The Hottest Crust

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The number of recognised UHT terrains and localities has more than doubled over the past eight years, reflecting both the acceptance of UHT as a major form of metamorphism and improvements in the tools used to record it. The implied regional scale deep (7-12 kb) crustal metamorphism at temperatures as extreme as 1120°C raises major questions for the transfer of heat in the crust-mantle system during orogenesis and the response of the UHT crust to deformation. Critical to any evaluation of these questions is the robust definition of the physical conditions of UHT, particularly temperature and fluid activities, and the timescales of UHT in key terrains. Some recent advances in methodologies applied to address these issues are considered here.

The best methods for quantifying peak temperatures remain those based on the Al content of orthopyroxene coexisting with aluminous silicate minerals (e.g. garnet, cordierite, sapphirine). Such estimates are further improved, and able to be interpreted within P-T path contexts, when the Al-thermometry is considered in tandem with contoured pseudosections produced via THERMOCALC. The combined approach, applied to equilibrium assemblages and then to reaction textures, allows documentation of near-peak P-T histories. Integration of H_2O and CO_2 activity calculations based on the volatile contents of cordierite allows construction of pseudosections at appropriate fluid activities which in turn enables the role of melting and melt crystallisation in the UHT P-T history to be quantitatively assessed. In very dry UHT rocks where melting is limited to a few percent even at c. 1000°C, the melts may segregate, crystallise and undergo wall-rock reaction at various times and over a wide temperature interval (>200°C) following the peak. This proves to be critical to the interpretation of zircon ages in UHT terrains.

The timing of zircon growth, recrystallisation and reequilibration with respect to UHT metamorphism, a source of current controversy, can now be assessed utilising in-situ zircon U-Pb and zircon-garnet REE analysis, combined with Zr-in-rutile thermometry in optimal cases. This shows that in rutile-bearing mineral assemblages from the UHT Napier Complex ‘metamorphic’ zircon rims, produced by recrystallisation and local regrowth on detrital zircon cores, formed at 720-760°C - long after the UHT peak itself. These 2510-2460 Ma zircons reflect late-stage reactions associated with near-isobaric cooling and fluid-melt-rock interactions, whereas 2556 Ma and older higher-Ti zircons in localised leucosomes formed on the crystallisation of dry melts whilst UHT conditions stll prevailed.