Different mobility of Nb and Ta along a thermal gradient

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Niobium and Ta have long been regarded as "identical twins" because of similar geochemical behaviors during processes linked to the evolution of the Earth's mantle. A recent study indicates major Nb/Ta fractionation in subducted slab setting, which was used to interprete the systematically lower Nb/Ta in the continental crust compared to the mantle (Xiao *et al*., 2006). Here we report an experiment which shows that Ta and Nb are mobile and can fractionate from each other during migration in a temperature gradient.

A homogeneous andesitic powder (AGV-1) along with 4 wt% H_2O was sealed in a 20 mm long double capsule, compressed to 0.5 GPa and run in a temperature gradient ranging from 950-350 ºC for 66 days. The run product was analyzed using JEOL 8100 eletron microprobe and laser-ablation inductively-coupled-plasma mass spectrometry for major and trace elements, respectively.

The results show large variations in Nb and Ta concentrations as well as Nb/Ta along the temperature gradient. In the matrix of the low-temperature section that contains no melt, the Nb/Ta ranges between 7.5 and 24.8, with supra-chondritic value near the low temperature end and sub-chondritic value at adjacent higher temperature region. More specifically, the highest Ta concentration is observed close to the section where amphibole is present. As the temperature decreases further, the Ta concentration drops quickly to considerably lower than that of the starting material, indicating net transportation of Ta from both low and high temperature ends towards the intermediate temperature region. By contrast, the highest Nb concentration is observed in the lower temperature end, ~3 mm away from the Ta peak. The different migration patterns of Nb and Ta result in the large fractionation of Nb/Ta in the amphibole absent section.

We interpret that variations in Nb and Ta concentration and Nb/Ta to reflect a thermal migration process during which Nb and Ta partition between supercritical fluid and different minerals, likely driven by chemical mobility difference between Nb and Ta. Different thermal migration provides a feasible mechanism to produce lower Nb/Ta in the lower continental crust compared to the upper continental crust.

References

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Formation history of Archaean TTG gneisses in the Taihua complex, Lushan area, central China: in situ U-Pb age and Hf-isotope analysis of zircons

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The Taihua complex is discontinuously exposed along the southwest margin of the North China Carton (NCC). It can be divided into two main rock units, nameing quartzofeldspathic gneisses and supracrustal rocks. Among these rock unites, tonalite–trondhjemite–granodiorite (TTG) gneiss is the dominant rock type, making up 80% of the total exposure of the Late Archaean basement (Zhang *et al*.,1985). Zircon grains of TTG gneiss are euhedral, and have oscillatory zones with the high Th/U ratios(0.20-1.49), indicating their igneous origination. The LA-ICP-MS zircon U-Pb dating yields age population at 2.8 Ga, representing the TTG magma emplaced at 2.8Ga. Zircons from gneiss have variable Hf isotopic compositions with $^{176}Hf/^{177}Hf$ ratios from 0.281021 to 0.281189 and $\varepsilon_{Hf}(t)$ values from +0.68 to +7.09, with a weighted mean of 2.2±0.8, It is suggests that the protoliths of the gneisses were mainly derived from depleted mantle, Correspondingly, their Hf model ages are 2924–3059 Ma (T_{DM1}), with a weighted mean of 2966 Ma. T_{DM1} model ages, which are calculated using the measured $^{176}Hf/^{177}Hf$ of the zircon, can only give a minimum age for the source material of the magma from which the zircon crystallized, Therefore zircon Hf isotopic data reveal that crustal component older than 3.0Ga may exist in Lushan area, and zircon debris of this age have been found.

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