Numerous peridotites, as a minor but significant component of orogenic belts, occur in the east extension Sulu UHP metamorphic belt of Dabie-Sulu collision zone between the Sino-Korean and Yangtze cratons, China. The initial tectonic setting and the processes responsible for the exhumation of orogenic peridotites from the upper mantle to Earth’s surface are major issue in the evolution of orogenic belts. In addition to main drillhole (Maobei, Donghai, 5158 m), Chinese Continental Scientific Drilling (CCSD) project completed a number of additional drill holes, such as PP1 (Zhamafang, Donghai), PP3 (Gangshang, Gugyi), PP5 (Chijiadian, Rongcheng), PP6 (Macaokuang, Rongcheng) and PP7 (Hujialing, Rizhao), to investigate petrogenesis of Sulu UHP peridotites (Fig. 1). These drill holes recovered abundant continuous fresh core samples of ultramafic rocks. Petrological, geochemical and geochronological studies of peridotites from 6 drillhole cores and surface samples provided important constraints on the genesis and tectonic setting of peridotite protoliths, and subsequent UHP metamorphism, metasomatism and retrogression during Triassic continental subduction and exhumation.

General petrological characteristics

The Sulu peridotites were divided into two types: mantle-derived (Type A) and crust-hosted (Type B, i.e., it is a part of crustal mafic-ultramafic complex, formed by crystal cumulation in a differentiating mafic magma chamber prior to continental subduction (Zhang et al., 2000). Most Sulu peridotite cores (such as PP1, PP5-7 and possible PP3) and surface samples from Yangkou and Xugou are Type A peridotites. They occur as blocks or lenses from m to km size in country-rock gneisses with thickness of single lens or block ranging from 10 to 480 m in drill holes. Such peridotites comprise garnet lherzolite and harzburgite with minor dunite and wehrlite except for those from Rizhao where about 60 peridotite bodies consisting chiefly of wehrlite and dunite with interlayeres and lenses of clinopyroxenite occur. Type A peridotites have wide bulk-rock compositions with high Mg number [Mg/(Mg+Fe) > 0.90]. In general, Al2O3, CaO, Na2O and TiO2 contents of peridotites exhibit pronounced negative correlations with MgO contents. This feature, combined with MgO/FeO ratios suggests that these peridotites experienced 20-40% degrees of partial melting and melts extraction (Zhang et al. 2000, 2007; Yang et al. 2007a). However, the presence of hydrous phases (phlogopite, K-bearing amphibole and Ti-clinohumite) and LREE-enriched distribution patterns indicate that metasomatism have affected on these residual peridotites. The crystallization of phlogopite and magnesite in PP1 peridotites is attributed to infiltration of K-rich hydrous fluid/melt and Mg-carbonatitic metasomatism, respectively. Stable isotopic compositions of phlogopite (dD, -76‰ to -91‰; d18O, +5.0‰ to +5.9‰) and magnesite (d13C, –2.2‰ to –3.4 ‰; d18O, +5.5‰ to +8‰) suggest that the metasomatic agents derived from an enriched mantle. Minerals of Type A peridotites have high Mg# [Ol: 0.91-0.93; Opx: 92-94; Cpx: 93-94; Grt is Prp-rich (0.61-0.69)], and have mantle O isotopic signatures, most d18O values between 5.5‰ and 6.5‰ (Zhang et al., 2000; Z. Zhang et al., 2005; Zhao et al., 2007). Exsolution textures are common in type A peridotites. However, there are arguments about whether the mantle-derived peridotites (such as PP1) have been subjected to UHP metamorphism, and how to transport the dense mass from mantle depths to lower-meddle crust or surface. So far, at least three hypotheses have been proposed for PP1 peridotite: (1) the PP1 peridotite was not subjected to UHP metamorphism, but was brought to the surface by exhumation of the subducted slab (Yang et al., 2007a), (2) the peridotite was decoupled from the mantle wedge and incorporated into the subducting slab, and then subjected

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to Triassic UHP metamorphism together with the downgoing slab (e.g., Zhang et al., 2007), and (3) it was an ancient mantle block emplaced from the upper mantle into the lower crust or the magic corner in mantle wedge, and was later subducted to great depths together with its host crust (Yang and Jahn, 2000; Yang, 2003). The CCSD-MH peridotite (Maobei) occurs as lens or layer (10-80 m in thickness) in eclogite (Yang et al., 2007b), which was thought to be a part of a Neoproterozoic layered intrusion formed at a continental environment (Z. Zhang et al., 2006) or Type B crust-hosted peridotites (Zhang et al., 2000, 2010). They comprise garnet wehrlite and dunite (± Grt) with minor interlayers of Grt-bearing websterite and orthopyroxenite. Mini-bands, nodules or veins of eclogite and garnet clinopyroxenite (“internal”) also irregularly occur in garnet wehrlite. The peridotites have lower Mg/(Mg+Fetotal) values of 0.79-0.83 and higher Al2O3 and CaO contents in comparison with the mantle-derived peridotites. Garnet wehrlite displays variable REE patterns, from LREE-enriched to slightly LREE depleted relative to MREE and HREE. In general, Rb, Ba and LREE increase, and compatible elements (e.g. Cr, Co and Ni) decrease from peridotite, pyroxenite to “internal eclogite and Grt-clinopyroxenite. These characteristics suggest that the protoliths of the Maobei peridotites are cumulates derived by differentiation of basaltic magma; the “internal eclogite and Grt-clinopyroxenite” result from postcumulus crystallization of the trapped melt (Zhang et al., 2010).

Both Type A and B garnet peridotites were undergone subduction-zone UHP metamorphism indicated by P-T estimates of 795-840°C and 4.5-6.5 GPa (CCSD-MH), 800°C and 6.8 GPa (PP1), 5.6-6.2 GPa at 800°C (PP5), 850 ± 30°C and 5.5 ± 5 GPa (PP7), 750 ± 50°C and 4.0-4.5 GPa (Yangkou) and 780-870°C, 4.5-6.5 GPa (Xugou), the occurrence of coesite-bearing eclogite in peridotite and SHRIMP U-Pb age dating (see below). Garnet is a key Al-bearing phase in most Sulu peridotites. In contrast, Cr-spinel is a major phase in PP3 and PP6 peridotites; garnet is minor in PP3 and rare in PP6 peridotites. The PP3 and PP6 peridotites have lower P-T estimates of 720-750°C and 2.8-3.5 GPa than other peridotites.

Geochronology of peridotitic zircon

U-Th-Pb analyses of zircon were performed with the sensitive high-resolution ion microprobe (SHRIMP). Zircon separates of 50-200 mm cross from Type A peridotite and garnet clinopyroxenite have rounded to sub-rounded form without igneous core except for zircon from PP3 peridotite. Th/U ratios of zircon range from 0.02 to 0.79 (most < 0.4). Th-U-Pb analyses of zircon grains yield an age range of 220-240 Ma (PP1: 221-220 ± 2-3 Ma, PP3: 240 ± 3 Ma, PP5: 242 ± 8 Ma, PP7: 226.3 ± 1.8 Ma) (Li et al., 2008; Yang et al., 2009; Zhao et al., 2007; Zhang et al., 2005). The eclogites layered with PP6 and Xugou harzburgite have metamorphic ages of 225 ± 2 and 237 ± 5 Ma, respectively (Zhao et al., 2005, 2007). Two types of zircon are identified in PP3 peridotite. Type one is inherited zircon without or with very thin metamorphic rim, and has high Th/U ratios of 0.19-1.85 (most 0.5 - 1.0). Zircon of type two shows uniform bright CL image with Th/U ratios of 0.07-0.36. Two mean ages of 726 ± 56 Ma for inherited zircon and 240 ± 2.7 Ma for metamorphic zircon were obtained (Yang et al., 2009). The age of inherited cores probably represents metasomatic event that responds to the formation of the early stage zircon. Based on geochemical data and mode of occurrence, the PP3 peridotite is unlike a crust-hosted peridotite; instead it is a depleted mantle fragment. Zircon from CCSD-MH garnet wehrlite has a rounded form and ~0.1 mm or less in size. Some zircon crystals have dark CL cores without oscillatory zoning and gray CL rims. The cores with high Th/U (>1) have apparent ages of 346-461 Ma, much younger than the protolith age of MH eclogite
without peridotite interlayer (Yang et al., 2009). This probably suggests that the Maobei mafic–ultramafic body is composite complex.

**Tectonic implication**

Chemical compositions of whole rock and mineral indicate that most Sulu peridotites are depleted peridotite derived from mantle wedge above the subduction slab, and have experienced 20%-40% partial melting and melt extraction. Metasomatism of multiple stages imposed on mantle peridotite of variable compositions led to significant compositional heterogeneity of subcontinental lithosphere. Metamorphic agents may be derived from mantle and/or crust-derived fluids. P-T estimates, P-T evolution and consistent metamorphic ages of 220-240 Ma with the regional UHP metamorphic ages obtained from type B peridotites, eclogites and gneisses from the Dabies-Sulu UHP terrane suggest that these mantle wedge-derived fragments were tectonically squeezed into the subduction zone and mixed with the continental slab at different depths and underwent in situ Triassic UHP metamorphism in an extremely low thermal gradient (≤ 5°C/km) environment in the “forbidden zone”. Metamorphic peak pressure estimates of the Sulu peridotites (especially type B peridotites, which share the same processes of subduction and exhumation with the continental crust) testify the continental crust has subducted to 200 km deep. However, some peridotites from the PP6 and PP3 drill holes may have exhumed from mantle depths of about 100-120 km.

**Key words:** garnet peridotite, Chinese continental scientific drilling (CCSD), subduction-zone UHP metamorphism, mantle wedge

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