COLLISIONS IN THE EJECTA PLUME OF THE AUSTRALASIAN IMPACT EVENT
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Major impacts on earth produce glassy ejecta distributed in widespread strewn fields, a classic example of which are tektites and microtektites. Although several models have been proposed on the process of impacts and ejecta emplacement (eg. 1, 2), very little is actually known on the immediate post impact scenario in terms of ground truth. We present here the phenomenon of microimpacts on microtektites which, we suggest here, have taken place within the ejecta plume of the impact which generated the Australasian tektite strewn field. Microimpacts, although have been found on virtually every cm$^2$ of the lunar soil (3), they however, formed due to cosmic dust collisions on the moon. Since tektites and microtektites are the ejecta of major impacts on earth, the microimpacts presented here are the first such occurrence not only on earth but also have not been reported in the ejecta of any other known major impact. This study has importance in understanding cratering mechanics of major impacts on terrestrial planets.

Following our discovery of impact microcraters on an Australasian microtektite (4), three Australasian microtektite bearing samples from the Central Indian Basin, two of which are cores (1 & 2 in Fig. 1) and the third the substrate of a ferromanganese crust (3 in Fig. 1) were investigated for microimpacts. The microtektites were first observed in a stereomicroscope having a magnification of up to 40X, and those suspected of having microimpacts were observed in a scanning electron microscope. In all, 838 microtektites of >250 μm size were thus observed, of which 60 contained microimpacts. In the cases where the projectiles were found adhering to the target microtektites, EDAX analysis was done to identify the projectiles. Further, chemical composition on polished sections of 35 microtektites from these samples was determined by quantitative microprobe.

Of the 60 impacted microtektites, 31 had more than one impact on their surface, the largest number being 11 impacts on a 1225 μm size, smooth, light yellow sphere from SK-69/001. The impacts can be described as: very low velocity where spherical projectiles adhere to the target (the smallest projectile observed here measures 10μm), low velocity with distorted projectiles, and projectiles splattered on to the target surface: in these cases melt is invariably observed suggesting a ‘hot’ target and/or projectile (Fig. 2a,b). Further, hypervelocity craters with pits, radial cracks and well developed spallation zones (Fig. 2c), commonly shown by lunar microcraters, have also been observed indicative of a sufficiently cool target. In majority of the samples the projectiles appear to have defined near vertical trajectories as suggested by circular craters, however, some microtektites showed grooves made by projectiles defining an oblique incidence. The targets as well as the projectiles observed so far appear to be Australasian microtektites as suggested by their chemistry.

The microimpacts presented here have resulted due to collisions in the ejecta plume of the Australasian impact event and have taken place subsequent to the melt break within a very short span of time after the droplet formation and condensation. The average size of the impacted microtektites in this study is ~900 μm, given such a small target multiple impacts on >50% of the observed microtektites could be because of their interaction with a dense swarm of projectiles.

During the excavation stage of a major impact, a high speed vapor plume comprising of vaporized projectile as well as target material expands out of the crater site (1). According to Vickery (2) the vapor plume moves faster than the ejecta, resulting in violent interactions between the vapor cloud and ejecta due to differential velocities, which could have been the process responsible for the microimpacts observed here. Furthermore, droplet size is an important factor for determining impact dynamics (5), the smallest droplet observed here is a 10 μm projectile. However, this projectile could also have been an ablation droplet from a larger microtektite/tektite, generated due to friction with atmosphere after the ejecta droplet decoupled from the plume (1).
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Fig. 1. Map showing the boundaries of the Australasian tektite strewn field, and the locations of the samples in this study.

Fig. 2. (a) Large, smooth microtektite with a low velocity impact. (b) Distorted projectile adhering to the surface of (a): melt and radial cracks are seen. (c) Hyper velocity impact on an elongated microtektite showing a pit, halo zone, radial cracks; melt flow is seen at the crater edge. Scale bar: (a) = 1000 μm, (b) and (c) = 100 μm.