Heating from within and without, tales of contrasting long-lived crustal hots spots

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High thermal gradient conditions in the crust can be generated by a number of mechanisms: direct advection of heat via magmatism, high basal heat flow associated with extension/removal of lithospheric mantle, rapid exhumation of deeply buried rocks and high rates of internal heat generation. While each of these mechanisms may have characteristic time and length scales, the duration of metamorphism as perceived by geologists is generally controlled by the exhumation potential in the system which determines the thermal record of an individual rock. Therefore long-lived high-T metamorphism generally points to thermally anomalous conditions in crust with low exhumation potential where material stays within the system for an extended period of time (e.g. orogenic plateaus).

More intriguing is apparently long-lived (~ 100 Ma) high-T "hot-spot" metamorphism that appears to have operated on a sub-orogenic (~ 100km) scale length scale. This sub-orogenic scale means that rocks can potentially easily move out of the high-T region curtailing the duration of their high-T history. Such systems can be plausibly be driven by high rates of internal radiogenic crustal heat generation in chemically anomalous crust undergoing limited deformation. For example in parts of central Australia, crustal heat generation rates are regionally in excess of $8\mu Wm^{-3}$, and are spatially associated with high-T low-P granulite metamorphism.

"Long-lived crustal "hot spots" can also be generated in highly localised rift basins developed in thick continental lithosphere. Continental rift basins may accumulate in excess of 25km of sediment fill associated with voluminous mafic magmatism. This creates a logical setting for high-T, medium P metamorphism associated with on-going basin development, including high-grade intrabasinal deformation.

We discuss salient features of internally and externally driven crustal "hot spots".

Carbon budget during alteration of the oceanic crust

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Although it is largely accepted that volatile elements are incorporated into the oceanic crust during alteration, the flux of carbon involved in this transfer remains poorly known. The detailed study of altered rocks is a key to better constrain the C uptake during alteration. In this work, we studied carbon concentrations and isotopic compositions in altered basaltic samples drilled from 2 different sites. We first selected a young section of altered oceanic crust (15 Ma): the ODP/IODP Hole 1256D, providing a large variety of rocks from lavas down to the gabbroic rocks. The second set of samples, which is of Jurassic age (Site 801, 150 Ma), was selected to evaluate C uptake variations during aging of the crust. All samples are enriched in carbon relative to fresh basalts. For 1256D samples, total CO_2 ranges between 564 and 2823 ppm with $\delta^{13}C$ values from -14.9‰ to -26.6‰. The carbon isotope compositions are interpreted in terms of a mixing between two components: (1) carbonate with $\delta^{13}C$ = -4.5‰ and (2) organic compound with $\delta^{13}C$ = -26.6‰ representing more than 75% of the total C in most of the samples. Jurassic samples are enriched in carbon relative to 1256D samples (with total CO_2 between 0.3 and 2wt%). Although the organic carbon concentration and isotope composition remains constant in these samples, the carbonate concentration strongly increases. A possible explanation is that higher atmospheric CO_2 in the Mesozoic [1] may have led to higher carbonate contents in the old 801 basement. Alternatively, we propose a two-step model for carbon cycling during crustal alteration: (i) organic compounds are formed close to ridge axis, either through recycling of biogenically-derived material or Fischer-Tropsch-type reactions; (ii) away from the ridge axis, the organic production decreases and carbon uptake is dominated by carbonate precipitation from seawater. The total flux of C stored in the altered oceanic crust, as carbonate and organic compounds, is estimated at $2.9\pm0.4\ 10^{12}$ molC/yr with a mean $\delta^{13}C$ of -4.7‰.

[1] Gillis & Coogan (2011) *EPSL* **302**,385-392.

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