Retrogression and recrystallization of the Stak eclogite in the northwestern Himalaya: constrains from Raman spectroscopy of residual pressures of quartz in garnet

Yui Kouketsu[1], Kéiko Hattori[2], Stéphane Guillot[3], Nicole Rayner[4]

[1] Gehchemical reserch center, Graduate School of Science, The University of Toyko, Tokyo 113-0033, Japan, kouketsu.yui@eqchem.s.u-tokyo.ac.jp
[2] Department of Earth Science, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada
[3] ISTerre, Université Grenoble I, CNRS, 1381 rue de la Piscine, 38400 Grenoble Cedex 09, France
[4] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada

Several eclogites have been reported along the western Himalayas. Among them, the rocks in the Stak massif in northern Pakistan were extensively retrogressed and Le Fort et al. (1997) was the first to recognize the relict evidence of eclogitic metamorphism. Recent study by Lanari et al. (2013) unravelled the condition of this eclogitic metamorphism, 750 °C and 2.5 GPa, using electron microprobe X-ray compositional mapping. These results suggest that the rocks in the Stak massif have undergone high-pressure metamorphism, ~ 2.5 GPa. We present residual pressures preserved in quartz enclosed by garnet in the Stak massif and discuss the evolution of pressure (P)–temperature (T) conditions of the unit together with new U–Pb ages of zircon grains measured in-situ using SHRIMP.

Residual pressure is commonly preserved in a mineral enclosed by a sturdy metamorphic mineral, such as garnet, and detected as a frequency shift of the Raman spectrum (e.g., Nasdala et al. 2003). Kouketsu et al. (2014) recently calculated the residual pressure of quartz inclusion in garnet and proposed a method to constrain the metamorphic P–T conditions using the residual pressure. We used this method to evaluate the P–T conditions of quartz grains in highly retrogressed Stak rocks. We measured Raman spectra of more than 100 grains of quartz from five samples. The quartz grains in garnet show residual pressures of up to 0.52 GPa, which correspond to the metamorphic conditions of 1.6 GPa at 600 °C and 1.8 GPa at 700 °C. The evidence of high pressures, ~ 2.5 GPa, calculated by Lanari et al. (2013) was not detected by the residual pressure of quartz inclusions in garnets.

Zircon grains occur both within garnets and the matrix and are all small, <50 μm, which makes the separation difficult. Therefore, U–Pb ages of zircon grains were measured in situ using a SHRIMP. The ages range from 158 to 27 Ma. Zircon grains containing low Yb and low Th/U, < 0.03, yielded the age between 36–30 Ma. The compositions suggest that they are metamorphic ages, but the values are much younger than that of the peak UHP metamorphic ages for the nearby eclogitic units: ~ 51 Ma for the Tso Morari massif (St-Onge et al. 2013) and ~ 47 Ma in the Kaghan massif (Wilke et al. 2010). Considering the proximity of these eclogitic units, it is difficult to consider ~ 36–30 Ma as the peak metamorphic age. Furthermore, the Stak massif occurs adjacent to the Nanga Parbat-Haramosh massif (NPHM) and the metamorphic ages of the granulite-migmatites of the massif vary from 25 to 30 Ma (Zeitler et al. 1989). Based on the evidence, we suggest that the rocks in the Stak massif were heated to amphibolite to granulite facies conditions with NPHM at around 36–30 Ma and are almost totally recrystallized after the peak metamorphic condition. These data imply that the Stak massif continued to underthrust beneath the Asian plate while the other HP and UHP massifs in the western Himalaya were exhumed.

References

Kouketsu, Y., Nishiyama, T., Ikeda, T. and Enami, M., 2014, Evaluation of residual pressure in an inclusion–host system using negative frequency shift of quartz Raman spectra, Amer. Mineral., 99, 433–442.

Lanari, P., Riel, N., Guillot, S. et al., 2013, Deciphering high-pressure metamorphism in collisional context using microprobe mapping methods: Application to the Stak eclogitic massif (northwest Himalaya), Geology, 41, 111–114.

Le Fort, P., Guillot, S. and Pêcher, A., 1997, HP metamorphic belt along the Indus suture zone of NW Himalaya: new discoveries and significance, Comptes Rendus de l'Académie des Sci., Ser. IIA, Earth and Planetary Sci., 325, 773–778.

Nasdala, L., Hofmeister, W., Harris, J.W. and Glinnemann, J., 2005, Growth zoning and strain patterns inside diamond crystals as revealed by Raman maps, Amer. Mineral., 90, 745–748.

St-Onge, M.R., Rayner, N., Palin, R.M. et al., 2013, Integrated pressure-temperature-time constraints for the Tso Morari dome (Northwest India): Implications for the burial and exhumation path of UHP units in the western Himalaya, J. Metamorphic Geol., 31, 469–504.

Wilke, F.D.H., O'Brien, P.J., Gerdes, A. et al., 2010, The multistage exhumation history of the Kaghan Valley UHP series, NW Himalaya, Pakistan from U-Pb and $^{40}Ar/^{39}Ar$ ages, Eur. J. Mineral., 22, 703–719.

Zeitler, P., Sutter, J., Williams, I.S. et al., 1989, Geochronology and temperature history of the Nanga Parbat–Haramosh massif, Pakistan, Geol. Soc. Am. Spec. Pap., 232, 1–22.

Cite as: Kouketsu, Y., Hattori, K., Guillot, S. and Rayner, N., 2014, Retrogression and recrystallization of the Stak eclogite in the northwestern Himalaya: constrains from Raman spectroscopy of residual pressures of quartz in garnet, in Montomoli C., et al., eds., Proceedings for the 29th Himalaya-Karakoram-Tibet Workshop, Lucca, Italy.