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Spinel compositions and tectonic relevance of the Bibong ultramafic bodies in the Hongseong collision belt, South Korea

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ABSTRACT

The Hongseong area in the western Gyeonggi Massif, South Korea, is characterized by the occurrence of several isolated ultramafic lenses in close association with metabasites within the granitic gneiss. Most of these bodies suffered various degrees of serpentinization and also have been highly deformed and metamorphosed. The Bibong ultramafic rock is assumed to be a mantle section of a probable Neoproterozoic supra-subduction zone (SSZ) and its evolution involved two igneous stages overprinted by later stage metamorphism. The compositions of the chromian spinel cores and olivines representative of the igneous stages were used to deduce the petrogenesis and tectonic environments for the formation of the Bibong ultramafic rocks. Spinel Cr# (100*Cr/(Cr + Al)) for the igneous stages in lherzolite, harzburgite and chromitite are 24.5–33.3, 37.4–61.2 and 37.3–50.9, respectively. During the first stage, magma formed in the nascent back-arc basin spreading center by a small degree of partial melting of wedge mantle intruded the preexisting lithospheric mantle causing the melt/rock interaction that resulted in lherzolite with Al-rich chromian spinel. During the second stage more evolved magma formed in the mature back-arc basin by high degrees of partial melting due to the increased supply of fluid or melt from the subducting oceanic crust and intruded the lherzolitic mantle forming harzburgite with chromian spinel (with high Cr#) through the coupled process of olivine precipitation and dissolution of pyroxene. The Bibong ultramafic rocks have later undergone three metamorphic episodes. The first stage is evidenced by development of medium to fine grained olivine, orthopyroxene, clinopyroxene and amphibole around orthopyroxene porphyroblasts. The second stage is serpentinization which is followed by the third stage amphibolite facies metamorphism as evidenced by Fe-rich rims around Al-rich chromian spinel due to the diffusional exchange of Al, Mg, Cr, and Fe between chromian spinel and adjacent silicate minerals. The spinel composition shows that the transition from the nascent back-arc basin to mature back-arc basin tectonic setting may have been caused by trench roll back during the Neoproterozoic in the Hongseong area, and the serpentinization and amphibolite facies metamorphism could have occurred during uplift after Triassic collision between the North and South China blocks.

1. Introduction

Recent studies have suggested that the Hongseong belt in the southwestern Gyeonggi Massif, South Korea, is the extension of the Triassic Dabie–Sulu collision belt that occurs between the North and South China blocks (Oh et al., 2005; Kim et al., 2006). Ultramafic rocks in close association with eclogite are considered as one of the typical features of many collision/suture zones. In the Hongseong collision belt, metabasites and ultramafic rocks occur as lensoidal bodies. The metabasites in the Bibong and Baekdong areas within the Hongseong collision belt originated in an arc tectonic setting during the late Neoproterozoic and underwent eclogite facies high-*P*/*T* metamorphism during the Permo-Triassic collision between the North and South China blocks (Oh et al., 2004, 2005; Kim et al., 2006). The occurrence of the high-*P*/*T* metabasites of island-arc tholeiite (IAT) affinities with spatially associated ultramafic rocks suggest that at least some ultramafic rocks in the Hongseong area may also be derived from an ancient arc tectonic setting, probably of Neoproterozoic age. The origin and tectonic affinity of the ultramafic rocks are unclear because few studies had been done on them and the original igneous assemblages have been almost obliterated by several later stages of metamorphism (including serpentinization and amphibolite facies metamorphism). Spinel-group minerals occur as common accessory minerals in ultramafic rocks of diverse tectonic settings.

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They display a wide range in composition reflecting their primary magmatic or secondary origin. Unaltered, primary chromian spinel in serpentinite can be used as a petrogenetic and geotectonic indicator because its chemical composition depends on the petrogenesis and physical conditions of the host peridotites and the primary chromian spinel composition is well preserved during later stage serpentinization or metamorphism (Ozawa, 1983; Arai, 1992, 1994; Zhou et al., 1994; Zhou and Robinson, 1997; Karipi et al., 2007). In the Hongseong collision belt, most ultramafic lenses are strongly serpentinized but contain unaltered spinel (e.g., Seo et al., 2005; Arai et al., 2008). Therefore, unaltered spinel composition can be used to interpret the petrogenetic and tectonic history of the ultramafic rocks in the Hongseong collision belt.

The ultramafic lens in the Bibong area is one among the ultramafic rock exposures in the Hongseong collision belt. The Bibong ultramafic rocks occur in close association with metabasites (Oh et al., 2005; Seo et al., 2005). These metabasites had undergone eclogite and/or amphibolite facies metamorphism during Triassic collision (Oh et al., 2005). The present study focuses on the petrography and mineral chemistry of chromian spinel in the Bibong ultramafic rocks in order to determine their petrogenesis and tectonic environment.

2. General geology

The three main Precambrian blocks in the Korean Peninsula are the Nangrim, Gyeonggi and Yeongnam Massifs (Fig. 1A). The Gyeonggi Massif is separated from the Nangrim Massif to the north by the Paleozoic Imjingang fold-thrust belt, and from the Yeongnam Massif to the south by the Late Precambrian–Paleozoic Okcheon (Ogcheon) fold-thrust belt. The Hongseong area is situated in the southwestern part of the Gyeonggi gneissic complex (henceforth, Gyeonggi Massif) in the Korean Peninsula and is the extension of the Dabie–Sulu collision belt between the North and South China blocks in China (Fig. 1A; Oh et al., 2005; Kim et al., 2006). The Hongseong collision belt is suggested to extend towards the Odesan Area in the eastern part of the Gyeonggi Massif (Fig. 1A) indicating that the collision belt between the North and South China blocks goes all the way across Korean Peninsula (Oh et al., 2006; Oh, 2006; Oh and Kusky, 2007). The Hongseong area includes the Wolhyeonri Formation and the Deokjeongri granitic gneiss (Fig. 1B). The predominant lithological units of the Wolhyeonri Formation are closely related biotite schists, metabasites, and marbles. Amphibole- and biotite-bearing granitic gneiss and leucogranite are the dominant orthogneisses of the

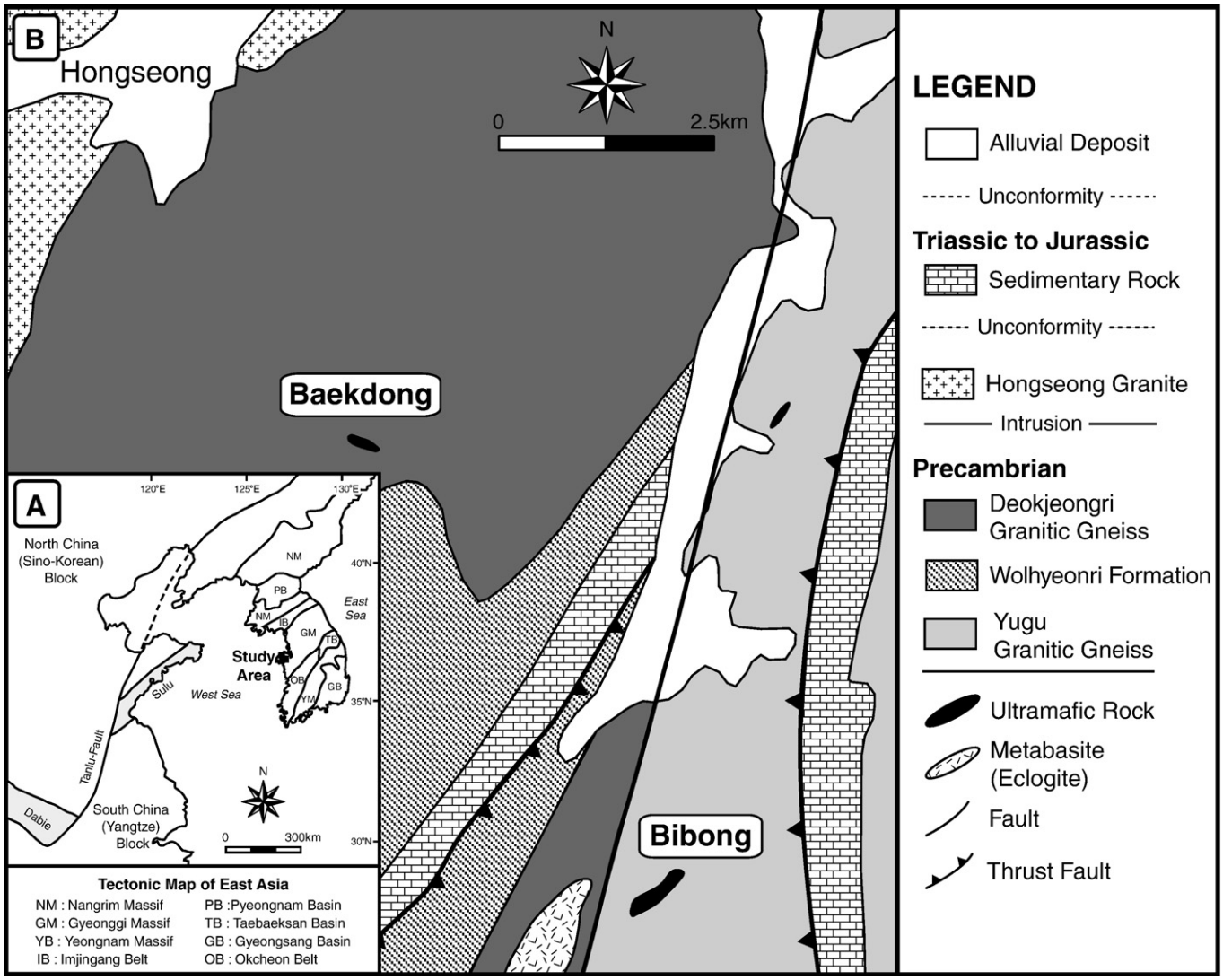

Fig. 1. Generalized geological map of the Hongseong area, Gyeonggi massif, depicting the isolated occurrence of serpentinized harzburgites (modified from Oh et al., 2004). A tectonic map of the Korean Peninsula is shown as an inset.