BASALTIC PYROCLASTIC DEPOSITS ON EARTH AND MARS: CONSTRAINTS FOR ROBOTIC EXPLORATION OF MARTIAN PYROCLASTIC DEPOSITS. J. Filiberto[1] J. Gross[2], and A.H. Treiman[2], [1]Department of Earth Science, MS-126, Rice University, 6100 Main Street, Houston, TX 77005 [2]Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058. Justin.Filiberto@rice.edu

Introduction: Basaltic pyroclastic rocks are uncommon on Earth because most mafic magmas are too volatile-poor to drive explosive eruptions [3-4]. However, basaltic pyroclastic deposits maybe much more common on Mars than on Earth [4-7] because Mars' lower gravity and thinner atmosphere permit explosive eruptions from magmas with lower volatile contents. Though rare, basaltic pyroclastic rock on Earth provide a crucial way to help understand the formation of pyroclastic deposits on Mars, and to help identify them from orbital and lander data. We are investigating one such deposit, the Trailbridge basaltic ignimbrite near McKenzie Bridge, OR. Here, we give a preliminary description of an outcrop of the Trailbridge ignimbrite, and compare it to several possible basaltic pyroclastics on Mars [3-7].

Trailbridge Resevoir Ignimbrite: The Trailbridge ignimbrite, described only in preliminary reports [8-9], is best exposed in road cuts along OR highway 126 (Fig. 1). The ignimbrite unit is horizontally extensive, ~10 m thick, overlies vesicular basalt and laminated sediments, and is overlain by a conglomerate. The ignimbrite is dark gray and massive, and contains many angular, light-colored clasts and mineral fragments, mm- to cm-sized. The rock basaltic or basaltic andesite, with SiO_2 of 52-54%, like many other lavas of the High Cascades. The unit is interpreted as a welded ash flow (ignimbrite), because of its: compostion; lack of basalt flow structures; and abundance, preferred orientations, and zoned ditribution of clasts [9]. Representative samples were taken and analyzed in thin section by electron microprobe.

Basal portion: The lower few meters of the unit are massive, gray, and rich in lithic clasts up to several cm long. The clasts are accompanied by euhedra and fragments of plagioclase with pyroxene. The matrix is microcrystalline, with small pockets of brown basaltic glass and rare pores. These textures suggest hot deposition and welding, but rapid cooling so that some glass was preserved.

Middle portion: The middle meters of the unit are dark gray, massive, dense, fine grained and fracture-tough. This rock consists of a crystalline matrix of plagioclase, pyroxene and small oxide grains. These minerals are similar to, but coarser-grained than the minerals in basal portion. No fresh basaltic glass remains in this sample. Within the matrix are rare mineral euhedra (olivine and plagioclase) up to several mm in length and very rare lithic clasts (Fig. 1). There is almost no porosity in this sample. The coarser, crystalline matrix of this portion suggests that it cooled relatively slowly and was likely the most intensively welded.

Upper portion: The upper few meters of the ignimbrite are similar to the basal portion in containing abundant rounded and angular lithic clasts in a fine-grained matrix with uncommon mineral fragments (mostly plagioclase with pyroxene and olivine). As in the basal unit, the matrix is microcrystalline (probably devitrified glass), basaltic glass, and significant porosity. These features suggest that the upper portion of the unit cooled relatively rapidly.

Fig. 1: Trailbridge Reservoir ignimbrite: (above left) basal portion; (above right) middle portion; (left) upper portion. Person and hammer for scale.

Possible Martian Pyroclastic Deposits: Several possible pyoclastic deposits have been identified on Mars, both from orbital and landed data. Here we will compare 3 different localities with the Trailbridge ignimbrite.

Wishstone-Class rocks, Columbia Hills, Gusev. Wishstone-Class rocks are alkaline and basaltic, and are composed of plagioclase, pyroxene, olivine, and phosphates [2, 10]. Texturally, these rocks contain abundant lithic clasts (irregular, angular, poorly sorted) up to ~2mm in a fine-grained matrix (Fig. 2). From their texture and mechanical strength, the Wishstone-class rocks are thought to represent an ash flow tuff, possibly driven by a CO_2-rich fluid [10]. Texturally and mineralogically, the images of Wishstone rocks are similar to the basal Trailbridge rocks: angular, irregular clasts in a fine-grained matrix with minimal pore space (Fig. 2); mineralogy dominated by plagioclase with pyroxene. Thus, our observations on Trailbrigde confirm previous inferences that Wishstone-class rocks represent a welded ignimbrites [7].

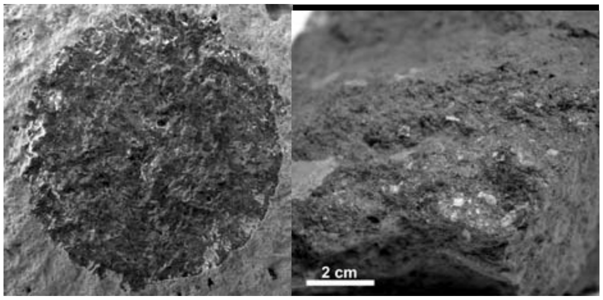

Fig. 2: Sample images of Wishstone rock [2] (left) (5.5 cam across), compared to rock from the basal Trailbridge unit (right).

Home Plate, Columbia Hills, Gusev Crater. Home Plate is a low flat-topped exposure [1], of a layered sequence of slightly altered clastic rocks with the compositions of alkaline basalts [1, 11]. Its rocks are composed mostly of basaltic glass (~45%), with pyroxene, olivine, plagioclase, nanophase Fe-oxide, and magnetite (from both Mössbauer and Miniature Thermal Emission Spectroscopy) [1, 12]. Based on stratigraphy, structure, sedimentology, mineralogy, and bulk chemistry it is thought to represent a pyroclastic deposit of a primitive basaltic melt [1, 13-14].

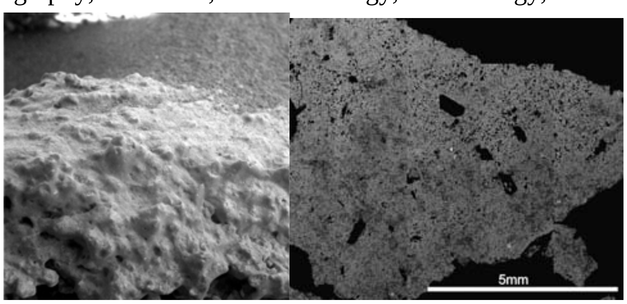

Fig. 3: Lowest Home Plate unit [1] (left) (3 cm across), and the upper most Trailbridge unit (right).

The basal portion of Home Plate is similar to the upper most Trailbridge section (Fig. 3). Both samples contain angular, irregular nobby clasts in a fine-grained matrix with abundant pore space. Mineralogically both are dominated by basaltic glass with plagioclase, pyroxene, olivine, and oxides grains. This suggests that they represent poorly welded ash flow tuffs and are less welded then the Wishstone-Class basalts.

Hadriaca Patera and Tyrrhena Patera. Hadriaca Patera and Tyrrhena Patera are low-relief volcanoes with layered, friable deposits along their flanks. These units have been identified as pyroclastic deposits based on their morphologies, slopes, and ease of weathering. These are unlike the Trailbridge road cut, but other exposures of the Trailbridge unit are reported to be strongly layerd [9]. Therefore, the Tyrrhena Patera and Hadriaca Patera deposits (being more distal) may have been less welded than the Trailbridge ignimbrite.

Constraints for Robotic Exploration of Pyroclastic Deposits: From our preliminary examination of the Trailbridge outcrop, we can place constraints on the types of data we would need to recognize a pyroclastic deposit on Mars. However, identifying pyroclastic deposits is not a simple feat because welded ignimbrite deposits are complex and diverse.

In order to recognize such a deposit on Mars it is vital to first have bulk chemistry to ensure it is basaltic. Second, it is important to investigate the whole exposure, because the properties of a pyroclastic deposit can vary laterally and vertically. If a rover had, for instance, examined only the middle portion of the Trailbridge outcrop, it would be difficult to recognize it as a welded pyroclastic rock. Instead, the unit might be dismissed as a massive basalt flow instead (Fig. 1). Therefore, robotically exploring an entire outcrop, similar to what was done at Home Plate by Spirit [1], is needed in order to confirm a basaltic pyroclastic deposit on Mars. Finally, it is important to examine the deposit microscopically. The Trailbridge oucrop samples range in porosity, density, and amount of crystallization and lithic material. The least welded samples have low densities and high porosities, with abundant lithic clasts; more welded rocks are darker, denser, mostly crystalline, and have low porosity and few lithic clasts. Therefore, to fully understand the complex eruption and depositional history of a pyroclastic deposit, we need to not only examine the macroscopic textures and properties but also the microtextures, mineralogy, and chemistry.

Summary: A benefit of having terrestrial analogs for Martian surface deposits is to place constraints on the types of data needed to recognize these features on the Martian surface. Studying the Trailbridge Resevoir outcrop provides intriguing new data on rock textures, hardness, porosity, and mineralogy for a terrestrial basaltic pyroclastic deposit. This research provides caution that recognizing a basaltic pyroclastic deposit remotely is not a simple feat.

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