

Can rutile thermometry link to rutile U-Pb age?

ZHENYU CHEN¹ AND QIULI LI²

¹Institute of Mineral Resources, Chinese Academy of Geological Science (czy7803@126.com)

²Institute of Geology and Geophysics, Chinese Academy of Geological Science (qiuli8@263.net)

T-t information of metamorphic rocks are basic and critical content in petrogenesis study. Rutile U-Pb dating are often used to constrain cooling age of metamorphism. Zr-in-rutile thermometry is a newly developed single mineral thermometry. According to the experimental data, diffusion parameter of Pb and Zr are similar in rutile. So can we link rutile thermometer to its' U-Pb age?

Jinheqiao 99JHQ-1 eclogite is the only one which has got precise rutile U-Pb age in China up to now^[1]. It is tectonically located in the South Dabie UHPM zone. Peak conditions estimated in Jinheqiao area were 680~940°C and 3.2~4.3Gpa. Here we present Zr content of rutiles analyzed by electron probe in 99JHQ-1 eclogite and discuss the link between rutile temperature and its' U-Pb dating.

Fourty-two rutiles were analyzed and gave Zr content between 37~118ppm, average in 67ppm. Rutiles as garnet inclusion have a little higher Zr (75ppm) than rutiles in matrix (64ppm), but they share the similar variation range. Temperatures calculated by Watson^[2] and Zack^[3] were 519~563°C and 507~600°C respectively. Zr-in-rutile thermometry are often used to calculate peak temperature of high grade metamorphic rocks. However, rutile Zr temperature in 99JHQ-1 eclogite is obviously lower than the peak temperature calculated by garnet-quartz O isotope thermometry of 695°C, but is significantly higher than T_c of about 460°C for U-Pb system in rutile and rutile-quartz O isotope thermometry of 460±15°C estimated in this eclogite.

Petrographical observation show that 99JHQ-1 eclogite had experienced strong retrograde metamorphism. Omphacite were almost transformed into simplectite, garnets were always surrounded by a wide rim of hornblende, and many rutiles were partly transformed into ilmenite or titanite. These phenomena show that the retrograde fluid were intensive during the exhumation of this eclogite. Rutiles were recrystallized or retrogress to various extent. Large variation of Zr content in rutile indicate that Zr in rutile had also been reset to various extent, i.e. Zr in rutile were not equilibrate with retrograde zircon and quartz.

In summary, Zr-in-rutile thermometry may bear any geologic meaning in highly retrograde eclogite. Despite the experimentally similar diffusion parameter of Zr and Pb, O in rutile, T_c of Zr may be higher than those of Pb and O in actual geological condition, and one should be careful in linking the rutile thermometry to its' U-Pb dating.

Reference

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Rates of eclogitic metamorphism of subducted continental slab

H. CHENG¹, R.L. KING², E. NAKAMURA³ AND J.D. VERVOORT²

¹State Key Laboratory of Marine Geology, Tongji University, 200092, Shanghai, P.R.China (chenghao@mail.tongji.edu.cn)

²School of Earth & Environmental Sciences, Washington State University, Pullman, Washington 99164, USA (rlking@wsu.edu, vervoort@wsu.edu)

³The Pheasant Memorial Laboratory for Geochemistry and Cosmochemistry, Institute for Study of the Earth's Interior, Okayama University, 682-0193, Misasa, Japan (eizonak@misasa.okayama-u.ac.jp)

Knowledge of the duration of concurrent processes affecting the rocks such as heating, recrystallization and deformation is fundamental to an understanding of metamorphism. Various approaches such as thermal modeling, radioisotopic dating, chemical and textural analysis can be utilized to envisage these durations. Combined textural analysis (CSDs), chemical analysis with Lu-Hf and Sm-Nd geochronology study on the Dabie HP/UHP eclogites can thus provide a comprehensive understanding regarding garnet growth histories so as to the subduction and exhumation processes of its host rocks. Garnet compositional profiles show well-preserved growth zoning with a decrease in Mn, Ca and heavy rare earth elements (HREEs) and an increase in Mg towards rims. Textural quantification analysis for the garnets reveal apparent pseudo-lognormal CSDs, which alone can be interpreted by several plausible nucleation growth mechanisms; however, the mineralogy of inclusions in garnets and the compositional zoning patterns reveal a three-episodic nucleation and growth process. The Rayleigh-type HREE zoning and near-constant MREE zoning in the garnets indicate that the obtained ~5 Ma time span, defined by the decoupling between 224.2±1.9 Ma Lu-Hf and 217.8±4.2 Ma Sm-Nd ages, represents timing of the last garnet growth episode deviating from the nucleation process. Based on the absence of significant diffusional reequilibration as indicated by the compositional zoning, the textural analysis and the mineralogy of inclusions in garnets, we interpret the initiation of garnet growth during prograde metamorphism must have predated the 224.2±1.9 Ma Lu-Hf age and the 217.8±4.2 Ma Sm-Nd age is an estimation for the closure of garnet growth corresponding to the amphibol-facies overprint along exhumation path; therefore, the time elapsed at eclogitic condition should be extremely short.