Thermal Structure of the Cratonic Lithosphere

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Surface heat flow data provide the only direct constraints on the deep thermal structure of the continental lithosphere. In the cratons that have been stable for more than 1,000My, the temperatures in the lithosphere are near conductive equilibrium. The temperature profile in the lithosphere depends on the thermal conductivity, and on the vertical distribution of heat producing elements (HPE) which are abundant in the crust. Thermal conductivity at depth is estimated from laboratory measurements on rock samples. The distribution of HPEs must be inferred from surface sampling, and from other geological and geophysical data on crustal structure. In select regions where substantial sections of the crustal column can be sampled, the Moho heat flow can be determined with good confidence. Moho heat flow, in turn, serves as a boundary condition to compute temperatures in the lithospheric mantle. However, in most other regions, estimates of Moho heat flow and temperature distribution in the lithosphere are largely model-dependent. Even small variations in Moho heat flow result in large differences in temperatures at depth and in lithospheric thickness. Additional information from upper mantle seismic velocities and geothermobarometry of mantle xenoliths further constrain the sub-crustal temperature regime. They additionally constrain the heat production and throw light on likely compositional heterogeneities in upper mantle that cannot be gleaned from heat flow data alone.

The key results emerging from a large number of studies carried out by different workers in select cratons of North America, southern Finland, India (Dharwar) and South Africa (Kaapvaal) are listed as follows: (i) Archaean cratonic nuclei are characterized by low surface heat flow not exceeding 50 mW m^{-2}. Proterozoic provinces, in contrast, are associated with both high and variable heat flow. (ii) Studies of the spatial scale of the variations in surface heat flow have demonstrated that most of them originate in the crust and that variations in the heat flow at the base of the lithosphere should not exceed +/- 3 mW m^{-2}. (iii) Moho heat flow estimates in the cratons generally fall within the narrow range of 12-20 mW m^{-2}. (iv) Lithospheric stability requires low heat production in upper mantle lithosphere.

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