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Age and Geochemical Characteristics of Major Mafic Dyke Swarms in the Southern Part of the Siberian Craton

Tatiana V. DONSKAYA[1], Dmitry P. GLADKOCHUB[1], Richard E. ERNST[2,3], Sergei A. PISAREVSKY[4,5], Anatoliy M. MAZUKABZOV[1], Ulf SÖDERLUND[6],Michael T.D. WINGATE[4,5,7], Michael A. HAMILTON[8] and Elena I. DEMONTEROVA[1]

1 Institute of the Earth's Crust, Siberian Branch of the Russian Academy of Sciences, Irkutsk, 664033, Russia
2 Department of Earth Sciences, Carleton University, Ottawa, Ontario, K1S 5B6, Canada
3 Faculty of Geology and Geography, Tomsk State University, Tomsk, 634050, Russia
4 Australian Research Council Centre of Excellence for Core to Crust Fluid Systems (CCFS) and the Institute for Geoscience Research (TIGeR), Department of Applied Geology, Curtin University, Perth, WA 6845, Australia
5 School of Earth and Environment, University of Western Australia, Crawley, WA 6009, Australia
6 GeoBiosphere Science Centre, Department of Geology, University of Lund, Lund, SE-22362, Sweden
7 Geological Survey of Western Australia, East Perth, WA 6004, Australia
8 Department of Earth Sciences, University of Toronto, Toronto, ON, M5S 3B1, Canada

Several generations of mafic dyke swarms of different ages and geochemical characteristics cut Precambrian rocks of the southern part of the Siberian craton (Irkutsk Promontory). Each generation of dykes is related to a specific stage of Siberian evolution. Here, we present geochronological and geochemical data for Palaeoproterozoic – Palaeozoic mafic dyke swarms, located within the Sharyzhalgai and Goloustnaya inliers of the Siberian craton.

An older generation of Palaeoproterozoic dolerite dykes is exposed in the Kitoi area (Sharyzhalgai inlier). Zircon from the Kitoi dyke has yielded a U-Pb age of 1864 ± 4 Ma, while baddeleyite from the Malozadoisky dyke provides an age of 1863 ± 1 Ma (Ernst et al., 2016). The Malozadoisky dyke is 150-m-wide, whereas the Kitoi dykes are 0.5-m-wide (Ernst et al., 2016). Compositionally, the Kitoi dolerites are sub-alkaline and alkaline tholeiites. The dolerite compositions are close both to OIB with high K2O and P2O2 contents of 2.28–2.52 and 0.74–0.77 wt.% respectively, and to arc basalts with moderate TiO2 (1.18–1.25 wt.%) and Nb (12.4–14.7 ppm), high concentrations of Sr (907–989 ppm), La (116–120 ppm), and Th (7–12 ppm). It is likely that these dolerites originated from melting of a mixed mantle source. The emplacement of these dykes could be related to post-collisional extension following accretionary and collisional events responsible for amalgamation of the Siberian craton.

Mesoproterozoic dykes are exposed along the coast of Lake Baikal near the village of Listvyanka (Sharyzhalgai inlier) and in the Goloustnaya area (Goloustnaya inlier). U-Pb baddeleyite–zircon ages are 1350 ± 6 Ma for the Listvyanka dolerites (Ernst et al. 2016) and ca. 1338 Ga for the Goloustnaya dolerites. Known exposures of the Listvyanka dykes include one relatively thick dyke (30 m) and several smaller dykes, whereas the width of Goloustnaya dykes varies from about 10 to 100 m. The chemical compositions of these dolerites are essentially sub -alkaline basalts (Na2O+K2O = 2.2–3.9 wt.%). The rocks are differentiates (Mg# = 36–54) of tholeiitic magmas with relatively high TiO2 (1.6–3.2 wt.%) and P2O5 (0.2 – 0.6 wt.%). A clear, positive Nb–Ta anomaly in normalized multi-element diagrams suggests an OIB affinity. These dykes are interpreted to have been generated during plume-related Mesoproterozoic intra-continental extension, and likely represent part of the plumbing system of a Large Igneous Province (LIP).

The Neoproterozoic (725 – 715 Ma) Irkutsk mafic dyke swarm (Ernst et al., 2016) is widespread in the Sharyzhalgai and Goloustnaya inliers, with individual dyke thicknesses ranging from 1 to 15 m. These dykes are sub-alkaline tholeiitic dolerites (Na2O + K2O = 1.4–4.2 wt.%). With Mg#'s that vary from 30 to 78, these dolerites include some of the most primitive chemical compositions among

* Corresponding author. E-mail: tatiana_donskaya@mail.ru

all Siberian mafic intrusions. The dolerites have low concentrations of TiO2 (0.3–1.5 wt.%) and P2O5 (0.04–0.13 wt.%), and non- or weakly fractionated REE spectra (La/Ybn = 1.1–6.1). Some dolerites, located in the Kitoi area only (Sharyzhalgai inlier), are not contaminated and characterized by low Th contents with (Th/Nb)pm < 1. Other dolerites are contaminated and have higher Th contents, and (Th/Nb)pm > 1. In multi-element diagrams, contaminated dolerites display clear negative Nb−Ta and Ti anomalies. We suggest that non-contaminated dolerites were derived from a primitive mantle source, whereas other dykes formed as the result of crustal or lithospheric contamination of a primitive mantle source. The emplacement of these and other south Siberian mid-Neoproterozoic dykes could be related to breakup of the Rodinia supercontinent, and specifically separation of Siberia from northern Laurentia (Ernst et al. 2016).

Early Palaeozoic dykes (U-Pb zircon age of 495 ± 4 Ma, Gladkochub et al., 2013) are exposed locally near the village Goloustnaya (Goloustnaya inlier), where they include one dyke more than 30 m thick and several smaller dykes. The thick dyke produced hybrid rocks near inner contacts of dolerites. The dolerites are geochemically close to sub-alkaline tholeiites. They have moderate TiO2 (0.96–2.57 wt.%), P2O5 (0.14–0.49 wt.%) and Nb (6.2–14.3 ppm), as well as high abundances of La (22–72 ppm) and Th (4.3–11.3 ppm). They are characterized by fractionated REE patterns (La/Ybn = 5–17). On normalized multi-element diagrams there are negative Nb−Ta, and Ti anomalies. The dolerites have (Th/La)pm>1 and slight negative Eu anomalies. We hypothesize that these dolerites were derived from mantle sources contaminated by continental crust. Emplacement of these dykes could be related to Early Palaeozoic post-collisional extension after the accretion of Neoproterozoic – Early Palaeozoic terranes to the southern margin of the Siberian craton.

The youngest group of dykes (U-Pb zircon age of 275 ± 4 Ma, Pisarevsky et al., 2006) is exposed along the Krugobaikal railway (Krugobaikal swarm). The thickness of these dykes varies from a few tens of centimetres to two meters. These Permian dolerites are highly alkaline (Na2O+K2O = 4.0–6.0 wt.%), and some of them are similar to alkaline basalts in composition. They have high contents of TiO2 (1.6–3.9 wt.%) and P2O5 (0.3–0.7 wt.%). Multi-element patterns display clear negative Nb−Ta anomalies, and positive Sr anomalies. Initial eNd(t) values fall between +3.4 and +7.3. Altogether the isotopic and geochemical data indicate a mixed mantle source with both recycled and enriched components. These dykes were probably emplaced through the interaction of a mantle plume with the subducted slab of the Mongol-Okhotsk Ocean.

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