Clinoenstatite exsolution in diopsidic augite of Dabieshan: Garnet peridotite from depth of 300 km

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ABSTRACT

Clinoenstatite exsolution lamellae have been discovered in clinopyroxene grains of garnet peridotite from the Bixiling massif of the ultrahigh-pressure metamorphic (UHPM) terrane in the Dabie Mountains, China. Using transmission electron microscopy, we show here that although the lamellae are low clinoenstatite (Lclen) with P2_1/c space-group symmetry, they contain nanometer-scale antiphase domains indicating that the originally precipitating phase had C2/c space-group symmetry. The lamellae are oriented parallel to [010] and ~18° to [001] of the host—approximately parallel to (401). Both the very cold exhumation path of the Dabie UHPM terrane and the orientation of the lamellae preclude the possibility that the originally precipitating phase could have been high-temperature clinoenstatite (HTclen). We conclude that the lamellae precipitated as high-pressure clinoenstatite (HPclen) and subsequently inverted to Lclen. Analysis of the incomplete high-pressure crystallographic data available for compositions approximating those of the lamellae and host suggests a minimum pressure of precipitation of ~9 GPa for Dabie and about 12 GPa for similar exsolution previously observed in the Alpe Arami peridotite, Switzerland. The Bixiling complex is a crustal cumulate, hence this result extends the minimum depth of subduction of continental rocks in the Dabie/SuLu orogen to ~300 km (P > 9 GPa).

Keywords: High-pressure clinoenstatite, deep subduction, exsolution, Dabieshan, ultrahigh-pressure metamorphism

INTRODUCTION

Exsolution microstructures in minerals such as olivine, pyroxene, and garnet from ultrahigh pressure (UHP) rocks such as eclogite and eclogite have attracted people’s attention after coesite and diamond had first been discovered from UHP metamorphic crustal rocks. In contrast to exsolution microstructures in most igneous and metamorphic rocks, which are the result of cooling, UHP mineral exsolutions are more likely formed during decompression from more than 100 km depth to the surface. At the present state of knowledge, the most common exsolution products in olivine of garnet peridotite from UHP metamorphic rocks are ilmenite, chromite, and magnetite. The exsolution of this type was first discovered in the Alpe Arami massif, Switzerland (Dobrzynska et al. 1996; Green et al. 1997, 2000), and shown to require pressures greater than 10 GPa to explain the abundance of ilmenite and chromite (Dobrzynska et al. 2000; Bozhilov et al. 2003). Similar precipitates (but lower abundance) have since been found in many UHP terranes, including Dabie-Sulu in China and Sulawesi in Indonesia (e.g., Jin et al. 1998; Zhang and Liu 1999; Zhang et al. 1999). Also found in Alpe Arami were exsolution lamellae of clinoenstatite in diopside (Yamaguchi et al. 1978; Bozhilov et al. 1999). Based upon the presence of antiphase domains within the lamellae that indicate the former presence of C2/c pyroxene, the orientation of the lamellae within the diopside, and other observations, Bozhilov et al. (1999) concluded that the originally precipitating phase was high-pressure clinoenstatite, stable only at pressures greater than ~8 GPa. At the time of Bozhilov et al. (1999) publication, there were insufficient data to make any attempt to interpret the orientation of the lamellae quantitatively. Since then, however, fragmentary data have appeared. Here, we report a similar occurrence of clinoenstatite exsolution lamellae from clinopyroxene in garnet peridotite from the Bixiling locality of the Dabie UHP terrane, China, and estimate the minimum depth at which these precipitates could have formed.

GEOLOGICAL BACKGROUND OF THE BIXILING COMPLEX

The geological setting of the Dabie collision orogen has been studied by many authors (e.g., Hacker and Wang 1995; Liou and Zhang 1995; Suo et al. 2000). The Bixiling Complex, the largest coesite-bearing mafic-ultramafic body (~1.5 km²) in the Dabie Mountains, occurs as a tectonic block enclosed within quartzofeldspathic gneisses in the eastern part of the Dabie UHPM terrane. The Complex consists predominantly of layered eclogites that contain many lenticular bodies of ultramafic rocks (garnet peridotite, garnet pyroxenite, and wehrlite; Zhang et al. 1995). The contacts between eclogite and ultramafic rocks are gradational. The occurrence of this Complex is in contrast to most other eclogite bodies, which commonly form small, disrupted blocks, lenses, or nodules in enclosing gneisses. Field relation-