COARSE-GRAINED RIPPLE PATTERNS AT THE ALGODONES DUNE FIELD, CALIFORNIA. L.M. Berger[1] and R.C. Ewing[2], M.G.A Lapôtre[3], M. Hasson[4] [1]Texas A&M University, College Station, TX (lauren.m.berger@tamu.edu). [2]Texas A&M University, College Station, TX (rce@tamu.edu). [3]Stanford University, Stanford CA (mlapotre@stanford.edu) [4]Stanford University, Stanford CA (mhasson@stanford.edu).

Introduction: Aeolian dune-field patterns are among the first surface features observed in remote images of planetary surfaces and are robust signals of the surface-atmosphere environment [1]. Because of the prevalence of aeolian features across the solar system, dune-field patterns have been widely used to reconstruct environments. Patterns reflect wind direction, sediment availability, and relative atmospheric density, and provide a measure of constructional time [2].

Patterns of coarse-grained ripples, which have a surface armor of grains significantly coarser than their interiors, are also widely observed across many planetary surfaces. Many studies have examined coarse-grained ripples on Earth and Mars and demonstrated the challenges of using coarse-grained ripples as detailed indicators of surface environments [3][4]. With the aim of expanding the database of coarse-grained ripple patterns and improving the utility of these patterns as detailed environmental indicators, here, we used a dune-field pattern analysis approach to examine coarse-grain ripple patterns. We assess the boundary conditions of the ripple fields and their effect on the ripple patterns.

Methods: A survey of ripple pattern types at Algodones Dunes was conducted in November 2022. Along the western sand sheet of the dune field (Fig. 1), patches of coarse-grained ripples were imaged using a DJI Mavic Pro 2. Images were processed into a 0.5 cm/pixel orthomosaic using Agisoft. These images were brought into ArcGIS Pro software. The ripples were mapped with polylines at a scale of 1:10 from north to south to determine length and orientation trends. Wavelengths were calculated by measuring along transects placed perpendicular to the ripple orientation.

Grain size data was gathered from 16 samples across the study area (Fig. 1, 2) to correlate grain size distribution to patterns. Surface samples from ripple trough, crest, and bulk were collected by scooping the surface and ripple interior. Particle size and shape were measured using dynamic image analysis.

Results & Discussion: The coarse-grained ripple patterns at the Algodones Dunes varied in their wavelength, orientation, crestline length, and presence/absence of superimposed ripples. Ripple wavelengths ranged from 19.5 to 111.6 cm ($\bar{u}$ = 29.3 cm, n = 154). Coarse-grained ripples had an average crest length of 91.5 cm, and an average superimposed length of 19 cm (Fig. 2). Some ripples possessed superimposed ripples of many scales whereas others had no superimposed ripples. For example, the bottom images in Figure 4 have superimposed ripples while the top images do not. The bottom images also have larger wavelengths than the top images.

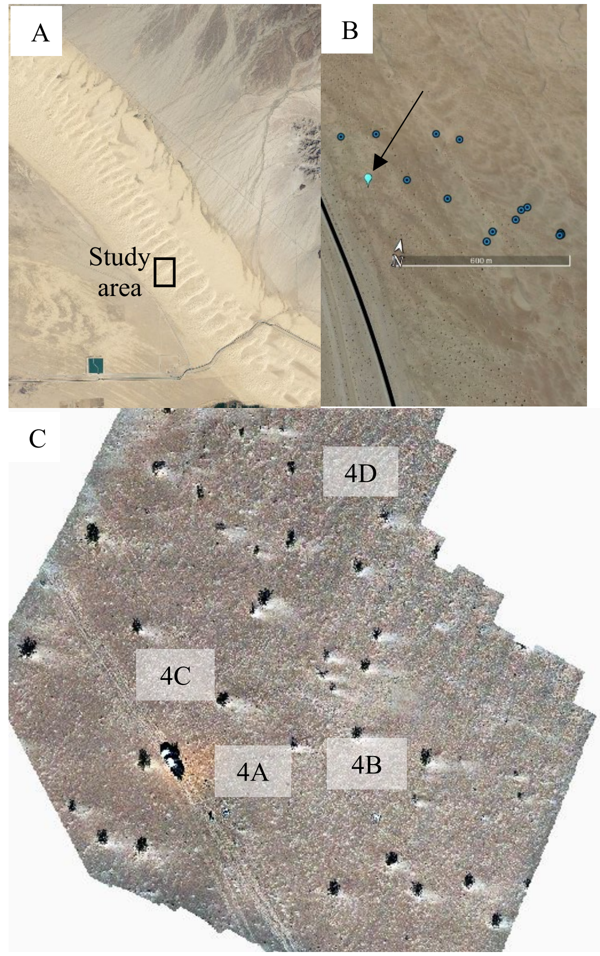

Figure 1. Overview of study areas. A) Satellite image of the Algodones Dunes. B) Observation locations made during the November 2022 survey. Area 1 shown in cyan. C) Area 1 orthoimage created from images gathered using drone data taken on November 8, 2022. Sand shadows (light toned) form behind bushes (dark spots) indicate an W-E transport direction.

The grain size distribution is bimodal (Fig. 3). Across the 16 samples, the bulk samples had peak mode values of 150 um and 1200 um. The crest samples had peak mode values of 150 um 1100 um, similar to the bulk samples. The trough samples had varying peak values but generally had a high volume of coarse grains The sand shadow is mostly composed of fine-grained sand particles (Fig. 4).

Boundary conditions of the ripple fields included the presence of wind drifts behind bushes, proximity to active dunes, and topographic slope (Fig. 4). Topographic barriers, such as vegetation affect the flow of wind and the fraction of fine-to-coarse particles, which may explain why the ripples in Figure 4B, which have vegetation to the E and S, possess different wavelengths than 4A (Fig. 4, 1). Downwind of the bush there is an increase in fines due to baffling and trapping of the fine fraction of sand in transport. This increases the fine fraction in the coarse grain ripples, which appears to manifest as more sinuous and widely spaced crests. A similar effect was observed where coarse grain ripples formed adjacent to active sand dunes.

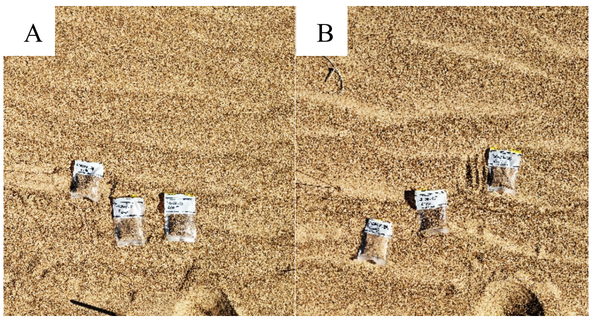

Figure 2. Coarse-grained ripple variation in Area 1 (Fig. 1C). Both images show low-sinuosity coarse-grained ripples with average wavelengths of ~6 cm, however, A) shows a coarse-grain armoring across the entire ripple while B) contains a higher percentage of fine particles (light toned).

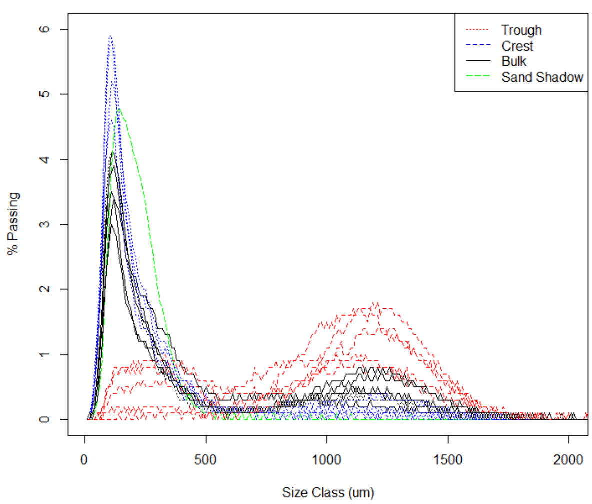

Figure 3. Graph of the grain size of 16 samples taken from Area 1 at Algodones Dunes, California. Samples were organized into categories based on what part of the coarse-grained ripple they were gathered from.

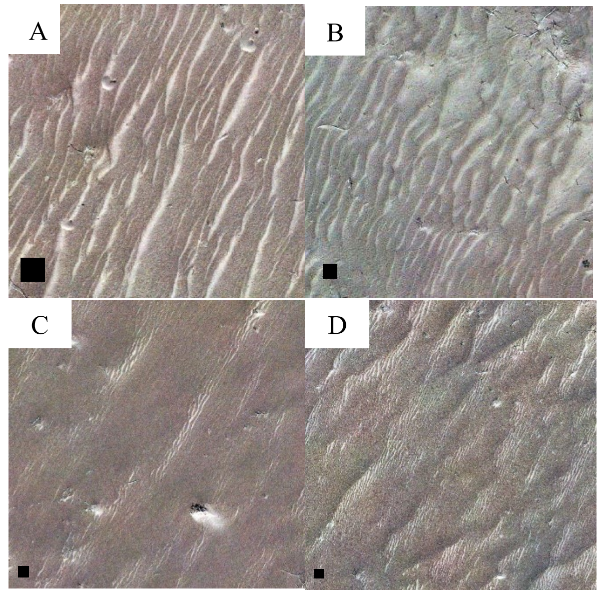

Figure 4. Superimposed pattern variation and effect of boundary conditions in Area 1. The black box is 30x30 cm. (A) coarse-grained ripples with low sinuosity and straight, continuous crest lengths. (B) coarse-grained ripples with sinuous crests. The light-toned material shows a greater abundance of fine-grained sand. (C) Long-wavelength, low-amplitude ripples covered with superimposed ripples. Note the change in wavelength of the superimposed ripples at the crest of the larger ripples where fine sands accumulate. (D) Long-wavelength, low-amplitude, sinuous crests with superimposed ripples and abundant fine grains.

Conclusion: The coarse-grained ripple fields that flank the western ramp of the Algodones Dunes possess a variety of ripples that are shaped by the winds that drive the region and grain size availability across the ramp that drives different fractions of coarse and fine grains. Future work includes detailed mapping of pattern parameters, topographic analysis of ripples and of the study area, and correlation of grain size distributions to patterns.

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References: [1] Ewing R. C. et al. (2017) *JGR: Planets*, 122(12), 2544-2573. [2] Lapotre M. G. A. et al. (2016) *Science*, 353(6294), 55-58. [3] Lapôtre M. G. A. et al. (2021), *JGR: Planets*, 126(21). [4] Kocurek G. and Ewing R.C. (2012) *Sedimentary Geology of Mars* 102. 151-168. [5] Derickson D. et al. (2008) *Geomorphology*, 99(1), 186-204. [6] Sharp R.P.. (1963) Wind Ripples, 617-636.