

PSEUDOCRATERS AS INDICATORS OF GROUND ICE ON MARS

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In the search for reliable indicators of the past location of surface or near surface volatiles on Mars, pseudocraters (if they exist) would be of direct but limited use. We have previously suggested that the thousands of small (subkilometer) pitted cones which dot portions of the plains-forming units in northern Mars may be volcano-ice analogs of Icelandic pseudocraters (1,2), which on Earth form where lava flows over water or water-saturated ground (3). The steam explosion caused by this interaction is only marginally less efficient if (as is likely on Mars) ice is the volatile(4). Positive identification of martian pseudocraters would therefore be strong indication of past occurrence of ice at or near the surface of Mars.

The basis for suggesting that the small cones on Mars are pseudocraters includes: (a) small size, (b) abundant but patchy distribution on what appear to be volcanic plains, (c) presence of other features suggestive of surface or subsurface ice. (d) morphological similarities to Icelandic pseudocraters, and (e) the similarity in distribution of crater/cone diameter ratios to Icelandic pseudocraters(2). This last morphometric parameter may be the most important, since other possible small terrestrial volcanic analogs have very different crater/cone diameter ratio distributions(2). In a survey of the available high resolution Viking Orbiter imagery, abundant fields of possible pseudocraters were found in SE Acidalia Planitia, S Utopia-Elysium, W Isidis Planitia and, perhaps, near Hellas (2,5,6). However, only a small fraction of the plains-forming units imaged at high resolution (range ≤ 2000 km) were found to contain the small cones: of some 12,200 images searched we found subkilometer cones with central pits on less than 350 (<3%). This low discovery rate, combined with the limited high resolution imagery, restrict martian pseudocraters as global indicators of surface or subsurface ice.

There are only minor morphological differences between the subkilometer cones found in Acidalia and those found in Utopia-Elysium-Isidis; more striking is the variation in background terrain on which the cones are found. In Acidalia the cones are found on smooth plains of both uniform and mottled appearance but also on widespread fractured and subdued fractured plains (2,7). The fractured plains are of interest because they may themselves be indicators of ground ice(8). All the plains-forming units on which cones have been found also contain rampart craters, but there are regional differences in the size distributions of these craters which may be interesting (see below). In Acidalia there are general trends in the dimensional and distributional characteristics of the cones which seem to depend on background terrain: the younger plains (which are smooth, not fractured) have a higher density of cones, but the average cone diameter is lower (<700 m) than on the fractured plains (>700 m). Cones on subdued fractured plains (9), which are under-populated in impact craters at the smallest diameters and have soft, incomplete or interrupted fracture patterns, have the largest mean diameters observed and also the highest percentage of widest central craters. Preferential obscuration of small cones and decrease in the observed cone base diameter due to blanketing by dust seems likely (7).

This demonstrates another problem with using pseudocraters as indicators of ground ice on Mars: because of their small size they are easily removed or obscured by a variety of erosional processes.

Pseudocraters do have one important contribution to make to the study of the distribution of volatiles in the martian crust. Because of the way they form, they indicate the presence of only surface (or very near surface) ice over which relatively thin lava flows have been emplaced. If the lava flow is too thick, cones will not form as the work required to lift the overlying molten rock becomes greater than that available from the explosion. Likewise, if the ice is buried too deeply beneath an insulating layer, the heat from the lava flow may dissipate before sufficient volatilization of the buried ice occurs(4). Therefore the size of pseudocraters and their spatial density depends on a combination of lava flow thickness and temperature, depth to the ice layer and fraction of ice in mixed layers (soil and ice). Dense concentrations are favored by relatively thin flows over abundant ice close to the surface; more wide-spread groupings may indicate variations in flow thickness and/or the depth to the (top of the) ice layer.

It would be interesting to compare the spatial density of possible martian pseudocraters with the size frequency distribution of rampart craters (10,11,12,13). Not only could such comparisons help to define the thickness of the ice layer(14), but comparison of rampart and non-rampart crater populations with a varying density of pseudocraters could place temporal constraints on the longevity of the ice-rich layer. For example: in Utopia Planitia where widely scattered small cones occur, rampart craters are rare for diameters < 3 km, but for $D > 5$ km almost all craters have this structure. Perhaps the small craters formed largely after the near-surface ice vanished. By contrast the rampart craters found in the fractured plains in Acidalia occur at very small diameters in the regions where small cones exist.

Despite the sampling problem, the latitudinal distribution of martian pseudocraters and its comparison with other ice-related features is of interest. In Acidalia Planitia most of the small cones lie at latitudes greater than 38°N , ranging up to 50°N . We find no convincing evidence for such features below $\sim 35^{\circ}\text{N}$; however, there is very little high resolution imagery available. No small pitted ones are found in Chryse between 20 and 30°N , even though good imagery does exist (15,2). By contrast small cones are found as low as 10°N latitude in Isidis. These are unusual in their spatial distribution, however, being very densely grouped and often occurring in long chains(2). If these are also pseudocraters, then at the time they formed surface or near surface ice must have existed at this low latitude in eastern Mars.

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