Geochronological constraints from zircon on the evolution of Himalayan UHP rocks

H. U. Rehman[1], K. Kobayashi[2], S.-L. Chung[3] and P. J. O'Brien[4]

[1] *Grad. Sch. Of Sci. & Engineering, Kagoshima Univ., Japan*
[2] *Institute for Study of the Earth's Interior, Okayama Univ., Japan*
[3] *Institute of Geology, National Taiwan Univ., Taiwan*
[4] *Institute of Earth & Env. Sci., Univ. of Potsdam, Germany*
hafiz@sci.kagoshima-u.ac.jp

Zircon, a common accessory and durable mineral in crustal rocks, is an important geochronological and geochemical tracer and has the ability to retain information of its formation, recrystallization and metamorphic growth. Major and trace element composition of zircon reveal its origin, and the U-Th-Pb isotope ratios provide information on the time of its growth, recrystallization and metamorphism. Whereas textural features and type of micro-inclusions trapped in zircon during its growth elucidate its formation conditions and pressure-temperature-time paths. That is why zircon is most commonly used for understanding the Earth's crustal and mantle processes.

We report a detailed study (zircon morphology, inclusion types, trace and rare earth element geochemistry and U-Pb geochronology) on zircons from the Himalayan high- and ultrahigh-pressure (UHP) rocks from the Kaghan Valley of Pakistan.

Zircons in HP eclogites were larger in size (200-500µm) and irregular in shape (rounded or ovoidal, prismatic or skeletal). Based on a cathodoluminescence (CL) image, most of the zircons display irregular, patchy or sector zoning. A few prismatic grains displayed oscillatory zoning with thick inner CL-dark cores and thin CL-bright outer rims. Middle or core domains contained inclusions of albite, biotite, quartz and k-feldspar whereas outer or rim domains contained inclusions of garnet, omphacite, kyanite, phengite and rutile with tiny silica (quartz).

Zircons in UHP eclogites were smaller in size (10-200µm), ovoidal, and sector or patchy zoned. Several grains displayed CL-bright cores and CL-dark outer domains, whereas most grains were irregularly zoned. They contained garnet, omphacite, phengite, kyanite, dolomite, rutile and tiny silica (coesite?). In contrast, zircons in UHP-grade gneisses were euhederal, well developed prisms and were elongated with a length to width ratio ranging from 2 to 5. Based on CL imaging, they were oscillatory zoned with CL-bright cores and alternate CL-dark and CL-bright concentric growth domains outwards. These zircons contained quartz, biotite, k-feldspar, muscovite, rutile in core domains and garnet, omphacite, rutile, kyanite and coesite in middle growth domains, whereas quartz and rutile at rim domains.

Trace and REE contents in HP eclogites show a decrease in the heavy REE from core to rims in the prismatic zircons. Cores of these zircons yielded concordant U-Pb zircon age of 267 Ma (HR-SIMS Cameca ims 1270), indicating magmatic protolith age. Similar age values and trace element patterns were obtained when zircon separates from the same samples were dated using LA-ICP-MS. Rims or outer portions of these zircons yielded a U-Pb age from 250 to 170 Ma, suggesting latter growth or recrystallization from the older domains. No age for the eclogite facies metamorphism was obtained from those samples. In contrast, zircons from UHP eclogites and UHP-grade gneisses yielded concordant ages of 46±1 Ma, representing the UHP event. Rim portions yielded 40 Ma. These zircons have significantly lower heavy REE compositions as compared to the magmatic zircons and clearly indicate their metamorphic origin. Our results reveal that mafic (eclogites) and crustal (felsic gneisses) blocks subducted to mantle depth together and experienced UHP metamorphism (at 46 Ma) and after a probable slab break-off, the whole sequence rapidly exhumed to crustal levels while experiencing amphibolite facies metamorphism (at < 40 Ma) at relatively higher temperatures (indicated by zircon growth and inclusions in rim parts) before their final exhumation to the surface.

Key words: Himalaya, Kaghan, UHP eclogites, zircon age, SIMS, ICP-MS, trace elements