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Gypsum gravel devils in Chile: Movement of largest natural grains by wind?

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Benison (2017) draws attention to the presence of large gypsum crystals in gravel ripples in the Atacama desert (Chile). Because these crystals (typically 1 × 8 cm) are several kilometers from the evaporite pools in which they likely formed, and Benison observed some dust devils near the pool, the inference was drawn that dust devils were responsible for entraining the gypsum crystals and transporting the crystals in suspension and the term "gravel devils" was invoked.

That the crystals are transported by wind is not in question. However, an important distinction must be drawn between wind being responsible generally, and dust devils being specifically a factor. A further distinction is whether the transport process is sustained suspension, rather than episodic rolling or saltation near the ground.

The elevated dry plains of this region—the Atacama in Chile studied by Benison, and the nearby Argentine Puna—see prominent aeolian activity of all kinds. One Puna site (Fig. 1) can be seen to have extensive yardangs, gravel ripples, and dust devils. Indeed, although the statistics are poor, there is some quantitative evidence (Lorenz and Radebaugh, 2016) that Puna dust devils (at 3000–4000 m elevation) are more intense than typical low-altitude sites in the United States. An early anecdotal report by Scottish astronomer Piazzi-Smith in 1858 supports the notion that high-elevation dust devils can be intense: while exploring its volcanic mountains as possible sites for astronomical observatories in Tenerife (Canary Islands) he reports "being peppered with little pebbles. . .almost blinded by dust" at an elevation of ~3000 m (Lorenz et al., 2016).

Figure 1. Digital photo obtained with a GoPro® camera lofted by a parafoil kite at the Campo Pedro Pomez site in the Argentine Puna, ~300 km southeast of the gypsum gravel location discussed by Berison (2017). Prominent yardangs in ignimbrite, and dark gray pumice gravel ripples, are seen in the foreground: a dust devil can be seen in the center.

The scoured bases of yardangs imply that the particle transport occurs predominantly near the ground. Further, the physical plausibility of Benison's proposed suspension can be questioned. It should be noted that the vertical velocity of winds in dust devils is typically only ~10%–20% of the circumferential wind speed. Thus, while large objects can often be lifted and thrown on pseudoballistic trajectories over short distances near the ground, sustained suspension is much less common. That said, it can occur in rare cases: a famous one in the dust devil literature being Ives' (1947) observations of lofted kangaroo rats. Kinematically, however, it is difficult to retain more massive objects in the devil over long periods, since their inertia tends to overcome the pressure gradient force such that the objects are flung out of the vortex. Indeed, careful visual observation of dust devils (e.g., Balme and Greeley, 2006) often reveals a visually distinct structure at their base, the "saltation skirt."

Most telling is that gypsum crystals are found with other gravel in large bedforms. It should be noted that while these are called "gravel dunes" by Benison, it may be that they are more accurately considered ripples; see, e.g., Lorenz and Zimbelman (2014) for the distinction. Ripples emerge from pseudoballistic transport of gravel near the ground, with the ripple wavelength being defined by shadowing, and the giant gravel ripples in this region are well-documented (e.g., de Silva et al., 2013). Dust devils may or may not play a role in causing occasional enhancement of near-surface winds, but the emergence of bedforms with a preferred orientation, as shown in Benison's figure 2C, attests to the fact that prevailing large-scale (i.e., unidirectional) winds, rather than (random) vortex flow, dominates the particle transport. Although the directional winds required to launch gravel into the air, albeit briefly, are rare, they are known to occur in the region (Milana, 2009) and are similarly responsible for the general orientation of the Puna yardangs. Thus, it seems a more parsimonious hypothesis that the gypsum gravel transport is near the ground by occasional gusts of wind, as already required for the ripple formation, and it is not necessary to invoke an improbable new process of suspension in "gravel devils." The more quotidian transport process suggested here does, however, raise questions of its own, for example to what extent the crystals are eroded as they clatter along the ground.

The improbable movement of surprisingly large rocks by wind is a recurring topic in geology, a notable example being the "sailing stones" of Racetrack Playa in Death Valley, California, USA (Norris et al., 2014). However, quantitative consideration of the particle kinematics and atmospheric dynamics involved is an essential part of establishing any proposed mechanism. Further, as also in the case of the sailing stones, the gypsum transport will probably be controversially speculative until the transport process is actually observed in action with instrumentation. While I would contend that "gravel devils" have not yet been shown to exist, or it is at least a misleading term, Benison's report does usefully call attention to the extreme aeolian processes in this region which surely deserve further study.

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