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On regional ultrahigh temperature crustal metamorphism

Ultrahigh temperature (UHT) metamorphism is the most thermally extreme form of regional crustal metamorphism, with temperatures exceeding 900 °C. Some of the progress that has been made in recent years for understanding UHT metamorphism, includes: 1) development of a ferric iron activity–composition thermodynamic model for sapphirine, allowing phase diagram calculations for oxidized rock compositions; 2) quantification of UHT conditions via trace element thermometry, with Zr-in-rutile more commonly recording higher temperatures than Ti-in-zircon; 3) recognizing that crust partially melted either in a previous event or earlier in a long-duration event has greater capacity than fertile, unmelted crust to achieve UHT conditions due to the heat energy consumed by partial melting reactions; 4) more strongly linking U–Pb geochronological data from zircon and monazite to P–T points or path segments through using Y + REE partitioning between accessory and major phases, as well as phase diagrams incorporating Zr and REE; and 5) improved insight into the settings and factors responsible for UHT metamorphism via geodynamic forward models. These models suggest that regional UHT metamorphism is principally geodynamically related to subduction, coupled with elevated crustal heat generation rates. Time permitting, I will then present some work from the Musgrave Province, a large Grenvillian-aged UHT belt in central Australia. The Musgrave Province occupies the junction between three older cratonic blocks and is comprised of mostly juvenile magmatic rocks emplaced over a protracted (and episodic) interval of ca 1330–1020 Ma. Magmatic rock compositions evolved over time from arc-like to within-plate-like and the within-plate varieties have high-Ti-P charnockitic compositions, strongly suggestive of very hot (~1000 °C) emplacement temperatures. Rare Fe-rich metasediments preserve peak garnet–sillimanite–quartz ± spinel ± magnetite paragenesis with P–T conditions of 7–8 kbar and ~950 °C, implying extreme apparent thermal gradients. The UHT phase of the Musgrave system lasted from ca 1220–1140 Ma. Globally the Grenvillian system appears to be characterized by large, hot orogens. The Musgrave Province appears to be one of a number of such systems including the Rayner–Eastern Ghats system and the North American Grenville Orogen.