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The role of auto-contamination in Nb mineralization: insights from the Saint-Honoré Alkaline Complex and the Shipshaw dyke swarm

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Worldwide Nb production comes from deposits which are almost exclusively hosted in carbonatites. The Nb-rich zones are commonly located close to contacts between carbonatite and syenite within these alkaline complexes. However, only a few of these carbonatite-syenite contacts are mineralized in Nb, while others remain barren. This raises the question: which specific conditions are required for Nb mineralization to develop at such contacts? This study aims to characterize carbonatite and syenite from both Nb-mineralized and non-mineralized zones to evaluate the role of auto-contamination as a driver of Nb enrichment. The Saint-Honoré Alkaline Complex and the Shipshaw dyke swarm, located in the Saguenay graben (Quebec, Canada), were selected as case studies because they are undeformed and unmetamorphosed carbonatites that exhibit a wide range of carbonatite-silicate rock interactions and Nb concentrations. The study integrates whole-rock geochemistry, in situ trace-element analyses of carbonates, apatite, phlogopite, magnetite, and feldspars, as well as C and O stable isotope compositions of carbonates. At Saint-Honoré, geochemical results show that only the intermediate to evolved carbonatites host Nb mineralization, whereas the most primitive carbonatites are barren. The whole-rock geochemistry data from this study, combined with previous radiometric U–Pb and Ar–Ar dating and Rb-Sr and Sm-Nd isotope results [1], enable discrimination between syenites genetically related to the carbonatites and fenites previously misidentified as syenite due to alteration. Nb mineralization is observed only at the contact between intermediate to evolved carbonatites and nepheline syenite belonging to the same alkaline complex. The presence of ductile deformation textures and localized hydrofracturing within syenite enclaves at Saint-Honoré supports an auto-contamination model in which carbonatitic and syenitic magmas were emplaced contemporaneously. This co-emplacement promoted extensive reaction zones leading to Nb mineralization. These results provide new constraints on the processes controlling Nb mineralization in alkaline complexes and offer insights that may guide future exploration strategies for Nb mineralization.

[1] Van Weelderen et al., accepted. The origin of carbonatites and its implication for Nb mineralization; new U-Pb and Ar-Ar ages with isotopic Sr-Nd source comparison of the alkaline complexes in the Saguenay graben (Quebec, Canada). Geological Society Special Publications