The use of the volcanic rock record to document changes in the Earth's thermal and tectonic history

J. ADAM[*1], A. WELLHAUSER[123], T. RUSHMER[1]

[1]Department of Earth & Planetary Sciences, Macquarie University, NSW, Australia
[2]Geochemistry Division, Georg-August University, Göttingen, Germany
[3]School of Earth Sciences and Engineering, Nanjing University, Nanjing P.R. China

The use of the volcanic rock record to document changes in mantle temperatures over time is complicated by two problems. One is sampling bias. The other is the inherently assumption-dependent nature of the thermobarometry involved. Similar problems of preservation apply to the identification of past tectonic regimes. Nevertheless, it can be noted that most magmas are saturated with two or more phenocryst phases when they erupt and must therefore have evolved by crystal fractionation along magmatic cotectics for their own phenocryst phases (as noted by O'Hara, Earth Sci. Rev., 1968). This can be demonstrated for most Phanerozoic magma types, as can the physical conditions required for their production. When viewed from this perspective, the Archaean and Phanerozic records are broadly similar, as is the range of absolute Fe concentrations in Archaean and Phanerozoic lavas (significant for the calculation of mantle potential temperatures). Exceptions to this generalization are the absence of mid-ocean ridge and intraplate magmas (of OIB-type) from the Archaean record, and the absence of komatiites from the Phanerozoic record. Unlike their closest Phanerozoic analogues, the latter have compositions that are inconsistent with either cotectic control or with simple olivine addition/subtraction. For both the Archaean and Phanerozoic, felsic magmas are chiefly represented by plutonic rocks (and ignimbites during the Phanerozoic). Compositional differences between granitic rocks from the two periods suggest that there may have been differences in the source materials, conditions of melting and/or other processes involved in felsic magma production. In spite of this, the compositional similarities of Archaean and Phanerozoic volcanics (not including komatiites) is consistent with similar conditions and processes of basaltic magma production during both Eons. From this it may be concluded that, since early in the Earth's history, the temperature of its upper mantle has been largely self-regulating, in spite of changes in total heat production and tectonic regime.