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Pressure-temperature-fluid evolution of the Mongolian Altai in the Central Asian Orogenic Belt: evidence from mineral equilibrium modeling and fluid inclusion studies on amphibolite-facies rocks from western Mongolia

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The Central Asian Orogenic Belt (CAOB), also known as Altaids, located between the Archean Siberian Craton to the north and the Tarim and North China Cratons to the south, is regarded as one of the largest accretionary and collisional orogen in the world. Detailed petrological studies on the CAOB therefore provide useful information of pressure-temperature (P-T) history of the orogeny as well as the tectonic evolution of East Asia. This study reports detailed petrological data, particularly the results of phase equilibrium modeling and fluid inclusion analysis, of pelitic schists and amphibolites from Bodonch area, southwestern Mongolia, which occupies a significant part of the Paleozoic history of the Altai Orogen in the southwestern margin of the CAOB, and discuss pressure-temperature-fluid evolution of the area.

The dominant mineral assemblages of pelitic schist in Bodonch area are garnet + kyanite + staurolite + biotite + plagioclase, garnet + biotite + staurolite + cordierite, and garnet + biotite + sillimanite + plagioclase with quartz and ilmenite, while amphibolite contains calcic amphibole + quartz + plagioclase + garnet + ilmenite assemblage. Application of conventional garnet-biotite and garnet-cordierite geothermometers as well as GASP geobarometer gave metamorphic conditions of 615-635°C/8.2-8.9 kbar from kyanite-bearing pelitic schist samples. Slightly higher P-T condition of 640-690°C/6.3-10.7 kbar was obtained by mineral equilibrium modeling of garnet-kyanite-staurolite and garnet-staurolite-cordierite assemblages using Theriak-Domino software. The calculation was made in the system Na2O-CaO-K2O-FeO-MgO-Al2O_3-SiO_2-H_2O (NCKFMASH). We constructed a clockwise P-T path staring from high-pressure amphibolite facies condition within the stability field of kyanite (approximately 650°C/9 kbar) possibly through the stability field of sillimanite by post-peak decompressional cooling.

Our petrographical observations of fluid inclusions in pelitic schists identified primary, secondary and pseudosecondary fluid inclusions trapped in quartz grains. The melting temperatures of all the categories of inclusions lie in the narrow range of -57.5 to-56.6°C, close to the triple point of pure CO_2. Homogenization of fluids occurs into liquid phase at temperature between -33.3 to +19.4 °C, which convert into densities in the range of 0.78 to 1.09 g/cm3. The estimated CO_2 isochores for primary and pseudosecondary high-density inclusions is broadly consistent with the peak metamorphic condition of the studied area. The results, together with the primary and pseudosecondary nature of the inclusions, indicate CO_2 was the dominant fluid component during the peak amphibolite-facies metamorphism of the study area. The common occurrences of carbonates and graphite in the study area suggest the origin of CO_2 either by oxidation of organic carbon or devolatilization of carbonates in the protolith sedimentary rocks.

Key words: P-T condition; geothermobarometry; mineral equilibrium modeling; fluid inclusion; Altai Orogeny; Central Asian Orogenic Belt; Mongolia