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Granulites and Palaeoproterozoic lower crust of the Baidarik Block, Central Asian Orogenic Belt of NW Mongolia

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ABSTRACT

Mafic granulite xenoliths are hosted by garnetiferous charnockites in the Archaean to Palaeoproterozoic Bumbuger Complex of northwestern Mongolia, one of the exotic basement terranes in the Central Asian Orogenic Belt. These rocks crystallized at ca. 1850 Ma under granulite-facies conditions (800 ± 27 °C, 6.8 ± 0.6 kbar) in the lower crust and were partly retrogressed to amphibolite-facies during ascent to higher crustal levels as a result of strong deformation resulting in northwest-trending isoclinal folds. The mafic xenoliths are likely derived from gabbroic protoliths, and geochemical, Hf-in-zircon and Nd whole-rock isotopic data suggest these rocks to have originated from parental melts of an enriched mantle source or from a depleted mantle with minor contamination by crustal material. The host garnetiferous charnockites crystallized from a strongly inhomogeneous melt predominantly derived from an Archaean to early Palaeoproterozoic lower crustal source, as also evidenced by partly recrystallized xenocrystic zircons, and minor contributions of mantle-derived material. The above data are compatible with a model whereby mantle-derived gabbroic melts under- and intraplate the lower crust, causing high-grade metamorphism, migmatization and anatexis, and the resulting ascending melts are mixtures of mantle and crustal sources. We speculate that the late Palaeoproterozoic events in the Baidarik Block may be the result of ca. 1.90–1.85 Ma accretion and collision processes that led to formation of the Columbia supercontinent. In the Neoproterozoic this block drifted toward Siberia and was incorporated into the Central Asian Orogenic Belt.

1. Introduction

The Central Asian Orogenic Belt (CAOB) south of the Siberian Platform is made up of fragments of early to late Precambrian blocks of variable size, tectonically sandwiched between late Neoproterozoic to early Palaeozoic oceanic and island arc assemblages and resulting from subduction and accretion processes in the late Neoproterozoic and Palaeozoic (Zonenshain, 1972; Zonenshain et al., 1990; Mossakovsky et al., 1994; Didenko et al., 1994; Berzin et al., 1994; Kuzmichev, 2015; Kröner et al., 2014). Among of Precambrian blocks, the Tuva-Mongolian and the Dzabkhan "microcontinents" are the largest structures with supposed early Precambrian basement. The medium- to high-grade metamorphic rocks of the structurally separated Songino, Dzabkhan, Otgon and Baidarik blocks, and the Tarbagatai promontory were previously combined into the Dzabkhan microcontinent (Mossakovsky et al., 1994) on account of similar high-grade metamorphic rock associations. However, these blocks are now considered as separate crustal entities (Kozakov et al., 2014), and geochronological and whole-rock Nd isotopic data have shown that pre-Neoproterozoic metamorphic assemblages occur solely in the northwestern part of the Baidarik Block (Kozakov et al., 1997, 2007), in the southwestern part of the Dzabkhan Block (Bold et al., 2016), in the Ider Complex of the Tarbagatai promontory (Kozakov et al., 2011; Kröner et al., 2015), and in the Gargan Block of eastern Sayan, southern Siberia (Kovach et al., 2005;

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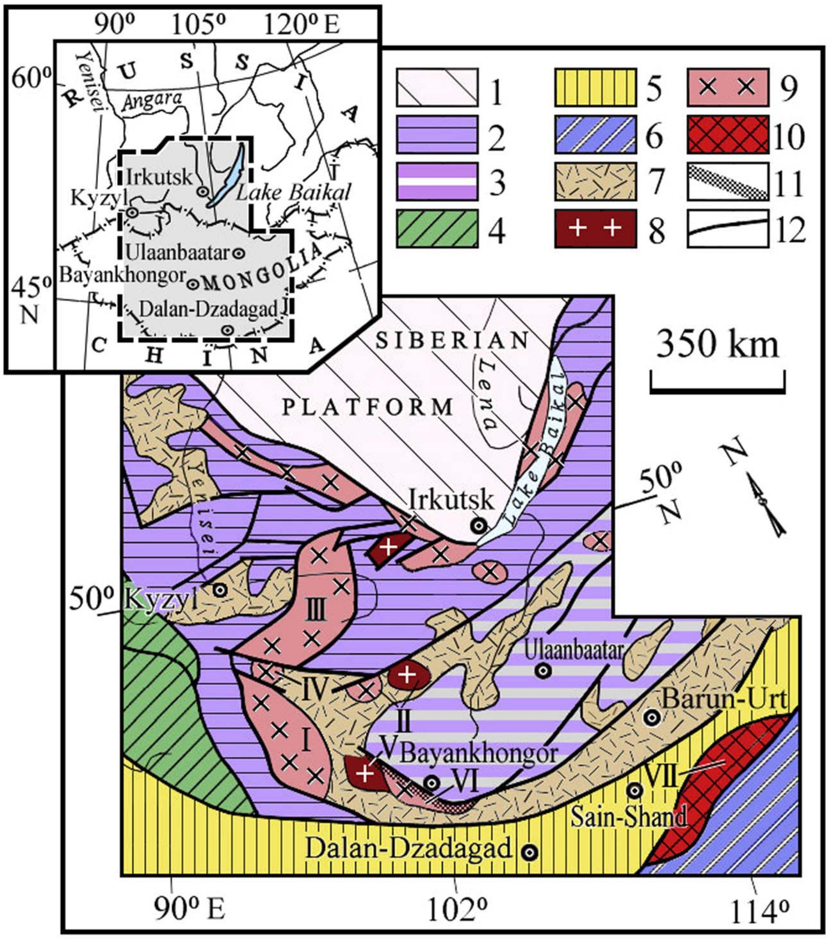

Fig. 1. Schematic map showing location of Precambrian crustal fragments in the central part of the Central Asian Orogenic Belt (modified after Mossakovsky et al., 1994; Yanshin, 1989). 1 – Ancient platforms; 2–10 – CAOB structures: 2 – late Neoproterozoic - early Palaeozoic, 3 – middle to late Palaeozoic rocks of the turbidite basin, 4 – early Palaeozoic, 5 – middle Palaeozoic, 6 – late Palaeozoic–Mesozoic, 7 – late Palaeozoic–Mesozoic volcano-plutonic belts; 8–10 – continental crustal fragments: 8 – with a early Precambrian basement, 9 – with Neoproterozoic basement, 10 – with Grenville-age basement; 11 – Bayankhongor ophiolite zone; 12 – major tectonic boundaries. Roman numbers: I – Dzabkhan Block, II – Tarbagatai promontory, III – Tuva-Mongolian Massif, IV – Songino Block, V – Baidarik Block, VI – Tatsaingol Block, VII – South Gobi microcontinent.

Anisimova et al., 2009) (Fig. 1).

Geological, geochronological and Nd whole-rock isotopic data suggest that the Baidaragin and Bumbuger Complexes in the northwestern part of the Baidarik Block (Fig. 2) formed during the Neoarchaean and the Palaeoproterozoic respectively and experienced two major events of regional granulite-facies metamorphism at lower crustal conditions at about 2500 and 2370 Ma (Bibikova et al., 1990; Kozakov, 1986, 1993; Kotov et al., 1995; Kozakov et al., 1997, 2007). Amphibolite-facies metamorphism at ca. 1850 Ma (Kozakov, 1993) was associated with regional retrogression of the older granulite-facies assemblages in the Baidaragin and Bumbuger Complexes, i.e. the lower crustal rocks were uplifted to the upper crust. A prominent feature, synchronous with the emplacement of amphibolite-facies granitoids, is an abundance of mafic granulite xenoliths in these granitoids, regarded as being derived from Neoarchaean or early Palaeoproterozoic lower crust. However, there was no information on the age, geochemistry and isotopic characteristics as well *P-T* conditions of these mafic granulite xenoliths.

We present *P-T* estimates, zircon ages, as well as Hf-in-zircon and Nd whole-rock isotopic data of mafic granulite xenoliths and host charnockites and discuss the origin of the late Palaeoproterozoic lower crust of the Baidarik Block. A summary of the analytical techniques is given in Appendix A.

2. Regional geology and geochronological background of the northwestern Baidarik Block

Early Precambrian rock associations are best developed in the northwestern part of the Baidarik Block near Bumbuger village (Figs. 2 and 3). They consist of the Baidaragin and the Bumbuger Complexes (Mitrofanov et al., 1985; Kozakov, 1986), overlain with an angular unconformity by mainly black shales of the Meso- to Neoproterozoic Uldzitgol sequence (Fig. 3). The tectonic boundaries of the Baidaragin and Bumbuger Complexes are represented by shear zones that are parallel to the axial planes of upright, northwest-trending isoclinal folds, which define the general structure of the early Precambrian complexes of the Baidarik Block (Fig. 3).

The Baidaragin Complex is composed of migmatized biotite- and hornblende-bearing gneisses of tonalite-trondhjemite composition as well as rare amphibolites and boudins of two-pyroxene gneiss of andesite-basalt – dacite composition (Fig. 4). Zircon cores from the two-pyroxene gneiss boudins yielded $^{207}Pb/^{206}Pb$ ages from 2804 ± 17 to 2890 ± 14 Ma, whereas sub-idiomorphic rounded zircons that probably formed during granulite-facies metamorphism have $^{207}Pb/^{206}Pb$ ages of ca. 2.55–2.48 Ga (Kozakov et al., 2007; Table 1). Multigrains fractions of magmatic zircons from a tonalitic-trondhjemitic gneiss were dated by TIMS at 2646 ± 45 Ma (Mitrofanov et al., 1985; Kozakov, 1993). Similar single zircons from a trondhjemitic gneiss and a two-pyroxene gneiss boudin were dated by SHRIMP II at 2603 ± 26 and 2659 ± 20 Ma (weighted mean $^{207}Pb/^{206}Pb$ ages; Kozakov et al., 2007). The youngest age of 1836 ± 37 Ma was obtained for the outermost rims and recrystallized domains of zircons from these samples.

The Bumbuger Complex consists of two rock associations: (1) interlayered mafic and felsic gneisses (originally metabasalt and metarhyolite); (2) an alternation of forsterite-bearing marble, magnetite quartzite, pyroxene and hornblende gneiss (originally metabasalt and metagreywacke), garnet and biotite gneiss (originally immature