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Conditions, durations and the response of the lower crust to high-temperature metamorphic events

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Lower crustal rocks that have undergone regional metamorphism at high-grade (T> 850 °C; P< 12kbar) conditions are interesting and thought provoking, because explaining how such high temperatures are attained—and, perhaps, sustained—regionally in the crust is challenging in the context of plate tectonics. Regional scale high-grade metamorphism might be caused by i) heating during thickening of an unusually radiogenic crust (perhaps depleted of H_2O, but not radioactive elements by an earlier melting event), ii) advection of heat through mantle-derived (possibly plume-related) plutonism, iii) conduction of mantle-derived heat following delamination, iv) conduction of mantle derived heat during extensional phases. Each requires special circumstances to produce temperatures that exceed the conductive geotherm typical of continental lithosphere. To understand the physical and chemical processes that cause regional scale high-grade metamorphism one must quantify the spatial and temporal scales over which such high temperatures prevailed. Accurately constraining the pressure-temperature-time (*P*–*T*–*t*) evolution of rocks that have experienced such high temperature conditions is difficult and has required the development of a new suite of analytical techniques aided by recent advances in the calibration of mineral thermometers. The development of revolutionary new technologies (Atom Probe Tomography, Laser Ablation Split-Stream petrochronology) that enable previously unachievable access to mineral chemistries at a scale and acquisition rate have significantly advanced our ability to characterise entire orogenic systems. This presentation will review the evolution of a number of high-temperature terrains based on recent petrological and geochronological datasets. These results will then be discussed in the context of the geodynamic drivers of high-temperature metamorphism in order to evaluate the relative roles of heat production, magmatism, supercontinental cycles and the evolution of mantle temperature through Earth history.