LUNAR PYROCLASTIC DEPOSITS: NATURE AND DISTRIBUTION OF PYROCLASTIC GLASSES AT TAURUS-LITTROW. C. M. Weitz and J. W. Head III, Brown University, Department of Geological Sciences, Providence, RI, 02912.

Introduction: Comprehensive analyses of remote sensing data has shown that a wide variety of pyroclastic deposits and landforms exist on the Moon. Our goal is to relate the range of these features to theoretical predictions of magma disruption and pyroclastic dispersal in the lunar environment. One type of pyroclastic deposit is the volcanic glass sampled at all of the Apollo landing sites, with large concentration of glasses found at the Apollo 15 and 17 sites. Regional (>100 km diameter) and localized dark mantle deposits composed of pyroclastic glasses have been identified on the Moon, with both deposits generally associated with sinuous rilles or irregular depressions. In this analysis, we concentrate on the glasses found at the Taurus-Littrow (TL) region where the Apollo 17 landing site is located. The dark mantle deposit at TL covers over 100 km from north to south while the western portion of the deposit has been buried by younger low-Ti basalts within Mare Serenitatis. A drive tube taken at Shorty Crater showed orange glasses on top of their crystallized equivalents (black glasses). Assuming that the glasses were not inverted by the impact, the stratigraphy indicates that either the black glasses were deposited first or that the glasses cooled slower at the base of the deposit. In this analysis, we have combined petrogenesis, remote sensing, and modelling studies of the glasses found at TL in order to understand their origin, distribution, and mode of emplacement.

Petrogenesis: At least six different types of glasses have been identified at TL, including Very Low Titanium, Green, Yellow, Orange I, Orange II, and the orange 74220-type [1]. The age for the high-Ti, 74220-type glasses range from 3.48-3.66 Ga [2,3]. In contrast, the Apollo 17 high-Ti mare basalts have ages from 3.69-3.75 Ga [4], indicating that the basalts are older than the glasses. Liquid lines of descent from the glasses do not produce the basalts [5], implying that the glasses and basalts were produced from separate sources. Three potential models have been suggested for the origin of the glasses with all cases indicating different mantle sources between the glasses and mare basalts [6]. Major element characteristics of the high TiO_2 magmas and ilmenite melting relationships support a depth of segregation for the glasses at 400-500 km where the glasses equilibrated with orthopyroxene and olivine [7]. The lack of correspondence between the glasses and basalts, both in remote sensing data and samples, may be due to incomplete sampling, burial of the basalts by younger flows, fractionation of the basalts after eruption, or the eruption of only pyroclastic glasses with no associated basalts. Continued modelling of eruption conditions and remote sensing of dark mantle deposits may provide insight into the relationship between the mare basalts and pyroclastic glasses.

Modelling: A range of eruption conditions conducive to the formation of pyroclastic deposits is interpreted to occur in the lunar environment. In long-lived, high effusion rate eruptions, hot ejected droplets will coalesce to feed flows which will thermally erode the surface beneath them to produce sinuous rilles and source depressions. Pyroclastic deposits could result from steady eruptions at high effusion rates with <1% magma disruption into submillimeter droplets or by low effusion rates in strombolian eruptions [8]. If submillimeter droplets form only a very small fraction of the total ejecta then the droplets can be expelled for distances of tens of kilometers. Explosive eruptions could produce clasts greater than a few centimeters in diameter that would remain within several meters of the vent. For example, small cones formed on or adjacent to linear rilles are interpreted to be related to pyroclastic activity during minor eruptions and degassing of the upper parts of dikes [9]. Osiris and Isis, located southwest of the Apollo 17 site in southern Mare Serenitatis, are probably spatter cones formed by this type of eruption. Clasts much smaller than 1 mm may be projected for many tens to hundreds of kilometers to produce regional deposits [8]. Experimental work indicates that both the Apollo 15 green glasses and the Apollo 17 orange glasses cooled at rates slower than those

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they would have experienced under free-flight conditions [10]. The slower cooling may be a result of a hot vapor environment or a radiation shielding effect in a dense cloud of radiating droplets. Therefore, by understanding the distribution of orange and black glasses in the dark mantle deposits, this information can be used to constrain eruption conditions in the fire fountain.

Remote Sensing: The pyroclastic glasses are identifiable in remote sensing data because of their low albedo and absorptions at 1.0 and 1.8 μm from Fe-bearing glasses. The black glasses also have a strong absorption at 0.6 μm from ilmenite crystals. At least three compositional types of localized dark mantle deposits have been identified based upon the depth, center, and overall shape of the 1.0 μm absorption feature and the continuum slope [11]. TL and Rima Bode have similar spectral characteristics dominated by the black glasses [12], suggesting similar eruption conditions. In contrast, Sulpicius Gallus and Aristarchus Plateau have a higher percentage of orange glasses, perhaps due to faster cooling rates in an optically thinner fire fountain. The dominance of the black glass spectra at TL suggests that the black glass resides at a shallower depth than the orange glass and hence, the core sample at Shorty Crater shows an inverted stratigraphy at depth.

Source of the Taurus-Littrow Deposit: On the basis of the lack of correlation between the mare basalts and picritic glasses, the paucity of apparent volcanic vents in the landing site area, and the fact that regional pyroclastic deposits are generally associated with sinuous rille formation, we have investigated whether Rima Carmen, a 20-km long sinuous rille, may be the source vent for the pyroclastic glasses at TL. An oval depression at the southern end of Carmen is approximately 1 km across, 3 km long, and 160 km deep. Unlike other source heads for rilles, Carmen's source head is not breached or lower in elevation on the side where the rille begins. This suggests that this oval depression could not have been the source head for the rille. This observation, combined with the fact that Carmen is not centrally located in the dark mantle deposit, implies that Rima Carmen is an unlikely source for the regional deposit. The most probable source for the dark mantle deposit is located to the west of TL, buried beneath the low-Ti basalts in Mare Serenitatis. A similar interpretation has been suggested for the dark mantle deposit at Rima Bode [12] where the deposit is located in the eastern highland terrain while younger mare basalts in the west have covered the source rille(s) for the deposit. If the source rille for the TL deposit is now buried by low-Ti basalt flows then basalts produced during the same eruption that produced the glasses could also be buried beneath these younger basalts [13]. The regional slope would have been towards the center of the Serenitatis basin so lava would have flowed here, away from the highland terrain of TL.

Discussion: At Taurus-Littrow, the 74220-type orange glasses and their crystallized equivalents appear to be the dominant pyroclastic glasses produced during explosive volcanic activity in the region. Other types of glasses are either from other localized eruptions or from impacts into other glass deposits. We plan to use Clementine data to look for differences in the spectra of the dark mantle deposit that will show the distribution of various types of glasses. If localized eruptions have contributed glasses to the regional dark mantle deposit at TL then it may be possible to identify these localized deposits from remote sensing using variations in the shape of the absorption band at 1.0 μm. If the regional deposit was produced from one eruption, then distinguishing black and orange glasses will provide important constraints for the eruption conditions during fire fountaining. A similar analysis will be conducted on other pyroclastic deposits to expand our understanding of the volcanic eruptions that produced the deposits and the relationship between the glasses and mare basalts.

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