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Campanian and Early Eocene granite magmatism in accretional and collisional settings on the example of Sredinniy Range, Kamchatka

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In the Sredinniy Range of Kamchatka intrusive complexes of granite composition, located within metamorphic sequences of Malka Rise, are widespread. New U-Pb SHRIMP zircon datings, analysis of composition peculiarities and tectonic setting (accretional and collisional) of two granite complexes indicate that granites mark stages of tectonic evolution of metamorphic complexes of Sredinniy Range and are indicators of newly formed continental crust of Kamchatka.

The questions of origin, age, structure, interrelations between complexes and protolith nature of metamorphic rocks of Kamchatka Sredinniy Range are debatable [1–5]. According to works of last years the structure of Malka Rise is described as fold-and-thrust [1–3, 5]. Complexes of Kolpakova Group, intruded by gneissosed Krutogorova granites, deposits of Kamchatka Group, Kheivan and Khozgon formations are included in autochthon. Allochthon is composed of complexes of Andrianovka, Khimka, Iruney and Kirganik formations. Lower Eocene deposits of Baraba Formation, which unconformably overlie both metamorphic complexes and Cretaceous deposits of Iruney Formation, belong to neoautochthon [3, 5].

Granites of Malkinsky Rise of Sredinniy Range are represented by two types: gneissosed and equigranular. Gneissosed granites correspond to granites of Krutogorova complex, intruding metamorphic formations of Kolpakovka Group. Equigranular granites intrude complexes of Kolpakovka and Kamchatka groups. In one place equigranular granites intrude schists of Heivan Formation (autochthon), metabasites of Andrianovka Formation (allochthon) and thrust zone between them, thus being “stitching” intrusions. Gneissosed and equigranular granites and host schists and gneisses of Kamchatka Group are intruded by veins of aplites, granite-porphyres and pegmatites.

U/Pb SHRIMP zircon datings of granites indicate that within Malka Rise of Kamchatka Sredinniy Range two stages of granite formation are distinguished: Campanian ($\sim$78–80 m.a.) and Early Eocene ($\sim$52$\pm$2 m.a.). Granites of the first stage were metamorphosed and became gneissosed; Early Eocene granites formed synchronously with peak of metamorphism during collision [5].

Interrelation between SiO_2 and alkalis in the studied granites indicates that they belong to rocks of normal row and partly subalkaline. Equigranular granites correspond to granites and granodiorites, gneissosed and rocks from enclaves in equigranular granites, to granodiorites. Interrelation between K_2O and SiO_2indicates that they belong to medium and high-K calc-alkaline series; they are characterized by similar ASI index (0,95–1,3) and plot in the field of peraluminous granites. Petrochemical features (interrelations between ASI and SiO_2, FeO_t+MgO+$TiO_2$and SiO_2) of both equigranular and gneissosed granites indicate their similarity to S-granites of collisional orogens of different age. The most of granites plot in the field of S-type granites, compiled by P.Sylvester according to indicator characteristics such as Al_2O_3/TiO_2 è CaO/Na_2O.

REE chondrite-normalized patterns allow distinguishing among equigranular and gneissosed granites two rock groups. The first group of equigranular and gneissosed granites is characterized by significant LREE/HREE fractionation (La_N/Yb_N=14.30–71.37). The second group is more enriched in HREE (La_N/Yb_N=2,68–5.59) and is characterized by distinct negative Eu-anomaly (Eu/Eu*=0.41–0.46). REE patterns of gneissosed and equigranular granites of this group is similar to those of host gneisses of Kolpakovka and Kamchatka groups consequently and REE patterns of collisional S-granites, which formation is related to partial melting of metapelites (syncollisional Miocene Manaslu leucogranites, Hymalaya).

As a whole geochemical features of first group granites (increased La_N/Yb_N and Sr/Y ratios) make them similar to high-Al tonalites, trondhjemites, dacites (TTD) and adakites. REE features of the second group of gneissosed and equigranular granites are similar to those of collisional S-type granites.

Petrography and petrochemical characteristics of granites of Malka Rise of Sredinniy Range indicate their similarity to S-type granites. The latter are usually considered as a result of partial melting (anatexis) of metasedimentary crustal protolith either as a result of increased radioactive decay and heating at the formation of abnormally thickened crust ($>$50 km) of collisional systems, or a result of delamination of lithosphere and underplating of hot asthenosphere mantle at postcollisional setting [6, 7]. REE features suggest that both gneissosed and equigranular granites may be formed as a result of partial melting of different sources: magmatic rocks of basic composition or graywacks metamorphosed in amphibolite to granulite facies (the first group) and metasedimentary rocks (second group). Rb/Ba è Rb/Sr variations in granites of the second group show that both clay-poor and clay-rich metasedimentary rocks may exist in their protolith.

Data in [3, 4] show that complexes of Kolpakovka Group are metamorphosed deposits of accretionary prism and carried out dating of terrigenous protolith indicates their Cretaceous age [3, 5]. Thus the first stage of granite magmatism of Sredinniy Range, formation of gneissosed granites with age $\sim$78-80 m.a., is probably related to accretional setting at the Kamchatka margin of Eurasia. The reasons of granite magmatism in accretionary prisms both on the example of Kamchatka and other regions of Pacific margin still remain debatable. The first variant is underplating of mafic material at the base of accretionary prism as a result of mantle wedge melting above subduction zone. The second variant is the oceanic ridge subduction beneath Kamchatka margin, mantle window formation, heating of the accretionary prism base and granite melting (similar to Shimanto and Hidaka accretionary prisms, Japan [9, 10]).

The second stage of granite magmatism, formation of equigranular granites, coincides in time with collision between Achayvayam-Valaginskaya ensimatic island arc and Kamchatka margin of Eurasia. 60 m.y. ago Achayvayam-Valaginskaya ensimatic island arc was at the distance of first hundreds km to Kamchatka margin of Eurasia. In relic basin between the margin and island arc the terrigenous sedimentation (upper horizons of Khozgon Formation) was followed till $\sim$ 55 m.y. ago. These deposits were protoliths for schists of Kamchatka Group. After 55 m.y. ago during collision the quick thrusting of marginal-marine and island arc slices over heterogeneous formations of the margin occurred. Intensive and quick transformations of the structure, including deep submergence, quick (3-5 m.a.) heating of the crust took place. It is resulted in metamorphism of high temperatures (550–650˚Ñ) and moderate pressures in the deep part of collisional zone and melting of granites. This event took place 52±2 m.y. ago. According to U-Pb SHRIMP zircon datings migmatization, partial melting and intrusion of equigranular granites occurred simultaneously.

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