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# Fluidizate-Explosive Occurrences in Ophiolites as Indicator of the Subduction Zone Activity: The Urals Example

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## 1 Abstract

It is known that the formation of oceanic crust occurs in different geodynamic settings, accompanying by the emergence of mantle-magmatic ophiolite complexes having a distinctive properties. In the process of mantle-crustal evolution of the ophiolites are undergoing significant changes with the formation of peculiar (on structure and composition) rocks, sometimes with unusual mineral paragenesis. The presence of such rocks in mélange tectonic zones greatly complicates to determine their origin. In the Ural folded belt (length more than 2,000 km) separating the East European Platform and the West Siberian sedimentary basin, ophiolites are widespread forming a chain of mafic-ultramafic massifs (Fig. 1) located in the allochthonous position with mélange at the bottom (Puchkov, 2013). With the Urals ophiolites are associated occurrences of eclogites, jadeites, ruby and other rocks of unclear nature, sometimes regarded as potentially diamondiferous.

Such formations of unclear genesis include the associating with ophiolites metabasites of higher alkalinity composing the body in the mantle peridotites of the mélange Main Uralian Fault (MUF) zone (Shmelev, 2005). By this time they are determined in different parts of the fault zone, but most completely are known in the SubPolar Urals, where are distinguished under the name of Sertynya alkaline-ultramafic complex, which is located just 25 km east of Hartes kimberlitic complex (Fig. 1). Formally, its affiliation to diamond-bearing associations is confirmed by finding of grains and fragments of natural diamond in the weathering crust.

A detailed study of the rock complexes shows that in reality they have a polygenic nature, combine the

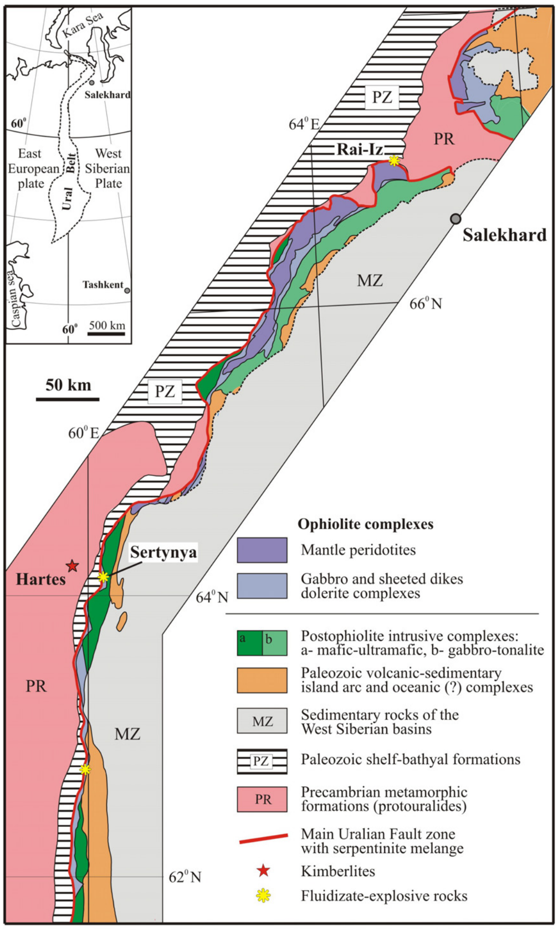


Fig. 1. Simplified tectonic map of the Urals (northern part) with the fluidizate-explosive occurrences.

elements of proper magmatic and fluidizate-explosive formations, the appearance of which was interfaced with the processes at the slab-mantle wedge boundary in subduction zones. Polygenic nature of the rocks is reflected in the existence of three interrelated structural-geological units: (1) bodies and dikes of uniform metadiabases and dense fine-grained

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metadolerites (lamprophyres), (2) fluidal-brecciated dolerites ("tuff breccias") and (3) structural weathering crust with angular or rounded fragments (blocks) of metadolerites and serpentinites. The rocks have experienced rodingitization and permeated with net of veins a vesuvianite composition. The host peridotite matrix (harzburgites and dunites) has undergone serpentinization and chloritization. Structural relationships give grounds for distinguishing in the history of the complex formation the magmatic proper (dolerite dyke and lamprophyre intrusion) and infiltration fluidizate-explosive (metasomatic transformation of dolerite) stages.

Peculiarities of petrography and mineralogy of rock complexes does not allow to compare them with lamproites and kimberlites. Metadiabases demonstrate relics of ophitic structure, as primary paragenesis is completely replaced by aggregate of chlorite, zoisite and leucoxene. Dolerites (lamprophyres) have a uniform fine-grained or porphyry structure with phenocrysts of clinopyroxene, brown amphibole and leucoxene (sphene), which are immersed in a fine-scaly aggregate of light green mica. In the rocks amphibole, garnet and vesuvian are present. Clinopyroxene corresponds to augite with moderate content of titanium and alumina (up to 3.5 wt.%), showing a normal magmatic zonation in composition. Mica previously wrongly called as phlogopite, actually has an extremely ferrous composition and corresponds to biotite (annite). Amphibole is presented by magmatic titaniferous tschermakite hornblende and metamorphic (bluish) variety of sodium-calcium composition (taramite). Garnet is presented by exceptionally grossular of rodingite type. Mineralogy of weathering crust reveals similar features, but in the samples it is marked the presence of muscovite, orthoclase and weakly ferrous diopside. An important feature of the weathering crust is the presence of shear surfaces on minerals, resulting in fracturing due to internal stress, confirming the explosive nature of protolith.

The bulk chemical composition of rocks is characterized by significant variations in the content of silica (30-46 wt.%) and alkalis (0-6.5 wt.%). These metabasites have consistently a low magnesia number and high titanium oxide content (1.5-3.0 wt.%). Side by side with these are been established the uniform slope REE distribution trends similar to the trend of oceanic basalts N-MORB type (Fig. 2). The level of trace element compositions does not depend on variations in the alkalinity of the rocks, but clearly correlates with the titanium content. Unlike them the Hartes kimberlites demonstrate the distribution with deficit of HREE, and the level of the elements content is correlated with the alkalinity of rocks (Mahotkin et al., 1998).

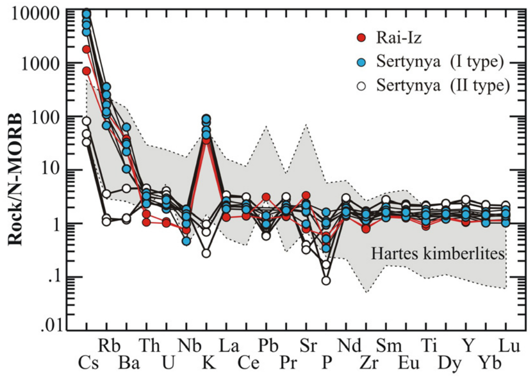


Fig.2. N-MORB-normalized trace element patterns of the fluidizate-explosive rocks of the Urals (normalization values from Sun and McDonough, 1989).

Another important geochemical feature of the Sertynya complex rocks is a regular behavior of the mobile LILE elements (Cs, Rb, Ba, K). In the varieties of rocks with mica enriched by alkalis, it is recorded extremely high level of LILE, exceeding the level of contents in N-MORB basalts at 10-10000 times! In the metabasites varieties with low level of alkalinity, LILE content is sharply (except Cs) reduced to minimum values (Fig. 2). The observed pattern of the element distribution is undoubtedly the result of postmagmatic fluid-metasomatic alteration of the original rocks.

Tectonic position and the primary composition characteristics of the metadolerites give reason to consider them as fragments of the ophiolite sheeted dike complex (Shmelev, 2005). The famous dike complexes in the ophiolite massifs of the MUF zone (east of mélange) belong to suprasubduction formations of Paleozoic age. However the obtained mainly ancient U-Pb zircon dating (up to Archean inclusive) for metadolerites of the Sertynya complex, make it possible to assume its Vendian-Early Cambrian (530-617 Ma) age. It permits to compare the Sertynya metabasites with the Vendian metaophiolites of the MUF zone in the Middle Urals (Petrov et al., 2010). It is noteworthy that similar age datings (520-550 Ma) are also established for kimberlites of the Hartes complex located to the west of ophiolites. Therefore, the presence of the Vendian-Cambrian ophiolite of MOR-type in the MUF mélange zone, "changing" to the east of Ordovician ophiolites SSZ-type, seems quite possible.

The obtained data allow to suggest an original interpretation of nature of the Urals fluidizate-explosive formations considering the process specifics in the subduction zones (Bebout and Barton, 2002). According to this model, the pre-Ordovician (?) oceanic crust has undergone transformations and deformations on the slab -mantle wedge boundary during the subduction. As a result of slab dehydration it occurred a flow of aqueous fluids, which were enriched with the extracted from sedimentary rocks the LILE elements and percolated through the mantle substrate with dolerite dyke complex. Interaction with them led to the formation of chlorite-zoisite and/or mica (biotite-bearing) fluidizates and in the presence of a gas phase - fluidizate-explosive breccias with subsequent development of weathering crust. In the surrounding peridotites an explosive process is marked by the formation of pseudokimberlite breccias.

Fluidized-explosive occurrences in mantle peridotites of mélange zones should be considered as indicators of the subduction slab-mantle interaction at relatively shallow levels involving enriched LILE fluids (without melts participation), rising as the front from the subduction zone. In this interpretation, there is no need to appeal to the alkaline-ultramafic or lamproit-kimberlite hypothesis of the genesis of these formations, however, the question of their potential diamondiferous remains to be open. The proposed interpretation of the fluidizate-explosive occurrences makes it possible to comprehend that in reality the mélange is a complex formation with signs of not only collisional (as usually is considered), but also of earlier subduction events.

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