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G. M. Brown, M. J. O'Hara and E. R. Oxburgh

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Introduction

By G. M. Brown,[†] F.R.S., M. J. O'Hara[‡] and E. R. Oxburgh[§]
[†] *Department of Geological Sciences, University of Durham, U.K.*
[‡] *Grant Institute of Geology, University of Edinburgh, U.K.*
[§] *Department of Geology and Mineralogy, University of Oxford, U.K.*

During the last fifteen years, three major developments have influenced thinking on temperature distributions within the Earth and on the origin of magmas.

Perhaps the most important was the recognition that large scale plate movements which have occurred at the Earth's surface require large scale counterflow of mantle material in the solid state. The thermal diffusivity of mantle rocks and the scale of mantle flow are such that even if the flow velocity is as low as 1 mm/a, the temperature distribution within the Earth is governed by convective, rather than conductive, transfer of heat. This has meant that the majority of thermal models of the Earth's interior have had to be discarded as irrelevant; nearly all were based on assumptions of conductive heat transfer with a transition downwards to radiative processes. It was a feature of these models that they all gave rather high temperatures in the lower mantle; indeed, in order to keep the lower mantle below its melting temperature it was commonly necessary both to invoke radiative heat transfer and to postulate concentration of nearly all the radioactive heat production in the upper few hundred kilometres.

Today the approach is very different. Conductive calculations are thought to be appropriate for only the outermost part of the mantle – that part which is incorporated in the surface plates; below the plates and at their margins, which are zones of localized upwelling or downward motion, temperatures are related to the circulating motions within the mantle. It is not clear at present how deep these motions extend; beyond reasonable doubt to 700 km, but possibly over the full depth of the mantle. Remaining constraints on the distribution of heat-producing elements are largely chemical rather than physical.

The second major development was the recognition, independently by F. Birch and his group at Harvard, and by A. H. Lachenbruch at the U.S. Geological Survey, that against all reasonable expectation there exists, for many plutonic and meta-plutonic continental regions, an empirical dependence of surface heatflow on the radioactive heat production from the near-surface rocks at the site where heatflow is measured. Lachenbruch subsequently showed that the most reasonable explanation of this relation was some kind of exponential decrease of radioactivity with depth in the Earth's crust. This fractionation of uranium, thorium and potassium, which is still without a satisfactory explanation, seems to be characteristic of crust which has undergone some kind of high-temperature reworking.

Taken together, the appreciation of both the importance of convective heat transfer beneath plates, and the new understanding of the distribution of heat production within continents, have led to a new generation of thermal models for the Earth's crust and upper mantle which are hopefully more realistic than their forebears; they differ from them in two principal ways: they allow much larger *lateral* gradients of temperature in the mantle, and they permit rather lower temperatures in the deep mantle.

Before this information can be put to use in the understanding of magma genesis, it is essential that there be some knowledge of the depths from which different magmas are derived. In the broadest view, all basaltic magmas are derived by the partial melting of an ultramafic upper mantle, but there are great uncertainties concerning its detailed composition and mineralogy and the degree of scale of heterogeneity which may be expected. During the last ten years or so, the widespread use of high-precision mass spectrometers has produced a third major development by making available large quantities of high-quality information not only on the isotopic composition of lead and strontium in magmatic rocks, but also on a range of other trace elements including the rare earths. Although many uncertainties remain, this geochemical evidence has provided important constraints on the degrees of partial melting involved in the generation of various magma types, and in favourable circumstances may place limits on the depth at which the melting occurred. The isotopic evidence can also constrain the length of time during which the source region has been in isolation without experiencing change in chemical or isotopic composition.

It is clear that within the Earth there is a subtle interplay between the distribution of heat-producing elements and all dynamic phenomena. The heat-producing elements generate thermal instabilities which give rise to large scale motions, which may themselves produce partial melting and a redistribution of heat sources.

Rapid advances are currently being made in the understanding of when and how the major redistribution of heat-producing elements has occurred within the Earth, in quantifying the effects of such processes and in measuring temperature distributions within the crust and upper mantle at earlier times in the history of the Earth. This meeting brought together geophysicists, geochemists and petrologists who are concerned with theoretical, laboratory-based and field aspects of this interdisciplinary subject for a discussion of some of the important points in this active field of research.