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Thermochronological modelling of the Central Aldan metamorphism age (Eastern Siberia)

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The difference in petrological interpretation of experimental data and natural systems often can be explained by kinetic factors controlled by diffusion in solid media. Numerical modelling of the diffusion zoning of rock forming minerals demonstrates the degree of reversibility of mineral equilibrium in natural petrogenous systems and allows to develop an additional thermocronological sensors to control the rate of cooling and exhumation. Kinetic sensors and diffusion experiments are also helpful to recognize limitation of using a traditional thermodynamic modelling in application to geological processes. This paper demonstrates the possibility of the thermochronological approaches to reconstruct the most important event of the metamorphic evolution of the Aldan Shield, using diffusion models. The Aldan Shield is an outcropping crystalline basement of the Precambrian Siberian craton. The Central Aldan unit metamorphosed in general under the granulite and amphibolite facies conditions. The most informative metamorphic rock samples of the Deoss iron-ore deposit zone were studied in detail using electron microprobe and thermochronological technique. Regional metamorphic high alumina gneiss of the Deoss zone is represented by mineral assemblage: Grt-Bt-Crd-Sil-Pl-Qtz. Special attention was paid to investigation of diffusion zoning in garnets contacting with biotite and cordierite. Very narrow (20-30 mkm) interdiffusion zoning of Fe-Mg retrogressive redistribution of this components between minerals were detected by electron microprobe. Diffusing zoning locate only on the mutual grain boundary of Fe-Mg rock-forming minerals and several diffusion profiles demonstrate the mass-transfer balance of iron and magnesium during counter-diffusion between minerals. The model of the nonequilibrium exchange reaction in cooling petrological systems *(Lasaga 1983; Gerasimov 1987, 1991)* was used to estimate the cooling rate during metamorphism by diffusion zoning of garnet. It was shown that the initial rate of cooling was about s=3^{o}C/Ma at the temperature

of metamorphic process T_o=610^{o}C fixed by Bt-Grt equilibrium and pressure P=4-5 kbar estimated by Grt-Crd thermo-barometer. Specially prepared thin sections of the same samples were used to obtain the age data of Bt grains by the laser microprobe technique of 40Ar/39Ar method. Isotopic measurements were conducted using the laser mass-spectrometric complex of IGEM RAS. Transparent sandwich thin sections with quartz glass and the built-in monitors of neutron flow contain small amount of substance and have low radio-activity after irradiation. They are convenient for microscopic phase diagnosis of K-containing minerals and to control the homogeneity and orientation of the crystals and diffusion loss of argon at the lattice. The argon was extracted from small areas of Bt grains partially melted by YAG pulse infrared laser and analysed by MI1201 IG noble gas mass spectrometer. Depending on the mineral grain dimension the K-Ar age of Bt was in the range 1.70-1.75 Ga. The calculation of time-temperature (T-t) trend using Dodson's Closure Temperature model *(Dodson 1973)* and independently estimated rate of cooling (s=1-3^{o}C/Ma), has shown that the closure temperature of Bt (K-Ar) system could occur at temperature range 340-360^{o}C. The thermochronological modelling demonstrates that the time span between the last metamorphic thermal event (610^{o}C) and the restarting of isotope clock could reach 120-150 Ma. In this case the real geological age of the Central Aldan regional metamorphism is about 1.90 Ga. This result is in a good agreement with previous geological research of the Aldan Shield. It was shown by various isotope methods that active regional endogenous processes completed at the period 1.9-2.0 Ga.

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