Concentration of REE-Nb-Zr-Be in the Baerzhe Deposit, NE China: Insights from Textural and Chemical Features of Amphibole and Rare Metal Minerals

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The early-Cretaceous Baerzhe deposit in Inner Mongolia, NE China hosts a world-class resource of rare-earth elements (REE), Nb, Zr, and Be. The host igneous phases evolved from a hypersolvus porphyritic granite through a variably altered transsolvus granite, both of which are miaskites, to a strongly-altered, transsolvus, granitic or syenitic agpaite. Amphibole chemistry shows that all these phases share a common igneous lineage. The occurrence of most Zr as zircon-quartz pseudomorphs suggests that Zr mineralization resulted mainly from the reconstitution of primary zirconosilicates (e.g., elpidite, vlasovite) and thus an agpaitic mineralogy that was not previously recognized. Stage I comprises Na metasomatism, secondary snowball quartz, and zircon formation. Na measomatism is represented by albite and aegirine that replaced magmatic alkali-feldspar and amphibole, respectively. Na metasomatism and snowball quartz are constrained to the agpaite, which is the only phase that contains Zr mineralization. REE, Nb, and Be mineralization postdates Stage I and occurs in both the agpaite and the transsolvus miaskite. Stage II comprises hingganite, aeschynite-(Y), columbite-(Fe), hematite, and ilmenite that commonly occur in pseudomorphs in secondary quartz. Stage III-A consists of euxenite-(Y) – polycrase-(Y) and monazite-(Ce). Stage III-B, which is unconstrained in timing relative to Stage III-A, but clearly postdated Stage II, is represented by bastnäsite-(Ce). Fluocerite-(Ce) and synchysite-(Ce) replaced bastnäsite-(Ce) during Stage-IV. The low REE, Nb, and Be concentrations in amphibole and the temporal and spatial separation of REE-Nb-Be from Zr mineralization, preclude amphibole or zirconosilicates as significant sources of REE, Nb, or Be. Possible sources for these elements are immiscible fluoride melts and/or late-stage magmatic fluids. Although Baerzhe and analogous deposits, such as Strange Lake, are hosted by agpaites and underwent multiple stages of redistribution and concentration of rare elements, our studies indicate that such systems may evolve from miaskites to agpaites, and that Ca metasomatism may not accompany hydrothermal redistribution.