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Discovery of ultrahigh-T spinel-garnet granulite with pure CO_2 fluid inclusions from the Altay orogenic belt, NW China*

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Abstract: We first report discovery of the spinel-garnet-orthopyroxene granulite with pure CO_2 fluid inclusions from the Fuyun region of the late Paleozoic Altay orogenic belt in Central Asia, NW China. The rock is characterized by an assemblage of garnet, orthopyroxene, spinel, cordierite, biotite, plagioclase and quartz. Symplectites of orthopyroxene and spinel, and orthopyroxene and cordierite indicate decompression under UHT conditions. Mineral chemistry shows that the orthopyroxenes have high X_{Mg} and Al_2O_3 contents (up to 9.23 wt%). Biotites are enriched in TiO_2 and X_{Mg} and are stable under granulite facies conditions. The garnet and quartz from the rock carry monophase fluid inclusions which show peak melting temperatures of around –56.7 °C, indicating a pure CO_2 species being presented during the ultrahigh-T metamorphism in the Altay orogenic belt. The inclusions homogenize into a liquid phase at temperatures around 15.3–23.8 °C translating into CO_2 densities of the order of 0.86–0.88 g/cm^3. Based on preliminary mineral paragenesis, reaction textures and petrogenetic grid considerations, we infer that the rock was subjected to UHT conditions. The CO_2-rich fluids were trapped during exhumation along a clockwise P-T path following isothermal decompression under UHT conditions.

Key words: UHT granulite, Petrology, Pure CO_2 fluid inclusion, Altay orogenic belt, NW China
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INTRODUCTION

Study of ultrahigh-T (UHT) granulites in the world has resulted in much recent attention because this study can indicate high-grade metamorphism and deep crust evolution process. The UHT granulites have been reported from a number of higher-grade crustal segments in the world including the Napier Complex in East Antarctica, Eastern Ghats Belt and Ganguvarpatti, Panrimalai, Perumalmalia and Karur in India, Ouzzal Complex of Algerria, Andriamena in North-Central Madagascar, Mollendo-Camana Block, Andes in Peru, Brasilia Fold Belt in Brazil; Rogaland in SW Norway, Saxon Massif and Schwarzwald in Germany, Epupa Complex in NW Namibia, Highland Complex in Sri Lanka and Kontum Massif in Central Vietnam (Brown and Raith, 1996; Raith *et al.*, 1997; Osanai *et al.*, 2000; Rotzler and Romer, 2001; Sajeev *et al.*, 2001; Moller *et al.*, 2002; Moraes *et al.*, 2002; Tsunogae *et al.*, 2001; 2002; Brandt *et al.*, 2003; Marschall *et al.*, 2003; Martignole and Martelat, 2003; Santosh and Tsunogae, 2003; Paquette *et al.*, 2004).

Recent research in the Altay orogenic belt

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resulted in some important achievements in regional geology, magmatism, metamorphic petrology and geochronology (Han *et al.*, 1997; Li and Poliyangsiji, 2001; Windley *et al.*, 2002; Xiao *et al.*, 2004; Li *et al.*, 2004a; 2004b). The fundamental tectonic outline of the Altay orogenic belt was built based on the last-stage collision between the Siberian plate and Kasakhstan-Junggle plate in the Early Carboniferous (Coleman, 1989; Sengör *et al.*, 1993). A NW-SE directed Ertix tectonic belt is widely distributed in the Altay orogenic belt and Central Asia, and consists mainly of metamorphic rocks.

The UHT granulite in the Altay orogenic belt was not reported so far, so that the studies of the UHT granulite with pure CO_2 fluid inclusions would play a significant role for better understanding tectonic evolution of the Altay orogenic belt, and even Central Asia. This paper will address preliminary character of petrology and fluid inclusions in the spinel-garnet granulite from the Altay orogenic belt, NW China.

SAMPLES, PETROGRAPHY AND ANALYTICAL METHOD

Samples of the rocks were collected from the Wuqiagou, Funyun region, Altay orogenic belt with the UHT granulite being a part of the Ertix tectonic belt. Field survey showed that the UHT granulite occurred in the northeast of the Altay mafic granulite body 500 m away from the Altay mafic granulite reported recently by Li *et al.*(2004a; 2004b) from this area and indicates lower crustal metamorphism. The contact relationship shows continuous change between the UHT rocks and host rocks. The rock is characterized by an assemblage of garnet, orthopyroxene, spinel, cordierite, biotite, plagioclase and quartz. Direct contact relationship between spinel and quartz can be observed. Symplectites of orthopyroxene and spinel, and orthopyroxene and cordierite indicate decompression under UHT conditions. Chemical and fluid inclusion data were analyzed using the XRF (Rigaku 3270E), EPMA (JEOL-8900M) and the Freezing-Heating Stage (THMS600, Nikon) in Kobe University and Kochi University, Japan.

RESULTS AND DISCUSSION

Mineral chemistry shows that orthopyroxenes have high X_{Mg} (0.61–0.65). Orthopyroxene grains in the matrix have the highest Al contents (0.355–0.398), while orthopyroxenes occurring as fine-grained symplectite intergrowths show the lowest Al values (0.229–0.286). Garnets in the rock are almandine rich. Biotites are enriched in the TiO_2 (2.81–4.48 wt%) and X_{Mg} (0.59–0.69), and are stable under granulite-facies conditions. Spinel and cordierite have X_{Mg} of 0.29–0.31 and 0.81–0.84 respectively.

The garnet and quartz from the UHT rock carry monophase fluid inclusions (Fig.1), which show peak melting temperatures of around –56.7 °C, indicating a pure CO_2 species being presented during the ultrahigh-T metamorphism in the Altay orogenic belt. The inclusions homogenize into a liquid phase at temperatures of around 15.3–23.8 °C translating into CO_2 densities of the order of 0.86–0.88 g/cm^3. Based on mineral paragenesis, reaction textures and petrogenetic grid considerations, we infer that the rock was subjected to UHT metamorphism, although P-T calculations applying empirical and experimental geothermobarometers yield only the retrograde P-T signature of ca. 800–860 °C and 7–8 kbar. The CO_2-rich fluids were trapped during exhumation along a clock-wise P-T path following isothermal decompression under UHT conditions. The presence of pure CO_2 fluids in quartz and garnet from the Altay orogenic belt indicate the origin of the granulites and the formation of continental deep crust. The

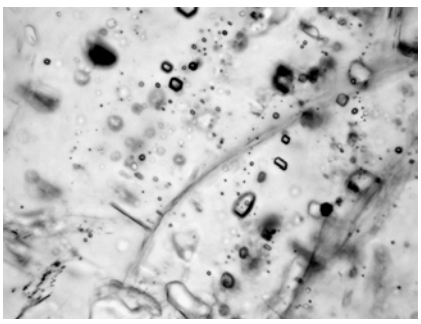

Fig.1 Photomicrography of pure CO_2 fluid inclusions in quartz from the Altay spinel-bearing garnet granulite. The inclusions measure 20 microns

discovery of the Altay UHT rocks have important implications on the structure of deeper crust, crust-mantle interaction in the Altay region and on the continental geodynamics in North Xinjiang, China as well as Central Asia.

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