Calculation of changes in the Ta/Nb ratio in differentiates of granite melt based on experimental data

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A change in the Ta/Nb ratio in acid igneous rocks is related to crystallization differentiation processes. The genesis of rock-forming and accessory minerals, the formation of an aqueous fluid at the magmatic stage, or the separation of another liquid phase from a silicate melt through liquation can lead to a change in the Ta/Nb ratio and an increase in the contents of Ta and Nb in the residual melt. A calculation of the possible change in the Ta/Nb indicator ratio in the residual deeply differentiated granite melt is performed.

We used experimental data from various literature sources (T = 650–800 °C, P = 1–2 kbar) on the solubility of columbite and tantalite in a silicate melt and on the distribution of Ta and Nb among a coexisting silicate melt, aqueous liquid, and aluminum fluoride melt. The Clarke values of these metals in acid rocks of the Earth's crust were taken as the initial contents of Ta and Nb in the melt. The calculations were made using the mass balance method. It is shown that the separation of fluid in a closed magmatic system rock-forming minerals–silicate melt–water can lead to an approximately twice increase in Ta/Nb in the residual melt as compared to the initial Clarke value. In the system rock-forming minerals–silicate melt–alumino fluoride melt with the initial content of fluorine close to that in biotite granites, the Ta/Nb ratio in the residual melt can increase to ~1. Successive crystallization of minerals of the isomorphic columbite–tantalite series can lead to Ta/Nb > 2 in the residual melt. Crystallization of biotite causes a significant increase in Ta/Nb but significantly prevents the accumulation of these metals in the residual silicate melt.