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Thermal Structure of Precambrian Terrains: Current Approaches

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Crustal thermal models for Precambrian terrains, derived by integrating regional heat flow and radiogenic heat production datasets with high-resolution crustal sections inferred from geological and geophysical probing (e.g., seismic, gravity and electrical methods), have found worldwide recognition over the last decade. Relative to crustal temperature-depth models derived from heat flow data and assumed mathematical models for distribution of heat production with depth, the present-day models incorporate a realistic distribution of heat production with depth in the crust (obtained from extensive radioelemental measurements on major rock types likely constituting the crust), and models for temperature dependence of thermal conductivity (obtained from a growing experimental dataset on lower crustal rocks). Heat production of the lower crust not only depends on constituent rock types but also upon later geological episodes such as P-T metamorphism and fluid interactions that the rocks have undergone. Therefore it is essential to characterize the heat production of each lithological formation of the crustal column. Robust models have resulted from studies in which heat flow values have been best determined (i.e., from carefully chosen borehole sites where uncertainties caused by subsurface groundwater flow, large variations in thermal conductivity in and around the borehole column, and large variations in heat production of rocks, are minimal) and the crustal columns are best characterized. Obviously, only very few regions, such as parts of the Canadian, southern African and southern Indian shields that meet the criteria described above, have been found amenable to such studies. Nevertheless, these few situations help in understanding better the present-day thermal structure of the Precambrian lithosphere. Studies carried out in Precambrian shields bring out the following characteristics: (i) Surface heat flow is generally low (<50 mWm^{-2}) in Archaean provinces whereas it is variable in the Proterozoic provinces. (ii) In general, heat generated in the crust constitutes ~60% of the surface heat flow; the remaining ~40% comes from below the crust. (iii) Mantle heat flow generally ranges from 10 to 18 mW m^{-2} in the granite-gneiss as well as gneiss-granulite provinces, except in a part of the gneiss-granulite province of southern India where it is significantly higher. Such variations have strong implications for the temperature structure of the crust and upper mantle. There is therefore a growing need to carry out similar studies in other, suitable, Precambrian provinces.

Keywords: Heat flow; Heat production; Thermal Structure; Precambrian terrain