European integration of mineral raw material data (EIMIDA)

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FIELD TRIP GUIDEBOOK

1st General Workshop and Field Trip

Kyiv – Zhytomyr, Ukraine

May 22-27, 2016
Introduction

The previous field trip of NUMIRE Project (May 15-22, 2013) was held in the south-east of Ukraine, Dnipropetrovsk and Zaporizhzhya regions, and in Middle-Dniiproan geoblock of Ukrainian Shield (Fig. I-1). That time, the iron-ore (BIF) and manganese-ore (carbonate) deposits as well as Khortysya granite were visited to get an impression of the area minerals. The given field trip of EIMIDA Project between Geological Survey of Norway (NGU) and Geoinform of Ukraine (GIU) is arranged with the same aim in the north-west of Ukrainian Shield, in Volyn geoblock, where geology and minerals are different, and administratively in Zhytomyr Region (Fig. I-2).

Zhytomyr region (29.9 thousand km²) is located geographically in the north-western part of Ukraine on the right bank of Dnipro River in 100-130 km to the west of Kyiv and is bordered in the north by Belarus.

In tectonic respect, the area is located in the north-western part of Ukrainian Shield and is composed by ancient folded structures of Archean and Lower Proterozoic age with various superimposed multistage ultra-metamorphic and magmatic processes.

Precambrian formations are overlain by Carboniferous, Triassic, Jurassic, Cretaceous, Paleogene and Neogene-Quaternary sediments.

The oldest formations in the Region are Lower Archean mafic gneisses and gneisses of different composition (amphibole-biotite, amphibole, pyroxene, biotite-garnet, etc.), and amphibolites. Paleo-Proterozoic rocks include Korosten and dike complexes composed of ultramafic, magic, felsic and alkalic varieties (anorthosite, norite, gabbro and gabbro-anorthosite, granite, syenite, monzonite, and others). The products of their weathering in Paleozoic-Mesozoic, kaolin weathering crusts, are often exposed at the surface.
Younger Cenozoic sandy-clay sediments of water-glacier, alluvial-deluvial and aeolian origin are also widespread in the territory of Zhytomyr Region and overlain by Quaternary sediments and modern top soil.

Zhytomyr Region is essentially rich in minerals related to the mentioned wide development of igneous intrusive rocks and metamorphic complexes. In general, by the diversity and number of identified reserves of facing stone and aggregate Zhytomyr Region occupies a leading position among other regions of Ukraine. Color palette of decorative facing stone is constantly expanding, and resources for a range of deposits are practically inexhaustible. In addition, the white, grey and colored marble reserves are explored and evaluated.

With regard to gemstones, deposits are the most common in the rocks of granite-pegmatite series and include rock crystal, opal, amethyst, morion, topaz, and beryl. High-quality amber deposits are found in the north-western part of Zhytomyr Region at the borders with Belarus and Rivne Region of Ukraine.
Sedimentary sand-clay rocks widespread in the region and are associated with cement and porcelain industry, pottery and brick production, and variable Quaternary sands are being used in construction industry and glass production.

Titanium minerals are especially valuable in the Region and include deposits and occurrences in mafic and low-alkali hard rocks of Korosten Pluton, their overlaying Paleozoic-Mesozoic weathering crust, and sedimentary placer deposits. By their number, importance and preparation for commercial development, Zhytomyr Region occupies a leading position in the country.

The brief description of regional geology is given below which would encompass not only the patterns of the area to be visited but also the wider scope of certain geological units. It especially concerns Ukrainian Shield that occupies considerable territory of Ukraine and differs across in composition and structure.

In reminder, NUMIRE Project field trip aforesaid had included the objects developed both in the Precambrian and Phanerozoic rock complexes. In fact, Ukraine is top-ranked in the world with the iron-, manganese-, and titanium ores. Two former ore types were examined in the previous field trip, and in that case the iron-ore deposits have been found to be the part of Precambrian crust of Ukrainian Shield whereas manganese-ore deposits were related to the Phanerozoic sedimentary cover of the Shield. In the given EIMIDA Project field trip we would also find that the mineral wealth of Ukraine is being derived from both the olden Precambrian and young Mesozoic rock complexes, from the basement and sedimentary cover of Ukrainian Shield. Respectively, the short information on these patterns is given below although one can find that these descriptions do differ in size and details.

The area selected for the field trip this time, is actually one of the most geologically-complicated parts of Ukraine. A number of various rock complexes are developed over there, and it is quite difficult to visit all distinct units within the single field trip. That is why the most prominent objects were selected for the observation (see Fig. 1-2):

A. Khoroshiv ornamental and gemstone museum  
B. Liznykvivske facing-stone granite deposit  
C. Mezhyrichne ilmenite placer deposit  
D. Ocheretyanske facing-stone labradorite deposit.

Principal Types of Precambrian Rock Associations in the Ukrainian Shield

Up to the present knowledge, six litho-tectonic complexes (LTC) of different age are distinguished in the Ukrainian Shield (Fig. I-3, [4]). Each complex displays the distinct composition, internal regularities and tectonic framework as well as specific position in the Precambrian crust. Evidently, each one reflects diverse crustal evolution trends and events. Spatial distribution of LTCs is rather variable and being coupled with mentioned features it provides the ground for the Shield major subdivision into six so called mega- or geoblocks (that means some major domain): Volyn (Northwest), Dnister-Boug, Ros-Tykych, Kirovograd, Middle-Dniproan, and Azovian (see Fig. I-3).

Each LTC includes certain set of the rock associations that differ in genetic respect: supercrustal (oldest primary-stratified), pluto-no-metamorphic, plutonic, metasedimentary-volcanogenic, metaterrigenous. Conditions of their formation do actually define the main patterns of the geoblocks including tectonic framework, metamorphic fabric, spatial heterogeneity; out of these reasons, the mapping and geological exploration vary from domain to domain.

The LTC sets and their concrete representatives are variable in different geoblocks. The geoblocks have their analogous in other shields all over the world and their LTCs can be grouped into the following six types:
• charnockite-granulite,
• plagiogranitoid-amphibolite,
• granite-greenstone,
• granitoid-metasedimentary,
• volcano-plutonic, and
• volcanic-sedimentary.

Fig. I-3. Distribution of litho-tectonic complexes over geoblocks of Ukrainian Shield.

The geoblocks constitute the large segments of Precambrian crust individualized at certain stages of geological history and therefore these are autonomous geodynamic systems characterized by the specific history of development, composition, tectonics, and metallogeny.

The rocks of oldest charnockite-granulite LTC are known in all geoblocks but mainly occur in the Dnister-Boug, Middle-Dniprean and Azovian ones (see Fig. I-3) where the columns differ depending on preservation extent of the rock associations in vertical sections of the geoblocks, on the variations of PT-conditions and the scale of subsequent transformations (metamorphism, ultrametamorphism, retrogressive metamorphism). The complex is weakly mineralized and just graphite deposits (Zavallya) and some iron-ore and marble occurrences are known in relation to these rocks. The distinct superimposed mesothermal gold mineralization (Maiske deposit) is developed in granulite-facies rocks of Dnister-Boug geoblock.

Plagiogranitoid-amphibolite LTC is restricted to the Ros-Tikich and Middle- Dniprean geoblocks (see Fig. I-3), and is observed in a number of small areas within Volyn geoblock and the western part of Kirovograd (Ingul-Ingulets) geoblock. The complex is weakly mineralized and the rocks (granite, amphibolite) are being locally used in construction purposes.
The tonalite-greenstone LTC is distributed in the units of two types: the Middle-Dniirean granite-greenstone terrain and Azovian granite-greenstone terrain, both are developed in respective geoblocks (see Fig. I-3). Metallogenic features of the tonalite-greenstone LTC are defined on the one hand by diverse mineralization and deposits that were syngenetic to particular volcano-plutonic associations (iron ores, sulphide and silicate nickel in the weathering crusts) and, on the other hand, due to re-activating influence of metarhyodacite-plagiogranite volcano-plutonic association with the subsequent superposition of epigenetic mineralization over greenstone piles (ore-metal pegmatites, gold- and molybdenum-ore objects, PGM, uranium, etc.).

Granitoid-metasedimentary LTC, in contrast to the previous ones, displays the zoned metamorphic patterns (from granulite to greenstone facies), domination of primary-sedimentary stratified associations, two-feldspar granitoids in plutonic associations and local occurrence of plutono-metamorphic associations (Fig. I-4).

Granitoid-metasedimentary LTC overlies three previously described complexes with clear discontinuity. Associations of the LTC are extremely heterogeneous laterally and are mainly presented in two geological conditions, which allow their two types to be distinguished: ferruginous-siliceous and carbonaceous-gneissic.

The former type is distributed in the territory of the Middle-Dniirean and Azovian geoblocks (see Fig. I-3) and consists of primary-sedimentary stratified associations actually lacking of ultrametamorphic reworking (Kryvyj Rig – Bilozerskiy and Gulyaipole-Osypenko complexes). The second type complex is encountered in the Volyn (Northwest) and Kirovograd (Ingul-Ingulets) geoblocks (Teteriv and Ingul-Ingulets complexes respectively).

The grouping of these rather complicated associations into a single LTC is under discussion; this concerns not only two distinguished main types but also the correlation or comparison of the Kryvyj Rig and Bilozerskiy columns.

The isotope age of the first type rocks, according to data available (metarhyodacites of the Bilozerskiy belt) is 3.0 Ga [1] and that of mafic rocks from Kryvyj Rig series 2.4 Ga. Gneisses and amphibolites of the Teteriv and Ingul-Ingulets type are exceptionally related to Paleo-Proterozoic.

The complex contains world-class iron-ore deposits in Kryvyj Rig belt in Middle-Dniirean geoblock, as well as uranium mineralization in albrites, and mesothermal gold mineralization in granite-gneisses in Kirovograd geoblock.

Plutonic and volcano-plutonic LTC is characterized by much more voluminous plutonic associations formed in the same time spans of stratified units. These features allow distinguishing [7] of volcano-plutonic (Osnytsya), anorthosite-rapakivi-granite (Korosten, detailed description of its rock types is given in [2, 3, 4, etc.] and Korsun-Novomyirgorod ([8, 9, etc.], see Fig. I-4) complexes and the complex of granitoids of high alkalinity (East Azovian [6, 8, etc.]). The isotope age of the complex rocks according to data available is within 2.0 Ga (the former) and 1.8-1.7 (the latter). Zircons from metarhyolites and metadacites are defined as those of 2.0 Ga. Intrusive rocks of the Korosten pluton have been characterized in more details as to their age (Ga): anorthosites of early phase – 1.8; labradorite-gabbro-norite phase – 1.76; rapakivi granites – 1.7; biotite granites (Liznyk) – 1.7 and granite-porphyres – 1.7 [13]. Labradorites of the Korsun-Novomyirgorod pluton were formed later than 1.7 Ga ago [10].

Diverse mineralization is related to the plutonic formations, including phosphorus-titanium-bearing gabbro-anorthosites (Stremygorodske, Fedorivske, Kropyvnyanske, deposits and numerous occurrences in the Korosten and Korsun-Novomyirgorod plutons), rare-earth-zirconium-bearing syenites (Azov-Yastrubetske deposit), and tantalum-niobium-zircon-bearing nepheline syenites (Mazurivske deposit). Rare-metal complex mineralization (Perga deposit, Volyn geoblock, and a number of occurrences in this ore field; occurrences in the
Katerynivka, Kamyana Mogyla and Starodubivka massifs of Azovian geoblock) is linked to the complex of subalkalic granites in the zones of hydrothermal-metasomatic alteration.

Volcanogenic-sedimentary LTCs are represented by the Ovruch complex characterized by presence of weakly- and non-metamorphosed volcanic associations of Bilokorovychi, Ovruch and Vilchany depressions distributed in the north-western part of the Shield; copper, lithium, beryllium, and zirconium mineralization is found in these units. Successions begin with sandstone-aleurolite and trachyandesite-rhyolite associations that are followed upward firstly by quartzite-sandstone, and then by aleurolite rocks associations. The isotope age of the complex rocks, according to data available is within 1.8-1.6 Ga [13].
Sedimentary cover development in the north-west Ukrainian Shield

In general, over Paleozoic and early Mesozoic entire Shield area, and its north-west part, was eroded and peneplained in different extent with development of weathering crust and then accumulation of Jurassic, Cretaceous, Paleogene, Neogene, and Anthropogenic sediments of diverse thickness, up to hundred meters, and normally within the range 20-50 meters. Due to alternating epeirogenic crust movements, the long-term sedimentation epochs were changing by shorter periods of erosion.

In the north-west Ukrainian Shield, during Jurassic Bathonian time the area was in continental regime. In the ancient valleys and depressions the sand sediments with layers of clay and kaolin were accumulated, and mainly carbonaceous clays with layers of brown coal were deposited in the swamp areas. In Callovian time, the sea transgression occurred and detritic limestones were accumulated. Jurassic rocks are locally developed in the north of the area and are overlain by the younger sediments.

Due to uprising epeirogenic crust movements in Lower Cretaceous time, marine conditions were changed to continental sedimentation. Ilmenite-bearing coarse-grained sands (mineral sands) have been formed in depression, ancient valleys and dimples (Fig. I-5).

In late Albian time, the new and greatest sea transgression had encompassed entire territory. In the shallow-water parts the sandy sediments enriched in carbonate material were formed; chert and siliceous sandstone layers, lenses and concretions were formed in these sediments during diagenesis.

Since the second half of the Late Cretaceous, the area turned towards a long stage of continental development. Sedimentation resumed in Middle Eocene, when sand-clay coal-bearing sediments have been accumulated in the river valleys and lakes. The continental regime was changed to marine in the late Middle Eocene, and glauconite-quartz sands with minute layers of silts and clays were deposited in the open, relatively shallow basin. Coastal-marine sedimentation regime continued in Late Eocene with fine-grained glauconite-quartz sand sedimentation. At the end of Paleogene, the upward movements have led to the erosion of Late Eocene sediments in the most territory of north-west Ukrainian Shield.

Sedimentation had resumed in Miocene, and since that time up to now the continental conditions are dominated in the area. In the Early – Middle Miocene, as a result of descending tectonic movements of individual basement blocks, the series of depressions emerged, where kaolin-bearing sands with kaolin layers and lenses have been deposited in the lakes. These rocks however were eroded in early Late Miocene because of upward tectonic movements. The continental Upper Miocene facies (parti-colored clays) reflect fluvial and lacustrine conditions of accumulation plain.

In the Pliocene and Eo-Pleistocene the plain was slightly elevated and subaerial (hydromorphic soils, clay loess, eluvial-deluvial clay) and subaqueous (alluvial sands) facies were accumulated combined with partial or complete erosion of previously accumulated sediment. Further on the small-amplitude oscillatory movements have caused swampy-denudation plains with numerous lakes and river valleys where subaerial, alluvial and lacustrine sediments were deposited. Erosion occurred only in the slightly uplifted blocks.

The Middle Pleistocene time is marked with glacial (moraine loam) and fluvioglacial (sandy loam, sand) sedimentation that filled almost all the pre-glacial surface irregularities. After the glacier retreat, the large gently undulating moraine-outwash plain was formed.
Fig. I-5. Geological map (A) and cross-section (B) showing distribution of Precambrian basement and sedimentary cover rocks in north-west Ukrainian Shield exemplified by the field-trip area (see section C).
Simplified after [11]. The map showing location and list of titanium placer deposits will be provided in separate outlet supplementary to the given guidebook.

The network of river systems, which serve as the main dismembering factor to the modern-denudation plains, has been created in Middle and Late Pleistocene. In Early Holocene, relatively shallow lake basins and marsh areas predominated, and backwaters were formed in the valleys. It should be noted that the thickness and nature of the Quaternary sediments were controlled by the movements of blocks of different sizes along tectonic zones and some faults.

In the next sections, from A to D, the objects (stops) are described on the actual field trip day-by-day basis. Despite of cross-cutting references, figures and tables contained therein are conveniently numbered separately for each section.
A. Khoroshiv Ornamental and Gemstone Museum

Rough distance 130 km, estimated duration 4 hours.

The field trip commences with the exposition at the Ornamental and Gemstone Museum in Khoroshiv town.

Mineralogical collection in the backbone of the Museum has been launched in 1951, and in 1958 the Museum was registered in Zhytomyr Regional Administration of Culture, entitled "Volunteer Mineralogical Museum". In 2001, the Museum awarded the status of "Scientific facility, which is the national property of Ukraine."

In the display windows of the Museum one can see the crystals of green beryl, pale blue aquamarine, clear examples of rock crystal, smoky quartz and black morion; pink, blue and polychrome topaz, crimson-purple amethyst crystals and many other amazing minerals and rocks. In total, the Museum collection includes about 1800 samples of geological formations from Ukraine, CIS countries, Europe, America, Africa and other places around the world.

The Museum exposition consists of five rooms (Fig. A-1).

The first room exhibits ornamental stones of Ukraine which are famous for its unique color saturation, high strength and endurance.

Among the large variety of ornamental stone tiles, a special attention is paid to unsurpassed in color and pattern (structure) species of pink and red Liznykovskiy granite, grey Kornynskiy granite, grey Pokostivskiy granite of Zhytomyr Region, dark crimson Tokivskiy granite and grey Kudashivskiy granite of Dnipropetrovsk Region, red Kapustianskiy granite and pink Krupsky granite of Kirovograd Region, grey Yantsivskiy granite of Zaporizhzhya Region, pinkish-grey Novodanylivskiy granite and green-grey Kostyantynivskiy granite of Mykolaiv Region.

Among labradorites, decorative tiles from Ocheretyanske, Nebizhske and Andriivske deposits (Zhytomyr Region) should be noted. Amazing labrador from Fedorivskе deposit has an unique golden-orange-green iridescence. Gabbro from Rudnya-Shlyakhtova, Zarichne, and Torchynske deposits (Zhytomyr Region) comprise attractive decorative material as well.

Some finished products from ornamental stone are also exhibited in the room. These include beautiful big vases of green and pink granite, mini-fountain of red Kapustianskiy granite, and a table of Nevyrivskiy iridescent labradorite, stone bowls, and others.
The **second room** includes most typical examples of chamber pegmatite host rocks, as well as crystals, druses and mineral aggregates characteristic for the different structural zones of chamber pegmatites of Volynske morion deposit. In the exhibition one can see the rocks hosting the pegmatite body and samples from their internal zones. It is possible to look at the fine details of "script" granite, to see huge feldspar druses, shining goethite "hedgehogs", and white phenacite crystals.

Significant part of the second room is dedicated to the pegmatite quartz crystals – one of the most interesting minerals. The largest quartz crystal, mined in Volyn, has been weighted to 10 tons. Later on giant quartz crystal of 7 t in weight was mined. In the museum one can see black quartz morion druse of 361 kg in weight.

The samples of characteristic zonal structure in large crystals of quartz from Volyn are presented in a separate showcase, where quartz changes from the center to periphery from rock crystal, to smoky quartz, and then to morion.

In addition, the visitors are always regarded other exhibits of this room with interest: the regolith – a real lunar soil, which was gifted to the museum by astronauts; large single quartz crystal and rock crystal strange druses from Ural deposits.

The **third room** talks more about diversity of quartz – transparent and white crystals resembling forever frozen ice; black, similar to a miniature obelisks; golden lemons with sun rays in and light green prasem. The distinct “Marmarosh diamonds” are admirable – small (less than 5 mm) water-clear crystals that play with many sun shining faces. Brazilian amethyst geodes are filled inside with small purple crystals, which are put closely each other, forming sharp-angled brushes.

The **fourth room** exhibits samples of precious minerals from Volyn chamber pegmatites: topaz and beryl (Fig. A-2).

*Topaz* is known from the ancient times as a jewelry stone. It is characterized by a special internal play of light, shine, sky blue, golden color of the sun, ease and transparent dew drops. By color, Volyn topaz crystals are single-color (colorless, blue, pink) and polychrome (blue and pink). Most common crystal habit is prismatic.

The findings of large transparent (jewelry) crystals of topaz 1 to 50kg in weight are the common things in Volyn. The biggest topaz crystal mined in 1964 in Volyn was 117 kg in weight and 82 cm in height. The central part is yellow and peripherals – pink and yellow. The head is quite crystal clear and the base in non-transparent due to the large number of cracks and gas-liquid inclusions. The jewelry material output from this crystal was 48 kg. The second large topaz crystal 110 kg in weight, fully transparent (jewelry), pink and yellow, which is now in Fersman Mineralogical Museum (Moscow), was also mined in the same pegmatite. The third by weight topaz crystal of 68 kg was mined in Volyn in 1952 and transferred to the Museum of Geography at Moscow University.

![Fig. A-2. Topaz and beryl in exhibition. Source: www.museumstone.com.ua.](image)
The pale blue topaz crystal available in the Museum is 28.520 kg in weight and 32*27*23 cm in size. Unique (jewelry) crystals of topaz stored in the Museum under good tradition are assigned with own names – "Academician Alexander Fersman", "Dzhereltse" (Spring), "Kazka" (Fairy Tale), "The Golden Polissya". These unique world famous topaz crystals are pride and beauty of Polissya (the area that covers north of Ukraine, south of Belarus, and west of Poland).

Beryl crystals are really unforgettable. They are transparent and clean, each facet prism has its own unique pattern of deep rough cavity – "digestion figures" that imparts unique and attractive features of beryl in Volyn. These crystals display diverse range of green color – olive green, grass green. Golden-yellow heliodor is typical, as if it is filled with the sun warmth. The pale-blue aquamarine and colorless goshenite crystals are rare.

The biggest beryl crystal mined in Volyn – 135 cm long and 66.6 kg in weight – can be seen in the museum. It is opaque due to the large number of gas-liquid inclusions and cracks.

Unique (jewelry) beryl crystals are assigned with their own names. The crystal "Academician Yevgen Lazarenko" is named after well-known Ukrainian geologist Academician Y.K. Lazarenko, one of the initiators and chief of research in Volyn deposit for many years. After the expert estimates, this is jewelry crystal of highest quality. One facet is polished and makes it possible to see all the perfection of this amazing clear crystal. Another great beauty transparent olive-green beryl is named "Apostles Peter and Paul" – a unique parallel splice of two beryl crystals covered with natural digestion figures.

The room also contains other minerals of Ukraine: the amazing yellow-green Fedorivskiy labrador crystals, highly decorative variegated Kirovograd jasper, Carpathian pale-pink rhodonite, funny petrified wood twigs, pieces of precious opal from Azovian geoblock, "tiger" and "falcon" eye jaspilites from Kryvyj Rig, and pyrophyllite schist of Zhytomyr Region.

The minerals and rocks from around the world are also shown in the museum. These include blue aquamarines from Brazil and Pakistan, brownish-yellow gypsum from Poland, bright-green malachite from Ural, bright-red ruby from Brazil, and greenish-blue turquoise from Central Asia. A wide range of agates is presented: thin plate of rhythmically-zonal layers resembling mysterious caves; “castle” agate similar to vintage prints from the castle towers. There are also colorful garnets, purple charoite and pale-green amazonite, sky-blue lazurite, Iceland spar, and many examples of different colored stones.

Finally, the fifth room displays the finished products of precious and decorative stones. These include diverse semi-precious wares: morion rock crystal, jasper, malachite, onyx beads, rhodonite, maripolite candlesticks; serpentine, selenite, onyx vases; obsidian, unakite caskets. Synthetic minerals – corundum, garnet, turquoise, fianite – are shown in a separate showcase.

A special place in the room takes solar stone – amber. The showcases provide samples of amber from Klesivske deposit, the first industrial amber deposits in Ukraine. Ukrainian amber is characterized by a large variety of sizes, colors and shapes. The size of individual specimens attains up to 200 mm. Impressive color range of Klesivskiy amber is from colorless and white through various shades of yellow, red to almost black.

The real gem of the room is a showcase of products made from faceted gems of Volyn deposit. These include perfectly faceted olive-green beryl, unique topaz, and quartz of different colors.
B. Liznykivske facing-stone granite deposit

Rough distance 60 km, estimated duration 4 hours.

The purpose of the visit to this object is to examine the felsic rocks of Korosten pluton.

Liznykivske deposit is located in the southern part of Korosten pluton (Fig. B-1), just nearby Liznyk village and to the north-east from Chervonogranitne village, in 10 km to south-east from Khoroshiv town (Zhytomyr Region, see Fig. I-2).

The main mineral product in the deposit comprises red sub-alkalic non-ovoid leucogranites of Liznykivsiki Massif (12 thousand km² in size) developed at the final stages of igneous activity in Korosten Pluton (1.75 Ga). Other rocks in this location are represented by xenoliths of older anorthosites, gabbroides including ore-bearing, ovoid rapakivi-like granites. Granite-porphry dykes also occur that are the youngest in the rock association of the Korosten Pluton (1.74 Ga). Deposit is explored over area of 77.5 hectares. The area stratigraphy is given in Table B-1.

<table>
<thead>
<tr>
<th>Index</th>
<th>Geological section</th>
<th>Thickness, m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quaternary</strong></td>
<td></td>
<td></td>
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<tr>
<td>Q₄</td>
<td>Soil-fossil layer</td>
<td>0.2–0.5</td>
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<tr>
<td>Q₄</td>
<td>Brown loam, dense</td>
<td>0.6–1.6</td>
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<td><strong>Middle-Quaternary</strong></td>
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</tr>
<tr>
<td>Q₂</td>
<td>Overburden clayey sand</td>
<td>0.3–5.4</td>
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<tr>
<td><strong>Neogene</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N₁np</td>
<td>Quartz sand, diverse-grained, 50%-kaolinized in the bottom, lenses of weakly cemented sandstone and brown clay occur somewhere</td>
<td>1.1–9.3</td>
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<td><strong>Paleozoic-Mesozoic (weathering crust)</strong></td>
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<tr>
<td>Pz-Mz</td>
<td>Gruss and weathered crystalline rocks</td>
<td>0.7–10.0</td>
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<tr>
<td><strong>Paleoproterozoic-II</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>γPR₂ks</td>
<td>Granite and mafic rocks, slightly weathered</td>
<td>0.0–14.2</td>
</tr>
<tr>
<td>γPR₂ks</td>
<td>Granite, unaltered, red and various coloured, from pink to beef-red, medium-grained, rarely coarse-grained, fractured</td>
<td>Disclosed – 0.0–83.7</td>
</tr>
<tr>
<td>γPR₂ks</td>
<td>Granite, unaltered, red and various coloured, from pink to beef-red, medium-grained, rarely coarse-grained, ovoid, fractured (by depth 114 m)</td>
<td>Disclosed – 1.6–74.4</td>
</tr>
<tr>
<td>υPR₂ks</td>
<td>Anorthosite (labradorite), unaltered, dark-grey to black, coarse-grained to giant-grained</td>
<td>11.2–39.7</td>
</tr>
</tbody>
</table>

Liznykivski granites in the Korosten Pluton do form the body about 7 by 2 km in size extended along the contact between rapakivi-like granites and anorthosites of Volodarsk-Volynskyi massif confined to Liznyk fault. Origin of these granites is still under discussion while their relationships with rapakivi-like granites are not studied in details. Liznykivski granites differ from the latter in regular mode of the grain texture with evidences for linear orientation of the rock-forming minerals, and lacking evidences for hybridism. These are pink, pink-red to beef-red medium-coarse-grained, slightly-banded rocks with characteristic quartz grains elongation.
Fig. B-1. Geological map (A) and cross-section (B) of the southern part of Korosten Pluton, and geological setting of Liznykivske granite deposit. Simplified after [12]. The map showing location and list of other facing stone deposits will be provided in separate outlet supplementary to the given guidebook.

Characteristic micro-textures of Liznykivskiy granite include micro-perthite, granite, granulite and poikilite. The rock (Fig. B-2) is composed of microcline-perthite (50-60%), plagioclase (5-15%), quartz (25-40%) and biotite (3-5%). Alkali content is increased and the rocks also display the features of trace elements enrichment. Chemical composition of granite is given in the Table B-2.
Table B-2. Chemical composition of Liznykivsky granites

<table>
<thead>
<tr>
<th>Major</th>
<th>Content, %</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>elements</td>
<td></td>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td></td>
<td>74.53</td>
<td>75.68</td>
</tr>
<tr>
<td>TiO$_2$</td>
<td></td>
<td>0.20</td>
<td>0.37</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td></td>
<td>11.02</td>
<td>11.91</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td></td>
<td>1.70</td>
<td>3.17</td>
</tr>
<tr>
<td>MgO</td>
<td></td>
<td>0.30</td>
<td>0.36</td>
</tr>
<tr>
<td>CaO</td>
<td></td>
<td>0.70</td>
<td>1.01</td>
</tr>
<tr>
<td>Na$_2$O</td>
<td></td>
<td>3.02</td>
<td>4.50</td>
</tr>
<tr>
<td>K$_2$O</td>
<td></td>
<td>4.40</td>
<td>5.24</td>
</tr>
<tr>
<td>SO$_3$</td>
<td></td>
<td>traces</td>
<td>traces</td>
</tr>
</tbody>
</table>

Unaltered and slightly altered red granites (Liznykivski) comprise the value of deposit. Other rocks – anorthosites, gabbroides (including ore-bearing), and ovoid granites are observed in xenoliths of different size. Dyke (vein) rocks of Korosten complex are represented by granite-porphyry.

Explored thickness of deposit varies from 58.4 to 101.2 m being 85.9 m in average, including 2.2 m of weathered rocks. Overburden thickness varies from zero to 18.8 m and is 7.7 m in average. Bench height varies from 10 to 25 m, being about 20 m in average (Fig. B-3, B-4).

Deposit is in production since 1898. Long time and scale blasting works provided sufficient values of industrial materials. Earlier in deposit the block granite was processed that is used in architecture and building including facing stones. It should be noted that Liznykivskiy
granite has distinct ornamental properties and is well known outside Ukraine. In Moscow, the housing of tomb, Lenin Mausoleum, where Ukrainian people hope to get Putin soonest instead of Lenin, is mainly built of Liznykivski granites. Today granite blocks can be exploited to the east and northeast from the quarry and in these directions reserves also may be increased. By 01.01.2016, reserves of deposit are estimated to 54920.733 thousand m$^3$ by categories A+B+C$_1$, including 1663.374 thousand m$^3$ of A, 10532.359 thousand m$^3$ of B, and 42725 thousand m$^3$ of C$_1$.

Fig. B-4. Simplified quarry wall model based on staff observation data presented for reserves approval.
Day 2, Tuesday, May 24, 2016

C. Mezhyrichne ilmenite placer deposit

Rough distance 120 km, estimated duration 7 hours.

Excursion purpose includes examination of the geology and ore composition in the Volyn group ilmenite placer deposits taking Mezhyrichne deposit as an example. The excursion route crosses the mined portion of deposit and then goes to the processing mill.

Mezhyrichne deposit represents Volyn (or Irshanska) group of ilmenite placer and residual deposits. Administratively they are located in Khoroshiv, Chernyakhivsk, Korosten and Malyn areas of Zhytomyr Region (see Fig. I-2). Irshansk town is situated in the central part of the cluster and this is the settlement where administration, processing and residential complexes of Irshanskiy Mining-Beneficiation Plant are disposed. Mezhyrichne deposit is located to the south of Irshansk.

The surface of deposit looks like slightly rolling plain of so called Podillya-type and most of the area is covered with forests being partly swamped.

Deposit was discovered and preliminary evaluated in 1953-1958. Later on occasional prospecting and exploration works have been performed while the exploitation started in 2000.

Geology of the deposit is fairly simple. The crystalline basement is composed of mafic rocks of Volodarsk-Volynskiy igneous massif included in the Korosten Complex. In the massif, the coarse-grained gabbro-anorthosites predominate whereas minor rocks including labradorite, gabbro, gabbro-peridotite occur in the small separate bodies. The rocks contain ilmenite, apatite and titanomagnetite mineralization which extent increases with the rock mafic index and somewhere attains the economic grade.

The mafic rocks are almost totally overlapped by Paleozoic-Mesozoic areal-type weathered crust, which is partially eroded along the river valleys. The thickness of this crust varies widely up to 30-50 m. The kaolin and gruss-kaolin zones are of highest thickness. These are the zones of increased and economic ilmenite bearing. High ilmenite concentrations found mainly in the upper portion of the kaolin zone.

Ilmenite-bearing weathered crust does form the base of the ilmenite placer. This unit is not studied sufficiently yet, particularly ilmenite and apatite distribution is not clear. It is known that in the placers of Volyn group the upper horizons of the weathering crust (mainly kaolin and gruss-kaolin zones) are enriched in ilmenite. In Mezhyrichne deposit these horizons are involved into production. Thickness of ilmenite-enriched weathered crust attains 5.6 m, ilmenite grade is about 78-81 kg/m³ in average.

The placer deposits of Volyn group are located in the submerged Upper Jurassic – Lower Cretaceous 15-20 km wide paleo-valley of northeast strike that transects entire Volodarsk-Volynsk igneous massif. Mezhyrichne deposit is confined to the southeastern part of the area (Fig. C-1).

Deposit is elongated in longitudinal direction over 12 km. Due to extensive water-glacial erosion-accumulation processes deposit is split into a range of blocks. Quaternary water-glacial and glacial sediments overlap economic ilmenite placers.
Fig. C-1. Regional geological sketch of Volyn-group titanium placer deposits (A) and cross-section by line K-L (B). Modified after [4].

The blocks have similar geology, which is exemplified by six and seven blocks where excursion has to be spent. Particularly, the column consists of age-different continental and
marine sediments that overlie kaolin weathering crust of mafic rocks or directly the latter bedrocks. The following genetic types of the continental sediments are distinguished:

- Upper Jurassic – Lower Cretaceous alluvial and alluvial-deluvial
- Lower Quaternary alluvial
- Middle Quaternary water-glacial and glacial
- Modern alluvial and organogenic

Marine sediments include Upper Cretaceous Cenomanian glauconite sands and clays and Turonian sandstone-siliceous horizon. These rocks are developed outside the blocks and are commonly of insufficient economic value.

**Upper Jurassic – Lower Cretaceous sediments** are confined to the valley-like subsidence forms in the basement relief. These rocks are underlain by kaolin weathering crust after mafic rocks. Maximum thickness is about 18 m being 5-8 m in average (see Fig. C-2).

Alluvial sediments are two-folded. Lower horizon is composed of diverse-grained (up to coarse-) sands with gravel, and the upper horizon consists of mainly secondary kaolin. Average composition of the sand fraction is as follows, %: < 0.01 mm – 10-18; 0.1-0.01 mm – 3-7; 0.1-2.0 mm – 65-75; > 2 mm – 10. The sands are essentially quartz in composition.

Deluvial sediments include sandy secondary kaolin (commonly with gravel and fine quartz and siliceous pebble). These rocks comprise the upper section of the placer but sometimes may be found in the basal portion. Gravel-pebble sandy secondary kaolins express the highest ilmenite concentrations. Clay fraction content in these rocks attains 40-50%, and rarely – 55-65%.

Transitions between alluvial and deluvial sediments are commonly gradual and in the geological section these sediments are often undivided.

Besides quartz and feldspar, about 50 other minerals have been found in the continental sediments including leucoxenized ilmenite, leucoxene, rutile, titanomagnetite, spinel, apatite, topaz, kyanite, andalusite, sillimanite, staurolite, garnet (almandine), anataze, tourmaline, pyroxene, siderite, marcasite, etc. Of these, ilmenite and its altered varieties are of economic value as well as rutile and zircon. Apatite grade does not exceed 0.2-0.5 kg/m³ and sometimes only attains 1-3 kg/m³.

Cretaceous sediments provide the main 6-10 m thick ore horizon and ilmenite grade varies from 40 to 400 kg/m³ being of 60-68 kg/m³ in average.

Ilmenite occurs in black angular, rounded and irregular grains, rarely crystals and their fragments. The grains 1.00-0.25 mm in size predominate. The grains greater than 1 mm comprise just about 10%.

The TiO₂ content in ilmenite varies from 51.2 to 63.4% being 55% in average. Minor components include, %: V₂O₅ – 0.257; Nb₂O₅ – 0.024; Ta₂O₅ – 0.008, and traces, %: SiO₂ – 0.74; P₂O₅ – 0.14; SO₃ – 0.58; Cr₂O₃ – 0.055.

Leucoxenized ilmenite and leucoxene have been formed after ilmenite. These minerals are of irregular composition and physical properties. TiO₂ content sometimes attains 80% and higher. Color is commonly dark-red, brown, yellow, grey and white. Final product of ilmenite alteration is presented by the secondary leucoxene with TiO₂ content 91.00-94.78 %.

**Quaternary sediments** include diverse time-genesis rock types. They almost completely overlie eroded surface of Mesozoic rocks. Diverse-grained quartz sands predominate, sometimes with gravel and fine siliceous pebbles, clay sands, loamy soils (river and glacial). Disclosed thickness is about 6-10 m. Economic ilmenite grade found in some parts of the submerged valleys in the basal portions of diverse-grained sands.
With regard to the ore potential, the ilmenite deposits in weathering crust (Paleozoic-Mesozoic) and Jurassic-Cretaceous alluvial-deluvial deposits are of economic interest. The barren overburden is mainly composed of Paleogene-Neogene-Quaternary sediments.

By thickness, the ore productive layers vary in the range of 1-2 m to 15-20 m and more with ilmenite content from 1% to 5-7%, and in the bedrock gabbro and gabbro-norite rocks – up to 20-25%. The thickness ratio of ore to barren piles in Irshanskiy camp does not exceed 1.2-1.5.

All deposits in production are equidistant (25-30 km) from Irshansk administrative center. Irshansk is a town of titanium miners with well-developed infrastructure, providing a comfortable and compact accommodation for 7 thousand people.

Irshanskiy Mining-Beneficiation Plant (IMBP), one of the biggest enterprises of Zhitomir Region, was established in 1954 to develop Irshanska group of ilmenite ore deposits. To date, it consists of four active mines, two beneficiation factories and some auxiliary shops. Mineral resources are represented by eight ilmenite deposits, three of them are in final stage of development, the development of rest five is in progress and considered to be started one after another in the future. All the deposits are at the equal distance (20-25 km) from administrative center Irshansk located in 65 km north of Zhitomir, where all necessary auxiliary shops are concentrated. The mining works are conducted by two methods (Fig. C-2, C-3):

- by "excavator" method with the help of rotary excavators in complex with conveyors;
- by "hydraulic-excavator" method in complex with hydro-monitors and gravel pumps.

Fig. C-2. Rotary excavator at Mezyrichne ilmenite placer deposit.
Two types of beneficiation are in use at the enterprise – ‘continuous' cycle and 'interrupted'.

An ‘interrupted' cycle considers open-cast mining and only primary upgrading of sand in situ. The further upgrading up to final concentrate is conducted at separate beneficiation plant.

A ‘continuous' upgrading cycle means mining and upgrading of sand up to the stage of final concentrate at once. At the wet plant the sand transported from the mine passes three stages of disintegration, desliming, screening, upgrading at spiral separators to the stage of primary concentrate with 70-80% of ilmenite, then at the dry mill it is enriched to customized concentrate at magnetic and electrostatic separators.

Water for both mining and processing is recycled, thus it does not contaminate natural ponds and rivers and does not affect ecology. Worked out areas are reclaimed to agricultural lands, forests, artificial ponds, etc.

The auxiliary shops are the following: mechanical, transport, electrical, construction, shipment-loading base, geological investigation department, central laboratory and others, each of them is oriented for the fulfillment of separate tasks. For example, mechanical shop, which consists of the subdivisions of mining equipment repairing, boilers-pipe welding, rubber shop, instrumentation, etc., fulfills all range of refurbishing works for equipment engaged in operation, manufactures spare parts and also fulfills other request from outside organizations.

Apart from the main product, ilmenite concentrate, IMBP produces the following: natural kaolin, technological oxygen, spiral separators, parts for pumps and quartz sand for soft roofing production.

Both final concentrate and intermediate products are continuously monitored for quality. All intermediate products are being analyzed for ilmenite and titanium dioxide grade, and final
product – also for phosphorus pentoxide, chrome oxide, iron oxides and so on. IMBP laboratories conduct full range of mineralogical, chemical and granulometric analysis to determine qualitative and quantitative characteristics of deposits.

The main customers of ilmenite concentrate produced by IMBP are chemical enterprises of Ukraine, Czech Republic, and USA. Due to discipline of shipment, high quality of the product and some unique material properties, IMBP ilmenite concentrate has a stable selling market and interest in it is constantly growing up.

IMBP is working for development of new ilmenite deposits. A new pit and upgrading plant are being constructed at Mezhyrichne deposit to compensate in the nearest future those mining capacities, which are at the end of their life. In the long term IMBP considers development of Stremigorodske complex deposit of apatite-ilmenite ore.

Apparently, Cretaceous ilmenite placer deposits were partly formed through erosion of Paleozoic and Mesozoic weathering crust after anorthosite and gabbro, but the latter rocks were probably also the source of primary ilmenite accumulations elsewhere, that is, the distal hard-rock titanium ore deposits. Example of this kind will be given in the end of next section of the next field trip day.
Day 3, Wednesday, May 25, 2016

D. Ocheretyanske facing-stone labradorite deposit

Rough distance 60 km, estimated duration 6 hours.

The idea to visit this deposit is to examine the second important constituent of Korosten Pluton – anorthosites and labradorites.

Ocheretyanske deposit is located on the southern outskirts of Rudnya village in Chernyakhivskiy area of Zhytomyr Region (see Fig. I-2), on the right bank of Ocheretyanka river, on grazing lands of Ocheretyanka commune council. The nearest railway station Toporyshche is in 5 km northwest of the deposit. The distance from Liznykivske granite deposit (see Section B) is about 10 km to the west. Deposit is situated in Zhytomyr Polissya. In orographic respect, this is slightly dissected, lumpy plain with altitudes from 197.0 m to 205.0 m.

The principal commodity is unaltered labradorite of Volodarsk-Volynskiy Massif of Korosten Complex (Fig. D-1). Labradorite is quite suitable for block making. Thickness of explored unaltered labradorite is 11.0-19.6 m being 15.8 m in average. Overburden thickness is 0.0-2.9 m, and 1.1 m in average. The geological column at the deposit is summarized in Table D-1 and geological cross-sections across the open pit are shown in Fig. D-2.

Table D-1. Geological column through Ocheretyanske deposit

<table>
<thead>
<tr>
<th>Index</th>
<th>Geological section</th>
<th>Thickness, m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quaternary</td>
<td></td>
</tr>
<tr>
<td>Q₄</td>
<td>Soil-fossil layer (loamy rock abundant gruss and low humus content)</td>
<td>0.1</td>
</tr>
<tr>
<td>Mz-Cz</td>
<td>Weathering crust – brown gruss, coarse-grained, with different kaolin development, friable, oxidized</td>
<td>0-2.7 (avg. 1.1)</td>
</tr>
<tr>
<td></td>
<td>Paleozoic-Mesozoic (weathering crust)</td>
<td></td>
</tr>
<tr>
<td>Korosten igneous complex</td>
<td>Labradorite, extensively fractured, weathered</td>
<td>0-3.4 (avg. 1.4)</td>
</tr>
<tr>
<td>uPR₂ks</td>
<td>Labradorite, dark-grey to black, diverse-grained, uniform, massive. In the upper portion extensively fractured</td>
<td>11.0-19.6 (avg. 15.8)</td>
</tr>
</tbody>
</table>

Mineral composition of labradorite is as follows: plagioclase - 85-98% pyroxene - 2-10%, biotite, olivine - up 2% to 5%, amphibole, ore, accessory - single grains. Chemical composition of labradorite is given in the Table D-2.

Average block output from the rock mass is 30.3%. Labradorite is well-polishing, black, black and grey with iridescent eyes (20-120 cells per 1 m² of polished surface). By decorative properties labradorite of Ocheretyanske deposit is classified for Class II. According to Lundhs AS (Norway), labradorite is classified as Aurora Blue Anorthosite (Fig. D-3), and of many Ukrainian anorthosites, Lundhs Aurora Blue is regarded to be the kind with the darkest background color and highest density of big blue crystals.
Fig. D-1. Geological map (A) and cross-section (B) of the southern part of Korosten Pluton, and geological setting of Ocheretyanske labradorite deposit and Fedorivske hard-rock apatite-ilmenite deposit. Simplified after [12]. The map showing location and list of other facing stone deposits will be provided in separate outlet supplementary to the given guidebook.
Fig. D-2. Geological cross-sections A1-A2 and B1-B2 across the open pit of Ocheretyanske labradorite deposit. Compiled from the data presented for reserves approval.
Geological conditions of Ocheretyanske deposit are favorable for open cast development. The volume of hard overburden is estimated to 12.6 thousand m³, and volume of unconsolidated overburden – 11.0 thousand m³.

**Table D-2. Chemical composition of labradorite**

<table>
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<th>Major elements</th>
<th>Content, %</th>
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</thead>
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<td>SiO₂</td>
<td>51.43</td>
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<tr>
<td>TiO₂</td>
<td>1.08</td>
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<tr>
<td>Al₂O₃</td>
<td>22.73</td>
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<tr>
<td>FeO</td>
<td>4.68</td>
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<tr>
<td>Fe₂O₃</td>
<td>1.55</td>
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<tr>
<td>MnO</td>
<td>0.07</td>
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<tr>
<td>MgO</td>
<td>2.25</td>
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<tr>
<td>CaO</td>
<td>9.81</td>
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<tr>
<td>Na₂O</td>
<td>3.91</td>
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<tr>
<td>K₂O</td>
<td>0.81</td>
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<tr>
<td>P₂O₅</td>
<td>0.21</td>
</tr>
<tr>
<td>LOI</td>
<td>0.80</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.21</td>
</tr>
<tr>
<td>SO₃</td>
<td>0.12</td>
</tr>
</tbody>
</table>

The mining and processing waste is suitable for the by-product aggregate manufacturing. By 01.01.2016, labradorite reserves of deposit are estimated to 48.657 thousand m³ by categories A+B, including 12.027 thousand m³ of A, and 36.63 thousand m³ of B. Aggregate reserves are estimated to 11.253 thousand m³ by categories A+B, including 3.0 thousand m³ of A, and 8.253 thousand m³ of B.

Deposit is being mined by Galactic Ltd., Ukraine, in cooperation with Lundhs AS, Norway. It might be of interest that in 2011 representatives of Lundhs AS, Tom Frode Hansen – Vice President, and Ole Petter Nyhagen – Marketing Executive, took part in the 4th cooperation meeting between NGU and SGSSU in Trondheim, Norway, and since that time the Norway-Ukraine cooperation in the field of mineral resources has been developed to the stage when the NGU delegation is visiting the company in Ukraine which is operating under Norwegian investments.

While further talking about the links and possible cooperation between Ukraine and Norway in the field of mineral resources, it should be noted that our countries are the European leaders of titanium ore production (Norway – 54%, and Ukraine – 46% of ilmenite production in Europe in 2012). The difference is that in Ukraine the ilmenite placer deposits are being mined (see Section C) whereas in Norway the hard-rock titanium deposits are in production. In this conjunction, it might be of interest that the hard-rock apatite-ilmenite mineralization in mafic rocks is also known in the visited area of Ocheretyanske labradorite deposit. Unfortunately, these deposits and occurrences are not exposed and have been studied and explored by gravity and magnetic geophysical surveys and drill-holes while amount of information by each particular site is not sufficient for their field trip observations. Nevertheless, because of the noted similarity between this type of titanium mineralization in Ukraine and hard-rock titanium deposits of Norway, the short description is given below in this section for the **Ferodivske apatite-ilmenite hard-rock deposit** located next to Ocheretyanske labradorite deposit (see Fig. D-1).

Fedorivske deposit (phosphorus-titanium ores with concomitant vanadium and scandium) is located in Chernyakhivskiy area of Zhytomyr Region in 30 km to the north from Zhytomyr (see Fig. D-1). In geological respect, deposit is confined to the southern part of Volodarsk-Volynskiy gabbro-anorthosite massif.
Deposit occurs in the layered groove-shaped gabbroid intrusion 240-450 m wide and 3.5 km long extended in the north-eastern direction (Fig. D-4).

Fig. D-4. Geological map and cross-section by line A-B of Fedorivske apatite-ilmenite deposit. Modified after [4].
The maximum depth of the ore-bearing gabbro attains 322.2 m. The dipping angle of the contact between intrusion and host rock varies from 45 to 80°. The northwest part of the intrusion roof (2.3 km long) is eroded about half by thickness and is capped by thin weathered crust of kaolin type and 2-15 m thick sand-clay sediments.

The composite ores of economic value occur in the southwest flank of the massif in about 1 km from its pinch. To the north the ore body splits into separate layers and dips beneath barren gabbro-anorthosites; the ore grade drops in the same direction.

In the deposit the ore-bearing rocks are gabbros that gradually change to leucocratic and melanocratic varieties. The gabbro contains variable amount of the rock-forming (plagioclase, pyroxene, olivine) and ore (ilmenite, apatite, titanomagnetite) minerals. In the cross-section, the ore body splitting into three ore horizons is observed. The upper horizon is represented by mesocratic fine-medium-grained gabbro with high Ti and P content. Middle horizon is composed of melanocratic fine-grained gabbro-peridotite with increased (in comparison to upper layer) ore content. The lower horizon comprises alternating gabbro-anorthosite and leucocratic gabbro to gabbro-peridotite; the phosphorus content is low. The ratio of the horizons by thickness in the studied section is about 1:0.8:0.5.

Average ore composition is as follows, %: plagioclase – 29.9; pyroxene – 28.6; olivine – 20.0; ilmenite – 11.09; apatite – 7.0; titanomagnetite – 3.4.

Ilmenite is the major titanium-bearing mineral; it is responsible for 81.9% of the total TiO₂ in the ore. Titanomagnetite contains 8.56% of TiO₂ and remaining are the rock-forming minerals, mainly pyroxene (7.37%). Phosphorus is concentrated in fluorapatite (88.25%) and some part is contained in the rock-forming minerals. Vanadium as isomorphic trace element occurs in two minerals – titanomagnetite (62.96%) and ilmenite (37.04%).

Chemical composition of the minerals is as follows, %:

**Ilmenite**: TiO₂ – 48.42; Fe<sub>tot.</sub> – 50.67; P₂O₅ – 0.087; Y₂O₅ – 0.227; Sc – 22.47 g/t.
**Apatite**: P₂O₅ – 41.23; CaO – 53.30; TiO₂ – 0.046; Fe<sub>tot.</sub> – 0.54; F – 2.94.
**Titanomagnetite**: TiO₂ – 16.52; Fe<sub>tot.</sub> – 52.55; P₂O₅ – 0.48; Y₂O₅ – 1.25; Sc – 32.98 g/t.
Conclusions

Ukraine appears to have been underexplored and underestimated by the Western mineral business, which is still weakly informed about Ukrainian mineral potential and undergoes considerable difficulties entering Ukraine. It is expected that the situation will be progressively getting better and compliant with the Western standards since the trend of Ukraine towards the European Union is obvious, and this trend reflects the fundamental choice of Ukraine between an inefficient, corruptive post-Soviet Russian model and the European democratic, free-market economy model.

EIMIDA Project comprises one of the efficient measures in making the mineral information gate to Ukraine. While we are not essentially aware of the other lines followed by Ukrainian government, SGSSU policy is to declare the strong wishes for the Western investment engagement. In this respect, the GIU efforts towards the European integration of mineral raw materials data are thought to be the most reliable, comprehensive and considerable mechanism facilitating practical awareness of the Western investors in the mineral resources of Ukraine. Besides the modern IT approaches, some field observations are also required and the given EIMIDA Project field trip (likewise previous NUMIRE Project field trip in 2013) is definitely organized in these purposes in order to show the principal geological domains and associated minerals of Ukraine, to our Norwegian colleagues first of all.

Perhaps any geological field trip is limited in time and capacity to visit and examine a wide range of the interesting objects. With this regard, both mentioned field trips (2013 and 2016) were designed in the way to visit mineral deposits in production. It is clear as far as these objects are most impressive and give explicit information on the practical value of respective deposits. Nevertheless, the Western exploration and mining companies might be even more interested in the mineral occurrences to be further developed by their own. In this respect, the information contributed to the Minerals4EU portal under NUMIRE Project support, as well as anticipated GIU web service "Mineral resources of Ukraine" to be developed in 2017 in the frame of EIMIDA Project using European standards, does seem extremely valuable. It is also expected that both NGU and GIU will contribute to the new EGS flagship project GeoERA (after Commission approval) scheduled for 2018-2020 (at 66% of in-kind costs by partners), although further support in 2018-2020 by the Norwegian Ministry of Foreign Affairs to the direct NGU-GIU cooperation in the field of mineral resources would be invaluable and extremely appreciated. Besides mentioned directions, the MFA funding also would be used to ensure GIU visibility at the EU level and participation, together with NGU and other geological surveys of Europe, in the calls, commitments and projects under EU Horizon 2020 Programme, that in turn would facilitate and speed up European integration of Ukrainian mineral data.

Apparently, the next EIMIDA Project field trip in Norway in 2017 would also be essentially devoted to the application of the mentioned standards and further European integration of Ukrainian mineral data using outstanding NGU experience in this field.
References

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Open pit sunrise © Tamara Bardygola, 2005

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