KIMBERLITES ON MARS

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Observation of surface features, geophysical data, surface chemistry, and theoretical models of solar system cosmology are consistent with the inference that kimberlite-like ultrabasic ash may be a very abundant constituent of Martian soil and that kimberlitic volcanism may be an important process on Mars.

The density of the Martian mantle is estimated to be about 3.55 gm/cc, significantly greater than that of the Earth. This higher density has been taken to imply a greater abundance of FeO. Model mineral assemblages have been calculated for a variety of chemical compositions at 30 kb using a high pressure norm scheme. For the simplest models, FeO was added to Pyrolite III and the densities of the resulting mineral assemblages calculated. The model yielding a density of 3.55 is not a garnet lherzolite, but rather is an assemblage of 2% oxide, 11% garnet, 73% olivine (Fo_{67}) and 12% clinopyroxene. Such an oxide-garnet wherlite is a rather different assemblage than any calculated for Earth, and may be unique among the terrestrial planets. Partial melting of such an assemblage would be likely to yield iron-rich ultrabasic lavas of extremely low viscosity. Model partial melts, assuming quaternary eutectic melting (at $ol_7gar_{42}cpx_{43}oxide_8$) yield an ultrabasic picritic alkali-olivine basaltic melt, with a computed viscosity of 12 poises at 1200°C.

There is evidence for abundant lava flow and flood volcanism on Mars. On the earth, pyroclastics associated with basaltic volcanism on the earth are minor. However, kimberlites reflect the accumulation of deep-seated volatiles which are blown through the lithosphere in violent gas-dynamic eruptions. Hence, if volatiles are abundant in the interior of Mars, ultrabasic pyroclastics may be common. Current models for early solar system evolution (Lewis, 1972; Cameron, 1963, 1973) suggest that Mars formed at cooler temperatures than the Earth, and therefore may have accreted five to six times the abundance of volatile material per unit mass. If this is correct, Mars may have (or have had) an extremely volatile-rich interior. The rift features suggest global extension of the lithosphere, and thermal evolution models also imply global expansion, at least throughout most of Martian history. A tensional stress state in the lithosphere would promote eruption of internally generated melt and gas.

If the mantle of Mars is indeed richer in FeO and volatiles than that of the Earth, there are a number of geological implications which follow that appear to be compatible with results of Mariner and Viking experiments and observations. (1) Copious ultrabasic flood volcanism may account for some of the massive flood and erosional features commonly ascribed to water erosion on Mars. (2) The Viking 1 and 2 XRF inorganic chemistry experiments may be measuring compositions of such lavas. (3) A number of unusual Martian mantle mineralogies, and therefore unusual magma types, are possible which depend largely on the activity of volatile substances--S, O, C, H. (4) A relatively small amount of ferro-granite might be produced by liquid immiscibility. (5) Ultrabasic (ferro-kimberlitic) ash may be a very important constituent of the Martial soil--especially if cosmological models concerning accretion of volatile material within Mars are correct. Thus, kimberlitic volcanism may have been major process on Mars.