Trace element mobility at mineral scale: evidence from titanite U-Pb dating and trace element analysis for UHP gneisses from the Sulu orogen

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Titanite is a common accessory mineral in subduction-zone HP to UHP metabasite and metagranite. Because it is sensitive in metamorphic reactions, feasible to date by the U-Pb method, and its high contents of REE and HFSE, titanite has received much attention in the study of element mobility in response to P-T change and fluid action during subduction-zone metamorphism. We present a combined U-Pb dating and trace element analysis for titanites in UHP metamorphic gneisses from the Sulu orogen, China.

LA-ICPMS titanite U-Pb dating yields Triassic ages for low common Pb domains, generally in agreement with the U-Pb ages of metamorphic zircon from the same sample. However, there are significant differences in trace element composition between different titanite domains. Based on REE distribution patterns and trace element compositions, three types of titanite domains are distinguished. The relict domains of magmatic origin (Ttn-I) exhibit high common Pb contents, high Th and REE contents and high Th/U ratios, but low Nb contents and Nb/Ta ratios. The newly grown domains of metamorphic origin (Ttn-III) show significantly declined Th and REE contents and low Th/U ratios, but elevated Nb contents and Nb/Ta ratios (up to 239). Metamorphosed titanite domains (Ttn-II) exhibit similar REE patterns, Th/U or Nb/Ta ratios to the relict protolith domains. The Ttn-I domains show similar U-Pb ages to the other domains, indicate reworking of the U-Pb radiometric system during the Triassic metamorphism.

The different titanite domains exhibit large and systematic variations in trace element contents, indicating significant mobility of these elements at mineral scale. Especially, the variably elevated Nb contents and Nb/Ta ratios for the Ttn-II and Ttn-III domains suggest large Nb/Ta fractionation during the metamorphism. This is probably caused by differential release of Nb and Ta from breakdown of amphibole and biotite to metamorphic fluid. A model was proposed to interpret the different element responses during the interaction between metamorphic fluid and the protolith titanite to form the Ttn-II and Ttn-III domains.