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Is the kaolinization process the key to explaining the enrichment of critical metals in the apical zones of rare-metal granites?

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At the top of rare-metal granites, kaolinitic alteration is often associated with high grades of rare metals (e.g. Ta, Nb, Sn), which could suggest a link between the alteration process and metal enrichment. However, textural and petrogenetic constraints indicate that this apical mineralization is not genetically related to the kaolinization process. These facts suggest that the enrichment could be primary, or that the alteration itself could have caused an increase in the concentration of the ore through a process of mass loss. The latter increases the concentration of elements contained in alteration-resistant minerals (e.g. Nb and Ta of the columbite group minerals) and decreases the concentration of elements contained in altered minerals. It is generally accepted that the increase in rare metal concentrations due to mass loss can be quantified by mass balance modeling, in which the concentrations of the original granite are compared with those of the altered granite, considering a frame of reference such as the immobility of certain elements. The rare metal granite of Golpejas (Spain) was chosen as a case study. The combination of clusters of slopes and component ratios confirmed that Al_2O_3, Nb, Ta, Zr and Hf behave mostly as immobile elements. Mass transfer modeling confirms that the more kaolinized the sample, the greater the mass loss. In all cases, the higher Nb and Ta concentrations of kaolinized samples compared to fresh granites can be explained by the mass loss associated with the alteration. This work shows that the kaolinization process in the Golpejas granite can increase the concentration of Nb and Ta in altered samples up to 100 ppm compared to unaltered samples, which is not negligible in low-grade, high-tonnage granites. The model also shows the possibility that the high Ta-Nb contents of kaolinized samples from the Golpejas granite are mainly due to alteration, while hydrothermal processes mobilizing the ore or a previous differentiation process played a limited role in the enrichment.

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