AQUEOUS ALTERATION OF THE PROXIMAL AND DISTAL EJECTA BLANKET AT LONAR CRATER, INDIA. H. E. Newsom[1], S. Misra[2], M. J. Nelson[1], [1]Univ. of New Mexico, Institute of Meteoritics, Dept. of Earth & Planetary Sci., Albuquerque, NM 87131, USA newsom@unm.edu, [2]Dept. of Geology and Geophys., Indian Inst. of Tech., Kharagpur- 721302, India

Introduction – New work on Lonar materials is resulting in a new understanding of the chemical alteration environments and effects in this small basaltic impact crater. Hydrothermal alteration and chemical transport involving impact craters could have occurred on Mars, the poles of Mercury and the Moon, and other small bodies [1]. As a basaltic impact crater, Lonar is an analog for craters emplaced on the martian crust. Studies of thin sections from beneath the floor of the crater suggest the limited role of hydrothermal activity [2], prompting work on the extent of aqueous and hydrothermal activity in the ejecta blanket.

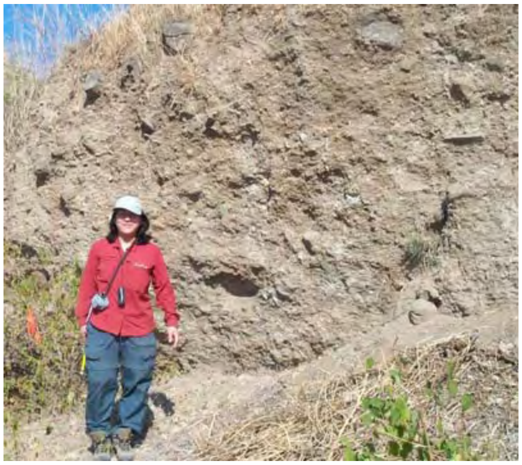

Fig. 1, Distal ejecta at the Kalapani dam outcrop with S. Stewart for scale. Note the high amount of matrix.

Fig. 2, Proximal ejecta near the rim of Lonar crater with V. Narasimham for scale. Note the limited amount of matrix. This is an area containing a large amount of relatively fresh unshocked basalt.

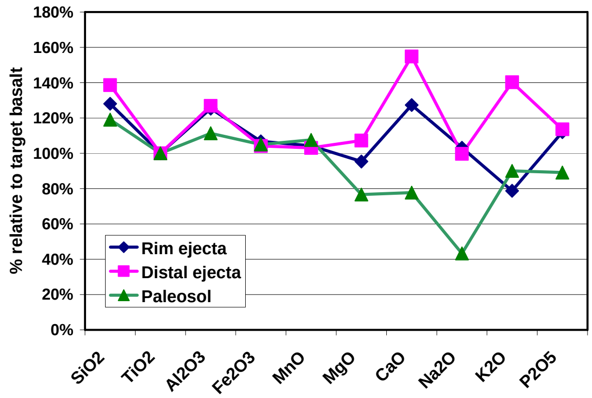

Fig. 3, Major element chemical composition of Lonar materials, compared to target rocks and impact melts. The materials analyzed by XRF include ejecta from the rim of the crater (n=30), distal ejecta (n=9), and paleosol samples (n=8), normalized to un-altered target basalts (n=18).

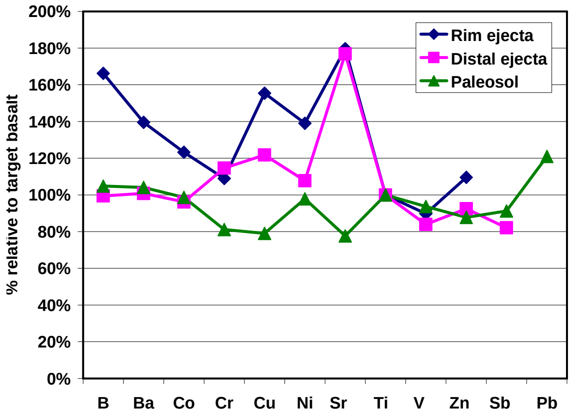

Fig. 4, Minor and trace element composition of Lonar materials obtained by ICP, compared to target rocks and impact melts. The materials analyzed include ejecta from the rim of the crater (n=8), distal ejecta (n=3), and paleosol samples (n=6), normalized to un-altered target basalts (n=6).

Field work in 2004 - 2005 and subsequent analytical work has clarified the role of alteration in the ejecta blanket at Lonar crater. In 2004 we discovered previously unknown alteration zones in the ejecta blanket around the rim of the crater. In 2005, during a more extensive field effort, it became clear that the alteration zones probably represent discrete, but broken up, portions of the target rocks that were altered to different extents prior to the impact. Sampling by Newsom and by Dr. Misra has produced a comprehensive collection of samples from the ejecta blanket (e.g. **Figs. 1,2**). This paper reports new analytical work and new insights into the nature of the ejecta at Lonar Crater.

Lonar eject blanket studies - The ejecta blanket at Lonar extends beyond 1350 m from the rim with discontinuous patches as far as 3000 m. The large number of accumulating analyses of ejecta blanket materials is being used to address two questions: 1) what is the nature of the alteration and chemical transport in different portions of the ejecta blanket (**Figs. 1, 2, 5**) and associated paleosol? 2) Given the increase in matrix content of distal ejecta, are there substantial components of the paleosol incorporated in the ejecta?

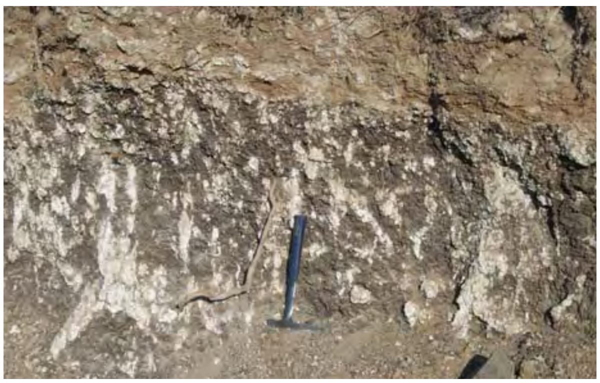

Fig. 5, Paleosol deposit with caliche under the ejecta at the distal Kalapani Dam site.

Geochemical observations – Samples have been analyzed by XRD and ICP at the University of New Mexico and in India [3]. During weathering of basaltic rocks certain elements are presumed to be immobile, especially titanium. For this reason, the geochemical data for the basaltic samples in this study have been normalized to titanium. There are interesting differences between the four types of materials compared here (**Figs. 3,4**). The ejecta samples and paleosol samples are not identical to the target basalts, but are different from each other. The normalized paleosol samples are quite similar to the target basalts (with plus or minus 20%), with the largest difference being a depletion of Na. In contrast, the ejecta samples are not depleted in Na, but are enriched in some elements. Both groups of ejecta are enriched in Si, Ca, K, and Sr, while the proximal rim ejecta is also enriched in B, Ba, Cu and Ni.

Interpretation – The paleosol samples from several areas around the crater represent a much more advanced state of chemical evolution than the ejecta samples, which are probably much younger. The contrasting chemistry of the ejecta suggests a much less advanced state of alteration, but still representing a substantial difference from the target rocks. The physical process of creating the large volume of fine-grained matrix material present in the ejecta may be the most important aspect of promoting chemical alteration by aqueous processes. The presence of caliche, a carbonate-rich material at the base of the impact deposits supports the role of leaching and chemical transport. Clearly some alteration and transport under ambient conditions has occurred. In terms of possible hydrothermal effects, the enrichments of B, Ba, and Cu in the proximal rim ejecta and not in the distal is intriguing. Newsom et al. [4] found limited evidence for mobility of B and Ba in the drill core from the Chicxulub impact crater. Additional work on the detailed mineralogy of the altered ejecta [e.g., 5] will help address this issue.

The other question raised in the introduction is the possible incorporation of paleosol material in the distal ejecta. Field observations by S. Misra do show evidence for the incorporation of clasts of paleosol in the distal ejecta. However, our current results do not support a major component of the paleosol as a well mixed component of the distal ejecta matrix. For example, the proximal rim ejecta and the distal ejecta have similar average Na contents.

Implications – The studies of alteration products and mobile elements in impact craters provides evidence that cratering can affect the surface composition of planets such as Mars by the formation of hydrothermal alteration minerals and the transport of mobile elements [1]. These results emphasize the role of comminution due to impact cratering, enhancing the later ambient or hydrothermal processing of the ejecta material. However, by themselves, impact craters the size of Lonar (1.8 km diameter) and smaller will not directly contribute to substantial mobile element transport, especially in the absence of substantial amounts of water. Another important point, however, is the apparently different behavior of Na compared to Ca and K during the limited alteration in the Lonar ejecta, and in the more evolved paleosols. Contrary behavior of Ca compared to Na and K is also observed in many of the rocks of the Columbia Hills on Mars [6]. This similarity suggests that further study of Lonar Crater as a martian analog is warranted.

References [1] H.E. Newsom et al., (2001) *Astrobiology*, *1*, 71-88. [2] Hagerty, J. J., and Newsom, H. E. (2003) *Meteoritics and Planet. Sci*., **38**, 365-381. [3] Misra S. et al. (2006) *LPSC 37th*, abs. no. 2123. [4] Newsom et al., (2006) *MAPS* 41, 1929-1946. [5] Misra et al. (2007) *LPSC 38th*, submitted. [6] Ming, D.W., et al., (2006) *J. Geophys. Res.*, 111, no. E02S12, doi:10.1029/2005JE002560, 2006. Supported by NASA P.G.&G. The field party in 2005 included S. Wright, S. Stewart, K. Lousma, B. Weiss, and A. Maloof.