Gb-015 Room: IM Time: June 8 15:30-16:00

ULTRAHIGH-TEMPERATURE (UHT) CRUSTAL METAMORPHISM: OCCURRENCE, PEAK TEMPERATURES AND P-T HISTORIES

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Ultra high temperature (UHT) metamorphism occurs when crustal rocks experience temperatures of 900-1100 C at pressures equivalent to depths of 24-50 km. UHT conditions are indicated by experimentally-constrained mineral associations, by high Al2O3 contents (8-12 wt%) in the mineral orthopyroxene, and occasionally by the Fe-Mg compositions of coexisting minerals. Post-UHT pressure-temperature evolution may either involve cooling at depth in the crust, or exhumation to shallower crustal levels whilst the rocks are still hot. Such P-T paths rely on interpretations of reaction textures preserved between UHT minerals, but they can also be deduced from mapping of Al2O3 zoning in orthopyroxene. UHT metamorphism could arise from removal of lower lithosphere during or after crustal thickening.

Ultra high temperature (UHT) regional metamorphism is defined as metamorphism in which crustal rocks are subjected to temperatures of 900-1100 C at moderate pressures (7-13 kbar). Classic examples include the Napier Complex of Antarctica, Wilson Lake and Sipiwesk Lake in Canada, the Eastern Ghats of India and Labwor Hills in Uganda. UHT metamorphism also has been recognised from Scotland, southern India, Sri Lanka, Madagascar, and localities in Antarctica.

The key UHT indicators are mineral assemblages involving sapphirine, garnet, aluminous orthopyroxene, cordierite, sillimanite, spinel and quartz. Experimentally-constrained FMAS and KFMASH grids involving these phases and osumilite and melt show that sapphirine + quartz is stable only at >1040 C in reduced rocks, that osumilite is restricted to >900 C and has a stability limit of 9 kbar in FMAS, and that orthopyroxene + sillimanite + quartz is restricted to pressures (P) greater than 8 kbar in KFMASH. These criteria and grids isoplethed for mineral compositions allow peak P-T conditions to be defined and the post-peak P-T paths delineated.

New Fe-Mg exchange thermometry using the garnet-orthopyroxene calibration of Ganguly et al. (1996: Contrib Min Pet 126, 137-151) yields temperatures of 900-1100 C for many UHT areas. However, the best UHT compositional indicator is high Al2O3 content (8-12 wt%) in orthopyroxene. Thermometry based on the Al2O3 content of orthopyroxene coexisting with garnet, in assemblages constrained to be >1000 C, often support these UHT conditions. For example, the Aranovich and Berman (1997: Am Min 82, 345-353) thermometer returns 960+/-50 C for UHT granulites from the Napier Complex.

Preserved UHT P-T records are varied in that both near isobaric cooling (IBC) and near-isothermal decompression (ITD) post-peak P-T paths are deduced from reaction textures. In contrast the prograde P-T histories of most UHT areas are poorly known. Kyanite inclusions (Motoyoshi and Ishikawa 1997: The Antarctic Region: Geological Evolution and Processes, 65-72) or pseudomorphs after kyanite (Raith et al. 1997: J Met Geol 15, 379-400) imply clockwise P-T trajectories for specific UHT-ITD occurrences. At Mather Peninsula, Rauer Islands, mineral compositions (Harley 1998: J Met Geol 16, 541-562) produce a peak P-T estimate, 11-12 kbar and 1033+/-30 C, that is consistent with petrogenetic grids. A UHT-ITD path is derived here from grid-based interpretation of reaction textures in which garnets are replaced by lower-pressure equivalents such as sapphirine + orthopyroxene + cordierite. Identical textures described from several other UHT occurrences are interpreted similarly, and ITD from 10-12 kbar to ca. 7-8 kbar at temperatures in excess of 900 C, and even 1000 C, is considered to be the post-peak P-T path typical of these UHT localities.

How have such high temperatures been generated, even transiently, prior to decompression and/or cooling of the UHT granulites? Local heat sources may explain individual cases, but do not provide a general explanation for the rare clockwise P-T paths and common ITD histories which imply that significant heat-transfer followed burial and accompanied exhumation. Advected heat has to be a major contributor to the thermal budget, and this heat must in many cases be delivered during deformation of the crustal rocks. Convective thinning of the lithospheric thermal boundary layer (TBL) during or after a phase of crustal thickening provides a plausible model for UHT metamorphism, and would account for rapid exhumation and hence ITD P-T paths if TBL removal triggered crustal extension. Evaluation of this and other models requires better constraints on the timescales of metamorphism and post-peak ITD or IBC in UHT terrains.