Ultrahigh-pressure metamorphism in western Tianshan, China: Part I. Evidence from inclusions of coesite pseudomorphs in garnet and from quartz exsolution lamellae in omphacite in eclogites

LIFEI ZHANG,1,2,* DAVID J. ELLIS,2 AND WENBO JIANG1

1Department of Geology, Peking University, Beijing, China
2Department of Geology, Australian National University, Canberra, Australia

ABSTRACT

Inclusions of coesite pseudomorphs in garnets have been found in type I eclogites interlayered with mafic blueschists and carbonate eclogites, and quartz exsolution lamellae in omphacites have been recognized in type II eclogites with pillow structure in western Tianshan, China. Based on mineralogy and petrology, the metamorphic evolution of western Tianshan eclogites can be divided into three stages: (1) pre-peak, ultrahigh-pressure (UHP), eclogite-facies stage (356–443 °C, 8–10 kbar); (2) UHP eclogite-facies stage (496–598 °C, 25.7–26.7 ± 1 kbar); and (3) retrograde epidote blueschist-facies stage (500–530 °C, 10–12 kbar). Consequently, the eclogites from the western Tianshan region of China have undergone unambiguous UHP metamorphism.

INTRODUCTION

Since coesite was first discovered by Chopin (1984) in metamorphic rocks from the Dora Maira massif, western Alps, and by Smith (1984) from the western gneiss region of Norway, more than 10 ultrahigh-pressure (UHP) metamorphic terranes have been documented throughout the world (Coleman and Wang 1995; Schreyer 1995; Liou et al. 1998). Most UHP metamorphic complexes occur in continental collision zones of the Eurasian continent and possess similar supracrustal protoliths (Coleman and Wang 1995; Liou et al. 1998). However, UHP metamorphic rocks of ophiolitic affinity are considered rare (Schreyer 1995; Liou et al. 1998). Quartz exsolution lamellae in omphacite have been reported in both eclogites and garnet clinopyroxenites of several UHP metamorphic terranes (e.g. Smith 1984, 1988; Bankun-Czubaow 1992; Gayk et al. 1995; Zhang and Liou 2000) and are considered diagnostic indicators of UHP metamorphism (see discussion in Liou et al. 1998). More recently, similar quartz lamellae have been found in eclogites from the North Dabie region, China (Tsai and Liou, 2000) and from the Kokchetav massif, Kazakhstan (Katayama et al. 2000).

In this paper, we describe inclusions of coesite pseudomorphs in garnet, and quartz exsolution lamellae in omphacite, from ophiolitic eclogites of the western Tianshan, China, and discuss their UHP metamorphic evolution.

GEOLOGIC SETTING AND PETROGRAPHY

The western Tianshan eclogite-facies metamorphic rocks are exposed in a 200 km long, Late Paleozoic orogenic belt between the Yili-Central Tianshan and Tarim plates, China. This belt extends westward to connect with the Aibashy eclogites-blueschist belt in Kazakhstan, which contains coesite pseudomorphs (Dobretsov et al. 1987; Tagiri et al. 1995), and eastward to link up with Kumish blueschist belt in Eastern Tianshan, China (Fig. 1a). This high P/T metamorphic belt consists predominantly of eclogites, blueschists, and greenschists on the northern side, and marbles with interlayered chlorite-muscovite schists on the southern side (Fig. 1b). According to our SHRIMP analyses of zircons from eclogites, the age of UHP metamorphism is younger than 310 ± 5 Ma, which supports the Early Permian metamorphism proposed by Chen et al. (1999). This belt is considered to have formed by the subduction of the Tarim plate beneath the Yili-central Tianshan plate when the south Tianshan paleo-ocean closed in the Paleozoic (Gao et al. 1999).

Based on their geologic setting and petrologic characteristics, the eclogites can be divided into 3 types. The type I eclogites occur as interlayers within pods of mafic blueschist (10–20 cm in diameter), as boudin (0.2 × 0.6 m across), as thin (2–30 cm in width) or thick layers (>50 m wide), and as large massive blocks (almost 2 km2 in plan view). Type II eclogites occur as 40 × 80 cm structures that are interpreted to be former pillow basalts (Fig. 2). Type II and type I eclogites are concordant with each other. Type III eclogites are banded calcite/dolomite rocks occurring as lenticular bodies within marbles. They are characterized by carbonate (30%), garnet (15%), omphacite (20%), glaucophane (20%), zoisite (10%), and paragonite (5%) with minor titanite and rutile. The banded structure is defined by laminated calcite or dolomite, garnet, and omphacite layers. Their protoliths may have been marly limestone.

Inclusions of coesite pseudomorphs are found in type I