ASTROPHYSICS

Megashatter Cone Hypothesis of the Origin of Lunar Volcanoes

I BELONG to the school that interprets the main observable lunar topographical features as the result of impacts with asteroids and comets. To proponents of this belief, a stunning blow was delivered in 1959 when Kuiper¹ exhibited, during a space symposium in Washington, his beautiful pictures of small features that just could not be impact explosion craters. The discovery of release of carbon dioxide gas also strengthened the picture of some internal lunar feature through which gas could be released.

Now another possibility occurs that the lunar volcanoes are not volcanoes at all, but extremely large shatter cones (which will be referred to as megacones or megamegacones) produced by the shock-waves resulting from impact of an asteroid. These would appear as stumps in the central uplifts of very ancient eroded lunar craters, namely, lunar astroblemes. Dietz² has found terrestrial shatter cones as large as 6 ft. long in the Kentland, Indiana, 'cryptovolcanic' structure. He proposed the term 'astrobleme' for features of the Kentland type.

It is proposed that megacones of extremely large size exist and that these are composed of the smaller groups of shatter cones discussed in refs. 3 and 4. It is proposed that the roots of a central uplift in a crater formed by a large impact explosion produced by a nickel-iron asteroid consist of a megamegacone in turn composed of many concentrically arranged megacones all originally pointing upwards and inward toward the centre of impact. Most of these will have been almost instantly blown outward leaving a centre region filled with explosion breccia and/or devitrified impact glass. If glass is present, it will undoubtedly contain small spherulites of nickel-iron vapour.

The rebound after impact will lift up this root structure a considerable distance; however, it would always remain below the original lunar surface. Hydrodynamic forces resulting from the melting of the original ground-mass under extreme pressure and plastic flow of breccia dust produced would also tend to force the cone structure upward and outward. This megamegacone structure would then consist of somewhat tilted megacones with vertically up-ended ground-mass and breccia filling the voids between megacones during the original uplift.

After a couple of billion years one would expect that erosion of the uncompressed shattered matter around the stronger megacones would be removed as dust by methods as proposed by Gold⁵ for a few craters at least. Shock of later impacts might also tend to unearth the buried compressed megacones by scattering the enclosing dust and exposing the volcano-shaped structure. A crater-like centre might be present in the original megamegacone because of the upward and outward thrust of its megacone components and the shape charge type of ejection of matter from the final rest point of the asteroid. If the volcano-like lunar structures are megacones, then their geometry may be a clue to their mineralogical composition and to the general selenology of the Moon. If the subsurface features of the Moon are largely strained, compressed, cone-like buried structures, then the shallow seismic effects of these regions may be predicted by a study of similar terrestrial features. Sharp, shattered rocks would be expected to be present near megacones because of gradual flaking from the compressed material resulting in the

well-known small shatter-cone shapes and dust. The shattered nature of lunar astroblemes would probably promote faster dust formation by action of the extreme variations of temperature during lunar day and night than by the radiation damage mechanism proposed in ref. 5.

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³ Dietz, R. S., *J. Geol.*, **67**, 496 (1959).

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Sun-Earth Relations and Associated Periodicities

PERIODICITIES of less than 27 days in geophysical disturbance data have been investigated for many years, with inconclusive results, due to inherent difficulties in determining the statistical significance of the computations. However, there is now an increasing amount of evidence, arising from the examination of independent data samples, to support the existence of such periodicities. Some of the recent evidence is summarized here.

Auto-correlation of the 3-hourly magnetic planetary index a_p , during short moderately disturbed intervals in 1952, disclosed periods of from one to four days¹. Moreover, the times of occurrence of magnetic impulses seemed to be closely connected with the amplitude of these periodicities, and with changes from one periodicity to another.

Ward² computed the variance spectrum of the daily C_t , K_p , and A_p indices for some portions of 1941-56, and found periods of $27/n$ days, with $n = 1, 2, 3, 4, 5$ and 6. No interpretation of the overtones of the 27-day period was given.

An examination has been made of the time separation, ΔT , between 817 magnetic impulses occurring during 1949-59. Intervals of up to 70 days were tabulated. The declining portion of the sunspot cycle, 1949-54, shows maxima in the number of occurrences $N(\Delta T)$ at about the period of solar rotation. Similar maxima do not occur in $N(\Delta T)$ during 1955-59. The same data were examined for higher frequencies, using a one-day running average. During 1949-54, in addition to the solar rotation maxima, other maxima in $N(\Delta T)$ occur at multiples of about $3\frac{1}{2}$ days. Similar maxima during 1955-59 occur at multiples of about 3 days (Fig. 1). This periodicity in $N(\Delta T)$ was

Fig. 1. The time separation ΔT between magnetic impulses, 1955-59