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Thermochronological modeling of the age of Vologda crystalline basement of the Russian platform

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The results of the complex petrological and isotope-geochronological study of the crystalline rock from the deep drilling hall of the south of Vologda segment are presented in this work. The crystalline basement of the platform in Vologda region lie in a depth 2.5 km and represented by high alumina mica schist. The thick sedimentary cover consists of vendian and phanerozoic sediments. Upper level covered by quaternary glacial deposits up to 50 m. A core sample from the borehole of Fedotovo village was obtained from the depth 2600 m. It is fine-medium grained metamorphic mica schist with sillimanite. The mineral assemblage represented by association: Pl-Bt-Ms-Sil-Qtz-Mag +Zrn +Mnz. The metamorphic schist of the crystalline basement contains several radio isotope sensors. There are two rock forming potassium reach mica, - biotite (Bt) and muscovite (Ms) and accessories monazite (Mnz), - the phosphate of REE enriched by Th and U. It was a reason why traditional K-Ar isotope dating method in the combination with electron microprobe U-Th-Pb dating method CHIME [Suzuki et al. 1991] was used for Vologda metapelite rocks dating. In addition to geochronology, the detailed petrological investigation using electron microprobe allowed also to determine thermodynamic parameters of metamorphic system with a help of the mineral thermobarometry and finally estimate the age of the metamorphic thermal event using experimental diffusion data of Ar and Pb in minerals [Gerasimov et al. 2004]. The temperature of the regional metamorphism was estimated using Bt+Mag+Qtz and Bt+Ms geothermometers [Glassley 1983, Hoisch 1989]. Taking into account the field of the sillimanite P-T stability it is possible to conclude that the peak of metamorphism was reached at temperature about =550+/-30° C and pressure =4+/-1 kbar. Isotope thermochronology of the sample demonstrate nearly Svecofenian age 1.7-1.8 Ga of Vologda crystalline basement. K-Ar isotope dating of black and white mica demonstrates regular progression of ages in a concordance with closure temperature of each mineral. The apparent Bt age is about 1670 Ma and Ms age is 1710 Ma. The estimation of closure temperature (Tc) for each of the minerals using Dodsn's theory [Dodson 1973] and DCT computer program with concordance procedure of cooling rate simulation for the two coexisting minerals demonstrate value 340° C and 460° C for Bt and Ms respectively. The rate of cooling in this temperature range is about 3° C/Ma and time span between closure temperatures of the two micas is about 40 Ma. The value of the cooling rate is a very typical for regional metamorphism conditions. The linear extrapolation of the simulated time-temperature trend to the thermal peak of the regional metamorphism (estimated by mineral equilibriums at 550° C) demonstrates that cooling of the metamorphic system from the thermal peak to 460° C(closure temperature of Ms) takes about 30-40 Ma. It is a value of systematic thermochronological correction to the muscovite apparent K-Ar age which has to be added to estimate the age of regional metamorphism, after that we finally receive the age 1750+/-40 Ma. U-Th-Pb system of monazite grains was tested by electron microprobe JEOL 8200 in IGEM RAS using CHIME method. The analysis of 8 grains demonstrated averaged value of age 1790+/-55 Ma. It is in a very good agreement with K-Ar isotope dating results. Moreover, the estimation of monazite closure temperature using experimental data of Pb diffusion [Smith & Giletti 1997] shows the value Tc=540-560° C which almost exactly corresponds to the peak temperature of regional metamorphism. It is also an explanation of the very close results of dating in different isotope systems (conservative U-Th-Pb system of monazite and flexible K-Ar system) in the condition of slow cooling and demonstrates the thermochronological modeling effectiveness.