Magma Mixing and Tectonic Implications of Hailin Pluton at The Southeastern Margin of Songnen–Zhangguangcai Range Massif, Northeast China

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Abstract: We report zircon U-Pb geochronology, whole-rock geochemistry, mineral chemistry and zircon Hf isotopic compositions analytical research of the Hailin pluton from the Mudanjiang region in the southeastern Songnen-Zhangguangcai Range Massif, which to confirm the formation ages, petrogenesis and related geodynamic mechanisms of the Hailin pluton, further to provide important constraint for the tectonic evolution of the Mudanjiang Ocean between the Songnen-Zhangguangcai Range and the Jiamusi massifs. Through the geological survey and petrographic study, we find that the Hailin pluton is composed of the host granitoids (monzogranites and granodiorites) and the mafic microgranular enclaves (MMEs; diorites). The MMEs are common in the host granitoids and are characterized by irregular spheroidal shapes, with sharp, rounded, or irregular transitional contacts, chilled margins, acicular apatites. It can preliminarily determine that the Hailin pluton was the product of the magma mixing. Then mineral chemistry, whole-rock geochemistry and zircon U-Pb dating are conducted to further support the role of magma mixing in the petrogenesis of the Hailin pluton. The evidence is as follows: (1) the mineral compositions of plagioclase and amphibole in MMEs are in disequilibrium. And the plagioclase is composed of oligoclase-andesine, suggesting plagioclase and amphibole in MMEs are in disequilibrium. And evidence is as follows: (1) the mineral compositions of typical reverse zoning characteristic. The amphibole can be classified as magnesiohornblende and tschermakite and belongs to crust-mantle amphibole; (2) the geochemical characteristics of the Hailin pluton show that the MMEs and the host granitoids plot along the trend of mixing line between mantle and crustal magmas in the Fe2O3−MgO diagram. The MMEs and the host granitoids show a linear relationship in the Harker diagrams and a hyperbolic relationship in the noncommon denominator ratio diagrams. The characteristics of trace elements are similar but the ratios are different, which reflects that the MMEs and their host granitoids were from different magma sources and underwent a magma mixing process; (3) Zircon U-Pb ages data show that the diagenetic ages of the host granitoids in Hailin pluton were 215~219 Ma, and those of the MMEs were 221 Ma, suggesting they were both formed during the Late Triassic. All the above evidence shows that the Hailin pluton has petrogenesis of magma mixing, and the MMEs were formed by the mixing of felsic magma and mafic magma. As for the origin of felsic magma and mafic magma which formed the Hailin pluton, here we take the host granitoids as the felsic end-member rocks. The host granitoids are characterized by high silica content (SiO2 = 63.18~70.44 wt.%), high alkali content (Na2O+K2O=6.59~7.95 wt.%), low MgO (0.69~1.94 wt.%) and low Fe2O3 (2.39~4.68 wt.%). They are enriched in light rare earth elements (LREEs) and depleted in heavy rare earth elements (HREEs), with total rare earth elements of 88.55~116.29ppm, LREE/HREE ratios of 7.47~13.43 and (La/Yb)N values of 5.80~18.62. They are also enriched in large ion lithophile elements (LILs; e.g., Rb, Sr, and Ba) and depleted in high field strength elements (HFSEs; e.g., Nb, Ta, and Ti). Zircons from the host granitoids yield εHf(t) values of +6.6 to +3.0, and two-stage Hf model ages (TDM2) of 1060~1669Ma. Taken together the above geochemical and zircon Hf isotope characteristics, it is shown that the host granitoids belong to I-type granitoids and they were derived from the partial melting of Mesoproterozoic lower crust. In addition, we take the coeval mafic rocks (209~228Ma) with similar geochemical characteristics in the study area reported by Wang et al. (2015) as the mafic end-member rocks. These mafic rocks have SiO2 concentrations of 49.1~51.9 wt.% and high Mg# values of 58~69, with enrichments in LREEs and depletions in HREEs, Nb, Ta, Zr, Hf and Ti. Zircons of the mafic rocks yield εHf(t) values of +2.5 to +9.8, and single-stage Hf model ages (TDM1) of 477~801Ma, suggesting that the mafic magma of the Hailin pluton were derived from partial melting of mantle wedge that had been metasomatized by slab-derived fluids. Combined with related study of the spatial variation characteristics of contemporary igneous assemblages and the history of regional tectonic evolution in the study area, we suggest that the Late Triassic Hailin pluton from the Mudanjiang region in the southeastern Songnen-Zhangguangcai Range Massif was formed by the mixing of felsic and mafic magmas in an active continental margin setting, closely related to the westward subduction of the Mudanjiang oceanic plate beneath the Songnen-Zhangguangcai Range Massif. It is because the subduction that the mafic magma was derived from partial melting of the mantle wedge which had been metasomatized by slab-derived fluids. And the felsic magma generated from partial melting of the lower crust which triggered by the resulting thermal pulse. Then the mafic magma mixed with the felsic magma. The hybrid magmas underwent upward emplacement and ultimately crystallized to form the Hailin pluton.

Key words: Songnen-Zhangguangcai Range Massif, magma
mixing, zircon U-Pb geochronology, geochemistry, Hf isotope

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Reference

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