Mantle jets and mantle plumes

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Because of internal heating and effects of viscosity and pressure mantle flow is characterized by large sluggish upwellings. Jets and plumes have been introduced into mantle dynamics and geochemistry because of the perceived need for narrow hot and rapid upwellings to fuel Hawaii and other intraplate volcanoes. These imply a fluid strongly heated from below, no internal heating, non-Stokes law behaviour, flow controlled by external forces and an important role for inertia and momentum. Jets and plumes, as defined in fluid dynamics, and as used in geodynamic and geochemical modeling, are precluded by the equations of fluid dynamics and solid-state physics. The underlying homogeneity, isotropy, adiabatic and thin plate assumptions are ruled out by seismology.

The Morgan plume hypothesis, the McKenzie-Bickle geotherm and mantle jet hypotheses and whole mantle convection scenerios violate fluid dynamic and lattice dynamic scaling relations and the 2^{nd} law of thermodynamics, and do not satisfy well-constrained unsmoothed seismic models that allow for anisotropy. Physics, and geochemical modelling, show that the outer 200 km of the mantle is an appropriate source for intraplate magmas, including their diversity, volumes, compositions and temperatures. The thermal overshoot of boundary layer convection and the subadiabaticity of the deep geotherm explain the relative temperatures of Hawaiian and midocean ridge magmas. Anisotropy shows that the ridge source is in the transition zone.

Top-down processes, driven by secular cooling, fertilize and cool the mantle and create shear boundary layers that are responsible for shear- driven upwellings and intraplate volcanoes. The upper boundary layer of the mantle is a metasomatised, sheared melange that has all the attributes required to explain volcanoes such as Hawaii and the largest igneous provinces.

ca. 1750 Ma arc-related metamorphism in the southern Arunta Complex, central Australia?

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The Arunta Complex, central Australia, is a ~200,000 km^2 poly-metamorphic complex, with a cryptic record of tectonism from the Paleoproterozoic to the Paleozoic. The Arunta Complex records evidence for ~200 Myr of orogenic activity between ca. 1800–1600 Ma, but with the exception of minor magmatism interpreted to have arc-related petrogenesis [1], evidence for subduction-related magmatism and high pressure metamorphism is limited.

This study uses calculated pressure-temperature phase diagrams and *LA-ICP-MS* U–Pb monazite geochronology to investigate a series of granulite facies supracrustal and magmatic rocks from the southern Arunta Complex.

High-grade, regional metamorphism occurred at ca. 1760–1740 Ma. This timeline has previously been interpreted as an igneous event, including magmatism with subduction-related geochemical signatures in the south-eastern Arunta region (Calcalkaline–Trondhjemite Suite). However, recent evidence has highlighted that metamorphism also occurred during this time in the eastern Arunta Complex [2]. If the ca. 1750 Ma magmatism is arc-related, it is possible that we have characterised the thermal structure of the arc (medium pressure, apparent thermal gradient of ~25– 35 °C/km).

The characterisation of the physical conditions of the crust in the southern Arunta Complex at ca. 1760–1740 Ma may provide supporting evidence from a metamorphic standpoint for an active margin in the southern proto-North Australian Craton. If so, the ca. 1760–1740 Ma regional metamorphism is an important constraint for deciphering the Proterozoic tectonic evolution of the Arunta Complex and North Australian Craton.

[1] Zhao & McCulloh (1995) Precambrian Research **71** 265-299. [2] Whelan *et al* (2011) Annual Geoscience Exploration Seminar (AGES), Record of Abstracts **Record 2011-003**, 40-42.

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