TESTING THE VOLCANICLASTIC HYPOTHESIS FOR MARTIAN DUNE SEDIMENTS: THE MEDUSAE FOSSAE FORMATION, MARS, AND ANDEAN IGNIMBRITES, EARTH. D. M. Burr[1], J. R. Zimbelman[2], S. L. de Silva[3], N. T. Bridges[4], M. Chojnacki[1], and F. B. Qualls[1] [1]University of Tennessee Knoxville, Knoxville, TN (dburr1@utk.edu), [2]Smithsonian Institution, Washington, D.C. 20013-7012, [3]Oregon State University, Corvallis, OR 97331, [4]JHUAPL, Laurel, MD 20723.

Introduction: Dark dunes have been observed on Mars since the Mariner and Viking missions [1], and the Mars global dune data base [2] shows them to be widespread. Most terrestrial sand is formed by comminution of granitic material into durable quartz grains [1], but Mars apparently lacks appreciable amounts of this parent material [*e.g.*, 3]. Previous work traces dune sand to polar layered deposits [4,5] or local sedimentary units [6], but a mechanism for global sand distribution has not been identified.

One hypothesis for the origin of dark dune-forming sand on Mars is as volcaniclastic deposits [7], which are widely distributed [*e.g.*, 8]. Inferred volcaniclastic deposits include the Medusae Fossae Formation (MFF) [*e.g.*, 8,9], with dark dunes documented in the western MFF (wMFF) [10]. Thus, comparison of the wMFF and terrestrial volcaniclastic deposits and their dune-forming sediments allows us to test the volcaniclastic hypothesis for the source of dark dune sand on Mars.

Data and methods: For the wMFF, we used data from the Context Camera (CTX; res. 6m/px;[11]) and the Compact Reconnaissance Imaging Spectrometers for Mars (CRISM;[12]) for feature identification, and gridded Mars Orbiter Laser Altimeter (MOLA;[13]) data for topographic information. On Earth, we used remote images in conjunction with field observations.

Dark dunes in the wMFF: The MFF is a 2.1×10^6 km^2 equatorial unit with multi-scale layering, whose pervasive erosional scarps and yardangs demonstrate its friable, particulate nature and the prevalence of aeolian sand transport [*e.g.*, 14]. The two lobes of the wMFF (Fig. 1) stretch from the dichotomy boundary into the Cerberus lava plains with total relief of ~1500m, and host fields of dark bedforms. These bedforms are preferentially located in low elevations, primarily in the trough between the wMFF and southern highlands (Fig. 1), and exhibit barchan, barchanoid, mound, and echo dune morphologies with rippled surface textures [10] characteristic of Martian dunes [15]. Thermal inertia values are consistent with (sub-)mm sized sand [10]. On these bases of morphology, texture, and thermal inertia, these bedforms are interpreted as aeolian dunes [10].

Evidence for the MFF as the source for the dark dunes. Dune orientations indicate their emplacement by northerly (N-to-S) winds [10]. Given the strong concentration of dunes in the south wMFF, this northerly direction of sediment transport is consistent with the wMFF as the sand source. Another possible source is the Cerberus lava plains to the north and east, but the roughness and topography of the wMFF would limit sediment influx from that direction. Catabatic winds down Elysium Mons could have transported volcaniclastic sediment from the north, but sediment transport pathways from this direction are not apparent. Evidence in support of the MFF as the sand source includes erosional scarps that decrease in albedo down slope to dunes at their base (Fig. 2). On these bases, we hypothesize that erosion of the wMFF liberates dark dune sediments, with deflation of lighter and lighter-toned material [10].

Andean ignimbrites as MFF analogs: To examine this hypothesis, we consider dark dunes in Andean ignimbrites [16,17], proposed as analogs for the MFF [9]. Andean ignimbrites are late Neogene to Quaternary-age ash flow tuffs that extend from southern Peru and Bolivia to central Chile and Argentina [18 and refs. therein]. In the northwestern Catamarca province, Argentina (26°36’S 67°30’W), the light-toned Campo Piedra Pomez ignimbrite (CPP) [18,19] is extensively eroded into yardangs like the MFF [9], and likewise yields dark dune-forming sediments (Fig. 3;[20]). These similarities between the wMFF and CPP provide a basis for using CPP dark dunes as analogs for the wMFF dark dunes.

Dark dunes in the CPP: The erosional morphology of the CPP controls dune-forming sediments, which are located between yardangs [20], as in the wMFF. These deposits also form extensive sheets with rippled surface texture, as seen on wMFF dunes. Comparative componentry and granulometry of particles within the CPP and of the superposed dark sediments are consistent with the dark sediments being derived from the ignimbrite.The source of these clasts is mainly surface derived – picked up by the pyroclastic flow as it travelled – although some sediments may have come from the conduit as the erupting mixture made its way to the surface [20].

Although most volcanism on Mars appears to have been basaltic instead of felsic [*e.g.*, 3, 21 and refs. therein], basaltic volcanism under the low gravity and atmospheric pressure of Mars is postulated to have produced pyroclastic flows [*e.g.*, 22, 23]. The derivation of dark sediments from the CPP (Fig. 3) demonstrates that dark bedforms may be derived from light-toned deposits. The pervasive dust over the MFF makes determination of true albedo uncertain, but terrestrial basaltic ignimbrites [e.g., 24, 25] are commonly darker that felsic ignimbrites, making the derivation of dark sediments from the wMFF even more plausible.

Hypothesis testing/future work: If dark dune sand is sourced in the wMFF, then other regions of the MFF should host dark dunes. However, the central and eastern MFF do not show extensive dark dunes, possibly because of their higher stratigraphic position. Examination of hypothesized Martian ignimbrites of various elevations for dark dunes investigate this idea.

Implications: If the MFF is the source for locally derived dark dunes, this finding implies that other dark dunes also originate in Martian volcanoclastic rocks. The mafic composition of the wMFF dark dunes [10] is similar to that of other dunes on Mars. Vast expanses of the Martian surface show evidence of having been mantled and, in places, subsequently exhumed [26]. Although the origin of the mantle is not known, a major component of the light-toned mantles could be ignimbrites. Light-toned layered deposits, hypothesized to be ignimbrites, are extensive in the equatorial region of Mars, with a total exposed area of ~2.9x10^{6} km^{2} [7]. These hypothesized ignimbrites would provide a ready source for dark dune sands. Their large extent would obviate the need for global transport and, in face of the rapid breakdown during transport of aeolian sand, could explain the wide-spread distribution of dark dunes on Mars.

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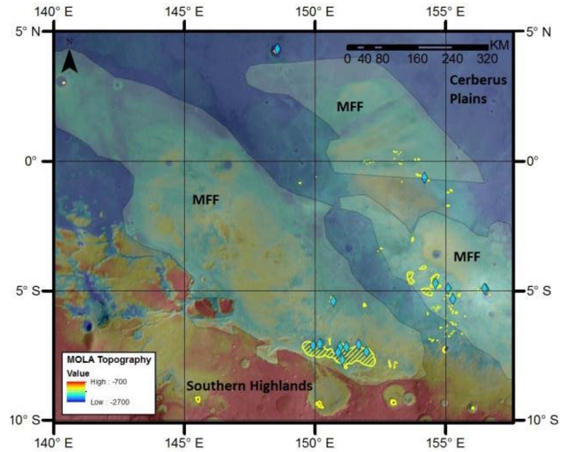

Fig. 1: wMFF study area, showing the locations of dark dunes (yellow hatching). Sites from which thermal inertia values were derived (blue diamonds) are indicated [10].

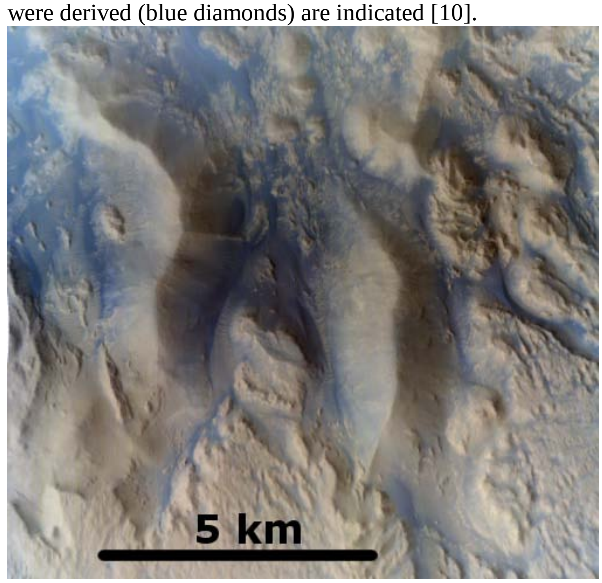

Fig. 2: CRISM FRT63A8 (nr -7.7, 151E) in enhanced color (R=590nm, G=530nm, B=440nm) showing erosional scarps that decrease in albedo downward to dark dunes at their bases.

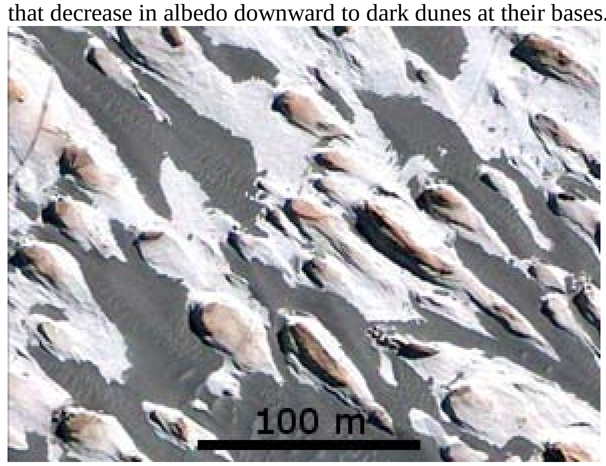

Fig. 3: Image of yardangs formed in the CPP with intervening dark dunes, Catamarca, Argentina. Credit: Google Earth.