The tentative APWP of the Korean Peninsula since Cretaceous and its tectonic implications

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Abstract: The representative Cretaceous-Tertiary paleomagnetic poles of the Korean Peninsula have been obtained from primary remanences of unremagnetized rocks: 59.6°N, 194.7°E for K_{1M}; 67.6°N, 207.7°E for K_{1L}; 71.1°N, 215.2°E for K_2; and 84.9°N, 292.6°E for the Miocene. Chemical remanences of remagnetized rocks also yield Early Tertiary paleomagnetic pole (83.9°N, 88.3°E). These paleopoles provide the tentative APWP of the Korean Peninsula since the Cretaceous, and suggest some tectonic interpretations as follows. The Korean Peninsula was located at similar latitude to the present position, and rotated clockwise with respect to the adjacent blocks during the Cretaceous. The Korean Peninsula experienced latitudinal movement during the Early Tertiary, which was possibly associated with the continental collision between India and Asia. The Korean Peninsula and Southwest Japan might be independent terrains during the Cretaceous based on the temporal discrepancies of the southward movements and the clockwise rotations of the two blocks with respect to Eurasia.

Keywords: Cretaceous, Korean Peninsula, paleomagnetism, rotation, tectonics, Tertiary

1. INTRODUCTION

Over the last decade, many paleomagnetic studies for various rocks in the Korean Peninsula have provided important clues on tectonic history of the East Asia, as well as those of the Korean Peninsula (e.g., Kim, 1989; Kim and Van der Voo, 1990; Kim *et al*., 1992; Min *et al*., 1993; Doh and Piper, 1994; Lee *et al*., 1996, 1997, 1999; Doh *et al*., 1997, 1999, 2002; Park et al., 2003, 2005, 2007). The purpose of this study is to suggest some possible interpretations on the tectonic evolution of the Korean Peninsula in the tectonic framework of East Asia since the Cretaceous based on the previously published paleomagnetic data in Korea.

2. METHODS

All Cretaceous-Tertiary paleomagnetic data of the Korean Peninsula have been collected and reviewed using seven reliability criteria for paleomagnetic data by Van der Voo (1990). The criteria are as follows: (1) well-determined rock age; (2) sufficient number of samples ($N \geq 24$),

k (or K) ≥ 10 and α_{95} (A_{95}) ≤ 16.0; (3) adequate demagnetization; (4) eligible field test results; (5) tectonic coherence with block involved; (6) the presence of reversals; (7) no resemblance to paleopoles of younger age (by more than a Period). As with the scheme of Van der Voo (1990), one point was scored for each of the criteria that were judged to have been satisfied. Then a quality factor (Q), in the range 0–7, was derived from the overall point score, and was assigned to each paleomagnetic data set. Because there is no Cretaceous-Tertiary paleomagnetic data from the Korean Peninsula showing Q = 7, we considered the priority of the above criteria for the tectonic interpretation. Three former criteria (1), (2), and (3) are the most significant acceptance criteria for the reliable paleomagnetic data. Although the latter four criteria (4), (5), (6), and (7) still enhance the reliability of paleomagnetic data, we judge the paleomagnetic data that satisfy at least four criteria, surely including (1), (2), and (3), to be reliable. We reject paleomagnetic data with a negative fold test or negative reversal test to ensure the absence of remagnetization. On the other hand, the paleomagnetic poles calculated the remagnetized components were judged using other criteria such as (i) consistency of paleomagnetic pole positions, (ii) proper rock magnetic experiments and microscopic observations and (iii) origin of the remagnetization. Then we calculated representative paleomagnetic poles for each geologic time from the reliable paleomagnetic data in order to propose a tentative apparent polar wander path (APWP) and interpret the tectonic evolution of the Korean Peninsula.

3. RESULTS AND DISCUSSION

Representative Cretaceous-Tertiary paleomagnetic pole positions calculated from unremagnetized sedimentary and volcanic rocks in the Korean Peninsula are summarized as follows: 59.6°N, 194.7°E (A_{95}=4.6°) for the middle Early Cretaceous (K_{1M}); 67.6°N, 207.7°E (A_{95}=2.5°) for the late Early Cretaceous (K_{1L}); 71.1°N, 215.2°E (A_{95}=5.4°) for the Late Cretaceous (K_2); and 84.9°N, 292.6°E (A_{95}=4.5°) for the Miocene. The mean paleomagnetic pole position calculated from the remagnetized components in the Jeongseon and Pyeongchang areas is at 83.9°N, 88.3°E (A_{95}=4.9°). The timing of the remagnetization in these areas is constrained to Early Tertiary (i.e., Paleocene to Eocene) times. Therefore, this paleomagnetic pole obtained from the remagnetized components is added to the tentative APWP of the Korean Peninsula.

The tentative APWP shows that the paleomagnetic poles of middle Early Cretaceous to Miocene age plot along a small circle centered at the Korean Peninsula (Fig. 1). This result indicates that the Korean Peninsula was located at similar latitude to the present position, although subject to clockwise rotation by approximately 22° about a vertical axis during the

Cretaceous. The Cretaceous clockwise rotation of the Korean Peninsula with respect to the adjacent blocks has been ceased after the Cretaceous (Park *et al.*, 2005, 2007).

Fig. 1 also reveals that paleopoles from the remagnetized component form a hairpin-curved portion of the APWP of the Korean Peninsula between the middle Early Cretaceous and the Miocene. Such a hairpin-curved APWP is similar to the APWP of Eurasia showing a tight hairpin-curve at about 50Ma (Fig. 1). The paleomagnetic paleolatitude calculated from the remagnetized component in the Jeongseon and Pyeongchang areas (so called Bakjisan Syncline) is about 41°N, which is slightly higher than the present latitude as well as than the Cretaceous and Miocene paleolatitudes. Thus, this result indicates that the Korean Peninsula may have experienced laltitudinal movement during the Early Tertiary. Generally, the cusps in APWP have been attributed to continental collision or break-up (Evans, 2003). It is interpreted that the continental collision between India and Asia is a possible tectonic event that could have caused the hairpin-curved APWP of Eurasia and the Korean Peninsula at about 50Ma.

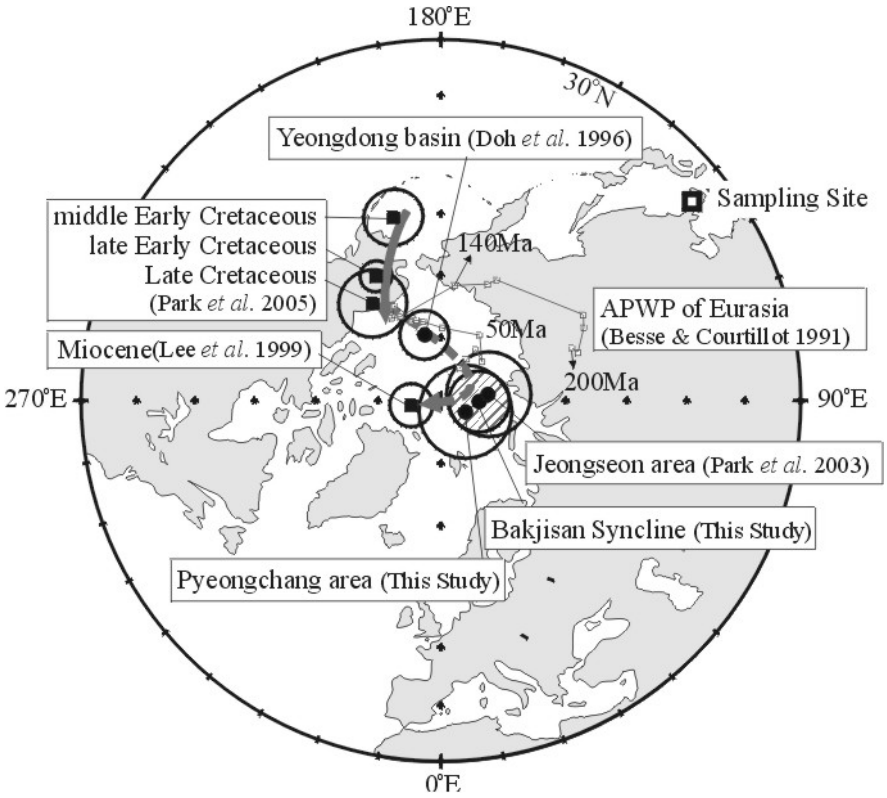

Fig. 1. The tentative apparent polar wander path (APWP) of the Korean Peninsula since the Cretaceous. The APWP of Eurasia since 200 Ma (Besse and Courtillot, 1991) is also shown for the comparison. The paleomagnetic poles obtained from primary magnetizations and remagnetized components are shown as solid squares and circles, respectively.

The tectonic relationship between the Korean Peninsula and Southwest Japan have been

determined by the comparison of paleopoles (Fig. 2). The Korean Peninsula and Southwest Japan have been regarded as a tectonically single terrain during the Cretaceous (e.g. Otofuji *et al.*, 1999; Uno, 2002). However, the temporal differences in the clockwise rotations between the Korean Peninsula and Southwest Japan suggest that these two blocks did not behave as a tectonically single terrain during the Cretaceous Period. This aspect can be also found in comparisons of the palaeolatitudes of the Korean Peninsula and Southwest Japan. The Korean Peninsula was situated at about 42°N during the middle Early Cretaceous, and drifted southward to its present latitude (37°N) during the late Early Cretaceous. For Southwest Japan, a significant amount of latitudinal displacement was observed between the palaeopoles for K1L–earliest K2 and K2 (Fig. 13). Thus, it is interpreted that the Korean Peninsula and Southwest Japan may have been independent terrains since the Cretaceous, based on the temporal discrepancies of the clockwise rotations and southward migrations of the two blocks with respect to Eurasia.

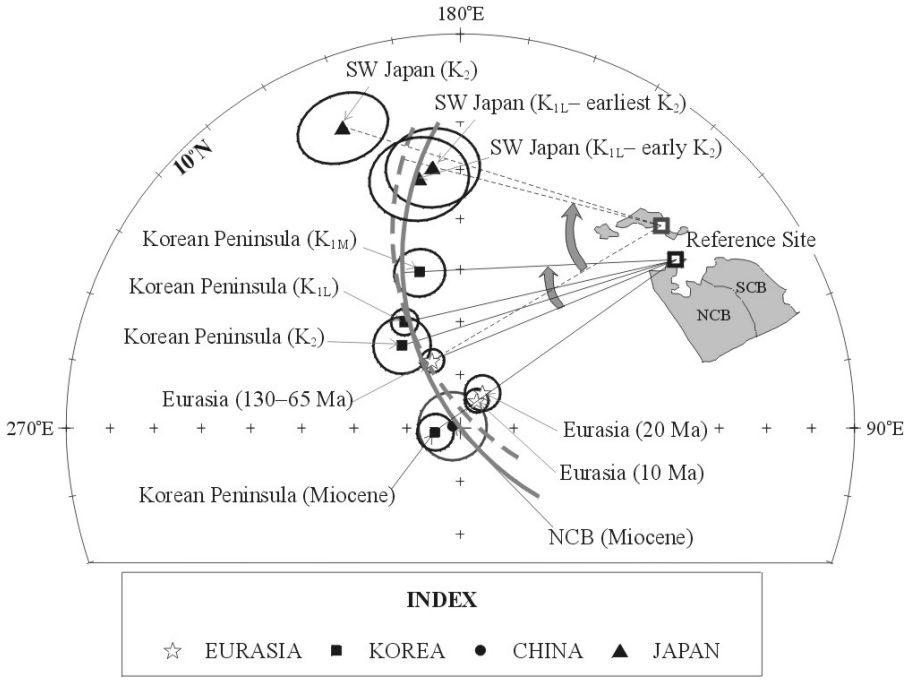

Fig. 2. Cretaceous paleomagnetic poles of the Korean Peninsula compared with those of Eurasia (135–65 Ma: Besse and Courtillot, 1991) and Southwest Japan (K_{1L}–earliest K_2 (Albian–Cenomanian): Kodama and Takeda, 2002; K_{1L}–early K_2 (Albian–Coniacian): Otofuji and Matsuda, 1987; K_2: Uno, 2002), showing clockwise rotations of the Korean Peninsula and Southwest Japan with respect to Eurasia. Tertiary palaeomagnetic poles of the Korean Peninsula (Miocene: Lee *et al*., 1999), North China Block (Miocene: Zhao *et al*., 1994) and Eurasia (10 Ma and 20 Ma: Besse and Courtillot, 1991) are also plotted for comparison.

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