DARK AEOLIAN MEGARIPPLES FROM THE PUNA OF ARGENTINA: SEDIMENTOLOGY AND IMPLICATIONS FOR DARK DUNES ON MARS S. L. de Silva[2], D. M. Burr[2], A. Ortiz[3], M. Spagnuolo[4], J. R. Zimbelman[5], N. T. Bridges[6]; [1]Oregon State University, Corvallis, OR 97331 (desilvas@geo.oregonstate.edu), [2]University of Tennessee Knoxville, Knoxville, TN, [3]University of Salta, Argentina; [4]University of Buenos Aires, Argentina , [5]Smithsonian Institution, Washington, D.C. 20013-7012, [6]JHUAPL, Laurel, MD 20723.

Introduction: Dark dunes on Mars have been hypothesized as volcaniclastic sediments [1], including those of the western Medusae Fossae Formation (MFF) [e.g., 2,3,]. Thus, comparison between the western MFF and terrestrial volcaniclastic bedform-forming sediments allows us to test this volcaniclastic hypothesis for the source of dark dune sand on Mars. Herein, we describe the context and sedimentology of dark megaripples in the Puna of Catamarca Province in Argentina as analogs for dark dunes on Mars. We posit that they are the final result of the erosional history of the local bedrock. Analogous relationships between bedforms, topography, and bedrock [4, this conf.] and equivalent weights of materials on the Puna and Mars provide the basis for comparison.

Geologic Background: The gravel megaripple fields of Catamarca, Argentina are located in one of the windiest parts of the Argentinean Puna. In the region of the Cerro-Blanco caldera complex, late Pleistocene ignimbrites ranging in age from 70,000 to 13,000 years dominate the landscape [7, 8]. These rhyolitic ignimbrites are weakly to moderately indurated and have been carved up by the wind to produce prominent yardangs and demoiselles. They contain about 5% by volume of lithic clasts with densities ranging from 2.6 to 3 g/cm^3, and up to 10% crystal-poor pumice clasts with densities of ~0.8 to 1.3 g/cm^3. Erosion liberates these clasts and the crystals from the matrix ash, which is quickly elutriated away leaving a lag of crystals and clasts dominated by older ignimbrites, lavas, basement metamorphic-rich lithics, and pumice fragments.

The gravel ripples are distributed in five distinct fields in close proximity to each other in the region of Catamarca, Argentina centered around 26°45'S 67°45'W. The fields vary in areal extent from 300 km^2 to 50 km^2, representing the largest areas of coarse gravel ripples yet described on Earth [9, 10]. Each field is a separate "basin" demarked by bounding volcanic and basement (metamorphic) highlands and is distinct in lithological characteristics and macroscopic appearance reflecting variable sources of the lithic clasts. The largest of the fields is Campo Piedra Pomez that is built on the bedrock of the 70 ka Campo Piedra Pomez ignimbrite (CPP).

Puna Dark Gravel Megaripples: Dark gravel is found on an erosional surface where the upper indurated layer of the Campo Piedra Pomez ignimbrite is dissected into yardangs and has gradually eroded away [10]. The resulting surface is distinctively wavy and scalloped at the 1 to 2 m vertical and 10m horizontal scale. Gravels collect on the erosional surface and in the swales or interfoils between yardangs and vary from areally extensive sheets through diffuse lenses to distinct bedforms (Figure 1). The best developed bedforms appear to nucleate and develop on the crest of the surface topography and are characterized by cleaner sorting of the gravels with coarse outer layer and finer cores of more sandy material. Crests are dominated by coarse lithic fragments while the lee-side has a greater concentration of pumice. The bedforms have broadly symmetric profiles with shallow <20° stoss and lee slopes.

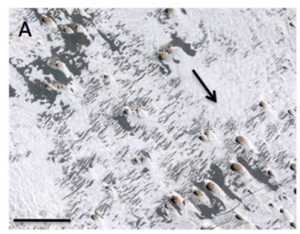
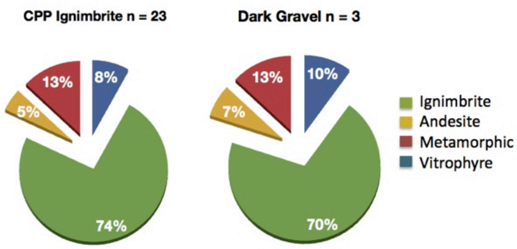


Figure 1. A) Dark gravel ripples on the CPP ignimbrite. Scale bar is 50m. (Extract of Google Earth/GeoEye scene centered on 26°41'05.47"S, 67°33'21.77'W; North to top). Arrow shows wind direction (NW-SE). B) Sequence of four discrete dark gravel armoured megaripple. C) Dark barchanoid megaripple. Wind in both B and C is from the right.

The dominant surface material of the gravels are dark dense lithic fragments up to 3 cm. These consist of four main lithologies: Indurated ignimbrite, both orange and red, metamorphic rocks (gabbros, metasediments, amphibolites, gneiss, and schists,) and lavas (andesites and vitrophyres). These have densities ranging from 1.9 to 2.3 g cm^{-3}. A significant proportion (15 to 35%) of the clast population is also pumice with maximum sizes exceeding those of associated lithics by upto 3x. Pumice represents juvenile material, whereas lithics generally represent exotic material incorporated into the pyroclastic flows from the substrate (local basement) or from the eruption conduit or vent system.

Componentry supports the macro- and mesoscale observations that the origin of the gravels is from erosion of the bedrock ignimbrite (Figure 2). The diversity and proportions of the lithic clasts in the ignimbrite [11] and those in the gravels are indistinguishable. Locally there is abundant evidence for release of lithics by aeolian deflation of the matrix of the ignimbrite.



	Ig. Matrix	Gravel[1]
Vitrophyre	8	10
Ignimbrite[2]	74	70
Andesite	5	7
Metamorphic[3]	13	13

Figure 2. Simplified classification and proportions of exotic lithic clasts in bedrock CPP ignimbrite (average of 23 samples; data from [11]) compared with those for the dark gravels (pumice was not included). Analysis is based on a minimum of 130 clasts >1 cm per sample.

Origin of the Dark Gravels: New granulometry and componentry support previous assertions [10] that the gravels that constitute the dark megaripples are a lag material derived from erosion of the bedrock ignimbrite. The gravels are thus the by-product of yardang formation. Moreover, the strong association of the discrete megaripple bedforms with local topographic “highs” and pumice with the gravels suggests that organization of the gravels into bedforms was influenced by these two factors. The concentration of pumice on the lee side of the bedforms implies a symbiotic relationship between gravel bedform and pumice. We suggest that saltation of pumice (and sand) results in reptation of gravel through impact energy transfer. Undulose topography on the bedrock surface may set up local turbulence and Bernouli effects that might promote accumulation of gravel on crests. Bedforms start to nucleate and stabilize on highs setting up a feedback between the bedform, airflow and lee-side accumulation of saltating pumice. Once the bedform stabilizes it produces a lee-side wind shadow zone that allows pumice to concentrate. Thus we envisage an evolution of the surface from bedrock to yardangs to gravel sheets to gravel bedforms.

Implications for Mars: The obvious local origin of dark gravels that organize into megaripples on light colored bedrock may inform the possible origin of dark bedforms on Mars, and in particular the western MFF. If the Martian dark gravel/sand is locally derived, the sources could be distinct dark layers (welded, vitrophyric ignimbrite or interbedded lava flows) seen commonly during image analysis [12]. Alternatively, as we have seen in the CPP, exotic lithics/sand could be released from bedrock erosion. This would obviate the need for large scale atmospheric transport of dark sediment to be deposited locally before allowing the local wind to do? its work. The onus would then be on understanding how dark materials could have been incorporated into the MFF in the first place. If ignimbrites are a significant component of the MFF, then local or conduit entrainment of exotic lithics during pyroclastic eruption and transport would be the most likely origin. Thus, a unique aspect of these dunes,is that they may be locally derived from the putative ignimbrite materials that make up the mantled yardang materials of the MFF. This is in contrast to most other dunes on Mars for which their ultimate source is unknown. Moreover, it may be that much dark sand elsewhere on Mars, prior to transport to its present location, could have been derived from ancient volcanoclastic mantles that have subsequently been stripped away..

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