The largest wind ripples on earth: REPLY

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We thank de Silva (2010) for the opportunity to discuss the origin of the unique megaripples (MR) found on the Puna Plateau. Forman and Kröhling were invited as co-authors of this Reply, because we produced new data supplied here. De Silva suggests that the genetic relationship inferred by Milana (2009) between MR and bedrock topography is in error. The next four topics may encompass de Silva's concerns.

1) Age of MR: We do not agree with the assertion that all MR form in days or weeks. If they do, they are quite small, such as those 1 cm high described by Jerolmack et al. (2006) and Yizhaq et al. (2009). The latter showed those same MR becoming 0.7 m long and 4 cm high after a year. At the Puna Plateau, wind reworked flat, well locations into 1-m-long and 10-cm-high MR in 5 yr (Fig. 1). Bagnold (1941), suggested it may take decades or centuries to form large MR, as they grow progressively slower. The Puna Plateau MR reach 43 m long and 2.3 m high. We dated several giant MR by optically stimulated luminescence. An average MR (Fig. 1) gave an age of 1710 ± 130 yr (7.5 cm over bedrock) and 635 ± 45 yr (20 cm over bedrock, 22 cm under surface), although some MR are as old as 3 ka. De Silva used ignimbrite deflation rates to postulate a dissimilar rate of evolution between MR and ignimbrite morphology. Three main ignimbrites are associated with these MR, with different resistance to erosion: The Campo of the Piedra Pómez ignimbrite (ca. 73 ± 23 ka) is quite resistant due to its vapor-phase crystallization, whereas the Purulla (22.9 ± 8.6 ka) and El Médano (12.2 ± 8.6 ka) ignimbrites (Arnosio et al., 2008) are unconsolidated, and show deflation corridors of 20–25 m deep excavated in the Holocene. Even if deflation rates mentioned are from the harder ignimbrites, the time claimed by de Silva to excavate MR troughs is compatible to our findings, also proving Bagnold's (1941) beliefs about large MR age. Thus, we do not see any controversy in encompassing MR evolution and ignimbrite deflation.

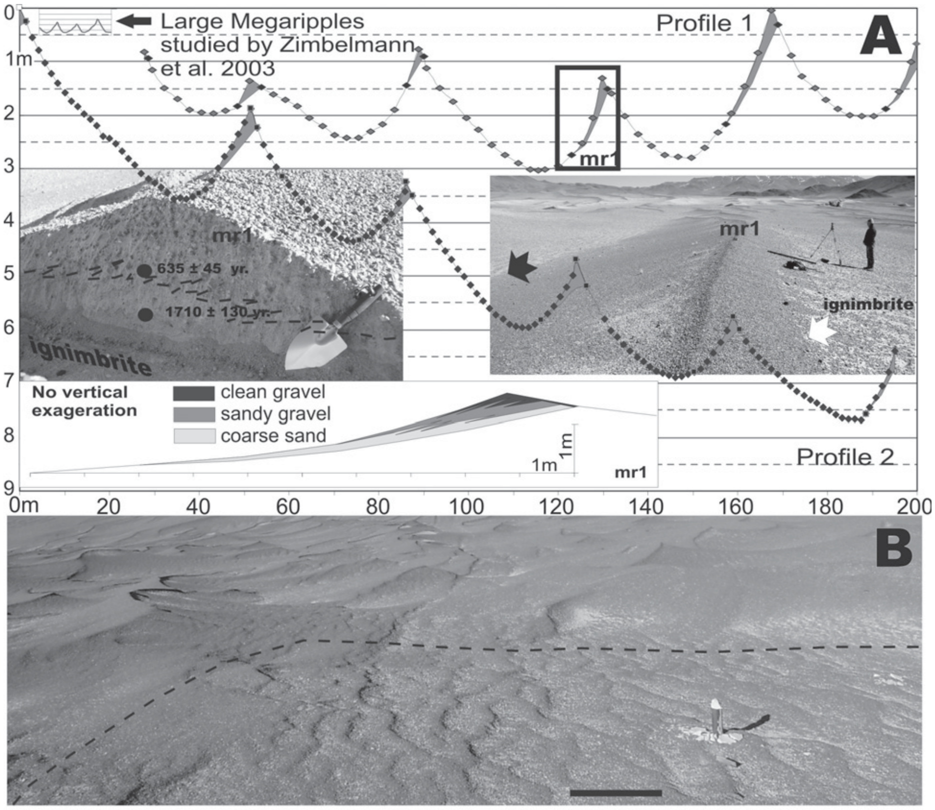

Figure 1. A: Two topographic profiles of giant megaripples showing the granular part in gray, and troughs excavated 1–2 m on the ignimbrite. Inset shows distribution of main facies within the dated bed form (mr1), without exaggeration. Right and left photos show mr1 before and after cutting to extract dated samples. Ignimbrite position is indicated. B: Bulldozed well location (dashed line shows limit), with development of small megaripples after 4 yr. Bar is ~1 m.

2) Structure: The bedrock-MR association is shown by two profiles (Fig. 1) measured with a topographic instrument. Six crests were excavated, exposing profiles along all the granular parts to check position of the ignimbrite. They show coarsening upward, while each MR bed that slopes at ~10° is truncated upslope and fines downwind, downlaping on the ignimbrite. This is coherent with the present surface: coarsest and heaviest clasts on the crest and a progressive fining along the lee face. This structure results from MR migration along with a net vertical accumulation over the locally bare ignimbrite surface, starting ~3000 yr ago. The topographic survey shows an average depth of ignimbrite troughs at 1.5 m, probably excavated during MR evolution. These perpendicular troughs, only observed in association with MR, cannot be ascribed to anything other than aeolian action due to (1) the exact match between granular crests and troughs on the ignimbrite (see GoogleEarth at 26º37´S; 67º46`W), (2) trough orientation perpendicular and oblique to a significant local slope, precluding formation by flowing water, and (3) their high regularity only comparable to mature linear bed form networks.

3) De Silva also questioned the creep of 2–3-cm-sized volcanic clasts. Creep was assumed by Milana (2009) as the main transport mode of the Puna gravel in the smaller MR type present between giant MR. The action of saltating pumice clasts cannot be used to explain the creep of 1–3 cm denser clasts, as many MR are formed in the absence of such pumice clasts. Besides, de Silva's calculations for a pumice clast (0.8 g/cm^3) at the initiation of movement (creep or reptation) seems insufficient to catalyze movement of three-times heavier clasts (as occurs in sand beds), and less likely to push them 10° upslope until the MR crest. Replacing density in de Silva's formulations with the correct clast density (2.42 g/cm^3) increases the threshold friction speed by approximately three times more than estimated, suggesting that his scenario is unrealistic.

4) While creep action is not in debate, its linkage to MR final shape should be. The lack

of correspondence between grain size and MR size does not accomplish the modified ballistic hypothesis. On the other hand, shape and size of MR seem controlled by topography as shown by Milana (2009, his figure 3), suggesting that wind flow structure controls, to some extent, large MR formation. However, this is hypothetical and will remain so until instrumental data can be acquired.

In conclusion, we do not find any disagreement with data supplied by de Silva and the genetic relation between MR and bedrock topography. Thus, the most likely explanation for this type of bedrock erosion is the still unknown interplay between wind flow structure and a granular bed.

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