THE ANCIENT MICROMETEORITE FLUX. R.S. Rajan*, D. E. Brownlee** and F. Hörz***.
*Div. of Geological and Planetary Sciences, Calif. Institute of Technology, Pasadena, CA 94720. **Dept. of Astronomy, Univ. of Washington, Seattle, WA 98195. ***Geology Branch Johnson Space Center, Houston, TX 77058.

It is possible to detect long term variations in the micrometeoroid complex by analysis of solar flare tracks and micrometeorite craters on surfaces extracted from lunar and meteoritic breccias. Gas-rich meteorites provide surfaces which were exposed to micrometeoroids and solar flare particles for a short period some time in the interval beginning with the dissipation of the solar nebula and ending probably about 4 b.y. ago. Unmetamorphosed lunar breccias potentially are capable of providing surfaces exposed for varying intervals over the past 4 b.y.

On exposed surfaces, measurement of the ratio of crater density to solar flare track density yields a determination of the micrometeoroid flux. The uncertainties in this process are exposure geometry, track fading and possible long term changes in the flux of solar flare particles. In spite of these problems, however, it appears possible to measure the ancient micrometeoroid flux with order of magnitude accuracy on unmetamorphosed surfaces exposed in the distant past. Additional information on the ancient meteoritic complex can be gained by measurement of crater size frequency and analysis of crater morphology. The size frequency can be converted to a meteoroid size distribution and crater shapes can be used to determine certain physical particle perameters such as shape and density. Crater depths can also be used to obtain a crude estimate of impact velocity.

To date microcraters have been found on glass spheres extracted from the gas-rich howardite Kapoeta, from the low grade (1) lunar breccia 15086 and tentatively from the howardite Malvern. Analysis of craters and solar flare tracks in kapoeta indicates that, at the time gas-rich meteorites formed, the micrometeoroid complex was very similar to that observed today. The flux, size distribution and physical particle properties appear to have been roughly equivalent to similar parameters of contemporary micrometeoroids as implied by analysis of craters on lunar surfaces with recent exposure histories. A similar but some what tentative conclusion is reached from analysis of green glass spheres from 15086. Craters on 15086 are morphologically similar to modern craters indicating roughly similar particle shapes and densities. Although detailed track work has not been done on cratered spheres, statistical comparison with other analyzed spheres from 15086 implies an order of magnitude agreement between the modern micrometeoroid flux and that when 15086 was formed. A key problem in determining the evolutionary history of the micrometeoroid complex is the ability to determine when surfaces inside an ancient breccia were actually exposed. The ^{40}Ar-^{39}Ar age for the green glass spheres is 3.4 b.y. (2), but presently this age can only be considered an upper limit for the time at which the craters on 15086 were formed. There is a real difficulty for low grade lunar breccias in that while "educated-estimates" can be made of the time of compaction, in reality only upper limits can be established. On the other hand, meteoritic breccias appear to have had much simpler histories and it seems very probable that dating their glass component may date the time of compaction. At the present time an ^{40}Ar-^{39}Ar age is being

THE ANCIENT MICROMETEORITE FLUX.

Rajan, R.S. et al

determined for glass from Kapoeta and Malvern.

Detection of time variations in the micrometeoroid complex is of considerable interest in the light of influences which could have caused past changes. The microparticle complex in the inner solar system is a quasi-stable system in which particle lifetimes on the order of 10^4-10^5 years necessitate a constant supply of new material in order to maintain stability. There is considerable (although not conclusive) evidence that the major particle source at the present time is short period (SP) comets. Collisions (3) and the fact that particle lifetimes are longer than SP comet lifetimes tend to stabilize the number of particles in the solar system. However, fluctuations on the order of a factor of 10 can be expected due to the uneven rate of production of SP comets capable of putting particles with bound orbits into the inner solar system. In addition to these relatively short term fluctuations (millions of years) it is also possible that the rate of comet ejection into the inner solar system has undergone a long term secular change due to a general depletion of the Sun's comet inventory. Nezhinskij (4) has shown that as a result of stellar perturbations the half-life of the comet cloud is approximately 1 b.y.

Flux changes in the past can also be expected because of large fluctuations in the density of interstellar grains in the solar system. Micrometeorite experiments on Pioneer 8/9 (5) have shown that a non-negligible fraction of interplanetary particles have hyperbolic orbits and are interstellar in origin. Because of the highly nonuniform distribution of dust in the Galaxy it is not unreasonable to expect that, several times during the past 4.6 b.y., the particle contribution by the interstellar medium could have exceeded the contribution by SP comets.

A final effect of particular importance to the Moon is the enhancement of the particle flux at the time of formation of mare basins. An Imbrium sized cratering event could easily inject a mass of debris into solar orbit which would exceed Whipple's estimates (6) for the total mass of particulates in the solar system. Although the lifetime of this debris would be short, it does seem possible to find ancient breccias which would have recorded the enhanced micrometeoroid flux. Enhancements of this type would be easily distinguishable from enhancements due to comets or interstellar particles because debris from the earth-moon system would have Earth-like orbits and hence would re-impact the lunar surface at relatively low velocities (<10 km s^{-1}). Because of the lower impact velocity a suite of craters from this type of event would be systematically shallower than typical contemporary lunar craters.

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