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Paleomagnetic Study Groups in Korea

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ABSTRACT

Since the paleomagnetic study was introduced in Korea about 40 years ago, its scientific findings contributed to the understanding of geologic settings and tectonic processes of the Korean Peninsula and eventually to the escalation of geology and geophysics in Korea. It is worth summarizing and introducing the up-to-date paleomagnetic results produced by the representative paleomagnetic working groups in Korea, such as K. D. Min, I. S. Kim, S. J. Doh, Y. S. Lee, D. W. Suk, the late K. H. Kim and others.

Key words

paleomagnetic study, direction of magnetization, pole position

1. Introduction

Paleomagnetic studies for the Korean Peninsula have been carried out vigorously by a relatively small group of Korean paleomagnetists for the last 20 years. The paleomagnetic paper entitled “The study of remanent magnetism for basalts in Yeoncheon and Pohang districts in Korea” by Kim (1964) is considered as the first scientific results conducted by a Korean scholar in Korea. The paper reported a reversed magnetic direction of the Seokgol basalt from Pohang area, while rest of the samples, Gampo basalt from Pohang and Yeoncheon basalt from Yeoncheon area, revealed a normal direction. Although one reference (Baag, 1963) was cited in the forementioned paper, it would be hardly the first paleomagnetic paper because it was an unpublished general description of a paleomagnetic study. Other than this, only several publications by foreign researchers in the 60's and 70's could be found. Kienzel and Scharon (1966) reported paleomagnetic results for volcanic rocks in Pohang, Gyeongsan and Kimhae area. Paleomagnetic study for sedimentary rocks in the northern part of the Korean Peninsula (Gurarii *et al*., 1966) and the comparison of relative positions of Korea and Japan using paleomagnetic directions obtained from the Cretaceous rocks (Yaskawa, 1975) are the rest.

A full-scale paleomagnetic study was initiated after the installation of an atatic magnetometer in the Geophysics Laboratory at Yonsei University in the early 1980's by Kim and Min (1981). The astatic magnetometer allowed measurements of natural remanent magnetization directions recorded in rock samples in Korea, although it was primitive without any means of demagnetization of specimens. A master's thesis by Oh (1981) whose title was “A paleomagnetic study of the Cretaceous rocks from the southeastern part of Korean Peninsula” should be the first systematic and comprehensive paleomagnetic study conducted in Korea, although the measurements of characteristic directions were made in Japan. In 1982, another master's thesis of “Paleomagnetic study of basalts in Jeongog area and along the Hantan river valley” (Suk, 1982) could be finished using the astatic magnetometer in the Geophysics Laboratory at Yonsei University. The structural and petrological studies of the Chugaryeong Rift Valley (Lee *et al*., 1983; Kim *et al*., 1984) showed that paleomagnetic results could provide important clues in deciphering the tectonic processes. After Kwang Ho Kim, one of the pioneering paleomagnetists in Korea, received his Ph.D. degree in 1985 with a thesis of "A study on the paleomagnetism of southern Korea since the Permian" (Kim, 1985), various paleomagnetic research projects for the wide range of rocks of the Korean Peninsula have launched and flourished. This paper is intended to introduce and summarize paleomagnetic results of the rocks in the Korean Peninsula produced by Korean investigators according to the ages of rocks for each paleomagnetist.

2. Paleomagnetic Studies in Korea

Paleomagnetic studies for Cenozoic rocks resulted in publications containing directions of remanence and pole

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positions of the Tertiary and Quaternary rocks. Papers for the Pohang area (Min *et al*., 1994), Eoil Basin (Kim and Kang, 1989), Pohang Basin (Kim *et al*., 1986; Kim *et al*., 1993d; Son and Kim, 1996), Yangnam-Yeonil Basin (Kim and Doh, 1994; Lee *et al*., 1999), Janggi Peninsula (Kim *et al*., 1994; Kim and Kang, 1996), and Jeongja-Ulsan Basin (Son *et al*., 1996) are some, if not all, for the Tertiary rocks, whose debates were focused on whether the study areas had experienced horizontal rotation or not. On the other hand, the Quaternary rocks distributed along the Chugaryeong Rift Valley (Lee *et al*., 1983; Kim *et al*., 1984, Lee *et al*., 2001) including Jeongog-Hantan river valley (Suk, 1982), Ulleung Island and Jeju Island (Min *et al*., 1986; Won *et al*., 1986) were subjected to some paleomagnetic studies. Paleomagntic results for the Quaternary rocks showed paleomagnetic pole positions of the Pliocene and Pleistocene Epochs for the Korean Peninsula.

Among the Mesozoic strata in the southern part of the Peninsula, the Cretaceous Gyeongsang Supergroup, consisting of the Sindong, Hayang and Yucheon Groups, is well exposed in the Gyeongsang Basin, which is in turn divided into the Yeongyang, Euiseong and Milyang sub-basins. In addition, many small Cretaceous basins, such as Poongam, Eumseong, Gongju, Buyeo, Tongri, Yeongdong, Muju, Jinan, Neungju, Haenam, Hampyeong, and Goheung Basins, were developed along the northern and southern boundaries of the Ogcheon Belt. Because the very well exposed Cretaceous rocks in these basins were suitable for paleomagnetic studies, numerous research papers have been published. As a result, the characteristic directions and paleomagnetic pole positions for the Cretaceous Period for the Gyeongsang Basin as well as the sub-basins along the boundaries of the Ogcheon Belt are well established (Doh *et al*., 1994; Kang and Kim, 2000a; Kim and Noh, 1993; Kim *et al*., 1993b; Kim *et al*., 1998; Doh *et al*., 2002; Park and Doh, 2004; Park *et al*, 2005; Suk and Doh, 1996;).

Paleomagnetic studies for the Late Triassic-Middle Jurassic Daedong Supergroup have been carried out for the areas where the Daedong Supergroup is distributed, such as in the Chungnam Basin (Nampo Group, Min *et al*., 1992; Kim and Kim, 1998; Suk *et al*., 2004), Gyeonggi Basin (Kimpo Group, Kim *et al*., 1993b), Mungyeong Basin (Min *et al*., 1990; Kim *et al*., 1995) and Danyang Basin (Bansong Group). However, there still are some discrepancies and arguments in determining the characteristic directions and tectonic processes for each basins. Paleomagnetic investigations were performed for the Late Carboniferous-Early Triassic Pyeongan Supergroup distributed in the northeastern Ogcheon Belt, specifically for the Early Triassic Tonggo (or Nokam) Formation in the Baekunsan Syncline in Taebaek area (Doh, 1993), the Nokam Formation in Danyang, Jeongseon, Taebaek areas, the Bagjisan and Sangwonsan Formations in Jeongseon area (Park *et al*., 2003a, 2003b). Rest of the southern part of the Peninsula is covered with the Juressic granites, which have also been subjected to paleomagnetic works (Kim and Van der Voo, 1990; Kim *et al*., 1990).

In addition, in order to decipher the tectonic porcesses of the Korean Peninsula for Paleozoic, paleomagnetic investigations for Paleozoic rocks were increasingly needed and Paleozoic paleomagnetic works became possible as a much more sensitive magnetometer (SQUID magnetometer) became available in Korea. Scientific investigations for the Paleozoic Era by Otofuji *et al*. (1989), Min *et al*., (1993), Kim and Jeong (1994), Lee and Min (1995), Doh *et al*., (1998), Suk *et al*., (2004) were carried out for the Paleozoic rocks in the Ogcheon Belt. Main discussion is still focused on whether the vicinity of the Ogcheon Belt was part of the North China Block (NCB) or the South China Block (SCB). However, it is believed that such debates will reach a conclusion after the Apparent Polar Wander Path (APWP) of Korea is established.

3. Paleomagnetic Study Groups in Korea

After a paleomagnetic study was introduced in Korea by B. G. Kim, C. G. Baag and K .D. Min, the first generation paelomagnetists, such as K. H. Kim, I. S. Kim, S. J. Doh, Y. S. Lee and D. W. Suk who received their degrees in the field of paleomagnetism/rock magnetism in the middle of 1980's and in the early 1990's, have led the field. Since then, the second generation scientists consisting of H. C. Kang, S. W. Kim, M. Son, Y. J. Ryu, Y. H. Park and B. Y. Kim have devoted themselves to the flourishing development of paleomagnetic studies in Korea. Follows are summaries of papers published by each group of paleomagnetists.

3.1 Professor K. D. Min at Yonsei University

The Geophysics Lab run by Professor Min at Yonsei University has produced many paleomagnetic papers for various strata of widely spanning geologic ages conducted by many master's students (e.g. Oh, 1981). Results by Dr. Y. S. Lee, who is now in the Korea Institute of Geoscience and Mineral Resources (KIGAM), are introduced here because he has played an important role and has participated as a co-author in many of the papers.

Papers on Cenozoic rocks in Korea include Min *et al*., (1994) for the Tertiary rocks in Pohang, Janggi and Eoil Basins and Lee *et al*., (1999) for Yangnam and Yeonil Basins. The latter yielded a paleomagnetic pole position at 84.9°N, 292.6°E from the Yangbuk and Yeonil Formations representing the Miocene Epoch of Korea. Based on this result, they interpreted that the study area experienced a clockwise rotation at around 17.3 Ma under the influence of the Yangsan fault system in association with the opening of the East Sea. For Quaternary rocks, the Jeongog basalt in Jeongog-Yeoncheon-Cheolwon areas was studied by Kim *et al*. (1984), and Min *et al*., (1986) examined the Quaternary sedimentary and volcanic rocks in Jeju Island paleomagnetically. Most recently, Lee *et al*., (2001) reported a paleomagnetic pole at 86.5°N, 134.2°E (A_{95}=7.1°), which is statistically coincide with that of the present rotation axis of the Earth, from the Jeongog basalt in Cheolwon-Yeoncheon area.

The paleomagnetic study for the Cretaceous Sindong, Hayang, and Yucheon Groups from the Gyeongsang Basin in Jinju-Daegu-Gyeongju area (Otofuji *et al*., 1983), of which Professor Min and his student J. Y. Oh were co-authors, yielded the characteristic direction of D/I=26.6°/62.3° (k=85.0, α_{95}=8.3°) and the pole position at 68.9°N, 191.2°E (dp=10.1°, dm=12.9°). A conglomerate test to check remagnetization for the Silla Conglomerate of the Hayang Group in Jinju-Goryeong area was performed (Kim *et al*. 1998). A baked contact test to the uppermost Jinju Formation of the Sindong Group and the intruding andesitic dykes in Milyang Basin was carried out (Jeon *et al*., 1998).

The Late Triassic-Middle Jurassic Daedong Supergroup is distributed in the Kimpo and Chungnam Basins of the Gyeonggi massif and in the Mungyeong Basin of the Ogcheon Belt. The paleomagnetic study for the Borim, Dangog, Maseong and Bongmyeongsan Formations of the Daedong Supergroup in the Mungyeong Basin showed the characteristic direction of D/I=52.4°/-57.3° (k=11.7, α_{95}=7.4°) and the pole position at 1.2°N, 269.4°E, which led a conclusion that the study area was not a part of either the NCB nor the SCB (Min *et al*., 1990). Min *et al*. (1992) carried out the similar study for the Daedong Supergroup in the Chungnam Basin and concluded that the northwestern part of the study area had experienced a 45° rotation with respect to the southeastern part without excluding the possibility of remagnetization (Min *et al*., 1992).

Lee *et al*. (1996) published a paper containg results from the Late Permian-Early Triassic Tonggo Formation in the Baekunsan Syncline and the Late Carboniferous Manhang and Yobong Formations, whose characteristic directions were D/I=271.9°/-33.4° (k=57.1, α_{95}=16.5°) and D/I=255.5°/-2.4° (k=14.5, α_{95}=20.8°), respectively. The paleomagnetic pole positions corresponding to these directions could be found in Lee *et al*. (1997), the Late Carboniferous pole from the Manhang and Yobong Formations at 12.2°N, 226.8°E (K=25.2, A_{95}=15.5°) and that from the Late Permian-Early Triassic Tonggo Formation at 9.4°N, 203.1°E (K=40.2, A_{95}=19.7°). As Professor Min, who introduced a paleomagnetic study in Korea and led his working group until now, retires from Yonsei University at the end of August, 2006, his active role in the field of paleomagnetism will be greatly missed.

3.2 Professor I. S. Kim at Pusan National University

Professor Kim has devoted himself to the search for representative magnetic directions and pole positions of each and almost every Periods in the geologic time scale. Notably he has great deal of interests in the tectonic processes for the Tertiary and Quaternary Periods in Pohang and adjacent areas. Research works done by Drs. H. C. Kang, S. W. Kim and M. Son, who received their degrees from Pusan National University, are also included here.

For Cenozoic rocks, Professor Kim published many papers, among which Kim and Kang (1989) for the Tertiary rocks in the Eoil Basin reported the magnetic direction of D/I=357.4°/53.8° and the pole at 87.4°N, 5.7°E. The study of paleomagnetism and anisotropy of magnetic susceptibility (AMS) for the Tertiary basalt (Daljeon basalt) in the Pohang Basin (Son and Kim, 1996) yielded a conclusion

that the Basin rotated counterclockwise for about 20° by the sinistral simple shear exerted from the sinistral transform faults in the area. Kim and Kang (1996) also reported a local rotation in the Janggi Basin. The paper by Son *et al*. (1996) for the Tertiary and Cretaceous rocks in the Jeongja-Ulsan Basin, and one by Kim *et al*. (1997a) for the rocks around the Ulsan Fault in Gyeongju-Ulsan areas can be found in the literature. The paleomagnetic/magnetostratigraphic study for the Seoguipo Formation and Seoguipo trachyte (Kim and Lee, 2000) yielded paleomagnetic pole positions at 88.9°N, 182.5°E (dp=4.4°, dm=6.4°) for Middle Pleistocene and at 84.2°N, 182.3°E (dp=6.7°, dm=9.3°) for Late Pliocene Epoch.

Paleomagnetic results for Cretaceous rocks include Kim (1988) for the Dadaepo Formation in Pusan, and Kim *et al*. (1993a) for the Early Cretaceous rocks (Nakdong, Hasandong, Jiju, Chilgog, and Haman Formations) in Jingyo-Sacheon area, indicating that the rocks are older than Neocomian Epoch (124 Ma). Paleomagnetic studies were continued for the Sindong, Hayang, and Yucheon Groups in the Euiseong Basin (Kim *et al*., 1993c) revealing the conclusion that the Yucheon Group is younger than Campanian Epoch (83 Ma) and the Chilgog Formation of the Hayang Group is older than Barremian Epoch (124 Ma). Kang and Kim (2000a) again carried out a project for the Hayang Group and determined the characteristic direction of D/I=27.0°/56.1° (k=336, α_{95}=5.0°) and a pole position at 68.1°N, 210.7°E (K=237.4, A_{95}=6.0°). In addition, a paper for the Yucheon Group in Goseong area (Kang and Kim, 2000b) and another paper for the Hayang and Yucheon Groups as well as the Bulguksa Granites (Kang *et al*., 1996) are also found in the list.

For the Mesozoic Daedong Supergroup in Mungyeong area, Kim *et al*. (1995) interpreted that the study area were a part of the NCB, or at least in the vicinity of the NCB, for Triassic Period, and a local rotation due to thrusts and/or any signs of remagnetization by the intrusion of granites in the study area were not detected. Studies for the Daedong Supergroup in the Kimpo Basin (Kim *et al*., 1993b) and in the Chungnam Coal Field area (Kim and Kim, 1998) also concluded that these areas were a part of the NCB based on the comparison of the characteristic directions obtained from the two areas.

On the other hand, the paleomagnetic study for the Carboniferous-Triassic Pyeongan Supergroup and Chosun Supergroup in Taebaek area reported the representative paleomagnetic pole positions from Cambrian to Triassic Periods (Kim and Lim, 1993, Table 1). The comparison of the pole positions for the Taebaek area to those of the Chinese Continent revealed that the study area had been in the close vicinity of the NCB for the late Paleozoic Era and had become a part of the SCB since Permian.

3.3 Professor S. J. Doh at Korea University

Professor Doh has collected, measured and analyzed wide variety of rocks in Korea for paleomagnetic studies. Recently, he spent more time to investigate the Cretaceous rocks in the Gyeongsang Basin as well as the small basins along the northern and southern boundaries of the Ogcheon Belt. Since Dr. Y. H. Park, once Professor Doh's student and now at Kangwon National University, has been a key researcher in these works, his accomplishments are also included here.

One of many papers for Cretaceous rocks, Doh and Kim (1994), reported the characteristic direction of D/I=22.5°/

Table 1 Summary of characteristic directions and paleomagnetic pole positions from Cambrian to Triassic Periods by Kim and Lim (1993).

Period	D (°)	I (°)	α_{95} (°)	k	VGP		dp	dm
					Lat. (°N)	Long. (°E)	(°)	(°)
Triassic	264.9	-39.8	5.8	69.2	17.3	203.3	4.2	7.0
Permian	41.2	28.1	11.1	17.8	47.3	239.0	6.7	12.2
Carboniferous	3.8	-5.9	10.1	15.2	49.9	303.0	5.1	10.2
Ordovician	348.3	10.4	12.6	14.1	56.5	330.4	6.5	12.7
Cambrian	344.0	16.7	11.7	10.9	58.1	339.9	6.2	12.1

Note: D (I); declination (inclination) of site-mean ChRM direction, α_{95}, k, dp, and dm; statistical parameters, VGP; Virtual Geomagnetic Pole position.

57.2° (k=66.1, α_{95}=4.6°) and the corresponding pole position at 72.0°N, 206.4°E (dp=4.9°, dm=6.7°) for the Hayang Group, D/I=351.2°/60.5° (k=10.0, α_{95}=11.2°) and the pole at 81.3°N, 79.0°E (dp=13.0°, dm=17.0°) for the Yucheon Group, and the mean direction of D/I=353.6°/38.8° (k=43.6, α_{95}=18.9°) for the Bulguksa Granite in Euiseong area. Continued study for the Milyang Basin, Doh *et al*. (1994) showed that the direction of the Sindong Group (D/I=37.9°/58.6°, k=139.0, α_{95}=3.1°, pole at 59.9°N, 198.8°E, K=75.5, A_{95}=4.3°) was statistically different from that of the Hayang Group (D/I=29.3°/56.8°, k=96.6, α_{95}=3.3°, pole at 66.4°N, 204.1°E, K=62.3, A_{95}=4.2°). However, the paleomagnetic investigation for the Hayang Group in the Yeongyang Basin revealed the direction of D/I=6.1°/55.3° (k=41.5, α_{95}=4.2°) and its pole position at 85.5°N, 217.4°E (K=27.7, A_{95}=5.2°) for the basin, indicating a 25° counterclockwise rotation of the Yeongyang Basin with respect to the Euiseong and Milyang Basins (Doh *et al*., 1999a).

For the small Cretaceous basins outside of the Gyeongsang Basin, paleomagnetic results are indicative of remagnetization in general. Doh *et al*. (1999b) reported a remagnetization of the Cretaceous Chopyeong Formation in the Eumseong Basin, while granite in the basin revealed the ambiguous direction of magnetization (D/I=347.0°/47.0°, k=40.2, α_{95}=3.6°) and the pole position (77.6°N, 33.3°E, K=33.3, A_{95}=8.1°), which are similar to those of Jurassic in Korea. For the Gongju Basin, it was found that the sedimentary rocks were completely remagnetized. On the contrary, the volcanic rocks in the basin possessed the direction (D/I=204.2°/-43.8°, k=36.6, α_{95}=8.6°) and pole position (67.2°N, 235.3°E, K=34.6, A_{95}=8.9°) coincident with those for Campanian-Maastrichtian (Kim *et al*. 2002).

Park *et al*. (2005) reviewed all of the paleomagnetic data of the Korean Peninsula for Cretaceous and determined the representative paleomagnetic pole of the Cretaceous Period. The data include those from the Milyang-Euiseong-Yeongyang Basins in the Gyeongsang Basin, Neungju-Yeongdong-Eumseong-Haenam-Gongju-Pungam Basins along the boundaries of the Ogcheon Belt, and areas in the Gyeonggi massif (Cheolwon, Cheonsuman, Yesan). The paleomagnetic pole positions for middle Early Cretaceous (K_{1M}), late Early Cretaceous(K_{1L},) and Late Cretaceous (K_2) were determined from the 23 data sets that fulfill the quality criteria of Van der Voo (1990) (Table 2).

Doh (1993) measured the typical Early-Middle Triassic direction (D/I=1.1°/19.4°, k=26.4, α_{95}=18.2°) and pole position (63.2°N, 306.1°E, A_{95}=12.6°) from the Tonggo Formation in the Baekunsan Syncline and interpreted that the study area had been in close association with the SCB. In addition, he pointed out that the Baekunsan Sycline rotated clockwise for about 30° based on the direction of the secondary magnetization from the same specimens. Doh *et al*. (1997) also reported the Tertiary remagnetization direction from the Hongjeom and Sadong Formations of the Pyeongan Supergroup in Yeongwol area, without eliminating the possibility of the 30° rotation of the study area. In addition, the paleomagnetic results from the Tonggo Formation of the Pyeongan Supergroup in Danyang area indicated that the study area had been a part of the NCB since Early Triassic (Doh *et al*, 1998). The paleomagnetic study of the Pyeongan Supergroup in Jeongeon area (Park *et al*., 2003a, 2003b) showed the Cretaceous-Tertiary remagnetization due to the acquisition of chemical remanent magnetization (CRM) under the influence of fluids percolated through the thrust faults in the study area. Similarly, the paleomagnetic investigation of the Pyeongan Supergroup in Pyeongchang area (Park and Doh, 2006)

Table 2 Cretaceous paleomagnetic poles for the Korean Peninsula determined by Park *et al*. (2005).

Locality	Age	N	PMP		A_{95}	R± △R
			Lat. (°N)	Long. (°E)	(°)	(°)
Korean Peninsula	K_2	7	71.1	512.2	5.4	+6.1± 5.8
	K_{1L}	7	67.6	207.7	2.5	+10.9± 3.4
	K_{1M}	5	59.6	194.7	4.6	+21.9± 5.5

Note: N; number of studies, D (I); PMP; paleomagnetic pole position; Lat., north latitude; Long., east longitude; A_{95}, the radius of the 95 per cent confidence circle about the calculated mean pole; R, rotation clockwise (+) or counterclockwise (-) with respect to Eurasia in pole space; direction, △R, uncertainty of R; K_{1M}, middle Early Cretaceous; K_{1L}, late Early Cretaceous; K_2, Late Cretaceous. Modified from Table 3 of Park *et al*. (2005).

identified the Early Tertiary (Paleocene-Eocene) remagnetization by the acquisition CRM at the time of the formation of new magnetic minerals.

3.4 Professor D. W. Suk at Hanyang University

Professor Suk at Hanyang University have been carrying out several projects in collaboration with Professor Doh using the paleomagnetic equipments at Korea University until recently when a paleomagnetic lab was furnished at Hanyang University several years ago. Since much of the paleomagnetically suitable strata in Korea has already been subjected to investigations by the above mentioned paleomagnetists, he is searching for areas and rocks that are new to paleomagnetic studies, or tries to redefine the magnetic directions and pole positions in areas where arguments and discrepancies exist.

The Quaternary Jeongog basalt and Jangtanri-Tonghyeon basalts of unknown age were measured using an astatic magnetometer without proper demagnetization treatments in Korea (Suk, 1982). Fortunately, the results indicated that the Jeongog basalt were formed during Brunhes Epoch and the study area was tectonically stable since the formation of the basalt.

The Gusandong tuff and the Yucheon Group in the Euiseong Basin were subjected to an anisotropy of magnetic susceptibility (AMS) study and reveled plausible eruption sites for the rocks based on the converging point of the directions of the maximum AMS (Suk, and Doh, 1994). In addition, the paleomagnetic study for the Hayang and Yucheon Groups resulted in the mean direction of D/I=31.7°/57.8° (k=32.4, α_{95}=5.8°) and the pole at 64.9°N, 202.2°E (A_{95}=7.6°) for the Hayang Group, while the Yucheon Group showed four different magnetic directions, presumably indicative of the formation of the rocks during geomagnetic reversal processes (Suk and Doh, 1996). Preliminary results for the Cretaceous sedimentary rocks (Hong *et al*., 2004) and volcanic rocks (Ko *et al*., 2005) from the Hampyeong Basin revealed the primary magnetic directions of D/I=28.2°/59.4° (k=53.8, α_{95}=8.3°) and D/I=25.8°/55.8° (k=27.7, α_{95}=8.0°), respectively. The volcanic rocks also recorded the reversed direction of D/I=150.0°/-61.9° (k=13.3, α_{95}=14.6°).

The Lpper Triassic-Middle Jurassic Daedong Supergroup in the Chungnam Basin was examined again by Suk *et al*. (2004). The magnetic direction of D/I=74.5°/ 36.7° (k=60.7, α_{95}=5.1°) and the corresponding pole position at 24.5°N, 208.0°E (A_{95}=4.9°) after tilt correction were statistically similar to those from the SCB, indicating that the study area and the SCB were in the tectonically same unit.

3.5 The late Professor K. H. Kim

Although Professor K. H. Kim passed away in 1998 at the age of 56, his passion for the paleomagnetic studies re-

Table 3 Summary of characteristic directions and paleomagnetic pole positions from Permian to Quaternary Periods by Kim and Jeong (1986) and Otofuji *et al*. (1986).

Period	Formation	D (°)	I (°)	α_{95} (°)	k	VGP		dp	dm
						Lat. (°N)	Long. (°E)	(°)	(°)
Quaternary	Jeju Island Jeongog basalt	2.0	55.8	6.6	69.5	87.4	178.8	<A_{95}=	6.6°>
Late Cretaceous	Chilgok Haman Jindong	28.3	58.1	6.4	376.2	67.0	202.0	7.0	9.5
Early Cretaceous	Nakdong Jinju	41.3	64.6	4.5	~60	58.0	187.0		
Early Jurassic	Bansong Nampo	313.4	43.1	16.0	11.2	49.0	39.0	12.3	19.8
Triassic	Nokam	325.6	46.1	11.8	19.8	60.0	30.0	9.7	15.1
Permian	Kobangsan	331.5	25.1	12.8	16.9	55.0	2.0	7.4	13.7

Note: D (I); declination (inclination) of site-mean ChRM direction, α_{95}, k, dp, and dm; statistical parameters, VGP; Virtual Geomagnetic Pole position.

mains in many research papers. His works, which are still cited despite rather old data, are briefly introduced.

For Cenozoic Erathem, the paleomagnetic papers for the Tertiary rocks from the Pohang Basin (Kim *et al*., 1986; Kim *et al*., 1993d), the Yangnam Basin (Kim and Doh, 1994), and from the Janggi Peninsula in Pohang area (Kim *et al*., 1994) were published. Also, he was a co-author of Lee *et al*. (1983) for the Quaternary and Cretaceous rocks along the Chugaryeong Rift Valley and Won *et al*. (1986) for the Quaternary trachyte in Jeju Island.

For Cretaceous rocks, Kim and Kim (1991) for the Hayang Group in Daegu-Gyeongju area and Kim and Noh (1993) for the Neungju Formation in the Neungju Basin were published. Furthermore, he studied the Cretaceous volcanic rocks along the Chugaryeong Rift Valley in Jeongog-Yeoncheon area (Kim and Song, 1995), in Cheonsuman area (Song and Kim, 1995) and in areas between Seoul and Daecheon (Kim *et al*., 1997b).

He found a complete remagnetization of the Chosun and Pyeongan Supergroups from the Baekunsan Syncline, Taebaek area as summarized in Otofuji *et al*. (1989). Three years later, he carried out the project for the Pyeongan Supergroup from the Baekunsan Syncline in Danyang-Yeongwol-Jeongseon-Taebaek-Sabuk areas again, and reported the pole positions for Middle Carboniferous, Permian, and Early Triassic Periods for Korea and interpreted that the study area was not a part of the SCB before Jurassic (Kim *et al*., 1992). His interests extended to the Jurassic and Triassic granite and some sedimentary rocks in the Gyeonggi massif-Ogcheon Belt-Yeongnam massif. He found that the Gyeonggi and Yeongnam massifs had experienced a 60° clockwise rotation with respect to the Ogcheon Belt due to the sinistral simple shear during the Daebo Orogeny (Kim *et al*., 1990; Kim and Van der Voo, 1990).

He reported the frequently cited characteristic directions and pole positions of the Korean Peninsula for Permian, Triassic, Early Jurassic, Cretaceous and Quaternary in papers by Kim and Jeong (1986) and Otofuji *et al*. (1986), although these are rather old results (Table 2).

3.6 Other Researchers

Although Professor G. D. Lee at Andong University published a paleomagnetic paper in early years of paleomagnetic research history in Korea, he seems inactive nowadays. His paper, Lee *et al*. (1987), reported the magnetic direction of D/I=37°/60.9°(k=120, α_{95}=5.0°) with a pole at 60.8°N, 194.2°E (A_{95}=6.5°) for the Sindong, Hayang and Yucheon Groups in Daegu area, the direction of D/I=15.4°/57°(k=74.4, α_{95}=8.9°) and the pole at 77.9°N, 207.1°E (A_{95}=11.6°) for the Hayang Group in Andong area, and the mean direction of D/I=29.5°/57° (α_{95}=9°) with the pole 67.6°N, 205.1°E (A_{95}=5.8°) for these two areas. Based on the comparison of the results with those from NCB, SCB and Japan, it was interpreted that these units have formed a single tectonic block and maintained its position similar to that of present time since Cretaceous.

Dr. M. T. Lim at KIGAM stepped in the field of paleomagnetism recently and carried out the paleomagnetic study for the volcanic and pyroclastic rocks in the Haenam Basin (Lim *et al*., 2001). They reported that the magnetic direction of D/I=21.4°/57.1° (k=350.0, α_{95}=13.4°) and its pole at 72.5°N, 199.9°E (dp/dm=14.2°/19.5°) were similar to those for the Eurasian continent for the period of 80-90 Ma.

Paleomagnetic studies expand their horizons into the field of the environmental magnetism using the magnetic parameters, such as the natural remanent magnetization (NRM) intensity, low field magnetic susceptibility, anhysteretic remanent magnetization (ARM), saturation isothermal remanent magnetization (SIRM), ARM/SIRM, and S-ratio (-IRM_{100mT}/SIRM), which are proven to be the invaluable clues to be utilized in identifying paleosols (e.g., Kim *et al*., 2004), or in reconstructing sedimentation environments for recent sediments (Kim *et al*., 2003). Although paleomagnetic investigations for the Korean Peninsula now face some difficulties, such as complexities of geology in Korea due to variable degrees of metamorphism and consequent deformation and increasing lack of interests by a succeeding group of students, every effort to complete the APWP of Korea for the entire geologic time will be made.

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