LETTERS TO THE EDITOR

ASTRONOMY

Origin of the Mare Imbrium

G. K. GILBERT[1] proposed that a large-scale collision occurred in Mare Imbrium and this hypothesis has been supported by R. B. Baldwin[2] and, ardently, by H. C. Urey[3]. Other authors, however, have preferred to explain the radial symmetry without resort to dualism. Thus, Tomkins[4], Spurr[5], Kuiper[6] and von Bülow[7] considered that parts of the radial system were produced by faulting.

When details of the lunar surface are considered, it appears that there is no clear evidence that a collision ever occurred in Mare Imbrium. The rock-striæ, which are roughly radially orientated with respect to Mare Imbrium, and which Gilbert[1] considered to be of a 'pasty' material which had splashed out from the supposed collision centre, are nothing less than portions of the walls of much-eroded craters. This conclusion is based on protracted visual observations which I have made at various observatories, and especially at the Pic-du-Midi Observatory. It follows that these ridges cannot be splash-deposits. Furthermore, the forms of some of the ridges in question are such that they cannot have been cut from pre-existing crater walls by the action of any projectiles which may have been ejected from Mare Imbrium. I have illustrated this point by a photograph[8].

Additional evidence, which is strongly against the collision hypothesis, has now been assembled. This is based on measurements of the orthogonal axes of craters in fields near the centre of the Moon's disk and crossed by the striæ which are generally associated with Mare Imbrium. One of the axes was chosen so as to lie approximately parallel to the most prominent family of striæ. The ellipticities, Π, of 590 craters in the Vaporum and Hipparchus regions of the Moon have been computed, after application of curvature corrections to the measured axes x, y, according to the equation:

$$\Pi = 1 - x/y \qquad (1)$$

It was found that the craters were distorted preferentially, their longer axes most frequently lying parallel to the striæ which are under discussion.

Craters were divided into different size-groups and into two or three age-groups. The relative age of a crater was decided by combining characteristics such as the ease of recognition of a crater and the height or degree of erosion of its walls; but not by considering the degree of distortion of its walls. When three age-groups were considered it was found that independent observers never mixed the old and the young craters. Those in the intermediate age-group were confused with those in one or other of the age-groups in only 18 per cent of the cases.

Some results have been published already[9]: these are now compared with additional data in Table 1. Two important conclusions may be drawn from the figures displayed in Table 1: (i) the mean percentage ellipticities of the craters generally increase, in a given area on the Moon, with the age of the craters; (ii) the craters of a given group generally show higher ellipticities in the Vaporum region than in the Hipparchus region of the Moon.

Table 1

Range of diameter (km.)	Vaporum region mean Π (per cent)		Hipparchus region mean Π (per cent)		
	Young	Old	Young	Intermediate	Old
0–20	6	17	1	8	6
20–40	5	17	1	8	8
40–60	2	15	5	6	9

The first result leads to the conclusion that the craters were distorted from their original, nearly circular shapes by certain stresses in the Moon's 'crust', and that these stresses acted for a longer time on an old crater than on a young crater. It follows that the system of striæ which is radial to Mare Imbrium cannot have been produced by a sudden catastrophe.

As the Vaporum region is closer to Mare Imbrium than the Hipparchus region, result (ii) might indicate that the crustal stresses which produced the distortions of the craters are in some way to be associated with the formation of Mare Imbrium. It therefore appears most plausible to assume that Mare Imbrium itself formed over a very long interval of time.

Further details of this work will appear in *Planetary and Space Science*. I am indebted to Imperial Chemical Industries for a research fellowship.

GILBERT FIELDER

University of London Observatory,
Mill Hill Park, London, N.W.7.

1 Gilbert, G. K., *Bull. Phil. Soc. Wash.*, **12**, 241 (1893).
2 Baldwin, R. B., *Pop. Astron.*, **50**, 365 (1942); **51**, 117 (1943). *The Face of the Moon* (Univ. Chicago Press, 1949).
3 Urey, H. C., *The Planets*, Chapter 2 (Oxf. Univ. Press, 1952). *Sky and Tel.*, **15**, 108 and 161 (1956); *Z. Phys. Chem.*, *N.F.*, **16**, 346 (1958); *Endeavour*, **19**, 87 (1960).
4 Tomkins, H. G., *J. Brit. Astro. Assoc.*, **18**, 125 (1907).
5 Spurr, J. E., *Geology applied to Selenology*, **1** and **2** (Science Press, 1944).
6 Kuiper, G. P., *Proc. U.S. Nat. Acad. Sci.*, **40**, 1096 (1954).
7 Bülow, K. von, *Geologie*, **6**, 565 (1957); *Abh. dtsch. Akad. Wiss.*, Klasse 3, **1**, 332 (1960).
8 Fielder, G., *Structure of the Moon's Surface*, Chapter 11 (Pergamon Press, London and New York, 1961).
9 Fielder, G., *Plant and Space Sci.*, **8**, 1 (1961).

RADIOPHYSICS

Extra-Galactic Radio Emission at 4·8 Mc./s.

THE lowest radio frequency at which extensive observations of cosmic radio noise have been made is 19·7 Mc./s. (ref. 1). These showed that, by comparison with similar pencil beam observations at 85·5 Mc./s. (ref. 2), there are significant differences in the pattern of sky brightness and in the appearance of the discrete sources. At the lower frequency, for example, there is greater absorption of the radiation in galactic ionized hydrogen, while the coronal structure of some radio galaxies such as Centaurus *A* (*NGC* 5128) appears to be more extensive.

Much greater spectral effects due to absorption and in addition to changes in the emission process[3,4] may be expected at still lower frequencies, and the further exploration of the cosmic radio noise spectrum is likely to produce important information about the properties of the interstellar and intergalactic gas.