N89-21292

THE CRATERING RECORD IN THE INNER SOLAR SYSTEM: IMPLICATIONS FOR EARTH; N. G. Barlow, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058.

Internal and external processes have reworked the Earth's surface throughout its history, destroying much information about the early conditions existing on our planet. In particular, the effect of meteorite impacts on the early history of the earth is lost due to fluvial, aeolian, volcanic and plate tectonic action. The cratering record on other inner solar system bodies often provides the only clue to the relative cratering rates and intensities that the earth has experienced throughout its history.

Of the five major bodies within the inner solar system, Mercury, Mars, and the Moon retain scars of an early episode of high impact rates. Large areas older than about 3.8 BY do not exist on the earth, and crater statistical studies of radar images indicate that large expanses of ancient terrains also are not common on Venus (1, 2). The heavily cratered regions on Mercury, Mars, and the Moon show crater size-frequency distribution curves similar in shape and crater density, whereas the lightly cratered plains on the Moon and Mars show distribution curves which, although similar to each other, are statistically different in shape and density from the more heavily cratered units (Fig. 1). These differences have been interpreted as indicators that different populations of impacting objects dominated during the heavy bombardment and post heavy bombardment periods (3). The impact rate during heavy bombardment was much higher and basin forming events were more common in this earlier period than today.

The similarities among crater size-frequency distribution curves for the Moon, Mercury, and Mars suggest that the entire inner solar system has been subjected to the two populations of impacting objects but Earth and Venus have lost their record of heavy bombardment impactors. Absolute age-crater density relationships established for the Moon place the end of heavy bombardment at about 3.8 BY ago (4), and this time horizon probably holds at least throughout the Earth-Moon system. Thus, based on the cratering record on the Moon, Mercury, and Mars, we can infer that the Earth experienced a period of high crater rates and basin formation prior to about 3.8 BY ago. The lack of evidence for life forms during and shortly after the period of heavy bombardment may be due at least in part to the hostile conditions existing at this time. Recent studies have linked mass extinctions to large terrestrial impacts (5), so life forms may have been unable to establish themselves until impact rates decreased substantially and terrestrial conditions became more benign.

The possible periodicity of mass extinctions has led to the theory of fluctuating impact rates due to comet showers in the post heavy bombardment period (6). The active erosional environment on the Earth complicates attempts to verify these showers by erasing geological evidence of older impact craters. Uncertainties in dating the existing impacts causes large error bars which tend to mask any alleged evidence of comet showers (7). The Moon displays few geologic units which formed less than 2.8 BY ago and studies of small craters superposed on young crater ejecta blankets also produce statistically questionable evidences for comet showers (8, 9). Mars exhibits a number of geologic units with varying crater densities, thus spanning various ages, and may provide the best information on fluctuations in the cratering record when absolute ages for these regions become available (10). Thus, at the present time evidence from the cratering record for the existence of comet showers is inconclusive.

The estimated size of the impactor purportedly responsible for the Cretaceous-Tertiary mass extinctions is 10 km in diameter (6). Using scaling relations for crater diameter versus impactor diameter (11), a 10 km diameter impactor would create a 440 km diameter crater on the moon and a 350 km diameter crater on Mars, assuming cometary density and impact velocity. No craters >200 km exist on the lunar mare and only 3 craters >300 km exist on the martian plains. Thus impactors greater than or equal to the size postulated for K-T impactor have been rare within the inner solar system since the end of heavy bombardment. Therefore mass mortalities caused by catastrophic impacts on the Earth should not be expected to be common events.

REFERENCES: (1) Basilevsky, A.T., et al. (1987). JGR, 92, 12869-12901. (2) Barlow, N.G. (1988). LPSC XIX, 34-35. (3) Woronow, A., et al. (1982). In Satellites of Jupiter, 237-276. (4) Soderblom, L.A., et al. (1974). Icarus, 22, 239-263. (5) Alvarez, L.W., et al. (1980). Science, 208, 1095-1105. (6) Hut, P., et al. (1987). (6) Hut, P., et al. (1987). Nature, 329, 118-126. Nature, 329, 118-126. (7) Grieve, R.A.F. (1984). JGR, 89, B403-B408. (8) Guinness, E.A. and Arvidson, R.E. (1977). Proc. Lunar Planet. Sci. Conf. 8th, 3475-3494. (9) Neukum, G. (1988). LPSC XIX, 850-851. (10) Barlow, N.G. (1988). Icarus, in press. (11) Holsapple, K.A. and Schmidt, R.M. (1982). JGR, 87, 1849-1870. (12) Basaltic Volcanism Study Project (1981). Basaltic Volcanism on the Terrestrial Planets, 1069-1081.

FIGURE 1