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Multisourced fluids-controlled beryllium mineralization in a magmatic-hydrothermal system: evidence from the Early Cretaceous Nasigatu beryllium deposit in the southern Great Xing'an Range, NE China

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Beryllium (Be) deposits are associated with highly evolved granites that record long and complex magmatic-hydrothermal evolution processes. However, there is lack of understanding of the genetic link between Be mineralization and magmatic-hydrothermal processes. Particularly, the origin of the fluids and their role in transporting and enriching Be is unclear. This paper presents zircon U-Pb ages and O-Hf isotope compositions, cassiterite U-Pb ages, whole-rock, and muscovite elemental compositions of the newly discovered Nasigatu greisen-type Be deposit in the southern Great Xing'an Range, NE China, to clarify the relationship between Be mineralization and magmatic-hydrothermal processes, understand the fluid activities, and elucidate the ore-forming mechanism. Zircon and cassiterite U-Pb dating results reveal that Be mineralization occurred during the Early Cretaceous, i.e., ca. 139~144 Ma, consistent with the ages of the ore-related granites. Zircon O-Hf isotope and whole-rock elemental compositions suggest that Nasigatu granites are A2-type granites with a complex source region, involving juvenile lower crusts with ancient continental and altered oceanic crusts. However, partial melting of these sources with low Be content can produce magma with low Be content. Specific muscovite elemental compositions indicate that the fluid system in Nasigatu region is complex. Silicon, Cl, Ca, Mn, K, and Al contents in muscovites are consistent with the evolution trend of A-type granites, indicating the involvement of magmatic fluids derived from highly differentiated shallow granitic melts. These magmatic fluids react with Nasigatu granites and extract Be into fluids due to the low $D_{mineral/fluid}$ values for Be of feldspar and biotite. Iron, Mg, Na, Ti, and F contents and crystallization temperatures in muscovites are in contrast to the routine, indicating coexistence of deep magmatic fluids with lower evolution degree exsoluted from a large deep magma reservoir and meteoric water transported from a penetrating fracture system. Such deep magmatic fluids not only provide heat and promote water-rock reactions, but also possibly transport Be from deep magma reservoirs. While good linear relationships between Be and F in muscovites suggest that Be-F complexes is the most important migration model in fluids, the addition of meteoric water promotes the destruction of complexes, leading to precipitation of fluorite and beryl.