HYDROTHERMAL ALTERATION OF LONAR CRATER BASALTS, INDIA-IMPACT RELATED? S. Misra, Md. Arif, H. Newsom, D. Ray, 1SAEES, University of KwaZulu-Natal, Durban-4000, South Africa (misras@ukzn.ac.za), 2Indian Institute of Geomagnetism, Navi Mumbai-410218, India, 3Institute of Meteoritics, University of New Mexico, New Mexico 87131, USA (newsom@unm.edu), 4PLANEX, Physical Research Laboratory, Ahmedabad- 380009, India.

Introduction: The Lonar asteroid impact crater of the west-central India [1, 2], is always a special attraction to the planetary geologists because this impact crater is completely excavated in the basaltic target of the Deccan Trap (~65 Ma) [3], and hence studies on this crater has planetary significance. The crater was formed ~570 ka ago [4] by impact of a chondritic meteorite that struck the pre-impact target basalt from the east at an angle between ~30 and 45° [5, 6]. This nearly circular impact crater has an average diameter of ~1810 m and depth of ~150 m [6, 7].

The Lonar crater has some interesting alteration features. There are altogether six basalt flows of ~8-40 m thickness exposed in and around the Lonar crater of which only the four bottom flows are exposed along the crater wall [7]. Several geological field work has established that the upper ~50m of basalt flows on the crater wall are fresh, whereas below this level, the flows are heavily weathered and friable [7]. The exact reason of this alteration is not known and could be pre- or post-impact in nature, or impact related. In our present study, we report the results of our preliminary geochemical investigation on these altered basalts to evaluate the possible reasons of this alteration.

Sampling and analytical techniques: The drill core samples of altered target basalts were collected from two locations LN1 and LN2 (two samples from each location) on the eastern crater wall from heights of ~524.25 m and ~538.58 m respectively. The major oxides and selected trace elements (Sc, V, Cr, Co, Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Nd, Pb, Th) were analyzed by XRF (AXIOS, PANalytical) technique at the University of KwaZulu-Natal, Durban, South Africa. BCR-2 has been employed to check the accuracy and precision of analyses for the major oxides and trace elements which were better than 2% and 14% respectively.

Experimental data: The relative variations in bulk compositions of the fresh and altered basalts from the Lonar crater are examined in Al2O3-CaO+Na2O+K2O+MgO (CNKM)-FeOt plot [8], where both varieties of basalts show almost overlapping composition except negligible enrichment of Al2O3 and FeOt for the altered basalts (Fig. 1). Furthermore, the altered basalts are plotted to the right of the feldspar line within the CNKM field indicating the minimal effect of surface weathering on these basalts.

Further observation on variation in bulk composition of the altered Lonar basalt is examined in a major oxide spidergram in figure 2. The average composition of the altered Lonar basalts is normalized using the average composition of the fresh basalt samples from the four basalt flows exposed inside the crater [9]. The altered basalt is moderately enriched in K2O (~1.1 times) and depleted in MgO (~0.9) and Na2O (~0.8). Among the major oxides, K2O shows maximum variation in abundance (standard deviation ±20%).

Fig. 1. Plots of fresh Lonar basalt from crater rim and altered basalts from bottom of carter wall in Al2O3-CaO+Na2O+K2O+MgO (CNKM)-FeOt diagram after [8].

Fig. 2. Spidergram showing relative variations in major oxides in average altered basalts on Lonar crater wall, *Fresh basalt- average of four basalt flows exposed in Lonar crater wall [9]. Relative variations (Standard deviation in %) of oxides (e.g., Si indicates SiO2) in altered basalts are in inset.

The compositional variations in incompatible trace elements of altered Lonar basalts are shown in figure 3. These basalts are significantly enriched in Ba (~1.4)
The geochemical variation diagrams (Figs. 2-4) suggest that the basalt flows at the base of the Lonar crater wall are geochemically altered particularly in terms of some important major oxides and trace elements. The important variations in K, Ba, Sr, La, Y, Zr etc. in the altered basalts definitely suggests the role of hot hydrothermal fluid in this alteration process [11]. The temperature of this hydrothermal fluid could be more than 350°C [12, 13, 14]. The two important processes that can generate high temperature hydrothermal fluids are as follows:

The basalt flows exposed in the lower part of the Lonar crater wall are potential traps of ground water at present [15]. It could be the case that these three lower basalt flows at Lonar also acted as a reservoir of ground water in geological past, and this ground water could be superheated and formed a hydrothermal fluids by the heat of the top fourth basalt flow (~25 or 40 m thick) [15, 16] during its eruption on the surface. This possibility is rare because this type of auto-metamorphism is not documented for the Deccan Trap basalts (H. Sheth, pers. com.) or even larger igneous provinces like Karoo flood basalts (M. Watkeys, pres. com.).

The alternative possibility is that this alteration could have occurred during the impact, if the impactor chondritic asteroid brought the water with it. The chondritic meteorites, which excavated the Lonar crater, contain high proportion of water from 3 to 22 wt% [17]. This water along with the ground water present within the Deccan Traps in the pre-impact stage could have form a hot hydrothermal fluid, and this fluid was responsible for the alteration of the lower basalt flows of the Lonar crater. Further studies are in progress.

**Discussion:**

The overlapping plots of the fresh and altered basalts in the Al₂O₃-CNKM-FeOt plot (Fig. 1) rule out any possibility of alteration of the basalt flows exposed at the lower part of the Lonar crater wall by either surface weathering or lake water activity (i.e. rise in water level) in the geological past.

The compositions of the altered basalts are shown in inset of Fig. 2. The relative variations (SD%) in abundance of elements are shown in inset.

The compositional variations in transitional elements of these altered basalts are shown in figure 4. These altered basalts have similar abundances in most of the transitional elements to those of the fresh basalts except in Cr (~0.55 times) and Ni (0.6) in which the altered basalts are importantly depleted; the altered basalts are also marginally depleted in V and Zn (~0.8). The variations in abundances of Cr and Ni in the altered basalt are also very high.

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**References:**