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SHRIMP U–Pb dating and geochemistry of the Cretaceous plutonic rocks in the Korean Peninsula: A new tectonic model of the Cretaceous Korean Peninsula

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ABSTRACT

The Cretaceous tectonomagmatism of the Korean Peninsula was examined based on geochemical and geochronological data of the Cretaceous plutonic rocks, along with distribution of volcano-sedimentary nonmarine N- to NE-trending fault bounded sedimentary basins. We conducted sensitive high-resolution ion microprobe (SHRIMP) zircon U–Pb ages and whole-rock geochemical compositions of 21 Cretaceous plutonic rocks, together with previously published data, from the central to southern Korean Peninsula. Four age groups of plutonic rocks were identified: Group I (ca. 119–106 Ma) in the northern to central area, Group II (ca. 99–87 Ma) in the central southern area, Group III (ca. 85–82 Ma) in the central to southern area, and Group IV (ca. 76–67 Ma) in the southernmost area. These results indicate a sporadic trenchward-younging trend of the Cretaceous magmatism in the Korean Peninsula. The Group I, II, and III rocks are dominated by high-K calc-alkaline I-type rocks with rift-related A-type granitoids. In contrast, the Group IV rocks are high-K calc-alkaline I-type plutonic rocks with no A-type rocks. The geochemical signatures of the entire groups indicated LREEs (light rare earth elements) enrichments and negative Nb, Ta, and Ti anomalies, indicating normal arc magmatism. A new tectonic model of the Cretaceous Korean Peninsula was proposed based on temporal and spatial distribution of the Cretaceous plutons represented by four age groups; 1) magmatic quiescence throughout the Korean Peninsula from ca. 160 to 120 Ma, 2) intrusions of the I- and A-type granitoids in the northern and central Korean Peninsula (Group I plutonic rocks from ca. 120 to 100 Ma) resulted from the partial melting of the lower continental crust due to the rollback of the Izanagi plate expressed as the conversion from flat-lying subduction to normal subduction. The Gyeongsang nonmarine sedimentary rift basin in the Korean Peninsula and adakite magmatism preserved in the present-day Japanese Islands supported the slab rollback followed by steepening of the Izanagi plate with an injection of upwelling of the hot asthenosphere into the mantle wedge. 3) Alternating shallow (from ~100 to 85 Ma) to steep (from ~85 to 65 Ma) subduction resulted in the migration of the normal arc magmatism in the southern Korean Peninsula, expressed as the intruded I- and A-type (Group III) and I-type granitoids (Group IV), respectively. The tectonomagmatism of the Korean Peninsula showed the unique style of evolution, different from those of South China and Japanese Islands.

1. Introduction

The Jurassic to Cretaceous tectonomagmatic framework, particularly the subduction of the Izanagi plate along the northeast Asian continental margin, has been the subject of numerous investigations (Chen et al., 2003; Chen et al., 2013, 2014; Kee et al., 2010b; Kim et al., 2012, 2015a; Kiminami and Imaoka, 2013; Li and Li, 2007; Li et al., 2014; Maruyama et al., 1997; Meng et al., 2012; Sagong et al., 2005; Sun et al., 2012; Wang et al., 2012; Zhou and Li, 2000). In the Korean Peninsula, the tectonic and magmatic activities during Early to Middle Jurassic show inlandward-younging trend, and were unusually extended ~1000 km into the continent from the ancient trench (Figs. 1 and 2), which might be due to the shallow subduction of the Izanagi plate (Kee et al., 2010b; Kim et al., 2009, 2015a). Early to Middle Jurassic basin developments were rare during this period. Subsequent magmatic quiescence (ca. 165–120 Ma) (Kim et al., 2012; Sagong et al., 2005) could be due to flat-lying subduction (Imaoka et al., 2014; Kiminami and Imaoka,

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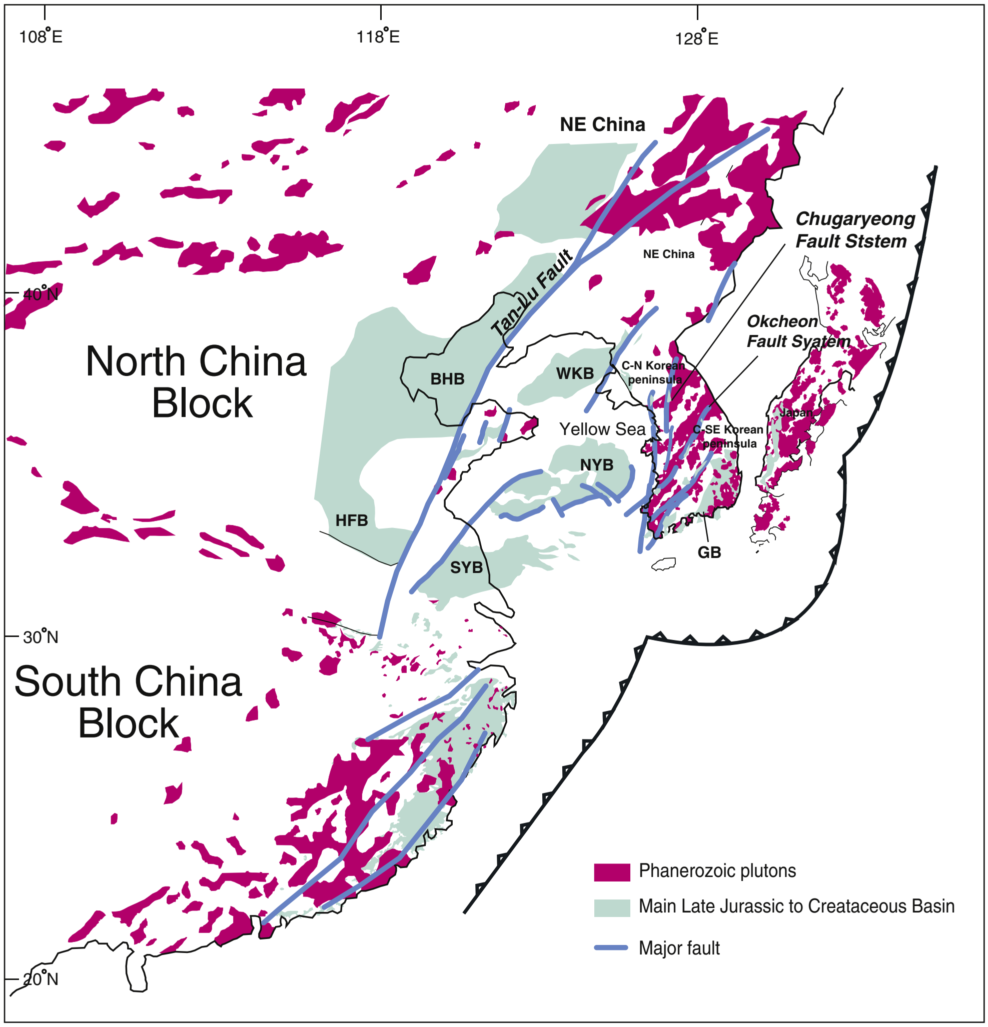

Fig. 1. Tectonic map of northeast Asia showing the overall distributions of the Mesozoic plutonic rocks and sedimentary basins with major N- to NE-trending faults. BHB, Bohai Bay Basin; GB, Gyeongsang Basin; HFB, Hefei Basin; NYB, North Yellow Sea Basin; SLB, Songliao Basin; SYB, South Yellow Sea Basin; WKB, West Korean Bay Basin.

2013). After the magmatic quiescence, tectonomagmatic activity migrated trenchward because of conversion from flat to normal subductions by slab rollback. The subduction direction of the Izanagi plate is also changed from normal to oblique convergence. During this period, Cretaceous volcanosedimentary basins were developed along the major N- to NE-trending transcurrent faults (viz. Tan-Lu Fault, Chugaryeong, and Okcheon-Boundary Fault systems; Fig. 1) in and around the Korean Peninsula (Kim et al., 2012; Kiminami and Imaoka, 2013; Lan et al., 2011; Lee et al., 2011; Lin et al., 2011; Pei et al., 2011). However, few detailed studies have been carried out to constrain the geochemistry and geochronology of the Cretaceous plutonic rocks in the Korean Peninsula, crucial for evaluating the geodynamic evolution related to the Izanagi plate in East Asia.

Adakites are intermediate to felsic volcanic rocks that have geochemical characteristics of high Sr and low Y (Sr/Y > ~20), which was created by the partial melting of the altered basalt such as eclogited oceanic crust (Castillo, 2012; Kay, 1978; Peacock et al., 1994). However, subsequent researches show that adakite-like rocks (adakitic rocks) can be formed by diverse petrogenetic processes including partial melting of the lower continental crust (e.g., Wang et al., 2006), cold plume (e.g., Gerya and Yuen, 2003) and even magma fractionalization (e.g., Castillo et al., 1999). To avoid confusion, we use adakite for the plutonic rocks created by partial melting of the eclogited oceanic crust, and adakitic rocks for those created by one of the other petrogenetic processes. The Cretaceous adakitic rocks and A-type granitoids were emplaced broadly along the Dabie-Sulu collision zone (ca. 136 to125 Ma) and sporadically along the coastal area of southeast China (ca. 107 to 99 Ma), and are thought to be attributed to partial melting of the thickened or delaminated lower continental crust (Chen et al., 2014; Gao et al., 2008; Wang et al., 2006, 2012; Xiong et al., 2003), though partial melting of the normal continental crust was also suggested for the genesis of the adakitic rocks (Ma et al., 2015). On the contrary, the southwest-to-northeast migration of the granitoids including adakites and A-type granitoids along the southwest Japan from ~120 to 80 Ma has been correlated to the ridge subduction, causing partial melting of the young subducted oceanic crust (Kamei, 2004; Kiji et al., 2000; Kinoshita, 2002).

For decades, the Cretaceous tectonic history of the northeast Asia has been correlated to the southwest-to-northeast migration of the ridge subduction (e.g. Kinoshita, 2002; Ling et al., 2009; Maruyama et al., 1997; Sagong et al., 2005). However, ridge subduction interpretation is problematic because of no existence of ridge subduction in the northeast Asian continental margin during the entire Cretaceous (Sdrolias and Müller, 2006). In addition, the old Izanagi oceanic plate (>80 Ma) subducted along the ancient plate margin did not generate partial melting of the eclogited oceanic crust, required for the adakite magmatism. Thus, an intracontinental mantle plume during the Cretaceous (Lee and Ryu, 2015) has been suggested for magmatic and paleogeographic evolution. They suggested that the intracontinental mantle plume resulted in foundering (delamination) and partial melting of the lower