ERUPTION AND EMPLACEMENT OF LUNAR PYROCLASTIC GLASSES AS INFERRED FROM THE 74001/2 SECTION. Catherine M. Weitz, James W. Head III, Department of Geological Sciences, Brown University, Providence, RI 02912; David S. McKay, Johnson Space Center, Houston, TX 77058.

Introduction. We have examined the 26 thin sections made along the length of the 68-cm deep 74001/2 core. The core is composed of ~99% submillimeter orange volcanic glasses and their crystallized equivalents (black beads) [1,2]. The Taurus-Littrow dark mantle deposit on the southeastern edge of Mare Serenitatis represents a mixture of these volcanic beads with other lunar soils [1]. The source(s) location and eruption conditions that produced the volcanic beads at Taurus-Littrow and other regional dark mantle deposits is still under debate. In this study, we have examined thin sections and determined the cooling histories for the volcanic beads based upon their textures. In addition, several digital elemental images were made of four of the thin sections taken at different depths within the core. Our goal is to use the petrology of the beads to determine the eruption conditions in the fire fountain and the most likely location and number of vent sources associated with the Taurus-Littrow deposit. Eventually, we intend to apply our results from the Taurus-Littrow study to other regional dark mantle deposits on the Moon using Clementine multispectral data.

Eruption of Beads: We identified four types of volcanic beads and interpreted them depending upon the cooling rate they experienced in the fire fountain (figure 1): I) Orange glasses resulted from rapid quenching that inhibited crystal formation; II) In rare instances, ilmenite and linear olivine formed on one side of the glass bead causing half of the bead to appear black and the other half to appear orange; At slower cooling rates, III) partial crystallization and later IV) complete crystallization of olivine, ilmenite, spinel, and iron metal blebs increased in frequency and size. In general, once nucleation of olivine and ilmenite occurred, it was rapid enough to cause the bead to become black in color with little residual orange glass visible. Hence, the beads were either completely orange or black in appearance but rarely half orange/half black.

The surfaces of linear olivines provided nucleation sites for ilmenite crystals while euhedral olivines formed at slower cooling rates have no ilmenite on their surfaces. Those beads that experienced the slowest cooling rates dominate the lower half of the section (74001) and they are heavily fragmented compared to the smaller beads in the 74002 section. The largest black bead was 1100 μm in length and it was found at 54 cm depth in the core. However, the bead is irregular in shape, as are the majority of the larger beads, and most likely represents a fragment of a larger bead. Many of the larger black beads show several types of olivine textures, suggesting that they experienced a complex cooling history in the fire fountain. At least two black beads are completely enclosed inside larger brown beads. Black beads with smaller orange and brown beads attached to their surfaces imply that the orange beads were still molten and could adhere to the larger black beads, in some instances devitrifying to a brown color.

We produced one microprobe digital image of Na, K, and S on a thin section taken at the bottom of the core. Of the approximately 50 beads larger than 50 μm in diameter within the 900x900 μm^2 area, only one black bead fragment had an identifiable coating of Na, K, and S on it unbroken surface. Na had a thickness of 6 μm while K and S were thinner and lower in concentration. However, the thickness of the volatile deposit inside the residual glass varied considerably, apparently because olivine crystals near the surface prevented inward diffusion at several locations. This particular bead indicates that it was able to cool slowly enough in the fire fountain to crystallize large and relatively high-Mg olivines (Mg #0.78) followed by condensation and inward diffusion of volatiles associated with the volcanic gas cloud.

Deposition of Beads: After deposition onto the lunar surface, devitrification altered many of the orange glasses to a brown color if the deposit consisted predominantly of black beads. Microprobe analyses show that there is a concentration of Mg in regions of brown but only a few olivine crystals are optically identifiable. Generally, the brown texture appears as radiating fibre crystals of olivine, similar to textures formed in devitrification experiments on green glasses [3]. Because the number of brown glasses increases with depth, and hence, with an increase in the number of black beads in the core, we propose that the orange glasses devitrify after being emplaced into a relatively hot deposit. In contrast, when the deposit consists predominantly of orange glasses, it is too cold to cause reheating and devitrification.

The upper 74002 section shows clustering of the beads into cm-size fragments, producing a breccia-like appearance. We interpret this texture in the 74002 section to be the result of compaction in the orange glass-rich layer during deposition, followed by the Shorty Crater impact, cm-scale fragmentation, and small-scale mixing. If the 74001/2 deposit was inverted by the Shorty Crater impact [4], then the beads composing the 74002 section were originally deposited earlier than the beads of the 74001 section and thus, would have experienced more compaction. During impact and overturn, the entire section experienced small-scale mixing of the beads but mixing with other lunar soils did not occur.

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Application to the Taurus-Littrow Deposit. The Apollo 17 landing site is located towards the southeastern edge of the Taurus-Littrow deposit. Because the Taurus-Littrow deposit is embayed by the younger low-Ti flows of Mare Serenitatis, it is difficult to determine the extent and most likely location of the source vent(s). Other regional dark mantle deposits are also embayed by younger flows, indicating that the deposits represent an older style of explosive volcanism [5]. While regional dark mantle deposits like Taurus-Littrow and Rima Bode appear spectrally to match black beads [6,7], the Aristarchus Plateau appears to be dominated by a homogeneous distribution of orange glasses. We suggest that the uniform concentration of orange glasses is due to a low optical density in the fire fountain that was continuous for a significant period of time but then rapidly decreased to prevent deposition of a large quantity of black beads. The rapid cessation of the fire fountain may have been due to exhaustion of gas in the magma or to blockage of the dike, as seen during Hawaiian fire fountain eruptions [8]. In the case of Taurus-Littrow, the deposit represents a mixture of orange and black beads, possibly due to a relatively slow change from high to low optical density in the fire fountain. A change from high to low optical density is supported by a study of metal bleb formation in the 74001/2 core [9].

Ballistic trajectories calculated by Wilson and Head [10] predict that deposits produced by fire fountain eruptions should be concentrated near the vent and/or at the farthest distance where the ejection angle is 45°. Volcanic deposits associated with Io plumes follow this style of ballistic trajectory [11]. However, lunar dark mantle deposits are either very homogeneous (ie. Aristarchus) or show variations in the concentration of black beads (Taurus-Littrow, Rima Bode) over large areas. Wilson and Head [9] have shown that to eject submillimeter beads to large distances (~100 km), the majority of the clasts must be larger than a few centimeters in size. The larger clasts can decouple rapidly from the expanding gas cloud and give added momentum to the submillimeter clasts still locked to the cloud. Thus, lunar eruptions should resemble Hawaiian-style fire fountain eruptions and produce a broader size distribution of clasts emplaced over a larger area. Finally, even though the Apollo 17 landing site is located on the edge of the deposit and only submillimeter beads were sampled, larger beads/clasts and a thicker deposit may exist towards the northwest. In addition, the larger clasts (figure 1, V) will land adjacent to the vent and because they are still molten, they can coalesce to form lava flows and sinuous rilles.

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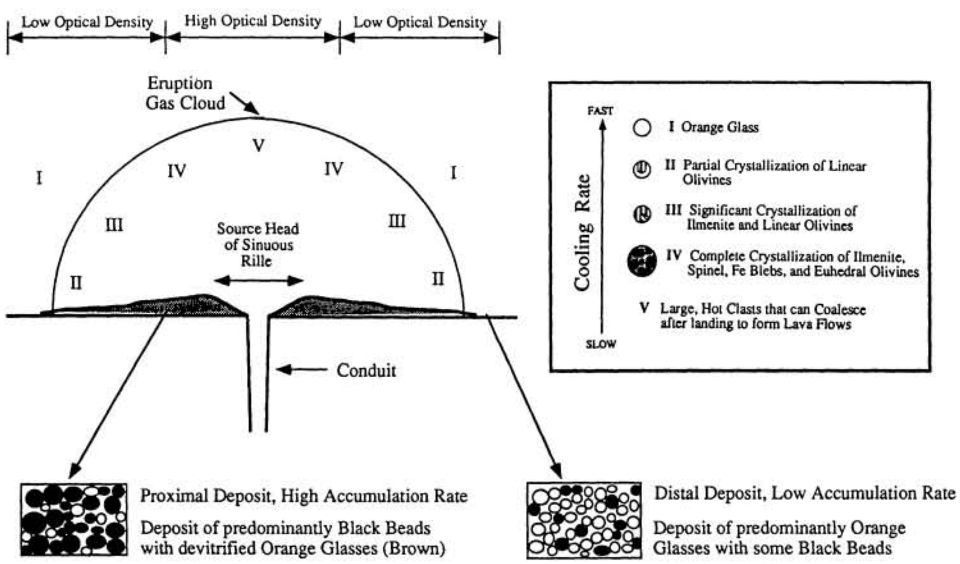

Figure 1. Cross-section through a lunar volcanic plume showing the types of beads produced in the fire fountain and after deposition. Over time, the plume may fluctuate in size and intensity.

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