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Assessing the REE resource potential of the Rattlesnake Hills Alkaline Complex, Wyoming, USA: Petrogenetic considerations

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Alkaline magmatism in post-collisional settings may be enriched in REEs. However, many variables control the abundances of REEs in alkaline silicate-carbonatite complexes, including the composition of the parental magmas, the crystallizing assemblages during the differentiation of alkaline magmatic systems, the timing of separation of carbonate melts from silicate magmas, the nature of the fluids involved, and the effects of late-stage alteration. Here we describe the Paleogene post-collisional Rattlesnake Hills alkaline magmatic complex (RHAC), which was emplaced as a set of 46 small plugs, domes, diatremes, and volcanic rocks within the central part of the Archean Wyoming craton. It is composed of two magma series: a Central Alkalic Group of nepheline-normative alkaline rocks and sparse carbonatite dikes, and Eastern and Western Felsic Groups of quartz-normative subalkaline rocks. Nd and Sr isotopic data suggest that the parental magmas originated in the enriched aesthenospheric mantle with minor amounts of partial melt from the Archean subcratonic lithospheric mantle. Only the least-differentiated magmas and clinopyroxene-rich cognate inclusions contain calcite phenocrysts, suggesting that extraction of carbonatite melt from silicate magma may have occurred early in differentiation. Complex zoning in clinopyroxene and amphibole suggests magma recharge during differentiation. Sodalite group phenocrysts are present only in phonolite, relatively late in magmatic differentiation. Petrographic, textural, geochemical and isotopic evidence suggests that the Eastern and Western Felsic Group rocks formed by assimilation of Archean granitic gneiss into nepheline-normative alkaline magmas. The RHAC shares many petrographic, geochemical, and isotopic characteristics with the Black Hills alkaline complex (BHAC) on the northeastern edge of the Archean Wyoming craton, which is under development for REE mining. However, crystallization of clinopyroxene, titanite, and apatite phenocrysts may have more effectively sequestered LREE in the RHAC compared to the BHAC. The RHAC carbonatites identified to date are less enriched in REE than those in the BHAC, and it is possible that carbonate immiscibility occurred earlier in the RHAC than in the BHAC. Further exploration for additional carbonatite localities and evaluation of the effects of alteration on REE contents of carbonatite are important in assessing this resource in the RHAC.