THE INTERPRETATION OF LUNAR PALAEOMAGNETIC DIRECTIONS. S.K.Runcorn, Institute of Lunar and Planetary Sciences, School of Physics, The University, Newcastle upon Tyne, NE1 7RU, England.

It has been long argued that the varied evidence of lunar palaeomagnetism, viewed in toto, can best be interpreted on the hypothesis that the Moon possessed an early magnetic field generated by a dynamo process in a small iron core(1). The dependance of palaeointensity values on age gives strong support to this interpretation (2). Recently, successful determinations of palaeomagnetic directions of large areas of crustal layers provides a crucial test for this hypothesis (3) as the dominance of the Coriolis force in the magnetohydrodynamic equations of the core leads to the conclusion that the ancient field would have been a dipole along the axis of rotation (4). However, the liklehood that changes in the orientation of the Moon with respect to its rotation axis occurred in the early history as a consequence of changes in the axes of inertia due to basin formation and later flooding must be taken into account (5)(6).

The modelling of the 3 component magnetometer data of the Apollo 15 and 16 subsatellites demonstrates a considerable degree of uniformity, on the scale of 100 km, in the directions of magnetization of near surface strata, as does the magnetic anomaly surveys from the electron reflection data.

Empirically the pole positions calculated from the directions of magnetizations falls into three sets, each having antipodal groupings of poles, but with markedly different axes. The sources of the 3 sets are (a) the central and eastern far side, (b) the central and eastern near side except for 2 sources in (c) and western far side, (c) Oceanus Procellarum and sources at 12°E and south of Mare Crisium. The intensities of magnetization of the returned lava specimens are less than those of breccia and the thin flows in Oceanus Procellarum and the exceedingly thin and enigmatic light covering known as Reiner γ , are not plausible as sources of the observed magnetic anomalies at the heights of the subsatellite. It was suggested by Strangway (7) that the large anomalies on the central far side were due to breccia ejected from impacts. The anomalies in Oceanus Procellarum are, therefore, attributed to the Fra Mauro formation - ejecta from the Mare Imbrium collision. By analogy, the magnetic anomaly just south of Mare Crisium is attributed to the ejecta from that impact. The similarity in the age of these impacts (about 3.82 by) is, therefore, the date of the pole positions (c). The set (b) include sites just north of Mare Nectaris and by analogy are interpreted as magnetization of ejecta from the Nectarian impact.

TABLE

	Mean pole positions		95% circles of confidence	Age
(a)	2°N	289°E	59°	Pre-Nectarian
	19°N	90°E	49°	
(b)	50°N	332°E	20°	Lower Nectarian
	51°S	166°E	56°	
(c)	48°S	341°E	23°	Upper Nectarian and Imbrium
	38°N	177°E	8°	

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Hood (8) in his paper determining the directions of magnetization of the sources on the lunar near side and on the far side has come to a different conclusion, which is that the magnetizations are randomly distributed and may be due to impact processes. He reaches this conclusion because he does not attempt to separate pole positions according to age. However, significance of the antipodal grouping of poles is clear: that the axis depends on age is a fundamental palaeomagnetic principle. Thus the antipodal grouping of poles about an axis is a prima facie case for saying they are of the same age.

The palaeoequators corresponding to the mean poles of (b) and (c) have a most significant relationship with the multi ring basins on the near and far side. The palaeoequator (b) is close to Mare Humorum, Nectaris and all the multi ring basins on the far side of lower Nectarian age, as dated by Wilhelms (9). The palaeoequator (c) runs close to the last great impacts which produced Mare Imbrium, Serenitatis, Crisium and Orientale and the only multi ring basin on the far side Schrödinger of Imbrium age.

It can be simply shown that the creation of a large basin, penetrating the anorthositic highland crust will, if the impact is in low latitude, cause polar displacements tending to move the basins into higher latitude, provided that solid state creep below the lithosphere enables the known hydrostatic equatorial bulge to continually re-adjust so that it remains perpendicular to the axis of rotation. It is clear that this mechanism implies a relatively thin lithosphere and an interior in which solid state creep is the significant mechanical behaviour in the long term. It is also clear that the present non-hydrostatic second degree harmonic in the lunar figure could not then have been present: this argues in favour of its explanation in terms of solid state convection (10) rather than a primeval distortion (e.g. a fossil tide) retained by the finite strength of the interior.

The low palaeo-latitudes of the multi ring basins imply that the Moon collided, as it moved away from the Earth as a result of tidal friction, with small moons orbiting exactly in the Moon's orbital plane.

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