Shmelev V.R., 2015. The Polar Urals Ophiolites. *Acta Geologica Sinica* (English Edition), 89(supp. 2): 85-86.

The Polar Urals Ophiolites

Shmelev V.R.

Institute of Geology and Geochemistry, Pochtovy per. 7, 620075, Ekaterinburg, Russia

The Urals folded belt extending for about 2,500 km is located on the border between the East European and West Siberian platforms (Fig. 1a). Its distinctive feature are the rocks of ophiolite association, which are the most well represented in the Main Uralian fault (MUF) zone. In the southern part of the MUF they form large ophiolite massifs - Nurali, Kraka, Habarny and Kempirsai. In the northern part of the MUF the Polar Urals ophiolite belt presented by Syum-Keu, Rai-Iz, Voikar and Khulga massifs are distinguished (Fig. 1b). Large deposits of chromite ores are connected with the Kempirsay and Rai-Iz peridotite massifs.

1 Tectonic setting

The Polar Urals ophiolite belt occupies a definite position in the region structure by tracing from the Kara Sea in the south-eastern direction for a distance up to 500 km, with a width of 30-40 km (Fig. 1b). In the west ophiolite massifs tectonically thrust over on predominantly Precambrian metamorphic formations (gneisses, amphibolites, schists) or Paleozoic rift and shelf-bathyal sedimentary formations of the paleocontinental sector. In the thrust are observed fragments of polymictic serpentinite melange, zones of garnet amphibolites and glaucophane schists (Dobretsov et al., 1977). In the east massifs are bordering with Silurian-Devonian island arc volcano-sedimentary and intrusive formations of the Voikar-Shchuchya zone. The ophiolites of the Voikar and Rai-Iz massifs break through en extended gabbro-diorite-tonalite Sob pluton (Shmelev, Meng, 2013). The ophiolites of the Syum-Keu massif are intruded by olivine and two-pyroxene gabbro of the Maslo complex. In the eastern part these formations overlap Meso-Cenozoic sediments of the platform cover of the West Siberian basin.

2 Geology

The Polar Urals ophiolites are presented by mantle peridotites (lherzolite, harzburgite and dunite), the rocks of dunite-clinopyroxene-gabbro (DCG) complex as well as the sheeted dolerite dyke complex and subordinate amount of sedimentary-volcanic formations (Dobretsov et al., 1977). The composition and structure of the rock complexes, as well as their relative importance varies along the Belt strike direction. Unlike the classical "stratified" model of the structure ophiolites, mantle peridotite not only "overlap," but also "underlain" rocks of DCG complex (Fig. 1b). Such "doubling", is considered by us as a result of crystallization of basaltic melts at different (relative peridotites) levels of section.

Mantle peridotites are the main element of the ophiolite association, occupying up to 50% of its volume. They are characterized by significant variations in the composition and complex internal structure, which is a result of high-temperature plastic deformation and metamorphism (Shmelev, 2011, Shmelev et al., 2014). In the Polar Urals massifs are distinguished two main peridotite rock complexes: early lherzolite-harzburgite (LH) and late dunite-harzburgite (DH).

Lherzolite-harzburgite complex is the earliest formation showing signs of zonal structure. The zoning is caused by the existence of relict cores of lherzolite and diopside harzburgite (Cr-sp # = 0.14-0.3) among the ordinary harzburgites. The rocks are characterized by subisotropic or schlieren-like texture and protogranular structure. Dunites veins and larger bodies are no more than 10-20% of the complex. Rare manifestations chromitites relate primarily to the aluminous type. *Dunite-harzburgite* complex forms zones and areas of complicated configuration that intersect the rocks of LH complex. It is composed of banded harzburgites, with distinct mineral deformation flattening, containing stockwork veins (bands), and large subisometric and lenticular bodies of dunite. The rock distribution of this complex is often controlled by zones of intense brittle-plastic flow. The manifestations and large chromite deposits are associated with areas of the dunite concentration.

Dunite-clinopyroxene-gabbro (DCG) complex is present in all massifs of belt, revealing significant differences in structure and composition. The complex consists of two rock series: dunite-wehrlite-clinopyroxenite and the essentially gabbro ones. The first forms a relatively thin (tens to hundreds of meters) transition zone (MTZ) on the border with mantle peridotites. It is presented by dunites, massive and/or banded wehrlites and clinopyroxenites with rare interlayer of gabbro bodies. The second ones is presented by different bodies of gabbro with wehrlites and clinopyroxenites. At the base of the section are dominated layered olivine gabbro and troctolites, and in the upper part

* Corresponding author. E-mail: shmelev@igg.uran.ru

- massive gabbro and gabbro-norites.

The sheeted dike complex corresponding to the upper part of ophiolites and most fully represented in the Voikar eastern part of the massif, localizing mainly in gabbroids (Saveliev et al, 1999). In its structure participate individual dykes and packets of dolerite dykes of several generations, oriented in accordance with a general northeast strike of the ophiolite belt. Inter-dike spaces (screens) are composed of gabbro and peridotites (wehrlites and pyroxenites). Overlying lava basalts with dolerite dykes are known only in the Syum-Keu massif.

3 The origin of ophiolites

Analysis of mineralogical, geochemical and other materials indicates that formation of the Polar Urals ophiolites is the result of different scale mantle-magmatic processes implemented under various geodynamic conditions (Shmelev, 2011).

The process of oceanic spreading and partial melting of different depth levels of the mantle caused formation of peridotite LH complex. In the "root" parts of spreading zones it was realized a process of mantle partial (15-20%) melting in garnet, and then in spinel facies with the formation of diopside harzburgite, preserved fragmentary in Voikar and Rai-Iz massifs. At shallower depths, by partial (from 5-8 to 12%) melting in the spinel facies lherzolites and diopside harzburgites, widespread in Syum-Keu and Rai-Iz massifs were formed. Under the influence of primitive MORB melts the protolith has experienced refertilization, fixed by a slight increase of REE in clinopyroxenes.

In the suprasubduction setting the mantle protolith suffered a full-scale transformation with the formation of the DH complex peridotites. At fluid induced partial (14-16%) melting of the protolith, were formed harzburgites with distinct signs of refertilization, expressed in the enrichment of light and medium REE in clinopyroxenes. Conjugately, under the influence of percolating melts occurred depyroxenization of harzburgites with the appearance of dunites and chromite mineralization in areas of brittle-plastic deformations, as well as the formation of vein series pyroxenites.

The crystallization of melts separating from the mantle protolith was accompanied by the formation of the DCG rocks and sheeted dike complex ophiolites with inherent geochemical characteristics. The compositions and character of LREE, Zr, Hf, and other element distribution in basites testify their formation exclusively in suprasubduction geodynamic setting (Saveliev et al., 1999).

Ophiolites tectonic detachment to upper horizons of the Earth crust was accompanied by metamorphism with formation of garnet gabbro-amphibolites, olivine-antigorite (tremolite, talc) metaperidotites and jadeite-omphacite rocks. Metavolcanics in the MUF sole have been transformed into garnet amphibolites and glaucophane (garnet-glaucophane) schists.

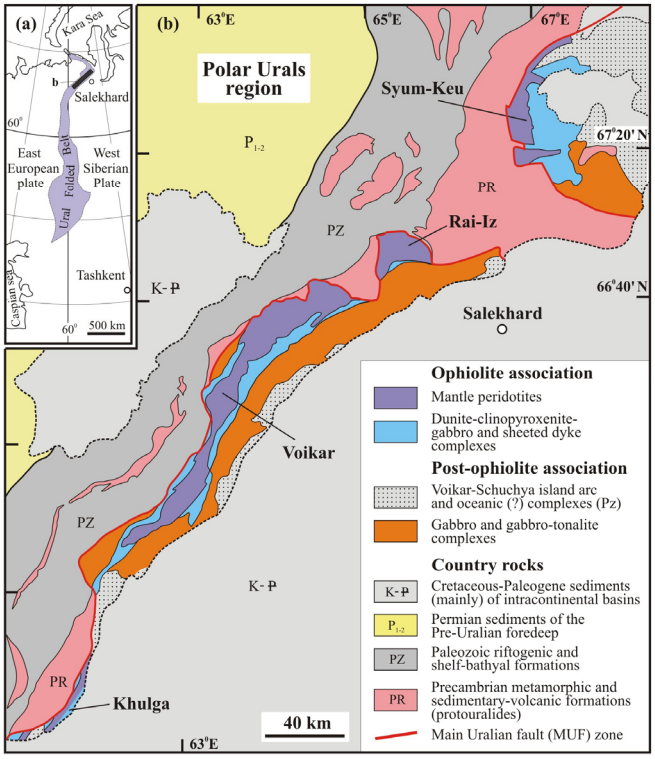

Fig.1. (a) Position of the Urals folded belt; (b) Tectonic setting of the Polar Urals ophiolites

The age of the MUF zone ophiolites is usually estimated within the range of Upper Ordovician - Lower Silurian. Recent isotope studies assume the existence of a temporary discontinuity between the formation of mantle peridotites and basites. According to the Re-Os isotopic data on peridotites and a few U-Pb zircon dating from chromitites (Savelieva et al., 2013) one can mark two age boundaries of their formation: Archean – Middle Proterozoic (more than 1Ga) and Upper Proterozoic (about 600 Ma) which is associated with the formation of dunites and chromitites. Along with these, the results of U-Pb dating of zircons from ophiolite gabbro and plagiogranites indicate their younger Late Ordovician–Early Silurian (440-450 Ma) age. In the Late Silurian (418 ± 2 Ma) ophiolites were intruded by gabbro and plagiogranitoids of the Sob island arc complex (Shmelev, Meng, 2013).

A peculiarity of the Polar Ural ophiolites is the presence in them of rubies, nephrites and jadeite-omphacite rocks. According to the recent data jadeites in peridotites had been formed in Early Carboniferous (404 ± 7 Ma) at pressures about 14 kb fixing the beginning of the subduction (Meng et al., 2011). Exceptionally important is the presence in the Rai-Iz massif chromitites the association of ultra high-pressure minerals, including diamonds (Yang et al., 2015).

Acknowledgement

This work was supported by RFBR fund (project № 15-05-00576) and by Program of UD RAS (project № 15-15-5 -31 and 15-18-5-24).