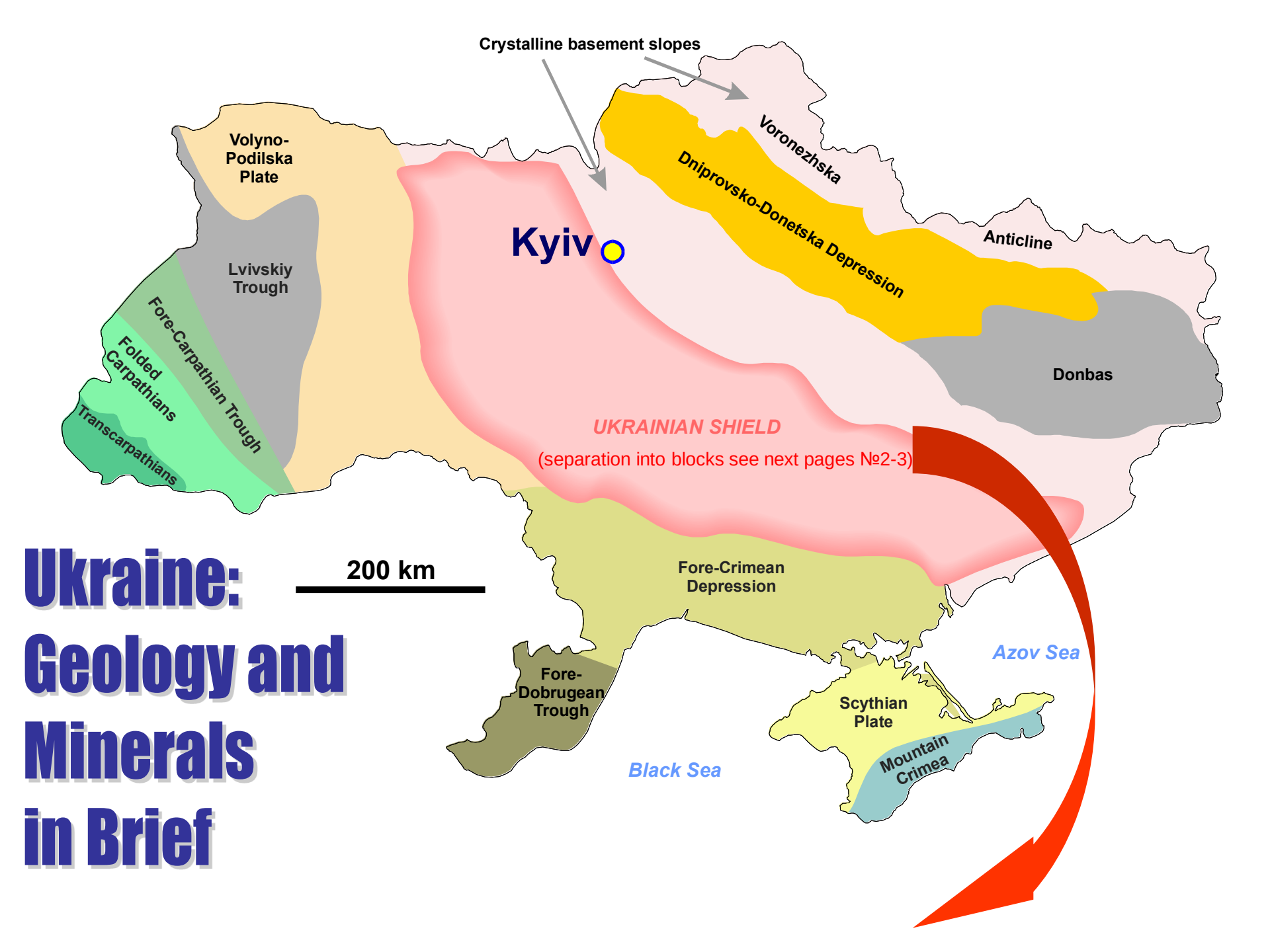

Crystalline basement slopes
Volyno-
Podilska
Plate
Voronezhska
Anticline
Dniprovsko-Donetska Depression
Kyiv
Lvivskiy
Trough
Fore-Carpathian Trough
Folded
Carpathians
Transcarpathians
Donbas
UKRAINIAN SHIELD
(separation into blocks see next pages №2-3)
Ukraine:
Geology and
Minerals
in Brief
200 km
Fore-Crimean
Depression
Azov Sea
Fore-
Dobrugean
Trough
Scythian
Plate
Mountain
Crimea
Black Sea

GEOLOGICAL MAP OF THE PRECAMBRIAN ROCKS COMPLEXES
AND ZONING OF THE UKRAINIAN SHIELD

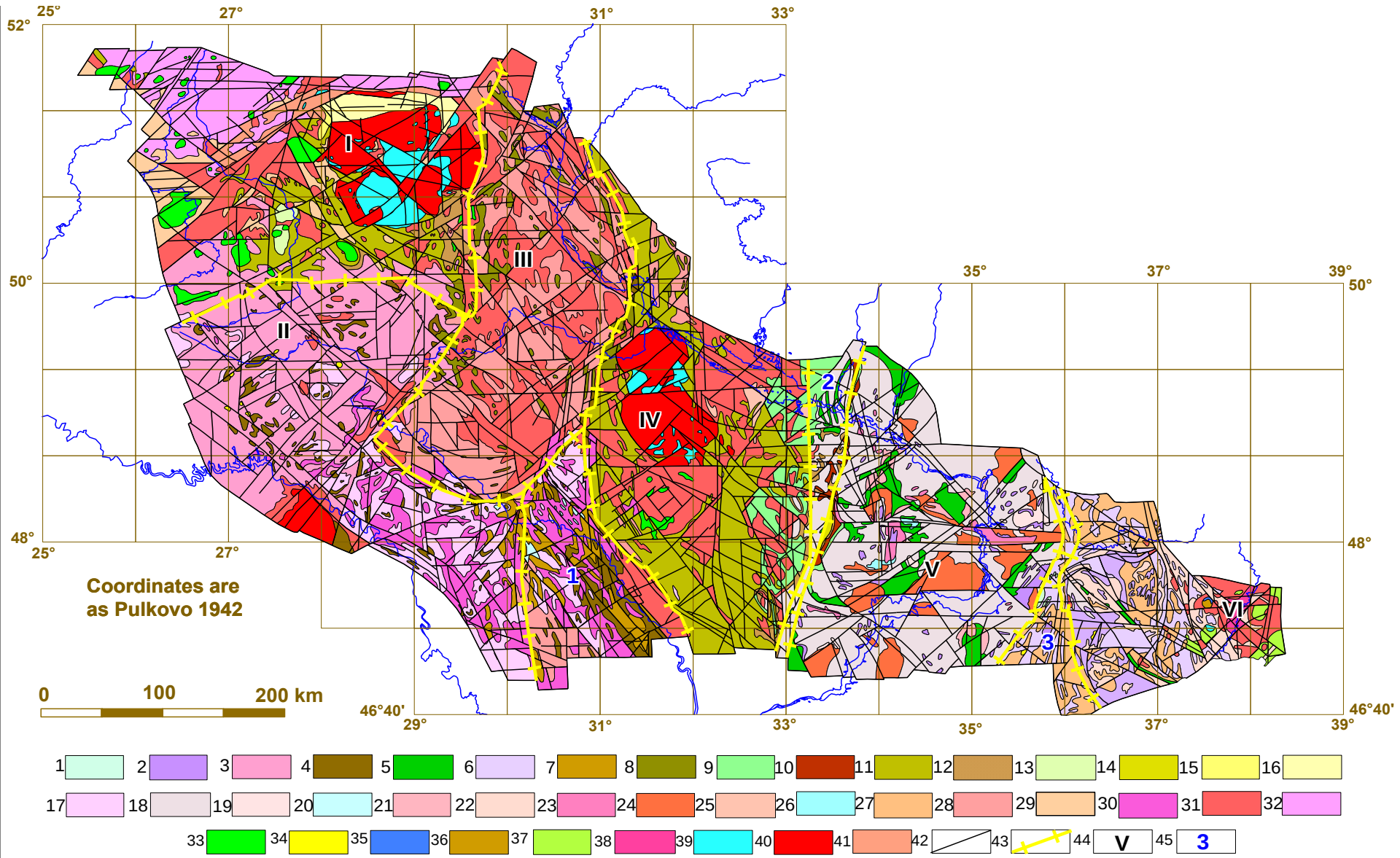


Figure 1. Schematic geological map of the crystalline basement of the Ukrainian Shield

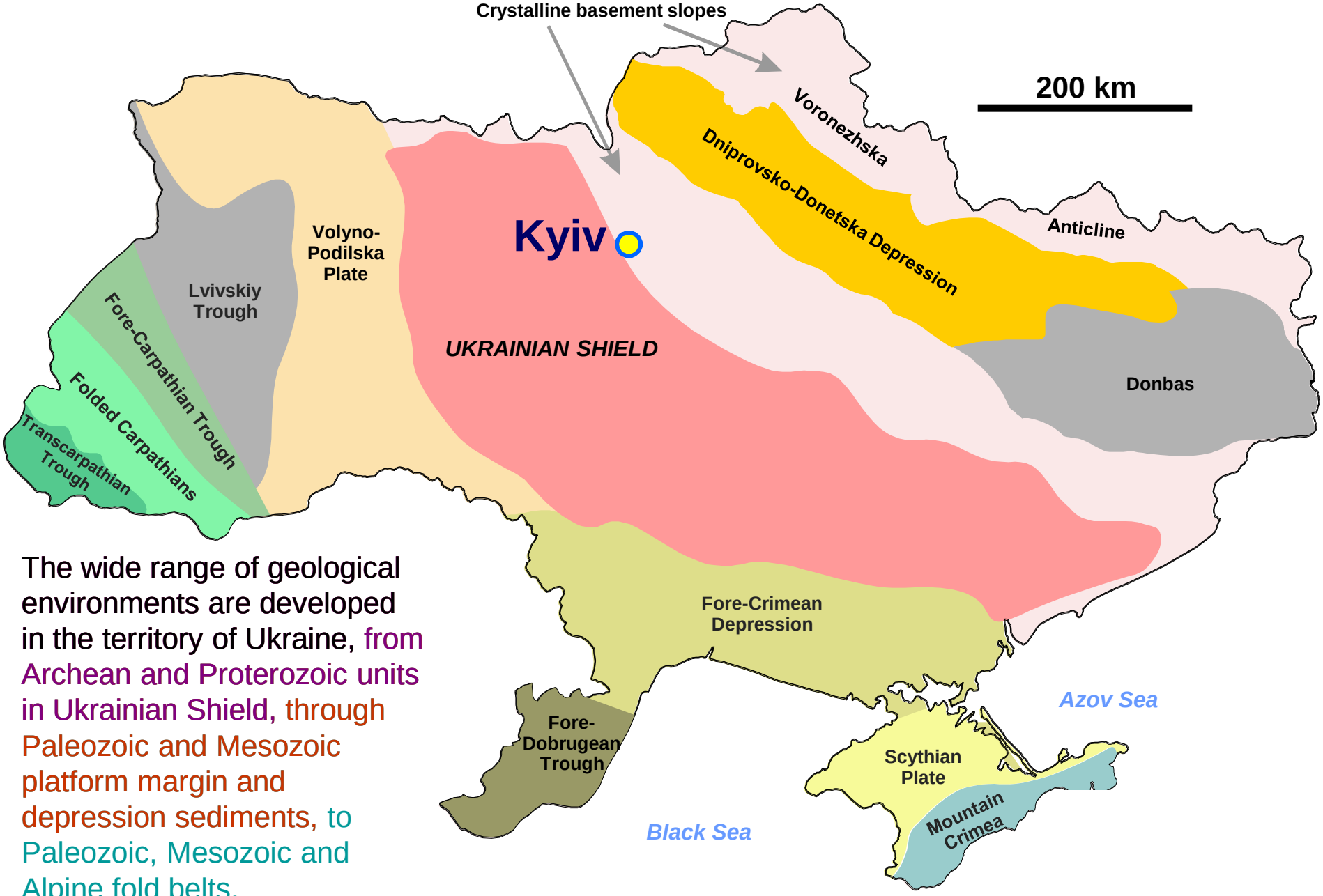
Legend to Fig. 1.

Supracrustal strata and series:1 – Tovopavlivsk stratum and complex (bimodal - ultramafites and tonalites, crystalline schists and gneisses of appropriate composition) (> 3.65 billion years) 2 – western Azov series (crystalline schists and gneisses of granulite and high-temperature parts of amphibolite facies) (Paleoarchean); 3 – Aulska series (amphibolites, meta-ultramafites, crystalline schists and gneisses (amphibolite facies within Slavgorodskaya block - granulite facies); 4 – Dniester-Bug series (crystalline schists and gneisses of granulite facies) (> 3650 m.y.); 5 – Konkska and Verhivtsevska series (the latter is only within Verhivtsevska structure) - metavolcanic formation (metakomatiites, komatiites and tholeiites metabasalts, in subordinate quantities - metadacites, metarhyodacites and metarhyolites; the less terrigenous formation (metasandstones, metasiltstones, metaconglomerates, apoclay shales, ferruginous quartzites) (green shales and epidote-amphibolite facies, in the Azov Region - epidote-amphibolite, amphibolite to granulite facies) (3200-2980 m.y.); 6 – Central Azov series - crystalline schists and gneisses (mainly biotite), quartzites (granulite and amphibolite facies) (Neoarchean); 7 – Bug series - highly aluminous, pyroxene, biotite, graphite gneisses; calciphyres, marbles, ferruginous quartzites, barren quartzites, mafic crystalline schists (granulite facies) (Neoarchean 2800-2560 m.y.); 8 – Rosinsko-Tikytska series (gneisses and biotites and biotite-amphibole crystalline schists, amphibolites, occasionally ferruginous quartzites (only in Belotserkivsk and Volodarsk blocks) (amphibolite facies) (2800 m.y.); 9 – Novokryvorizka suite of Kryvyi Rig series - meta-andesite-basalts and meta-andesites (epidote-amphibolite facies) and Zelenorichenska suite of Ingul-Ingulets series (amphibolite to granulite facies) (Paleoproterozoic); 10 – Saksagansky suite Kryvyi Rig series (epidote-amphibolite facies) and Artemivska suite of Ingul-Ingulets series (amphibolite facies) (Paleoproterozoic); 11 – Vilna and Horodska suites of Teteriv series (epidote-amphibolite facies), Spasivska and Checheliyivska suites (amphibolite facies), Kam'yano-kostovatska and Roschahivska suites (granulite facies within the Bratsk synclinorium) - mainly biotite and garnet-biotite gneisses (Paleoproterozoic); 12 – Kocherivska suite of Teteriv series, Rodionovskaya suite of Ingul-Ingulets series, Hdantsivka suite of Kryvyi Rig series - mainly calciphyres, marbles, limestones, gneisses, schists, barren quartzites, conglomerates (Rodionovskaya - amphibolite facies, Teterevsky - epidote-amphibolite to amphibolite facies, Kryvyi Rig - greenschist and epidote-amphibolite facies) (Paleoproterozoic); 13 – Novograd-Volyn stratum - mostly neutral and acid metavolcanics (epidote-amphibolite facies) (2430 m.y.); 14 – Hleyuvatska suite - metasandstones, metaconglomerates, schists (greenschist facies) (Paleoproterozoic); 15 – Topilnyanska series - sandstones, shales (pre-greenschist facies) (1980-1800 myr); 16 – Ovruchskaya series - basic, neutral and acid volcanics (Zbrankivska suite) (1740 m.y.) and the quartzite stratum with interbedded pyrophyllites and clay shales (pre-greenschist and greenschist facies) (1700-1600 m.y.).

Ultrametamorphic and intrusive-magmatic complexes: 17 – Gayvoronsky complex - enderbites (3650-3400 m.y.); 18 – plagiomigmatites and plagiogranites of Dnepropetrovsk complex (Paleoarchean); 19 – tonalities and diorites of Dnepropetrovsk complex (Paleoarchean); 20 – stratified mafic and ultramafic intrusions, genetically related to mafic and ultramafic volcanic rocks of the greenstone structures (3150-3000 myr); 21 – Sursky complex - intrusive plagiogranites and tonalites, genetically related to acid volcanic rocks of the greenstone structures; 22 – Shevchenko complex - plagiogranites and granodiorites (2800 m.y.); 23 – Saksagansky complex - leucocratic aplite-pegmatoid plagiogranites (post greenstone) (2980-2900 m.y.); 24 – Demurynsky, Tokovsky and Mokromoskovsky complexes - essentially microcline subalkaline postkinematic doublefeldspar granites (2860 m.y.); 25 – Inguletsky complex - plagiogranites and plagiomigmatites (Mesoarchean, parallelize with Saksagansky complex); 26 – Captain-Derenyuhynsky complex - ultrabasites and basites (Neoarchean); 27 – Obitochnensky complex - diorites, granodiorites, plagiogranites (Paleoproterozoic); 28 – non stratified Tetievsky (Neoarchean) and Zvenigorod (Paleoproterozoic – 2140 m.y.) complexes - granodiorites, plagiogranites, biotite-amphibole and biotite plagiomigmatites; 29 – Sheremetiv complex - plagiomigmatites (Paleoproterozoic); 30 – Pobuzky complex - aplite-pegmatoid biotite leucogranites (Paleoproterozoic); 31 – Berdichevsky complex - garnet-biotite, sillimanite-garnet-biotite, orthopyroxen-garnet-biotite (vinnicite) granites and migmatites, sometimes with cordierite (2080–1980 m.y.); 32 – Zhytomyrsky, Khmelnitsky, Stavischanskaya, Umansky, Kirovogradsky, Anadolsky complexes - biotite, doublemica, garnet-biotite doublefeldspar granites (2060–2020 m.y.); 33 – осницький комплекс (з рештками клесівської серії – метавулканіти основного, середнього та кислого складу) – granodiorites, essentially microcline subalkaline granites (1980 m.y.); 34 – Bukynsky and Novoukrainskiy stratified multiphase complexes of postkinematic intrusions (gabbronorites, monzodiorites, monzonites, quartz monzonites, granodiorites, granites) (2060–1980 m.y.); 35 – intrusive complexes of alkaline rocks and carbonatites - Chernigovsky, Proskurivsky, Malotersyansky (2060–2000 m.y.); 36 – Oktabrsky alkaline intrusive complex - ultramafic and mafic rocks; 37 - Oktabrsky alkaline intrusive complex - alkaline syenites, nepheline rocks (1790 m.y.); 38 – Pivdennokalchytsky complex - gabbro-syenites, syenites, granites (1790 m.y.); 39 – Kamyanomohylsky complex - subalkaline leucogranites (1790–1800 m.y.); 40 – Korostenskyj and Korsun-Novomyrgorodsky complex - gabbronorites, anorthosites (1800-1760 m.y.); 41 – Korostenskyj and Korsun-Novomyrgorodsky complex – rapakiwi granites (1770 m.y.); 42- Perzhansky complex - alkaline and subalkali leucogranites (1760 m.y.); 43 – deep faults; 44 – megabloks boundaries; 45 – Roman numerals – **megabloks/domeins**: I – Volyn, II – Dniester-Bug, III – Rosinsko-Tikytsky, IV – Ingulsk, V – Middle Dnieper, VI – Azov; 46 – blue Arabic numbers – **interblock suture zones**: 1 – Golovanivska, 2 – Kryvorizko-Kremenchutska, 3 – Orikhivsko-Pavlogradska.

Ukrainian Shield

separation into blocks and a major gold deposits that are available to studying during excursions



The wide range of geological environments are developed in the territory of Ukraine, from Archean and Proterozoic units in Ukrainian Shield, through Paleozoic and Mesozoic platform margin and depression sediments, to Paleozoic, Mesozoic and Alpine fold belts.

Mineral Foreword

Under Ukrainian law, all the country's mineral resources are the property of Ukrainian people and being managed by the State.

The State Geological and Subsurface Survey of Ukraine is responsible for monitoring mineral resources and compiling the mineral inventory – the State Balance of Mineral Reserves and Resources (State Inventory).

Increases in reserves and resources based on exploration, as well as those written off in the course of production, are recorded on an annual basis.

Recently Ukrainian Parliament has approved the Law of Ukraine N 3268-VI of April 21, 2011 "On approval the Whole-State Program for development the mineral resource base of Ukraine up to the year 2030".

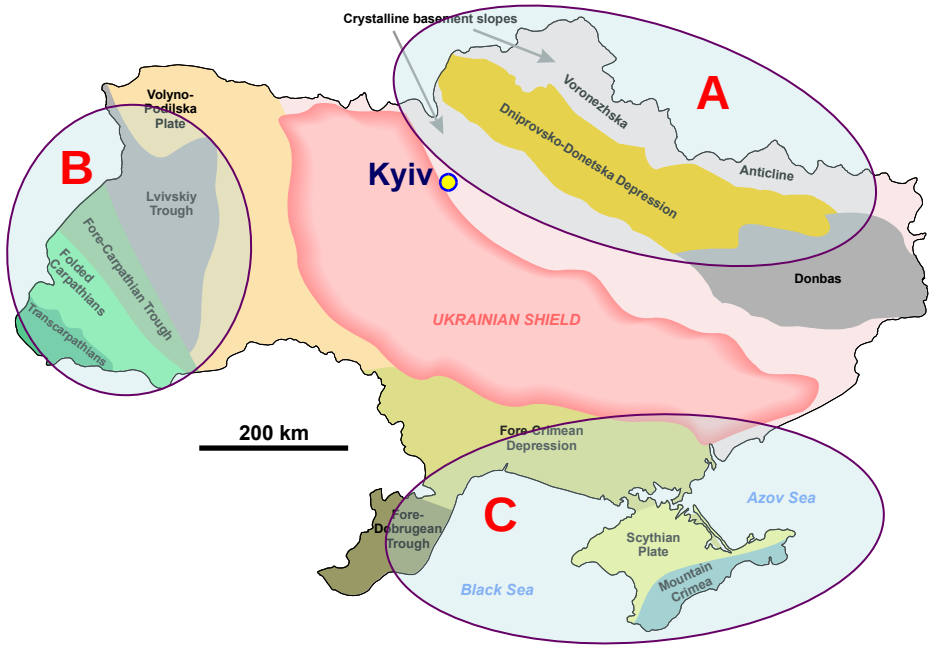
Scope

In the following review the main mineral commodities, which are of particular importance to the Ukrainian economy, are described with their figures recorded by January 1, 2011.

These will include:

- Energy Resources
- Ferrous metals
- Base metals
- Rare and rare-earth metals
- Precious metals
- Other minerals

Energy Resources. Oil & Gas 1/3



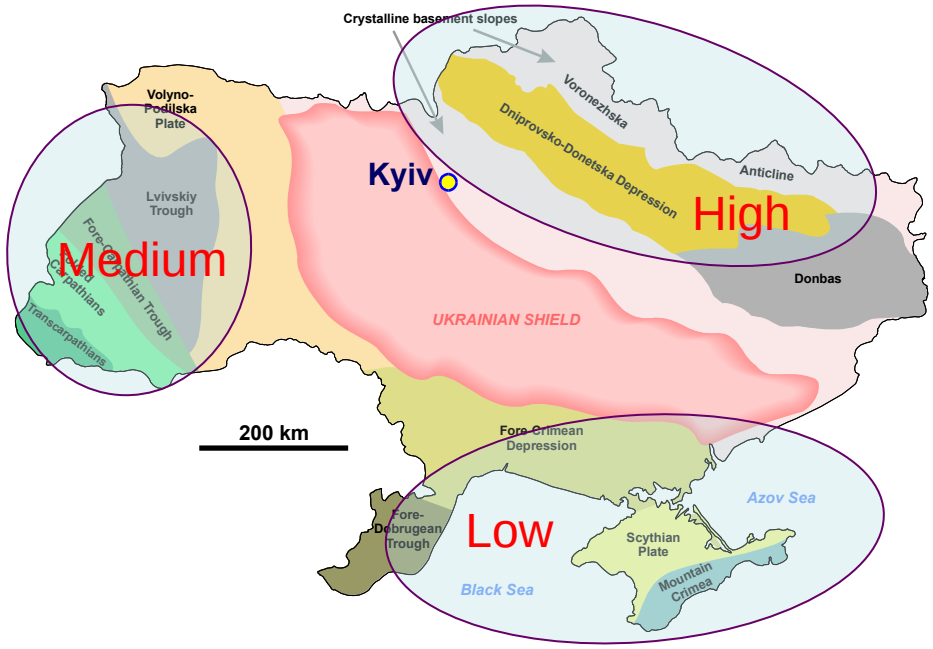
Four oil and gas provinces are recognized in the country, including 11 oil-gas basins and 35 prospective areas. Hydrocarbon deposits are being exploited for oil, gas, and condensate in the following regions:

- **A** – the Eastern Region (Dniprovsko-Donetska Depression and northwestern portion of Donbas);
- **B** – the Western Region (Volyno-Podilska Plate, Fore-Carpathians, Folded Carpathians, and Trans-Carpathians);
- **C** – the Southern Region (Prychornomorya, Crimea, and the exclusive marine economic zone of the Black Sea and Azov Sea offshore).

Energy Resources. Oil & Gas 2/3

In 2010, production amounted to 3 million tons of oil, 1 million tons of condensate, and 21 billion cubic meters of natural gas.

The State Inventory includes 178 oil deposits (114 in production), 193 condensate deposits (127 in production), and 298 natural gas deposits (167 in production).



Proven and probable reserves are estimated to:

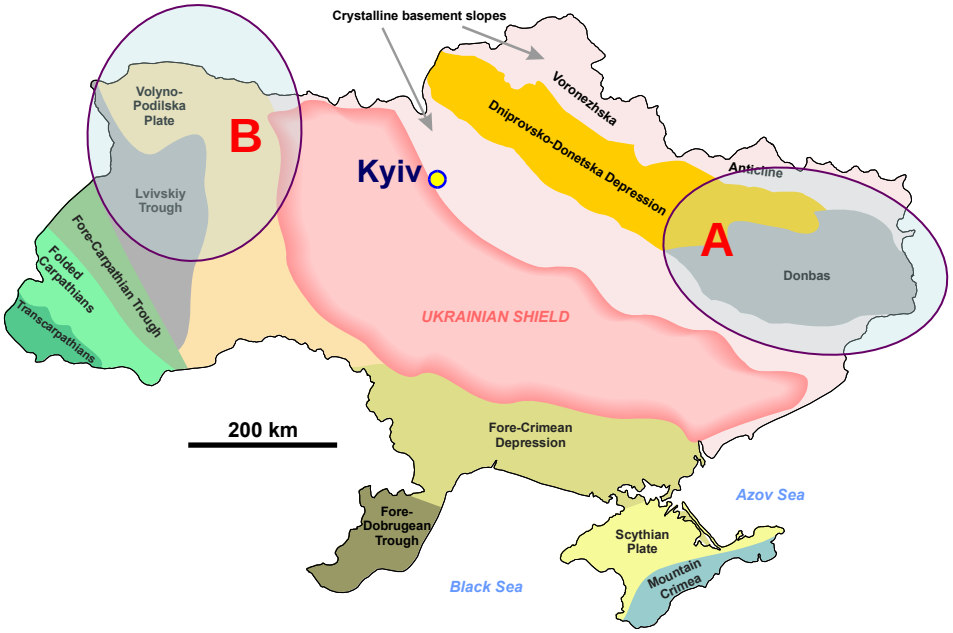
- 140 million tons of oil
- 60 million tons of condensate
- 1.1 trillion cubic meters of natural gas

Energy Resources. Coalbed Methane

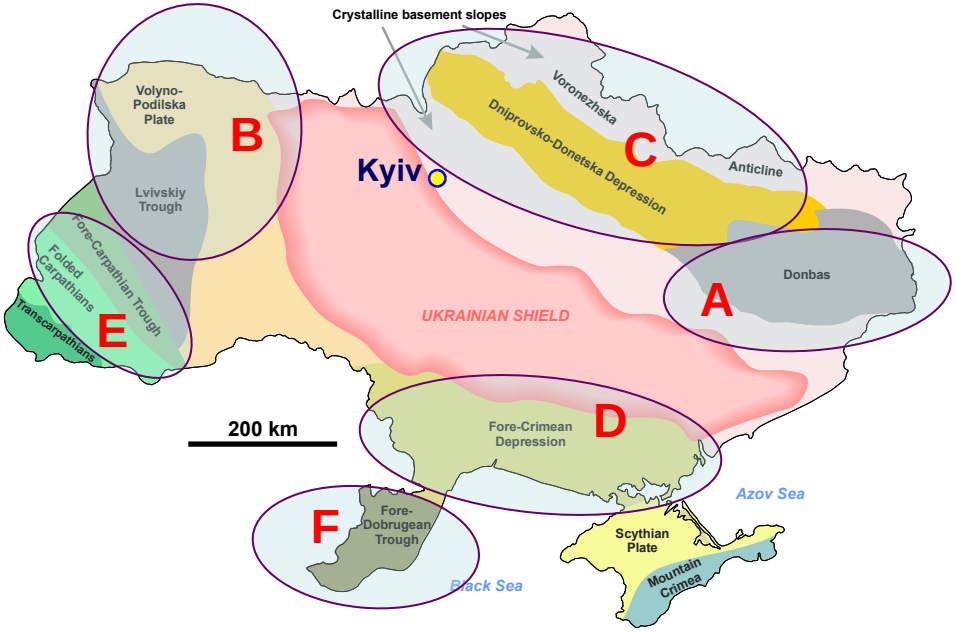
This is potentially an important non-conventional additional hydrocarbon resource confined to coal deposits in the Donetskiy (**A**) and Lvivsko-Volynskiy (**B**) coal basins.

The State Inventory comprises 186 deposits, of which 95 are in production. Proven and probable reserves of methane are estimated at 300 billion cubic meters.

In 2010, production totaled to 600 million cubic meters of methane.



Energy Resources. Shale Gas



Non-conventional shale gas resources are not recorded yet in the State Inventory being preliminary estimated to some trillions of cubic meters.

Up to recent no research and practical exploration were conducted in Ukraine.

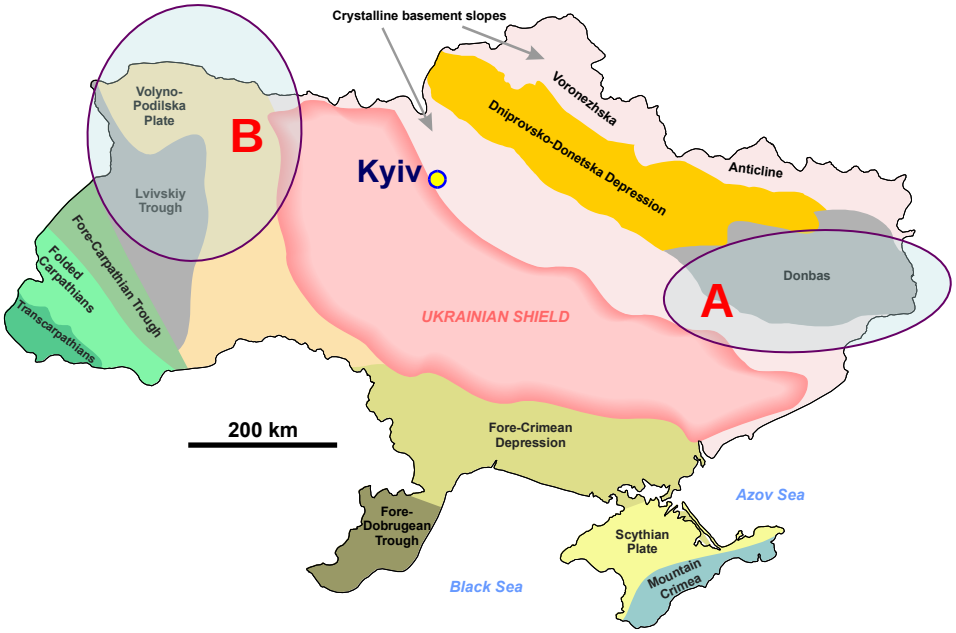
Nevertheless, reconnaissance studies commenced last year in Donetskiy (**A**) and Lvivsko-Volynskiy (**B**) coal basins as well as Dniprovsko-Donetska (**C**) and Prychornomorska (**D**) depressions and Fore-Carpathian (**E**) and Fore-Dobruja (**F**) troughs (fold belts).

Energy Resources. Coal

The State Inventory contains 970 deposits with proven and probable reserves, located in Donetskiy (**A**) and Lvivsko-Volynskiy (**B**) coal basins, of which 375 are being exploited by underground mining by various owners.

Ukraine's proven and probable coal reserves are estimated at 56 billion tons.

In 2010, production totaled to 48 Mt.

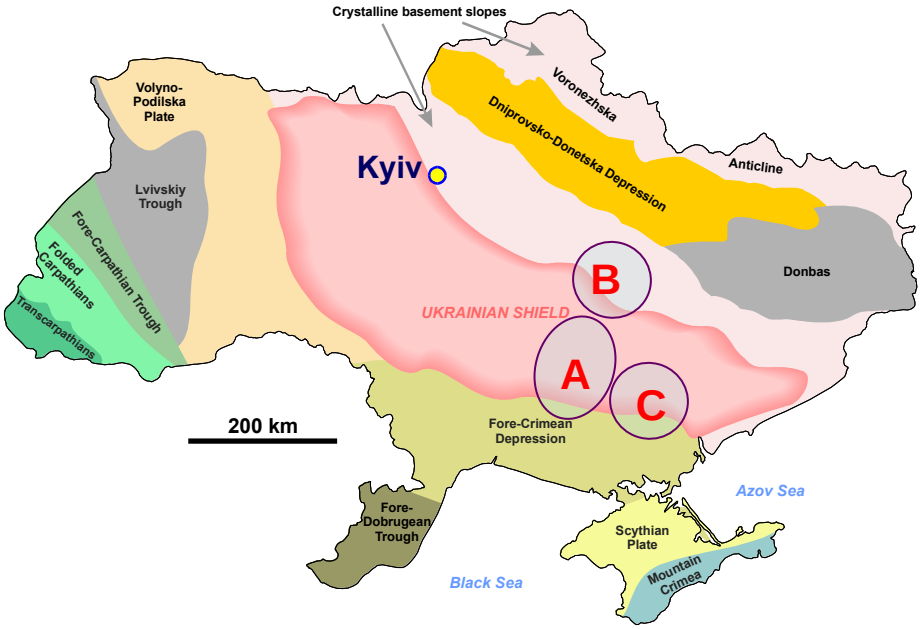


Energy Resources. Uranium

The State Inventory comprises 17 deposits of which 4 are in production. The bulk of reserves is confined to **major** large-tonnage deposits hosted in Precambrian sodium metasomatites of Ukrainian Shield.

The **minor** uranium deposits are contained in Palaeogene coalifirous sediments.

Ferrous Metals. Iron Ore



In 2010, iron-ore production totaled 148 Mt. The State Inventory includes 57 deposits, of which 22 are in production.

Rich ores are being mined in deposits within the Kryvorizkiy (**A**), Kremenchutskiy (**B**), and Bilozerskiy (**C**) basins.

Ukraine possesses an estimated 6% of the world's iron-ore reserves and up to 30% of iron-ore resources in the CIS countries.

Proven and probable reserves are estimated as 31 billion tons (13 billion tons in production areas).

Ferrous Metals. Manganese Ore

Ukraine produced 3 Mt of manganese ore in 2010 and ranked first amongst CIS countries in terms of reserves and production (75% of reserves and 86% of production).

The major producers operate in South-Ukrainian manganese ore province (**A**) and produce manganese concentrate and agglomerate for ferroalloy and metallurgical plants. They supply not only Ukrainian industry but also export their products to various countries.

The State Inventory comprises 5 deposits of which 2 are in production. Proven and probable reserves are estimated at 2,400 Mt (172 Mt in production).

Ferrous Metals. Chrome Ore

The State Inventory includes two complex ore deposits, one of which is in production.

Output in 2010 totaled 1,800 t of ores containing 411 t of Cr_2O_3.

Proven and probable reserves are estimated at 1.6 Mt containing 384,416 t of Cr_2O_3.

There are no new deposits currently being prepared for commercial mining although considerable potential exists in respect of the chromite-bearing ultramafic bodies in Pobuzhzhya (**A**), where the Kapitanivske deposit has undergone preliminary evaluation.

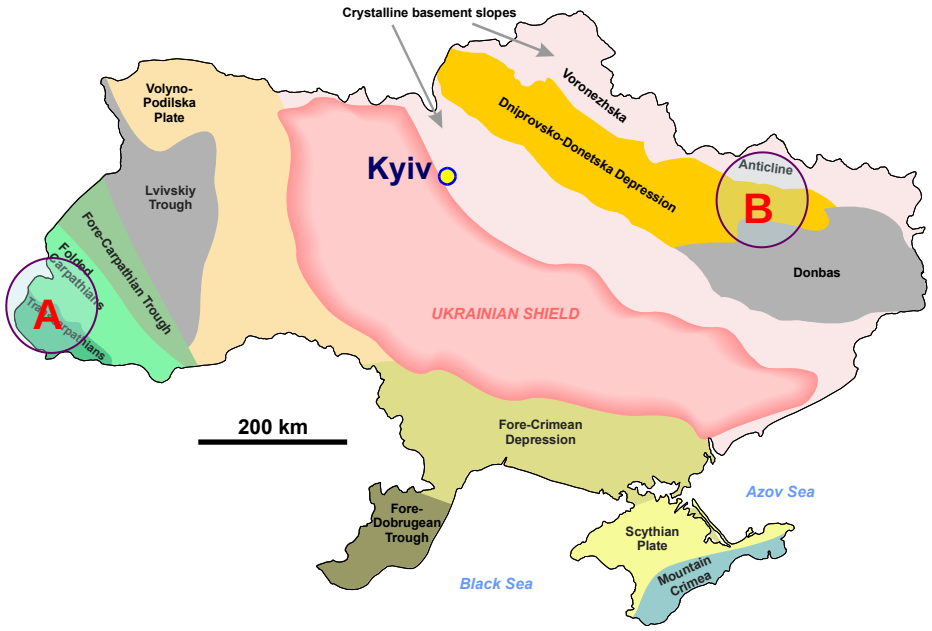
Base Metals. Aluminum

According to preliminary feasibility studies, potential resources of Al-bearing ores exist at a number of locations, eg, ferruginous bauxites such as the Vysokopilske deposit in the Dnipropetrovska region (**A**), nepheline ores in Pryazovya (**B**), and alunites and kaolin in the Trans-Carpathians (**C**).

However, none of these can be processed economically using current technologies.

The State Inventory contains one deposit with ore proven and probable reserves of 19 Mt.

Base Metals. Lead & Zinc



There is no primary lead or zinc production in the Ukraine at the present time although there are a number of potential projects.

The most prospective are considered to be the Biganske complex alunite-barite-polymetallic deposit in the Trans-Carpathians (**A**), and the Bilyaivske deposit in the Kharkivska region (**B**).

In total, the State Inventory includes 4 complex deposits (one in production), with proven and probable reserves of 40 Mt of polymetallic ore, including 302,000 t of lead and 724,000 t of zinc.

Base Metals. Titanium

The resource base includes 24 deposits of which 7 are either in production or at the exploration/development stage.

Ilmenite concentrates are being produced at the Irshanskiy plant in Zhytomyrskiy region (**A**), and at the Vilnogorskiy plant in Dnipropetrovska region (**B**). Both are state-owned enterprises, and their combined capacity reportedly corresponds to about 20% of worldwide ilmenite concentrate production.

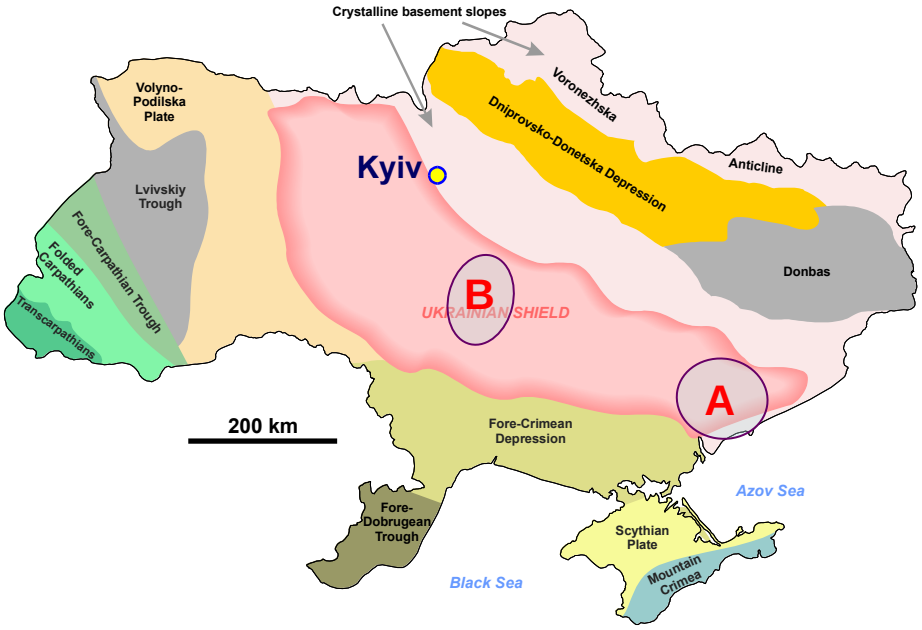
The operations supply all of Ukraine's domestic titanium needs and also provide significant export sales.

Rare Metals. Lithium

Ukraine possesses considerable reserves and resources of lithium and, recently, the Shevchenkivske lithium deposit in Zaporizka region (**A**) has been prepared for commercial production.

A preliminary feasibility study for the Polokhivske lithium deposit in Kirovogradska region (**B**) has also been prepared.

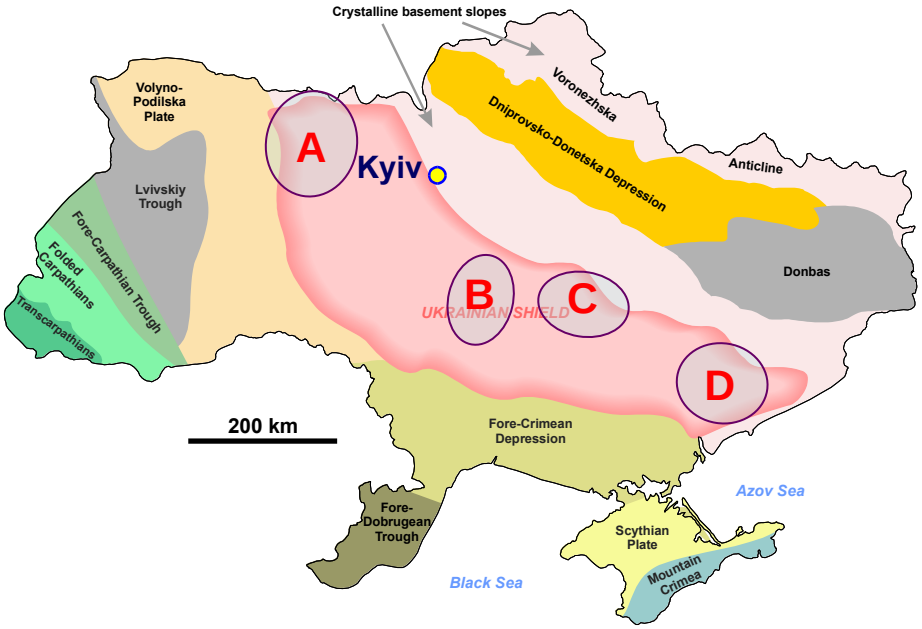
Both deposits are considered to be economic but the latter seems to be more attractive for mining.



Rare Metals. Tantalum and Niobium

Significant tantalum-niobium resources occur in the northwestern part of the Ukrainian Shield (**A**), as well as in the Kirovogradskiy (**B**) and Pryazovya regions.

The Pryazovya deposits have been studied in most detail. They have sufficient reserves and resources, and also display suitable mining and hydrogeological conditions. Commercial mining of these deposits, however, would require complex treatment as the ores also contain zirconium, nepheline and feldspar.



At present, tantalum and niobium are produced from the Malyshevske deposit (**C**) in Dnipropetrovska region by the Vilnogorskiy mining-metallurgical plant.

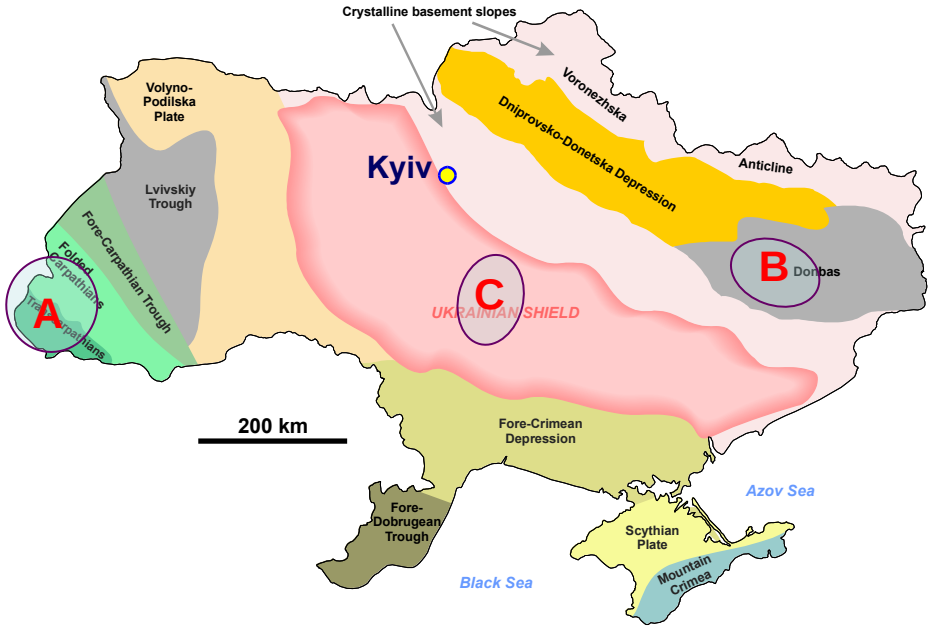
In the Donetska region, the Mazurivske deposit (**D**), located close to the Donetskiy chemical-metallurgical plant, has been studied in some detail and preparations for commercial mining are in progress.

Rare Metals. Zirconium and Hafnium

The Vilnogorskiy mining-metallurgical plant is the principal enterprise and produces zirconium concentrates and products, exploiting substantial reserves at the Malyshevske placer deposit (**A**).

The State Inventory accounts 1 hafnium deposit (in production). Proven and probable reserves estimated to 6 Mt of hafnium oxide, measured and indicated resources – 33 Mt of hafnium oxide. In 2010 production totaled to 476 tons of hafnium oxide.

Precious Metals. Gold and Silver 1/2



At present there are three gold deposits prepared for commercial production located in three gold provinces: the Carpathians (**A** – Muzhyivske deposit); the Donbas (**B** – Bobrykivske deposit); and the Ukrainian Shield (**C** – Klyntsivske deposit).

The first two deposits are already being mined.

Also, there are a number of prospective gold deposits distributed throughout the country and exploration is delineating substantial resources that are expected to be developed in the near future.

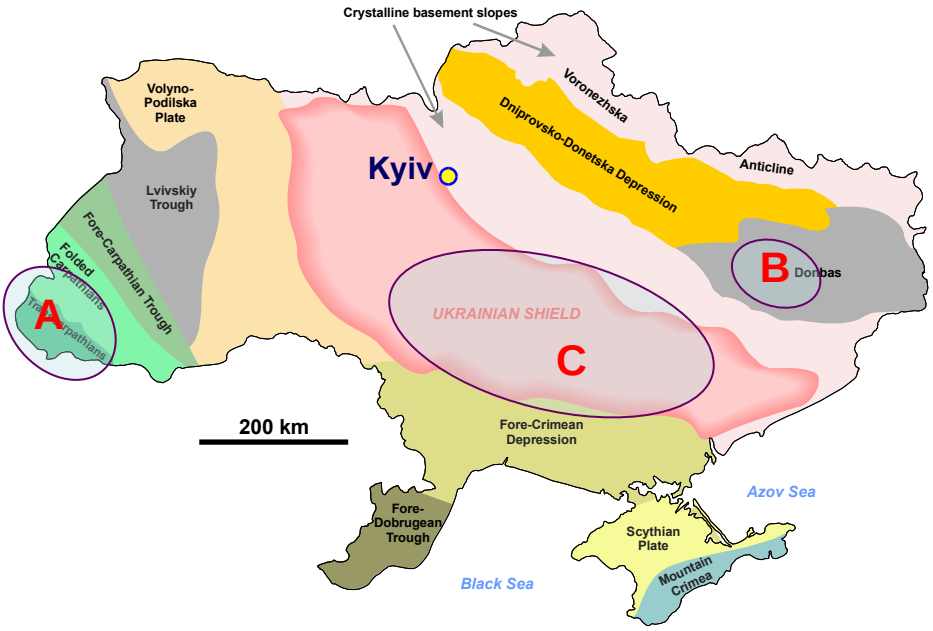
Ukraine's total gold resource potential is estimated at 3,200 t (100 Moz).

Precious Metals. Gold and Silver 2/2

The Carpathian region (**A**) has been explored in most detail and contains the Saulyakske as well as the Muzhyivske deposit. According to preliminary estimates, the total Carpathian resource is about 400 t of gold and 5,500 t of silver.

Total inferred resources in the Donbas region (**B**) are estimated at 400 t of gold. The small Bobrykivske gold-sulphide deposit is being developed by the Nagolniy Kryazh enterprise.

The Ukrainian Shield (**C**) is the most important gold province and the total inferred resource is estimated at about 2,400 t. To date, seven deposits have been studied in details: Maiske, Klyntsivske, Yuriivske, Sergiivske, Balka Zolota, Balka Shyroka, and Surozke. They contain a total resource estimated at 620 t (20 Moz).

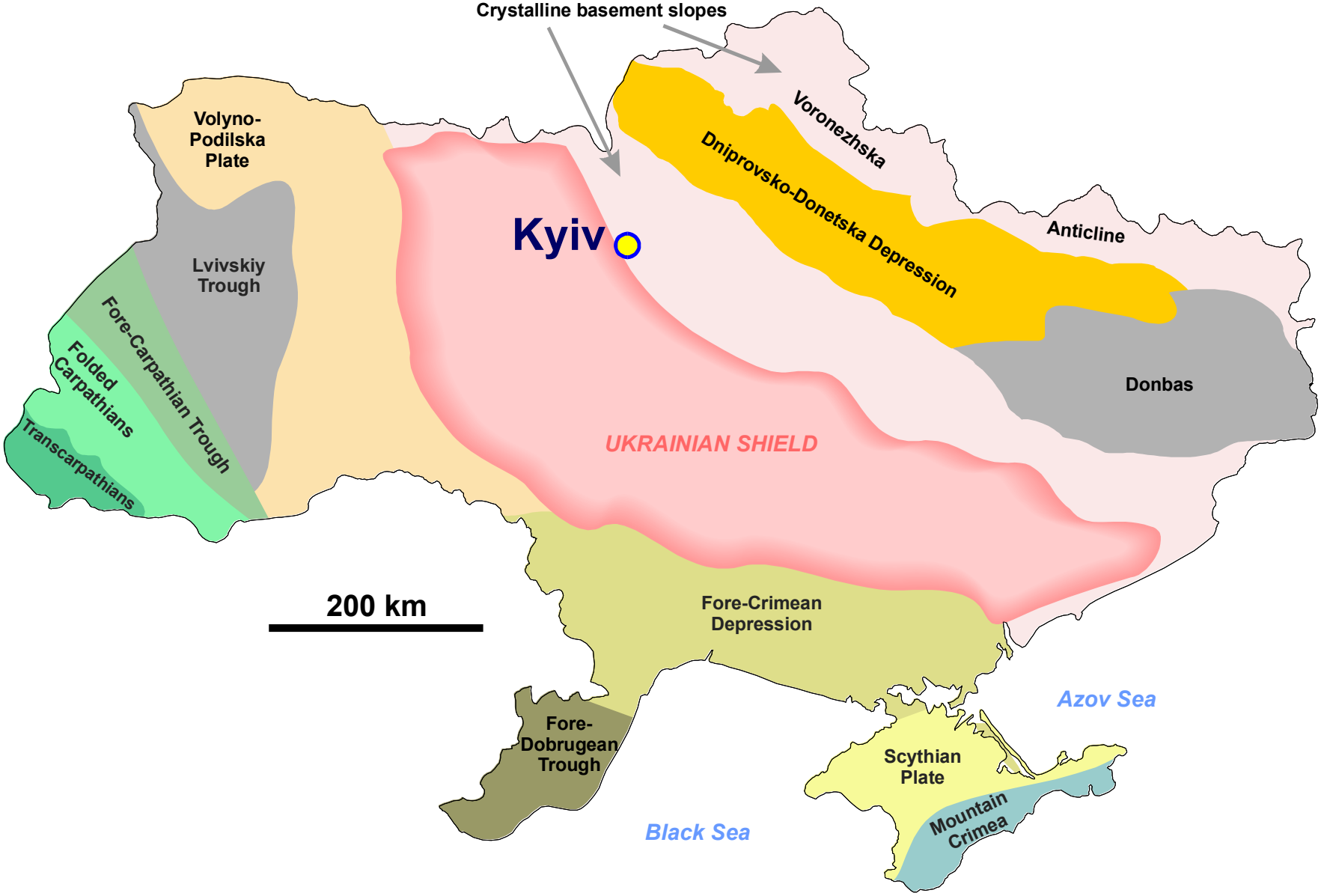


Other Minerals

Other Ukrainian minerals include non-metallic diamond prospects (Volyno-Podilska Plate, Pryazovya).

The State Inventory also accounts deposits of industrial raw materials – fluorspar, flux limestones and dolomites, bentonite clays, magnesite, high-alumina rocks, fertilizer (apatite, phosphorites, native sulfur, potash), kaolin, glauconite, barite, gemstone, as well as a range of various construction raw materials (dimension stones, aggregates, construction sand, loam, clay), etc.

In addition, Ukraine is rich enough in groundwaters which comprise 40-80% water supplying for inhabited localities and technical needs.


Crystalline basement slopes
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