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MANTLE-CRUST INTERACTION AT THE LATE STAGE OF EVOLUTION OF HERCYNIAN ALTAI COLLISION SYSTEM, WESTERN PART OF CAOB

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Altai collision system of Hercynides was formed in Late Paleozoic as a result of oblique collision of Siberian continent and Kazakhstan composed terrane [*Vladimirov et al., 2003; 2008; Xiao et al., 2010*]. At the late stages of its evolution (time interval from 310–300 to 280–270 Ma) the huge different mafic and felsic magmatism occurred at the territory (Fig. 1) [*Vladimirov et al., 2008; Khromykh et al., 2011, 2013, 2014, 2016; Kotler et al., 2015; Sokolova et al., 2016*]. It is evident about increased thermal gradient in lithosphere and about significant role of mantle and active manifestation of mantle-crust interactions. Some magmatic complexes may be considered as indicators of mantle-crust interaction processes.

1. Gabbro-granite intrusions. Within the Char zone (see Fig. 1) some intrusions with complicated structure occur. The feature is diversity of composed rocks – from olivine gabbro to leucogranites. In the studied Preobrazhenka massif in many places the specific interactions between mafic and felsic rocks were described (Fig. 2). They could be classified as mingling-relations (i.e. interaction of gabbro and granite magma in un-solidified conditions). Executed detail petrologic studies of rocks of Preobrazhenka intrusion [*Khromykh et al., 2017*] show that all different rocks of the massif may be divided into two groups: mafic (from olivine gabbro to monzodiorites) and felsic (from Qtz monzonites to leucogranites). They were produced during differentiation of different parental magmas. Mafic rocks were formed from parental trachy-basalt magma in the course of its fractionation and contamination by crust anatectic melts. Granitoid rocks were formed as a result of melting of lower or middle-crust substrates under thermal effect of mafic magma. Parental

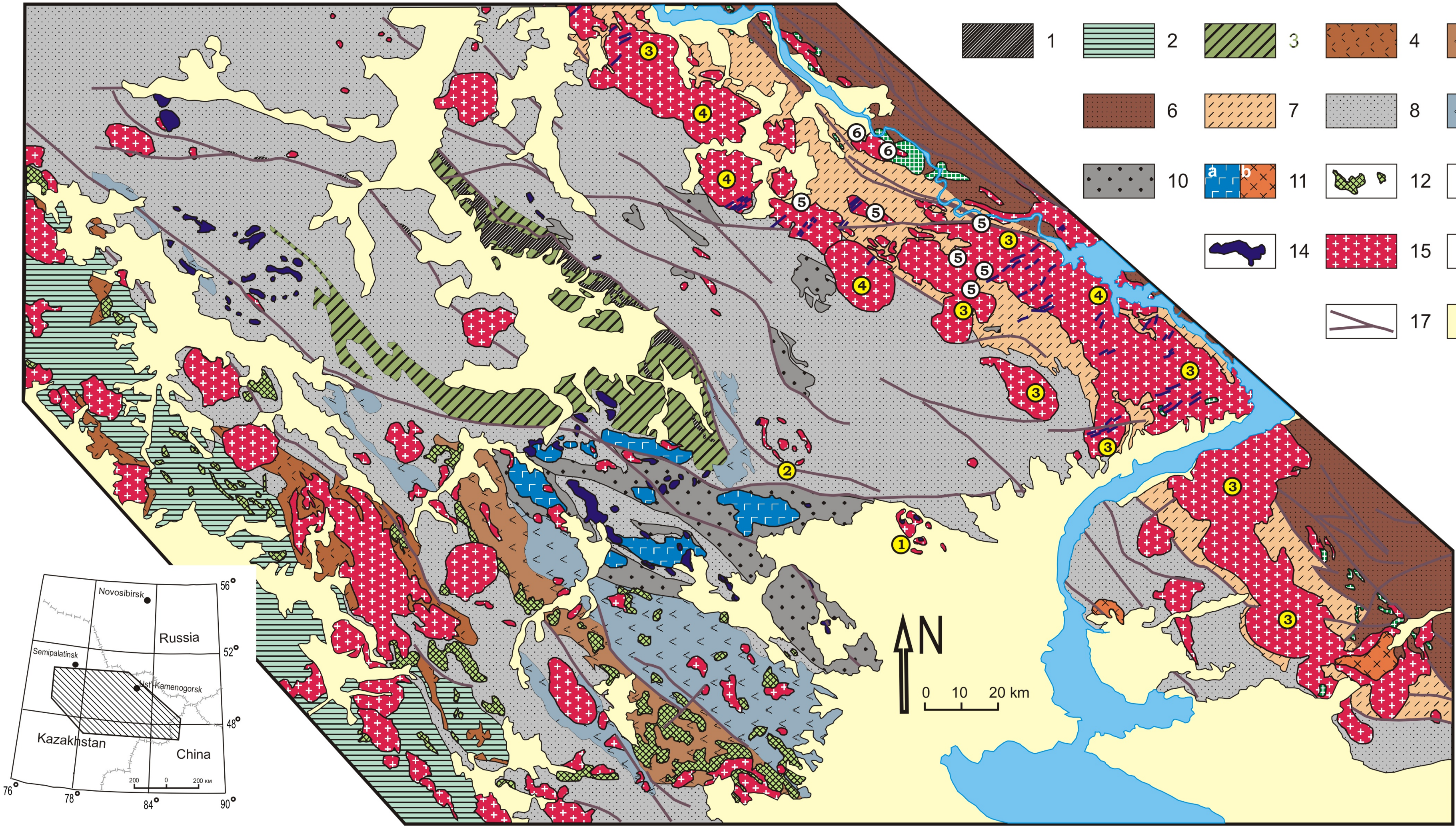

Fig. 1. Geological scheme of central part of Hercynian Altai collision system. Based on Geological map of USSR (Eastern Kazakhstan series) 1:500000 scaled and new geological, petrological and geochronological data.

1 – serpentinite melange and other rocks of Char ophiolitic belt (Є–O); *2* – sedimentary and volcanic deposits (Є–O–S) in Zharma-Saur zone; *3* – sedimentary deposits and basalts (O_3–S–D_{2-3}) in Char zone; *4* – volcanic deposits of middle and felsic composition (D_{1-2}) in Zharma-Saur zone; *5* – andesites and basalts (D_3) in Zharma-Saur zone; *6* – sedimentary and volcanic deposits (D_2gv) in Kalba-Narym zone; *7* – terrigenous deposits (D_3-C_1) in Kalba-Narym zone; *8* – terrigenous deposits C_1; *9* – basalts and andesites C_1; *10* – molasses with basal conglomerates C_{2-3}; *11* – volcanic covers C_2-P_1 in troughs: a – andesites and basalts, b – dacites and rhyolites; *12* – gabbro intrusions (C_1?) in Zharma-Saur zones; *13* – gabbro intrusions (C_2) in Kalba-Narym zone; *14* – gabbro and picrite intrusions (P1) in Char zone; *15* – granitoid intrusions (C_2-P_1), undivided; *16* – post-batholith dykes (P_{1-2}); *17* – faults; *18* – loose sediments (N-Q). Numbers in circles – objects of research. Gabbro-granite intrusions: 1 – Preobrazhenka massif, 2 – Tastau massif. Kalba-Narym batholith: 3 – rocks of granodiorite-granite association, 4 – rocks of leucogranite-granite association. Rare-metal manifestations: 5 – ore rare-metal pegmatite deposits, 6 – Chechek and Akhmirovka ongonite dyke belts.

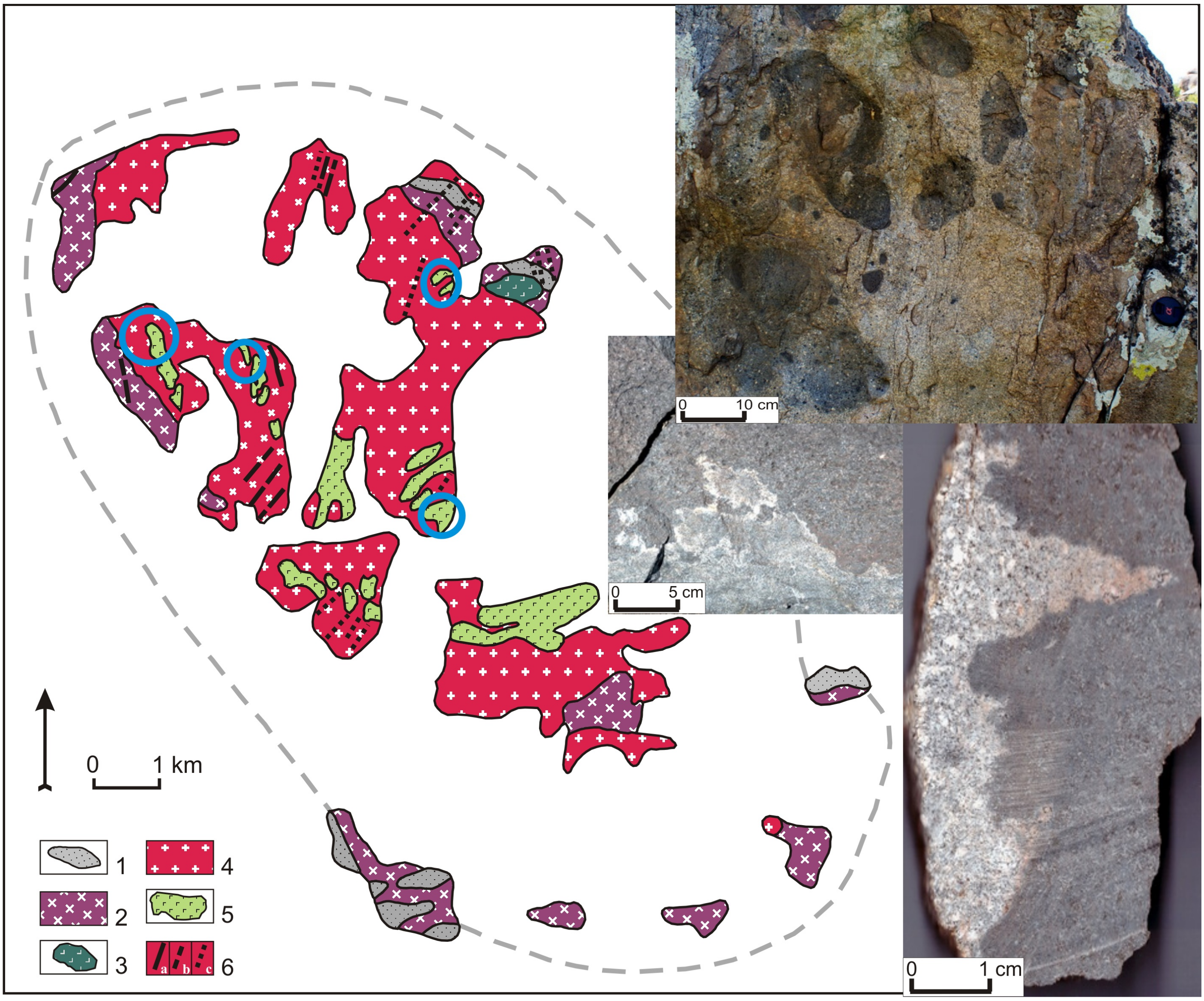

Fig. 2. Scheme of Preobrazhenka massif.

1 – host rocks (hornfels on sandstones and siltstones); *2* – monzonites and Qtz monzonites of 1st phase; *3* – monzogabbro of 2nd phase; *4* – granosyenites and granites of 3rd phase; *5* – monzodiorites of 4th phase; *6* – after-intrusion dykes of dolerites (a), granosyenite-porphyres (b); aplites (c). The blue circles indicate the revealed manifestations of the mingling relationships between monzodiorites and porphyritic granosyenites. Photos illustrate the relationships between igneous rocks. Above – nodules of monzodiorites (dark grey) and porphyritic granosyenites (light grey) in granites of the 3rd phase. Below – contact of monzodiorites and porphyritic granosyenites, outcrop and scan image from the sample.

trachy-basalt magmas were formed from enriched mantle substrates and then the under-crust chamber of mafic magma was formed. During cooling of this chamber and through olivine fractionation the composition of mafic magma changed from olivine gabbro to monzogabbro.

The first intrusion of monzogabbro to lower-crust levels excited the melting of metamorphic rocks and appearance of anatectic melts. The interaction between monzogabbro magma and granitoid anatectic melts occurred at different levels. At the lower-crust level this interaction led to reciprocal contamination of mafic and felsic magmas and manifestation of Quartz-bearing monzogabbro and Quartz monzonites. At the middle-crust level the reciprocal contamination did not play a crucial role, so the mingling- relation structures were formed. At the upper-crust level, after the solidification of intrusion the mafic magmas did not interact with granites and formed only some dykes.

2. Kalba-Narym granitoid batholith. This is one of the largest granitoid batholithes in western past of CAOB (see Fig. 1). It extends from NW to SE within Kalba-Narym turbidite terrane that was formed as trench along Rudny Altai – active margin of Siberian continent

in Late Paleozoic. In last few years the new geochronological data were obtained [*Kotler et al., 2015; Khromykh et al., 2016*]. They prove that the time interval of formation main volume of Kalba-Narym granitoid batholith is no more than 20 Ma (296–276 Ma). It's formation may be divided into two stages: 1) Granodiorite-granite association with similar to S-type composition formed the main volume of batholith (296–286 Ma); 2) Leucogranite-granite association with similar to A-type composition formed some large independent intrusions (284–276 Ma).

Analysis of mineralogy and composition of granitoids from these two associations and composition of sedimentary and metamorphic rocks and also experimental data about melting of crustal protolithes allow to determine the sources and conditions of formation of granitoid magmas. It was determined that formation of granodiorite-granite association (similar to S-type granites) resulted from melting of mixed metapelitic and metabasitic substrates. The formation of per-aluminous granitoids of leucogranite-granite association (similar to A-type granites) resulted from melting of crustal metapelitic substrates but only under introducing of HSF-Elements and RE-Elements with juvenile fluids that interacted with metamorphic rocks during its melting.

3. Rare-metal granitoid magmatism. The important feature of Kalba-Narym zone is a wide spread of rare-metal mineralization (Ta, Nb, Li, Be, Sn, W etc.) relating with rare-metal granitic pegmatites. The facial analog of rare-metal pegmatites are ongonites and rare-metal granite-porphyres that compose two dyke belts – Chechek and Akhmirovka (see Fig. 1). Study of mineralogical and geochemical features of dyke rocks [*Khromykh et al., 2014; Sokolova et al., 2016*] allows to determine that they were formed from highly enriched in rare metal granitic melts. The formation of such rare-metal granitic melts is supposed to occur during differentiation of granitic chambers of Kalba-Narym batholith under introducing of some juvenile fluids (enriched in F, P_2O_5, rare metals, etc.). The under-crust reservoir (of mafic magma probably) can be a source of these juvenile fluids. Within the Kalba-Narym zone the manifestations of mafic magmatism are represented by some dyke belts of Myrolyubovka complex that intruded all granitoids. Dykes of Myrolyubovka complex are mainly sub-alkaline diorites and dolerites and they are enriched in K_2O, F, P_2O_5 and some rare elements.

Geochronological data (U-Pb dating of zircons) confirm the synchronism of gabbro-granite intrusions (290 Ma), granitoids of Kalba-Narym batholith (296–276 Ma) and rare-metal granites and pegmatites (290–285 Ma). Thus at the territory of Altai collision system the two types of mantle-crust interaction processes occurred. The direct interaction of mantle magmas with crustal substrates and anatectic melts is the first. It includes contamination of mafic magmas by crustal material, chemical mixing of different magmas with forming hybrid rocks, and also interaction of mafic and felsic magmas in un-solidified conditions (magmatic mingling). The thermal and fluid effect of mantle on crustal substrates is the second type. It includes interaction between juvenile fluid and crustal substrates or granites in chamber and indtroduction of some specific elements that may cause forming rare-metal granitoids.

Mantle activity at the territory of Altai collision system may be explained as a result of plate-tectonic processes – general relaxation and extension of lithosphere after finish of orogeny [*Xiao et al., 2010; Xiao, Santosh, 2014; Cai et al., 2016*]. The alternative viewpoint is an opinion about activity of independent mantle plumes (particularly Tarim mantle plume in western CAOB, 300–270 Ma) that caused huge different Late Paleozoic magmatism in wide territory of Central Asia [*Pirajno et al., 2009; Ernst, 2014; Xu et al, 2014; Yarmolyuk et al, 2014*; etc]. At the territory of Altai collision system the geological evidence for both opinions are preserved. It allows to suppose that combination of plate- and plume-tectonic factors caused the observed geological structure of this territory. The accretion-collision processes were a structural factor, and Tarim mantle plume was a thermal source for different mantle and crust magmatism and their interaction.

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