Mesozoic Granites and Associated Mineralization in South Korea

Yong-Joo Jwa

Department of Earth and Environmental Sciences, Gyeongsang National University, Jinju 660-701, Korea; GEMOC Key Centre, Department of Earth and Planetary Sciences, Macquarie University, Sydney, NSW 2109, Australia

1. Tectonic Setting and Distribution of Mesozoic Granites

Tectonically, South Korea can be divided into four provinces based on the distribution of sedimentary basins upon Precambrian basements. The pre-Cretaceous basement comprises two Precambrian massifs, the Yeongnam Massif in the South and the Gyeonggi Massif in the north, which belong to the Sino-Korean microcontinent. They exhibit Sinian tectonic trends (SW-NE direction) and are made up of Precambrian gneiss complexes with some Proterozoic to Jurassic metasedimentary cover (Lee, 1987). The Okcheon Belt between the two massifs consists of a northeastern non- to weakly-metamorphosed Paleozoic-Mesozoic sequence which grades into the Okcheon metamorphic belt to the southwest. The Cretaceous sedimentary basins in South Korea were formed by transtension driving the movement of the sinistral strike-slip faults (Lee, 1999). The sedimentary strata, the so-called Gyeongsang Supergroup, comprises non-marine sedimentary and andesitic to rhyolitic volcaniclastic rocks. The basins overlie the pre-Cretaceous sequences with a marked unconformity. The products of Cretaceous granitic magmatism are quite evident in two large Cretaceous basins; the Gyeongsang Basin and the Yeongdong-Gwangju Basin.

Mesozoic granites of South Korea have been divided into two groups based on intrusion age: the younger granites of late Cretaceous to early Tertiary age, and the older granites of Jurassic age (Lee, 1974; Kim, 1975; Hong, 1987). This two-fold discrimination seems to be in accord with the conventional idea that the older granites are genetically associated with the Jurassic Daebo orogeny and the younger granites with the Cretaceous Bulguksa disturbance in South Korea (Lee, 1987). The Jurassic granites occur in the Gyeonggi Massif, the Yeongnam Massif, the Okcheon Belt, and the Gyeongsang Basin, whereas the Cretaceous granites occur in the Okcheon Belt and the Cretaceous Gyeongsang and Yeongdong-Gwangju basins. New radiometric ages reportedly argue that there exist some Triassic granites in the older granite group (Kim and Turek, 1996; Cheong and Chang, 1997; Cheong et al., 2002; Sagong et al., 2002). The Triassic granites have quite distinct petrologic and geochemical characteristics from the Jurassic granites, and they crop out in a restricted area of the Yeongnam Massif and the Gyeongsang Basin.

From a comprehensive study on the radiometric ages of the Mesozoic granites in South Korea, Sagong et al. (2002) argue that the crystallization ages of the granites show three episodes of Mesozoic magmatism in South Korea: Triassic (248-210 Ma), Jurassic (197-158 Ma) and late Cretaceous-early Tertiary (110-50 Ma), with a late Jurassic-early Cretaceous (~50 Ma) hiatus. They suggest that the age structure of the granites is closely related to temporal changes in relative plate motion of the oceanic Izanagi plate to the eastern Eurasian continent during the Mesozoic. The geochemical contrasts among the Mesozoic granites in South Korea possibly reflect different tectonic environments where the granites intruded (Jwa, 1994, 1998, 1999).

2. Geochemical Characteristics of Mesozoic Granites

The Precambrian cratonic crust in South Korea is divided into two massifs – the Gyeonggi Massif to the north and the Yeongnam Massif to the south. Mesozoic granites intrude both massifs, and these are mostly calc-alkaline, I-type and magnetite-series but some S-type and/or ilmenite-series granites are also present. The Jurassic granites form extensive deep-seated batholiths, the Triassic granites are deep-seated stocks, and Cretaceous granites occur as volcanic-plutonic complexes.

Inferred parental compositions of most Mesozoic granites (metaluminous to weakly peraluminous compositions and high $^{87}Sr/^{86}Sr$ initial ratios (> 0.709)) suggest that the magmas formed by melting of an evolved igneous protolith. However, the Cretaceous and Triassic granites, from the Gyeongsang Basin along the southeastern margin of South Korea, are metaluminous and have low Sr isotopic initial ratios (ca. 0.705), implying a more juvenile igneous source material. Because the exposed basement rocks are strongly peraluminous, they are not a feasible source for the metaluminous Mesozoic granites. Also, isotopic compositions of the exposed Precambrian basement rocks differ greatly from those of the Mesozoic granites. The Precambrian basement has highly evolved Nd isotopic signatures (εNd ≈ -20 to -35), and old depleted-mantle model ages (TDM > 2.0 Ga). In contrast, the Mesozoic granites, except for the granites in the Gyeongsang Basin, have less evolved εNd values (-15 to -20) and younger TDM ages (1.5 to 2.0 Ga). These data imply that the Mesozoic granites were not directly derived from the exposed Precambrian basement rocks. The narrow range of εNd values and TDM ages of the granites would indicate that the granitic magmas were produced from an isotopically homogeneous lower crust that underplated the current exposed basement during the Middle Proterozoic. Intense Middle Proterozoic orogenic events recorded in the Precambrian basement rocks may indicate the underplating of young crust at this time. On the other hand, the isotopic signatures and model ages of the granites could be due to the interaction of the granitic magmas from the juvenile sources with the highly evolved basement rocks. Slightly depleted εNd values (-5 to 4) and younger TDM ages (< 1.5 Ga) of the granites in the Gyeongsang Basin suggest Late Proterozoic addition of more juvenile crust to the continental margin. If the juvenile crust was the source of the Mesozoic granitic magmas then the isotopic data imply that these magmas interacted with the more highly evolved basement rocks.

3. Mesozoic Metallogenesis in South Korea

Metallogenic provinces in South Korea can be divided into four main provinces by means of the metallogenic epoch; Precambrian, Paleozoic, Jurassic, and Cretaceous to early Tertiary (Yun, 1982). The Mesozoic metallogenic provinces are well constrained by the distribution of the Mesozoic granites, showing SW-NE Sinian trends. Hydrothermal vein-type and skarn-type ore deposits which are closely related to the Mesozoic granites are the most important base metal-bearing resources.

W-Mo and Pb-Zn mineralization is the most common among the base metal (W-Mo-Pb-Zn-Cu-Au-Ag-Fe) deposits. Source and host rocks strongly control the metallogenesis of the ore deposits. Hydrothermal fluids from the granitic magma produced most vein-type deposits, and the Paleozoic limestone was an excellent host for the skarn-type metal deposits. The Mesozoic metallogenic provinces can be divided into several sub-provinces (metallogenic zones) according to the distribution of base metals. For example, at least five zones are identified in the Cretaceous Gyeongsang Basin; those are from SE to NW Cu zone, Fe zone, Cu-Zn-Pb zone, W-Mo zone, and Pb-Zn zone.

Certain types of mineralization are closely related to the age and mode of emplacement of the Mesozoic granites. Gold-silver mineralization would be the best example for the spatial and temporal relationship between the mineralization and the felsic magmatism in South Korea. The Au-Ag deposits can be typically divided into auriferous massive quartz veins (Jurassic type), and multistage gold-silver quartz veins (Cretaceous type). The Jurassic auriferous deposits are spatially associated with uplifted Precambrian metamorphic terranes and temporally with the Jurassic granites. On the other hand, the Cretaceous lode deposits are genetically related to the contemporaneous granites intruded in extensional environments such as the Cretaceous sedimentary basins. Choi (2002) divided the Au-Ag deposits into eight subgroups on the basis of Au fineness, associated metals, vein character and mineral assemblages, and argued that each subgroup reflects a variety of thermal episodes and ore-forming fluids from granitic magmas with contrasting age and mode of emplacement.

4. References

Cheong, C.-S. and Chang, H.-W., 1997, Sr, Nd, and Pb isotope systematics of granitic rocks in the central Ogcheon belt, Korea. Geochemical Journal, 31, 17-36.

Cheong, C.-S., Kwon, S.-T. and Sagong, H., 2002, Geochemical and Sr-Nb-Pb isotopic investigation of Triassic granitoids and basement rocks in the northern Gyeongsang Basin, Korea: Implications for the young basement in the East Asian continental margin. The Island Arc, 11, 25-44.

Choi, S.-G., 2002, The genetic implications of Mesozoic gold-silver mineralization, South Korea. In Mesozoic sedimentation, igneous activity and mineralization in South Korea (Jin, M.-S. et al., eds.). The 1st and 2nd Symposium on the Geology of Korea. Special Publication No. 1. Korea Institute of Geoscience and Mineral Resources, 216-226.

Hong, Y.K., 1987, Geochemical characteristics of Precambrian, Jurassic and Cretaceous granites in Korea. Journal of Korean Institute of Mining Geology, 20, 35-50.

Jwa, Y.-J., 1998, Temporal, spatial and geochemical discriminations of granitoids in South Korea. Resource Geology, 48, 273-284.

Jwa, Y.-J., 1999, Cretaceous granitic magmatism in South Korea and its implication to the Mesozoic tectonic evolution of the eastern Eurasian continental margin. Proceedings of the 4th Hutton Symposium on the Origin of Granites and Related Rocks. Clermont-Ferrand, France. p. 153.

Jwa, Y.-J., Moutte, J., Cho, W.-S. and Choi, W.-H., 1994, Petrochemistry of Mesozoic granites in the central Ogcheon belt and its tectonic implication. Proceedings of the 4th International Symposium, IGCP 321, 48-49.

Kim, C.-B. and Turek, A., 1996, Advances in U-Pb zircon geochronology of Mesozoic plutonism in the southwestern part of Ryeongnam massif, Korea. Geochemical Journal, 30, 323-338.

Kim, O.J., 1975, Study on the intrusion epochs of younger granites and their bearing to orogenesis in South Korea. Journal of Korean Institute of Mining Geology, 8, 223-230.

Lee, D.S., 1987, Geology of Korea, Kyohak-sa, Seoul, 514p.

Lee, D.W., 1999, Striki-slip fault tectonics and basin formation during the Cretaceous in the Korean Peninsula, The Island Arc, 8, 218-231.

Lee, S.M., 1974, The tectonic setting of Korea, with relation to plate tectonics. Journal of Geological Society of Korea, 10, 25-36.

Sagong, H., Kwon, S.-T. and Ree, J.-H., 2002, Age structure of the Mesozoic granitoids in South Korea: Plate tectonic connection to episodic magmatism with ca. 50 Ma hiatus. Proceedings of the 57th Annual Meeting of the Geological Society of Korea, p. 13.

Yun, S.K., 1982, Introduction. In Geology and mineral Resources of Korea. Yonsei University, Alumni Association, p. 9.