex or their combination) are well highlighted by the fine-aggregate magnetite. By structure-texture patterns O.B.Bobrov [68] had distinguished 21 differentiated komatiite flows. Thickness of individual flows attains 16.7

m. The fully-differentiated flows predominate with the basal or cumulative, transitional and upper spinifex-textured zones.

By chemical composition the flows are differentiated from high-magnesium (peridotite) komatiites (cumulative zone) to low-magnesium pyroxenite (spinifex-textured zone) komatiites. By petrochemical features the rocks are transitional between Barberton (Africa) komatiites and most widespread rocks of komatiite series (Canada, Australia, Zimbabwe). In term of chemistry they are also similar to meta-komatiites of the Middle-Dniprean area.

Meta-basalts are comprised of amphibolites similar to the upper sub-sequence.

The upper sub-sequence is mainly composed of diopside-plagioclase-amphibole schists and amphibolites and is more widely distributed. Rarely ultramafic interbeds are observed. The column is uniform enough and is only complicated by the numerous (up to 25-30% by volume) conformable, rarely discordant plagiogranites and quartz porphyry dykes of Dobropilskiy and Shevchenkivskiy complexes. Thickness of the column in the north-western part of Kosivtsivska greenstone structure is 1080 m and in the south-eastern part it does not exceed 250 m (at the southern margin of the map sheet L-37-I-D).

The contact of meta-basalts with gneisses of Zakhidnopryazovska Series (DH 802 [73]) is discontinuous. In the contact zone the meta-basalts are slightly granitized. The contacts with the younger rocks are tectonic.

Characteristic column of the sub-sequence is intersected by DH 741 and 742 [73] to the east of Kosivtsive village. Macroscopically the rocks exhibit the distinct fine-banded "quartzite-like" appearance allowing their confident mapping. Rock colour is dark-grey and greenish-grey. Petrophysical properties: meta-komatiites – density 2.9 g/cm^3, magnetic susceptibility 7000 χ ($4\pi\times10^{-6}$ CI units); meta-basalts – density 2.99 g/cm^3, magnetic susceptibility 263 χ ($4\pi\times10^{-6}$ CI units).

By petrochemical features, amphibolites correspond to the tholiite basalts of komatiite-tholeiite trend or to the oceanic mid-ocean ridge basalts. Ultramafic rocks by all features (except structure-texture) correspond to meta-komatiites of the lower sub-sequence [73].

To the south-east from Kosivtsivska greenstone structure, in the south-eastern part of Gaychurska greenstone structure, in Ternovatsko-Kuybyshevska fault zone (in the junction zone of the latter with Gaychurskiy Fault), three linear sites of undivided Kosivtsivska Sequence rocks are mapped. The first one – Western, 15 km long, is confined to the north-west-trending fault that complicates Gaychurskiy Fault and occupies transitional position between Gaychurska and Kosivtsivska greenstone structures. The second one – Eastern, 39 km long, is extended in the narrow strip 150-500 to 1500 m wide, along Ternovatsko-Kuybyshevskiy Fault from its eastern side. The third one – Skhidnouspenivska, least lengthy (5.5 km), is located in the eastern limb of Gaychurska structure, at its turn (the strike is changed from north-western to the west-north-western). The second and third sites are separated by the strip of Ternovatska Sequence terrigenous rocks. Their tectonic relationships suggest for the older age of meta-volcanics in the third site which lie over the gneisses of Zakhidnopryazovska Series. Overlaying ("cutting") the meta-volcanic sequence by the rocks of Ternovatska Sequence suggest for the slight tectonic (angular) discontinuity between them. Thickness of the sequence varies from 40 to 315 m. Rock dipping is steep (60-70^o), western.

At the column base in Skhidnouspenivska site the batch (lower) of alternating amphibolites and ultramafites (actinolitites and tremolitites) is observed, from 200 m thick in the south to 10 m in the north-west. Higher in the column more felsic batch (upper) is mapped composed of the cyclic intercalation of biotite and amphibole-biotite schists and amphibolites. In places undivided ultramafic rocks are observed. The rhythms start with biotite or biotite-amphibole gneisses and finish with amphibolites. Three complete and one incomplete rhythm are distinguished. Thickness of the batch varies from 30 m in the north-west to 200 m in the south.

Another (Rozdolnenska) site of Kosivtsivska Sequence meta-volcanics is encountered in the northern part of Gaychurska structure, in the area of Rozdolne village remnants (DH 801 [73]). Thickness of the batch does not exceed 100 m, length – 2 km. The setting of meta-volcanics is similar to those of Skhidnouspenivska (third) site. The batch is composed of alternating mafic gneisses and amphibole-biotite, biotite, rarely diopside-amphibole schists. Amphibolite interbeds are known twice only at the rhythm base. More frequently the rhythm base is composed of amphibole-plagioclase schists and the rhythms are finished with gneisses. In total, seven rhythms are distinguished which constitute the minor, middle part of Kosivtsivska Sequence.

By petrochemical features, the mafic gneisses correspond to andesite-basalts and dacites [105] while the paragenetic associations in the upper batch – dacite-andesite-tholeiite rock association.

The rocks comprising the second (Eastern), most extended site, occupy the top position in the greenstone column of Gaychurska structure. They mainly include the distinct "quartzite-like" amphibolites and plagioclase-amphibole, in places diopside-bearing schists. Sometimes the sheet-like bodies of extensively actinolitized, tremolitized and serpentinized ultramafic rocks are observed.

By petrochemical features, the rocks, alike Kosivtsivska structure ones, fall into the komatiite-tholeiite trend, but in contrast to the latter, in Gaychurska structure the ultramafic rocks do correspond to pyroxenite and basalt komatiites [18].

Thus, it can be assumed that Gaychurska and Kosivtsivska structures comprise the counterparts of the single greenstone belt with the distinct tectono-magmatic mode of development in the zone of disseminated rifting. Succession of volcanic complex deposition and magma evolution are subordinated to the general developing trend of greenstone belts elsewhere in the world [18]. Described rock paragenesises provide the following vertical range: lower komatiite-tholeiite (peridotite) – dacite-andesite-tholeiite – upper komatiite-tholeiite. The only significant difference from the Middle-Dniprean greenstone belts comprises the lacking of jaspilite-tholeiite rock association in the Pryazovian structures.

The linear Chystopilska monocline (greenstone structure) [87] is mapped in Orikhovo-Pavlogradska LTZ; its western part is composed of undivided Kosivtsivska Sequence rocks, and the eastern part – the rocks of Ternovatska Sequence. Apparently, the monocline comprises the tectonically separated south-western flank of Gaychurska (Ternovatsko-Uspenivska) monocline. The strip of meta-volcanics, from 15 to 450 m wide, is traced along Molochanskiy Fault over the distance about 40 km. The northern part of the monocline is tectonically separated as the detachment about 8 km long. The monocline dipping is mainly steep (70-80^o) to the east; in places it varies from 45 to 90^o.

In the geophysical fields Chystopilska greenstone structure is expressed in the chain of positive gravity anomalies up to 3 mGal, and positive magnetic anomalies up to 5000 nTl. Their high magnitude is caused by the integrated effect of the petrophysical properties provided by the combined rocks of Kosivtsivska and Ternovatska sequences.

In Chystopilska structure Kosivtsivska Sequence is composed of mafic (meta-tholeiites) and ultramafic (meta-komatiites) meta-volcanics, rarely intermediate rocks: amphibolites, plagioclase-amphibole, amphibole- and biotite-amphibole-plagioclase schists, actinolitites, tremolitites and serpentinites. Amphibole-magnetite and pyroxene-amphibole-magnetite quartzites are observed in subordinate amounts. A.O.Sivoronov and V.D.Koliy [87] had distinguished jaspilite-komatiite-tholeiite and dacite-andesite-tholiite rock associations in the greenstone column. Meta-komatiites are mainly peridotitic, particularly, spinifex-textured.

Throughout volcanics of Kosivtsivska Sequence are metamorphosed under amphibolite facies PT-conditions. Development of greenstone complexes had accompanied by extensive intrusive magmatism. In Kosivtsivska and the south-eastern part of Gaychurska greenstone structures the numerous minor ultramafic intrusions of Gaychurskiy Complex are mapped. Perhaps, at the final orogenic stage emplacement of the first-phase diorites of Dobropilskiy Complex occurred as well as extensive injecting of meta-volcanics by the sub-conformable minor dykes of tonalites and plagiogranites.

The upper age boundary of Kosivtsivska Sequence rocks is 3310 Ma (the zircon age from the first-phase diorites of Dobropilskiy Complex). The lower boundary is limited by the age of Novopavlivskiy Complex plagiogranitoids about 3400 Ma.

Ternovatska Sequence (AR_2tr)

The Sequence is developed in Chystopilska and Gaychurska greenstone structures and also constitutes Shevchenkivska monocline and Fedorivska brachy-syncline. In the latter case it is divided in two sub-sequences, and the upper one, in turn, is divided into the lower (terrigenous-carbonate) and upper (amphibole) batches. The rock dipping throughout is steep, to the east in the first and third structures, and in the second one it is centriclinal (from south-eastern to western). In Fedorivska brachy-syncline the rock dipping is more flat – 50-60^o (see “Tectonic scheme” to the “Geological map of crystalline basement”, map sheet L-37-I (Pology)).

Normally the Sequence exhibits the complex and variable composition. In all structures the column is discontinuous by strike and displays the facial variability that complicates the Sequence correlation by lateral within the single structure and between structures. Nevertheless, the Sequence throughout retains the distinct petrotype appearance and is confidently mapped in the various areas of Pryazovya.

The distinct features of the Sequence include high rock alumina content and lower, in comparison to the surrounding rocks (epidote-amphibolite and amphibolite facies), metamorphic degree providing respective mineral assemblage (muscovite, sillimanite, tremolite) and lacking the signs for the rock ultra-metamorphism except its limited development in the contact portions, as well as association with pegmatites containing rare-earth-rare-metal mineralization. Taken together, these factors (tectonic, lithological, metamorphic and magmatic) had caused the distinct litho-tectonic Tarnovatskiy complex that controls lithium deposit and yttrium, uranium, molybdenum, gold, tantalum, beryllium, tin and rubidium occurrences.

In the most extent the Sequence column is studied in Gaychurska [71, 73, 114], Shevchenkivska [61, 74, 85] and Fedorivska [77, 85] structures.

The *lower sub-sequence* (AR_2tr_1) is composed of rhythmic intercalation of plagiogneisses and biotite, muscovite-, garnet-, cordierite-, sillimanite-, garnet-cordierite- and graphite-biotite schists, biotite-amphibole, amphibole, diopside-amphibole and magnetite-amphibole-biotite-garnet schists (skarnoids), silicate and ferruginous quartzites, calciphyres, amphibolites and actinolitites. The rhythms are studied in details in the Gaychurskiy and Uspenivskiy gold and yttrium occurrences respectively [73]. The most complete rhythms are five-folded. They begin with ultramafic schists (actinolitites, tremolitites), changed by amphibolites, biotite- and diopside-amphibole gneisses and schists, biotite- and two-mica gneisses and schists, garnet-biotite gneisses, further replaced by high-alumina gneisses and schists, in places with cummingtonite. In some upper rhythms the amphibole-magnetite quartzites or magnetite-amphibole-biotite-garnet schists (schists lie higher of quartzites) are observed. The rhythms are fairly variable by lateral and vertical; most commonly the upper rhythm members (actinolitites, amphibolites and amphibole-magnetite quartzites) pinch out. Calciphyres are observed in the upper portions of the rhythms, in the upper column part in Fedorivska structure, and in the single interbeds in Shevchenkivska structure. Normally two- and three-folded rhythms are developed composed of biotite, two-mica, garnet- and sillimanite-biotite gneisses and schists.

Sub-sequence rocks unconformably lie over the Paleo-Archean level and with less prominent discontinuity over meta-volcanics of Kosivtsivska Sequence.

Thickness of sub-sequence varies from 150 to 800 m.

The *upper sub-sequence* (AR_2tr_2) is developed in the core of Fedorivska brachy-syncline. According to A.G.Kutko [85] and E.B.Glevaskiy [40], the rocks conformably lie over the aluminous rocks of the lower sub-sequence. The contact is gradual and is set conventionally by the fact of abundant calciphyre and mono-mineral quartzite (meta-sandstone) appearance in the column. In the geophysical fields the rocks are expressed by positive gravity anomaly and negative magnetic anomaly.

By lithological composition sub-sequence is divided in two batches: lower terrigenous-carbonate and upper amphibole [85].

The *lower terrigenous-carbonate batch (*$AR_2tr_2^1$) is encountered in both syncline limbs. It is mainly composed of marbles, calciphyres and biotite, amphibole-biotite and tourmaline-biotite schists. At the base almost 100 m thick pile is observed composed of alternating calciphyres, marbles and mono-mineral quartzites. Amounts of carbonate rocks increase upward in the column. Thickness of the batch gradually increases from the west to east from 100-150 m at Vesele village to 750-800 m at Dniproenergiya village. In the syncline limbs the facial variability is observed. In the northern limb, the layers of coarse-grained diopsidites from some centimeters to first tens of meters thick often occur within calciphyres. In the southern limb these rocks are almost absent. At the same time, amount and thickness of the mono-mineral quartzite beds increase.

Upper amphibole batch ($AR_2tr_2^2$) conformable lies over the rocks of lower batch and constitute the brachy-syncline core which western centricline closure is mapped in the junction zone of Shevchenkivska and Fedorivska structures where it controls the lithium deposit. The contact between the batches is set conventionally by considerable amount of amphibole schist appearance in the column of the upper batch. Thickness of transitional zone is 100-145 m. The batch is weakly studied and is actually intersected by the single drill-hole profile in the subsided portion of the structure. The batch column is composed of biotite-, garnet-, pyroxene- and graphite-garnet-amphibole, rarely two-mica schists and calciphyres. Thickness of the batch varies in the range 500-650 m.

Reconstruction of the primary rock composition [85] suggests for the origin of most rocks in the upper batch through metamorphism of terrigenous and chemogenic rocks. Origin of amphibolites and amphibole gneisses and schists is dual. Some of them comprise the mafic igneous rocks and remaining ones apparently developed after greywackes. Thus, it is logically to assume that these rocks had formed through the metamorphism of mafic and intermediate lava flows (basalts and sub-alkaline basalts, andesites and aluminous thrachy-andesites) and the products of their disintegration.

Physical properties of the Sequence major rock types vary in the wide range depending on their mineral composition. Density of biotite and two-mica gneisses and schists is 2.64-2.70 g/cm^3, garnet-biotite – 2.85 g/cm^3, amphibolites and actinolitites – 2.94 and 2.96 g/cm^3 respectively, high-alumina gneisses and schists – 3.01 g/cm^3, amphibole-magnetite quartzites – 3.32 g/cm^3. Magnetic susceptibility is low, mainly it does not exceed 455 χ ($4\pi\times10^{-6}$ CI units), and a bit higher for actinolitites – 1604 χ ($4\pi\times10^{-6}$ CI units). The high magnetic susceptibility is characteristic for the high-alumina schists – 6560 χ ($4\pi\times10^{-6}$ CI units) and is very high for magnetite quartzites – 50773 χ ($4\pi\times10^{-6}$ CI units).

Increased density of most the rocks and high magnetic susceptibility of magnetite quartzite and high-alumina schist layers define the patterns of the physical fields in the sites of the Sequence development where it is expressed in the chains of linear positive gravi-magnetic anomalies.

The total thickness of the Sequence is variable in different structures and varies in the range 150-800 m in Gaychurska to 200-300 m in Chystopilska structures. In Shevchenkivska and Fedorivska structures its

thickness attains ~2250 m (see "The map of anomalous magnetic field" to the "Geological map of crystalline basement", map sheet L-37-I).

Isochrone radiological age of the Sequence rocks is more than 3310-3390 Ma, apparent time of metamorphism – 3158 Ma [73, 105]; the lower age boundary, alike Kosivtsivska Sequence, is < 3400 Ma.

Throughout the Sequence rocks are intruded by pegmatites of Neo-Archean Yanvarska granite association, and in Fedorivska and Shevchenkivska structures – by Krasnokutskiy massif granites of Yanvarska granite association. The latter had assimilated the part of northern limb in Fedorivska structure and, probably, the eastern limb of Shevchenkivska structure; their relicts are being mapped in the tectonically-oriented xenoliths in granites to the east and north of Krasnokutski granites. The rare-earth (Uspenivskiy occurrence) and rare-metal (Shevchenkivske lithium deposit) mineralization is associated with the pegmatites of this complex. Much rarely the Sequence is cut by plagiogranites and tonalites of Dobropilskiy and Shevchenkivskiy complexes.

Neo-Archean Eonotheme (Dniproviy) (AR_3)

Neo-Archean complexes include metamorphosed 3.6-3.2 Ga sedimentary-volcanogenic associations of greenstone belts. In the Middle-Dniprean area these rocks constitute Konkska and the north-eastern flank of Bilozerska greenstone structures and are divided into Konkska and Bilozerska series; in Pryazovian area – Novogorivska structure composed of meta-volcanics of the same-named sequence. The latter meta-volcanics together with the rocks of Osypenkivska Series (outside the studied map sheets) do form the upper greenstone tectonic sub-level and are confined to Orikhovo-Pavlogradska LTZ exclusively.

Konkska Series

In the map sheet L-36-VI (Zaporizhzhya) the Series includes jaspilite-tholeiite subdivision of the Surska Suite komatiite-tholeiite rock association.

Surska Suite (AR_3sr). The most complete column of the Suite is observed in the south-eastern part of Konkska greenstone structure. The thick (up to 4100-4500 m) sedimentary-volcanogenic sequence, described in the monographs [30, 31], is intersected by Veselyanskiy drill-hole profile and numerous mapping drill-holes. The sequence is mainly composed of metamorphosed mafic volcanics which correspond to the basalt-dolerite family by chemical composition. Meta-komatiites, characteristic to the Suite columns in other greenstone structures in the Middle-Dniprean region, are almost lacking in Konkska structure.

The rock metamorphic degree is variable providing wide variability in the rock mineral composition. Fairly clear zonation is observed in the horizontal projection. In the core of structure the primary rocks are modified under greenschist facies PT-conditions. The gradual increasing in metamorphic degree to epidote-amphibolite and amphibolite facies is observed toward the marginal portions of the structure.

Meta-sediments comprise up to 10% of the Suite column but their role is important since they mark the interruptions in basalt extrusions, highlight the rhythmic patterns of the Suite and allow the column detailed subdivision. Notable development of sedimentary rocks and lack of meta-komatiites in the column allow ascription the rock association to the lower sub-suite of Surska Suite. By lithological composition, mainly by increased amount of sedimentary rocks, it is subdivided into five batches: two terrigenous-meta-basite and three mainly meta-basite ones. The change of sub-suites is regular enough suggesting for their conformable position.

The first batch (lower meta-basite – $AR_3sr_1^1$) is essentially amphibolite in composition and most widespread in comparison to other batches. The southern extension of amphibolites is traced to the south-east up to Shcherbakivskiy massif. The batch in stretched along the south-western limb of structure in the band 1.0-1.2 km wide.

Thickness of the batch intersected by Veselyanskiy profile and numerous drill-holes is estimated to 2000 m. Metamorphosed volcanics of mafic composition predominate (> 80% of the column): amphibolites and subordinate amphibole schists. By composition amphibolites correspond to the basalt-dolerite family. Amphibole schists actually are the same amphibolites but sheared and altered in tectonic zones. Of these, the schists with clearly expressed relic clastogenic texture are found which are treated as metamorphosed tuffs and tuffites (V.V.Sukach). Pyroclasts are composed of plagioclase, quartz, hornblende, actinolite and in places of the rocks fragments composed of these minerals. At the same time, the interbeds of light-grey subtle-banded meta-tuff-sandstones and meta-tuff-aleurolites are observed; alien grains of clastic nature occur in the fine-grained groundmass of these rocks.

In the south-eastern flank of the field the crystal- and rarely litho-crystaloclastic meta-tuff-lavas of mafic composition are developed. These are massive rocks with cryptic- or fine-crystalline groundmass where amphibole porphyry-clasts and rocks fragments up to 1.5 cm in size (coarse fraction predominate) are observed. By chemical composition the rocks correspond to the olivine basalts. The thin (up to first meters) meta-volcanic

interbeds of ultramafic composition composed of chlorite-actinolite and actinolite schists are encountered in association with the above rocks.

Relationships of the batch with underlaying stratified complexes are not defined. The field of the batch development is extensively intruded by plagiogranites of Surskiy Complex and Khortytska Association as well as granites of Tokivskiy Complex; as a result, the field became the intricate spongy shape in the plane. In the field marginal parts the rocks are extensively migmatized. The contact with meta-volcanics of the second batch is tectonically-conformable.

In petrophysical respect, meta-basites of the batch are non-magnetic or slightly-magnetic rocks of high density – 2.9-3.2 g/cm^3. In magnetic field they are mainly "transparent" and in the gravity field they are commonly expressed by contrasted residual anomalies up to 3-5 mGal (see "Map of anomalous magnetic field" and "Map of gravity residual anomalies", map sheet L-36-VI (Zaporizhzhya)).

The rocks are metamorphosed under epidote-amphibolite facies PT-conditions. In the contact zones with granite massifs the metamorphic degree is increased to amphibolite facies.

The second batch (terrigenous-meta-basite – $AR_3sr_1^2$) is traced in the band from 500-700 to 1500 m wide and 12-13 km long along the south-western limb of Konkska greenstone structure. The column includes alternating amphibolites (meta-basalts) and barren quartzites and quartzite-schists (meta-sandstones), as well as ferruginous quartzite interbeds. The contacts of quartzite-schists with amphibolites are clear, sharp. Amphibolites and quartzites are contained in the column in roughly equal amounts and are observed in the layers from first meters to 30-80 m and more thick with some increasing the role and thickness of quartzite beds from the batch bottom to top.

Ferruginous quartzites include magnetite-cummingtonite and magnetite-chlorite varieties. They are observed in the numerous (up to 15) interbeds, from parts of meter to 1-2 m thick, mainly within amphibolites. In the middle of the section they are closely spaced and form the pile up to 120 m thick which is the marker horizon due to the high magnetic susceptibility.

Barren quartzites and quartzite-schists include mica (sericite, sericite-biotite and biotite), mono-mineral, rarely chlorite and mica-feldspar varieties. Often transitions from quartzites to quartzite-schists are observed in the same layer. The facial variability is also displayed in the column by strike. The pinching out of amphibolite layers and contained ferruginous quartzite interbeds in the south-western direction is clearly expressed and in 2.5-3.0 km from Veselyanskiy drill-hole profile the barren quartzites and quartzite-schists strongly predominate in the column. Often their beds are merged into the piles up to 200-250 m thick. In the gravity field the rocks are expressed by the reduced gravity values.

The rocks of second batch are injected by numerous thin dykes (0.9-1.5 m, rarely more) of fine-grained often porphyry trachytes (DH 42-46 [30, 66]).

The batch conformably lies over the meta-basites of the first batch and is overlain by the rocks of the third batch. The contact between the rocks is gradual and is put conventionally. Thickness of the batch is estimated to 700 m.

The third batch (second meta-basite – $AR_3sr_1^3$) is observed in the band from 500 to 1300 m thick and 16-17 km long. It is composed of the basalts metamorphosed under epidote-amphibolite facies: quartz-plagioclase-epidote-hornblende, quartz-chlorite-actinolite and plagioclase-quartz-carbonate-chlorite schists of highly variable mineral composition. In places the schists exhibit vesicular structure. The vesicles up to 12-15 mm in size are filled with carbonate. In addition, the schists contain abundant conformable and cutting thin (first millimeters) carbonate veinlets and pods often arranged in the dense network. Rhyodacites (keratophyres) up to 25 m thick are encountered in the column (DH 9^c [70]). In places the rocks are sheared and contain the remnants of plagioclase-carbonate-quartz-chlorite schists up to 1 m thick.

Thickness of the third batch varies from 1000 m in the eastern part to 600-500 m in the south-west.

The fourth batch (upper terrigenous-meta-basite – $AR_3sr_1^4$) comprises intercalation of meta-volcanogenic mafic schists (plagioclase-quartz-carbonate-chlorite, quartz-chlorite-actinolite etc.) with quartz-mica schists, quartzite-schsists and barren quartzites. The internal structure of the fourth batch is similar to that of the first sub-suite; the differences are provided by decreasing of the volcanic rock metamorphic degree and lacking the ferruginous quartzite interbeds.

The batch is less studied in comparison to other ones but from the gravity survey data it can be supposed that low-density para-rocks predominate in the column expressed in the chain of gravity minimums extended over the batch strike.

In DH 16^c [70] keratophyre veins 4-14 m thick are intersected with the sharp cutting contacts with the schist visible in the core sections.

Thickness of the batch is estimated to 600-800 m.

The fifth batch ($AR_3sr_1^5$) caps the column of Surska Suite. Complete column is intersected by DH 30-33 and 35 of Veselyanskiy drill-hole profile [66] that allowed its detailed study [30]. The batch is composed of

meta-spilites and schists after them. The former are typical for the upper part and the latter – to the lower one. The upper is metamorphosed under epidote-amphibolite facies conditions and the lower one – under greenschist facies. The single thin (first meters) interbeds of vesicular amphibolites are known.

Meta-spilites exhibit the relic textures (spilitic, intercertal, in places porphyry). The schists include albite-epidote-, albite-quartz- and quartz-chlorite, albite-epidote, albite-chlorite-epidote-amphibole (-hornblende and –actinolite), as well as muscovite-quartz-chlorite-carbonate magnetite-bearing varieties. In the fine-grained meta-volcanic schists three conformable (?) bodies of massive well-crystallized dolerites 20-25 m thick (DH 34, 36) are encountered.

In the middle part of the batch column the 50-60 m thick marker pile of magnetite-bearing rocks is encountered (DH 40 [66]). In the upper part it is composed of intercalating chlorite-carbonate-quartz schists with diverse-banded magnetite-carbonate-actinolite, magnetite-chlorite-carbonate and barren (interbeds from parts of meter to 1-2 m thick) quartzites; in the lower part chlorite-carbonate-quartz schists with magnetite dissemination (from 3 to 10%) are developed. By strike in the north-eastern direction the ferruginous quartzites are almost completely replaced by magnetite-bearing schists.

Thickness of the batch is about 2000 m.

The schists of the batch often are cut by dense network of carbonate and in places quartz-carbonate and quartz variously-oriented veinlets from 1 mm to 10 cm thick; in some places quartz veins up to 0.2-1.0 m thick (by core sections) occur.

In some places the schists are cut by the veins of light-grey and pink fine-grained porphyry massive rocks (DH 37, 35, 33 [66]) 1-2.5 m thick, in single cases – up to 10 m (DH 37) and 60 m (DH 33). By chemical composition the rocks correspond to rhyodacites and andesites. In the sites of these veins close spacing, enrichment of the schists by quartz and carbonate-quartz veinlets and abundant sulphide mineralization in places is observed.

Undivided rocks of Surska Suite (AR_3sr) are defined in the relatively large (up to 10 km^2) sites of meta-basite development which are observed to the north-east from Konkska greenstone structure, very close to Orikhovo-Pavlogradskiy Fault. The biggest ones include Dubovogayska monocline and Pivnichnotersyanska site where the same-named iron-ore deposit is located.

The arch-shaped band up to 1 km wide composed of the ferruginous-meta-basite rocks of Sursja Suite is encountered within the para-schists of Bilozerska Series (Promizhna site). This occurrence can be explained by the thrusting tectonics of Konkska greenstone structure although it is not excluded that here it is complicated by the anticline fold [30].

The undivided rocks normally include melanocratic amphibolites and quartz-epidote-biotite-albite-hornblende schists with quite variable mineral composition. The thin lenses and interbeds of amphibole-magnetite-quartzites are recorded (Dubovogayska monocline, Pivnichnotersyanska and Promizhna sites). In the latter case 12-15 to 40 m thick interbeds of ultramafic rocks are also observed – chlorite-actinolite, chlorite-tremolite, talc-tremolite- and talc-chlorite schists. In places they also contain up to 15 m thick interbeds of garnet-amphibole schists.

The undivided rocks are being mapped through the extensive anomalies of gravity field – up to 3.0 mGal and (in case of ferruginous quartzite occurrence) magnetic field – up to 2500-5000 nTl.

In the north-eastern flank of Bilozerska greenstone structure (map sheet L-36-VI, square IV-1) meta-basites of Surska Suite include the uniform amphibolites and amphibole schists (meta-dolerites), chloritized and epidotized in various extents. In the gravity field these rocks are expressed by extensive residual anomalies especially contracted (up to 2 mGal) on the background of granitoids of Mokromoskovskiy, Surskiy and Dnipropetrovskiy complexes which surround or cut the meta-basic rocks.

There are no direct age determinations of Surska Suite rocks in the studied area. The Neo-Archean age is defined on the ground of indirect data, particularly, the fact of rock cutting by the granitoids of Mokromoskovskiy and Surskiy complexes.

Novogorivska Sequence (AR_3ng)

The Sequence is established in the same-named structure stretched over 15-16 km along Orikhovo-Pavlogradskiy Fault from the east (southern part of L-36-VI map sheet) [87]. This 1.0-1.6 km wide structure is constituted of meta-volcanics similar in term of composition and age to the greenstone complexes of Middle-Dniprean area.

In the gravity field Novogorivska greenstone structure is expressed by the extensive (up to 4.0 mGal) high-gradient residual anomaly. And in the magnetic field it is 1500-5000 nTl anomaly caused by the ferruginous quartzite batch. The northern part of this structure is non-magnetic.

The Sequence is essentially volcanogenic. It is mainly composed of calc-alkaline basalts and mafic tuffs metamorphosed under amphibolite facies – amphibolites and plagioclase- and biotite-plagioclase-amphibole schists.

In the west, close to Orikhovo-Pavlogradskiy Fault, in the 150-200 m wide band (DH 308, 309) the felsic and intermediate volcanics (rhyodacites, dacites, andesites and andesite-basalts) are observed in thin (first meters) beds (veins?). These are grey and greenish-grey fine-grained schistose rocks of variable composition [87].

In the south of Novogorivska structure meta-basites contain numerous lens-like amphibole-magnetite quartzite interbeds up to first meters thick. Altogether they form the batch up to 200 m thick [97]. In general the column corresponds to the jaspilite-tholeiite subdivision of komatiite-tholeiite rock association characteristic for the lower Surska Suite.

Thickness of the Sequence is estimated to 1000-1200 m.

The upper time boundary of Novogorivska Sequence meta-basites is 3100 Ma [87].

Bilozerska Series (AR_3bl)

The Series rocks constitute the upper column portion in Konkska greenstone structure and lie over the rocks of Surska Suite with minor angular discontinuity. The unit mainly includes metamorphosed primary-sediment rocks. The terrigenous sediments predominate with subordinate chemogenic ferruginous rocks. The latter comprise the marker horizons and define the general stratification of Bilozerska Series by analogy with the stratotype section in the same-named structure.

In Konkska greenstone structure, the lower essentially terrigenous Mykhaylivska and the upper terrigenous-ferruginous Zaporizka suites are distinguished.

Mykhaylivska Suite (AR_3mh) is developed in the west of Konkska greenstone structure and in its narrow (0.6-1.0 km) graben-like north-east tail (Myrolyubivska monocline) extended over 20 km to the maps sheet L-36-VI limits.

The Suite is composed of metamorphosed sandy-clayey sediments with thin ferruginous rock interbeds; the metamorphic degree varies from greenschist to the facies of andalusite-(sillimanite)-muscovite schists. The westward increasing of the metamorphic degree is explained by the influence of Mokromoskovskiy Complex granites and Khortytska Association plagiogranites which completely assimilated meta-basites in the western limb of Konkska greenstone structure. To the north of metamorphic facies boundary, which intersects the field of the Suite rocks under acute angle, the mineral assemblages of andalusite-muscovite schist facies are developed in the Suite column.

The composition and structure of meta-terrigenous piles in Konskiy area are described in details by V.D.Ladieva [29-31].

In Veselyanska site the meta-sediments (greenschist facies) include quartz-chlorite-sericite, chlorite-quartz, biotite-chlorite-quartz and somewhere garnet-biotite-chlorite-quartz, in places with magnetite and graphite, phyllite-like and aspide schists.

To the north of Veselyanska site the rock batch is mapped composed of augen quartz-, chlorite-two-mica and alvite-sericite-biotite-chlorite, spotty and nodulous biotite-quartz with garnet and chlorite-garnet-two-mica schists. It places higher-temperature varieties are noted: coarse-grained staurolite-plagioclase-quartz- and andalusite-staurolite-two-mica and biotite-staurolite schists and micro-gneisses often containing sillimanite and cordierite in places.

In the lower Suite part up to 250 m wide batch of alternating ferruginous-siliceous rocks and schists is encountered. The rock dipping is inconsistent – 0-90°. Visible thickness of the ferruginous rocks varies from first meters to 40-70 m [66]. These include diverse-banded cummingtonite, in places grunerite quartzites and quartzite-schists. Magnetite content is 10-20%. In the magnetic field the batch is expressed by the sheet-like anomaly from 0.5 to 5 nTl. The batch comprises the marker horizon extended over 28 km and smoothly changed its strike from sub-longitudinal in the north to the south-western in the south, being complicated by the sharp flexure turn in Veselyanska site. Higher in the batch column two ferruginous beds each 40-50 m thick are found separated by up to 150 m thick high-ironiferous schists of quartz-chlorite-biotite composition. The total thickness of the batch is 250 m; magnetic field magnitude above the batch increases to 10-11 thousand nTl.

Zaporizka Suite (AR_3zz). The iron-ore portion of Bilozerska Series, which caps the greenstone column in Konkska structure, is ascribed to Zaporizka Suite. It is distinguished in the north-western flank (Kyrpotynska site) where it constitutes the southern and northern strips. The southern one borders on Mykhaylivska Suite schists along the flat thrust “sealed” by the gabbro and actinolitite dykes. The unit comprises the flat syncline where two sub-suites are distinguished: the upper (iron-ore) is developed in the core and the lower is observed in

the limbs. The syncline width is 1500 m; from the north-west it is in tectonic contact with Mokromoskovski granites.

The *lower sub-suite* (AR_3zz_1) exhibits rough (10-70 m) alternation of meta-terrigenous rocks and volcanics of mafic and ultramafic composition. The column base is composed of para-rocks: garnet- and staurolite-bearing two-mica schists and gneisses, magnetite-cummingtonite quartzites, and interbeds of garnet-magnetite-pyroxene-amphibole skarnoids. Volcanics include fine-grained amphibolites (meta-basalts), biotite- and carbonate-phlogopite-chlorite-actinolite, tremolite-talc- and carbonate-phlogopite-chlorite schists (meta-ultramafites). The rock dipping is mainly flat to sub-horizontal; by these reasons, despite of the high magnetic susceptibility (up to 36154 χ ($4\pi\times10^{-6}$ CI units)), magnetic-active horizons of ferruginous and ultramafic rocks are actually not expressed in the magnetic field. Thickness of sub-suite is estimated to 300-500 m.

The *upper sub-suite* (AR_3zz_2) is studied in details over prospecting and exploration works for the iron ores [97, 98]. The boundary is being drawn by the bottom of lowermost ferruginous quartzite bed. In the southern Kyrpotynska strip the sub-suite conformably stacks up the lower sub-suite column and consists of four 20-150 m thick ferruginous quartzite beds alternating with biotite-actinolite, actinolite, chlorite-hornblende, garnet-biotite-amphibole, quartz-chlorite and garnet-chlorite-biotite-quartz schists up to 50-80 m thick. Quartzites include magnetite-cummingtonite and garnet-magnetite-amphibole, rarely magnetite-carbonate-cummingtonite varieties.

Thickness of the upper sub-suite is 300-350 m. In the magnetic field it is expressed by the highest (20.0-21.0 thousand nTl) anomaly in Konkska structure accompanied by the high-gradient residual gravity anomaly up to 1.5 mGal.

The upper sub-suite column in the northern Kyrpotynska strip is almost identical to that described above and only schist bed thickness is decreased a bit. However, magnetic anomaly magnitude here is several times lower apparently due to the very flat rock laying.

Proterozoic Acrotheme

The stratified rocks of Proterozoic Acrotheme in the studied area are only encountered in the Pryazovian Mega-Block within Zakhidropryazovska LTZ (map sheet L-37-I) in the volume of Gulyajpilska Suite.

Paleo-Proterozoic Eonotheme (Kryzorizhiy) (PR_1)

Gulyajpilska Suite ($PR_{1-2}gp$) is developed in the south-western quarter of the map sheet L-37-I where it constitute Gulyajpilska and Balochkivska brachy-synclines and the tectonic remnant in the south-eastern extension of the former. The Suite development area is confined to the Gaychursko-Sorokynska fault zone. The column is well studied in Gulyajpilska structure in the course of prospecting-exploration works [80, 84, 96].

Gulyajpilska structure (square III-1) comprises the ellipse-like syncline fold which long axis is oriented by azimuth 310°. The fold length is 9.5 km, width – 3 km. The limb dipping is steep – 75-80°. Due to the ferruginous quartzites it is well expressed in the gravi-magnetic fields.

By the rock composition the Suite is divided into three sub-suites.

The *lower sub-suite* (PR_1gp_1) is composed of metamorphosed sandstones and gravelites with aleurolites interbeds; the latter in the column lower part include quartzites and quartz-sericite schists, and in the upper part – quartz-andalusite-muscovite-sericite, staurolite-quartz-andalusite- and garnet-quartz-biotite-muscovite schists. The column is not always consistent. Both essentially meta-sandstone and schists column varieties are known. At the bottom often lie gravelites which contain well-rounded fine quartz pebble and mark unconformable stratigraphic laying the sub-suite rocks over cataclased and retrograded plagiogranites of Shevchenkivskiy Complex with the remnants of Verkhnyotokmatska Sequence meta-volcanics. Thickness of the sub-suite varies from 250 to 750 m. In the north-west of the structure (DH 6 and 18) the remnants of apparently Paleo-Proterozoic micro-phytofossils are found in the meta-sandstones [116].

The *middle sub-suite* (PR_1gp_2) is composed of magnetite-cummingtonite, stilpnomelane-cummingtonite- and stilpnomelane-riebeckite-cummingtonite-magnetite and magnetite-biotite quartzites alternating with quartz-albite-carbonate-biotite and magnetite-cummingtonite schists and “barren” quartzites up to 5-6 m thick. The former are interpreted by E.B.Glevaskiy and N.I.Bosa as leptite micro-gneisses – metamorphosed volcanics of trachyte and andesite composition. The latter are light-grey and quartzite-like with irregular discontinuous gneissosity; some contains plagioclase (andesine) phenocrysts up to 3 mm in size. Paragenesis of leptites and ferruginous quartzites defined leptite-porphyry type of sub-suite rock association.

Thickness of sub-suite is 150-450 m.

The *upper sub-suite* (PR_1gp_3) constitutes the syncline core and is about 1 km thick. By lithological composition it is divided into the lower, essentially schist, 396 m thick, and upper, schist-quartzite, 603 m thick, batches [71]. The lower one is composed of quatz-biotite, rarely quartz-sericite-biotite schists which almost throughout contain garnet, graphite, carbonaceous matter and staurolite. In the lower part the interbeds of leptite micro-gneisses (meta-volcanics) up to 75 m thick are encountered (E.B.Glevaskiy). The upper batch is composed of the same schists and quartzites (meta-sandstones) with relic clastic textures. According to some opinions, the column of sub-suite corresponds to the flyschoid formation.

PHANEROZOIC

Paleozoic Eratheme

It is represented by Carboniferous System.

Carboniferous System

In the studied area the System is represented by the Lower Division.

Lower Division – (C_1)

The Lower Division of Carboniferous System is encountered in the north-eastern part of map sheet L-37-I (Pology), in the area of Fedorivka, Bogatyr, Novyj Komar, Rozdolne inhabited localities, in the Kalmius-Nesvetayska LTZ.

The boundary between the development fields of Carboniferous sediments and the rocks of crystalline basement apparently follows the series of north-west-trending vertical breaks. The rocks, with erosion and sharp angular discontinuity, lie over the crystalline basement and its weathering crust. In turn, they are overlain by Cretaceous and in places of their lacking – Paleogene, Neogene and Quaternary sediments.

By the complex of organic remnants, the age of chemogenic-terrigenous sediments corresponds to Tournaisian and Visean stages. By the lithological and faunistic features the Mokrovolnovakhska and Mezhevska suites are distinguished.

Tounraisian and Visean stages undivided

Bugaivskiy and Efremivskiy horizons undivided

Mokrovolnovakhska Suite (C_1^1(A)). The Suite is exposed at the pre-Quaternary surface in the lower course of Mokri Yaly River (Fig. 2.1.a). It is composed of grey, dark-grey, fine- and medium-crystalline limestones, in places dolomitized and flinted, slightly bituminous, with argillite and aleurolites interbeds (up to 1 m). At the bottom diverse-grained up to 1 m thick sandstones are observed. Maximum thickness of the Suite is 185 m.

The following organic remnants are contained in the limestones: brachyopoda: *Eomartiniopsis ef elongata* S o k., E. *Waschkuricus* (F r e d), *Chonetipustula ef carringtonia* (D a v .), *Avonia ex gr. youngiana* (D a v .) and others. Foraminifera: *Arhaesphaera suleimanovi* B o g. et I m f., *Tetrabaxis pataminima* V i s s., *Planarhaediscus eospirilinoides* B r a z h n., *Eostaffella mosquensis* V i s s. and others.

The complex of fauna remnants affirms the Early Tournaisian – Visean age of the Suite.

Visean Stage

Olenivskiy horizon

Mezhevska Suite (C_1^2(B)). The Suite exposures on the pre-Quaternary surface are found in the area of Stepne and Bogatyr villages (Fig. 2.1.a). It is composed of terrigenous pile – thin (by 0.2-0.5 m) intercalation of dark-grey aleurolites, argillites and grey diverse-grained polymictic sandstones with carbonate-clayey and siderite cement. The coal interbeds 0.1-0.2 m thick are observed sporadically.

In the terrigenous sediments after 14-33 m lie the beds of marker limestones (B_1-B_7): green-grey to dark-grey, fine-crystalline, clayey, in places bituminous (B_6) with mollusc shell imprints; thickness is up to 2.0 m (B_1). The marker beds include limestones B_1, B_4, B_6 and B_7. Thickness of the Suite is 190 m. The Suite rocks

contain foraminifera remnants: *Erlandia vulgaris* (R a n s e t R e i t l), *Loblichia ukrainica* (B r a z h n.), *Archaediscus moelleri* R a u s. and others. This micro-fauna complex allows the Late Visean Mezhevska Suite age definition.

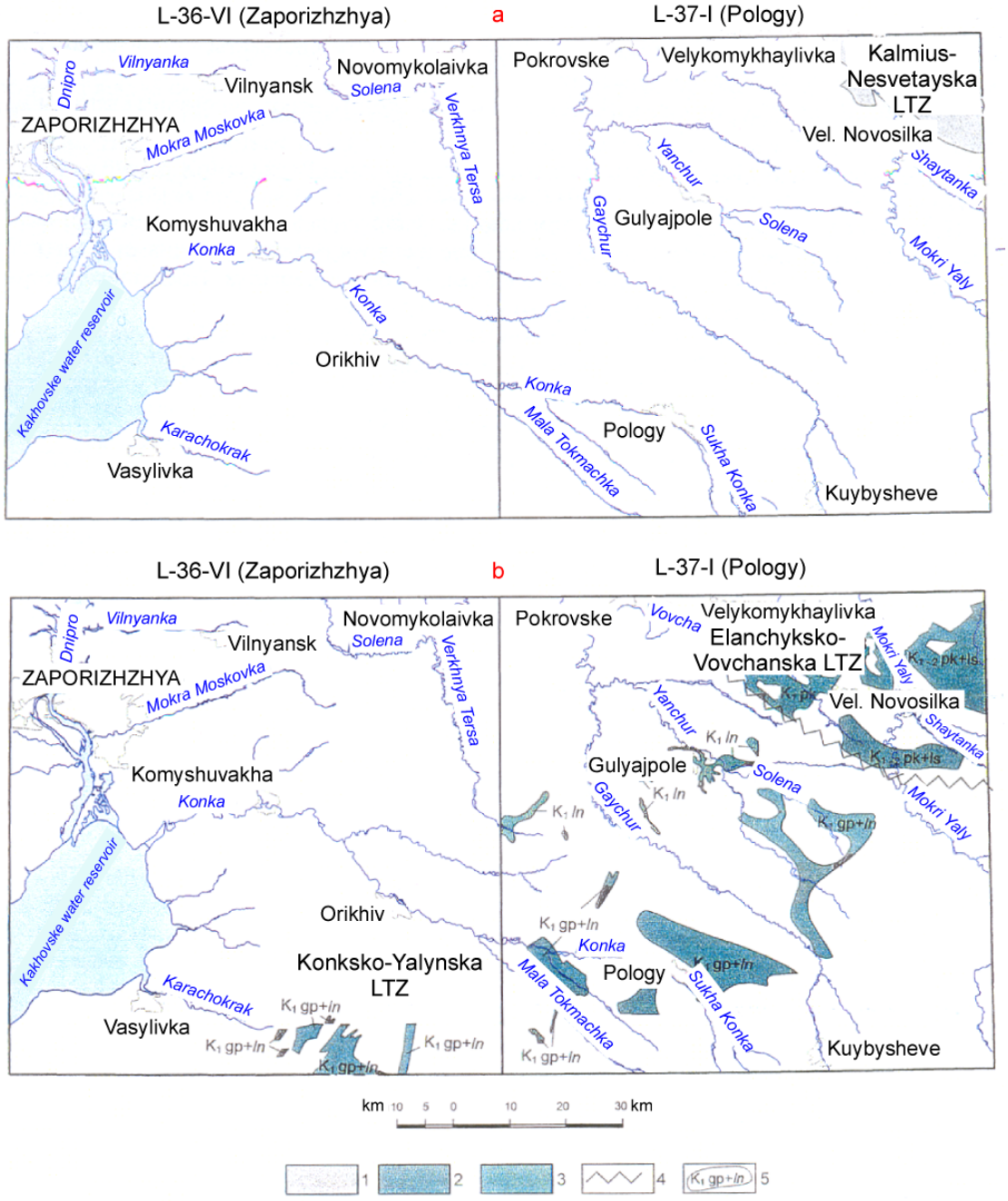

Fig. 2.1. Sketch maps of stratigraphic zonation and distribution.
a) Carboniferous System - Mokrovolnovakhska (C_1^1(A)) and Mezhevska (C_1^2(B)) suites;
b) Cretaceous System – clayey-sandy batch (K_1gp), Lunacharska Suite (K_1ln), Pokrovo-Kyreivska (K_1pk) and Lysogorska ($K_{1\text{-}2}ls$) sequences.
Distribution fields: 1 - Mokrovolnovakhska and Mezhevska suites; 2 - clayey-sandy batch, Pokrovo-Kyreivska and Lysogorska sequences; 3 - Lunacharska Suite; 4 – boundary between litho-tectonic zones; 5 – geological boundaries of the sediments and their indexes.

Mesozoic Eratheme

In the studied area it is represented by Cretaceous System.

Cretaceous System

These sediments are widely developed over the studied territory and occupy its south-eastern part being absent in Pryazovskiy block (map sheet L-37-I). The distribution boundary is complex, winding. In general, it crosses Vasylivka, Orikhiv, Dolynka, Pryvilne and Voskresenka inhabited localities.

Cretaceous rocks are known in Konksko-Yalynska and Elanchyksko-Vovchanska litho-tectonic zones. The boundary between these zones follows the line of northwest-trending Temyrivskiy Fault which crosses Staromlynivka-Novopil-Zaporizke-Stepove inhabited localities. Elanchyksko-Vovchanska LTZ is located in the north-eastern part of L-37-I (Pology) map sheet and differs in sedimentation conditions and thickness of Lower Cretaceous sediments.

In general, the thickness decreasing of Cretaceous sediments is observed in the southern direction, toward Prychornomorska Depression.

Cretaceous System includes Lower, Lower-Upper undivided and Upper divisions.

Lower Division – (K_1)

The rocks, with erosion and angular discontinuity, lie over the crystalline basement and are overlain by the sediments of Upper Division; they are intersected by drill-holes to the south-west of Orikhiv town, in the area of Pology town, Lyubymivka and Vel. Novosilka villages. The upper portion is presented – Aptian and Albian stages.

In Konksko-Yalynska LTZ the clayey-sandy batch and Lunacharska Suite are distinguished, and in Elanchyksko-Vovchanska LTZ – Pokrovo-Kyreivska Sequence.

Aptian Stage

Clayey-sandy batch (K_1gp). The distribution area of these rocks is controlled by the position of buried erosion-tectonic valleys in the crystalline basement which opens toward Prychornomorska Depression (see Fig. 2.1.b). The batch is composed of diverse-grained sands, aleurites and coaliferous clays, secondary kaolines, brown coal lenses (up to 0.2 m). Fine-pebble and gravelous rocks are observed at the bottom. The fragments are composed of crystalline rocks.

The Late Aptian age of the batch is determined after the spore-pollen complex of Filicinae (*Gloicheniceae loetus* B o l c h., *G. decora* (B o l c h.), *Plicifora delicata* (B o l c h.) and pinian (*Cedrus sp., Seleginella candata*) and the fact of their overlaying by the fauna-containing sediments of Lunacharska Suite. Thickness of the batch does not exceed 20 m.

Pokrovo-Kyreivska Sequence (K_1pk) is composed of the continental rocks: diverse-grained kaolineous sands with gravel and pebble, parti-coloured clays and secondary kaolines that fill up the erosion-accumulative valleys which open toward the DDD (see Fig. 2.1.b). The Sequence is exposed on the pre-Quaternary surface in the lower course of Mokri Yaly River. Maximum thickness is 50 m.

In the rocks the spore-pollen complex is determined: *Sphagnumsprites antiguasporites*, *Matonisporites phlebopteroides, Concavisporites jurienensis, Clarifera triplex* and others suggesting for the Aptian age.

Albian Stage

Lunacharska Suite (K_1ln). The distribution area of the coastal-marine sediments is controlled by the forms of pre-Mesozoic relief (see Fig. 2.1.b). The rocks are intersected by drill-holes in the area of Orikhiv and Pology towns and Lyubymivka village. The Suite is composed of quartz-glauconite sands and sandstones, silica-clay-like rocks with gravel and pebble at the base, rarely clays. Thickness of the Suite is 25 m.

Middle-Late Albian age of the Suite is determined after foraminifera complex found in the clays: *Guroidinoides subconicus* (V a s s i l e n k o), *Orbitalina lenticularis* (B l u m e n b a c h) and others.

Lower-Upper divisions undivided – (K_{1-2})

These sediments are developed in Elanchyksko-Vovchanska LTZ and include Lysogorska Sequence of Albian – Lower Cenomanian age.

Albian Stage and Lower Cenomanian sub-stage undivided

Lysogorska Sequence ($K_{1-2}ls$) is encountered in the area of Vel. Novosilka village (map sheet L-37-I) (see Fig. 2.1.b). It is composed of the coastal-marine carbonate sandstones with glauconite and interbeds of marls, silica-clay-like rocks and clays. Maximum thickness of the Sequence is 20 m. In glauconite-bearing clays at the column base foraminifera found: *Guroidinoides subconicus* (V a s s i l e n k o), *Orbitalina lenticularis* (B l u m e n b a c h) providing determination the Early Cretaceous age of the Sequence [104]. The age of silica-clay-like rock age by radiolaria is defined as Late Albian – Early Cenomanian. Foraminifera *Conceparea ex gr. naeckel* A l i e v., *C. Kizilkazmensis* A l i e v and others from the upper column part is dated as Early Cenomanian [90]. The stratigraphic position and paleontological remnants define the Sequence age as Late Albian – Early Cenomanian.

Upper Division (K_2)

Upper Cretaceous marine sediments are most widespread; with the angular and stratigraphic discontinuity they lie over the crystalline basement, Lower Carboniferous and Lower Cretaceous rocks and are overlain by the sediments of Paleogene, Neogene and Quaternary systems. The rocks are developed in the Konksko-Yalynska and Elanchyksko-Vovchanska LTZs. Complete column is encountered in the map sheet L-37-I (Pology) where it si subdivided into Genicheska, Berdyanska, Kozeletska (Elanchyksko-Vovchanska LTZ), Staromlynivska and Oleksandrivska suites. In contrast to the Lower Division, the Upper Cretaceous column includes all stages.

Cenomanian Stage

Genicheska Suite (K_2gn) is most widely developed and is intersected by drill-holes (Fig. 2.2.a). On the pre-Quaternary surface the rocks are exposed in the lower course of Mokri Yaly River. The surface altitudes vary from +95 m in the north to -325 m in the south of the area.

At the base lies up to 2 m thick conglomerate-breccia with crystalline rock fragments and phosphorite concretions cemented by marl with P_2O_5 content up to 22% [73]. Higher lie up to 15 m thick sands and quartz-glauconite carbonate sandstones with gravel and pebble, marls with flint bunches and silica clays with glauconite. The latter are developed in the map sheet L-36-VI territory. Maximum thickness of the marls is 60 m, silica clays – 50 m. Total thickness of Genicheska Suite in Konksko-Yalynska LTZ is 165 m, and in Elanchyksko-Vovchanska LTZ – 156 m.

The rocks contain foraminifera: *Anomalina cenomanica* (B r o t z e n .), *Cumbelina cenomanica* (R o l l e r), *Eponides concinnus* (B r o t z e n.), *Brotzenella Belorussica* (A k i m.) and others allowing Cenomanian age definition.

Turonian and Coniacian stages undivided

Berdyanska Suite (K_2bd). The sediments are developed in Konksko-Yalynska LTZ (Fig. 2.2.b). The Suite is composed of chalk-like marls with glauconite and subordinate chalk. Thickness of the Suite is up to 10 m. It is characterized by the contained Turonian-Coniacian foraminifera: *Anomalina nana* A k i m, *Cibicides polyrraphes* (R e u s s.), *Reussella turonica turonica* A k i m, *Stensioina praeexculpta* (K e l l e r), *Eovigerina cretacea* (H . A l l e n e f , E a r l) and others.

Kozeletska Suite (K_2kz). It comprises the age and lithological analogue of Berdyanska Suite in Elanchyksko-Vovchanska LTZ (Fig. 2.2.b). In contrast to the latter, the chalk predominates in the column and rarely chalk-like marls are observed. Thickness of the Suite is 10 m.

The Suite is characterized by Turonian foraminifera: *Globoro talites hangousis* V a s s., *Globigerinella aspera* (E h r o u b.) and others. Taking into account position of Kozeletska Suite in the column and lithology similar to Berdyanska Suite the age is taken as Turonian-Coniacian.

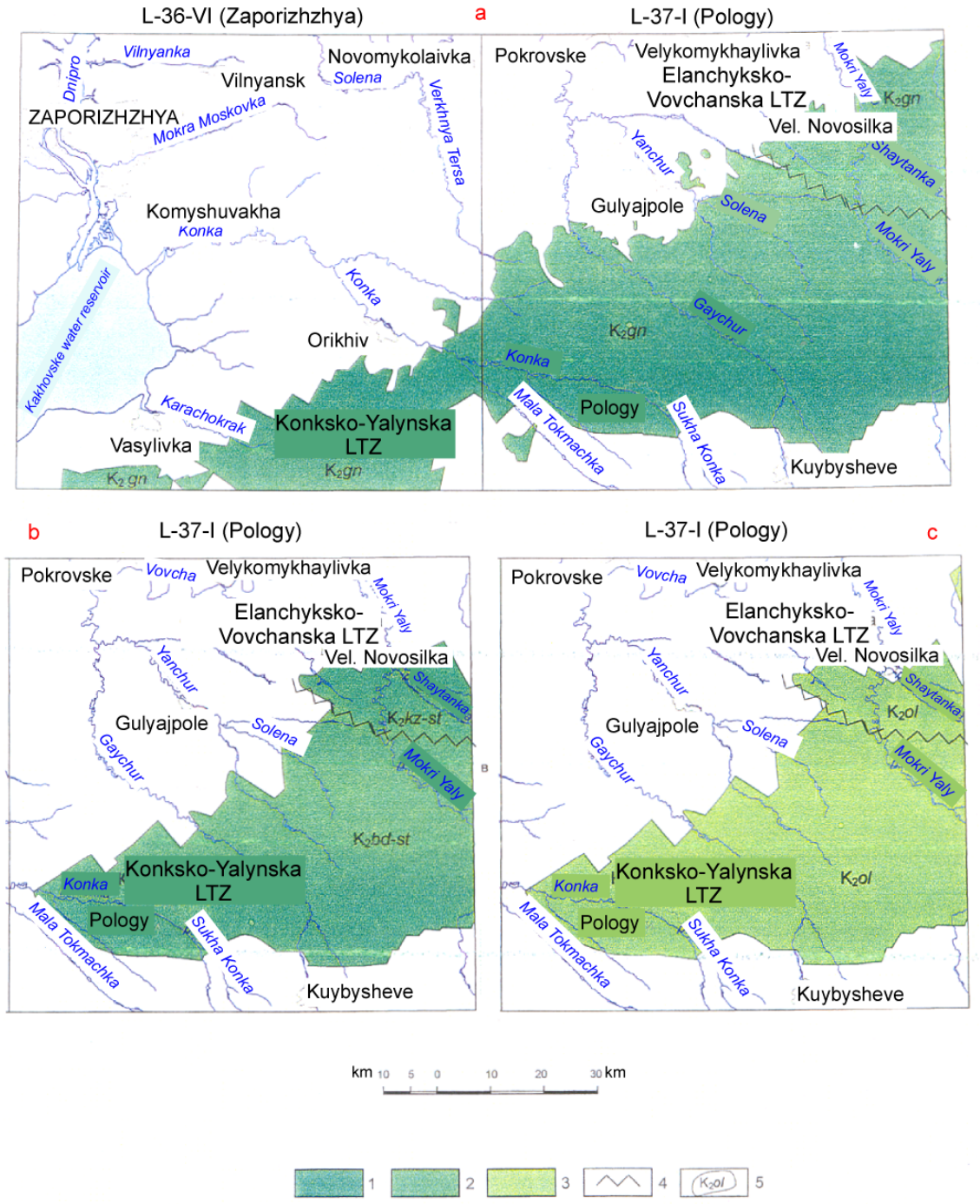

Fig. 2.2. Sketch maps of stratigraphic zonation and distribution of Upper Cretaceous.
a) Genicheska Suite (K_2gn);
b) Berdyanska (K_2bd), Kozeletska (K_2kz) and Staromlynivska (K_2st) suites;
c) Oleksandrivska Suite (K_2ol).
Distribution fields: 1 - Genicheska Suite; 2 – Berdyanska, Kozeletska and Staromlynivska suites; 3 – Oleksandrivska Suite; 4 – boundary between litho-tectonic zones; 5 – geological boundaries of the sediments and their indexes.

Santonian stage and Lower Campanian sub-stage undivided

Staromlynivska Suite (K_2st) is developed in Konksko-Yalynska and Elanchyksko-Vovchanska LTZs, in the development limits of Berdyanska and Kozeletska suites (see Fig. 2.2b). The Suite surface altitudes descend from +90 m in the north to -295 m in the south of the territory. The Suite is composed of marls, chalk-like marls with flint bunches and chalk lenses with minor glauconite. Upward in the column the sand fraction content increases. In places marls are gradually changed by glauconite-quartz marleous sands. Maximum thickness of the Suite is 55 m.

The Suite rocks contain foraminifera: *Discorbis scanika* Brotzen, *Rotalia calcariformis mediocra* Plotnicova, *Praebulimina ventricosa* (Brotzen) and others affirming Santonian and Early Campanian age of the sediments.

Upper Campanian sub-stage and Maastrichtian stage undivided

Oleksandrivska Suite (K_2ol) is developed in the map sheet L-37-I (Pology) (see Fig. 2.2.c). The hanging-wall surface altitudes vary from +98 m in the north to -248 m in the south. In the lower part the Suite is composed of marls (chalk-like in places) which contain glauconite, rarely of silica-clay-like sandstones. Thickness is up to 15 m. The marls are conformably overlain by sandstones with clayey-siliceous cement and belemnite rostrums, quartz-glauconite carbonate sands. Maximum thickness of the Suite in Konksko-Yalynska LTZ is 24 m, and in Elanchyksko-Vovchanska LTZ – 36 m. Foraminifera are found in the Suite rocks: *Discorbisscanica* Brotzen, *Anomalina ekblomi* Brotz., *Cibicidoides betlix* (Marss.), *Eponides (?) seudogranulstus* Plotnicova, *Lamarskina pauxsiliaformis* Plotnicova and others [104]. The Suite age is Late Campanian – Maastrichtian.

Cenozoic Eratheme

The Cenozoic Eratheme in the studied area is represented by Paleogene, Neogene and Quaternary systems which constitute the northern margin of Prychornomorska Depression, the south-western margin of Dniprovsko-Donetska Depression, and overlie the Ukrainian Shield.

The rocks are developed in Pologivska and Vasylivska LTZs. Generalized boundary between the two follows the line of inhabited localities Ocheretuvate – Novoselivka – Chervoniy Yar – Rayske – Vilnyansk of Zaporizka Oblast over the distance of 38 km. In the south-east it is confined to the zone of Zakhidnopryazovskiy Fault and further it changes its direction to the south-western where it is controlled by the transgression boundaries of specific time.

Paleogene System

The rocks of Paleogene System are widely developed over the studied map sheets. With the angular and stratigraphic unconformities they lie over the eroded surface of crystalline basement and Cretaceous System. It includes Eocene and Oligocene divisions.

Eocene Division (P_2)

The lower, middle and upper sub-divisions are distinguished in the Eocene Division.

Lower Sub-Division

Ypresian Stage

The rocks are widely developed over the studied territory. The distribution boundary is complicated and oriented in the north-eastern direction by the line of inhabited localities Vasylivka – Orikhiv – Gulyajpole – Bogatyr. The field of the sediments development is broken and dismembered into non-equal tectonic blocks where the rocks either lacking or fill up the negative relief forms.

In genetic respect the rocks include sediments of the single shallow sea with sulphur-hydrogen enrichment. The surface is inclined to the south-west descending from +80 m to -80 m of altitude. By

lithological features the Kanivskiy and Bakhchysarayskiy regio-stages are distinguished being represented by Kanivska Series and the green sand batch.

Pologivska LTZ

Kanivskiy Regio-Stage

Kanivska Series (P_2kn). The rocks are developed in Konksko-Yalynska LTZ in the maps shhet L-37-I (Pology) (Fig. 2.3.a). By lithology the rocks are uniform enough. They include layered quartz-glauconite and glauconite-quartz sands with gravel and pebble at the bottom. Thickness of the Series is up to 40 m [68, 89, 112]. In the southern adjacent territory these sediments overlain Paleocene Ochakivska Suite and are overlain by the brown-coal sequence of Eocene Simferopolskiy regio-stage [87]; these relations provide the ground for the Lower Eocene age definition of Kanivska Series.

Vasylivska LTZ

Bakhchysarayskiy Regio-Stage

The *green sand batch* (P_2p) comprises the age and lithological analogue of Kanivska Series in Vasylivska LTZ, in the map sheet L-36-VI (Zaporizhzhya) (Fig. 2.3.a). The rocks include quartz-glauconite sands with gravel and pebble at the batch bottom. Rarely aleurolites and clays are observed. Thickness of the batch is up to 16 m.

Middle Sub-Division

In the Middle Sub-Division the Simferopolskiy, Kumskiy (Vasylivska LTZ), Buchatskiy and Kyivskiy (Pologivska LTZ) regio-stages are distinguished. The first and third ones are being correlated with Lutetian, and the second and fourth ones – with Bartonian stages of Paleogene after the International Stratigraphic Scale.

The continental rocks of Simferopolskiy and Buchatskiy regio-stages, and the sequence of sands and clays and Buchatska Series respectively, lie over the Eocene Lower Sub-Division with erosion, and with the angular and stratigraphic unconformity over the rocks of crystalline basements and Cretaceous System. The sediments fill up the paleo-dimples which are opened to Dniprovsko-Donetska and Prychornomorska depressions. This explains the complex, winding shape of their distribution boundaries. The general inclination of the surface descends in the southern and south-western directions from +80 m to -120 m of altitude. The rock normal laying is complicated by tectonic breaks. Geology of the horizons is very similar: sub-coaliferous, coal-bearing and supra-coaliferous batches are distinguished in the vertical column. By lateral the sequences gradually replace one another and the conventional boundary between the two is drawn by the zone of Zakhidnopryazovskiy Fault; the batch footwall altitudes are essentially different to the both sides of the Fault.

The age position of the sequences, after results of palinologic studies, is thought to be somewhat different. The sequence of sands and clays apparently encompasses the upper part of Bakhchysarayskiy and Simferopolskiy regio-stages while Buchatska Series (Horizon) - Simferopolskiy and Novopavlivskiy regio-stages which correspond to the Buchatskiy regio-stage in the stratigraphic scale of the Central area.

Lutetian Stage

Vasylivska LTZ

Simferopolskiy Regio-Stage

Sequence of sands and clays (P_2pg). The sediments are developed in Vasylivska LTZ. Three batches are distinguished in the column: sub-coaliferous, coal-bearing and supra-coaliferous.

The sub-coaliferous batch is widely developed and surrounds Pryazovskiy horst from the west and Dniprovske uplift from the south (Fig. 2.3.b). It is composed of the alluvial and alluvial-lake facies rocks including sands with gravel and pebble, secondary kaolines and clays. The rock clastic material is weakly sorted and rounded; coalified organic remnants are common. The lower column portion of the coal-bearing batch is composed of the alluvial and alluvial-lake facies rocks. The lake-swamp sediments and brown coal are developed in the upper portion and control Orikhivske brown coal deposit. The supra-coaliferous batch is mainly composed of kaolineous clays (65-70%); the sands and secondary kaolines are observed in equal amounts. The

total thickness of the Sequence close to Pryazovskiy horst attains 55 m reducing to 20-25 m toward the periphery.

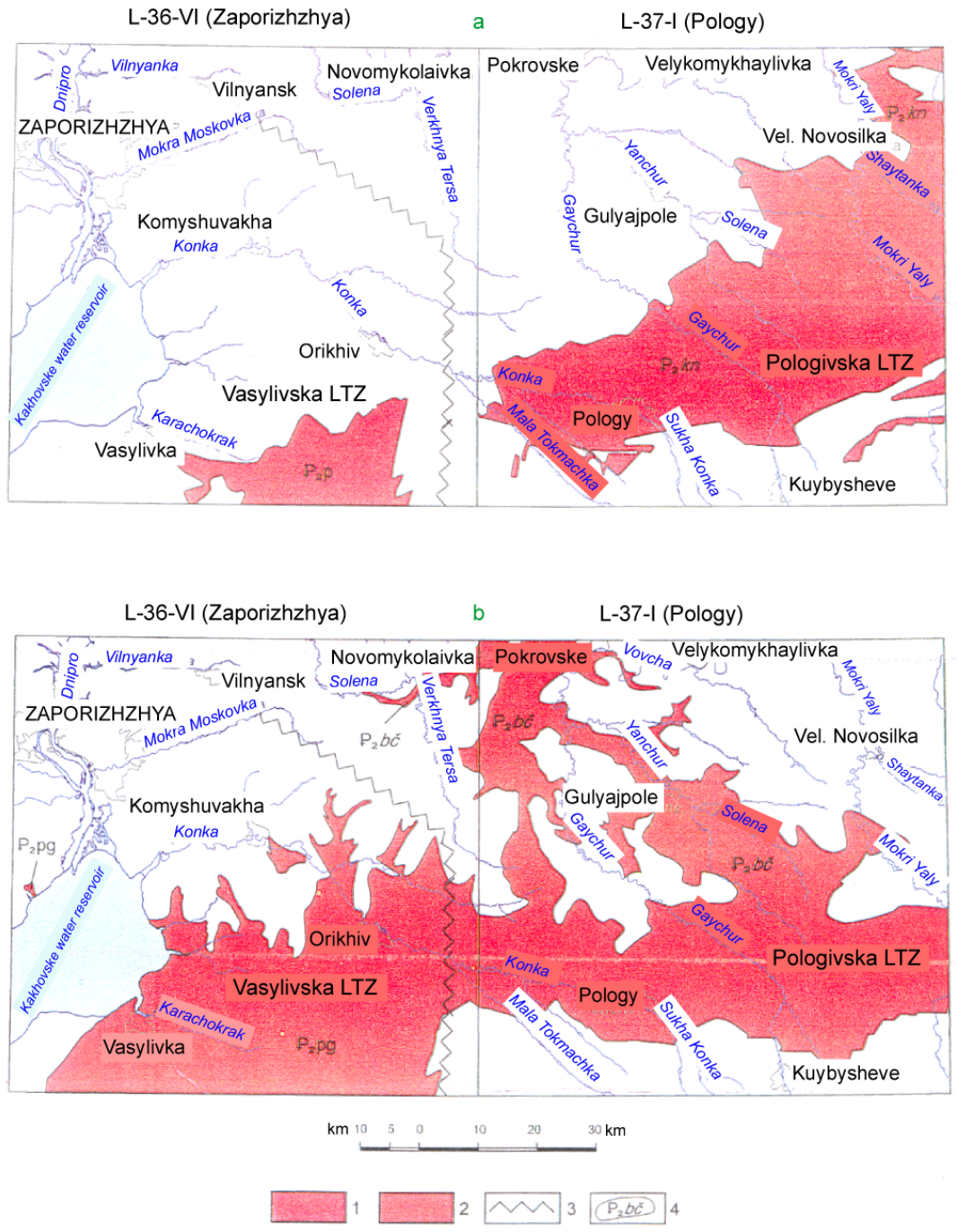

Fig. 2.3. Sketch maps of stratigraphic zonation and distribution of Eocene sediments.
a) green sand batch (P_2p) and Kanivska Series (P_2kn);
b) sand and clay sequence (P_2pg) and Buchatska Series (P_2bu).
Distribution fields: 1 – green sand batch and Kanivska Series; 2 – sequence of sands and clays and Buchatska Series; 3 – boundary between litho-tectonic zones; 4 – geological boundaries of the sediments and their indexes.

Middle Eocene age of the Sequence is defined by its position in the column – it lies between the fauna-containing sediments of the green sand batch and Khadzhybeyska Suite.

Pologivska LTZ

Buchatskiy Regio-Stage

Buchatska Series (P$_2$*bu*) is developed in Pologivska LTZ. Alike the sequence of sands and clays three batches are distinguished. The sub-coaliferous batch is developed to the north of Konkskiy Fault in the area of Pology town and pinches out in the south-east of territory (see Fig. 2.3.b). The coal-bearing batch is developed over entire LTZ; its thickness is 25-30 m. Sanzharske brown coal deposit is confined to this batch. The supra-coaliferous batch up to 145 m thick is composed of deluvial-proluvial facies rocks. These rocks are developed to the north of Pryazovskiy horst in the band 15-20 km wide. Five sedimentation cycles are distinguished. The rhythms 10-23 m thick start with coarse sediments and finish with clays, secondary kaolines or the brown coal beds.

Middle Eocene age of the Sequence is defined by its position between the fauna-containing sediments of Kanivska Series and Kyivska Suite, as well as on the ground of palinologic studies.

Bartonian Stage

The rocks of Late-Middle Eocene age in the map sheet territory include marine sediments of Khadzhybeyska and Kyivska suites of Kumskiy regio-stage.

Kumskiy Regio-Stage

Khadzhybeyska Suite (P$_2$*hd*) is developed in the south-west of map sheet L-36-VI (Zaporizhzhya) (Fig. 2.4.a). It transgressively lies over the rocks of Simferopolskiy horizon and is overlain by Borysfenska and Alminska suites; in the Dnipro River valley – by Quaternary sediments. The eastern boundary of the Suite distribution is set to the west of Zakhidnopryazovskiy Fault and the north-eastern boundary follows the line of inhabited localities Zaporizhzhya – Veselyanka – Shcherbaky – Robotyne.

The Suite is composed of marine sediments. Diverse-grained carbonate glauconite-quartz sands with quartz pebble are observed at the bottom. Their thickness is 1-2 m and increases to 5-7 m toward the coastline. The coastal-marine zone is traced in the narrow (up to 2 km) band. Surface is inclined in the south-western direction; the altitudes descend from +5 m to -60 m. Higher in the column up to 20 m thick calcareous clays are observed. The column is capped by greenish-grey marls containing Middle Eocene macro-fauna (Venericardia cf. tamida Koenen. Var *aneprovensa* Slodkew., *Pocoides contoitus Defrano ukrainica* Kluceh n., *Leda crispote* Koenen. *Var. ukrainica* Sok., *Turitella granulosa* Desh and others) and micro-fauna: foraminifera – *Marginulinopsis fragaria* (Gumb.), *Lenticulina laticostata* (Tutk.); *Baggina Korobkovella grosserugosa* (Gumb.) and others; ostracoda – *Paracurpis ex. gr. contorta jones; Pterugocutheris cornata* (Poem.), *Haplocuteria hebertiana* (Bosg). Thickness of the marls is 25-30 m; the maximum thickness of the Suite in the south of the territory is 54 m.

Pologivska LTZ

Kyivskiy Regio-Stage

Kyivska Suite (P$_2$*kv*) transgressively overlies Buchatska Series, and with angular and stratigraphic discontinuity – the rocks of Cretaceous System and crystalline basement (Fig. 2.4.a). It is overlain by Eocene Reshetylivska Sequence and in places it lacks – by Neogene and Quaternary sediments. The Suite is developed in the central and north-western parts of map sheet L-37-I (Pology). The distribution boundary follows the strato-isohypse 70-80 m.

The deeply-eroded surface of the Suite is inclined in the south-western direction and in Vovchanska Depression only it is inclined to the north-east. The surface altitudes descend from +80 m to +35 m. Maximum thickness of the Suite in the axial portions of paleo-dimples attains 54 m.

The sediments include shallow-water marine rocks: glauconite-quartz sands, aleurolites and dark-green argillites. In the column lower part the brown coal material, flint and phosphorite bunches, quartz and crystalline rock gravel admixtures are observed. The rocks contain abundant sponge spicules and Upper Eocene fauna: *Arca sulcicosta* Nyst., *Pectunculus sp., Cardita tumida* Koen., *Cardium charcovensis* Slod., *Lucina sp., Corbula cospidata* Sow., *Pecten idoneus* Wood., *Chlamys sp., Lima eximia* Giep., *Meretrix sp., Solen sp., Tomyris ukrainae* Mich., *Matildia cf scobrella* Semper., *Fusus elongatus* Nyst.; the mud-worm passes occur.

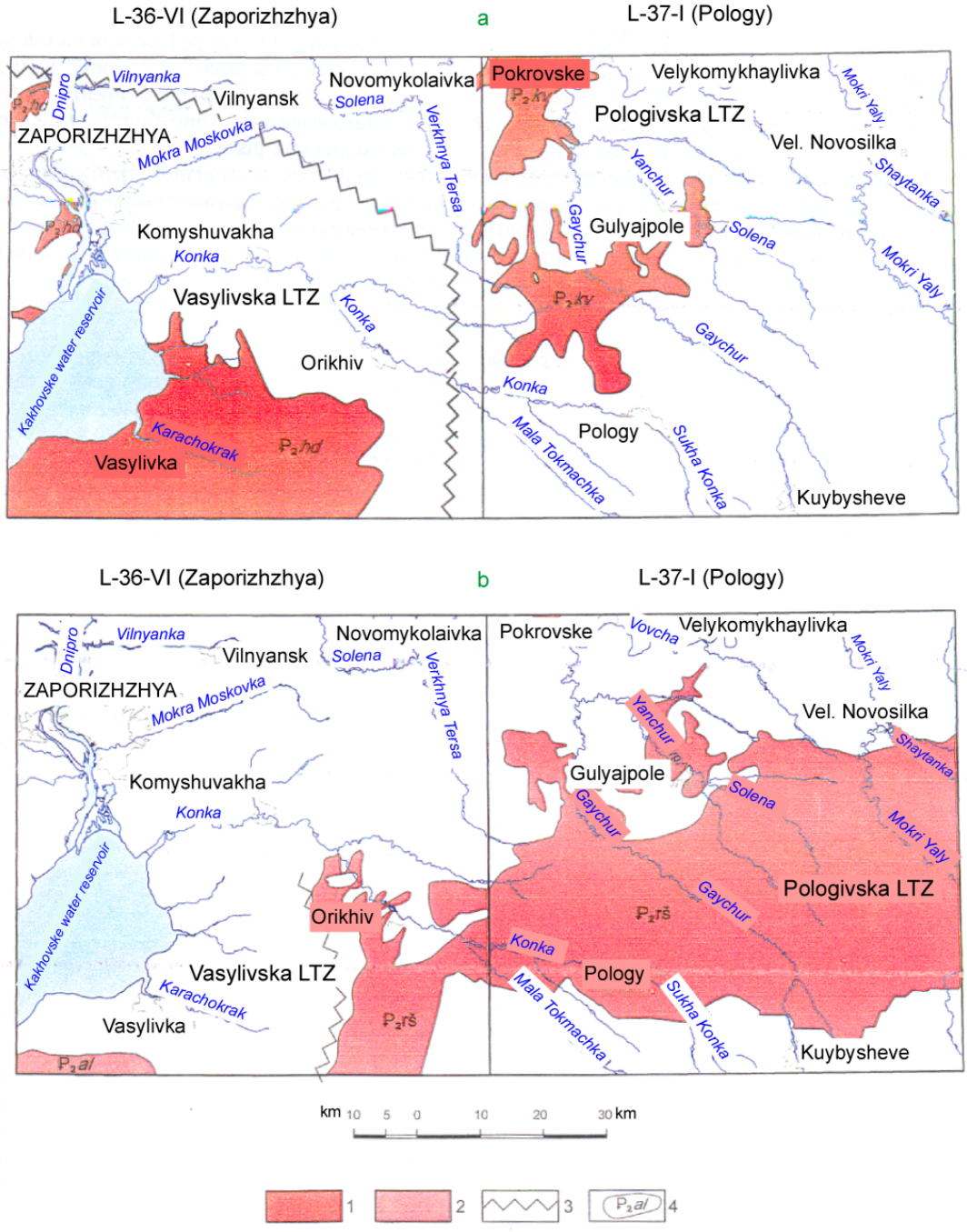

Fig. 2.4. Sketch maps of stratigraphic zonation and distribution of Eocene sediments.
a) Khadzhybeyska (~~P~~$_2$*hd*) and Kyivska suites (~~P~~$_2$*kv*);
b) Alminska Suite (~~P~~$_2$*al*) and Reshetylivska Sequence (~~P~~$_2$*rc*).
Distribution fields: 1 – Khadzhybeyska and Kyivska suites; 2 – Alminska Suite and Reshetylivska Sequence; 3 – boundary between litho-tectonic zones; 4 – geological boundaries of the sediments and their indexes.

Upper Sub-Division

In the general stratigraphic scale Pryabonskiy stage corresponds to this Sub-Division being subdivided into Alminska Suite (Vasylivska LTZ) and Reshetylivska Sequence of Kharkivska Series (Pologivska LTZ). The Alminska Suite corresponds to the same-named regio-stage of Northern Prychornomorya. Kharkivska Series is distinguished in Pologivska LTZ where it includes the Upper Eocene – Lower Oligocene continental rocks in Konksko-Yalynska Depression. the Series column is divided into Reshetylivska and Yalynska sequences which correspond to Obukhivskiy and Mezhygirskiy regio-stages in DDD.

Valylivska LTZ

Alminskiy Regio-Stage

Alminska Suite (~~P~~$_2$*al*). Marine sediments conformably overlie Khadzhybeyska Suite and are transgressively overlain by marine Borysfenski sediments. The rocks are mapped only in the south-western part of map sheet L-36-VI (Zaporizhzhya) (Vasylivska LTZ) (see Fig. 2.4.b). Their thickness is 10-16 m. The rocks include quartz-glauconite aleurites, aleurolites and sands.

In the column upper part Late Eocene fauna is often observed: *Chlamys (Aequipecten)bellicostus s.* W o o d . , *var. orientalis* S o k., *Ch. biarritz* A r c h., *var. subtripartitus* A r c h., Ch. Solea D e s h., *Ch. idowens* W o o d., *Phacoides (Miltha) contortus* D e h r., *var ukrainica* K l u s c h., *Murex Williamski* S o k., *Rotalina lithotanica* U h l i s, *Cardium restispina* K o e n., C., *(Trahicardium) praepitatum* S l o d k., *Ostrea (Gigantostrea) gigantica* S o l., *Pteria media* S o w., *Spondulus solen* D e s h., *Nucula nichalski* S o k., *Pectunculus – Williamis Sokol* and others. Foraminifera: *Nodosaria ewaldi* R e n s s., *N. longiscata* (O r b.), *Rotalia beccarii* (L i n n e), *R. conguisita* K r a s h., *Gyroidina soldanii* (d'O r b.), *Clandulina laevigata* (d ' O r b .), *Robulus inornatusi* (O r b.), *Lenticulina rųmesi* R e u s s, *Anomalina Samoilova* and others.

Pologivska LTZ

Obukhivskiy Regio-Stage

Kharkivska Series

Reshetylivska Sequence (~~P~~$_2$*rc*). The continental sediments of this Sequence comprise the lower part of Kharkivska Series. The rocks with erosion lie over marine Cretaceous sediments, Kanivska Series, Khadzhybeyska and Kyivska suites, as well as continental rocks of Buchatska Series (see Fig. 2.4.b). The rocks are overlain by Oligocene Borysfenska Suite, Novopetrivska Suite and Miocene Chokrakski Layers, continental Oligocene Yalynska Sequence and in the valleys of Gaychur and Yanchur rivers – by Quaternary sediments. The Sequence is easily defined in the section by the characteristic lithology and green colour of the rocks.

The sediments are developed in the central part of map sheet L-37-I and in the south-eastern part of map sheet L-36-VI. The rocks surround Pryazovskiy horst from the west and north with the strip 15-40 km wide smoothing the negative relief forms. The distribution boundary is complex. In the latitudinal direction it mainly follows the line of inhabited localities Vel. Novosilky – Ternuvate and then to the south-west toward Ternuvate-Orikhiv and Kopaniv in the south. The surface is inclined to the south-west descending from +120 m to -20 m of altitudes. The sediments are extensively eroded. Their normal laying is complicated by tectonic breaks. Alluvial, alluvial-lake and lake-swamp sediments of the coastal plain and proluvial fans of the fore-mountain plains are distinguished in the territory.

The fan sediments are characterized by the frequent intercalation of variously-textured clastic rocks (sands, clays, aleurites, sandstones, gravel) from 0.7 to 4.5 m thick with gradual transitions between the varieties. It is also characteristic for the rocks the weak grain sorting and rounding, various clay content; the clays are of montmorillonite composition. Outward the Pryazovskiy horst the clastic material size decreases and the degree of its sorting increases. Just nearby Konkskiy Fault the clast size is from 2-3 cm to 10 cm.

Obscured sedimentation cycling is observed in the Sequence column. It is counted from 3 to 11 rhythms from 6 to 70 m thick. The fossil and coalified wood fragments are frequently observed. In places the buried soil interbeds (0.2-0.3 m thick) occur which contain the thin network (1-3 mm) of coalified fossil roots. Somewhere the sun cracks are also observed [58]. The rock laying is inclined under the angle 10-15^o, rarely 45-50^o. Maximum thickness of the Sequence is 210 m.

Upper Eocene age of the Sequence is confidently defined by the stratigraphic method – the rocks are underlain and overlain by the fauna-containing sediments of Khadzhybeyska and Borysfenska suites respectively.

Oligocene Division (P_3)

In the studied area two isolated sites of various Oligocene sediments are mapped. Almost complete Oligocene section composed of Maykopska Series marine sediments, except Gornostaivska Suite, is mapped in Vasylivska LTZ, the counterpart of Oligocene-Miocene Prychornomorska Depression. In Konksko-Yalynska Depression, separated apart in Late Eocene time, Division includes continental rocks of Lower Oligocene Yalynska Sequence of Kharkivska Series (Pologivska LTZ). In Vasylivska LTZ the lower sub-division includes Planorbelloviy and Molochanskiy regio-stages which in Pologivska LTZ correspond to Mezhygirskiy regio-stage; in the upper sub-division – Sirogozkiy and Askaniyskiy regio-stages. In the general stratigraphic scale Rupelian stage correspond to the lower sub-division and Chattian stage – to the upper sub-division.

Lower Sub-Division

Rupelian Stage

Mezhygirskiy Regio-Stage

Kharkivska Series

Yalynska Sequence (P_3*jl*) is developed in the central part of map sheet L-37-I (Pology) in the broad (up to 40 km) strip to the north of Konkskiy Fault (Fig. 2.5.c). The north-western rock distribution boundary follows the line of inhabited localities Vel. Novosilka – Obratne – Novovasylivka – Gulyajpole – Ukrainske. The rock surface is inclined to the north and north-west gradually descending from +130 m to +110 m of altitude. At the pinching margin it drops abruptly to +80 m. The surface outcrops are encountered in the area of Pology town.

The Sequence rock colouring comprises the reliable mapping feature: light (white, light-grey) with distinct violet, lilac, crimson, rarely ochreous iron hydroxide stains; these are strongly contrasted to the dark-green, dark-grey with greenish shade rock colours of Reshetykivska Sequence. Lower limit of the Sequence is set by the bottom of gravel-pebble sediments.

The intricate alternation of sands, sandstones, clays, secondary kaolines with coalified fossil remnants. In the northern part the lake-swamp rocks are mapped – brown coal beds. In the upper part the clays are kaolineous and in the lower part – hydromica with beidellite and kaolinite admixtures. Transitions between the layers are gradual, in places the contacts are sharp at the angle 45° to the horizon. Thickness of individual layers is 0.7-1.8 m, gravelous rocks – 0.1-0.4 m. The cycling is observed in the Sequence. Outward from the Konkskiy Fault amount of rhythms decreases from 4 to 2. Thickness of the Sequence close to the Konkskiy Fault is 74 m gradually decreasing in the north-western direction.

Early Oligocene age of Yalynska Sequence is defined on the ground of its laying over Reshetylivska Sequence (Late Eocene) and the history of geological development in the region.

Maykopska Series

In the south-western part of map sheet L-36-VI (Zaporizhzhya) only lower (Borysfenska and Molochanska suites) and middle (Sirogozka and Askaniyska suites) portions of the Series are encountered. The upper portion (Gornostaivska, Chornobaivska and Karzhynska suites) is known outside the southern map sheet margin. The suites of Maykopska Series do correspond to the Planorbelloviy and Molochanskiy (Ostrakodoviy) regio-stages of Oligocene lower sub-division, as well as Sirogozkiy and Askaniyskiy regio-stages of the upper sub-division.

Planorbelloviy Regio-Stage

Borysfenska Suite (P_3*bs*). Borysfenski sediments are developed in the southern half of map sheet L-36-VI (Zaporizhzhya) (Fig. 2.5.c). The eastern distribution boundary is confined to Zakhidnopryazovskiy Fault; north-eastern one follows the line of inhabited localities Uspenivka – Orikhiv – Balabyne. The rocks transgressively lie over Alminska and Khadzhybeyska suites and Reshetylivska Sequence or over the rocks of crystalline basement. They are overlain by Oligocene Molochanska Suite or Middle Miocene rocks, and in

Dnipro River valley – by Quaternary sediments. The Suite surface is inclined in the south-western direction and descends from +55 m to -17 m of altitude. Thickness of the Suite is up to 35 m. The manganese ores are related to the Suite.

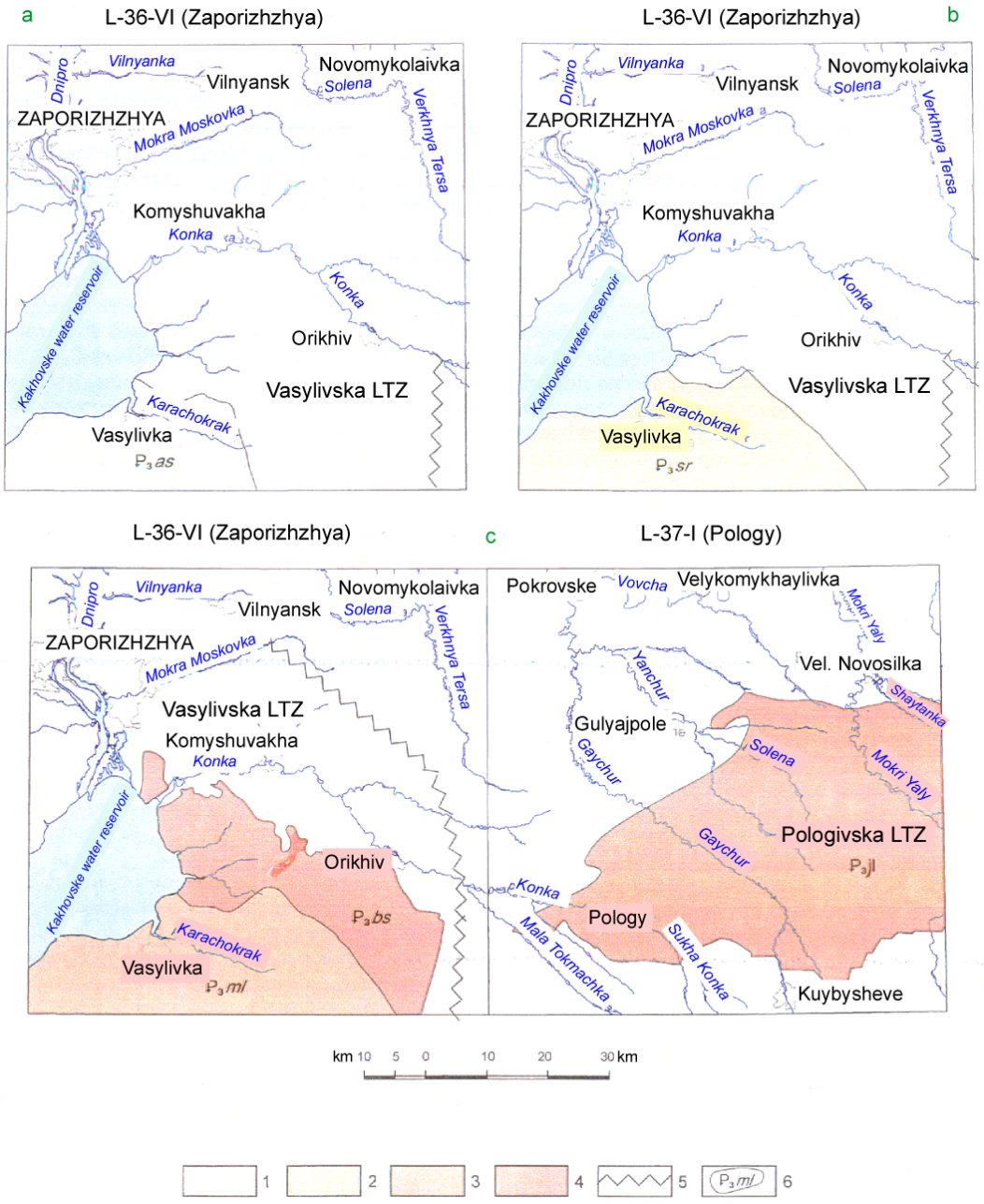

Fig. 2.5. Sketch maps of stratigraphic zonation and distribution of Oligocene sediments.
a) Askanivska Suite (P_3as);
b) Sirogozka Suite (P_3sr);
c) Molochanska (P_3ml) and Borysfenska (P_3bs) suites and Yalynska Sequence (P_3jl).
Distribution fields: 1 – Askaniyska Suite; 2 – Sirogozka Suite; 3 – Molochanska Suite; 4 – Borysfenska Suite and Yalynska Sequence; 5 – boundary between litho-tectonic zones; 6 – geological boundaries of the sediments and their indexes.

At the column base the coarse- and medium-grained dark-grey and dark-green quartz-glauconite sands are observed which contain fauna *Bolivina mississippiensis* C u s h m., *Uvigerinella majcopica* K r a e v a i n

Z i t t . , *Angulogerina cf. pulchella* C u s h m. e t E d., *Cassidulina sp.* and others. Transition from the sands to the overlaying manganese ores is gradual.

The ore bed is composed of oxide, carbonate and mixed ores. Oxide ores are confined to the northern part of the deposit and carbonate ores are developed in the remaining portions. The mixed ores are observed in between in the band 0.5-3.0 km wide. Oxide ores comprises the aggregated concretions of manganite and psilomelane composition within the soot-clayey material. Thickness of the ore bed is 0.5-2.3 m. The bed of mixed ores includes oxide ores in the upper part and carbonate ores in the bottom. Thickness of the bed is 0.9-2.5 m. In the 0.3-1.5 m thick bed of carbonate ores two portions are distinguished connected by the gradual transitions: the upper concretion and the lower platy ones.

Organic remnants in the ores are rare. The general content: *Nucula compta* G o l d f., *Lucina batalpaschinica* K o r o b., *Thgasira Unicarinata* N y s t., K o e n., *Cardium cf. Charcovensc* S l o d. and others [23].

Above the manganese ores the dark-grey 5-40 m thick clays of hydromica-montmorillonite composition are observed. The clays contain micro-fauna: *Spiroplecta mmina carinata* (d'O r b.), *Miliolina circularis* B o r n . , *Caucasina schischkinskye* (S a m l.), *Bolivina mississippiana* C u c h., *Bolivina cf heyrichi* R e u s s., *Angulogerina ex gr. oligocenica* A n d r e a e , *A. pulchella Cush. et* E d w., *Uvigerinella majcopica* K r a e v a msc. and others suggesting for Oligocene age of Borysfenska Suite.

M o l o c h a n s k i y R e g i o - S t a g e

Molochanska Suite (P$_3$*ml*) is developed over much less territory than Borysfenska Suite (see Fig. 2.5.c). The sediments lie over Borysfenska Suite without interruption and are overlain by the rocks of Sirogozka Suite. The north-eastern boundary is set to the south-west from the inhabited localities Kharkove – Kopani – Shcherbaky. The sediments include grey, dense, micaceous, aleuritic, carbonate hydromica-montmorillonite clays with abundant ostracoda *Disopontocypris Oligocaenica* (Z a l a n y i). Thickness of the Suite is 8 m.

Upper Sub-Division

C h a t t i a n S t a g e

S i r o g o z k i y R e g i o - S t a g e

Sirogozka Suite (P$_3$*sr*). The sediments lie over Molochanska Suite without interruption and are overlain by Askaniyska Suite and in places it lacks – by Miocene rocks. They are mapped in the south-western part of map sheet L-36-VI (Zaporizhzhya) (see Fig. 2.5.b). The distribution boundary is switched by 10-15 km to the south-west from the distribution boundary of Borysfenska Suite and replicate this in general outlines.

The Suite is composed of dark-grey and grey with greenish shade, dense, aleuritic, micaceous, often fine-banded, montmorillonite and hydromica clays with organic admixture. Thickness of the Suite is 8-10 m, maximum – 15 m. The sediments contain Late Oligocene fauna: *Corbula sokolovi* (K a r l.), *Lentidium vinogrodskii* M e r k l., *Cardium cerastoderma serogosicum* N o s s o v., *Crassatella desmaresti* D e s h.

A s k a n i y s k i y R e g i o - S t a g e

Askaniyska Suite (P$_3$*as*) without interruption lies over Sirogozka Suite and is overlain by the Miocene rocks. The sediments are developed in the south-western part of map sheet L-36-VI (Zaporizhzhya) (see Fig. 2.5.a). The distribution boundary follows the line of inhabited localities Novogorivka – Peremozhne – Vesele, then to the west toward Kakhovske water reservoir, to the north of Grozove and Verkhnya Krynytsya villages. The surface is inclined in the south-western direction descending from +5 to -15 m of altitude.

Askaniyska Suite is composed of clays with aleurolite interbeds (up to 1 m). The clays are grey, greenish-grey, dark-grey, carbonateless, aleuritic with iron hydroxide stains; by composition they are montmorillonite with hydromica and kaoline admixture. Thickness of the Suite is 15 m.

The Late Oligocene age is supported by micro-spores *Polypodiaceae*; *Gleichenia sp., Hystrichocphaerideae*; *Dinoflagellata, Taxodiaceae*, *Carpinus sp., Corilus sp., Ulmus sp.*

Neogene System

In the volume of Neogene System the Miocene and Pliocene divisions are distinguished which are developed in the Ukrainian Shield, Prychornomorska and Dniprovsko-Donetska depressions.

Miocene Division (N_1)

In the studied area Miocene Division includes mainly middle and upper sub-divisions. Of the lower sub-division, just the Tomakivski Layers with marine sediments of Tarkhanskiy regio-stage are sporadically observed in Vasylivska LTZ.

Lower Sub-Division

Tarkhanskiy Regio-Stage

Tomakivski Layers (N_1tm). The sediments are fairly locally developed and do not form the solid development area. They are encountered in the outskirts of Zaporizhzhya city, Baburka, Balabyne, Chkalove villages and Kapustyana gully. In the geological map and geological cross-sections the rocks are not indicated.

Tomakivski Layers lie over the weathering crust of crystalline basement and with the stratigraphic unconformity are overlain by the rocks of Sarmatian regio-stage. The Layers are composed of green marine sandy clays with iron hydroxide stains which contain Early Miocene fauna: *Ostrea griphoides* Schlotth., *O. griphoides var. gingensis* Schlith., *O. griphoides var. angustata de serr., O. digitalina* Dub., *Pecten domgeri* Mich., *Cardium cf. platovi* Bog., *Meretrix rudis* Poli., *Tellina commpress* Brocc., *Turitella sokolovi* Mich., *Chlamys domgeri* Mich., *C. malvinae* Dub., *Mutilus fuscus M.* Hoern and others.

The coarse-grained sands with gravel and pebble (up to 0.5 m) are observed at the Layers bottom. Maximum thickness of the Layers preserved from erosion does not exceed 4 m.

Middle Sub-Division

In the studied area Chokrakskiy, Karaganskiy and Konkskiy regio-stages of Northern Prychornomorya are distinguished (Vasylivska LTZ); they correspond to the middle and upper sub-regio-stages of Novopetrivskiy regio-stage in DDD (Pologivska LTZ).

Chokrakskiy Regio-Stage

Chokrakski Layers (N_1uk) include shallow-water marine sediments and are developed in the southern part of map sheet L-36-VI (Zaporizhzhya) (Fig. 2.6.a). With the stratigraphic discontinuity they lie over Paleogene and crystalline basement rocks and are overlain by Karaganskiy and Konkskiy regio-stages.

The rocks include calcareous clays with marl, rarely limestone interbeds. In the eastern direction they are facially replaced by sandy clays, aleurites and glauconite-quartz sands. Thickness of the layers does not exceed 14 m.

The clays are green, emerald-green, dense, carbonate. The rocks are underlain by diverse-grained gravelous sands. The clays contain Chokrakska fauna: *Area turonica* Duj., *A diluvii* Lmk., *Ervilia praepodolica* Andrus, *Loripes dentatus* Bast and others. The marls are observed in thin interbeds (20-30 cm) in clays. Aleurites are clayey, micaceous, dense, with glauconite and in the bottom contain fauna: *Bittium Ligitatum* Lhich., *Potamides rubiginosum* Eichw., *Potamides sp., Ervilia sp., E. praepodolica, Trohus aff. bayarunosi* Kol. Foraminifera include: *Streblus beccarii* (L) and *Muliolnella sp.*

The coastal-marine sediments of Chokrakske sea are correlated with the continental sediments of the middle sub-suite of Novopetrivska Suite of Poltavska Series in Pologivska LTZ.

Karaganskiy Regio-Stage

Kartvelski Layers (N_1kr) are developed in the south-west of map sheet L-36-VI (Zaporizhzhya) (Fig. 2.7.a). Their northern boundary follows the line Lugove – Vesele – Chervonoarmiysk villages; eastern one – Ternuvate – Novogorivka.

Kartvelski Layers with erosion lie over Chokrakski Layers and are overlain by the rocks of Konkskiy regio-stage. The sediment surface is inclined to the south-west and altitudes descend from +18 m to -12 m.

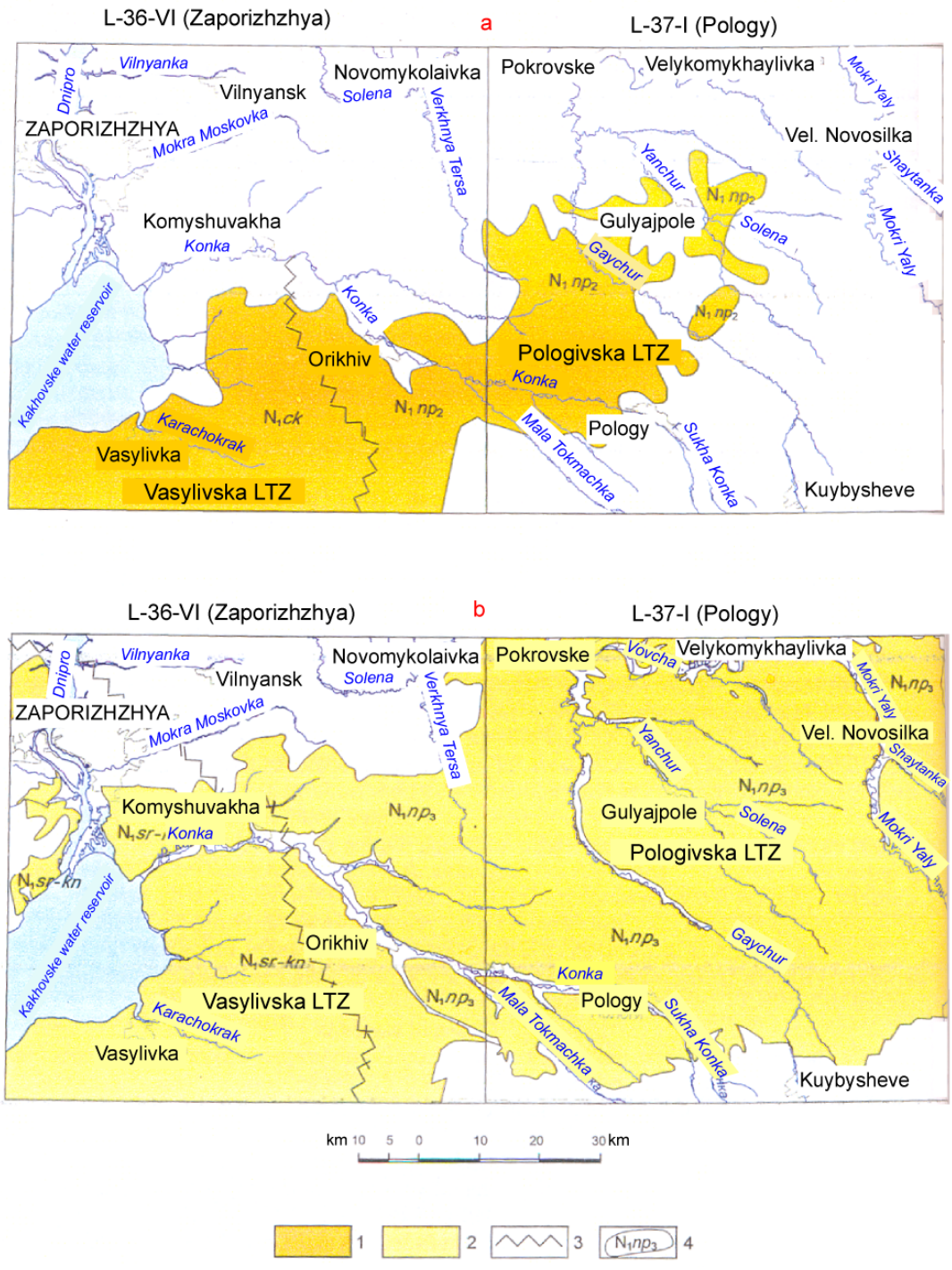

Fig. 2.6. Sketch maps of stratigraphic zonation and distribution of Early Miocene sediments.
a) middle sub-suite of Novopetrivska Suite (N_1np_3) and Chokrakski Layers (N_1uk);
b) upper sub-suite of Novopetrivska Suite (N_1np_2) and Sartagansko-Konkski Layers (N_1sr-kn).
Distribution fields: 1 – middle sub-suite of Novopoltavska Suite and Chokrakski Layers; 2 – upper sub-suite of Novopoltavska Suite; 3 – boundary between litho-tectonic zones; 4 – geological boundaries of the sediments and their indexes.

The sediments include light-greenish-grey, bluish-green, dark-green, dark-grey, carbonate and carbonateless clays with marl interbeds up to (0.1-0.5 m thick). At the bottom quartz gravel is observed. The clays are composed of hydromica, kaolinite and montmorillonite with minor palygorskite; they contain fauna: *Ervilia ex. gr. pusilla* P h i l., *Spaniodontella pulchella* B a i l y, *Rotamides bicostatus* E i c h w., *Mohrensternia grandis* A n d r u s., *Nassa cf. obligna* H i l b., *Potamides ex. gr. mitralis* E i c h w.

Thickness of the Layers is 11-12 m, maximum – 17 m.

K o n k s k i y R e g i o - S t a g e

Sartaganski and Konkski layers undivided (N_1*sr-kn*). Marine sediments, which transgressively lie over Oligocene, Miocene and crystalline basement rocks, are developed in the southern and central parts of map sheet L-36-VI (Zaporizhzhya) (see Fig. 2.6.b). The distribution boundary follows the line Zaporizhzya – Tarasivka – Kamyshuvakha – Shcherbaky – Kopani. The rocks are eroded in the Konka River valley and nearby Veselyanka village they are exposed at the surface. The Layers are overlain by Upper Miocene and Quaternary sediments (in Dnipro River valley). The surface descends to the south-west from +35 m to 0 m of altitude.

The column is composed of clays and sands. The latter in subordinate amounts are observed at the column bottom and are developed in the 20-25 km wide strip mainly in the north-eastern part of Konkskiy basin. The south-western distribution boundary passes Kamyanske – Shyroke – Barvynivka villages. The clays are grey, greenish-grey, baddeleyite, non-layered, lumpy, carbonate, from fine-elutriated to aleuritic, confined to the upper column part. Thickness varies from 4-5 to 7-8 m. In the northern part of the clay distribution area the thin limestone interbeds are characteristic while in the southern part – marl interbeds. Limestones contain Middle Miocene fauna: *Mactra cf. hasteroti* M a y e r, *Cardium andrussovi* S o k., *Loripes nivens* E i c h w., *Barnea pseudous ttjurtensis* B o g., *Donax rutrum* S o k., *Corbula gibba* O l., C. *michalskii* S o k., *Venus konkensis* S o k . , *Cardium sciloficum* S o k., *Modiola sp.* and others.

The maximum total thickness of the layers is 12 m.

The coastal-marine sediments of Kartvelskiy, Sartaganskiy and Konskiy horizons in Vasylivska LTZ are correlated with the continental sediments of upper sub-suite of Novopetrivska Suite of Poltavska Series in Pologivska LTZ.

Pologivska LTZ

N o v o p e t r i v s k i y R e g i o - S t a g e

Poltavska Series (N_1pl)

In the studied map sheets the Series includes only middle and upper sub-suites of Novopetrivska Suite.

Novopetrivska Suite (N_1*np*), *middle sub-suite* (N_1np_2). By its position in the column the middle sub-suite of Novopetrivska Suite does correspond to Chokrakskiy regio-stage of Vasylivska LTZ. The sediments comprise different-facial even-aged rocks of the single sea basin.

Sub-suite rocks are developed in the central part of map sheet L-37-I (Pology) (see Fig. 2.6.a). The distribution boundary is intricate, winding, and highlights its deep erosion. The surface is inclined to the south-west descending from +80 m to -20 m of altitude. The rocks include coastal-marine sediments which lie over Paleogene and crystalline basement rocks with stratigraphic discontinuity and are overlain by the upper sub-suite of Novopetrivska Suite. In lithological respect they include white uniform, well-sorted, fine-grained, quartz with minor feldspar sands with sponge spicules. At the top of sands the fine-grained with siliceous cement, strong, porous, nodose, 0.5-1.5 m thick sandstones are observed. Thickness of sub-suite is 25 m.

The sediments are exposed in the Konka River valley to the north-west from Pology town where organic remnants are found: *Dentatium sp., Cardium sp., Loripes sp., Chlamys sp.*

Upper sub-suite (N_1np_3). These continental sediments with the stratigraphic discontinuity overlie Paleogene and Miocene rocks and in places of their lacking – with the angular and stratigraphic discontinuity overlie the crystalline basement rocks. The rocks are overlain by the Upper Miocene sediments and in places of their lacking – by Pliocene and Quaternary rocks.

Sub-suite is developed over the territory of map sheet L-37-I and in the eastern half of map sheet L-36-VI (see Fig. 2.6.b). It is absent in the elevated sites of crystalline basement and in the river valleys being exposed on their slopes. The norther distribution boundary is set at the latitude of Zaporizhzhya city and the southern boundary follows the outlines of Pryazovskiy hosrt. The surface is inclined to the north and north-west and in the

map sheet L-36-VI – to the south and south-west. The maximum altitudes (+200 m) are observed in the north-eastern part of map sheet L-37-I while the minimum ones (+30 m) – to the central part of map sheet L-36-VI.

The rocks include the intricate coastal lowland plain rock complex of various genetic types – diverse-grained kaolineous sands with gravel, secondary kaolines, clays, coaliferous clays with brown coal interbed. The rocks lie between the fauna-characterized Middle and Upper Miocene rocks.

Thickness of the upper sub-suite of Novopetrivska Suite attains 70 m.

Upper Sub-Division

In the map sheet territories this sub-division includes marine sediments of Sarmatian, Meotychniy and Pontychniy regio-stages. The widespread rocks, especially in Pologivska LTZ, also include the continental parti-coloured clays which encompass the whole time interval of the sub-division.

Sarmatian Regio-Stage

These marine sediments are widely distributed except the southern part of map sheet L-37-I and south-eastern part of map sheet L-36-VI. The outcrops of Sarmatian sediments are observed in the valleys of Dnipro, Konka, Gaychur and Mokri Yaly rivers where they constitute Vasylivska and Pologivska LTZ. The most complete column is developed in Vasylivska LTZ where it includes lower, middle and upper sub-regio-stages represented by Kuzhorski and Zbruchski layers undivided, Novomoskovski and Vasylivski layers undivided, and Geliksovi layers. In Pologivska LTZ the middle and upper sub-regio-stages only are distinguished being represented by Novomoskovski and Geliksovi layers respectively.

Vasylivska LTZ

Lower Sub-Regio-Stage

Kuzhorski and Zbruchski layers undivided (N_1*kh-zb*). The shallow-water marine sediments with erosion lie over the rocks of Konkskiy regio-stage and are developed in the south-western part of map sheet L-36-VI (Zaporizhzhya) (Fig. 2.7.b). The distribution boundary crosses the southern outskirts of Zaporizhzhya city up to Kamyshuvakha village where it sharply turns to the south and exits the map sheet at Barvynivka village. The sediment surface descends in the southern direction from +60 m to +2 m of altitude. The layers are composed of clays, sands and limestones. Maximum thickness is 12 m.

Kuzhorski layers are known in the far south-western part of the territory [5]. They are composed of sandy-clayey rocks and are confined to the column lower part. The clays are hydromica-montmorillonite with minor chlorite, micro-layered, contain fauna: *Cardium plicatum* E i c h w., *C. obsoletum vindobonense (Partsch)* L a s k. and others.

Zbruchski layers are composed of clays and limestones. Clays (up to 5 m thick) are grayish-green, dark-grey, with interbeds of organogenic-detritus sands (up to 0.8 m). Limestones are organogenic-detritus, light-grey, yellowish-grey, weakly-cemented, consist of the fragments and solid mollusc shells. Thickness of limestones is 1-5 m. Clays and limestones contain fauna: *Mactra eichwaldi* L a s k., *M. eichwaldi crassa N.* S i d., *Cardium gleichenbergense* P a p p, *Ervilia dessita* E i c h., E. *pusilla andrussovi* K o l e s. and others.

Vasylivska and Pologivska LTZs

Middle Sub-Regio-Stage

Novomoskovski and Vasylivski layers undivided (N_1*nm-vs*) occupy the widest space over the map sheets (Fig. 2.7.c). With erosion and stratigraphic discontinuity they lie over the rocks of Novopetrivska Suite and conformably overlie the rocks of Zbruchski and Kuzhorski layers. In Vasylivska LTZ they are overlain by the fauna-characterized sediments of Geliksovi Layers and Pontychniy regio-stage, and in Pologivska LTZ – by Pliocene red-brown clays. After the fauna complex the undivided up to 23 m thick Novomoskovski and Vasylivski layers are distinguished in Vasylivska LTZ, and in Pologivska LTZ – only Novomoskovski Layers up to 42 m thick [5].

By lithology the shallow-water marine sediments include sands, montmorillonite clays, organogenic-detritus limestones and pelitemorphic marls. The sandy sediments are fairly widespread surrounding crystalline basement uplifts. The clayey rocks occupy the central positions. The clays are dark-grey to black, getting green upward, fine-layered with the interbeds of aleurite, fine-grained sand (part of centimeter) or shell detritus.

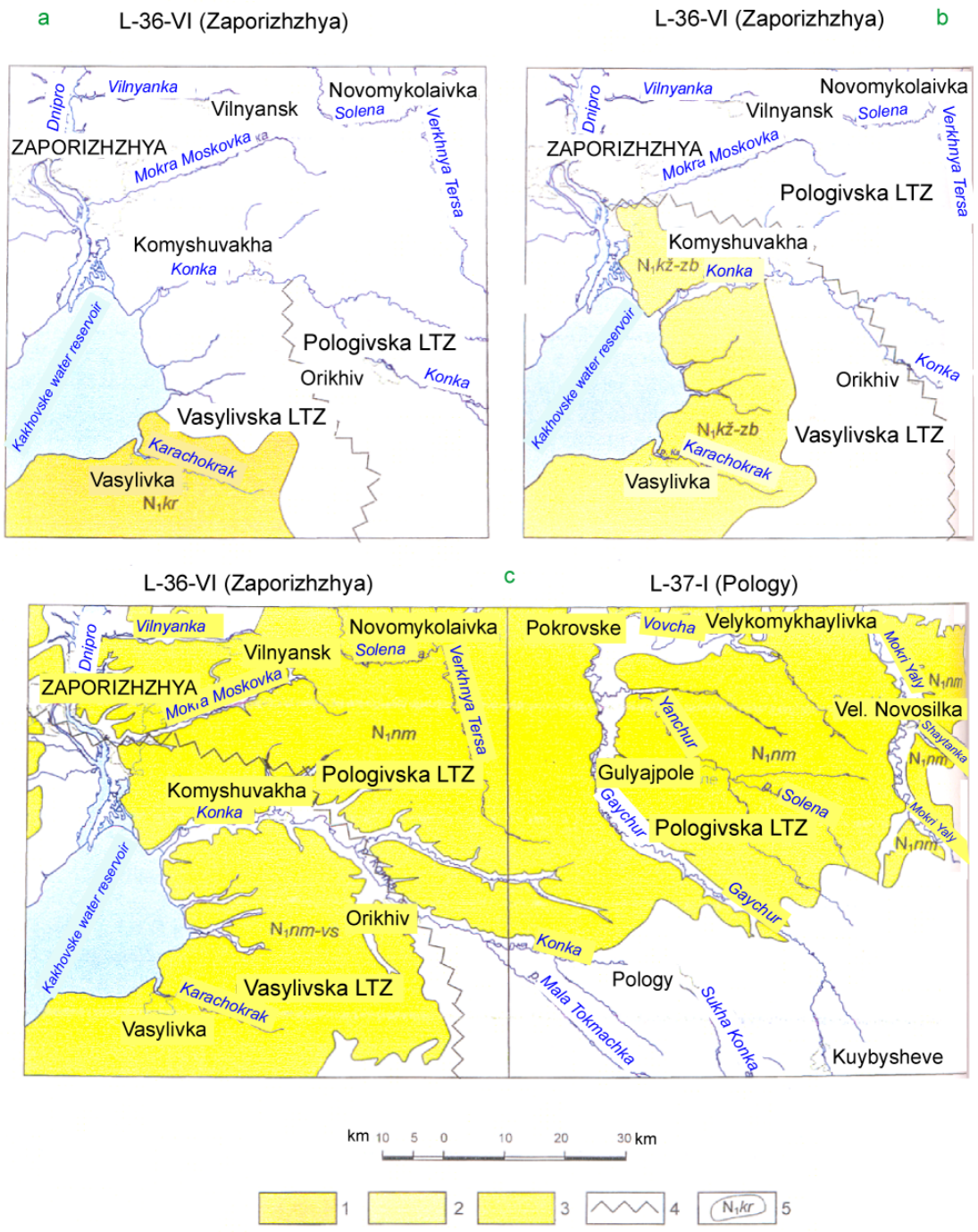

Fig. 2.7. Sketch maps of stratigraphic zonation and distribution of Late Miocene sediments.
a) Kartvelski Layers (N_1kr);
b) Kuzhorski and Zbruchski Layers (N_1kh-zb);
c) Novomoskovski and Vasylivski Layers (N_1nm-vs).
Distribution fields: 1 – Kartvelski Layers; 2 – Sartaganski and Konkski layers; 3 – Novomoskovski and Vasylivski layers; 4 – boundary between litho-tectonic zones; 5 – geological boundaries of the sediments and their indexes.

Of the organic remnants the clays contain *Mactra vitaliana* d'O r b., *M. naviculata* B a i l y , *Cardium fittoni* d'O r b., *M. naviculata* B a i l y , *Cardium aff. bajarunasi* K l e s, *Cardium fittoni* d'O r b *C. plicatifittoni* S i n z . , *C. sulssi* B a r b., *Hydrobia viratamensis* K o l e s ., *H. elongata* E c h w., *Paphia vitaliana* O r b i g n y and others; foraminifera: *Quingueloculina arculata* D i d. e t G u d i n a, *Q. consorbina plana* V o l o s c h i n o v a and others.

Upper Sub-Regio-Stage

Geliksovi Layers (N_1gl) constitute the upper portion of Sarmatian regio-stage. They are developed in Vasylivska LTZ and partly in the watershed plateau in between Mokra Moskovka, Verkhnya Tersa and Konka rivers. In Pologivska LTZ their eastern boundary crosses the western outskirt of Novogorivka village then to the north in sub-longitudinal direction toward Grygorivka village and further to the west-north-west up to the southern edge of Khortytsya Island (Fig. 2.8.b). The surface altitudes descend in the south-western direction from +105 m to +30 m.

The shallow-water marine sediments unconformably overlie Novomoskovski and Vasylivski layers and are overlain by the fauna-characterized rocks of "Pontychniy" regio-stage as well as Pliocene-Quaternary sediments. The layers include sands, sandstones, clays, limestones and marls. The sands and sandstones are confined to the lower column part in Vasylivska LTZ. The clays are greenish-grey, green, rarely grey and dark-grey, montmorillonite, carbonate and carbonateless. Maximum thickness in Vasylivska LTZ is 9 m, in Pologivska LTZ – up to 16 m. Limestones are organogenic-detritus, contain the shells and shell fragments: *Mactra caspia* E i c h., *M. bulgarica* T o u l a., *M. crassiolis* S i n z., *M. nalivkini* K o l e s. and others; formainifera: *Noniongranosus* (O r b.), *N. bogdanovicz* V o l o s c h i n o v a and others allowing definition the Late Sarmatian age of the layers.

Meotychniy Regio-Stage

Meotychniy regio-stage is not continuously distributed over the map sheet territory. It is intersected by the single drill-holes in the area of Prymorske, Kamyanske and Mali Shcherbaky villages to the east of Kakhovske water reservoir (map sheet L-36-VI). In the natural exposure the sediments are encountered at Kamyshuvakha village. In the geological map and cross-sections they are not indicated. By fauna composition they are identified as Akmanayski Layers.

Vasylivska LTZ

Akmanayski Layers (N_1ak) include limestones which occur between Sarmatian and Pontychniy regio-stages with some signs of erosion. Their thickness is 0.5-1.2 m. Limestones are light-grey, fine-oolite, from dense to cavernous, contain fauna: *Congeria novorossica* S i n z., C. *panticapaea* A n d r u s ., *Cardium mitridatis* A n d r u s . , *Abra tellinoides* S i n z., *Neritina* sp., *Micromelania sf gorianowici* A n d r u s , *Dosinia macotica* A n d r u s and others.

Pontychniy Regio-Stage

The regio-stage is developed in the map sheet L-36-VI (Zaporizhzhya) in Vasylivska LTZ; it is lacking in the valleys of Dnipro, Konka, Yanchokrak rivers. It is distinguished as the sequence of sands and limestones.

Sequence of sands and limestones (N_1pv) with the stratigraphic discontinuity lies over the Middle and Upper Miocene sediments, and in places of their lacking – with the angular discontinuity over the rocks of crystalline basement (Fig. 2.8.a). It is overlain by the sequence of parti-coloured clays. The distribution boundary is twisting. In general it is oriented from the north-west to south-east by the line of inhabited localities Andriivka – Vilnyansk – Novoivanivka – Omelnyk where it turns to the south and is extended along Zakhidnopryazovskiy Fault. The surface is inclined to the south-west and extensively eroded in Pliocene epoch. Maximum latitudes attain +100 m, minimum ones – +50 m. Thickness of the Sequence attains 72 m.

The sediments are observed in the natural exposures along Kakhovske water reservoir and in the numerous gullies flowing into Dnipro and Konka rivers. By lithology the Sequence is constituted of the sands, limestones and calcareous clays. The column is divided into the lower sandy and upper clayey-limestone batches.

The lower batch, 30-70 m thick, fills up the paleo-valley mapped in the squares 3-II, -III, -IV of the map sheet L-36-VI (Zaporizhzhya). The paleo-valley sand surface altitudes are 7-20 m. The sands are quartz, light-grey, yellowish-grey with greenish shade, clayey, fine-grained, at the bottom with gravel and pebble. In the

outcrops the oblique bedding (up to 45° [67]) is often observed. The rock colouring is gradually changing upward in the column: light-grey – yellow, brown – brick-red. The fauna remnants are lacking in the sandy sequence and its Late Miocene age is defined by the stratigraphic position in the column. The batch, with erosion, lies over Meotychni sediments and is overlain by the Cimmerian iron ores in the adjacent (from the south) territory [104, 116].

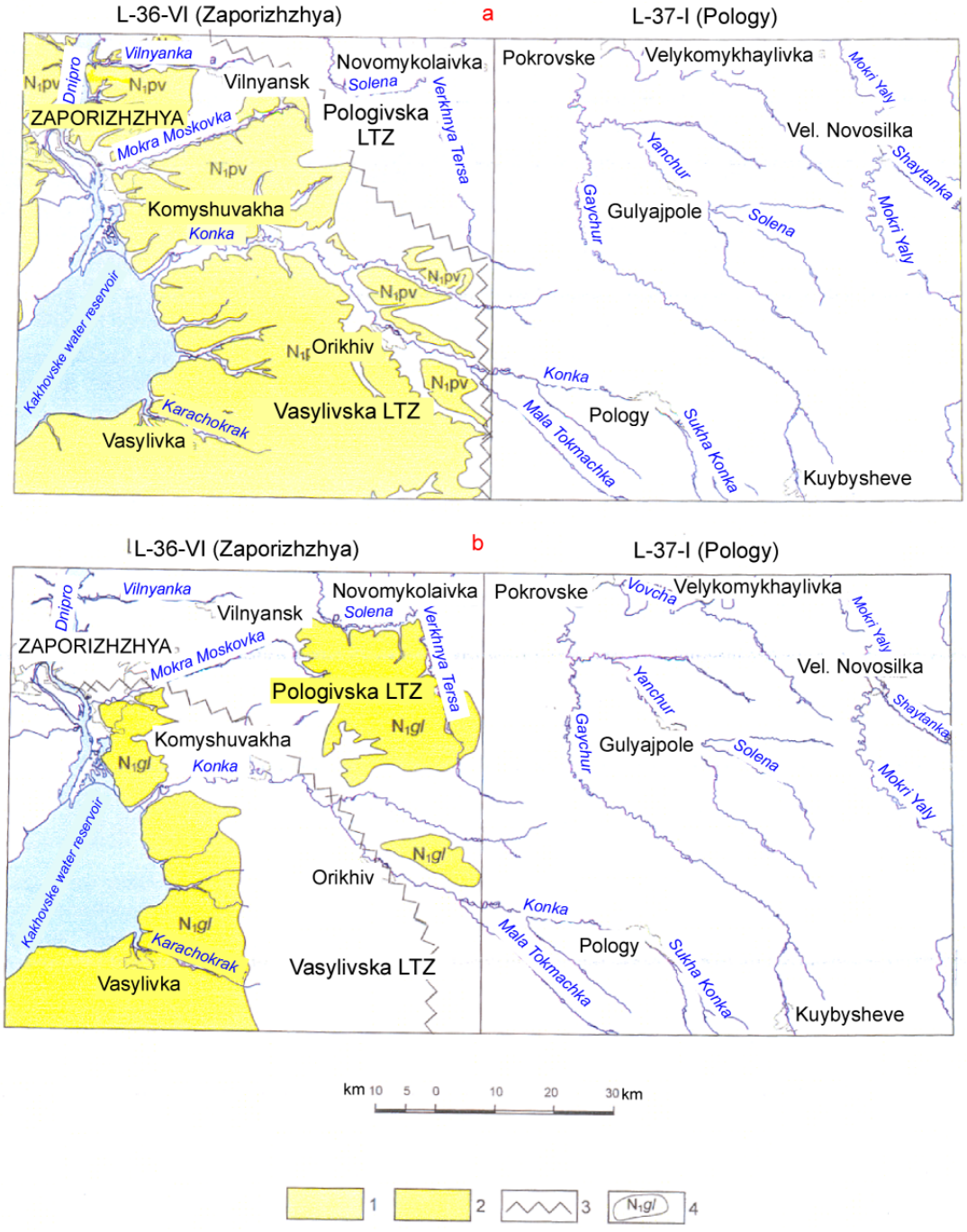

Fig. 2.8. Sketch maps of stratigraphic zonation and distribution of Late Miocene sediments.
a) sequence of sands and limestones (N_1pv);
b) Geliksovi Layers (N_1gl).
Distribution fields: 1 – sequence of sands and limestones; 2 – Geliksovi Layers; 3 – boundary between litho-tectonic zones; 4 – geological boundaries of the sediments and their indexes.

The upper batch, developed in the western and partly in the eastern parts of the Sequence distribution area, is in turn divided into the lower and upper horizons. The lower horizon is composed of the green, dark-green clay with interbeds of stain-yellow or the pink cavernous shelly limestone. In the south-west, where limestones directly overlie the older rocks, the pebble 4-5 cm thick layer of dense oolite limestone is observed at the bottom. Organic remnants include *Didacna cf. novorossica* B a r b., *Limnocardium sp. ind., Dreissensia cf. simplex* B a r b o t., *Neritina sp. ind., Prosodacna ex gr. littoralis* E i c h w., *Congeria novorossica* S i n z., *Monodacna cf. pseudocattillus* B a r b. and others. Thickness of the horizon is 5.0-5.5 m. The upper horizon is composed of calcareous clays with marl interbeds and dense oolite limestones, often cemented at the bottom, with shells: *Congeria sp., Monodacna pseudocattillus* B a r b., *Didacna novorossica* B a r b. Thickness of the horizon is 1-5 m.

Vasylivska and Pologivska LTZs

Sequence of parti-coloured clays (N_1sg) is developed over most part of the territory. With stratigraphic discontinuity it lies over the rocks of Poltavska Series, Sarmatian and Pontychniy regio-stages and is overlain by the sequence of red-brown clays.

The clays are greenish-grey with numerous stains of ochre, brown and cherry-red colours, with gypsum druses, marleous concretions, and iron-manganese beans; at the bottom they often are ash-grey, grey with irregular mechanic composition. Thickness of the Sequence is 2-4 m, in places 8 m. Among the organic remnants re-deposited radiolaria and siliceous sponge spicules are known.

Pliocene Division (N_2)

Sub-aerial rocks of watershed plateau and sub-aqueous sediments of the ancient river terraces are ascribed to the Pliocene sediments which are distinguished as the undivided sequence of red-brown clays.

Sequence of red-brown clays (N_2cp) lies over the Miocene sediments (sequence of parti-coloured clays) with the stratigraphic discontinuity, and at the elevated sites – with angular and stratigraphic discontinuity over the rock of crystalline basement. It is lacking in the river and large gully valleys, where it is eroded in Quaternary time, and in Pryazovskiy uplift. It is overlain by the Quaternary sediments being connected to them with gradual transitions. Thickness of the Sequence attains 11 m.

Red-brown clays include dense non-layered varieties, almost without clastic admixtures. Content of the <0.05 mm fraction is 96-99%. They are composed of montmorillonite and beidellite. The gliding planes with black dendrite films of manganese hydroxides are developed. The iron-manganese oolites 2-3 mm in diameter are often observed. The carbonate concretions and gypsum are frequently contained in various amounts being restricted to the lower column part. Concretions size attains 30 cm across. Gypsum is observed in the single crystals and druses and does not form significant accumulations. In places where clays overlie the crystalline rocks the gruss and fragments of the latter are observed at the bottom.

Two horizons are distinguished which correspond to Siverskiy and Beregivskiy climatoliths.

The lower, Siverskiy horizon is composed of grey, dark-grey clay with brownish, rarely greenish shade, carbonate, gypsum-bearing. In comparison to the host layers, the sandy and aleuritic fraction content is increased in the clays. In the logging plots the horizon exhibits decreasing in the rock radioactivity and is confidently defined. The clays belong to aeolian-deluvial genetic type. Thickness is 4-6 m.

The upper, Beregivskiy horizon comprises the former soil – red-brown dense, non-layered, carbonate clays. The sun cracks 0.5-2.0 cm wide are observed in places filled with the dark-grey material of Berezanskiy climatolith. The cracks are wedge-shaped and their surface is irregular, the cracks spread down to 50-70 cm. Thickness of the horizon is 2-6 m.

Alluvial sediments of the Sequence (Siverskiy climatolith) comprise the tenth terrace which is traced in the narrow band in the upper course of Yanchur, Gaychur [73] and Mokri Yaly [112]. Thickness of alluvial sediments is 5-7 m. The green colouring, weak sorting of terrigenous material and high clay fraction content are characteristic.

Quaternary System

Quaternary sediments are throughout developed in the territory and cover the underlaying rocks. The lower boundary is set by the footwall of Berezanskiy climatolith in compliance with the "Legend to the geological map of Ukraine in the scale 1:200 000, Central Ukrainian Series", 1996. The underlaying rocks in most cases comprise Pliocene red-brown clays and otherwise – the rocks of crystalline basement, Cretaceous, Paleogene and Neogene systems. Thickness of Quaternary sediments is 20-40 m, and in Pryazovskiy uplift – 10-20 m.

The Quaternary continental cover belongs to the loess formation of back-glacier zone. Two facies groups are distinguished: sub-aerial (loess and loess-like loams intercalating with the former soils) and sub-aqueous (alluvial piles). The sub-aerial sequence in discontinuous by lithology both in lateral direction and in the column. In Pryazovskiy uplift and adjacent areas the fragments and gravel of crystalline rocks are often observed at the column bottom.

In the south-west of the area the pod sediments of eluvial, aeolian-deluvial and lake origin are developed in the Sequence.

Continental sub-aqueous Quaternary sediments include alluvial pebble-stones, conglomerates, sands, sandy loams, clays and loams of river-valley terraces expressed in the relief or buried. The ledge is taken as the mapping straton.

Aeolian sediments are only developed in the Vovcha River valley and include sands being scattered by the wind. Deluvial sediments are confined to the river and gully slopes.

Pleistocene and Holocene are distinguished in the Quaternary System. Pleistocene includes lower, middle and upper subdivisions. The lower one comprises Eo-Pleistocene Branch, and middle and upper ones – Neo-Pleistocene Branch.

Eo-Pleistocene Branch (E)

It includes the lower and upper divisions and is distinguished in the branch (e,vdE) or together with the lower division of Neo-Plesitocene (e,vdE+P_1).

Lower Division (E_I)

It includes alluvial and aeolian-deluvial sediments.

Kyzyldzharskiy ledge. Alluvial sediments of the tenth terrace ($a^{10}N_2$-$E_I$kh) include the pile of sands, pebble-stones and sandy-clayey rocks 6-15 m thick. It is overlain by aeolian-deluvial loams with interbeds of the Neo-Pleistocene former soils up to 20 m thick. It is developed along Dnipro, Vovcha and Mokri Yaly rivers. The sediments of this terrace are only intersected by drill-holes. In the modern relief it is expressed by the smoothed bars bounded by the contour lines 110-115 m for Dnipro River, 130-140 m – for Gaychur and Yanchur rivers, 140-150 m for Mokri Yaly River. Terrace footwall altitudes are +90…+94 m in Dnipro River area and +114…+120 m in Mokri Yaly River area.

Berezanskiy climatolith (vdE_1br). Sub-aerial, aeolian-deluvial rocks are developed in the middle course of Gaychur and Yanchur rivers, on the left bank of Dnipro River, and in Prychornomorska Lowland. Climatolith is composed of dark-grey, dark-brown, often with greenish shade, sandy, non-layered, slightly-carbonate, gypsum-bearing with manganese hydroxide clays. The sand fraction (quartz, carbonate and feldspar) is diverse-grained, acute-rounded. Clay fraction is composed of montmorillonite with minor hydromica. At the top of horizon the bifurcated pores of leached fossil root system are observed, composed of the material from overlaying horizon and spread down up to 0.3 m. Thickness of climatolith is 1-3 m.

Upper Division (E_{II})

It includes Kryzhanivskiy and Illichivskiy climatoliths and is composed of alluvial, eluvial and aeolian-deluvial sediments.

Nogayskiy ledge. Alluvial sediments of the ninth terrace (a^9E_{II}ng) include sands with gravel and sandy-clayey rocks 10-18 m thick. It is overlain by aeolian-deluvial loams with the interbeds of Neo-Pleistocene former soils. It is developed along the rivers Dnipro, Vovcha, Gaychur and Mokri Yaly. The rocks are intersected by drill-holes. Terrace footwall altitude varies from +80…+84 m to +108…+104 m for Dnipro and Mokri Yaly rivers respectively.

Kryzhanivskiy climatolith ($eE_{II}kr$) is composed of the former soil. It is light-, reddish-brown clay with carbonate inclusions, manganese hydroxide films and dendrites by fractures, montmorillonite with minor hydromica, aleuritic in various extents. Thickness is 0.9-6.0 m.

Illichivskiy climatolith ($vdE_{II}il$) is developed at the watersheds. The sediments comprise the marker horizon. These include aeolian-deluvial heavy loams and grey, dark-grey, ash-grey, rarely dark-brown clays. The rocks are gypsum-bearing in various extents, carbonate; they are well-expressed in the gamma logs. The clay fraction content is up to 60%, aleuritic – up to 5%, sandy by 0.25 mm – 35%. Thickness is 0.5-10.5 m.

Neo-Pleistocene Branch (P)

The lower, middle and upper divisions are distinguished.

Lower Division (P_I)

It includes the sediments of alluvial, eluvial, aeolian-deluvial and complex genetic types.

Alluvial sediments constitute Budatskiy ledge of the eighth terrace (a^8P_Ibk)*, Donetskiy ledge of the seventh terrace* (a^7P_Idc) *and Krukenytskiy ledge of the sixth terrace* (a^6P_Ikn). In the relief these ones are not expressed. They are intersected by drill-holes in the valleys of Dnipro, Konka, Gaychur, Vovcha and Mokri Yaly rivers. At the base of the terraces the coarse-grained sands with gravel and pebble are observed. Higher in the column they are gradually changed by sandy clays and loams. Alluvial column is overlain by the 25-30 m thick loess facies of Neo-Pleistocene middle and upper divisions. Surface of terraces is often deeply eroded. Thickness of alluvium is 8-16 m.

The Budatska terrace footwall is controlled by the contour line +100 m for Dnipro and Konka rivers, +130 m for Vovcha River, and +140 m for Konri Yaly River.

Sub-aerial eluvial and aeolian-deluvial sediments are being mapped as undivided units of the lower division (e,vdP_I) or in the combined straton together with the middle division of Neo-Pleistocene (e,vdP_{I-II}). Six horizons or climatoliths are distinguished in the lower division.

Shyrokynskiy climatolith (eP_Ish) is composed of the former soil – dark-brown, often with reddish shade, heavy loam. In the areas close to Pryazovskiy uplift the rocks are enriched in the fragments of crystalline rocks. Thickness is 1-6 m.

Pryazovskiy climatolith (vdP_Ipr) is composed of aeolian-deluvial loess-like brown medium loams 1-5 m thick.

Martonoskiy climatolith (eP_Imr) includes the range of former soils 1-6 m thick. These are composed of heavy loams, close to Pryazovskiy uplift with the brown and red-brown fragments. The rocks are dense and contain gypsum and carbonate.

Sulskiy climatolith (vdP_Isl) is composed of pale and brownish-pale medium and heavy loams. Due to complete re-working by the Martonoski soil-forming processes the Sulskiy climatolith often drops down from the column. Thickness is 0.2-6 m, 2-3 m in average.

Lubenskiy climatolith (eP_Ilb) is composed of the former soil, often the range of soils. It is composed of brown, dense, heavy loams. Close to Pryazovskiy uplift the rocks contain the fragments of crystalline rocks and gypsum crystals. Thickness is 2-4 m, in places up to 7 m.

Tyligulskiy climatolith (vdP_Itl) reflects the hard periglacial environments over the time of the loams formation. It is composed of brown and pale-brown medium and heavy loess-like loams. Thickness is 0-5 m, commonly 1-3 m.

Complex genetic type (e,vd,lP_I) includes undivided pod rocks which are known in Prychornomorska Lowland. The sediments were formed in the lake environments via eluvial, aeolian-deluvial processes and are composed of the hydromorph soils, clays and loams with interbeds of sandy loams and sands. Thickness does not exceed 15 m.

Middle Division (P_{II})

It includes alluvial, eluvial, aeolian-deluvial and complex genetic types.

Alluvial sediments constitute *Khadzhybeyskiy ledge of the fifth terrace* ($a^5P_{II}hd$) and *Cherkaskiy ledge of the fourth terrace* ($a^4P_{II}cr$) which are not expressed in the relief. The sediments are encountered over all rivers of the territory. Cherkaska (fourth) terrace is exposed in the banks of Dnipro River higher the Dniproges dam. They are composed of diverse-grained grey, yellowish-grey sands and loams. Thickness is 10-15 m. Terrace sediments are overlain by the 15-18 m thick rocks of Neo-Pleistocene upper division. Surface of terraces is eroded.

According to P.K.Zamoriy [12], the numerous shells *Vivipara fagiata* Mull., *Lythoglyphus naticoides* Fer., *Fruticicola hispida L., Succinea pfeiferi* Ross., *Bithynia leacht troscheli* Paasch. and bones of *Vulpes lagapus meridionalis* are found in the alluvial sediments of Cherkaska (fourth) terrace.

Sub-aerial eluvial and aeolian-deluvial sediments are being mapped as undivided units of the middle division (e,vdP$_{II}$) or in the combined straton together with the lower division of Neo-Pleistocene (e,vdP$_{I+II}$). Four horizons or climatoliths are distinguished in the middle division.

Zavadivskiy climatolith (eP$_{II}$zv) is most widespread and is well expressed in the column. It is composed of brown and red-brown former soil, often range of soils. The loams are porous, glued, carbonate with gypsum crystals. Thickness attains 5 m, normally 1.5-2.5 m.

Dniprovskiy climatolith (vdP$_{II}$dn) is composed of pale, light-pale, medium loess and loess-like loams, porous, non-layered. Columnar jointing, occurrence of carbonate tubes and concretions, gypsum crystals are characteristic features. In the southern direction the composition is changed from relatively coarse to the finer fractions, and colour – from pale to yellow-pale and brown. Thickness of the horizon in Azovo-Prydniprovska and Donetska heights is 0.3-1.5 m. In Prychornomorska Lowland the thickness increases to 5.0-7.6 m.

Kaydatskiy climatolith (eP$_{II}$kd) is composed of the former soil and widely developed over the studied area. In the northern part it includes brown, brown-grey medium loams which are more dark up to black, black-earth-like in the south. The gypsum crystals and crumble carbonate aggregates are observed in the rocks. Kaydatskiy former soil comprises the reliable marker horizon. Thickness attains 3.4 m, normally 0.5-2.0 m.

Tyasminskiy climatolith (vdP$_{II}$ts) is least developed. It is composed of thin (0.3-1.2 m) brown-pale loamy loess. Often it is completely reworked by Prylutskiy soil-forming processes.

Complex genetic type (e,vd,lP$_{II}$) includes pod rocks. Alluvial-lake sediments constitute hydromorph soils (1.0-1.5 m) alternating with aeolian-deluvial loams (1-2 m). The soils are composed of yellow-grey, brown, humus, spotty medium loams containing iron-manganese oolites. Aeolian-deluvial loams are dark-brown, green, bluish-grey, fine-layered, dense, medium and heavy. The rocks contain the iron-manganese beans.

Upper Division (P$_{III}$)

It is comprised of alluvial, eluvial and aeolian-deluvial rocks.

Alluvial sediments comprise *Trubizkiy ledge of the third terrace* (a^{3}P$_{III}$tb), *Vilshanskiy ledge of the second terrace* (a^{2}P$_{III}$vl) and *Desnyanskiy ledge of the first terrace* (a^{1}P$_{III}$ds) which are expressed in the relief and are identified in all rivers of the territory except Dnipro River higher the Dniproges dam where the rocks are flooded by the waters of reservoir V.I.Lenina. Lower the dam the first (Desnyanska) terrace only is flooded by the waters of Kakhovske reservoir. In some sections of the river valleys terraces are deformed by the neo-tectonic motions [73, 104]. Terraces are composed of yellowish, grey-yellow ad light-grey sands 10-15 m thick.

Desnyanska (first terrace) is composed of the fine-grained muddy and friable grey sands with interbeds of greenish-grey muddy sandy loams and sludges. The shells of *Dreissensia, Lithoglyphys, Adacna, Unio, Valvata, Planorbis* and others are found in alluvium. Thickness of sediments is 20-25 m.

The rocks of sub-aerial (eluvial and aeolian-deluvial) facies are widely developed at the watersheds. They are being mapped in two stratons composed mainly of the former soils (e,vdP$_{III}$pl-vt) and aeolian-deluvial sediments (vd,eP$_{III}$bg-pc). Three climatoliths are distinguished in each straton.

Eluvial, aeolian-deluvial sediments (e,vdP$_{III}$pl-vt)

Prylutskiy climatolith (eP$_{III}$pl) includes grey and brownish-grey former soil or the range of soils. These are composed of medium, rarely heavy dense loams. Their thickness varies from 0.4 to 3.5 m, mainly 1.5-2.0 m.

Udayskiy climatolith (vdP$_{III}$ud) is composed of pale-brown and grey-brown loamy loess up to 2.5 m thick. It is rarely observed and normally is absent in the column being reworked by Vytachivskiy soil-forming process.

Vytachivskiy climatolith (eP$_{III}$vt) includes brown and greyish-brown medium loam 0.2-2.0 m thick, rarely more.

Aeolian-deluvial, eluvial sediments (vd,eP$_{III}$bg-pc)

Buzkiy climatolith (vdP$_{III}$bg) comprises the marker horizon. It is composed of light-grey, porous, regularly-calcareous loess and loess-like loams with minor (up to 20%) aeolian sand. Thickness of horizon is up to 2 m, and in Prychornomorska Lowland 4-5 m.

Dofinivskiy climatolith (eP$_{III}$df) includes dark-grey, light-grey loamy, carbonate, humused former soils with mole passes. Thickness is 0.2-1.8 m.

Prychornomorskiy climatolith ($vdP_{III}pc$) is well-expressed in the columns of northern part of the territory. It differs in brown-pale colour, loamy granulometric composition, in places with sand admixture. In the central and southern parts of the area it is difficult to distinguish due to the modern soil formation. Thickness is 0.5-2.0 m.

Pleistocene and Holocene divisions undivided (P-H)

These undivided sediments include aeolian, deluvial and alluvial-deluvial genetic types.

Aeolian sediments ($vP_{III}pc$-H) are developed in the Vovcha River valley in the area of Pokrovske and Kolomiytsi villages. At Pokrovske village minor sites of sand scattering are known. Over remaining territory the sands are strengthened by the plants. The sands are fine-grained, grayish-yellow, and are confined to Vilshanska (second) and Trubizka (third) terraces. They are observed in the sand heaps 2.5-4.0 m high, crescent-shaped, which are commonly called "kuchugury".

Deluvial sediments (dP_{III}-H) are not indicated in the geological map. They are confined to the hard-rock slopes of the river valleys. The rocks are being formed due to the permanent planar erosion. With the narrow bands deluvial sediments surround the back contours of Cherkaska (fourth), Trubizka (third) terraces and provide smoothed terrace edges. Maximum thickness of deluvial is 5-7 m, rarely more. Depending on the composition and colour of re-deposited rocks, deluvium is composed of brown-pale or brown loams. The hard-rock fragments are often observed in deluvium, and some layering occurs.

Alluvial-deluvial sediments ($adP_{III}pc$-H) fill up the gully and ravine bottoms. They are composed of brownish-grey and greenish-grey loess-like loams. Down the column they are changed by the brown layered loams with sandy material and hard-rock fragment admixtures. Black iron-manganese beans and carbonate concretions are observed in places. Thickness of the gully alluvium increases towards the gully mouth from 4-6 to 15 m.

Holocene (H)

Alluvial and eluvial genetic types are distinguished in Holocene. The technogenic rocks are widely distributed.

Alluvial sediments (aH) include the flood-land units of Dnipro, Konka, Vovcha and other rivers. The flood-land facies predominate composed of the dark-bluish-grey-coloured lake, lake-swamp and former river-bed sediments. The river-bed alluvium includes light-grey, yellowish-grey and brown-grey diverse-grained sands. The crystalline rock gravel and pebble are observed at the bottom of river-bed alluvium. Thickness of alluvium attains 30 m, normally 22-26 m.

Of the *technogenic rocks*, in the geological map three genetic types are indicated: covering, washing and construction and buildings. Of these, the biggest sites are indicated in the map which can be expressed in respective map scale.

The *covering genetic type* (tfH) is mapped in the northern part of Zaporizhzhya city, in Serednya gully. It comprises the site of industrial waste utilization. The smaller sites for the housing and industrial waste utilization as well as the minor objects (dams, mounds) are not indicated in the map. The latter type comprises stripping rock dumps in quarries, the mounds of roads and railways, dams. Most of these are indicated in the map in the eastern part of Zaporizhzhya city and in the valley of Mokra Moskovka River in Yantsivskiy quarry. The units are composed of the rocks from sedimentary cover and crystalline basement. Thickness of covering sediments attains 10 m.

The *washing genetic type* (taH) is mapped in the southern part of Zaporizhzhya city. The city district 1.5 by 4.5 km in size is built onto the washed site.

Genetic type of *constructions and buildings* (tbH) is widely distributed over the territory and includes the inhabited localities. Most of them are indicated in the map.

Eluvial genetic type (aH). The soil-forming rock comprises the loess-like loam. Most widespread are the dusty-heavy-loamy southern black-earths confined to the watershed plain, and the dusty-loamy southern black-earths developed on the river and gully slopes. Thickness of the soil layer is 0.2-1.0 m, rarely more, in places attaining 1.8 m.

3. NON-STRATIFIED (INTRUSIVE AND ULTRA-METAMORPHIC) UNITS

Diverse intrusive, palingenic-anatectic and ultra-metamorphic rocks – from ultramafic to granitoid – as well as metasomatites are widely developed in the studied area and reflect five tectono-magmatic development cycles in the eastern part of Ukrainian Shield: Dnistrovskiy (AR_1), Azovskiy (AR_2), Dniprovskiy (AR_3), Kryvorizkiy (PR_1) and Klesivskiy (PR_2) with respective time boundaries at 3800-3400, 3400-3200, 3200-2600, 2600-2000 and 2000-1700 Ma.

On the ground of obtained geological records the correlation scheme is developed (given below downward, intrusive complexes hereafter are marked with asterisk) which corresponds to the approved correlation scheme with some exceptions. The latter comprise the definition of Khortytska and Yanvarska associations of plagiogranites and granites respectively.

Correlation scheme of non-stratified units

Middle-Dniprean area	***Pryazovian area***
Proterozoic (PR)	
Meso-Proterozoic (Klesoviy) (PR_2)	
PR_2(?)* – dyke complex. Diabases	PR_2(?)* – dyke complex. Diabases, lamproites
Paleo-Proterozoic (Kryvorizhiy) (PR_1)	
	PR_1an – Anadolskiy Complex (2100 Ma). Vein, aplitoid granites, ceramic pegmatites
	PR_1kl* – Kolarivskiy Complex. Sub-alkaline ultramafic rocks
Archean (AR)	
Neo-Archean (Dniproviy) (AR_3)	
AR_3dv* – Devladivskiy mafic-ultramafic complex. Gabbro, peridotites, serpentinites	
AR_3tk – Tokivskiy Complex (2810 Ma). Leucocratic granites, microclinites, grano-syenites	AR_3jn – Association of Yanvarski granites (~2750 Ma). Pegmatites, albite, alaskite granites
AR_3mk – Mokromoskovskiy Complex (2835 Ma). Aplitoid granites, pegmatites	AR_3šv – Shevchenkivskiy Complex (2750-3050 Ma). Quartz porphyry dykes, albitites, plagioclasites, plagiogranites
AR_3hr – Association of Khortytski plagiogranites. Amphibolized biotite plagiogranites	
AR_3vv* – Varvarivskiy mafic-ultramafic complex. Peridotites, talc-carbonate rocks	
AR_3sr* – Surskiy Complex (3110 Ma). Rhyodacites, andesites, trachytes, plagiogranites	
AR_3vr* – Verkhivtsivskiy mafic-ultramafic complex. Meta-gabbroids, seprentinites, talc-carbonate rocks	

Meso-Archean (Azoviy) (AR_2)

AR_2dbp* – Dobropilskiy Complex (3140-3390 Ma). Plagiogranites, tonalites, diorites

AR_2gu* – Gaychurskiy mafic-ultramafic complex (3140-3390 Ma). Actinolitites, tremolitites, serpentinites

AR_2dn – Dnipropetrovskiy Complex (>3250 Ma). Biotite plagiomigmatites, plagiomigmatites of diorite composition

AR_2rm – Remivskiy plagiogranitoid complex. Biotite plagiomigmatites

Paleo-Archean (Dnistroviy) (AR_1)

AR_1np_1 – Novopavlivskiy enderbite-tonalite complex (3370-3470 Ma). Plagiomigmatites, tonalites, enderbites

AR_1np_2* – Novopavlivskiy mafic-ultramafic complex (3650-3800 Ma). Gabbro, pyroxenites, peridotites

Archean (AR)

Majority of the non-stratified rocks in the area formed over Archean time within three aeons. Of these the ultra-metamorphic and intrusive complexes are distinguished; ultra-metamorphic processes predominated in pre-greenstone Paleo-Meso-Archean stage of the territory development. Then over greenstone Meso-Neo-Archean and post-greenstone Neo-Archean – Proterozoic stages mainly intrusive rocks were formed. By composition in these units almost entire rock spectrum is encountered except the alkaline ones – from ultramafic (peridotites) to felsic (alaskite granites and albitites).

Paleo-Archean (Dnistroviy) (AR_1)

Paleo-Archean intrusive and ultra-metamorphic rocks are distinguished in Pryazovskiy area only and are ascribed to Novopavlivskiy mafic-ultramafic and Novopavlivskiy granitoid complexes. In view of the even names of these complexes to avoid misunderstanding the first and second numbers are given to them respectively.

Novopavlivskiy mafic-ultramafic complex (AR_1np_1*). The Complex intrusive rocks are developed mainly in Orikhovo-Pavlogradska LTZ and in the south of Gulyajpilskiy Block. The single bodies are encountered in Vovchanskiy Block and in the south of Remivskiy Block. The Complex petrotype is located in the Novopavlivskiy Block of OP LTZ where the rocks are studied in details [67, 70]. The Novopavlivska site of the Complex minor intrusions is confined to the intersection of Orikhovo-Pavlogradskiy deep-seated and Pologivskiy regional fault zones. Intrusive bodies are mainly linear-shaped, often slightly turned. Their size varies from first meters to 2.0 km in width and from first tens-hundreds of meters to 9 km in length.

Increased tectonic mobility in the site (fracturing, cleavage) caused extensive penetration the country rocks by magmatic melt expressed in the series of sub-conformable veins resembling stratigraphic rock interbedding. The clear active contacts of gabbroids with the host rocks are very rarely observed (DH 15290 [67]).

In the magnetic field intrusions are clearly expressed by positive anomalies up to 10000 nTl whereas only big bodies are reflected in the gravity field because of the high density country rocks. After geophysical data, intrusions steeply dip to the east at the angle 65-85°, sub-conformably to the host rocks. To the depth (by geophysics) they are traced to 4-10 km.

In the south-western and southern parts of map sheet L-37-I the Complex rocks are observed in the quite different geological situation. Here they are mainly confined to the old sub-latitudinal Prakonkska fault zone. To the north of the latter they are less developed. The bodies are observed in xenoliths, schlieren and lenses within granitoids of Novopavlivskiy-2, Shevchenkivskiy and Anadolskiy complexes. The rocks are tectonized, gneissed, amphibolized and transformed into amphibolites, actinolitites, mafic gneisses and gneisses

in much more extents than in the Novopavlivskiy Block. Intrusive bodies from first square kilometres to 2 by 6 km in size are deformed, variously oriented, often are involved in the folding.

The Complex is mainly composed of mafic rocks: gabbro, gabbro-amphibolites and apo-gabbro amphibolites. Ultramafic rocks (peridotites, serpentinites, pyroxenites, and rarely hornblendites) are less developed. Almost throughout the mafic and ultramafic rocks are accompanied by the ironiferous metasomatic rocks: quartzites and quartz-garnet-magnetite-amphibole-pyroxene rocks – "skarnoids". Ultramafic rocks are mainly observed in the lens-like "interbeds" within mafic rocks, rarely they form the own minor intrusions. A.G.Shenderova had described the differentiated bodies where the central part is composed of peridotite then changed by pyroxenite and further by hornblendite, pyroxene and amphibole gabbro. Transitions between these rock varieties are gradual without visible discontinuities. Thickness of ultramafic bodies varies from tens of centimeters to 40-50 m.

Gabbroid rocks are tightly interconnected and often are changed from typical pyroxene gabbro with relic primary igneous textures (gabbroic) to gabbro-amphibolites and granoblastic apo-gabbro amphibolites. Gabbro occurs only in the minor relic remnants 2-5 m thick within amphibolites of Novopavlivskiy Block (DH 427, 426, 1050, 1052). Amphibolized gabbro and gabbro-amphibolites are more widespread. Apo-gabbro amphibolites exhibit deeper retrograde transformations of the primary minerals: pyroxene amphibolization up to complete replacement and plagioclase reduction to # 36-50.

Peridotites are encountered in the area of Skhidnodanylivska site (DH 352, 355, 357, 353), and in less amounts in Novopavlivska site (DH 438, 466, 59) and in Gulyajpilskiy Block. In the latter case the rocks are almost completely actinolitized and serperntinized and are being classified by chemical analysis data only. Pyroxenes include mainly hypersthene-enstatite, rarely sahlite.

Ferruginous rocks are observed in lens-shaped, sheet-like and irregular bodies of variable thickness (0.4-40 m and more) and length (up to 3 km). Normally they are confined to the margins of ultramafic bodies and in places are observed within mafic rocks too [67]. In DH 429 the gradual enrichment of gabbro-amphibolites in magnetite is observed up to formation of spotty-banded ferruginous silicate quartzite which with depth is changed by gabbroid in the reverse order. Elsewhere ferruginous quartzites sometimes are changed by "skarnoids".

Ferruginous rocks are variable in composition: from very inhomogeneous distinct magnetite-pyroxene-amphibole-garnet "skarnoids" to the typical pyroxene-magnetite quartzites. Often quartzites are arranged in the up to 100 m and more thick series of contiguous interbeds within mafic and ultramafic rocks. Their composition is discontinuous both by strike and by depth.

Isochrone age of the Complex rocks is 3650 Ma [65].

Novopavlivskiy granitoid complex (AR_1np_2). Ultra-metamorphic and palingenic granitoids of this Complex in the map sheet territory constitute the large enough fields. Their definition is grounded on the results of isotopic geochronological studies and on their relationships with the units of established radiogenic age, as well as on the similarity of petrochemical and structure-texture features. Massive and gneissose structure is characteristic. By composition the rocks correspond to diorites and tonalites. Unclear-banded plagiomigmatites of the same composition, derived from diorites, and enderbites are also ascribed to the Complex.

The Complex rocks are observed in the series of irregular massifs in the southern and south-western parts of map sheet L-37-I, and partly in the south-western quarter of the map sheet L-36-VI mainly to the east of Zakhidnopryazovskiy Fault. The size of massifs varies in the range 5 × 16 km – 1 × 2 km. Their outlines often are irregular, amoeba-like. In gravi-magnetic fields they are clearly expressed by positive anomalies 200-500 nTl and 0.25-0.75 mGal.

The internal structure of the massifs is often complicated by the abundant xenoliths and schlieren of gabbroids, pyroxenites, actinolitites and serpentinites of Novopavlivskiy mafic-ultramafic complex. The marginal parts of these massifs are composed of tonalites and plagiomigmatites of diorite composition and the central parts – mainly of quartz diorites. The diorites are locally developed and are observed only at the contacts with gabbroid remnants. To the depth diorites are traced by 3-4 km.

In the Novopavlivskiy Block the Complex is composed of enderbites, banded tonalites and plagiomigmatites of tonalite, diorite and enderbite composition. They are mainly developed in the marginal parts of gabbroid massifs. The space they occupy is not sufficient to be indicated in the map. Their laying is conformable to gabbroids.

The Complex rocks are throughout associated with the rocks of Novopavlivskiy mafic-ultramafic complex, same-named sequence of Zakhidnopryazovska Series and Vovchanska sequence; the contacts between the rocks unequivocally reflect their genesis – ultra-metamorphism under granulite facies PT-conditions. The process was accompanied by the high enough degree of rock melting and the melt homogenization evidenced by the massive structure of diorites. It is also not excluded the melt squeeze out and further emplacement in intrusions. Structure of the diorite and granite development field in the south of the area provides an idea on the

genetic link between the two Novopavlivski complexes (first and second ones). The rocks resemble content of gabbro-diorite-tonalite formation as it was earlier suggested by Yu.D.Shkovyra [107].

Diorites, quartz diorites and tonalites comprise the group of macroscopically similar amphibole-bearing rocks with frequent mutual transitions. Plagiomigmatites of diorite composition visually differ from the above group in prominent gneissic or banded structure and lighter shade. By mineral composition the rocks correspond to tonalites.

Isochrone age of enderbites (Novopavlivska site) and tonalites (Bila Skelya gully) is 3370-3470 Ma.

Meso-Archean (Azoviy) (AR_2)

Azovian tectono-magmatic cycle includes extensive ultra-metamorphic modification of Early Archean stratified sequences and intrusive-magmatic activity.

Meso-Archean ultra-metamorphic rocks, derivative from the older rocks, are widely developed both in the Middle-Dniprean and Pryazovian blocks where Dnipropetrovskiy and Remivskiy complexes are distinguished respectively. The extensive intrusive activity occurred in Western Pryazovya in the Late Meso-Archean time (in the map sheet territory) expressed in emplacement of numerous minor intrusions of ultramafic Gaychurskiy and diorite-granodiorite Dobropilskiy complexes. These bodies are mainly developed in Gulyajpilskiy Block.

Remivskiy Complex ($p\gamma mAR_2rm$). It includes plagiogranitoids observed in the linear, lens-like bodies which conformably lie within the stratified Paleo-Archean gneisses and together with the latter are involved in the folding. Throughout they contain abundant skialites of metamorphic rocks and exhibit the oriented (banded and gneissic) structures. By chemical composition the plagiogranites mainly correspond to plagiogranites, and in places of extensive secondary alteration, even to the two-feldspar granites. At the same time, the amphibole- and (rarely) pyroxene-bearing varieties are often observed which by chemical composition do correspond to the tonalites and enderbites.

The obvious cutting contacts between Meso-Archean diorites of Dobropilskiy intrusive complex, meta-volcanogenic-terrigenous rocks of Ternovatska Sequence (3310-3390 Ma) and plagiomigmatites of Remivskiy Complex as well as overlaying of the latter by meta-volcanics of Kosivtsivska Sequence in the map sheet L-37-I-C and D [73] unequivocally suggest for the relatively older Early Meso-Archean age of Remivskiy Complex. At the same time, a great number of isotopic age determinations for the zircon from plagiomigmatites within 2970-2800 Ma suggest for their extensive reworking (remobilization) in Late Meso-Archean time (Shevchenkivska granitization).

Granitoids of the Complex are developed in the Pryazovian area and occupy considerable spaces. They are observed in the sheet-like and lens-shaped bodies together with the rocks of Zakhidnopryazovska Series, Vovchanska and Dragunska sequences which look floating in the granitoid matrix. The boundaries between them and primary-stratified rocks are gradual, rather conventional, with predomination of paleo- or neosome. In the physical fields the granitoids are expressed by decreased or negative magnetic and gravity values on the background of mainly linear positive anomalies.

Mineral composition of granitoids is governed by composition of the source metamorphic rocks they developed after which. Among the aluminous complexes the garnet- and sillimanite-bearing migmatites are noted and after the mafic rocks – amphibole- and pyroxene-bearing varieties. Major and trace element geochemistry of granitoids is also mainly inherited after the source rocks. By composition of dark-coloured minerals the biotite-, garnet-biotite, amphibole and pyroxene varieties of plagiomigmatites are distinguished. Aforementioned varieties comprise the marginal members of ultra-metamorphic ranges and actually the rocks are mixed in composition. Biotite plagiomigmatites predominate while pyroxene and amphibole-pyroxene plagiomigmatites are intersected by some drill-holes in Remivskiy Block and in OP LTZ. By structure patterns the gneissic, banded and spotty-banded migmatites are distinguished.

Plagiomigmatites comprise the polychronous rocks formed after the source complexes of Zakhidnopryazovska Series, Vovchanska and Dragunska sequences and Novopavlivskiy enderbite-tonalite complex under amphibolite facies PT-conditions late in Paleo-Archean – beginning of Meso-Archean. Further on plagiomigmatites repeatedly underwent the thermal impact of retrograde kind which, however, did not provide significant changes in their primary geochemical and structure-texture patterns. Relationships of plagiomigmatites with the younger rocks also remain unchanged. Considerable remobilization and palingenesis with subsequent formation of Shevchenkivskiy Complex plagiogranite massifs had occurred in Gulyajpilskiy and Saltychanskiy (to the south from the map sheet L-37-I) blocks only. Most changes are expressed in the partial demolishing of granulite mineral assemblages and breaking the U-Pb equilibrium in zircons made them younger. Another significant reworking had occurred in Paleo-Proterozoic during formation of Anatolskiy Complex of autochthonous and para-autochthonous granites. Actually throughout they are microclinized, most

extensively in OP LTZ, up to the formation of two-feldspar migmatites. In the geological map Anadolska granitization of plagiomigmatites in indicated in red.

Dnipropetrovskiy Complex (AR_2dn). It includes diverse plagiogranitoids – the products of ultra-metamorphic reworking of Aulska Series and Bazavlutska Sequence amphibolites and gneisses which are observed in the numerous remnants and are connected with granitoids by gradual transitions. Plagiomigmatites constitute the old gneiss-migmatite domes – Kamyshuvakhskiy and Kamenskiy, as well as the fields of various shape and size remained from complete assimilation in the envelopes of large Neo-Archean granites massifs. Of these the Kupriyanivske and Lysogirske fields are the biggest ones.

Kamyshuvakhskiy Dome comprises the oval up to 650 km^2 in size with the axis oriented in the north-eastern direction located in between the Konkska greenstone structure and Orikhovo-Pavlogradskiy Fault. The Dome margins are mainly composed of biotite, and the core – of biotite-amphibole and amphibole, rarely garnet-bearing plagiomigmatites. The fields of various petrographic types are irregularly-shaped due to the flat rock laying.

Plagiomigmatites normally are non-magnetic low-density (up to 2.76 g/cm^3) rocks thus the Dome exhibits negative magnetic and low gravity fields; on this background the minor mainly irregularly-shaped positive residual gravity anomalies are observed reflecting the remnants of biotite-amphibole and amphibole gneisses and amphibolites.

Kamenskiy Dome 300-320 km^2 in size is located to the south of Konkska greenstone structure. It is composed of biotite plagiomigmatites and in the physical fields is expressed in the manner similar to Kamyshuvakhskiy Dome.

Lysogirske field is located in the right-bank side of Dnipro River, to the south of Zaporizhzhya city, surrounding from the east Zaporizkiy massif of Mokromoskovskiy Complex granites. It is irregularly-shaped and 100-110 km^2 in size. The south-eastern edge of the field plunges beneath Kakhovske water reservoir. Apparently the field comprises the north-western extension of Kamenskiy Dome. The "field" is mainly composed of biotite, and in the southern flank also of biotite-amphibole and amphibole plagiomigmatites well expressed in the gravity field by its increased values (up to +0.3 mGal).

Kupriyanivske field is distinguished to the south-east from Mokromoskovskiy massif. It is extended in the north-eastern direction over 28-29 km at the width from 1.5 to 4 km. The most part the field is composed of light-grey, almost white muscovite and two-mica microclinized plagiomigmatites, and in the north-east – of biotite plagiomigmatites. The field is cut by the numerous pegmatite veins and actually is impregnated by pegmatite material.

Gaychurskiy mafic-ultramafic complex (AR_2gu*). The tectonic setting of the Complex intrusive rocks is quite defined. This Complex is only known in Kosivtsivska, Gaychurska and Chystopilska greenstone structures and their envelope. The rocks are comagmatic to the meta-volcanics of greenstone structures and are observed in the minor stocks and sheet dykes and sill-shaped bodies arranged in two fields (arrays). The first irregularly-shaped field in the map sheet L-37-I-C is confined to the north-western part of Kosivtsivska structure. Through the chain of minor stocks it is traced to the south where it almost reaches Gulayjpilska brachy-syncline. The second, south-eastern extension, is confined to Kosivtsivska monocline; it is located in the map sheet L-37-I-D in the area of Uspenivska site of Gaychurska structure [73, 87] and is shorter and smaller in size.

The high magnetic susceptibility of ultramafic rocks is expressed in magnetic fields by positive anomalies from 100 to 1500 nTl. In the gravity field the rocks often are not expressed because of the small size and extensive serpentinization decreasing their density. The same reasons preclude tracing the bodies by depth using density modeling of gravity field.

The Complex includes serpentinites, actinolitites, tremolitites and, rarely, talc-carbonate rocks providing continuous range of peridotite metamorphic transformations. Often all varieties can be observed in the same intrusion being connected with the gradual transitions (DH 121, 738, 739 and others).

Petrochemical studies [73] had revealed the peridotite family harzburgites affinity of ultramafic rocks and their similarity with peridotite meta-komatiites of Kosivtsivska Sequence.

Meso-Archean age of the ultramafic rocks is evidenced from their cutting by the dykes of Shevchenkivskiy Complex quartz porphyries, micro-plagiogranites and albitites (DH 757 [73]; DH 116 [113]) with radiogenic age 2960-3200 Ma [73].

Dobropilskiy Complex (AR_2dbp*). The Complex is locally developed in the map sheet L-37-I (Pology). It is confidently identified in two intrusions: Dobropilska – at the margin of map sheet L-37-I-C,D, and Rozdolnenska located to the north at the western margin of map sheet L-37-I-D, and in the series of dykes in these map sheets. In the geophysical fields these intrusions are variously expressed. The first one exhibits negative gravi-magnetic fields on the background of the high-magnitude positive anomalies provided by the meta-basites of Verkhnyotokmatska and Kosivtsivska sequences. Only the north-eastern flank of this intrusion

situated within the gneiss-migmatite field is expressed by positive magnetic anomaly. Rozdolnenska intrusion is expressed in a similar manner.

The Complex is mainly composed of quartz biotite-amphibole diorites and amphibole-biotite tonalites with distinct "breccia-like" structure. It is caused by abundant minor (from 3×5 mm to 3×4 cm, in places more) xenoliths of host rocks including actinolitites and single fragments of amphibolites and plagiogranitoids [73]. Much rarely and in the vein fraction only the micro-plagiogranites and quartz porphyries are observed; their belonging to the Complex may be revealed only through the isotopic rock dating.

Dobropilska intrusion is confined to the junction zone of Gulyajpilskiy and Remivskiy blocks along the Gaychurska fault zone; most part of the intrusion is located in the first block. By morphological and genetical features the massif resembles fissure hypabyssal intrusion. It is about 25 km^2 in size. In the plane the shape is dumbell-like and is oriented in the west-north-western direction. Intrusion is discordant in relation to the all units in both blocks and to the Gaychurska fault zone. Intrusion length is 13 km and width from 600 m to 3 km. In the cross-section the massif is sheet-like; by geophysical data it is traced to the depth > 5 km. The contacts with the country rocks are sub-vertical with apophyses to the latter.

Geological and geochronological study results suggest for two-stage (phase) formation of Dobropilska intrusion and respective formation of the Complex.

The first phase of emplacement includes quartz diorites and plagiogranites dykes. The former ones constitute the western part of the massif and the separated body up to 1.5 km^2 in size in its eastern part; prior to the second emplacement phase these units had comprised the single body. Quartz diorites are variable in composition. At the margins (northern contact) the "rim" up to 150 m thick is mapped composed of more felsic tonalites whereas in the core portion the diorite schlieren are observed.

The second phase includes tonalites which constitute the central and south-eastern parts of intrusion. Their contact with the first-phase diorites is intrusive and is accompanied by the extensive granitization. Actually the contact comprises the zone of diorite body injecting by the numerous tonalite dykes (DH 832 [73]). In the tonalite body the minor xenolith of highly acided first-phase diorites are observed.

Emplacement of intrusion was accompanied by injection of the numerous dykes both of typical "breccia-like" quartz diorites and tonalites and the normal plagiogranites, micro-plagiogranites and quartz porphyries. They are observed throughout in Gulyajpilskiy Block, including blasto-tectonites which directly underlie Gulyajpilska brachy-syncline (DH 847 [73]). But preferentially they are confined to the zone of Gaychurskiy Fault (to the north-west and south-east from Dobropilska intrusion) forming the dyke belt extended along the fault. Thickness of the belt south-eastern flank attains 1.5 km, length – 10 km. Thickness of the dykes is 0.5-25.0-30.0 m.

The second-phase tonalites visually are almost identical to the quartz diorites. The differences include the less number of contained xenoliths, their smaller size, higher degree of their granitization and more leucocratic appearance of the rocks.

Rozdolnenska intrusion is composed of the first-phase diorites but, in contrast to Dobropilska intrusion, it is more gneissose and is cut by numerous veins of gneiss-like plagiogranites and albilites of Shevchenkivskiy Complex.

Isochrone age of the first-phase quartz diorites is 3280-3310 Ma (DH 785 [73] and DH 200 [71]). The second-phase tonalite age (DH 833 [73]) is 3137 Ma. The time of second phase emplacement is coherent with the age of metamorphism in Ternovatska Sequence – 3160±45 Ma that allows their contemporaneous development (single tectono-magmatic cycle).

Neo-Archean (Dniproviy) (AR_3)

Dniprovskiy tectono-magmatic stage is marked by the wide development of basaltoid and rhyodacite volcanism accompanied by the intrusive magmatism and the processes of extensive anatexis and palingenesis resulted in the formation of numerous minor intrusions and large massifs of autochthonous, para-autochthonous and intrusive granites.

In the Middle-Dniprean Block six Neo-Archean complexes are distinguished (Verkhivtsivskiy, Surskiy, Varvarivskiy and Devladivskiy intrusive as well as Mokromoskovskiy and Tokivskiy palingenic) and the association of Khortytski plagiogranites; composition of the rocks involved vary from ultramafic to felsic. In the Pryazovskiy Block the only Shevchenkivskiy ultra-metamorphic plagiogranitoid complex and the association of Yanvarski palingenic two-feldspar granites are distinguished.

Verkhivtsivskiy Complex (AR_3vr^*). The Complex combines intrusive gabbroids and ultramafic rocks related in space and time with the Konkskiy stage of Konkska greenstone structure development. The first rock group (gabbroids) includes two sets of minor intrusions: the southern one consisting of the four stocks, and the north-eastern one of three intrusions, as well as a great number of sub-volcanic vein bodies conformably

injecting meta-volcanogenic column of Surska Suite. The second (ultramafic) group is developed in the three stocks more or less considerable in size, of which two isometric bodies are encountered in the south-eastern part of Konkska greenstone structure and the third oval-shaped body to the south from Shcherbakovskiy massif.

Ascription of mentioned units to Verkhivtsivskiy Complex is disputable and is grounded on the established association of most these units with the rocks of Surska Suite. Part of these rocks is located within granitoids. But the intrusive contacts of the stocks with host complexes and similarity of mineralogical and petrochemical rock composition with respective meta-volcanics of Surska Suite allow their ascription to the given stage of intrusive activity. It is not excluded that partly these rocks belong to Varvarivskiy Complex but the rock separation from Bilozerska Series units preclude unequivocal solution to the problem in this way.

The mineralogical-petrographic summary of gabbroids is typical. They are mainly composed of highly amphibolized gabbro with slight gneissosity. In places the rocks are completely transformed into gabbro-amphibolites and even schistose amphibolites.

Ultramafic rocks intersected by single drill-holes are talc-carbonate and rarely serpentine in composition. In magnetic field they are expressed by minor (0.2×0.5 km) isometric positive anomalies. The thin (40 m by core sections) ultramafic body of actinolite-chlorite composition is intersected within meta-spilites of Surska Suite (DH 36) in 700 m to the south-east from Veselyanska intrusion. The body exhibits linear-sheet morphology and apparently comprises the inter-bed sill-like intrusion. Here ultramafic rocks are associated with the underlaying dolerites which form another body of approximately same thickness.

Surskiy Complex (AR_3sr*). The Complex includes intrusive tonalite-plagiogranite and rhyodacite rock associations which in the Middle-Dniprean granite-greenstone terrain are spatially connected with the greenstone structures. The rocks are observed in the separate bodies mainly at the contact zones of the latter or are located inside.

The age of Surskiy Complex granitoids falls into the interval 2950-3170 Ma.

The Complex granitoids had formed within two phases. The first phase comprises plutonic tonalite-plagiogranite rock association and the second phase – sub-volcanic andesite-rhyodacite association. The first-phase intrusive rocks are observed in the individual massifs of various shape and size (Lukyanivskiy and Verkhnyotersyanskiy); the second-phase sub-volcanic rocks constitute specific, mainly contact, portions of these massifs or are arranged in the large enough fields being observed in the numerous out-of-scale veins and dykes within greenstone rocks (Pivnichnobilozerskiy).

Pivnichnobilozerskiy massif is located inside the northern Bilozerska greenstone structure and by perimeter is rimmed by Konkska Series meta-basites. The massif exhibits zoned-asymmetric structure: its oval-shaped "core" 11×16 km in size is composed of the first-phase tonalites and granodiorites and from the south is surrounded in horseshoe fashion by the second-phase meta-rhyodacites [87]. The latter constitute the tongue-shaped field about 60 km^2 in size which cut the meta-basalts in the eastern flank of structure. Isochrone age of the first-phase tonalites is 3080 Ma and the second-phase meta-rhyodacites – 3055 Ma [1].

The massif's north-eastern part composed of tonalites and meta-rhyodacites is located in the map sheet L-36-VI (Zaporizhzhya). Meta-rhyodacites constitute the arc-shaped body (5.0×0.7 km) convexed to the south-east which intrudes meta-basites of Surska Suite. Meta-rhyodacites comprise schistose rocks of porphyry and augen texture, in places felsite-like. By composition they correspond to the family of low-alkali rhyodacites.

Lukyanivskiy massif intrudes the south-eastern part of Konkska greenstone structure stretching in sub-longitudinal direction over 25 km being up to 8 km wide in the central part. The southern part is amoeba-shaped with the "tentacles" deeply tongued (up to 10 km) into the meta-basite complex of Surska Suite. The western contact is twisting, typically intrusive. Along almost entire its length the contact zone is accompanied by the zones of milonitization and cataclasm. The eastern contact of the massif over the distance of 20 km is tectonic and follows the zone of regional Vasylivsko-Kamyshuvakhskiy Fault. The massif is composed of the massive and gneissose plagiogranites. The rocks are non-magnetic, low-density (2.69-2.72 g/cm^3) and are reflected in the negative magnetic and lowered gravity fields.

Another (Verkhnyotersyanske) plagiogranites field (up to 25 km^2) is located in the north-eastern part of the Middle-Dniprean Block and is spatially connected with the band of Surska Suite meta-basites (Dubovogayska monocline) surrounding the massif from the north in the horseshoe fashion.

The vein facies of Surskiy Complex includes numerous veins and dykes of the second-phase rocks confined to the meta-basite field in the south-eastern limb of Konkska greenstone structure. The dykes are differentiated in composition from rhyodacites to andesites and trachytes and apparently comprise the differentiation products of the same melt derived probably from the deep "inter-greenstone" felsic massif about 5 km^2 in size which is not exposed at the basement surface but is assumed on the ground of the gravity minimum interpretation. The most widespread vein-facies rocks include andesites and trachytes.

Trachytes are mainly developed in the narrow (up to 1 km) amphibolite band in the south-eastern limb of Konkska greenstone structure. Thickness of trachyte dykes normally does not exceed 1-2 m. These are grey or

pink-grey, fine-grained, dense, often porphyry rocks with alkali content (Na_2O+K_2O) from 7.7 to 10.2% (K_2O from 5.0 to 6.0%; silica content from 58 to 62%). V.D.Ladieva [30] had distinguished these rocks as metasomatic syenite-porphyries. Andesites are observed in the dykes from first meters to 50 m thick (DH 32, 33, 37). Meta-trachy-andesites (quartz-muscovite schists) are intersected in DH 36. Major element content (%): SiO_2 – 64.15, Al_2O_3 – 20.3, Na_2O – 1.97, K_2O – 5.78.

Dacite dyke with coarse, up to 5-6 mm, rounded porphyry quartz grains (plagiogranites-porphyry) is intersected in DH 30 within ultramafic rocks of Veselyanska intrusion. Rhyodacites (keratophyres [48]) are intersected in DH 37, 11^c, 9^c, 16^c. Other keratophyre vein bodies with sharp discontinuous contacts are also ascribed to rhyodacites.

Varvarivskiy mafic-ultramafic complex (AR_3vv*). The Complex is distinguished on the ground of general tectonic setting of ultramafic intrusions in the Middle-Dniprean area which are confined to the unconformable contact between Konkska Series meta-volcanics and Bilozerska Series meta-sediments with the evidences for the active influence on the both. In Konkska greenstone structure some sheet-like ultramafic intrusions are encountered at the post-Bilozerskiy level.

Veselyanska intrusion is the biggest in size and most studied. It is confined to the contact between Konkska and Bilozerska Series and comprises typical inter-bed body. Over the traced length of 5.5-6.0 km it sharply changes its strike several times following the strike of the host rocks. This suggests for its pre-folding emplacement. Thickness of intrusion at the core is 300-350 m and toward the margins it gradually pinches out. Intrusion was studied by A.A.Nastenko [92] and is described in details by V.D.Ladieva [30].

Intrusion is composed of carbonate-talc-magnesite, rarely talc-carbonate and talc-serpentine-carbonate rocks interconnected with gradual transitions. Chlorite and actinolite mono-mineral rocks are observed in the middle part of the body and in the north-eastern part the thin (up to 0.8-1.5 m) interbeds of biotite-chlorite metasomatites are encountered. The latter are also characteristic for the western endo-contact of intrusion highlighting its later age in relation to the rocks of Bilozerska Series.

By chemical composition the talc-magnesites are high-magnesium rocks: they contain 31.0-38.3% MgO with minor amounts of alumina (1.2-2.6%) and CaO (0.2-3.6%). The rocks correspond to the dunite-harzburgite group and comprise the same-named talc-magnesite deposit. Talc-dolomites at the high MgO content (25.0-28.0%) contain 5-10% of CaO and belong to the dunite-lherzolite group. Throughout the ultramafic rocks contain magnetite (up to 10-14%); in magnetic field intrusion is clearly expressed by the linear anomaly up to 1000-1200 nTl.

In some places Veselyanski ultramafic rocks are cut by the veins of porphyry-like rhyodacites and granite-porphyries as well as pink aplitioid granites from parts to 20-30 m thick (by core sections).

Another body, similar to Veselyanske in tectonic setting, shape and mineral composition, is mapped in Promizhna site. Its length is estimated to 2.0-2.5 km, width- up to 100 m. The body is composed of the rocks with major minerals including talc, carbonate, biotite, chlorite and actinolite.

Association of Khortytski plagiogranites (AR_3hr). Plagiogranites of this Association are excluded from Surskiy Complex on the ground of their active influence on the rocks of Bilozerska Series observed along the western limb of Konkska greenstone structure where the narrow (0.6-2.0 km) band of these rocks is mapped over the distance of 12-13 km. The host schists are silicified and pyritized at the contact with plagiogranites. It is possible that considerable portion of the structure western limb is also assimilated by plagiogranites of this Association during emplacement of Khortytskiy massif. Microclinization of plagiogranites under influence of Mokromoskovskiy Complex granites evidences for their older age. Thus, these relations define the time of the Association development in the interval from 3110 (Surskiy Complex age) to 2835 Ma (Mokromoskovskiy Complex age). Single radiogenic age determinations for zircon from Khortytsya Island plagiogranites (2970 Ma) fall into this interval. Assumed genesis of plagiogranites is palingenic-anatectic (ultra-metamorphic).

Plagiogranites in the studied area constitute the large, 72-75 km long and from 12-14 to 3-6 km wide Khortytskiy massif linearly elongated in the south-eastern direction. It includes the plagiogranite fields at the outskirt of Zaporizhzhya city, the site in the south-western limb of Konkska greenstone structure and further to the south from Shcherbakivskiy granite massif and to the west from Novogorivska greenstone structure.

The composition of plagiogranites is typical. Biotite varieties predominate while the amphibole-biotite ones are rarely observed. In the south-western limb of Konkska greenstone structure, in the zone of Khortytskiy Fault, plagiogranites are extensively gneissed, cataclased and milonitized up to their transformation into cataclasites and milonites with subsequent formation of blasto-tectonites. Cataclasm was accompanied by epidotization, chloritization and microclinization.

In the physical fields Khortytskiy massif is expressed by negative magnetic and decreased gravity values.

Shevchenkivskiy Complex ($AR_3šv$). The Complex includes late-folding massive plagiogranites of ultra-metamorphic origin observed in relatively separated individual massifs and numerous minor dyke-like

bodies of plagiogranites, quartz porphyries and albitites in Pryazovskiy area. The Complex rocks are most developed in Gulyajpilskiy Block and in Remivskiy Block some minor irregularly-shaped bodies are known. Being the final product of the multi-phase ultra-metamorphism of Paleo-Archean rocks, the Complex plagiogranites regularly occupy considerable fields in the central and northern Gulyajpilskiy Block changing the diorite and tonalite fields of Novopavlivskiy granitoid complex. The latter, being the product of initial granitization after the rocks of Zakhidnopryazovska Series, are located between the latter and plagiogranites. In the north of the Block they are observed in two massifs: Vozdvyzhivskiy and another minor (1.5×2.7 km) unnamed one. Vozdvyzhivskiy massif is confined to the same-named anticline [73] and comprises phacolith 12×1.5 km in size.

To the south of Gulyajpilska structure plagiogranites are observed in the irregularly-shaped bodies within diorites being confined to the fault zones suitable for anatectic melts input. In the area of Gulyajpilska brachy-syncline and to the south-east from the latter they constitute the large uniform field. According to some authors [107], plagiogranites also constitute the basement of this brachy-syncline.

The vein plagiogranite bodies are confidently observed only in cases of their injection into the contrasted rock complexes. Their most amounts are encountered in the mafic meta-volcanic fields of Verkhnyotokmatska and Kosivtsivska sequences. The vein albitite bodies are being mapped easily enough. They are developed mainly in the north of Gulyajpilskiy Block in the fields injected by sub-parallel 0.3-1.0 m thick dykes. In the north-western part of map sheet L-37-I albitites constitute two minor bodies confined to the tectonic breaks.

Due to the low density (2.65-2.69 g/cm^3) and magnetic susceptibility (10-300×10^{-6} CI units) in the physical fields plagiogranites exhibit the lower, in comparison to diorites and tonalites of Novopavlivskiy Complex, values of magnetic field – from 300 (in the south) to 600 nTl (in the north) and negative values of residual gravity field (from 0.2 to 1.0 mGal). The vertical "thickness" of plagiogranites by geophysical data does not exceed 5 km. The contacts are sub-vertical and in view of the rock ultra-metamorphic genesis the contacts most likely are gradual.

Macroscopically plagiogranites are gneissose and massive rocks; cataclazed varieties are schistose-lens-shaped-banded and fine-augen. By mineral composition biotite and rarely amphibole-biotite varieties are distinguished.

Plagiogranite dykes exhibit fine- to criptic-crystalline often porphyry texture and mainly gneissic structure. Porphyry phenocrysts are composed of quartz, rarely plagioclase.

Albitites are the distinct rocks. Macroscopically these are coarse-, medium- and fine-grained, in places porphyry, pink, light-grey and milky-white rocks with irregular distribution of the opaque minerals (biotite, actinolite, chlorite). Albite and oligoclase-albite comprise up to 70-95% of the rock mass. Their radiogenic age is 3050 Ma [73]. Relationships of albitites with the host rocks do not allow unequivocal considerations concerning their genesis. The sharp, discontinuous contacts of most bodies suggest for their intrusive origin whereas gradual transitions of albitites into the host rocks with formation of hybrid albite-chlorite-actinolite metasomatites (DH 96 [107]) evidence for metasomatic genesis. Most likely they are resulted from the residual melt of plagiogranite magma and its emplacement was accompanied by the sodium metasomatism of the wall rocks.

Secondary alteration of the Complex plagiogranites is observed throughout. Most prominent are processes of cataclasm and retrograde metamorphism under epidote-amphibolite facies conditions expressed in chloritization, epidotization, muscovitization and sericitization. In addition, plagiogranites are cut by vein and stock-like bodies of Anadolskiy Complex granites accompanied by microclinization.

Mokromoskovskiy Complex (AR_3mk). The Complex includes two-feldspar palingenic-anatectic granites of Mokromoskovskiy, Skelkivskiy (Vasylivskiy) and Zaporizkiy massif [25] and aplite-pegmatoid granites occurring in minor spatially disconnected bodies in Kamenskiy and Kamyshuvakhskiy gneiss-migmatites domes, as well as numerous out-of-scale veins and schlieren. Their radiogenic age is 2835 Ma [1].

Mokromoskovskiy massif comprises the major intricate irregularly-shaped pluton of the total square in excess of 1000 km2 which adjoins Devladivskiy Fault to the north-east from Zaporizhzhya city. Its southern part is mapped in the map sheet L-36-VI (Zaporizhzhya). Numerous cliff exposures of the rocks are observed by the banks of Mokra Moskovka, Vilnyanka and Dnipro rivers. The massif was formed in two phases.

The first phase is released in the rocks including diverse-grained, in places porphyry-like granites of mainly grey shades. They are observed in the field 6-10 km wide and up to 35 km long extended along Konkska greenstone structure. Granites are in the active contacts with the host migmatites of Dnipropetrovskiy Complex [25]. In the west of massif the gradual transitions into the Surskiy Complex plagiogranites are observed. The eastern part is composed of two-mica granites.

The second phase includes formation of pegmatoid and aplite-pegmatoid granites and pegmatites. The rocks are observed both in the individual fields and in the numerous veins, stocks and schlieren in the country rocks and in the first-phase granites. Their biggest field – Vilnyanske, 190 km^2 in size, is located on the left-bank

side of Dnipro River, in the north-western part of map sheet L-36-VI. It is composed of pegmatoid granites which often transform into the typical pegmatites containing numerous fine (up to the first meters thick, in places up to 10 m and more) remnants of assimilated gneisses. Their "interbedding" with pegmatites is characteristic to the entire group of outcrops by Vilnyanka River; since pegmatites predominate over gneisses the field was ascribed to Mokromoskovskiy massif being located in its core with the flat (up to 20-25°) rock dipping.

Pegmatites, pegmatoid and aplite-pegmatoid granites are also often observed in the marginal facies of the first-phase regularly-grained granites. But normally they are developed in the south-eastern up to 6-7 km wide envelope of Mokromoskovskiy massif. Particularly, in the 1.5-3.0 km wide exo-contact migmatite band of Kupriyanivske field amount of veins and schlieren attains 30-50%, then gradually descending away from the massif. Abundant pegmatites are also developed in the narrow band of Mykhaylivska Suite. In view of metamorphic degree (facies of sillimanite-muscovite schists) and tectonic setting this band is favourable for localization of rare-metal pegmatites.

Skelkivskiy (Vasylivskiy) massif is located in the south-western part of map sheet L-36-VI. It true size and shape are not known yet. The north-western flank plunges beneath Kakhovske water reservoir. In the land, the massif is up to 300-310 km^2 in size and is extended in sub-latitudinal direction being conformable to the general tectonic framework. From the north and east the massif is surrounded by migmatites of Dnipropetrovskiy Complex, and from the south – by the Aulska Series gneiss field and meta-volcanics of Bilozerska greenstone structure.

Considerable western part of Skelkivskiy massif and its 1.5-2.0 km wide "branch" extended in the north-eastern direction over 14-15 km are composed of fairly uniform grayish-pink coarse-grained biotite and muscovite-biotite first-phase granites; total square is up to 180-190 km^2. The eastern part is composed of the second-phase aplite-pegmatoid granites which form the latitudinal field 18-19 km long. Alike Vilnyanske field it is composed of numerous granite bodies with minor remnants of biotite gneisses and plagiomigmatites.

Numeric relations between substratum and granites changing in the eastern direction and in the north-eastern extension of the field only the linear zone of numerous aplite-pegmatite veins in migmatites is observed being expressed by the gravi-magnetic minimum.

Zaporizkiy massif is located in the map sheet L-36-VI, on the north bank of Kakhovske water reservoir. Its southern part is flooded. Apparently is comprises extension of Skelkivskiy massif. The studied map sheet encompasses only its eastern flank about 90 km^2 in size. Granites include mainly coarse-grained biotite varieties; fine-grained granites also widespread and in the area of Rozumivka – Maryivka – Bilenke villages they constitute two fields 5-7 km^2 in size each. Two biotite gneiss remnants in granites of almost same size are mapped.

Besides the mentioned massifs, pegmatoid granites of Mokromoskovskiy Complex are developed in the junction zone of Devladivskiy and Orikhovo-Pavlogradskiy deep-seated faults and are also known in some minor (first square kilometers) massifs within Kamyshuvakhskiy and Kamenskiy gneiss-migmatite domes.

Tokivskiy Complex (AR_3tk). In the map sheet L-36-VI (Zaporizhzhya) the Complex granites constitute Shcherbakivskiy massif confined to the junction of Orikhovo-Pavlogradska, Khortytska and Vasylivsko-Kamyshuvakhska fault zones which bound the massif from the east, south and west respectively. In the plane the massif comprises 15 km long and 6-7 km wide oval-shaped body elongated in the sub-longitudinal direction. The contacts with host rocks are sharp, intrusive, complicated by faults over the long distance.

Shcherbakivskiy massif is composed of unclear-porphyry, coarse- and medium-grained, leucocratic, mainly two-mica granites, in places containing minor granitized remnants of gneisses and amphibolites. Essentially microcline rocks (by mineral composition they correspond to grano-syenites and syenites), albitites, greisenized granites, quartz-epidote-chlorite rocks are developed in the zones of metasomatic reworking (mainly along the eastern endo-contact). The schlieren-like pegmatoid bodies and late quartz veins are observed in granites.

In the massif south-western part granites contain accessory magnetite in amount up to 2-3% providing variable mosaic magnetic field up to 300-400 nTl. In the gravity field the massif southern part is expressed by the minimum with the high-gradient contact zones.

Isotopic age of granites in Shcherbakivska intrusion is 2810 Ma [65].

Association of Yanvarski granites (AR_3jn). For the first time this association is distinguished by results of EGSF-200 [104]. The needs to separate it from the formerly known Pryazovskiy Neo-Archean granite complex, which is currently defined as Paleo-Proterozoic Anadolskiy Complex, in the status of the age and composition analogue of the Middle-Dniprean two-feldspar complexes, have been repeatedly argued by B.Z.Berzenin, L.V.Isakov, V.M.Kichurchak and others.

Two-feldspar granites of Yanvarska association are developed in the northern part of map sheet L-37-I in the minor isometric and bigger amoeba-like bodies and massifs arranged in Yanvarske field of the total square about 520 km^2. Granites are confined to the junction zone between Vovchanskiy Block (Orikhovo-Pavlogradska

LTZ) and Remivskiy Block (Zakhidnopryazovska LTZ). The southern field boundary is controlled by Andriivsko-Fedorivska zone of regional faults. The central field part is divided in two halves by Shevchenkivsko-Fedorivska structure composed of meta-sedimentary rocks of Meso-Archean Ternovatska Sequence.

M.Ya.Yashchenko. B.Z.Berzenin, L.V.Isakov and V.M.Kicurchak [74] who studied Yanvarski granites in details assume their two-phase emplacement. To the first phase they ascribe very irregular in composition and structure-texture patterns granites with numerous remnants of the hosting Zakhidnopryazovska Series and Vovchanska Sequence rocks. The field of their development is entitled as Yanvarskiy massif. The second phase is related to Krasnokutski granites which intrude Ternovatska Sequence. Both phases accompanied by the veins of pegmatoid microcline granites. The phases definition is not properly proven and thus to date all two-feldspar granites in the area are considered to be even-aged facial varieties.

In the map sheet L-37-I (Pology) association includes amphibole-biotite magnetite-bearing, biotite and alaskite granites and veins of aplite-pegmatoid granites and pegmatites.

Granites are mainly biotite, muscovite-biotite and (rarely) amphibole-biotite. Sporadically garnet and diopside are found being inherited from the assimilated host rocks. Macroscopically these are pink-grey or light-grey medium-grained, massive, rarely slightly-banded rocks of variable mineral composition. Microcline content varies from 0 to 65%.

Amphibole-biotite magnetite-bearing granites are developed in the far south-western part of the massif, surround it from the south in the narrow (1.0-1.5 km) band and constitute the individual body in the junction zone of Shevchenkivska and Fedorivska structures. In chip samples these are grey and pink-grey, medium-grained, massive, rarely banded rocks. By chemical composition they correspond to granodiorites.

Muscovite- and biotite-bearing alaskite granites constitute most part of Yanvarske field. These are grey, pink-grey, light-grey and light-greenish-grey, medium- and coarse-grained, massive rocks of consistent mineral composition (microcline – 40-60%).

Relationships of granites with the host rocks in the marginal field parts are mainly gradual, sub-conformable. Considerable zones of the hybrid rocks are observed between granites and plagiomigmatites. At the same time, the cutting ("active") granite contacts with the host rocks are observed often enough. The body shape and contact relationships suggest for para-autochthonous (anatexis of Paleo-Archean rocks up to the stage of homogenous melt – magma formation, with subsequent minor melt movement into the zones of tectonic weakness) origin of granitoids in association. Emplacement of granitoid melt provides all necessary intrusive records. Its crystallization was accompanied by extensive microclinization of the host rocks. By these reasons Yanvarske granitoid field exhibits irregular, nodose structure, amoeboid shape and quite irregular petrographic composition and includes a number of minor separated massifs. The known *Krasnokutskiy massif* with active contacts comprises the typical example of mentioned relations. At the Precambrian surface the massif is exposed in three separate localities. The western one is observed directly along the western margin of Shevchenkivska graben-syncline; the eastern, horseshoe-shaped, about 15 km^2 in size, is located to the north-east from the junction of Shevchenkivska and Fedorivska structures. The northern, up to 6 km^2 in size, is encountered inside Fedorivska brachy-syncline and its north-western part extends into Shevchenkivska structure. It is assumed that all three portions are merged into the single body at the depth. Granites of the massif assimilate the eastern limb of Shevchenkivska structure and intrude the junction zone of the latter with Fedorivska structure.

In the geophysical fields granites are expressed by decreased gravity and magnetic values and magnetite-bearing granites – by increased (up to 500 nTl) values of magnetic field.

The regular change in granite composition from the south-west to north-east (amphibole-biotite to biotite and alaskite) provides the prominent zonation of the massif. The silica and potassium content increase respectively.

Radiogenic age of Yanvarska association granites (Vovcha River, 3 km to the north from Yanvarske village) is 2735 Ma [G.V.Artemenko, 1999, IGMOF]; alaskite granites – 2650-2800 Ma [L.V.Sumin, VIMS; V.M.Kichurchak].

Pegmatites and aplite-pegmatoid granites in the map sheets are observed throughout both in granites and host rocks. By metallogenic criteria ceramic, rare-metal and rare-earth varieties are distinguished. It is actually impossible to define the complex which pegmatites belong to. It is thought that majority of pegmatites, especially ceramic, in Pryazovskiy area are of Paleo-Proterozoic age and belong to Anadolskiy Complex. Rare-metal and rare-earth pegmatites in the map sheets constitute Shevchenkivsko-Fedorivske, Ternovatsko-Kuybyshevske and Chystopilske pegmatite fields. The first one is confined to the field of Yanvarski granites and displays geochemical specialization similar to them. Rare-metal pegmatites of Shevchenkivske and Fedorivske fields are studied in details in the course of DGM-50 (Kichurchak, 1985), prospecting and exploration works (Isakov, 1986, 1988), and reviewed in some publications (Galetskiy, 1987; Kichurchak, 1988; Isakov, 2000).

It is argued in the mentioned studies that pegmatites of these fields belong to the IV tectono-volcanic phase of Yanvarskiy (Voskresenivskiy) multi-phase massif of the same association. It is established zonation in various-type pegmatite localization in relation to the massif, as well as the direct link of individual pegmatite bodies with them.

Presented data unequivocally suggest for the genetic link of rare-metal pegmatites with granites of Yanvarska association[1]. In tectonic respect all three pegmatites fields are confined to the superimposed tectonic structures of the second level composed of Meso-Archean Ternovatska Sequence rocks. Tectonic setting of pegmatite fields, metallogenic specialization and genetic link with granites of Yanvarska association allow ascription of pegmatites of the mentioned fields to Yanvarska association. Most often microcline and oligoclase-microcline, rarely oligoclase, albite-oligoclase, albite-spodumene and albite-petalite pegmatite varieties are observed. By petrochemical, geochemical and metallogenic features three groups of pegmatoid granites are distinguished: ceramic, rare-earth and rare-metal. The first one comprises the typical example of ceramic pegmatites and does not differ from Anadolski or Mokromoskovski ones. The latter, in the map sheet L-37-I (Pology) contain Shevchenkivske lithium deposit and prospective occurrences of beryllium, rubidium, tin, tantalum, yttrium, ytterbium, lanthanum, cerium and uranium; by these reasons their description is given in more details.

Kuybyshevske field of rare-earth pegmatites is confined to the south-eastern limb of Gaychurska rifting structure filled with the Meso-Archean rocks of Ternovatska Sequence. The field is stretched over 40 km in the north-north-western direction, its width attains 2-3 km. Pegmatites comprise sheet-like bodies with sub-conformable and sub-vertical dipping. Thickness varies from 0.5 to 59.0 m (DH 824 [73]). By strike some bodies are traced over 300 m. Macroscopically the rare-earth pegmatites are pale-pink-grey and light-grey, massive, coarse-grained rocks. Opaque minerals include biotite and muscovite.

Geochemical features of rare-earth pegmatites include strong positive specialization for bismuth, positive – for yttrium, ytterbium, lead, tin, scandium, gallium, zirconium and silver, and unclear – for niobium and lithium [73]. According to the classification of A.I.Ginzburg, described pegmatites are ascribed to the ceramic pegmatites of xenotime-cyrtolite-uraninite sub-type of uranium-rare-earth type (II type in classification of A.E.Fersman).

In Kuybyshevske pegmatite field zonation is defined – from the north to south their rare-earth specialization is changed to the rare-metal one. In the southern part in DH 89 [113] the pegmatites with lithium-niobium mineralization are encountered.

By geophysical data (P.G.Pigulevskiy, "Dniprogeofizika"), to the north-east from pegmatite field, at the depth 1 km, high-ohm body is encountered apparently composed of granites which could be the source with regard to the rare-earth pegmatites. To the depth the body is traced over 7-8 km.

The rare-metal pegmatites of Shevchenkivske and Fedorivske pegmatite fields are confined to the even-named structures. Various paragenetic pegmatite types are encountered in the fields: microcline, oligoclase-microcline, oligoclase, albite, albite-spodumene and albite-petalite [74]. The first two ones are ascribed to ceramic while remaining ones are essentially rare-metal. Zonation is established in the field expressed in the regular change of pegmatite types from microcline to albite-petalite-spodumene in the direction from the western margin of Shevchenkivska structure toward the same-named deposit. Morphology of the bodies gets more complex and the body size increases in the same direction. And in the reverse one amount and crystal size of tourmaline increases; in the west it becomes the rock-forming mineral. The most complex structure is characteristic for the bodies of albite-spodumene and albite-petalite types.

In the structure of ore pegmatites in *Shevchenkivske field* two types of zonation are encountered [74]: the simple – in albite-spodumene and the complex – in microcline-albite-spodumene and albite-spodumene-petalite pegmatites. In the first case just the quartz-albite zone 0.5-2.0 m thick is known, at the margins, and thicker, albite-spodumene zone in the centre. In the second-type bodies the following zones are distinguished from the centre to periphery: quartz-albite grahic, quartz-albite or quartz-microcline, muscovite-quartz-albite, lepidolite(zinnwaldite)-quartz-albite, quartz-albite-spodumene, quartz-albite-petalite, block microcline and block quartz. There is no strong regularity in the order of zone changing. The vertical zonation is expressed in the changing with depth the intricate bodies to the simple ones. In geochemical respect pegmatites exhibit strong positive specialization for bismuth, zirconium, chromium, and positive – for lithium.

According to P.G.Pigulevskiy ("Dniprogeofizika"), at the depth about 5 km, to the south-west from Shevchenkivske field, roughly in the middle between it and Kuybyshevske rare-earth pegmatite field, by

[1] Note of K.Yu.Esypchuk, Editor-in-Chief of the Derzhgeolkarta-200 Central-Ukrainian Series: "Ascription of the rare-metal pegmatites of Shevchenkivske and Fedorivske fields to the Late-Archean association of Yanvarski granites is not argued properly. Archean rare-metal pegmatites are quite rarely observed. Most likely, they belong to Paleo-Proterozoic Saltychanskiy, at the least rate to Anadolskiy complexes.

geophysical methods the high-ohm body is encountered which is thought to be granite intrusion. On this ground it is assumed the single source intrusion for both fields. Thus, it can be assumed that mentioned fields do form the zoned pegmatite belt where the southern (Kuybyshevske) field underwent essential uplift and deep erosion.

The age of rare-metal and rare-earth pegmatites is not defined unequivocally. To date some isotopic determinations available for rare-metal pegmatites of Shevchenkivske field (2200-2220 Ma, N.V.Sumin, VIMS [74]) and the only dating for ceramic pegmatites of Kuybyshevske rare-earth pegmatite field – 2100 Ma.

Association of Yanvarski granites completes Archean development stage in Pyazovya and is correlated with the similar complexes in the Middle-Dniprean area – Mokromoskovskiy and Tokivskiy by age. By composition and tectonic setting they are closer to Mokromoskovskiy granites.

Devladivskiy Complex (AR_3dv^*). The dyke bodies of ultramafites and gabbroids that intrude sedimentary-volcanogenic rocks of greenstone structures and granitoids of all age groups in the Middle-Dniprean area are ascribed to this Complex. They seal the faults of various scale and directions and are observed in the linear lenses 3-9 km long and up to 100-450 m thick. Somewhere they constitute stocks confined to the fault intersections. Such ultramafic body about 0.2×0.4 km in size is observed within migmatites in the north-western envelope of Konkska greenstone structure.

In the granitoid fields the dykes of Devladivskiy Complex are mapped in the western and northern parts of map sheet L-36-VI where they are confined to the zone of Devladivskiy Fault. They are also typical for the eastern limb of Bilozerska greenstone structure where they constitute three sub-longitudinal en-echelon bodies from 5 to 17 km long. In the studied area the north-western body of talc-carbonate rocks 4.5-5.0 km long and 200-450 m wide is located.

Ultramafic dykes are mainly composed of actinolitites, rarely serpentinites; in the western part of the area peridotites are intersected by some drill-holes.

The dyke of complex mineral composition which seals the flat fault (thrust?) in the north-western part of Konkska greenstone structure is also ascribed to Devladivskiy Complex. Its eastern part is composed of actinolitites which in the western direction are substituted by gabbro.

The Complex rocks are high-density (up to 3.0-3.1 g/cm^3 in actinolitites) and contain up to 10% of magnetite. In magnetic field the bodies are expressed by the anomalies 50-600 nTl.

Proterozoic (PR)

Proterozoic tectono-magmatic cycle of crystalline basement evolution in the studied map sheets occurred mainly in the Pryazovian Mega-Block. Here non-stratified complexes were forming in two stages: Paleo- and Meso-Proterozoic. In the Middle-Dniprean Mega-Block only Meso-Proterozoic stage is known.

Paleo-Proterozoic (Kryvorizhiy) (PR_1)

Kolarivskiy and Anadolskiy complexes are resulted from the Paleo-Proterozoic tectono-magmatic activization of the Archean folded complex in Pryazovskiy area.

Kolarivskiy Complex (PR_1kl^*). The Complex is established after recommendation of V.F.Rozdorozhniy, responsible executive of EGSF-200 in the map sheet L-37-VII (Berdyansk), which adjoins the map sheet L-37-I from the south. According to this author, Kolarivskiy Complex includes stock- and dyke-like bodies of ultramafic composition with increased alkalinity. In the south of map sheet L-37-I, in between Konka and Sukha Konka rivers, the single stock-like 440×560 m in size isometric body is encountered. In magnetic field the stock is expressed by the ring magnetic anomaly up to 300 nTl. The stock is zoned and is treated to be the "pipe". The margins up to 50 m thick are composed of sub-alkaline peridotites of olivine-pyroxene-actinolite-tremolite composition and the core – of phlogopite-actinolite-tremolite ultramafic rocks. Visually the rocks are greenish-grey, massive.

According to A.V.Dyukov [60], the Complex rocks contain 42.1-47.1% of silica, 17.4-29.4% of magnesium and up to 3% of alkali (Na_2O+K_2O). V.F.Rozdorozhniy considers them as cortlandite-lamproites and supposes the rocks are perspective for diamond prospecting.

Paleo-Proterozoic age of ultramafites is defined on the ground of their injection by the dykes of aplites, plagioclasites and oligoclasites of Anadolskiy Complex providing the upper time boundary for the Complex about 2100 Ma.

Anadolskiy Complex (PR_1an). The Complex in the map sheets includes majority, except Yanvarski associations, of two-feldspar granites, aplite-pegmatoid granites and pegmatites of ultra-metamorphic origin formed in Pryazovya in the time span 2600-2000 Ma. This long period of the Complex development allows

assumption that either it includes some complexes or their subdivision is impossible without detailed isotopic works.

By geological setting and relationships with the host rocks all the Complex granites are conventionally divided in two groups: granites observed in the individual massifs or fields and the vein granites (pegmatites, aplites and aplite-pegmatoid granites). The first group includes numerous massifs (Biloglynskiy, Lugivskiy, Pologivskiy, Zolopotopyanskiy, Novodachynskiy, Gusarskiy, Novomlynkivskiy) and bodies of various shape (often amoeboid) and size in the south-western and southern parts of map sheet L-37-I. In the northern part the only large amoeboid body of this Complex to the south from Fedorivska brachy-syncline is distinguished.

In tectonic respect, the tight link of granite development sites with fault zones and their junctions is established. In gravity field granites are expressed mainly by negative values and in some cases they are not expressed at all due to the low thickness. In magnetic field granites are expressed by demagnetized sites, often discontinuous in relation to the general field patterns. Amphibole varieties of granites in places exhibit increased values of magnetic field (Biloglynskiy and Novomlynkivskiy massifs).

Relationships of granites with the rocks of Zakhidnopryazovska Series, Vovchanska and Dragunska sequences suggest for their dual nature. The gradual contacts of many bodies – gneissose and unclear-banded structure, enrichment of endo-contact zones with opaque minerals and xenoliths, extensive microclinization of host rocks – support the ultra-metamorphic autochthonous genesis of granites. Part of granites exhibits clear evidences for intrusive genesis: sharp unconformable contacts, massive structure, porphyry-like textures. Similar mineralogical and chemical composition of granites, geochemical specialization, joint occurrence allow assumption for their common palingenic-anatectic origin with subsequent partial melt separation, moving and emplacement in intrusions.

By mineral, quite variable composition melanocratic (granodiorites), mesocratic and leucocratic (alaskites) granites of Anadolskiy petrotype are subdivided into biotite and amphibole-biotite, rarely pyroxene-bearing; by structure-texture patterns – into massive medium- and coarse-grained, often porphyry-like, fine-grained (aplitoid), gneissose. Their colour is mainly pink with various shades.

Vein aplite-like, aplite-pegmatoid granites and ceramic pegmatites are widely developed. In places they are observed in accumulations and pegmatite fields. Their mineral composition and internal structure are fairly simple. Thickness of the veins attains 25-30 m. By strike the veins are discontinuous. Their length may exceed over the thickness in 3-17 times varying from 1-5 to 350-500 m (Solodov, 1971). The dipping is mainly conformable to the host rocks, rarely not. Most of the veins are non-zoned and in some places only up to five zones are distinguished (DH 746 [73]). By mineral composition the microcline, microcline-oligoclase and rarely albite-oligoclase-microcline varieties are distinguished. Opaque minerals include biotite, muscovite, tourmaline and garnet. Macroscopically, these are pink-greyish, pink (almost red), rarely grey, light-grey and greenish-grey (oligoclase-albite), diverse-grained (from fine- to giant-grained) and pegmatoid-textured massive rocks. Granite emplacement accompanied by extensive host rock microclinization up to formation of two-feldspar migmatites. This process is especially prominent in Orikhovo-Pavlogradska LTZ and in Remivskiy Block.

In view of insufficient size of aplite-pegmatoid granite and ceramic pegmatite bodies in the geological map they are indicated with the out-of-scale red symbol.

Isotopic age of ceramic pegmatites (DH 178 [114]) is 2100 Ma.

Meso-Proterozoic (Klesoviy) (PR_2)

In the studied are Meso-Proterozoic stage actually completes development of crystalline basement and is characterized by the faint and sporadic igneous activity. The rocks are weakly studied and are united in the single dyke complex.

Dyke Complex (PR_2(?)*). The Complex conventionally includes all the diabase and gabbro-diabase dykes which are in the cutting relations to the host rocks highlighting their younger age, and the numerous lamprophyre dykes in the upper course of Konka River. The known bodies are irregularly distributed over the territory. Most of them are encountered in the Pryazovskiy area where the bodies form the dyke belts, in the broad sense: the north-eastern confined to the south-western boundary of Dniprovsko-Donetska Depression, the central or Gaychursko-Gulyajpisliy, and the southern observed to the south from Konkskiy Fault. In the Middle-Dniprean area two diabase dykes only are encountered. The first dyke of north-western strike is mapped in the area of Pivnichnotersyanske iron-ore deposit in the north-western extension of Gaychursko-Gulyajpisliy belt. The second one is traced by strike over the distance of 16 km in the north-western part of map sheet L-36-VI, to the north from Bilozerska greenstone structure; it is stretched in the west-north-western direction and in tectonic respect, alike the southern dyke belt of Pryazovya, apparently is related to the tectonic activity of Konkskiy Fault.

The north-eastern dyke belt of Pryazovya extended outside the studied are is most studied. The dykes composed of diabases fill up sub-parallel fractures in Samarska fault zone related to the initial movements in Dniprovsko-Donetskiy Aulacogen. The dyke strike is north-west 300-310^{o}, their length attains 38-40 km, thickness – mainly first tens of meters, in places up to 200 m [45]. In magnetic field diabases are expressed by the series of anomalies 150-200 nTl, and in the gravity field the anomalies are almost invisible due to the low dyke thickness.

In the thickest dykes zonation is observed – the contact diabase criptic-crystalline, aphanitic zone toward the centre is gradually changed by the medium-grained gabbro zone.

The central or Gaychursko-Gulyajpilskiy belt is developed in the map sheets L-37-I-C,D (squares II-1, II-2) and is divided in two sites.

The first site includes en-echelon northwest-trending diabase dykes similar to those above and most likely related to the initial movements in Dniprovsko-Donetskiy Aulacogen. The belt is traced over the distance of 56 km (including Pivnichnotersyanska dyke). Single body length does not exceed 5 km. Their thickness (by geophysical data) is lower than in the north-eastern belt.

The second site is encountered in the area of north-western closure of Gulyajpilska brachy-syncline and includes a series of sub-parallel dykes one of which cut the meta-sediments of Gulyajpilska Suite. The latter suggests for the post-Paleo-Proterozoic age of the dykes. By geochronological data outside the studied area (K-Ar method) the age of diabases varies from 2400 Ma (Middle-Dniprean area) to 1100 Ma (Pryazovya).

The southern belt is mapped in the upper course of Konka River. In comparison to the previous ones it exhibits different strike, scale and composition of the dyke bodies. The dykes are confined to the sub-latitudinal Prakonkska fault zone. Extension of the dykes is mainly north-eastern and north-western. Thickness normally varies from parts of meter to 2 m, rarely 4-5 m, in single cases up to 50 m [93]. Their length does not exceed first hundreds of meters. Rock dipping is steep – 80-90^{o}. Normally the dykes are composed of diabases and sub-alkaline lamprophyres are much rarely observed. The latter comprise the brown, melanocratic, quartzless, full-crystalline rock of amphibole-biotite-feldspar composition.

4. WEATHERING CRUST

The rocks of weathering crust are widespread in the studied area and are mainly developed after the rocks of crystalline basement. The age of weathering crust is treated to be Paleozoic – pre-Carboniferous (the area is covered by Carboniferous rocks in the area of Dniprovsko-Donetska Depression), Mesozoic (pre-Cretaceous – buried beneath Cretaceous sediments in Prychornomorska and Konksko-Yalynska depressions) and Cenozoic (Paleogene-Neogene and Neogene). The Mesozoic (pre-Cretaceous) weathering crust after Carboniferous rocks is locally developed.

The weathering crust after the crystalline basement rocks provides most interest as the potential container of mineral deposits, the source of ore minerals for the placer objects, and the source for other minerals and materials. The main regularities in distribution of weathering crust are given in the "Sketch map of weathering crust" in the scale 1:500 000 (Fig. 4.1).

By morphological features the planar and linear weathering crusts are distinguished. The planar crust is spread almost throughout except the sites where it is completely eroded; the linear weathering crust is developed along the fault zones and the contacts between steeply-dipping rocks of different composition. The linear crusts are being merged with the planar ones and are thicker.

Depending on the substratum there are distinguished weathering crust developed after the rocks of felsic and intermediate (most widespread), mafic with minor ferruginous quartzites and ultramafic composition and after ferruginous quartzites. In addition, in the north-east of map sheet L-37-I are known weathering crusts developed after Carboniferous carbonate and terrigenous rocks.

The section of weathering crust exhibits zoned patterns. In the complete column four zones are distinguished (upward): disintegration, transitional, persistent and final weathering products. The zone of disintegration and incipient leaching is developed throughout (~80% of territory). Here physical weathering processes predominate resulted in the extensive rock fracturing and formation of gruss. Mafic rocks are lightened. Ferruginous quartzites get brown colour and nodose structure (essential leaching). Chemical processes are expressed in the slight sericitization and pelitization of feldspars, slight hydration of micas and mafic minerals (development of hydromicas and iron hydroxides). Texture and structure patterns of the primary rocks are preserved. The newly-formed minerals (kaolinite, montmorillonite, beidellite – after felsic rocks; hydromicas, hydrochlorite, montmorillonite, goethite-hydrogoethite, carbonate, kaolinite – after mafic and ultramafic rocks; martite, hydrohematite, chlorite, calcite – after ferruginous quartzites) constitute up to 25%.

The ratio of silica to alumina remains very close to that of primary rocks although their relative content in the rock somewhat increases due to migration of alkaline and alkali-earth elements.

Thickness of the zone is 0.5-20 m, in places up to 40 m [60-65, 79, 104, 106, 107].

The zone of transitional weathering products (leaching) differs in predominate chemical weathering processes resulted in alkaline and alkali-earth elements and silica removal; mica hydration, dissolution of mafic minerals and feldspars. The zone includes clayey, light-grey rocks of kaolinite-quartz-hydromica (after felsic rocks) composition, brown-green – beidellite-montmorillonite-kaolinite-hydromica composition, in places with minor talc and chlorite (after mafic rocks). In the upper part of the zone hydromicas are replaced by montmorillonite and kaolinite.

Transitional horizons after felsic rocks contain abundant kaolinite (25-40%), goethite-hydrogoethite (10-20%), montmorillonite and hydromicas; after mafic rocks – montmorillonite (30-50%), hydromica (20-40%). In the upper part hydromicas are replaced by montmorilonite and kaolinite. After amphibolites kaolinite is developed in considerable amounts, often epigenetic pyrite and siderite are observed. In the horizon transitional to the zone of persistent weathering products essentially rises amount of kaolinite (25-40%), goethite-hydrogoethite (10-20%), relicts of biotite and amphibole are preserved. On the hollow walls and between kaolinite flakes and goethite-hydrogoethite colloform aggregates rarely the fine (<0.01 mm) gibbsite and boehmite (tenth percent) crystals are observed [47].

Weathering crust after ultramafic rocks gets colourful (ochreous-green, bluish-brownish colours). Primary minerals are replaced by montmorillonite, nontronite, chlorite, hydrochlorite, hydromicas, kaolonite, goethite-hydrogoethite. Relic structure of minerals is highlighted by iron and titanium hydroxides. In the lower and middle column parts hypergenic quartz and calcite are developed, in the upper – calcite, siderite as well as gibbsite.

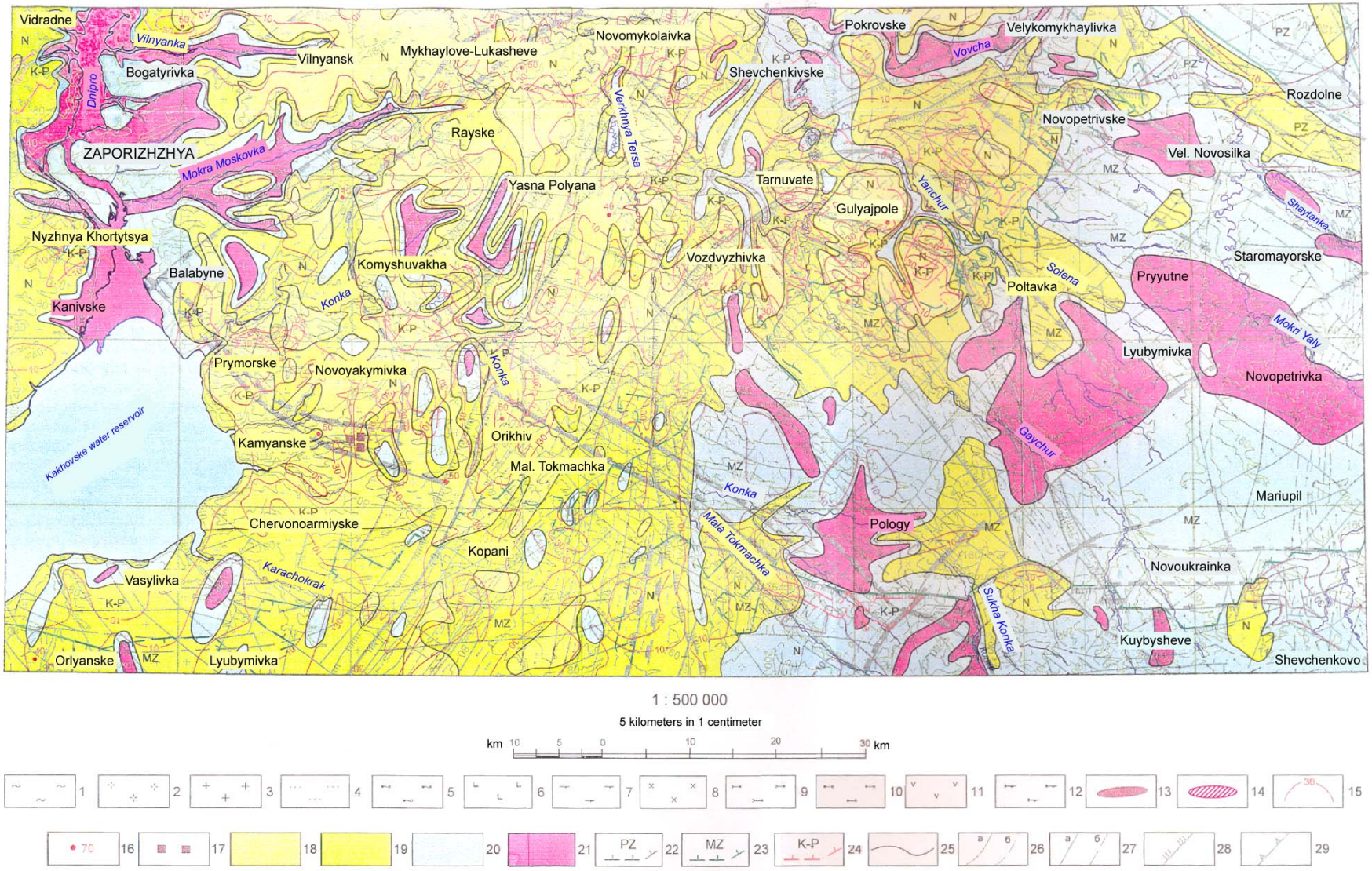

Fig. 4.1. Sketch map of weathering crust. See next page for the legend.

Fig. 4.1. Continued. Legend.

1 – metamorphosed sandy-clayey and ferruginous rocks of Mykhaylivska and Zaporizka Suites of Bilozerska Series; 2 – granites of Shevchenkivskiy and Anadolskiy complexes and plagiomigmatites of Remivskiy Complex with remnants of Kainkulatska Sequence gneisses; 3 – granitoids of Dnipropetrovskiy, Surskiy and Tokivskiy complexes and Khortytska association with remnants of Aulska Series and Bazavlutska Sequence gneisses; 4 – meta-sediments: meta-sandstones, meta-aleurolites and meta-argillites of Gulyajpilska Suite with thick ferruginous quartzite beds; 5 – two-mica, sillimanite-garnet-biotite high-alumina gneisses and schists; marbles, calciphyres and amphibolites with interbeds of ferruginous and mono-mineral quartzites of Ternuvatska Sequence; 6 – meta-basalts, meta-spilites and meta-komatiites with interbeds of ferruginous quartzites of Surska Suite (Konkska Series), Kosivtsivska and Novogorivska sequences; 7 – amphibolites and biotite-amphibole gneisses of Bazavlutska Sequence; 8 – diorites, diorite-like migmatites, tonalites and enderbites of Novopavlivskiy and Dobropilskiy complexes; 9 – high-alumina pyroxene-amphibole and biotite gneisses and mafic gneisses of Dragunska Sequence and granitoids of Remivskiy and Anadolskiy complexes of Yanvarska association; 10 – mono-mineral quartzites, alumina quartzite-schists, garnet-, sillimanite- and graphite-biotite, biotite gneisses; amphibolites with ferruginous quartzite interbeds and "skarnoids" lenses of Vovchanska Sequence and granitoids of Remivskiy and Anadolskiy complexes of Yanvarska association; 11 – amphibolites, actinolitites, tremolitites and melanocratic gneisses with Verkhnyotokmatska Sequence ferruginous quartzite interbeds and plagiomigmatites of Remivskiy Complex; 12 – amphibolites and pyroxene mafic gneisses, pyroxene-, amphibole- and garnet-biotite gneisses with interbeds of Novopavlivska Sequence ferruginous rocks and thin bodies of gabbroids and ultramafites of Novopavlivskiy mafic-ultramafic Complex; 13 – linear weathering crust after ferruginous rocks: magnetite quartzites, schists and skarnoids; 14 – local site of weathering crust after mafic rocks (gabbroids and ultramafites of Novopavlivskiy, Gaychurskiy, Verkhivtsivskiy, Varvarivskiy and Devladivskiy complexes; 15 – weathering crust isopachs; 16 – maximum thickness of weathering crust; 17 – zone of final products of weathering crust - sialites; 18 – zone of consistent weathering products; 19 – zone of transitional weathering products; 20 – disintegration zone; 21 – sites of lacking weathering crust; 22 – zone boundaries of Paleozoic (pre-Carboniferous) weathering crust; 23 – zone boundaries of Mesozoic (pre-Cretaceous) weathering crust; 24 – zone boundaries of Cretaceous-Paleogene Mesozoic weathering crust (Neogene weathering crust is developed over remaining territory); 25 – boundaries of weathering crust zones; 26 – unit boundaries of various age (a – defined, b – probable); 27 – tectonic breaks (a – major, b – minor); 28 – thrusts; 29 – reverse faults.

Higher in the column more extensive removal of alkaline and alkaline-earth elements occurs; alumina (in gibbsite and boehmite) and iron hydroxide accumulation is observed suggesting for the laterite trend in weathering processes [47].

Ferruginous quartzites include red-brown, ochreous-yellow, greyish-green rocks composed of hydrogoethite, martite, hydrohematite, quartz, calcite, hydrochlorite, and montmorillonite.

Thickness of the zone is from 2 to 38 m [60-65, 104, 106, 107].

The zone of persistent weathering products is mainly developed in the map sheet L-36-VI (Zaporizhzhya) and in the lesser extent in the map sheet L-37-I (Pology). Total space of its development comprises almost 25% of the territory. It is characterized by more active chemical weathering processes resulted in accumulation of persistent minerals (kaolinite, hydrogoethite, halloysite, montmorillonite, nontronite). Partial quartz dissolution is observed and iron removal or accumulation in the upper column part in brown, red-brown stains composed of hydrohematite and hydrogoethite. The relic structures and textures of primary rocks are absent at all.

The zone includes clayey rocks of quartz-kaolinite composition, white, yellowish- and brownish-white coloured (after felsic rocks); light-greenish-grey, dark-green, brownish-grey with red, ochreous-yellow, raspberry stains, hydrogoethite (up to 25%) and halloysite-kaolinite (up to 70-80%) composition with minor talc, hydrochlorite, baidellite (after mafic rocks); ochreous goethite-hydrogoethite-kaolinite composition with minor nontronite, brown with greenish-yellow shade, porous structure, in places with hydromica flakes and cherry-red iron hydroxide veinlets (after ultramafic rocks).

By chemical analysis in the latter the iron content is 13.3-40.3%, nickel – 0.16-.40%, cobalt – 0.01-0.04%.

Ferruginous quartzites in this zone comprise quartz-hydrohematite-hydrogoethite, slightly-banded stain-brown nodose rock where hydromica, hydrochlorite, montmorillonite and kaolinite bunches are observed. In the upper column part siderite is found.

Thickness of the zone is 10-18 m, in places (in felsic rocks) it attains 70 m.

The zone of final weathering products is actually not preserved. It is developed after mafic and ultramafic rocks and is intersected by drill-holes in the map sheet L-36-VI [54, 65]. The zone includes ochreous-brown and red-brown sialites with bean structure. Sialites are composed of kaolinite (25-30%), goethite-hydrogoethite (35-40%), gibbsite and boehmite are found. In the upper portion siderite appears (25-30%). A.A.Goyzhevskiy [47] had found free alumina for the first time. In the weathering crust after amphibolized pyroxenite with signs of banding he had described the red rock containing silica – 20-31%, alumina – 18.0-21.6%, iron oxide – 35.4-51.6%, and free alumina (gibbsite, boehmite) – almost 10% [47].

Content of nickel, cobalt and Fe_2O_3 in the zone rocks attains 2.6, 0.15 and 58.7% respectively.

Thickness of the zone varies from 3.8 to 9 m.

It should be noted that most complete weathering crust profile after crystalline basement rocks is preserved beneath Paleogene sediments while beneath Cretaceous rocks it is almost completely eroded especially in the map sheet L-37-I.

Upper age boundary of weathering crust is defined by the age of overlaying sediments: Carboniferous – Paleozoic crust, Cretaceous – Paleozoic-Mesozoic crust, and Paleogene-Quaternary – Paleozoic-Cenozoic.

Infiltration of underground and ground waters facilitates the weathering processes continuation in the buried crystalline basement nowadays.

Weathering crust after the crystalline basement rocks contains Bilyaivske kaoline deposit (I-2-56) and Mykhaylivsko-Lukashivskiy and Spasivskiy kaoline occurrences, as well as numerous occurrences of nickel, cobalt, zirconium, and rare-earth elements.

5. TECTONICS

The map sheet territory is situated in the southern part of Eastern-European Platform (EEP). Its major tectonic elements include Ukrainian Shield surrounded from the north-east and south-west by Dniprovsko-Donetska and Prychornomorska depressions respectively; both latter elements consist of two tectonic levels. The lower level comprises highly-dislocated crystalline basement; the upper level comprises up to 550 m thick platform sedimentary cover which unconformably lies over the lower level or covers it with blanket. Considerable differences in strike and size of tectonic elements in these levels preclude single tectonic zonation and below it is described separately.

Lower tectonic floor

Crystalline basement comprises first-order tectonic structure of Ukrainian Shield which includes the Shield itself and its north-eastern and southern slopes representing in two latter cases the basement of Dniprovsko-Donetska and Prychornomorska depressions. According to the scheme of Ukrainian Shield tectonic zonation [14], the map sheet territory is situated in the junction zone of Middle-Dniprean and Pryazovian Mega-Blocks (I order) or lithospheric micro-plates. The junction is observed along the I-order Orikhovo-Pavlogradskiy deep-seated fault. The Mega-Blocks considerable enough differ one another in completeness of geological column, magmatism, folding mode, internal structure and history of geological development. The Middle-Dniprean Mega-Block is classified as the classic granite-greenstone terrains while the Pryazovian Mega-Block – as granulite-greenstone terrain. In the frame of EEP the former is the fragment of Sumsko-Prydniprovska and the latter – of Kursko-Pryazovska terrains (E.B.Glevaskiy, K.Yu.Esypchuk, G.I.Kalyaev, M.P.Shcherbak) which, in turn, comprise the Kursko-Prydniprovska granite-greenstone terrain (K.I.Sveshnikov, V.A.Kolosovska). Pryazovska granulite-greenstone terrain exhibits fairly inhomogeneous and complex structure. On the gneiss-granulite background the blocks with typical granite-greenstone patters are distinguished (Gulyajpilsko-Saltychanskiy or Zakhidnopryazovskiy). This actually suggest for the contemporaneous and joint development of the mega-blocks over the early (Paleo-Meso-Archean) stages up to formation of the general paleo-geodynamic structure in EEP. And since Neo-Archean only the mega-blocks was developing separately in some extent. While Middle-Dniprean Mega-Block had actually completed its active evolution, the Pryazovian Mega-Block was undergoing multi-phase tectono-magmatic activization up to Paleozoic inclusively resulted in relative mega-block displacement, different degree of igneous reworking, erosion and distinct mosaic tectonic fabric.

With the higher-order faults, partly deep-seated, the mega-blocks are split into the blocks and litho-tectonic zones of II and III orders. Middle-Dniprean Mega-Block in the studied map sheets is represented by the II-order Konksko-Bilozerskiy Block. Its internal structure is dominated by anticline and syncline structures. The biggest ones include Zaporizkiy Dome, Konksko-Bilozerskiy synclinorium belt and Kamyshuvakhska antiform.

Zonation of Pryazovskiy Mega-Block is more complex. In the western part Orikhovo-Pavlogradska LTZ (OP LTZ) is distinguished, and in the central part – Zakhidnopryazovskiy (Gulyajpilsko-Saltychanskiy) Block which corresponds to the same-named anticlinorium. In the east, along the L-37-I map sheet margin, Tsentralnopryazovska LTZ is distinguished also known as the same-named synclinorium. Zakhidnopryazovskiy Block is divided into Gaychurskiy and Obitochnenskiy (Saltychanskiy) II-order blocks [14], and the former one, in turn, is divided into Gulyajpilskiy and Remivskiy III-order blocks. The western part of OP LTZ does correspond to Orikhovo-Pavlogradskiy synclinorium which from the west is bounded by the same-named, and from the east – by Zakhidnopryazovskiy, Andriivskiy and Chaplynskiy faults (fragments of regional Azovo-Pavlogradskiy Fault). In the north-eastern and south-eastern parts of OP LTZ are distinguished respectively Vovchanskiy and Korsatskiy III-order blocks, and in the centre – Novopavlivskiy Block. Defined blocks and zones comprise the major thrusts (nappes) overprinted one onto another via the series of flat faults; the units differ in erosion degrees and the sets of rock associations.

Mentioned relations are supported by interpretation results of magneto-telluric sounding, seismic sounding and gravity field modelling shown in the deep geological-geophysical cross-section. Extensive development of the fault-block tectonics makes difficult definition of the II-order plicative structures. Moreover, outlines of the latter often follow the block boundaries: Remivska anticline – same-named block, Pologivska syncline – Gulyajpilskiy Block. Orikhovo-Pavlogradska syncline is divided into the northern – Tersyanska and southern – Korsatska II-order syncline structures.

The higher-order plicative structures and granitoid massifs which complicate tectonic fabric of the mega-blocks are shown in the "Tectonic scheme in the scale 1:500 000" for each of the studied map sheets.

In the structure of Precambrian crystalline basement three tectonic levels are distinguished composed of respective litho-tectonic complexes (LTC): lower Paleo-Archean (proto-metamorphic, pre-greenstone), middle Meso-Neo-Archean (proto-oceanic, greenstone), and upper Paleo-Meso-Proterozoic (continental, post-greenstone). The levels exhibit distinct tectonic regime, folding type, magmatism and metamorphism. The lower level is most dislocated. The folding degree in the second (middle) level is lower and its complexes constitute simpler structures on the consolidated base of the lower level. In the upper level mainly mould-like synclines are developed. The levels normally are divided into the sub-levels separated by tectonic discontinuities. The lower sub-levels are composed of sedimentary-volcanogenic LTCs, mainly of mafic composition, whereas upper sub-levels – volcanogenic-terrigenous LTCs of more felsic composition.

Pre-greenstone Paleo-Archean tectonic level includes Middle-Dniprean (Aulskiy) "grey-gneiss" and Pryazovian gneiss-granulite LTCs.

The lower sub-level in the Middle-Dniprean and Pryazovian Mega-Blocks is composed, respectively, of Slavgorodskiy (?) and Zakhidnopryazovskiy essentially volcanogenic granulite-basite LTCs. The first one corresponds to the same-named undivided gneiss-amphibolite LTC while the second sub-level includes (upward from below) the even-aged (?) Novopavlivskiy and Verkhnyotokmatskiy LTCs of two-pyroxene gneisses and mafic gneisses as well as Kainkulatskiy gneiss LTC. The upper volcanogenic-sedimentary sub-level, developed mainly in the Pryazovskiy Mega-Block, comprises Vovchanskiy quartzite-gneiss LTC including Vovchanskiy and Dragunskiy leuco-granulite LTCs. Corresponding Tomakivskiy LTC in the Middle-Dniprean Mega-Block is known sporadically in the area of Zaporizkiy Dome, to the west of the studied area [104]. The upper sub-level lies over the lower one with clear tectonic and stratigraphic discontinuity and is separated by the stage of extensive tectonic activity when the major system of the regional and deep-seated faults was established; this fault system provided random movements of the newly-formed blocks and plates including their thrusting one another ("hummocking" the lower sub-level).

The LTCs of lower and upper sub-levels, together with folded Dnipropetrovskiy and Remivskiy plagiogranitoid and Novopavlivskiy enderbite-tonalite complexes, developed after these LTCs and cut by minor intrusions of Novopavlivskiy mafic-ultramafic complex, comprise the folded basement of greenstone belts (structures). Its typical tectonic forms include granite-gneiss domes, ovals and arcs. This folding type is more characteristic for the Middle-Dniprean Mega-Block whereas in the Pryazovian Mega-Block both dome (Vovchanskiy, Korsatskiy, Gulyajpilskiy and Saltychanskiy blocks) and isocline (Orikhovo-Pavlogradska and Tsentralnopryazovska synclines) folding are developed. This is because the mentioned structures are confined to the mega-block junction zones. Thus, under the unilateral north-west compression from the Gaychurskiy Block the primary dome folding of Orikhovo-Pavlogradska syncline became isocline over there whereas in the south-eastern and north-eastern parts of this syncline (Korsatskiy and Vovchanskiy blocks) it is preserved in almost primary mode.

The middle greenstone proto-oceanic tectonic level is more locally developed especially in the Pryazovian Mega-Block. In the Middle-Dniprean Mega-Block it is known in the stretched greenstone belts. In the studied map sheets the fragment (central part) of Konksko-Bilozerskiy belt is mapped. In the Pryazovian Mega-Block it includes Gaychursko-Sorokynskiy greenstone belt which northern part (Kosivtsivska and Gaychurska or Rizdvyansko-Uspenivska or Ternovarska structures) is situated in the central part of L-37-I map sheet, as well as minor greenstone structures (Novogorivska, Chystopilska) and distinct Shevchenkivsko-Fedorivska structure.

In contrast to the pre-greenstone level, the "middle" one includes two LTCs which correspond to the sub-levels: Azovskiy – Meso-Archean early-greenstone sub-level composed of Bazavlutskiy and Gaychurskiy LTCs, and Dniprovskiy – Neo-Archean late-greenstone sub-level composed of Konksko-Bilozerskiy and Novogorivsko-Osipenkivskiy LTCs. Gaychurskiy and Konksko-Bilozerskiy sub-levels, in turn, exhibit two-fold structure. Their lower portions are composed of komatiite-tholeiite Kosivstsivskiy and Surskiy jaspilite-tholeiite LTCs; the upper ones – volcanogenic-sedimentary Ternovatskiy and ferruginous-siliceous-schist Bilozerskiy LTCs respectively. Novogorivsko-Osipenkivskiy and Bazavlutskiy LTCs include only lower sedimentary-volcanogenic sub-LTCs (Novogorivskiy dacite-andesite-tholeiite and Bazavlutskiy meta-tholeiite). The stratified LTCs of the upper and lower divisions are supplemented by respective non-stratified complexes.

Early-greenstone complexes in the Middle-Dniprean area are preserved in the separate various-size remnants within granites in around Konksko-Bilozerskiy greenstone belt and the late-greenstone rocks are observed in large enough syncline structures. In Pryazovya the Meso- and Neo-Archean greenstone structures comprise the narrow elongated troughs and monoclines or their systems (Kosivtsivsko-Gaychurska). Volcanogenic-sedimentary LTCs of the upper portions fill up the secondary trough-like structures which are superimposed with tectonic and partly spatial unconformity (more characteristic for Pryazovian Mega-Block)

over the LTCs of lower portions. Morphological features of the upper-portion structures are similar to those of the lower ones with exception of the Fedorivska brachy-syncline. The elongated volcano-plutonic greenstone syncline structures are complicated by the minor intrusions of mafic and ultramafic Gaychurskiy, Verkhivtsivskiy and Varvarivskiy complexes and the large massifs of diorite-tonalite-plagiogranite Dobropilskiy, Surskiy, Shevchenkivskiy complexes and Khortytska association. In the general approximation, the large, batholite-like two-feldspar granite massifs of Mokromoskovskiy, Tokivskiy complexes and Yanvarska association are also confined to the greenstone belts.

The upper post-greenstone proto-continental level is defined in Pryazovya, in the map sheet L-37-I (Pology). Gulyajpilskiy essentially sedimentary ferruginous-siliceous-schist LTC is locally developed and constitutes Gulyajpilska and Balochanska brachy-synclines. They are confined to the zone of Sorokynsko-Gaychurskiy Fault in direct proximity to Kosivtsivska greenstone structure. The principal non-stratified units of this level in the studied area include Anadolskiy Complex of two-feldspar granites and outside the given map sheets also Chernigivskiy, Khlibodarivskiy, Pivdennokalchytskiy and Oktyabrskiy alkaline massifs. Granitoids either constitute individual massifs (Stepnyanskiy, Bogatyrskiy, Biloglynskiy, Pologivskiy etc.) or in the amoeba-like bodies are developed along the fault zones and also extensively injecting the stratified and ultra-metamorphic complexes of the lower levels. From the geodynamic point of view, this type granitoids comprise collision granites resulted from tectonic activization of Pryazovian Mega-Block during subduction beneath it the Prydniprovska plate and melting of granitoid rocks in this subduction zone.

Middle-Dniprean and Pryazovian mega-blocks considerably differ one from another in term of their gravi-magnetic field. The fields of Middle-Dniprean Mega-Block include large anomalies displaying some general sub-longitudinal elongation. It is characteristic mainly negative field Za confined to the granitoid sites which also exhibit reduced gravity field. In the central and south-western parts of L-36-VI map sheet the positive gravity anomalies are known which correspond to the Konkska and Bilozerska greenstone structures.

In contrast to the Middle-Dniprean, Pryazovian Mega-Block displays linear-banded gravi-magnetic fields and their higher values coupled with the much lower values of the efficient resistance. The boundary between the mega-blocks is sharply expressed. Even brief analysis of gravi-magnetic fields suggests for the block structure of the mega-block. On the general increased background of magnetic field the sites with decreased Za values are distinguished which correspond to Tsentralnopryazovskiy synclinorium, Vovchanskiy and Korsatskiy III-order blocks. In addition, on the background of sub-longitudinal gravi-magnetic fields in Orikhovo-Pavlogradska and Tsentralnopryazovska LTZs, the Gaychurskiy Block with northwest-trending anomalies is distinguished in the central part of Pryazovian Mega-Block; it includes Gulyajpilskiy and Remivskiy III-order blocks. The superimposed structures are expressed by the local gravi-magnetic anomalies: Gulyajpilska, Kosivtsivska, Gaychurska, Fedorivska, Shevchenkivska, Chystopilska and Novogorivska.

Internal structure of the mega-blocks

Middle-Dniprean Mega-Block

Konksko-Bilozerskiy greenstone belt comprises the principal tectonic structure of the Mega-Block. Granitoid magmatism, fault tectonics and long-term erosion have split the belt into separate sections and fragments arranged in the chain of contiguous syncline and monocline structures composed of Neo-Archean sedimentary-volcanogenic rocks which unconformably lie over the older gneiss-migmatite basement. The major elements of the belt include Konkska and Bilozerska synclines with minor Novogorivska monocline (Pryazovian Block) and Pryshybske extension of Bilozerska syncline in between [87].

Konkska syncline is the folded unit of irregular shape located in centre of L-36-VI map sheet. Its major portion is extended in the north-north-eastern direction over the distance of 28 km being 3-7 km wide. In the south the rock strike is persistent sub-longitudinal, complicated by flexure bend, expressed by magnetic-active ferruginous quartzite and ultramafic horizons. The western limb is almost completely replaced by granitoids. At present structure is actually monocline which western hanging-wall is composed of Bilozerska Series meta-sedimentary rocks and the eastern limb – of Konkska Series meta-basites. The steep sub-vertical rock dipping to the west-north-west is characteristic. Syncline patterns are observed in the north-western flank only where in the iron-ore sections of Kyrpotynska site the gradual decreasing of the rock dipping angle is observed up to sub-horizontal and further change to the reverse flat (up to 30^{o}) south-eastward dipping at the margin.

North-western part of structure is complicated by very flat (up to $10\text{-}15^{o}$) anticline bend which core is composed of plagiogranites massif not exposed at the Precambrian surface. Thickness of the preserved cap above is 150-300 m (Kyrpotynska site). By results of the local gravity minimum interpretation another granitoid massif, also not exposed at the surface, is foreseen in the south-eastern part of structure. Its derivates include numerous trachyte, andesite and dacite veins which intrude greenstone complex. Granitoids essentially affected

the shape of Konkska structure in the plane. In the north-west flank the "wedge" of Mokromoskovski granites is emplaced providing separation of Pivnichnokyrpotynska site from the major syncline. In the south-east the tongue of Lukyanivskiy massif plagiogranites intrudes meta-basites. The massif's endo-contact over entire its length is accompanied by the zones of cataclasm and milonitization including the contact with meta-volcanics of Bazavlutska Sequence.

Anticipated depth of Konkska syncline closure is 4-5 km.

The third-order structures, in relation to the major Konkska syncline, includes its Myrolyubivska (western) and Dubovogayska (eastern) monocline extensions which continue the syncline to the north-east and are confidently traced by the complex of geophysical data.

Pivnichnotersyanska monocline, which is composed of the ferruginous-siliceous-meta-basite rock association and tectonically separated in the zone of Orikhovo-Pavlogradskiy Fault, apparently comprises extension of Dubovogayska monocline.

Bilozerska syncline is the folded structure studied by G.I.Kalyaev [14] and E.M.Lapitskiy [87]. In the map sheet L-36-VI its north-eastern flank is observed composed of Surska Suite meta-dolerites and injected by the inter-greenstone Pivnichnobilozerskiy two-phase rhyodacite-tonalite massif. From the north meta-dolerites are intruded by Skelkivskiy massif granites of Mokromoskovskiy Complex. Syncline is complicated by the northwest-trending fault as well as by sub-longitudinal dyke of talc-carbonate rocks (Devladivskiy Complex) and sub-latitudinal diabase dyke.

Zaporizka anticlinorium structure (dome) is located in the east of mega-block. It includes Lysogirskiy, Kupriyanivskiy, Kamenskiy and other minor plagiomigmatite fields with remnants of Paleo- and Meso-Archean gneisses and amphibolites, and the massifs of Neo-Archean two-feldspar (Mokromoskovskiy, Zaporizkiy, Skelkivskiy) and plagioclase (Khortytskiy) granites. With its south-eastern flank the dome separates Konkska and Bilozerska greenstone structures.

Kamyshuvakhska anticlinorium structure, which adjoins Konkska syncline from the east, in tectonic respect comprises the oval-shaped gneiss-migmatite dome, surrounded along periphery by Neo-Archean sedimentary-volcanogenic rocks. In the east it is bounded by Orikhovo-Pavlogradskiy Fault. In the south it is complicated by Shcherbakivskiy massif of two-feldspar, and in the north – Verkhnyotersyanskiy massif of plagioclase granites. Very flat, close to horizontal dipping of involved plagiomigmatites and gneisses is characteristic for the dome.

Pryazovian Mega-Block

Paleo-Archean pre-greenstone tectonic level

Orikhovo-Pavlogradska LTZ is located in the west of mega-block at its junction with Middle-Dniprean Mega-Block. It is composed of Pryazovskiy gneiss-granulite LTC rocks (Zakhidnopryazovska Series and Vovchanska Sequence together with the products of their ultra-metamorphism – plagiogranitoids of Novopavlivskiy Complex) extensively reworked by the younger granites. The rocks of Novopavlivskiy mafic-ultramafic complex are also developed in this LTZ. Orikhovo-Pavlogradskiy synclinorium, Vovchanskiy and Korsatskiy blocks are distinguished.

Orikhovo-Pavlogradskiy synclinorium (OPS) is traced in the east of map sheet L-36-VI and partly in the north-western corner of L-37-I map sheet in the strip gradually expanding to the south (from 7 to 30 km). The physical fields exhibit prominent linear-banded patterns with prevailing sub-longitudinal extension. Positive and negative magnetic anomalies from 1000 to 10000 and more nTl clearly reflect the rock strike. Patterns of gravity anomalies from -1.0 to +1.0, rarely 1.5 mGal are similar. In the north of OPS the prominent flexure bend is observed caused by flexure displacement in the south-western direction along Gaychurskiy Fault. This flexure divides OPS in two syncline structures: the northern – Tersyanska, with north-north-west rock strike, and the southern – Korsatska.

Extensive diagonal and sub-latitudinal faults cause fold-block and nappe structure of OPS. Its western limb is cut by Orikhovo-Pavlogradskiy deep-seated fault and is buried beneath the nappe of younger rocks (captured by the micro-plate of Middle-Dniprean Mega-Block subducted beneath Pryazovian one). This also explains the overturned isocline folding in OPS which steeply dips to the west [14, 15]. In the cores of anticline folds the rocks of Novopavlivska Sequence of Zakhidnopryazovska Series are often exposed. The eastern edge of OPS is less expressed due to the sub-conformable orientation of physical fields in the contacting blocks and the bounding tectonic breaks (Zakhidnopryazovskiy and Chaplynskiy).

Definition of the higher-order structures in OPS is difficult due to the lack of relevant studies. Confidently the oldest Novopavlivskiy Block only is defined where extensive Paleo-Archean mafic-ultramafic magmatism occurred (Novopavlivskiy Complex). The Block is tectonically bounded and is segment-shaped in

the plane with the convex oriented to the east. The gravity field density modelling result clearly suggest for essentially granite-gneissic (low-density) composition of the Block. Thin gabbroid bodies of Novopavlivskiy Compex considerable affect the gravity field. Thickness of the upper folded Vovchanskiy LTC in the western fault-side part of OPS varies from 2-3 km in the south to 5-6 km in the north. Below the rocks of granitoid composition are developed.

Vovchanskiy Block adjoins from the north Gulyajpilsko-Saltychanskiy Block and connects the OPS with Tsentralnopryazovskiy synclinorium. From the west it is bounded by Chaplynskiy regional fault. The southern boundary comprises the system of separated breaks in the frame of Andriivskiy and Fedorivskiy faults. The Block junction with Tsentralnopryazovskiy synclinorium in the east is obscured by granite intrusions of Yanvarskiy complex and the younger fault system sealed with magnetic-active diabases. The Block is mainly composed of the Late Paleo-Archean Vovchanskiy LTC and only in its marginal southern part the Early Paleo-Archean Novopavlivskiy LTC is developed. Analysis of gravi-magnetic field patterns suggests for predominate brachial, dome-shaped anticline forms in combination with the isoclinal variously-oriented inter-dome synclines.

Korsatskiy Block is separated from OPS by Zakhidnopryazovskiy, and from Saltychanskiy Block – by Korsatskiy faults; in the plane the block shape is equilateral triangle with the northward-oriented top, it enters the map sheets from the south, just in the central part. Alike Vovchanskiy Block, the internal structure is two-fold.

Gaychurskiy Block, the northern counterpart of Zakhidnopryazovskiy Block, occupies the central part of L-37-I map sheet and comprises Early Paleo-Archean anticlinorium structure surrounded by the Late Paleo-Archean synclinorium zones (OPS and Tsentralnopryazovskiy synclinorium). In the south, along the southern map sheet margin, the Block is separated from Saltychanskiy Block [14] by thick zone of sub-latitudinal Prakonkskiy Fault. The Block is divided into Gulyajpilskiy and Remivskiy III-order blocks which considerably differ one from another in geology and history of development. The first one comprises the fragment of typical granite-greenstone proto-oceanic terrain whereas the second – granulite-gneiss proto-continental. The boundary between the two (the north-eastern extension of the thick Gaychursko-Sorokynska fault zone) is the northwest-trending Gaychurskiy Fault which controls Kosivtsivska greenstone structure.

Gulyajpilskiy Block includes the oval-shaped Pologivska syncline 45 km long and 35 km limb range wide [73]. This structure is composed of meta-volcanics of Verkhnyotokmatskiy LTC. The central, north-western and south-eastern syncline parts are almost completely replaced by granitoids of Novopavlivskiy, Shevchenkivskiy and Anadolskiy complexes. In the syncline fragments the rock dipping is steep, centriclinal (70-90^{o}). In the core of Pologivska syncline the Gulyajpilska IV-order brachy-syncline is distinguished.

In the observed field Δg the Block is expressed as the tectonically-bounded structure. From Vovchanskiy and Remivskiy blocks it is separated by the extensive gradient zones. Magnetic field is inhomogeneous over the Block. The granitoid sites are expressed in low-magnitude mosaic field (from -200 to +200 nTl); the diorite and tonalite sites with xenoliths of gabbroids and ultramafic rocks exhibit elevated field values up to 1000 nTl and more with clear enough orientation of the anomaly axes. In the residual gravity field the northern and north-eastern Block parts are expressed by positive anomalies up to 1 mGal, composed of meta-volcanics, as well as some diorite massifs.

The fault tectonics is extensively developed over the Block. It is located in the influence zone of Gaychurskiy and Pologivskiy northwest-trending regional faults and sub-latitudinal Prakonkskiy Fault. Almost entire north-eastern part of the Block actually comprises more or less tectonized rocks.

Remivskiy Block, comprising anticlinorium structure, is located in the eastern part of map sheet L-37-I. The Block shape resembles right-angled triangle which joins Gulyajpilskiy Block by its hypotenuse and the right angle is oriented to the north-east. The Block length (along “hypotenuse”) attains 65 km and its width is 45 km. The Block is composed of undivided rocks of Zakhidnopryazovskiy granulite-basite LTC. Tectonic fabric of the Block is mainly linear. To the west from sub-longitudinal Mokroyalynskiy Fault the rock strike is north-western, parallel to the south-western Block margin, and to the east the strike is sub-longitudinal, conformable to the eastern margin. In the central part the elements of brachy-form folding are also observed (Krutoyarivska syncline). The marginal Block parts correspond to Novovasylivska (in the west) and Mokroyalynska (in the east) anticlines.

Remivsky Block is mapped in gravi-magnetic fields confidently enough. In magnetic field the linear positive anomalies up to 600 nTl, in places up to 1000 nTl are observed on the background of 100-300 nTl. Residual gravity field of the Block is mosaic and weakly reflects the internal structure. The gravity values are lower in comparison to Gulyajpilskiy Block and Tsentralnopryazovskiy synclinorium. Mainly isometric positive anomalies up to +0.5 mGal are distinguished on the background of negative values -0.5 (up to -1.0) mGal.

Tsentralnopryazovskiy synclinorium is represented by its western limb only which is traced along the eastern margin of map sheet L-37-I, and the northern limb fragments of the II-order Bilotserkivska (Dragunska) syncline in the far south. The lower Late Paleo-Archean level is composed of the leuco-granulite associations of

Dragunska Sequence. In the gravity fields the western synclinorium limb is expressed in the positive linear anomalies.

Meso-Neo-Archean greenstone and Paleo-Proterozoic post-greenstone tectonic levels

These tectonic divisions of Pryazovian Mega-Block include superimposed IV and higher-order structures. Of these, both typical greenstone riftogenic structures (Novogorivska, Chystopilska, Kosivtsivska and Gaychurska) and the units of undefined origin (Shevchenkivska, Fedorivska, Gulyajpilska and Balochkivska) are distinguished.

Novogorivska greenstone structure is located in the southern part of L-36-VI map sheet, in the eastern side of Orikhovo-Pavlogradskiy deep-seated fault. Structure comprises northeast-trending (40-45^o), 15-16 km long and 1.0-1.6 km wide band of Neo-Archean Novogorivska Sequence meta-volcanics. In fact, this is typical monocline structure with consistent south-eastern rock dipping at the angle 45-60^o. The western and eastern contacts are mainly tectonic. Apparently, structure comprises tectonic detachment of Konksko-Bilozerskiy greenstone belt.

In the physical fields structure is expressed by positive gravity anomaly up to 2 mGal, and in the magnetic field it provides the negative background for the linear positive anomaly up to 4000 nTl caused by the ferruginous quartzite beds.

Chystopilska greenstone structure is located in the southern part of Orikhovo-Pavlogradska LTZ, in the south-eastern part of map sheet L-36-VI, and is confined to the north-northeast-trending Molochanskiy regional fault sub-conformable to the general strike of Paleo-Archean gneiss-granulite LTC in Pryazovian Mega-Block. It is fault-side monocline which footwall western limb is composed of Kosivtsivskiy LTC volcanics and the eastern hanging-wall limb – of Ternovatskiy LTC meta-sediments. Structure is traced along the fault over 40 km. The northern part about 8 km long is tectonically separated. Thickness of structure does not exceed 1000 m, normally 400-600 m. The rock dipping is steep, eastward, at the angle 70-80^o. Tectonic setting of Chystopilska structure allows assumption that it could be the detached fragment from the south-western flank of Gaychurska structure.

In the geophysical fields Chystopilska structure is expressed in the series of positive gravity anomalies up to 1 mGal, and by magnetic anomalies up to 5000 nTl.

Kosivtsivska greenstone structure is located in the north-western corner of L-37-I map sheet. It is confined to the junction zone of Gulyajpilskiy granite-greenstone and Remivskiy granulite-gneiss blocks – Gaychurskiy Fault. It is classified as the suture, fault-side riftogenic structure [73]. In the regional context this comprises the north-western fragment of Gaychursko-Sorokynskiy greenstone belt extended over more than 120 km from Azov Sea to Ternovate village where it is cut by Andriivskiy Fault. The strike of Kosivtsivska structure and the entire belt in general is north-western (300-330^o). Thus, it forms the right angle to the strike of Konksko-Bilozerskiy greenstone belt suggesting for apparent contemporaneous origination of these structures over the single orthogonal fault system.

Structure is composed of Kosivtsivskiy meta-komatiite-tholeiite LTC, occurring in the linear monocline with sub-vertical dipping, traced to the depth over 2.5 km [73]. In the junction zone with Gaychurska structure the monocline is complicated by Oleksandropilska syncline fold. In the residual gravity field this part of structure is expressed by positive anomaly up to 2.0 mGal. Magnetic field is oscillating: from 100 to 400 nTl. In the south-east the monocline is expressed by the chain of local gravity maximums (up to 0.4 mGal). The central part is intruded by Meso-Archean Dobropilski granites.

Gaychurska greenstone structure is extended over 72 km from the western (square II-1) to southern (square IV-3) margins of L-37-I map sheet in the arc-shaped band with northern convexity. It is confined to the triple junction (at the angle 120^o) of Andriivskiy, Ternovatskiy and Kuybyshevskiy faults and comprises two-level trough-like monocline, riftogenic in the south. The lower level is composed of Kosivtsivska Sequence (meta-komatiite-tholeiite LTC) and the upper one – of Ternovatska Sequence (ferruginous-siliceous-schist LTC). The monocline width is fairly variable – from 0.1 to 1.5 km, rock dipping – 65-85^o to the south-west; to the depth structure is traced over 2 km [73]. In the south-eastern part structure is split into three branches.

In the gravity field structure is expressed by linear positive contrasted anomalies $\Delta g_{tot.}$ up to 0.25-1.5 mGal, and in magnetic field – by elongated positive anomalies from 300-500 to 4000 nTl.

Tectonics of the jointed Kosivtsivska and Gaychurska greenstone structures is similar to that of Verkhivtsivskiy-type greenstone structures in the Middle-Dniprean Mega-Block (being recalculated to the greater heights in gravity field Verkhivtsivska structure at the depth comprises the "spreading rift", that is, junction of the variously-oriented rifting structures) but is much more eroded.

Shevchenkivska structure is located in the north-eastern corner of L-37-I map sheet; it comprises about 14 km long and 200-800 m wide narrow graben of sub-longitudinal (azimuth 340^o) strike. The southern flank represents the classic centriclinal syncline closure. In view of this structure is considered to be the relict of the

large fold which eastern part is destroyed by granites of Chervonokutskiy massif. The western limb is complicated by sub-latitudinal syncline fold. Structure is composed of Ternovatska Sequence rocks. In the gravi-magnetic fields structure is expressed by the elongated linear anomalies up to 1.5 mGal and 1000 nTl.

In the east structure orthogonally joins *Fedorivska brachy-syncline*. The junction zone is complicated by granite intrusion of Yanvarska association. The range of the limbs is 4.5 km. The northern limb is essentially destroyed by granites. Alike Shevchenkivska structure, it is composed of Ternovatska Sequence terrigenous-chemogenic rocks. In the gravi-magnetic fields structure is expressed by positive anomaly up to 1.5 mGal and by oscillating local anomalies from -200 to +600 nTl on the background of negative field. By geophysical data, the depth of Fedorivska brachy-syncline closure is about 2 km. It is assumed that structure is confined to the same-named sub-latitudinal regional fault which bound Remivskiy Block from the north.

Gulyajpilska barchy-syncline is located almost in the centre of the same-named block or Pologivska syncline structure (square III-1). It is oval-shaped in the plane, 9 km long and 3.5 km wide. The long axis is oriented by azimuth 310°. In the gravi-magnetic fields syncline is expressed by the linear positive anomalies up to 1.5 mGal and 10000 nTl arranged in the oval. The core is reflected in the negative field values. Structure is composed of Paleo-Proterozoic Gulyajpilskiy ferruginous-siliceous-schist LTC which lies over Archean units with the sharp tectonic discontinuity. Dipping of the limbs is centriclinal at the angle 50-70°. The fold depth, by geophysical data, is estimated to 2.1-2.3 km.

Fault structures

Disjunctive structures are widely developed over both studied map sheets. These are variable in the scale, rank, shape, amplitude and time, morphology and strike. G.I.Kalyaev [14] had distinguished the first-order deep-seated mantle-driven faults which define the Shield splitting into mega-blocks; the second-order deep-seated faults which divide the mega-blocks into the blocks or II-order LTZ; the third-order faults of various morphology and depth. Origination of the first- and second-order faults occurred in post-Early Paleo-Archean time, upon formation of granulite-basite LTC and development of primary proto-crust and prior to formation of Late Paleo-Archean Vovchanskiy quartzite-gneiss LTC. Some faults had originated at the boundary between Paleo-Archean and Meso-Archean stages of the Shield evolution (beginning of greenstone belt development). Another part of faults (in the north-east of the map sheets) formed late in Proterozoic, during initiation of Dniprovsko-Donetskiy Aulacogen, and in Paleozoic (over Donetska folded structure formation). Activization of the faults is noted over entire Phanerozoic period of the Shield development and some of them even in Holocene.

The major fault structure of the area is *Orikhovo-Pavlogradskiy Deep-Seated Fault* (OP DSF) which separates Middle-Dniprean and Pryazovian mega-blocks. G.I.Kalyaev considers this Fault, together with Kryvorizko-Kremenchutskiy Fault, the principal units in the tectonic-historical respect. The Fault intersects the eastern part of Ukrainian Shield in sub-longitudinal direction and is traced (A.V.Chekunov) over the distance up to 1200 km from Voronezkiy Shield through DDD, Ukrainian Shield and Black Sea to the folded structures in Turkey.

OP DSF is observed in the eastern part of L-36-VI map sheet; strike is north-eastern by azimuth 30-35°, and closer to the northern map sheet margin it smoothly turns to the sub-longitudinal direction. The Fault separates Middle-Dniprean granite-greenstone and Pryazovian granulite-greenstone terrains. From the geodynamic point of view OP DSF comprises suture zone by which the Middle-Dniprean Mega-Block under-thrusting beneath Pryazovian Mega-Block [14]. The Fault is quite clearly expressed in the gravi-magnetic and geoelectric fields. In the latter case the high-ohm field of Middle-Dniprean Mega-Block is sharply changed by the low-ohm field of Pryazovian Mega-Block. The dipping of the Fault major displacement plane is eastward at the angle 50-60°, stair-like. By means of modelling this plane can be traced below the Moho surface in the upper mantle. The Fault is expressed by the 2-3 km wide band of tectonites.

The second-order deep-seated faults include Devladivskiy, Zakhidnopryazovskiy and Chaplynskiy (Azovo-Pavlogranskiy), Andriivskiy and Fedorivskiy, Gaychurskiy, Kuybyshevskiy and Prakonkskiy.

Devladivskiy Fault crosses the Middle-Dniprean Mega-Block in sub-latitudinal direction and separates it into Slavgorodskiy and Konksko-Bilozerskiy II-order blocks. The zone width is 3-5 km and at the junction site with OP DSF it expands to 15-16 km. In the physical fields the clear fan-like junction mode is expressed. Throughout the breaking zones include the bands of cataclased and retrograded rocks and milonites. The thick latitudinal ultramafic dykes and isometric gabbroid massifs of Devladivskiy Complex and Sofiivska greenstone structure are confined to the Fault zone; in the east the zone is sealed by aplite-pegmatoid granites of Mokromoskovskiy Complex which actually did not undergo tectonic impact. In the map sheet L-36-VI only southern extension of the zone are noted.

Zakhidnopryazovskiy Fault comprises the southern segment of Azovo-Pavlogradskiy deep-seated fault. It is being mapped along the southern half of the eastern margin of L-36-VI map sheet. In the map sheet centre it

is “cut” by the northeast-trending Andriivskiy regional fault. In the south the Fault bifurcates into the western branch of north-north-eastern strike which extends it further, and the eastern branch – Korsatskiy Fault of the north-north-western strike. The northern part of the Fault by morpho- kinematic features is classified as the thrust steeply (75^o) dipping to the east whereas its southern part comprises the series of also steep but normal faults dipping to the west. The Fault essentially affects Precambrian and Phanerozoic tectonic development in the area: it separates OP LTZ from Gaychurskiy Block and in the south it divides OP LTZ into OPS and III-order Korsatskiy Block and separates Pryazovskiy Horst from Prychornomorska Depression. The Fault zone served the feeding channel to the mantle products (ultramafic and mafic rocks of Novopavlivskiy and Gaychurskiy complexes and Kosivtsivska Sequence).

The Fault is confidently expressed in the physical fields. It separates mainly linear-mosaic fields of Gulyajpilsko-Saltychanskiy Block from the contrasted sub-longitudinal oscillating linear field of OPS. In the magnetic field the zone is expressed by the negative broad band (-400 up to 0 nTl). To the south, in the map sheet L-36-XII (Melitopol), the Fault is expressed in the residual gravity field by the zone of high horizontal gradients Δg_a (1.5-2.0 km wide). This corresponds to the hypsometric stair of Pryazovskiy Horst which includes the system of contiguous reverse faults 30-60 m of magnitude each (total – 200-300 m) the latter Horst was uplifted by. The Horst is clearly defined by results of magnetic-telluric sounding. In material respect the Fault is comprised of the sub-parallel rock crushing and milonitization zones [88, 68].

Chaplynskiy Fault is being mapped in the north-eastern corner of map sheet L-37-I as the segment of Azovo-Pavlogradskiy deep-seated fault. It separates Orikhovo-Pavlogradskiy Synclinorium from Vovchanskiy Block and comprises the steeply-dipping normal fault by which the former is subsided relatively to the latter.

Korsatskiy Fault comprises the south-eastern branch of Azovo-Pavlogradskiy deep-seated fault. It is steeply-dipping thrust by which Gulyajpilsko-Saltychanskiy Block is napped over Orikhovo-Pavlogradska LTZ.

Gaychurskiy [73] *regional fault* is observed in the thick (up to 7 km) zone of northwest-trending faults in the north-western part of L-37-I map sheet. Its segments are also noted to the north-west from Andriivskiy Fault which bounds the zone. In the south-eastern direction the zone is faded by Prakonkskiy sub-latitudinal fault zone. From the north-east the Fault bounds Gaychursko-Sorokynska tectonic zone which includes the same-named Meso-Neo-Archean greenstone belt; it also separates the same-named II-order block into the Gulyajpilskiy granite-greenstone and Remivskiy granulite-basite III-order blocks.

The upper time boundary of the Fault activity is 3310 Ma and corresponds to the age of the first phase in Dobropilska intrusion which unconformably cut the zone. Activization stages are noted in Neo-Archean (formation of Konksko-Bilozerskiy greenstone belt, Shevchenkivskiy Complex) and in Paleo-Proterozoic (formation of Gulyajpilskiy ferruginous-siliceous-schist LTC).

In the morpho-kinematic respect the Fault zone comprises the system of thrusts steeply-dipping to the east by which Remivskiy Block is napped over Gulyajpilskiy Block.

Andriivskiy Fault comprises the series of northeast-trending arc-shaped faults with convexity oriented to the north. In the east it is joined with sub-latitudinal Fedorivskiy Fault and together the two bounds Zakhidnopryazovskiy Block from the north. Their junction zone controls the field of granites and rare-metal pegmatites of Neo-Archean Yanvarska association, and the intersection point of Shevchenkivskiy and Fedorivskiy faults – the lithium deposit. The same-named brachy-syncline adjoins Fedorivskiy Fault. The south-western flank of Andriivskiy Fault, which controls the western flank of Meso-Archean Gaychurska structure, comprises the zone of steeply-dipping thrusts whose displacement planes steeply dip to the south-east and by which Gaychurskiy Block is napped over Orikhovo-Pavlogradskiy synclinorium and Vovchanskiy Block.

Prakonkskiy deep-seated fault is observed in the thick zone along the southern margin of L-37-I map sheet up the Korsatskiy Fault. Some segments are also known to the west from Orikhovo-Pavlogradskiy deep-seated fault and in the map sheet L-36-VI (Lyubymivskiy Fault, southern branch of Vasylivsko-Kamyshuvakhskiy Fault). The zone is expressed in the abrupt rock strike changing, increasing the folding degree, appearance the series of sub-latitudinal faults and related crushing and milonitization zones, extensive magmatism (gabbroids, diorites, lamprophyres, granites etc.). Bilotserkivska (Dragunska) syncline which complicates Tsentralnopryazovskiy synclinorium is confined to the Fault. Prakonkskiy Fault separates Early Paleo-Archean Zakhidnopryazovskiy Block in Gaychurskiy and Saltychanskiy blocks.

By the scale and geodynamic impact Prakonkskiy Fault can be ascribed to the major deep-seated faults. The zone is set up parallel to Devladivskiy and Borodaivskiy faults while Prakonkskiy Fault is traced at the same distance away from the former as Devladivska one from Borodaivska suggesting for their even-aging and ranking.

Prakonkska zone is long-lived. Activity phases are noted over entire Precambrian stage of the Shield evolution as well as in Phanerozoic. At present the zone is prominently expressed by Konkskiy regional fault of Paleogene age which bounds Pryazovskiy Horst from the north and in the relief of Precambrian basement is reflected in the stair up to 540 m high. In view of morpho-kinamatic nomenclature the latter lineament of

Prakonkskiy Fault comprises the thrust whose displacement plane is inclined to the south and by which Pryazovskiy Horst is napped over Konksko-Yalynska Depression.

Ternovatsko-Kuybyshevskiy Fault is being mapped in the central part of L-37-I map sheet as the arc which connects the intersection points of Gaychurskiy Fault with Andriivskiy and Konkskiy faults. It comprises the junction (at the angle 120°) system of Ternovatskiy and Kuybyshevskiy faults which supplement Gaychurskiy Fault. Gaychurska trough-like greenstone structure is confined to the Fault zone.

By morphogenetic type the Fault comprises the deep-seated zone with signs of rifting. At present this is a zone of thrusts by which Gulyajpilskiy Block together with small segment of Remivskiy Block are thrusting in the north-western direction over Orikhovo-Pavlogradskiy synclinorium.

Among the III-order faults of regional inter-block and crossing kinds it should be noted Khortytskiy, Molochanskiy, Chernigivskiy, Mokromoskovskiy (Bekarivskiy), Vasylivsko-Kamyshuvakhskiy and others.

Khortytskiy Fault is the disjunctive structure diagonal to the Orikhovo-Pavlogradskiy and Devladivskiy faults extended over 90 km in the north-western direction. It is observed in the outcrops in the right bank of Dnipro River along Khortytsya Island. The Fault bounds Konkska greenstone structure and Shcherbakivskiy granite massif from the south-west. Just on its extension is the western lank of Konkskiy Fault which bounds Pryazovskiy Horst from the north. The Fault comprises the system of normal faults by which Konkska greenstone structure is subsided relatively to Kamenskiy Dome.

Mokromoskovskiy (Bekarivskiy) normal fault is transversal in relation to Khortytskiy Fault extending from their intersection point over 50 km in the north-east direction along Konkska greenstone structure. It is expressed in the 200-300 m wide zone of cataclasm. milonitization and alkaline metasomatism within Mokromoskovski granites. In the north-eastern part it is "sealed" by peridotite and actinolitite dyke of Devladivskiy Complex suggesting for the Late Neo-Archean time of its activization.

Molochanskiy regional fault is being mapped in the south-eastern part of L-36-VI map sheet as the zone of contiguous sub-parallel north-northeast-trending faults sub-conformable with the general strike of Orikhovo-Pavlogradskiy synclinorium. Chystopilska riftogenic greenstone structure is confined to this Fault. In the southern extension the zone controls Starobogdanivskiy syenite massif [87].

Chernigivskiy regional fault is observed in the northeast-trending broken line in the south-eastern part of L-37-I map sheet and is extended outside its margins where it controls Chernigivskiy carbonatite massif. Throughout along the zone the extensive development of Anadolskiy Complex two-feldspar granites and microclinization are observed. These records suggest for Paleo-Proterozoic time of the Fault origination within period of the continental activization in Pryazovya. Activity of the Fault is also noted in Phanerozoic. Along the Fault north-eastern flank tectonic ledge from 40 to 120 m high is mapped in the relief of crystalline basement surface.

The local faults cover entire territory and especially its Pryazovian part with the dense network and significantly complicated the general patterns. These faults are normally defined by the complex of geological-geophysical data and commonly are younger in relation to the major faults, often cut them with displacements. With regard to their low impact on the development history in the region their description is not given.

Deep geological-geophysical structure of the map sheets territory

On the ground of complex interpretation of seismic and electric data together with gravity field modelling it was established that Ukrainian Shield and Pryazovian Mega-Block in particular strongly differ from the surrounding structures of the Eastern-European Platform. Calculated field $\rho_{ef.}$ at the Moho surface in Ukrainian Shield varies from some tens to some hundred thousands Ohm×m. By resistance values the territory is divided into low-Ohm Zakhidnopryazovskiy and high-Ohm Skhidnopryazovskiy (to the east from L-37-I (Pology) map sheet) blocks. They are separated by Volodarsko-Pavlivskiy fault and differ in the earth crust composition. The prominent vertical zonation is observed in Skhidnopryazovskiy. In the west it is separated from the high-Ohm Middle-Dniprean Mega-Block by Orikhovo-Pavlogradskiy deep-seated fault.

In the deep geological-geophysical cross-section the obvious heterogeneous structure of Middle-Dniprean and Pryazovian mega-blocks both in lateral direction and by depth up to 50 km is observed. The latter unit exhibits greater crustal heterogeneity and upper mantle complexity. The anomalous upper mantle beneath Pryazovian Mega-Block defined by geophysical data [14] is also evidenced by increased thickness of the transitional zone crust-mantle (velocity – 7.0-7.1 km/s, calculated density – 3.1-3.25 g/cm^3). Transitional zone underneath Zakhidnopryazovskiy Block is extremely broken; in the seismic profiles it contains the series of en-echelon lengthy flats.

The blocks of various-type crust are identified in Orikhovo-Pavlogradska LTZ; apparently some of these blocks through the side branches of deep-seated faults are connected with the mantle. The Moho surface (crust-mantle boundary) in the studied area is buried to the depth about 45-50 km [9]. In the electric-seismic-

density cross-section Orikhovo-Pavlogradskiy fault is generally inclined to the east. The dipping angle, depending on the deep intersecting layers, varies from 85 to 65° (at depth). It exhibits complex bifurcating patterns (splitting in two parts). At the various deep levels the fault does not comprise the main displacement line but is constituted of the higher-order structures – extension and shear fractures, compression and extension structures, isoclinal and monoclinal folds. Formation of numerous higher-order structures in the fault zone is accompanied by cataclasm, milonitization, shearing processes, breaking the hydro-physical, temperature and pressure rock equilibrium, and provides the major cause of the fault individualization as the body with abnormal physical properties. In the upper mantle apparently the principal mechanism of ductile deformation is dislocated drift which does not cause dilatation. The intricate fault system does form the distinct Orikhovo-Pavlogradska structure (OP DSF) which is being mapped at the surface in geoelectiric and seismic (along IV geotransect) cross-sections and constitutes the integrated part of Zakhidnopryazovskiy Block. The only difference is that K_2 and M surface are subsided in the zones by 5 and 8 km respectively. The total rock magnetization in the zone also drops down in comparison to Middle-Dniprean Block by 0.5 and Zakhidnopryazovskiy Block by 0.2 A/m and is 0.3 A/m in the upper earth crust (to the depth 12-13 km). Magnetization in the middle and lower crust is 3.0 A/m which is also lower than in the adjacent blocks (Middle-Dniprean – 5.0 A/m, Zakhidnopryazovskiy – 4.0 A/m). The M boundary is defined by the extreme velocity almost 8.1 km/s (V.B.Sologub).

In the deep structure of Zakhidnopryazovskiy Block the vertical zonation is released in the three-fold (net of sedimentary layer) crustal divisions: upper, middle and lower. The crustal thickness varies in the range from 7 to 20 km. In the lower crust composed mainly of the mafic rocks velocity values are 6.8 ± 0.2 km/s, $\rho_{ef.}$ from 100 to 1000 Ohm×m, and density – 3.17-3.31 g/cm^3. Two major inclined zones are defined which dip to the east in the cross-section. The lower crust apparently corresponds to the "proto-basaltic" layer whose upper portion was stacking up in Archean simultaneously with the formation of the middle crust where somewhat less velocities (6.4-6.6 km/s), resistance ($\rho_{ef.}$ – 200-5000 Ohm×m) and density (2.87-2.95 g/cm^3) are characteristic. The upper crust is most gradiented with velocities from 5.9 to 6.35 km/s, high resistance from 20 to 500 Ohm×m, and density 2.71-2.77 g/cm^3; these features apparently reflect tectono-magmatic events in the Neo-Archean – Proterozoic time with subsequent structure complication in Paleozoic.

The crustal division into the layers is in good agreement with the results of modern experimental studies of the rocks under various PT-conditions, in particular, with the plot of the "cold" lithosphere mechanical strength.

It is possible that the "lower" and "transitional" (crust-mantle) layers are composed of the granulite and eclogite facies rocks. The granulite facies rocks exhibit density from 2.7 to 2.85 g/cm^3 (Vp = 6.53-6.95 km/s) for the rocks of intermediate and felsic composition; eclogite facies – up to 3.0-3.45 g/cm^3 (Vp = 6.7-7.9 km/s) for the rocks of mafic and ultramafic composition (gabbro, gabbro-amphibolites, diorites, pyroxenites, peridotites and pyroxene gneisses) while their magnetization should not exceed 2-3 A/m.

The lowest values (mainly from 100 to 1000 Ohm×m) of the effective specific resistance are observed in the western part of Pryazovian Mega-Block (in OP LTZ). The magnitude and patterns of $\rho_{ef.}$ are not explained, in our opinion, by the composition of rock complexes involved but in most extent by geodynamic processes. The linear tectonic patterns, most likely, are caused by tectonic position. It is thought that OP LTZ comprises paleo-Benioff zone with two-fold earth crust (from 0 to 30 km) [14]. The lower layer includes Early Paleo-Archean rocks of Zakhidnopryazovskiy LTC and forms the ancient plate ledge where mainly sedimentary rocks of Late Paleo-Archean Vovchanskiy LTC were deposited comprising the continental slope sediments. Later on, under subduction of Middle-Dniprean micro-plate, due to "huddling" Vovchanskiy Complex was transformed into the system of sub-longitudinal isocline folds. At the same time, extensive breaking of the lower ledge rocks occurred.

Increased fracturing of Pryazovian Block in the Benioff zone and mineralization of the fracture and pore waters, higher metamorphic degree, increased graphite, magnetite and sulphide content of the rocks provided higher electric conductivity of Zakhidnopryazovskiy Block.

Middle-Dniprean Mega-Block exhibits high values of the effective specific resistance exceeding that of Zakhidnopryazovskiy Block by more than three orders. Most common values in the middle and lower crust are about 25-50 kOhm. On this background three high-Ohm areas-"isolators" with values from 100 to 200 kOhm are distinguished. The first one is located to the west of Konkska structure and is extended over the depth from 22 to 5 km. After results of deep sounding by MSDP method this is seismically "transparent" area which may represent the igneous body. Its calculated density is 2.76 g/cm^3 and most likely it can be composed of diorites developed to the north away from the map sheet territory. At the "bottom" (beneath the body) the zone of almost horizontal "reflecting" flats is noted which can be interpreted as the bottom rocks enriched in electro-conducting minerals: magnetite, sulphides etc. If this assumption is correct, this suggests for the long-term cooling of the intrusive body and gravity differentiation of the magmatic melt. The second high-ohm area, located to the east of Konkska greenstone structure, displays the $\rho_{ef.}$ values two times less and calculated density of 2.82 g/cm^3

allowing interpretation for the gabbro-norite massif. In the MSDP seismic section it is almost "transparent" suggesting for the intrusive origin. Underneath the area of variously-oriented flats is located which provide the maximum seismic reflection; apparently it is composed of the Aulska Series rock remnants. The biggest high-ohm body is located at the western margin of L-36-VI map sheet, beneath the crust-mantle boundary, and exhibits $\rho_{ef.}$ value in excess of 1 mOhm. Above, in the lower crust, the relatively low-Ohm ($\rho_{ef.}$ = 10 Ohm) area is located which can be extension of the former area but is enriched in electro-conducting minerals. To the west from this area (outside the map sheet) the similar anomaly is noted but observed in the lower crust. It is possible that the mantle intrusion (plume) is broken through the boundary "crust-mantle" over there.

It should be noted that some "transparent band" (lacking of any seismic reflection) is observed in the dash seismic field from the depth 3-6 km (in the west of L-36-VI map sheet) to 30-35 km (in its east). Subsidence of this area is correlated with decreasing in anomalous gravity field values. It is not excluded that this is a fragment of subduction zone by which the Middle-Dniprean Mega-Block is under-thrusted beneath the Pryazovian Mega-Block.

The Moho surface in the limits of map sheet L-36-VI lies at the depth from 35-37 to 50 km. This surface relief designed by complex of geophysical methods reflects the mantle uplift to the depth of 35 km beneath Konkska greenstone structure. The similar uplift is also observed beneath other greenstone structures in the Middle-Dniprean area. Apparently these uplifts comprise the ultramafic magma chambers supplied the greenstone rock formation.

Velocity of elastic vibrations in the eastern part of Middle-Dniprean area varies from 6.48 at eh K_2 surface to 7.05 km/s at the Moho.

Granite-gneiss layer of the Middle-Dniprean Mega-Block is mainly composed of ultra-metamorphic and intrusive granitoids with numerous remnants of Lower Archean Aulska Series. It contains the most abundant "reflecting" seismic flats and exhibits the broad variations of magnetic and density parameters. Granite-gneiss layer commonly provides refracted waves with 5.9-6.2 km/s velocity. However, these values rise to 6.8-7.0 km/s in the sites of mafic intrusive rocks. Density of the rocks is 2.78 g/cm^3.

Upper tectonic floor

The upper tectonic level – platform cover – lies over crystalline basement with major interruption and angular discontinuity. It is composed of Paleozoic, Mesozoic and Cenozoic sediments up to 500 m thick which cover the lower tectonic level with irregular blanket filling tectonic and erosion depressions on its surface. Tectonic patterns of the cover strongly differ from the sub-longitudinal layout of the crystalline basement.

The major (I-order) tectonic elements in the map sheets include Ukrainian Shield extended from the north-west to south-east, and Prychornomorska and Dniprovsko-Donetska depressions surrounding Ukrainian Shield from the south-west and north-east respectively. Combinations of these structures in the map sheets territory had defined major tectonic features and zonation of the upper tectonic level. The boundaries between structures except tectonic ones are conventional enough. It especially concerns the boundary between Prychornomorska Depression and Dniprovskiy Ledge of Ukrainian Shield.

Ukrainian Shield is divided by Konksko-Yalynska Depression, the III-order structure of Prychornomorska Depression, into the II-order structures including Dniprovskiy Ledge (uplift) – the northern part of map sheet territory, and Pryazovskiy Horst – the southern part of L-37-I (Pology) and south-eastern part of L-36-VI (Zaporizhzhya) map sheets. Dniprovskiy Ledge in the studied map sheets is represented by its south-eastern segment – Vovchanckiy Ledge which, in turn, is divided by Vovchanska Depression into the IV-order structures including Vilnyanskiy (L-36-VI map sheet) and Pokrovskiy (L-37-I map sheet) ledges. The internal structure of crystalline basement is described above.

Tectonic zonation of Dniprovsko-Donetska Depression (DDD) is not properly defined for this particular area. The fragment of DDD south-western margin which is being mapped in the north-eastern corner of map sheet L-37-I (Pology) is included into so called junction zone between Dniprovskiy Graben and Donetska Folded Structure and is defined as Kalmiuska Plate – the III-order structure. DDD comprises the northwest-trending trough which separates Ukrainian Shield and Voronezkiy Shield. By the complex of evidences it is interpreted as aulacogen. Kalmiuska Plate is characterized by the gentle plunging of basement surface and sedimentary cover at the angle 2-3^o to the north-east, toward the Central Graben. The monocline is complicated by sub-vertical disjunctive breaks (normal faults): Zhdanivskiy, Rozdolnenskiy, Shakhtarskiy northwest-trending faults and Yasnopilskiy fault of the north-eastern direction. The magnitude of vertical displacement is 150-500 m. The age of Zhdanivskiy fault activization is Tournaisian, Rozdolnenskiy – pre-Early Eocene, and Shakhtarskiy – Pliocene.

Most part of the map sheet territory is included into the major unit of the Eastern-European Platform – Prychornomorska Depression. This is II-order marginal depression formed on the southern slope of Ukrainian

Shield in Late Mesozoic – Cenozoic time. Development of depression occurred in two stages. Over the first one, Late Mesozoic – Early Eocene, Prysyvaska paleo-ledge was established and by the orthogonal system of Zakhidnopryazovskiy-Konkskiy faults the ancient Konksko-Yalynska depression was separated. Over the second, Middle Eocene – Miocene, the next destruction, blocking and subsidence of Ukrainian Shield southern slope and expansion of Prychornomorska Depression occurred. At present Khersonskiy Block, Molochanskiy Graben and the modern Konksko-Yalynska depression are distinguished. The boundary between two first structures follows Mokromoskovskiy normal fault. Khersonskiy Block in the map sheet territory is represented by its eastern element – IV-order Dniprovskiy Block. In the Konksko-Yalynska depression the Middle Eocene – Miocene IV-order Chubarivskiy Block is distinguished. Characteristic boundary expansion to the north and north-east is observed in the modern structures.

Prychornomorska Depression is asymmetric platform structure, depression, bounded from the north and east by Dniprovskiy Ledge and Pryazovskiy Horst respectively. The southern part plunges beneath the Black Sea depression. The platform cover in the map sheet territory includes only Late Mesozoic – Cenozoic and Pliocene – Quaternary tectonic sub-levels.

In the upper tectonic level Paleozoic, Mesozoic-Cenozoic and Pliocene-Quaternary tectonic levels are distinguished.

Paleozoic tectonic level is developed in DDD. It is composed of Lower Carboniferous shallow-water carbonate-terrigenous LTC of Mokrovolnovakhska and Mezhevska suites which lie over crystalline basement with the stratigraphic and sharp angular unconformity. Thickness of the level within map sheet limits does not exceed 350 m.

Mesozoic-Cenozoic tectonic level is three-folded and includes Late Mesozoic – Early Eocene, Middle Eocene – Oligocene and Miocene tectonic sub-levels.

The first sub-level constitutes the lower platform cover column part of Prychornomorska Late Mesozoic – Cenozoic depression and the lower part of middle level in Kalmiuska Plate of DDD. It is composed of Early Cretaceous (Aptian-Albian) continental and shallow-water marine terrigenous (K_1a+al), Late Cretaceous (Cenomanian-Maastrichtian) coastal-marine terrigenous-carbonate (K_2s+m) and Early Eocene coastal-marine terrigenous (Kanivska Series and green sand batch – P_2nn+p) LTCs. It lies with the stratigraphic and angular discontinuity over the rocks of crystalline basement and Paleozoic tectonic level at the angle 1-2° toward DDD and Prychornomorska Depression. The continental Early Cretaceous sediments fill up erosion-tectonic depression on the surface of crystalline basement.

The middle sub-level is developed in Prychornomorska Depression, DDD and partially in Ukrainian Shield where it fills up paleo-valleys of the ancient hydro-network. The rocks are gently inclined (up to 2°) to the south, toward Prychornomorska Depression, and to the north-east, toward DDD, and with stratigraphic and angular discontinuity lie over the rocks of Paleozoic level, Late Mesozoic – Early Eocene sub-level and the lower tectonic level. It is composed of marine facies (Middle-Late Eocene carbonate-terrigenous Kyivska, Khadzhybeyska and Alminska suites ($P_2kv+hd+al$), Oligocene terrigenous rocks of Maykopska Series) and continental facies (Middle Eocene and Late Eocene – Oligocene coaliferous-terrigenous Buchatska Series and sands and clays (P_2bu+pg) and Kharkivska Series ($P_{2+3}hr$) respectively). The intricate facial intercalation of marine and continental sediments, reflecting complex tectonic regime in the marginal part of Prychornomorska Depression and in its junction zone with DDD resulted in the relative vertical basement block motions and facial complexity of the column, provides an apparent impression the level is four- or even five-folded.

The Miocene, upper tectonic sub-level is composed of mainly marine Early-Middle Eocene Tarkhansko-Konkskiy (N_1t+kn) coastal-marine carbonate-terrigenous, Novopetrivskiy continental and coastal-marine terrigenous (N_1np) and Late Miocene Sarmatian-Pontychniy (N_1s+p) coastal-marine and shallow-water marine carbonate-terrigenous LTCs. Tectonic sub-level with erosion and slight angular discontinuity lies over the Middle Eocene – Oligocene sub-level or with the angular and stratigraphic discontinuity – over the crystalline basement. Marine sediments are gently (parts of degree) inclined in the southern direction.

Pliocene-Quaternary tectonic level includes various-genesis rocks of the loess facies which cover the rocks of Paleozoic, Late Mesozoic – Early Eocene and Miocene tectonic sub-levels and Precambrian basement. The territory uplifting over entire period had caused formation of numerous river terraces. The aggregate thickness of Pliocene-Quaternary terrace sediments of Dnipro River is 102 m, Konka River – 70 m, Mokri Yaly River – 65 m.

Plicative dislocations in the sedimentary sequence are not identified. Disjunctive structures are observed frequently enough. The highest density of tectonic breaks is confined to the field of Cretaceous rocks in around Pryazovskiy Horst (southern part of map sheets) and to the Carboniferous rocks (north-east of L-37-I map sheet). The first field is related to the extensive uplift of Pryazovskiy Horst while the second one is located in the junction zone of DDD and Ukrainian Shield. The earliest occurrences of tectonic activization in the sedimentary cover are dated to Paleozoic. Later on some phases of tectonic activization are noted in Late Mesozoic, Early

Eocene, Oligocene and pre-Pliocene times. Major disjunctive units include Zakhidnopryazovskiy, Konkskiy, Chernigivskiy, Mokromoskovskiy and Chaplynskiy faults.

Zakhidnopryazovskiy Fault is observed along the eastern margin of L-36-VI map sheet, in its southern part. It includes the series of normal faults with vertical and sub-vertical dipping of displacement planes. The Fault is expressed by the 6.5 km wide stairwise-block zone which bounds Pryazovskiy Ledge from the west in sub-longitudinal direction. The width of individual blocks is 1.5-3.5 km. The total displacement magnitude over zone in the south of map sheet is 210 m. The stratigraphic magnitude is roughly estimated to 650 m [104]. In the area of Babashiv village the Fault is cut by the northeast-trending Andriivskiy Fault. Apparent extension of the Fault – Chaplynskiy normal fault – is clearly interpreted in the gravi-magnetic fields in the north-western corner of map sheet L-37-I (Pology) and is well expressed in the relief of crystalline basement surface; Vovchanska paleo-depression (of pre-Buchatske origination) is confined to this fault. By geophysical data, displacement plane dips westward. Any plicative or disjunctive units related to this fault in sedimentary cover are not found. Zakhidnopryazovskiy and Chaplynskiy fault comprise the segments of Azovo-Pavlogradskiy deep-seated fault which contributed much to the development of Prychornomorska Depression eastern part.

Konkskiy Fault is extended in the sub-latitudinal direction from the junction point with Zakhidnopryazovskiy Fault to the east, far away the studied territory. To the west it is locally seen and is almost not expressed in the relief morphology of crystalline basement but impact of this Fault on the relief formation is defined unambiguously. The Fault bounds Pryazovskiy Ledge from the north and comprises the stairwise-block zone 5-10 km wide. Displacement plane dipping is mainly vertical and sub-vertical. The major plane of Konkskiy Fault is the thrust expressed in the map by broken line. These patterns are caused by extensive development of the dextral and sinistral strike-slips in the frontal thrust provided relative movement of the blocks over the distance up to 2 km (up to 6.5 km in aggregate). The calculated stratigraphic magnitude of vertical displacement attains 1100 m. Observed maximum magnitude of crystalline basement displacement in the south-east of map sheet L-37-I (Pology) is 520 m. Recorded magnitude of the horizontal displacement along the thrust (overlapping) is 105-400 m (see the Legend to "Geological map of pre-Quaternary units", cross-sections 1, 4, 6). The Fault is long-lived, established as far back as Paleo-Archean. Its activization is noted in Eocene, Miocene, Pliocene and even in Holocene (see cross-section 2 ibid). The thrusting tectonics in Cenozoic is caused by the uplift and north-eastward movement of Pryazovskiy Horst occurred through its compensatory squeezing out due to the activization (subsidence) of Indolo-Kubanskiy trough [27]. Another thrust of pre-Eocene age with horizontal overlapping of 15 m and vertical magnitude of 12 m is encountered in 40 km to the north apart from Konkskiy Fault, in the map sheet L-37-2-C, at the eastern outskirt of Krutoyarivka village.

Chernigivskiy Fault of the north-eastern extension is encountered in the map sheet L-37-I (Pology). It comprises the normal fault with elevated south-eastern side. The dipping of displacement plane is sub-vertical, displacement magnitude is 40-120 m with pinching in the north-eastern direction. The Fault divides Konksko-Yalynska depression in two parts: north-western and south-eastern (Chubarivskiy Block) elevated in relation to the former. The Fault is originated in Paleo-Proterozoic time and its activization occurred in pre-Cretaceous (assumed), Paleocene and pre-Neogene times.

Mokromoskovskiy Fault comprises the northeast-trending normal fault developed in the north-western part of map sheet L-36-VI (Zaporizhzhya) with weakly defined morpho-kinematic parameters. By geophysical data, apparent dipping of displacement plane is steep to the south-east. The Miocene Kushugumska erosion-tectonic paleo-depression, the left branch of Middle Eocene Vasylivska Depression, and the north-western bank of Kakhovske water reservoir are confined to the Fault. Mokromoskovskiy Fault divides Middle Eocene – Miocene Prysyvaska paleo-ledge of Prychornomorska Depression.

In Miocene the active tectonic regime of Paleogene period had been changed by the relatively calm neo-tectonic regime. Amount of blocks, involved in the mutual movements with the vertical magnitude up to 15-30 m, had decreased.

The jointed analysis of anomalous river slope maps and crystalline basement fault maps had allowed territory subdivision in tectonic blocks where the aggregate magnitudes of neo-tectonic movements over Neogene-Quaternary times are estimated.

The most active blocks which underwent uplifts include Vilnyanskiy, Chubarivskiy, Velykomykhaylivskiy and Pryazovskiy while Orikhivskiy and Zaporizkiy blocks underwent subsidence (see "Neo-tectonic scheme"). In general, the territory of Pryazovian Mega-Block (map sheet L-37-I (Pology)) underwent uplift whereas the Middle-Dniprean Mega-Block (map sheet L-36-VI (Zaporizhzhya)) – subsidence.

The river valleys mainly follow the weakened zones of the sub-longitudinal, north-western and sub-latitudinal tectonic breaks and inherit the post-Miocene surface relief.

6. HISTORY OF GEOLOGICAL DEVELOPMENT

Development history of the map sheet territory is tightly related to the evolution of the Eastern-European Platform and Ukrainian Shield as its integrated part. By the type and magnitude of geological processes two major stages are distinguished in the area: Precambrian and Phanerozoic. The folded structure of crystalline basement was formed over the first stage and the platform cover – over the second one.

Precambrian Stage

Precambrian development history is fairly intricate. In the south-eastern part of Ukrainian Shield three tectono-magmatic mega-cycles are distinguished which correspond to the tectonic levels of crystalline basement and aeons of the geochronological scale. Performed Precambrian stage periodization respects the geo-historic principle of the Earth directed and irreversible evolution resulted in the distinct and sometimes unique in the geological history rock types or their associations. From this point of view, the following mega-cycles are distinguished in the studied area: Paleo-Archean pre-greenstone, Meso-Neo-Archean greenstone and Proterozoic post-greenstone. It is thought that the rock complexes were developing in the certain succession. Volcanogenic and sedimentary-volcanogenic complexes were deposited in the initial stages whereas intrusive magmatism and fault-tectonic activity have been associated with the final stages [26].

Paleo-Archean pre-greenstone mega-cycle

The mega-cycle encompasses the time span of 4.0-3.4 Ga. The most part of crystalline rocks formed over this period: Zakhidnopryazovska and Aulska series, Vovchanska and Dragunska sequences, Novopavlivskiy mafic-ultramafic and Novopavlivskiy granitoid complexes. Their formation occurred within two phases: early and late. Over the early phase the Eastern-European Platform comprised the single unit with uniform tectono-magmatic activity. In the beginning volcanics of ultramafic to intermediate composition of Slavgorodska, Novopavlivska and Verkhnyotokmatska sequences, Aulska and Zakhidnopryazovska series respectively were depositing. The final phase released in gradual increasing the intermediate and felsic volcanics and sedimentary rocks in the column of Zakhidnopryazovska series (Kainkulatska sequence). As a result, the primary proto-continental granulite-basite 20-25 km thick crust was formed. Beginning of the late phase of Paleo-Archean mega-cycle is marked with the extensive fault tectonics. The deep-seated faults (Orikhovo-Pavlogradskiy, Kryvorizko-Kremenchutskiy) were set up splitting the common proto-continent [26] into the first-order mega-blocks (Kirovogradskiy, Middle-Dniprean and Pryazovian). The deep-seated faults were accompanied by the parallel (Bazavlutskiy, Zakhidnopryazovskiy, Tsentralnopryazovskiy), orthogonal (Devladivskiy, Fedorivskiy, Prakonkskiy) and diagonal (northwest Gaychursko-Sorokynskiy, Dniprodzerzhynskiy, Pologivskiy and northeast Andriivskiy and Skhidnokonkskiy) faults of deep origin and regional extension. The faults are complicated by the higher-order breaks (Korsatskiy, Chaplynskiy, Ternovatskiy, Kuybyshevskiy, Molochanskiy). As a result, the common proto-continental granulite-basite massif was split into the blocks of various order, size and shape. Block motions were accompanied by extensive rock cataclasm. Thickness of Gaychursko-Sorokynska zone of tectonites is 20-25 km. Subduction of the Middle-Dniprean Mega-Block beneath Pryazovian one had commenced along Orikhovo-Pavlogradskiy deep-seated fault and around the latter the shallow but large troughs appeared filling with the waters of primary “Panthalassa” ocean [29]. Volcanogenic-sedimentary rocks of Vovchanska and Dragunska sequences were depositing. Essential influence of volcanic factor occurred in the initial phase. The aggressive atmospheric composition and calm tectonic regime facilitated extensive chemical dissolution, leaching of granulite complexes and deposition over the broad areas the very consistent by strike distinct chemogenic sediments – “barren” quartzites, high-alumina gneisses and quartzite-schists and ferruginous quartzites intercalating in the regular manner. The lack of coarse-clastic sediments in Vovchanska Sequence suggests for the weak relief differentiation in the source regions comprised of the periodically flooding lowland plains. Appearance of graphite-bearing rocks suggests for the origin of primitive life in the ocean – blue-green algae facilitated by the high temperature of the water and atmosphere, high pressure, their chemical composition (CO_2, NH_3, CH_4, HF, HCl), extensive ultra-violet radiation, volcanism and thunderstorm electricity.

Formation of Late Paleo-Archean complexes accompanied by the brachy-form and dome folding, emplacement of mafic-ultramafic minor intrusions of Novopavlivskiy Complex, metamorphism and ultra-metamorphism under granulite-facies PT-conditions. These processes were developed in the regional scale and the early-formed complexes were also involved in the rock transformations. Being driven by tectonic movements, considerable masses of the high homogenization degree melt of tonalite-diorite composition moved in space and emplaced in the large intrusions (batholiths) providing additional rock granitization through their assimilation. Most extensive granitization of granulite complexes occurred in the Middle-Dniprean and Gulyajpilsko-Saltychanskiy blocks.

As a result, the Paleo-Archean pre-greenstone 30-40 km thick tectonic level was formed where the "grey-gneiss" (Middle-Dniprean and Zakhidnopryazovska) and granulite-gneiss (Tsentralnopryazovska) terrains and the III-order blocks (Korsatskiy, Vovchanskiy and Remivskiy) inside these terrains were separated by that time.

The first geodynamic events are related to that time. During the motions of minor blocks (micro-plates) they thrust one over another while subduction of Middle-Dniprean Mega-Block beneath Pryazovian Mega-Block continued.

The huge amount of heat released through the mentioned processes led to the cooling of the Earth resulted in compression and ceasing of tectono-magmatic activity.

Meso-Neo-Archean greenstone mega-cycle

Duration of this mega-cycle is 800 Ma (from 3.4 to 2.6 Ga). The middle tectonic level of the crystalline basement does correspond to this mega-cycle. It is composed of the distinct rocks not known before. It especially concerns the ultramafic volcanics – komatiites. Their formation requires certain tectonic environments and high heat flow ensuring long lava crystallization. The mega-cycle is divided in two cycles: the early Meso-Archean Azovian and the late Neo-Archean Dniprovian resulted in formation of Bazavlutskiy and Gaychurskiy then Konksko-Bilozerskiy and Novogorivsko-Osypenkivskiy complexes respectively. In turn, each cycle is divided into the early and late phases. The early ones accompanied by extensive ultramafic-mafic magmatism and deposition of essentially volcanogenic Bazavlutskiy Meso-Archean and Kosivtsivskiy and Novogorivskiy Neo-Archean complexes. The late phases are mainly composed of terrigenous complexes with subordinate volcanics of predominantly intermediate and felsic composition: Ternovatskiy Meso-Archean and Bilozerskiy and Krutobalkinskiy Neo-Archean. The cycles are finished with the formation of intrusive and ultra-metamorphic complexes (Oleksandrivskiy, Dnipropetrovskiy, Gaychurskiy, Dobropilskiy, Verkhivtsivskiy, Surskiy, Varvarivskiy, Shevchenkivskiy, Khortitskiy). In this mega-cycle, in the time span 2950-2600 Ma, the third (proto-continental) cycle is also distinguished which includes development of magmatic and ultra-metamorphic two-feldspar granite (Mokromoskovskiy, Tokivskiy, Yanvarskiy) and dyke mafic-ultramafic (Devladivskiy) complexes.

With beginning of the early cycle (3400-3450 Ma) the new epoch in the Earth evolution commenced – expansion accompanied by Paleo-Archean proto-crust extension. In the weakened sites, confined to the zones of regional faults established in the previous development phase, extension zones appeared which further were gradually transformed into riftogenic structures: Konkska and Bilozerska in the Middle-Dniprean Mega-Block and Kosivtsivska, Gaychurska, Sorokynska and Chystopilska in Pryazovian Mega-Block. The local structures merged into riftogenic then greenstone belts. The fragments of two belts are known in the studied map sheets: Konksko-Bilozerskiy and Gaychursko-Sorokynskiy joined at the right angle. Chystopilska monocline is set parallel to the former belt and to Orikhovo-Pavlogradskiy deep-seated fault.

In the environments of still heated lithosphere and its high enough viscosity the stretching did not cause formation of high-magnitude faults and was only released in the fracture system opening ("embryonic" rift) served the channels for igneous melts and were quickly sealing with these melts [37]. O.B.Bobrov defines this type of structures as the spreading rift. It is especially clear expressed in Pryazovian greenstone belts. Kosivtsivsko-Gaychurska greenstone structure includes separated linear bodies of meta-volcanics which fill up mentioned rifting structure. Tectonic environments of Pryazovian block, which was thrusting over Middle-Dniprean block, precluded long-term existence of the open fractures and deposition of thick volcanics by analogy with greenstone belts in the Middle-Dniprean Mega-Block. Tectonic environments in the latter differed from Pryazovian ones. The vertical (downward due to the over-thrusting of Pryazovian and Kirovogradskiy mega-blocks) tension over the marginal parts of Middle-Dniprean Mega-Block facilitated fracture opening (and also, perhaps, multiple renewal of the sealed and formation of new ones) and prolonged magma emplacement.

In the initial phase extrusion of peridotite, pyroxenite and basaltic komatiite magma occurred whereas at the final phases, upon differentiation in the magma source, the mafic-ultramafic volcanism is changed by more felsic dacite-andesite and rhyodacite ones. Volcanic activity accompanied by emplacement of comagmatic

intrusions. The lava deposition in greenstone structures of two mega-blocks under review differed not only by tectonic regime and scale but also in other features. Meta-volcanics in Kosivtsivska greenstone structure contain full-differentiated spinifex-textured olivine-bearing komatiites while meta-basalts do not exhibit the ball-shaped jointing. Insufficient volume of extruded magma, in contrast to the greenstone belts of the Middle-Dniprean Mega-Block, precluded formation of compensated depressions filled with the water and terrigenous-chemogenic sediments.

The final stage of the early cycle displays the ceasing of volcanic activity and its substitution by plagiogranitoid magmatism. The distinct Early Meso-Archean tectonic environments in Pryazovya led to the closure of Kosivtsivska structure, emplacement of the first-phase diorites of Dobropilskiy Complex and establishment of the new micro-rifting structures (Shevchenkivska and Fedorivska) and activization of Chystopilska and Gaychurska ones. The latter is expanded through the junction with the zones of Andriivskiy and Ternovatskiy faults. Emerged fault-side troughs were filling with volcanogenic-terrigenous, and in Fedorivska structure also with chemogenic complexes of Ternovatska Sequence. In the Middle-Dniprean Mega-Block Bazavlutskiy Complex developed without notable interruptions.

Formation of Meso-Archean complexes at the final stage accompanied by metamorphism and ultra-metamorphism (Dnipropetrovskiy Complex) under amphibolite facies PT-conditions and scattered enough magmatism of ultramafic-mafic and tonalite composition (Oleksandrivskiy, Gaychurskiy, Dobropilskiy complexes).

Beginning of the late greenstone Neo-Archean cycle is marked with rifting activization especially in the Middle-Dniprean granite-greenstone terrain. Long-term development of rifting systems, considerable volume of extruded magma, root collapse above magmatic bodies and thinning of the crust led to its breaking and transformation of primary “embryonic” rifting structures into the true rifts up to the spreading zones. The “grey-gneiss” proto-crust spread out in the western and eastern directions beneath Pryazovian and Kirovogradskiy blocks. Above the rifts the broad compensatory depressions were formed filled with volcanics of mainly mafic composition. In Pryazovya this process occurred in limited amounts: just Novogorivska and Sorokynska linear greenstone structures were developed.

At the final stage of early cycle volcanic activity is ceased and changed by plagiogranitoid magmatism. It could be caused by another short-term compression of the Earth resulted in closure of the lava-feeding channels and squeezing out residual melts of granitoid composition. Compression had also caused extensive folding and orogenesis resulted in the Earth crust additional heating, its melting and formation of large plagiogranite massifs of Surskiy Complex, metamorphism of early Neo-Archean complex under amphibolite facies PT-conditions. The mountain systems and deep secondary trough-like depressions, sea basins emerged at the sites of primary riftogenic basins. Their position coincides with the previously existed early Neo-Archean troughs although notable displacement of their axes in the plane is observed.

Deposition of essentially terrigenous Bilozerska Series sediments in these basins occurred under extensive oscillating movements. The Series column comprises alternating coarse-grained and fine-grained sediments with subordinate volcanics of mainly rhyodacite composition. As a result of volcanic activity the ferruginous-siliceous sediments of Zaporiska Suite are deposited. Formation of late greenstone volcanic-sedimentary complex accompanied by extensive folding and thrusting as well as metamorphism under greenschist-epidote-amphibolite facies PT-conditions. Formation of the late greenstone complex occurred over the long period of 3200-2950 Ma.

Development of greenstone complex resulted in the continental crust growing up to 35-40 km. Apparently the uppermost mantle material had also contributed to the crustal thickness increasing through the depleting igneous activity. Further geological development of the map sheet territory had got the proto-platform mode. The large two-feldspar granite massifs of Demurinskiy, Tokivskiy, Mokromoskovskiy complexes and Yanvarska association were forming over long time in the Middle-Dniprean and Pryazovian areas accompanied by the extensive microclinization of the early-formed rock complexes. In addition, in Pryazovya two-feldspar magmatism and ultra-metamorphism are accompanying by the pegmatite formation. The pegmatite fields with rare-earth-rare-metal mineralization are formed in the tectonically weakened trough-like zones (Shevchenkivska, Gaychurska and Chystopilska). Deposition of volcanogenic and chemogenic-sedimentary (ferruginous-siliceous) rocks of Teplivska Sequence is noted only in Bilozerska and Verkhivtsivska greenstone structures.

At the final stage of Neo-Archean cycle the next phase of the Earth compression occurred resulted in the crust break up into the blocks (plates), their relative movements and emplacement of long enough Devladivskiy Complex dykes of mafic and ultramafic composition.

As a result, the common Kursko-Pryazovska granite-greenstone terrain was formed by the end of Archean mega-cycle which included Middle-Dniprean, Zakhidnopryazovskiy (Gulyajpilsko-Saltychanskiy) and Sumskiy geo-blocks.

The double change of compression by extension processes over the Meso-Neo-Archean mega-cycle accompanied by folding, thrusting, metamorphism under amphibolite-greenschist facies PT-conditions and extensive magmatism (complicating emplacement of mafic and ultramafic minor intrusions of Gaychurskiy, Verkhivtsivskiy and Varvarivskiy complexes and large diorite-tonalite-plagiogranite massifs of Dobropilskiy, Surskiy, Shevchenkivskiy complexes and Khortytska association) led to the significant destruction of pre-greenstone folded units and emerging the lengthy volcano-plutonic synclinorium structures – greenstone belts.

Proterozoic post-greenstone mega-cycle

This mega-cycle corresponds to the platfrom stage of the region development and completes Precambrian evolution of the folded basement over the studied map sheets. At the margins of granite-greenstone terrains, almost completely arranged by that time, the Kryvorizko-Kremenchutskiy and Sorokynsko-Gulyajpilskiy troughs with miogeosyncline regime are emerged. In the map sheet territory the north-eastern flank of the latter is observed including Gulyajpilska and Balochkivska depressions. The trough was dominated by the calm subsidence and limited intermediate and felsic volcanic activity [14]. In the initial stage the long enough (up to 40 km) Gulyajpilska depression was forming filled with terrigenous sediments of the lower and chemogenic-terrigenous (thick piles of ferruginous quartzites with leptite and trachy-andesite interbeds) rocks of the middle sub-suites of Gulyajpilska Suite. Further on the sea basin isolation and shallowing occurred over most part of the trough and only in Gulyajpilska and Sadova (Sorokynska greenstone structure) depressions sedimentation of sandy-clayey and mainly carbonate rocks respectively continued.

The final stage of Paleo-Proterozoic cycle is accompanied by folding, metamorphism under epidote-amphibolite and greenschist facies PT-conditions, emplacement of mafic and ultramafic minor intrusions (Kolarivskiy Complex) and fairly extensive two-feldspar ultra-metamorphism. The latter process most extensively appeared in Orikhovo-Pavlogradska and Tsentralnopryazovska LTZs expressed in emplacement of numerous granite and pegmatite veins and dykes, both sub-conformable and discordant, of Anadolskiy Complex. In Gulyajpilsko-Saltychanskiy Block ultra-metamorphism was accompanied by development of two-feldspar amoeboid intrusions along the faults.

Late Paleo-Proterozoic – Meso-Proterozoic cycle in the south-eastern part of Ukrainian Shield (outside the map sheet margins) is marked by the extensive development of alkaline complexes.

Precambrian stage is finished with the continental crust break up and formation of northwest-trending fracture system injected by the mafic and intermediate minor intrusions (dykes). In the north-east of map sheet L-37-I (Pology) Dniprovsko-Donetska Depression is emerged.

Phanerozoic Stage

In the geological history of the studied territory over Phanerozoic two major phases can be distinguished: *pre-Carboniferous*, which is almost completely unknown, except the theoretic assumptions that in the end of Proterozoic – beginning of Paleozoic emerging of Dniprovsko-Donetska Depression occurred while the territory comprised the land over entire period [2], and *Carboniferous-Holocene* which history is recorded in the diversity of sedimentary rocks. The second phase history, in turn, is divided into some mega-cycles: Paleozoic (Carboniferous), Late Paleozoic – Early Mesozoic (Permian, Triassic, Jurassic), Late Mesozoic – Cenozoic (Miocene) and Pliocene – Quaternary. The cycle before the last is further divided into the minor cycles: Late Mesozoic – Early Eocene, Eocene – Oligocene and Miocene.

In the Early Carboniferous time the north-eastern part of the territory was subsided. The carbonate sediments (limestones, marls and dolomites with thin interbeds of terrigenous rocks) were depositing over Tournaisian-Visean time.

At the end of Early Visean time the slow uplift of the DDD north-western limb and sea shallowing occurred. The cycling basement motions had caused frequent intercalation of Visean "g" zone marine and continental sediments. Remaining part of the map sheet territory apparently comprised the land over entire Paleozoic.

The normal laying of Carboniferous sediments is complicated by the faults. The stairwise subsidence of crystalline basement occurred. On the elevated limb of DDD the Carboniferous sediments were eroded in Mesozoic and are preserved in the graben-like troughs in the area of Novogeorgiivka and Shevchenko villages (map sheet L-37-I, square I-3).

Since the mid-Carboniferous time up to the beginning of Jurassic the history of geological development is obscured because of lacking respective sediments. Beginning of Jurassic time is marked by the downward motions and commencement of the sea transgression. The grey and dark-grey argillite-like clays with marine

fauna were forming which are preserved from erosion and studied in 2 km to the south, in Mykhaylivska graben-depression, in adjacent territory (map sheet L-37-VII).

In the Late Jurassic epoch regression of Jurassic sea is accompanied by activization of Shakhtarskiy, Rozdolnenskiy and other faults (young Kimmerian phase of Kimmerian tectonic cycle). The vertical block movements occurred along Temyrivskiy Fault. The north-eastern block goes down below the western block and forms Elanchyksko-Vovchanska LTZ while in the south-western block was formed Konksko-Yalynska LTZ. In the south-eastern part (map sheet L-37-I) Chernigivskiy Fault is activated while Chubarivskiy and Pryazovskiy blocks go up and form the ledge above surrounding territory.

The paleo-depressions over crystalline basement are being filled with Lower Cretaceous continental sediments (Aptian stage). In Konksko-Yalynska LTZ depressions are filled with sands, coaliferous clays, secondary kaolines, gravel and pebble. Thickness of sediments does not exceed 20 m. In Elanchyksko-Vovchanska LTZ depressions are opened toward DDD and filled with parti-coloured clays, diverse-grained kaolineous sandstones, gravel, pebble, debris. Thickness of alluvial sediments is up to 50 m.

At the end of Aptian time the sea transgresses from Prychornomorska Depression. The Aptian continental sediments undergo extensive erosion. The northern boundary of Albian sea is traced along the margins of Aptian depressions. The sediments are formed in the coastal environments of shallow sea and in erosion-accumulative valleys. In Konksko-Yalynska LTZ the quartz sands with glauconite are deposited. In Elanchyksko-Vovchanska LTZ the carbonate sandstones with glauconite and silica-clay-like rocks were forming. At the end of Albian time the territory undergoes uplift, the sea regresses and most of sediments are eroded.

In Cenomanian time the downward motions are activated and transgression deeply expands inside the land by paleo-valleys. The marl, chalk-like marls, chalk, silica clays, and glauconite-quartz marleous sands are deposited.

In Turonian time commenced regression and sea shallowing, and in Maastrichtian time marine sediments include the coastal-marine facies: carbonate-glauconite-quartz sands, silica clays, sandstones. At the end of Maastrichtian time the sea leaves the territory.

In the Late Cretaceous time commenced activization of differentiated vertical basement block movements along Zakhidnopryazovskiy and Konkskiy faults. It is evidenced by the different rock thickness of stratigraphic horizons which overlie different blocks of Precambrian basement. The motions were slows with insignificant magnitudes.

In Paleocene epoch the territory underwent short-time uplift and comprised the denudation area. The lack of Paleocene sediments suggests for predomination of denudation processes.

On the Cretaceous surface the paleo-depressions emerged which valleys had inherited position of depressions developed on the crystalline basement in Aptian time. Depressions are opened toward Prychornomorska Depression. Those located to the west from Pology town are oriented in the south-western direction and remaining ones – in the south-eastern direction.

At the end of Paleocene epoch the young Laramian phase of Alpine cycle appeared. Sub-longitudinal faults activization occurred and erosion-tectonic depressions emerged: Vasylivska, Lugivska, Shcherbakivska and others. In the map sheet L-37-I the northwest-trending faults are activated. Vovchanska depression regresses from the north by the zone of Chaplynskiy Fault and combines Pokrovska and Shevchenkivska depressions into the single system. Vovchanskiy ledge was split into Vilnyanskiy and Pokrovskiy ledges.

Beginning of Eocene epoch is marked with the Early Eocene transgression. Its distribution boundary is sub-parallel to the boundary of Cretaceous sediments, in 3-5 km to the south-east. In the shallow-water basin the sequence of carbonate-less diverse-grained glauconite sands is deposited.

At the end of epoch the territory rises and completely gets rid of the sea. Tectonic activization of Zakhidnopryazovskiy Fault continues and adjacent blocks are involved in the inversion. Within these blocks, in the area of Bilogirya, Yabluneve, Solodka Balka, Burchak and Orlyanske villages, the Early Eocene sediments were removed. The inherited hydro-network is being formed. The composition of plants suggests for the tropic and sub-tropic climate predomination. Formation of Pryazovskiy ledge is commenced in the eastward-driven repeating mode when its north-west part, bounded by Zakhidnopryazovskiy, Konkskiy and Chernigivskiy faults, rises first. The ledge is being enveloped by the sequence composed of diverse-grained kaolineous sands alternating with secondary sandy kaolines. Thickness of the sequence decreases from 20 to 3-5 m in direction from the ledge to periphery. Alluvial, alluvial-lake and swamp facies are widely developed in the lowland where coaliferous sandy-clayey rocks, sands and clays were depositing. At the same time, the denudation and weathering crust-forming processes were developing in the north part of the territory.

Beginning of the second half of Middle Eocene epoch is marked by the broad sea transgression expanded into Prychornomorska and Dniprovsko-Donetska depressions. In Vasylivska LTZ (map sheet L-36-VI) the moderate deep-water sediments were depositing: marls, carbonate clays with fauna; closer to the coastline –

coastal-marine sediments: aleurites, quartz-glauconite sands. Transgression deeply expands into the land along Vasylivska Depression to the north of Zaporizhzhya city. The quartz-glauconite sands, silica clays, aleurites with sponge spicules were depositing. The modern development limit is controlled by the contour-line +40 m. From the side of Dniprovsko-Donetska Depression along Vovchanska Depression transgression expands into Pologivska LTZ (map sheet L-37-I). The rocks include shallow-water marine sediments: glauconite-quartz, aleurites with sponge spicules, silica-clay-like rocks. Development margin is controlled by the contour-line +60 m. The geological column, rock lithology and sequence hypsometry suggest for clear connection of sea basins in Prychornomorska and Dniprovsko-Donetska depressions.

The Late Eocene epoch is marked by the general territory uplift and sea escape toward the south-west (map sheet L-36-VI). The shallow-water sediments of Alminska Suite include glauconite-quartz aleurites and sands with fauna. In the coastal-marine plain, gently inclined to the south-west, the continental rocks of Reshetylivska Sequence are being deposited: proluvial fans of temporary streams, alluvial, alluvial-lake and swamp facies. The terrigenous clastic material was taken down from Chubarivskiy and Pryazovskiy blocks. The clastic material grain-size decreases and its sorting get better away from Konkskiy Fault. The brown coal of Sanzharske and Orikhivske deposits is being deposited in the swamps. Thickness of continental sediments close to Konkskiy Fault attains 210 m decreasing to 50-70 m away from. At the end of Late Eocene some cooling occurred. Among the plants the ancient tropical forms predominate.

The Late Eocene epoch the Pyrenean tectonic phase of Alpine cycle and tectonic re-arrangement occurred. Actively rising Pryazovskiy block supplies huge amount of clastic material to Konksko-Yalynska depression and form the surface inclined in the northern direction. At the same time, the north-eastern part of the territory still retained the southern surface inclination. The watershed line between the two Prychornomorski hydrographic systems drifting to the east from Pology town by 20 km. Depression along Konkskiy Fault is oriented in the eastern direction and suggests for retained direct connection with Prychornomorska Depression.

In the Early Oligocene the broad transgression in Vasylivska LTZ occurred. It is accompanied by extensive erosion and relief smoothing. Above the coarse-grained sands of basal horizon the manganese ore sequence is formed from colloid solutions with minor motions of bottom waters under conditions of slow tectonic movements. Upon formation of ore-bearing layers Oligocene sea transgression attains its peak and supra-ore clays are deposited. At the end of Early Oligocene epoch tectonic activization and Oligocene sea regression commenced.

In Pologivska LTZ the continental sedimentation occurred in Early Oligocene epoch. In the zone adjacent to Kuybyshevskiy block the coarse-grained fan sediments 74 m thick are deposited. Alluvial, lake and swamp sediments composed of coaliferous sandy-clayey rocks and brown coal are formed away from the block. Formation of Sanzharske brown coal deposit is completed.

In the Late Oligocene epoch the general territory uplift and sea basin regression occurred coupled with erosion of the rocks deposited over Early Oligocene. The relief tectonic re-arrangement is completed. The territory of Pryazovskiy ledge, located to the east in adjacent map sheet up to Zlatoustivskiy fault, is involved in the upward movements. Depression existed at the end of Eocene and the southern inclination of its surface disappeared. Direct connection with Prychornomorska Depression is interrupted. Thus, the Savian phase of Alpine cycle completed the multi-phase formation of Pryazovskiy Horst. The watershed line runs over its surface. Oligocene surface of the map sheet L-37-I has got the north-western inclination. The cooling commenced in the Late Eocene, continued in Oligocene. The composition of plants changes into predomination of broad-leaved ancient varieties with minor sub-tropic flora.

In the Early Miocene the denudation and weathering crust-forming processes predominate. At the end of Early Miocene epoch, in Tomakivskiy time, the sea occupied the south-western part of the territory and expanded into the land through the paleo-depressions where marine sediments of Tomakivski Layers were depositing. Later the sediments were eroded and only nearby Zaporizhzhya city their lower parts are scarcely preserved in the dimples of crystalline basement.

In the beginning of Middle Miocene, in Chokrakskiy time, the sea transgresses and floods the southern part of map sheet L-36-VI and central part of map sheet L-37-I. In Vasylivska LTZ the shallow-water sediments are deposited: carbonate clays with fauna and limestone interbeds. In Pologivska LTZ the coastal-marine facies are formed: glauconite-bearing sands and aleurites with fauna. The land comprised the plain where clastic material from Pryazovskiy and Vovchanskiy ledges was brought to. In Karaganskiy time the sea escapes and is only retained in the south-western corner of map sheet L-36-VI (Zaporizhzhya) where the clays with marl interbeds were depositing.

The end of Middle Miocene epoch is marked by transgression encompassed Vasylivska LTZ. The Konkske sea waters attain the latitude of Zaporizhzhya city filling Vasylivska and Khortytska depressions. In the shallow-water sea basin the clays with fauna and limestone interbeds were deposited. The territory, adjacent to the sea, is composed of continental sediments including alluvial, lake, lake-swamp and proluvial facies. Proluvial

fans of temporary streams are developed in the south-east and adjoins Pryazovskiy block (map sheet L-37-I). The lake and lake-swamp sediments are confined to the north part of the territory. In addition, in the north of map sheet L-36-VI the weathering crusts were formed.

The Middle Miocene surface in the map sheet L-37-I is inclined to the north and north-west, and in the map sheet L-36-VI – to the south and south-west. The watershed between the two follows the line of inhabited locations Magedove (in the south) – Gulyajpole – Novomykolaivka. Over period of Oligocene – Middle Miocene Pryazovskiy ledge was uplifted by 60 m. The plant composition suggests for continuation of cooling although climate used to be moderate-warm.

The Late Miocene epoch is marked by the gradual development of Sarmatian, Meotychni and Pontychni transgressions.

The Early Sarmatian sea follows previous Konkske sea and attains latitude of Zaporizhzhya city. The basin used to be shallow-water and clays, rarely limestones and fine-grained sands were depositing at the bottom. The climate used to be moderate-warm and relatively wet. The plants included conifers, myrtle and broad-leaved.

In the Middle Sarmatian time the sea waters flood almost entire territory except the ledges of crystalline basement and Middle Miocene sediments (Pryazovske and Chubarivske uplifts). The basin used to be shallow and sediments are parti-coloured: sands, black thin-platy clays with mollusc fauna, limestones with minor marls. The climate of that time retained features of previous epoch. Among the plants the conifers, rarely broad-leaved predominated.

At the end of Middle Sarmatian the sea regression occurred. The Late Sarmatian sea is located in the area of Verkhnya Tersa River upper course and Konka River lower course (map sheet L-36-VI). The shallow-water marine sediments include oolite and organogenic limestones, carbonate clays with marl interbeds. Following the Late Sarmatian sea regressing southward, the southward-oriented hydrographic network appears on the marine lowland plain. In the eastern part of the territory the north-western surface inclination retained.

Meotic transgression has reached Vasylivska LTZ and attained the lower course of Konka River. Its shallow-water sediments were deposited under conditions of essentially freshened marine basin and, alike considerable part of Upper Sarmatian ones, were eliminated by Pontian transgression.

In Pontian time of Late Miocene epoch the territory became the site of the last broad transgression which encompassed almost entire map sheet L-36-VI (Zaporizhzhya) territory. The sea north coast was extended along the northern map sheet margin, to the south of inhabited locations Vilnyansk, Lyubymivka, Georgiivka, Andriivka. It is not excluded that the sea might expand to the north along Pradnipro river valley but reliable data supporting this mention are not preserved. As the transgression expanded, the ancient valley was forming on the surface of Sarmatian sediments, and alluvial-marine sediments were depositing (Pradnipro delta). The rocks include fine-grained well-sorted sands up to 72 m thick. Over remaining territory in the shallow-water freshened marine basin the oolite and shelly limestones and clays, rarely marls, sands were depositing.

At the end of Late Miocene epoch regression of Pontychne sea commenced. The red-brown clayey material was removed by temporary water streams from the site of eluvial processes. This explains occurrence of the red-brown sands in the upper column parts which are gradually changed downward by grey and grayish-yellow ones. Activization of latitudinal and allied longitudinal faults occurred which caused development of new hydrographic network. The southern orientation of paleo-valleys switched to the western one.

Neo-tectonic activation of Pryazovskiy Horst fragment located in the southern part of map sheet L-36-VI caused crystalline basement block inversion. The barrier hampering Dnipro River flow to the south has been created and at the end of Late Pontychniy time its valley sharply turns to the west into the graben-like dimple "instead of southward flowing in compliance with the general bottom inclination of the Novorosiyske sea moved to the south that time" [92].

In the map sheet L-37-I the block movement with breaking the Novopetrivska Suite rocks occurred along Konkskiy Fault (Valakhska tectonic phase of Alpine cycle reflection). In the north-eastern part, in the basin of Mokri Yaly river, the normal rock laying of Sarmatian regio-stage is upset.

At the end of Pontychniy time the northern slope of Prychornomorska Depression has been uplifted. The territory comprised peneplainized lowland plain with gently-hilled relief and general inclination to the north (map sheet L-37-I) and south (map sheet L-36-VI). Erosion valleys were developing over the steppe plain. The fauna and flora suggest for the warm climate.

In Pliocene, under conditions of dry and warm enough climate the red-brown eluvial-deluvial and eluvial clays are deposited. Over the steppe areas the winters were snow-less and the summer dry and hot. In these favourable environments the camels and ostrich lived and the wormwood-cereal steppe existed with the scarce forests over river valleys [2, 65].

The valleys of modern rivers have been established in pre-Early Pliocene epoch. Their further development and the slope terracing occurred in Late Pliocene and Quaternary times. In Eo-Pleistocene epoch

the Kyzyldzharska and Nogayska terraces were formed along Dnipro, Konka, Gaychur and Mokri Yaly rivers. Eluvial, aeolian-deluvial red-brown clays were forming at the watersheds and their slopes. In Early Pleistocene epoch the physico-geographic conditions slightly changed and climate used to be warm and wet enough. The steppe vegetation predominates. Eluvial and aeolian-deluvial processes caused alluvium development in Budatska, Donetska and Krukenytska terraces.

In the Middle Pleistocene epoch the drastic cooling occurred. More cold-resistant flora and fauna varieties appeared. Eluvial and aeolian-deluvial processes caused formation of loess-like loams and former soils. In Pryazovskiy ledge the debris-loamy rocks are formed. Over the river valleys accumulation of Khadzhybeyska and Cherkaska terraces occurred. In places tectonic activation is observed; in the right bank of Vorona River, left branch of Vovcha River, the block displacement over 15-16 m along the northwest-trending fault is recorded (map sheet L-37-I, square I-3).

The Late Pleistocene epoch is marked by formation of loess and loess-like loams with former soils on the plateau and its slopes. The flora and fauna suggest for colder climate in the south of Ukraine in comparison to the modern one. In the river valleys alluvium of Trubizka, Vilshanska and Desnyanska terraces was forming. The flood-land bed is developed; the sand material in Vovcha River valley is re-deposited by the wind and ravine-gully system is extensively developed.

In the modern epoch the river flood-land and gully bottom alluvium is deposited in alluvial-deluvial sediments.

7. GEOMORPHOLOGY AND RELIEF-FORMING PROCESSES

The map sheet territory, in compliance with zonation, is situated in the junction zone between Azovo-Prydniprovska (A) and Donetska (B) heights and Prychornomorska lowland (C). Azovo-Prydniprovska morpho-structure occupies 92% of the territory. Over there, Zaporizka plain on the Neogene-Cretaceous base (A-I) and Pryazovska height on Precambrian basement (A-II) are developed. In the north-east Donetska erosion-denudation height on Herzinian folded base is located. The boundary between the latter and Azovo-Prydniprovska height follows the distribution boundary of Carboniferous sediments. Prychornomorska lowland is bounded by Konkskiy Fault from the north and Zakhidnopryazovskiy Fault from the east (map sheet L-36-VI). It included Nyzhnyodniprovska left-bank accumulative plain on the Neogene-Cretaceous base. Zonation is conducted in accordance with "Geomorphologic map of Ukrainian SSR and Moldavian SSR edited by I.L.Sokolovskiy, Kyiv, 1980". In tectonic respect Azovo-Prydniprovska height encompasses Vovchanskiy ledge, Konksko-Yalynska depression and north-western part of Pryazovskiy ledge. Donetska height is confined to the north-western margins of DDD and Prychornomorska lowland – to Prychornomorska depression.

The modern geomorphologic image of the territory comprises result of the long-term inherited history of geological development of the area. Relief is created by endogenous and exogenic processes developed over prolonged history of the territory geological evolution in Mesozoic-Cenozoic stage. In this period the territory underwent multiple tectono-epeirogenic activizations.

In the course of various-system fault activization the crystalline basement was split into the blocks in stair-wise fashion. The major blocks affected geological structure, conditions of sedimentation and relief formation include Pryazovskiy, Chubarivskiy, Velykomykhaylivskiy, Vilnyanskiy and others (see "Neo-tectonic scheme in the scale 1:500 000").

Structure-denudation, denudation, erosion-accumulative, aeolian, gravitational, and technogenic relief types are distinguished (see "Geomorphologic scheme in scale 1:500 000").

Structure-denudation relief comprises plateau. It is mainly constituted of the Late Mesozoic – Cenozoic rocks. In Pryazovskiy and Vilnyanskiy ledges the relief structure is only controlled by Pliocene-Quaternary sediments whereas in DDD relief is formed over Paleozoic-Cenozoic sediments. Plateau descends in the northern direction from 280 to 140 m over the distance of 80 km and in the western – from 160 to 50 m over 70 km comprising 7 minutes. The highest altitude (284.9 m) is located in the map sheet L-37-I in the area of Kuybysheve village.

Denudation relief is developed on the plateau slopes. The sharp boundary between plateau and slopes is not observed. The river valley slopes are often cut by the gullies.

Erosion-accumulative relief includes terraced valleys of Dnipro, Konka, Gaychur, Yanchur, Vovcha and Mokri Yaly rivers. Transversal profiles of rivers and gullies are asymmetric; the valley shape is trough-like and gullies are V-shaped. The depth of erosion cut is 60-70 m. In the upper river courses their beds are composed of Neogene rocks, in the middle course – Paleogene rocks, and in the lower course rivers flow through the crystalline basement rocks.

The river valleys includes flood-land and up to ten terraces. By the relief type they are erosion-accumulative. Somewhere the hard-rock (erosion) terraces are observed. At the base of flood-land and terraces the coarse-grained sands with gravel, pebble, gruss and debris occur. The column is capped by sandy clays, sandy loams and loams which are overlain by the loess facies and former soils.

The Pliocene terraces are locally developed; their fragments are observed in the right bank of Dnipro River and in the upper courses of Gaychur, Yanchur and Mokri Yaly rivers. In the modern relief terrace areas are expressed by the smoothed flats bounded by the contour lines 110-120 m in the right bank of Dnipro River and from 130-140 m to 120-130 m in Gaychur and Yanchur rivers. In case of Mokri Yaly River these values are 150-160 m. In the geological map Pliocene terraces are not shown.

Eo-Pleistocene terraces (Kyzyldzharska – tenth and Nogayska – ninth) in the modern relief are expressed by the smoothed flats bounded by the contour lines 100-110 m for Dnipro River, 130-150 m – for Mokri Yaly River, and 120-130 m – for Gaychur and Yanchur rivers. Lower Neo-Pleistocene terraces (Budatska – eighth, Donetska – seventh, Krukenytska – sixth) are identified by drilling. Middle Neo-Pleistocene terraces (Khadzhybeyska – fifth and Cherkaska – fourth) are weakly expressed in the relief. Upper Neo-Pleistocene terraces (Trubizka – third, Vilshanska – second and Desnyanska – first) and the flood-land are well expressed in the modern relief. In Dnipro River valley, higher the Dniproges Dam, Upper Neo-Pleistocene and Cherkaska

terraces are flooded beneath the waters of Lenina Lake. Lower of Khortytsya Island Desnyanska terrace is flooded beneath Kakhovske water reservoir.

The neo-tectonic activization in the area is observed along the latitudinal, longitudinal and north-western fault systems. Unequal uplift is observed being expressed in formation of cycle terraces. Elevation magnitude varies from 102-106 m for Dnipro River to 65-70 m for Konka and Mokri Yaly rivers. The valley of Verkhnya Tersa River comprises the young morpho-structure where Upper Neo-Pleistocene terraces only are encountered. Vilnyanska (tectonic) site is elevated by 22 m. The river valleys underwent some deformations along the latitudinal fault system which is well expressed in the outlines of Desnyanska terrace. These deformations are evidenced from the valley shortening, river bed deepening, lack of the low and high flood-lands, and the cliffy banks. Terrace socles are elevated by 6-8 m at these sites. Re-working of Vilshanska and Cherkaska terraces is observed at the point of Gaychur River inflow into Vovcha River and along the valley of Mokri Yaly River – re-working of Trubizka terrace with river bed bifurcation and formation of bypass remnants. The valley deformation is also expressed in the sharp change of the lengthwise river profile inclination degree. In general, the territory of map sheet L-37-I was ascending whereas adjacent map sheet L-36-VI – descending.

Aeolian relief is developed in the valley of Vovcha River where alluvial sands of the first terrace are being re-deposited by the wind and the hilly relief forms 3-5 m high are being formed.

Gravitational relief is encountered in the left bank of Dnipro River and in Kamyshuvakha and Chyngul gullies where it comprises circum-like land-slides. The hilly or stair-like relief is being formed through the sliding of loams over the surface of red-brown clays. The length of circum-like land-slides does not exceed 25 m and in the left bank of Dnipro River dimension of slides comprises hundreds of square meters, in places first square kilometers.

Anthropogenic relief forms in the map sheet territory include quarries, dumps, dams and newly-formed sites of geomorphologic landscapes where mining, irrigation and agricultural ones predominate. In Dnipro River valley, on the left bank (square II-1), the area 1.5×4.5 km in size is washed up where inhabited micro-district of Zaporizhzhya city is built.

8. HYDROGEOLOGY

According to "The State Water Cadastre of Ukraine" [11a] the map sheet territory is situated in the three first-order hydrogeological basins: Ukrainian basin of fractured waters (III-10A), Prychornomorskiy artesian basin (III-5B) and Donetskiy basin of bed-block waters (I-9A) (Fig. 8.1).

Ukrainian basin of fractured waters (UBFW) occupies the most space over the map sheets where Konksko-Yalynskiy minor II-order artesian basin as well as Prydniprovskiy and Pryazovskiy hydrogeological areas are distinguished. Prydniprovskiy area is located in the eastern and northern parts of map sheet L-36-VI (Zaporizhzhya). It is confined to the rocks of crystalline basement overlain by Paleogene and Neogene sandy-clayey, limestone, marleous sediments and Quaternary loams and loess. Pryazovskiy hydrogeological area is located in the southern part of map sheet L-37-I (Pology) in the 10-15 km wide band and comprises the ledge of crystalline basement rocks overlain by Quaternary sediments.

Konksko-Yalynskiy minor artesian basin is located to the north from Pryazovskiy area, in the map sheet L-37-I (Pology) and partly in the western part of map sheet L-36-VI (Zaporizhzhya). It belongs to the type of semi-closed basins where water-proof rocks are confined to the upper column part. The underground waters are contained in Cretaceous, Paleogene, Neogene and Quaternary sediments and constitute hydraulically-connected system. Feeding of the horizon is being performed through infiltration and discharge of fractured water from Prydniprovskiy and Pryazovskiy hydrogeological areas.

Prychornomorskiy artesian basin (PAB) is represented by its north-eastern part in the south of map sheet L-36-VI (Zaporizhzhya). Underground waters are contained in Cretaceous-Quaternary rocks. The waters are of low quality and are being formed through atmospheric precipitates as well as infiltration from water reservoir and irrigation systems. The water discharge is being conducted into Azovske Sea and river valleys. The water regime is affected by the scoops for water supplying and water outflow from mining operations.

Donetskiy basin of bed-block waters (DBBBW) occupies minor area in the north-east of map sheet L-37-I (Pology). Underground waters are contained in Quaternary, Neogene-Paleogene, Cretaceous and Carboniferous sediments.

In view of geology and hydrogeological features of the rocks in stratigraphic column the following water-bearing horizons are distinguished.

1. *Water-bearing horizons in modern alluvial and alluvial-deluvial sediments* (a,adH) are developed in the flood-lands of rivers and big gullies. Water-containing rocks include fine-grained sands and sandy loams 3-5 m thick. Water depth is up to 5 m. Water content of the horizons is variable and low. Water quality is inconsistent, mineralization – 1-5 g/dm^3. Sulphate-chloride-hydrocarbonate sodium-magnesium-calcium waters are being used by inhabitants for the housing needs. Water horizons are not protected from contamination.

2. *Water-bearing horizon in Pleistocene alluvial sediments* (aP) is developed in the Dnipro, Vovcha, Konka, Mokri Yaly and other river valleys and confined to the over-flood terraces. Water-bearing rocks up to 15-18 m thick include diverse-grained sands, in places with gravel admixture. Static level depth varies from 3 to 20-30 m. Borehole yield is 0.04-12 m^3/h, wells – 0.9-3.2 m^3/h. Horizon is hydraulically linked with underlaying ones. Dry residuum is 1-2.3 g/dm^3. By chemical composition the waters are mainly sulphate, hydrocarbonate-chloride-sulphate sodium-magnesium. The waters use being used for local water supplying. Horizon is not protected from contamination.

3. *Water-bearing horizon in Neo-Pleistocene aeolian-deluvial sediments* (vdP$_I$-P$_{III}$) is developed over entire studied area and is absent in the river and gully valleys. In the scheme (see Fig. 8.1) it is not indicated. The horizon is confined to the loess sediments. Porous-bed non-pressurized waters are contained in the loams and sandy loams. The depth of water-bearing horizon varies from 1 to 10-20 m (normally 5-10 m). The waters are mineralized, dry residuum varies from 1.5 to 3-4 g/dm^3; waters are hard, mainly sulphate and chloride-sulphate, of cations calcium and magnesium predominate. Horizon is not protected and undergoes surface contamination. Underground waters are not suitable for practical use.

4. *Water-bearing horizon in Pontychniy regio-stage sequence of sands and limestones* (N$_1$*pv*) is developed in map sheet L-36-VI (Zaporizhzhya). It is confined to sandy sediments and limestones. Depth of water-bearing horizon varies from 1-2 to 40 m, thickness – 5-8 m. High hypsometry causes horizon drainage. Water content is low. Water quality is inconsistent, dry residuum is 0.5-4.0 g/dm^3. Water type in the area varies from hydrocarbonate-sulphate sodium-magnesium-calcium to sulphate magnesium-calcium. Practical use is limited by the housing needs of water consumers. Water-bearing horizon is conventionally protected.

5. *Water-bearing horizon in Middle and Late Miocene sediments* (N_1ck, N_1kh+gl, N_1np_{2+3}) is developed in map sheets L-36-VI and L-37-I; it is absent in Pryazovskiy ledge. In Prychornomorskiy artesian basin this horizon is confined to the limestones and sands of Chokrakskiy and Sarmatian regio-stages (Neogene). There is no stable water-proof between the sediments that allows their consideration to be the common hydrodynamic system. The depth of water-bearing horizon varies from some meters on the river valley slopes to 80 m at watersheds. Over most part of area the horizon is non-pressurized with low yield – up to 1 dm^3/sec (rarely attains 2.8 dm^3/sec) and variable composition. Waters are mainly chloride-sulphate calcium-magnesium-sodium or hydrocarbonate-sulphate sodium-magnesium-calcium. Dry residuum is 0.7-4.6 g/dm^3. The water complex is being exploited by separate boreholes and is conventionally protected from surface contamination.

6. *Water-bearing complex in Upper Eocene – Lower Oligocene sediments* ($P_2^3+P_3^1$) is developed in Prychornomorskiy artesian basin and in Ukrainian basin of fractured waters. In the former case the complex is stratigraphically confined to the diverse-grained sands (with gravel admixture) and manganese ores of Planorbelloviy and aleurites of Alminskiy regio-stages. Thickness of the complex does not exceed 10 m. Depth of water-bearing horizon increases in the southern direction from 30-60 to 110 m. The complex is characterized by low filtration parameters and variable chemical composition; dry residuum is 0.8-4.0 g/dm^3. Water type is mainly sulphate, chloride-sulphate, in places hydrocarbonate-sulphate. Of cations, sodium, calcium and magnesium are contained in amount of more than 20 mg-equiv. The complex is not of practical use.

In Konksko-Yalynska depression this complex provides water supplying of Gulyajpole town. Water-bearing sediments include diverse-grained sands of Paleogene Reshetylivska and Yalynska sequences. In Gulyajpolske deposit approved reserves of the complex are estimated to 2800 m^3/day of which 620 m^3/day are scooped. Water mineralization does not exceed 1.5 g/dm^3; water type is mainly sulphate-hydrocarbonate calcium-magnesium-sodium.

Toward Pryazovskiy ledge the complex gets more complicated due to water-proof layers up to 10 m thick separating the common complex into the individual lenses and horizons. Number of water-proofs increases southward. The complex becomes pressurized with pressure values from 60-70 to 100-120 m. Water content does not exceed 2-5 m^3/h, dry residuum – 0.5-1 g/dm^3. Waters are chloride-sulphate-hydrocarbonate and hydrocarbonate-chloride-sulphate; of cations, sodium and calcium predominate. Water-bearing horizon is protected.

7. *Water-bearing complex in Lower-Middle Eocene sediments* (P_2^{1+2}) is developed in PAB, Prydniprovskiy hydrogeological area and in Konksko-Yalynska depression. Water-bearing rocks include coarse-grained sands with gravel. There are no water-proof rocks between Lower and Middle Eocene sediments and the water-bearing horizons are combined into the common complex. The depth varies from 40-50 to 200 m; thickness of water-bearing rocks is 20-30 m. Water content is high. Borehole yield varies from 0.8-2.3 to 5-6 dm^3/sec at the depression up to 6 m. Water quality is appropriate. Dry residuum is 0.4-1.5 g/dm^3; total hardness – 0.4-10 mg-equiv./dm^3. Water type is hydrocarbonate-sulphate sodium-calcium-magnesium to sulphate-chloride and chloride, mainly calcium-sodium. The complex regime is broken due to the development and exploitation of Southern Bilozerske iron-ore deposit and extensive scooping for water supplying. This caused water level descent over entire area of complex development. For the last 37 years the water level descent is 1-3 m per year in average. Four water scoops are based on the complex which exploiting non-approved reserves of underground waters; some water-scooping boreholes are also in operations.

8. *Water-bearing horizon in Upper Cretaceous sediments* (K_2) occupies the north-eastern part of map sheet L-36-VI and most of map sheet L-37-I. It is located in PAB, Konksko-Yalynskiy minor artesian basins and in DBBBW. In PAB horizon is 2-5 to 26 m thick. Its depth increases to the south from 100 to 250 m. Pressure value attains 185 m. This horizon is actually out of production and weakly studied. In Konksko-Yalynskiy basin and DBBBW the horizon is confined to the upper 5-20 m thick fractured part of the sequence of marls, marleous sands and sandstones. Water content of Cretaceous horizon is high, borehole yield – 0.5-76 m^3/h, dry residuum – 0.7-1.1 g/dm^3. Waters are hydrocarbonate-sulphate-chloride calcium-magnesium-sodium. Horizon is of limited use; it is protected.

9. *Water-bearing zone in fractured Lower Carboniferous sediments* (C_1) is located in DBBBW and is related to the fractured and karsted limestones and dolomites. Hanging-wall depth is 20-200 m, thickness of water-bearing zone – 40-260 m. Piezometric surface is located at the depth 0.5-50 m. Borehole yield is 0-39.6 dm^3/sec. Water-bearing horizon is hydraulically connected with adjacent water-bearing complexes. Water quality is inconsistent, dry residuum is 0.9-4.1 g/dm^3. Chloride-sulphate-hydrocarbonate waters are being used for water supplying of Bogatyr, Konstantynivka, Komar, Fedorivka and other villages. Mineralized underground waters are mainly of chloride sodium composition, increased bromine content is observed. Water-bearing horizon is conventionally protected and protected.

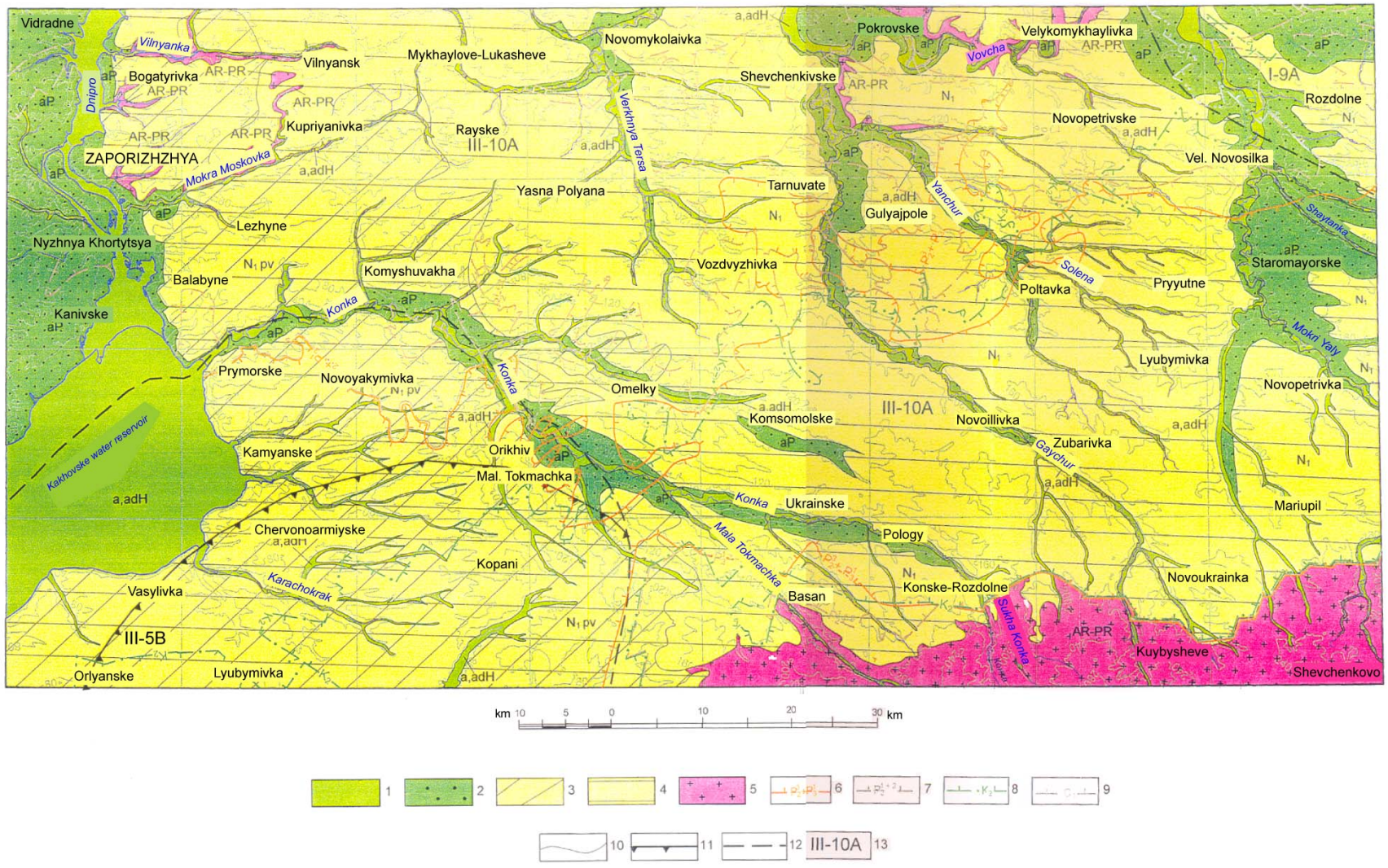

Fig. 8.1. Distribution scheme of water-bearing horizons (complexes). See next page for the legend.

Fig. 8.1. Distribution scheme of water-bearing horizons (complexes). See next page for the legend.

Distribution areas of water-bearing horizons: 1 – in modern alluvial and alluvial-deluvial sediments (a,adH); 2 – in Pleistocene alluvial sediments (aP); 3 – in Pontychniy regio-stage (N_1pv); 4 – in Middle-Late Miocene sediments (N_1); 5 – in Archean and Proterozoic fractured rocks of crystalline basement (AR-PR).

Contours of buried water-bearing horizons and complexes: 6 – in Late-Eocene – Early-Oligocene, 7 – in Early-Middle Eocene, 8 – in Late Cretaceous, and 9 – in Early Carboniferous sediments; 10 – boundary of water-bearing horizon; 11 – groundwater depression boundary; 12 – boundaries of I-st order hydrogeological basins; 13 – basin indices according to the State Water Cadastre of Ukraine (III-10A – fractured waters of Ukrainian Shield, III-5B – Prychornomorskiy artesian, I-9A – Donetskiy of bed-block waters).

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10. *Water-bearing zone in fractured Archean and Proterozoic crystalline rocks* (AR-PR) is developed in Prydniprovskiy and Pryazovskiy hydrogeological areas. Thickness of the fractured zone is 5-90 m. Filtration properties and water quality is variable. Borehole yield is 0.01-20 m^3/h, water quality is not appropriate. Water type varies from hydrocarbonate-sulphate sodium-magnesium-calcium to sulphate-chloride calcium-magnesium-sodium. Dry residuum is 1-5 g/dm^3. Waters are being used for water supplying by single exploitation boreholes from where the total scooping is 34.6 thousands m^3/day.

In Konksko-Yalynska depression waters from the basement are being used in limited amounts at Gulyajpilskiy water-scoop. Reserves in Gulyajpilske deposit are approved to 200 m^3/day.

In the studied area occurrences of mineral and medical radon waters are known. Their description is given in the section “Mineral resources and regularities in their distribution”.

9. MINERAL RESOURCES AND REGULARITIES IN THEIR DISTRIBUTION

In the history of geological development Precambrian and Phanerozoic stages are known which various mineral resources are related with. According to the metallogenic zonation of Precambrian folded basement the map sheet territory is situated in the Middle-Dniprean, Orikhovo-Pavlogradska and Zakhidnopryazovska tectonic-metallogenic zones (TMZ) where Konkskiy and Bilozerskiy, Orikhivskiy and Shevchenkivsko-Fedorivskiy, Gaychurskiy, Gulyajpilskiy and Kuybyshevskiy ore camps are defined respectively as well as numerous ore (or ore-bearing) fields. Metallogenic zonation coincides with the defined litho-tectonic zones and tectonic blocks.

Mineral resources of crystalline basement include deposits and occurrences of iron ores, rare, trace, base and precious metals, primary kaoline, facing-ornamental and construction stones etc.

The Meso-Cenozoic sedimentary cover is included into Dono-Dniprovska province and province of Ukrainian Shield. Over there manganese, brown coal, brick and refractory clays, secondary kaolines, construction and foundry sands, fresh and mineral waters are encountered.

This section contains description of major mineral deposits and occurrences of each type. Remaining objects are briefly described in the lists of deposits and occurrences (Annexes 1-6). Mineral deposits and occurrences in the map sheets L-36-VI and L-37-I are indicated in the following order: "Geological map and map of mineral resources of pre-Quaternary units" (Annexes 1 and 4), "Geological map and map of mineral resources of Quaternary sediments" (Annexes 2 and 5), "Geological map and map of mineral resources of crystalline basement" (Annexes 3 and 6).

Combustible minerals

Solid

Brown coal

In the studied area brown coal is known in Paleogene sediments. Conducted geological-prospecting works identified two brown coal deposits and three occurrences mainly in the map sheet L-37-I.

Sanzharske deposit (I-1,2-13, II-2,3,4-13 – map sheet L-37-I). Square is 171 km^2, length – 75 km, width – 2-12 km, strike – north-western. Thickness of the brown coal layer attains 15 m, depth – 30-90 m. Coal ash content is 9-40%, volatiles – 43.5%, heating value of dry fuel per flammable mass is 6693 cal. The layer contains interbeds of high-ash coal. Hydrogeological conditions are hard. Reserve growth is possible through extended exploration of brown coal occurrences which contain bypass mineralization of uranium, rare and trace elements. Brown coal can be used in the energy purposes.

Orikhivske deposit (IV-3-32 – map sheet L-36-VI) is located in Orikhivskiy area. It is extended in the north-eastern direction over 40 km. Two brown coal layers are encountered which are separated by 22-24 m thick sandy-clayey sediments. The upper layer exhibits complex structure. Its thickness is 1-9.6 m, lower one – 1.0-6.3 m. Depth of layers is 15-122 m. Coal of the upper layer can be used in the energy purposes whereas motor oil can be obtained from the lower layer coal.

Metallic mineral resources

In the studied area, in the crystalline basement rocks, increased concentrations of base, precious, radioactive, rare, trace and rare-earth metals are encountered, as well as iron-ore and lithium deposits. The sedimentary cover contains major manganese deposit as well as gold occurrences.

Ferrous metals

Considerable amount of ferrous metal deposits are identified in the studied area, mainly iron-ore, and one manganese deposit. In genetic respect the iron-ore objects are confined to the Precambrian metamorphosed units whereas manganese ones – to the rocks of Oligocene marine carbonate-terrigenous formation.

Iron

In the studied map sheets Gulyajpilske and Vasynivske iron-ore deposits with explored reserves are located. In addition, four minor deposits and a number of prospects are encountered. By genesis the iron-ore objects are related to ferruginous-siliceous-schist formation. Geological-economic type is metamorphogenic; ore-body shape – sheet-like; composition cummingtonite-magnetite and amphibole-magnetite; ore-bearing structures – synclines and monoclines with steeply-dipping limbs.

Gulyajpilske deposit (III-1-81) is located in Gulyajpilskiy area of Zaporizka Oblast, within Zakhidnopryazovska LTZ. It comprises ellipse-like syncline 9 km long and 3 km wide extended in the north-western direction. Square of deposit is 27.5 km^2. The depth of ferruginous quartzites is 40-140 m; fold hinge – 3 km. The layer of ferruginous quartzites lies dips at the angle 68-87^o conformably to the host rocks.

Gulyajpilska magnetic anomaly is encountered in 1930 by Ukrainian geophysical trust. Deposit is explored by Bilozerska GEE in 1985. The iron-ore balance reserves by categories A, B, C_1 and C_2 are approved. The overburden rocks are suitable in the construction material purposes (III-1-104). The site in western limb is developed for economic mining by open-cast method [84].

Deposit is complicated by the rocks of Gulyajpilska Suite which lies over granitoids of Shevchenkivskiy Complex and is overlain by 40-140 m thick Meso-Cenozoic sediments. The middle sub-suite contains 40-425 m thick ore body composed of cummingtonite-magnetite, stilpnomelane-riebeckite-magnetite and cummingtonite-biotite-magnetite quartzites. The ores are almost free of the harmful and dopant admixtures; content of total iron is 25.82% and magnetite iron – 16.57%. Magnetite contains idiomorphic admixture of germanium – 2.5-19.5 g/t. The rocks of lower sub-suite 50-80 m thick contain staurolite and andalusite in great amounts. Their bypass mining is possible.

Deposit is overlain by 2-60 m thick weathering crust. In the southern part the linear oxidation zone up to 300 m deep is confined to the quartzite layer. The crust profile is incomplete: disintegration, leaching and transitional weathering product zones predominate.

Vasynivske deposit (II-4-77) is located in Orikhivskiy area of Zaporizka Oblast, in the central part of Orikhovo-Pavlogradska LTZ. It is confined to sub-longitudinal syncline 5.4 km long with limb range up to 1.3 km. Square of deposit is 7 km^2, depth – 40 m below the surface. It is discovered in 1933 by Leningradskiy institute of applied geophysics. Detailed exploration is conducted by Pryazovska GEE in 1989 [82]. The iron-ore reserves are approved by categories $B+C_1$ and C_2. By technical-economic parameters is not of separate economic value.

Deposit is composed of Paleo-Archean Vovchanska Sequence where in the column two ore batches are distinguished. The ores are composed of amphibole-magnetite quartzites. The ore structure (syncline) is divided by tectonic breaks into the Central and Western parts and these ones, in turn, into the Central, Eastern and Transitional and Western ore bodies respectively. Thickness of ore layers varies from 5 to 65 m, length – from 200 to 3000 m. To the depth quartzites are traced up to 400 m. The ores require beneficiation; they are free of the valuable and harmful impurities. Average germanium content in the ores is 3.34 g/t.

Thickness of weathering crust is 20 m in average.

Regularities in the distribution of iron-ore deposits and occurrences are related to the history of geological development where several stages are distinguished.

The Early-Archean stage is marked by deposition of thick sedimentary-volcanogenic and volcano-sedimentary sequences and formation of “Baltic type” amphibole-pyroxene quartzites under granulite facies conditions (Vasynivske and Pivdennotersyanske deposits and occurrences of Novopavlivskiy Block).

In the Late Archean stage greenstone belts were forming in the Middle-Dniprean TMZ constituted of Konkska and Bilozerska series; formation of minor deposits of Verkhivtsivskiy-type low-grade amphibole-magnetite quartzites (Pivnichnotersyanske deposit) and large enough Kryvorizkiy-type deposits (Kyrpotynske and Veselyanske) respectively.

The Early Proterozoic stage is most favourable for the iron-ore object formation and Gulyajpilske deposit of Kryvorizkiy type was formed that time.

Geological control of mineralization is expressed in deposit location at the sites of ore-hosting formations. The following formations are most productive in the studied area: jaspilite-siliceous-gneiss in

Orikhovo-Pavlogradska LTZ (Vasynivske deposit and some ferruginous quartzite occurrences); jaspilite-tholeiite – in the Middle-Dniprean TMZ (occurrences by periphery of Konkska greenstone structure and Pivnichnotersyanske deposit); jaspilite-siliceous-schist developed in the western part of Konkska structure (Veselyanske and Kyrpotynske deposits) and in Zakhidnopryazovska TMZ (Gulyajpilske deposit (III-2-81)).

Manganese

The eastern flank of Southern-Ukrainian manganese-ore province is located in the map sheet L-36-VI. In the coastal-marine Paleogene Borysfenska Suite sediments *Velykotokmatske deposit* of manganese ores (IV-3-30) is discovered. It is located in 20 km to the south-east of Zaporizhzhya city and comprises the ore body extended in sub-longitudinal direction over up to 100 km. The map sheet territory encompasses its northern flank.

The manganese ore layer 0.1-3.0 m thick lies at the depth 25-140 m. Deposit contains oxide, mixed and carbonate manganese ores. Oxide ores are observed at altitudes 0-11 m and carbonate ores lie below at altitudes 0-2 m. Carbonate ores include platy (below) and lumpy varieties. Oxide ores do exhibit friable, lumpy and oolite textures. Manganese content in the ores (%): oxide – 26, mixed – 23, carbonate – 22. Phosphorus content (%): 0.34, 0.3 and 0.21 respectively.

On the base of manganese ore reserves Tavriyskiy MBP is built up which at present is suspended by economic reasons.

Non-ferrous metals

This group in the studied area includes occurrences of copper, molybdenum, nickel, lead and zinc confined to the rocks of crystalline basement.

Copper

In the studied area four copper occurrences are encountered in Konkska greenstone structure, Fedorivska structure and zone of Prakonkskiy Fault. Kyrpotynska site in Konkska greenstone structure is most perspective.

The copper occurrence in Kyrpotynska site (I-2-59) comprises massive copper-sulphide mineralization in the rocks of meta-dacite-andesite-tholeiite association. Mineralization is epigenetic (superimposed, re-mobilized). The faults break the site into the blocks where the rocks are extensively silicified, sulphidized, microclinized, albitized and greisenized [46, 63].

In the perspective site the minor copper deposits are foreseen in the disseminated zones and columnar ore bodies in the fault-related fractures and flexures in greenstone sequences.

In Gulyajpilsko-Saltychanskiy Block, in the south of map sheet L-37-I, the Konksko-Rozdorivska (IV-3-95) and Kuybyshevska (copper resources are evaluated by category P_3) sites are distinguished. Copper occurrences include quartz-sulphide and copper-porphyry types related to the minor monzonite massifs and dykes (outside the map sheet).

In Fedorivska structure two copper (Cu content up to 1%) occurrences (I-4-68, I-4-69) of quartz-sulphide (vein) type related to the hydrothermal processes are encountered in two-mica gneisses, schists and calciphyres. Their perspectives are limited.

Nickel and cobalt

In the map sheets over the previous works 13 nickel occurrences are encountered most of which are located in the map sheet L-36-VI (Zaporizhzhya), in Konkska greenstone structure and Novopavlivskiy Block of Orikhovo-Pavlogradska LTZ. Most of nickel-cobalt occurrences are related to the nontronite weathering crust developed after the rocks of scattered minor mafic-ultramafic intrusions. Weathering crust after ultramafic rocks contains up to 2.5% of nickel, 0.044% of cobalt and 40.3% of iron. Amount of nickel resources foreseen in weathering crust of the biggest massifs and mining-geological conditions do not promise economic interest [63]. In the map three only most notable occurrences of this mineralization type are indicated (III-3-78, III-3-80 and III-3-81).

The nickel sulphide type of mineralization is encountered in the map sheet L-37-I (Pology); three nickel sulphide ore occurrences are found in outcrops at Konksko-Rozdorivska site of Gulyajpilskiy Block, in the remnants of actinolite schists (meta-gabbroids) within granitoids (IV-2-92, IV-2-93 and IV-2-94). Nickel content

is up to 1%, cobalt – up to 0.007%. Together with copper and rare-earth occurrences and numerous findings of copper mineralization they form Kuybyshevske ore field. Another nickel occurrence (II-2-71) is encountered in Kyrpotynske ore field (Konkska greenstone structure); it is confined to the silicified and carbonatized amphibolites, actinolitites and tremolitites of Surska Suite. Mineralization comprises pentlandite dissemination. Nickel content is 0.3%, cobalt – 0.04%. Perspectives for new discoveries are not clear.

Lead and zinc

Occurrence of lead-zinc ores (I-4-65) and lead (III-2-85) are encountered in the map sheets.

Occurrence (I-4-65) of lead-zinc mineralization is found in the map sheet L-36-VI, in Tersyanske ore field, in retrograde rocks of carbonate-talc-chlorite composition and sheared serpentinized magnetite-amphibole skarnoids, in the gneiss sequence, in the zone of Orikhovo-Pavlogradskiy Fault. By drilling data, zinc content is up to 10%, lead – 5%, molybdenum – 0.3%, cerium – up to 0.1%, scandium – 0.03%. Mineralization is of skarn type. Prognostic resources are evaluated by category P_3 [63].

Occurrence (III-2-85) of lead (0.7%) with tin (0.05%) and antimony (0.1%) is encountered in the map sheet L-37-I, in Gulyajpilskiy Block, in the contact zone between biotite granites and plagiomigmatites. Prognostic resources of the metals are evaluated by category P_2 [63, 71].

Rare metals

Occurrences of rare-metal mineralization, except zirconium ones, in the map sheet territory are confined to the second tectonic level of crystalline basement – superimposed Meso- and Neo-Archean greenstone belts.

Beryllium

Beryllium occurrence (III-4-82) is located in the south of Orikhovo-Pavlogradska LTZ, in Kampaniivske ore field. It is located is silicified amphibolites of Novopavlivska Sequence, in the contact zone with granitoids. Mineralization is of skarn type [53].

The bypass-component beryllium is encountered in spodumene pegmatites of Shevchenkivske lithium deposit.

Lithium, rubidium, cesium

Lithium deposit and occurrence and two rubidium occurrences are encountered in the map sheet territory. The major objects are located in Shevchenkivska and Fedorivska structures composed of gneiss-schist rocks of Ternovatska Sequence containing rare-metal granite pegmatites.

Shevchenkivske lithium deposit (I-3-66) is located in Velykonovoselkivskiy are of Donetska Oblast nearby Shevchenko village. Square is 0.8 km^2; sedimentary cover thickness – 70-120 m; explored to the depth 500 m. Deposit is discovered by Novomoskovska GEE of SE "Pivdenukrgeologiya" in 1982 [74]; explored in 1983-1988 [64]. Reserves of lithium ore and valuable components (niobium, tantalum, beryllium and rubidium) are approved by SCMR of USSR.

Deposit is confined to the north-eastern margin of Zakhidnopryazovskiy Block (contact of Gaychurskiy and Vovchanskiy blocks), the junction zone of Shevchenkivska structure and Fedorivska brachy-syncline. Structure is extended in sub-longitudinal direction over 15 km being 0.5-2.5 km wide. It is composed of gneisses and mafic gneisses which are divided into the alumina, carbonate and mafic-gneiss batches. The metamorphic rocks are surrounded by Archean granites and migmatites. Rare-metal pegmatites are observed in the 700 m thick mafic-gneiss batch. The width of pegmatite field is 260-300 m, length – 500 m, by depth it is traced up to 600 m. Thickness of weathering zone is up to 35 m. Ore minerals in this zone are replaced by clayey products which do not keep lithium.

Defined ore pegmatite veins are closely-spaced; they are of steeply-dipping, northern extension, complex zoned patterns, highly-variable thickness. Seven tectonic-mineralogical zones are distinguished. Mineralization is related to albite-, microcline- and petalite-spodumene zones. Major ore minerals are spodumene and petalite; accompanied minerals: lithium micas and phosphates, niobium, tantalum and beryllium minerals which occur in accessory admixtures. Lithium oxide content is 0.3-4%.

Notable lithium occurrence (I-3-64) is located in Shevchenkivska structure in 8 km to the north from above deposit. It contains albite-spodumene pegmatite vein [74].

In Fedorivska structure occurrence (I-4-70) of rare alkaline metals (rubidium) is related to granite pegmatites of microcline, microcline-albite and albite-spodumene composition [77]. Prognostic resources are evaluated by category P_2.

In Konkska structure rare alkali mineralization is associated with rare-metal pegmatites of Mokromoskovskiy Complex confined to the tectonic zones composed of Mykhaylivska Suite meta-volcanogenic-sedimentary rocks of Bilozerska Series or retrograded granitoids.

Rubidium occurrence of this type is encountered in the tectonically broken eastern contact of Mokromoskovskiy massif nearby Kupriyanivka village (I-2-58). Ore body comprises muscovite pegmatites about 1 m thick and up to 10 m long. Rubidium content is 0.13%, lithium – 0.024%, cesium – 0.007%. Ore mineral is not determined.

Molybdenum

Five occurrences of molybdenum mineralization are encountered in the studied area (three ones in map sheet L-36-VI and two – in map sheet L-37-I). These are located in Konkska greenstone structure and in the eastern part of Gulyajpilskiy Block (Gaychurska and Kosivtsivska greenstone structures). In Konkska greenstone structure two molybdenum occurrences are found – II-2-69 of quartz-vein type and II-2-72 of skarn type confined to the silicified rocks of Bilozerska Series. Molybdenum is paragenetically linked with tungsten, copper and nickel.

Molybdenum occurrence (III-2-84) is encountered in the south-eastern flank of Kosivtsivska greenstone structure (Kosivtsivskiy prospect) in the junction zone of Gaychurskiy and Kuybyshevskiy faults within biotite-amphibole gneisses (AR_1vt). Molybdenum content is 0.15% [63]. Occurrence is of greisen type. Molybdenum is associated with yttrium.

Occurrence (II-2-79) is encountered in the south of Gaychurska structure in two-mica gneiss greisen formation. Molybdenum content is 0.15% (tungsten – 0.015%, lead – 0.02%, silver – 1.5 g/t). Prognostic resources are evaluated by category P_3 [63, 71].

Perspectives for discovery of economically valuable molybdenum deposits in the map sheets are limited.

Niobium and tantalum

Tantalum (III-3-79) and niobium (IV-3-85) occurrences are encountered in the map sheet L-36-VI (Zaporizhzhya), and two niobium occurrences (II-1-72 and IV-2-90) – in the map sheet L-37-I (Pology). Major perspectives of the area are related to the rare-metal pegmatites confined to the trough-like superimposed structures (Gaychurska, Shevchenkivska, Fedorivska and Chystopilska).

Tantalum occurrence (III-3-79) is located in the western exo-contact zone of Shcherbakivskiy massif granites with cataclased amphibolites of Bazavlutska Sequence and is complicated by Zakhidnoshcherbakivskiy (section of Vasylivsko-Kamyshuvakhskiy) fault. Mineralization is contained by the quartz (fenite) formation. Tantalum content is 0.02%, niobium – 0.07%, zirconium – 0.15%. Occurrence is not evaluated.

Promising occurrence (IV-3-85) is encountered in Chystopilska greenstone structure of Orikhovo-Pavlogradska LTZ (Kompaniivskiy prospect). Mineralization is confined to the rare-metal pegmatites (AR_3jn). Niobium content is 0.5%, copper – 0.04%, lead – 0.2%. Structure is perspective for discovery of rare-metal and rare-earth deposits of pegmatite genesis.

Niobium occurrence (II-1-72) in biotite gneisses of Ternovatska Sequence in the zone of Andriivskiy Fault, in the area of the south-western flank of Gaychurska structure, apparently is related to the rare-metal pegmatite formation. High (0.7%) content of the principal and accompanied elements comprising association atypical for niobium (tungsten – 0.5%, copper – 0.5%, cobalt – 0.07%, and gold – 0.5 g/t) makes some doubts concerning the natural genesis of this occurrence. Further works over there [73] did not provide positive results.

Zirconium

Occurrences of zirconium mineralization (I-1-62 and II-2-74) with content up to 1% are only encountered in the map sheet L-37-I (Pology). They are confined to the weathering crust after granitoid rocks. Numerous occurrences with undefined parameters were taken off as non-perspective. Perspectives for discovery of considerable zirconium deposit in the map sheets are limited.

Precious metals

Gold

Gold mineralization in the studied map sheets is related to the greenstone belts. In the map sheet L-36-VI (Zaporizhzhya), in Konkska greenstone structure, perspective occurrences are not identified so far; in the map sheet L-37-I (Pology) Gaychurskiy gold occurrence (II-1-71) is encountered in Gaychurska structure in its junction zone with Kosivtsivska structure. Another occurrence and three points of gold mineralization are found in Gulyajpilska syncline. In the southern part of Gulyajpilskiy Block, over prospecting for diamonds, in the heavy concentrate from the modern alluvium in the upper course of Konka River and its branches, the gold traces 0.5-1 mm in size are encountered in three points.

Gaychurskiy gold occurrence (II-1-71) is located in the central part of the same-named structure. The zone of sulphide mineralization and silicification is encountered within sheared garnet-biotite gneisses and mafic gneisses of Ternovatska Sequence containing ultramafic rocks of komatiite composition. The sequence is injected by micro-plagiogranite veins and dykes. Gold content varies in the range 0.3-10.8 g/t, silver – 0.2-20 g/t. Ore structure is vein-disseminated. Ore minerals: pyrite (15%), native gold (10-15 particles), magnetite (3%), chalcopyrite and pyrrhotite.

Gold is the latest mineral. It forms isometric grains 0.05-0.2 mm in size, often rims around pyrite grains, and is also developed along quartz grains. Fineness is 917. Impurities include silver – 7.9% and iron 0.1%. Location of gold mineralization is related to the mineralized zones of superimposed shearing controlled by granite dykes (veins). Mineralization is accompanied by bismuth, scandium, vanadium findings and copper, molybdenum and tungsten mineralization points.

Prognostic gold resources in Gaychurska structure are evaluated by category P_3 [73, 113, 110]. In Gulyajpilska syncline, in meta-sandstones of lower sub-suite, gold content does not exceed 0.1-0.3 g/t, in vein quartz – 0.3 g/t. In gold occurrence (III-1-83) in the chip sample from pyritized quartz-biotite schists and meta-sandstones of upper sub-suite gold grade, by fine assay data, attains 17.4 g/t. Occurrence is not evaluated.

Trace metals

The trace metals (germanium, gallium, thallium and scandium) are widespread enough in the map sheets but at present of practical value can be germanium only which concentration is related to the iron ores of Gulyajpilske and Vasynivske deposits where germanium reserves are estimated.

Gallium

The only occurrence of gallium mineralization (I-3-65) in the map sheet L-37-I is found in the northern part of Shevchenkivska structure in muscovite-biotite gneisses of Ternovatska Sequence. The ore mineral is not identified. Perspectives of the occurrence are not defined.

Thallium

The thallium occurrence (IV-2-87) is encountered by DH 0282 [77] in the southern part of Gulyajpilskiy Block, in 2 km to the north from Konkskiy Fault, at its intersection with the zone of Pologivskiy regional fault. The host rocks include brecciated and cataclased granitoids of Novopavlivskiy Complex with the remnants of Zakhidnopryazovska Series rocks. Ore mineralization comprises sulphide and magnetite disseminations. Thallium content is 0.007%, bismuth – 0.1%, chromium – 0.05%, nickel – 0.07%. Occurrence is not appraised and its perspectives are not defined.

Scandium

Scandium occurrence (IV-2-29) in the map sheet L-36-VI is related to the coaliferous sediments of Simferopolskiy horizon (Paleogene). Scandium is disseminated in xenotime and monazite and is appraised as the concomitant element together with yttrium, cerium and lanthanum. Buchatskiy occurrence encountered by DH 0412, 0285-0287 [76] is thought to be perspective.

Rare-earth metals

Yttrium, ytterbium

Eight occurrences of yttrium mineralization are encountered in the studied area. Particularly, one occurrence (IV-4-86) [68] is found in Orikhovo-Pavlogradska LTZ in the map sheet L-36-VI (Zaporizhzhya), and seven ones – in the map sheet L-37-I (Pology), specifically, four – in Uspenivska site (II-2-75, II-2-76, II-2-77 and II-2-78), and three (IV-1-86, IV-1-88 and IV-1-91) – in the southern part of Gaychurskiy Block, in the zone of Prakonkskiy Fault (Kuybyshevskiy ore camp). Occurrences are related to the rock association of rare-metal-rare-earth granite pegmatites and their weathering crust with xenotime, monazite and orthite. Most of occurrences (five of seven) in tectonic respect are confined to Meso-Archean trough structures (Chystopilska and Gaychurska), composed of Ternovatska Sequence rocks, metamorphosed under andalusite-(muscovite)-sillimanite facies PT-conditions and injected by pegmatites. And most of occurrences (five) are confined to weathering crust. Yttrium content in occurrences varies from 0.07 to 0.3%, mainly 0.15%. Accompanied components in the ores include ytterbium (up to 0.02%), lanthanum (up to 0.2%), niobium (up to 0.07%) and molybdenum (up to 0.3%).

Most studied yttrium occurrences are located in Uspenivske ore field located in the eastern flank of Gaychurska structure and composed of two-mica, garnet-biotite and high-alumina gneisses and mafic gneisses of Ternovatska Sequence. Metamorphic rocks are intruded by pegmatite and pegmatoid granite veins; chloritization and carbonatization are recorded. Thickness of weathering crust is up to 30 m. The intervals with high yttrium content are accompanied by ytterbium, niobium, zirconium, molybdenum and lead geochemical anomalies.

Prognostic yttrium resources in Uspenivskiy occurrence are evaluated by categories P_2 and P_3 [73]; Kuybyshevskiy ore camp and occurrences in Orikhovo-Pavlogradska LTZ – by category P_3 [63].

Radioactive metals

Uranium

Five uranium occurrences are encountered in the map sheet territory: Bekarivskiy, Vasynivskiy (map sheet L-36-VI), Gulyajpilskiy, Malynivskiy, Rizdvyanivskiy and Solodkivskiy (map sheet L-37-I).

Gulyajpilskiy (II-2-73), Bekarivskiy (I-2-61) and Vasynivskiy (II-4-76) occurrences belong to the hydrothermal uranium geological-economic type. Mineralization is located in biotite gneisses, mica-chlorite-amphibole schists, plagioclase-biotite mafic gneisses, cataclased granites and quartzites. Radioactive mineralization includes uraninite, monazite, coffinite, oxidized pitchblende. Valuable component content is as follows: uranium – 0.016-1.222%, thorium – 0.002-0.11%.

Gulyajpilskiy complex uranium occurrence (II-2-73) is located in Gulyajpilskiy area of Zaporizka Oblast, in 25 km to the north of Uspenivka village. Occurrence is discovered in 1977 bu Novomoskovska GEE.

In tectonic respect occurrence is confined to the tectonically broken contact of volcano-sedimentary Vovchanska Sequence, observed in the horseshoe-like 1000 m wide syncline, and granitoids of Novopavlivskiy Complex. In the fault zone the rocks are extensively crushed and milonitized; pyrite-pyrrhotite mineralization is recorded with silver content – 30 g/t, gold – 0.5 g/t, copper – 0.015%, and lead – 0.01%.

By gamma-logging data two anomalous intervals up to 3500 mCu/h are defined. Uranium mineralization is resulted from low-temperature hydrothermal metasomatism of gneisses at their contact with ferruginous quartzites. Being the adsorbed impurity, uranium is included into organic matter, chlorite, epidote, leucoxene, iron hydroxides, and is also observed in uranium blacks and uranium oxides occurring in the tight intergrowth with organic matter.

Scientific-Technical Council of SE “Kirovgeologiya” has appraised this occurrence as one requires special prospecting-evaluation works and approved occurrence for the mineral inventory.

Uranium mineralization is related to the brown coal of Rizdvyanivskiy and Solodkivskiy occurrences. Of these Solodkivskiy occurrence (II-2-7) is more studied; it is confined to the Eocene Buchatski sediments fill up the left branch of Vovchanska Depression. The layer thickness in the occurrence is 2-18 m, depth – 67-100 m. Uranium is contained by coaliferous clays and brown coal. In the mineral admixture 0.01-0.1 mm in size accompanied minerals are observed: zircon, leucoxene, monazite and xenotime. They contain rare metals, trace and rare-earth elements: yttrium – 0.01-0.3%, scandium – 0.007-0.02%, zirconium – 0.2-1%, germanium – 0.002-0.007%, niobium – 0.007-0.02% and lanthanum – 0.05-0.07%. Occurrence is non-perspective.

Non-metallic minerals

This group of minerals includes numerous deposits and occurrences of raw materials for chemical, agro-chemical industries and metallurgy, construction materials, raw materials for porcelain, mineral fibre and abrasives, as well as underground fresh and mineral waters.

Secondary kaoline, clay

These include Paleogene-Neogene sediments developed in the map sheet L-37-I where clay and kaoline deposits and occurrences are encountered.

Pologivske deposit (III-1-18) is in production. It is located nearby Pology town. The minerals include Miocene Novopetrivska Suite secondary kaolines and refractory clays of kaolinite composition. Average thickness of the layer is 3.55 m, overburden rocks – up to 30 m. Kaolines comprise principal and major mineral commodity. They are suitable for class "A" chamotte and class "B" refractory wares manufacturing. Commodity is being used in machinery construction, in ceramic and cement industries.

Pivnichnopologivske deposit (III-2-23) is located in 4 km to the north from Pology town. It is out of production, recorded in reserve.

Sanzharivske deposit (II-3-13). Secondary kaolines are observed at the bottom of brown coal layer in Sanzharivske depositat the depth 30-90 m. Commodity is suitable for chamotte wares manufacturing. Kaolines can be mined bypass to the coal extraction.

Perspective occurrences include Mykolaivskiy (II-1-4), Dobropilskiy (II-1-5) and Myrniy (III-1-17) which are recommended for exploration. Occurrence Myrniy is a complex one. Kaoline-hosting quartz sands 15-20 m thick (N_1np_3) comply with the State Standard 2138-74 to the foundry raw materials and are suitable for high-quality glass manufacturing (optical, lead-less cut-glass ware etc.).

Talc-magnesite

In the studied area, in Konkska greenstone structure, *Veselyanske deposit* (II-2-75) is encountered; it is confined to the same-named intrusion of Varvarivskiy Complex and is located nearby Veselyanka village of Zaporizkiy area. Deposit is discovered by Konkska GEE in 1955. It is explored in details.

Talc-magnesites comprise the hydrothermal reworking product of ultramafic rocks. Ore body is 5 km long, 30-300 m wide; overburden thickness is 20-60 m. Mineralogical composition of the rocks in deposit is consistent. Refractory capacity encompasses interval of 1370-1670^{o}C. Talc-magnesites are suitable for the forsterite refractory ware manufacturing assuming preliminary milling and crude talc-magnesite briquetting and roasting under temperature 1450-1500^{o}C.

Foundry raw materials

Sand

In the map sheet L-36-VI Mokryanske and Orikhivske, and in the map sheet L-37-I – Pologivske deposits are known.

Mokryanske deposit (II-2-14) is located close to the eastern part of Zaporizhzhya city and is out of production.

Orikhivske deposit (III-3-25) is related to the sandy sediments of Miocene Pontychniy regio-stage. Economic thickness is 1.0-19.3 m. Deposit is in production and it can be expanded to the south. Quartz sands are uniformly-grained with unit weight 1.57 g/cm^3. Refractory value is 1750^{o}C. Foundry sands comply with the grades 1KO2B and KO16.

Pologivske deposit (IV-2-36) is related to the Miocene sandy sediments. Thickness of mineral commodity is 6.0 m. Foundry sands comply with the grades 1KO2A, TO2A, B and TO16A, B.

Chemical raw materials

Agro-chemical raw materials

Phosphorites

Nodular phosphorite economic contents are concentrated in the basal horizon of Upper Cretaceous Genicheska Suite. Phosphorites were only appraised in the map sheet L-37-I (II-2-11) in the course of DGM-50 [73]. Productive sequence lies at the depth 60-130 m; thickness is 0.5-4 m. Content of P_2O_5 varies from 8% to 22%. Phosphate matter is amorphous and constitutes up to 45-53% of the rock. Occurrence is non-perspective due to the great depth.

Non-metal ore commodities

Abrasive raw materials

Corundum

In the south of L-37-I map sheet the north-eastern block of *Dragunske corundum deposit* (IV-2-40) is located. Prospecting works were conducted by Pravoberezhna GEE in 1962.

Together with sillimanite and kyanite, corundum comprises rock-forming mineral in gneisses and mafic gneisses of Dragunska Sequence. Aggregate average thickness of the productive batches is 80 m, the length of north-eastern block – up to 3 km. Weighted-average corundum content in some batches varies from 24 to 36 kg/t. Prognostic resources are evaluated to the depth 100 m.

Jewelry raw materials (precious stones)

Diamond

Zakhidnopryazovska site. Prospecting works for diamonds were performed in 1972-1981. The control heavy concentrate sampling of alluvial sediments in Konka River and its branches is surveyed, profile drilling through the Konka River valley in the southern limb of Konksko-Yalynska Depression is conducted, four big-volume (30-50 m^3 each) samples are taken, and geophysical anomalies are evaluated for the hard-rocks diamond sources.

In alluvium of Konka River two diamond crystals (of these one – in the map sheet L-37-I margins) are recovered. Crystal size is 0.2×0.3 mm, colour is green, no signs of mechanic transportation. In the big-volume samples up to 26 pyrope grains are recovered.

To the south, outside the map sheet margins, the places are defined to be perspective for the hard-rock diamond sources. They are confined to the deep faults where pipe-like bodies of rare-metal carbonatites, monzonite-shonkinite, alkaline peridotites, basaltoid breccias are already encountered as well as widespread but weakly studied dyke complex of kimberlite-like rocks. In the course of drilling over perspective geophysical anomaly in Konkska site, according to V.F.Razdorozhniy, Lower Proterozoic Kolarivskiy Complex sub-alkaline lamproites of amphibole and olivine-amphibole composition are discovered.

Facing and ornamental stones

Granite

The natural facing stones in the map sheet L-36-VI (Zaporizhzhya) include the rock of crystalline basement – granites and migmatites, and in the map sheet L-37-I (Pology) – marbles.

Yantsivske deposit (I-2-4) is located in 15 km to the east from Zaporizhzhya city. Deposit is in production and includes two sites – "Osnovna" and "Kamyana" where grey and light-grey granites of Neo-Archean Mokromoskovskiy Complex. Thickness of mineable benches is 33 m ("Osnovna") and 20 m ("Kamyana"). Block yield from the rock mass is 34% and polished plates from 1 m^3 block – 15.4 m^2. Waste can be used in construction and crushed stone manufacturing.

Bekarivske deposit (I-2-3) of grey uniformly-grained granites of Mokromoskovskiy Complex is out of production. Thickness of mineable bench is 49.5 m, overburden – 77 m in average. Granites comply with requirements of the State Standard 9479-76 to the facing stones.

Marble

Veselivskiy occurrence (I-4-67) of map sheet L-37-I is encountered in the core portion of Fedorivska structure composed of Ternovatska Sequence carbonate rocks. Mineable commodity includes marble and calciphyre, thickness – 95-128 m, overburden – 44.5 m. Perspectives are not clear.

Construction materials

Glass and porcelain-faience raw materials

Sand

Miocene Pontychni regio-stage sands of alluvial-marine genesis are being used in the glass raw materials.

Buryakivske deposit (III-3-24) is located in the map sheet L-36-VI and includes white, yellow and grayish-pink fine-grained quartz sands 2-36 m thick. In the south thickness increases to 50-60 m. Overburden rocks include red-brown clays and loams 0-25 m thick. Raw material is suitable for conditional crockery, pane and bottle glass manufacturing.

Secondary kaoline

Pologivske III deposit (IV-2-38) is located in the map sheet L-37-I. Mineral commodity comprises secondary kaolines of Miocene Novopetrivska Suite. Productive thickness is 10.8 m, overburden – 1.9 m. Raw material is suitable for ceramic block and brick manufacturing. Deposit is out of production.

Primary kaoline

All principal objects: Bilyaivske deposit (I-2-56), Spasivskiy (I-2-57) and Mykhaylo-Lukashivskiy (I-3-62) occurrences of the raw material suitable for fine ceramic and refractory ware manufacturing are closely located in the map sheet L-36-VI at the outskirts of Vilnyansk town in Zaporizka Oblast.

Bilyaivske primary kaoline deposit (I-2-56) is encountered nearby Bilyaivka village. Deposit square is 12 km^2; it is explored by Kharkivska GEE of SE "Pivdenukrgeologiya" in 1974-1983. Mineral commodity comprises irregularly-shaped layer of primary kaoline developed in weathering crust after two-feldspar granites of Mokromoskovskiy massif. Deposit includes Eastern, Central and Western bodies of which the Eastern one is explored in details.

Thickness of kaolines varies from 1.5 to 51.0 m. Overburden rocks include Quaternary and Neogene loams and clays 14-63 m thick. Kaolines are mainly composed of kaolinite (40-70%) and quartz (25-30%). Microcline, halloysite, albite and hydromica are also contained. Unit mass is 1.94 t/m^3. By total alkali content (K_2O+Na_2O) kaolines are divided into alkaline (lower part) and normal (upper part). High-grade kaolines (KF-1 and KF-2 grades) comprise about 58% in the deposit.

Hydrogeological conditions of the deposit are governed by two water-bearing horizons – in Quaternary sediments (non-pressurized) and in weathering crust (pressurized). Calculated aggregate inflow into the quarry is 298 m^3/day.

Institutes "VNDInerud" and "Uralmekhanobr" have conducted positive feasibility studies concerning kaoline concentrate output for consumption in ceramic, paper, chemical, rubber and other industries.

The sands being obtained in kaoline beneficiation are appraised to be the concentrates for ceramic industry as well as construction sands.

Kaoline reserves are approved by categories B, C_1 and C_2. Reserve growth is possible by switching C_2 reserves into economic categories. Deposit provides reserves for Prosyanivskiy MBP.

Dimension-wall raw materials

Limestone

The shelly and oolite limestones of Miocene Sarmatian and Pontian regio-stages are being used is these purposes. In the map sheet L-36-VI 14 deposits are encountered.

Kushugum-Osetrivske limestone deposit (II-1-11) is located at the southern outskirt of Kushugum village. Mineral commodity comprises Miocene limestone occurring beneath Quaternary loams up to 1 m thick. Upper layer of 0.8-1.0 m platy limestone is separated from the lower 3-5 m thick layer by the green clay up to 5 m thick. Lower limestone layer is thin-platy, re-crystallized, nodose. Limestones are suitable for II and III grade lime manufacturing.

Grygorivske limestone deposit (II-2-16) is located nearby Grygorivka village, in 10 km to the south-east from Konkrynivka railway station. Geology of the deposit includes Quaternary loams 0.8-1.0 m thick, and limestones of Pontian (oolite, 0.3-1.2 m thick) and Sarmatian (shelly, 3.7 m thick) regio-stages. Mineral commodity is limestone; mechanic strength under compression – 25-70 kg/cm^2. Limestones can be used for roasting to lime as well as in construction purposes.

Fisakivske limestone deposit (II-3-17) is located nearby Fisaky railway station in the right slope of Kamyshuvakha gully. Deposit includes "Terniy" and "Syrkova" sites. Mineral commodity comprises thin-platy re-crystallized limestone; mechanic strength under compression – 18-20 kg/cm^2. Limestones are being used in construction purposes.

Khytrivske limestone deposit (II-3-19) is located at the south-western outskirt of Khytrivka village. Deposit is composed of Quaternary loams 3.5 m thick and Miocene thin-platy re-crystallized limestones 3 m thick. Limestone is suitable for III grade lime manufacturing and can be used in construction purposes.

Konkrynivske limestone deposit (III-2-23) is located in 2 km to the north-east from Konkrynivka railway station. Geology of the deposit includes 2.5 m thick Quaternary clays and 0.2-1.2 m thick limestones of Sarmatian regio-stage. Below green clays up to 2.5 m are observed which lie over the platy limestones 1.4-5.6 m thick. Limestone mechanic strength under compression is 14 kg/cm^2.

Concrete light-filler raw materials

Clay, loam

Two claydite deposits are located in the map sheet L-36-VI.

Drugotravneve deposit (II-2-49) is located in Veselyanka village. Deposit is complex, it is out of production. The loams (brick-tile) are 8-12 m thick. Red-brown clays 2-5 m thick are suitable for claydite gravel manufacturing with addition 1% of straw oil.

In Kamyshuvakhske sand deposit (II-3-18) the overburden rocks contain red-brown clays which can be used for grade "500" claydite gravel manufacturing.

Crushed stone and aggregate raw materials

Granite, migmatites

The crystalline igneous and metamorphic rocks exposed in the Dnipro, Mokra Moskovka and Vovcha river valleys comprise the natural construction stone material. These rocks are being mined for crushed stone manufacturing to be used in construction purposes and in the road and railway building. In the studied area 17 deposits are encountered. Of these, the major ones include Zaporizke, Yantsivske, Mokryanske, Peredatochnyanske and others (map sheet L-36-VI); Pokrovske, Velykomykhaylivske, Shevchenkivske (map sheet L-37-I) and others.

Yantsivske granite deposit (I-2-4) is located in 15 km to the east from Zaporizhzhya city. It consists of three sites: "Nova", "Druzhelyubivska" and "Ivano-Gannivska". The "Nova" site is in production being backed with reserves (life-of-mine) for 53 years. Two other sites are in reserve.

Zaporizke migmatite deposit (I-1-1) is located in the Zaporizhzhya city limits. Deposit is in production within the land allotment. Reserve growth is possible to the quarry depth.

Natalivske granite deposit (I-2-5) is located nearby Natalivka village on the non-arable lands. Overburden thickness is 2.54 m, mineral commodity thickness – 54.4 m. It is backed with reserves for 28 years. Reserve growth is possible from the arable lands.

Mokryanske granite deposit (I-2-6) is located in 6 km from Rostushcha railway station. Overburden rocks 4.8 m thick in average do not contain any mineral resources. Average thickness of the mineable bench is 53.1 m, backing with reserves – 25 years. Reserve growth is possible in the east from arable lands.

Mokryanske II migmatites deposit (II-2-12) is located in 4 km to the east from Zaporizhzhya city. Deposit is in production, reserve backing is 14 years. Reserve growth is possible from the land between Peredatochnyanskiy and Mokryanskiy-II quarries.

Peredatochnyanske migmatite deposit (II-2-13) is located in 1 km to the east from Zaporizhzhya city and consists of two sites: "Pravoberezhna" and "Livoberezhna"; deposit is in production. In "Livoberezhna" site the overburden rocks contain approved reserves of brick-tile raw materials. Average thickness of mineable bench in "Livoberezhna" site is 135.5 m, in "Pravoberezhna" – 115.3 m. Deposit backing with reserves is 59 years.

Shevchenkivske migmatite deposit (IV-1-35) in map sheet L-37-I is located in 0.3 km to the south-east from Shevchenkivske village. Mineral commodity comprises migmatites of Novopavlivskiy Complex ($pmAR_1np_2$). Mineable thickness is 19 m, overburden rocks – 5.9 m. Reserve growth is possible to the depth and from non-arable lands.

Konksko-Rozdorivske plagiogranite deposit (IV-2-39) in map sheet L-37-I is located in 2.5 km to the south-east from Konkski Rozdory village. Mineral commodity comprises plagiogranites of Shevchenkivskiy Complex ($p\gamma AR3sv$). Mineable thickness is 16-43 m, overburden rocks – 4.0-21.6 m.

Sand-gravel raw materials

Sand

It is used in construction liquids and concrete, road works, silicate ware manufacturing. In the studied area 18 deposits of construction sands are encountered of which six are in production. Besides the natural sands, the riddling material from stone crushers is used. In Mokryanskiy, yatsivskiy and Zaporizkiy granite quarries more than 800 thousands m^3 of construction sand are mined annually.

In the map sheet L-36-VI (Zaporuzhzhya) Mykilske, Veselogaivske, Kamyshuvakhske, Grygorivske, Orikhivske and other deposits are situated.

Mykilske deposit (I-3-8) is located in Mykilske village. Mineral commodity comprises Miocene sands, 6.3 m thick in average, overburden rocks – 2.5 m. The sands are suitable for silicate wares, aggregate, construction liquids manufacturing. Deposit is in production.

Grygorivske deposit (II-2-15) is located in 2.5 km to the east from Grygorivka village. It consists of two sites. The first one is situated nearby Veselyanka village where Sarmatian regio-stage sands with clay interbeds are developed. Thickness of mineable sequence is 15-20 m, overburden – 2-6 m. The sands are fine- and medium-grained; suitable for concrete filler and construction liquid manufacturing. Due to the overburden great thickness reserve growth perspectives are limited.

Kamyshuvakhske deposit (II-3-18) is located in 5 km to the east from Kamyshuvakha village. It consists of two sites: Yurkivska and Lyubymivska where Sarmatian regio-stage sands are developed. Average sand thickness in Yurkivska site is 14.4 m, in Lyubymivska site – 10.8 m, overburden rocks – 7.4 and 9.6 m respectively. The sands are suitable for silicate brick manufacturing. Bypass red-brown clays can be used for claydite manufacturing.

Orikhivske II deposit (III-3-26) is located at the western outskirt of Novoandriivka village. Sarmatian regio-stage sands are 19.3 m thick in average, overburden rocks – 6.9 m. The sands are suitable for "125"-"150" grade silicate brick manufacturing.

Dniprovske I deposit (II-1-43) is located in 4 km from Zaporizhzhya city. It is extended over 10 km from Khortytsya Island to Biliy Island, between the right bank of Dnipro River and the fairway zone. Mineral commodity comprises modern alluvial river-bed sands from 2.8 to 20 m thick, 11.3 m in average. The sands are suitable for construction liquid and concrete manufacturing.

Vynogradivske deposit (II-1-44) is situated nearby the southern outskirt of Zaporizhzhya city, on the slope of Vynogradna gully. Mineral commodities include Quaternary sands and loams. The sands are quartz, fine-grained. Thickness is 1.5-17.6 m, overburden – 1.8-18.7 m. The sands are suitable for "125" grade silicate brick manufacturing. Reserve growth is limited.

Kushugumivske sand deposit (II-1-45) is located in 1.5 km to the west from Kushugum village, in Dnipro River flood-land buried beneath the waters of Kakhovske reservoir. Mineral commodity comprises modern alluvial river-bed sands 12.2 m thick in average. Reserve growth can be achieved in the southern direction. The sands are suitable for silicate ware manufacturing.

Dniprovske sand deposit (II-1-46) is situated in the water area of Dnipro River, between Biliy Island and "Bilenke" quay, in 15 km lower the river course from Zaporizhzhya city. Mineral commodity comprises alluvial river-bed sands which can be used for construction liquid and concrete manufacturing.

Lisogirske deposit (II-1-47) is located on the right bank of Dnipro River, in 6 km to the north from Bilenke village, encompassing non-arable lands. Mineral commodity comprises alluvial sands 20 m thick in average; no overburden rocks occur. The sands are suitable for grade "150" silicate brick manufacturing and use in construction purposes.

Velykokuchugurske sand deposit (IV-1-54) is located in 15 km to the north-east from Dniprorudne town and in 6 km from Kakhovske water reservoir coast. Deposit is confined to the modern alluvium 13.5-19.2 m thick. The sands lie beneath the water 0.8-4.5 m deep and are suitable for concrete manufacturing.

Sand deposit B.Shyroka (IV-3-42) is located at the northern outskirt of Novoukrainka village. Mineral commodity comprises 9 m thick diverse-grained sands of Miocene Novopetrivska Suite, overburden rocks – 3.5 m. The sands can be used in construction purposes and for brick manufacturing.

Zaporizki sand deposits (II-1-39, 40) are located in Zaporizhzhya city. Deposits are confined to the modern alluvium. Mineral commodity comprises quartz fine-grained sands 7.1 m thick in average. The sands are suitable for silicate ware manufacturing.

Dniprovske sand deposit (II-1-41) is located in the right bank of Dnipro River. Mineral commodity comprises modern alluvial sands 10.9 m thick, overburden rocks – 0.95 m. Deposit is being exploited by hydro-mechanic facilities.

Pokrovske sand deposit (I-1-47) is located nearby Pokrovske village (map sheet L-37-I). Deposit is confined to the Quaternary aeolian sediments. Mineral commodity comprises 0.3-2.5 m thick sands. Deposit is in production. The sands are used for silicate brick manufacturing and in the road-construction works.

Pologivske sand deposit (IV-2-54) in the map sheet L-37-I is located in 2.5 km to the east from Pology railway station. Deposit is constituted of the II and III over-flood terrace sands 4 m thick in average. The sands are diverse-grained with pebble and are confined to the overburden rocks of kaoline deposit.

Pologivske-III sand deposit (IV-2-56) in the map sheet L-37-I is located in 4 km to the south-east from Pology railway station. Deposit is constituted of the II and III over-flood terrace sands, diverse-grained, clayey, 3.9 m thick in average. The sands are suitable for the road-construction works.

Brick-tile raw materials

Loam, clay, secondary kaoline

The Quaternary loess-like loams and clays are used for brick manufacturing, rarely together with the Pliocene red-brown clays. Consumption of Miocene red-brown and green clays is limited due to their high plasticity.

In total, 37 deposits of brick-tile raw materials are recorded, of these 28 are explored and 11 are in production.

Mokryanske loam deposit (I-2-36) in the map sheet L-36-VI is located in 0.7 km to the south-east from Myrne village. Mineral commodity comprises Quaternary loams 8.5-13.8 m thick; overburden rocks include 0.5 m thick modern soils. Mineral reserves are situated in the arable lands, reserve growth is not possible.

Orikhivske-II loam and sand deposit (III-4-53) in the map sheet L-36-VI is the complex one. It consists of two sites: No. 2 (Novodanylivska) and No. 7 which is in production. Mineral commodity comprises 5.6-12.5 m thick loams.

Chapaivske loam deposit (IV-2-55) in the map sheet L-37-I is complex: loams, sands, secondary kaolines. It is located in Chapaivka village and consists of five sites. Mineral commodity comprises Quaternary loams of the second, third and fourth sites. Deposit is in production. Thickness of the mineable sequence is 2.7 m. The enterprise is backed with reserves for 29 years. Reserve growth is possible from the arable lands.

Groundwaters

In the territory of studied map sheets 29 deposits and 14 occurrences of underground waters are encountered. Most of these are located in Prychornomorska Depression, mainly in Konksko-Yalynska unit (map sheet L-37-I). The north-western and northern territories are almost free of underground waters. Over there, the low-producing water-bearing horizon in the fractured crystalline basement zone is used for water supplying.

By dry residuum and dissolved gas content the underground waters are divided into fresh (dry residuum up to 1.0 g/dm^3) and mineral; the latter, in turn, are divided into salty (up to 3 g/dm^3), low-salt (up to 6 g/dm^3) and radon waters.

Fresh

The fresh waters are used for drinking water supplying of the towns and other inhabited localities. The major water scooping is being provided from the water-bearing horizons in Cretaceous, Paleogene and Neogene sediments. Borehole water yield is 2-76 m^3/h.

Mineral

Salty

The waters are confined to the fractured zones in crystalline rocks. Borehole yield is 0.01-20 m^3/h, dry residuum – 1.0-1.5 g/dm^3. Waters are sulphate-hydrocarbonate and sulphate-chloride.

Low-salt

The mineral waters are sulphate and chloride-sulphate with mineralization 2.1-6.4 g/dm^3; in composition they are close to Izhevska, Ugluchska and Feodosiyska waters. Occurrences of chloride sodium waters with mineralization 3.3-5.5 g/dm^3 are close in composition to Myrgorodska mineral water.

Radon

The medical radon waters are confined to the tectonic breaks in crystalline basement (map sheet L-36-VI). Occurrence of radon chloride-sulphate sodium mineral water of Bilokurykhinskiy type (I-2-60) is encountered in the area of Natalivka village. Mineralization is 1.4 g/dm^3. Water-bearing horizon is contained in the fractured Precambrian rocks. Radon content is 152×10^{-10} Curie/dm^3.

10. ASSESSMENT OF THE TERRITORY PERSPECTIVES

Analysis of mineral deposits and occurrences distribution revealed certain regularities. Iron, lithium, construction and facing stone, primary kaoline and majority of metallic mineral resources are related to the igneous and ultra-metamorphic rocks. Major perspectives of the territory for discovery of mineral deposits and occurrences confined to the crystalline basement are mainly attributed to the superimposed structures of the second greenstone Meso-Neo-Archean tectonic level which contain deposits and promising occurrences of iron, lithium, gold, rare (niobium, tantalum, lithium, rubidium, caesium, molybdenum, cobalt) and rare-earth (yttrium, ytterbium, cerium, lanthanum) metals.

In sedimentary cover deposits and occurrences of brown coal, manganese, phosphorites, refractory clays and secondary kaolines, foundry and construction stones, rare-metal and rare-earth placers etc. are encountered.

Brown coal deposits (Sanzharske and Orikhivske) occupy considerable areas of arable lands and lie at the great depth; these are non-perspective.

In view of giant iron-ore reserves in Ukraine, both Gulyajpilske and Vasynivske iron-ore deposits are considered to be the base reserve. Analysis of the forming conditions and study degree of manganese ores do not allow discovery of the new ore fields. Phosphorites of Genicheska Suite (Upper Cretaceous) are locally studied and due to the great depth in the given area they are considered to be non-perspective. The shallow sites of Senomanian sediments in the north-eastern part of map sheet L-37-I (Pology) are more promising.

Discovered deposits and occurrences of refractory clays and secondary kaolines comprise the mineral resource base while new discoveries are constrained by results of prospecting-reappraisal works.

Orikhivske foundry sand deposit supplies the metallurgy. Deposit “Mokre” is filed in reserve. Reserve growth perspectives are unlimited. The sands for glass manufacturing are lacking in the natural state. Buryakivske deposit sands upon beneficiation can be used for low-grade glass manufacturing. Reserves of construction sands are significant. In addition, the crushed-stone screenings can be used in substituting the sands.

Geological reserves of clay raw materials are quite considerable but their use is limited by the areas of low-arable lands suitable for the mining allotments for their exploitation.

Major water-bearing horizons providing water supply of the towns and inhabited localities are confined to the Cretaceous, Paleogene and Neogene sediments as well as fractured rocks of crystalline basement.

It is notable increasing of the underground water depression funnel due to the extensive water scooping under exploitation of Pivdennobilozerske iron-ore deposit. Over the last 40 years the water level descending is 1-3 m per year in average. The damage appears for drainage of Paleogene and Neogene complexes in the territory of map sheet L-36-VI.

Mineral and radon waters are confined to the water-bearing horizon in fractured zone of crystalline basement and Paleogene water-bearing horizon.

Iron

All iron-ore objects in the map sheets are related to the rocks of jaspilite-tholeiite and jaspilite-siliceous-schist rock associations developed in Gulyajpilska, Orikhovo-Pavlogradska and Konkska structures. Their geological and geophysical study degree is high. Almost all highly-contrasted magnetic anomalies are proven by drill-holes, prospected or explored. Within two anomalies Gulyajpilske and Vasynivske deposits are discovered, explored and prepared for economic development; in case of jointed exploitation these deposits are considered to be reserve for mineral-resource base of iron ores. Available geological and geophysical data suggest for the lack of perspectives in the area in term of new discovery of economic deposits.

Manganese

Explored reserves of manganese ores in Velykotokmatske deposit allow life of mine for 150 years. Discovery of new considerable ore-bearing fields in the map sheets (in view of high study degree of the deposit) seems to be improbable. E.M.Lapytskiy [88], conducted analysis of manganese ore layer preservation conditions and probability of drilling data, had defined minor sites of possible manganese mineralization in the south-western flank of Velykotokmatske deposit (outside the map sheet).

Copper

In compliance with the data available, the perspectives for discovery of potentially-economic copper deposits in the studied area are attributed to greenstone structures where epigenetic (remobilized) hydrothermal copper mineralization with nickel or molybdenum is developed. This type searching objects include Kyrpotynske and Veselyanske ore fields. In Veselyanska site of Konkska greenstone structure the copper mineralization is related to the minor ultramafic intrusions and rhyolite-porphyry dykes within greenstone sequences of Konkska and Bilozerska series with the host rocks deep reworking by tectonic, metasomatic and hydrothermal processes. The profile drill-holes had intersected the ore zones with copper content 1-3%, gold – up to 1 g/t, and lead – up to 0.5%, within quartz-albite-chlorite and epidote-chlorite-albite schists with thin (10-15 m) rhyolite-porphyry bodies. Copper prognostic resources are evaluated by category P3 [63]. In the perspective areas discovery of small copper deposits is foreseen in the disseminated zones and columnar ore bodies in the fault-side fracture and flexure units of greenstone sequences.

In Gulyajpilsko-Saltychanskiy Block, in the south of L-37-I map sheet, Konksko-Rozdorivska (IV-3-95) and Kuybyshevska (prognostic copper resources are evaluated by category P3) are distinguished [63]. Findings and copper mineralization points include quartz-sulphide and copper-porphyry types related to the minor monzonite massifs and dykes (outside the map sheet).

In Kuybyshevske ore camp the promising copper mineralization of copper-porphyry type is genetically and spatially related to monzonite massifs.

Lead and zinc

The territory perspectives for discovery of polymetal deposits are attributed to the only occurrence (I-4-65) in Tersyansle ore field where lead-zinc mineralization of skarn (?) type is encountered in retrograde rocks of carbonate-talc-chlorite composition within gneiss sequence in the zone of Orikhovo-Pavlogradskiy Fault. The high content of zinc, lead, molybdenum, scandium and cerium in this occurrence looks promising.

Nickel and cobalt

Despite of the considerable number of previously encountered nickel findings and mineralization points, the perspectives of the area for discovery of economic deposits are constrained. Nickel silicate ore occurrences in weathering crust are hopeless due to the small size of primary rocks while nickel sulphide occurrences in Kyrpotynske and Veselyanske ore fields may be interesting only in case of complex appraisal of copper-nickel mineralization.

Minor deposits of epigenetic (remobilized) nickel sulphide ores seems to be probable in Novopavlivske ore-bearing field in ultramafic rocks of the same-named complex and in fault zones.

Small deposits of the composite copper-nickel sulphide type related to the gabbroids of Novopavlivskiy Complex and monzonite minor intrusions can be foreseen in Kuybyshevske ore field where three nickel sulphide occurrences are encountered.

Molybdenum

In the studied area five molybdenum occurrences and 20 mineralization points are found allowing positive appraisal to the area perspectives for discovery of mainly hydrothermal vein and linear-stockwork deposits. Most promising objects include Kosivtsivske ore-bearing field in the map sheet L-37-I, Shcherbakivske and Skelske – in the map sheet L-36-VI. Discovery of molybdenum mineralization in association with copper and copper-nickel ores is possible in Kyrpotynske and Veselyanske ore fields. The targeted prospecting works are recommended in the mentioned fields.

Lithium, rubidium, caesium, beryllium

The territory perspectives for discovery of rare alkaline metal deposits are attributed first of all to Shevchenkivske and Fedorivske ore fields. Shevchenkivske lithium deposit with associated rubidium and caesium is discovered and explored in the first one. To the north from this deposit albite-spodumene pegmatites are encountered. In Fedorivska structure rare alkaline metal findings and mineralization points related to the rare-metal pegmatites are recorded.

In Konkska structure rare alkali mineralization is related to the rare-metal pegmatites of Mokromoskovskiy Complex confined to the tectonic zones filled with Mykhaylivska Suite meta-volcanogenic-sedimentary rocks of Bilozerska Series or with retrograded granitoids. Rubidium occurrence of this type is encountered in the tectonically broken eastern contact of Mokromoskovskiy massif nearby Kupriyanivka village (I-2-58). Increased caesium (0.04%), rubidium (0.064%) and lithium (0.04%) content is determined by previous works [46] in the synclinorium marginal site within granitized, biotitized and phlogopitized mafic rocks transformed into the mica rocks of Surska Suite. Prognostic resources of alkaline metals in this occurrence are evaluated by category P2 [46]. In view of uncertain type of ore mineralization its perspectives are not defined.

Yttrium

The real perspectives for discovery of yttrium deposits in the area are attributed to the rare-earth granite pegmatites which constitute Uspenivske ore-bearing field and Kompaniivske ore field where certain number of yttrium findings is encountered and yttrium mineral form – xenotime is determined. Importantly, these occurrences are confined to the trough-like Meso-Archean Gaychurska and Chystopilska structures composed of similar litho-tectonic complexes of Kosivtsivska and Ternovatska sequences. It is not excluded that these structures comprise dismembered fragments of the common structure.

Gold

Major territory perspectives for gold deposit discovery are attributed to the greenstone formations developed in Konkska, Novogorivska, Chystopilska (map sheet L-36-VI), Gaychurska and Kosivtsivska (map sheet L-37-I) structures, as well as chemogenic-terrigenous sediments of Gulyajpilska syncline. Except the ten mineralization points of gold-sulphide-quartz type (in quartz veins and veinlets up to 10-20 cm thick the highest gold content by spectral-chemical analysis attains 10 g/t, by fine assay – 0.8-0.1 g/t) considerable gold mineralization is not found so far in greenstone structures of map sheet L-36-VI (Zaporizhzhya) and their perspectives are mainly appraised from geological considerations. Instead, gold objects with economic parameters are encountered in Gaychurska, Kosivtsivska (perspective gold occurrence is found in their junction zone) and Gulyajpilska (one gold occurrence and three mineralization points) structures. Defined Central-Gaychurske and Kosivtsivske ore-bearing fields are thought to be highly perspective for discovery of gold-sulphide-quartz type objects.

In the far north-eastern part of map sheet L-37-I, at the depth 50-150 m, the Lower Carboniferous terrigenous-chemogenic sediments are mapped. The site belongs to Pavlogradsko-Dokuchaivskiy metallogenic belt considered to be perspective for discovery of Carlin-type gold deposits (Artemenko, 1996, UkrIMR).

The gold perspectives of map sheet L-37-I (Pology) are supported by results of heavy concentrate sampling conducted in the southern part of Gulyajpilskiy Block in the course of prospecting for diamonds. In the samples from modern alluvium at the upper course of Konka River and its branches the gold “signs” 0.5-1 mm in size were encountered in three points.

Diamond

In the territory, adjacent from the east and south, in the junction zone of Donbas and Pryazovya, the Middle Devonian kimberlite magmatism is encountered unequivocally. In the course of searching for the hard diamond sources of kimberlite-lamproite type, four pipe-shaped kimberlite bodies and one dyke body are found, which contain the full set of diamond mineral-satellites and some fine diamond crystals. In the Carboniferous, Neogene and Quaternary terrigenous sediments numerous findings of diamond mineral-satellites and fine diamond crystals are encountered.

Mineralogical study of heavy concentrate and large-volume samples from alluvial sediments of Konka River (upper course) and its branches (southern part of map sheet L-37-I) revealed 25 pyrope grains and 2 diamond crystals 0.2-0.3 mm in size, green-coloured, without signs of mechanic transportation. From the mineral-satellite aureoles and by geophysical data the sites are defined to be perspective for the hard diamond sources. According to V.F.Razdorozhniy, at the perspective geophysical anomaly in Konkska site (Kuybyshevskiy ore camp) sub-alkaline ultramafic rocks (lamproites) of Middle Proterozoic Kolarivskiy Complex are intersected by drill-holes.

The data above suggest for potential perspectives of the territory in term of discovery the hard diamond source rocks of kimberlite-lamproite type.

11. ECOLOGICAL-GEOLOGICAL SITUATION

The powerful territorial-industrial complexes – Dnipropetrovsko-Dniprodzerzhynskiy, Zaporizkiy and Zaphidnodonbaskiy – situated in the limits of the studied map sheets do strongly affect their geological environments (Fig. 11.1).

In compliance with the landscape-geochemical zonation two groups of landscape complexes are distinguished – natural-technogenic and natural partly modified by the human activities. Pure natural landscapes, not affected by the latter, are absent. The first – natural-technogenic group includes landscapes of the big industrial zones (Zaporizhzhya city), urban and rural agglomerations, railways and roads, gas pipelines, irrigation systems. The natural landscape complexes partly modified by the human activities, include forest massifs (in Vovcha River valley), agro-landscapes (most developed over the territory), and the complex of long-lived flood-land shrub-grass meadow vegetation (in Dnipro River valley).

Appraisal of the soil contamination has revealed that:

- in the territory of Zaporizka industry-urban agglomeration (IUA) the planar (except some intended for building and green zones) contamination with lead (1-3 times in excess of TAC – 30 mg/kg, in some places up to 500-1000 mg/kg), chromium (up to 300 mg/kg, in places up to 500 and 5000 mg/kg), manganese (up to 1 TAC – 1500 mg/kg in the most of Dnipro River right bank, and 2-6 TAC in the left bank, in the industrial zones) is observed; in some points or minor areas with zinc (150-200 mg/kg) and copper (up to 200-500 mg/kg);
- in some places of IUA contamination with other heavy metals is encountered (tin, zirconium, germanium and niobium) in amounts exceeding levels of CSF;
- organic contamination of the soils is not encountered. Pesticides are observed in excess of TAC in some places and in Khortytsya Island in single point their content exceeds TAC 6 times;
- agrarian area are least contaminated, mono-element anomalies are almost absent except lead and silver anomalies in the north which apparently are of technogenic origin;
- by the bulk concentration number (BCN) agrarian areas belong to the least contaminated, in some places – low-contaminated;
- by BCN, the territory of Zaporizhzhya city in most cases belong to low- and medium-contaminated; in the industrial zones and adjacent intended for building and green zones – from medium- to high-contaminated.

Quality of the ground and underground waters over most part of the studied area does not comply with the drinking and housing standards. The waters are sulphate-chloride with mixed cationic composition and enhanced mineralization 0.7-4 g/dm^3, in some places (wells in Kopany village of Orikhivskiy area, Vozdvyzhivka and Yablukove villages of Gulyajpilskiy area) more than 8-10 g/dm^3. Over almost entire map sheets, except Zaporizhzhya and Orikhiv town outskirts (90 km^2) and Vasylivka village of Zaporizka Oblast (180 km^2), the ground waters are contaminated with nitrates in amount from 45 to 1065 mg/dm^3, and in Omelnyk village of Orikhivskiy area it attains 1250 mg/dm^3. Almost throughout enhanced sulphate concentrations are noted (1-12 times higher of the standard, maximum – 6120 g/dm^3 in Vozdvyzhivka village, and 6095 g/dm^3 – in Rivnopillya village of Gulyajpilskiy area). Besides sulphates, almost throughout increased over TAC chloride contents (1-4 times) are observed in the waters; their highest content – 2708 g/dm^3 is encountered in the area between Gaychur and Mokri Yaly rivers. The bulk hardness number over entire territory by 2-7 times exceeds TAC (the highest value – 92.5 mole/dm^3 is determined in Rivnopillya village of Gulyajpilskiy area).

In the territory of map sheets increased concentrations of I-III class hazardous chemical elements in the ground waters are determined. Of the I-II class hazardous elements (extremely- and high-hazardous), the cadmium and beryllium local anomalies are encountered. Bromine content almost throughout 2-38 times exceeds TAC, lithium – 1.5-2 times over most territory, aluminum – 1.5-5 times locally (in places 20 times – Dniprorudniy and Oktyabrskiy towns of Velykonovoselkivskiy area), and boron content exceeds TAC over 20% of the territory. Water contamination with manganese and iron is planar, over entire territory, and 1-32 and 1-16 times exceeds TAC respectively. In the central and eastern parts of the territory increased (1-2 times) strontium concentration is encountered. Chemical composition of the ground waters is mainly controlled by the natural factors.

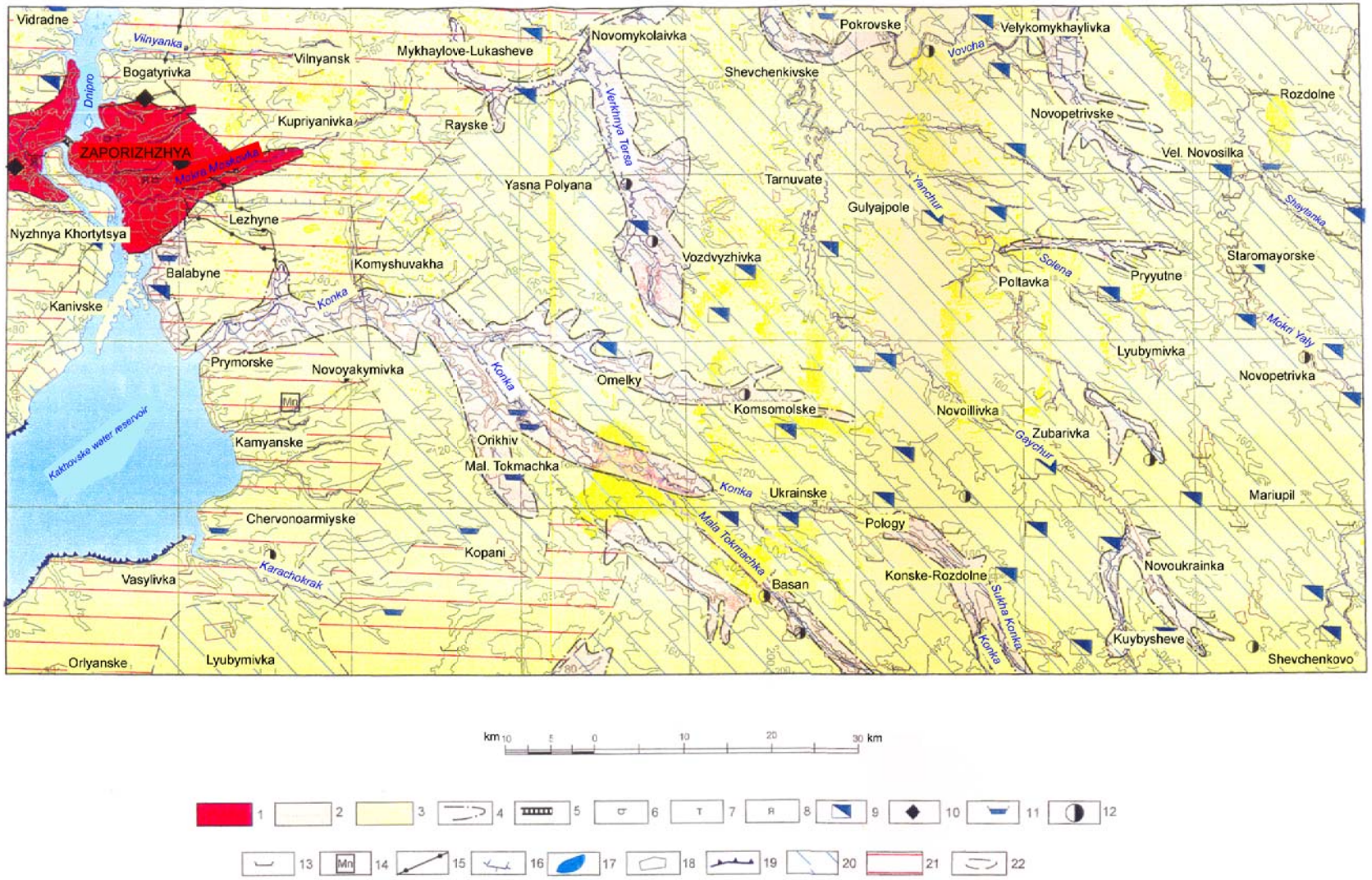

Fig. 11.1. Schematic map of the ecological state of geological environment. See next page for the legend.

Fig. 11.1. Continued. Legend.

I – levels of ecological state of geological environment: 1 – very charged, 2 – charged, 3 – moderate charged, 4 – boundaries of the areas with different assessment of the state of geological environment. *II – technogenic objects affecting the state of geological environment*: 5 – hydro-power, 6 – heavy industry (non-ferrous and ferrous metallurgy, machinery, metal processing), 7 – chemical industry; 8 – mining industry (construction raw materials), 9 – agriculture complex (mineral fertilizer and pesticide stores). *Storage, bury and utilization of all kinds of industrial and housing wastes*: 10 – landfills, 11 – sewage accumulators, 12 – petroleum bases, 13 – quarries, 14 – shaft, 15 – pipelines, 16 – irrigation systems (channels), 17 – hydro-technical objects (water reservoirs, big ponds), 18 – contour of industrial-urban agglomerations, area administrative centers, villages. *III – zone of negative geological processes development*: 19 – coast abrasion. *IV – zones by degree of suitability for engineering-geological development*: 20 – conventionally suitable zone, 21 – unsuitable zone, 22 – boundaries by degree of suitability for engineering-geological development.

Contamination of the aeration zone is studied for the five column types depending on geomorphologic position and rock composition. It is established that geomorphologic position of the columns does not affect content of the elements and their concentrations do not actually change with depth. In general, the average element content in the rocks of aeration zone is observed at the level which is equal or slightly below one in the soils of agrarian areas.

Contamination of the bottom sediments is studied by the rivers and their branches, in the reservoirs and industrial water ponds in Kapustyanka gully. Most contaminated (in comparison to the bottom sediments of Dnipro River higher the course from Zaporizhzhya city) are the bottom sediments in Kapustyanka gully and Mokra Moskovka and Sukha Moskovka rivers. Zinc concentrations are 1000-5000 and 70-500 mg/kg respectively, and lead in their sediments – from 20 to 300 mg/kg. Increased contents of nickel and chromium are determined in the same water flows. Over remaining territory the modern water flow and reservoir sediments by chemical composition do not differ from the bottom sediments of Dnipro River.

Analysis of the surface water composition has revealed that:

- Dnipro River waters are hydrocarbonate with mineralization 0.2-0.35 g/dm^3; waters are soft and medium-hard (up to 5 mg/equiv.); chloride, sulphate, nitrate- and nitrite-ion contents are normal and only in the central beach of Zaporizhzhya city ammonia contamination (2 times of TAC) is encountered;
- in contrast to the normal macro-component composition, essential micro-component contamination of Dnipro River water is noted, specifically, with manganese (1-4.5 TAC), iron (2-8 TAC), aluminum (2-13 TAC) and bromine (up to 5.5 TAC);
- the waters of Mokra Moskovka and Sukha Moskovka rivers and Kapustyanka and Serednya gullies are most contaminated; their chemical composition is essentially affected by the dropped industrial waters. Sulphate content and mineralization of these waters 4 times exceeds TAC, hardness number – 5 times, bromine – 9 times, manganese – 5 times, and lithium – 2 times.
- the waters of other flows are contaminated with the same components but in lesser extents;
- the phenols, oil products and nitrate contents are within the norm; pesticides are not found.

Radiological situation in the area does not exceed the norm. Gamma-radiation figures vary from 10 to 17 mCu/h. Two anomalous sites are encountered: in the area of Skelki village – 27 mCu/h (square 70 km^2) apparently related to the influence of Zaporizka nuclear power station located in 25 km to the west, and 25 mCu/h (square 15 km^2) in the area between Mokra Moskovka and Konka rivers. Radionuclide contamination of the territory does not exceed 370 Bk/kg.

The area corruption by exogenic geological processes (EGP), first of all by erosion and land sliding, under-flooding, coast reworking etc. is uneven. Degree of EGP corruption in the northern, north-eastern and eastern parts of the map sheet territory is less than 5% (mainly erosion and land sliding). To the south from Orikhiv town degree of EGP corruption (mainly the same processes) is about 15%. Over remaining portion of the Dnipro River left-bank side and over entire right-bank side EGP corruption degree varies in the range 5-10% (erosion, under-flooding, coast reworking). The I and II compaction soil types are mainly developed in the studied area. The II-type soils are developed over more than 75% of the right-bank side and in the left-bank side, in the strip from north to south, from Verkhnya Tersa river valley to Vasylivka village; over more than 50% of the area to the south and south-east in Vasylivka village. In the central, north-eastern and eastern parts of the

map sheets most soils belong to the II type comprising 25-50% of the territory. In the south-east, in the widened sections of Konka, Verkhnya Tersa river valleys and in over-flood terraces of Dnipro River the I-type soils are developed over 25% of the territory. By majority of parameters the most part of the territory, the central and eastern ones and some terraces of Dnipro River are conventionally ascribed to the suitable zone for engineering-geological development whereas most of the right-bank side and entire western part of the left-bank side – to the unsuitable zone.

The centres of environment contamination in Zaporizhzhya city and adjacent territories comprise the objects of chemical, mining, food, glass and porcelain-faience industry, metallurgy, machinery construction and metal processing, construction materials manufacturing. Just in Zaporizhzhya city the enterprises drop into the air 150 thousand tons of contaminating substances and more than 195 millions m^3 of sewage are being dropped into the hydrographical network. At the outskirts and inside the city in 1994 more than 660 thousand tons of solid industrial and housing wastes were stockpiled. Module of technogenic charge (by amount of drops) in Zaporizka IUA and adjacent areas (almost 200 km2) is 975 th. m^3/km^2 per year (data for the year 1994).

Ecological-geological zonation of the territory by the state of geological environment is conducted on the ground of appraisal the natural and technogenic factors influence (by method of V.I.Pochtarenko, O.I.Styopina, E.A.Yakovlev with additions and amendments) on the counterparts of geological environment. Three levels of ecological state are distinguished – very charged, charged and moderate charged.

The moderate-charged territories (soil contamination level by BCN is lowest, sulphate, chloride, nitrate, bromine contents in underground waters are increased, EGP are mainly erosion processes) include most part of the map sheets, actually all agrarian areas. The charged territories encompass almost 25% of the map sheets (most part of Konka, Verkhnya Tersa, Gaychur – upper course, Mokri Yaly river valleys) and are mainly caused by increased concentrations of chemical elements in the underground waters (nitrates, manganese, iron, bromine). Contamination degree by BCN is lowest, in places up to low-contaminated; EGP include erosion and land sliding, under-flooding. The most unsuitable ecological situation emerged in the IUA of Zaporizhzhya city. The latter territory and adjacent agrarian areas (up to 10% of the map sheet territory) are very charged in term of ecological state of geological environment. This level is mainly caused by considerable contamination of underground waters, soils (by BCN – from low to medium over most the city, and from medium to high in the industrial and adjacent zones), surface waters and bottom sediments inside the city. Among the EGP, the under-flooding, erosion and ground subsidence are most active.

At the best of present knowledge on ecological-geological situation the further EGP development is foreseen (sliding, under-flooding, subsidence, erosion). In view of unsuitable ecological situation in Zaporizhzhya city and aiming prediction of changes in some components of geological environment, development of the complex monitoring system is vital, primarily over the most charged territory of Zaporizka IUA.

CONCLUSIONS

The work does summarize results of the studies of geology and mineral resources over map sheets L-36-VI (Zaporizhzhya) and L-37-I (Pology) conducted for many years and follows the issue of new edition of the State Geological Mp of Ukraine in the scale 1:200 000. The most important results of the work include: compiling the set of new-generation geological maps; subdivision and mapping of crystalline basement and sedimentary cover rocks in compliance with the current stratigraphic schemes; the distribution boundaries of sediments from all stratigraphic subdivisions of sedimentary cover are essentially adjusted, geology and history of geological development of Phanerozoic sediments are studies in most details. In Konksko-Yalynska Depression Paleogene sediments are further subdivided into the Late Eocene and Early Oligocene sequences; Novopetrivska Suite (Neogene) is divided into the middle and upper sub-suites; Akmanayski Layers of Meotychniy regio-stage (Neogene) are distinguished for the first time; it is proved that Pryazovskiy ledge comprises the horst formed over Cretaceous and Paleogene times; the modern structures are distinguished in the studied area for the first time and the neo-tectonic map is designed; the territory perspectives for mineral resources are assessed and the territory ecological state are appraised.

Generalization and re-interpretation of geological and geophysical information collected over previous 20-30 years coupled with the recent achievements of geological sciences had allowed design of the geological model for crystalline basement in Zaporizko-Pologivska area, which, in the authors' opinion, most logically explains the history of area development and regularities in related mineral resources localization.

It is for the first time when the Middle-Dniprean and Pryazovian areas are considered to be the segments of common Kursko-Prydniprovska granite-greenstone terrain allowing in both areas the definition of three stages in their Precambrian development: pre-greenstone, greenstone and post-greenstone with corresponding tectonic epochs. On the ground of new geophysical data sudbuction of Middle-Dniprean Block beneath Pryazovian Block in the zone of Orikhovo-Pavlogradskiy deep-seated fault is confidently argued. The authors recognize the first geodynamic events as far back as the end of Late Paleo-Archean.

On the ground of developed model the correlation scheme of Precambrian stratified and non-stratified units is designed which considerably differ from that one approved in 1996 by NSC for the map sheets of Central-Ukrainian Series. Granulite-basite complexes are ascribed by the authors to the Early Paleo-Archean – Novopavlivska Sequence. High-alumina and quartzite rocks previously correlated with Neo-Archean Tsentralnopryazovska Series, are defined by the authors as Late Paleo-Archean Vovchanska Sequence, occurring stratigraphically higher of Zakhidnopryazovska Series, at the same level as Dragunska Series rocks which underlies Tsentralnopryazovska Series. After tectonic analysis the greenstone complex in Pryazovya is upgraded by the rocks of Ternovatska Sequence.

From the mentioned position the major regularities in formation of mineral resources in the crystalline basement are revised.

Nevertheless, some issues of sedimentary cover and crystalline basement geology remain unsolved. These problematic, disputable and unexplained questions are as follows:

I. Concerning sedimentary cover:

a. the age position of the sequence of parti-coloured clays is not defined completely;
b. the possible extension of Pontychniy regio-stage (Neogene) continental sediments to the north (into the map sheet L-36-VI) from the distribution boundary of the even-aged marine sediments of the sand and limestone sequence, assumed by some authors (G.V.Pasichniy, 1978), requires additional studies;
c. the correlation problem of Reshetylivska and Yalynska sequences, defined in Konksko-Yalynska Depression, with, respectively, Obukhivska (Mandrykivska) and Mezhygirska suites of Kharkivska Series.

II. Concerning crystalline basement:

II.A. Middle-Dniprean area:

a. the age of Dnipropetrovskiy Complex and Khortytska Association plagiogranitoids is not defined;
b. relationship patterns between meta-basite rocks of Slavgorodska and Bazavlutska sequences and Surska Suite of Konkska Series require additional studies;
c. it is necessary to develop the principles for subdivision of pre-greenstone complexes (Slavgorodska, Tomakivska and Bazavlutska sequences) and define their stratotypes;

d. the scheme and principles of Konkska Series meta-volcanics require urgent extended study. At present any arbitrary section of greenstone rocks can be identified with one of Surska Suite sub-suites;
e. the separate granitoid complex should be established which intrudes volcanogenic-sedimentary rocks of Bilozerska Series and is comagmatic to the felsic meta-volcanics of the Series. For the time being the authors have defined interim Khortytska association of plagiogranites.

II.B. Pryazovian area

a. the problem is to be solved of stratification the meta-volcanic sequences in the basement of Meso-Archean Pologivska syncline which are conventionally ascribed by the authors to the Verkhnyotokmatska Sequence of Zakhidnopryazovska Series. By most parameters it is correlated with the similar rocks of Bazavlutska Sequence;
b. the age is not defined for Gulyajpislka Suite meta-sediments, two-feldspar granites, rare-metal and rare-earth pegmatites of Yanvarska association as well as these rocks affinity to this association;
c. Vovchanska Sequence should be further studied aiming subdivision into sub-sequences and possible separation of younger rocks and definition the reliability for its combining with Novopavlivska Sequence into the common (Orikhovo-Pavlogradska) Series;
d. repeating, more precise age determination and genesis of the Dobropilski rocks is required. As a result, the problem of two-level greenstone structures formation in Pryazovya could be solved as well as their correlation with Neo-Archean greenstone units;
e. the issue of Kosivtsivska and Ternovska sequences jointing into the common Series, or Meso-Proterozoic greenstone geodynamic complex, remains important.

REFERENCES

Published

1. Artemenko, G.V., 1998. Geochronology of Middle-Dniprean, Pryazovian and Kurska Granite-Greenstone Terrains // Theses Doctor Geol.Sci. – Kyiv. - 32 p. (In Ukrainian).

2. Atlas of Paleogeographic Maps of Ukrainian and Moldavian SSR (with litho-facies elements), 1960. – Kyiv: AS UkSSR Publishing. – 36 p. (In Ukrainian).

3. Barg, I.M., 1993. Upper Cenozoic Biostratigraphy of Southern Ukraine. – Donetsk: Donetsk University Press. – 196 p. (In Russian).

4. Belevtsev, Ya.N., Koval, V.B., Bakarshyev, A.K., et al, 1995. Genetic Types and Regularities in Localization of Uranium Deposits in Ukraine. – Kyiv: Naukova Dumka Publishing. – 395 p. (In Russian).

5. Belokrys, L.S., 1976. Cenozoic Stratigraphy of Northern Prychornomorya and Crimea. – Donetsk: Donetsk University Press. – 21 p. (In Russian).

6. Berzenin, B.Z., Kichurchak, V.M., 1977. Rare-metal mineralization in contact zones of Mokromoskovskiy massif // In: Mineralogical criteria of prospecting for rare and base metals in Ukrainian Shield. Abstracts. – Dneprorundoe. – p. 2. (In Russian).

7. Berzenin, B.Z., Dudnik, N.F., Ilvitskiy, M.M., 1979. Petrology of Middle-Dniprean ultramafic and mafic complexes, their formation correlation and ore-bearings // In: III Regional petrographic meeting on European part of USSR. Abstracts. – Kyiv: Naukova Dumka Publishing. – p.17-18. (In Russian).

8. Veklych, M.F., 1968. Stratigraphy of Loess Formation of Ukraine and Adjacent Countries. - Kyiv: Naukova Dumka Publishing. – 238 p. (In Russian).

9. Geological Map of USSR, scale 1:1 000 000, map sheet L-(36), (37) Simferopol. Explanatory Notes, 1986. – Leningrad. – 133 p. (In Russian).

10. Ginzburg, A.I., Timofeeva, I.N., Felman, L.G, 1979. Basic Geology of Granite Pegmatites. – Moscow: Nedra Publishing. – 296 p. (In Russian).

11. Gryaznov, A.I., 1967. Genesis of Manganese Ores of Nikopolskiy Basin and Prognosis Method for Marine Sedimentary Manganese Deposits. – Moscow: Nauka Publishing. – 246 p. (In Russian).

11a. The State Water Cadastre. (In Ukrainian).

12. Zamoriy, P.K., 1961. Quaternary Sediments of Ukrainian SSR. Kyiv: Kyiv University Press. – 550 p. (In Ukrainian).

13. Regularities of Coal Deposition in the Territory of Dniprovskiy Brown-Coal Basin, 1963 // P.G.Nesterenko (Ed.). – Moscow: GNTIL Mining Press. – 212 p. (In Russian).

14. Kalyaev, G.I., Glevaskiy E.B., Dimitrov, G.Kh., 1984. Paleotectonics and Crustal Structure of Precambrian Iron-Ore Province of Ukraine. – Kyiv: Naukova Dumka Publishing. – 240 p. (In Russian).

15. Kalyaev, G.I., 1989. Problems of Precambrian tectonics of Ukrainian Shield // In: A.V.Chekunov (Ed.). Tectonosphere of Ukraine. – Kyiv: Naukova Dumka Publishing. – p. 64-67 (In Russian).

16. Kerchenskiy Iron-Ore Basin, 1967. – N.M.Strakhov (Editor-in-Chief). – Moscow: Nedra Publishing. – 576 p. (In Russian).

17. Kruglov, S.S., Tsypko, A.K., 1988. Tectonics of Ukraine. - Spec.Publ. UkrNIGRI, v. XXXVI. – Moscow: Nedra Publishing. – 254 p. (In Russian).

18. Lazko, E.N., Sivoronov, A.A., Yaroshchuk, M.A., et al, 1990. Ferruginous-Siliceous Precambrian Formations in European Part of USSR. Greenstone Belts and Role of Volcanism in Deposit Formation. – Kyiv: Naukova Dumka Publishing. – 172 p. (In Russian).

19. Lashmanov, V.I., 1989. To the question of Pryazovian Khondalite Formation volume, structure and position in Precambrian column // Geological Journal (Ukraine). – N 3. – p. 69-77 (In Russian).

20. Lysak, A.M., et al, 1989. To the question of stratigraphy of Lower Precambrian gneiss-migmatite rocks of Pryazovya // Geological Journal (Ukraine). – N 3. – p. 60-68 (In Russian).

21. Metallogeny of Ukraine and Moldavia, 1974. // Ya.N.Belevtsev (Ed.). – Kyiv: Naukova Dumka Publishing. – 512 p. (In Russian).

22. Moroz, S.A., Savron, E.B., 1975. Cenozoic Seas of Donbass. – Kyiv: Vyshcha Shkola Publishing. – 200 p. (In Russian).

23. Nikopolskiy Manganese-Ore Basin, 1964. – Moscow: Nedra Publishing. – 536 p. (In Russian).

24. Nosovskiy, M.F., 1971. Biostratigraphy of Middle Miocene sediments of the northern part of Evksinskiy basin (Southern Ukraine) // In: Geology and Ore-Bearings of the South of Ukraine. Sci.Proc. Dnipropetrovsk University, v.IV. – Dnipropetrovsk. – p. 3-18. (In Russian).

25. Orsa, V.I., 1988. Granite Formation in Precambrian of Middle-Dniprean Granite-Greenstone Terrain. – Kiev: Naukova Dumka Publishing. – 204 p. (In Russian).

26. Pastukhov, V.G., et al, 1993. Geodynamic Map of Ukraine, scale 1 :1 000 000. Explanatory Notes. – Kyiv: Geoprognoz. – 213 p. (In Russian).

27. Petrenko, A.A., 2001. On the patterns of tectonic relationships of Pryazovskiy massif and Konksko-Yalynska depression // Mineral Resources of Ukraine. – N 1. – p. 14-17. (In Russian).

28. Rukhin, L.B., 1953. Principles of Lithology. Leningrad: GNTI of mining and petroleum. – 671 p. (In Russian).

29. Salop, L.I., 1982. Geological Evolution of the Earth in Precambrian. – Leningrad: Nedra Publishing. – 343 p. (In Russian).

30. Semenenko, N.P., Ladieva, V.D., Boyko, V.L., et al, 1982. Metabasic and Keratophyre Alumosilicate Formations in the Central Part of Ukrainian Shield. – Kiev: Naukova Dumka Publishing. – 375 p. (In Russian).

31. Semenenko, N.P., Ladieva, V.D., Bordunov, I.N., et al, 1978. Ferruginous-Siliceous Formations of Ukrainian Shield. Vol. 1. – Kiev: Naukova Dumka Publishing. – 328 p. (In Russian).

32. Semenenko, N.P., Boyko, V.L., Bordunov, I.N., et al, 1979. Ultramafic Formations of the Central Part of Ukrainian Shield. – Kiev: Naukova Dumka Publishing. – 412 p. (In Russian).

33. Solodov, P.A., 1971. Scientific Principles of Perspective Appraisal of Rare-Metal Pegmatites. – Moscow: Nauka Publishing. – 292 p. (In Russian).

34. Handbook of Traveller and Local Lore Student. 1950. S.V.Obruchev (Ed.). Vol. II. – Moscow: State Geographic Press. – p. 251-350, 380-413. (In Russian).

35. Stratigraphy of UkSSR, 1963. Vol. IX. Paleogene. – Kyiv: AS UkSSR Publishing. – 320 p. (In Russian).

36. Strakhov, N.M., 1971. Development of Litho-Genetic Ideas in Russia and USSR. – Moscow: Nauka Publishing. – 605 p. (In Russian).

37. Khain, V.E., Bozhko, N.A., 1988. Historic Geotectonics. Precambrian. – Moscow: Nedra Publishing. – 382 p. (In Russian).

38. Shavlo, S.G., Kyrykylytsa, S.I., Knyazev, G.I., 1984. Granite Pegmatites of Ukraine. – Kiev: Naukova Dumka Publishing. – 264 p. (In Russian).

39. Shantser, E.V., 1961. The types of alluvial sediments // In: Issues of Anthropogenic Geology at VI Congress in Poland. – Moscow: AS USSR Publishing. –p. 188-197. (In Russian).

40. Shcherbak, N.P., Esypchuk, K.E., Berzenin, B.Z., 1985. Precambrian Stratigraphic Columns of Ukrainian Shield. – Kiev: Naukova Dumka Publishing. – 168 p. (In Russian).

41. Shcherbak, N.P., Artemenko, G.V., et al, 1989. Precambrian Geochronological Scale of Ukrainian Shield. – Kiev: Naukova Dumka Publishing. – 144 p. (In Russian).

42. Shcherbak, N.P., et al, 1990. Uranium-lead isotopic age of Gulyajpilska Suite meta-volcanics (Western Pryazovya) // Reports of AS UkSSR. Ser. B. – N 9. p. 26-29. (In Russian).

43. Shcherbakov, I.B., Esypchuk, K.Yu., Orsa, V.I., 1984. Granitoid Formations of Ukraine. – Kiev: Naukova Dumka Publishing. – 192 p. (In Ukrainian).

Unpublished

44. Alyabyeva, N.S., 1971. Prospecting works for hard coal in Solenovsko-Andreevskaya field. – Kyiv: Geoinform. (In Russian).

45. Andreev, A.I., 1973. Report on the results of geological mapping works in the scale 1:50 000 conducted in 1967-1972 by geological mapping team No. 27 in the map sheets M-37-134-C, L-37-1-A,B and 2-A (Dnipropetrovska GMG). – Kyiv: Geoinform. (In Russian).

45a. Database “Geolkarta-200” of map sheets L-36-VI (Zaporizhzhya) and L-37-I (Pology), 2005. – Kyiv: Geoinform. (In Ukrainian).

46. Berzenin, B.Z., et al, 1976. Report on results of deep geological mapping in the scale 1:50 000 conducted by Yantsevskaya GMG in the area of Mokromoskovskiy granitoid massif in the map sheets L-36-11-B,D and -12-A in 1974-1976. – Kyiv: Geoinform. (In Russian).

47. Berzenin, B.Z., 1979. Report on project: “Study of data on Precambrian geology in Middle-Dniprean area aiming selection and substantiation the basic stratigraphic sections”, 1976-1979. – Kyiv: Geoinform. (In Russian).

48. Berzenin, B.Z., et al, 1982. Report on project: „Study of basic stratigraphic sections of Aulskaya and Zapadnopriazovskaya series". Research Group, 1980-1982. – Kyiv: Geoinform. (In Russian).

49. Berzenin, B.Z., 1988. Design of geological map for Precambrian rocks in Ukrainian Shield in the scale 1:200 000 of Pryazvoskiy and Middle-Dniprean areas. Research Group, 1985-1988. – Kyiv: Geoinform. (In Russian).

50. Berzenin, B.Z., 1990. Study of composition, ore-bearing and the column correlation of Osipenkovskaya, Gulyajpolskaya, Sachkinskaya suites and Kosivtsevskaya sequence of Pryazovian Block. – Kyiv: Geoinform. (In Russian).

51. Goyzhevskiy, A.A., 1956. Materials to the State Geological Map of USSR in the scale 1:200 000. Complex geological map of the map sheet L-37-1 (Pology). Report of Gulyajpilska GMG on the works of 1955-1956. – Kyiv: Geoinform. (In Russian).

52. Gonchar, A.A., 1977. Design of metallogenic and prognosis maps of Middle-Dniprean area in the scale 1:200 000 (M-36-XXIX (southern half), M-37-XXXV (SW part), L-36-V, -VI, -XI (northern part), -XXII (northern part), L-37-I (western part)) in 1975-1977. – Kyiv: Geoinform. (In Russian).

53. Gonchar, A.A., 1982. Report on project: "Analysis and appraisal of previously encountered occurrences and anomalies in the territory of SE "Yuzhukrgeologia". – Kyiv: Geoinform. (In Russian).

54. Gonchar, A.A., Skrypnikov, N.F., et al, 1986. Report on results of prospecting for apatite-rare-metal carbonatites in Tarasivskiy, Basanskiy and Dmitrievskiy sites (Western Pryazovya) over 1983-1986. Verbovskiy Group. – Kyiv: Geoinform. (In Russian).

55. Gonchar, A.A., et al, 1988. Report on data generalization on apatite-bearings in Pryazovya and Middle-Dniprean areas. Report on project BP 4/622/28 over 1985-1988. – Kyiv: Geoinform. (In Russian).

56. Gryaznov, V.I., et al, 1983. Report «Mineralogy and geochemistry of manganese ores and overburden rocks of Nikopolskiy basin» – Kyiv: Geoinform. (In Russian).

57. Dobrenkiy, A.E., et al, 1974. Report on bauxite prospecting in the southern margin of Dniprovsko-Donetska Depression in the south-eastern part of Ukrainian Shield over 1969-1973. – Kyiv: Geoinform. (In Russian).

58. Dralov, V.M., et al, 1979. Report on work results of deep geological mapping in the scale 1:50 000 in the territory of map sheets L-37-13-C,D; L-37-25-A,B (Western Pryazovya) in 1975-1979. – Kyiv: Geoinform. (In Russian).

59. Dyukov, A.V., et al, 1979. Report on results of ilmenite deposit prospecting in the left-bank side of Middle-Dniprean area (Kamenskiy, Zelenogayskiy, Sokolovskiy and Novoaleksandrovskiy sites) in 1976-1979. – Kyiv: Geoinform. (In Russian).

60. Dyukov, A.V., 1985. Report on diamond exploration in the junction zone of Donbass and Pryazovya (Verkhnekonkskiy and other sites) in 1982-1985. – Kyiv: Geoinform. (In Russian).

61. Isakov, L.V., 1986. Report on rare-metal prospecting in the junction zone of Donbass and Pryazovya (Shevchenkovskiy site) in 1983-1986. – Kyiv: Geoinform. (In Russian).

62. Ignatkin, V.A., et al, 1959. Geological report on exploration works conducted by Zaporozhskaya Group in 1956-1959 in Sanzharskoe brown-coal deposit. – Kyiv: Geoinform. (In Russian).

63. Inin, V.D., 1990. Design of prognosis-metallogenic map in the scale 1:200 000 for crystalline basement in the territory of activities of SE "Yuzhukrgeologia". Report of the Central Research Group over 1986-1990. – Kyiv: Geoinform. (In Russian).

64. Isakov, L.V., 1988. Preliminary exploration of Shevchenkovskoe deposit (central part). Prospecting-Exploration Group, report on 1984-1988. – Kyiv: Geoinform. (In Russian).

65. Kiktenko, V.F., Golenchuk, V.D., et al, 1968. Report on complex geological mapping in the scale 1:50 000 conducted by GMG No. 14 in 1963-1968 in the map sheets L-36-11-A,C,D and L-36-23-B (area of Konkskie magnetic anomalies). – Kyiv: Geoinform. (In Russian).

66. Kiktenko, V.F., Ladieva, V.D., et al, 1971. Report on results of geological works on drilling of Kirpotinskiy and Veselyanskiy basic profiles aiming the study of composition and metal-bearing of Precambrian sedimentary-volcanogenic formations in the area of Konkskie magnetic anomalies in 1964-1971. – Kyiv: Geoinform. (In Russian).

67. Kiktenko, V.F., Panasyuk, I.S., et al, 1972. Report on results of geological mapping in the scale 1:50 000 conducted by GMG-15 in the southern part of Orekhovo-Pavlogradskaya litho-tectonic zone (map sheets L-36-12-C,D; L-36-24-A,B) in 1966-1971. – Kyiv: Geoinform. (In Russian).

68. Kiktenko, V.F., et al, 1974. Report on results of geological mapping in the scale 1 :50000 conducted by Vasilyevskiy Group in the territory of map sheets L-36-24-C,D (southern part of Orekhovo-Pavlogradskaya litho-tectonic zone) in 1972-1974. – Kyiv: Geoinform. (In Russian).

69. Kiktenko, V.F., et al, 1978. Report on results of deep geological mapping in the territory of map sheets M-36-144-D-b,c,d and L-36-12-B (junction area of Devladovskiy and Orekhovo-Pavlogradskiy deep-

seated faults) in the scale 1:50 000 conducted by Tersyanska PGG in 1975-1978. – Kyiv: Geoinform. (In Russian).

70. Kiktenko, V.F., et al, 1982. Report on results of large-scale deep geological mapping in the southern part of Orekhovo-Pavlogradskaya zone, map sheets L-36-24-A; -B-a,c; -C-a,b in 1979-1982. Shcherbakovskaya Group. – Kyiv: Geoinform. (In Russian).

71. Kiktenko, V.F., et al, 1988. Report on deep geological mapping in the scale 1:200 000 in Western Pryazovya in the map sheets M-37-XXXI ; L-37-I ; VII (sheets M-37-133-A,B,C,D; -134-C; L-37-I-A,B,C,D; -2-A,B,C,D; -13-A,B,C,D; -14-A,B,C,D; -25-A,B; -26-A,B) in 1982-1987; Zapadnopryazovskiy GMG. – Kyiv: Geoinform. (In Russian).

72. Kinshakov, V.N., et al, 1977. Report on results of medium-scale deep geological mapping of Precambrian basement and Lower Cretaceous sediments in the southern slope of Ukrainian Shield conducted in the map sheets L-36-V, VI, X, XI in 1974-1976. – Kyiv: Geoinform. (In Russian).

73. Kinshakov, V.N., et al, 1990. Report of Gaychurskiy Group on results of deep geological mapping in the scale 1:50 000 with general prospecting conducted in 1986-1990. Map sheets L-37-I-C,D. – Kyiv: Geoinform. (In Russian).

74. Kichurchak, V.M., et al, 1983. Report on deep geological mapping in the map sheets M-37-134-C-c,d (southern half) and L-37-2-A-a,b,c,d (western half) in the scale 1:50 000. Volchanskaya GMG, 1979-1983. – Kyiv: Geoinform. (In Russian).

75. Kichurchak, V.M., 1988. Geological structure and mineral resources in the upper course of Volchya River. Report of Volchanskiy Group on results of deep geological mapping in the scale 1:50 000 conducted in 1984-1988 in the junction zone of the north-western part of Pryazovskiy crystalline massif with Donetskiy trough. Map sheets M-37-133-A,C-a,b; -D and M-37-134-C-a,c (northern part), d (northern part). – Kyiv: Geoinform. (In Russian).

76. Kovalenko, V.Yu., et al, 1986. Complex geological map in the scale 1:50 000 of the map sheets L-36-21-C,D ; L-36-22-C,D ; L-36-23-C,D. Report of Kakhovskaya GMG 250/81 on the group mapping in 1981-1985. – Kyiv: Geoinform. (In Russian).

77. Koval, E.M., 1990. Report on prospecting results for rare metals in Fedorovskaya tectonic zone conducted in 1987-1990. – Kyiv: Geoinform. (In Russian).

78. Konkov, G.G., et al, 1965. Report on results of complex geological mapping in the scale 1:50 000 over map sheets L-37-14-C (southern half); L-37-26-A,C,D and L-37-27-C (Tsentralnopryazovskiy area). – Kyiv: Geoinform. (In Russian).

79. Kochanov, E.N., et al, 1973. Report on results of prospecting-reassessment works for ferruginous quartzites in the southern part of Orekhovo-Pavlogradskie magnetic anomalies in 1970-1973. – Kyiv: Geoinform. (In Russian).

80. Kochanov, E.N., Krylov, A.I., et al, 1982. Report on preliminary exploration in the western and eastern limbs of Gulyajpolskoe ferruginous quartzite deposit in 1976-1982. – Kyiv: Geoinform. (In Russian).

81. Krivonos, V.P., Sapunov, E.A., 1983. Report on results of prospecting for iron ores in the sites of gravity anomalies in slight magnetic fields in 1980-1983. – Kyiv: Geoinform. (In Russian).

82. Krivonos, V.P., 1989. Report on detailed exploration of Vasinovskoe ferruginous quartzite deposit conducted in 1983-1989 with reserve estimation by 01.08.1989. – Kyiv: Geoinform. (In Russian).

83. Krongauz, E.G., et al, 1975. Report on prospecting works for diamonds conducted in 1972-1975 (appraisal of perspectives for diamond in modern and old alluvial sediments in Middle-Dniprean area and Paleozoic terrigenous coarse-clastic facies in the junction zone of Ukrainian Shield and Dneprovsko-Donetskaya Depression). – Kyiv: Geoinform. (In Russian).

84. Krylov, A.N., Kochanov, E.N., et al, 1985. Report on detailed exploration in the western limb of Gulyajpolskoe ferruginous quartzite deposit in 1981-1985. – Kyiv: Geoinform. (In Russian).

85. Kutko, A.G., et al, 1978. Report on results of large-scale deep geological mapping in Fedorovskiy site (junction zone of Pryazovskiy crystalline massif with Donetskiy trough). – Kyiv: Geoinform. (In Russian).

86. Lapitskiy, E.M., 1973. Report on results of works on appraisal the perspectives for tantalum and niobium in the zone of Chernigovskiy Fault in 1972-1973. – Kyiv: Geoinform. (In Russian).

87. Lapitskiy, E.M., 1994. Geological structure and mineral resources in the upper course of Molochnaya River. Report on results of deep geological mapping in the scale 1:200 000 of Belozerskiy area in the map sheets L-36-VI, XII conducted in 1989-1994. Map sheets L-36-24-C,D; L-35-A,B,D; L-36-A,B,C,D. – Kyiv: Geoinform. (In Russian).

88. Lapitskiy, E.M., 1995. Perspective appraisal of Nikopolskiy manganese-ore basin. Report on project: “Analysis of mineral resource base of manganese-ore industry with elements of prognostic appraisal for perspective fields” conducted in 1992-1995. – Kyiv: Geoinform. (In Russian).

89. Lebedev, N.I., et al, 1965. Report on geological mapping in the scale 1:50 000 conducted by GMG No. 10 in 1961-1964 over map sheets L-37-13-C,D; L-37-25-A,B. – Kyiv: Geoinform. (In Russian).

90. Leye, N.A. Kutko, A.G., et al, 1973. Report on complex geological mapping in the scale 1:50 000 in Volchansko-Vladimirovskiy geological area. – Kyiv: Geoinform. (In Russian).

91. Lipilin, V.A., 1986. Report on project: "Generalization of prospecting-exploration results on study of iron-ore formations in Gulyajpolskiy, Konkskiy, Chertomlykskiy areas and Orekhovo-Pavlogradskaya zone with their prognosis-metallogenic appraisal", 1983-1985. – Kyiv: Geoinform. (In Russian).

92. Litvin, B.A., et al, 1978. Report on design of aerophotogeological maps over the territory of SE "Yuzhukrgeologia" activities, 1976-1978. – Kyiv: Geoinform. (In Russian).

93. Mitkeev, M.V., et al, 1975. Report on project: "Design of prognostic map for iron ores of Ukrainian Shield in the scale 1:200 000 over the territory of SE "Yuzhukrgeologia" activities (Middle-Dniprean area)", 1973-1975. – Kyiv: Geoinform. (In Russian).

94. Mogilevits, I.I., et al, 1977. Report on results of prospecting works for ferruginous quartzites in North-Tersyanskiy, Vasinovskiy and Bolshenovodanilovskiy sites of Orekhovo-Pavlogradskaya magneric anomaly in 1973-1977. – Kyiv: Geoinform. (In Russian).

95. Mogilevits, I.I., et al, 1977. Report on results of preliminary exploration in the north-western part of Gulyajpolskoe ferruginous quartzite deposit in 1974-1977. – Kyiv: Geoinform. (In Russian).

96. Mogilevits, I.I., Solovyev, V.P., 1978. Report on results of prospecting works for iron ores in the Novogorovskaya magnetic anomaly in 1977. – Kyiv: Geoinform. (In Russian).

97. Nastenko, A.A., Zolotar, M.L., 1953. Report on geological prospecting works for iron ores in the Konkskaya magnetic anomaly conducted by Konkskaya Group (Kamyshevakhskiy area, Zaporozhskaya Oblast). – Kyiv: Geoinform. (In Russian).

98. Nastenko, A.A., Tyazhlov, G.T., 1955. Report on geological exploration works conducted by Konkskaya Group in Veselyanskoe talc-magnesite deposit in 1952-1955 (Zaporozhskaya Oblast). In 4 volumes. – Kyiv: Geoinform. (In Russian).

99. Nekryach, A.I., 1973. Report on results of extended study of deep structure in the territory of geological mapping in the scale 1:50 000 over map sheets M-36-132-D, M-36-144-B, M-37-133-A, conducted by Vasilkovskiy Group in 1968-1973. – Kyiv: Geoinform. (In Russian).

100. Nekryach, A.I., et al, 1975. Report on results of data generalization and preliminary field works conducted in 1974-1975 aiming preparation to the deep geological mapping in the scale 1:50 000 over map sheets L-37-13-C,D and L-37-25-A,B (Chernigovskaya Group). – Kyiv: Geoinform. (In Russian).

101. Pasechniy, G.V., 1970. Lower and Middle Miocene of the Eastern Prychernomorye. Dissertation of Candidate Geograph.Sci. – 150 p. – Dnipropetrovskaya GMG.

102. Pasechniy, G.V., et al, 1978. Report on project: "Study of Cenozoic stratotype and basic sections in Ukraine aiming their correlation and substantiation the boundary of Neogene and Quarter in 1976-1978". – Kyiv: Geoinform. (In Russian).

103. Pereverzev, S.I., et al, 1992. Geological structure and mineral resources in the basin of Tomakovka River. Report on results of deep geological mapping in the scale 1:200 000 of Zaporozhskiy anticlinorium (Tomakovskiy gravity maximum) in the map sheets M-36-XXXV, L-36-V, VI in 1988-1992. – Kyiv: Geoinform. (In Russian).

104. Petrenko, A.A., 1999. Report on extended geological study of the fields in the scale 1:200 000 over map sheets L-36-VI (Zaporozhye) and L-37-I (Pology) conducted in 1990-1999 by Eliseevskiy GMG. – Kyiv: Geoinform. (In Russian).

105. Ploskiy, A.P., Dorozhkina, L.V., et al, 1984. Report on detailed exploration in the Northern site of Bolshe-Tokmakskoe manganese-ore deposit (shaft fields 5, 6), 1980-1984. – Kyiv: Geoinform. (In Russian).

106. Ploskiy, A.P., et al, 1990. Report on detailed exploration of the Northern site of Bolshe-Tokmakskoe manganese-ore deposit (shaft fields 9, 10) with reserve estimation by 01.09.1989 (1984-1989). – Kyiv: Geoinform. (In Russian).

107. Repina, E.V., Solovitskiy, V.N., et al, 1957. Complex geological map in the scale 1:200 000 of map sheet L-36-VI (Zaporozhye). – Kyiv: Geoinform. (In Russian).

108. Selin, Yu.I., 1958. Bolshe-Tokmakskiy area of Middle-Dniprean manganese-ore basin. Geological report on results of prospecting-exploration works conducted by Zaporozhskaya Group in 1952-1957. – Kyiv: Geoinform. (In Russian).

109. Solovey, B.A., et al, 1971. Report on prospecting works for complex placers conducted in Middle-Dniprean area in 1968-1970. – Kyiv: Geoinform. (In Russian).

110. Tsyma, N.T., 1988. Prospecting for gold in Middle-Dniprean area. Report of prospecting-exploration group on results of prospecting works and appraisal of gold mineralization in greenstone structures of Middle-Dniprean area over 1985-1988. – Kyiv: Geoinform. (In Russian).

111. Shamonov, Zh.Z., Matyushonok, V.A., et al, 1973. Report on profile parametric and interpretation drilling and analysis of study degree in the area of Konksko-Yalynskaya depression conducted in 1972-1973. – Kyiv: Geoinform. (In Russian).

112. Shamonov, Zh.Z., et al, 1977. Report on results of the group geological mapping in the scale 1:50 000 in Konksko-Yalynskaya depression (map sheets L-37-2-C,D; L-37-14-A,B,C (northern half); L-37-15-A), 1973-1977. – Kyiv: Geoinform. (In Russian).

113. Shipilov, V.M., et al, 1981. Report on geological mapping in the scale 1:50 000 over map sheets L-37-1-C,D conducted by Novopoltavskaya Group in 1977-1981. – Kyiv: Geoinform. (In Russian).

114. Shkovyra, Yu.D., et al, 1962. Report on complex geological mapping in the map sheets L-36-11-B and L-36-12-A,B conducted by GMG No. 6 in 1960-1962. – Kyiv: Geoinform. (In Russian).

115. Shkovyra, Yu.D., et al, 1977. Report on results of geological mapping in the scale 1 :50 000 cinducted by Gulyajpolskaya GMG over map sheets L-37-13-A,B in 1975-1977. – Kyiv: Geoinform. (In Russian).

116. Shpylchak, V.A., 1995. Report on results of geological mapping over map sheets L-36-48-A,B,C,D in the scale 1:50 000 conducted by Stroganovskiy GMG in 1991-1995. – Kyiv: Geoinform. (In Russian).

117. Shrubovich, F.V., 1961. Report on prospecting works for corundum conducted in the upper course of Konka River in 1959-1961. – Kyiv: Geoinform. (In Russian).

118. Yunak, V.S., 1988. Report on project: “Review of construction materials resource base in Zaporozhskaya Oblast”. – Kyiv: Geoinform. (In Russian).

119. Yartseva, E.A., 1990. Report on project: “Review of construction materials resource base in Dnipropetrovskaya Oblast of UkSSR”. – Kyiv: Geoinform. (In Russian).

ANNEXES

Annex 1. List of deposits and occurrences indicated in the geological map and map of mineral resources in pre-Quaternary units of map sheet L-36-VI (Zaporizhzhya)

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 Occurrence				
III-4-32 IV-3,4-32	Orikhivske; Orikhivskiy area	Explored; in reserve	Sedimentary	67
Metallic mineral resources Ferrous metals Manganese Deposit				
III-2,3-30 IV-3,4-30	Velykotokmatske	Explored; in conservation	Sedimentary	67
Trace and rare-earth metals Scandium (yttrium, lanthanum) Occurrence				
IV-2-29	Burchatskiy	Scandium, lanthanum and yttrium are encountered in coaliferous Eocene sediments in interval 176-217 m	Sedimentary	76
Non-metallic mineral resources Non-ore raw materials for metallurgy Foundry raw materials Sand Deposit				
II-2-14	Mokryanske; Mokra village	Explored; in reserve	Sedimentary	65
III-3-25	Orikhivske; 2.7 km to NW from Orikhiv town	In production	Sedimentary	67
Non-metal ore commodities Facing stone raw materials (ornamental stone) Granite Deposit				
I-2-3	Bekarivske; 0.5 km to SW from Bekarivka village	Explored; in reserve	Igneous	118
I-2-4	Yantsivske; 6-8 km from Yantseve station	In production	Igneous	118

1	2	3	4	5
Construction raw materials Glass and porcelain-faience raw materials Sand Deposit				
III-3-24	Buryakivske; 3 km to NW from Orikhiv town	Explored; in reserve	Sedimentary	118
Dimension stone for wall raw materials Limestone Deposit				
II-1-10	Zaporizke; SE outskirt of Pivdenniy village	Explored; in reserve	Sedimentary	118
II-1-11	Kushugum-Osetrivske; S outskirt of Kushugum village, Kakhorske reservoir bank	Explored; in reserve	Sedimentary	118
II-2-16	Grygorivske; 10 km to NE from Konkrynivka station	Explored; in reserve	Sedimentary	118
II-3-17	Fisakivske; nearby Fisaky station, right bank of Kamyshuvakha gully	Explored; in reserve	Sedimentary	118
II-3-19	Khytrivske; SW outskirt of Khytrivka village, left slope of Konka River valley	Explored; in reserve	Sedimentary	118
III-2-23	Konkrynivske; 2 km to NE from Konkrynivka station, right bank of Konka River	Explored; in reserve	Sedimentary	118
Quarry-stone raw materials Migmatite Deposit				
I-1-1	Zaporizke; Zaporizhzhya city, 2 km from Dniproges Dam	In production	Ultra-metamorphic	118
II-3-20	Odarivske; 1.5 km to S from Odarivka village	In production	Ultra-metamorphic	118
Granite Deposit				
I-2-4	Yantsivske; site “Nova”, 8 km from Yantseve station	In production	Igneous	118
	site “Druzhelyubivska” 3 km to SE from Yantseve station	Explored; in reserve	Igneous	118
	site “Ivano-Gannivska” nearby Ivano-Ganniva village	Explored; in reserve	Igneous	118
I-2-3	Bekarivske; 0.5 km to SW from Bekarivka village	Explored; in reserve	Igneous	118
I-2-5	Natalivske; 0.5 km to N from Natalivka village	In production	Igneous	118

1	2	3	4	5
I-2-6	Mokryanske; 6 km from Rostushcha station	In production	Igneous	118
I-3-7	Mykilske; 0.5 km from Mykilske village	Explored; in reserve	Igneous	118
II-2-12	Mokryanske-II; 4 km to E from Zaporizhzhya city	In production	Igneous	118
II-2-13	Peredatochnyanske; 1 km to E from Zaporizhzhya city	In production	Igneous	118
Sand-gravel raw materials Sand Deposit				
I-3-8	Mykilske; N outskirt of Mykilske village	In production	Sedimentary	118
I-4-9	Veselogaivske; 1 km to E from Veseliy Gay village	Explored; in reserve	Sedimentary	69
II-2-15	Grygorivske; 2.5 km to E from Grygorivka village	In production	Sedimentary	118
II-3-18	Kamyshuvakhske; 5 km to E from Kamyshuvakha village	Explored; in reserve	Sedimentary	118
III-3-26	Orikhivske-II (Novoandriivska site No. 6); W outskirt of Novoandriivka village	Explored; in reserve	Sedimentary	118
Brick-tile raw materials Clay Deposit				
I-2-2	Bilyaivske; to N from Vilnyansk town nearby Bilyaivka and Zelene villages	Explored; in reserve	Sedimentary	118
I-4-9	Veselogaivske; Veseliy Gay village	Explored; in reserve	Sedimentary	69
Underground waters Mineral (mineralized) Low-saline (3-10 g/dm^3) Deposit				
II-4-22	Vasynivske; Kirove village	Explored; in reserve	Bed-fracture	104
III-4-27	Orikhivske; Orikhiv town	In production	Bed-fracture	104
Occurrence				
II-4-21	Mykilske; 2.5 km to NE from Mykilske village	In production. Water type Myrgorodskiy. Depth 53 m, yield 1.6 l/s	Bed-fracture	104
IV-2-28	Zeleniy Gay village	In production. Water type Feodosiyskiy Depth 167 m, yield 5.3 l/s	Bed-fracture	104
IV-3-31	Kopani village	In production. Water type Feodosiyskiy Depth 125 m, yield 1.2 l/s	Bed-fracture	104

Annex 2. List of deposits and occurrences indicated in the geological map and map of mineral resources in Quaternary sediments of map sheet L-36-VI (Zaporizhzhya)

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 Construction raw materials Raw materials for light concrete filler Clay Deposit				
II-2-49	Drugotravneve; Veselyanka village	Explored; in reserve	Sedimentary	118
Sand and gravel raw materials Sand Deposit				
II-1-39	Zaporizke; Zaporizhzhya city	Explored; in reserve	Sedimentary	65
II-1-40	Quarry of Zaporizkiy silicate plant; Zaporizhzhya city	Explored; in reserve	Sedimentary	65
II-1-41	Dniprovske; right bank of Dnipro River former course	In production	Sedimentary	71
II-1-43	Dniprovske-I; 4 km to SW from Zaporizhzhya city to Biliy Island, between right bank and fairway	Explored; in reserve	Sedimentary	118
II-1-44	Vynogradivske; Zaporizhzhya city	Explored; in reserve	Sedimentary	118
II-1-45	Kushugumivske; 1.5 km to W from Kushugum village	Explored; in reserve	Sedimentary	118
II-1-46	Dniprovske; water area of Dnipro River, between Biliy Island and quay of Bilenke village	Explored; in reserve	Sedimentary	118
II-1-47	Lysogorske; 6 km to N from Bilenke village	Explored; in reserve	Sedimentary	118
IV-1-54	Velykokuchugurske; 15 km to NE from Dniprorudne town, 6 km from bank	Explored; in reserve	Sedimentary	118

1	2	3	4	5
Brick and tile raw materials Loam, clay Deposit				
I-1-33	Bogatyrivske; site 1 in 2 km to S, site 2 in 0.6 km to W from Bogatyriv village	Explored; in reserve	Sedimentary	118
I-1-34	Verkhnyokhortytske; 0.5 km to S from V.Khortytsya village, right bank of Dnipro River	Explored; in reserve	Sedimentary	118
I-2-35	Bilyaivske; to N from Vilnyansk town	Explored; in reserve	Sedimentary	118
I-2-36	Mokryanske; 0.7 km to SE from Myrne village	In production	Sedimentary	118
I-4-37	Veselogaivske; nearby Veseliy Gay village	Explored; in reserve	Sedimentary	69
II-1-38	Zaporizke; nearby E outskirt of Zaporizhzhya city	In production	Sedimentary	65
II-1-42	SE from Zaporizhzhya city, nearby Pershotravneve village	In production	Sedimentary	65
II-1-44	Vynogradivske; S outskirt of Zaporizhzhya city	Explored; in reserve, non-perspective	Sedimentary	118
II-2-48	Peredatochnyanske; 1 km to S from Zaporizhzhya city	Explored; in reserve, non-perspective	Sedimentary	118
II-2-50	Drugotravneve (Veselyanske); S outskirt of Veselyanka village	Explored; in reserve	Sedimentary	118
III-3-51	Orikhivske-II (Novoandriivska site No. 6), W outskirt of Orikhiv town	Explored; in reserve	Sedimentary	118
III-4-52	Orikhivske-I (“Nova” site), SW outskirt of Orikhiv town	Explored; in reserve	Sedimentary	118
III-4-53	Orikhivske-II (sites No. 2, 7), nearby Orikhiv town	Explored; in reserve; sites No. 2 and 7 in production	Sedimentary	118
IV-2-55	Vasylivske; SE outskirt of Vasylivka town	Explored; in reserve	Sedimentary	118

Annex 3. List of deposits and occurrences indicated in the geological map and map of mineral resources in crystalline basement of map sheet L-36-VI (Zaporizhzhya)

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 ores Deposit				
I-4-64	Pivnichnotersyanske; Ternivka village	Prospected; out of production	Metamorphosed	93
I-4-67	Pivdennotersyanske; Sergiivka village	Prospected; non-perspective; out of production	Metamorphosed	93
II-2-70	Kyrpotynske; Novostepnyanske village	Prospected; non-perspective; out of production	Metamorphosed	93
II-2-74	Veselyanske; Grygorivka village	Prospected; non-perspective; out of production	Metamorphosed	93
II-4-77	Vasynivske; Vasynivka village	Explored; out of production	Metamorphosed	82
Occurrence				
III-4-83	Novodanylivskiy (Skhidniy); Novodanylivka village	No economic value	Metamorphosed	70
Non-ferrous metals Copper Occurrence				
I-2-59	Kyrpotynskiy; Bekarivka village	Konkska greenstone structure. Silicified and carbonatized chlorite-epidote-albite schists of Zaporizka Suite. Copper content 3%, lead 0.06-0.5%, cobalt 0.01%, gold 1 g/t. Perspective for prospecting	Quartz-sulphide (vein-type)	46, 63
Nickel Occurrence				
II-2-71	Kyrpotynskiy; Novostepnyanske village	Konkska greenstone structure. Silicified and carbonatized amphibolites, actinolitites and tremolitites (AR_3sr); pentlandite dissemination. Nickel content 0.3%, cobalt 0.04%. Perspectives unclear	Sulphide copper-nickel	53
III-3-78	Novopavlivske; Novopavlivka village	Orikhivsko-Pavlogradska TMZ, western contact of Novopavlivskiy gabbroid massif (AR_1np). Weathering crust. Nickel content 1.5%. Perspectives are limited	Nickel silicate weathering crust	70

1	2	3	4	5
III-3-80	Novopavlivske; Mali Shcherbaky village	Orikhivsko-Pavlogradska TMZ. Weathering crust of ultramafic rocks (AR_1np_1). Nickel content 2.6%, cobalt 0.04%. Perspectives are limited	Nickel silicate weathering crust	67
III-3-81	Shcherbakivske; Shcherbaky village	Shcherbakivskiy massif (western exo-contact). Weathering crust of ultramafic rocks (AR_3vr). Nickel content 1.6%, cobalt 0.15%. Perspectives are limited	Nickel silicate weathering crust	67
Lead, zinc Occurrence				
I-4-65	Tersyanske; Tersyanka village	Orikhivsko-Pavlogradska TMZ. Carbonate-talc-chlorite schists and magnetite-amphibole quartzites (skarnoids). Content (%): Zn – 10, Pb – 5.0, Mo – 0.3, Ni – 0.1, Cr – 0.3, Sc – 0.03, Zr – 0.03, Ce – 0.1. Perspective for prospecting	Skarn (?)	53, 63
Rare metals Beryllium Occurrence				
III-4-82	Kompaniivske; Novodanylivka village	Orikhivsko-Pavlogradska TMZ. Cataclased and silicified amphibolites (AR_1np_1) at the contact with migmatites (AR_1np_2). Be content 0.05%, Ag – 0.1 g/t. Perspectives unclear	Skarn (?)	53
Molybdenum Occurrence				
II-2-69	Kyrpotynske; Kyrpotyne village	Konkska greenstone structure. Quartz vein. Exo-contact of granites (AR_3mk) with mafic rocks (AR_3sr). Mo content up to 1%. Promising	Vein (?)	65
II-2-72	Kyrpotynske; Kyrpotyne village	Konkska greenstone structure. Schists (AR_3mh). Content (%): Mo – 0.1, Cu – 0.1, W – 0.01, Ni – 0.1. Perspectives not defined	Skarn (?)	65
IV-1-84	Skelskiy; Pershotravneve village	Skelskiy granite massif. Western exo-contact, amphibole-biotite migmatites. Mo content 0.24%. Promisiing	Vein (?)	76
Niobium Occurrence				
IV-3-85	Kompaniivske; Ilchenkove village	Orikhivsko-Pavlogradska TMZ. Chystopilska greenstone structure. Pegmatite (PR_1an). Nb content 0.5%, Cu – 0.04%, Pb – 0.2%. Promising	Rare-metal pegmatite	87
Rubidium Occurrence				
I-2-58	Kupriyanivka village	Mokromoskovskiy massif. Muscovite pegmatite. Thickness ~1 m, length up to 10 m. Content: Rb – 0.13%, Li – 0.024%, Cs – 0.007%. Promising	Rare-metal granite pegmatite	46

1	2	3	4	5
Tantalum, niobium Occurrence				
III-3-79	Shcherbakivskiy; Shcherbaky village	Shcherbakivskiy massif (western contact). Cataclased amphibolites (AR_2bz). Content: Ta – 0.02%, Nb – 0.07%, Zr – 0.15%. Perspectives unclear	Granite-like metasomatites	67
Precious metals Silver Occurrence				
II-2-73	Kyrpotynskiy; Novomokryanske village	Konkska greenstone structure. Metasomatites in meta-mafic rocks (AR_3sr). Content: Ag – 30 g/t, Cu – 0.2%, Ni – 0.2%, Co – 0.04%, Zn – 0.06%. Perspective for nickel-sulphide mineralization	Vein (quartz-sulphide)	46
Rare-earth metals Yttrium Occurrence				
IV-4-86	Kompaniivske; Novodanylivka village	Orikhivsko-Pavlogradska TMZ. Chystopilska greenstone structure. Weathering crust of pegmatoid granites (PR_1an) within amphibolites (AR_2ks). Yttrium content 0.2%. Perspective for prospecting	Rare-earth pegmatites	68
Radioactive metals Uranium Occurrence				
I-2-61	Bekarivskiy; Novotavriyske village	Prospected. Konkska greenstone structure (eastern contact of Mokromoskovskiy massif). Uranium nature. Cataclased mica-chlorite-amphibole schists. Ore mineral – pitchblende. Maximum content of U-equiv. – 0.045%, radiation – 1040 mcr/h. Perspectives unclear	Hydrothermal vein-fracture	46
II-4-76	Vasynivskiy; Klyuchi village	Not appraised. Orikhivsko-Pavlogradska TMZ. Thorium-uranium nature. Cataclased and silicified granitoids, quartzites and gneisses. Ore minerals: uraninite, coffinite, monazite. Uranium content up to 0.13%, Th – 0.01-0.011%. Perspectives unclear	Hydrothermal vein-fracture	94
Non-metallic mineral resources Non-ore raw materials for metallurgy Refractory raw materials Talc-magnesite Deposit				
II-2-75	Veselyanske; Veselyanka village	Explored; out of production	Hydrothermal	65

1	2	3	4	5
Facing raw materials Ornamental stone Granite Deposit				
I-2-3	Bekarivske; Bekarivka village	Explored; in production	Igneous	104
I-2-4	Yantsivske; Zaporizhzhya city	Explored; in production	Igneous	104
Construction raw materials Glass and porcelain-faience raw materials Primary kaoline Deposit				
I-2-56	Bilyaivske; Vilnyansk town (Bilyaivka village)	Explored; out of production	Exogenic, residual	104
Occurrence				
I-2-57	Spasivskiy; Spasivka village	Weathering crust of Mokromoskovski granites. Kaolines of II and III grades. Average thickness 20.5 m. Overburden 30.6 m. Square 1 km^2. Promising	Exogenic, residual	104
I-3-62	Mykhaylo-Lukashivskiy; Mykhaylo-Lukashive village	Weathering crust of Mokromoskovskiy and Dnipropetrovskiy complex granites. Content of highest and first grades for ceramic – 35-80%. Average thickness 6-8 m; overburden – 38-48 m. Square 2 km^2. Promising	Exogenic, residual	104
Quarry-stone raw materials Granite, migmatite Deposit				
I-1-1	Zaporizke; Zaporizhzhya city	Explored; in production	Igneous	104
I-2-4	Yantsivske; 20 km to E from Zaporizhzhya city	Explored. 3 sites: “Nova” in production; “Druzhelyubivska” and “Ivano-Gannivska” out of production	Igneous	118
I-2-5	Natalivske; 0.5 km to N from Natalivka village	Explored; Pravoberezhna site in production	Igneous	118
I-2-6	Mokryanske; 6 km from Rostushcha station	Explored; in production	Igneous	118
I-2-3	Bekarivske; Bekarivka village	Explored; out of production, in reserve	Ultra-metamorphic	118
I-3-7	Mykilske; Mykilske village	Explored; used to be mined, now in reserve	Ultra-metamorphic	118
II-2-12	Mokryanske-II; Zaporizhzhya city	Explored; in production	Ultra-metamorphic	118
II-2-13	Peredatochnyanske; Zaporizhzhya city	Explored; in production	Ultra-metamorphic	118
II-2-30	Odarivske; Odarivka village	Explored; in production	Ultra-metamorphic	118

1	2	3	4	5
Underground waters Mineral (mineralized) Low-saline (3-10 g/dm^3) Deposit				
II-4-22	Vasynivske; Kirove village	Explored; in reserve	Bed-fracture	104
III-4-27	Orikhivske; Orikhiv town	In production	Bed-fracture	104
Occurrence				
I-3-63	Rayskiy; Rayske village	Sulphate-chloride potassium-sodium water of Izhevskiy type. Water-bearing horizon – fractured Precambrian rocks, depth 48.5 m. Mineralization 3.6 g/dm^3, yield 0.56 l/s	Bed-fracture	104
I-4-66	Krynivskiy; Krynivka village	Sulphate-chloride sodium water of Izhevskiy type. Water-bearing horizon – fractured Precambrian rocks, depth 45.3 m. Mineralization 5.4 g/dm^3, yield 0.8 l/s, temperature 12^{o}C	Bed-fracture	104
II-1-68	Zaporizkiy; Zaporizhzhya city	Chloride-sulphate sodium water of Izhevskiy type, mineralization 3.6 g/dm^3, yield 0.9 l/s. Water-bearing horizon – fractured Precambrian rocks	Porous-fracture-bed	104
IV-4-87	Verbivskiy; Verbove village	Chloride-sulphate sodium water of Uglytskiy type, mineralization 4.7 g/dm^3, yield 1.7 l/s. Water-bearing horizon – fractured Precambrian rocks	Porous-fracture-bed	104
Radon Occurrence				
I-2-60	Natalivskiy; Natalivka village	Radon mineral chloride-sulphate sodium water of Bilokurykhinskiy type. Mineralization 1.4 g/dm^3. Water-bearing horizon – fractured Precambrian rocks. Radon content – 152 em.	Porous-fracture-bed	104

Annex 4. List of deposits and occurrences indicated in the geological map and map of mineral resources in pre-Quaternary units of map sheet L-37-I (Pology)

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 Deposit				
I-1,2-13 II-2,3,4-13	Sanzharivske; in map sheets L-37-I-A,B,D; L-37-2-C; L-37-14-A,B and further to E outside studied area	Explored; in reserve	Sedimentary	62
Occurrence				
II-1-3	Rizdvyanskiy; 1 km from Rizdvyanka village	Bed thickness – 2.0-15.0 m, depth – 94.0-112.0 m. Coal contains accompanied components – rare, rare-earth and trace metals	Sedimentary	73
II-2-7	Solodkivskiy complex; in Solodke, Shevchenkivske, Grusheve villages	Bed thickness – 2.0-18.0 m, depth – 67.0-100.0 m. Coal contains accompanied components – rare, rare-earth, trace and radioactive metals	Sedimentary	73
II-2-10	Sanzharivskiy complex; in Noviy, Novouspenivka, Novomykolaivka, Poltavka villages	Bed thickness in Novoselivske brown coal occurrence – 1.5-12 m, depth – 65.0-102.0 m	Sedimentary	73
Metallic mineral resources Radioactive metals Uranium Occurrence				
II-2-7	Solodkivskiy; in Solodke, Shevchenkivske, Grusheve villages	Bed thickness – 2.0-18.0 m, depth – 67.0-100.0 m. Brown coal contains rare, rare-earth, trace metals and uranium	Sedimentary	73
Non-metallic mineral resources Non-ore raw materials for metallurgy Refractory raw materials Clay, secondary kaoline Deposit				
I-1,2-13 II-2,3,4-13	Sanzharivske	Explored; in reserve	Sedimentary	62
III-1-18	Pologivske; nearby Pology town	In production	Sedimentary	118

1	2	3	4	5
III-2-23	Pivnichnopologivske; 4 km to N from Pology town	Explored; in reserve	Sedimentary	118
Occurrence				
II-1-4	Mykolaivskiy; in Mykolaivka village	Secondary kaolines of Novopetrivska Suite. Thickness 2-26 m; overburden 16-22 m. Kaolines are refractory (1730-1770^{o}C)	Sedimentary	73
II-1-5	Dobropilskiy; 2 km to NW from Dobropillya village	Secondary kaolines of Reshetylivska sequence. Kaoline depth 35-40 m, thickness 4-5 m	Sedimentary	73
III-1-7	Myrniy (complex); Myrne village	Kaolines 0.5-4.0 m thick, refractory (1750^{o}C). Quartz foundry sands 15-20 m thick (N_1np_3), comply standard 2138-74; suitable for high-quality glass (optic, lead-less crystal etc.) manufacturing	Sedimentary	115
Foundry raw materials Sand Deposit				
IV-2-36	Pologivske; 3.5 km to NW from Pology station	Explored; in reserve	Sedimentary	115
Chemical raw materials Agro-chemical raw materials Phosphorite Occurrence				
II-1-11 II-2-11	Gulyajpilskiy	Non-perspective	Sedimentary, nodular	73
Non-metal ore commodities Abrasive raw materials Corundum Deposit				
IV-2-40	Dragunske; NE part of Zrazkove and Tykhiy Gay villages	Explored; in reserve	Metamorpho-genic	117
Construction raw materials Quarry-stone raw materials Migmatite Deposit				
I-2-1	Pokrovske (Druzhba, Lyasheva Balka quarries); 6 km to E from Velykomykhaylivka village	In production; average thickness of mineable sequence 10 m, overburden 6.9 m	Ultra-metamorphic	119
I-2-2	Velykomykhaylivske (Lyashevobalkivskiy quarry); Velykomykhaylivka village	In production; thickness of mineable sequence 10 m, overburden 6.9 m	Ultra-metamorphic	119
IV-1-35	Shevchenkivske; 0.3 km to SE from Shevchenkivske village	In production	Ultra-metamorphic	118
Plagiogranite Deposit				
IV-2-39	Kinsko-Rozdorivske; Kinski Rozdory village	In production	Ultra-metamorphic	118

1	2	3	4	5
IV-3-43	Pivnichno-kuybyshevske; 2 km to N from Kuybysheve village	Explored; in reserve	Ultra-metamorphic	118
Sand-gravel raw materials Sand Deposit				
IV-3-42	Balka Shyroka; S outskirt of Novoukrainka village	In production	Sedimentary	78
Brick-tile raw materials Clay, loam, secondary kaoline Deposit				
IV-1-34	Basanske; NE outskirt of Basan village	In production	Sedimentary	118
IV-2-37	Chapaivske; NE outskirt of Chapaivka village	In production	Sedimentary	118
IV-2-38	Pologivske-III; 4 km to SE from Pology town	Explored; in reserve	Sedimentary	118
Groundwaters Fresh Deposit				
II-1-6	Gulyajpilske-III; Gulyajpole town	In production	Porous-fracture-bed	104
II-2-9	Gulyajpilske; Poltavka village	In production	Porous-fracture-bed	104
II-3-14	Konksko-Yalynske	Explored; in reserve	Porous-fracture-bed	104
III-1-15	Gulyajpilske; Zaliznychne village	Explored; in reserve	Porous-fracture-bed	104
III-1-16	Orikhivske; Novoselivka village	In production	Porous-fracture-bed	104
III-2-20	Gulyajpilske-I; Gulyajpole town	In production	Porous-fracture-bed	104
III-2-21	Gulyajpilske-II; 3.5 km to S from Gulyajpole town	In production	Porous-fracture-bed	104
III-2-22	Konksko-Yalynske; Shevchenkove village	Explored; in reserve	Porous-fracture-bed	104
III-2-24	Pologivske; Shevchenkove village	In production	Porous-fracture-bed	104
III-2-25	Konksko-Yalynske	Explored; in reserve	Porous-fracture-bed	104
III-3-26	Konksko-Yalynske; Novozlatopol village	Explored; in reserve	Porous-fracture-bed	104
III-3-27	Konksko-Yalynske; Samiylivka village	Explored; in reserve	Porous-fracture-bed	104
III-3-28	Konksko-Yalynske; Khliborobne village	Explored; in reserve	Porous-fracture-bed	104
III-4-29	Konksko-Yalynske; Novgorod village	Explored; in reserve	Porous-fracture-bed	104
III-4-30	Konksko-Yalynske; 2 km to S from Zhovtneve village	Explored; in reserve	Porous-fracture-bed	104
IV-1-31	Pologivske; Inzhenerne village	In production	Porous-fracture-bed	104
IV-1-32	Pologivske; site No. 1, Pology town	In production	Porous-fracture-bed	104

1	2	3	4	5
IV-1-33	Pologivske; site No. 2, Pology town	In production	Porous-fracture-bed	104
IV-3-41	Konksko-Yalynske; Novoukrainka village	Explored; in reserve	Porous-fracture-bed	104
IV-4-44	Konksko-Yalynske; Urytske village	Explored; in reserve	Porous-fracture-bed	104
IV-4-45	Kuybyshevske; 2.5 km to NW from Maryanivka village	In production	Porous-fracture-bed	104
Mineral (mineralized) Very low-saline (1-3 g/dm^3) Deposit				
IV-3-96	Kuybyshevske; Kuybysheve town	In production; reserves not approved	Porous-fracture-bed	104
Low-saline (3-10 g/dm^3) Occurrence				
II-2-8	Uspenivka village	Mineral waters. In production. Water type Myrgorodskiy. Depth 33 m, yield 2.78 l/s	Porous-fracture-bed	104
II-3-12	Novopol village	Mineral waters. In production. Water type Izhevskiy. Depth 75 m, yield 0.5 l/s	Porous-fracture-bed	104
III-2-19	Gulyajpole town	Mineral waters. In production. Water type Myrgorodskiy. Depth 21 m, yield 2.78 l/s	Porous-fracture-bed	104
IV-4-46	Vershyna village	Mineral waters. In production. Water type Almaatynskiy. Depth 169 m, yield 2.8 l/s	Porous-fracture-bed	104

Annex 5. List of deposits and occurrences indicated in the geological map and map of mineral resources in Quaternary sediments of map sheet L-37-I (Pology)

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 Precious metals Gold				
IV-2-57	Sukha Konka River	In modern alluvium 3 gold grains 0.5-0.7 mm in size encountered	Sedimentary	104
IV-2-59	Konka River	In modern alluvium 3 gold grains 0.5-1.0 mm in size encountered	Sedimentary	104
IV-2-60	Konka River; Tykhiy Gay village	In modern alluvium 1 gold grain is encountered	Sedimentary	104
Non-metallic mineral resources Non-metallic raw materials Jewelry raw materials (precious stones) Diamond				
IV-2-58	Sukha Konka River; Kinski Rozdory village	In modern alluvium diamond crystal 0.3 mm in size is encountered	Sedimentary	104
Construction raw materials Sand and gravel raw materials Sand				
I-1-47	Pokrovske; NW outskirt of Pokrovske village	In production	Sedimentary	119
IV-2-54	Pologivske; 2.5 km to E from Pology station	Explored; in reserve	Sedimentary	118
IV-2-56	Pologivske-III; 4 km to SE from Pology town, Otryshkova gully	Explored; in reserve	Sedimentary	118
Brick and tile raw materials Loam, clay Deposit				
II-1-48	Varvarivske; SE outskirt of Varvarivka village	In production	Sedimentary	118
II-1-49	Kalmytske; 3.5 km to N from Gulyajpole town	Explored; in reserve	Sedimentary	118
II-1-50	Gulyajpilske; 3 km to W from Gulyajpole town	In production; non-perspective	Sedimentary	118
III-1-51	Gulyajpilske; nearby SW outskirt of Gulyajpole town	Explored; in reserve, non-perspective	Sedimentary	115
III-1-52	Pologivske-II; in sites I, II, III of Pologivske kaoline and refractory clay deposit	In production	Sedimentary	118
IV-1-53	Basanske; NE outskirt of Basani village	In production	Sedimentary	118

1	2	3	4	5
IV-2-55	Chapaivske ; NW outskirt of Chapaivka village	In production	Sedimentary	118
IV-2-56	Pologivske-III; 4 km to SE from Pology town	Explored; in reserve	Sedimentary	118
IV-3-61	Kuybyshevske; SW outskirt of Kuybysheve village	Explored; in reserve	Sedimentary	118

Annex 6. List of deposits and occurrences indicated in the geological map and map of mineral resources in crystalline basement of map sheet L-37-I (Pology)

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 ores Deposit				
III-1-81	Gulyajpilske; Zaliznychne village	Explored, prepared for development; out of production; in reserve	Metamorphosed	18, 63, 80, 84, 95
Non-ferrous metals Copper Occurrence				
I-4-68	Fedorivske; Dniproenergiya village	Fedorivska structure. Two-mica gneisses, mafic gneisses and calciphyres (AR_2tr_2) and granites (γcAR_3jn). Copper content 1.0%, W - 0.15%, Li - 0.2%, apatite – 5%. Perspectives unclear	Quartz-sulphide (vein-type) and greisen (?)	71
I-4-69	Fedorivske; Dniproenergiya village	Fedorivska structure. Calciphyres (AR_2tr_2). Copper content 1.0%. Perspectives unclear	Quartz-sulphide (vein-type)	71
IV-3-95	Gusarka village	Zone of Prakonkskiy Fault. Kuybyshevskiy ore camp. Plagiomigmatite (AR_1np). Copper content 1.0%, zinc 0.1%. Perspectives unclear	Quartz-sulphide (vein-type)	71
Nickel Occurrence				
IV-2-92	Kinski Rozdory village	Zone of Prakonkskiy Fault. Kuybyshevskiy ore camp. Fault zone. Actinolitites, metagabbroids. Nickel content 1%. Perspectives unclear	Sulphide copper-nickel	53
IV-2-93	Nova Dacha village	Zone of Prakonkskiy Fault at intersection with Pologivskiy Fault. Kuybyshevskiy ore camp. Granitized gabbroids (AR_1np_1). Content (%): Ni – 1, Co – 0.007, Cr – 0.05. Perspectives unclear	Sulphide copper-nickel (?)	53
IV-2-94	Nova Dacha village	Zone of Prakonkskiy Fault. Kuybyshevskiy ore camp. Actinolitized gabbroids (AR_1np_1). Nickel content 1%. Perspectives unclear	Sulphide copper-nickel	53

1	2	3	4	5
Lead Occurrence				
III-2-85	Chumatske village	Zone of Gaychursko-Sorokynskiy Fault, Kosivtsivske ore field. Cataclased and microclinized plagiogneisses (AR_1vt). Content (%): Pb – 0.7, Sn – 0.05, Sb – 0.1. Promising	Vein-type	63, 71
Rare metals Lithium Deposit				
I-3-66	Shevchenkivske; Shevchenko village	Explored; out of production; in reserve	Albite-spodumene pegmatites	64
Occurrence				
I-3-64	Oleksandrograd village	Promising	Rare-metal granite pegmatites	74
Molybdenum Occurrence				
II-2-79	Uspenivske; Pavlivka village	Gaychurska structure. Cataclased gneisses and mafic gneisses (AR_2tr_1) penetrated by pegmatoid garnet- and tourmaline-bearing granites. Molybdenum content 0.15%, Pb – 0.02%, W – 0.015%, Li – 0.03%, Ag – 1.5 g/t. Promising	Vein	63, 71, 73, 113
III-2-84	Mezhyryn village	Kosivtsivska greenstone structure. Kosivtsivske ore field. Junction zone of Dobropilskiy and Kuybyshevskiy faults. Remnant of biotite-amphibole gneisses (AR_1vt). Mo content 0.1%, Y – 0.007%. Promising	Vein	63, 71
Niobium Occurrence				
II-1-72	Vozdvyzhivka village	Gaychurska structure, in biotite gneisses of Ternovatska Sequence in zone of Andriivskiy Fault. Nb content – 0.7%, W – 0.5%, Cu – 0.5%, Co – 0.07%, Au – 0.5 g/t. Not confirmed	Alkaline granite-like feldspar metasomatites	71, 73, 113
IV-2-90	Ulyanivka village	Zone of Prakonkskiy Fault, Gaychurskiy Block. Kuybyshevskiy ore camp. Diorites (AR_1np_2) in zone of Semenivskiy Fault. Nb content 0.3%, Ag – 2 g/t. Perspectives unclear	Alkaline feldspar metasomatites	58
Rubidium Occurrence				
I-4-70	Dniproenergiya village	Fedorivske ore field. Southern limb of Fedorivska brachy-syncline. Pegmatites (PR_1an). Rb content 0.2%, Ce 0.098%. Promising	Rare-metal granite pegmatite	71, 77

1	2	3	4	5
Zirconium Occurrence				
I-1-62	Trudove village	Orikhivsko-Pavlogradska TMZ. Weathering crust after plagiomigmatites (AR_1np_2). Zr content 0.88%, La 0.06%. Perspectives unclear	Residual	54
II-2-74	Novovasylivske village	Weathering crust after amphibole-biotite gneisses (AR_1zp). Zr content 1%, Ti – 1%, P 0.1%. Perspectives unclear	Residual	71
Precious metals Gold Occurrence				
II-1-71	Gaychurskiy; Kosivtsivo village	Gaychurska structure. Central-Gaychurske ore field. Zone of skarnation, silicification, sulphdization (3-10 m) in mafic gneisses with vein-disseminated gold, pyrite, chalcopyrite, molybdenite, magnetite. Au content 0.3-10.8 g/t (5.6 g/t in average), Ag 0.003%, Bi 0.1%, Mo 0.05%, Cu 0.03%. Promising in term of gold-sulphide-quartz deposit	Gold-sulphide-quartz vein	73, 113, 110
III-1-83	Gulyajpilskiy; Kostyantynivka village	Gulyajpilska syncline. Pyritized meta-sandstones of Gulyajpilska Suite with gold and pyrite. Gold content 17.4 g/t. Promising in term of metamorphogenic-hydrothermal gold deposit	Quartz, gold-sulphide-quartz vein	110
IV-2-57	Heavy concentrate sample, Sukha Konka River, Kinski Rozdory village	Kuybyshevskiy ore camp. Modern surface alluvium. Three gold grains 0.5-0.7 mm in size. Prospecting evidence	Exogenic, placer	59
IV-2-59	Heavy concentrate sample, Konka River, Kinski Rozdory village	Modern surface alluvium. Three gold grains 0.5-1.0 mm in size. Prospecting evidence	Exogenic, placer	59
IV-2-60	Heavy concentrate sample, Konka River, Kinski Rozdory village	Modern surface alluvium. One gold grain. Prospecting evidence	Exogenic, placer	59
Silver Occurrence				
II-2-73	Gulyajpilskiy composite (Silver-uranium); Pryvilne village	Uspenivska structure. Weathered amphibole-garnet-biotite gneisses of Vovchanska Sequence. Ag content 30 g/t, Au 0.5 g/t, U 1.222%, Th 0.002%, Cu 0.015%, Pb 0.01%. Promising for prospecting	Vein	113, 63

1	2	3	4	5
Trace metals Gallium Occurrence				
I-3-65	Oleksandrograd village	Shevchenkivska structure, in muscovite-biotite gneisses. Ga content 0.02%, Li 0.1%, Be 0.002%. Perspectives unclear	Massive-sulphide-polymetallic (?)	53
Thallium Occurrence				
IV-2-87	Ulyanivka village	Kuybyshevskiy ore camp. Zone of Prakonkskiy Fault. Remnants of brecciated biotite gneisses in granitoids of Novopavlivskiy and Anadolskiy complexes. Thallium content 0.007, bismuth 0.1%, chromium 0.05%, nickel 0.07%. Perspectives unclear	Massive-sulphide-polymetallic (?)	77
Rare-earth metals Yttrium Occurrence				
II-2-75	Uspenivka village	Gaychurska structure, Uspenivske ore field. Pegmatite (PR_1an) in two-mica mafic gneisses (AR_2tr_1), Yttrium content 0.15%, xenotime 5 kg/t. Promising	Rare-earth granite pegmatites	73
II-2-76	Uspenivka village	Gaychurska structure, Uspenivske ore field. Pegmatite (PR_1an) in two-mica mafic gneisses (AR_2tr_1), Yttrium content 0.1%, bismuth 0.05%, ytterbium 0.007%. Promising	Rare-earth granite pegmatites	73, 113
II-2-77	Rivnopillya village	Gaychurska structure, Uspenivske ore field. Weathering crust after pegmatites (PR_1an) and mafic gneisses (AR_2tr_1). Total REE content 0.134%. Promising	Residual	73
II-2-78	Poltavka village	Gaychurska structure, Uspenivske ore field. Weathering crust after xenotime-uraninite pegmatites (PR_1an) in Ternuvatska Sequence rocks (AR_2tr_1). Total REE content 0.18%. Promising	Residual	73
IV-1-86	Ulyanivka village	Zone of Konkskiy Fault. Weathering crust after granitoids (AR_1np_2). Yttrium content 0.1%, Nb 0.01%, Mo 0.3%. Promising	Weathering crust	58, 63
IV-2-88	Magedove village	Zone of Prakonkskiy Fault. Kuybysgevskiy ore camp. Diorites (AR_1np_2). Yttrium content 0.1%, Nb 0.01%, Cu 0.3%. Perspectives unclear	Hydrothermal-plutonogenic rare-earth-polymetallic	100, 53

1	2	3	4	5
IV-2-91	Ulyanivka village	Zone of Prakonkskiy Fault. Kuybysgevskiy ore camp. Primary kaolines after diorites (AR_1np_2). Yttrium content 0.3%, La 0.2%, Yb 0.02%, Nb 0.07%. Perspectives unclear	Residual	58, 63
Radioactive metals Uranium Occurrence				
II-2-73	Gulyajpilskiy composite (silver-uranium); Pryvilne village	Zakhidnopryazovska TMZ. Uspenivska syncline. Vovchanska Sequence. Uranium nature. Thickness 5.9 m, by dip up to 100 m. Uranium content 1.222%, Th 0.002%, Ag 30 g/t, Au 0.5 g/t over thickness 0.5 m. Promising	Hydrothermal	113
JJ-2-80	Malynivskiy; Malynivka village	Gaychurska greenstone structure. Kosivtsivske ore field. Uranium nature. Veins of pegmatoid granites (PR_1an). Mineralization – uraninite, monazite, xenotime and uranium blacks. Uranium content 0.029%, Th 0.004% over thickness 0.5 m. Perspectives unclear	Pegmatite	113
Non-metallic mineral resources Non-ore raw materials for metallurgy Abrasive raw materials Corundum Deposit				
IV-2-40	Dragunske; Zrazkoviy and Tykhiy Gay villages	Promising; out of production	Metamorpho-genic	117
Jewelry raw materials (precious stones) Diamond Occurrence				
IV-2-58	Heavy concentrate sample, Sukha Konka River, Kinski Rozdory village	Kuybyshevskiy ore camp. In modern alluvium of Sukha Konka River single greenish diamond crystal 0.3 mm in size encountered. Prospecting evidence for hard-rock diamond sources	Exogenic, placer	60
Facing raw materials (ornamental stone) Marble Deposit				
I-4-67	Veselivskiy; Fedorivka village	Fedorivska structure. Ternovatska Sequence. Mineral commodity – marble and calciphyre, thickness 95.0-128.0 m, depth 44.5 m. Perspectives unclear	Metamorpho-genic	104
Quarry-stone raw materials Granite, migmatite, diorite Deposit				
I-2-1	Porkovske (quarries “Druzhba”, “Lyasheva Balka”; 6 km to E from Velykomykhaylivka village	In production; average thickness of mineable sequence 10 m, overburden 6.9 m	Ultra-metamorphic	119

1	2	3	4	5
I-2-2	Velykomykhaylivske; Lyashevobalkivskiy quarry, Velykomykhaylivka village	Explored. In production	Igneous	119
IV-1-35	Shevchenkivske; Shevchenko village	Explored. In production	Igneous	104
IV-2-39	Kinsko-Rozdorske; Kinski Rozdory village	Explored. In production	Igneous	104
IV-3-43	Pivnichno-kuybyshevske; Kuybysheve village	Explored. Used to be in production; in conservation	Ultra-metamorphic	104
III-1-81	Gulyajpilske	Hard stripping rocks of Gulyajpilske iron-ore deposit. Suitable for crushed stone and heavy concrete filler manufacturing	Metamorpho-genic	104
Underground waters Mineral (mineralized) Very low-saline (1-3 g/dm^3) Deposit				
II-1-6	Gulyajpilske-III; Gulyajpole town	In production	Porous- fracture-bed	104
III-1-15	Gulyajpilske ferruginous quartzite deposit; Zaliznychne village	Explored; out of production; in reserve	Porous- fracture-bed	104
IV-3-96	Kuybyshevske; Kuybysheve village	In production; reserves are not approved	Porous- fracture-bed	104
Low-saline (3-10 g/dm^3) Deposit				
III-1-82	Gulyajpilske ferruginous quartzite deposit; drainage waters, Zakhidna-1 site; Zaliznychne village	Explored; out of production	Porous- fracture-bed	104
Occurrence				
I-2-63	Pokrovskiy; Pokrovske village	Sulphate-chloride potassium-sodium water of Izhevskiy type. Mineralization 4.1 g/dm^3, yield 0.09 l/s. Water-bearing horizon – fractured Precambrian rocks, depth 11-16 m	Porous- fracture-bed	104
IV-2-89	Kinsko-Rozdorskiy; Kinski Rozdory village	Chloride-sulphate sodium water of Uglitskiy type. Mineralization 6.4 g/dm^3, yield 0.49 l/s. Water-bearing horizon – fractured Precambrian rocks, depth 10-115 m	Porous- fracture-bed	104

Annex 7. Catalogue of nature landmarks

Geological landmarks

Stratigraphic and geochronologic landmarks

1. *Outcrop of Archean rocks*. Mokromoskovskiy granite massif (Neo-Archean). In Ntalivka village of Zaporizkiy area, by Mokra Moskovka River, on the slope of Skelyuvata gully, grey, greiysh-pink biotite medium-grained granites of Archean (2835 Ma) Mokromoskovskiy Complex are exposed. Mokromoskovskiy massif is extended over more than 30 km. Granites are being mined in Yantsevskiy quarry in Ivano-Gannivka village on the slope of Skelyuvata gully.

Exposure comprises petrographic type of Mokromoskovskiy Complex granites and is of scientific value. It is suggested to give the status of the State-rank nature landmark.

2. *Outcrop of Archean granites*. Khortytsya Island. In Zaporizhzhya city, in the mid-stream of Dnipro River, the Khortytsya Island is located which from the ancient times had impressed travelers by its greatness and beauty. In the times of Kozak liberty the settlement of Zaporizki Kozaks was situated in Khortytsya because the Island comprised unassailable nature fortress.

The Khortytsya landscape is variable. It includes agglomerations of granite cliffs, vertical walls, numerous ravines and gorges overgrown with shrubs; steppe sites are changed by the pine forests and poplar woods. Since the times of Zaporizki Kozaks up to now the titles of specific cliffs are remained related to numerous legends – Dva Braty (Two Brothers), Stovby (Pillars), Zaporizka Myska (Zaporizka Plate) etc.

The ridges and individual cliffs composed of Archean Khortytska association granites are exposed in the island coast. Their isotopic age is 2840-2640 Ma. Khortytsya Island comprises the State history-lore reserve and is protected by Zaporizkiy city authorities.

3. *Outcrops of Neogene sediments*. In Veselyanka village of Zaporizkiy area, in Skelyuvaya gully and in the left bank of Konka River (directly in the village) the continuous section of Upper and Lower Miocene sediments is exposed. From the gully top to mouth, in the slope cliffs, the following units are exposed: Khersonskiy regio-sub-stage sands, limestones and dark clays, Besarabskiy regio-sub-stage clays and sands, and Volynskiy regio-sub-stage sandy-shelly rocks of Sarmatian regio-stage. In the village, in the Konka River bank cliff the rocks of Miocene Konkskiy horizon are exposed.

The outcrop comprises basic section of the Upper and Middle Miocene sediments and is of scientific value. The local-rank nature landmark if protected by the local authority. The land allotment is 5 hectares in size.

4. *Outcrop of Sarmatian sediments*. Saur-Mogyla. In Grygorivka village of Zaporizkiy area, in the right bank of Konka River, the hill Saur-Mogyla is located. It is composed of shelly limestone exposed in several places. Saur-Mogyla is of stratigraphic and geomorphologic values. It is the local-rank landmark under protection of the local authorities. The land allotment is 5 hectares in size.

Paleontologic landmarks

5. *Location of Sarmatian flora*. Close to the area centre Orikhiv town, in Velyka Kamyanka gully the parti-coloured clays with Sarmatian flora remnants are exposed.

These paleontologic findings are of considerable scientific value being fairly rare in the given sediments.

It is the local-rank nature landmark under protection of local authorities. The land allotment is 5 hectares in size.

Impressive landmarks

6. *Velyka Kamyana cliff*. It is located in 2 km from Gusarka village of Kuybyshevskiy area in the bank of Sukha Konka River. The cliff is composed of Lower Proterozoic Anadolskiy (formerly Pryazovskiy) Complex granites.

Nature landmark is protected by the local authorities.

STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

CENTRAL-UKRAINIAN SERIES

Map sheets
L-36-VI (Zaporizhzhya) and L-37-I (Pology)

EXPLANATORY NOTES

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Published according to the decision of Scientific-Editorial Council
of the State Geological Survey of the Ministry of Ecology and Natural Resources of Ukraine
of January 23, 2003 (Protocol No. 124)

Chief of Publishing Center	S.O.Nekrasova
Editor	G.G.Golubeva
Technical Editor	K.N.Koliychuk
Computer arrangement	S.I.Vyshnytska, A.V.Volkogon

English translation and computer arrangement B.I.Malyuk (2010)

Published by UkrSGRI.
Registration Certificate Series DK No. 182 of 18.09.2000

Address: UkrSGRI Publishing Centre, 04114, Kyiv-114, Autozavodska Str., 78A
Tel.: 206-35-18; tel./fax: 430-41-76