Forum

The largest wind ripples on Earth: COMMENT

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The dominance of aeolian features on the surface of Mars requires a better understanding of potential terrestrial analogs to provide constraints on models of origin. In his timely article, Milana (2009) describes the largest wind ripples on Earth from the Puna plateau of Argentina. Inverting morphometric parameters and sedimentological observations, he discusses implications for the development of large ripples on Earth and Mars. Critically, Milana neglects the ballistic reptation (creep) hypothesis (Anderson, 1987) in favor of wind-flow characteristics for the development of these ripples. If correct, these inferences will have a major impact on our understanding of ripple formation. I am also familiar with these ripple fields as part of my work to understand the Altiplano-Puna as an analog laboratory for Mars (Mandt et al., 2008, 2009; de Silva et al., 2009). I find that important sedimentological and geological relationships of these megaripples have been ignored by Milana, and that his interpretation of a direct genetic relationship between the largest ripples and bedrock topography are in error. His assertions about the origin of megaripples on Earth and Mars are therefore questionable.

Missing from Milana's report is the context that the ripple fields occur within, broadly north-south elongate lows flanked by highs of young ignimbrites of the Purulla and Campo Piedra Pomez areas (70–13 ka; my unpublished ^{40}Ar-^{39}Ar data) that are spectacuarly dissected into yardangs. Comparison of components in the ignimbrites and gravels indicates that the ripples are produced by reworking of a lag gravel from deflation of the ignimbrites (de Silva et al., 2009). This is inconsistent with one of Milana's (2009, p. 343) key assertions that "mature ripples are partly excavated in bedrock." My observations are that the troughs in the bedrock are oriented orthogonal to the direction of yardangs and other wind direction proxies like wind streaks, ventifacts, flutes, and grooves in the bedrock. Moreover, ignimbrite bedrock surfaces without gravels show significant meter-scale topography. I also note that not all megaripples are located on crests and many are found on flat bedrock surfaces, as well as in broad troughs. Mean aeolian downcutting rates of ignimbrite, based on studies of yardang formation here, range from 0.007 to 0.03 cm year (de Silva, et al., 2009). Thus, trough depths of several decimeters, as described by Milana, require time scales of 1000–10,000 yr to form, whereas time scales for the formation of fully developed megaripples can be very rapid, ranging from days to weeks (Sharp, 1963; Sakamoto-Arnold, 1981; Yizhaq et al., 2008). This connotes that the troughs in bedrock already existed during ripple formation, and were not formed as a consequence of ripple formation as Milana believes. Furthermore, migration rates of several centimeters per year are not uncommon for small megaripples (Zimbelman et al., 2009). Although the Puna gravel megaripples are more extreme, there is every reason to believe, given the presence of a bimodal density distribution of grains (pumice and andesite clasts) and extreme winds, that these would form and move at similar rates if creep could be initiated.

The viability of creep in the Puna gravels can be demonstrated by inverting their grain size characteristics (e.g., Jerolmack et al., 2006). Following Bagnold (1941), impact of saltating 1–3 cm pumice clasts found in the Puna gravels should be able to induce creep in 1–2 cm andesite clasts. Simple calculations (e.g., Shao and Lu, 2000) yield threshold friction velocities (U*t) for 1–3 cm pumice grains of 1.7–2.0 m/s (using a particle density of 800 kg m^{-3} and an atmospheric density of 0.7 kg m^{-3} appropriate for 4500 m elevation). Using a friction speed of 1.7 m/s, a roughness height of 5 mm, and taking von Karman's constant as 0.4, the predicted threshold wind velocity (at 2 m height above the bed) is (1.7/0.4)*ln(2/0.005) = 25 m/s. These velocities are consistent with the peak sustained wind velocities of 20–30 m/s (at a height of 2 m) measured in the month of July in this region; significantly lower than the record wind gusts claimed by Milana. Thus, migration of the ripples through creep seems quite likely on time scales orders of magnitude shorter than those required to produce the erosional troughs in the bedrock ignimbrite. It is highly unlikely that bedrock topography and ripple formation are related.

The Puna gravel ripples forms are indeed spectacular and they may be, as Milana claims, the largest wind ripples on Earth. However, contrary to Milana, I do not find a genetic relation between bedrock surface and ripple formation. I find that the sedimentological and physical character of the Puna gravel megaripples is consistent with formation by creep and subsequent coarsening, bringing into question Milana's disregard of this mechanism and his conclusions about megaripple formation on Earth and Mars.

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