IMPACT MELT FORMATION BY LOW-ALTITUDE AIRBURST PROCESSES, EVIDENCE FROM SMALL TERRESTRIAL CRATERS AND NUMERICAL MODELING. H. E. Newsom[1], and M. B. E. Boslough[2], [1]Univ. of New Mexico, Institute of Meteoritics, MSC03-2050, Albuquerque, NM 87131, USA newsom@unm.edu, [2]Sandia National Laboratories, PO Box 5800, Albuquerque, NM 87185

Introduction – Airbursts in the lower atmosphere from hypervelocity impacts have been called upon to explain the nature of the Tunguska event and the existence of unusual impact-related silicate melts such as the Muong-Nong tektites and Libyan Desert Glass of western Egypt [1]. Impact melts associated with impact craters, however, have been traditionally attributed to shock melting of the target material that experiences strong shock compression and heating. The characteristics of impact melts from small terrestrial craters (< 4 km diameter) leads to the possibility that the airburst phenomena may have been responsible for these melts. This conclusion is supported by numerical modeling of the airburst phenomena using super computer class facilities at Sandia National Laboratories [1].

Numerical modeling results – Recent models of the airburst phenomena have revealed several important insights into the coupling of the airburst with the surface and the possible nature of the resulting silicate melts. The center of mass of an exploding projectile is transported downward in the form of a high-temperature jet of expanding gas (Fig. 1). The jet descends by a significant fraction of the burst altitude before its velocity becomes subsonic. The time scale of this descent is similar to the time scale of the explosion itself, so the jet simultaneously couples its kinetic energy and its internal energy to the atmosphere.

Because of this downward flow, larger blast waves and stronger thermal radiation pulses are felt at the surface than would be predicted by a point source explosion at the height where the burst was initiated. For impacts with a kinetic energy above some threshold, the hot jet of vaporized projectile (the descending "fireball") makes contact with the Earth's surface, where it expands radially. During the time of radial expansion, the fireball can maintain temperatures well above the melting temperature of silicate minerals, and its radial velocity can exceed the sound speed in air. Boslough and Crawford [1] suggest that the surface materials can ablate by radiative/convective melting under these conditions, and then quench rapidly to form glass after the fireball cools and recedes. For crater-forming impact events, the atmosphere also plays an important, if not dominant role. The iron projectile that formed Meteor Crater (Arizona) deposited more than 2.5 times as much energy directly into the atmosphere than it carried to the surface [2]. Small crater-forming impacts should therefore exhibit phenomena similar to those associated with airbursts.

Impact melts from small terrestrial craters – Small craters with impact melt fragments include; Wabar, Aouelloul, Henbury, and Lonar. The striking characteristics of the impact melt fragments from these craters is the presence of thin layers of melt. These layers are sometimes isolated fragments (e.g. Aouelloul), sometimes stacked into layered accumulations (Lonar), and sometimes form coatings around unmelted material or layered melt bodies (Lonar). The layered accumulations have much in common with the Muong-Nong type silicate melt materials. Materials from individual craters are described below, as a function of the diameter of the structure

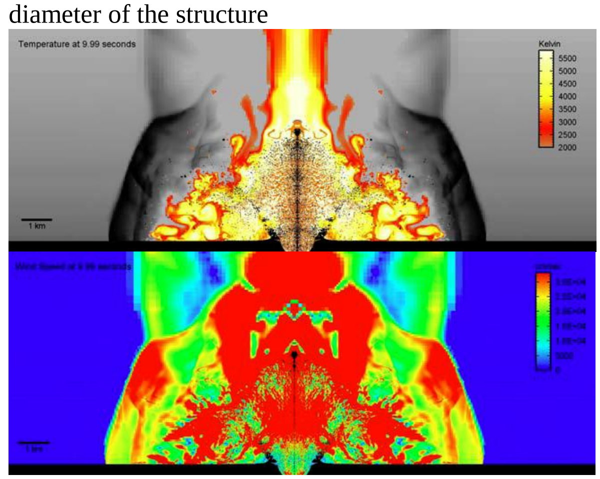

Fig. 1, Airburst for which the fireball descends to the surface [1]. White = 5800 K; Red = 2000 K. Bottom image shows wind speeds. Red represents supersonic flow.

Wabar, Saudi Arabia, 0.12 km diameter, sedimentary target – The impact melt samples from this crater are unique in consisting of white material coated by dark impact melt [e.g. 3] (Fig. 2).

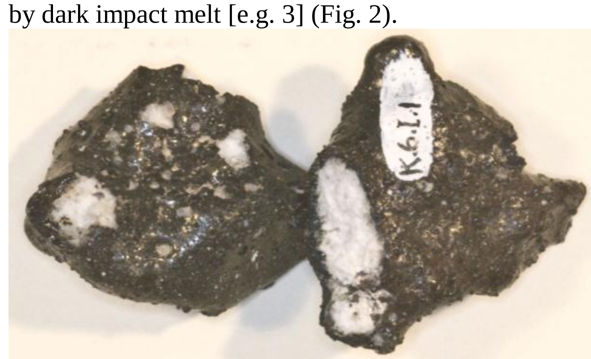

Fig. 2, Samples of impact melt coating matrix from the Wabar impact crater in Saudi Arabia. Image 6 cm width.

Henbury, Australia, 0.16 km diameter, sedimentary target – The Henbury impact structure consists of numerous small craters, with the largest being 0.16 km in diameter, ranging down to depressions only a few meters in diameter containing iron meteorite fragments [e.g. 4]. The Henbury craters reflect the disruption of the impactor at some significant altitude. The Henbury samples in our collection have a distinct coating of melt in many cases (Fig. 3). Evidence for high temperature gas flow rupturing vesicle walls in Henbury melt samples has also been reported [5].

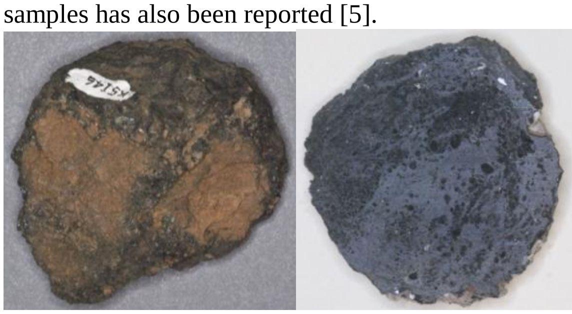

Fig. 3, Impact melt clast (6 cm diameter) surface (left image) and cross section (right image) from Henbury, Australia. Note the layered texture.

Aouelloul, Mauritania, 0.39 km diameter, sedimentary target – The Aouelloul impact crater contains impact melt fragments (Fig. 4). structure is a distinct impact crater with impact melt fragments [6].

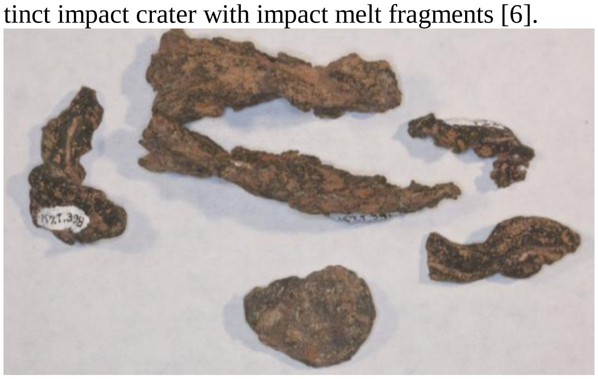

Fig. 4, Impact melt fragments from Aouelloul (image 10 cm across). The impact melts form layers placed on edge in the image, except for the sample on the bottom.

Lonar, India, 1.83 km diameter, basaltic target – The impact melt deposits described in this abstract (e.g., Fig. 5) come from the eastern rim of the impact crater, and are thought to represent the uppermost layer of ejecta [7-10]. The samples consist of layers of impact melt loosely organized into large coherent masses. In some cases (not illustrated) the melt forms ropes and blobs like taffy, on a scale of a few mm. The formation of the impact melt by an airburst, as opposed to shock melting, may be consistent with the limited evidence for hydrothermal processes in the ejecta blanket at Lonar [8] and the absence of abundant impact melt in the drill cores from the floor of the crater [9]. A similar sample has recently been found at the 4 km diameter Ramgarh structure [11].

Fig. 5, Impact melt bomb from the eastern side of the Lonar impact crater. Note the layered texture of this sample. Width 6 cm.

Conclusions – Numerical modeling suggests that low altitude airbursts due to the interaction of hypervelocity projectiles with the atmosphere can produce surface melting forming thin layers as seen in the materials from Aouelloul. The accompanying supersonic velocity flow field can redistribute the melted surface layer forming accumulations of layers as seen in the Muong-Nong tektites and some of the larger Lonar impact melt masses. The ropy surface textures of some of the Lonar melts could result from transport of the melted layers. The impact melt rinds found on samples from Wabar, Henbury and Lonar can be the result of melting due to incorporation of materials into the hot flow field, much like the fusion crust on meteorites.

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