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Magmatic and hydrothermal controls on diverse Nb mineralization associated with carbonatite-alkaline complexes in the southern Qinling orogenic belt, Central China

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Abstract

Although carbonatite-alkaline complexes are the primary source of the world's niobium (Nb) supply, the mineralization style is largely variable in these complexes and the processes behind their formation are still poorly understood. Exemplifying with our new observations on the ~430 Ma Miaoya and Shaxiongdong carbonatite-syenite complexes in the southern Qinling orogenic belt, central China, show that disseminated Nb mineralization in these two deposits is pervasive throughout the entire complexes in both syenite and carbonatite. Both magmatic and hydrothermal processes have contributed to Nb mineralization in both deposits, despite differences in the mineralization style. The Nb-bearing minerals in the mineralized Miaoya syenites include magmatic U-poor pyrochlore, rutile, and ilmenite with minor amounts of columbite, and hydrothermal columbite and rutile, whereas those in the mineralized carbonatites are mainly magmatic U-poor pyrochlore, uranpyrochlore, U-rich betafite, and rutile with minor amounts of columbite, and hydrothermal columbite and rutile. On the other hand, the Nb-bearing minerals in the mineralized Shaxiongdong syenites include magmatic U-poor pyrochlore, titanite, rutile, and ilmenite, and hydrothermal fersmite, rutile, and ilmenite, whereas those in the mineralized carbonatites are mainly magmatic U-poor pyrochlore without any hydrothermal Nb-bearing minerals. Field observations, whole-rock chemical and Sr-Nd isotopic compositions strongly constrained that assimilation of U-rich rocks (e.g., the hosting Yaolinghe and Meiziya Groups) and magma differentiation are responsible for diverse magmatic Nb mineralization in the two deposits. On the other hand, the diverse assemblages of hydrothermal Nb minerals in Miaoya and Shaxiongdong are mainly controlled by variations in the nature of the fluids, which is constrained to be genetically related to ~220 and ~420 Ma hydrothermal events, respectively. In summary, both magma evolution (e.g., differentiation, assimilation) and late hydrothermal overprinting are responsible for the diverse Nb mineralogy in carbonatite-alkaline complexes, a situation that is commonly observed worldwide.

Keywords: Pyrochlore group minerals, columbite, diverse Nb mineralization, Miaoya, Shaxiongdong, carbonatite-syenite complexes