

Museum of kimberlites of Yakutia

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Savrasov, D. 1998. Museum of kimberlites of Yakutia. - *Geologica Balc.*, 28, 3-4; 125-128

Key words: kimberlite, diamonds, xenoliths, Yakutia

Introduction

The Museum of kimberlites of the stock company "Almazy Rossii-Sakha" Co. Ltd located in the town of Mirny of the Sakha (Yakutsk) Republic has been constructed over forty years. The Museum has on display collections of kimberlite rocks from 500 pipe, dike and vein bodies found in west Yakutia from 1954 to 1998. The most representative collections are from explored and mined diamond deposits, among them pipes Mir, Sytykanskaya, Aikhal, Zarnitsa, Yubileinaya, Botuobinskaya. The exposition includes following varieties of kimberlite rocks.

Kimberlites proper

Kimberlites are deep-seated magmatic rocks of peralkaline composition that form separate stock, dike and vein bodies, or cement of kimberlite breccias. The principal rock-forming minerals in them are olivine (or serpentine pseudomorphs after olivine), calcite, mica, ilmenite, garnet (pyrope), chrome-diopside, apatite. Many varieties of kimberlite proper are recognized depending on structure, texture, content and shape of rock-forming and accessory minerals. The most typical varieties from large kimberlite pipes are displayed in the Museum.

Kimberlite tuffs and tuff breccias

Blocks in some large pipe bodies, the pipe "Mir" included, are composed of kimberlite tuffs. They are characterized by homogeneous crystal-clastic structure and, as a rule, higher concentration of garnet-

pyrope. The amount of clastic material varies from 40-50% in tuffs to 70-80% in some varieties of tuff breccias. The clasts are chiefly represented by pseudomorphs after olivine. Cementing mass consists of fine grained aggregate of serpentine and olivine. The pipe "Mir" is characterized by exclusive diversity of such formations. Tens of varieties of these formations are on display in the Museum.

Kimberlite breccias

All known diamond deposits are mainly composed of kimberlite breccias, i.e. rocks which in addition to kimberlite proper, also contain a great quantity of inclusions of xenogenic rocks evacuated by kimberlite magma from different horizons of the Earth's crust. The concentration of clasts of foreign formations may be as much as 80-90% of the total bulk of kimberlite breccias.

Kimberlite breccias are rather dissimilar in texture and structure, petrological composition and amount of clastic material, the degree of deuteritic alteration and tints. There are bluish and greenish breccias with light to dark tints, there are brown, dark-brown or even almost black breccias. Each kimberlite pipe is characterized by rock of peculiar tints of different colours. There is scarcely any kimberlite body similar to another one in all generic features. Large kimberlite pipes are commonly composed of several varieties of kimberlite breccias and tuff breccias originated at different periods of pipe bodies formation. Over ten types, subtypes and varieties of kimberlite breccias from pipes "Mir", "Zarnitsa", "Sytykanskaya", "Udachnaya" are held in expositions of the Museum.

Xenoliths of sedimentary rocks

Kimberlite breccias contain almost the entire range of formations of the platform sedimentary cover broken by kimberlite volcanoes: limestones, dolomites, argillites, siltstones, sandstones, as well as their silicified and marbled varieties. Clasts of hard rocks less subject to destruction in the process of transportation are, of course, most common.

Inclusions of sedimentary rocks can vary in size from microscopic to tens of centimeters and even to several meters in diameter. Very large xenoliths are called "floating reefs". The latter mainly occur near contacts of kimberlite bodies. Small xenoliths are often altered, the original minerals being replaced by kimberlite minerals. Secondary-magnetite and iron-hydroxide fringes occur along the periphery of some xenoliths, holes in them may be filled in by quartz, calcite, gypsum or sulphides. Nice coloured tracers often occur in sections of silicified xenoliths. A brachiopod fauna was found in limestone xenolith from the pipe "Zarnitsa", in a layer of sedimentary rock mass already destroyed by erosion.

Crustal xenoliths

Clasts of rocks of the platform crystalline basement occurring in areas of manifestation of kimberlite magmatism at depths from 1.5 to 3 km have been recorded almost in all large pipes and sometimes in smaller bodies as well. These are micaceous and garnet gneisses and plagiogneisses, clastalline schists, anorthosites, amphibolites, granitoid rocks. Clasts of the crustal layer are normally smaller in size and more rounded than inclusions in rocks of the sedimentary mantle. But in some pipes there occur nodules of crystalline rocks weighing as much as 20-30 kg; they are also kept in the collections of the Museum. Small xenoliths of crystalline rocks are usually altered one way or another. But in large xenoliths only peripheral parts were subject to alterations. But their centers underwent neither heating nor the action of hydrothermal solutions. They may be used in the study of physical structure and petrology of the lithosphere as deep as 50-70 km. Judging by the diversity of petrological composition, mineralogy, petrography and physical properties of inclusions of metamorphic rocks, the crystalline basement of the Siberian Platform and the Earth's crust as a whole are of very composite structure.

Mantle xenoliths

Inclusions of deep ultrabasic rocks occur in all explored kimberlite pipes. There is a reason to think that a major portion of these inclusions was transported from the layers of the upper mantle where

kimberlite magma originated. According to the recognized estimate of scientists, these are depths of about 150-250 km, where the pressure may be as much as 30.000-40.000 atm. Varieties in which mineral associations could occur only under such pressure have been recorded among xenoliths of parent ultrabasic rocks. These are the so called bimineraleclogites consisting of garnet-pyroxene and pyroxene (omphacite).

Apart from eclogites, various garnet peridotites and pyroxenites, lherzolites, websterites, dunites have been found among abyssal inclusions. For instance, in the pipe "Sytykanskaya" there are tens of varieties only of garnet peridotites differing in appearance, content of garnet-pyroxene, the size of its grains and their arrangement in cementing mass.

As a rule, abyssal inclusions are small, to 10-15 cm across. Rarely there occur large eclogite nodules weighing as much as 5-7 kg and garnet peridotites weighing as much as 15-20 kg (such samples are kept in the Museum). Very small inclusions of abyssal rocks are also rare, for they cannot survive in the process of transporting but dissolve in the kimberlite substrata.

The major portion of abyssal inclusions in kimberlites are substantially altered. Primary minerals, olivine and pyroxene, are replaced by serpentine, carbonate and calcite, garnets are heavily fissured and covered by kelyphitic rims. Slightly altered abyssal xenoliths occur only in kimberlite bodies in the north of the diamondiferous province (pipes "Obnazhennaya", "Ruslovaya", "Slyudyanka"). Rare findings of "fresh" eclogites and garnet peridotites have been registered even in pipes "Udachnaya" and "Zarnitsa".

Xenoliths of deep rocks in pipes almost without exception occur separately; they are apparently arranged rather evenly in kimberlite. But in pipes "Mir" and "Udachnaya" there were blocks of kimberlite breccias overfilled with diverse mantle inclusions. Their origin is not understood, there is no scientific explanation to this phenomenon yet. Large samples of such formations are available in the collections of the Museum.

Minerals - indicators of diamonds

Many samples of the Museum collections contain minerals formed synchronously with diamonds. They are called minerals-indicators. Among them are garnet-pyroxene, zircon, picroilmenite, chrome-diopside, chrome-spinellids. In the collections of the Museum there are samples of kimberlite rocks with segregations of blood-red pyroxene to 4-5 cm across, nodules of jet-black picroilmenite to 6-7 cm across, bright-emerald grains of chrome-diopside and spinel. Aside from separate grains even larger aggregates of these minerals have been recorded. Minerals-indicators stand out sharply against light kimberlite breccias because of their garish colour.

Large grains of light-green olivine to 10 mm in size are contained in kimberlite samples from some of the pipes. Olivine is not an accessory mineral of diamonds but it also was generated at great depths. Samples of garnet olivinites occurring in some pipes in the north Yakutsk diamondiferous province are especially effective.

Xenoliths of basic rock

Abundant xenoliths of rocks of the trappe formation occur in pipes of some kimberlite fields. In such areas kimberlites were apparently in the vicinity of chambers of trappe magma outflows. If the introduction of trappe intrusions had proceeded the emergence of kimberlite volcanoes, the latter broke trappe bodies occurring at different depths and transported fragments of these bodies along with other rocks of the lithosphere.

The activation of trappe magmatism took place in the Siberian Platform at different periods of the geological history, and therefore the lower age boundary of kimberlite magmatism can be inferred by the presence and petrochemical features of basite rock inclusions, kimberlite samples with inclusions of trappes from intrusions of Middle Paleozoic (Devonian-Carboniferous) magmatic cycle, inclusions from Late Paleozoic-Early Mesozoic intrusions (Permian-Triassic magmatic cycle), and inclusions from intrusions of previous and subsequent magmatic cycles are on display in the Museum.

All petrographic varieties of trappe rock are available in the Museum; from porphyritic microdolerites to coarse-grained varieties - gabbro-dolerites and ferro-gabbro. As in the case of xenoliths of sedimentary rocks trappean inclusions vary in size over a wide range; from a few centimetres to 2 or 3 metres across. Traces of roundness can be observed on many inclusions, but they are not so pronounced as on xenoliths of deep-seated ultrabasic rocks.

Kimberlite inclusions in kimberlites and autoliths

Xenoliths of kimberlites of one type in kimberlites of another type have been registered in kimberlite breccias in many of the volcanic pipes. These are fragments of pipe or dike bodies of earlier phases of kimberlite magmatism. There may be more than one such phases and using xenoliths of this kind geologists gain information on stages and succession of formation of intricately constructed kimberlite bodies. Kimberlite inclusions in kimberlite are sometimes rounded, sometimes angular. They vary widely in size. Kimberlite xenoliths in kimberlite to 0,5 m across are kept in the collections of the Museum.

Kimberlites of many pipes not infrequently contain concentrically zonal kimberlite formations of another type around peculiar "germs"; these may be fragments of xenogenic inclusions, pieces of kimberlite in kimberlite, large grains of rock-forming or accessory minerals. These are the so-called autholiths. Autholiths are commonly a few centimetres in size, but rather large specimens, to 20 cm across, have been recorded.

Some of the kimberlite varieties contain abundant small autoliths in one lump. These rocks are generally called autolith kimberlites, or, if these are breccias, breccias of autolith kimberlites. The concentration of autoliths in rock can be so dense, that in section this rock represents a mosaic of concentrically zonal autoliths cemented by small amount of serpentine-carbonate mass.

Sections of composite autoliths, when a rather small autolith serves as a seed for a larger autholith are available in the Museums collections.

Secondary minerals of kimberlites

Secondary mineralization, the result of active post-magmatic processes, normally occurs in all types and varieties of kimberlites of secondary crystalline formations, quartz holds the lead. Quartz formations are abundant and diverse. It occurs as veins, branching veinlets, druses, concretions of various shape. Quartz occurs in the whole of the colour range: from milky-white and transparent to almost black (morion). Pale-pink to dark-purple amethyst is widespread. Kimberlite cavities to 0,5 m across whose walls were covered with large amethyst crystals have been reported from pipes "Udachnaya" and "Aikhal". Some of the crystals were as great as 2 or 3 cm.

Quartz of bright tints occurs only in upper horizons of kimberlite pipes. Amethyst is lacking at a depth of more than 70 m from the level of their erosional shear. Quartz is not infrequently associated with calcite which is also widespread in kimberlite rocks in the form of veinlets, crusts on cavity walls, sinters on quartz druses. Samples of composite sinter formations, showing composite multicoloured traceries in sections are available in the collections of the Museum.

Gypsum appears in kimberlites and exocontacts of kimberlite bodies at a depth of more than 100 m. Transparent laminated plates of gypsum are most frequent, but opaque white or pink amorphous formations occur as well. Particularly large gypsum crystals have been recorded from the pipe "Aikhal". A transparent gypsum crystal weighing about 100 kg is on display in the Museum.

A ubiquitous secondary mineral is pyrite. It sometimes impregnates large blocks of deposits and hinders gravely the process of diamond extraction. Py-

rite is sometimes found as rims around xenoliths and druses with well edged crystals.

Kimberlites and near-contact enclosing rock contain other sulphides as well: pyrrhotite, chalcopyrite, sphalerite, galena. The latter sometimes forms large crystals and aggregates galena is most often encountered in the pipe "Mir", in sulphide veins in association with calcite, pyrite and bitumen.

Various concentrations of magnetite have been reported almost from all known pipes. A distinction is made between primary magnetite accompanying kimberlite magma and secondary magnetite formed in the postmagmatic period. Forms of magnetic manifestation are highly diversified. These may be fine, to powdered, impregnation, and branching veins and veinlets, and separate crystals, and druses of crystals, and concentric amorphous concretions, and radiate-fibrous aggregates. Spheroidal magnetite nodules to 0,5 m in diameter have been found in pipes "Aikhal" and "Leningradskaya". Magnetite often passes into hydrous ferric oxides in the near-surface zone of the

pipes. The latter as well as goethite and hematite accompanying magnetite impart a peculiar outlook to kimberlite: with dark-brown veinlets or rims around xenoliths of sedimentary rocks.

Information of the Museum on kimberlites

In addition to the collections of stone material, the geological Museum of the stock company "Almazy Rossii-Sakha" Co. Ltd has at its disposal illustrative information on geological structure of kimberlite pipes (horizon-by-horizon geological plans, geological sections of wells and well lines), on physical properties of kimberlites and on geophysical fields above kimberlite pipes, on petrological and mineralogical composition of kimberlites and inclusions (thin sections and polished sections, information in the form of tables and texts), on geological structure of kimberlite fields and on Yakutsk diamondiferous province as a whole. A computer database on kimberlite geology is being compiled.