INVOLVEMENT OF ARCHAEAN BASEMENT IN FORMATION OF IMACT-MELT BOMBS FROM LONAR CRATER, INDIA: A GEOCHEMICAL HYPOTHESIS ORIGINATED FROM ANTHROPOGENIC SAMPLES.

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Introduction: The Lonar impact crater, central India, is a bowl-shaped semi-circular asteroid impact crater of a diameter ~1.81 km that was excavated in the Deccan Traps basalts of ~65±1 Ma [1]. This crater was formed by an oblique impact of a chondritic impactor of a diameter ~120 m that hit the pre-impact surface from the east, while the duration of impact was estimated ~1 s [2-5]. The most elaborate ^{40}Ar-^{39}Ar dating suggests the crater is ~ 570±47 ka old [6].

The Lonar crater had a special interest to the planetary geologists because it was considered as one of the few known terrestrial impact craters excavated completely in a basaltic target and hence comparable to those impact craters formed on planetary surfaces having basaltic crusts [7]. However, new emerging concept from geochemical and isotopic studies on glassy objects from this crater is that the Lonar impact penetrated the thickness of the Deccan Traps in this region and extended into the Archaean basement lying beneath the basalt flows, and the basement gneisses were involved in the formation of Lonar impact-melt bombs [4, 8-10]. However, no field and petrographic evidence exist till date to support this hypothesis. The Lonar crater has been occupied by anthropogenic activities for last many hundreds of years and thus sampling of glassy material of proper impact origin is a major problem in evaluating the formation mechanism of this crater. In the present abstract, we thus focus on this sampling problem that could have originated the current hypothesis.

Field Occurrence and petrography: The present authors (S. M. and H.E.N.) began their study on the Lonar crater about two decades ago when the status of glassy-looking samples occurring in and around the crater was not fully known. After a research over decades, the glassy objects occurring in and around the Lonar crater can be classified with confidence into two groups: (a) insitu glassy samples {Class I glasses in [11]}, and (b) non-insitu glassy samples {Class II glasses}.

The insitu glassy samples include aerodynamically shaped, dark-coloured, mm- to sub-mm sized impact-spherules {type 'a' glass of [11]} and cm- to decimeter sized, dark-coloured, ellipsoidal to irregular shaped, vesicular, impact-melt bombs {type 'c' glass}, which are found deposited only within the ejecta blanket surrounding the crater's rim during the crater formation [11, 12] (Fig. 1). Under the microscope and in BSE images, both the impact spherules [1, 3] and impact-melt bombs [11] show flow and/or schlieren structure (Fig. 2) that satisfies the definition of terrestrial impact melts [13]. These samples were also documented by previous workers to establish the impact origin of Lonar crater [1, 5]. These in-situ impact-melt bombs also contain fragments of both unshocked and shocked basalts containing maskelynite and clinopyroxene [12].

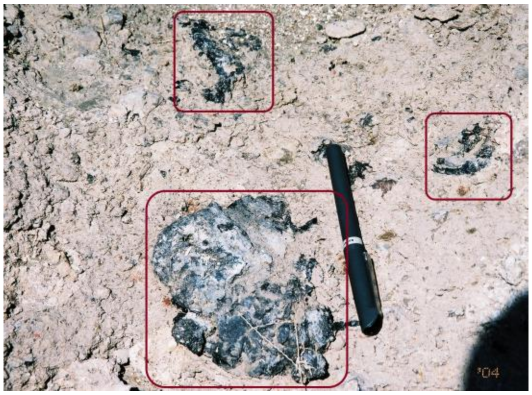

Fig. 1. Cross-sectional profile of Lonar ejecta showing ellipsoidal/ irregular shaped, in-situ impact-melt bombs (shown in box) within it, east of Lonar crater.

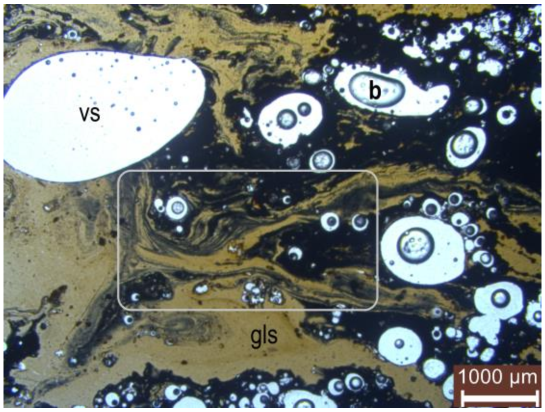

Fig. 2. Photomicrograph of Lonar in-situ impact-melt bomb showing flow structure defined by colour compositional bandings (shown in box), abbreviations: gls-glass, vs-vesicles, b- glue bubble.

The non-insitu Lonar glassy samples {'b, d and f' glasses of [11]}are also dark-coloured, cm-sized fragments, which occur as loosely scattered pieces on the surface of the ejecta blanket around the crater rim, as well as in the vicinity of the historic temples around the lake inside the Lonar crater and in the Lonar village away from the crater. These are highly vesicular in nature, and under the microscope, these samples (e.g., L-27 from close to Hanuman ji Temple at Little Lonar) contain sub-rounded pieces of basalts within a highly vesicular, dark coloured matrix containing unshocked fragments of plagioclase and sub-rounded pyroxene (Fig. 3, 4). After a substantial field work and discussion with local people (Mr. S. Bugdani, and priest of the Hanuman ji Temple at ~700 m north of Lonar crater, near Little Lonar), the first author is convinced that these non-insitu glassy materials were actually the remains of anthropogenic bricks prepared by ancient people to construct roofs of local temples in and around the Lonar crater. Hence, samples L-22, L-23, L-29, GSI-1, SG-1, SG-2 and SG-3 in [11] only represent the insitu impact-melt glassy sample analyses.

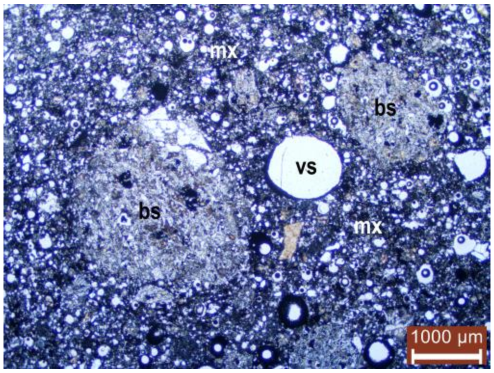

Fig. 3. Photomicrograph of Lonar non-insitu glass (L-27) showing presence of subrounded basaltic fragments (bs) within vesicular matrix (mx), vs- vesicles.

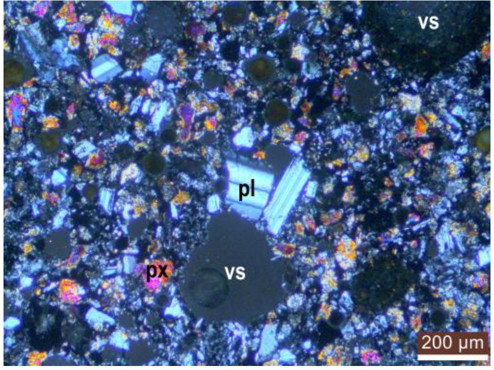

Fig. 4. Enlarged photomicrograph of vesicular matrix of Lonar non-insitu glass (L-27) showing presence of unshocked plagioclase and granular pyroxene fragments, pl- plagioclase, px- pyroxene, vs- vesicle.

Discussion: The target Deccan Traps basalt, overlying the Archaean basement in and around Lonar, has an estimated thickness of >350 m [14]. If we accept the diameter/depth ratio for terrestrial impact crater in [15], the Lonar crater, having a current diameter of ~1.8 km, has a maximum depth of ~200 m or less, and hence was completely excavated within basaltic target. Additionally, the available drill core that penetrated ~335 m below the crater floor did not show any evidence of Archaean basement [1].

The Lonar impact spherules and insitu impact melt bombs could be considered genetically related in terms of source rock(s) and process of formation [12]. If strong positive Pb anomaly observed in multi-element diagram of the Lonar glassy samples is considered as the signature of Archaean crustal contamination [4, 10], this signature is absent in the analyses of Lonar impact spherules [9, 16]. These spherules show strongly negative to mildly positive Pb anomaly. Our analyses on Lonar in-situ impact-melt bomb also do not show any enrichment of Pb over target basalts [17].

Around 2002, the first author gave samples of insitu and non-insitu Lonar glasses to a few scientists for research. The whole-rock chemical data of both these samples were only published in [11], however, these data did not contain Pb analyses. The analyses published in [4, 18] were of non-insitu glassy samples from around Lonar lake [19]. No field description of Lonar glassy sample is available in [10]. In terms of hand specimen study and petrographic description under the microscope, these samples look similar to non-insitu Lonar glassy sample described in [11].

This review, thus, concludes that the geochemical model of involvement of basement Archaean crust in the genesis of the Lonar glassy samples is actually originated from studies of anthropogenic samples. A future drilling in the Lonar crater beyond the thickness of the Deccan Traps target can only resolve the problem.

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