PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

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Phil. Trans. R. Soc. Lond. A 1971 **268**, 493
doi: 10.1098/rsta.1971.0009

Phil. Trans. Roy. Soc. Lond. A. **268**, 493 (1971) [493]
Printed in Great Britain

Characteristics, occurrence and origins of basalts of the oceans

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Dredge hauls from major faults along ridges, rises, and fracture zones of the oceans and cores obtained by J.O.I.D.E.S. indicate that basalt, gabbro, and their metamorphosed derivatives comprise three-quarters or more of the oceanic crust.

Over 99 % of the little altered basalts and gabbros are related (hereafter oceanic tholeiites are unique among basalts of the crust, specifically because of their high contents of SiO_2, CaO, Al_2O_3 (commonly $> 16\,\%$), K/Rb, Si/K, Ca/K and the consistently low abundances of large ions, the paucity of Ba relative to Sr, of La and Ce relative to heavy rare earth elements, low Th/U and other features. The abundance distribution patterns of constituent rare earths are similar to those in the calcium-rich achondritic meteorites.

Large variations in composition appear in Al_2O_3 (14.6 to 22.8) and TiO_2 (0.4 to 2.0). The gabbroic 'equivalents' commonly contain even less K, Ti, U, Th, Pb, and have averages (but not mean deviations) higher in Al_2O_3 and CaO.

Other basalts of the oceans include: (1) Hawaiian and Icelandic tholeiites, relatively depleted in Na, Al, and enriched in Ti, Fe^{3+}, and Mg, with lower Ca/Mg+Fe, K/Rb; and (2) alkali basalts. Neither appears to be volumetrically significant and, excepting the Icelandic tholeiites, they seem confined largely to volcanoes and breaching flank eruptions therefrom.

The alkali basalts appear to be derivative rocks, fractionated and distilled from tholeiitic parent magmas, or from magmas parent to the tholeiites. This interpretation seemingly conflicts with existing phase-equilibria studies and dogma but is indicated by: (1) wide variations in composition but relatively high ratios, in most alkali basalts, of Fe^{3+}/Fe^{2+}, high combined water or hydroxyl, and high K, Ba, U, Th, Pb, Th/U, low K/Rb, more 'fractionated' abundance distribution patterns of rare earths; (2) occurrence largely as surficial encrustations on thick piles of tholeiitic lavas; (3) eruption of alkali basalts largely in waning stages of tholeiitic magma cycles, from the same vents; (4) their scarcity ($< 1\,\%$ of all crustal basalts); and (5) their virtual absence as sills or dykes along the great fault scarps of the oceans, and in the deeply eroded continental terranes populated with dykes and sills of tholeiitic basalt.

Probably the oceanic tholeiites are partial melts of a more peridotitic mantle, but the only unaltered samples of peridotites (lherzolite) from the oceanic ridges contain less than $100/10^6$ K. The tholeiites average about $1400/10^6$ K. This suggests one or more of the following: (1) the known ultramafics are partial residuates from which basalt has been extracted; (2) potassium and related elements have been mobilized in the mantle by volatile fluids and moved to sites of generation of the tholeiitic magma; (3) the tholeiites are themselves derivative; or (4) the oceanic tholeiites represent less than 10 % of the sub-oceanic source mantle. Obviously these and other possibilities may pertain for it is clear we lack the necessary data to explain precisely the derivation of the so-called 'tholeiites' and other lava kindreds of the crusts.