N89-18340

ABSOLUTE AGES FROM CRATER STATISTICS: USING RADIOMETRIC AGES OF MARTIAN SAMPLES FOR DETERMINING THE MARTIAN CRATERING CHRONOLOGY; G. Neukum, DFVLR Oberpfaffenhofen, Institute for Optoelectronics, Planetary Remote Sensing Section, 8031 Wessling, FRG

In the absence of dates derived from rock samples, impact crater frequencies are commonly used to date martian surface units (1-4). All models for absolute dating rely on the lunar cratering chronology (integrated cratering rate on the moon vs. elapsed time resp. age as derived by relating crater frequencies at the Apollo landing sites to radiometric ages of the lunar rocks from those sites) and on the validity of its extrapolation to martian conditions. Starting from somewhat different lunar chronologies, rather different martian cratering chronologies are found in the literature as discussed by (2,3). Currently favored models of (1) and (3,5) are compared in Fig. 1. The differences at old ages ($> 3.5 \cdot 10^9$ years) are insignificant, the differences at younger ages ($< 3.8 \cdot 10^9$ years) are considerable and give absolute ages for the same crater frequencies as different as a factor of 3. The total uncertainty could be much higher, though, since the ratio of lunar to martian cratering rate which is of basic importance in the models is believed to be known no better than within a factor of 2. Thus, it is of crucial importance for understanding the evolution of Mars and determining the sequence of events to establish an unambiguous martian cratering chronology from crater statistics in combination with clean radiometric ages of returned martian samples.

For the dating goal, rocks should be as pristine as possible from a geologically simple area with a (desirably) one-stage emplacement history of the local formation. We need as a minimum at least one highland site for old ages, two intermediate-aged sites (Lunae Planum age to northern plains ages), and one very young one (Tharsis volcanoes or young surrounding plains).

It is especially important, as seen in Fig. 2, to determine the knee in the chronology, where the high decaying post-accretional cratering rate bends over to a constant rate, i. e. between Early Hesperian and Early Amazonian time. The actual position in time of the transition from decaying flux to steady flux (if the analogy to the lunar case holds at all) determines whether Mars developed very rapidly in the beginning with e. g. fluvial activity concentrated very much in the interval 4 - 3 billion years ago, or whether there was prolonged activity possibly until very recently. All evolutionary models of the surface and atmosphere as discussed by (6,7,8) do critically depend on such age information on a global scale. Age information on a global scale through careful calibration of the martian cratering chronology is essential for understanding the history of chemical differentiation of Mars. Calibrating the martian cratering chronology for global absolute age measurements should be one of the prime goals of a Mars Rover/Sample Return mission.

Fig. 1: Comparison of Hartmann's (1981) and Neukum's (1981, 1983) martian cratering chronology models.

Fig. 2: Stratigraphic relationships and minimum radiometric age/crater frequency data points (circles) needed to establish the martian cratering chronology.

References

(1) Hartmann W.K. et al. (1981), in Basaltic Volcanism on the Terrestrial Planets (Pergamon Press), p. 1049-1127; (2) Neukum G. and Wise D.U.. (1976) Science 194, p. 1381-1387; (3) Neukum G. and Hiller K (1981) JGR, p. 3097-3121; (4) Tanaka K.L. (1986) Proc. 17th LPSC, JGR 91, p. E139-E158; (5) Neukum G. (1983) Habilitationsschrift Univ. of Munich; (6) Carr M. (1986) Icarus 68, p. 187-216; (7) Greeley R. (1987) Science 236, p. 1653-1654; (8) Kahn R. (1985) Icarus 62, p. 175-190.