Nb-Ta fractionation in rutile from eclogites

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The formation of the continental crust is an important topic in Earth sciences. Many geologists believe that the continental crust started mainly from the melting of subducted slabs in the early history of the Earth, which then experimenced complicated modifications, e.g., melting at the bottom of thickened oceanic crust, arc accretion and delamination of thickened lower crust, etc. Others believe that melting at the bottom of the thickened oceanic crust may have contributed more to the formation of the early continental crust and thus shaped its chemical features. Currently, the debate on the formation of the continental crust is mainly focused on the unique subchondritic Nb/Ta values of the continental crust, because Nb and Ta are “geochemical identical twins,” which usually do not fractionate from each other. As a result, the Nb/Ta has long been regarded as constant and chondritic in major silicate reservoirs of the Earth. By contrast, the Nb/Ta of the CC is 12-13, considerably lower than the chondritic value. Given rutile is the dominant carrier of Nb and Ta and a common minor phase in high-grade metamorphic rocks, the subchondritic Nb/Ta of the CC has been attributed to the melting of subducted slabs in the presence of rutile. Experiments however, show that rutile favors Ta over Nb, such that partial melting of rutile-bearing eclogites with chondritic Nb/Ta results in suprachondritic Nb/Ta in the melts. We find rutile grains from different depths of the slab have different Nb/Ta, indicating major fractionation of Nb and Ta that probably occurred during blueschist to amphibole-eclogite transformation before rutile appeared. Given Ta is more mobile durring dehydration, the fluids have subchondritic Nb/Ta, which then forms hydrous rutile-bearing eclogite with low Nb/Ta, leaving suprachondritic Nb/Ta in dehydrated eclogite. Dehydration-melting of such eclogite results in building blocks of the continental crust (e.g., TTG) with subchondritic Nb/Ta, and variable but overall suprachondritic Nb/Ta in residual eclogites. Dehydration of hydrous rutile-bearing eclogites cannot transfer the fractionated Nb/Ta features to the mantle wedge due to their low solubilities in fluids, which explains the Nb/Ta characteristics of modern arc magmas.