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Heat flow in the deforming Indian oceanic lithosphere

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More than 300 heat flow values have been collected since 1960 in the Indian Ocean by various marine surveys. While some high heat flow measurements show non-linear temperature gradients in the Bengal sediments and thus seem to be related to fluid circulation, the average surface heat flow (85 mW/m^2) is anomalously high near the Afanasy Nikitin Seamount chain compared to the 55 mW/m^2 given by plate cooling of a 75 Ma old lithosphere.

The origin of this anomaly has been a long term debate between two main possibilities (1) reheating of the base of the lithosphere by hot spot activity or (2) heat produced by ongoing Indian intraplate deformation. The first solution is now commonly rejected in favor of a shallower origin because of the absence of a significant bathymetric swell in the area. Recent kinematic modeling using GPS and seismicity data shows that a valid instantaneous intraplate deformation field is obtained using heat flow as a proxy for rheological weakness. Although spatial correlation between high heat flow and active intraplate deformation was earlier mentioned, the origin of that link was not quantified so far.

We first built a conductive thermal model describing frictional heating on thrust faults to conclude that friction can only account for a maximum of 5 mW/m^2 out of an observed 30 mW/m^2 anomaly. At a shorter scale, re-processing of deep wide-angle seismic (PHEDRE profile) across the active fault network allows us to image the lithosphere structure down to Moho and upper-mantle depth at ODP Leg 116 site, where closely spaced high heat flow measurements have also been acquired. Two reflectors corresponding to active thrust faults, with several hundred meters of vertical offset at the surface, cut the entire oceanic crust. They clearly reach mantle depth, and may thus act as preferential conduits to supply water, possibly triggering the exothermic suite of serpentinization reactions.

We next explore – through a simple transient conductive model - the possibility that the high heat flow is the result of widespread serpentinization initiated some 7 to 8 Myrs ago when intraplate deformation started. Serpentinization does not only provide a plausible mechanism for the high heat flow, but it is also supported by the presence of a low seismic velocity layer found at the base of the oceanic crust using seismic refraction. The loss of rigidity of the Indian oceanic lithosphere at that time could then be the result of a dramatic decrease of fault's friction due to serpentinization.