POSSIBLE TERRESTRIAL ANALOGS AND THEIR IMPLICATIONS FOR DARK SAND SOURCE OUTCROPS IN AEOLIS DORSA, WESTERN MEDUSAE FOSSAE FORMATION, MARS. D. M. Burr[1], C. E. Viviano[2], T. I. Michaels[3], M. Chojnacki[4], R. E. Jacobsen[5], [1]Department of Astronomy and Planetary Science, Northern Arizona University, Flagstaff, AZ, USA (Devon.Burr@nau.edu), [2]JHU Applied Physics Laboratory, [3]SETI Institute, [4]Planetary Science Institute, [5]University of Tennessee Knoxville.

Introduction: Dark aeolian sand on Mars is observed both globally [1,2] and locally [e.g., 3,4]. However, the primary origins of this sand have remained inconclusive [5]. This fundamental knowledge gap in our understanding of Martian aeolian sedimentary processes [6] is highlighted by detection of widespread dune movement today [7,8], during which the more-energetic impacts of saltating grain are inferred to break down those grains to sub-sand sizes [9]. Consistent with limited sand transport distances, local sand sources have been inferred [4] and lithified sand grains have been recycled [10]. However, the mechanism(s) that originated sand-sized grains remain(s) a key area of inquiry on Mars, as throughout the Solar System [5].

A volcaniclastic origin for Martian sand, a hypothesis formalized ~30 years ago on the basis of remote and in situ compositional information and terrestrial analogs [11], has been supported by the identification and volcanic interpretation of sand source outcrops [4 and references therein]. We recently added our interpretation of the Medusae Fossae Formation (MFF) as a sand source lithology in the Aeolis Dorsa region [12]. Given the interpretation of the MFF as a pyroclastic deposit [13] and modeling of explosive volcanism on Mars as producing sand-sized sediments [e.g., 14], the MFF sand source outcrops, having a distinctively olivine-rich mineralogy, also point to a sand genesis, namely, as explosive sedimentation.

Our investigation into the source of sand in the Aeolis Dorsa region and the identification of sand-source outcrops relied on terrestrial outcrops of explosive (pyroclastic) sediments [12]. Having identified from sand mapping, compositional analysis, and sand flux modeling that some sand deposits in Aeolis Dorsa were source from MFF outcrops, we reviewed the appearance of sand source outcrops in terrestrial explosive deposits. Given the olivine-rich mineralogy of the sand from the MFF outcrops, we particularly sought out examples of olivine-rich sand in terrestrial explosive sedimentary lithologies. Sand in these terrestrial analog outcrops was in some cases found in or sourced from meter-scale sand-rich strata. On the basis of those terrestrial analogs and their morphologies, we inspected all images from the HiRISE camera over the MFF in Aeolis Dorsa for similar sand sources. The results of this survey identified several MFF outcrops from which sand appeared to be weathering out of discrete strata and creating talus slopes (Fig. 1). We identified these locations in AD as the sources for the sand deposits at their bases [12].

In this abstract, we present an overview of certain terrestrial volcaniclastic deposits that correspond to some pyroclastic interpretations the MFF [13]. The purpose is i) to give a more complete view of these potential analogs to the MFF and its sand-source outcrops in Aeolis Dorsa and ii) to support discussion regarding possible implications from those potential analogs. Given the sand grain sizes we derived of ~100 to 1000 µm and the olivine-rich sand, we particularly sought out pyroclastic deposits with sand-sized olivine-phenocrysts

Results: The Late Devonian Tolmie Igneous Complex (TIC) in north-eastern Victoria, Australia, composed of both plutonic and volcanic rocks, hosts multiple felsic ignimbrites that contain multigenerational phenocrysts [15]. The ignimbrites exhibit phenocrysts of quartz, biotite, garnet, cordierite and orthopyroxene, with one unit that contains fayalitic olivine. In this unit, the Toombullup Ignimbrite, fayalite (Fo# = 10 to 15) occurs as phenocrysts ~2 mm in diameter and only within the upper level (denoted as 'rhyodacite') of this single crystal-rich ash flow. Modeling of pressures and temperatures for the Toomhullup Ignimbrite implies equilibration at a low pressure (<180 MPa) and still moderate temperature (T >780C), interpreted as evolution in a very shallow-level magma chamber.

The basaltic ignimbrites of the Neogene La Garrotxa volcanic field in Spain are interpreted as deposits from pyroclastic density flows [16]. These massive deposits contain juvenile fragments with megacrysts (1-2 cm in diameter) of olivine and plagioclase, eroded from an underlying layer, likely during multiple explosive episodes.

The LLaima pumice of southern Chile is an andesitic to dacitic deposit from an early Holocene eruption [17]. Mineralogical studies of phenocrysts reveal two chemically distinct olivine compositions, one with Fo# ranging from 32 to 35 and one with Fo# ranging from 76 to 82 (Fig. 2). From these two distinct populations, the eruption trigger is interpreted as resulting from magma mixing.

Implications: These prior terrestrial studies reviewed briefly here support the inference from Mars data analysis that the MFF as an explosive volcanic deposit is a reasonable source for the olivine-rich sand identified in the AD [12]. On Mars, geologic units spectrally dominated by olivine are confined to the early Noachian and the early Hesperian and interpreted as suggesting a mid- to late Noachian mantle cooling that minimized olivine crystallization [18]. MFF emplacement was temporally extended, with the westernmost early Hesperian-age deposits, as found in the Aeolis Dorsa region, younging to the east [19]. The composition of any sand sourced from the central and eastern MFF, by providing primary (original) volcanogenic mineralogies of decreasing age, offer the opportunity to investigate magmatic evolution on Mars.

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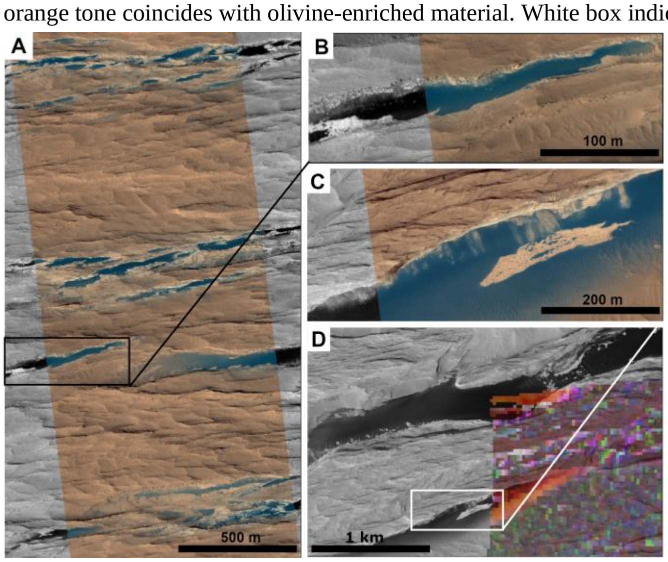
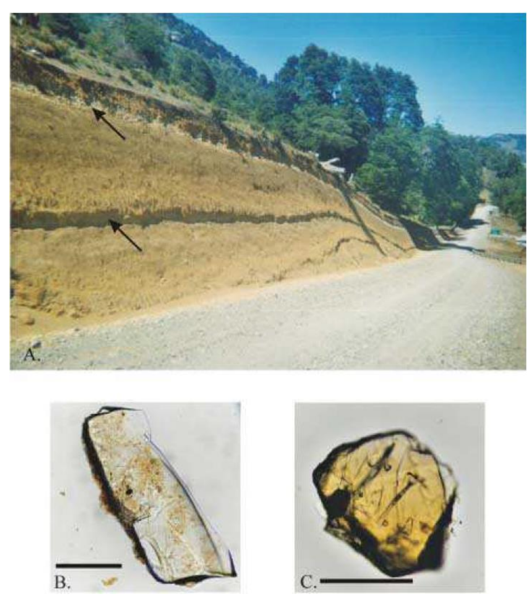
<u>**Fig. 1 (below)**</u>:
Examples of sand source outcrops south of Zephyria Planum (location shown on Fig. 1C).
A) Several sand source outcrops in HiRISE image ESP_048246_1750_MRGB. The location of panel B is outlined in black.
B) A sand source outcrop shown in panel A.
C) A sand source shown in HiRISE image ESP_048747_1750_MRGB.
D) Outcrop in panel C overlain by CRISM data from cube FRS0003977D with R: BDI1000VIS, G: BD1300, B: BDI1000IR; red-orange tone coincides with olivine-enriched material. White box indicates location of panel C.





<u>**Fig. 2 (left)** (from de Vleeschouer et al., 2005):</u> A. View of an outcrop (height: 6 m) with the Llaima pumice in the middle of the outcrop and the Alpehue pumice is at the top (black arrows).
B. Colourless olivine (Fo76-82).
C. Honey yellow olivine (Fo32-35) from the Llaima pumice.
Scale bars are 100 μm long.