

Flux of Micrometeoroids: Lunar Sample Analyses Compared with Flux Model

From an analysis of trace element abundances in lunar soils, the influx of meteoritic mass into the lunar surface has recently been estimated by Keays *et al.* (1) as $3.8 \times 10^{-9} \text{ g cm}^{-2} \text{ yr}^{-1}$ and later by Ganapathy *et al.* (2) as $4 \times 10^{-9} \text{ g cm}^{-2} \text{ yr}^{-1}$. I shall show in this note that these numbers are in agreement with independent estimates of the mass distribution for cometary meteoroids.

Using the results of satellite penetration measurements and ground observation of meteors, I have recently derived a best estimate of the meteoroid mass distribution (3). Accordingly, the flux of meteoroids into the earth's atmosphere per square meter per second per 2π sterad in the mass range from m to $m + dm$ kg is given by

$$\begin{aligned} f(m)dm &= Am^{-\alpha} dm \quad (m \geq \mu) \\ f(m)dm &= A\mu^{-\alpha+\beta} m^{-\beta} dm \quad (m \leq \mu) \end{aligned} \quad (1)$$

where A is the flux density of particles with unit mass; α, β are the slopes, on a plot of logarithm flux versus logarithm mass, for masses larger or smaller than μ , respectively. Their numerical values are

$$A = 3 \times 10^{-18} \text{ (kg)}^{\alpha-1}, \quad \alpha = 13/6, \beta = 1.5 \quad (2)$$

An uncertainty of half an order of magnitude may be present in A .

Using measurements collected by the Pioneer 8 and Pioneer 9 cosmic dust detectors, Berg and Gerloff (4) found that the cumulative deep space flux of micrometeoroids having masses of $5 \times 10^{-15} \text{ kg}$ or greater is $2 \times 10^{-4} \text{ m}^{-2} \text{ sec}^{-1} (2\pi \text{ sterad})^{-1}$. If one uses the Pioneer velocity measurements for eight micrometeoroids, a gravitational focusing factor (5) for the earth of 1.9 is obtained, which agrees well with the value of 1.8 that I obtained from photographic meteors (6). For the moon, these factors are 1.04 for micrometeoroids and 1.03 for photographic meteors.

When appropriate focusing factors for the Pioneer results are used, it follows that a choice of

$$\mu = 10^{-10} \text{ kg} \quad (3)$$

will produce a match between the Pioneer data and Eq. 1.

We can now calculate the influx of meteoritic mass $\dot{M}$ grams per square centimeter per year caused by micrometeoroids:

$$\dot{M} = \int_0^{\infty} f(m)m dm \quad (4)$$

When Eqs. 1, 2, 3, and 4 and the appropriate focusing factors are used, it is readily shown that, for the moon,

$$\dot{M} = 2.0 \times 10^{-9} \text{ g cm}^{-2} \text{ yr}^{-1} \quad (5)$$

which is slightly lower than the independent estimates of 3.8×10^{-9} by Keays *et al.* (1) and 4×10^{-9} by Ganapathy *et al.* (2). From Eqs. 1, 2, and 4 it can easily be shown that the dominant term in $\dot{M}$ is proportional to $\mu^{-1/6}$ and is, therefore, not sensitive to modest changes in μ . In view of the uncertainties involved, the estimate for $\dot{M}$, Eq. 5, and the estimates by Keays *et al.* and Ganapathy *et al.* (1) and Ganapathy *et al.* (2) are surprisingly close.

Relation of Sunspot and Earthquake Activity

Recent evidence presented by Challinor (1) points to a probable link between the rotation rate of the earth and the activity of the sun, the mechanism operating through the effect of solar activity on the earth's atmosphere. There is also a more tenuous link relating changes in the rotation rate of the earth with the frequency of occurrence of earthquakes (1, 2).

Challinor dismisses as implausible the hypothesis that both these links could be real on the grounds that this would imply a link between solar activity and the frequency of occurrence of earthquakes. But if the link between sunspot occurrence and the change in the earth's rotation rate is indeed real, producing the sudden increase in the rate of change of the mean annual length of the day reported by Challinor, it would seem entirely plausible that the strains in the earth's interior that would arise

We may, therefore, conclude that the influx of meteoritic mass into the lunar surface obtained from the analysis of trace elements in lunar samples (1, 2) can be explained by our present knowledge of the micrometeoroid distribution at 1 astronomical unit from the sun. The present influx of micrometeoritic mass into the lunar surface, based on recent estimates, is consistent with a relatively constant mass flux of micrometeoroids over the last 3.6 billion years.

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could trigger regions of instability into earthquake activity.

In this way, both earthquakes and sunspot activity can be linked to the variations in the rate of rotation of the earth, but the earthquakes are caused by the change in rotation rather than the change being caused by the earthquakes. One might even speculate that the San Andreas fault, now overdue for a major slippage according to some authors (3), might be triggered in this way in the late 1970's or early 1980's, shortly after the next period of maximum solar activity.

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