AEOLIAN DUNES FROM VOLCANICLASTIC SEDIMENTS: THE MEDUSAE FOSSAE FORMATION, MARS, AND ANDEAN IGNIMBRITES, EARTH. D. M. Burr[1], S. L. de Silva[2], J. R. Zimbelman[3], N. T. Bridges[4], [1]University of Tennessee Knoxville, Knoxville, TN (dburr1@utk.edu), [2]Oregon State University, Corvallis, OR 97331, [3]Smithsonian Institution, Washington, D.C. 20013-7012, [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 across the planet. Although previous work traces dune sand to polar layered deposits [3] or local sedimentary units [4], global origin(s) for Martian dune sand has(have) not been identified.

One long-standing hypothesis for the origin of dark dune-forming sediments on Mars is as volcaniclastic sediments [5]. Inferred volcaniclastic deposits on Mars include the Medusae Fossae Formation (MFF) [e.g., 6,7,8], with dark dunes documented in the western MFF [9,10]. Thus, comparison of the western MFF (wMFF) and terrestrial volcaniclastic 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 an equatorial unit between 130^{o} to 240^{o} E [e.g., 14]. Erosional scarps and yardangs are ubiquitous [7,8], demonstrating its particulate nature and the prevalence of aeolian sand transport. The wMFF (Fig. 1) consists of two lobes stretching from the dichotomy boundary into the Cerberus lava plains with elevations ~500-1000m above the lava plains. These lobes host fields of dark bedforms with barnchan, barchanoid, mound, and echo morphologies [9,10] and rippled surface textures as observed on other Martian dunes [15]. Thermal inertia values are consistent with (sub-)mm sized grains [10]. On these bases of morphology, texture, and thermal inertia, these bedforms are interpreted as aeolian dunes [9,10].

At the regional scale, these bedforms are located preferentially at low elevations. The strongest concentration is found in the topographic trough of several hundred meters depth between the western-most MFF lobe and the southern highlands (Fig. 1). At the local scale, the dunes are generally located at the base of erosional scarps that decrease in albedo with distance down the scarp to the dark dunes (Fig. 2). Sand sheets are inferred between erosional knobs/yardangs; although largely covered with bright dust, their echo-dune morphologies and and transitional albedoes imply dark sand-sized material.

Evidence for the MFF as the source for the dark dunes. Dune orientations indicate their emplacement by northerly (N-to-S) winds [9,10]. Given the strong concentration of dunes in the south of the 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 the erosional scarps that decrease in albedo down to the dunes at their base. On these bases, we hypothesize that erosion of the MFF liberates dark dune sediments, with deflation of lighter-toned material [10].

Andean Ignimbrites as MFF analogs: To examine our hypothesis that the wMFF is the source of sand for its dark dunes, we consider dark dunes in Andean ignimbrites (ash flow tuffs) [16,17], proposed as analogs for the MFF [7]. Andean ignimbrites are late Neogene to Quaternary-age pyroclastic deposits 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) is found the 70 ka Campo Piedra Pomez ignimbrite (CPP) [18,19]. This ignimbrite is extensively eroded into yardangs, with morphologies similar to MFF yardang morphologies [7,8], and yields dark dune-forming sediments (Fig. 3; see also [20 this conf.]). The similarity between the MFF and the CPP ignimbrites provides a foundation for using the CPP ignimbrite dark dunes as analogs for the wMFF dark dunes.

Dark dunes in the CPP: As detailed in [20 this conf.], the erosional morphology of the CPP controls dune-forming sediments, which are located in between yardangs. In addition to distinct bedforms, these deposits also form extensive sheets with rippled surface texture. Thus, the CPP and wMFF dark dunes are analogous in topographic context, morphology, and texture.

Comparative componentry and granulometry of particles within the ignimbrite rock and in the dark sediments are consistent with the dark sediments being derived from the ignimbrites.The source of these clasts is mainly surface derived – picked up by the pyrocalstic flow as it travelled – although some sediments may have come from the conduit as the erupting mixture made its way to the surface [20 this conf.].

A similar process is likely for Mars. Although most volcanism on Mars appears to have been basaltic instead of felsic [e.g., 21 and refs. therein], both wet and dry basaltic volcanism under the low gravity (and possibly atmospheric pressure) of Mars have been posited to have produced pyroclastic flows [e.g., 22, 23].

Hypothesis testing/future work: If dark dune sand is sourced in the MFF as proposed, then other portions of the MFF should host dark dunes. Thus, one test of our hypothesis will be a survey for dark dunes in the central and eastern MFF, which are stratigraphically higher than the wMFF. Determining the geospatial extent and stratigraphic level of the dunes and the direction of the wind during their emplacement will help us understand the source for these dunes.

Implications: If the MFF is the source for local dark dunes, this finding could imply that other dark dunes also originate in Martian volcanoclastic rocks. Vast expanses of the Martian surface show evidence of having been mantled and, in places, subsequently exhumed [24]. Although the origin of the mantle is not known, a major component could be ignimbrites. Light-toned layered deposits, inferred to be ignimbrites, are extensive in the equatorial region of Mars, with a total exposed area of ~$2.9x10^6$ km^2 [6]. These hypothesized ignimbrites would provide a ready source for dark dune sands. Their large extent would obviate the need for global transport anad explain the wide-spread distribution of dark dunes on Mars.

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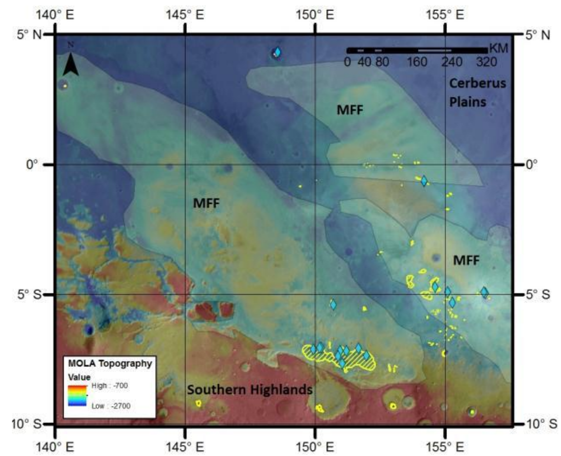

Fig. 1: wMFF study area, showing the locations of dark dunes (yellow hatching). Sites from which thermal inertia values were derived (blue diamonds) are indicated [10].

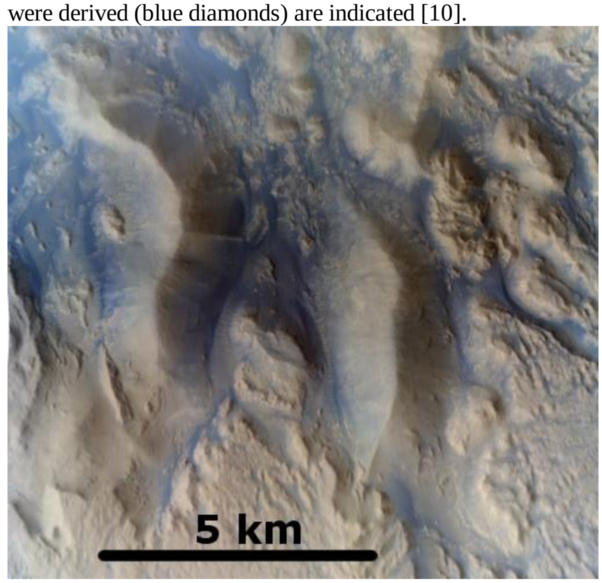

Fig. 2: CRISM FRT63A8 (nr -7.7, 151E) in enhanced color (R=590nm, G=530nm, B=440nm) showing erosional scarps that decrease in albedo downward to dark dunes at their bases.

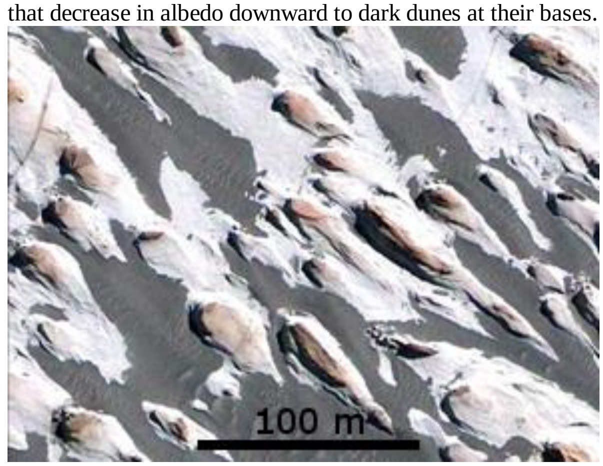

Fig. 3: Image of yardangs formed in the CPP with intervening dark dunes, Catamarca, Argentina. Image: Google Earth.