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LARGE IGNEOUS PROVINCES THROUGH EARTH HISTORY: MANTLE PLUMES, SUPERCONTINENTS, CLIMATE CHANGE, METALLOGENY AND OIL-GAS, PLANETARY ANALOGUES (LIP – 2019)

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КРУПНЫЕ ИЗВЕРЖЕННЫЕ ПРОВИНЦИИ В ИСТОРИИ ЗЕМЛИ: МАНТИЙНЫЕ ПЛЮМЫ, СУПЕРКОНТИНЕНТЫ, КЛИМАТИЧЕСКИЕ ИЗМЕНЕНИЯ, МЕТАЛЛОГЕНИЯ, ФОРМИРОВАНИЕ НЕФТИ И ГАЗА, ПЛАНЕТЫ ЗЕМНОЙ ГРУППЫ (КИП – 2019)

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MAIN STAGES OF THE PALEOZOIC ALKALINE MAGMATISM IN THE WESTERN CAOB: ISOTOPE AGE AND GEOCHEMISTRY OF PLUTONIC ROCKS ACCORDING THE PERIODIC MANTLE PLUMES ACTIVITY

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Introduction

Alkaline magmatic activity in the continents and the oceans usually is related to periods of mantle plume activity (Ernst, 2014; Yarmolyuk et al., 2014). Geochemical and isotopic characteristics of formed volcanic-plutonic associations can be attributed to participations of distinct mantle components (Bell et al., 1998; Gwalani et al., 2010). Contamination by material of accretionary-collisional complexes of primary alkaline magmas from orogenic belts complicates their mantle characteristics (Doroshkevich et al., 2012; Vrublevskii, 2015; Vrublevskii et al., 2012, 2014, 2016, 2018, 2019a, b).

Results

With minor exceptions, the alkaline magmatism in the Western Central Asian orogenic belt (CAOB) is Paleozoic. There are alkaline plutonic complexes of the NE Kuznetsk Alatau, SE Russian Altai (Edel'veis complex), SE Tuva (Sangilen plateau), Western Transbaikalia (Vitim plateau) and Baikal region, Northern Mongolia (Hovsgol region) and East Sayan. The complexes form differentiated series of rocks and include subalkaline and alkaline gabbro, foidolites, nepheline and alkaline syenites. According to U–Pb, Sm–Nd, Rb–Sr, and Ar–Ar data, the 520–470, 405–385, 310–250 Ma intervals of alkaline rock emplacement are distinctly determined (Figure 1).

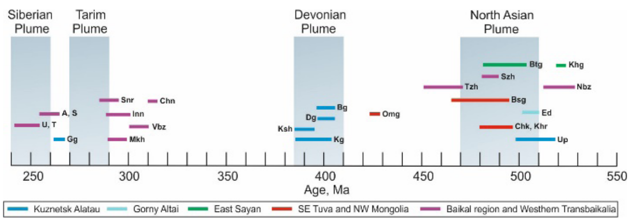

Figure 1. Correlation between plume activity events and pluton ages: plutons of the alkaline provinces are shown according to published data. Igneous provinces are shown by different colors.

Massifs of subalkaline gabbro and foidic igneous rocks of all age events (Late Cambrian (~ 500 Ma), Early Devonian (~ 400 Ma) and Late Permian (~ 265 Ma)) occur in the NE Kuznetsk Alatau (Vrublevskii et al., 2014, 2016; Mustafayev et al., 2017). Alkaline complexes in the Vitim plateau and Baikal region were emplaced at Early Paleozoic and Late Carbon-Early Triassic (Sklyarov et al., 2009; Doroshkevich et al., 2012, 2018). Some massifs in the SE Russian Altai, SE Tuva, East Sayan and Hovsgol region (NW Mongolia) can be formed in relatively wide age interval from Cambrian through Silurian (Vrublevskii et al., 2012, 2019a,b; Sal'nikova et al., 2018).

Independent of ages, these alkaline igneous rock associations exhibit geochemical convergence that suggests a participation in magma generation of mantle plume material and continental lithospheric material. Such mixing of heterogeneous material is evidenced by the features of both trace element composition and radiogenic isotope relationship. Wide variations of initial Nd–Sr isotope ratios ($\varepsilon_{Nd}(t) \approx$ from –1 to +8; $^{87}Sr/^{86}Sr(t)$ from 0.7032 to 0.7076) can testify the interaction of depleted (PREMA-type) and enriched (EM-type) mantle components in the sources and/or contamination of primary melts at crustal levels. Furthermore, Nd–Sr isotopic compositions of alkaline rocks correlate to trend of isotopic evolution of the mantle plumes that are responsible for Paleozoic mafic magmatic activity in the CAOB (Figure 2).

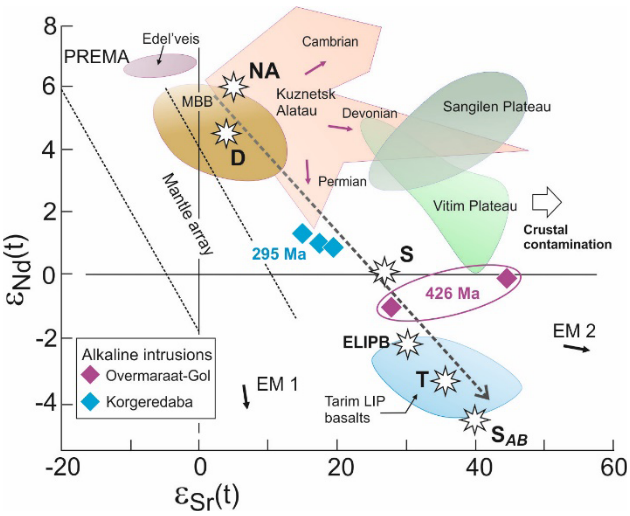

Figure 2. $\varepsilon_{Nd}(t)$ vs. $\varepsilon_{Sr}(t)$ plot for alkaline complexes from the Western CAOB (our published data). MBB=Devonian Minusa basin basalts in the Altai–Sayan area, after Vorontsov et al., 2013. Nepheline syenites of the Korgeredaba (~ 295 Ma, SE Tuva) and Overmaraat-Gol (~426 Ma, NW Mongolia) plutons, after Nikiforov et al., 2018; Vrublevskii et al., 2019a. White stars are average basalt compositions of the North Asian (NA), Devonian (D), Siberian (S, AB = alkali basalts) and Tarim (T) mantle plumes, after Yarmolyuk and Kovalenko, 2003; Vorontsov et al., 2013; Lightfoot et al., 1993; Zhang et al., 2010; Li et al., 2012; Wei et al., 2014. Dash line shows composition trend of the

plume component. ELIPB=the average basalt composition of the Emeishan large igneous province (Li et al., 2015). Predominant basalt compositions from the Tarim LIP given by (Zhang et al., 2010; Li et al., 2012; Wei et al., 2014). "Mantle array" domain and PREMA, EM 1 and EM 2 modern mantle reservoirs are according to (Zindler and Hart, 1986; Stracke et al., 2005).

Predomination of EM component in the primary source is a typical at the Late Paleozoic plume activity. However, initial Pb isotope ratios in rocks and minerals confirm the presence of enriched components in Cambrian and Devonian alkaline intrusions ($^{208}Pb/^{204}Pb$ 37.21–38.02; $^{207}Pb/^{204}Pb$ 15.40–15.71; $^{206}Pb/^{204}Pb$ 17.28–19.67). Direct correlation between $^{87}Sr/^{86}Sr(t)$ and high $\delta^{18}O$ (to ~ 8–14 ‰) values in rocks is an evidence of crustal contamination signatures; these features are typical for magmatic complexes in orogenic belts. $\delta^{34}S$ values (to 4.6 ‰) in sulfides from alkaline rocks are higher than those of the mantle values. Isotopic heterogeneity is observed within individual massifs and can be caused by different degree of mixing of heterogeneous material in intermediate chambers.

Conclusions

The primary melts for Paleozoic alkaline rocks of the Western CAOB were formed from heterogeneous mantle sources. The main mixing components are PREMA and EM mantle sources. High $^{87}Sr/^{86}Sr(t)$ and $\delta^{18}O$ values in rocks is an evidence of crustal contamination signatures of magmas. It can be a result of interaction between mantle plume components and materials of accretionary-collisional complexes.

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