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Multiple generations of mafic–ultramafic rocks from the Hongseong suture zone, western South Korea: Implications for the geodynamic evolution of NE Asia

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ABSTRACT

Dismembered mafic and serpentinized ultramafic bodies within the Hongseong suture zone of the Gyeonggi massif, southwestern Korean Peninsula are tectonically correlated with those from the Chinese Qinling–Dabie–Sulu collisional belt. We report sensitive high-resolution ion microprobe (SHRIMP) U–Pb zircon ages, detailed mineral compositions and whole rock geochemical data from the mafic rocks including eclogite and garnetite from the Hongseong suture zone. The zircon U–Pb data show multiple protolith ages corresponding to Neoproterozoic (ca. 815–770 Ma), Paleozoic (ca. 310 Ma) and Middle Triassic (ca. 240 Ma). The peak high-pressure and retrograde regional intermediate-pressure metamorphic events of Middle Triassic (ca. 240–230 Ma) are also recorded in zircons from the mafic rocks in the Hongseong suture zone. The ages and P–T estimates presented in this study match well with those of the peak ultra-high-pressure metamorphism in the Sulu area of China. Our results from the Hongseong suture zone provide important insights into the geodynamic history of the NE Asian region, with evidence for both Neoproterozoic subduction and a Paleozoic to Triassic subduction/accretion event.

1. Introduction

Mafic and ultramafic rocks from various tectonic settings provide important clues to the geodynamic history and crustal evolution in oceanic and continental realms (e.g., Metcalf et al., 2000; Safonova et al., 2009; Sajeev et al., 2010; Santosh et al., 2009; Stern and Bloomer, 1992; Taylor et al., 1992; Wakabayashi and Dilek, 2003). These rock suites form in mid-ocean ridges, active continental margin supra-subduction zones (SSZs), island arcs, oceanic islands, continental rifts, back-arc basins, and intraplate hotspots. The geochemical variations in these rocks have been used as effective tracers for characterizing backarc–arc–forearc processes such as the effects of diminished slab fluid in backarc regions and the across-strike variations in the composition of the mantle wedge (Taylor et al., 1992). However, the causes and sources of widespread OIB-like magma remain enigmatic, especially in continental settings (Fitton, 2007).

Since the discovery of retrogressed eclogites from Bibong area in South Korea (Oh et al., 2005), the Hongseong suture zone, part of the Korean collision belt (Kim et al., 2011b; Kwon et al., 2009) has been identified as a possible tectonic correlation of the Qinling–Dabie–Sulu collision belt in China (e.g., Ames et al., 1993; Dong et al., 2011a,b; Ernst and Liou, 1995; Li et al., 1993; Metcalfe, 2006; Ratschbacher et al., 2006; Yin and Nie, 1993; Zhai and Liu, 1998; Zhai et al., 2007; Zhang et al., 2009). One of the remarkable geological features observed within the Hongseong suture zone is the occurrence of dismembered mafic and lenticular serpentinized ultramafic bodies such as those of Hongseong, Gwangcheon, Baekdong, Wonnojeon, Gwangsi, Gyewol, and Singok, with minor mafic diabases (Figs. 1 and 2). Recent petrological, geochemical, and geochronological data on these rocks have led the proposal that the Hongseong suture zone preserves evidence of subduction at Neoproterozoic and of subduction/collision from Paleozoic to Mesozoic (e.g., Arai et al., 2008; Kee et al., 2011; Kim et al., 2006, 2011b,c; Kwon et al., 2009; Oh et al., 2004, 2005, 2009, 2010, 2012; Seo et al., 2005). Recently, two different tectonic interpretations were suggested from studies on the serpentinized ultramafic bodies at Bibong and Baekdong (Kim et al., 2011b,c; Kwon et al., 2009; Oh et al., 2004, 2005, 2009, 2010, 2012). The Neoproterozoic interpretation suggests that these bodies are the mantle sections of a supra-subduction zone (SSZ) ophiolite (Oh et al., 2009, 2010, 2012). They further suggest that both bodies were originated from oceanic lithosphere that was formed during the transition from backarc to mature island arc in relation to the subduction rollback before the amalgamation of Rodinia at ca. 860–890 Ma (Oh et al., 2009, 2010, 2012). In contrast, the serpentinized ultramafic body at Baekdong has been interpreted as a Paleozoic forearc mélange-like hydrated peridotite based on different ages of exotic blocks and chromian spinel chemistry (Kim et al., 2011c). These rocks may have formed by hydrous metasomatism of the mantle wedge above a SSZ by fluids released from subducted

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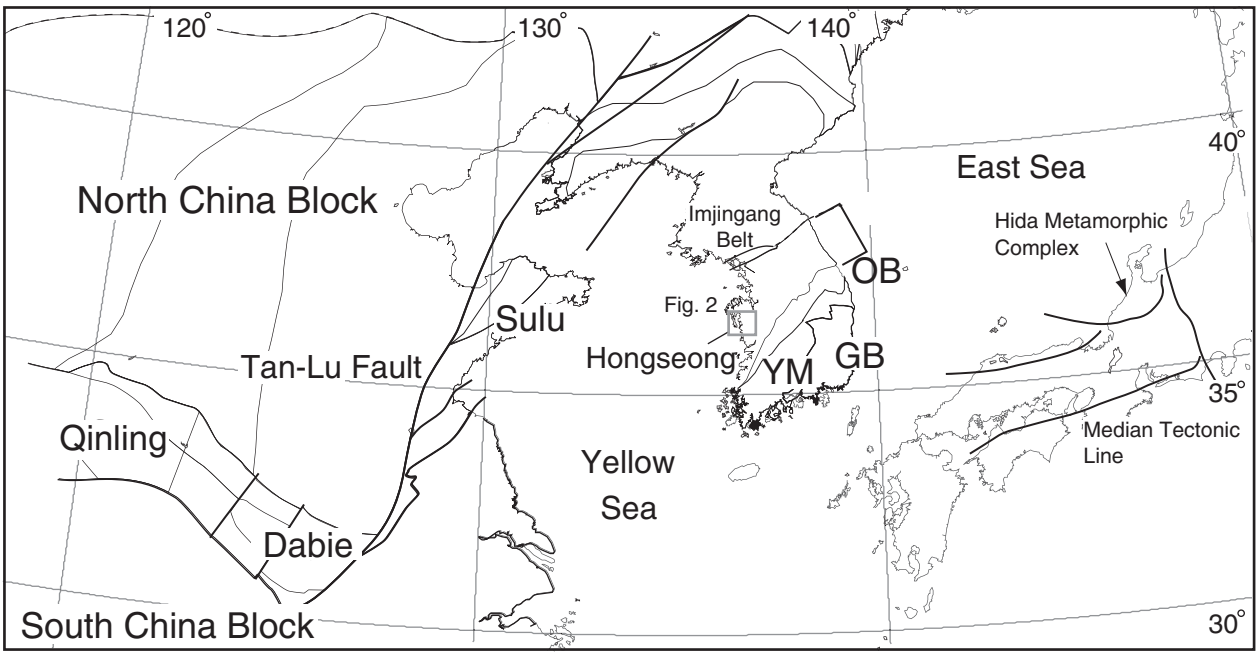

Fig. 1. Simplified tectonic map of Northeast Asia showing the locations of Hongseong suture zone. GM, Gyeonggi massif; OB, Okcheon belt; YM, Yeongnam massif; GB, Gyeongsang basin.

slabs (e.g., Stern and Bloomer, 1992). These differences in interpretation arise largely from the lack of detailed geochronological and geochemical data on mafic and serpentinized ultramafic rocks that were formed during the evolution of the Hongseong suture zone. Consequently, a better understanding of the mafic protolith of the eclogite, metamorphosed mafic rocks associated with mélange-like serpentinite bodies, and high- to intermediate-grade mafic diabase from the Hongseong suture zone will help us better understand the evolution history of the region in particular and the tectonics of East Asia in general.

This paper reports sensitive high-resolution ion microprobe (SHRIMP) zircon U–Pb ages, mineral chemistry and geochemical data for high- to intermediate-grade mafic rocks from the Hongseong suture zone of the Korean collisional belt. SHRIMP zircon U–Pb age of an amphibolite and garnetite in a lenticular mafic body, combined with published data for the eclogite in the Hongseong suture zone, will also be used to assess the geodynamic implications in relation to the evolution of East Asia during Neoproterozoic and from Paleozoic to Mesozoic.

2. Regional geology of the Hongseong area

The Hongseong area, located at the southwestern part of the Korean Peninsula, is considered to be the trace of the Imjingang–Hongseong suture that is tectonically correlated with the central orogenic belt of China (the Chinese Qinling–Dabie–Sulu belt). The discovery of eclogites and high-pressure (HP) mafic granulites, as well as serpentinite mélange along this zone supports the interpretation for the existence of a suture zone (Fig. 2; Kim et al., 2006, 2011b,c; Kwon et al., 2009; Oh et al., 2005). Other rock types in the area include Neoproterozoic tonalite–trondhjemite–granodiorite (TTG) plutons (the Deokjeongri gneiss), Paleozoic Wolhyeonri complex, and Paleozoic Taean Formation (Fig. 2; Kim et al., 2006, 2008; Kwon et al., 2009; Zhai et al., 2007). The Hongseong area is bounded by Paleoproterozoic (ca. 1.8–1.9 Ga) supracrustal and basement rocks of the Gyeonggi massif to the east along a thrust/shear zone (Fig. 2; Kee et al., 2011; Kim et al., 2008, 2011b,c).

The Neoproterozoic TTG plutons are mainly exposed in the northwestern part of the Hongseong area (Fig. 2). They commonly preserve primary magmatic fabrics and contain mafic enclaves. Most of these rocks, however, are overprinted by later Triassic metamorphic events and show strong deformational features. Based on their geochemical and Nd–Sr isotopic characteristics together with SHRIMP U–Pb zircon dating, the TTG plutons and associated mafic enclaves are interpreted as the products of arc-related magmatism at ca. 850–820 Ma in a convergent margin setting related to the assembly of the Rodinia supercontinent (Kim et al., 2008; Kim et al., 2012). In addition to the early Middle Neoproterozoic (ca. 850–820 Ma) Deokjeongri gneiss, Early Neoproterozoic (ca. 900–890 Ma) tonalite–trondhjemite plutons are also reported near the boundary between Wolhyeonri complex and the Paleoproterozoic Gyeonggi massif (Kim et al., 2012; Song, 2010). Middle Neoproterozoic alkali plutons (ca. 749–742 Ma) also occur sporadically as discrete small stocks around the TTG plutons (Kim et al., 2012), and represent anorogenic-type magmas correlated with the break-up of Rodinia (Lee et al., 2003). The western Hongseong area includes the Middle to Late Paleozoic Taean Formation (Fig. 2). It is composed mainly of low- to intermediate-grade turbiditic metasediments (Choi et al., 2008). The Wolhyeonri complex, preserved at the center of the Hongseong area, consists mainly of volcanic-sedimentary rocks including intermediate- to high-grade metamorphic paragneiss, orthogneiss, schist, impure marble, mafic metavolcanics, and mafic orthogneiss. Kim et al. (2011b) subdivided the Wolhyeonri complex into two litho-tectonic units: a western domain with Middle to Late Paleozoic medium-grade metasediments (western complex; Fig. 2) and an eastern domain of Middle Paleozoic high-grade metavolcanics/metasediments (eastern complex; Fig. 2). The eastern complex is interpreted to have been formed in a convergent margin environment during the Middle era (Kim et al., 2011b). Remnants of Neoproterozoic TTG plutons are exposed in and around the eastern complex (Kim et al., 2011b, 2012). In particular, impure marbles with mafic diabases are exposed at the eastern boundary of the western complex (Kim and Kee, 2010). Late Triassic and/or Early to Middle Jurassic sedimentary successions occur in and around the Wolhyeonri complex and in the Taean Formation (Fig. 2; Jeon et al., 2007; Kim et al., 2008, 2011b). All the rocks described above were intruded by Mesozoic granites (Kim et al., 2011a; Park et al., 2009; Seo et al., 2010; Williams et al., 2009), and are covered in part by Cretaceous volcanic-sedimentary sequences (Fig. 2).