Zonation and multiphase growth of garnet in UHP metamorphic rocks of continental subduction zone

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We prersent a combined study of mineral inclusions and in-situ major-trace elements in garnets with U-Pb dating of inclusion zircons from different occurrences of ultrahigh-pressure (UHP) metamorphic gneisses and eclogites in the Dabie-Hong'an orogens. The results indicate multiphase growth of the garnets during continental subduction-zone metamorphism, including prograde growth during subduction and retrograde growth during exhumation in addition to preservation of residual garnet of magmatic protolith.

The magmatic garnet residue in the UHP gneisses display high spessartine components, extremely high trace element abundances, remarkably negative Eu anomaly, and steep LREE to HREE patterns. Metamorphic garnets from UHP eclogites preserve prograde and retrograde growth zonings in trace elements despite homogeneity in major elements. Stage-I garnet shows steep patterns from LREE to HREE, with abundant inclusions of Amp+Ep+Rt+Pl+Qtz±Zrn, and its grown time was indirectly constrained by matrix zircon U-Pb ages of ~240 Ma. Stage-II garnet displays enrichment of MREE relative to LREE and HREE, with sporadic inclusions of Omp±Rt±Zrn, and its grown time was directly dated by its inclusion zircon U-Pb age of ~220 Ma. Thus, the two stages of garnets are the prograde growth during the final subduction and the retorgrade growthe during the early exhumation, respectively.

While these garnet zonings record the important information on the metamorphic P-T-X at the depths of continental subduction zone, they are also dictated by the protolith composition of hosted rocks. Garnets in two occurrences of eclogites (foliated and massive) at the same locality in the Hong'an orogen show discrepant core-rim patterns in major-trace elements and minerals inclusions. Distinct garnet zonings were also observed from UHP eclogite and its wallrock granitic gneiss in the same locality in the Dabie orogen. Pseudosection calculations for the massive and foliated eclogites suggest that the different whole-rock compositions are the basic cause for the lithological difference in the two occurrences of eclogites, resulting in a series of the differences not only in mineral reactions and relevant mineral compositions but also in mineral assemblages and even lithological structures.