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This Week's Citation Classic®

O'Hara M J. The bearing of phase equilibria studies in synthetic and natural systems on the origin and evolution of basic and ultrabasic rocks. *Earth-Sci. Rev.* 4:69-133, 1968.
[Grant Institute of Geology, University of Edinburgh, Scotland]

This review and synthesis brought an appearance of order to the results from a rapidly expanding set of experimental observations of the high-pressure melting and crystallization behavior of natural basaltic and peridotitic rocks. The principal conclusions remained highly controversial. [The *SCI*® indicates that this paper has been cited in more than 390 publications, making it the most-cited paper published in this journal.]

Volcanic Plumbing and Mantle Melting—A "CMAS" Hit?

Michael J. O'Hara
Institute of Earth Studies
University College of Wales
Aberystwyth, Dyfed SY23 3DB
Wales

The work for the paper was carried out in the Grant Institute of Geology at Edinburgh in 1966-1967, essentially as a review prior to the planning of experimental petrology.

One contribution of the paper was its use of data projection schemes to represent and relate phase equilibria data for natural rocks. The data pointed to three main conclusions: partial melting of a peridotite upper mantle would not yield liquids directly with compositions resembling the lavas commonly erupted by volcanoes; the liquids that were produced could evolve into the common volcanic eruption products by physicochemical processes known to operate within the Earth's crust, if not at greater depths; and this requirement for chemical modification (principally by removal of olivine crystals) by near-surface processes was then widely postulated to consist of the unmodified products of the melting of the upper mantle.

These results and general conclusions have been supported by most subsequent studies of the phase chemistry, major element compositions, and field relationships of basic and ultrabasic rocks,[1] but there has been very extensive refinement and improvement of the details as the database has expanded. The procedures have been extended tentatively to pressures of 15 GPa,[2] yielding conclusions that bear on major questions of whole-Earth evolution immediately after the planet's accretion.

Much, if not most, of this publication's "success" in terms of citations arose, however, from its being quoted because its conclusions appeared to be inconsistent with the most obvious interpretation of a wealth of geochemical data on the concentrations of trace elements in these same rocks.

Those "incompatible" trace elements varied dramatically in absolute concentration and in their ratios one to another in basaltic rocks whose major element compositions were very similar. These features are a predictable consequence of the equations that describe what would happen during a partial melting process.

Most geochemists believed, therefore, that chemical modification of the erupted liquids, since their formation by partial melting, must have been insignificant and the experimental data or their interpretation of the trace element geochemical data must be common. Reconciliation between the two approaches came when more sophisticated models of the near-surface physicochemical processes were introduced.

Much observational evidence showed that mixing of a liquid whose chemistry had evolved by fractional crystallization with a fresh input of less evolved liquid might be a common feature in magma chambers beneath volcanoes and that this might be a repetitive process.[1] When the magma chamber is large relative to the average size of the periodic inputs and eruptions, the equations that describe this process predict trace element behavior which is barely distinguishable from that predicted by the partial melting equations;[3] but the major element and phase equilibria data for erupted basalt liquids are simultaneously satisfied.

For my work, I was elected a Fellow of the Royal Society of London (1981) and awarded the Bowen Medal of the American Geophysical Union (1984).

1. **Thompson R N.** Phase equilibria constraints on the genesis and evolution of oceanic basalts. *Earth-Sci. Rev.* 24:161-210, 1987. (Cited 10 times.)
2. **Herzberg C T & O'Hara M J.** Origin of mantle peridotite and komatiite by partial melting. *Geophys. Res. Lett.* 12:541-4, 1985. (Cited 35 times.)
3. **O'Hara M J & Mathews R E.** Geochemical evolution in an advancing periodically replenished, periodically tapped, continuously fractionated magma chamber. *J. Geol. Soc.* 138:237-77, 1981. (Cited 150 times.)

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