LIMITS TO THE PRESENCE OF IMPACT-INDUCED HYDROTHERMAL ALTERATION IN SMALL IMPACT CRATERS ON THE EARTH: IMPLICATIONS FOR THE IMPORTANCE OF SMALL CRATERS ON MARS. H. E. Newsom and Hagerty J. J., University of New Mexico, Institute of Meteoritics, Dept. of Earth & Planetary Sciences, Albuquerque, NM 87131 U.S.A. Email: Newsom@unm.edu

Introduction: Impact craters on the earth contain evidence for hydrothermal activity. An important property of small craters is the limit to the amount of energy deposited during the impact that can lead to hydrothermal activity. Hydrothermal activity is potentially important for producing alteration minerals, trapping water, and transporting mobile elements to the martian surface. Hydrothermal systems in impact craters may also be important for astrobiological investigations in terms of providing environments for organic chemical processes to occur and as near-surface locations that could be easily investigated by surface exploration missions [1]. Another important reason for understanding the lower limit on thermal effects for small craters is in the use of small superimposed craters as probes of larger craters during surface missions. If hydrothermal material is found associated with superimposed craters it will be important to distinguish between hydrothermal events associated with the earlier versus the later crater. In the future, comparisons of our observations with numerical models for the formation of small craters can lead to a better understanding of the role of small craters on Mars.

Lonar Crater: The 50,000 year old, 1.8km diameter Lonar crater is located in Maharashtra, India (19º58'N, 76º31'E) [2]. This relatively small crater is of particular interest because of its unique morphological and mineralogical properties, which make it a valid analogue for similar craters on the surface of Mars [2, 3]. We show that even in this relatively small crater substantial hydrothermal alteration has occurred, probably due to the thermal effects of the impact event.

In addition to textural data from the SEM, microprobe and X-ray diffraction were used to determine the nature of alteration minerals in the Lonar samples. The microprobe results suggest that the majority of the clay materials in the Lonar samples are saponites and celadonites. Both saponite and celadonite are produced during the hydrothermal alteration of basalt, typically at temperatures of 130-200°C. The production of these "hydrothermal" clays at Lonar was further established through geochemical modeling of the alteration process, and by stable isotope analysis.

Limits to hydrothermal activity in terrestrial craters: The presence of hydrothermal alteration at the Lonar crater can be used to suggest that Lonar is near the lower heat limit for generating hydrothermal processes, thus establishing a new lower size limit of 1.8 km diameter for impact-induced hydrothermal activity. A hydrothermal system has been documented in the somewhat larger 4 km diameter Kärdla impact crater [4]. In contrast, no evidence of hydrothermal activity has been found in the smaller 1.13 km diameter Pretoria Saltpan (Tswaing) crater [5], or in the 1.2 km diameter Meteor Crater in Arizona [6]. This information can be used to imply that small martian craters greater than one or two kilometers in diameter may also have the potential to form hydrothermal systems, as long as water was present in some form.

Implications for Mars: Hydrothermal alteration is important for trapping fluids, such as water in the subsurface of Mars, and for releasing material to the surface. As a preliminary example, the amount of water that could be trapped due to alteration of craters in the size range from 2 to 11 km in diameter can be calculated. Assuming an average depth of alteration of 400 m, a degree of alteration of 3% based on the average of our SEM feature scan determinations, a volume of altered material equivalent to a global layer of 2.8 m will be formed over martian history. Assuming a water content of 10 wt% (e.g. similar to the amount in Lafayette martian meteorite iddingsite alteration material) this amount of material could trap an amount of water equivalent to a global layer of water 0.7 m deep. The one-meter value compares to estimates of the amount of water on Mars ranging up to a few hundred meters. In contrast Griffith and Shock [7] estimated that 8% alteration of 10% of the Martian crust could trap 30 m global equivalent of water.

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