EVIDENCE FOR IMPACT-INDUCED HYDROTHERMAL ALTERATION AT THE LONAR CRATER, INDIA, AND MISTASTIN LAKE, CANADA. H. E. Newsom, and J. J. Hagerty, University of New Mexico, Institute of Meteoritics, Dept. of Earth & Planetary Sci., Albuquerque, NM 87131 U.S.A. Email: newsom@unm.edu

Introduction: The 50,000 year old, 1.8km diameter Lonar crater is located in Maharashtra, India [1]. 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 of shocked breccias in the floor of the crater has occurred, probably due to the thermal effects of the impact event. The 38 my old, 28 km diameter, Mistastin crater contains an 80 m thick impact melt sheet [10, 11]. We have also documented the presence of alteration phases in the material from this larger crater.

Fig. 1a. Backscattered electron image of “felty” clays in thin section NMNH 116569-13 (drill core LNR-2).

Fig. 1b. Microprobe analyses indicate the clays in Fig. 1a are consistent with saponite.

Analytical methods: A JEOL 733 electron microprobe was used to determine the chemical composition of several altered Lonar and Mistastin samples. The alteration materials were analyzed with a 15kV accelerating voltage, a 20nA beam current, counting times of 20 seconds for major element peaks, and a 5-10µm spot size. A ZAF correction was used during all microprobe analyses.

A JEOL 5800LV scanning electron microscope was used to image several alteration textures in the Lonar samples. The SEM was optimized for high-resolution imaging, which requires a 20 kV acceleration voltage, a sample current of 20 nA, a spot size of 8-10 µm, and a working distance of 8-16 mm. An automated technique for determining the abundances of trace phases was also applied to the thin sections. A Cameca 4f ion probe was used to obtain trace element data.

Results: SEM images of the altered Lonar samples show that there is abundant textural evidence for post-impact hydrothermal alteration, including classic replacement textures (Fig. 1a, b), and ubiquitous pockets of alteration. The abundance of the alteration phases in the Lonar sections was determined by an automated SEM technique suggesting a maximum of 5% clay (Fig. 2).

Microprobe results from this study were compared with several reference clays [4,5] plotted on a SiO₂, MgO, and Al₂O₃ ternary diagram. The excellent correlations suggest that the majority of the clay materials in the Lonar samples are Fe-rich saponite, with minor celadonite in some thin sections. The identification of Fe-rich saponite was confirmed by X-ray diffractometry. Both saponite and celadonite are produced during the hydrothermal alteration of basalt, typically at temperatures of 130-200°C [6]. The production of these “hydrothermal” clays was further established through geochemical modeling of the alteration process. For instance, the modeling clearly demonstrated that similar clay minerals should be produced at elevated temperatures; whereas ambient alteration appears to produce a completely different alteration assemblage.

Analytical data for the Mistastin crater samples produced somewhat different results. SEM images show alteration filling voids and possible vesicles in the impact melt samples (Figs. 3a,b). However, the analytical results suggest the presence of illite and glauconite (Fig. 4).

Conclusions and applications to Mars: We have shown that hydrothermal alteration under low water/rock ratios in impact craters can produce Fe-rich alteration phases. These results can be used to understand the behavior of hydrothermal alteration on Mars [7]. For example, an example of ion probe data...
for the Lonar alteration material compared with alteration material in the Lafayette martian meteorite shows a remarkably similar pattern [8](Fig. 5).

**Acknowledgements:** Lonar crater samples provided by the Smithsonian Mineral Sciences Dept., and Mistastin samples provided by Richard Grieve. Research supported by the NASA Planetary Geology and Geophysics program (NAG5-8804, NAG 5-10143), H. Newsom P.I.

**References:**


**Fig. 2.** Saponite abundances in Lonar thin sections determined by an automated SEM method. Typical abundances range up to 5% [2].

**Fig. 3a.** SEM image of alteration phases in Mistastin samples.

**Fig. 3b.** SEM image of alteration phases in Mistastin samples.

**Fig. 4.** Mistastin alteration materials are chemically consistent with illite and glauconite.

**Fig. 5.** Ba/Li vs. Ba diagram for preliminary SIMS data on Lonar clays and feldspar compared to similar data on Lafayette iddingsite [8]. The strikingly similar pattern suggests that similar processes have affected the terrestrial and martian basalts.