Some Special Features of Kimozero kimberlites of Onega flexure (Karelia, Russia)

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Kimberlite formations of Kimozero were discovered in 1992 – 99 by Karelian geologists headed by V.V.Ushkov. These represented the first kimberlite basement phenomenon in the territory of Karelia which was reliably proved to be diamondiferous[1].

Kimozero kimberlites is situated within the Povenetz block of Onega flexure situated in the south-eastern karelide zone of the Baltic shield, limited by the Svecofennian zone in the south-west and by the Belomorsk zone in the north-east.

The Onega flexure is a brachiform synclinorial structure which was formed in the proterozoic era on the granite-gneiss basis of the late Archaean about 2.6 Ga[2]. Some researchers believe that the basis of the geoblock is a huge granite-gneiss complex of corresponding dimensions which was being formed above a long-living mantle plume[3]. The flexure is formed by volcanogenic deposits of the Karelian (early Proterozoic) complex, ranging from Sumian-Sariolian to Vepsian inclusively. The south part of the flexure is overlapped Vend-Paleozoic platform mantle.

Kimozero kimberlites and the rocks containing them form a part of a third-order brachianticlinal structure which was formed as a result of kimberlite intrusion into the axial part of a larger synclinal fold, made up of metadiabases containing small streaks of shungit-containing siltstone and gabbrodolerite sills of Zaonezhski Ludicovian complex. On the existing erosion section, basic kimberlite outcrops have an oval shape measuring 2 km along the longer axis going from north to west and 800 m along the shorter axis.

Kimozero rocks are among the most ancient of kimberlites; their early proterozoic age was determined by the Sm-Nd method as 1764±125 Ma [4].

Within the limits of the territory investigated, as a result of field observations confirmed by petrographic data, we found enclosing gabbrodolerites and diabases and kimberlite rocks in the proper sense, including kimberlite tuffs: phlogopite tuffs, stratified and massive; kimberlite tufobreccias, phlogopite, consisting of small fragments, carbonaceous, magnetite and properly kimberlite breccias (fig.1). Depending on epigenetic changes, these varieties are subdivided into serpentized, chloritized and amphibolitized.

The main rockforming minerals of all kimberlite varieties are olivine and phlogopite (fig.2). The amount of olivine in the rocks is up to 60%. The mineral is completely replaced by serpentine and small impregnations of magnetite. In sections olivine pseudomorphosis often possess the characteristic barrel-like shape due to the loss of crystallographic outline of the mineral. Sometimes a combination of a partly smoothed crystal edge and its idiomorphic continuation. The size of impregnations varies from 0.1 to 5 mm. There are three morphotypes of pseudomorphoses after olivine depending on age. The early generation seeds, sized 1 to 4 mm, are characterized by roundish and oval shapes, probably determined by the smoothing of the original outlines of the mineral. Idiomorphic outlines are typical of the second generation impregnations (size up to 1 mm), and in some varieties (stratified kimberlite tuffs) skeletal shapes are to be seen. The first and second generations are met with

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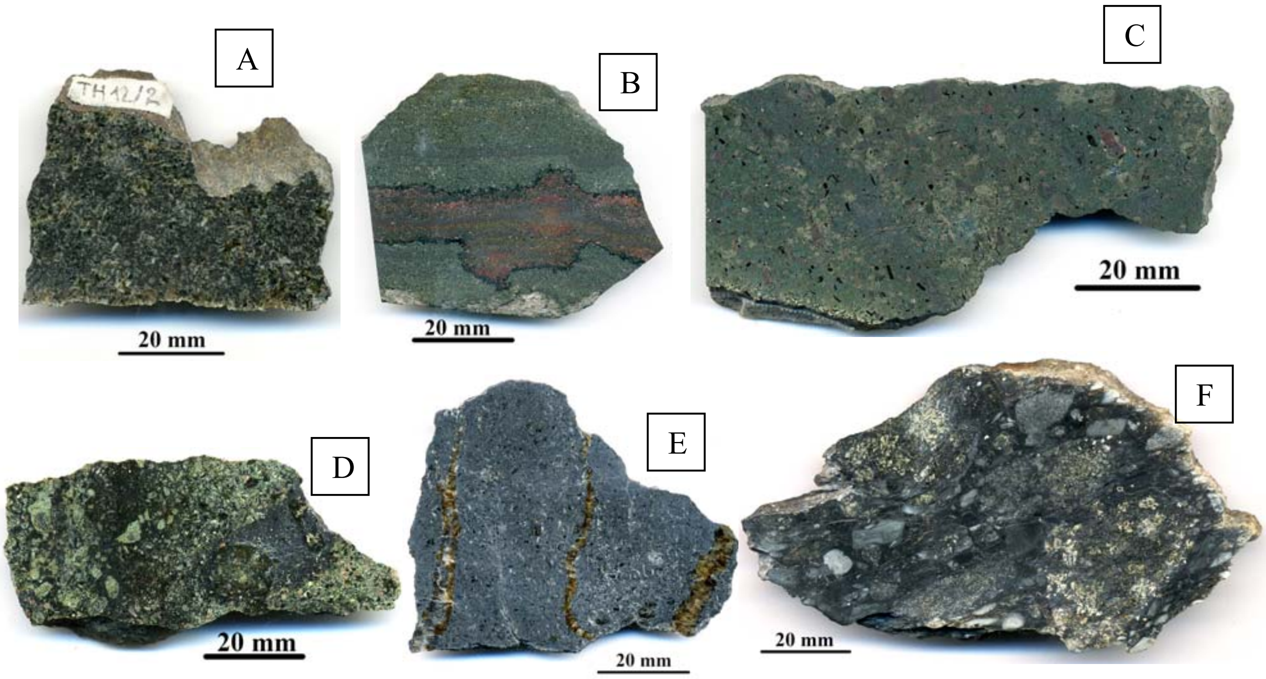

Fig. 1. Photographs of some varieties of rock: A – enclosing gabbrodolerite (sample. 12/2); B – stratified phlogopite tuff (sample K-17); C – phlogopite tufobreccia (sample Ш-82), D – magnetite tufobreccia (sample Ш 90-1Л), E – carbonic tremolitized tufobreccia (sample. Ш-95), F – kimberlite breccia (sample.Ш-56).

in the matrix as well as in xenolith and autolith cores in kimberlites of later impregnation period. The third-generation pseudomorphoses are represented by small (up to 1 mm) seeds of roundish shape. They are seen in kimberlite rocks where xenolith from early impregnation phases were also found.

The amount of phlogopite in the rock reaches 70%. It is mostly replaced by chlorite and tremolite; in the case of incomplete pseudomorphoses a pleochroism of the mineral can be observed ranging from rosish-brown to greenish-yellow colour. The presence of phlogopite is confirmed by radiologically [5], and its composition (n=6) corresponds to the design equation $\mathbf{K_{0.36-0.74}(Mg_{2.74-2.92}Fe_{0.08-0.24})(Si_{2.88-2.96}Al_{0.96-1.05}Fe_{0.04-0.14}O_{10})(OH)_2}$. In its composition the amount of MgO is up to 27 %, the amount of ΣFeO does not exceed 7%, the amount of K_2O is up to 7%; the amount of the latter decreases with chloritization. In sections we see mostly chlorite pseudomorphoses after phlogopite retaining its original shape, as single oval or roundish crystals (probably fused) measuring from 0.1 to 5 – 7 mm.

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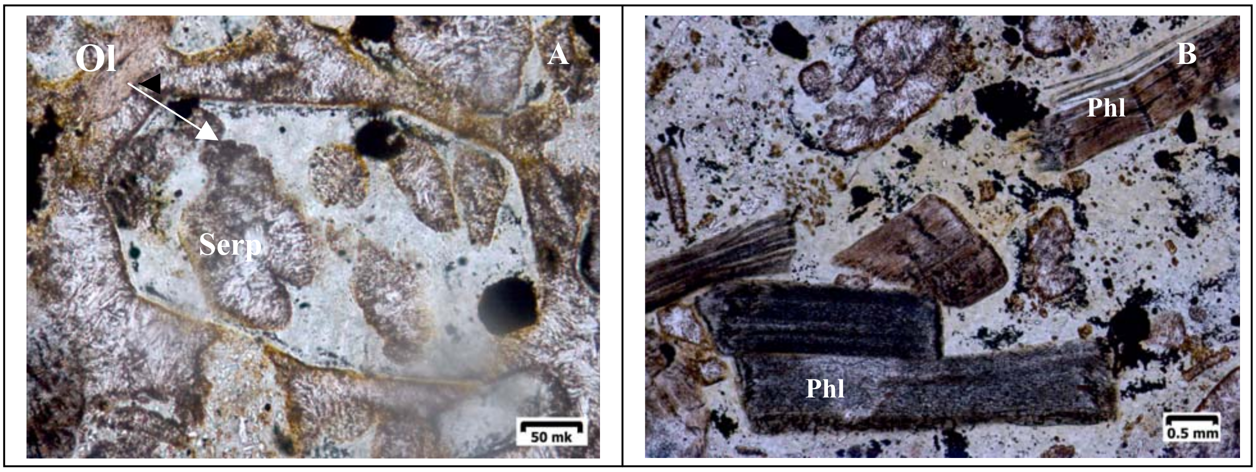

Fig. 2. Microphotograph of a section (K-117) of kimberlite tuff. A – serpentized (Serp) olivine (Ol); B – phlogolite (Phl), largely replaced by chlorite. Passing light, without analyzer.

Ore mineralization is represented by minerals which are indicators of diamond: chromspinelide and ilmenite as well as rutile, titanite, chalcopiryte, magnetite and hematite. The content of ore material reaches 20% in some rock varieties; it must be noted that in such cases it is concentrated either in a subparallel fashion, which makes the kimberlites look streaked (fig 1b) or as globular accumulations typical of magnetite. Chromspinelide crystals are mostly roundish and characterized by a zonal structure: the fringe around the seeds is formed by ilmenite which is often replaced by titanite. According to L.I.Lukyanova[6], a wide range of content and trends which are typical of kimberlites. Ilmenite is often represented by single skeletal crystal forms with sizes from 0.25 to 1.5 mm, along which titanite also develops.

Minerals-indicators of diamond in Kimozero area are chromspinelide and ilmenite. An important characteristic of kimberlites is an almost complete absence of pyropes and chromdiopsides from minerals-indicators of diamond in rocks. Just some single instances of seeds of these minerals have been recorded. This testifies to the impossibility of using pyropes and chromdiopsides as indicators of this type of kimberlites.

The degree of epigenetic transformation of the rocks is high. This blurs and sometimes eliminates completely their original structural and textural features and also modifies the content of the original minerals. The general sequence of secondary changes of kimberlite rocks and their development are as follows: at the earliest stage, serpentization (antigorite and lizardite) takes place, accompanied by formation of ore minerals, then carbonatization and partial silicification of the rocks and, finally, at a late stage, chloritization (clinochlore and shamozite) and amphibolitization (tremolite and actinolite). It must be noted that this process is not typical of the known kimberlite fields in South Africa, Yakutia, Archangel region and others.

The investigation of chemical composition of Kimozero rocks with ISP MS methods has confirmed the petrographic variety observed. According to V.A.Milashev's classification[7], which was based on the data of Yakutia diamondiferous region and comprises all the kimberlite types found there, representatives of four populations out of seven are present within the limits of the territory in question. The diamondiferous rocks of it are

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characterized by a wide variety of petrogenic and other elements, which can be explained by various proportions of the main rockforming minerals and the specifics of secondary transformations. For instance, the percentage of TiO_2 varies from 0.31% in small-fragment tufobreccia up to 2.57% in stratified phlogopite tuff. Kimberlites differ also as regards REE (rare earth) content, and the nature of these differences according to our data is similar to the results obtained by other researchers[8].

Diamonds counting more than 100 seeds were found in small kimberlite samples gathered in the Kimozero area by Karelian geologists on behalf of Ashton Mining Ltd. Their size ranges from 1 to 2 mm; morphologically they represent resorbed octahedra. The diamonds are colourless, bear green pigmentation spots and contain dark impurities. These findings confirm the diamondiferous nature of kimberlites, yet do not allow to assess its richness because the samples gathered are not representative enough (from 40 to 3340 kg)[1]. Recently the morphological range of previously discovered crystals has been widened by the finding of a diamond which is a spinel-law twin of OD type (octahedron-dodecahedroid)[7]. Currently the RIO TINTO company is exploring the location.

Thus the Kimozero kimberlites in Karelia differ from known diamondiferous kimberlites in the following: 1. Pyropes and chromdiopsides are absent from minerals-indicators; 2. Chromspinelids and ilmenites exhibiting a specific composition are prevalent; 3. A high degree of epigenetic rock transformation and a substantial participation of late amphibolization; 4. A possibly late Karelian genesis.

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