K130-012 **Room: 101A** **Time: May 26 12:00-12:15**

Origin of zonal distribution of the Early Cretaceous adakitic to non-adakitic rocks in the Kitakami Mountains, Japan

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Early Cretaceous igneous rocks in northeast Japan, defined as the region northeast of the Tanakura fault, are mainly distributed in the Kitakami and Abukuma belts, and southwest Hokkaido. These igneous rocks are geologically divided into two stages; plutonic and volcanic rocks in later stage (120-108 Ma) and dike rocks in earlier stage (130-116 Ma). Dike rocks preceding the Early Cretaceous plutonic activity distributed in southern part of the north Kitakami belt and in the south Kitakami belt, northeast Japan. These dike rocks are mainly classified into high-Ti andesite, high-Sr andesite, high-Mg andesite, and shoshonite (Tsuchiya et al., 2005). Among these rocks, high-Ti andesite is distributed in northeastern part, and shoshonite is distributed in southwestern part. The high-Sr andesites and high-Mg andesites show similar petrochemical characteristics to those of adakite except higher Cr, Ni, and Mg contents. Petrochemical investigation indicates that the high-Sr andesite and high-Mg andesite magma can be resulted from interaction of slab derived adakitic melt with overlying wedge mantle (Tsuchiya et al., 2005). The shoshonites are characterized by the similar petrochemical characteristics to those of adakite except higher K and Rb contents. The chemical characteristics of shoshonites can be explained by partial melting of mantle peridotite assimilated by adakitic slab melt. On the other hand, high-Ti andesite show no genetical relationships to slab melt.

Plutonic to volcanic rocks are dominated by adakitic plutons associated with northeastern part of Sr-poor plutonic and volcanic rocks (Harachiyama Formation), and western part of shoshonitic rocks. Adakitic plutons, which show remarkable petrochemical variation, occupies the largest area of the Early Cretaceous igneous rocks in the Kitakami Mountains. The adakitic pluton consists of the adakitic granites in central part of zoned plutonic bodies (central facies) surrounding by adakitic to non-adakitic granites in marginal part (marginal facies). The central facies granites are characterized by low Y and high Sr concentrations and fractionated LREE/HREE patterns, characteristics common to Archean TTG and modern adakite. Chemical compositions of the central facies granites can be explained by the “slab melting” model. On the other hand, the marginal facies granites are characterized by slightly lower Sr/Y ratios, less fractionated REE patterns, and weak negative Eu anomalies. The marginal facies magma is considered to be derived from the reaction of slab melts with mantle peridotite and lower crustal amphibolite (Tsuchiya et al., 2007).

On the basis of the petrochemistry of the Early Cretaceous dike rocks, ridge subduction and subsequent subduction of young lithosphere may have caused various petrochemical features of these rocks (Tsuchiya et al., 2005). According to Thorkelson and Breitsprecher (2005), adakitic magma is generated where garnet is stable as a restite phase at some distance away from the slab edge, while non-adakitic magma forms along the feather edge at pressures below that of garnet stability. Namely, adakitic magmas in Kitakami may be produced by slab melting under the eclogitic condition, on the other hand, partial melting of subducted slab may occur at a shallower depth stabilizing plagioclase and produce Sr-poor melt such as high-Ti andesite. The model of Thorkelson and Breitsprecher (2005) can explain the zonal distribution of non-adakitic and adakitic rocks, approximately trench-parallel distribution at distances from the slab window. The boundary between adakitic and non-adakitic rocks, however, has migrated progressively farther southwestwards from earlier to later stages, some tectonic events such as migration of slab window may have occurred.