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Genesis of garnet peridotites in the Sulu UHP belt: Examples from the Chinese continental scientific drilling project-main hole, PP1 and PP3 drillholes

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ABSTRACT

The main hole (MH), and pre-pilot holes PP1, and PP3 of the Chinese Continental Scientific Drilling Project (CCSD) penetrated three different garnet peridotite bodies in the Sulu ultrahigh pressure (UHP) metamorphic belt, which are 80 m, 120 m, and 430 m thick, respectively. The bodies occur as tectonic blocks hosted in eclogite (MH peridotite) and gneisses (PP1 and PP3 peridotites). The peridotites in the MH are garnet wehrlites, whose protoliths were ultramafic cumulates based on olivine compositions ($Fo_{79–89}$) and other geochemical features. Zoned garnet and omphacite (with 4–5 wt.% Na_2O) are typical metamorphic minerals in these rocks, and, along with *P–T* estimates based on mineral pairs, suggest that the rocks have undergone UHP metamorphism. SHRIMP U–Pb isotope dating of zircon from the garnet wehrlite yielded a Paleozoic protolith age (ca. 346–461 Ma), and a Mesozoic UHP metamorphic age (ca. 220–240 Ma). The peridotites in PP1 consist of interlayered garnet (Grt)-bearing and garnet-free (GF) peridotite. Both types of peridotite have depleted mantle compositions (Mg# = 90–92) and they display transitional geochemical features. The intercalated layers probably reflect variations in partial melting rather than pressure variations during metamorphism, and the garnets may have been formed by exsolution from orthopyroxene during exhumation. These peridotites were probably part of the mantle wedge above the subduction zone that produced the UHP metamorphism and thus belonged to the North China Block before its tectonic emplacement. The exhumation of the subducted Yangtze Block brought these mantle fragments to shallow crustal levels. The ultramafic rocks in PP3 are dominantly dunite with minor garnet dunite. Their high Mg# (92–93) and relatively uniform chemical compositions indicate that they are part of a depleted mantle sequence. The presence of garnet replacing spinel and enclosing pre-metamorphic minerals such as olivine, clinopyroxene and spinel suggests that these rocks have undergone progressive metamorphism. SHRIMP U–Pb isotope dating of zircon from these rocks yielded two age groups: 726 ± 56 Ma for relic magmatic zircon grains and 240 ± 2.7 Ma for the newly formed metamorphic zircon. The older group is similar in age to granitic intrusions within the Dabie–Sulu belt, suggesting that the PP3 garnet peridotite may record the early emplacement of the peridotite into the crust. The younger dates coincide with the age of UHP metamorphism during continent–continent collision between the Yangtze and North China Blocks, suggesting that these peridotites were subducted to depths equivalent to the coesite facies and later exhumed. Thus, the garnet peridotites in the CCSD cores include both ultramafic rocks that existed originally in the subducted plate and rocks from the mantle wedge above the subducted plate, i.e., part of the North China Block.

1. Introduction

Eclogite is typically formed by ultra-high pressure metamorphism (UHPM) in subduction zones. Although less abundant than eclogite, garnet peridotite and other ultramafic rocks also occur in these environments. For example, garnet peridotites have been found in all of the well-documented UHPM belts of the world, such as the gneiss province of Western Norway (Van Roermund et al., 2000), the Alpe Arami massif in the Alps (Dobrzhinetskaya et al., 1996); the Kokchetav massif in Kazakstan (Parkinson and Katayama, 1998), the Rhodope terrane in Greece (Mposkos and Kostopoulos, 2001), and the Dabie–Sulu UHPM belt in China (Yang, 1991; Zhang et al., 1994; Liou and Zhang, 1996). The ultramafic rocks in such environments contain valuable information on UHP metamorphic processes, on the nature and extent of interaction between mantle and crust, and on the subduction and exhumation of lithospheric plates. In addition, they may also contain information on their protoliths and their environment of formation, as well as mantle processes and mantle mineralogy.

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Since the discovery of coesite in the Dabie Mountains, the UHP belt in the Dabie–Sulu terrane has been recognized as the largest such belt in the world (Xu, 1987; Enami and Nagasaki, 1988; Yang and Smith, 1989; Okay et al., 1989; Wang et al., 1989). Study of this belt by numerous geoscientists from around the world has provided new views on subduction and exhumation of lithosphere at convergent plate boundaries (Zhang et al., 2004, 2005a,b; Yang et al., 2007; Zheng et al., 2007). Like many other UHPM belts, the Sulu terrane contains a number of exposed lenses and blocks of ultramafic rock. Xu et al. (1998) suggested that these rocks represent the deepest parts of the

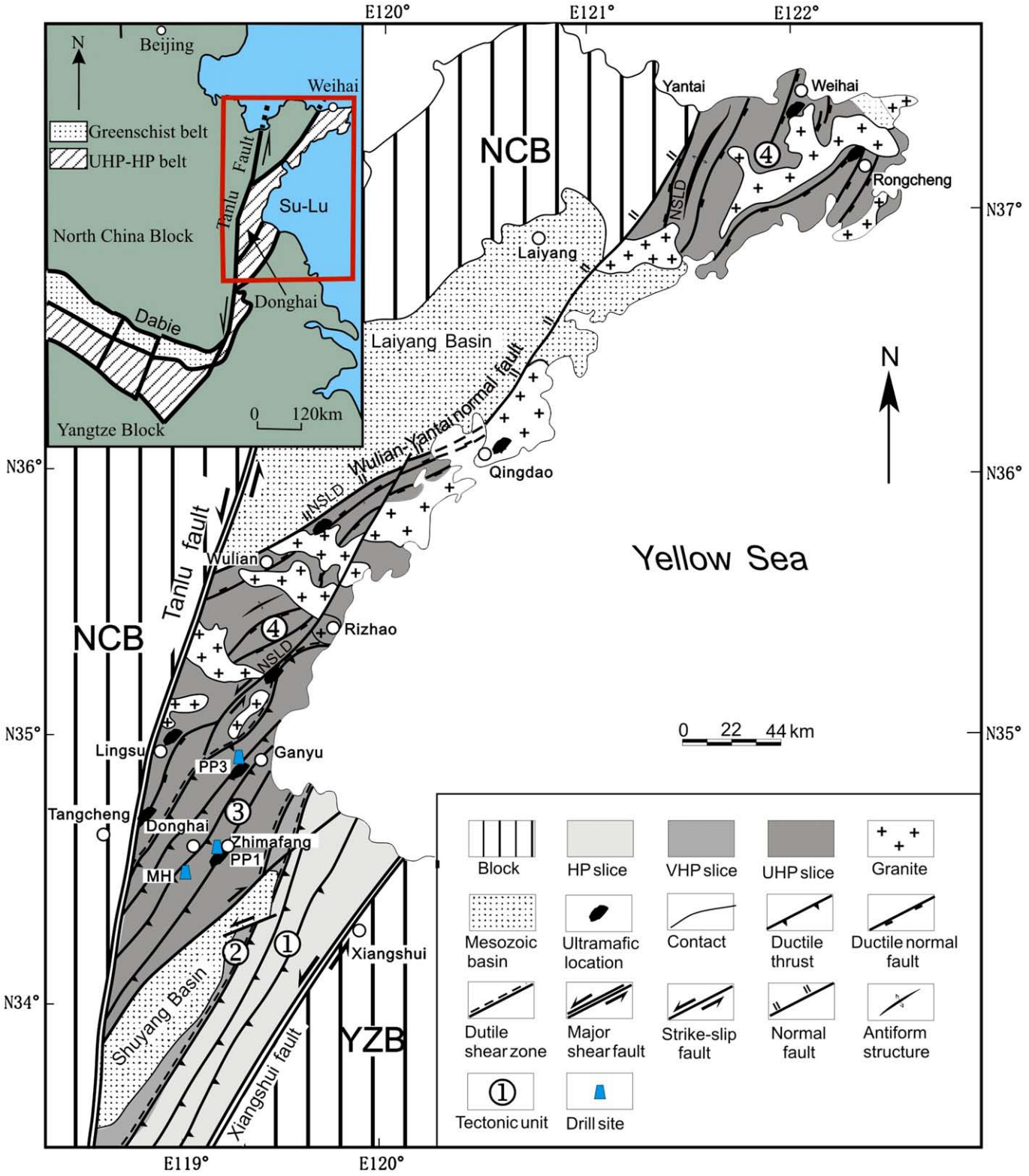

Fig. 1. Simplified structural map of the Sulu HP-UHP metamorphic terrane, showing the locations of the CCSD-MH, PP1 and PP3 drill sites. DSZ — ductile shear zone.