Gondwana Research 26 (2014) 684–698

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Paleozoic tectonics of the southwestern Gyeonggi massif, South Korea: Insights from geochemistry, chromian-spinel chemistry and SHRIMP U–Pb geochronology

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ARTICLE INFO

Article history:
Received 8 August 2012
Received in revised form 10 July 2013
Accepted 12 July 2013
Available online 7 August 2013

Handling Editor: Z.M. Zhang

Keywords:
Paleozoic magmatism
Forearc serpentinite
Chromian spinel
Subduction
Hongseong

ABSTRACT

Arc magmas, metavolcanics and hydrated mantle peridotite from the Hongseong area in western Gyeonggi massif provide evidence for Paleozoic subduction tectonics in the Korean Peninsula. Zircons in a tonalitic orthogneiss from the Wolhyeonri complex dated in this study through SHRIMP U–Pb technique yield ages of ca. 437 Ma and ca. 414 Ma. In addition, SHRIMP U–Pb zircon dating of a garnet-bearing paragneiss in the Wolhyeonri complex records evidence for Middle Paleozoic (ca. 427 Ma) thermal metamorphism. Petrological and geochemical data from the Paleozoic suite provide robust evidence for mid Paleozoic arc-related magmatism.

Petrological and geochemical data from the Paleozoic suite, including the composition of chromian spinel from the serpentinite bodies enclosing high-pressure mafic and felsic blocks also suggest rifted arc/forearc tectonic setting in a supra-subduction zone environment. The serpentinite bodies preserve the imprints of forearc magmas derived through significant mantle/melt interaction during the opening and subsequent evolution of the forearc. These results indicate that the Paleozoic Hongseong area might have been located in an arc–forearc tectonic environment coeval with the plutonism and volcanism preserved in the Wolhyeonri complex. The Hongseong area thus preserves important clues to the Paleozoic subduction prior to the subsequent Triassic "Alpine-type" collision, suggesting a common tectonic linkage among Paleozoic to Triassic East Asian continents before the final assembly of the Pangaea supercontinent.

1. Introduction

The occurrences of eclogites and serpentinite belt containing high-grade metamorphic rocks have long been considered as evidence for oceanic sutures resulting from the collision of exotic terranes (e.g., Hess, 1965; Maekawa et al., 2004; Brueckner et al., 2009; Kim et al., 2011c; Kwon et al., 2013). One of the world's best example is the Triassic Qinling–Dabie–Sulu belt (Fig. 1) between the Sino-Korean (North China) and Yangtze (South China) Cratons that extend for more than ~2000 km (e.g., Yin and Nie, 1993; Ernst and Liou, 1995; Chang, 1996; Ernst et al., 2007; Zhang et al., 2009; Wu and Zheng, 2013). Tectonic correlations of this collisional belt with the Korean Peninsula and the Japanese Islands (Fig. 1) have also been proposed based on the occurrence of HP and serpentinite belts (e.g., Yin and Nie, 1993; Ernst and Liou, 1995; Chang, 1996; Ree et al., 1996; Kim et al., 2006; Oh, 2006; Cho et al., 2007; Ernst et al., 2007; Oh and Kusky, 2007; Kwon et al., 2009; Oh et al., 2009; Zhang et al., 2009; Sajeev et al., 2010; Kim et al., 2011c).

Since the discovery of retrograded eclogite (e.g. Oh et al., 2005; Kim et al., 2006) and the belt of dismembered serpentinite bodies along the southwestern Gyeonggi massif, the Hongseong area has been the focus for studies related to Phanerozoic convergent tectonics in the Korean Peninsula. Several studies related to the geochemistry, mineral chemistry and geochronology of igneous and mafic/ultramafic rocks have been attempted (e.g. Oh et al., 2005; Seo et al., 2005; Kim et al., 2008; Kim and Kee, 2010; Kim et al., 2011a,b,c, 2013). These investigations revealed a prominent Neoproterozoic magmatism related to the amalgamation/disruption of the Neoproterozoic supercontinent Rodinia, and Triassic collision-related tectonics in the Hongseong area of the southwestern Gyeonggi massif. However, the Paleozoic tectonic history prior to the final Triassic collision is not well understood probably because of the absence of reports on Paleozoic arc-related magmatic bodies and the scarcity of information on the palaeo-subduction complex.

This study presents new SHRIMP zircon U–Pb ages of orthogneisses and paragneiss within the western Gyeonggi massif. In addition, geochemistry results of the Paleozoic arc-related orthogneisses and

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1342-937X/$ – see front matter
http://dx.doi.org/10.1016/j.gr.2013.07.015

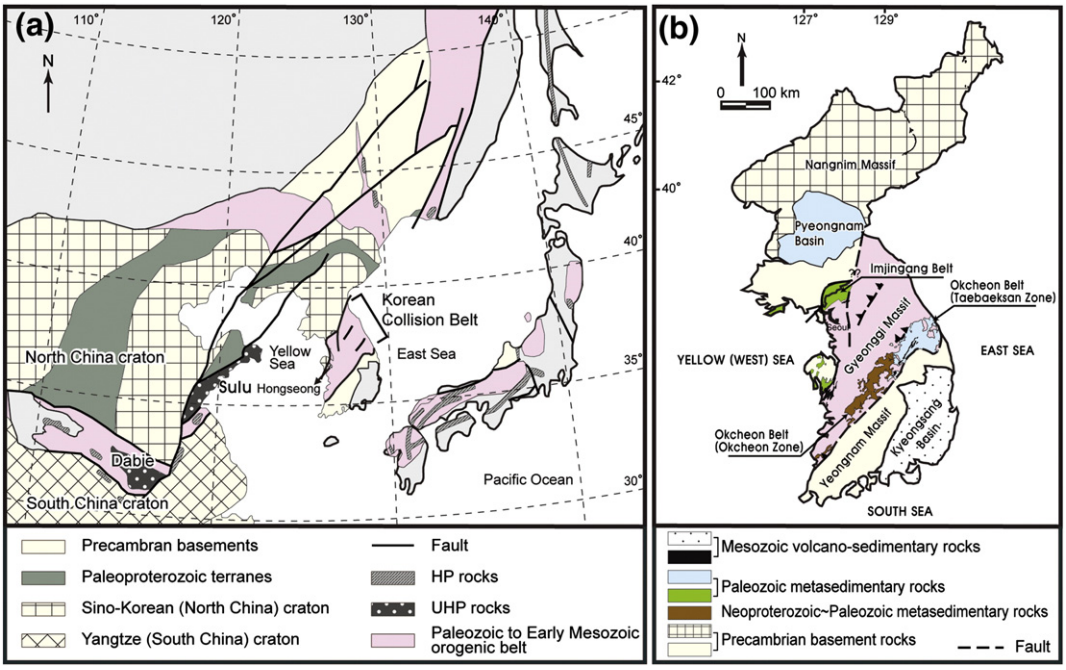

Fig. 1. Simplified tectonic map of Northeast Asia (a) and regional tectonic map of the Korean peninsula (modified after 1:1,000,000 tectonic Map of Korea; KIGAM, 1995), showing the locations of major tectonic provinces including the newly defined "Korean collision belt" suggested by Kwon et al. (2009).

chromian spinel compositions from the serpentinites are also reported to present the Paleozoic tectonic environment in this region prior to the final amalgamation of the Triassic NE Asia.

2. Regional geology

The Precambrian basements of the Korean Peninsula have been classified into Nangnim, Gyeonggi and Yeongnam massifs from north to south. They are separated by the Imjingang and Okcheon belts consisting mostly of Paleozoic supracrustal rocks (Fig. 1) (e.g., Paek et al., 1996; Geological Society of Korea, 1999).

The Gyeonggi massif geographically covers the central part of the Korean Peninsula (Fig. 1), and is composed of Paleoproterozoic (ca. 1.8 Ga) rocks intruded by Mesozoic granitoids (e.g., Lee and Cho, 2003; Sagong et al., 2003; Kim et al., 2008). Limited exposures of Middle Paleozoic supracrustal rocks also occur along the southwestern part of the Gyeonggi massif at the Hongseong area (Cho, 2007; Choi et al., 2008; Cho et al., 2010; Kim et al., 2011b,c). The Neoarchean cratonic basement, tectonically correlated to the North China Craton (Cho et al., 2008), is only reported in an island (the Daeijak Island) in Yellow Sea.

The Hongseong area, the main focus of this study, is composed of a variety of lithologic units ranging in age from Paleoproterozoic to Paleozoic (e.g. Kim et al., 2006, 2008; Kwon et al., 2009; Oh et al., 2009; Cho et al., 2010; Kim et al., 2011b,c, 2013). The rocks were regionally metamorphosed during the Triassic collisional event and intruded by Mesozoic granitoids (Kim et al., 2006; Choi et al., 2009; Kwon et al., 2009; Williams et al., 2009; Seo et al., 2010). The oldest rocks are Paleoproterozoic paragneisses intruded by similar-aged (ca. 1.88–1.86 Ga) plutons formed in an arc tectonic setting (Kim et al., 2008). The Neoproterozoic rocks are represented by arc-related TTG (tonalite–trondhjemite–granodiorite) suite and metabasites as well as rift-related alkaline plutons (Kim et al., 2008; Oh et al., 2009; Kim et al., 2013; Kwon et al., 2013). These Neoproterozoic intrusive rocks are interpreted to be associated with Rodinia amalgamation and disruption (Kim et al., 2013). The Paleozoic units in the Hongseong area are composed of metasedimentary rocks including low to intermediate grade Taean Formation and high grade Wolhyeonri complex. The Taean Formation consists mainly of turbiditic metasandstones that were deposited between ca. 402 Ma and ca. 230 Ma (Cho, 2007; Choi et al., 2008; Cho et al., 2010). The Wolhyeonri complex is mainly composed of gneisses, schists and metavolcanics with minor marble and mafic/ultramafic rocks (Kim et al., 2011b,c; Kwon et al., 2013) that are interpreted as forearc volcanic sequences (Kim et al., 2011b). It should be noted that Middle Paleozoic metamorphic events are recognized together with the Triassic event in the Wolhyeonri complex (Kim et al., 2011b). All the rocks described above are invaded by Mesozoic intrusives and covered in part by Mesozoic sedimentary and volcanic sequences (Figs. 1 and 2).

The evidence for Paleozoic subduction is preserved in the dismembered oval-shaped serpentinite bodies including Baekdong, Gwangcheon and Wonnojeon (Song et al., 1997; Song and Song, 2001; Song et al., 2004; Seo et al., 2005; Oh et al., 2010; Kim et al., 2011c; Oh et al., 2012). These rocks occur in association with the Neoproterozoic plutons (Baekdong and Wonnojeon) and the Wolhyeonri metavolcanics (Gwangcheon) (Fig. 3). Several of these bodies contain blocks of high-grade mafic and felsic rocks, with peak metamorphic temperatures and pressures varying widely from place to place.

Among these, the Baekdong serpentinite body is recently interpreted as: (1) a fragment of the hydrated upper mantle under passive margin tectonic setting (Seo et al., 2005), (2) the hydrated mantle section of Neoproterozoic suprasubduction ophiolite (Oh et al., 2010, 2012) and (3) forearc mélange-like serpentinite body (Kim et al., 2011c). As mentioned above, several serpentinite bodies contain blocks of high grade garnet-bearing mafic rocks and gabbroic anorthosites and anorthosites (Kim et al., 2011c). Although ultramafic rocks preserved within the Baekdong body (Fig. 3a) are metasomatized into serpentinite, they are grouped as weakly to strongly serpentinized lherzolite and harzburgite (corresponding to hydrated mantle peridotite) based on the modal abundance of olivine, orthopyroxene, clinopyroxene, spinel, amphibole, phlogopite, serpentine and chlorite (Seo et al., 2005). The presence of Neoproterozoic inherited zircons in the mafic body prompted Oh et al. (2012) to suggest that the rock was formed during the transition from backarc to mature island arc in relation to the subduction rollback before the amalgamation of Rodinia at ca. 890–860 Ma. However, recent investigations revealed the presence of Paleozoic zircons in the anorthosite