"ON THE INTERNAL DYNAMICS OF THE MOON" S.K. Runcorn,

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Three lines of evidence concerning the internal dynamics of the Moon have emerged during the Apollo programme which challenge comparison with what is known about the Earth (and Mars)

(1) present internal activity in the Moon: the occurrence of moonquakes and the phenomenon of lunar transient events.

(2) evolution of its internal constitution: the lava now proved to originate internally in a former lunar "asthenosphere", the chemical differentation required to separate the "anorthositic" highlands.

(3) its thermal evolution: the apparent absence of extensive volcanism in recent times, the thick lithosphere necessary to support the mascons.

By comparison with the Earth (1) is weak, (2) is fully comparable and (3) shows a great contrast in the last 3000 m.y. Very tentatively Mars appears intermediate between the Earth and Moon in respect of its internal dynamics.

One speculates that the differences between these three bodies is connected fundamentally with their sizes. Clearly if temperature, rather than pressure or composition is the critical parameter differentiating between a rigid solid behaviour over the lifetime of the body and a fluid of very high viscosity, then the difference in the thicknesses of their rigid lithospheres must arise from them having different vertical temperature gradients. This is easily explained on a common thermal model with comparable density of heat source per unit volume and the different ratios of surface area to volume.

The non-hydrostatic figures of the Moon (and of the Earth and Mars) - or at least the lower harmonic components - have been postulated to result from convection below the lithosphere. For the Moon two pieces of evidence for this hypothesis are compelling:

(1) the discrepancy between the ellipticity of the best fitting second harmonic surfaces and the dynamical ellipticity, which demonstrates the existence of internal density differences with angle.

(2) the agreement between the ellipticities of the highlands' surface and the much later lava surfaces of the maria, which show the present non-hydrostatic shape to have been produced subsequent to the filling of the maria basins, requires a mechanism which can, like convection, change its pattern in time.

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Hydrostatic head arguments (after J.A. Wood) can account for the excess (about 1.5 km) filling of the circular maria resulting in the mascons. The discovery in the geometrical libration data of a systematic height difference between the surfaces of the irregular and circular maria, shows that the latter have fallen 1.5 km in 3000 m.y. Thus a cylindrical fault system extending through the lithosphere must surround the circular maria. Potential energy is therefore released at the average rate of 10^{18} erg/y adequate to explain the moonquakes. The clustering of the locations of lunar transient events around the circular maria are also thus explained.

The remanent magnetization of the lunar lavas, discovered in the Apollo samples, and the highlands, inferred from the subsatellites, requires the presence of a lunar magnetic field of internal origin. Determinations of its intensity will decide between the alternative theories of a dynamo in an iron core which through decay of the heat sources has ceased to operate in the last 3000 m.y. and the Urey-Runcorn theory of a permanent magnetization of a undifferentiated Moon acquired from an early solar system magnetic field, now destroyed by the heating of the deep interior above the Curie point.

The thermal convection model of the Moon inevitably entails a rigid lithosphere which thickens with time. Thus the absence of any phenomenon remotely comparable with continental drift is understandable in the decipherable history of the lunar surface, but very early large horizontal displacements of the crust may have occurred, and the asymmetry of the near and far sides of the Moon may be explainable on this hypothesis.

The further analysis of global surveys is crucial to many of the problems discussed. For example, determination of the small dipole field of the Moon could give information concerning the distribution of crustal magnetization. This might be determined from the long period of Explorer 35 data. Possible further polar orbiter magnetic field data might enable the global variation of magnetization direction to be determined.