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The Mesoproterozoic mantle plume beneath the northern part of the Siberian craton

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Abstract

The study of the Mesoproterozoic (1473 ± 24 Ma) dolerites of the Olenek uplift of the Siberian craton basement has shown their petrologic and geochemical similarity to typical OIB produced with participation of a mantle plume. The dolerites are characterized by variations in the geochemical composition explained by different degrees of melting of the same source. A conclusion is drawn that the parental melts of the rocks were slightly modified by crustal contamination, as evidenced from their Nd isotope composition ($\varepsilon_{Nd}(T)$ = +0.6 to –0.8) and the presence of inherited zircons of four ages (2564, 2111, 2053, and 1865 Ma). Since the Siberian craton in the structure of the Nuna supercontinent (Columbia) was located relatively close to the Baltic continent and the Congo and São Francisco cratons, we assume that the Early Mesoproterozoic mafic intrusions (1500–1470 Ma) of all these cratons belong to the same large igneous province (LIP). The province formation was related to the activity of superplume (or mantle hot field), which supplied mantle matter to the lithosphere basement. The superplume core was probably located beneath the northern part of the Siberian craton, where basites are compositionally most similar to the primary mantle source.

Keywords: dolerites; geochemistry; mantle plume; Mesoproterozoic; Olenek uplift; Siberian craton; Nuna supercontinent (Columbia)

Introduction

The ancient cratons bear little evidence on the magmatic activity and large-scale tectonic restructuring in the period from Late Paleoproterozoic (1.7 Ga) to Cryogenian (Middle Neoproterozoic). Therefore, this geochronological interval is considered to be "a period of global uncertainty" (Gladkochub et al., 2008, 2010a), "the boring billion" (Roberts, 2013), or "The Earth's middle age" (Cawood and Hawkesworth, 2014). It is remarkable that it coincides with the time of existence of two supercontinents: Nuna (or Columbia), formed between 1.8 and 1.6 Ga and partly broken between 1.4 and 1.2 Ga (Pisarevsky et al., 2014; Rogers and Santosh, 2009), and Rodinia (Li et al., 2008), assembled between 1.1 and 0.9 Ga and broken later than 0.8 Ga. Since the knowledge of the Earth's evolution over the above time interval is extremely poor, any igneous rock complexes formed in this "boring billion" are of great interest. Most of this mysterious time span falls on the Mesoproterozoic, or the Lower–Middle Riphean (according to the USSR and Russian Stratigraphic Scale).

Today, only a few igneous complexes whose Mesoproterozoic age has been confirmed by reliable geochronological dating are known to exist in the area of the Siberian craton. Besides the dikes and sills localized within the eastern flank of the craton in the Riphean Sette-Daban sections (1339 ± 54 Ma (Khudoley et al., 2007) and 1005–974 Ma (Rainbird et al., 1998)), intrusive complexes of this age interval were also found in the northern areas of the Siberian craton. In particular, Mesoproterozoic dikes (1513 ± 51 Ma (Veselovsky et al., 2006) and 1503 ± 5 Ma (Ernst et al., 2000)) are present in the Anabar Shield and in the Udzha aulacogene (1074 ±

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11 Ma (Gladkochub et al., 2009)). Within the Olenek uplift of the craton basement, mafic intrusions of Mesoproterozoic age were also detected. They became the subject of research, the results of which are presented in this paper.

Geological background

The study area is located on the Olenek uplift (or province) of the Siberian craton basement (Fig. 1) (Gladkochub et al., 2006; Rosen, 2003). In the west (in the modern coordinates), the Olenek province borders the Anabar province along the Billyakh collision zone, whose age is estimated by the time of granulite metamorphism of the Khapchan Group deposits on the margin of the Billyakh zone, 1.97 ± 0.02 Ga (Bibikova et al., 1988).

The basement deposits of the Olenek uplift are rocks of the Eekit Formation (metasandstones, phyllite-like schists, and metasiltstones), metamorphosed under greenschist facies conditions, and granitoids of the Olenek complex, cutting the folded structure of the Eekit Group and thus regarded as postdeformational rocks (Fig. 1). The granitoids comprise biotite granites, granodiorites, diorites, and leucogranites.

The sedimentary-cover rocks of the Olenek uplift (Figs. 1 and 2) rim the basement salient and compose a monocline gently subsiding in the western and northern directions (Shenfil', 1991; Shpunt et al., 1979, 1982). The angle of the layer slope in the monocline varies from 5º to 12º. In places, the monocline is complicated by low-amplitude flexures of the NE strike, often combined with faults. The angles of layer slope in the common limb of flexure reach 60º. The lower horizons of the Proterozoic sedimentary cover are formed by the Sygynakhtakh and Kyutingde Formations, namely, subcontinental deltaic deposits (Sygynakhtakh Formation) passing into rhythmically constructed shallow-water offshore facies (Kyutingde Formation).

The Sygynakhtakh Formation overlies, with angular discordance, the deposits of the Eekit Formation and the granitoids of the Olenek complex. It is composed of fine-grained quartz-pebble conglomerates, gravelstones, and glauconite-containing quartz sandstones.

The Sygynakhtakh Formation is concordantly overlain by the Kyutingde Formation. The latter is composed mostly of dolomites, pinkish-gray in the lower part and yellowish-gray, with black syngenetic flints, in the upper part. There are also diverse stromatolites (Shenfil', 1991) and occasional thin siltstone and mudstone intercalates. The sedimentary deposits of the Kyutingde Formation are broken by dolerite sills.

The overlying pre-Vendian sequence of three formations reflects a megacycle of terrigenous-carbonate sedimentation in the shallow-water shelf of continental sea (Fig. 2). Basal variegated siltstones and sandstones of the Arymas Formation are ubiquitously separated from the Kyutingde Formation by a dolerite sill; therefore, the relationship between these formations is unclear (Shenfil', 1991). Taking into account the below-presented radiochronological data, we suggest the ex-

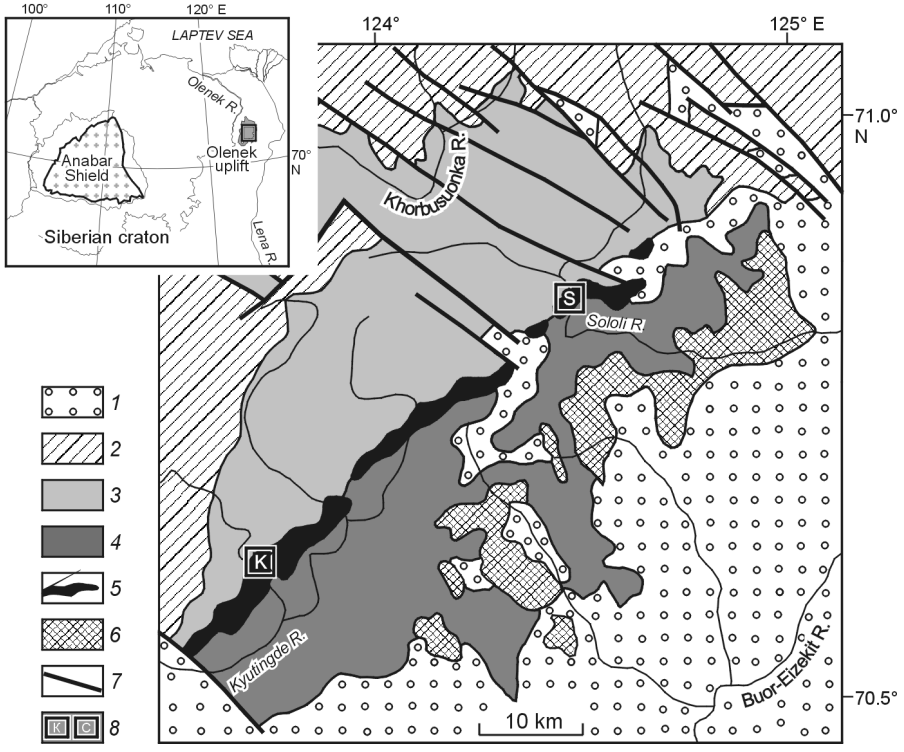

Fig. 1. Geological scheme of the Olenek uplift of the Siberian craton basement. *1*, Phanerozoic sedimentary cover; *2*, Khorbusuonka Group (Ediacaran); *3*, united Arymas, Debengde, and Khaipakh Formations (Meso-Neoproterozoic); *4*, united Sygynakhtakh and Kyutingde Formations (Mesoproterozoic); *5*, dolerite sill (Mesoproterozoic); *6*, basement (granitoids, metasedimentary rocks) (Paleoproterozoic); *7*, faults; *8*, sampling localities (K, Kyutingde River; S, Sololi River). Inset shows the location of the study area.