STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

CARPATHIAN SERIES

MAP SHEETS
M-34-XXIX (Snina), M-34-XXXV (Uzhgorod), L-34-V (Satu Mare)

EXPLANATORY NOTES

Designed by: B.V.Matskiv, B.D.Pukach, Yu.V.Kovalyov, V.M.Vorobkanych

Carpathian Series map sheet Editor-in-Chief: S.S.Kruglov

Editor: V.V.Kuzovenko

Expert of Scientific-Editorial Council: G.D.Dosyn (Lviv Branch of UkrSGRI)

English translation (2008): B.I.Malyuk

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Authors:

B.V.Matskiv, B.D.Pukach, Yu.V.Kovalyov, V.M.Vorobkanych

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B.I.Malyuk, Doctor of Geological-Mineralogical Sciences, UkrSGRI

In the Explanatory notes the data on stratigraphy, magmatism, tectonics, history of geological development, geomorphology, hydrogeology, mineral resources and regularities of their distribution for the map sheets Snina, Uzhgorod and Satu Mare within Ukraine are presented. The perspectives for discovery of the ore and non-ore mineral resources, drinking, mineral and thermal waters are evaluated, brief description of ecologo-geological environment in the area is given, the list of disputable problems is provided. The lists of all discovered deposits and occurrences are presented in the annexes.

Key words: Eastern Carpathians, scale 1:200 000, Trans-Carpathian Depression.

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Abbreviations used in the text

CSF - conventionally-safe factor
Derzhgeolkarta-200 - the State Geological Map in the scale 1:200 000
DGM-50 - Deep Geological Mapping in the scale 1:50 000
GM-50 – Geological Mapping in the scale 1:50 000
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
GPM-200 - Geological-Prognostic Mapping in the scale 1:200 000
IP - Induced Polarization
LTC - Litho-Tectonic Complex
LTZ - Litho-Tectonic Zone
MTS - Magneto-Telluric Sounding
NSC - National Stratigraphic Committee of Ukraine
SCMR – State Commission on Mineral Reserves
SGE - State Geological Enterprise
TAC - top admissible concentration
TAL - top admissible level
TIC - Territorial-Industrial Complex
TC[I]T – Trans-Carpathian [Internal] Trough
SEP – Standard [vertical] Electric Profiling
INTRODUCTION

The territory of map sheets M-34-XXIX (Snina), M-34-XXXV (Uzhgorod), and L-34-V (Satu Mare) includes portions of Lvivska and Zakarpatska (Trans-Carpathian) Oblasts of Ukraine, bounded by the 23°00' E longitude and 49°20' N latitude, and the State borders with Poland, Slovakia, Hungary and Romania. This is a segment of the Eastern (Ukrainian or Forest) Carpathians and Trans-Carpathian Plain which include the following elements: Skyboviy Thrust, Kroskenska Zone, Duklyanskiy, Porkuletskiy and Magurskiy Thrusts (External Carpathians), Marmaroska and Peninska Zones, and Trans-Carpathian Internal Trough (Internal Carpathians).

In the relief of north-eastern macro-slope of Carpathians there are distinguished a range of low-height ridges of the general Carpathian strike which constitute Verkhnyodnisterski Beskydy and Striysko-Syanska Verkhovyna. Narrow straight-line ridges with altitudes 800-1000 m, relative heights 400-600 m and slope angle 15-30°, are separated there by the wide by-strike valleys in upper courses of Dniester and Syan rivers.

In the middle part of Kroskenska Zone there is located Vododilnyi (Watershed) Ridge from 889 m (Uzhotskiy pass) to 1406 m (Pikuty Mountain) high south-westward of which there is extended Volovetsko-Mizhgoriska Verkhovyna and the highest in the territory Polonynskiy Ridge (Polonyna Rivna Mountain of 1479 m height). This part of the area is of medium-mountain type, extensively eroded, with narrow ridges, steep (25-40°) slopes, narrow river and stream valleys, and altitudes 400-800 to 1000 m. Mountain slopes are overgrown with beech forests, and at the watersheds Alpine meadows (polonyny) are developed.

With an inter-mountain low-land (Berezne-Lypchanska) the Polonynskiy Ridge is separated from Vygorlat-Gutynskiy volcanic ridge, which, in turn, by the right branches of Tysa River is split into the range of low-mountain massifs: Poprichniy (Vitrova Skala Mountain – 1024.9 m), Makovysysa with the same-named mountain (976 m), Synyak (Dunavka Mountain – 1018 m), and Berliiv Dil (1017 m). These are ceased volcanoes. There the ridge crests are wide, flat or rounded but the slopes are steep enough (10-25°), extensively eroded, and overgrown with the beech and oak forests.

Asymmetry of mountain system as well as all its ridges comprises general relief feature of Ukrainian Carpathians is: the ridge south-western slopes are more flattened while the north-eastern ones are steeper. In Vygorlat-Gutynskiy case it is expressed in the wide fore-mountain belt with the heights 220-450 m which gradually changes into the Trans-Carpathian low-land. This is flat plain which is getting lower toward the Tysa River valley and is 100-120 m high. Some individual island-like mountains (Kholmets, Shalanky) or plateaus (Beregovo-Biganske) up to 300-368 m high are distinguished over the plain. And the plain is crossed by the dense river and drainage channel network.

The river network of the territory belongs to the basins of Black Sea and Baltic Sea. The biggest river Tysa, the left branch of Danube, flows from the east to west in the southern part of the area and in places it provides the natural border with Hungary. Its width is 80-150 m, depth – 2-3 to 6 m, flow speed – 0.6-0.9 m/sec, the bottom is mainly sandy, the banks are abrupt (2-7 m high). The flood-land is covered by meadows. Over its entire course the river is fenced by 2-5 m high dam.

The rivers in Trans-Carpathians, the right branches of Tysa River (Uzh, Latorytsya, Borzhava) and in the Carpathian northern mega-slope (upper courses of Dniester, Syan and Striy rivers) are normal mountain ones, fast-flow (up to 0.9-1.2 m/sec), with stony, pebbly, rarely sandy bottom, rapid. Their depth is normally 1-2 m and in Trans-Carpathian only it attains 3-4 m in lower courses. The floods, often catastrophic, are characteristic for the whole region, when water level sharply ups by 3-6 m (historical maximum is 13.86 m recorded on 4-5.11.1998 in Tysa River nearby Chop town).

The transport connection between Trans-Carpathians and Lvivska Oblasts is being carried out through Uzhotskiy pass by railroad and highway. The dense network of paved roads connect the towns and villages over Trans-Carpathian plain, and in Carpathians the paved roads are constructed along the valleys of all big rivers, as well as a number of dirty roads available. By highways and railroads Lvivska Oblast is also connected with other regions of Ukraine and with Poland, and Trans-Carpathians – with Slovakia, Hungary and Romania.

Major inhabited locations over the territory include Trans-Carpathian regional center Uzhgorod (105,000 inhabitants) as well as area centers Mukachevo (82,000), Beregovo (36,300), Svalyava (7,800), Perechyn (6,600), and V.Bereznyi (6,200). Ukrainian predominate among inhabitants, there are Russians, Slovaks, Jews, Hungarians (the latter are especially numerous in the south, specifically in the Beregovo area) in the big locations. The population is involved in agriculture (gardening, farming, winegrowing in the plain, and cattle-breeding in the mountains), forestry. The light industry is oriented for agriculture and wood raw processing, production of furniture and housing chemistry. Mining industry is based on the non-ore raw processing (quarries for crushed stone, quarry-stone, sand, gravel, limestone, brick and tile manufacturing). It is
commenced development of Beregivske gold-polymetallic deposit (1998). However, despite of deficiency in energy resources the known gas and brown coal deposits are not being exploited so far.

Exposure of the single-floor part of the territory (External Carpathians, Peninska and Marmaroska zones) is fairly well for mapping by the standard methods in geological routes. It also concerns the Vygorlat-Gutynskiy Ridge of the generally two-floor Trans-Carpathian Trough, which plain part is overlain by thick cover of Quaternary and Upper Pliocene sediments, and can be mapped only by drill-holes which amount (including deep ones intersecting basement rocks) is enough for the scale 1:200 000.

In the map set design, besides the own study, the data of geological mapping in the scale 1:50 000 (Titov, 1969, 1975; Zobkov, 1972, 1974, 1977; Kuzovenko, 1973; Tarasenko, 1982; Prykhodko, 1985; 1999) are used, as well as results of the targeted geo-indication deciphering of various-generalization satellite images in the scale from 1:1 000 000 to 1:157 000 (Landsat – USA, Salyut – USSR) performed in the Lviv University by O.M.Kolodiy.

B.V.Matskiv, Yu.V.Kovalyov, B.D.Pukach, O.V.Zobkov (1992), O.I.Korin (1992), V.A.Tkachuk and V.M.Vorobkanych had participated in the field studies. The same team had provided camp works and report preparation on extended geological study in the scale 1:200 000 over the territory of map sheets M-34-XXIX (Snina), M-34-XXXV (Uzhgorod) and L-34-V (Satu Mare) which was used by B.V.Matskiv, B.D.Pukach and V.M.Vorobkanych as the background for the given explanatory notes.

Spectral and chemical analyses are carried out in laboratory of Zakarpatska Expedition (chief L.G.Zelenenka); micro-fauna studies – in UkrSGRI (A.D.Gruzman) and Institute of Geology and Geochemistry of Combustible Minerals, National Academy of Sciences of Ukraine (L.D.Ponomaryova) in Lviv; absolute age determination by K-Ar method – in the institute ATOMKI of Debrecen, Hungary (Z.Pechkay) and Institute of Geological Sciences, National Academy of Sciences of Ukraine (M.M.Vyshnyak, B.B.Vitkovska). Part of micro-fauna studies of Neogene rocks is replicated in D.Shtura Geological Institute, Slovakia (A.Zlynska).
1. STUDY DEGREE

The history of early stages in the study is described in the explanatory notes to the published maps in the scale 1:200 000 [8, 12]. This description is essentially upgraded and detailed in the reports of GM-50 carried out in 1969-1985 [18, 19, 20, 21, 23, 24, 25, 26] which were used over EGSF-200. By these reasons just a brief reminder is given below on the recent works (mainly 70-80th) which are important for understanding of geology and metallogeny of the area.

Among the works of Zakarpatska GEE it should be noted the Vygorlat-Gutynskiy Ridge gold-potential evaluation in 1974-1977 (Galakhov et al., 1977); prospecting and evaluation of gold and silver ores in Kvasivska and Biganska sites (Rozdobudko, 1984, 1988); prospecting for gold and polymetals by geological-tectonic mapping in the scale 1:10 000 in Kvasivske ore field (Krechkovskiy, 1990); prospecting for vein lead-zinc ores in the western flank and metasomatic stratiform ores in pre-Neogene basement of Beregivske deposit (Cherepanya, 1988); prospecting and evaluation of ore potential in the neck-side portions of volcanic centres in Beregivske ore field (Verkhoglyad, 1993). These works had allowed essential data updating on ore potential of the area and increasing prognostic reserves of gold, silver and polymetals by study of new ore types, flanks of explored deposits, encountering new sites and prospective ore occurrences.

There were undertaken enhanced studies of non-ore deposits, underground waters (mineral, thermal, fresh). Particularly, it should be noted exploration in Nyzhnyovyznytske (Potylytskiy, 1989), Rativske (Dubyna, 1990), Golubyne (Zhytnyak, 1991), Velykomyshtye (Zamoryn, 1991), Ruskokomarivske (Kulyk, 1991), Obavske (Lyubka, 1991), Kamianske (Fedysheyn, 1991), Ozere and Fogosha (Khomutnyk, 1991, 1992) deposits of brick clays; prospecting for facing-plate clays in Mukachevskiy area (Potylytskiy, 1992); exploration of Beregivske alunite deposit (Melnik, 1984); prospecting and preliminary evaluation of brown coal deposits in around Uzhgorod, Mukachevo, Beregovo (Levytskyi, 1985), Lokhova (Zhytnyak, 1987).

In the beginning of 90th it was performed analysis of non-ore raw material supply for the operating enterprises of Trans-Carpathian Region (Selyanchyn, 1990; Fedysheyn, 1993). It was designed the map of non-ore deposits in the scale 1:200 000, and deposit description and reserve evaluation was also given.

In 1974-1976 it was performed the regional evaluation of the exploitation resources of underground (thermal and mineral) waters in Trans-Carpathians (Zharnykov, 1976). Thermal waters were explored for sanatoriums, swimming pools (Zharnykov, 1977, 1980, 1989; Sashchenko, 1983) in the flysch sequences at V.Berezniy, Soli (Patyutko, 1989; Nyshchenko, 1993). The fresh waters were explored for the water scoops of V.Berezniy (Sashchenko, 1979), Perechyn (Sashchenko, 1980), Uzhgorod (Sydoruk, 1989), Mukachevo (Sydoruk, 1990), Rembaza (Sashchenko, 1986).

The system observations over underground waters were especially important for evaluation of environment conditions (Petryk, 1986; Popovych, 1993 and others), as well as design of the map in the scale 1:200 000 for natural protection of underground waters (Petryk, 1989).

The works on regional and steady studies of exogenic geological processes are also being carried out in Zakarpatska GEE (Afanasyev, 1982; Chverenko, 1991), as well as geo-ecological studies in the scales 1:25 000 – 1:10 000 (Cherepanya, 1991, 1992).

Apart from the mentioned works of strongly applied fashion, there were performed researches on special studies in Zakarpatska GEE. In this respect it should be primarily noted design of geological map of Trans-Carpathians in the scale 1:200 000 (Tytov et al., 1979) and complex metallogenic map of Trans-Carpathians in the scale 1:100 000 (Galakhov et al., 1988) which summarized all data on geology and metallogeny of the area available to date.

In the recent years, in parallel to EGSF-200, in Zakarpatska GEE also were carried out the EGSF-50 (in the scale 1:50 000) over the territory of Beregivska map sheet group (headed by M.G.Prykhodko), prospecting for thermal waters in the Trans-Carpathian Trough (R.S.Zharnykov), and geo-ecological mapping in the scale 1:50 000 over the map sheet M-34-130-B (V.M.Mishchenko), which field data are used in this report preparation.

Important works (stratigraphic, paleontologic, map-design), which notably contributed to the territory study degree, were performed in UkrSGRI (Lviv). These results are summarized in the designed maps in the scale 1:200 000 (Geological Map of Ukrainian Carpathians edited by V.V.Glushko, 1976; Tectonic Map of Ukrainian Carpathians edited by V.V.Glushko and S.S.Kruglov, 1986), and in the Geodynamic Map of Ukrainian Carpathians in the scale 1:500000 edited by V.V.Glushko and S.S.Kruglov, 1985. The latter was included as integral part into the recent Geodynamic Map of Ukraine in the scale 1:1 000 000 (Editor-in-Chief L.S.Galetsksiy, Kyiv, 1993).
Studies of M.Yo.Petrashkevych and P.Yu.Lozynyak (1990) were fairly important for the modern understanding of the rock stratigraphy in the basement of Trans-Carpathian Trough.

Volcanism, magmatism and metallogeny of Trans-Carpathian Internal Trough were mainly studied in the Institute of Geological Sciences, Ukrainian National Academy of Sciences (Kyiv). Results from dissertation of V.A.Stepanov (1989) are especially important for subdivision of volcanogenic sequences in Vygorlat-Gutynskiy Ridge. Distinct thoughts on the geology of some volcano-structures were provided by A.Ya.Radzivil, V.Ya.Radzivil and V.S.Tokovenko (1986), and the general considerations on the origin of volcanics from various formations – by V.V.Naumenko and V.A.Stepanov (1987).


Recently published maps [14, 17] and obtained rock absolute age data [16] are very important in definition the time relations of sediments in Trans-Carpathians and Slovakia.
2. STRATIFIED UNITS

The territory of the area is composed of the rocks of two tectonic floors. The lower one comprises basement of Trans-Carpathian Trough and Folded Carpathians. In the Trough basement there are mainly developed extensively dislocated sedimentary, volcanogenic and metamorphic rocks of Paleozoic and Mesozoic (up to Oligocene inclusively). The Folded Carpathians are composed of Meso-Cenozoic carbonate-limestone and terrigenous and terrigenous formations (flysch mainly) which constitute some tectonic-facial zones. These ones are extensively dislocated and do form the batch of nappe structures. Coeval sediments of these structures often display diverse facial appearance and by these reasons are subdivided into the individual stratigraphic units (suites, sequences – see stratigraphic columns).

The upper tectonic floor sediments fill up the Trans-Carpathian Internal Trough. These are Neogene-Quaternary sedimentary, volcanogenic and volcano-mictic, coaliferous in places, molassa rocks of mainly horizontal laying. Volcanogenic rocks of this floor, isochronous to certain intervals of sedimentary column, are distinguished and described elsewhere [22].

Stratigraphic subdivision of the rocks developed over map sheet territory is conducted in compliance with the Stratigraphic Code of Ukraine approved on 02.04.1997, correlation stratigraphic schemes (Kyiv, 1993), and the legend for geological maps of Carpathian Series in the scale 1:200 000 approved by Scientific-Editorial Council of the former Derzhkomgeologia on 22.06.1995.

STRATIGRAPHIC SCHEME OF PHANEROZOIC ROCKS IN THE TERRITORY

**PHANEROZOIC EONOTHEME**

**Cenozoic eratheme**

**Quaternary System**

*Undivided sediments*

- e – watershed eluvial sediments
- dc – deluvial-coluvial slope sediments

**Holocene**

- aH – flood-land alluvial sediments
- dpH – devulial-coluvial sediments
- tH – technogenic rocks

**Neo-Pleistocene**

**Upper Pleistocene**

- qP – glacial sediments
- aP – alluvial sediments of the first over-flood terrace
- aP – alluvial sediments of the second over-flood terrace
- a, aP – alluvial, lake-alluvial sediments of the third over-flood terrace

**Middle-Upper Pleistocene undivided**

- la P – alluvial, swamp-lake sediments of Mynayska Suite

**Middle Pleistocene**

- aP – alluvial sediments of the fourth over-flood terrace
- aP – alluvial sediments of the fifth over-flood terrace
- aP – alluvial sediments of the sixth over-flood terrace
- aP – alluvial sediments of the seventh over-flood terrace
- aP – alluvial sediments of the eighth over-flood terrace

**Eo-Pleistocene – Lower Neo-Pleistocene undivided**

- laE + P – alluvial and swamp-lake sediments of Chopska Suite
- aE – undivided alluvial sediments of the eighth and ninth over-flood terraces
Eo-Pleistocene

\( a^9E_{II} \) – alluvial sediments of the ninth over-flood terrace
\( aE \) – alluvial sediments of the ninth and tenth over-flood terraces

**Neogene System**

**Pliocene**

_Dakian and Rumunian stages undivided_

\( N_2 il \) – Ilnytska Suite

**Miocene**

_Pontian regio-stage_

\( N_1 kš \) – Koshelivska Suite

_Pannonian regio-stage_

\( N_1 iz \) – Izhivska Suite

**Sarmatian regio-stage**

\( N_1 al \) – Almashskia Suite
\( N_1 ik \) – Lukivska Suite
\( N_1 db \) – Dorobrativska Suite

**Badenian regio-stage**

\( N_1 bs \) – Baskhevska Suite
\( N_1 ts \) – Teresvynska Suite
\( N_1 st \) – Solotvynska Suite
\( N_1 nv \) – Novoselytska Suite

_Otnangian and Carpathian regio-stages undivided_

\( N_1 tr \) – Tereshulska Conglomerate Sequence

**Paleogene-Neogene Systems undivided**

\( P_3-N_1 kr \) – Krosnenska Suite

**Paleogene System**

**Oligocene**

\( P_3 ml_1 \) – Menilitova Suite. Lower Sub-Suite
\( P_3 mv \) – Malovyzhenska Suite
\( P_3 tr \) – Turytska Suite
\( P_3 ds \) – Dusynska Suite

**Middle Eocene – Oligocene**

\( P_2-P_3 vs \) – Vulshavskia Suite

**Eocene**

\( P_2 sf \) – Sequence of parti-coloured flysch
\( P_2 lz \) – Lazivska Suite
\( P_2 dr \) – Dragivska Suite
\( P_2 sl \) – Solska Sequence
P vh – Vulkhivchynska Suite
P 2 p – Sandstone Sequence
P 2 ss – Sushmanetska Suite

**Paleocene–Eocene undivided**

P 1-2 jm+bs – Yamnenska, Manyavska, Vygodka and Bystrytska suites undivided
P 1-2 bv – Bilovezka Sequence
P 1-2 zf – Sequence of green and parti-coloured flysch

**Upper Cretaceous – Paleogene undivided**

K 2 - P 2 čh – Chornogolovsks Suite
K 2 - P 1 sr – Striyska Suite

**Mesozoic erathem**

**Cretaceous System**

**Upper Division**

K 2 jl – Yalovychorska Suite
K 2 kc – Krychevska Suite

**Upper-Middle Divisions undivided**

K 1-2 pr – Porkuletska Suite
K 2 ts+jr – Tysalska, Pukhivska and Yarmutska suites combined

**Lower Division**

K 2 šp – Shypitska Suite
K 1 dl – Dulivska Sequence

**Jurassic and Cretaceous Systems undivided**

J 1 pr+K 1 sv – Perechynska, Pryborzhavska, Zhubrakivska and Svalyavska suites combined
J 3 ?v – Limestone Sequence
J kv – Carbonate-Volcanogenic Sequence

**Triassic and Jurassic Systems undivided**

T-Jf – Parti-coloured Phillite Sequence

**Triassic System**

T 3 dv – Dolomite Sequence

**Paleozoic erathem**

**Devonian-Carboniferous Systems undivided**

D 3-C 1s – Shale Sequence
LOWER TECTONIC FLOOR

Paleozoic eratheme

Devonian-Carboniferous Systems undivided

2.1. The Shale Sequence (D$_3$-C$_1s$) is disclosed in drill-holes nearby Uzhgorod within Gumensko-Uzhgorodskiy horst, in Chopske and Velykodobronske uplifts, in Syriy Potik in the central part of Poprichna volcano-structure, and in the northern part of Ruski Komarivtsi site at the depths 897-4521 m. These are phillite-like quartz-micaceous, micaceous-carbonate shales, marbled limestones with dolomite lenses, rarely metamorphosed porphyries. The shales are grey, greenish-grey, dark-grey, red-brown, violet, fine- and medium-grained, and are composed of quartz, albite, carbonates, sericite, muscovite, low-temperature biotite, in places chlorite and epidote. Their metamorphic degree does correspond to chlorite-sericite sub-facies of green-schist facies. Thickness of rock lithological varieties in the sequence column from some centimeters to 0.1-0.5 m. Total thickness of the sequence exceeds 500 m.

No one of drill-holes exited shale sequence thus the mode of its lower boundary is not defined. With the regional unconformity the shales are overlain by Triassic and Jurassic sediments or Neogene molassa. Accepted age of the sequence rocks is only based on their correlation with similar by lithology and regional metamorphism rocks of Kuzynska and Roziska Suite of Marmaroskiy Massif [22].

Mesozoic eratheme

Triassic System

2.2. Dolomite sequence (T$_3dv$) is encountered in drill-holes at Nevytske village, in Velykodobronske, Beregivske and Chopske uplifts, Zaluzka anticline, and in Mukachevo area [22] at the depths 638-2705 m. With the regional unconformity the rocks overlie Paleozoic shales and stratigraphically are normally overlain by Jurassic carbonate-volcanogenic sequence, or, with regional unconformity – by Neogene basal layers. Besides dolomites, the diabase and dacite porphyries, dolerites, mafic tuffs and tuffites, limestones, interbeds of dark argillites, quartzite-like sandstones, jasper lenses, rarely gypsum and anhydrite are described in the sequence. Volcanogenic rocks predominate in the lower whereas terrigenous including gypsum-bearing rocks – in the upper part of the sequence.

Thickness of diverse lithological rock types in the lower sequence part attains 10-25 up to 90 m, middle part is coarse- and medium-layered (decimeters – first meters), and upper part – medium- and thin-layered. Total thickness of the sequence exceeds 1000 m.

In the jasper lenses within diabases intersected by DH 8 nearby Beregovo the complex of pre-Jurassic radiolaria is determined [23]. In DH 1331 at the depths 814-1173 m P.Yu.Lozyutyak in thin sections had determined radiolaria: Canoptum cf. triassicus Jao, Tricolocapra pilula Hinde and others [22] that suggests for Triassic age of the sequence. In compliance with “Stratigraphic Schemes of Triassic Sediments of Ukraine” (Kyiv, 1993) the sequence is assigned to the upper division of Triassic System.

Triassic and Jurassic Systems undivided

2.3. Parti-coloured phillite Sequence (T-Jf) is disclosed in the south-western part of Trans-Carpathian Trough, within Gumensko-Uzhgorodskiy horst and in Chopske uplift where are known the sediments considered by most authors to be Mesozoic. Besides parti-coloured phillites, these include marbled limestones, dolomites, lenses of porphyries, sandstones and argillites. With the regional unconformity they lie over Paleozoic shale sequence and are overlain by Neogene molassa. Little core support does not allow even general description of the sequence column. In fauna respect it is not characterized at all. These sediments are assigned to the undivided Triassic and Jurassic Systems in view of their lithological composition and by analogy with similar rocks in Slovakia at Prvsksha site adjacent to Chopska structure [17].
Jurassic System

2.4. Carbonate-volcanogenic Sequence (Jkv) is disclosed by drill-holes in the basement of Trans-Carpathian Trough in Beregivske, Velykodobronske uplifts and in the area of Nevytiske and Verbivets villages. In stratigraphy, normally the rocks overlie Upper Triassic sediments and commonly are changed by sediments of Lower Cretaceous Dulivska sequence, or with regional unconformity are overlain by Neogene molassa [22].

The sequence is composed of grey, light- or dark-grey limestones, marls, black argillites and volcanogenic rocks of mafic composition (spilites, porphyrites, diabases) with interbeds of sandstones, aeurolites and siliceous rocks. In the lower part, the rocks of Upper Triassic are overlain by diabases, porphyrites with interbeds of limestones, dark argillites, lenses of siliceous rocks with belemnites Passoleuothis and Holcobelus, which indicate Early- and Middle Jurassic rock age [23]. Upper in the sequence there lie dark marls, argillites, limestones with Megateuthis (Baeyer), which indicate Middle-Late Jurassic age of the rocks.

Upper part of the sequence is apparently composed of black crinoid limestones with argillite interbeds which is disclosed nearby Vel. Dobron village and is being correlated with similar Upper Jurassic limestones of Fore-Carpathian Trough and Peninska Zone [26]. Thus, the rocks of carbonate-volcanogenic sequence by age encompass all three divisions of Jurassic System.

Thickness of some lithological rock varieties in the sequence vary from the first centimetres to first metres, for extrusives increasing to 10, rarely 40 m. Total thickness of the column is 300-400 m.

2.5. Limestone Sequence (J3?v). In the area of Vyshka village, in the frontal part of one nappe of the Duklyanskiy Thrust, within Cretaceous-Palaeogene flysch sediments, with unclear relationships with their host rocks, there lie blue-grey (so called “Vyshkivski”) limestones – massive, medium- and fine-grained, often lumpy, re-crystallized, which resemble bioherm organogenic varieties. Their tectonic position and age are disputable [22]. They are thought to be tectonic seizure, olistolite, or bioherm within flysch sediments. The lesser blocks of similar limestones are encountered in the tectonic boundary zone of Bachavskaya nappe nearby Bukvistseve village, and in the frontal part of Krosno Zone thrust over Skybova Zone on Mshana River [22]. Their age is conventionally accepted to be Upper Jurassic.

Jurassic and Cretaceous Systems undivided

2.6. Combined Perechynska, Pryborzhavska, Zhubrakivska and Svalyavska suites (Jp + Ksv) are developed in Peninska Zone only, where they define its major geomorphologic feature and this is why this zone is also called as the Zone of Cliffs. Limestone cliffs are developed in the area of Perechyn and Svalyava towns. Their size varies from first tens of meters to 1-2 km being 200-500 m wide. All these exposures in the present position are tectonic seizures and occur within extensively dislocated parti-coloured marls of Pukhivska and Tyalska suites which comprise the matrix. By these reasons the columns of these sediments are discrete. The biggest one is known in Perechynskiy quarry (upward):

1. grey clays and sandstones with interbeds of limestones with Cardinia hybrida Sow., Arietites buclandi Sow. and others (more than 15 m);
2. spotty marls, clayey limestones, argillites with Echinoceras raricostatum Bay and others (15 m);
3. black and red argillites with Passolatheutis bragnier Orb. (4 m);
4. parti-coloured sandstones with Mesolatheutis sp. (2 m);
5. pink and green crystalline limestones with sandstone interbeds and flint lenses with brachiopods Belemnonsis sp., Karudogithyris gerda (Opp) and others (15 m);
6. crinoid brecciated limestones (11 m);
7. white fine-layered pelitomorphic limestones with Calpionella alpina Lor. (10 m).

In the above column layers 1-2 do correspond to Perechynska Suite (Hettangian-Pliensbachian); 3-4 – Pryborzhavska Suite; 5-6 – Zhubrakivska Suite (Bajocian-Callovian); 7 – Svalyavska Suite (Tithonian).

In the Novoselytskiy quarry Callovian-Tithonian part of column predominates, and close to Svalyava – Tithonian – Early Cretaceous (up to Barremian inclusive) part, where within light pelitomorphic thin- and medium-layered limestones flint lenses (up to 15 cm) occur. Thickness of this column part attains 100 m.

Total thickness of defined subdivision is 260 m; it encompasses time span from Lower Jurassic Hettangian stage to Lower Cretaceous Barremian stage.
Cretaceous System

These sediments are widespread in almost all litho-tectonic units, where the following stratigraphic subdivisions are distinguished: Dulivska sequence and Krychevska Suite in Trans-Carpathian Trough; Berriasian-Valanginian part of Svalyavska Suite and combined Tysalska, Pukhivska and Yarmutska suites – in Peninska Zone; Yalovychorska Suite and lower Sub-Suite of Chornogolovska Suite – in Porkuletskiy Thrust; Shypitska, Porkuletska suites and lower Sub-Suite of Chornogolovska Suite – in Duklyanskiy Thrust; Striyska Suite – in Krosnenska Zone and Skyboviiy Thrust.

Lower Division

2.7. Dulivska Sequence (K1dl) is disclosed by drill-holes in Trans-Carpathian Trough (Nevytske, Vel. Dobron and Lisarnya villages) at the depths 1513-2540 m. It is composed of dark marls, limestones, argillites and sandstones. Thickness of rock layers varies from first centimetres to first metres. Total thickness of the column is up to 600 m. In stratigraphy, the sequence rocks normally lie over Upper Jurassic and are normally changed by sediments of Upper Cretaceous Krychevska Suite [22]. In drill-holes at Nevytske and Vel. Dobron villages in the sequence rocks L.V. Linevskaja had determined Calpionella sp., Lor., and Tintinnopsis carpathia (M. f.). and at Lisarnya village, just below fauna-characterized Senonian sediments (Krychevska Suite) – Saccocoma sp. only [22]. On the ground of these data Early Cretaceous age of the sequence is accepted.

2.8. Shypitska Suite (K1šp) is developed only in Duklyanskiy Thrust where it lies mainly in the frontal parts of the nappes with narrow strips which are extended from Lyuty River through upper courses of Shypit Stream to Verkhnya Grabivnytsya. They are also known in the numerous olistolites in Oligocene rocks of Krosnenska Zone just in front of Duklyanskiy Thrust.

The kind of Suite lower boundary is unknown since all observed ones are tectonic. Transition from this Suite black siliceous sandstones and argillites to green-grey marls and argillites of Porkuletska Suite is normal, gradual [22]. The Suite is composed of black siliceous sandstones (0.05-0.3 m) and argillites (0.01-0.1 m) with interbeds of aleurolites, pelo-siderites, and rarely marls. Total thickness is 100-250 m.

Characteristic feature of the Suite rocks comprises their glassy appearance, mainly quartz composition of clastic material, siliceous cement, glauconite occurrence, and, in contrast to most flysch rocks, quartz fracture sealing.

In the Suite rocks L.D. Ponomaryova had determined Upper Albian micro-fauna [22]. Aptian and Barremian sediments are encountered in the Suite elsewhere in the territory [3]. It is accepted the Suite age within the limits of Lower Cretaceous Barremian-Albian stages.

Lower and Upper Divisions

2.9. Combined Tysalska, Pukhivska and Yarmutska suites (K1ts + K1jr) are mapped in Peninska Zone in two narrow strips (0.5-1.5 km) close to Svalyava and between Perechyn town and upper course of Kamenchuka River where the rocks conformably overlie limestones of Svalyavska Suite, and with sharp angular unconformity and basal conglomerates are overlain by sediments of Paleogene Vulkhivchytyska Suite.

Extensive dislocation of Peninska Zone, where described sediments actually comprise the matrix of giant tectonic mélange, precludes construction the full column of the subdivision.

Lower parts of the known section of Tysalska Suite in Perechyn quarry are composed of Aptian – Upper Albian black argillites, limestones and marls, which are overlain by grey-green, often facoid, Senonian marls. Higher lie pink, red, brown, green-grey facoid marls of Pukhivska Suite with aleurolite and sandstone interbeds; then – fine-rhythmic sandy-clayey grey-green or parti-coloured flysch of Yarmutska Suite. Thickness of partial continuous sections of described sediments is 30-200 m, and their total thickness attains 400 m.

Described sediments are rich in micro-fauna hedbergela and globotruncanca which are characteristic for Aptian-Senonian and Turonian-Maastrichtian respectively, and in Perechyn area there are found Upper Maastrichtian brachiopods in these rocks; by these reasons the age of this subdivision is accepted within the limits from Aptian to Maastrichtian stages of Cretaceous System.

2.10. Porkuletska Suite (K1gr) is mapped in Duklyanskiy Thrust, where it conformably overlies Shypitska Suite sediments, and normally is overlain by thin-rhythmic flysch of Yalovychorska Suite [22]. Previously [19, 20, 24] these sediments were mapped in the volume of lower sub-suite of Yalivetska Suite, and then were distinguished as independent stratigraphic units [6] during unification of stratigraphic schemes for Cretaceous sediments.

The distinct features of the Suite include its non-flysch lithology, parti-coloured appearance, and calcareous composition of all rocks involved. It is composed of red, cherry, green, grey, black argillites, marls,
rarely aleurolites, fine-grained sandstones, and fairly distinct ellipsoidal, ball-shaped 0.02-0.03 to 0.3-0.5 m in size aggregates (“bully”) of pelitomorphic limestones.

Lower part of the Suite is studied in the Lyuta River valley just in front of the church in Chornogolovo village, where over black siliceous argillites of Shypotska Suite there normally lies the 23 m thick sequence of green argillites, micaceous calcareous aleurolites and marls; based on the authors’ collection, L.D.Ponomaryova has determined complex of Senomanian-Turonian foraminifera [22]. Thickness of this sequence in the right branch of Zhdenivka River (Parazhena) is 18 m. Higher in the column there are encountered:

1. alternating green and red marleous argillites (0.1-0.15 m) – 3 m;
2. cherry argillites with lenses of green ones – 2.5 m;
3. green, brown-green, red argillites with “bully” of limestones – 7.5 m;
4. green-grey argillites with lenses of dark-grey, brown and red argillites and interbeds of fine-grained calcareous sandstones (0.1-0.7 m) – 26 m;
5. brown-grey marleous argillites with lenses (0.1 m) of brown limestones – 4 m.

Thickness of above partial column is 61 m. Total thickness of the Suite in different sections varies from 15 to 100 m.

From different Suite parts in Chornogolova and Rostotska Pastyl villages and Chechovatiy Stream, based on the authors’ collection, L.D.Ponomaryova has determined [22] foraminifera complex with Glomospira irregularis (Grzyb.), G. gordialis (J. et P.), Uvigerinamina jancoi Maiz, Hormosina ovulum crassa Geroch. and others; on this ground the age of Suite is accepted within the limits of Upper Albian, Senomanian and Turonian stages.

2.11. Krychevska Suite (К2кч) is developed in the basement of Trans-Carpathian Trough and is disclosed by drill-holes Lisarnya-I (1590-2400 m), Dobron-I (1855-212 m), Uzhgorod-I (1099-1255 m), and in Beregivske uplift: DH 22 (1063-1154 m) and DH 2028 (1123-1253 m).

In DH Lisarnya-I the Suite conformably lies over Lower Cretaceous rocks, and in DH Uzhgorod-I with angular unconformity it is overlain by Paleogene Pidgalskiy flysch [22]. The Suite is mainly composed of dark-grey calcareous argillites with interbeds of fine-grained calcareous polymictic sandstones, marls, limestones 0.1-0.5 m, rarely up to 1 m thick. Total thickness of the Suite attains 600 m.

In DH Lisarnya-I in lower part of Suite column N.V.Dabagyan had determined Senomanian Hormosina ovulum Grzyb., Hyperammina gaultina Dam. and others, and outside the studied area there are found rich globotruncana complex in the rocks of this Suite; on this ground its age is accepted within the limits of Upper Cretaceous Senomanian-Maastrichtian stages.

2.12. Yalovychorska Suite (K2 jl) is distinguished in Porkuletskiy and Duklyanskiy thrusts. Previously it was mapped as “Bereznyanska Suite” [19], “Upper Flysch Batch” [20], “Lower Sub-Suite of Bereznyanska Suite” [24]. In present volume it is defined during unification of stratigraphic schemes for Cretaceous sediments [6]. The rocks conformably overlie the sediments of Porkuletska Suite and are conformably overlain by the rocks of Chornogolovska Suite.

The Suite is composed of thin-rhythmic flysch intercalation of dark-grey, black calcareous argillites, aleurolites with interbeds of marls, crypto-crystalline, often ironiferous limestones and grey calcareous polymictic sandstones.

By rhythmic mode and ratio of main rock lithotypes three batches are conventionally [24] distinguished in the Suite (upward):

1. mainly thin dark sandy-clayey flysch (layers of dark-grey or black argillites, aleurolites 0.03-0.07 m, fine-grained thin-layered sandstones up to 0.1-0.12 m) – thickness 170-250 m;
2. essentially clayey thin- to medium-rhythmic batch where thin flysch batches (2-7 m) are separated by the layers of fine- and medium-grained grey sandstones (0.3-0.1 m) and interbeds of cream pelo-siderites, limestones, grey marls (0.02-0.3 m) – thickness 220-280 m;
3. intercalation of thin flysch batches (2-4 m) and diverse-grained, often curve-layered sandstones with lenses of marls and pelitomorphic limestones – thickness 300-350 m.

Total thickness of the Suite attains 1000 m.

The rich inoceramus and globotruncana fauna is described in the Suite rocks [19, 20, 24]; on this ground the Suite age is accepted within the limits of Coniacian-Santonian stages of Upper Cretaceous.

**Upper Cretaceous – Paleogene undivided**

Undivided Upper Cretaceous and Paleogene sediments are widespread in flysch Carpathians in Porkuletskiy, Duklyanskiy, Skyboviy thrusts and in Krosnenska Zone where they are distinguished in Striyska and Chornogolovska suites.
2.13. **Striyska Suite (K2-P1,sr)** is developed in Skyboviy Thrust in the upper course of Dnister River. In adjacent area the Suite rocks conformably overlie Golovynska Suite sediments [3]. In the area of Strilky village [22] they are conformably overlain by the undivided Paleocene and Eocene rocks.

The Suite is composed of rhythmic intercalation of grey argillites, aleurolites and sandstones with rare marl interbeds and gravelite lenses. In the column lower part in Dnister River valley [21, 22] lie coarse-layered to massive grey micaceous sandstones (0.8-2 to 3-4 m) with thin (0.05-0.1 m) interbeds of grey argillites, lenses of quartz gravels (0.2-0.5 m), and batches of grey flysch. Thickness of this column part is up to 250 m. Higher lies the medium- to thin-rhythmic flysch intercalation of grey diverse-grained sandstones, aleurolites and argillites with marl interbeds. Total thickness of studied Suite part exceeds 500 m.

The Suite is not characterized by fauna over the studied territory. In adjacent territories there is encountered micro-fauna characteristic for Turonian-Maastrichtian stages of Upper Cretaceous and Lower Paleocene [3, 22].

2.14. **Chornogolovska Suite (K2 -P2,ch)** is widely developed in Duklyanskiy and Porkuletskiy thrusts where it mainly constitutes the watershed ridge portions. Previously it was mapped as Upper Cretaceous “Lower Sandy Batch” and Paleogene “Lyutska Suite” [19], “Bachavska” and “Lyutska” suites [20], “Verkhyoberezynska Sub-Suite” and “Lyutska Suite” [24]. The Suite is distinguished [6] with the stratotype over the studied area in drill-hole Chornogolovo-I.

Since the stratotype column is not accessible for study, below is given description of the hypostratotype in the area of Yavornyk Ridge where conformable Suite laying over Yalovychorska Suite sediments is observed, as well as its conformable overlaying by Eocene Solska Sequence [22]. At this site the Suite can be clearly distinguished in two sub-suites: lower (Verkhyoberezynska) and upper (Lyutska) ones.

Along the gas-pipe line, on the left bank of Uzh River, between Zhornava and Kostryno villages, above dark-grey argillites of Yalovychorska Suite normally lie:

1. intercalation of medium-fine-grained grey micaceous calcareous sandstones (0.3-2 m), argillites, aleurolites – 22 m; not exposed – 40 m;
2. coarse and medium-rhythmic intercalation of dark-grey argillites, aleurolites, grey diverse-grained sandstones with hyeroglyphs – 70 m;
3. intercalation of batches (5-7 m) consisting of coarse- and medium-rhythmic dark-grey clayey-sandy flysch – 65 m;
4. coarse intercalation of grey diverse-grained sandstones (2-4 m) and green-grey, dark-grey argillites (0.5-0.8 m) – 50 m; not exposed – 55m;
5. medium-rhythmic dark-grey clayey-sandy flysch with batches (up to 5-8 m) of coarse-rhythmic flysch – 40 m;
6. medium-rhythmic dark-grey clayey-sandy flysch – 16 m;
7. medium-rhythmic dark sandy-clayey flysch – 15 m;
8. coarse- and medium-rhythmic intercalation of dark argillites, aleurolites, sandstones with some interbeds of the latter (up to 2.5-3 m) – 14 m;
9. intercalation (0.2-1.0 m) of dark- and green-grey argillites, aleurolites, grey diverse-grained calcareous sandstones – 20 m.

This 312 m thick (and about 400 m including not exposed bits) column portion is ascribed to the lower sub-suite. Further up in the column the following units occur:
10. coarse-layered medium-coarse-grained grey sandstones, micaceous, with fine-grained sandstone interbeds – 65 m;
11. coarse-layered to massive micaceous grey sandstones with lenses (up to 1.2 m) of polymictic gravelites – 80 m;
12. coarse intercalation of diverse-grained micaceous sandstones (1-4 m) with batches (0.5-2 m) of coarse grey clayey-sandy flysch – 140 m;
13. medium-coarse-rhythmic intercalation of grey sandstones, gravelites with metamorphic schist fragments, quartz pebble and lenses (up to 1 m) of polymictic sedimentary breccia – 30 m; not exposed – 20 m;
14. coarse-grained, gravelous, massive sandstones – 85 m;
15. coarse- and medium-rhythmic grey clayey-sandy flysch – 12 m;
16. massive diverse-grained grey micaceous sandstones – 10 m;
17. medium-rhythmic (0.2-0.7 m) grey clayey-sandy flysch – 27 m;
18. coarse (1-3.5 m) sandy flysch with batches of medium- and coarse-rhythmic clayey-sandy flysch – 68 m;
19. coarse-layered sandstones with schist-quartz gravelite lenses (1-3.5 m) – 45 m;
20. medium-rhythmic intercalation (0.3-1.0 m) of grey diverse-grained polymictic sandstones, aleurolites with green-grey argillite interbeds (0.2-0.4 m) – 65 m;
21. medium-coarse-rhythmic sandy and clayey-sandy grey flysch with massive sandstone interbeds (3-5 m) – 70 m; 
22. medium-rhythmic (0.1-0.4 m) intercalation of grey sandstones, aleurolites, argillites – 30 m; not exposed – 20 m; 
23. coarse-rhythmic intercalation (0.5-1.0 m) of grey sandstones, aleurolites, polymictic gravelite lenses – 80 m. 

Higher in the column thin-layered green argillites and aleurolites of Solska Sequence occur. 

Thickness of presented Upper Chornogolovska Sub-Suite column is 860 m. 

There are described [22] slight facial variations in Sub-Suite composition, increasing in coarse-clastic (gravelites, fine-pebble conglomerates) rock share and in its general thickness (up to 1200 m) in the central part of Yavornyk Ridge. Total thickness of Chornogolovska Suite is 1600-2000 m. 

Since the rocks of Verkhnyobereznyanska Sub-Suite, Lyutska, Stavnyanska and Strichavska suites (and outside the territory also Chornogorska, Tarnychorska and Blyznytska suites in addition) are combined in this unit, its stratigraphic boundaries are diachronous and “move” from Upper Cretaceous Campanian or Maastrichtian stages to Paleocene – Middle Eocene [6, 22]. Directly within the studied territory, in more than 50 rock sites, the rich micro-fauna complex is found [19, 20, 24] with *Hormosina ovulum gigantea* Ger., *Globorotalia angulata* White, *Nummulites fraasi* Harpe, *N. gallensis* Heim, *Glomospira charoides* Park. and others which indicate the age within the limits from Campanian or Maastrichtian stages to Paleocene – Middle Eocene. 

**Cenozoic eratheme**

**Cenozoic eratheme**

**Paleogene System**

These sediments are widespread in the External, in lesser extent in the Internal Carpathians including Trans-Carpathian Trough. 

**Paleocene-Eocene undivided**

2.15. *Sequence of green and parti-coloured flysch (P1.zf)* is mapped in Porkuletskiy Thrust in the Turya and Vel. Pynya river basins, where it conformably overlies Chornogolovska Suite sediments, and is overlain by Turytska or Dusynska Suite rocks [22]. Sequence is composed of thin- and medium-rhythmic sandy-clayey green flysch; grey-green, yellow-brown and grey argillites and aleurolites (0.01-0.1 m), green-grey fine-grained polymictic sandstones (0.01-0.05 m) predominate. Rarely intercalation lenses and batches (up to 0.1-10 m) of red and green argillites and aleurolites, and layers (up to 2-3 m) of diverse-grained sandstones occur. 

Due to the complex tectonics, the full sections of the Sequence are not encountered. The lower part is studied along Shypit Stream and its right branch Zvur [22]. There the following rocks lie over Chornogolovska Suite sandstones:

1. thin- and medium-rhythmic intercalation of yellow-brown argillites, aleurolites (0.01-0.05 m) and light-grey sandstones (0.01-0.15 up to 0.3 m) – 120 m; 
2. green-grey sandy-clayey medium-rhythmic flysch with thicker (up to 0.5 m) sandstones – 80 m; 
3. thin-rhythmic (0.01-0.06 m) intercalation of grey, yellow-grey, green-grey argillites, aleurolites, fine-grained sandstones – more than 100 m. 

Thickness of this column, bounded by tectonic break, exceeds 300 m. In the right branches of Turya River and in Vel. Pynya in this part of column the interbeds (from first centimeters to first meters thick) of red and green argillites occur. 

Upper part (550 m thick) of the Sequence column in the right branch of Turytsya River [22] is composed of thin-rhythmic intercalation of greenish-grey argillites, aleurolites (0.01-0.1 m) and fine-grained sandstones (0.01-0.05 m). There in the lower part lies a batch (10 m) of cherry-red argillites with thin (up to 0.01 m) green argillite interbeds. Lower boundary of this column is bounded by tectonic break. 

The facial rock variability both along and across the strike is characteristic for the Sequence. It is expressed in changes of red argillites by green and green-grey ones by strike, in frequent sandstone layer pinching out and in pretty sharp change in total thickness which decreases from 1000 m to 200 m nearby Olenevo village [22]. 

Based on the micro-fauna complex *Hyperammina lineaformis* (Mjatl), *Trochamminoides subfrillitatus* (Rzh.), *Recurvoides smugarensis* (Mjatl.), and others, the age of the Sequence is accepted in the limits of Paleocene – Middle Eocene [19].
2.16. *Bilovezka Sequence (P₁₂,bv)* is developed in Magurska Zone where it is traced from the border with Slovakia to Rakovo village. Underlaying rocks are not identified over the studies territory. The Sequence is normally overlain by Eocene sandstones. It mainly consists of thin- and medium-rhythmic parti-coloured sandy-clayey flysch composed of grey, green-grey or blue-grey, rarely red, cherry, dark-grey argillites, aleurolites (0.01-0.02 to 0.2-0.5 m) and grey, green-grey to dark-grey, polymictic, calcareous, mecaceous sandstones (0.01-0.5 to 1.5-2 m). Rarely 5-10 to 60 m thick batches of coarse-grained sandstones, gravelites are distinguished.

The Sequence column is studied along Kamenychka Stream nearby Novoselytsya village where the following units are distinguished (upward) [22]:
1. medium-rhythmic green-grey sandy-clayey flysch with grey diverse-grained sandstone interbeds (up to 2 m) – 100 m;
2. medium-thin-rhythmic sandy-clayey flysch with interbeds of light-grey sandstones (up to 1 m) and dark-grey argillites (0.1-1 m) – 150 m;
3. massive coarse-grained (to gravelous) grey sandstones – 5 m;
4. cherry-red, green soft argillites, aleurolites with of fine-grained sandstone interbeds (up to 0.05 m) – 50 m;
5. medium- and thin-rhythmic (0.03-0.15 m) intercalation of greenish-grey argillites, aleurolites, sandstones – 340 m;
6. thin-rhythmic sandy-clayey green and blue-grey flysch with sandstone interbeds (up to 0.2-0.5 m) – 50 m.

Higher conformably lie Eocene sandstones. Full thickness of the Sequence column at this site is 695 m. The facial variability is characteristic for the Sequence being expressed by strike in changes of medium-rhythmic flysch to thin-rhythmic one, decreasing amount of parti-coloured argillites, and emerging the batches (50-60 m) with sandstone predomination over argillites to the south-west from Kamenychka Stream [22].

On the ground of micro-fauna complex with *Hyperammina cylindrica (Glassn.), Dendrophrya excelsa (Grzyb.), Nummulites globa Leym.* and others [19, 22], the age of Sequence is accepted within the limits of Paleocene – Middle Eocene.

2.17. *Yamnenska, Manyavska, Vygodska and Bystrytska suites undivided (P₁₂,jm+bs)* are mapped in the narrow strips 0.2-0.8 km wide in Skyboviy Thrust and at the north-eastern margin of Krosnenska Zone where they cannot be divided even by most detailed studies [4, 21].

Due to the weak exposure, the Sequence column was studied in some hard-rock outcrops and in drill-holes. It is composed of thin- and medium-rhythmic sandy-clayey, rarely – clayey-sandy flysch where green-grey argillites, aleurolites, sandstones (0.05-1.5 m) intercalate with batches of cherry-red, green argillites (up to 10-15 m). Total thickness of the column is up to 400 m.

By foraminifera fauna, which is determined mainly to the east from the studied area and includes *Nummulites deserti Harpe, N. globulus Leym., Cyclammina amplectens Grs.* and others, Paleocene-Eocene age of the Sequence is accepted [3, 22].

Eocene

2.18. *Sushemanetska Suite (Psš)* occupies most part of Marmaroski Cliff Zone in Svalyava area.

The Suite underlaying rocks are not identified. And it is either conformably overlain by Dragivska Suite sandstones or by Neogene volcanics with sharp angular unconformity.

Suite is mainly composed of thin-rhythmic greenish-grey clayey and sandy-clayey flysch with batches (up to 5-10 m) of parti-coloured flysch and layers (up to 10-15 m) of grey and dark-grey sandstones with argillite interbeds (up to 0.05-1.0 m).

The Suite age is accepted to be Lower Eocene on the ground of *Nummulites partschi Harpe, N. galensis Heim.* and other nummulite findings to the east from the studied area in Borzhava River basin [3].

2.19. *Sequence of Eocene sandstones (P₂p)* is widely developed in Magurskiy Thrust where it conformably lies over Bilovezka Sequence and is overlain by Sequence of parti-coloured flysch [22]. In the south-west it is overlain with angular unconformity by Neogene volcanics.

The Sequence is composed of massive coarse-layered, diverse-grained, micaceous sandstones with rare interbeds of grey argillites (0.05-0.2 m), gravelites, small-pebble conglomerates (0.1-1 m) and sandy-clayey flysch batches (up to 20-40 m).

The Sequence column is studied nearby Myrcha village. In Kamenychka Stream [22] over thin flysch of Bilovezka Sequence the following units occur (upward):
1. grey, green-grey medium-layered (0.1-0.5 m) sandstones with aleurolites and argillite interbeds (0.05-0.2 m) – 30 m;
2. grey, light-grey, coarse-layered to massive, diverse-grained sandstones with minute green-grey aleurolites and argillite interbeds (0.05-0.15 m) – more than 160 m.

Total thickness is 190 m.

The total thickness increases from 200 m in the right-bank side of Uzh River to 800 m in the Turya River basin where amount of gravelite and conglomerate interbeds also increases [22].

In many places fauna of nummulites Nummulites distans Desh, N. gallensis Heim, and others is determined in the Sequence rocks [18, 19] indicating for its Eocene age.

Vulkhivychtsya Suite (Pvh) is mapped in Peninska Zone where in the narrow (0.2-0.8 km) strips it is traced in the right-bank side of Uzh River and nearby Svalyava town. With angular unconformity Suite lies over undivided sediments of Tysalska, Pukhivska and Yarmutska suites although at the surface the contacts are tectonic almost throughout. With angular unconformity the Suite sediments are overlain by Neogene volcanics.

In the column grey, light-grey, diverse-grained, calcareous, polymictic sandstones predominate with gravelite and conglomerate lenses or interbeds (0.1-2 m) and batches (up to 10-20 m) of intercalating grey argillites, sandstones, aleurolites which amount increases upward. Total thickness of the sediments is 200-300 m.

In the Suite rocks foraminifer complex is determined with Globorotalia imilata Subb., Nummulites partschi Harpe, Globorotalia crassata (Cushm.), and others [18, 22] providing its age acceptance within the limits of Lower and Middle Eocene.

Soloka Sequence (P 2 sl) is widespread in Duklyanska Zone. In the right-bank side of Lyuta River at the mouth of Shanklyanyk Stream the conformable laying of the Suite rocks over Chornogolovska Suite sandstones is described [22]. It is conformably overlain by dark argillites of Dusynska or Menilitova suites.

The Sequence comprises thin-rhythmic grey-green mainly clayey flysch with batches of parti-coloured flysch and grey or green-grey sandstone interbeds 0.01-0.03 m to 2-3 m thick. The Sequence stratotype is described at the Sil village outskirts [3] where exposed (upward):
1. thin intercalation of green-grey aleurolites (0.01-0.02 m) and argillites (0.05-0.2 m) with minute fine-grained sandstone interbeds (0.05-0.2 m) – 285 m;
2. grey and blue-grey calcareous argillites with rare aleurolites interbeds (Sheshorskiy Horizon) – 15 m.

Thickness of the column is 300 m.

As it is thought from the column type and sediment thickness, the upper part only is described in the stratotype. More complete section is studied [22] nearby Kostryna village:
1. rhythmic intercalation of grey-green, green and cherry-red argillites and aleurolites (0.03-0.1 to 0.2 m) with interbeds (0.01-0.05 to 0.25 m) of grey, green-grey fine-grained sandstones – 400 m;
2. intercalation of green, grey-argillites, aleurolites (0.02-0.15 m) and green-grey fine-grained sandstones (0.01-0.05 m) – more than 600 m.

Thickness of the Sequence is 1000 m.

It is characteristic for the Sequence the lateral and vertical facial transitions from grey-green argillites to cherry-red ones, and emerging lenses and interbeds (up to 1-3 m) of medium- and coarse-grained sandstones [22]. From the north to south, the total thickness of the sequence changes from 100 m in Stavne area to more than 1000 m (Lumshory-Kostryna).

Abundant Middle Eocene foraminifera complexes Globigerina eocaenica Terg., G. triloculinaides Plum. are known in the Sequence rocks [4]. L.D.Ponomaryova had also described Upper Eocene Globigerina corpulenta Subb., G. linaperta Finl., and others [22]. On this ground of these data Middle-Upper Eocene age is accepted for the Sequence rocks.

Dragivska Suite (P 2 dr) is mapped in Marmaroska Zone on the left bank of Svalyavka River where it conformably lies over Sushmanetska Suite argillites. Among the rocks grey, light-grey, diverse-grained, coarse-layered to massive, calcareous sandstones predominate with lenses, interbeds and batches (up to 10-15 m) of gravelites and conglomerates and rare batches (0.3-3 m) of grey thin-rhythmic sandy-clayey flysch.

The Suite age, by findings of foraminifera Subbotina eocaenica (Terg.), Acarinina triplex Subb., and others [24], is defined within the limits of Middle-Late Eocene.

Lazivska Suite (P lz) is disclosed in basement of Trans-Carpathian Trough by drill-holes 405 (Bigan) and 359 (Beregove). Below the Neogene basal layers lie black argillites with interbeds of diabases, aleurolites and sandstones of 245 m total thickness. Age of the Suite is thought to be Eocene on the ground of spore and pollen determinations [26, 22].

Sequence of thin-rhythmic parti-coloured flysch (P 2 sf) is mapped in the frontal part of Magurskiy Thrust in the Uzh River valley and left-bank between Mal. Bereznicy and Simerky villages. The Sequence conformably lies over Eocene sandstones and is the youngest unit in the section of Magurskiy Thrust. Thin- and medium-rhythmic clayey-sandy and sandy-clayey grey and dark-grey flysch predominate, with batches (up to 10-15 m) of green and parti-coloured clayey flysch and layers (up to 10 m) of grey quartz or polymictic calcareous sandstones.
Total thickness of the Sequence exceeds 400 m. Upper Eocene age is determined by foraminifera *Cyclammina amplectens* Grz., *Hyperammina lineaformis* (Mjatl.) and others [19].

**Middle Eocene – Oligocene**

2.25. *Vulshavska Suite* (*P2*-*P3vš*) is mapped at the surface in Uzh River basin at the northern margin of Trans-Carpathian Trough. It is also disclosed by drill holes Uzhgorod-1 and Nevytske-1 where with angular unconformity it lies over Upper Triassic dolomites and also unconformably is overlain by Neogene volcanics [18].

Most authors [4, 18] consider the Suite to be the element of Pidgalskiy flysch widely developed in Eastern Slovakia.

Due to weak exposure just a generalized Suite column is given below [22]. At the bottom in Vulshava Stream lie dark-grey argillites and aleurolites (0.05-0.1 m) intercalating with fine-grained micaceous sandstones (0.1-0.2 to 1.5 m).

Higher dark, green-grey argillites (0.2-1.5 m) rhythmically intercalate with grey fine-grained sandstones (0.1-0.4 m) and lenses (0.3-4 m) of diverse-grained sandstones, gravelites and small-pebble conglomerates. Upper part of the column is composed of dark-grey argillites with interbeds (0.1-1.0 m) of grey fine-medium-grained sandstones, rarely micro-grained limestones.

Thickness of the Suite attains 500 m.

In the Suite sediments foraminifera complex is determined [4, 18] with *Globorotalia crassata* (Cushm.), *Globigerina corpulenta* Subb., *G. brevispira* Subb., *G. vialovi* Mjatl., and on this ground the age is accepted in the limits from Middle Eocene to Oligocene.

2.26. *Dusynska Suite* (*P3ds*) is developed in the southern part of Duklyanskiy Thrust and in the north of Porkuletskiy Thrust where it conformably lies over, respectively, Solska Sequence and Sequence of green and parti-coloured flysch, and, in turn, is conformably overlain by sandstones of Malovyzhenska Suite.

In the Suite, the dark-grey and black argillites predominate, often marl-like, with interbeds of dark-grey and black marls (up to 0.8 m), sandstones (up to 10-15 m), rarely limestones (0.5 m), siderites (up to 0.4 m) and black flints (0.1-0.2 m) which in places form horizons up to 1.8-2 m thick (Olenevo village).

The stratotype Suite outcrop is located at Dusyno village. Detailed basic section is described [3] on the north-eastern slope of Maliy Vyzhen Mountain. We have studied generalized column on its western slope [22] where above thin-rhythmic parti-coloured flysch of Solska Suite after 50 m of unexposed interval the following units occur (upward):

1. dark-grey and black dense argillites with interbeds of dark-grey marls (0.5 m), sandstones (0.6 m), rarely siderites (0.2 m) – 50 m; not exposed – 100 m;
2. black parallel-layered argillites with interbeds (0.03-0.2 m) of fine-grained polymeric sandstones, grey limestones, single siderite lenses (0.4 m) – 150 m;
3. black, rarely green-grey argillites with black flint interbeds (up to 0.1 m) – 50 m;
4. black massive or parallel-layered argillites with interbeds (0.05-0.3 m) of fine-grained sandstones, rarely limestones – 70 m;
5. black argillites with numerous fine-grained sandstone interbeds (up to 0.4 m) – 30 m.

Higher conformably lie sandstones of Malovyzhenska Suite. Column thickness is 500 m.

On the Maliy Vyzhen Mountain the Early Oligocene nannofossil complex is described in the lower part of the Suite with *Helicopontosphaera reticulata* [3], and in other Suite parts, besides that, *Globigerina afficiinalis Subb., Cibicides carpaticus* Mjatl., that allow acceptance of the Suite Early-Late Oligocene age.

2.27. *Turytska Suite* (*P3tr*) is defined in Turytska Nappe of Porkuletskiy Thrust in the Turya River basin, and in the right-bank side of Pynya and Vel. Pynya rivers, where it conformably lies over the Paleocene-Eocene Sequence of green and parti-coloured flysch. The Suite lower boundary is set by the top of the last green argillite layer. The Suite is conformably overlain by sandstones of Malovyzhenska Suite.

The Suite stratotype is described on Turytsya River at western outskirt of the same named village [3]. At this locality the following units occur above green-grey argillites (upward):

1. dark-grey, black calcareous argillites (0.1-0.2 m), dark-grey aleurolites (0.03-0.08 m) and fine-grained flinted sandstones (0.05-0.35 to 1.5 m), single flint interbeds at the bottom – 125 m;
2. thin intercalation of black argillites, aleurolites, flinted sandstones – 55 m;
3. thin-rhythmic intercalation of dark-grey, tobacco-grey argillites, aleurolites and fine-grained sandstones with two marl interbeds (0.1-0.12 m) at the top – 190 m;
4. thin intercalation of grey, dark-grey argillites, aleurolites – 50 m.
Thickness of the section is 420 m, and upper portion of the Suite is eroded in this case.
Total thickness of the Suite is 650-700 m.
The rock composition and thickness discontinuity by strike is characteristic for the Suite. To the east from described section, in the right branches of Turya River, marls predominate at the column base, and intercalation of calcareous argillites and marls (1-2 m) with sandstones (0.5-1.5 m) occurs in the column upper part.

Oligocene age of the Suite is accepted on the ground of encountered foraminifera complex with *Globigerina officinalis* Subb., and others [19].

2.28. *Malovyzhenska Suite* (*P* 3*mv*) is developed in Duklyanskiy and Porkuletskiy Thrusts where it conformably lies over Dusynska or Turytska suites. The bottom is set by thick sandstone layers appearing.
The Suite is composed of coarse-layered grey sandstones with argillite interbeds (0.03-0.4 m) and batches (0.2-5 to 20 m) of thin-rhythmic grey sandy-clayey flysch.
The stratotype is described on the northern slope of Maliy Vyzhen Mountain along right branch of Uklynskiy Stream [3] where above black argillites of Dusynska Suite there are exposed grey diverse-grained micaceous polymictic sandstones (0.3-1.5 m) with thin (0.01-0.05 m) grey argillite interbeds. In the upper part sandstones are thin-layered and gradually changed by sandy dark-grey aleurolites. Section thickness is 215 m.
Total thickness of the Suite is up to 400 m.

Oligocene age of the Suite is based on nanofossil complex findings in its lower part with *Sphenolithus ciperoensi* [3], and foraminifera with *Pararotalia techicapa* Nutt. [24].

2.29. *Menilitova Suite. Lower Sub-Suite* (*P* 3*m1*) is mapped in Skyboviy Thrust, Krosnenska Zone, and in Luzka, Zhornavska and Kostrynska nappes of Duklyanskiy Thrust, where it conformably lies over thin-rhythmic Upper Eocene flysch and is gradually changed by Krosnenska Suite sediments. Lower boundary is set just above the last green argillite layer of so called Sheshorskiy Horizon by the bottom of black siliceous argillites.
The Sub-Suite is composed of black, dark-grey or dark-brown thin-flaky argillites with jarosite spots, which intercalate with aleurolites, rarely sandstones (up to 1 m) and marls (up to 0.5 m). In the lower part of the Sub-Suite, above 10-15 m thick Pidrogovykoviy (Under-Flint) Horizon, it is developed the regional marker Nyzhnyokremeneviy (Lower-Flint) Horizon (5-30 m) composed of thin (2-15 cm) interbeds of black flints and flinted argillites.

Besides this classic Sub-Suite column developed in Duklyanskiy and Skyboviy Thrusts, in Krosnenska Zone not only typical menilites are ascribed to this division, but also the rock pile, with elements of both Menilite and Kroskenskiy facial types, which under detailed works was previously mapped as Golovetska Suite [21], and in adjacent territories in Poland is known as “Transitional Layers” [15]. In this unit, besides flinted, black and dark-grey argillites and aleurolites of Menilite-type, considerable column part is comprised of grey diverse-rhythmic sandy-clayey flysch of Krosenskiy type. Both these facial types are being intercalated and their separation is not possible even under detailed studies.
The Sub-Suite stratotype is established on Chechva River [4]. The full section of classic Lower Menilitova Sub-Suite is described in Duklyanska Zone nearby Vyshka village [22]. There, above Upper Eocene Sheshorskiy Horizon, the following units occur (upward):
1. black thin-flaky argillites with black flint interbeds (0.03-0.1 m) (Pidrogovykoviy and Rogovykoviy horizons) – 20-30 m;
2. black schistose argillites with jarosite spots and interbeds (up to 0.08 m) of black marls, pyritized siliceous sandstones and tuffs (0.05-0.1 m) – 50-60 m;
3. thin- and medium-rhythmic intercalation of dark-grey calcareous argillites and aleurolites (0.05-0.15 m), grey calcareous fine-grained sandstones (0.01-0.25 m) with medium-grained sandstone interbeds (up to 0.8 m) which amount increases upward – 250-300 m.
Total Sub-Suite thickness in this locality is 300-350 m.
In Skyboviy Thrust thickness of the upper batch increases to 360-420 m and total thickness of Sub-Suite – up to 400-470 m [22].
In Krosenskiy Zone thickness of units 1 and 2 (typical menilites) decreases in places to 15-20 m, and thickness of diverse-rhythmic dark-grey sandy-clayey flysch, which is defined under the name “Veretskiy” [4] varies from 275 m to more than 1580 m (drill-holes Lomna-1, 2, section D1-D2). Thickness of Sub-Suite in this locality attains 1600 m.
In Poland [15] thickness of these beds (menilites and transitional) in places (Zatvarnytsya section) attains 2000 m and total thickness of Krosnenski layers increases respectively. Obviously, the territory of transitional layers development corresponds to the most subsided part of the Oligocene basin.

There are known in Lower Menilitova Sub-Suite the findings of ichthyo-fauna (including studied area in upper Dniester River course) and foraminifera with *Globigerina vialovi* Mjatl., *G. officinalis* Subb., and others, which indicate its age to be Early and Middle Oligocene.

**Paleogene-Neogene Systems undivided**

2.30. *Krosnenska Suite* (*P₃-N₁kr*) almost completely constitutes Krosnenska Zone and in lesser extent is developed in Skybovivny Thrust and in the north-eastern nappes of Duklyanskiy Thrust. The Suite stratotype is established at the outskirts of Krosno town (Poland). By lithology, the Suite is divided into three sub-suites.

2.30.1. *Lower Sub-Suite* (*P₃kr₁*) conformably overlies Lower Menilitova Sub-Suite sediments. The lower contact is set by the bottom of banded limestone (Golovetskiy horizon which is the marker for entire Carpathians where it is positioned at the specific age level and it does oblique cross various lithological rock types [4]). This feature causes equivocal thoughts on geological boundary and volume of sub-suites. In the studied area this horizon is located at the bottom of Krosnenska Suite while in the northern nappes of Skybovivny Thrust – at the boundary of Lower and Middle Menilitova Sub-Suite [3].

Section of lower sub-suite is studied at the outskirts of Bytlya village [22] where above black argillites of Lower Menilitova Sub-Suite lies 0.4 m thick banded limestones and the 500 m thick intercalation batch of grey fine- and medium-grained sandstones (0.03-0.3 to 1.5 m), argillites and aleurolites (0.01-0.2 to 0.7 m). Higher lie the 1050 m thick massive or coarse-layered micaceous sandstones with thin (up to 0.05 m) grey argillite interbeds and batches of thin-rhythmic sandy-clayey flysch (up to 1-1.5 m). Total thickness of this section is 1550 m.

It is characteristic for the Sub-Suite the lateral and vertical facial variability as well as considerable thickness changes (from 640-735 m in Duklyanskiy and Skybovivny thrusts to 1700-2000 m in Krosnenska Zone). Increasing in amount of clayey rocks from north-east to south-west comprises general feature. For instance, in contrast to the section described above, in Turkivska Sub-Zone the medium- and coarse-rhythmic clayey-sandy flysch predominates with sandstone thickness up to 2-3 m, argillites up to 0.3-0.4 m, and in the south-western nappes of Bytlyanska Sub-Zone argillites and aleurolites often prevail. This is thin-, rarely coarse-rhythmic grey flysch with characteristic distinct olistolite horizons. Olistolites, from first tens of centimeters to 200-400 m in size (biggest one of 0.2 by 2.4 km in size in the Uzh River valley), are composed of dark-grey glassy sandstones, argillites of Shypitska Suite, and cherry-red, green argillites and marls of Porkuletska Suite. In addition, parti-coloured Eocene and Yalovychorska Suite argillites, and sandstones of Chornogolovska Suite are observed in olistolites. Rock age in olistolites is determined by mollusc and foraminifera fauna [4, 22].

2.30.2. *Middle Sub-Suite* (*P₃-N₁kr₂*) is distinguished in Skybovivny Thrust and in Korskenska Zone where it comprises rhythmic intercalation of grey and green-grey argillites, sandstones and aleurolites which normally stack up the column of Lower Sub-Suite.

The basic section is described within the studied area [3] on the left branch of Yasenytsya River. In the 180 m thick lower part intercalate grey argillites (0.1-0.8 m) and medium-grained micaceous sandstones (0.2-0.3 m) which constitute up to 30% of the column. Black or brown argillite interbeds (0.05-0.7 m) are characteristic at the bottom. Upper column portion (270 m) is composed of similar rocks but argillite thickness ceases (up to 0.05-0.3 m), their black and brown varieties disappear, and thickness and amount of sandstones increases (up to 60-70%). Total thickness of Sub-Suite is 450 m.

In Krosnenska Zone the Sub-Suite is exposed over the full thickness in Grozivska Nappe only where its section is studied in the upper course of Dniester River [22]. There, above the Lower Sub-Suite sandstones normally lie 250 m thick grey and dark-grey argillites with fine-grained sandstone interbeds (up to 0.1 m), which is overlain by 350 m thick grey medium-rhythmic sandy-clayey flysch, with thickness of some argillite interbeds 0.2-0.5 m and sandstones – 0.2-0.3 m. Total amount of the latter attains 40% of the section. Higher lies 700 m thick intercalation sequence of grey micaceous sandstones (0.3-0.5 m) and grey, yellowish-grey argillites (0.1-0.4 m). In the upper part of Sub-Suite grey sandstones (0.2-0.6 to 1.2-1.5 m) and argillites (0.1-0.5 m) are intercalated. Total thickness of Sub-Suite is 1400 m.

2.30.3. *Upper Sub-Suite* (*N₁kr₃*) is distinguished in Grozivska Nappe of Krosnenska Zone and in Zemelyanka Nappe of Skybovivny Thrust where it is composed of argillites with rare sandstone interbeds which thickness increases in the upper part. The basic section is described within the studied area in the upper course of Dniester River nearby Sereda village [3, 22]. In the lower portion (about 300 m) soft, grey, calcareous argillites
intercalate with rare thin (0.02-0.3 m) grey, fine- and medium-grained sandstone interbeds. Higher lie about 150 m thick grey calcareous argillites with sandstone interbeds (0.4-0.8 to 1.2 m). Thickness of Sub-Suite exceeds 450 m.

In Skyboviy Thrust is exposed only lower 300 m thick part of Sub-Suite which is in general similar to one developed in Kronsenska Zone.

The age of Kronsenska Suite is defined on the ground of numerous findings of foraminifera and ichthyofauna. In Lower Sub-Suite argillites on Yasenitsya River are determined: *Bolivina subdilatata Pishv., Cibicides borislavensis Aisent*, and others [22]; in Middle Sub-Suite on left branch of Yasenitsya River: *Globigerina amplispetura Bolli, Globigerinoides cf. primordius Banner et Blow*, and others [3]; in upper course of Dniester River in Upper Sub-Suite: *Globigerina pseudoedita Subb., G. juvenilis Bolli*, and others [3]. All these data allow acceptance of general Oligocene-Miocene age of the Suite. Most authors [3] consider Lower Sub-Suite to be Oligocene, Upper one – Early Miocene, and the boundary between these units is set at various horizons of Middle Kronsenska Sub-Suite. This sub-suite age interpretation is accepted herein.

**UPPER (THRUSTED) TECTONIC FLOOR**

The sediments involved constitute the sedimentary-volcanogenic fill of Trans-Carpathian Internal Trough and encompass the interval from Lower Miocene (Otnangian) to Upper Pliocene (Dakian-Rumunian) of the regional stratigraphic scale. The following units are distinguished: Tereshulska Sequence of Otnangian-Carpathian regio-stages, Novoselytska Suite of Lower Badenian, Tereblinska Suite of Middle Badenian, Solotvyńska, Terešvenska and Baskhevska suites of Upper Badenian. In the section supplements to the maps are also distinguished undivided Tereblinski-Baskhevska or Terešvenska-Baskhevska suites. For Sarmatian, Pannonian, Pontian and Pliocene the terrigenous sediments (suites) and their volcanogenic age analogs (complexes) are distinguished in parallel. For Sarmatian these include Dorobrativska, Lukivska and Almashska suites and respectively Velykodobronskyi, Barkasivskiy and Chomynovskyi complexes; in Pannonian and Pontian – Izivska and Koshelivska suites (which almost throughout is mapped as undivided) and Kuchavskyi complex; for Dakian-Rumunian – Ilnytska Suite which in places is divided in two sub-suites, are respectively (upward): Antalivskyi, Makovytskyi, Matekivskyi, Synyakskyi, Obavskyi and Martynskyi complexes.

**Cenozoic eratheme**

**Neogene System**

**Otnangian-Carpathian regio-stages undivided**

2.31. *Tereshulska conglomerate sequence (N1tr)* is developed at the bottom of Neogene molassa as the basal horizon which, with regional angular unconformity, overlies basement rocks, and, with the slight stratigraphic interruption, is overlain by Novoselytska Suite sediments. The Sequence is composed of particoloured polymictic conglomerates, sedimentary breccias with interbeds of argillites, sandstones and aleurolites which are gypsum-imposed in places. Previously conglomerate portion of the Sequence was ascribed to Burkalivska Suite [26, 23], and particoloured rocks – to Upper Cretaceous Romanska Suite [25], Eocene Baylivska Suite, or to Oligocene [26].

It was later established that particoloured portion comprises olistostrome of rock fragments with Cretaceous and Paleogene micro-fauna, in its cement Neogene fauna occur, and it is more suitable to correlate the conglomerates with Tereshulski ones.

The Sequence rocks are disclosed by drill-holes at the outskirts of Zaluzh, Nyzhni Remety, Ruski Komarivtsi villages and in Beregivske uplift at the depths 590-3500 m [22]. Composition of coarse-clastic material depends on geology of the nearest elevated basement block. In Beregovo area, quartz, limestones, dolomites, diabases, jasper, spilites, porphyries, quartzites predominate in the pebble, cement is siliceous-calcareous, basal-type, amount of medium-degree rounded pebble is 40-70%, pebble size – 1-15 cm. In Zaluzh area, in addition, rock fragments and boulders from Peninska Zone are abundant (red marls, pink limestones, flints etc.), and close to Ruski Komarivtsi diverse metamorphic schists occur.

Thickness of the Sequence varies from some meters to 260-500 m.
In DH 405 nearby Mala Bigan village in the Sequence rocks I.V. Venglinskii [25] had determined foraminifera complex with *Globigerinoides cf. trilobus* (Reuss), *G. cf. bisphaerica* Told. and others of Otnangian stage.

From Zaluzh area just re-deposited Upper Cretaceous – Oligocene micro-fauna is known [22], and in the eastern (Solotvynska) part of Trough, besides re-deposited micro-fauna, A.D. Gruzman and V.M. Zavolyanska had determined *Globigerinoides trilobus* Reus, *Orbulina sp.*, *Haplophragmoides sp.* [22] characteristic for Lower Miocene Otnangian-Carpathian regio-stages. This age is accepted for Tereshulska Sequence herein.

## Badenian regio-stage

2.32. **Novoselytska Suite (N1nv)** with the slight stratigraphic interruption lies over Tereshyiska Sequence and throughout is conformably overlain by Tereblinska Suite. The Suite rocks are disclosed in all drill-holes in Beregivske uplift (Dobron, Zaluzh, Nyzhni Remety, Mukachevo, Ruski Komarivtsi areas) where they are often being mapped as “Lower Tuffs”. The rocks are absent in the western part of the Trough, in the areas of Chopske and Uzhgorodskie uplifts, and at Vygorlat-Gutynski Ridge.

The Suite is composed of rhyodacite, dacite, rhyolite tuffs with interbeds of tuffites, calcareous argillites which amount increases in the upper part of column.

The tuffs are light, green-light, crystal-vitroclastic, petite-psephitic, in Beregivske uplift often agglomerate. Total thickness of the Suite is 100-450 m.

In tuffs from lower part of the Suite are determined *Candorbulina universa* (Orb.), *Globigerinoides trilobus* (Reuss), and in argillite interbeds within tuffs in upper part: *Uvigerina pudica* (Cz.), *Bulimina buchiana* Orb. [2]; these data allow acceptance of the Suite Early Badenian age.

2.33. **Tereblinska Suite (N1tb)** is normally overlain by Solotvynska Suite rocks. At the same time, in Potashnya Stream (Yaslyshche village), where the rocks are exposed directly at the surface, these rocks unconformably lie over Pidgalskiy flysch, and, in turn, are unconformably overlain by Vygorlat-Gutynski volcanics [18, 22].

In the Trough the Suite is mainly composed of sandy-clayey sediments with rock salt, gypsum, anhydrites, salted argillites, aleurolites, and rarely tuffite lenses. At the surface it is composed of dark-grey, green-grey argillites, aleurolites with rare interbeds of fine-grained sandstones, rarely felsic tuffs, tuffites and marls [18].

In the Trough the Suite lies at the depths from 616 to 2920 m in the areas of Zaluzh, Nyzhni Remety, Chynadievo, “Karpaty” sanatorium, Ruski Komarivtsi. In these places it can be subdivided in two sequences: lower, mainly terrigenous, and upper, salt-bearing ones. Thickness of the latter is highest in Zaluzh area (up to 330 m), from where it gradually decreases in all directions [22], pinching out in the north at “Karpaty” sanatorium, and in the south – along the line Vynogradove-Shalanky-Drysynya-Dovge Pole. South-westward from this line the Suite is mainly comprised of terrigenous facies, its thickness sharply drops down, and in Beregivske uplift it is being mapped as “Lower Sedimentary Sequence” together with other Badenian sediments, pinching out in between DH 1330 and DH 1331 [22].

Total thickness of the Suite varies from 0 to 150-450 m, and in Potashnya area it is 55 m. Reduced foraminifera complex is characteristic for the Suite rocks, where in Zaluzh area are determined *Quinqueloculina acneriana* Orb., *Bulimina elongata* Orb. [2], and at Yaslyshche village *Gyroidina soldanii* Orb., *Asterigerina planorbis* Orb., *Globigerina bulloides* Orb., and others [18]. On the ground of these data the Suite sediments are ascribed to the Middle part of Badenian stage.

2.34. **Solotvynska Suite (N1st)** stakes up continuous Badenian stratigraphic column, it conformably lies over Tereblinska Suite and is overlain by Teresvynska Suite. Area of its distribution is similar to one of Tereblinska Suite, and over considerable territory in the south-western part of the Trough it is being mapped together with other Badenian sediments as the “Lower Sedimentary Sequence” [25, 23], or as undivided Tortonian [26]. Separately it is distinguished within Zaluzka anticline where the rocks are disclosed at the depths 824-1855 m. The Suite rocks are absent in the central parts of Chopske and Uzhgorodskie uplifts.

The Suite is mainly composed of grey and dark-grey calcareous argillites, aleurolites, fine-grained sandstones; in places felsic tuff lenses and tuffites occur.

Abundant foraminifera complex is known in the Suite rocks in Zaluzyka anticline: *Globigerina bulloides* Orb., *Bulimina elongata* Orb., *Bolvima dilatata* Reuss and others [26]. Using authors’ collection from DH 32-t (N.Solotvyno village) L.D. Ponomaryova had determined: *Bulimina elongata* Orb., *Orbulina universa* Orb., *Globorotalia majori* Cushm and others [22]. On the ground of these data the Suite rocks are ascribed to Upper Badenian.
2.35. *Teresvynska Suite (N1ts)* as the separate stratigraphic unit is only distinguished in Zaluzh site while in the most of territory it is being mapped within entire Badenian sequence or its upper part [22]. In the central parts of Uzhgorodskie and Chopske uplifts the Suite sediments are absent.

In Zaluzh site the rocks are disclosed by drill-holes at the depths 494-1420 m where they conformably overlie Solotvynska Suite and are overlain by Baskhevska Suite.

The Suite is mainly composed of grey, dark-grey calcareous clays with interbeds of diverse-grained grey micaceous sandstones, felsic ruffs, rarely conglomerates. Thickness of rock interbeds – centimeters to first meters, tuffs – up to first tens of meters. Total thickness of the Suite is 330-660 m.

In the Suite rocks in Zaluzh site are determined: *Hyperamina granulosa* Vengl., *Uvigerina asperula* Cz. and others [26] providing the ground to ascribe the rocks to Upper Badenian.

2.36. *Baskhevska Suite (N1bs)* conformably lies over Teresvynska Suite and is overlain by Dorobrativska Suite.

The Suite is composed of calcareous clays with interbeds of diverse-grained sandstones, aleurolites and conglomerate lenses. It is mapped at the surface in the area of Kuklyanskiy horst in Beregivske uplift and is disclosed by drill-holes in Zaluzh area, at Garazdivka, R.Komarivtsi, Velykiy and Maliy Dobron – at the depths from 431 to 1630 m. In the remaining territory the Suite is combined either with entire Badenian column (“Lower Sedimentary Sequence”) or with Teresvynska Suite only [22]. In the central parts of Chopske and Uzhgorodskie uplifts the Suite sediments are absent.

Total thickness of the Suite varies from 29-74 m in Zaluzh site to 260 m in Mala Dobron area. Abundant complex of Upper Badenian marine saline-water, in places fresh-water molluscs is described in the Suite rocks with *Ammonia galiciana* (Putrja), *Quinqueloculina akneriana* Orb., and others [18,22]. On this ground the rocks are ascribed to the top Badenian units.

2.37. *Tereblinska, Solotvynska, Teresvynska and Baskhevska suites undivided (N1tb+bs)*, or so called “Lower Sedimentary Sequence”, is distinguished within Beregivske uplift and is conformably overlain by Lukivska Suite rocks.

The Suite is composed of grey micaceous clays (1-5 m) with minute interbeds of aleurolites, sandstones, rarely rhyolite tuffs, rhyodacites (5-15 m) and tuffites. In some sections, besides that, conglomerate lenses appear at the bottom. Total thickness of the Suite here is 320-570 m.

Total thickness of sediments varies from 8 to 500 m. Badenian age of the rocks is defined by respective micro-fauna [26, 23].

Sarmatian regio-stage

These sediments are widespread in the Trough where they are often being mapped at the surface. Lower and Middle Sarmatian rocks are distinguished.

Lower Sarmatian rocks are combined in Dorobrativska and Lukivska suites. In addition, to Lower Sarmatian are also ascribed the coeval volcanogenic rocks which constitute two complexes respectively: Velykodobronskiy and Barkasivskiy1.

2.38. *Dorobrativska Suite (N1db)* is distinguished by I.V.Venglinskiy at outskirts of Dorobratovo village where in DH Zaluzh-2 at the depths 204-754 m its lectostratotype is described. The Suite conformably overlies Baskhevska Suite sediments and is conformably overlain by Lukivska Suite rocks. At the surface it is mapped in the central part of Zaluzka anticline, in Beregivske uplift, and in the area of Lynts-Kiblyary villages, and in drill-holes it is distinguished over entire territory of Trans-Carpathian Trough.

In the lecto-stratotype the Suite is composed of grey micaceous clays (1-5 m) with minute interbeds of aleurolites, sandstones, rarely rhyolite tuffs, rhyodacites (5-15 m) and tuffites. In some sections, besides that, conglomerate lenses appear at the bottom. Total thickness of the Suite here is 320-570 m.

Similar features the Suite retains mainly in subsided blocks in the Trough where considerable variations of total thickness (570-1000 m) and depth (700-2400 m) occur [22].

Other patterns are displayed by sediments in uplifts where time of its formation coincided with wide development of volcanic processes, which products for a long time, and in Beregivske uplift up to now [23], were ascribed to this Suite. In Velykodobronskie and Chopske uplifts Velykodobronskiy and, partially, Barkasivskiy volcanogenic complexes were distinguished in the Suite volume [26]. Thickness of the Suite here is 75-255 m, and together with isochronous parts of the complexes – up to 1000-1500 m.

The Suite sediments throughout are well characterized by micro- and macro-fauna. Among foraminifera these include *Cibicides badenensis* (Orb.), *Globigerina bulloides* Orb., *Saccammina sarmatica* Vengl., among

1 These and other volcanogenic complexes will be described in separate section.
molluscs – *Abra reflexa* Eichw., *Cardium inipinatum* Grischk., *Ervilia trigonula* Sak., and others. On the ground of these data the Suite is ascribed to Lower Sarmatian Volynskiy Horizon of the regional stratigraphic scale.

2.39. *Lukivska Suite* (*N1lk*) is developed over almost entire territory of the studied part of Trans-Carpathian Trough. At the surface it is exposed on the flat slopes of Zaluzka anticline, Beregivske and Velykodobronske uplifts. The Suite sediments conformably lie over Dorobrativska Suite and are overlain by Almashska Suite rocks.

The Suite is composed of carbonate clays with interbeds of aleurolites, sandstones, rhyolite tuffs and tuffites, in places brown coal lenses occur. It is established [25, 26] two-fold structure of the Suite where lower part is mainly terrigenous while upper one is volcanogenic-terrigenous. Normally, in subsided portions of the Trough terrigenous sediments predominate and in the uplifts volcanogenic rocks are ubiquitous. Thickness of the latter is 5-10 m in Ruski Komarivtsi area and it increases to 75-100 m on the southern slopes of Zaluzka anticline and northern slopes of Beregivske uplift where these rocks are being mapped as the separate horizon in between Kosyno-Ivanivka and Nyzhni Remety-Khmilnyk villages. In the area of M.Bigan and Ivanivka villages 0.1-3.5 m thick lenses of germanium-bearing lignites are encountered. Total thickness of the Suite is 250-400 m.

In the Suite rocks abundant macro- and micro-fauna complex is determined with correlative forms *Quinqueloculina reussi* (Bogd.), *Cardium transcarpaticum* Grischk.; on this ground the Suite is ascribed to the upper part of Early Sarmatian Volynskiy Horizon [2, 22].

**Middle Sarmatian**

Almashska Suite and Chomonynskiy volcanogenic complex are distinguished in Middle Sarmatian.

2.40. *Almashska Suite* (*N1al*) is mapped on the slopes of Zaluzka anticline, Beregivske and Velykodobronske uplifts, and in the central parts of Shalankivska, Drysynska and Chikoshska volcano-structures.

The Suite sediments conformably lie over the rocks of Lukivska Suite and in the south it is in places overlain by Pannonian sediments [25]. However, over the most territory in the central and northern parts of Mukachevska depression these rocks with stratigraphic or also with some angular unconformity are overlain by Pannonian and Dakian-Rumunian sediments or even completely omit the column [22].

The Suite is composed of calcareous, grey, dark-grey clays with interbeds of aleurolites, sandstones, limestones, marls, felsic tuffs, tuffites; lignite lenses occur in places. Four types of Suite sections are described [23, 25]: sandy-clayey and clayey for subsided parts of Mukachevska depression, and volcanogenic-clayey and coaliferous-volcanogenic-clayey developed by periphery of Beregivske, Velykodobronske and Chopske uplifts. These facial changes are accompanied by essential thickness variability: sections with marls, tuffs and lignites on the uplift slopes is 60-80 m and it increases for sandy-clayey sections in subsided depression parts to 120-325 m.

Abundant micro-fauna complex is encountered in the Suite rocks with zone forms *Porosononion subgranosus* (Egger) and pelecypoda *Cardium plicatofittoni* Sinz., *C. plum* Zhizh. and others; on this ground the rocks are ascribed to the lower part of Middle Sarmatian.

**Pannonian regio-stage**

2.41. *Izivska Suite* (*N1iz*). Over the most territory Pannonian sediment are being mapped as undivided together with Pontian sediments and with stratigraphic interruption lie over Sarmatian sediments. Separately Izivska Suite is distinguished in Vynogradivskiy block only where it conformably [25] lies over Almashska Suite sediments and is conformably overlain by Pontian Koshelivska Suite.

The Suite is composed of grey carbonate clays with interbeds of aleurolites, sandstones, limestones, marls, felsic tuffs, tuffites and lignites of 90-300 m total thickness.

The Suite age is defined after pelecypoda and ostracoda fauna: *Congeria partschi* Cz., *C. ornithopsis* Bzuz., *Hemicytheria foliculosa* (Reuss), *H. lorenthei* (Meh.) and others, by which the Suite is ascribed to Pannonian stage (sensu stricto).

**Pontian regio-stage**

This unit includes sediments of Koshelivska Suite and their volcanogenic analogue – Kuchavskiy complex.

2.42. *Koshelivska Suite* (*N1kš*) is established in separate stratigraphic unit within Vynogradivskiy block only [25] while over remaining territory it is mapped being combined with Izivska Suite [23, 26]. It conformably lies over Izivska Suite and is unconformably overlain by sediments of Dakian and Rumunian stages.
The Suite is composed of calcareous grey, dark-grey, greenish, brown, violent clays with sandstone interbeds, and lenses of conglomerates, brown coal and tuffs of felsic, rarely intermediate composition. Total thickness of the Suite is up to 350 m. Its age is defined by ostracoda and pelecypoda fauna with Candona lobata (Zei.), Congeria subglobosa Partsch., and others.

**Pannonian and Pontian regio-stages undivided**

2.43. Izivska and Koshelivska suites (N1iz+ks) are being mapped undivided over most part of studied territory [22, 25]. The rocks are developed in subsided areas between uplifts (Beregivske, Velykodobronske) and Zaluzka anticline, and to the south, south-east from Beregovske uplift, but are absent to the west of Velykodobronskiy fault [22].

The sediments of this unit display considerable facial variability. Normally two types of column are distinguished with gradual transitions in between: coaliferous sedimentary-volcanogenic and coal-free terrigenous [22, 26]. The first type is developed along the south-western fore-front of Vygorlat-Gutynskiy Ridge and on the north-eastern slopes of Beregovske uplift. It is composed of parti-coloured clays (0.7-36 m), rhyolite and andesite tuffs (2-37 m) with interbeds of aleurolites (up to 4.5 m), sandstones (0.1-3 m), conglomerates (0.5-1.5 m), tuffites, tuff-argillites, tuff-sandstones (0.2-8.8 m), lenses of brown coal (0.1-5.3 m), flints (up to 0.1 m), shell-limestones (up to 1 m). In the area of Mala Bigan organogenic limestones (up to 3.5 m) are observed. Thickness of this column type is 210-290 m.

Coal-free terrigenous column type is developed in the area of Velykodobronske uplift and in Vynogradivskiy subsided block. There diverse calcareous clays predominate, rarely sandstone and tuffite interbeds occur. Their thickness in Vynogradivskiy block is 144-600 m, and in Velykodobronske uplift it does not exceed 60 m [25, 26].

**Pliocene Division**

**Dakian and Rumunian regio-stages undivided**

This unit includes sediments of Ilnytska Suite and volcanogenic rocks of Antalivskiy, Makovtytskiy, Matekivskiy, Synyatskiy, Obavskiy and Martynskiy complexes which are correlated with this suite.

2.44. **Ilnytska Suite (N1il)** was previously mapped within Levantynian stage [18, 25, 26]. Its stratotype is established in the area of Ilnytske brown coal deposit where this stratotype included all coaliferous rocks. With stratigraphic, and in places with angular unconformity, they lie over the rocks of Pontian, Pannonian, Middle or upper part of Lower Sarmatian [22], and with stratigraphic interruption are overlain by Quaternary sediments of Chopska and Mynayska suites.

The Suite is composed of clays, sands, aleurites, tuffites, conglomerates with lignite lenses and horizon of rhyolite tuffs with garnet; by the bottom of the latter the boundary between Lower and Upper Ilnytska sub-suites is set. Definition of sub-suites is only possible on the slopes of Chopskij and Velykodobronske uplifts and at the western outskirts of Mukachevo town [12, 26] whereas over remaining territory the Suite sediments are being mapped undivided.

It is characteristic for the Suite significant facial variability depending on the column position in the system of elevated or subsided blocks in volcano-structures [22]. Two marginal column types are distinguished: coal-bearing tuffogenic-sedimentary and coal-free sedimentary with gradual transitions between these types.

Coal-bearing column type is developed on the slopes of volcano-structures, especially along the south-western side of Vygorlat from Uzhgorod to Bereznicky. It is composed of clays, aleurites, sandstones, tuffites, felsic, rarely intermediate tuffs, volcanomictic conglomerates and gravellites, brown coal, sometimes geyserites occur. Thickness of rock interbeds varies from 0.1-0.3 to 4-7 m. Coal seams are not consistent and often are lensed, pinched out; by these reasons despite of a number of coal seams (up to 15-20) in the column, 1-2 of them only attains economic thickness (Berezninka, Uzhgorod, Lokhovo).

Seamless (coal-free) column type is developed in the central parts of molds between volcano-structures. It is more persistent: this is a sequence of grey calcareous micaceous clays and aleurites with diverse-grained sandstone interbeds. Brown coal lenses (5-10 cm) rarely occur. In places where the Suite can be divided in two sub-suites, at the bottom of the upper one lies horizon with interbeds of felsic tuffs, tuffites (in places with garnet), which is correlated with Vorochevskiy Horizon and is analogues to Gazhynskiy tufts in Slovakia. Thickness of the horizon is 15-50 m, it is highest for the coal-bearing column type [22].

Total thickness of the studied coal-type columns is 170-200 m, and coal-free ones – 100-519 m.

Data on the Suite age are pretty controversial. At the beginning phases of its studies on the ground of micro-fauna and flora determinations is was thought Middle-Upper Sarmatian or Pannonian age [22]. This age
was taken for the Suite analogs in adjacent Slovakia, and up to now the tuffs at the bottom of Upper Ilnytska Sub-Suite (Gazhynski) are being ascribed to the bottom of Pannonian [17]. Later, upon discovery of abundant fresh-water ostracoda complex with Candona albicans Brady; these rocks were ascribed to Levantyn [25, 26], and this age (Dakian and Rumunian regio-stages at present) is approved in “Stratigraphic schemes …”, Kyiv, 1993.

This age is also accepted by the authors although it contradicts to the data on absolute age of Vygorlat-Gutynski rocks which are considered to be analogs of Ilnytska Suite [14, 16]. By these data, Vygorlat-Gutynski rocks, like ones of Beregivskiy ore camp, were formed over Late Badenian-Pontian. In this case, only that part of the Suite could be post-Pontian to which is proven it lies over volcanics of Vygorlat-Gutynskiy Ridge.

Quaternary System

The System includes continental deluvial, deluvial-coluvial, alluvial, lake and glacial sediments distinct for the two regions: Carpathians and Trans-Carpathians.

Eo-Pleistocene

2.45. Upper Branch. Alluvial sediments of IX terrace (аEії) occupy small areas on the south-western slopes of Vygorlat (Letsovysya, Babychi, Dilok villages) and in the pra-Latortysya valley banks at Svalyava town outskirts. Terraces are accumulative-erosion with relative height 210-300 m. Alluvium is composed of pebble-gravel sediments with limonitized loamy or sandy filler and quartz, andesite, sandstone pebble which are over lain by the layer (5-8 m) of grey or dark-yellow clay. In places at the bottom of sediments up to 15 m of grey or light-yellow clay with pebble occur. Total thickness of IX terrace sediments is 2-25 m.

The age is accepted on the ground of correlations with upper part of Kopanska terrace [1] where Late Eo-Pleistocene fauna of small mammals is encountered.

2.46. Undivided alluvial sediments of IX and X terraces (аE) are developed on the right-bank side of Borzhava River (“Remetivskiy isthmus”) and on the heights to the south-west from Khat Ridge. Also is included terrace to the east from Shalanskiy Khelmets Mountain which is the spur of Kopanskiy Massif. Due to neotectonic motions and erosion-denudation processes the relative heights of these terraces decreased to 20-40 m and they cannot be divided.

The sediments unconformably lie over age-different Sarma tian and Pannonian rocks and are composed of pebble-stone, gravel with sand lenses (0.3-2 m), clay and mineral pigment interbeds (up to 10 m), individual boulders. Sandstone, quartz, quartzite, andesite, liparite-dacite and metamorphic rock pebbles and boulders are well-rounded. The filler comprises brown, red-brown limonitized clay. Upper parts are composed of 1-23 m thick brown-yellow, red-brown clays or loams.

Total thickness of sediments is 20-30 m although in places it drops to 3-5 m (Beregivskiy uplift) or rises to 76 m (area of Shalanskiy Khelmets Mountain) [22].

In the area of Nyzhni Remety village in the sand lens the bones of Citellus sp., Villanyia sp., Lagurini gen. indet are collected and on this ground the sediments are ascribed to Eo-Pleistocene [1].

Eo-Pleistocene – Lower Neo-Pleistocene undivided

In Carpathians undivided alluvial sediments of VIII and IX terraces are ascribed to this unit, and in Trans-Carpathians – Chopska Suite.

2.47. Undivided alluvial sediments of VIII-IX terraces (аE-Рі) are mapped within ancient latitudinal valleys. Alluvium of these terraces is mainly eroded and is preserved in the area of Grozeva, Lopushanka, Yavoriv, Lyuta villages [21, 22]. The sediments unconformably overlie Cretaceous-Paleogene flysch rocks. They are composed of pebble-stones with minor detritus and boulders, clay and loam lenses, Sandstone, aleurolites, flint and limestone pebble is well-rounded. In places pebble-stones are overlain by loams (0.5-0.6 m). Total thickness of sediments is 0.5-13 m.

The sediments are conventionally ascribed to Eo-Pleistocene – Lower Neo-Pleistocene (Budatskiy Sub-Horizon) since they were formed prior to the Carpathian river system re-arrangement in Middle Pleistocene [21, 22].

2.48. Chopska Suite (лаE+Рір) is widespread in Trans-Carpathian Trough to the west of line Mukachevo-Beregovo. The Suite sediments with the stratigraphic and angular unconformities lie over

1 Most of paleontologists consider the age determination on the ground of fresh-water forms to be incorrect [9].
Sarmatian-Rumunian sedimentary-volcanogenic rocks and are unconformably overlain by Mynayska Suite rocks. The Suite is composed of parti-coloured clays with interbeds of sands, pebble-stones, rarely lignites.

The Suite is studied with a number of drill-holes where considerable variability of its thickness and facial composition is encountered. In the eastern part of its distribution area from Mukachevo-Beregovo to Vuzlove station the coastal sandy-clayey sections predominate with essential gravel-pebble-stone interbeds (up to 40-50 m) occurring at the Suite bottom. In the western part of the Trough there are developed parti-coloured clays with minute lenses of lignites, diverse-grained sands, pebble-stones, rarely tuffites. Often lake-swamp black and dark-grey clays with organic matter are observed.

Thickness of the Suite from the east to west increases from some metres to 240-400 m in the area of Chop town, Solona and Svoboda villages. There is lack of fauna in the rocks. Previously [20, 26] it was ascribed to the Upper Pliocene – Pleistocene but upon Apsheronskiy stage inclusion to the Quaternary System it is accepted Eo-Pleistocene – Lower Neo-Pleistocene age of the Suite (“Stratigraphic Schemes …”, Kyiv, 1993).

**Middle Pleistocene**

Middle Pleistocene sediments comprise alluvium of IV, V, VI, VII and VIII terraces.

2.49. **Budatska Ledge. Alluvial sediments of VIII terrace (a³Pbk)** are widespread on the south-western slopes of Vygorlat, where they unconformably lie over Neogene volcanics, and within ancient transverse valleys (Perechyn, Zhdenievo). Terrace relative heights are 130-150 m and in Carpathians – up to 170-180 m. Terrace alluvium is composed of pebble-stones with grey, brown-grey or yellow loams and clays which in places are overlain by thin dense red-brown clays. Total thickness of these sediments is 1-3 m.

Budatsky age of the rocks is defined through their overlying by former soils of Martonoskiy thermochrone nearby Gorinchevo village [22].

2.50. **Donetska Ledge. Alluvial sediments of VII terrace (a³Pdc)** are traced by terrace fragments from Ardanovo village through Seredne village to Uzh River at the relative heights 80-120 m. In Carpathians they are mapped on the ancient valley slopes at the heights up to 170 m, and along the northern rim of Trans-Carpathian Trough relative height of this terrace decreases to 20-40 m due to neo-tectonic motions and long-term erosion [22].

In alluvium gravel-pebble-stones with sand and clay lenses (0.3-2 m) strongly predominate. Pebble is mainly composed of Carpathian flysch rocks, rarely Neogene volcanics, the filler is comprised of red-brown loam. Total thickness of sediments is 1-40 m but in Carpathians over many of these terraces minute pebbles only are encountered. Often these terraces are of erosion-denudation type.

Alluvium age in VII terrace is not supported paleontologically.

Taking into account the sediments composition and terrace relative heights the terrace is ascribed to Donetsky thermochrone of Lower Pleistocene [22].

2.51. **Krukenytska Ledge. Alluvial sediment of VI over-flood terrace (a³Pkn)** are developed in the ancient valleys in Carpathian where they unconformably lie over Cretaceous-Paleogene flysch sediments at the relative heights 60-80 m. Terrace alluvium is composed of dark-brown non-calcareous loams with fine well-rounded pebble of flysch sandstones and aleurolites. Thickness of sediments is 1-16 m but a number of erosion terraces do not contain any pebble.

This terrace is being compared [22] with Mykhaylivska terrace of Dnister River where Early Pleistocene molluscs are found and on this ground it is ascribed to Krukenytsky thermochrone.

2.52. **Khadzhybeyska Ledge. Alluvial sediments of V over-flood terrace (a³Pshd)** are known in local places on the left-bank side of Dnister River at Strilky village where they unconformably overlie Cretaceous-Paleogene rocks. In the right-bank side of Uzh River (Guta village) the rocks unconformably overlie Neogene volcanics.

Relative height of the terrace is 50-60 m, rarely 70 m. Terrace alluvium is composed of pebble-stones (2-5 m) with well-rounded pebble (0.5-10 cm) of sandstones, aleurolites, flint, quartz, with filling yellow-brown loam. Pebble-stones are overlain by grey viscous clays (up to 1.5 m) or yellow-brown loams (1.5-2 m). Total thickness of alluvium is 1-8 m.

To the east from the studied area at Danylovo village in the terrace sediments the micro-fauna is encountered characteristic for Dniprovskas Epoch and by this reason this terrace is ascribed to Khadzhybeyskiy thermochrone [22].

\[1\] In the Eastern Slovakia the age of the Suite lithological analogue (Chechegovski layers) is Pliocene – Lower Pleistocene.
2.53. **Cherkaska Ledge.** *Alluvial sediments of IV over-flood terrace (а*1*P*III*dr)* are found in the ancient valleys and in the left bank of Dniester River valley nearby Strilky village at the heights 40-50 m. The sediments are composed of pebble-stones (1-5 m) with well-rounded pebble of sedimentary rocks, and are overlain by yellow, dense, micaceous loam (up to 1 m). Alluvium total thickness is 1-6 m with exception of 21 m in the left-bank side of Turya River. To the north-east of the studied area in this terrace on Dniester River mollusc fauna is encountered that allows its dating by Cherkaskiy thermochrone [22].

2.54. **Mynayska Suite (Іа*P*III*-РІІІ*mn)** occupies entire plain part of Trans-Carpathian Trough where it unconformably lies over Pliocene volcanogenic-sedimentary rocks and Chopska Suite and is overlain by the cover loams.

Alluvial and swamp-lake facies studied in a number of drill-holes are distinguished in the Suite. Alluvial sediments occupy most of the area and are composed of sandy-gravel-pebble rocks with clay lenses. Boulders and pebble are well-rounded and consist of sandstones, quartz, quartzites, metamorphic schists, liparites, and andesites. Swamp-lake sediments are developed in Chorny Mochar depression in the area of Zhnyatyno and Nyzhniy Koropets villages. These are well-sorted thin-layered dark-grey clays with sand and peat interbeds. At their bottom alluvial pebble-stone or sand horizon (7-25 m) normally occurs.

The Suite thickness is inconsistent. In the north-eastern part of the Trough is comprises 10-15 m, in the western part of Beregivske uplift and nearby Kosyno village – 30-60 m, and in the west in the area of Rozivka and Baranyntsi villages it rises to 175-300 m.

Fauna remnants are not found in the Suite sediments. The lower age boundary is taken conveniently by the Suite laying over Chopska Suite. The Suite top comprises the surface of alluvial plain; in geomorphologic respect this corresponds to the first over-flood terrace which age in Carpathians is definitely characterized by fauna to be Late Pleistocene. These data define the Suite age within the limits of Neo-Pleistocene Middle and Upper branches.

2.55. **Trubezka Ledge.** *Alluvial and lake-alluvial sediments of III over-flood terrace (а*3*P*III*tr)* are distinguished in the valleys of all major Carpathian and Trans-Carpathian rivers where they unconformably lie over Neogene volcanics and Cretaceous-Paleogene flysch rocks at the relative heights 20-30 to 40 m.

Terrace sediments are fairly uniform: just over the socle lie well-rounded pebble-stones (0.3-2 m) with sandy or loamy filler which upward the column are gradually replaced by sandy-loamy rocks (0.5-10 m). In the Dniester River valley at the bottom of alluvium dark- or blue-grey clays (up to 2 m) often occur. In the expanded valley parts in places the lake facies appear (bluish-grey clays and loams). Total thickness of these sediments is 3-15 m. Trubezkiy age of the rocks is accepted by results of their spore-pollen analysis in Fore-Carpathians [22].

2.56. **Olshanska Ledge.** *Alluvial sediments of II over-flood terrace (а*2*P*III*ds)* are widespread in the valleys of all Carpathian and Trans-Carpathian rivers where they unconformably lie over Neogene volcanics and Cretaceous-Paleogene flysch rocks at the relative heights 6-12 m. They are composed of boulder-gravel-pebble sediments with sandy-clayey filling which in places are overlain by the cover of grey, yellow-brown loam (up to 1 m). Thickness of terrace alluvium is 2-15 m, the highest (nearby Mukachevo town) – 56 m [22].

In the mid area of Dniester River in the terrace alluvium the fauna of Late Pleistocene mammals and molluscs, Upper Paleolite big mammals is collected, as well as former soils of Buzkiy and Vitachevskiy climatoliths. On the ground of these data the rocks are ascribed to Olshanskiy thermochrone.

2.57. **Desnyanska Ledge.** *Alluvial sediments of I over-flood terrace (а*1*P*III*ds)* are widespread in the valleys of all Carpathian and Trans-Carpathian rivers where they unconformably lie over Cretaceous, Paleogene and Neogene rocks at the relative heights 6-12 m. They are composed of boulder-gravel-pebble sediments with sandy-clayey filling which in places are overlain by the cover of grey, yellow-brown loam (up to 1 m). Thickness of terrace alluvium is 2-15 m, the highest (nearby Mukachevo town) – 56 m [22].

In the alluvium of I terrace on Dniester River is collected fauna and abundant spore-pollen specters which allow the rock definition by Prychornomorskyi and Dofinivskyi climatoliths, and, in general, to Desnyanskiy thermochrone of Upper Pleistocene [22].

2.58. **Glacial sediments (qP*III*)** are encountered on the northern slopes of Polonya Rivna Mountain where in the three cirques the 1-5 m thick side and final moraines are unclear expressed. The time of the young mountain glaciation is thought to be related to some phase of Valdayskiy (Vurmian) stage [22].
Holocene

Alluvial, deluvial-proluvial sediments, modern soils, travertines, land-slide and technogenic rocks are distinguished in Holocene.

2.59. **Flood-land alluvial sediments (aH)** are developed in the all river valleys. In most cases the low (0.5-3 m) and high (3-5 m) flood-lands are distinguished. High flood-lands are composed of weakly-sorted pebble-stones, gravel with sand and loam lenses, sedimentary and extrusive rock boulders. Modern river-course sediments of the low flood-lands are composed of pebbles, boulders, oblique-layered sands. Thickness of the modern alluvial sediments is 0.5-1.1 m and in the flood-lands of Tysa and Dnister rivers it attains 20-25 m.

2.60. **Deluvial-proluvial sediments (dpH)** are developed along the high terraces on the south-western slopes of Vygorlat, on the left-bank side of Turya River, and in the gully funs. They are composed of non-sorted coarse-clastic material: diverse rock boulders, detritus, sands, loams, clays. Their thickness varies from some to 41 m [22]. The modern age of sediments is defined by their laying over the flood-land sediments.

2.61. **Modern soils** are composed of loams of diverse origin: alluvial, aeolian, deluvial which cover entire surface of Trans-Carpathian lowland and terraces. Their thickness varies from 1-2 to 5-13 m. Holocene age of the soils is defined by their laying above Mynayska Suite sediments.

2.62. **Travertines** are quite locally developed (out of scale areas up to 10 by 50 m) in Carpathians where they are related to the mineral water discharge sites and the sites of soil water penetration on the ridge slopes composed of highly calcareous rocks. Thickness is 0.5-10 m.

2.63. **Land-sliding sediments** are often occur in Carpathians in the Uzh and Latorytsya river basins where they are developed over Cretaceous-Paleogene folded rocks and are composed of non-sorted diverse-clastic rocks (up to Quaternary inclusive). Rock thickness is 1-30 m.

2.64. **Technogenic rocks (tH)** are being deposited nearby large quarries (Muzhievo, Kamyanytsya etc.), adits and other mining workings. Area of their development varies from tens of meters to 1 km by length and from first meters to 200-300 m by width. Thickness is 0.5-3 m, rarely up to 10 m.

Undivided sediments

This group includes eluvial, deluvial and deluvial-coluvial sediments which were formed over entire Quaternary time.

2.65. **Eluvial sediments (e)** are developed on the flat watersheds of Carpathians, Vygorlat, on the uplifts in Trans-Carpathian Trough. In Carpathians these are loams and clays with flyschoid rock fragments, in Vygorlat – yellow-brown loams, clays with extrusive rock boulders. Thickness of eluvium in Carpathians is 0.1-3 m, in Trans-Carpathians – 0.3-12 m [22].

2.66. **Deluvial-coluvial sediments (dc)** of the slopes. This is the most widespread genetic type of Quaternary sediments in Carpathians and Trans-Carpathians. The rocks are being formed under combined activity of aerial flow-out and gravity transportation and are composed of weakly-sorted loams with detritus and boulders of local rocks. The steep slopes, and especially their feet, are oversaturated with accumulations of large sandstone boulders (stone rivers – “tskoty”, “grekhoty”). Thickness of sediments is 1-7 m, rarely up to 30 m.

2.67. **Deluvial sediments (d)** are developed to the north of Carpathian watershed on the ridge slopes in the field of low-mountain relief, rarely they overlie alluvium of some terraces. These are grey-yellow loams with detritus, clays in places. Their thickness is 0.3-4 m.
3. VOLCANISM

Volcanic rocks are widely developed over the studied territory, they lie in the basement of Trans-Carpathian Trough and, especially, in the Neogene cover complex. In the basement they occur among Upper Devonian – Lower Carboniferous schists, in Upper Triassic, Jurassic and Paleogene sediments [22]. These are mainly tuffs and lavas of intermediate-mafic composition which form the lenses and interbeds within terrigenous rocks.

In the cover complex, volcanic rocks define the geological patterns of Trans-Carpathian Trough comprising volcanic Vygorlat-Gutynskiy Ridge, and in the lowland portion they form a range of separated volcano-structures, individual mono-volcanoes, in various extents eroded and overlain by Neogene sedimentary molassa or Quaternary sediments. They are widespread in Badenian already (Novoselytska Suite tuffs, tuff horizons in Tereblinska, Solotvynska and Teresvenska suites) but localized and specified volcano-structures are developed in Sarmatian, Pannonian, Pontian and Pliocene. These are the rocks which are subdivided in separate volcanic complexes: Velykodobronskiy, Barkasivskiy and Chomonynskiy (Sarmatian), Kuchavskiy (Pontian), Antalivskiy, Makovytskiy, Matekivskiy, Synyatskiy, Obavskiy and Martynskiy (Dakian-Rumunian). Under the complex in this case is thought the totality of lava-pyroclastic rocks which are spatially related to certain volcanic centre or their group and correspond to the entire period or specific stage of volcano formation [22].

Volcanic complexes of Sarmatian volcano-structures

3.1. Velykodobronskiy Complex (N1vd)

This complex is established in the same-named uplift [26]. These rocks are also developed in Beregivske and Chopske uplifts where they form lower portions of the composite volcano-structures. With stratigraphic unconformity they lie over sedimentary rocks of Upper Badenian or lowest Sarmatian and are overlain by sedimentary rocks of Dorobrativska and Lukivska suites or lavas of Barkasivskiy Complex. Volcanics are composed of andesites, andesite-basalts and their tuffs with composition variations from very high-leucocratic andesites (andesite-dacites) to almost basalts.

The rocks are developed in maximum extent within Gorondynska caldera of Velykodobronske uplift [26]. At the column bottom lie coarse-porphyry hypersthene-augite andesite-basalts 1 (245 m) which by periphery are replaced by leucocratic hypersthene andesites and their tuffs (55-72 m). Higher hypersthene andesites and their lavaclasts occur (60-100 m) which are overlain by leucocratic andesites (up to 67-165 m) or medium-porphory hypersthene-augite andesites (150 m) and coarse-porphyry andesite-basalts (130 m). At the top andesites intercalate with their tuffs (130-250 m). Thickness of the Complex in this site is up to 850 m.

In Chopskiy volcano the lower section is composed of mainly andesite-basalts, rarely their tuffs, while at the top andesites and their tuffs predominate.

In Beregivske uplift the rocks are only encountered in the lower section of Kvasivska caldera (so called “Lower Andesites”) where diverse-porphyry, often very leucocratic andesites (4-135 m) and their tuffs (2-65 m) intercalate. Thickness of the Complex here is 400-450 m. Total thickness of the Complex rocks is up to 850 m.

The Complex rock age is defined in view of the sedimentary rock lenses with Lower Sarmatian micro-fauna encountered at the Complex bottom, and similar micro-fauna is described in the rocks which overlie Velykodobronskiy Complex [22, 23].

3.2. Barkasivskiy Complex (N1bh)

This complex is distinguished in Velykodobronske uplift [26] where it constitutes the caldera of the same-named volcano. By lithological-petrographic features and time of formation so called “Middle Tuffis” and “Upper Andesites” of Beregivske uplift which traditionally are ascribed to Dorobrativska Suite [23, 25] are identical to the Complex. The rocks of this Complex also form the slopes of Chopskiy volcano.

The Complex rocks with stratigraphic break lie over Velykodobronskiy Complex, Badenian sediments or also over Novoselytski tuffs but are overlain by Chomonynskiy Complex.

Barkasivskiy volcano, bounded by arch faults, is oval-shaped (15 by 9 km), elongated in latitudinal direction. In its central part, in terminal crater, andesite-dacite neck is mapped, and a range of satellite eruptive centers on volcano slopes had provided liparite or dacite extrusions. The Complex rocks here are divided in three units [22, 26]. In the lower, up to 100 m thick one, the mixed-composition tuffs and xeno-tuffs predominate, with horizons of ignimbrites, volcano-mictic rocks, coarse-porphyry hypersthene andesite-dacites; pumice rhyolite.

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1 Hereafter see [13, 22] for petrographic, petrochemical and petrophysical rock details.
tuffs and tuffites are developed in the middle part (up to 43 m), and the upper one is composed of rhyolites and their tuffs.

The thickness of the Complex is 50-250 up to 650 m. Within the limits of Chopskiy volcano in DH 10-u to the Complex are ascribed 115 m thick tuffites with clay lenses which are overlain by pumice rhyolite tuffs (105 m).

Most widely the rocks of Barkasivskiy Complex are developed in Beregivske uplift along the north-eastern periphery of Gekeneska mega-caldera and satellite calderas: Kosynsko-Zastavnenska (6 by 8 km), Zolotysta (4.5 by 5 km), Kvasivska (3.5 by 4.5 km) and Kalimenska (6 by 5 km).

At the column bottom here lies thick pile of so called “Middle Tuffs” composed of rhyolite tuffs and xeno-tuffs with minor interbeds of terrigenous rocks. Its thickness sharply increases from the north to south from 0 to 900-950 m, and in caldera of Zolotysta Mountain – up to 1100 m. This pile comprises major productive horizon of Beregivske ore field. It is being compared with the first batch of Barkasivskiy volcano column.

Middle part of the Complex is composed of the same rhyolite tuffs 260 and 110 m thick separated by the lenses of terrigenous rocks, and in the 320-350 m thick upper part are developed domes and flows of rhyolites, perlites, their lava-breccias, tuffs and tuffites.

Within the limits of Kvasivska and Kalimenska calderas the upper part of Complex is composed of up to 260 m thick andesites, andesite-dacites and their tuffs which do not have analogues in Barkasivskiy volcano.

Total thickness of the Complex is not less than 1200 m.

The Complex age is defined by micro-fauna encountered in the lenses of terrigenous rocks within volcanics. On this ground the Complex rocks are ascribed to the lower part of Middle Sarmatian and are correlated to the upper part of Dorobrativska, Lukivska, and lower part of Almashska suites.

3.3. Chomonynskiy Complex (N 1čm), established in the area of Chomonyn village [26], is known in Shalanska caldera, Chikoshskes and Drysynske uplifts. It is composed of andesite-basalts and their tuffs, with stratigraphic breaks it lies over the rocks of Lukivska, Almashska suites or Barkasivskiy Complex, and is overlain by the rocks of Pannonian Izivska Suite or Quaternary Chopska Suite.

In the Chomonyn area the 280 m thick flow is developed composed of coarse-porphyry hypersthene-augite andesite-basalts with lenses of their tuffs. In Shalanska caldera (6 by 11 km) two-pyroxene andesites (10-170 m) intercalate with their tuffs (30-90 m), totals thickness is 580 m. Similar rocks in the areas of Chikosh and Drysyn are 150-390 m thick. Total thickness of the Complex is up to 580 m.

The age is defined in view of the rocks laying above the fauna-characterized rocks of Lukivska or lower part of Almashska suites [23, 26] and their overlaying by Almashska Suite rocks [22]. Thus, the Complex comprises analog of Almashska Suite and corresponds to the lower part of Middle Sarmatian.

Volcanic complexes of Pontian volcano-structures

3.4. Kuchavskiy volcanogenic complex (N 1kč) is established in the fore-land of Vygorlat-Gutynskiy Ridge [26] where it constitutes Kuchavskiy and Zhukivskiy volcanoes. There are developed andesite-basalts, andesites and their tuffs, rarely liparites and their tuffs occur. The rocks unconformably lie over terrigenous rocks of Dorobrativska Suite or lower part of Pannonian, and also are unconformably overlain by Ilnytska Suite rocks.

In Kuchavskiy volcano (9 by 17 km) nearby Mukachevo town (DH M-1) the 410 m thick diverse-clastic andesite tuffs and their lava flows (10-15 to 77 m) lie at the column bottom. Higher medium- and coarse-porphyry hypersthene-augite or two-pyroxene andesite-basalts and andesite-basalt tuffs with their lava flows (up to 10-15 m) occur. Thickness of the Complex exceeds 600 m at this place.

Zhukivskiy volcano (6 by 6 km) is completely covered by Ilnytska Suite sediments and its full column is not studied. In DH 265 more than 340 m thick intercalation of diverse-clastic andesite tuffs, tuffites with tuff-sandstone lenses and sub-volcanic body (150 m) of medium-porphyry andesites is disclosed.

Besides this, the Complex rocks are known in Chernchea Mountain (andesites, rarely rhyolites and their tuffs) and Latorytska (andesite-dacites) extrusive-dome structures. In the narrow band to the east from Kuchavskiy volcano to Negrovo village are developed andesite tuffs and tuffites of 56 m total thickness which overlie fauna-characterized sediments of Lukivska and Almashska suites. These rocks also are ascribed to Kuchavskiy Complex.

Pontian age of the Complex is defined by the rock setting in the column between the fauna-characterized sediments of Lower-Middle Sarmatian, Lower Pannonian and Ilnytska Suite [22].
Volcanic complexes of Dakian-Rumunian volcano-structures

Vygorlat-Gutynskiy volcanic ridge (20-25 km wide) is extended from the border with Slovakia, along the north-eastern margin of Trans-Carpathian Trough, over the distance of 65 km to the eastern border of the studied map sheet. The ridge is composed of volcanic rocks which traditionally were mapped in the volume of Gutynska and Buzhorska suites [18] and later were subdivided into some volcanogenic complexes [19, 26, 22]. In the studied ridge limits these include Antalivskiy, Makovytskiy, Matekivskiy, Synyatskiy, Obavskiy and Martynskiy complexes, which under the same succession (upward) are involved in widely-accepted “Stratigraphic Scheme of Neogene Sediments…”, Kyiv, 1993.

3.5. Antalivskiy volcanic complex (N2an) is established [18] on Antalivska Polyana Mountain which comprises large strato-volcano. It is composed of andesites and their tuffs, andesite-dacites, rhyolites and their tuffs [22]. Besides Antalivskiy, it completely constitutes volcano-structure Poprichniy, and lower sections of Makovytsya, Khotar and Synyak volcano-structures.

With angular unconformity the Complex rocks lie over Jurassic, Cretaceous and Paleogene sediments of Peninska Zone and Magurskiy Thrust, and with stratigraphic break – over Neogene terrigenous sediments: Tereblinska, Solotvynska, Teresvynska, Dorobrativska, Lukivska and Almashska suites. It was thought [18, 26] that these rocks also overlie the Levantynian rocks which are being compared at present with Dakian-Rumunian (Ilnytska Suite). However, these thoughts are not supported by recent EGSF-200 works [22]. The Complex rocks with stratigraphic break are overlain by sediments of upper Ilnytska Suite.

At the Complex bottom, on the north-eastern slope of Poprichniy, lies up to 60 m thick horizon of rhyodacites, their tuffs and tuffites with garnet (analog of Gadhynski tuffs in Slovakia). Higher andesite tuffs (agglomerate, psephite-psammite) with minor lava flows (1-15 m) occur. Batch thickness increases from periphery (15 m) to the volcano core portion (200-340 m). The rocks are overlain by medium- and fine-porphyry hypersthene-augite andesites (“Kamyanetski”) which are developed over entire Poprichniy area and at the column bottom of Antalivskiy volcano. Maximum thickness in the volcano core portions is 200-260 m. Besides the flows, these rocks often constitute also eruptive bodies developed not only in the cores of volcano-structures but also by their periphery (Kamenytsya quarry). The column is stake up with fine- and medium-porphyry two-pyroxene or hypersthene-augite andesites and their tuffs which are widely developed both in Antalivskiy and Poprichniy volcanoes. It is notable that lava and agglomerate tuffs in batch section predominate in the core of volcano-structures. Thickness of the batch is highest at these places (350-450 m). Toward periphery amount and thickness of lava flows decrease, coarse tuffs are changed by lapilli gravel and psammite ones, tuffites appear, and batch thickness decreases to 150-100 m. The column is capped by lava flows of diverse-porphyry andesites, and in Poprichniy case the coarse- and medium-porphyry two-pyroxene varieties are more common whereas in Antalivskiy volcano fine-porphyry hypersthene ones are developed. The flows occur in periclinal dipping, getting more flat toward periphery of volcano-structures. Their thickness decreases from 200 m in the core (Antalivska Polyana Mountain) to 55-15 m at the periphery (in Uzhgorod area for instance) where the rocks are overlain by coal-bearing sediments of Ilnytska Suite.

Besides Poprichniy and Antalivskiy volcanoes, the Complex rocks are developed also on the slopes of Ostra intrusive-dome structure where nearby Kiblyary village garnet tuffs are known laying over Lower Sarmatian rocks [22]; these rocks are also known in the central part of Khotarska, Ilkivska and Synyatska volcano-structures [18, 24].

Total thickness of the Complex attains 700 m [18, 19].

The rock age of Antalivskiy Complex is disputable. According to the “Stratigraphic Scheme of Neogene Sediments...”, Kyiv, 1993, the rocks are ascribed to Pliocene Dakian and Rumunian stages [22]. At the same time, in Slovakian part of Vygolrat [14] by new data of absolute age the rock analogues are ascribed to Upper Badenian-Pannonian which is supported in their overlaying by Sarmatian and Lower Pannonian sedimentary rocks. Similar data obtained for the Complex rocks in the studied territory [16].

3.6. Makovytskiy volcanic complex (Nsmk) is established in the same-named volcano which is superimposed on the north-eastern segment of Antalivskiy strato-volcano [19]. It is mainly (80-86%) composed of fine- and medium-porphyry two-pyroxene or hypersthene andesites with minor andesite-basalts, andesite tuffs, rhyolites and their tuffs; the rocks with angular unconformity overlie Paleogene rocks of Magurskiy flysch.

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1 In Slovakia, the Complex analogs (from below) include Poprichniy and Petrovci [14] ascribed to Upper Sarmatian – Lower Pannonian.
and with stratigraphic break – the rocks of Antalivskiy Complex. Thickness of andesite flows is 5-100 m, their tuffs up to 5-15 m, the laying is periclinal. Total thickness of the Complex does not exceed 500 m.

Besides Makovytskiy volcano, the Complex rocks are mapped in Khotar volcano-structure up to the area of Kibilyary-Gaydosh villages and along the north-western of Synyak to Poroshkova village. The Complex rock age is accepted within the limits of Pliocene Dakian-Rumunian stages [22].

3.7. *Matekivskiy volcanic complex (N 2mt)* was established by P.V. Koronovskiy (1963) in Matekova River basin in Synyak volcano-structure. Besides this, the rocks are also known in Dekhmaniv, Khotar and Martynskiy Kamin structures, as well as in Khat Ridge between Dilok and Siltse villages [22]. The Complex is composed of andesites, andesite-basalts, their tuffs, lava-breccias, tuffites, being thick from first meters to tens of meters, rarely first hundreds of meters. The rock horizons are not consistent by strike. Normally, amount and thickness of lava flows and coarse pyroclastics are highest in the core parts of volcano-structures and decrease toward periphery. Reverse relations are determined for the tuffites. The Complex rocks along the north-eastern periphery of Synyak and Dekhmaniv structures with sharp angular unconformity overlie Jurassic, Cretaceous and Paleogene sediments; in central parts with stratigraphic break they overlie Neogene Badenian-Sarmatian molassa (from Tereblynska to Almashska suites); in places the rocks also lie over volcanics of Antalivskiy and Makovytskiy complexes [22].

Complete column of the Complex is studied in drill-hole nearby Chabyn village [22]. Here above andesites of Makovytskiy Complex the following rock sequence occur:

- basal tuff-conglomerates – 38 m;
- coarse-porphyry two-pyroxene andesite-basalts and their lava-breccias – 24 m;
- fine-porphyry andesites – 40 m;
- intercalation (7-15 m to 20-48 m) of fine-porphyry two-pyroxene andesites, andesite-basalts and their psephite-psammite and agglomerate tuffs – 153 m;
- intercalation (1-52 m) of fine-medium-porphyry andesites, andesite-basalts and their lava-breccias – 165 m;
- intercalation of agglomerate, psephite-psammite and pelite andesite tuffs (2-47 m) and fine-porphyry andesite lavas and their lava-breccias (20-33 m) – 216 m.

Higher coarse-porphyry andesite lavas of Obavskiy Complex occur. Total thickness of the column is 636 m. In the central part of structure thickness of the Complex rises to 800 m.

In Dekhmaniv volcano-structure the Complex is clearly divided in two parts: lower (volcano-mictic-pyroclastic) – up to 250 m, and upper (lava) – up to 200 m [26, 22]. Similar patterns are displayed also in Khat Ridge where thickness of the bottom tuff-sandstones and tuff-argillites decreases to 10-15 m, diverse-clastic andesite tuffs – to 25-40 m, and the Ridge is capped with olivine and two-pyroxene andesite-basalt flow (60-80 m). Total thickness of the Complex in this case decreases to 120 m.

On the southern and south-western slopes of Khotar in between Lyntsi and Bobovyshche villages at the Complex bottom the fine-porphyry two-pyroxene andesites occur which are overlain by medium-porphyry and coarse-porphyry rocks [19, 22].

Since the rocks overlie the rocks of Antalivskiy and Makovytskiy complexes its age is accepted within the limits of Dakian and Rumunian stages although its absolute age data yields 12.2-9.3 Ma [16].

3.8. *Synyatskiy volcanic complex (N 2sn)* is established (Koronovskiy, 1963) within the limits of the same-named structure. It is composed of dacites, rhyodacites and andesite-dacites, andesites and their tuffs. It is defined [22] that lower part of the Complex is composed of moderate-felsic rocks, and its upper part – mainly of andesites. Besides Synyak structure, the Complex rocks are mapped in the central part of Dekhmanivska structure and on the north-eastern slope of Khotar Ridge. Their minor occurrences are also known in volcano-dome uplifts Dilok and Vysoka. In all cases the Complex rocks with stratigraphic unconformity overlie the rocks of Matekivskiy, rarely – Kuchavskiy complexes.

In Synyak structure the Complex rocks do not extend outside the limits of caldera fault. At the bottom of the domes, sub-volcanic bodies of variable composition (from rhyodacites to andesite-dacites) occur at almost complete lacking of explosive facies (only narrow (100-200 m) bands of rhyodacite and dacite tuffs along sub-volcanic bodies of the same composition are observed). Thickness of this section part does not exceed 400 m. Upper Complex part (up to 300 m) is composed of fine- and medium-porphyry two-pyroxene and olivine-hyperthene andesites and their lava-breccias (8-50 m) with minute thin andesite tuff interbeds. This part of Complex section is also known in the southern slopes of Dekhmanivska structure.

Total thickness of the Complex is up to 700 m. Since the rocks overlie volcanics of Matekivskiy Complex, in accordance with “Stratigraphic Scheme of Neogene Sediments...”, Kyiv, 1993, the Complex Dakian-Rumunian age is accepted [22].
3.9. **Obavskiy volcanic complex (N-ob)** is defined to be the final one in Synyak volcano-structure (Koronovskiy, 1963). These rocks also constitute the top portion of Dekhmaniv shield volcano; some their occurrences are known on the southern slope of Khat Ridge where they lie over Synyatskiy and Matekivskiy complexes with the stratigraphic break.

In Synyak structure the Complex is composed of two thick flows of medium-coarse-porphyry andesites and andesite-basalts; at the bottom 15-25 m of andesite tuffs occur. From the centres at Dunavka and Obavskiy Kamin mountains the flows surround the central crater and dip outward at very low angle.

In Dekhmaniv structure the Complex is comprised of some thick lava flows (in the lower part – leucocratic medium-fine-porphyry hypersthene andesite-basalts, andesites, in the upper part – mainly coarse-porphyry olivine andesite-basalts). Thickness of the Complex herein is up to 550 m.

On the southern slopes of Dekhmaniv and in Khat Ridge the Complex 10-25 m thick erosion remnants are composed of distinct coarse-porphyry andesites and andesite-basalts with plagioclase phenocrysts up to 1-1.5 cm in size.

Total thickness of the Complex is up to 550 m. The rock age is considered to be Dakian-Rumunian [22].

3.10. **Martynskiy volcanic complex (N-mr)** is established by E.M.Tytov in Martynskiy Kamin volcano-structure which narrow band on the left-bank side of Irshava River is located in the studied territory [22]. Here Matekivskiy Complex tuffs with stratigraphic break are overlain by the flows of fine- and medium-porphyry two-pyrozone or olivine andesites and andesite-basalts with thin (1-5 m) lenses of their tuffs.

Total thickness of the rocks is 250-400 m.

Age of the Complex rocks is thought to be Dakian-Rumunian on the ground of their laying onto Matekivskiy Complex [22].

General appearance, chemical, geochemical, petrographic, petrophysical and petrological features of the rock types in all defined Neogene volcanic complexes over studied territory are close enough and uniform [13, 22]. Their characteristics are given below.

Andesite-basalts and andesites are known in all defined complexes. These are black, dark-grey, fine-, medium- and coarse-porphyry, massive rocks with apha nitic groundmass and hyalopilitic, pilotaxitic, andesitic, glomero-porphyry or intersertal texture. Phenocrysts (10-45% of the rock) 0.5-2 to 10-12 mm in size are composed of labrador-bitovnite, monocline, rarely rhombic pyroxenes, in melanocratic varieties olivine is observed. In the groundmass the glass, plagioclase microliths, pyroxenes, ore minerals (magnetite, titanomagnetite, ilmenite, titan-ilo-mnitite, pyrite), accessories (zircon, apatite) predominate. Secondary minerals: hydro-mica and montmorillonite, carbonates, kaolinite, nontronite, sericite, opal, rarely iddingsite, bastite, biotite.

Dacites and andesite-dacites are known in Barkasivskiy, Antalivskiy and Synyatskiy complexes. These are grey, green-grey or cream-grey fine-, medium- and coarse-porphyry rocks with hyalopilitic, pilotaxitic or micro-felsitic groundmass. Phenocrysts (0.2-14 mm) comprise 20-50% of the rock and include zoned andesite, hypersthene, monocline pyroxene, very rarely amphibole or biotite. Groundmass is composed of plagioclasie microliths, glass, pyroxenes, rarely quartz, ore mineral, accessories (apatite, zircon, orthite). Secondary minerals include kaolinite, hydro-micas, montmorillonite, zeolites, rarely chlorite.

Rhyolites and rhyodacites are developed mainly in Barkasivskiy Complex, rarely they occur in Synyatskiy and in the lower parts of Kuchavskiy, Antalivskiy and Makovytskiy complexes. These are light-grey, cream, pink or violent fluidal, massive, aphyric or fine-porphyry rocks with spherolitic, felsitic, macro-felsitic groundmass, in places with pertile patterns. Phenocrysts 0.5-2.5 mm in size (3-10%) include zoned potassium andesite, rarely quartz, even hypersthene, and in Antalivskiy Complex garnet as well. In the groundmass felsic glass, plagioclase, quartz (tridymite, cristobalite), in places microcline, ore dust are developed, among secondary minerals – kaolinite, chlorite, hydro-micas.

Besides extrusive, in all complexes and among all rock types pyroclastic facies are widespread: rhyolite, rhyodacite, dacite, andesite and andesite-basalt tuffs. By fragment size all rock spectrum is distinguished from ash to psephite-psammite and agglomerate varieties.

Distinct felsic varieties include ignimbrites widely developed in Beregivske uplift.

In summary, general petrologic and petrographic features of volcanic complexes in Trans-Carpathians are given below [13, 22]:

a) Neogene volcanics belong to the calc-alkaline strong and medium Pacific type (Ritman serial index 0.59-2.16, Kuno index 15.0-15.9 at calcium content 1-10%) making the range from basalts to dacite-rhyolites along Pele variability line for world natural volcanic associations;

b) all rocks are depleted in alkalies relatively to the average values;

c) magma generation depth for Sarmatian and Pannonin-Pontian complexes is 150-120 km, and for Pliocene ones – 150-220 km [26];
d) composition and numerical relations of groundmass minerals and phenocrysts (by rock varieties) are identical for all complexes;
e) it is observed some differentiation of the rock composition in space which in Vygorlat-Gutynskiy Ridge is expressed in general increasing of mafic content from west to south-east where olivine varieties appear, as well as in alumina content increasing in the west where the rocks with primary-magmatic garnet are developed;
f) among the mafic rocks in the complexes two-pyroxene varieties strongly predominate with subordinate amount of leucocratic (hypersthene) or melanocratic (olivine) ones.
4. INTRUSIVE ROCKS

Non-stratified igneous rocks are widely developed in the area. These are stocks, necks, dykes, laccoliths, sill-like and pipe-like bodies, domes of felsic, moderate felsic and intermediate-mafic composition which are related to the formation of volcano-structures in Trans-Carpathian Trough. Likewise the latter, Sarmatian, Pannonian-Pontian and Pliocene intrusive are distinguished which correspond to three phases of Neogene volcanism.

It is characteristic that the rock spectrum from felsic to intermediate composition is replicated in each phase (only their numeric relations are different). By these reasons, due to similarity of petrographic features, generalized rock description will be given at the end of this section.

Sarmatian intrusive rocks

Extrusive, neck, sub-volcanic, vein and sub-intrusive facies of Velykodobronskiy, Barkasivskiy and Chomonynskiy complexes are ascribed to this subdivision. In this first phase of intrusive activity three sub-phases are distinguished [23]: in the first one the necks, stocks, dykes, laccoliths of andesites and andesite-basalts are formed; in the second one – those ones of andesites, andesite-dacites and diorite porphyries; in the third – extrusions, dykes, stocks and necks of rhyolites, rhyodacites and their porphyries, granite-porphyries and quartz porphyries. Most of these bodies are not exposed at the surface (mapped surface) and are disclosed by drill-holes.

First sub-phase

4.1. Andesites, andesite-basalts (απ1N1)

The rocks of this sub-phase are known in Beregivske, Velykodobronske and Chopske uplifts. These rocks are the age analogues of Velykodobronskiy Complex. In Beregivske uplift some their necks 0.15-1.0 km in diameter are disclosed by drill-holes [22, 23]. Their core parts are composed of dense medium-porphyry dark-grey pyroxene andesites and andesite-basalts with sub-ophitic groundmass. Endo-contact zones are comprised of eruptive breccia of these andesites, diabase porphyries, rarely sedimentary rocks cemented by carbonate.

Second sub-phase

4.2. Andesite, andesite-dacite, diorite porphyries (απ2N1)

Andesite and andesite-dacite porphyry necks, as well as diorite porphyry stocks and laccoliths are mapped or are supposed on the ground of geophysical data in Beregivske and Velykodobronske uplifts where they are mainly located in the influence zones of Mukachevskiy, Kalimenskiy faults and on the slopes of Barkasivskiy volcano and are being correlated with respective rock analogues of Barkasivskiy Complex [22].

Size of isometric, oval necks, stocks, by drilling and geophysical data, varies from 0.3-0.4 to 3.6-4.8 km², thickness of laccolith bodies in drill-holes is 100-250 m, and dykes – from first metres to 40-50 m [22]. The contacts of steeply-dipping bodies with host rocks are mainly curvilinear, in the endo-contact zones andesite or andesite-dacite lava-breccias are developed. Inward facial changes are observed from andesites, andesite porphyries to diorite porphyries which occur over the distance of 150-250 m [22]. Just the rock textures (crystallization degree) are being changed at the constant chemical composition.

In Velykodobronske uplift, the andesite-dacite neck in the crater of Barkasivskiy volcano breaks through the tuffs of Barkasivskiy Complex and Lower Sarmatian sedimentary rocks, and is overlain by andesite-basalts of Chomonynskiy Complex; these relations define the age of the neck.

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1 The “augen” biotite-muscovite granite-gneisses of “Yavornytskiy type” known at the watershed between Simerky and Chechovatiy streams [22] are excluded from description to the request of Editor-in-Chief since their setting is disputable.
It is thought [22, 23] the silver-polymetallic occurrences (Kelchey, Bucha, Kalimen) are connected with the sub-volcanic and neck facies of these rock group. Relatively high specific gravity and magnetic susceptibility allow application of geophysical methods in prospecting for these occurrences [22].

**Third sub-phase**

4.3. **Rhyolites, their porphyries (\( \lambda \pi_3 N_1 \)); rhyodacites, their porphyries (\( \lambda \xi \pi_3 N_1 \)); granite-porphyries, quartz porphyries (\( \gamma \pi_3 N_1 \))**

These, visually parti-coloured rocks, apparently comprise the various-depth facies of the same felsic magma, which differ in geological setting and crystallization degree. They comprise the stocks, necks, dykes, extrusions (including domes) which are being correlated with the rocks of Barkasivskiy Complex and are tightly related to them in space. The rocks are known in all Sarmatian volcano-structures but are most widespread and studied in Beregivske uplift, especially in its central part, and on the slopes of Kosynska, Zolotytsya and Kvasivska calderas. At the surface (map slice) there are developed rhyolite and rhyodacite domes from 1 to 8-9 km² in size. In the contact zones their lava-breccias, in places perlites, are developed. Below they are facially changed by rounded and oval necks up to 0.5 km in diameter which contacts with surrounding rocks are steep, sub-vertical. Thin (up to 1 m) zones of terrigenous rock hornfelsization are observed around the necks [22].

Similar bodies in Velykodobronske uplift are developed on the slopes of Barkasivskiy volcano where they apparently are related to the ring faults around the neck. Their size is up to 1-2 km. In Chopska structure thin rhyodacite dykes only are disclosed by drill-holes [22].

Porphyry varieties of above rocks are developed in the central parts of necks and domes and at the bottom of the latter. Granite-porphyries and quartz porphyries comprise the deeper (sub-volcanic and sub-intrusive) rocks in Beregivske uplift where at the outskirts of Blazhievo, Orusievo and Ivaniivka villages their isometric stocks up to 1 km² in size are known.

In Beregivske ore field gold mineralization is encountered in relation to the neck facies of rhyolites [22].

4.4. **Andesites, their porphyries (\( \alpha \pi_3 N_1 \)); quartz diorite porphyries (\( \varphi \delta \pi_3 N_1 \))**

Intermediate rocks of the third sub-phase of Sarmatian volcanism are known in all volcano-structures of this age including minor ones (Chikoshka, Drysynska and Shalanska). Barkasivskiy Complex comprises volcanic analogue of these rocks. Only two isometric stocks of these rock sub-volcanic facies are mapped at the surface nearby Shalanka village. Their bodies 0.6-1 km² in size are composed of andesites and their porphyries. The same rocks also constitute 0.5-25 m thick dykes disclosed by DH 201, 206 and 2-VD in Chomonyn area [26].

Sub-intrusive and intrusive facies of these rocks (andesite and quartz diorite porphyries) are disclosed by drill-holes in the areas of Chomonyn, V.Dobron, Drysyno, Chikosh, Kvasovo villages at the depths from 80-400 to 3843 m. Their forms include stocks, ring intrusions, laccoliths, conic dykes, stockwork bodies with numerous variously-oriented branched veins [22].

In DH 1-VD these rocks break through Paleozoic, Mesozoic and Neogene sediments up to the lower part of Middle Sarmatian (Lukivska Suite). Their absolute age is determined to 11.0±3.0 – 14.3±2.6 Ma [10, 26].

**Pannonian-Pontian intrusive rocks**

These rocks are mainly developed over the distribution fields of Kuchavskiy Complex along the southwestern foot of Vygorlat and are correlated to this one by age [22]. Some their bodies are known in Beregivske and Velykodobronske uplifts, in the core and by periphery of Poprichniy. Sub-intrusive gabbro-porphyries, gabbro-diabases, granodiorite-porphyries, micro-granodiorites, and sub-volcanic, extrusive dacites, rhyodacites, andesites, andesite-dacites, and andesite-basalts are distinguished.

4.5. **Gabbro-porphyries, gabbro-diabases (\( \nu \delta \pi_3 N_1 \))**

These rocks are mapped only in the core part of Poprichniy in the upper course of Syriy Potik where they form some bodies from 0.25 by 0.5 km to 0.5 by 1.5 km in size.

Setting and age of these rocks are disputable [10, 18, 22]. Their Pannonian-Pontian age is accepted by analogy with similar rocks of Vyshkivskiy area.
4.6. Granodiorite-porphyries, micro-granodiorites (γδπ N₁)

Dykes and minor stocks of these rocks are mapped nearby Dubrynych, Perechyn, and are disclosed in drill-holes at the sites Svalyava and Ruski Komarivtsi.

In Dubrynych area, 2 km long and 40-65 m wide dyke of granodiorite-porphyries and micro-granodiorites under the angle 25-30° gently plunges to south-west along tectonic zone and is traced over 900 m by dip during mercury deposit exploration. Minor pipe-like oval bodies of these rocks being 5-30 m in diameter are traced by drill-holes to the depth up to 100 m. Inclination is steep to the east, a number of Eocene flysch rock xenoliths occur in endo-contacts, the rocks often look like eruptive breccias. In Kamenychka stream basin and at “Zailiv” site there are also known granodiorite-porphyry dykes up to 400 m long and 50 m thick which are overlain by Antalivskiy Complex volcanics [18]. Thick sheet-like bodies of granodiorite-porphyries, micro-granodiorites are described [10] in Svalyava site in DH 1-C and 3-C at the depths 650-915, 1230-1325 and 1405-1446 m. Here the rocks intrude the zone of gentle thrust between Peninsa and Marmaroska zones.

Almost round-shaped, 5 km in diameter laccolith of these rocks with thickness from 100-300 m in periphery to 650 m in the core (see section B1-B5, DH 1-RK, 2-RK) is encountered in Ruski Komarivtsi site at the depth 1454-2691 m. It lies within Lower Sarmatian rocks and does form flat antcline fold inside, which is overlain by Pliocene sediments with angular unconformity [22]. Thus, the interval provides apparent time of laccolith formation between Sarmatian and Pliocene. This age (Pannonian-Pontian) is accepted herein for all granodiorite-porphyries and micro-granodiorites.

4.7. Dacites (μζ N₁), rhyodacites (μλζ N₁), andesites, andesite-dacites (μαζ N₁), andesite-basalts (μαβ N₁)

Intricate range of the felsic sub-volcanic rocks occurs in stocks, dykes and domes within and in the nearest proximity of Kuchavskiy volcano, rarely they are observed in Velykodobronske and Beregivske uplifts.

Rhyodacites constitute some tent-like bodies, probably stocks, nearby Perechyn town. Their size is from 0.3 by 0.4 km to 1.2 by 1.5 km. In the upper course of Potashnya Stream the total square of some contiguous domes, overlain by volcanics of Antalivskiy Complex, is 2 by 2 km. The bodies are cone-shaped at the top, their contacts steeply (up to 70°) dip inward that is highlighted by rhyolite fluidal patterns.

Dacites are encountered on the northern slope of Gorondynskiy volcano where they form two stocks up to 0.6 by 1.2 km in size. One of the bodies at V.Luchky village is overlain by Ilnytska Suite sediments [26].

Andesites and andesite-dacites do form a range of extrusive-dome structures (Lovachka, Polanok, Chernecha) at Mukachevo outskirts. Lovachka and Polanok ones are composed of contiguous andesite-dacite domes which break through Kuchavskiy Complex tuffs and in the west of Polanok structure are overlain by Ilnytska Suite sediments providing their age definition. Chernecha is comprised of three andesite domes joined into a single body outward of which are bifurcated the dykes of the same composition [26]. Size of these bodies, mainly elongated from south to north, is 2-3.2 km by 0.8-1.6 km.

Andesite-basalts mainly occur in dykes, rarely in minor stocks. In the core of Kuchavskiy volcano these rocks do form 50-70 m thick semi-ring dyke around the central crater 1.6 km in diameter. The dyke breaks through Kuchavskiy Complex tuffs and in the crater it is partially overlain by Ilnytska Suite sediments. The rock stock 1.5 by 0.7 km in size is mapped on the northern slope of the volcano.

Andesite-basalt dykes 0.5-25 m thick are encountered by drill-holes in Velykodobronska and Drysynska structures where they break through the rocks of Chomonynskiy and Barkasivskiy complexes respectively [22, 26]. In Beregivske uplift dyke thickness does not exceed 20 m, their contacts with host rocks are sharp, clear, wall-rock alteration is not observed. Besides the dykes, sill-like bodies also occur [22, 23]. These are the youngest intrusive rocks in Beregovo area while they break through all Neogene sediments up to Lukivska Suite inclusively. The rocks are always fresh.

Pannonian-Pontian age of above rocks is grounded on the fact of their breaking through the Lower-Middle Sarmatian sediments and their overlaying by Pliocene rocks. This is supported by the rock absolute age dating by K-Ar method to 11.24±0.54 Ma for andesite-dacites of Lovachka Mountain, and 8.0±0.6 Ma for andesite-basalt in DH 252 in M.Bigan [22, 23].
Dakian-Rumunian intrusive rocks

The rocks of this age include extrusive, sub-volcanic, sub-intrusive and vein facies of volcanic complexes developed inVygorlat-Gutynskiy Ridge as well as hypabyssal rocks.

Because of petrologic similarity of all volcanic rocks in Vygorlat-Gutynskiy Ridge and the narrow time span of their formation it is impossible anchoring specific types of intrusive rocks to each volcanic complex [22] thus only their formal grouping by composition is provided. Andesite-basalts and their porphyries, andesites and their porphyries, rhyolites, rhyodacites, dacites, andesite-dacites, diorite porphyries, quartz porphyries and related hydrothermalites (secondary quartzites, argillizites) are distinguished.

4.8. Andesite-basalts and their porphyries ($\mu$αβ$\gamma$N$\delta$), andesite, andesite porphyries ($\mu$α$\delta$N$\gamma$)

Stocks, necks and dykes of these rocks are located along the radial and arch concentric faults in volcano-structures, mainly in their core portions, although in places are known in the country rocks in flysch zone, where they are also confined to the radial faults, by which in places (Synyak structure) they are extended up to 5 km far from volcanic margins.

Size of stocks and necks varies from first tens of meters in diameter to 0.6 by 1.4 km, and 0.7 by 2.6 km in the area of Kiblyary village. Thickness of dykes is from first meters to 50-150 m, length from ten meters to 2-2.8 km. Dipping of the bodies is mainly steep to vertical, but in places the dykes, related to thrusting in flysch rocks, gently (20-30°) plunge to the south-west (Suskovo village area). Ring conic dykes (in Dekhmaniv central crater) and arch dykes with dipping outward the central volcano uplift (Synyak, Poprichny) are distinguished. Their contacts with host rocks are sharp, clear, in pipe bodies wavy in places, with “gulfs”. Rock texture is porphyry, rarely to aphiric, structure is massive. Proto-tectonic jointing fissure systems are distinguished of which one is parallel and another one is normal to the contacts. Of wall-rock alteration, hornfelsitization of host rocks (for example, nearby Suskovo village in exo-contact of 18 m thick andesite porphyry dyke are developed rocks of hornfelsite texture composed of albite, quartz, carbonate, biotite and fine-disseminated ore mineral) and strong fracturing are rarely observed. Thin pipe-like bodies in the neck portion often are composed of explosive breccia of andesite, andesite-basalt and sedimentary rocks and in Oleneva village area they contain mercury mineralization [10].

4.9. Rhyodacites ($\mu$λζ$\gamma$N$\delta$), rhyolites ($\lambda$π$\gamma$N$\delta$), dacites ($\mu$ζ$\gamma$N$\delta$), andesite-dacites ($\muαζ$N$\gamma$)

Non-stratified rocks of felsic composition, ascribed to Dakian-Rumunian, are developed in elevated portions of volcano-structures where they form domes, laccoliths, dykes, rarely irregularly-shaped bodies.

Most widespread are rhyodacites, dacites and andesite-dacites which comprise mainly domes from 0.2 by 0.3 to 4 by 5 km in size, isometric or oval shape (Putka, Tokarnya, Ostra, group of seven equal-size domes between Mukachevo and Velykiy Koropets, Berezyinka village, Dilok village area). Stock-like bodies are mapped in caldera fault of Dekhmaniv volcano-structure, in Zhornyna structure, and on the southern slopes of Khotar volcano. Often bodies of this composition comprise dyke series. In the central Poprichny uplift the dykes of almost longitudinal strike attain 3 km of length at 0.5 km width. In Dekhmaniv structure they comprise up to 6 km long and 1 km wide belt extended along the north-eastern faults (length of individual dykes up to 500 m, thickness up to 70 m).

Body contacts are sharp, clear, in domes mainly with dipping toward centre of massifs with flattening to depth. The dykes are steep to vertical. In their endo-contacts crystallized (up to glassy) rocks are developed, and in the exo-contacts are described quartz, quartz-carbonate veinlets and thin fractures with pyrite, chalcopyrite, in places hematite dissemination.

Rhyolites ($\lambdaπ$N$\delta$) are developed in the northern, eastern and, in lesser extent, in southern sectors of Khotar-Ilkivtsi volcano-structure, in adjacent western part of Synyak, and on the northern side of Makovytysya volcano. Round- or amoeba-shaped bodies 0.2 by 0.3 km to 3 by 5-6 km in size with steep or fan-like fluidal elements are normally the fields of domes. In their marginal parts glassy rock varieties appear, in places perlites, lava-breccias.

4.10. Quartz diorite porphyries, diorite porphyries ($qδπN$)$\gamma$

The rocks of this type are developed in the central part of Synyak and Dekhmaniv volcano-structures, their minor stock is mapped in Ostra structure (here the rocks break through andesite-dacite shield). By
geophysical data they are also expected beneath the central necks of Antalivskiy and Makovytksiy volcanoes [22]. Size of their isometric surface exposures varied from 0.3 by 0.4 to 2 by 3 km, and nearby “Synyak” sanatorium such intrusion is studied in the depth interval from 0 to 1470 m. Contacts of intrusions are sharp, steeply-dipping, with expansion trend down-dip, in places with branches, gulls into the soft host rocks. Side-contact intrusion parts are fine-grained to aphanitic, dark-grey or black, and closer to the centre these are already fully-crystallized diorite or quartz diorite porphyries. In intrusion nearby “Synyak” sanatorium two jointing fracture systems have been observed which steeply dip along the contacts “outward massif”, and the third system is close to horizontal. Often along these fractures the rocks are being replaced with the soft brown-yellow argillizites which is places collate into the single fields up to 0.2-0.6 km² in size. The fields of opalolites, alunizated rocks and secondary quartzites (including tourmaline, topaz, hydro-micas, kaolinite, dumortierite) are also observed. Patterns of changes by depth are studied in drill-hole Synyak-1. From 450 to 750 m there are distinguished the berezite facies: hydro-sericite-carbonate-quartz (450-660 m), carbonate-sericite-chlorite-quartz (660-750 m); below the propilites are developed: actinolite-epidote (to 1050 m), chlorite-epidote with sericite, carbonate and tourmaline (to 1350 m), and biotite-chlorite-actinolite with tourmaline (1350-1470 m).

It is thought the ore concentrations of copper, molybdenum, and probably gold could be related to these rocks [22].

Detailed description of petrologic and petrophysical features, mineral composition of the area intrusive rocks is contained in numerous works [10, 13, 18, 19, 22, 23, 24, 26] and below only brief petrographic description is given by rock groups from mafic to felsic.

**Gabbro-diabases** are grey, green-grey massive coarse-crystalline rocks of gabbroic, gabbro-ophitic texture, composed of plagioclase tables (up to 60%) and augite (35-37%) 5-6 mm in size, accessory ilmenite and sphene, and secondary actinolite after pyroxene.

**Gabbro-porphyries** contain up to 60% of porphyry zoned plagioclase and augite (3-5 mm) phenocrysts in fine-grained ophitic groundmass of plagioclase laths and columnar pyroxene. Accessories include zircon, magnetite, ilmenite, rutile and spinel.

**Diorite and quartz diorite porphyries** comprise dense, grey, green-grey porphyry rocks with 25-40% of plagioclase, monoclinc pyroxene phenocrysts, rarely hornblende 1-3 mm in size, and fully crystallized groundmass of dioritic, gabbro-ophitic, rarely subhedral texture, composed of plagioclase, pyroxenes, rarely quartz, ore minerals with accessory apatite, ilmenite, hematite, topaz. In quartz diores potassium feldspar is observed in places.

**Andesite porphyries** by composition are similar to diorite ones but their groundmass is less completely crystallized and contains up to 10-15% of mafic glass.

**Andesites, andesite-basalts** are dark-grey, massive fine- and medium-porphyry rocks with intersertal, sub-ophitic, hyalopilitic or pilotaxitic groundmass (plagioclase laths, pyroxenes, glass) with 15-40% of phenocrysts 0.5-3 mm in size (plagioclase, monocline and rhombic pyroxenes, rarely olivine), with accessory (apatite, magnetite, ilmenite) and secondary minerals (montmorillonite, carbonate, hydro-micas, chlorite).

**Andesite-dacites, dacites** are grey, light-grey, cream rocks of massive or trachyte structure, medium-and coarse-porphyry, with felsitic, micro-hypidiomorphic, felsic-dacite or hyalopilitic groundmass (plagioclase, biotite, hornblende, quartz, glass), Phenocrysts (5-25%) 0.5-5 mm in size are composed of plagioclase, hypersthene, rarely biotite and hornblende. Accessories include apatite, zircon, rutile, ilmenite, spinel; secondary minerals – nontronite, hydro-mica, kaolinite, carbonate.

**Rhyodacites, rhyolites** are light-grey, violent, pink, fine-porphyry, fluidal or massive rocks with spherolitic, felsitic, micro-granitic groundmass of quartz, K-feldspar, plagioclase, biotite, rarely glass, with 8-15% of K-feldspar, plagioclase and biotite phenocrysts (0.5-1.5 mm), accessories (zircon, apatite, ilmenite, spinel, garnet) and secondary minerals (kaolinite, halloysite, tridymite, albite, adularia, hydro-mica).

**Granodiorite-porphyries, micro-granodiorites** by composition are close to above group but are completely crystallized very fine-grained.

**Granite-porphyries and quartz porphyries** are grey, light-grey massive rocks with spherolitic, micro-felsitic or granophyre texture of groundmass and 5-10% of plagioclase, K-feldspar, biotite or quartz phenocrysts (1-3 mm). Accessories include apatite, ilmenite, leucoxene, zircon, rutile; secondary minerals – kaolinite, adularia, sericite, melnikovite, hydro-mica, zeolites.
5. TECTONICS

The studied territory encompasses western part of Ukrainian Carpathians and Trans-Carpathian Internal Trough. A range of external and internal elements of Alpine Folded System are distinguished. Skyboviy Thrust, Krosnenska Zone, Duklyanskiy, Porkuletskiy and Magurskiy thrusts are being ascribed to the External Carpathians whereas Trans-Carpathian Trough – to the Internal Carpathians. These units are separated by Trans-Carpathian (Peri-Penninian) Deep-Seated Fault (Cliff Zone) which includes Marmaroskiy Thrust and Peninska Zone. The fault zone is often being considered as element of Internal Carpathians and this thought is followed herein [22].

External elements of Alpine Folded System are comprised of the thick continuous terrigenous complex of flysch formation deposited over period from Early Cretaceous to Late Oligocene – Early Miocene. Development history of Internal Carpathians is longer and more complicated, normally they consist of some tectonic complexes including metamorphic (in basement) and volcanogenic ones. The regional angular unconformities are observed between the basement and thrust complex, between the complex of Paleozoic metamorphic rocks and Mesozoic volcanogenic-sedimentary complex, between Mesozoic and so called Eocene flysch of Pidgalskiy (Central-Carpathian) type in the basement of Trans-Carpathian Trough. In Peninska Zone the angular unconformity between Jurassic-Cretaceous and Paleogene sediments is also known. In view of differences in geodynamic conditions of structure formation they will be described separately for External and Internal Carpathians.

External Carpathians

In the thick (up to 10 km) continuous terrigenous complex of flysch formation, which constitutes this structure, both sub-flysch or molassoid column elements (in Upper Oligocene – Early Miocene), and thin non-flysch carbonate-terrigenous rocks that reflect the phases of slowed development (Porkuletskiy Horizon of Senonian-Turonian) are distinguished. Most important geodynamic feature of modern structure is general rock compression with major trend directed from south-west to north-east apparently being related to the high Moho boundary position (25-30 km) in the Internal and much lower (50-65 km) one in the External Carpathians [7]. In this direction the bulk mass movement occurs as well as formation of north-eastern virgation thrusts and nappes. In the studied area, from north-east to south-west the following sub-units are distinguished [22]: in Skyboviy Thrust – Zelemyanky, Rozhanky and Slavyska1 nappes; in Krosnenska Zone: Turkivska Sub-Zone with Grozivska, Shumyach-Zavadska, Lomnenska, Ropavsko-Golyatynska and Yablunivska nappes; Bytlyanska Sub-Zone with Birynska, Nyzhnyoturivska, Verkhnyoturivska, Yavoriv-Pylypetska, Syanky-Siglovativska, Uzhok-Abranska, Gusne-Bukivetska and Volosyanka-Pidpolozivska nappes. In Duklyanskiy Thrust are distinguished: Stuzhytska Sub-Zone [7] with Luzka, Zhornavska, Kostrynska, Shypitska, Uklynska, Malovyzhenska, Yavornytska, Velykobereznyanska, Malobereznyanska nappes and tectonic remnant of Polonina Rivna. Structure of Porkuletskiy Thrust is less complicated in comparison to [7, 24], and in Turyapolyanska Sub-Zone Zvorska (Olenivska) and Turytska nappes and Chechovatogo tectonic remnant are distinguished.

In Magurskiy Thrust are distinguished Rachanska, Bystrytska and Kokhanivska nappes which pinch out within the studied territory.

Skyboviy Thrust occupies most external setting in Carpathians. It is divided into the range of 0.8-7 km wide nappes most of which are traced to the south-east to Romanian border. In tectonic respect the nappes are monoclines or comprise the combination of anticline fold in the frontal part, where Striyska Suite rocks are exposed, and syncline fold in the inner part, composed of Oligocene – Lower Neogene sediments. Mainly undivided Eocene rocks are developed in the fold limbs. The folds are steep, often isocline, in places overturned to the north east. The fault planes, which separate the thrusts and nappes, are often steep (65-80°) at the surface and get more flat (up to 10-15°) at the depth 2-4 km that is supported by drilling data [21]. By the same data, general displacement of the thrust rocks toward the fore-front trough is up to 20 km [7, 21]. Tectonic convergence of disjunctive and plicative elements (up to the least folds with about some meters range) is characteristic. This suggests for the single-stage diastrophism or for general tectonic frame

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1 Some authors include this one into Krosnenska Zone [7]
retaining over several stages. At any rate, the folding within the thrust commenced latest, in Early Miocene only, apparently in Egenburgian [7], and completed in Sarmatian.

Krosnenska Zone is considered to be the only non-thrust tectonic unit of External Carpathians. It is attributed to its depressive position between Skyboviy and Duklyanskiy thrusts. It is composed of thick flyschoid Oligocene – Lower Miocene sequence (3-4 km) and only along the border with Skyboviy Thrust more older Eocene-Paleocene rocks are known.

General structure of the Zone is folded-napped [7]. Nappe width varies from 0.5-1.5 to 4-5 km. They are extended in the north-western direction across entire studied territory except Yablunivska and Shumyach-Zavadivska nappes which are pinched out in 5-7 km short of Poland border. Nappe dipping is steep enough at the surface (45-80°) but at the depth 3-5 km it gets more flat up to almost horizontal [21, 22].

Internal structure of the nappes is simple. Steep anticlines predominate; in their cores along the front the Menilitova Suite rocks occur, the limbs are composed of south-westward dipping Krosnenski sediments which in the inner part are often overturned due to the next nappe thrusting. Nappe-monocones are also distinguished which limbs are complicated by the higher-order folds with the range from some meters to 0.3-0.5 km.

Most subsided portion of the Zone (Bytlyanska Sub-Zone) differs in reduced amount of sandstones confined to the upper column parts. This is the zone, especially two inner nappes (Gusne-Bukovetska and Volosyanka-Pidpolozivska), where olistostrome horizons are widely developed. Olistolite size varies from decimeters to hundreds of meters and the biggest one, in Volosyanka village, is extended over 2.2 km being 0.35 km wide. Olistolites are mainly composed of Lower Cretaceous – Eocene rocks developed in Duklyanskiy Thrust, rarely Upper Jurassic limestone and metamorphic schist fragments occur [22]. Olistolites are more or less uniformly distributed over the matrix of the fine-clayey Krosnenskiy column but two horizons 300 and 600 m thick are encountered where amount of fragments is increased up to 40-60% of the rock. The fragments are acute-angled, large olistolites are lens-shaped.

In the most of this Zone nappes, like Skyboviy Thrust, the fault and fold element convergence is characteristic but in some cases (Ropavsko-Golyatynska and Uzhok-Abranska nappes) the fold axes are cut by faults under the angle 15-20°; this can be explained by both the anomalies of rock mechanical properties and the “spinning effect” under repetitive deformations.

In general, the Zone, together with Skyboviy Thrust, is fairly uniform in tectonic respect and by deformation style differs a bit from the more internal tectonic elements. It is observed even in satellite-image analysis [22] and apparently is because the folding processes commenced here latest (probably, in Egenburgian) and then had finished already in Sarmatian with general uplift and mountain landscape formation [7].

Duklyanskiy Thrust is most complicated by internal structure and the given authors’ interpretation is not widely accepted [22]. This is multi-floor folded-napped unit. In the frontal batch of nappes (Luzka, Zhornavska, Kostrynska and Shypitska) the oldest Lower and Upper Cretaceous rocks are exposed. The limbs and nappeinner parts are composed of Paleogene and Lower Neogene rocks (in places up to Krosnenski Suite with olistolites). Normally the oldest rocks occur in the anticline core. The folds are mainly normal but overturned ones also occur, in places to the south-west (Ostra Gora area). There are no nappe-monocones. All the system of above nappes is flat. It is terminated in the east of studied area being cut by the line of frontal thrust and, changing its virgation to reverse one, is overlain by the upper batch of nappes including Malovyzhenska, Velykobereznyanska, Malobereznyanska ones and tectonic remnant of Polonyna Rivna1. These latter are also flat structures which altogether form actually single large synform, presently eroded and cut. Likewise frontal nappe batch, their flat patterns are highlighted by tectonic window occurrences (“Mlaky”, in the area of Kostryn, Sil, Stavne and other villages). Along Uzh River the upper nappe batch is cut by the steep north-east-trending strike-slip fault.

The lowest, inner batch of nappes (Uklynyska and Malovyzhenska) is more steeper; it is overlain by both the upper batch and, partially, by the frontal one in the area between Rodnykova Guta and Lykystsary.

Internal structure of the nappes is complex, often fine folding and deformed rocks occur. The axial lines of diverse-order folds mainly do not coincide with nappe-bounding faults direction. This suggests for durable and multi-stage deformation period.

In the thrust limits, in the inner portions of Zhornavska and Kostrynska nappes, within Krosnenski sediments olistolite horizons are encountered, identical to those developed in Krosnenska Zone. Here in Oligocene thin-rhythmic flysch acute-angled, from some decimeters to 0.4 by 1.2 km in size fragments of Shypitski sandstones and Eocene parti-coloured argillites are often observed. Occurrence of these rocks allows some authors to conclude that no folding processes appeared in the area prior to Lower Miocene [7]. This conclusion contradicts to the complex structure of the thrust and diversity of its tectonic style. Obviously, slight

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1 In opinion of Carpathian Series map sheet Editor-in-Chief S.S.Kruglov, there is no tectonic remnant here and sandstones that occur in this site are ascribed by him to Neogene
block motions in Pyrenean folding phase, which are assumed [7], were much more important. Occurrence of thick olistolite sequence in front of DuklyANSkiy Thrust in Krosnenska Zone and adjacent nappes inside the Thrust may suggest for essential differentiation of the latter in Early Miocene. Olistolites of Krosnenska Zone in this respect can be considered as a result of DuklyANSkiy Thrust margin movement toward subsided sedimentation basin, and for DuklyANSkiy Thrust itself—same process of higher nappe batch movement over the frontal ones.

In the same way it can be explained why DuklyANSkiy Thrust is flat over entire length of its contact with Krosnenska Zone. In the studied area the magnitude of its overlapping is 15-16 km at least.

Porkuletskiy Thrust commonly pinches out in the area of Maliy Bereznki village where it is clearly overlain by Magurskiy Thrust. In our interpretation, to its Chornogolovska Sub-Zone [7] does correspond the Chechovatogo tectonic remnant — large synform of Cretaceous-Eocene sandstones, cut by steep sinistral strike-slip, by which the remnant northern part is displaced over 9 km westward as far back as it was overlapped by Magurskiy Thrust. Minor rock sheets of DuklyANSkiy Thrust, exotic Jurassic (?) limestones and even granite-gneisses [22] are known in front of this remnant. By mining works and DH Chornogolovo-1 data the Thrust is flat. Internal elements of the Thrust (Zvorska and Turytska nappe) are more steep but they get flat again in the south. Axis lines of the wide syncline and anticline folds in the nappes mainly plunge north-westward (azimuth 290-315°, angle 5-25°), rarely to the south-east (azimuth 110-130°, angle 5-15°), and normally are cut by marginal faults. In the anticline core portions massive sandstones of Chornogolovska Suite are exposed, and in synclines – Dusynska Suite and Oligocene Malovyzhenski sandstones (in Zvorska nappe), or Turytska facies of Oligocene (in Turytska nappe). The limbs are composed of thin-rhythmic Eocene flysch where fine isocline folding is often developed, normally overturned to the north-east, rarely south-west [22].

The least displacement of Porkuletskiy Thrust relatively to DuklyANSkiy one is evidenced by Chechovatogo remnant size (across Carpathians). It is estimated to 11-12 km. Beginning of dislocations within the Trust is being connected with Oligocene-Miocene boundary [4, 7]. In Miocene up to four sequential stages of folding and motions along the faults are distinguished [22].

Magurskiy Thrust comprises inner part of External Carpathians and being 9.5 km wide at the Slovakian border it pinches out next of 40 km on the left-bank side of Turya River (actually it is overlain by Neogene volcanics). Over the distance of 22 km (from Poroshkovo to Zabrod village) it completely overlaps Porkuletskiy Thrust over its entire width (11 km). Internal structure of the Thrust is folded-napped. By analogy with Slovakia, from north to south Rachanska, Bystrytska and Kokhanivska Sub-Zones (nappes) are distinguished [18, 22]. In between the nappes the thrusts are flat (50-40 to 25° south-westward). Despite of pinching in the studied limits, the Thrust is buried enough and Paleocene and Eocene sediments only are known which form simple anticline and syncline folds with 20-80° rock dipping in the limbs.

Structure of the Thrust with north-eastern virgation had appeared in Pyrenean folding phase and was renewed in Savian phase [4, 7]. However, statements of these authors on Magurskiy Thrust overlapping over Peninska Zone in Styrian or Attian phases are outdated. In drill-hole Ganyushevets above Teplov (Kalichiyak, 1991) reverse relations are proved [22].

Internal Carpathians

In the territory limits these include Marmaroska and Peninska zones and Trans-Carpathian Internal Trough.

Marmaroska Zone is extended over 8 km from Svalyava, where it is 2 km wide, to Suskov village, where it collapses to 0.2 km and is overlain by Neogene volcanics. In the area the Zone is comprised of just the fragment of its internal part – Monastyretska Thrust which is thrust over Porkuletskiy one. By drilling data, in Svalyava site the Thrust plane at the surface dips south-westward under the angle 45° whereas next in 2 km of the Thrust front this plane is almost horizontal and in DH 1-s and 3-s it is intersected at the depth 550-560 m. The Thrust rocks do form the syncline fold, with Dragivska Suite sandstones in the core, and thin-rhythmic Sushmanetska Suite flysch in the limbs.

In the south-west the Thrust is tectonically overlain by the flat thrust of Peninska Zone. Peninska Zone comprises narrow (1.2-2 km), very complex suture zone which is traced form Svalyava town to Novoselytsya village (80 km distance) but at the surface is locally exposed in the Latorytsya and Uzh river valleys and is mainly overlain by younger volcanics. It is composed of Lower Jurassic – Upper Cretaceous carbonate-terrigenous sequences which are extensively deformed and constitute the lower tectonic floor, and Eocene basal conglomerates and sandstones which lie above with sharp angular unconformity. The fragments of diverse-order folds, narrow tectonic nappes, and boulders-cliffs of strong limestones from some metres to 0.35
by 2 km in size that occur within folded marl-clayey sequences are distinguished in the internal structure of the Zone. In general, this is the giant tectonic breccia, mélangé which traces very high-order suture. In opinion of Slovakian geologists, it is set up as far back as Precambrian, although Pyrenean (Late Senonian) and Laramian (Paleocene-Miocene boundary) the Zone, together with Marmaroska Zone, was thrusted over External Carpathians. The data on the Zone “overturn” toward the internal trough in Attian phase [7] are not confirmed in the studies area [22]. In the Uzh River valley along the steep tectonic break it contacts with Central-Carpathian Podgalskiy flysch developed in the basement of Trans-Carpathian Trough.

Trans-Carpathian Internal Trough comprises young Late-Alpine depression set up over heterogeneous basement and formed due to Carpathian Mountain System uplift. It is filled with thick (up to 2.5-4 km) terrigenous molassa and Neogene, Pliocene and Quaternary volcanics which provide the cover (shield) complex.

In geomorphological respect it is Trans-Carpathian depression and Vygoral-Gutynskiy Ridge, and in geological term it is the space bounded by deep-seated faults: Trans-Carpathian in the north-east and Prypanonskiy in the south-west [10].

Commonly the Trough is divided [7] in latitudinal Krayova (Marginal) or Monoclone Zone adjoins Trans-Carpathian Fault, and Central Zone of salt-diapir or brachy-anticline folds. Prypanonskiy Fault is also being included into the Trough under various names: “Chop-Beregovo-Baya Marska horst-anticline zone” [25], “Beregivske block-crestal uplift” [23]. We describe it as Beregivske uplift [22]. This Trough zonation mainly reflects its deep structure while most important for its present appearance are volcano-structures of diverse age and order [18, 22, 26]; their geomathematization is essentially provided by E.M.Tytov (1979) who had ascribed mentioned units in Mukachevska volcano-tectonic depression [22].

Buried basement relief of Trans-Carpathian Trough is extensively broken with altitude range up to 3 km. By drilling and seismic survey data three rock blocks are distinguished. The north-eastern one roughly coincides with Marginal Zone and comprises continuation of Uzhgorod-Inyachkovskiy horst of Slovakia [17, 22]. Here basement is composed of metamorphic schists, Triassic, Jurassic and Cretaceous sediments as well as Podgalskiy-type flysch, it occurs at the depths from +53 m (Syryi Potik, DH 11) to -515 m (Uzhgorod, DH S-T) and to the south-east from Mukachevo it is not subsided below 1000-1100 m. The second uplifted block is composed of metamorphosed Paleozoic rocks, undivided Triassic-Jurassic often volcanogenic, and Cretaceous terrigenous sediments. In the Central Zone of the Trough the basement of similar composition is subsided by faults to the depths from 2166-2326 m (Zaluzh area) to 3287-3385 m (Ruski Komarivtsi area), and at the Slovakia border area (Pavlovo village) by seismic data it lies below 4 km.

Gross basement structure is block-type but in the internal part flat thrusts also occur, for instance, those encountered in DH Nevyrska-1 where triple-replicated Triassic column overlies Jurassic sediments [22].

The issue of the Trough basement position in the general structure of Carpathians is fairly disputable. It is thought to be part of Pannonian Massif (Galakhov, 1988), separate structure of ancient anti-Carpathian Pannonian-Volynska trough [4, 7], or element which connects the central-Carpathian cores with structures of Maramures basin in Romania. The latter statement is supported by the column similarity with Inyachkovsko-Uzhgorodskiy horst and development of distinct Podgalskiy flysch up to the area of Zaluzh village [22].

In the cover complex of the Trough volcano-structures of different age and order and plicative structures of sedimentary rocks are tightly related; two tectonic floors are distinguished in the later: lower (Otnangian-Sarmatian) and upper (Pannonian-Pliocene-Anthropogenic) [11, 22]. Between these floors not only stratigraphic but in places also angular unconformity is known and in the Chop area mismatch of their tectonic patterns is described [11].

In the Trough Marginal Zone sedimentary sequences gently plunge to the south west. In the central part of the Trough the wide, flat, isometric and oval structures are developed, and of these – wrapping folds or “sidewall” structures. Here brachy-anticline folds are developed which contain natural gas deposits. Origin of the folds is different. The biggest one – Zaluzka – fold-dome 15 by 20 km in size comprises crypto-diapiric structure where Dorobrativska Suite rocks are observed in the core and Lukivskaya and Almashka suites – in the limbs. In the core rock dipping is 1.3°, and outward it increases to 10°. Down-dip, beneath salt-bearing sediments, the fold bifurcates into four domes (Stanivskiy, Sazydivskiy, Ardanivskiy and Yablunivskiy), 2.2 by 4.3 km in diameter, which are considered to be prospective for natural gas. Gas-bearing anticline fold of Geitvisi volcano-structure (Ruski Komarivtsi) is about 5 km in diameter and was formed during uplift of the dome-shaped granodiorite-porphry diapir [22]. Dipping angles in the fold limbs are 5-20°. Other large folds of anticline type in around volcano-structures and uplifts are typical wrapping folds at all levels from Otnangian-Carpathian to Sarmatian-Pliocene.

The fold size is comparable with one of volcano-structures, rock dipping in the limb is 10-15°, axis line strike is close to general-Carpathian and in some fault-side structures only is anti-Carpathian [22].
Most of syncline structures in the Trough actually comprise the flat con-sedimentation molds which are developed in between volcano-structures [26]. These are compensatory structures, rocks dipping decreases inward and their thickness increases in the same direction. In the core parts Pannonian and Dakian-Rumunian rocks occur, and Sarmatian sediments are in the limbs, with dipping angle 7-10°.

Volcano-structures occupy more than half of studied part of the Trough. Sarmatian, Pannonian-Pontian and Dakian-Rumunian units are distinguished.

Sarmatian volcano-structures are developed in the central part of the Prypannonian fault block (Chopske and Beregivske uplifts) and on its northern slope (Velykodobronske uplift and other “buried” volcanoes). So called Geleneshska mega-caldera which centre is located in Hungary, in Tarpà village area, comprises the biggest of these structures. Its marginal fault boundary in the studied area is treated equivocally [23, 25] but by the sharp gravity gradient it is set through Vary village, southern outskirts of Beregovo, Didovo [22]. On the north-eastern slope of this mega-caldera minor, 5 by 4 km in size, Kosynska, Zolotysta, Kvasivska and Kalimenska calderas and 2 km in diameter Buchanska intrusive-tectonic structure occur.

The belt of “buried” volcanoes can be considered as the external arch around mega-caldera centre. Here pretty large strato-volcanoes up 10 km in diameter (Chopskiy, Barkasivskiy, Gorondynskiy, Shalanskiy) and minor intrusive- and volcanic-tectonic structures up to 4 km in diameter (Drysynske, Chikoshke) are developed. Total thickness of Velykodobronske, Barkasivskiy and Chomonynskiy complexes or their various combinations attains 600-1100 m. Most of large volcano-structures, especially those composed of mainly intermediate-mafic rocks, are expressed in considerable gravity anomalies (up to 2-14 mGal). Minor, especially those volcano- and intrusive-tectonic structures where andesite porphyry stocks or rhyolite domes are confined to the cores, are expressed in magnetic field anomalies up to 2-3 mErsted [22, 23].

Most of mentioned structures pass through the caldera stage with their subsidence to 100-350 m. Caldera faults are inclined inward under the angles 65-80°. In places calderas are filled with Dakian-Rumunian sediments. Often they are re-inversed in case of upward input of rhyolite extrusions or blind intrusions of quartz diorite porphyres above which the veins are located with polymetallic or gold-polymetallic mineralization (Kelchey, Bigan, Zolotysta).

Pannonian-Pontian volcano-structures are developed along the southern foot of Vygorlat-Gutynskiy Ridge. In the Latorytsya River valley Kuchavskiy volcano is distinguished, further to the west – completely buried Zhukivskiy volcano, and in the Ruski Komarivtsi area – Geivska crypto-caldera.

Kuchavskiy volcano of oval shape (9 by 17 km) is composed of intermediate volcanic lens (up to 350 m) with the roof subsidence caldera 2 km in diameter, bounded by the ring porphyry dyke. Volcano slopes preserve their primary pericline dipping. Along the southern, western and northern volcano periphery the extrusive-dome structures Velyka, Palanok, Lovachka and Chernecha are developed which is clearly reflected in relief by andesite-dacite and andesite extrusions [22, 26].

Zhukivskiy volcano is buried beneath Ilnytska Suite sediments. By magnetic survey data the terminal and lateral craters are distinguished. It is thought this is central-type dome unit related to the north-west-trending fault which also control Kuchavskiy volcano [26].

Geivska crypto-caldera 9.5-10 km in diameter comprises the unique unit which ring-patterned nature is related to the isometric granodiorite-porphyry laccolith; above the latter in Badenian-Sarmatian rocks the brachy-anticle fold was formed which is over lain by thick cover of Ilnytska Suite [22].

Dakian-Rumunian volcano-structures constitute the Vygorlat-Gutynskiy Ridge extended along the north-eastern periphery of the Trough, and their main centres are located along the over lain Pivdennopeninskiy Fault which separates the Trough from Peninska Zone. The Ridge overlies not only Peninska Zone but also parts of Magurskiy and Porkuletskiy Thrusts. Its width is 12-22 km, thickness of volcanogenic complexes varies from 350-450 m in the Uzh River valley up to 1900-1050 m in the area of Lisarnya-1 drill-hole and adjoining hills. The Ridge is asymmetric. Along its steeper north-eastern part the compact, close to isometric 9-15 km in diameter strato-volcanoes are developed (Poprichniy, Antalivskiy, Makovytyska, Khotar, Synyak, Dekhmaniv, western part of Martynskiy Kamin); its south-western slopes are more flat, longer, the intrusive- or extrusive-dome units 3.5-7 km in diameter (Ostra, Zhornyna, Shkitena, Dilok, Putka) are defined on the slopes.

Clear-expressed central intrusive-tectonic uplift (3-5 km in diameter), caldera sunk (up to 300-400 m) and less patterned volcano slopes with individual eruption centres comprise the general features of strato-volcanoes. Hypabyssal intrusions of gabbro-porphories, diorite and quartz diorite porphyries, sub-intrusive, sub-volcanic bodies of intermediate-felsic composition, hydrothermally-altered rocks, secondary quartzites etc. are developed in the core portions of strato-volcanoes, intrusive- and extrusive-dome structures and these units are often reflected in the contrasted magnetic anomalies. The dykes of similar composition are located along concentric and radial faults. As an example, one of the most typical strato-volcanoes – Synyak is described below.
Diameter of this structure is 15 km. It is composed of Matekivskiy, Synyatskiy and Obavskiy rock complexes in pericline dipping. By satellite-image data, the central intrusive-tectonic uplift 5 km in diameter is defined. In its core, intrusion of quartz diorite porphyries is disclosed by drill-hole to the depth 1470 m, and above the field of hydrothermally-altered rocks is developed. Uplift-bounding ring faults dip outward under the angle 70-80° that is highlighted by similar dipping of diorite porphyry ring conic dykes. Likewise some other structures (Khotar, for example) here one more center (Grabovo) of volcanic activity is identified [24] which in the modern structure is overlain by thick lava flows but in highly eroded gully sections it is expressed in the fields of extensively argillized, silicified rocks with tellurium-bismuth mineralization. In geophysical fields this center is expressed in isometric positive gravity anomaly. Caldera fault is being well-mapped by image deciphering. By series of minor radial breaks this fault is split into the sections with 0.2-1 km displacement in horizontal projection. Southern flank of volcano is complicated by Shkitena structure 3 km in diameter with abundant minor andesite-basalt porphyry stocks. Along concentric and radial faults often thick dykes and stocks of andesite-basalt porphyries are developed which in places are extended into the country rocks and their pipe-like bodies control minor mercury deposits. Flat dykes are also encountered which penetrate the thrusts and lie under the angles 40-25° (Suskovo area).

The faults in cover complex of Trans-Carpathian Trough by their age are divided into Early Alpine, which mainly follow up tectonics of the previous development stages (especially in the basement), and Late Alpine (syn-volcanic and post-volcanic) related to formation of Mukachevska volcano-tectonic depression and its individual units.

All faults of Carpathian strike are ascribed to the Early Alpine: Ivanivskiy and Gechenskiy which bound Beregivske uplift from north and south; Gazhynsko-Mukachevskiy and Stretavsko-Geivskiy which stair-like sunk Inyachovsko-Uzhgorodskiy horst; Pidvygorlatskiy which almost throughout is overlain by younger sediments; Remitskiy and Irshavskiy. Fault planes are steep (70-85°), they mainly dip toward subsided blocks. Magnitude of basement subsidence by these faults varies from 400-750 m in Beregivske uplift to 650-1300 m in Gazhynsko-Mukachevskiy fault. Basement displacement by crosswise Irshavskiy fault exceeds 1000 m. Most of the faults in geophysical fields are reflected in the linear zones of gravity gradients [22, 24].

All regional anti-Carpathian and diagonal faults of Beregivske, Velykodobronske and Chopkske uplifts (Mukachevskiy, Rafaylovo-Velykoluchkivskiy, Gashparskiy, Kalimenskiy) which bound and split volcano-structures (concentric and radial) are ascribed to Late Alpine.

All crosswise faults are steeply-dipping, con-sedimentation in various extents; vertical displacement by the faults varies from 100-150 m at the basement level somewhere attaining 1000 m (Gashparskiy). They often control location of volcanic centres and contain intrusive bodies of diverse composition (Mukachevskiy and Kalimenskiy magma-controlling); by these reasons they are being traced through the chain of minor gravity anomalies which coincide with magnetic ones [23]. By deep seismic data, influence zone width of these faults is up to 3 km, their depth – 15-20 km.

Syn-volcanic faults are widely developed. These are mainly arch, ring, concentric breaks, which bound volcano-structures or their parts, and radial breaks. Likewise volcano-structures, the faults can be divided into Sarmatian, Pannonian-Pontian and Dakian-Rumunian (it is easy to do by geological map analysis). Evidently, some faults are inherited from previous development stages. Most of faults are excellently expressed in airborne and satellite images. Steep dipping (70-85°) toward subsided blocks comprises their general feature. Magnitude of vertical displacement varies from tens to first hundreds of meters, and horizontal one along radial breaks – up to 1 km. These faults are often used by minor stock-like, pipe-like bodies and dykes of various composition, and in ore camps some of faults coincide with the ore vein system [22].

Post-volcanic faults, apparently widespread, in the maps of all scales are weakly expressed due to insufficient magnitude of displacement by these faults. Existence of these faults is evidenced by displacement of Anthropogene sediments, deformation of terrace profiles and modern valleys, replicating triangulation data.
6. HISTORY OF GEOLOGICAL DEVELOPMENT

Two cycles of the territory geotectonic development are distinguished: pre-Alpine and Alpine.

The pre-Alpine history is only revealed for Trans-Carpathian Trough where in the western part Late Devonian – Early Carboniferous metamorphosed rocks are encountered in drill-holes. As it is thought from the rock composition, eugeosyncline basin existed in Middle Paleozoic where terrigenous sediments of flyschoid type were depositing and later they followed by active volcanic processes. This basin comprised periphery of the branched geosyncline-oceanic area of Para-Tethys [22].

In the second half of Carboniferous time due to Herzinian folding (Bretonian or Sudetian phases) eugeosyncline inversion took place accompanied by low-grade regional metamorphism, orogenesis, and formation of inter-mountain depressions filled with molassa. The elements of the latter (Triassic quartzites and parti-coloured aleurolites) are observed in the studied area.

Obviously, that time were set up the fault system which had affected subsequent Alpine history of the area. These include Trans-Carpathian Deep-Seated Fault with Peninska and Marmaroska zones. As a result of Herzinian folding, the mountain system was formed on the continental-type crust, and later this system underwent extensive breaking. In Late Paleozoic, Carpathian folded system together with Variscides of Central Europe was involved into the single belt that probably had united Europe and Africa.

In Triassic had commenced the stage of expansion, continental crust destruction and rift emerging, where carbonate-terrigenous sequences and mafic volcanics with jasper lenses, typical for early expansion phase, had formed; this suggests for eugeosyncline development mode and possible existence of oceanic-type crust.

In Jurassic time, which corresponds to the leptogeosyncline stage, transgression expanded considerably and marine basin, previously occurred in the territory of Trans-Carpathians and in Peninska Zone, to the end of the stage apparently had spread over entire territory of modern Carpathians [22]. The source region of terrigenous material was the land emerged in Late Triassic over the territory of Panonskiy Massif.

In the most extent Jurassic sediments are developed in Peninska Zone where thin carbonate and carbonate-terrigenous rocks of all divisions are known.

In Early Cretaceous epoch the regional expansion is changed by tension resulted in beginning of subduction processes and reduction of oceanic crust [5]. These were the processes caused abrupt tectonic activation of Trans-Carpathian Deep-Seated Fault which marks subduction zone. As a result, in the zone of deep-seated fault the narrow uplift had emerged – Marmaroska cordillera which bounded from the south extensively subsiding flysch trough. In the trough limits as far back as the early stage of geosyncline development the series of parallel faults appeared which split the geosyncline into the latitudinal blocks affected diverse facies distribution over Cretaceous-Paleogene time. The area of Trans-Carpathian Trough was subsided by renewed faults and here sea basin continued to exist which was retained from Jurassic time. Thick pile of dark carbonate-terrigenous sediments conformably overlaying Jurassic rocks was depositing in this basin in Cretaceous time.

In the territory of Peninska Zone situated southward of cordillera the shallow trough continued to exist where limestones of Svalyavska Suite gradually changed by argillites of Aptian-Senomanian age. In the south it was apparently bounded by the second cordillera of underwater, and in places probably above-water type, which had separated this trough from the basin of Trans-Carpathian Trough.

In Barremian-Aptian time it was continued extensive subsidence of the flysch trough, especially in Porkuletska Zone, where the rocks of terrigenous flysch formation were depositing. In Duklyanska Zone at the same time were formed the rocks of terrigenous siliceous-slate formation characteristic for the early stage of geosyncline trough development. Occurrences of ammonites, pelecypoda and gastropoda in these rocks suggest for normal salinity of the basin. In Cretaceous time the warm humid climate is characteristic for entire Tethys Ocean. The basin depth is being estimated from 500 to 1000 m [22].

In the beginning of Late Cretaceous time sedimentation conditions were unified in the flysch trough and in Senonian time the carbonate-terrigenous sediments of non-flysch type were deposited. Low thickness and rock diversity suggest for the distal location of the terrigenous material source regions. These conditions spread over not only flysch but also considerable part of Internal Carpathians (Marmaroska and Peninska zones).

In Senonian time geotectonic regime got activated, thick carbonate-terrigenous flysch sediments had formed, the splitting process of a single geosyncline trough continued accompanied by emerging and denudation
of the island ridges – cordilleras. The basin depth changed locally on the background of the general shallowing which is supported by shallow-water (150-300 m) inoceramans fauna findings [3]. Over that time mainly thin-rhythmic sandy-clayey flysch was depositing which in Porkuletska and Duklyanska zones in Maastrichtian gradually changed (maybe not isochronously) by coarse-rhythmic clayey-sandy flysch.

Over the territory of Peninska Zone in Turonian-Senonian time in shallow-water basin parti-coloured marls of Pukhivska Suite were depositing which in Maastrichtian time were changed by thin-rhythmic sandy-clayey flysch. From the inner part of the region this basin in Late Cretaceous apparently was separated by the underwater barrier.

In the end of Late Cretaceous in Internal Carpathians Cretaceous and older rocks were extensively dislocated with formation of thrust structures, mélange zones, and elevated to the surface providing the island archipelago. Starting from the Late Cretaceous, the Internal Carpathian region had passed though the island arc stage which formed above subduction zone, that is, the site of the Tethys Ocean lithosphere plate plunging beneath European continent, while zones of volcanism were related to the magma generation under selective melting of this plate. During Paleocene time Peninska Zone and probably part of Trans-Carpathian Trough were the mountain system underwent the denudation.

In the flysch basin, the complex of Cretaceous sediments is changed by Paleogene rocks without interruption. Paleogene is characterized by compensated subsidence and deposition of thick sandstone piles, upward motions predominate, the basin become shallower and increases its splitting into narrow facial zones and sub-zones separated by underwater, rarely above-water uplifts. In Magurska Zone Paleocene sediments are clayey (Bilovezka Sequence) that suggest for relative distal source regions.

Sandy sediments predominate in Early-Middle Eocene time which are gradually replaced by clayey ones (for instance, in Porkuletska and Duklyanska zones) that affirms extensive basement differentiation.

In the second half of Middle Eocene and especially in Late Eocene tectonic regime has been stabilized and over entire territory under conditions of warm sea with normal salinity [22] thin-rhythmic, often parti-coloured flysch was forming.

Peninska Zone has been abruptly subsided in Early Eocene and sea transgression commenced, which encompassed also adjacent northern part of Trans-Carpathian Trough, where the sequence of Pidgalskiy flysch was forming. In the limits of Marmaroska Zone the deep trough has been formed bounded by separated cordilleras from the north and south; as it is evident from the fragment composition, the cordilleras were composed of both sedimentary and metamorphic rocks as well as diverse granitoids [22].

In the beginning of Oligocene upward motions predominated over entire territory, sedimentation conditions were unified, and epigeosyncline development stage has commenced with general change in paleo-geographic environments. This change was caused by the processes, which as far back as Late Eocene appeared in Tatro-Veperides and in wavy fashion of vertical and horizontal tectonic motions spread from the south-west to north-east. The sea had regressed to the north-east and climate become cold. Due to general uplift most part of Trans-Carpathian Trough, Peninska, Magurska and Marmaroska zones become the land and denudation region.

Sedimentation conditions in the flysch basin had been considerably differentiated that time. In Early-Middle Oligocene in Skybova Zone and northern part of Duklyanska Zone the sequence of black siliceous bituminous clays of Menilitova Suite was forming. In Krosnenska, most subsided basin portion, these sediments are characteristic for the beginning of Oligocene and then they were replaced by sandy-clayey grey Krosnenskiy flysch with olistolite horizons. In the south of Duklyanska and in Porkuletska zones dark calcareous argillites, marls of Dusynska and Turytska suites were depositing which later were changed by sandstones of Malovyzhenska Suite. In Oligocene, in the north-western part of Trans-Carpathian Trough, the dark mainly clayey rocks of the upper part of Pidgalskiy flysch were depositing in the limited water reservoirs.

In Late Oligocene the upward motions enhanced. Most parts of Porkuleska and Duklyanska zones were uplifted above the sea and become the land. In the closed sea gulf's sandy piles of Malovyzhenska and Krosnenska suites were formed.

In Krosnenska and Skybova zones the sea basin continued to exist up to Early Miocene. Here mainly sandy, sandy-clayey and clayey sediments were depositing.

At the boundary of Oligocene and Early Miocene sequential geosyncline inversion (from internal zones to external) occurred.

In Savian phase of diastrophism the tight folds and disjunctive breaks were formed together with general uplift of the region. Due to tangential compression some litho-tectonic zones, sub-zones, nappes thrusting one another with prevailing north-eastern virgation that caused considerable shortening of geosyncline. Elevated flysch region was transformed into mountain system which became the source area of clastic material for trough filling (frontal Fore-Carpathian and internal Trans-Carpathian troughs).
Development of Trans-Carpathian Trough commenced from marginal fault formation as well as associated and sub-parallel faults in the internal part of depression, along which differentiated block subsidence occurred.

The oldest Miocene sediments in the Trough are comprised of Otnangian-Carpathian Tereshulskiy conglomerates which form the basal pile of molassa formation.

In Early Badenian the open sea transgression continued, coupled with extensive Trough subsidence and huge volcanic activity resulted in dacite tuffs of Novoselytska Suite. Eruption centres are expected to the south of mapped area although there are some evidences for their possible occurrence in Shalanky village area [23]. Sedimentation of the tuffs occurred under water that is evidenced by marl interbeds and plankton foraminifera content. The depth of such basin did not exceed 100 m [2].

In Middle Badenian the clays of Tereblinska Suite lower part were depositing in the normal salinity sea. However, starting from that time in some places the open-sea regime was changed to lagoon one evidenced from gypsum and anhydrite lenses. In the Late Tereblinsky time the sea was getting shallow that caused rock salt deposition in the central part of depression whereas its marginal parts in places were elevated to the surface. The next stage in the Trough development is related to the new sea transgression and formation of Solotvynska and Teresvynska suites sandy-clayey sediments. Periodic volcanic activity related to movements along faults is reflected in felsic tuff horizons. The basin gradually got the normal salinity.

The end of Badenian is characterized by sea regression, water desalination and basin isolation evidenced from abrupt biocenosis depletion, almost complete extinction of stenohaline complexes and blooming of euryhaline forms. Coarse-terrigenous Bashevska Suite was forming that time.

In Sarmatian available faults were activating and new ones emerging that caused essential area differentiation on the background of general uplift and continued sea regression. The marginal fault of Geleneshska mega-caldera was forming and its drastic subsidence resulted in the narrow residual reservoir. Fault tectonic activation caused restoration of volcanic activity, especially extensive over entire Sarmatian in Beregivske uplift. All major volcano-structures formed onto volcanic con-sedimentation uplifts and basement ledges.

It is thought [5] that in Sarmatian the Trans-Carpathian Trough got involved in the stage of mature island arc marked by felsic (Sarmatian), andesite (Sarmatian-Pannonian) and andesite-basalt (Pliocene) volcanism. In Early Sarmatian in Gorondynskiy and Chopsyki volcanoes of eastern Beregivske uplift the andesite lava flows and tuffs of Velykodobronskiy Complex were formed which occur within terrigenous sediments of Dorobrativska Suite. Over the next volcanic phases mainly pyroclastic felsic rock facies was forming (Barkasivski Complex). Over entire territory marine sedimentation was occurring that is expressed in the interbeds of Dorobrativska Suite interbeds. Gradually and asynchronously for various centers explosions are changed by felsic magma flows and extrusions. Upon the flowing or explosion commenced the stage of caldera formation, volcano-structure subsidence, formation of ring and radial fault systems which often control the dyke and minor stock location. Sarmatian stage is finished with intermediate-mafic lava flows (Chomonynskay Complex). Last fractions of felsic, intermediate-felsic to intermediate composition were localizing in intrusions and dykes, stopped at shallow depths in basement and cover complex rocks, providing overlaying fields of hydrothermally-altered rocks, which later were further overlapping by ore processes. Formation of hydrothermal veins and stockworks with gold-polymetallic mineralization in Beregivske camp is thought to be paragenetically related to igneous rocks of intermediate composition [23]. Sarmatian volcanism occurred in island environments with permanent changing of sea and land margins resulted in marine basin shortening, shallowing and desalination, although in the axial part the basin still retained to be deep. Con-sedimentation role of both non-volcanic and syn-volcanic faults increased in time, and some individual molasses separated by volcano-structure sides were formed. In Lukivske formation, by marginal Ivanivskiy and Gechenskiy faults, formation of con-sedimentation Beregivske uplift was commencing, which became the island and source region for terrigenous material. At both sides of the uplift the molds were forming, where, likewise other basin parts, under normal salinity conditions the terrigenous sediments of Lukivska Suite were depositing.

Establishment of continental regime in Beregivske uplift coincides in time with beginning of the long-term hydrothermal activity resulted in gold-polymetallic ores and associated hydrothermally-altered rocks [25].

By the end of Sarmatian the sea basin was reduced, desalinated, in places lagoons appeared, and some areas became the lands. Climate got warmer than in Dorobrativske time, and wet [2]. Under lagoon conditions here were forming coaliferous-terrigenous sediments of Almashska Suite, and in Malobiganska mold – lignites with high germanium content which source is thought to be hydrotherms that formed Biganske barite-polymetallic deposit [25].

In the end of Sarmatian formation of lower tectonic floor of Neogene molassa has completed [11] and over late stages of Styrian folding phase were formed flat (5-15° on limbs) wide folds which central anticline portions were elevated above sea level remained in the flat molds.
In Pannonian the regime was changed as well as the mode of sedimentary and volcanogenic deposition, which, instead of marine, became epi-continental related to the closed salty-water lake, where Izivska Suite clay sequence with tuffite, tuffs, and lignite lenses formed. Between the lower (Ottangian-Sarmatian) and upper (Pannonian-Pliocene) tectonic floors the stratigraphic, and in places slight angular unconformity occurred [11, 22], while the upper floor is very flat or horizontal. The basin fauna and micro-fauna changed abruptly upon transition; abilities for section correlation are essentially reduced and especially with regard to the adjacent regions.

Under the same paleo-geographic conditions were depositing Pontian clays, and Koshelivska Suite tuffites which formation accompanied by weak volcanic activity on the boundary between Marginal and Central sub-zones of Trans-Carpathian Trough. That time Kuchavskiy and Zhukivskiy volcanoes, andesite-dacite and rhyodacite extrusive domes in Mukachevo and Perechyn areas, as well as Geivtsi crypto-caldera were formed. Composition of volcanics is fairly variable (from liparite-dacites, granodiorite-porphryries to andesite-basalts).

Small mercury deposits in Dubrnychi village area are related to granodiorite-porphyry minor intrusions (dykes).

Tectonic layout of this stage is followed in Dakian-Rumunian during formation of coaliferous clays. This period is marked with significant tectonic movements in Marginal Sub-Zone of the Trough, and enforcement of volcanic activity in Vygorlat-Gutynskiy Ridge, which formed almost completely over that time. Strong predomination of calc-alkaline and moderate-Pacific type intermediate and mafic rocks (andesites, andesite-basalts to basalts) is characteristic for this period [13, 22]. Volcanic activity in Dakian-Rumunian commenced with thick explosions at the bottom of Antalivskiy and Matekivski complex, and finished with mainly their lava facies, as well as Makovytskiy, Synyatskiy and Obavskiy complex.

Explosive stage in most volcano-structures was completed with formation of calderas, ring and radial faults, which further were involved in location of minor stocks and dykes of andesite, andesite-basalt porphryries, rarely andesite-dacites and dacites.

At the final stage of volcano-structures, mainly in their central parts, the hypabyssal bodies of diorite, quartz diorite porphryries was forming, above which were developing the fields of hydro-mica-quartz type hydrothermally-altered rocks (up to secondary quartzites), that contain in places tellurium-bismuth and mercury mineralization, and in the root portions of neck and pipe-like porphryries bodies development (mainly in the country rocks) minor mercury deposits are also located. This, one of the last, volcanic activity bloom (like all previous Neogene ones), appeared in some extent not only in the Internal but also in External Carpathians.

Besides the obvious movements along available thrusts, in this period emerged minor crosswise anti-Carpathian tectonic floors the stratigraphic, and in places slight angular unconformity occurred [11, 22], while the upper floor is very flat or horizontal. The basin fauna and micro-fauna changed abruptly upon transition; abilities for section correlation are essentially reduced and especially with regard to the adjacent regions.

The regime of deposition of clays in the Carpathians changed in the Pliocene. At the end of Pliocene weak folding appeared expressed in very flat folds (5-7° on the limbs). In places their tectonic layout does not coincide with structures of the previous stage [11].

In Alpine cycle which encompassed entire studied area the following events are distinguished:

- stage of continental-type crust destruction and rift emerging where Late Triassic limestones, dolomites, igneous mafic rocks, conglomerates and parti-coloured argillites were depositing;
- stage of spreading (oceanic itself) when continued formation of Jurassic mafic volcanics, siliceous limestones, jaspers and argillites;
- stage of ocean shortening (Cretaceous-Paleogene, partly Early Miocene) is characterized by development of thick flysch formation in External Carpathians, and in Internal Carpathians, in places, by periods of folding and even thrusting. It is thought to be related to the change of
extension period by compression one in Early Cretaceous time resulted in oceanic crust subduction beneath the continental crust;

- stage of ocean closure (orogenic) completes development of the territory in Neogene. It is characterized by general folding under conditions of extensive compression, formation of fold-thrust structures, and general inversion. In the frontal and internal troughs molassa was forming, as well as felsic and intermediate volcanics of calc-alkaline strong and moderate Pacific-ocean type.
7. GEOMORPHOLOGY AND RELIEF-FORMING PROCESSES

Relief of the territory is irregular. In the north it is the region of Carpathian mountain system, and in the south – region of polygonal relief of Trans-Carpathian Trough [22].

7.1. Region of Carpathian mountain system

In tectonic respect it corresponds to the External Carpathians and is divided into three areas (Fig. 7.1).

7.1.1. The area of low-mountain denudation relief coincides with Skybovyi Thrust and is developed on the substratum of mainly clayey-sandy rocks of Cretaceous-Paleogene flysch. Characteristic features include wide watersheds with denudation surfaces at the heights 680-900 m, flat mountain slopes (up to 10-15°), relative heights 150-300 m, and U-shaped valleys of Dniester and Yasenytsya rivers.

7.1.2. The area of low- and medium-mountain structure-erosion relief occupies the part of Krosnenska Zone to the north of main Carpathian watershed ridge. Its features are defined by a range of north-westward-elongated tectonic nappes composed of thick sandstone batches which form the ridges, and thin intercalation of argillites, aleurolites and sandstones (areas of ancient latitudinal valleys). Mountain top altitudes vary from 650-900 m to 1022.1 m (Magura, Lomnivska mountains), relative heights – 200-500 m, mountain slopes – 6-15 to 25°.

Four transverse 0.6-3 km wide ancient valleys are known in the area: Mshanetska, Turkivska, Borynska and Verkhnyovosanska. In these units the thin pebble-stones and pebble-gravel soils of the high VIII and IX terraces, undivided because of extensive erosion-denudation processes, are encountered. River network rearrangement commenced in Middle Pleistocene during formation of V-IV terraces, and in the period of III-II terrace formation it had got the present appearance [21, 22].

7.1.3. The area of medium-mountain denudation-erosion relief occupies the north-western slope of Carpathians – from the main watershed to Vygorlat-Gutynskiy Ridge. Mountain tops occur at 900-1479 m heights (Polonyna Rivna Mountain), smoothed, slopes are steep, modern river and stream valleys are V-shaped, relative heights – 400-800 m. The denudation surface at the heights 900-1000 m and the fragments of the denudation surface at 1250-1300 m heights are encountered in the area, as well as three 0.5-3 km wide ancient latitudinal valleys in the sites between Svalyava and Perechyn, along Stuzhytsya-Tykhiy and Gusniy-Zhdenivka streams, where pebble-stones and pebble-gravel soils of undivided VIII and IX terraces are known [22].

Main features of the relief are defined by structure and rock lithology. Denudation-resistant sandstones constitute the watershed sites, they are less cut, mainly with crosswise valleys. In case of sandstone steep dipping, the ridges are narrow, steep, and in flat case the wide structure surface are being formed. The sites of unstable argillites and aleurolites provide the flat slopes and crosswise valleys extensively cut by gullies.

The modern river network is branched and comprises the combination of steep-slope narrow crosswise valley intervals (Uzh, Turya, Lyuta, Pynya rivers) with the renewed latitudinal U-shaped intervals.

Nine terrace levels of three complexes are distinguished in Carpathian rivers: high IX-VI, medium V-IV and low III-I over-flood terraces. The fragments of oldest IX erosion-denudation terrace are encountered in the right-bank side of Pnya River and at Vel.Berezniy village on Uzh River at the relative heights 260-210 m. Single plates of VIII erosion terrace nearby Perechyn town and Zhdeniev village are remained at the heights 160-120 m. Terrace VII at the relative heights 130-110 m is mainly erosion, rarely (Ploske, Oleneva villages) accumulative. The fragments of VI terrace of 80-60 m relative height are observed in all ancient valleys on the Carpathian south-western slope and on the northern slope in the area of Shumyach village and others. This terrace is erosion-denudation, rarely accumulative (Vyshka village area).

Complex of medium terraces (V – 60-70 m and IV – 40-50 m) is developed mainly in the ancient valleys, rarely it is being mapped in Dniester and Uzh river basins [22]. Terraces are accumulative, in the ancient valleys erosion-denudation in places.

Complex of low terraces (III – 30-40 m, II – 20-30 m, and I – 8-20 m) is developed in the valleys of all rivers and their main branches. Terrace III is erosion-accumulative, II and I – accumulative while II one often is socle. Their relative heights commonly increase upper the river courses [22].
Fig. 7.1. Geomorphologic zonation sketch (designed by Yu.V.Kovalyov)

Mountain Carpathian region, areas: 1 – low-mountain denudation relief; 2 – low-mountain, in places medium-mountain, structure-erosion relief; 3 – medium-mountain denudation-erosion relief;

Region of polygenic relief in Trans-Carpathian Trough: 4 – area of low-mountain accumulative relief in Vygorlat-Gutynskiy Ridge; 5 – area of structure-erosion and erosion-accumulative fore-mountain terraces; 6 – area of Trans-Carpathian alluvial plain (a) with island structure-erosion hills (b); 7 – region boundaries; 8 – area boundaries.
Glacier relief forms are developed only in the northern slopes of Polonya Rivna where three cirques are mapped being 0.8-1 km long, 300-400 m deep, and with wall inclination angle 30-60°. In the lower part of the cirques the final moraines 0.4-0.8 km long are observed. The glaciation age apparently is Valdayian.

7.2. Region of polygenic relief in Trans-Carpathian Trough

Three areas are distinguished in this region (Fig. 7.1).

7.2.1. The area of low-mountain accumulative relief in Vygorlat-Gutynskiy Ridge encompasses exposed sections of Neogene volcanics. The Ridge morphology is defined by multi-phase accumulative volcanic activity and the long-term period of erosion and denudation over primary forms of volcano-structures. Assymetry comprises the most characteristic feature of the Ridge: its northern slopes and steep and short whereas southern ones are flat and long. Thus highest mountain tops are located in the south-eastern part of the Ridge: Poprichniy (1024 m), Antalivska Polyana (988 m), Makovytsya (976 m), Dunavka (1018 m), Dekhmaniv (1016 m). These are central-type volcanoes which preserve characteristic conic shape and essential (400-450 m) relative heights above surrounding territory of classically-expressed radial patterns of hydrographic network. Near-top slope portions of central volcanoes are flat, smoother and comprise structure-denudation surfaces of lava flows; higher tuff accumulations also provide the broad watershed surfaces at latitudes 400-650 m and relative heights up to 200-450 m. On this background the extrusive domes and semi-isometric (up to 0.3-2 km across) slam cones are clearly expressed in the relief.

Valley morphology of the rivers cutting Vygorlat-Gutynskiy Ridge is defined by eroded rock lithology. The valleys set up in massive lavas are deep, V-shaped steep-slope, and in the tuffs – broad and trough-like. In the valleys of Uzh, Latorytsya rivers and their branches mainly low-complex terraces are observed. First over-flood terrace is most widespread, on exit from the Ridge its width attains 2-4.5 km.

7.2.2. The area of structure-erosion and erosion-accumulative fore-mountain terraces is extended over the broad band (2-15 km) along the south-western slope of Vygorlat-Gutynskiy Ridge. Erosion levels cut the extrusives of the Ridge, "pra-Ridge", and sedimentary rocks providing complicated geomorphologic and tectonic patterns. The relief is low-mountain with extensive gully-ravine network. Erosion forms predominate (remnants of high-terrace broad plates), while accumulative (alluvial terraces), erosion-denudation and volcanogenic-accumulative ones are less abundant.

Three erosion levels are distinguished which correspond to IX, VIII and VII terraces. Level ledges are turned to the south. The levels of IX (360-420 m) and VIII (230-280 m) terraces are almost completely erosion-type, quite rarely minute pebble or alluvial terrace remnants with thin layer of gravel-pebble sediments (Babychi village, Stara River) are observed. Relative heights are 130-150 m. The lowest erosion level comprises the surface of VII terrace most widespread in between Borzhava and Latorytsya rivers where the terrace is elevated by 20-80 m above Trans-Carpathian Lowland. To the west from Latorytsya river this surface is exclusively alluvial and is composed of pebble-gravel sediments. Terrace plates are well-expressed, horizontal, with clear ledges in the valley sides. Besides the high, low terraces are also developed in the all river banks. Fragments of the III terrace with relative height 20-30 mare erosion-accumulative whereas II terrace ones (15-20 m) are accumulative and observed in the narrow bands. Alluvial sediments of 8-10 m high I accumulative terrace are most widespread. In Mukachevo area it occupies the huge area but does not have the clear ledge and gradually merges with the lowland (its boundary is convenient in the map).

The fragments of volcanogenic relief are expressed by eroded liparite-dacite domes in Mukachevo area (Velyka, Pavlovo, Palanok mountains), and andesite-basalt extrusions and slam cones (Kuchava, Bystrytsya villages). Kuchavskiy volcano caldera ledges are clearly expressed in the relief; structure-denudation surfaces of lava flows are preserved in Khat Ridge and in the area of Kerek-Sek Mountain [22].

7.2.3. The area of Trans-Carpathian alluvial plain with island structure-erosion hills occupies the southwestern part of the region from Vygorlat-Gutynskiy Ridge to the State border (17-33 km). In morphological respect this is alluvial plain at the heights 104-120 m inclined to the west. The plain rivers (Tysa, Latorytsya, Uzh and their branches) slightly (3-8 m) cut through its surface. Flood-land is weakly or not expressed while courses of minor rivers are often swamped.

On the plain background the island heights are clearly expressed which formed under erosion of horst-anticline structures (Beregivske highland with maximum altitude 369.8 m, Kosyno-Biganske highland with altitudes 206-280 m), extrusive domes and mono-volcanoes (Shalanskiy Gelmets Mountain – 367 m, Kholmok – 301 m, and others).

Formation of such relief forms as slides, ravines, heaps is being continued up to now.
Land slides are widely developed on the southern slope of Carpathians where are mainly confined to the substratum of soft rocks (Eocene and Oligocene thin-rhythmic flysch, argillized tuff fields in Vygorlat-Gutynskiy Ridge). Slide size varies from some square meters to 3-4 km². Their appearing is often caused by extensive human activities (forest cutting, road setting at the steep slope foots). Often the slides overlap flood-land sediments.

Ravines are being extensively formed in the area of polygenic relief in Trans-Carpathians especially in fore-mountain terraces and in Beregivske highland. Their growth is continued in upper courses of minor streams and on the steep slopes.

The heaps are developed in the mid-mountains over the weathering sites of thick sandstone sequences where they form stone rivers up to 1-2 km wide and 6 km long (Rozhok, Lyutanska Golytsya Mountains).

Neotectonic motions are expressed over entire territory and in general are displayed in the permanent trend of Carpathian uplift and Trans-Carpathian Trough subsidence. In Quaternary time this trend is highlighted by mainly solc terrace formation which level permanently moves up from the lowland to the main Carpathian watershed, and by deposition thick sediments of Chopska and Mynayska suites in Trans-Carpathian Trough. Uplift and subsidence processes are relative and are being released in differential manner by the system of general-Carpathian strike faults which coincide with the boundaries of blocks, thrust and nappes. At the same time, in the relief formation exogenic-denudation processes are important and hence lithological factors as well. The highest ridges are composed of thick sandstone sequences whereas troughs in between and latitudinal valleys are confined to the sites of thin-rhythmic flysch or tectonic zones. Often tectonic structure is of primary importance. Over the steep isocline anticline folds the narrow steep-slope ridges are being formed (e.g. Lautyanska Golytsya), and over flat brachy-form folds – broad branchy uplifts (like Polonyna Rivna).

The territory history of development commenced from the inversion period of Carpathian geosyncline in the beginning of Neogene but the signs of this ancient relief are not preserved. In Middle Miocene is noted considerable area uplift accompanied by thrusting in Carpathians and extensive volcanic activity in Trans-Carpathian Trough. The morpho-structure is formed which will become the major one in modern relief formation. Its first stage is marked by the highest denudation level at altitude 1250-1300 (Polonya Rivna, Lautyanska Golytsya and others) which probably formed as far back as pre-Pliocene period. In the south-western part of Trans-Carpathian Trough, as a result of volcanic activity and upward tectonic motions, by the end of Sarmatian the mountain system was formed but due to denudation and erosion by the end of Pliocene just the highland was preserved of this system.

In Pliocene at the boundary between the Trough and uplifted Carpathian block, due to volcanic accumulation a huge positive relief form appeared (Vygorlat-Gutynskiy Ridge) which made a bar to the flows of Uzh and Latorytsya rivers. Coeavaly, in Carpathians the clearly expressed denudation level at the heights 900-1100 m was forming.

In Early Quaternary time due to extensive subsidence the lake-alluvial sediments of Chopska Suite were depositing in Trans-Carpathian Trough. The island mountains are being extensively smoothed, and due to extensive erosion in Carpathians and on the south-western slope of Vygorlat-Gutynskiy Ridge a number of high-level erosion terraces were forming.

Since Middle Quaternary time the last erosion cycle commences in Carpathians, breakthrough of Vygorlat-Gutynskiy Ridge by Carpathian rivers (apparently at the level of V terrace), and formation of medium and low terrace complex. In Mukachevska Depression the downward motions are being activated again (upon short-term uplift in the end of Early Quaternary stage), and thick pile of Mynayska Suite alluvial sediments are deposited.

The mode of relative motions in Carpathians and in the Trough remains over Holocene. Uplift in Carpathians is highlighted by formation of V-shaped valleys of mountain rivers with the hard-rock bed as well as by the hanging valleys of the branches. In the lowlands the slight subsidence is marked by river course displacement and former river-bed formation.

At present erosion, land-slide, heap and flood-land formation are being continued.
8. HYDROGEOLOGY

Hydrogeological environments of the area are defined by geology, climate and relief which affect formation of the complex of water-bearing horizons, mineral and thermal waters. Hydrogeological basin of Carpathian folded system and Trans-Carpathian artesian basin are distinguished in the area (Fig. 8.1).

The basin of Carpathian folded system, with its considerable amount of atmospheric precipitates, mountain relief and steep slopes, is characterized by fast discharge through the surface flow and comprises the zone of extensive water exchange.

Trans-Carpathian artesian basin is an area of slowed water exchange and essential mineralization of underground waters.

Water-bearing horizon of Middle Pleistocene – modern alluvial sediments (aQ ПII +Н) is being traced in Chop-Mukachevska Depression in Mynayska Suite rocks, and in the mountain part it occupies minor sites within sediments of flood-lands, low and medium terraces of Latotytsya, Uzh, Dnister rivers and their branches. Thickness of water-bearing horizon in sandy-gravel-pebble sediments with clay interbeds varies from 1-2 to 300 m (drilling data). The ground water table depth is 7 m in the plain and 0-25 m in the mountains. Waters of the horizon are non-pressurized or low-pressurized (2-3 m) and comprise the major source of water supplying for inhabited locations, industrial and agricultural objects. Borehole yield is 0.8-45 l/sec under depression from 2 to 15 m. Borehole yield on terraces is 0.02-2.5 l/sec and it decreases from low to high terraces. Spring yield varies from 0.01 to 3.3 l/sec.

Water-bearing horizon of Chopska Suite lake-alluvial sediments and high-terrace alluvium (aQ E+P1) is developed in Chop-Mukachevska Depression, Beregivske highland, and to the east from Shalanskiy Gelmets Mountain (spurs of Kopanska accumulative terrace).

Thickness of discontinuous water-bearing horizon in sands, pebble-stone interbeds and lenses within Chopska Suite clays varies from 3 m in the east to 100 m in the north-west of Depression. Hanging-wall depth of water-bearing rocks in the eastern part of Chopska Suite development area is 50-60 m, and in the western one – 140-280 m [22]. The waters are pressurized.

Piezometric levels are being encountered at the depth 1-5 m below the surface. Borehole yield is 1-12 l/sec under depression 6.2-40 m. Underground waters of Chopska Suite can be used for drinking water supplying. In this respect Gechenska and Uzhgorodska sites are most prospective.

Thickness of water-bearing gravel-sandy, sandy, sandy-gravel and boulder-pebble sediments of high terraces varies from 5-10 to 50-76 m. Depth of water-bearing horizons varies from 4 m (wells) to 70 m (boreholes). Spring yield is 0.01-0.1 l/sec, boreholes – 0.1-3.9 l/sec under depression from 4.8 to 13.3 m. The water-bearing horizon can be exploited by single boreholes and wells for water supplying of minor objects.

In Vygorlat-Gutynskiy Ridge the water-bearing horizon of Upper Miocene – Pliocene extrusive rocks is distinguished (Н1-2). Depth of ground water table in fractured andesites, andesite-basalts, rhyolites and their tuffs varies from 0.8 to 36 m. Well yield is 0.3 l/sec in average under depression 1 m, borehole yield – 2.7-22.7 l/sec under depression 15.4-17.9 m, spring one – 0.01-1.3 l/sec, rarely up to 15 l/sec. In the discharge area waters are pressurized, piezometric level is 1.5-5.3 m from the surface. These waters are being widely used for water supplying.

In Upper Miocene – Pliocene sediments of Ilnytska, Koshelivska and Izivska suites (Н1-2) just the waters of sporadic distribution are distinguished in the interbeds and lenses of fine-grained sands, sandstones, tuffites, tuffs, and brown coal within plastic clays. Horizon hanging-wall depth varies from 15-50 m (Uzhgorod) to 120-150 m (Berezyinka). Its thickness is 25-30 m, and in Berezyinka area – 100 m. Waters are pressurized, piezometric levels at the depths 0-25 m. Pressure value in Uzhgorod area is 5-120 m, in Berezyinka site – 150-240 m. Borehole yield is 0.4-2.5 l/sec under depression 12-43 m. Underground waters of this horizon can be used in the areas of low depth of water-bearing rocks.

In Sarmatian sediments the bed-fracture waters of extrusive-sedimentary rocks and fracture waters of volcanogenic rocks are distinguished (Н1s).

The bed-fracture waters in sediments of Almashska, Lukivska and Dorobrativska suites are confined to sandstones, sands, tuffites, rarely marls and lignites at the depths 0-380 m. Thickness of water-bearing horizons varies from first meters to 150-200 m. The waters are pressurized, fresh or slightly-mineralized. Pressure values attain 50-100 m and to the south and north from Beregivske uplift – 500-600 m. Piezometric levels occur at the heights up to 11 m above the surface. Borehole yield varies from hundredth to 6-17.2 l/sec under depression 6.7-54.5 m.
Fig. 8.1. Sketch of water-bearing horizon distribution (designed by Yu.V.Kovalyov).

I – region of Trans-Carpathian artesian basin. Water-bearing horizons: 1 – Middle Pleistocene – modern alluvial sediments of Mylnayska Suite, flood-lands, low and medium over-flood terraces (aQp1 +H); 2 – lake-alluvial sediments of Chopska Suite and alluvial rocks of high terraces of Eo-Pleistocene – Early Pleistocene time (aQe+P); 3 – volcanogenic rocks of Vygorlat-Gutynskiy Ridge (N2); 4 – sporadic development in Upper Miocene sediments of Ilnyska, Koshelivska and Izivska suites (N1+2); 5 – Sarmatian extrusive-sedimentary and volcanogenic rocks (N1s); 6 – undivided Badenian sediments (N1b);

II – hydrogeological basin of Carpathian folded system. 7 – Oligocene-Miocene sediments of Krosnenska and Menilitova suites (P3-N1); 8 – sporadic development in Paleocene flysch sediments (P); 9 – Upper Cretaceous – Eocene rocks of Chornogolovska Suite (K2-P); 10 – sporadic development in Cretaceous sediments (K); 11 – boundary of hydrogeological basins; 12 – boundaries of water-bearing horizons.
Fracture waters are confined to fractured, porous andesites, liparites, perlites and lava-breccias of lava flows and dome structures and in the faults at the depths 20-80 m. Piezometric level in places is above the surface [22]. Borehole yield is 0.05-4.3 l/sec under depression up to 18.2 m. In fault zones borehole yield is 7.6-23.4 l/sec under depression 12.6 m. Fresh waters of Sarmatian sediments can be used for drinking.

Beneath the tuffs of Barkasivskiy Complex almost everywhere the water-bearing horizon of undivided Badenian sediments (N b) is developed. Underground waters are locally occurred at the depth from 5-10 m to 400-500 m and more. Borehole yield does not exceed 5-6 l/sec. The waters in the near-surface column portions are fresh.

Water-bearing horizon of Oligocene-Miocene Krosnenska Suite sediments (P k-kr) is developed in the northern part of territory. Diverse-grained sandstones comprise the water-containing rocks. Thickness of horizon is 10-100 m. At the bottom Menilitova Suite argillites occur which are the waterproof rock. Waters are pressurized, their depth is 0.0-10 m. Piezometric levels are at the depth 0.2-0.4 m, in places above the surface (1.5-15 m). Spring yield is 0.05-0.7 l/sec, borehole yield – 1.2-3.6 l/sec. Krosnenska Suite horizon is used for drinking water supplying.

The waters sporadically distributed in Paleogene flysch sediments (P) are developed in Folded Carpathians within Magurskiy, Porkuletskiy, Duklyanskiy, Skybovyi thrusts and in Peninska Zone. Water-bearing horizons comprise fracture-ground waters which are related to the thin sandstone interbeds within sandy-clayey flysch, as well as massive sandstone horizons with gravelite interbeds (undivided Eocene sediments, Malovyzhenska and Vulkhivchtsytsa suites). Underground water depth is 0.0-15 m, horizon thickness varies from 0.5 to 8 m. Spring yield is 0.01-0.4, rarely 6 l/sec, borehole yield from hundredth to 1.5 l/sec. For water supplying these waters are unimportant since thin-rhythmic Eocene flysch often is completely water-free.

Underground waters of Chornogolovska Suite sediments are widely developed in Porkuletskiy and Duklyanskiy thrusts (P k-K2ch). Among underground waters of these sediments there are distinguished water-bearing horizon of fracture-ground waters related to weathering zone, and water-bearing horizon comprised of tectonic fracture waters. Thickness of the horizon of fracture-ground waters is 0.5-7 m, and horizon of tectonic fractures – 15-150 m and more. Depth of fracture-ground water horizon is 0.0-20 m, tectonic fracture horizon – up to 80 m. Waters are pressurized. Piezometric levels occur at the depth 2.5-15 m. Spring yield is 0.1-0.4 l/sec, borehole – 0.4-17 l/sec. This horizon can be used for water supplying of minor inhabited locations.

By chemical composition the waters of all water-bearing horizons are mainly hydrocarbonate-calcium, calcium-magnesium, and calcium-sodium. In Trans-Carpathian basin the waters are chloride-hydrocarbonate-sodium-calcium in the zones of slowed water exchange.

In underground waters of Mynayska Suite on the sites of extensive agricultural activities chlorides and nitrates are being encountered up to the depth of 10 m. In the waters of Sarmatian sediments sulphate-ion often occurs which amount increases in the areas of Beregivske and Biganske polymetallic deposits. Mineralization of underground waters varies from 0.05 to 0.5 g/l; in Trans-Carpathian artesian basin in the zone of slowed water exchange it increases to 1.0-7.5 g/l, and nearby salt stocks – up to 300-350 g/l.

Mineral waters often occur in the studied territory of which most widespread are hydrocarbon waters containing free carbon dioxide in amount up to 2 g/l (Uzhok, Polyana villages, Svalyava town and others) while their total mineralization is 0.1-3.6 g/l. These waters are related to tectonic zones in Cretaceous-Neogene sediments of Folded Carpathians and rarely occur in Trans-Carpathian Trough (Uzhgorod town, Batevo station).

In Vygorlat sulphuretted hydrogen waters (Synyk village, Vyznytsya River) occur in fractured Pliocene volcanic rocks. Total mineralization of the waters is up to 2 g/l, sulphuretted hydrogen content up to 60 mg/l.

In Trans-Carpathian Trough in Sarmatian sediments methane waters with mineralization 3-25 g/l are encountered (Zaluzychya village and others). Methane content in the gases is 86-88%.

Sub-thermal and thermal waters are known in the area. Sub-thermal waters (t = 19.5°C) are encountered in Vygorlat tuffs, and at the bottom of Almashska Suite water temperature at the DH 12 collar attains 25.2°C. The waters are ferruginous, siliceous, and provide the interest as the sub-thermal mineral ones (mineralization up to 4.7 g/l).
Among the fracture waters of Sarmatian sediments also encountered sub-thermal and thermal waters with water temperature 37-30.5°C at the depth 350-400 m and up to 46°C at the depth 600-680 m (DH 50). The waters are siliceous (silica content is 100-130 mg/l) and mineral (mineralization up to 7.5 g/l).

The thermal waters are encountered in the south-western outskirt of Beregovo town in tuff of Barkasivskiy Complex (DH 12-T, depth 808-1024 m, temperature 48°C) and in Badenian sediments (DH 2-T, 8-T, depth 876-993 m, water temperature at the collar up to 60°C). By chemical composition these are chloride-sodium waters with mineralization 2.5 g/l.

As it was pointed above, the horizon of alluvial Quaternary sediments of Mynayska Suite and over-flood river terraces (in Carpathians) comprise the major source for water supplying of inhabited locations in the studied area. The horizon is mainly overlain by more than 3 m thick clay layer and thus is considered to be conventionally protected [22]. This protecting layer in Trans-Carpathian plain is being broken over land-improvement works. Surface and river waters are being drained into the water-bearing horizon through river courses and the sites with broken and low-protected layer.

Other water-bearing horizons which are being used for technical and drinking water supplying in some areas (underground waters of Vygorlat-Gutynskiy Ridge and others) are also considered to be conventionally protected or non-protected.

There is no regional exhaustion or contamination of underground waters over studied territory. However, in some areas of Trans-Carpathian Trough and in the mountain river valleys occur the local contaminants which include: technical and housing sewers of animal farms, pesticides and chemicals in the territories or adjacent to their storages as well as in the fields under non-rational use, petroleum products and bitumens in the territories of storage tanks, gasoline stations, asphalt-bitumen plants etc. By these reasons in some places of Trans-Carpathian artesian trough is determined increasing of water mineralization and enrichment in nitrogen compounds like nitrates, nitrides and ammonia suggesting for extensive organic and bacterial contamination of the waters.

In general, water quality from horizons under exploitation through water scoops of centralized supplying is good and complies with requirements of the standard “Drinking water”.

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9. MINERAL RESOURCES AND REGULARITIES IN THEIR DISTRIBUTION

The studied area is included into Carpathian and Trans-Carpathian zones of Carpathian metallogenic province. In Carpathian Zone are known occurrences and deposits of oil, mercury, mineral waters, construction materials, occurrences of gas, antimony, arsenic. In Trans-Carpathian Zone are developed deposits of natural gas, brown coal, gold, silver, lead and zinc, germanium, occurrences of iron, mercury, antimony, rock salt, and in the fields of side-wall metasomatites occurrences and deposits of alunite, barite, primary kaolines, alkaline bentonites, mineral pigments. Construction materials include deposits of raw materials for cement, lime, glass, ceramic tile, bricks, crushed-stone, facing and ornamental stone, sand and gruss. In Trans-Carpathian Trough are encountered the thermal and sub-thermal waters with evaluated exploitation reserves.

9.1. Combustible minerals

9.1.1. Oil. In flysch Carpathians are known oil occurrences which had been being exploited in the past and thus are ascribed to minor deposits: Grozivske (V-4-1), Golovetske (I-4-6), Khashchiv (I-4-11), Vel.Yablunka (II-4-21), Bytlya (II-4-23) and Terek (III-4-49). Information on these objects is quite limited [12, 21], oil inputs and production amount are insufficient suggesting for minor scale of discovered oil-bearing structures.

Besides that, numerous oil occurrences are known (oil films on water or drilling solution surface over drilling, oil drops or its smell in rocks).

9.1.2. Natural gas. Flammable gas occurrences are known in all geological structures but they are insufficient by yield and do not have practical value except two minor deposits in Trans-Carpathian Trough.

Rusko-Komarivske deposit (V-2-151) is disclosed at the depth 935-1570 m where in Badenian-Sarmatian sediments seven 4-31 m thick gas-bearing sandstone beds are encountered which form intrusive-dome uplift up to 3.3-4.0 km across. Gas yield is 16-75 thousand m³/day, its composition: methane – 60-73%, ethane – 0.1-4%, nitrogen – 24-33%, carbon dioxide – 0.3-0.9%.

Yablunivske (Stanivske) deposit (IV-4-182) occurs in Sarmatian sandstones within anticline structure of similar dimensions with uplift magnitude up to 150 m at the depth 238-390 m. Gas yield is 15.3-115 thousand m³/day, its composition: methane – 96%, nitrogen – 3.5%, carbon dioxide – 0.2%.

9.1.3. Brown coal. Since the time of geological mapping completion (1969-1975) special prospecting and explorations works for coal were performed in Lokhivske deposit only. Together with Uzhgorodske (V-2-80) and Bereznyske (V-4-145) deposits and coal occurrences of Dakian-Rumunian these ones do form the band along the southern slope of Vygorlat. Similar quality figures and relatively accessible depth of working beds are characteristic for the deposits. Malobiganske deposit (VII-3-199) of Sarmatian germanium-bearing lignites in Biganske ore field (see 9.2.6) is considered separately. Most of coal deposits are earlier described elsewhere [8].

Lokhivske deposit (V-3-109) occupies 5 km² in the outskirt of the same-named village and is minor by explored reserves. Seven coal beds are known located within volcanogenic-sedimentary rocks of Ilnytska Suite but two ones only are economic: second and third “lower” which occur at the depths 75-195 m and are separated by the batch (10-55 m) of barren rocks. Working thickness of the beds is 0.8-3.7 m, ash content 24.3-43.5%, heating 3000-4895 kCal/kg. By sulfur content it is suitable as the fuel.

9.2. Metallic mineral resources

9.2.1. Lead and zinc. These metals are developed in the composite gold-polymetallic ores of Beregivske uplift and will be described later (9.2.7).

Chontosh occurrence (IV-2-61) is the only pure polymetallic object in Vygorlat. It is located in the central uplift of Poprichniy volcano-structure and is disclosed by drill-hole at the depths 509-649 m in the lower part of propilitized volcanics of Antalivsky Complex and phillites, quartz-carbonate schists of Paleozoic basement where dissemination, sporadic bunches, and thin quartz-sphalerite veinlets occur. Among the ore

1 Hereafter number of deposit or occurrence in the map of mineral commodities.
minerals. Sphalerite predominates over galena, pyrite and pyrrhotite occur, of non-ore – quartz and carbonate. Lead and zinc content does not exceed 0.24% over 2 m (592-594 m). Host propilitized rocks upward are changed by kaolinite-quartz-carbonate, sericite-quartz-carbonate metasomatites, and further at the surface – by secondary quartzites which are aerially distributed but strongly linearly developed. Vein steeply-dipping patterns of altered rocks are obvious, as well as their vertical zonation and occurrence “anchoring” to the specific level of hydro-column likewise the ore veins in similar by geology Remetske Game deposit [14, 22].

9.2.2. Mercury. Deposit and occurrences are confined to the flysch country rocks of Miocene volcanics [10, 22] where they are located within Olenyovo-Dubrnytska Zone and do from two mineralization types: in minor intrusions within clayey flysch (IV-2-57, IV-2-58, IV-4-75, V-4-110-114, V-4-124) and tele-thermal in sandstone beds and batches (III-2-32, IV-4-72, 73, 76, 77, V-4-128). Some occurrences are known in Beregivskie uplift (VII-3-218) and in Vygorlat (IV-2-60, V-4-134, 135).

The minor deposits are only related to the minor intrusions: Kolgospne (IV-2-58), Smerekove (IV-4-75), Bukove (V-4-114), Male (V-4-111), Kamyanyi Karyer (V-4-112). They are located in steeply-dipping eruptive bodies of andesites, andesite-basalts or their breccias, rarely – in flat dykes of micro-granodiorites (IV-2-58) which cut through thin parti-coloured or coaliferous clayey flysch. Kamyanyi Karyer deposit (V-4-112) is typical. Mineralization is related to the andesite-basalt stock (100 by 40 m) which cuts through parti-coloured clayey flysch to the north of Synyak volcano-structure. Deposit is explored by trenches, shafts, and adit at the horizon 23 m, as well as by drill-holes to the depth up to 130 m (in some sections up to 217 m). Eruptive breccias and altered andesite-basalts of contact zone are mineralized. Ore bodies do form the series of bunches from 10-15 m to 50-60 m in size by dipping. Their thickness is 1-12 m, mercury content – 0.06-16.03%. Ores are almost mono-metal; besides the cinnabar bunches, veinlets and dissemination, in the ores are also determined metacinnabarite, galena, sphalerite, pyrite, marcasite, melnikovite, and vein minerals: calcite, curitsite, siderite, quartz, barite, aragonite, nacrite. Prospective resources of the deposit can be evaluated bearing in mind that mineralization is open to depth over entire thickness of parti-coloured flysch.

Tele-thermal occurrences (IV-3-72, IV-4-76) are located in the most external setting in flysch Carpathians; it is fairly low-grade and irregular type of mineralization with undefined ore-control structures and low probability for deposit discovery. They are studied by trenches, deep shafts, adits and drill-holes. Mineralized rocks comprise Chornogolovski sandstones in frontal part of Porkuletskiy Thrust where in para-autochthon fine-rhythmic Eocene clayey flysch occurs. Mineralized sections 0.6-2.0 m by 1.6-3.5 m in size separated by barren intervals (2.7-16.0 m) are “anchored” to certain sandstone horizons. Thickness of these sections is 0.3-1.2 m, average mercury grade – 0.01-0.59%. Cinnabar is major ore mineral, rarely metacinnabarite, in places realgar, sphalerite, galena. Wall-rock alteration is weak and cannot be used in prospecting purposes. Occurrences of this type are thought to be non-perspective [22].

Maliy Chontosh occurrence (IV-2-60) is located in the upper part of hydro-column of altered rocks above polymetallic occurrence IV-2-61 where it lies in kaolinite-quartz and kaolinite-hydro-mica metasomatites of north-east-trending brecciation zones. Mineralized zone length established by trenches, adits and drill-holes is 50 m, average thickness 1.0 m, mercury grade 0.15%. Down-deep below the horizon 25 m mineralization is not found. Ore mineral – earthy variety of cinnabar fills up small bunches, thin veinlets and is associated with pyrite, marcasite and pyrrhotite. Occurrence is worthless but can be used as an indicator for the deeper polymetallic deposit.

Similar setting displays Beregivskiy occurrence (VII-3-218) which lies in “upper” tuffs above the vein bodies of the same-named gold-polymetallic deposit. Cinnabar is found in thin (0.25 m) zones filled with beidellite clay with mercury content 0.01-0.2%. Occurrence is non-perspective but can be used in prospecting purposes for gold-polymetallic deposit.

9.2.3. Antimony. Occurrences (VI-2-160, VI-3-169) are known in Velykodobronsky uplift and antimonite impurities – in arsenic occurrences Chornogolova [20, 22, 26].

Structure of Velykodobronske ore field is defined by considerable depth of pre-Neogene basement (1600-1700 m), high thickness of Sarmatian andesites (up to 700 m), and thin (100 m) Barkasivski felsic tuffs which are cut through by extrusions of quartz andesite-dacites and rhyolites. Antimonite mineralization is found within sub-latitudinal zone of mono-quartz, hydro-mica-quartz metasomatites which cut Velykodobronsky andesites and Barkasivski tuffs at the depth 191.5-199.5 m (Barkasove occurrence, VI-2-160) and 209.7-243.3 m (Velyky Luchky, VI-3-169). Thickness of mineralized intervals is 0.25-6.3 m, antimony grade 0.01-0.03%, arsenic – up to 0.03%. Antimonite does form dusty, sooty coatings, druses, spherical aggregates. Occurrences do not have practical value so far and can be only considered as one of the branches in general ore zonation of the region.

9.2.4. Arsenic. Occurrences (III-3-42, 44, 46) are grouped in the area of Chornogolovo village within the same-named ore field located in the 0.45-0.7 km wide inner part of Duklyanskaya para-autochthon along the front of Porkuletskiy Thrust. This zone is composed of diverse-rhythmic sandy-black-shale Cretaceous-
Paleogene sediments and is extensively dislocated at the general dipping of layering and thrusting planes to the south under the angles 15-35°. At the bottom of Porkuletskiy Thrust tectonic lenses of para-autochthon are “pull in”. In general this zone tectonically controls the realgar mineralization. Lithological control in this case is attributed to the black-shale rocks of Shypitska and Yalovychorska suites. By laying conditions two ore body types are distinguished: sub-layered in thrusting zones (III-3-43) and mineralized sandstone beds (III-3-44, 46).

Mineralization in thrusting zone (III-3-43) is traced at the surface over 450 m at thickness 1.5-5 m and dipping 15-35° to the south. In the lensed, ground-sandstones the realgar veinlets, dissemination and bunches (up to 0.5-5 cm) are contained. Arsenic content – down to 1.5%, mercury – up to 0.01%.

Mineralized sandstone bed (1.2-1.3 m) within black-shale flysch of Yalovychorska Suite is traced by the adit over 130 m and by drill-holes up to 400 m. Coarse-crystalline realgar fills up crosswise fractures which cut the bed, bunches (up to 3-4 cm), rarely it is disseminated in the groundmass. Antimonite, metacinnabarite, galena, cleiophane, cinnabar, single gold grains and vein minerals (quartz, opal, chalcedony) are associated with realgar. Mineralization is consistent by strike, arsenic grade is 0.01-15% (2.34% in average), mercury – 0.02%.

Wall-rock alteration is insufficient and cannot be used in prospecting purposes.

9.2.5. Bismuth, tellurium. Known occurrences of these metals (V-3-104, 105, V-4-130-132) and the site with prominent direct evidences for this kind of mineralization are confined to Vygorlat where they are located in the central or peripheral parts of volcano-structures. Occurrences are accompanied by the fields of altered rocks from the upper part of metasomatic hydro-column. They are studied at the prospecting stage using trenches, deep exploration shafts, adits and drill-holes. The authors of prospecting works have distinguished steeply-dipping breccia zones of halloysite-aluminitized rocks mineralized with berthierite, vehrellite and native bismuth (V-4-131, 132), silica-tourmaline, quartz-fluorspar veinlets (V-3-104, V-4-130), and kaolinite-dumortierite, opalolite lenses in agrillized rocks (V-3-105). Their common features include out-of-scale occurrence, undefined morphological type of mineralization, low thickness (203 to 10-20 cm), and fairly irregular low-grade mineralization style with metal content 0.00n%, rarely to 0.01% over one meter section. Occurrences are out of practical importance but are interesting from the point of view concerning indication of Poprichniy-like volcano-structures with deeply-set polymetallic (silver-polymetallic) mineralization.

9.2.6. Germanium. The only deposit is known in Trans-Carpathian Trough on the northern periphery of Biganske ore field (VII-3-199). Germanium is contained in lignites which can be used as the fuel commodity. Deposit is preliminary explored with reserve estimation of economic categories. Productive coal-bearing sediments of Almashska Suite lie in the flat southern limb of Malobiganska syncline (mold). Of three known mineralized coal beds the most persistent and major by reserves is the middle (“second”) one which lies at the depth 110-120 m. Its thickness is 0.1-3.2 m (1 m in average), germanium grade (50-900 g/t) is quite irregular by the bed strike and dip. Lignites are of fusain-clarain type, their heating is 6200-6500 kCal/kg, ash content 13-45%, sulfur content 4-5%.

By the laying conditions, morphology and ore type the deposit is of the bed (sheet) type, deeply-set with irregular metal distribution, its mining method is underground. Reserve update is possible in the north-western flank of coal-bearing structure.

9.2.7. Gold. Deposits are only known in Beregivske uplift within the same-named ore camp: Muzhiivske, Beregivske, Kuklyanske, Kelcheyske, Kvasivske, and Biganske. They are explored in different extents and economic development is commenced in the first one.

Muzhiivske deposit (VII-3-220) is located in the central part of Beregivske uplift where the depth of pre-Neogene basement is about 700 m. In the west it adjoins with Beregivske and in the east – with Kuklyanske deposits actually forming the single object with these deposits.

To date deposit is explored at seven horizons (90-290 m) where about 34,000 m of underground workings and one exploration-exploitation shaft are mined. At the upper horizons preliminary and detailed exploration is conducted over part of ore bodies while the deeper horizons are studied by drill-holes at the stage of prospecting evaluation or detailed prospecting. As a result it is established that to the depth 40-50 m below the surface the ore bodies are off-balance (non-economic yet) and further down-dip they are economic and respective ore sections are obtained to the depth 800 m.

The Neogene cover complex in deposit includes Novoselytski tuffs, Badenian-Sarmatian sedimentary sequence, and Barkasivskiy Complex. Triassic-Jurassic terrigenous-carbonate (with mafic volcanics) sequences occur in the basement. It is distinct in deposit that the rocks of main ore-bearing horizon (so called “middle” tuffs) do form the “wedge” which sharply gets thinner to the east while pinching out of sedimentary sequence occur in the reverse direction, that is from the east to west. In the mentioned “wedge” major ore bodies of the deposit are concentrated and include (upward) the vein, stockwork and sub-layer morphologic types.

Vein bodies of 1.5-3 m thick attain 900 m by strike, 800 m by dip, and contain up to 97% of ore reserves. Of these, 87% comprise the primary gold-polymetallic ores, 8% are just the gold ores, and remaining – oxide low-sulphide ores. Average grades are respectively: gold – 1.7, 4.8 and 4.2 g/t; silver – 38.8, 27.2 and 67.6
g/t; lead and zinc – 6.9, 1.0 and 2.0%. In primary complex ores disperse gold in sulphides predominates (96%), and in the gold and oxide ores – free gold related to quartz, oxides and carbonates.

Stockwork mineralization is located in the upper horizons of deposit above the hanging-wall of “middle” tuffs in coarse-clastic pyroclasts of Barkasivskiy Complex. Ore bodies are distinct by morphology, mineral composition, and are “anchored” to the sites of silicification and dickitization which roughly outline some vein zones in the “middle” tuffs. They are isometric, amoeba-like or elongated in horizontal projection being 120-2000 m² in size, and by dip these are 50-90 m long column- and pipe-like bodies. Gold (7.2 g/t) is the major ore component and sulphide content does not exceed 0.7%. Gold is native, up to 80% is more than 0.1 mm in size; fraction of these ores in deposit is 3%, gold reserves – 10%.

Sub-layer morphologic type includes off-balance ores located hypsometrically and stratigraphically higher in so called siliceous and siliceous-clayey rocks, kaolinitized, silicified tuffs and tuffites. By mineral composition, structure and texture features the ores are close to the stockwork ones but their gold grade does not exceed 1-2.5 g/t.

Beregivske (VII-3-219) and Kuklyanske (VII-3-223) deposits directly follow the ore structure of Muzhiivske deposit to the west, east and north-east. Linear steeply-dipping ore-control tectonic zones predominate. In contrast to Muzhiivske deposit, in Beregivske deposit mineralization is confined to the more than 200 m thick “middle” tuffs, and in Kuklyanske one – to the bottom of Badenian sedimentary sequence. Ore body depths respectively are 90-180 and 350-400 m except off-balance one exposed at the surface (evidenced from soil aureoles of gold, galena and sphalerite). Morphology, ore body size, mineral, chemical composition and technological properties of ores are close to those of vein type in Muzhiivske deposit but in the cases under consideration the sulphide-gold-copper massive sulphide type with copper content in excess of 0.2% is distinguished in addition.

Degree of erosion cut is low in all three deposits, they are almost non-eroded that can be evidenced from mercury occurrence (VI-3-218), which is located directly above ore zones 42-43 of Beregivske deposit, is genetically related to these zones and occupies the top position in the ore column.

Perspectives of ores reserve update in deposits of Beregivske ore field are being connected with deep horizons of the known ore zones and its western and eastern flanks.

Kelcheyske deposit (VII-4-244) in the east of Beregivske uplift belongs to Kvasivske ore field. It is hidden, lies at the depths 270-280 m below the surface, and major ore intersections are confined to the 350 m thick Velykodobronskiy andesites filling up Kvasivska caldera. Some ore intersections and mineralization sings are also known in the underlaying sedimentary sequence, in Novoselytska Suite, and in the basement, as well as in the overlying “middle” tuffs. The soil aureoles of galena and sphalerite as well as highly-contrasted mercury aureole resembling similar signs of the “blind” mineralization in Beregivske ore field are encountered at the surface. Size of deposit is about 1.4 km² and within these limits it is fairly irregularly studied by 550-600 m, rarely up to 800 m deep drill-holes under the grid 100-300 × 500 m. At the background grade 1.5 g/t of conventional gold and cut-off grade 5.6 g/t, in 13 drill-holes 15 ore intersections 0.7-8.1 m thick (3.7 m in average) received. In the core sections these are steeply-dipping veins and veinlet zones separated by the vein-disseminated mineralization. Correlation of ore intervals is problematic even using geophysical data (SEP, IP). Sub-latitudinal (north-western) trending of ore zones is expected.

Major ore minerals in deposit include sphalerite, galena, pyrite, rarely – marcasite, chalcopyrite, hematite, melnikovite, limonite; vein minerals – quartz, carbonates, barite, rarely – adularia, alunite, kaolinite. Average chemical composition of the ores: gold – 1.1 g/t, lead – 1.7%, zinc – 4.35%, gold-silver ratio – 1:1. Pure “gold” intersections are known with the grade 1.5-4.0 g/t over 1.1 m.

Most widespread wall-rock alteration includes silicification and adularization. The ores are polymetallic, gold-polymetallic, probably pure gold ones. Their major economic type comprises sulphide gold-clayey-quartz. Deposit is not eroded. It should be explored by the access shaft in its exploration-exploitation version.

Biganske deposit (VII-3-204) is located in the western periphery of Beregivske uplift in 3 km to the west of Velyka Bigan village on Kosynsko-Zastavnen ski highland.

Deposit contour is elongated over 2.4 km in the north-western direction at the occupied square 3.6 km².

Pre-Neogene basement (Paleogene pile) is disclosed at the depth 1000 m; upper tectonic floor is comprised of the same Badenian-Sarmatian sedimentary-volcanogenic rocks as in the Beregivske ore field. Thickness of the “middle” (up to 450 m) and “upper” (300-350 m) tuffs of Barkasivskiy Complex is also considerable. Structure of deposit is defined by the series of latitudinal (north-western) breaks which steeply dip to the south-west. Most of the vein zones and ore bodies are confined to these breaks. The 5.5-9.3 m thick Mayska ore zone is traced over 2.3 km by strike and 400 m by dip and is considered to be most consistent and significant by reserves. It is filled with crushed silicified rocks containing disseminated, bunched, veined, and veinlet-stockwork mineralization.
Deposit is complex. Up to 80-170 m below the surface barite ores are developed, within 80-300 m – mixed barite-polymetallic, then polymetallic (up to 350 m) and gold-polymetallic. Just the gold ores are also known. The lower boundary of mineralization is not established and some ore intersections are known in the basement.

In barite ores average grade of barium sulphate is 39.4%, silver – 53.4 g/t (dissemination of argentite, pyrargyrite and native silver in silicates and barite). The mixed ores contain 15% of barium, 2.9% of zinc, 0.8% of lead, 72 g/t of silver, up to 2.4-6.4 g/t of gold (0.1 g/t in average). In polymetallic ores: 1.3% of lead, 4.4% of zinc, 49.2 g/t of silver, 0.3 g/t of gold; in gold-polymetallic ores: 3.6 g/t of gold, 14.6% of silver, 0.92% of lead and 1.56% of zinc. Gold is platy up to 0.2 mm in size and disseminated in sulphides or free in quartz.

Two geology-economic ore types are distinguished: sulphide gold-clayey-quartz and sulphide gold-copper massive sulphide.

Mineralization is accompanied by the fields of altered rocks: hydro-mica-sericite at the top of metasomatic column, below – chlorite propilites, and at the bottom – adularitized rocks.

Perspectives of reserves update in deposit are related to the deep horizons and the flanks within the ore field.

9.2.8. Silver. Pure silver, actually sulphide-free ores are known only in Kvasivske ore field within the same-named deposit. In other deposits and occurrences silver is included into the complex ores.

Kvasivske deposit (VII-4-242) nearby Kvasovo village is situated in Borzhava River flood-land at the foot of the north-eastern slope of Beregivske uplift. In the contour clearly elongated in the north-western direction the size is 3.6 km². Part of the square (0.58 km²) is studied by drill-hole fences 250-500 m apart by strike and 150-300 m apart across while remaining part is weakly prospected by single drill-holes.

Mineralization is controlled by influence zone (300-700 m) of north-west-trending Ivanivskiy Fault with numerous shear fractures up to first ten meters magnitude. The pure silver ores in deposit occupy the “middle floor” and comprise conformable sheet-like lens-shaped bodies (8-15 m thick and 110 by 300 m up to 150 by 500 m in size) in the coarse-clastic facies of volcano-sedimentary rocks in the basal horizon of Lukivska Suite. Upper floor is composed of barite ores (up to 80 m below the surface), and the lower one – vein polymetallic and gold-polymetallic mineralization. Depth of silver ores is 0-150 m; by composition ores are quartz-silver; quartz, kaolinite, hydro-mica predominate in the ores. Average silver grade is 53.1 g/t, silver is native, sub-microscopic, it is contained in quartz (94-95%), barite and iron hydroxides.

Up to 0.2-0.25% of arsenic is contained in the ores. Ore type is silver-clayey-quartz.

Perspectives of the deposit are clear related to the possibility of upper barite ore exploitation. Reserve update is possible in the flanks of structure. The vein polymetallic mineralization in the lower floor of deposit also requires further studies.

9.2.9. Uranium. Occurrences in mineral form are known only in Beregivske ore field. Beregivskiy occurrence (VII-3-230) in the western outskirt of Muzhieve village is disclosed by DH 55 in rhyolite tuffs at the depth 452.3 m in argillite xenoclase (3 by 4 cm) where uranium black is encountered. Uranium grade is up to 0.039%. Hydrothermal alteration in above-ore tuffs by composition are adularia-hydro-mica-quartz, below-ore ones – albite-hydro-mica-quartz with carbonate. Occurrence is out of practical value but its location in the flank of gold-polymetallic deposit may suggest for the branching of ore-hydrothermal process in general and its scale.

9.3. Non-metallic mineral resources

9.3.1. Agro-chemical raw materials

9.3.1.1. Rock salt. In the course of prospecting for oil, natural gas and thermal waters in Trans-Carpathian Trough over the area 153.7 km² 13 intersections of salt-bearing part of Tereblinska Suite were disclosed. The prospective area occupies the northern portion of the Trough. Salt depth varies from 792 m (VII-4-238) to 2752 m (VI-2-150), thickness varies from 64 m (VI-4-179) to 339 m (VI-4-185).

9.3.1.2. Alunite. Occurrences are widely distributed in Beregivske uplift where they are related to the metasomatite fields in the upper column part of hydrothermally-altered rocks which accompany all known ore deposits. Of these three deposits (VII-3-203, 206, 222) are explored by categories C_1-C_2 and three ones (V-3-224, VII-4-240, VII-4-246) are preliminary evaluated (category C_2). The ores do form 40-90 m thick sheets and lenses with alunite content in the range 32.4% (VII-3-203) – 36% (VII-3-222). The ores are high-quality and comprise the alunite facies of secondary quartzites.

9.3.1.3. Alkaline bentonites. The only preliminary evaluated deposit Soleni Mlaky (V-3-101) in the upper course of Vyzhnytsya River occurs in hydrothermally-altered andesites of Synyatkiy volcano. Thickness
of bentonite bodies 1-9 m, their depth 5-50 m, total exchange capacity – 62-72 mg/equiv. Weakly studied fields of altered rocks in Khotar and Antalivska volcano-structures are thought to be suitable for bentonite prospecting.

9.3.1.4. Carbonate raw materials for soil improvement. Two limestone deposits are explored which are in production: Novoselytske (IV-2-59) in the north-west and Drachynske (V-4-142) in the west of Peninska Zone. Limestones are often being milled to the powder but mainly they are being used for the lime production and ornamental gravel manufacturing. Jurassic limestones are marbled and occur in the “cliffs” 70-470 m in size within clayey-marleous Cretaceous sediments. The rocks are traced by drill-holes to the depth 20-100 m. Rock composition: CaO – 52.8%, SiO₂ – 3.1%, Al₂O₃ – 0.8%, FeO – 0.4%, MgO – 0.6%, SO₃ – 0.3%, LOI – 41.5%.

9.3.2. Non-ore (technological) raw materials

9.3.2.1. Primary kaoline. Of practical value are occurrences and deposits in Beregivskiy ore camp (VII-3-215, 221, 225, VI-4-241) which accompany polymetallic and gold-polymetallic objects.

Beregivske kaoline deposit (VII-3-221) comprises a counterpart of Muzhiivske gold-polymetallic deposit related to the kaoline facies of secondary quartzites which occurs in sheeted bodies 300 by 190 m and 190 by 60 m in size at thickness 89 and 41 m. Overburden thickness is 2-50 m. Kaoline is being mined by JV “Keramnadra” and is used as the raw material for the fine ceramics and porcelain wares.

9.3.2.2. Barite. This mineral does not form self deposits but its considerable reserves are explored in Biganske gold-polymetallic and Kvasivske silver deposits where barite ores comprise top parts of ore zones and the sheet bodies. In Bigan at the depth 0-170 m just the barite, and in the interval 80-300 m – barite-polymetallic ores are developed with average barium sulphate content 34.2% and 20.7% respectively (VII-3-204). The sheet bodies in Kvasove of 2.7 m average thickness occur at the depth 10-80 m (VII-4-242). Here barium sulphate content is 15% in average.

9.3.2.3. Mineral pigments. In the studied area one deposit (VII-4-235), four occurrences perspective for further exploration (V-2-84, V-3-94, VI-3-162, VI-4-176), and five occurrences stated as non-perspective (V-2-85-87, V-3-93, VI-3-165) are known. The objects are confined to the volcanoes of Vygorlat and are thought to be the products of weathering crust developed after the fields of hydrothermally-altered (argillized) tuffs. Commodity is comprised of the clays that occur in lens-shaped or sheet-like 1-30 m thick bodies. The rocks are painted with goethite, hydro-goethite, hydro-hematite in pink, red-pink to various shade of red and grey colours and suitable for manufacturing of highly-artistic pigments.

Malokomyatskiy occurrence (III-4-79)¹ is considered separately, the constituted clays are re-deposited.

9.3.3. Construction raw materials

9.3.3.1. Cement raw materials. There are known marl and two clay deposits suitable for cement manufacturing. In the marl deposit (IV-2-62) commodity is comprised of 10-60 m thick marl beds of Pukhivska Suite in Peninska Zone. The alluvial clay deposits with sheet thickness 1.6-15 m (IV-2-6) and 50 m (VI-3-54) are overlain by the loams (0.2-1 m).

9.3.3.2. Glass raw materials. Commodity for glass manufacturing (bottle dark glass) is comprised of crystallized and glassy rhyolites in the upper part of Ardivska extrusion (VII-3-209) and Kerek kaoline deposit (VII-3-215) in Beregivske ore field.

9.3.3.3. Ornamental-facing stones. For manufacturing of the facing tile are suitable white porphyry rhyolites in two deposits: Zmiivka-1 (VII-3-214) and Zmiivks-2 (VII-3-212). Thickness of lava flows is 11.5 m and 50 m respectively.

9.3.3.4. Wall stone. There are known two deposits of tuff suitable for the wall stone manufacturing: Gorikhovytsya (V-2-79) and Muzhiivske (VII-3-227). Andesite tuffs in the first one are 10-50 m of productive thickness. In Muzhiivske deposit the layer of white rhyolite tuffs is 16 m thick, 70-90 m wide and is extended over 150 m.

9.3.3.5. Raw materials for artificial, kerb-stone, cobble-stone, crushed and quarry-stone. Artificial stone is produced in deposits Radvanka (V-2-83) nearby Uzhgorod and Klenovets (V-4-147) where more than 40 m thick andesite and andesite-basalt lava flows with columnar jointing are being mined. Reserves are considerable in Shelestivske deposit (VI-4-171) where 36.5 m thick andesite-basalt flow is being mined for cobble- and kerb-stone. The wastes of the major processing in these deposits are being used for manufacturing of crushed stone.

¹ The objects numbered in italic are indicated in the “Geological map and mineral commodity map of Quaternary sediments”.
Kamyanytske deposit (IV-2-63) is significant but essentially exhausted. Three andesite-basalt flows are mined for crushed stone and quarry-stone.

9.3.3.6. Claydite raw materials. Occurrences of this commodity are related to Oligocene black siliceous argillites nearby Pavlova village (V-4-117, 118). On roasting the rocks are being expanded enough and their unit weight decreases to 400-600 kg/m³.

9.3.3.7. Perlites. This variety of glassy rhyolites on roasting is expanded with formation of the light porous material which is being used for heat- and sound-proofing and as the super-light concrete filler. High-quality perlites constitute peripheral portions of rhyolite flows in Beregivske uplift where perlites are being mined in Pelikan (VII-3-228) and Ardov (VII-3-208) deposits.

9.3.3.8. Clays for ceramic tile. Commodity of explored Nyzhnyokoropetske deposit (VI-3-54) can be used not only for cement but also ceramic tile manufacturing. Prospected objects Znyatsevo (VI-3-44) and Zhukovo (VI-3-47) are composed of lens-shaped bodies (8.9 and 10.3 m thick respectively) of grey clays that occur at the depth 7.2 and 11.5 m respectively. Overlaying parti-coloured clays of expected deposits can be used for brick manufacturing.

9.3.3.9. Clays for brick and tile manufacturing. In the modern alluvial sediments of Chop-Mukachevska Depression and in terraces of Latorytsya, Uzh rivers and their branches (III-2-4, III-4-5, IV-3-7, IV-4-8, V-1-10, V-2-12, 21, 26, VII-4-77, 78), in deluvial-proluvial (VI-3-53, 55) and colluvial (V-2-24, 25 and others) sediments there are explored and being mined deposits of grey, dark-grey, brown clays and loams 4-13 m thick which are disclosed actually at the surface (0.2-0.5 m).

9.3.3.10. Construction sands and gruss. Deposit of Middle-Upper Pleistocene sands with significant reserves and thickness up to 20-30 m (VII-3-69) is disclosed and being mined in Beregivskiy area. The sands are watered and occur below the proofing loams at the depth 1.5-5 m.

Considerable potential gruss reserves are contained in Mynayska Suite sediments in Trans-Carpathian Trough. They are disclosed below thin loams to the depth 100 m and more (V-2-17, VIII-4-88). Less voluminous gruss sheets occur in the valleys of major rivers (V-2-14, VI-4-58, VIII-4-87) and in over-flood terraces (VII-4-76). Thickness of the sediments is 10-22 m.

9.3.3.11. Carbonate raw materials for lime manufacturing. Limestones of Novoselytske deposit (VI-4-59) are being used in these purposes.

9.4. Underground waters

9.4.1. Drinking waters. The major water-supplying source is water-bearing horizon of Middle Quaternary – Holocene alluvial sediments in Trans-Carpathian lowland and major river valleys, which accounts 85% of the total water consumption through boreholes. Reserves of drinking water deposits vary from 12 thousand m³/day (VI-3-51) to 45 thousand m³/day (V-2-20). In the mountain part of the territory the water scoops are mainly autonomous from the springs, wells etc.

9.4.2. Mineral and thermal waters. In the natural spring of Carpathians salty and low saline mineral waters predominate. In boreholes mineralization is higher – from low to high saline. Waters are carbon-dioxide-bearing (0.8-2.1 g/l) and also contain micro-components: boron (up to 20 mg/l), iron oxide (25-70 mg/l). Some deposits (V-4-141) contains up to 150-250 mg/l of boron. Reserves of mineral waters in deposits are 43-400 m³/day.

In volcano-structures of Vygorlat at the depth 110-580 m are disclosed fresh-salty siliceous sub-thermal waters with silica content up to 110 mg/l and explored reserves from 77.8 (V-3-99) to 1468.8 m³/day.

Outside the calderas and in the zones of neighbouring faults the range of encountered waters is more variable. In places waters with mineralization 1.4-36 g/l (V-2-82, VI-4-177, 180) are disclosed at the minor depth (96-250 m). At moderate and great depth (more than 690 m) high-mineralized thermal waters and brines are encountered (V-2-81, V-4-139, 146, VI-3-166, VI-4-183, 186, 188, VII-4-234, 237). Here free carbon dioxide content attains 5.0 g/l, boron – 161 mg/l, bromine – 302-671 mg/l, iodine – 68 mg/l, silica – 80 mg/l, iron oxide – 500 mg/l. Borehole yield is from 0.8 to 415 m³/day.

Over remaining territory of Trans-Carpathian Trough in the similar settings water mineralization does not exceed 20-25 g/l and geothermal gradients are higher a bit. The waters are siliceous (20-130 mg/l), boron and bromine content is 15-32 mg/l, in some cases fluorine up to 5 mg/l (VII-2-191, VII-3-205) and radon (12-25 eman) are encountered. Borehole yield is 10-80 to 200-400 m³/day.
9.5. Regularities in distribution of mineral resources

9.5.1. Oil and gas. In flysch Carpathians major oil and gas occurrences and minor oil deposits are related to Skybova and Krosnenska zones where thick piles of Oligocene rocks with batches of trapping sandstones and proofing clayey flysch; their folding facilitates formation of anticline reservoirs and widespread deep-seated thrusts ensure fluid-transporting functions. The tasks do concern prospecting for considerable oil-gas-bearing structures at reasonable depths.

Gas deposits in Trans-Carpathians are located in those places of Neogene molassa maximum thickness where tectonic traps are developed: intrusive-dome uplift in Geivska crypto-caldera and Zaluzka brachy-anticline structure. Formation of deposits is also facilitated by trapping sandstones in Badenian-Sarmatian column overlain by proofing clays.

9.5.2. Metallic mineral resources. The lateral zonation in distribution of these objects is clearly expressed being persistent outside the area boundaries [22]. Five linear metallogenic zones are distinguished; each one comprises distinct specialization and vertical ore zonation (Fig. 9.1). The lateral zonation in general coincides with the strike of volcanics in Vygorlat-Gutynskiy Ridge and, partially, Carpathian structures, and displays evidences for tectonic and lithological control of mineralization.

9.5.2.1. The zone of arsenic and antimony-arsenic mineralization occupies the external north-eastern position and in the studied area comprises Chornogolvska branch. In its north-western extension Baligrad (Poland) ore field is known, and in the south-east – Soymynske ore field in Mizhgirskiy area. These fields are far away enough one from another (55-65 km), do not contain concentrated mineralization, and not always are clearly traced by at least weak stream or soil aureoles of arsenic, antimony or their minerals. It is characteristic that Chornogolvske ore field is located in the back part of Duklyanskiy para-autochthon in front of Porkuletskiy Thrust, that is, in the extensively dislocated zone. Both the boundary zone and single sandstone beds of black-shale flysch in para-autochthon are mineralized. Depth of mineralization in the latter case is caused, in our opinion, by two interconnected factors: width of the favourable black-shale column portion and development of para-autochthon breaks. The third ore-control feature comprises thick sandstone pile in the frontal part of Porkuletskiy allochthon. Bearing in mind these circumstances and, certainly, direct prospecting evidences, one can foresee perspective fields and structures in the given metallogenic zone.

9.5.2.2. Same-trending zone of mercury mineralization occupies adjacent although more internal position in 8-16 km apart from the conventional axial line of Vygorlat-Gutynskiy Ridge. In the studied area it is confined to Porkuletskiy and Magurskiy thrusts and is two-folded with sub-zones of tele-thermal mineralization in sandstones and in mercury-bearing minor intrusions. Mineralization-controlling magmatic, lithological and tectonic factors in this case are sufficient and mutually-contributing. The primary role in mercury mineralization control is played by tectonic factor – the units of Porkuletskiy and Magurskiy thrusts. Tele-thermal mineralization is located in Chornogolvske sandstones within frontal part of Porkuletskiy Thrust given thin-rhythmic parti-coloured clayey flysch rocks are developed in the underlaying para-autochthon. In case of mineralized minor intrusions their location is primarily controlled by magmatic factor under lithological and stratigraphic control from the host thin-rhythmic parti-coloured or black-shale piles.

9.5.2.3. Zone of tellurium-bismuth and mercury mineralization extends just along the conventional axial line of Vygorlat-Gutynskiy Ridge connecting two ore camps: Perechynskiy and Svalyavskiy. In volcano-structures the central intrusions genetically related to mineralization are known or expected at the depth to 500 m. In all known occurrences mineralization is low-grade and irregular while further perspective objects for mentioned metals are lacking. Similar results are obtained in Slovakia over drilling in Remetske Gamre ore field [14, 22]. However, in this case the rare-metal mineralization occurs at the top of ore and metasomatic column whereas silver-polymetallic ores are encountered below at the level of pre-volcanic basement. Bearing this in mind as well as study results in Poprchny volcano-structure [19], it can be concluded that rare-metal occurrences provide evidences for the deeper silver-polymetallic mineralization. In our case these relationships can be expected when Vygorlat-Gutynskiy volcano-structures are set up directly on the local pre-volcanic uplifts in Peninska Zone. Elsewhere in other geological situation the lower portions of ore column may have the gold (Zagadkoviy, Noviy, Shtolnevyi), gold-polymetallic (Kibler) or gold-silver (Biskad) profiles.

9.5.2.4. Zone of antimony mineralization is further internal and is traced over 20-25 km in the closed part of Trans-Carpathian Trough in Velykodobronske uplift. Mineralization is known in up to 1850-1950 m thick Neogene cover complex. Ore intervals are intercepted in single drill-holes at the two levels: in Velykodobronski andesites and in Barkasivski rhyolite tuffs. Their linking by strike is supported in some extent by electric survey (SEP, IP). Occurrences are weakly studied, antimony grade is low. They are out of practical interest. Any data concerning possible antimony position in the vertical ore column are absent.
Fig. 9.1. Metallogenic zonation scheme (designed by B.D. Pukach using data of E.K. Lazarenko et al., 1973).

1 – Folded Carpathians; 2 – Peninska Zone; 3 – Trans-Carpathian Internal Trough, including volcanic rocks of: 4 – Dakian-Rumunian; 5 – Sarmatian; 6 – occurrences and deposits; 7 – stream aureoles.


Names of numbered deposits and their specialization: 29 – Zlata Banya (Hg); 30 – Zlata Banya (Pb, Zn); 31 – Dubnyk (Hg); 86 – Mernyk (Hg); 129 – Telkibanya (Pb, Zn); 164 – Tamu-Mare (Pb, Zn); 165 – Kemyrzana (Hg); 166 – Biskad (Au, Ag); 167 – Raksha (Au, Ag); 168 – Nistru (Pb, Zn); 169 – Ilha (Pb, Zn); 170 – Beitsa (Pb, Zn); 171 – Sesar (Au, Ag); 172 – Valya Rosha (Au, Ag); 173 – Dyalu-Krutsiy (Au, Ag); 174 – Kherzha (Pb, Zn); 175 – Baya Sprie (Pb, Zn); 176 – Shuyor (Au, Ag); 178 – Kavnyk (Pb, Zn); 179 – Beyuts (Pb, Zn).
Specialization of numbered deposits and occurrences: Remetske Gamre [Bi(Pb,Zn)]; Poprichniy [Bi,Te,Hg(Pb,Zn)]; Antalivska Polyana (Bi,Te); Khotar (Bi,Te,Hg); Synyak (Bi,Te,Hg); Smerekovyi Kamin (Bi,Te); Tovtiy Verkh (Bi,Te,Hg); Baligrud (As); Pastylky (Hg); Chornogolova (As,Sb); Kolgospne (Hg); Turytsya (Hg); Kamyaniy Karyer (Hg); Polyana (Hg); Butova (Hg); Ugolka (Hg); Shayan (Hg); Banya (Pb,Zn); Borkut (Hg); Velyka Dobron (Sb); Biganske, Beregivske and Kvasivske; one or more deposits are known in each one.

The common features of ore fields include transverse gold-polymetallic mineralization, direct evidences for mercury mineralization (Bigan, Kelchey) or mercury occurrences (Beregovo) in the upper part, mainly latitudinal or north-western strike of steeply-dipping vein bodies, and persistence of mineralization by dip including basement upper part.

At the same time, in each ore field and even deposit the self distinct lateral and vertical zonation is displayed. In Biganske deposit its upper parts are composed of barite and barite-polymetallic ores that further down are changed by polymetallic and gold-polymetallic ores. In the periphery of deposit and ore field germanium-bearing lignites occur. In Beregivske ore field the gold ores are observed near the surface and in Muzhiivske deposit these ores are located at the top comprising distinct lens-like and irregularly-shaped stockwork bodies whereas below gold-polymetallic, gold-bearing massive sulphide and polymetallic ores are developed.

In Kelchey deposit of Kvasivske ore field the ore bodies are located in the andesite flow while such flows are lacking at all in Biganske and Beregivske ore fields. It is the distinct feature of Kvasivske ore field that in its northern periphery the silver ores are developed in the bottom layers of Lukivska Suite that lie over the “heads” of steeply-dipping veins with low-grade polymetallic mineralization. By analogy, previous authors had predicted silver mineralization in Biganske deposit but this prognosis is not confirmed. From another hand, such permanent counterpart of the ore column as barite ores, in both cases is observed in the upper parts; nevertheless, an attempt to discover below barite ores the economic polymetallic mineralization in Kvasivske deposit has also failed.

The reasons for some uniqueness of each ore field, in our opinion, include position and lithological composition of basement rocks, composition, thickness and internal structure of overlaying volcanics and terrigenous sequences.
10. EVALUATION OF THE TERRITORY PERSPECTIVES

10.1. Oil and gas. The problem of searching for traditional oil and gas deposits includes indication and disclosure of suitable structures in Krosnenska and Skybova zones and comprises the task of the deep and super-deep drilling. At the same time, based on test results in DH Borynya-2 it is suggested the concept of new massive-fractured hydrocarbon trap type which is formed in the zone of anomalous-high rock pressure and does not depend on the rock laying conditions. In opinion of the concept’s author, R.T. Trushkevych (1992), in the studied area the size of such 1150 m high trap is 350 km² under position of gas-water contact at the depth 5150 m [22].

In Trans-Carpathian Trough one of gas deposits is confined to the local intrusive-dome uplift and at the surface is expressed with distinct deciphering patterns in satellite images looking like the combination of concentric faults with superimposed orthogonal system. By analogy, prospective Zhukivska gas-bearing structure is foreseen in 12-14 km to the north-east from Ruski Komarivtsi deposit being roughly equal to the latter by parameters and gas reserves [22].

10.2. Brown coal. Perspectives in growth of brown coal prognostic resources are related to the productive sediments of Pliocene Ilnytska Suite developed along the north-western slope of Vygorlat in the band up to 5 km wide and 50 km long.

10.3. Metallic mineral resources

10.3.1. Arsenic. The only prospective field for arsenic mineralization is thought to be Chornogolovskoe ore field where an occurrence is known in mineralized sandstone bed traced over 450 m. Its possible dipping over the half of length (220 m) is foreseen at the average thickness 1.25 m and arsenic content 2.8% [22]. Prognostic arsenic resources for entire ore field are being evaluated taking into account the horizontal share of Porkuletskiy Trust influence on the black-shale column of para-autochthon (1700 m), possible extension of mineralization over the half of this value by dipping, mentioned mineralization parameters, and reliability coefficient (0.5) [22].

10.3.2. Mercury. In the sub-zone of tele-thermal mercury mineralization in sandstones the ore intersections are not found and probability of their discovery is low. However, obtained results and new ideas on regularities of mineralization distribution make clearer the nature of the stream aureoles in Chornogolovskoe and Simerkivske ore fields. Ore mineralization in minor intrusions can be predicted over entire thickness of the host lithologically favourable clayey sequences in Porkuletskiy and Magurskiy thrusts [22].

Of not prospected aureoles which can be linked to the blind mineralized dykes and pipe-like bodies, the aureoles in the southern part of Perechynske, Simerkivske, Turytske and Polyanske ore fields are thought to be perspective.

10.3.3. Occurrences located at the surface in the zone of tellurium-bismuth and mercury mineralization, are not perspective themselves but they obviously indicate volcano-structures that contain worthwhile mineralization at the basement level. By analogy with Morske Oko structure where Remetske Gamre deposit is explored [14], this could be silver-polymetallic mineralization in the central part of our volcano-structures Poprichnyi, Antalivska, Khotar, Synyak and Dekhmaniv. However, their study requires considerable amount of drilling to the basement depth (800-1200 m) as well as underground workings.

10.3.4. The zone of antimony mineralization in Velykodobronskiy ore camp could probably get some attention in view of apparent mineralization persistence by strike (up to 4 km), thickness of encountered ore zones (2.2 and 3.2 m), and their vertical range, but uncertainty in definition of mineralization type and vertical ore zonation do not allow the zone consideration as the valuable object without additional prospecting and evaluation works.

10.3.5. Beregivskiy ore camp located in the zone of gold, gold-polymetallic and silver mineralization is most important in term of practical development with already established industrial infrastructure. By explored, perspective and prognostic resources, compact location of deposits and ore fields, and their complex features, the camp should be ascribed to the major ore regions of Ukraine. Perspectives of reserve growth are related to extended studies of the flanks and deep horizons in ore fields. Major gold reserves are concentrated in sulphide-gold-clayey-quartz economic ore type and therefore development of the camp should be directed to respective technologies of gold extraction from these ores.
Germanium-bearing lignites of Malobiganske deposit occupy specific position in this zone. Perspectives of germanium resources growth are related to the western flank of structure over the area 13.2 km² in size taking into account established productivity of the single square kilometre and calculation reliability coefficient (0.5).

If necessary, reserves of various construction materials, drinking, mineral and thermal waters can be significantly updated in the area.
11. ECOLOGO-GEOLOGICAL ENVIRONMENTS

The natural, natural-technogenic (transitional) and technogenic landscapes are distinguished in the area. Natural landscapes strongly predominate in the mountains while technogenic ones – in the plain. At the watersheds and on the northern slope of Carpathians the sub-Alpine meadow and conifer-broad-leaved landscapes of parallel ridges are developed where the elements of technogenic landscape (inhabited locations, agriculture-industrial objects, roads etc.) comprise up to 20% and are located mainly along the broad crosswise valleys. Remaining territory of External Carpathians, Peninska and Marmaroska zones, and major part of Vygorlat is occupied by the forest (broad-leaved) highly cut medium-mountain or low-mountain landscapes and weakly-cut sub-Alpine polonynes (meadows) where the rate of technogenic sites does not exceed 5%. In the transitional meadow-forest (broad-leaved) highly cut landscape of the Vygorlat north-western fore-land the technogenic sites comprise 20-40%. Technogenic forest-steppe (broad-leaved) and steppe landscapes of Trans-Carpathian alluvial plain with weakly-cut highlands contain up to 5-10% sites of relict natural landscapes.

In the defined landscape complexes the processes providing geological environment breaking and contamination with harmful substances are variously expressed. Of the breaking ones the modern exogenic geological processes (EGP) are distinguished: side erosion, slides, collapses, mudflows, aerial flow, swamping and flooding, which harmful influence is enhanced in the zones of increased seismic activity (up to 8 isoseists) and neo-tectonic motions. Besides the geological factors (clay or thin-rhythmic sandy-clayey Eocene-Oligocene flysch occurrence in the column), EGP enhancement is forced by the forest removing, dirty road construction at the slope foots and so forth. The sites of low (up to 5%), medium (5-20%) and high (more than 20%) EGP susceptibility are distinguished which strongly predominate in the conditions of medium-mountain extensively cut relief on the southern slope of Carpathians.

Trans-Carpathian alluvial plain is characterized by the processes of periodic flooding and progressive swamping trend which are being enhanced over the last times (catastrophic floods in 1998 and 2001).

The chemical, radioactive and bacteriological types of territory contamination are distinguished. Chemical contamination of soils, surface and underground waters by heavy metals of three toxic classes, phenols, chlorine-phenols, nitrates, pesticides, herbicides, petroleum products etc. is most widespread being carried out through the drop of untreated sewage and air emissions of gases and dust from industrial and agricultural enterprises. Maximum amounts of sewage drops and air emissions are estimated respectively to (thousand m³/year): Uzhgorod – 102 and 22.6; Mukachevo – 350 and 0.3; Beregove – 265 and 73; Svalyava – 243 and 0.3; Perechyn – 21 and 36; other inhabited locations – 0.2-15 and 0.2-0.3.

The areas of soil and surface water contamination by heavy metals are related to deposits and occurrences of lead, zinc, mercury, arsenic, antimony, copper and others in Beregovo-Biganskiy, Chornogolovskiy, Perechynskiy, Oleniyskiy and other ore fields and sites. The metal content comprises 1-10 units of the top admissible concentration (TAC), and arsenic content in places attains 100 TAC. Such contamination is actually absent in the area on the northern slope of Carpathians. Significant heavy metal content (especially lead, chromium, nickel) in ground waters is related to the metal processing enterprises and extensive auto-transport traffic (especially in the narrow valleys and gorges).

Bacteriological contamination by pathogenic organisms is related to the animal farms which are widely distributed both in the plain and mountains. Most of these units do not have purifying facilities.

Radioactive contamination mainly depends on the natural factors, specifically, on uranium, thorium, radium and radon content in the ores, rocks, soils and underground waters. Commonly this contamination occurs in the ore camps. The concentrations comprise: in soils – uranium up to 3×10⁻⁶%, thorium up to 1×10⁻³%; in rocks – uranium 1-5×10⁻⁹%; in waters – uranium 1×10⁻⁷%, radium – 1×10⁻¹¹-1×10⁻⁹%, radon – 5-110 eman.

Technogenic contamination by cesium-137 up to 0.4 curie/km² is encountered in two points (Svalyava area and in the upper course of Lyuta River).

Considering the interaction of geological environment with other components of ecological systems it should be noted that the studied area encompasses two contrasted crustal blocks of which one is being extensively uplifted (Carpathians) and another subsided (Trans-Carpathian Depression). This provokes considerable seismic activity in the area with possible earthquake energy up to 6-8 points by Richter scale. Their epicenters are mainly located in the most populated plain territory adjacent to Vygorlat-Gutynskiy Ridge. At the influence sites of many faults associated with neo-tectonic motions the rock fracturing zones are being formed.

Data of O.V.Zobkov [22] are used in the section.
that enhances EGP rate. It is also facilitated by irrational human activities especially total forest removal at the slope foots, nearby the roads and inhabited locations. Ecological equilibrium in the system is broken. In these places the snow is being melted extensively, surface waters much faster and in greater amount are being transported to the plain provoking territory flooding and frequent inundations. This scenario becomes common nowadays and, taking into account the trends in social development of the territory, it will predominate over the next decades. Thus, the major risk in the future comprises EGP enforcement in the mountain part of the area and flooding – in the plain one.

At the same time, taking into account considerable ceasing of industrial production and abrupt shortage in use of mineral fertilizers and pesticides, it can be predicted gradual decreasing of contamination by heavy metal (except ore camp sites), pesticides, herbicides, and cleaning of soils first of all, then surface and further underground waters.

Environment ecologo-geological typization and ecologo-geological zonation of the territory is grounded on the data of landscape types, degree of soil and surface water contamination and the trends in development of dangerous geological processes.

In the sub-Alpine meadow and conifer-broad-leaved landscapes of parallel ridges at the watershed zone and on the northern slope of Carpathians ecologo-geological environment is one of the best in the studied area. Available danger of EGP development over Oligocene clayey rocks in Krosnenska Zone is smoothed by the broad latitudinal valleys (technogenic landscapes) and lower territory seismicity; ravines, slides and mudflows are sporadic in these sites. Heavy metal contamination is almost lacking (short streams only with low lead content are found in the bottom sediments). Defined soil contamination by pesticides (not higher than 0.1-0.2 TAC) is getting decreased. The danger may appear under irrational forestry (wood cutting). The area is least economically and socially developed and requires improvement of communication facilities.

In the zone of natural forest (broad-leaved) highly-cut medium- and low-mountain landscapes and polonynas the technogenic landscapes are over-populated although the comprise only 5% of territory, and the industrial, agricultural and communication infrastructure often is located in the narrow valleys with steep slopes resulting in extensive chemical and bacteriological contamination of soils and surface waters enforced by occurrence of heavy metals (lead, zinc, copper, mercury, arsenic, antimony etc.) in rocks and some ore sites (Chornogolove, Turytsya, Dubrynchi, Simerky). Significant seismic activity of the territory (up to 7 points), neo-tectonic motions, irrational forest removal, roads along the slopes, essentially provoke EGP enhancement especially in the sites of soft clayey and sandy-clayey flysch piles in External Carpathians and argillized disintegrated tuffs of Vygorlat. Here the dense ravine network, slides, mudflows often cutting the rods, the sites of bank erosion, river course changes etc. are widely developed. These places of geological environment breaking occupy 5-10 to 20% of the territory, and more in places. The major danger in the territory comprises EGP enforcement at the sites of technogenic impact which, in perspective, will be increased unless urgent protection efforts are implemented at the State level. The situation is serious indeed because the EGP enforcement in this area considerably increases the danger of inundation and flooding in the lowland.

In the transitional meadow-forest highly-cut landscape of Vygorlat southern slopes developed over variously altered, argillized Neogene tuffs, the technogenic sites comprise up to 40%. This is dense-populated territory with considerable sites of chemical and bacteriological contamination of surface waters, rarely soils and bottom sediments by heavy metals (up to 1 TAC, in places more), rarely pesticides, pathogenic organisms. EGP are developed in sufficient extent which is facilitated by the highest seismic activity.

Taking into account the development trends (considerable shortening of industrial and agricultural production) degree of soil and underground water contamination is getting to be decreased and in general the geological-ecological conditions should become better. Most dangerous for the zone are the floods (especially for Mukachevo which is located at its southern margin).

In the zone of Trans-Carpathain alluvial plain the technogenic landscapes predominate with prevailing agricultural manufacturing, essential flooding lands in Borzhava and Latorytsya river basins. Surface water flows are often contaminated by heavy metals, petroleum products, pesticides at the level 0.1-0.9 TAC, rarely more. The soils in Biganske and Beregivske ore fields are contaminated by heavy metals (lead, zinc, copper, mercury), and manganese, chromium and lead are noted in the bottom sediments. The greatest danger, however, is provided by the floods which over last three years had caused significant losses not only for the territory itself but also for entire region in the basin of Tysa River upper course (including Romania, Hungary and Slovakia).

The principal ecological problems in the studied area include preservation of ecological equilibrium in the zone of Carpathians southern slope which requires the efforts in decreasing the EGP degree (internal problems) and flood-fighting (in this case the international collaboration is required for development of the program for joint activities).
CONCLUSIONS

As a result of the works the new set of maps in the scale 1:200 000 of Carpathian Series is designed for the map sheets M-34-XXIX (Snina) and M-34-XXXV (Uzhgorod), L-34-V (Satu Mare); the set includes geological map of pre-Quaternary units, geological map and mineral commodity map of Quaternary sediments, map of mineral resources and some supplementary schemes. This allowed complete characteristic of the mineral-resource base in the studied area.

Taking into account the complex geology and equivocal kind of some data, concepts and approaches to the geological problems some of them is not solved completely. Most important ones include:

- correctness in ascribing the thin-rhythmic flysch that lies below the horizon of banded limestones (Golovetski) in Krosnenska Zone to the Lower Sub-Suite of Menilitova Suite;
- reasons for ascribing volcanogenic complexes and intrusion of Vygorlat-Gutynskiy Ridge to Dakian-Rumunian (by absolute geochronology data the rocks do not differ from lithologically similar Sarmatian-Pannonian complexes [17];
- ascribing the Ilnytska Suite sediments to Dakian-Rumunian, and Chopska Suite sediments – to Eo-Pleistocene. Age analogs of Ilnytska Suite in adjacent territories (Slovakia, Romania) are dated by Pannonian, and Chopska Suite (Slovakia) – by Dakian-Rumunian.

The age of most distinguished terraces established mainly by analogy with adjacent territories requires confirmation by bio-stratigraphic methods.

Some statements expressed in designed maps and schemes do not have unequivocal solution due to lacking of data. This concerns, for instance, position of tectonic window “Mlaky” in the general structure of the area, as well as the semi-window in V.Grabivynstytsya area where additional studies by drilling are required. Similarly, it is disputable the position of Polonyna Rivna Mountain tectonic remnant which can be the element of either Duklyanskiy or Porkuletskiy thrusts.
REFERENCES

Published


Unpublished


Annexes

Annex 1. List of deposits and occurrences indicated in the maps of mineral resources of map sheets M-34-XXIX (Snina), M-34-XXXV (Uzhgorod), and L-34-V (Satu Mare).
Compiled by B.D.Pukach

<table>
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<tr>
<th>Cell index, number in map</th>
<th>Mineral type, object name and its location</th>
<th>Deposit exploitation state or brief description of occurrence</th>
<th>Geological-economic type</th>
<th>References</th>
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<td>Deposit. Out of production</td>
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<td>Occurrences. Emissions in borehole</td>
<td>Sheet-like body</td>
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<td>Cl-Na; 110 g/l; B=58.7 mg/l; SiO$_2$=35.5 mg/l; 42°C</td>
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<td>VI-2-154</td>
<td>Sub-thermal mineral water. Krasne Selo</td>
<td>Occurrence in borehole</td>
<td>HCO$_3$-Cl-Na-Ca-Mg; 3.2 g/l</td>
<td>[26]</td>
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<tr>
<td>VI-2-155</td>
<td>Mineral water. Chomonyn-1</td>
<td>Occurrence in borehole</td>
<td>Cl-Na; 5.2 g/l</td>
<td>[26]</td>
</tr>
<tr>
<td>VI-2-156,157</td>
<td>Gas. Svoboda-1,2</td>
<td>Occurrences. Emissions in boreholes</td>
<td>Sheet-like body</td>
<td>[26]</td>
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<tr>
<td>VI-2-158</td>
<td>Mineral water. Chomonyn-2</td>
<td>Occurrence. Intercepted by borehole</td>
<td>Cl-HCO₃-Na-Ca; 3.4 g/l;</td>
<td>[26]</td>
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<tr>
<td>VI-2-159</td>
<td>Mineral water. Chomonyn</td>
<td>Occurrence. Intercepted by borehole</td>
<td>Cl-Na; 28.6 g/l; SiO₂=60 mg/l; 40°C</td>
<td>[26]</td>
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<tr>
<td>VI-2-161</td>
<td>Mineral water. Barkasovo</td>
<td>Occurrence. Intercepted by borehole</td>
<td>Cl-HCO₃-Na; 1.5 g/l</td>
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<td>VI-3-162</td>
<td>Mineral ochre. Lokhovo</td>
<td>Occurrence. Lens in hydrothermalites</td>
<td>Ochre for pigments</td>
<td>[26]</td>
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<td>VI-3-163</td>
<td>Andesites. Lavky</td>
<td>Deposit. In production</td>
<td>Crushed stone</td>
<td>[26]</td>
</tr>
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<td>VI-3-164</td>
<td>Andesites. Kirovske</td>
<td>Deposit. In production</td>
<td>Crushed stone</td>
<td>[26]</td>
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<tr>
<td>VI-3-165</td>
<td>Mineral ochre. Lavky</td>
<td>Occurrence. Weathering crust after hydrothermalites</td>
<td>Ochre for pigments</td>
<td>[26]</td>
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<tr>
<td>VI-3-166</td>
<td>Brine. Mukachev</td>
<td>Deposit. Out of production</td>
<td>Cl-Na; 178-196 g/l; 34°C</td>
<td>[26]</td>
</tr>
<tr>
<td>VI-3-167,168,170</td>
<td>Mineral water. Strabychovo, Velyki Luchky, Drysyno</td>
<td>Occurrences. Intercepted by boreholes</td>
<td>Cl-Na; Cl-HCO₃-Na; 21.7 g/l; 1.3 g/l; 4.6 g/l</td>
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<td>VI-3-169</td>
<td>Antimony. Velyki Luchky</td>
<td>Occurrence. Antimonite mineralization in rhyolites</td>
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<td>Deposit. In production</td>
<td>Crushed stone, cobble-stone</td>
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<td>VI-4-172</td>
<td>Andesites. Glynyanets</td>
<td>Deposit. In production</td>
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<td>VI-4-173</td>
<td>Mineral ochre. Dilok</td>
<td>Occurrence. Three bodies over hydrothermally-altered tuffs</td>
<td>Ochre for pigments</td>
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<td>VI-4-175</td>
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<td>Energy raw materials</td>
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<td>VI-4-176</td>
<td>Mineral ochre. Klymovytsya</td>
<td>Occurrence. Weathering crust after hydrothermalites</td>
<td>Ochre for pigments</td>
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<td>VI-4-177</td>
<td>Iodine-bromine brine. Novoselytsya</td>
<td>Deposit. Out of production</td>
<td>Cl-Na; 27-60 g/l; J=20 mg/l; Br=76-93 mg/l; 26-38°C</td>
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<td>VI-4-178</td>
<td>Gas. Yabluneve-2</td>
<td>Occurrence. Inflow in borehole</td>
<td>Sheet-like body</td>
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<td>Rock salt. Yabluneve-2</td>
<td>Occurrence. Intersection in borehole</td>
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<td>Thermal brine. Fegerash</td>
<td>Deposit. Out of production</td>
<td>Cl-Na; 27-60 g/l; J=20 mg/l; Br=76-93 mg/l; 26-38°C</td>
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<td>VI-4-181</td>
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<td>Occurrence. Intersection in borehole</td>
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<td>Gas. Yabluneve</td>
<td>Deposit. Out of production</td>
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<td>VI-4-183</td>
<td>Thermal brine. Dorobratovo</td>
<td>Occurrence. Prospecting-evaluated, non-perspective</td>
<td>Cl-Na; 162-230 g/l; Br=151-302 mg/l; B=50-161 mg/l; 126°C at the bottom</td>
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<td>Occurrence. Intersection in borehole</td>
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<td>VI-4-185</td>
<td>Rock salt. Dorobratovo-2</td>
<td>Occurrence. Intersection in borehole</td>
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<td>VI-4-186</td>
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<td>Occurrence. Intersection in borehole</td>
<td>Cl-Na; 136-156 g/l; Br=221-224 mg/l; B=60 mg/l; 132°C (bottom)</td>
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<td>VI-4-187</td>
<td>Rock salt. Makarovo</td>
<td>Occurrence. Intersection in borehole</td>
<td>Chemogenic halite</td>
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<td>Brine. Makarovo</td>
<td>Occurrence. Prospecting-evaluated, non-perspective</td>
<td>Cl-Na; 65 g/l; Br=76-184 mg/l; B=30 mg/l</td>
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<td>VI-4-189</td>
<td>Rock salt. Yableneve-4</td>
<td>Occurrence. Intersection in borehole</td>
<td>Chemogenic halite</td>
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<td>VII-2-190</td>
<td>Sub-thermal mineral water. Derenkovets</td>
<td>Occurrence in borehole, perspective</td>
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<td>[25]</td>
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<td>VII-2-191</td>
<td>Sub-thermal mineral water. Gashpor</td>
<td>Occurrence in borehole, perspective</td>
<td>Cl-HCO$_3$-Na; 3.1 g/l; F=5 mg/l; Rn=16.2 eman; 34.7°C</td>
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<td>VII-2-192</td>
<td>Rhyolite. Kosny</td>
<td>Deposit. In production</td>
<td>Crushed stone</td>
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<tr>
<td>VII-2-193</td>
<td>Thermal mineral water. Kosny</td>
<td>Deposit. In production</td>
<td>Cl-Na; 9.8 g/l; 51°C</td>
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<td>VII-3-194</td>
<td>Thermal mineral water. Rafaylovo</td>
<td>Deposit. Out of production</td>
<td>Cl-HCO$_3$-Na; 2.2 g/l; 21.5°C SiO$_2$=80 mg/l; Rn=12.7 eman;</td>
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<td>VII-3-195</td>
<td>Thermal mineral water. Garazdivka</td>
<td>Occurrence. Intercepted by mapping borehole</td>
<td>Cl-Na; SiO$_2$=130 mg/l; 45.7°C</td>
<td>[25]</td>
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<td>VII-3-197</td>
<td>Sub-thermal mineral water. Mala Bigan</td>
<td>Occurrence. Intersection in mapping borehole</td>
<td>Cl-HCO$_3$-Na; 4.1 g/l; SiO$_2$=100 mg/l; 26.2°C</td>
<td>[25]</td>
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<td>VII-3-198</td>
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<td>Occurrence. Intersection in mapping borehole</td>
<td>Cl-Na; 0.65 g/l; SiO$_2$=11 mg/l; 28.5°C</td>
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<td>VII-3-200,201</td>
<td>Sub-thermal mineral water. Ivanivka</td>
<td>Deposits. Out of production</td>
<td>Cl-Na; 4.6-5.7 g/l; SiO$_2$=120 mg/l; 20-30.5°C</td>
<td>[25]</td>
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<td>VII-3-203</td>
<td>Alunite. Biganske</td>
<td>Deposit. Out of production</td>
<td>Alumina raw materials</td>
<td>[23]</td>
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<td>VII-3-204</td>
<td>Gold, polymetals, barite. Biganske</td>
<td>Deposit. Out of production</td>
<td>Sulphide-clayey-quartz</td>
<td>[23]</td>
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<td>VII-3-205,207</td>
<td>Sub-thermal mineral water. Bigan, Ar dov</td>
<td>Deposits. Out of production</td>
<td>Cl-HCO$_3$-Na; 3.2 g/l; Rn=16.6 eman; SiO$_2$=20 mg/l; 32.6°; 29.5°C</td>
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<td>VII-3-206</td>
<td>Alunite. Didove</td>
<td>Deposit. Out of production</td>
<td>Alumina raw materials</td>
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<td>VII-3-208</td>
<td>Perlit es. Ar dov</td>
<td>Deposit. Out of production</td>
<td>Claydite raw materials</td>
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<td>VII-3-209</td>
<td>Perlit es. Ar dov</td>
<td>Deposit. Out of production</td>
<td>Glass raw materials</td>
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<tr>
<td>VII-3-210</td>
<td>Mineral water. Beregy</td>
<td>Deposit. Out of production</td>
<td>Cl-HCO$_3$-Na; 1.3 g/l;</td>
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<td>VII-3-212</td>
<td>Thermal mineral water. Beregovo Deposit. In production</td>
<td>Cl-Na; 20-25 g/l; B=35 mg/l; Fe=60 mg/l; 55°C</td>
<td>[23]</td>
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<td>VII-3-213,214</td>
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<td>Facing tile, crushed stone</td>
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<td>Sulphide-clayey-quartz</td>
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<td>VII-3-217</td>
<td>Thermal mineral water. Beregovo Deposit. Out of production</td>
<td>Cl-Na; 8.1 g/l; B=15 mg/l; 48°C</td>
<td>[23]</td>
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<td>VII-3-218</td>
<td>Mercury. Beregivskiy Occurrence. Thin veinlets with low-grade mineralization</td>
<td>Hydrothermal cinnabar</td>
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<td>VII-3-219</td>
<td>Gold, polymetals. Beregivskye Deposit. Out of production</td>
<td>Gold-sulphide-clayey-quartz</td>
<td>[22]</td>
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<td>VII-3-220</td>
<td>Gold, polymetals. Muzhiivske Deposit. Exploitation commenced, in production</td>
<td>Gold-sulphide-clayey-quartz; Gold-clayey-quartz</td>
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<td>VII-3-222</td>
<td>Alunite. Beregivskye Deposit. Out of production</td>
<td>Alumina raw materials</td>
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<td>Alunite. Kuklya Deposit. Out of production</td>
<td>Alumina raw materials</td>
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<td>VII-3-225</td>
<td>Kaoline. Muzhiivo Occurrence. Low-quality Occurrence in borehole</td>
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<td>VII-3-226</td>
<td>Alunite. Muzhiivo Deposit. Out of production</td>
<td>Alumina raw materials</td>
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<td>VII-3-227</td>
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<td>VII-3-229</td>
<td>Rhyolites. Khaesh Deposit. In production</td>
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<td>VII-3-231</td>
<td>Thermal mineral water. Velyka Bakta Deposit. Out of production</td>
<td>Cl-SO₄-Na; 10.9-19.1 g/l; SiO₂=40 mg/l; 36-58°C</td>
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<td>VII-4-232</td>
<td>Rock salt. Volovystsya Occurrence. Intersection in borehole</td>
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<td>VII-4-234</td>
<td>Brine. Khmilnyk Occurrence. Prospecting-evaluated, non-perspective</td>
<td>Cl-Na; 147-202 g/l; B=20-60 mg/l; Br=87-671 mg/l;</td>
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<td>Mineral ochre. Siltse Deposit. In production</td>
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<td>VII-4-236</td>
<td>Rock salt. Nove Selo Occurrence. Intersection in borehole</td>
<td>Chemogenic halite</td>
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<td>VII-4-237</td>
<td>Thermal brine. Nove Selo Occurrence. Prospecting-evaluated, non-perspective</td>
<td>Cl-Na; 171.4 g/l; 91°C (1600 m)</td>
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<td>VII-4-241</td>
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<td>Silver. Kvasivske Deposit. Sheet-like bodies at the depths 10-100 m</td>
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<td>VII-4-244</td>
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<td>Fresh sub-thermal water. Borzhava</td>
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Annex 2. List of deposits and occurrences indicated in the geological map and map of mineral resources in Quaternary units of map sheets M-34-XXIX (Sina), M-34-XXXV (Uzhgorod), and L-34-V (Satu Mare). Compiled by Yu.V.Kovalyov, V.M.Vorobkanych

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STATE GEOLOGICAL MAP OF UKRAINE

Scale 1:200 000

Carpathian Series
MAP SHEETS M-34-XXIX (Snina), M-34-XXXV (Uzhgorod), L-34-V (Satu Mare)

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Authors:
B.V.Matskiv, B.D.Pukach, Yu.V.Kovalyov, V.M.Vorobkanych

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