MARTIAN CHRONOLOGY: NEW MARS GLOBAL SURVEYOR RESULTS ON ABSOLUTE CALIBRATION, GEOLOGICALLY YOUNG VOLCANISM, AND FLUVIAL EPISODES. W. K. Hartmann[1], J. A. Grier[1], D. C. Berman[1], W. Bottke[2;] B. Gladman[3], A. Morbidelli[3], J.-M. Petit[3]; and L. Dones[4]. [1]Planetary Science Institute, 620 N. 6th Avenue, Tucson, Arizona 85705, hartmann@psi.edu; [2]Cornell University, Center for Radiophysics & Space Resources, Ithaca, New York 14853; [3]Observatorie de Nice, BP 229, 06304 Nice, France; [4]Southwest Research Institute, 1050 Walnut St., Boulder, Colorado 80302.

We report new work on crater count chronology on various Martian units from Mars Global Surveyor (MGS) images. We have approached these data by starting with young features, especially young volcanic units. We have confirmed a moon-like crater size distribution on these, and thus we can estimate ages by estimating the current value of

$$R = [\text{craters/km}^2\text{-y on Mars}]/[\text{craters/km}^2\text{-y on moon}]$$

at a fixed crater diameter. Knowledge of R lets us estimate ages of specific units without circular arguments. Inferred ages are in proportion to 1/R. Hartmann [1] reviewed recent literature and estimated R = 1.6 with a factor 2 or 3 uncertainty. In Fall 1999, we organized a consortium involving W. Bottke, B. Gladman, L. Dones, A. Morbidelli, and J.-M. Petit) to review asteroid/comet dynamical data and improve this estimate. A subsequent review by Bottke suggests the value could be as low as 0.9, giving somewhat older Martian ages. We anticipate imminent progress in constraining R and hence Martian ages derived from crater counts.

There are several important implications. (1) While inferred Martian model ages have often been cited to 2 or 3 significant figures, only the first significant figure currently has value in absolute terms. (2) Inferred Martian surface unit ages in the range of 1 to 3 Ga have little value in terms of interpreting Martian geophysics, because we can't really be sure if the features formed in the last third or first third of Martian history. (3) Firm identification of volcanic units with crater densities less than 10% or 1% of the lunar mare values would be very important to Mars geophysics because it would establish geologically recent or contemporary Martian volcanism, independent of uncertainties in R.

Item 3 has been accomplished. MGS/MOC images show lava flow units in Amazonis Planitia and elsewhere with geologically young ages, around 100 My or less [1,2]. McEwen *et al.* [3] identified still younger lavas in Elysium Planitia for which Hartmann and Berman [4] have found a range of crater densities some well less than 1% of lunar mare values, with age estimates of the order 10 My. Elysium Planitia has flows of varying ages. We recently targeted a long moderate-resolution MGS/MOC image swath across Elysium Planitia (M09-02516), which extended and confirmed the earlier results, showing a well defined crater population at 40 m < D < 500 m, with less than 1% the lunar mare densities. On Olympus Mons, we find flows with a variety of crater densities and ages, but the youngest again have crater densities < 1% of lunar mare values. Some of these flows have probable ages of the order 10 Ma or less. Lavas of age 10 - 100 Ma are relatively rare on Mars; most lava plains have higher crater densities and older ages, probably of the order 1 Ga.

These results favor a relatively active Mars and are consistent with Martian basaltic meteorites' well-measured solidification ages of 1.3 Ga (one out of 3-5 impact sites), and other possibly younger igneous samples. The crater counts and meteorites rule out the widely applied early Martian chronology model of Neukum and Wise [5], which concluded that all Martian volcanism ended 2.6 Ga ago. Plausibly low values of R (around 0.6) would still be consistent with the younger of the two chronology models of Neukum and Hiller [6].

We are extending our work to investigate Martian channels and permafrost regions. We find evidence of episodes of ancient modification of the upper few hundred meters of surface, possibly by permafrost melting or partial melting. The second hematite area found in a large crater by the TES team clearly involved partial melting and collapse of crater fill material, ponding of water, and cutting of a canyon in the east wall, with drainage into Ares Vallis. Much of the Martian fluvial activity may be related to localized melting of permafrost due to geothermal heat sources. Such activity was more common in early Martian time and less common (but probably not non-existent) in more recent Amazonian time.

References:[1] Hartmann W. K. (1999) *Meteoritics & Planet. Sci.*, **34,** 167-177; [2] Hartmann, W. K. *et al.* (1999) *Nature*, **397,** 586-589; [3] McEwen A. S. *et al.* (1999), GSA abstract 30, No. 7; Hartmann W. K. and Berman D. C. (1999), submitted to *J. Geophys. Res.*; [5] Neukum G. and Wise D. (1976), *Science*, **194,** 1381-1387; Neukum G. and Hiller K. (1981), *J. Geophys. Res.*, **86,** 3097-3121

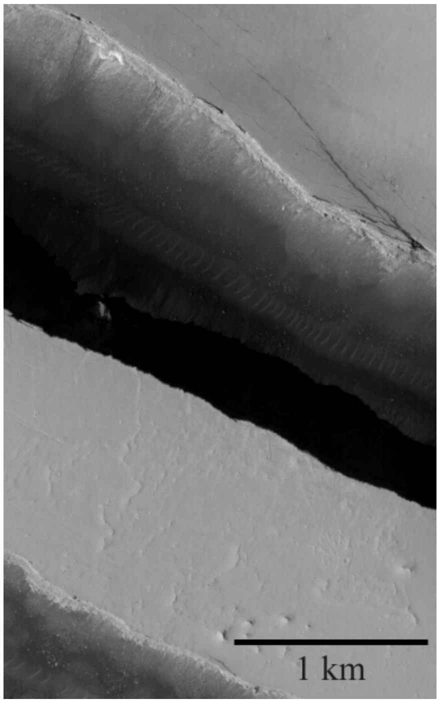

Figure 1. Portion of MGS/MOC image MO7-02347 showing the young, virtually uncratered surface in Elysium Planitia and the Cerberus Rupes faulted valleys. Note fractures suggesting incipient collapse and widening of the upper valley.

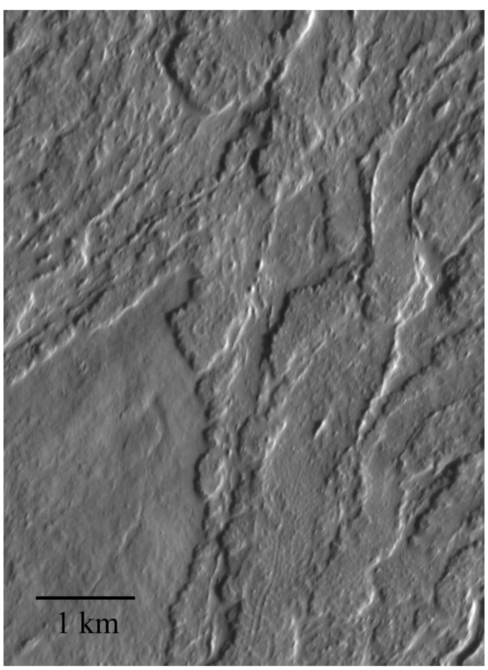

Figure 3. Portion of MGS/MOC image SPO02-41105. The youngest flows are virtually uncratered and geologically very recent.

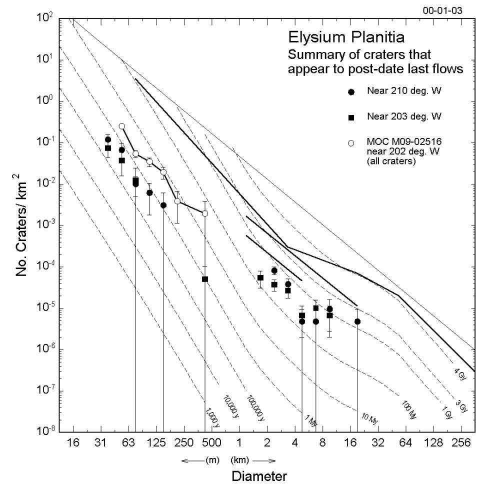

Figure 2. Crater counts (January 2000) on young lava flows in Elysium Planitia. M09-02516 is a strip 3 x 170 km across the plain; the counts averaged over the whole strip and include some slightly older units. The results suggest flows of various ages, including some with ages well less than 100 Ma and possibly less than 10 Ma. Isochron shapes are based on log average of Neukum and Hartmann production function shapes.

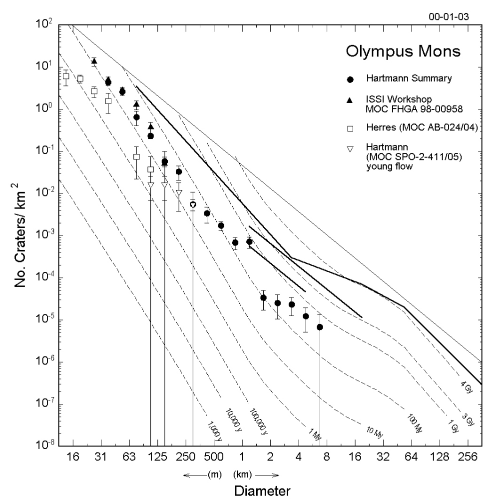

Figure 4. Crater counts (August 1999) on young lava flows on Olympus Mons. MGS/MOC images show overlapping flows of various ages. Small craters on uppermost flows suggest individual ages with ages well less than 100 Ma and possibly less than 10 Ma. Inverted triangles show counts from the region of Fig. 3.