Dolomite dissociation indicates ultra-deep (>150 km) subduction of a garnet-bearing dunite block (the Sulu UHP terrane)

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ABSTRACT

The dissociation of dolomite into magnesite and aragonite has been regarded as a useful indicator for ultrahigh-pressure (UHP) metamorphism. In this study we investigate an unusual texture involving magnesite and calcite intergrowths with dolomite relics in a garnet-bearing dunite block from the Sulu UHP terrane, eastern China. The carbonate intergrowths typically occur as interstitial grains with low dihedral angles against surrounding olivines and have a dolomitic precursor composition. Our observations indicate that the carbonate intergrowths were initially inherited from the well-documented magnesite and aragonite assemblage after dolomite dissociation. The initial dolomite grains were likely to crystallize during the dolomitic melt metasomatism within the shallow lithospheric mantle. A series of experimental studies have well determined the equilibrium boundary of dolomite = magnesite + aragonite greater than 5 GPa along a wide temperature range, which provides direct evidence that the dunite block was subducted to depths greater than 150 km during the Triassic continental subduction. The preservation of magnesite and aragonite (now calcite) intergrowths without dolomite synthesis reaction during exhumation is probably due to the lack of fluid and rapid decompression from the peak stage to the calcite stability field. In this study, we suggest that dunite blocks from high-pressure and UHP terranes could have subducted to UHP conditions similar to garnet lherzolite and pyroxenite and were then entrained into slab slices rapidly en route to the surface.

Keywords: Dunite, dolomite dissociation, ultra-deep subduction, Sulu belt

INTRODUCTION

Orogenic peridotite bodies of various sizes are minor but significant components within high-pressure (HP) and ultrahigh-pressure (UHP) terranes in orogenic belts. They originated mainly from the mantle wedge above subducting crust and later were tectonically emplaced into the subduction channel to various depths (50–200 km) before exhumation (Brueckner and Medaris 2000; Zhang et al. 2000; Scambelluri et al. 2008). Therefore, orogenic peridotites act as a natural laboratory to disclose the mass transfer from the downgoing slab into the overlying mantle wedge (Scambelluri et al. 2006; Malaspina et al. 2009; Chen et al. 2017), as well as the geodynamics of ultra-deep subduction (van Roermund et al. 2002; Ye et al. 2009). Compared with garnet lherzolites, which record important aspects of crust–mantle interactions and multistage metamorphic events in subduction zones (Zanetti et al. 1999; Sapienza et al. 2009), orogenic dunites lack the Petrological and mineralogical imprints of these processes (Beyer et al. 2006; Chen et al. 2009). In this regard, orogenic dunites, despite their wide distribution in HP and UHP terranes, have not attracted enough attention in previous investigations of orogenic peridotites.

However, orogenic dunites, with their upper mantle nature largely intact, are the best lithology among orogenic peridotites for tracing the provenances and initial compositions and can also shed light on the mantle wedge evolution prior to the onset of subduction (Kubo 2002; Beyer et al. 2004; Chen et al. 2015; Su et al. 2016a). They commonly exhibit different chemical and physical properties (e.g., density, wave velocity, viscosity, and magnetic conductivity) from garnet lherzolites (e.g., Lee 2003; Griffin et al. 2009). Understanding the distribution ranges (or depths) of these dunites in subduction zones may thus expand our knowledge of geochemical/geophysical heterogeneity in the mantle wedge. In general, orogenic dunites occur as minor components within larger bodies of lherzolite and harzburgite (Beyer et al. 2006; Zhang et al. 2008; Song et al. 2009), but there are also several blocks dominated by dunite, such as Otroy in the Western Gneiss Region (Spengler et al. 2006) and Ganyu and Lijiatun in the Sulu region (Chen et al. 2009; Su et al. 2016a). These dunite blocks mostly represent fragments of subcontinental lithospheric mantle (SCLM) characterized by highly depleted compositions (see review in Su et al. 2016b).

Although orogenic dunites have a great advantage over garnet lherzolites in addressing the early histories of orogenic peridotites, their geodynamic processes related to the slab subduction and exhumation are still poorly defined due to their simple mineral assemblages. Given the wide occurrence of spinel and lack of garnet in orogenic dunites, previous work suggested that dunite blocks have not undergone UHP metamorphism, but