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Detrital zircon U–Pb ages of the Jangsan Formation in the northeastern Okcheon belt, Korea and its implications for material source, provenance, and tectonic setting

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ABSTRACT

The Jangsan Formation distributed in the Taebaeksan Basin, central eastern Korea is unfossiliferous and is composed of quartz arenite. This formation is conventionally believed to be the lowermost stratigraphic unit of the lower Paleozoic sequence deposited on the Yeongnam massif in South Korea, corresponding to Early Cambrian in age. U–Pb dating of detrital zircon grains using a laser ablation inductively coupled mass spectrometer yields ages ranging from Archean to Middle Proterozoic (1738 ± 67 Ma to 3058 ± 53 Ma). Detrital zircons show no ages younger than 1.8 Ga, suggesting that the Jangsan Formation was deposited at some time after this age, but much prior to ca. 520 Ma, the depositional age of the immediately overlying Myobong Formation. This interpretation is supported by the recent report on the presence of the unconformity between the Jangsan and the Myobong formations (Kim and Lee, 2006). Zircon ages from Jangsan sandstones define two major groups: Archean-age grains with a maximum frequency at about 2.5 Ga and Paleoproterozoic-age grains with maximum frequencies at about 2.1 and 1.8 Ga. The observed zircon age distribution in the Jangsan sandstones may represent that of the Yeongnam massif on which the Jangsan Formation was deposited. Such an age distribution of the Yeongnam massif matches well with that the North China block, suggestive of the Yeongnam massif being a part of the Sino-Korean craton during the Precambrian.

1. Introduction

The depositional ages of the unfossiliferous mature sedimentary rocks such as quartz arenites cannot be easily determined unless they contain interbedded volcanic or intrusive rocks suitable for radiometric dating. Maximum depositional dates obtained from the analysis of detrital zircon age populations offer the only means available for constraining the time of deposition of such sedimentary rocks. Provided there has been no disturbance of the U–Pb system, the youngest igneous crystallization dates obtained on detrital zircons from a sedimentary rock sample will provide a maximum age for host sediment deposition (Nelson, 2001; Dunn et al., 2005). However, the maximum depositional age based on dates obtained from the youngest zircon or zircons identified may still be substantially older than the time of sediment deposition. To minimize this possibility sedimentary rocks containing detrital zircon populations derived from the widest possible provenance range are preferred to those derived from a restricted provenance range and with a small number of local, and possibly old, sources of zircon (Nelson, 2001).

The Jangsan Formation distributed in central eastern Korea (Fig. 1) is unfossiliferous and is composed of quartz arenites. This formation is conventionally believed to be the lowermost stratigraphic unit of the lower Paleozoic sequence in South Korea, corresponding to Early Cambrian in age (Kobayashi, 1966; Cheong, 1969). A different view was presented by Kim and Lee (2006) based on the discovery of an unconformity at the boundary between the Jangsan and the immediately overlying strata, and they proposed that the Jangsan Formation be of Precambrian in age and that this formation does not belong to the lower Paleozoic sequence. This finding is yet to be confirmed by further studies. To test this hypothesis geochronological information about the depositional age of the Jangsan Formation is needed.

The final amalgamation of the North China and South China blocks has occurred during the Triassic, resulting in the closure of the Paleotethys and the formation of the Qinling–Dabie–Sulu collisonal belt in central China. However, the eastward extension of this Chinese collisional belt has yet been established, and various tectonic relationships between the Korean Peninsula and the Chinese blocks have been proposed (Cluzel et al., 1991; Yin and Nie, 1993; Ernst and Liou, 1995; Chang and Park, 2001; Kim et al., 2001; Oh et al., 2006a, 2006b; amongst others). The Korean Peninsula comprises three Precambrian massifs, from north to south the Nangrim, Gyeonggi, and Yeongnam massifs (Fig. 1). The Nangrim and Gyeonggi massifs are separated by the Paleozoic Pyeongnam Basin and the Paleozoic Imjingang belt, whereas the Gyeonggi and Yeongnam massifs are separated by the upper Precambrian to Paleozoic Okcheon belt.

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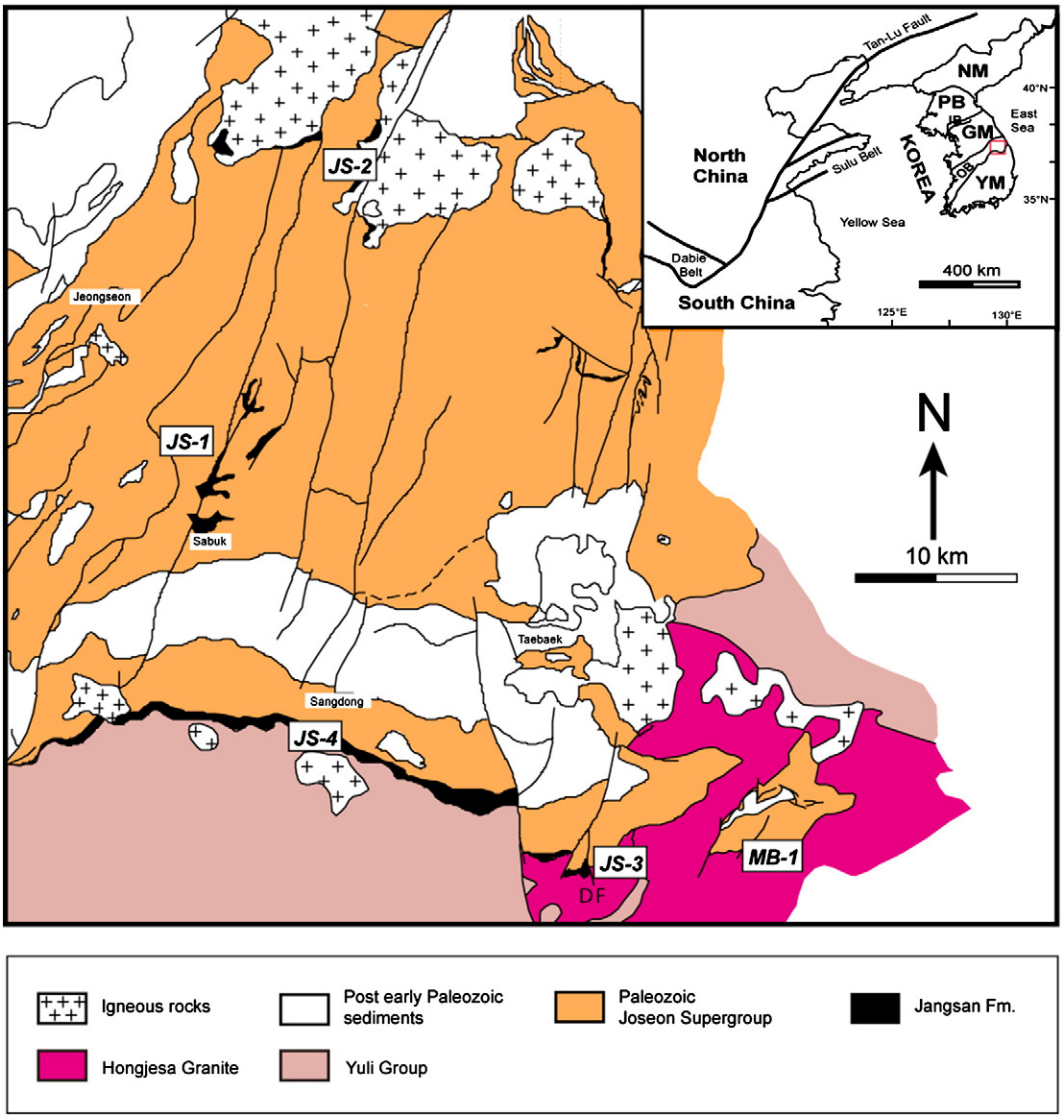

Fig. 1. Simplified geological map of the eastern Taebaeksan Basin with sampling sites for the Jangsan (JS-1 to JS-4) and Myobong (MB-1) Formations (modified after Geological Investigation Corps of Taebaegsan Region, 1962). The inset shows crustal blocks and massifs of the Korean Peninsula and adjacent China (modified after Jeong and Lee, 2000). The boxed area in the inset represents the Taebaeksan Basin. NM: Nangrim massif; PB: Pyeongnam Basin; IB: Imjingang belt; GM: Gyeonggi massif; OB: Okcheon belt; YM: Yeongnam massif.

There is a general consensus that the Nangrim massif is a part of the Sino-Korean craton (North China block) (cf., Zhao et al., 2006), but the tectonic affinity of the Gyeonggi and Yeongnam massifs is still under debate. The Jangsan Formation is distributed in the northeastern part of the Okcheon belt and is known to have been deposited on the northeastern margin of the Yeongnam massif. Provenance information of the Jangsan Formation may contribute to delineating the tectonic relationship of the Yeongnam massif with either of the two Chinese blocks.

The purposes of this study are to document the U–Pb geochronology of detrital zircons from the Jangsan Formation and, from this evidence, to interpret the provenance of the Jangsan sandstones. The data on the depositional age and provenance of Jangsan sandstones have not been reported previously. Then, our geochronological information of the Jangsan Formation will be discussed for understanding of the tectonic setting of the Korean Peninsula.

2. Geological setting

In the eastern central part of the Korean Peninsula distributed is the Joseon Supergroup (Fig. 1), the lower Paleozoic sediment in South Korea, ranging in age from Early Cambrian to Late Ordovician (Cheong, 1969; Lee, 1987). It overlies unconformably Paleoproterozoic granitic gneiss and metasedimentary rocks of the Yeongnam massif, and is in turn unconformably overlain by the upper Paleozoic–early Mesozoic Pyeongan Supergroup which is composed mainly of thick clastic succession of marginal marine to non-marine facies containing coal measures (Cheong, 1969). The Joseon Supergroup is exclusively of marine origin, dominated by shallow platform carbonate rocks with minor interbedded siliciclastic rocks. The development of the Joseon Supergroup sequence was mostly controlled by eustatic changes, having cyclic sedimentation of various temporal scales (Lee and Lee, 2003). During the early Paleozoic the Korean Peninsula was located in a low-latitude tropical region and experienced frequent storm activities (Lee and Kim, 1992; Lee et al., 2001; Kim and Lee, 2003a; Sim and Lee, 2006). The Joseon Supergroup is conventionally subdivided into five types of sequence based on distinct lithologic successions and geographic distribution: namely, the Duwibong, Yeongweol, Jeongseon, Pyeongchang, and Mungyeong units (Kobayashi et al., 1942). The Duwibong Unit is the type sequence of the lower Paleozoic in South Korea and is known to be subdivided into 10 stratigraphic units: the