Coesite inclusions in garnet from eclogitic rocks in western Tianshan, northwest China: Convincing proof of UHP metamorphism

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ABSTRACT

Coesite inclusions in garnet have been recognized in eclogitic rocks from western Tianshan, northwest China. The coesite grains exhibit distinct radial cracks in host porphyroblastic garnet; some coesite relics are well preserved, whereas others are partially replaced by quartz. Coesite has been identified optically and then confirmed by in situ Raman spectroscopy, showing the characteristic band at 522 cm⁻¹ and subsidiary bands at 428, 326, 271, 178, 151, and 121 cm⁻¹. The eclogitic rocks contain garnet, omphacite, and Na-Ca-amphibole, and they are rich in white mica (>30%) and graphite. Peak conditions of 570–630 °C and 2.7–3.3 GPa are constrained by garnet-clinopyroxene geothermometry and the occurrence of coesite. The presence of coesite and widespread quartz inclusions in garnet with radial cracks indicative of former coesite in these unique graphitic rocks confirms the previous suggestion of the UHP terrane for the western Tianshan, China.

KEYWORDS: Coesite, UHP metamorphism, Raman spectroscopy, western Tianshan, China

INTRODUCTION

Since coesite was first discovered in metamorphic rocks from Dora Maira (Chopin 1984) and in Caledonian eclogites (Smith 1984), more than 20 UHP metamorphic terranes have been reported worldwide (Carswell and Compagnoni 2003; Liou et al. 2004). In eclogite from western Tianshan, China, Zhang et al. (2002a, 2002b) first reported inclusions of coesite pseudomorphs in garnet, quartz exsolution in omphacite, and relics of metamorphic magnesite. In spite of these findings, the existence of UHP metamorphism in western Tianshan has remained suspect (see Klemd 2003; Zhang et al. 2003b); such doubts were raised mainly because no well-preserved coesite relics had been recognized in this terrane. However, UHP metamorphic conditions for eclogites and associated metasediments are indicated by the coexistence of magnesite and aragonite as HP breakdown products of dolomite in metapelites (Zhang et al. 2003a) and relic coesite exsolution in porphyroblastic omphacite in western Tianshan eclogite (Zhang et al. 2005). In this paper, we report well-preserved coesite inclusions in garnet from some eclogitic rocks and thus prove that some tectonic units of the western Tianshan, China, indeed experienced UHP metamorphism.

GEOLOGICAL SETTING AND OCCURRENCES

The Chinese western Tianshan HP-UHP belt extends for about 200 km between the Central Tianshan-Yili plate and the Tarim plate (Figs. 1a and 1b). This HP-UHP metamorphic belt continues westward to the Atbashy eclogite-blueschist belt, where inclusions of coesite pseudomorphs in eclogitic garnet have been reported in Kazakhstan and Kyrgyzstan (Dobretsov et al. 1987; Tagiri et al. 1995) (Fig. 1a). It consists mainly of eclogites, blueschists, and garnet-mica schists. So far, three types of eclogite have been recognized in western Tianshan, China: (1) eclogite with pillow structure; (2) eclogite lenses in blueschists and garnet-phengite schists; and (3) banded eclogite interlayered with marble (Zhang et al. 2002a, 2005). This HP-UHP belt is in fault contact with a low-P and high-T metamorphic belt to the north, which consists of cordierite-bearing garnet + sillimanite gneiss and two-pyroxene granulite (Li and Zhang 2004), and to the south with a unit of intercalated marble and chlorite muscovite schists (Fig. 1b). The HP-UHP belt formed by the northward subduction of the Tarim plate beneath the Central Tianshan-Yili plate during the closure of the Paleo-Tianshan ocean (Gao et al. 1999; Zhang et al. 2001, 2005). Recent SHRIMP zircon U-Pb dating shows that the HP-UHP metamorphic age is Triassic (220–230 Ma) and the formation ages of the eclogite protoliths are older than 310 Ma (Zhang et al. 2007).

The foliated coesite-bearing eclogitic rocks are lenticular, and are surrounded by garnet-mica schists along the Habutengsu River, in the northern part of the HP-UHP belt (Fig. 1c).

PETROGRAPHY AND MINERAL CHEMISTRY

Electron-microprobe analyses of minerals in this paper were performed on a Jeol 8100 super probe at Peking University, operated at 15 kV acceleration voltage, 20 nA beam current, and 20 s counting time. Synthetic silica (Si) and spessartine (Mn), and natural pyrope (Mg), andradite (Fe, Ca), albite (Na, Al), rutile (Ti), and sanidine (K) were used as standards. Final results were reduced by a ZAF correction program.

The coesite-bearing eclogitic schists investigated are mainly composed of garnet (15%), omphacite (20%), white mica (40%), Na-Ca-amphibole (20%), and retrograde albite (15%) (Fig. 2a). Accessory minerals include dolomite/calcite, graphite, rutile, and titanite. No quartz was found in the matrix probably owing to extensive retrograde consumption during the growth of albite.