# MARTIAN ATMOSPHERIC INTERACTION WITH BOLIDES: A TEST FOR AN ANCIENT DENSE MARTIAN ATMOSPHERE;

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The Magellan discovery of Venus' crater diameter distribution cutoff, due to atmospheric loss of small bolides, opens the door to using the size distribution of small Martian craters in ancient areas as a tool to search for the widely hypothesized, ancient, dense Martian atmosphere.

Melosh[1] looked at some aspects of this problem for the present Mars atmosphere, assuming ice, rock, and iron bolides. Under the assumptions of his calculations, he found that the smallest bolides to impact as effectively single bodies (making single or compound craters, instead of dispersed pits) were 66 to 24 m across, for a range of compositions from solid ice to iron, respectively. Thus, craters in dispersed clusters would be ≤ hundreds of meters across. However, this result assumed disruption of the bolide at 3 scale heights, and Melosh believes actual disruption for Mars would be much lower, meaning that dispersed clusters from these types of bolides would be much smaller, if visible at all (Melosh, private communication, 1994).

We have identified possible candidates for the fragmentation events in the form of isolated clusters of well-preserved craters. Individual pits in these clusters are typically hundreds of meters across and spread over 9 km (Fig. 1). These clusters have been noted previously by many workers (Barlow, Tanaka, private communications, 1993), but there has been little systematic study of them. They appear to have characteristics for breakup of very weak bodies, such as heavily fragmented, loosely bound icy cometary or carbonaceous bolides that have nearly zero tensile strength.

Existing work does not explain fully the variations in crater-cluster forms from planet to planet. Venus shows "cloverleaf" compound and misshapen craters; Earth shows quasi-elliptical fields of more isolated craters such as at Henbury; Mars shows tight clusters, rarely highly elliptical, according to our preliminary survey. The idea that Martian clusters might be limited to comet impacts presents an interesting opportunity to separate different types of impactors. At any rate, the existence of the Martian clusters encourages further application of Mars crater/atmosphere effects to problems of the planet itself.

The most important application is to use the crater size distribution to search for evidence of the widely hypothesized ancient dense Martian atmosphere, estimated by various workers at pressures as high as 100 or 1000 mb, or more.

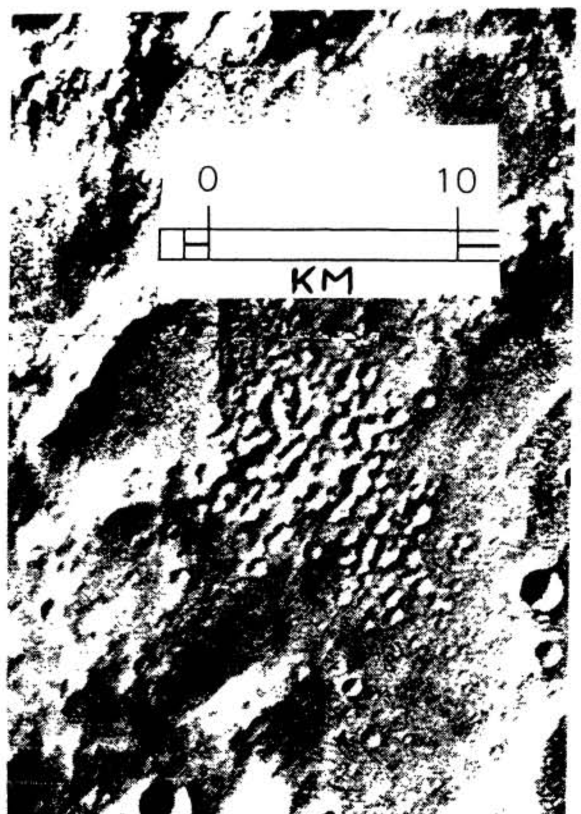


Fig. 1. Isolated crater cluster in the Ma'adim Vallis area of Mars. Such clusters may be signatures of atmospheric breakup of weak, cometary bolides.

## MARTIAN ATMOSPHERIC INTERACTION: Hartmann, W.K. and Engel, S.

We have completed new, preliminary calculations of the minimum sizes of bolides that would penetrate hypothetical Martian atmospheres. We let surface pressures range from 6 to 1000 mb, and assumed projectiles of various strengths (icy comets; carbonaceous bodies; coherent chondrites; irons). The calculations are based on a program kindly provided by Chris Chyba, as published by Chyba *et al.*[2], and modified for Mars by one of us (SE). The results are used to estimate the position and shape of the turndowns in the crater size distribution, according to assumed fractions of bolides of different composition. Figure 2 shows the results, and predicts an important result at larger crater sizes than might have been expected.

As pressure rises from 6 mb to 100-300 mb, icy and carbonaceous bolides are lost, but because these may amount to < half the total population, the total downturn from these losses may be < a factor 2, hard to detect in view of Martian erosion effects and statistical uncertainties in the counts. However, for an atmosphere greater than a few hundred mb, stony bolides would also break up, and a unique offset by a factor 20-30 would develop in the crater diameter distribution at D ~.5 to 4 km, due to loss of all but the rare iron bolides. This is shown in Fig. 2.

A careful search for this offset may allow us to detect evidence of a dense atmosphere during certain ancient time periods. This could put important constraints on some models of Martian history, such as models invoking ancient shorelines or global oceans in northern lowlands.

Subtraction of crater populations of younger areas from those of older areas would produce the diameter distributions created during specified early eras. Global detection of the predicted offset could establish the existence of a dense ancient atmosphere. Alternatively, failure to detect it could yield upper limits on the pressure of the atmosphere contemporaneous with the oldest surfaces. The main problem is to distinguish the predicted offset from erosional losses of ancient small craters; however the atmospheric effect would be global, while erosional losses could be local and variable; and the predicted offset is different in character than that predicted by Martian erosional models.

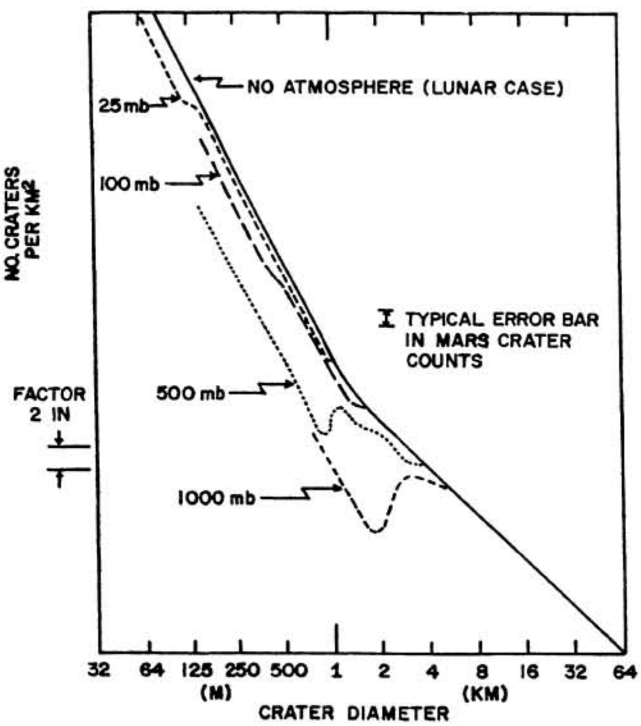


Fig. 2. Predicted shape of crater size distribution for different ancient Martian atmospheric surface pressures. A major kink appears at surface pressures >~300 mb (see text).

We are currently seeking support to refine the calculations and conduct the necessary search in the cratering records.

**References**
[1]Chyba, C. and others (1993) *Nature*, **361**, 40.
[2]Melosh, H. J. (1989) *Impact Cratering* (NY: Oxford U. Press).