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# Cumulates of arc magmas incorporated into the Sulu UHP metamorphic belt, eastern China

Zhipeng Xie[a,b], Jian Wang[b] and Keiko Hattori[c]

[a]Faculty of Land Resources Engineering, Kunming University of Science and Technology, Kunming, PR China; [b]College of Earth Sciences, Jilin University, Changchun, Jilin, PR China; [c]Department of Earth Sciences, University of Ottawa, Ottawa, Canada

**ABSTRACT**

The Hujialin ultramafic complex in the central region of the Sulu ultra-high pressure (UHP) metamorphic belt consists of discontinuous lenses of garnet-bearing clinopyroxenite and dunite surrounded by marginal serpentinite. The clinopyroxenite shows relatively low concentrations of compatible elements, such as Cr (≤1670 ppm) and Ni (≤514 ppm) and Ir-group platinum group elements (IPGE; Ir, Os, and Ru; ≤4.8 ppb in total). They show varying ratios (0.02–2.50) of IPGE to Pd-group PGE (PPGE). Their chondrite-normalized rare earth elements (REE) patterns are convex and the total REE concentrations range from 18 to 63 times that of CI chondrite. The bulk rocks show a 'subduction-related' geochemical signature, with high concentrations of fluid-mobile elements (i.e. Sr, Ba) relative to high-field strength elements (i.e. Nb, Y, Zr). Clinopyroxene is diopside and contains low $Al_2O_3$ (<2.76 wt.%) and high $SiO_2$ (54.6–56.9 wt.%). Olivine grains enclosed by clinopyroxene and in the matrix show relatively low Fo (76.6–80.7) and NiO contents (0.18–0.29 wt.%). The bulk rock compositions and mineral chemistry of olivine and clinopyroxene suggest that the unit was a cumulate of a subduction-related melt. On the other hand, dunite and its hydration product, serpentinite, have a different origin. The bulk rock and mineral chemistry suggest that dunite represents a mantle wedge peridotite in a spinel-stable field. Both clinopyroxenite and spinel-bearing dunite were once located in the mantle wedge below the southern margin of the North China craton (NCC), and were dragged by a mantle flow into the continental subduction channel along the interface between the subducting Yangtze craton (YZC) and the overlying NCC. Although clinopyroxenite and dunite are dense (2.8–3.2 g/cm$^3$), the buoyancy-driven exhumation of voluminous granitic rocks of the YZC likely brought clinopyroxenite and dunite to shallow crustal depths. The lack of the evidence for high pressure to ultra-high pressure (HP-UHP) metamorphism in spinel-bearing dunite may be explained by overall low Al and Ca in the bulk rocks. Alternatively, dunite was not subducted to deep levels, but exhumed together with the deeply subducted clinopyroxenites and granite during their exhumation.

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## 1. Introduction

The Dabie-Sulu ultra-high pressure (UHP) terrane was formed during the subduction of the northern margin of the Yangtze Craton (YZC) beneath the North China craton (NCC) following the collision of the two continents in Triassic time. The terrane is one of the largest and longest continuous ultra-high-pressure metamorphic (UHP) belts in the world (Yang *et al*. 2003). The terrane is primarily composed of granitic gneisses, but contains volumetrically minor ultramafic rocks that form massifs and large lenticular bodies measuring metres to hundreds of metres (Zhang *et al*. 2000; Ye *et al*. 2009). A majority (>90%) of ultramafic rocks contain garnet, suggesting that they underwent deep subduction, but some rocks contain spinel instead of garnet as an Al mineral (e.g. Chen *et al*. 2009; Xie *et al*. 2013).

Ultramafic rocks in the Dabie-Sulu belt are grouped into three based on field occurrences, bulk rock composition, and mineral chemistry. The first group includes garnet-bearing peridotites in the Rongcheng, Rizhao, Yangkou, and Donghai areas (Figure 1a). They are considered to be fragments of subcontinental lithospheric mantle (SCLM) below the margin of the NCC, subducted deep together with the YZC lithosphere (Zhang *et al*. 2000, 2005; Ye *et al*. 2009). The second group is cumulates of mafic magmas that show well-developed compositional layering and evidence of fractional crystallization from ultramafic to mafic rocks. The rocks were originally in the YZC and subducted to reach the

**CONTACT** Jian Wang wangjian304@jlu.edu.cn Faculty of Land Resources Engineering, Kunming University of Science and Technology, Kunming, PR China.

Supplemental data for this article can be accessed here.