An Evolving Understanding of Enigmatic Large Ripples on Mars

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Unlike terrestrial sandy deserts, Mars hosts two scales of ripples in fine sand. Larger, meter-scale ripples are morphologically distinct from small, decimeter-scale ripples, and their size, in particular, decreases with increasing atmospheric density. As a result, it was recently proposed that the equilibrium size of the larger ripples is set by an aerodynamic process, which makes them larger under thinner atmospheres. Under this hypothesis, large martian ripples would be distinct from smaller, decimeter-scale impact ripples in a mechanistic sense. Several workers have followed up on these initial observations to either corroborate, counter, or expand upon that hypothesis. Notably, a mechanistic model that not only corroborates the hypothesis that the size of large martian ripples is set by an aerodynamic process but also suggests that they arise from an aerodynamic instability, distinct from the grain-impact instability thought to be responsible for the formation of impact ripples, was developed. Conversely, other workers proposed that large ripples can develop from small impact ripples in a numerical model due to Mars' low atmospheric pressure. In the latter model, the ripples' growth-limiting mechanism is consistent with an aerodynamic process, but the large ripples would not be a separate class of ripples – they would simply be a larger version of the small impact ripples. Here, we explore this debate by synthesizing recent advances in large-ripple formation and offer potential avenues to address outstanding questions. Although significant knowledge gaps remain, it is clear that large martian ripples are larger where the atmosphere is less dense. The size of large martian ripples thus remain a powerful paleoclimate indicator.