LETTERS TO THE EDITOR

ASTRONOMY

A Case for Convection in the Moon

MODERN workers are agreed that the Moon has a small bulge, measured with reference to the mean radius of the limb, pointing in the direction of the Earth. The order of magnitude of this body-elongation is 0·1 per cent of the radius, but the actual value assigned to it depends quite critically on the selection of measured points used in the analysis.

A recent re-determination of the height of the bulge has been made by Baldwin[1], who separated points lying in the dark regions (excluding the deep, circular maria) from those of the bright regions (excluding the high mountains) and found values of about 1·2 km and 2·0 km, respectively. Conceding that the bulge is not significantly different in the low continents and in the irregular maria it seems that an explanation involving widespread uniformity of stress must be sought. For this reason I shall not detail the suggestion of Jeffreys[2], that the bulge was due to "irregular changes arising after solidification", or of Urey[3], that it was built up as a net deposit from differential impacts. Baldwin[1] has attributed the bulge to early tidal forces, while Runcorn[4] has proposed that currently operating convection cells keep the Moon's surface buoyed up as they rise in the centre of face.

The Moon's mechanical ellipticity, f, is found from observations to be at least 0·6 (cf. ref. 5). If the Moon had solidified as a synchronous satellite of the Earth the much smaller value $f=0{\cdot}25$ would obtain[6]; hence it is difficult to believe that the bulge can be a fossil tide raised by the Earth. Baldwin[1] has postulated that the bulge was indeed raised when the Moon was a synchronous satellite bound close to the Earth, but that "the theoretical value of $f=0{\cdot}25$ is more or less completely masked by the larger surface variations".

Yet on Baldwin's theory the original bulge formed more than 4×10^9 yr ago and, as the bulge is still present in the maria, their surfaces, too, must be very old. This seems to me to be a serious objection to the theory, for I find it difficult to believe that so few impact craters have formed in the maria in 4×10^9 yr. With different (I consider more realistic) assumptions about the rate of crater growth, based on crater-counts, I have found[7] that even the oldest maria are but one-seventh as old as the continents. It therefore seems to be at least equally reasonable to suppose that no mare is older than 7×10^8 yr. On this hypothesis the Moon would be little nearer to the Earth, when the maria were formed, than it is to-day; and the observed bulge in the maria could not have been raised by the appropriately weak value of the Earth's attraction.

Runcorn's convection theory[4] provides a solution to this problem : the general form of the bulge would be similar in the continents and in the maria if they were uplifted uniformly by rising convection currents. Regional isostatic adjustments could occur, as in the case of Baldwin's theory. There are, moreover, additional reasons for advocating a convection theory.

First, convection currents provide a means of carrying heat to the surface, and they would assist the mare melting and the Moon's differentiation that many authors advocate. Secondly, it is important to find an explanation for the remarkably uniform system of strike-slip faults[8] that traverse the Moon's face. A triaxial Moon adjusting to the equipotential shape is inadequate to explain this lunar grid system. Tidal forces are also unlikely to have been responsible unless, possibly, the Moon was warm at the time[9]. However, specially oriented, low-order convection cells would exert a drag on the crustal layers of the Moon, and the drag at any point would be fixed in direction for a very long period of time and, specifically, during the recent era of lunar history. In principle, this mechanism is capable of providing an explanation of the grid system.

Urey[10] has suggested that the lunar continents are between $3{\cdot}0\times10^9$ and $4{\cdot}5\times10^9$ yr old. I have estimated[7] that Mare Imbrium is only 1/19th of the age of the continents, so Mare Imbrium may have an age of 2×10^8 yr. Mare Frigoris appears to be of the same order of age[7]. The 'Frigorim Fault'[11] links Mare Imbrium and Mare Frigoris. It appears to be the longest strike-slip fault on the Moon, and has an offset of 200 km. It cannot be traced in the maria themselves, so it must be at least as old as they are ; hence the maximum rate of movement along this major fault has been $\sim0{\cdot}1$ cm yr^{-1}. This figure is not in conflict with Runcorn's estimate[12] of $\sim0{\cdot}2$ cm yr^{-1} for the rate of creep of the lunar convection currents.

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RADIO ASTRONOMY

Spectra of the Galactic Radio Emissions

RECENT observations of the spectra of the galactic emissions in the 1–10-Mc/s frequency range using satellite, rocket and ground-based receivers have produced apparently conflicting results[1–4].

The disagreement may be due partly to the difficulty of calculating the antenna efficiency in the ionospheric plasma for the orbital receivers, although the spectra obtained in the different ways have not been directly comparable since the low-resolution antennæ used above the ionosphere have looked at different areas of the sky from those surveyed from the ground. High-resolution studies[5], for example, have shown pronounced absorption within the galaxy, depending on galactic latitude and with an angular scale smaller than the beamwidth of the antennæ used for spectral observations. Below 3 Mc/s the absorption can be seen in the high-resolution profiles right out to the galactic pole[6].

It is suggested here that low-resolution spectra are meaningful only for directions near the poles where the brightness distribution is fairly uniform. The previously published ground observations did not meet this requirement since they were given for directions where the observed intensities were greatest and least during the right ascension scan. These directions were declination −42°, R.A. 2000 and R.A. 0400 h respectively. That is, galactic latitudes 30° and 45°, longitudes 325° and 214°. The subsequent high-resolution surveys showed consider-