Forum Reply

doi: 10.1130/G39294Y.1

Gypsum Gravel Devils in Chile: Movement of largest natural grains by wind?

Kathleen C. Benison
Department of Geology and Geography, West Virginia University, P.O. Box 6300, Morgantown, West Virginia 26506-6300, USA

I thank Lorenz (2017) for his interest in, and opinions about, the report of large abraded gypsum crystals and "gravel devils" at Salar Gorbea in Chile that likely transport this gravel (Benison, 2017). In his Comment, Lorenz compares the Salar Gorbea gravel devils to typical dust devils and other wind phenomena elsewhere. He also questions whether the abraded gypsum crystals were transported in suspension or in bedload. In general, Lorenz expresses a healthy skepticism about Salar Gorbea gravel devils.

Lorenz's Comment includes descriptions of unusual wind processes and sedimentary features at Campo Pedro Pomez on the Argentina Puna, at Tenerife in the Canary Islands, and at Racetrack Playa in Death Valley National Park in California, USA. However, none of these environments or their winds is particularly relevant to understanding Salar Gorbea gravel devils. Campo Pedro Pomez is characterized by spectacular yardangs, erosional landforms carved by the wind from pumice (de Silva et al., 2010; Lorenz, 2017). It is at a lower elevation and has lower topographic relief than Salar Gorbea, likely providing a long fetch for strong non-rotational winds. Tenerife, with volcanic peaks, yet at a lower elevation and more humid than Salar Gorbea, has abundant dust carried from the Sahara (i.e., Criado and Dorta, 2003). At Racetrack Playa, cobbles and boulders slide atop a slippery mudflat surface when wind moves melting ice sheets (Norris et al., 2014). At none of these places were gravel devils found.

Salar Gorbea is the home to a variety of eolian processes and products. During three days of fieldwork, I witnessed small- and medium-sized dust devils carrying clay, silt, and sand, and moving over both the salt-covered salar and the adjacent volcaniclastic alluvium. Some of these dust devils were translucent white with powdery salt from efflorescent crusts; others were translucent gray due to volcaniclastic grains. Megaripples composed of granules and small pebbles were seen adjacent to the southern end of Salar Gorbea, suggesting eolian movement of small volcaniclastic gravel. Ventifacts carved from volcanic rocks are common on the distal alluvium fans around the salar. However, my paper is not an overview of depositional and erosional eolian features at Salar Gorbea. In contrast, it is the first report of one specific eolian feature, the unusually large whirlwinds that are hypothesized to transport finger- to foot-sized bladed gypsum crystals.

The Salar Gorbea gravel devils seem to be larger than most other terrestrial dry convective helical vortices. Their diameter is estimated at ~500 m throughout their ~2000–2500 m height. They are also opaque and white, supporting the claim that they are transporting gypsum in suspension. The abraded gypsum crystals weigh up to ~25 g, an order of magnitude less than kangaroo rats (averaging ~128 g). Kangaroo rats have been rumored to fall from some dust devils in the southeastern United States, leading Ives (1947) to test and calculate the updraft velocity needed to lift them (see also, Heavens, 2017). More recently, bounce houses containing children have been lifted aloft by dust devils (i.e., Byrne, 2014). It should be easier for gypsum crystals to be entrained and transported in suspension by wind than it is for kangaroo rats and children in bounce houses. Dissipating whirlwinds drop kangaroo rats that are "usually very angry," but "apparently unhurt" (Ives, 1947), allowing them to leave the area; kangaroo rats and children in bounce houses do not leave sedimentary deposits as do the gypsum crystals. Therefore, abraded gypsum crystals randomly oriented in mounds and also scattered across the surface may be the first recognition of gravel deposits of past whirlwinds.

How is it known that the large abraded gypsum crystals at Salar Gorbea are not simply moved in bedload by rolling or by saltation? There are no criteria in the literature for recognizing the distinction between eolian gravel bedload and eolian gravel in suspension. However, moving large bladed gypsum crystals as bedload presents some additional challenges. With flat sides, it seems as if it would be difficult to entrain and transport the crystals in bedload. How would they roll along the bedding plane? How would air get under the flat-lying crystals to move them up off the surface as part of the saltation process? And, if saltated, how would a crystal dropping back onto the bedding plane be able to initiate movement of another flat-lying crystal by landing on it? Most physical sedimentological models for rolling and saltation use highly spherical and well-rounded grains to illustrate these processes. In contrast, non-spherical grains, such as bladed gypsum crystals, move less efficiently by saltation (i.e., Wang et al., 2014). A crystal oriented with its long axis perpendicular to wind direction, as are the gypsum crystals in the desiccated salar pools, might be easy to initially entrain. However, it would likely be difficult to entrain a bladed crystal with currents parallel the long axis, as would be the case for flat-lying crystals. In addition, one suspects that rolling or saltation of long bladed crystals would result in different sedimentary structures, such as oriented and imbricated crystals, and not in the randomly orientated abraded crystal gravel documented at Salar Gorbea (see my figures 3E–3G).

It is undeniable that more study of the wind processes at Salar Gorbea is warranted. The Salar Gorbea gravel devils and resulting gypsum crystal breccia highlight the need for (1) more direct observations of the physical sedimentology in extreme and remote environments, including quantitative measurements of wind speeds and directions and instrument documentation of maximum grain sizes in suspension; (2) new experimental studies of wind entrainment, transport, and deposition, using various shaped gravel; and (3) expansion of eolian models to better incorporate natural grains larger than sand.

ACKNOWLEDGMENTS

I thank West Virginia University's Technical Writing in Geology students Vikas Agrawal, Rawlings Akondi, Sofia Andeskie, Lynnette Eichenlaub, Natalie Odegaarden, and John Pilewski for discussion. Field work in Chile was funded by a National Geographic Society Research and Exploration grant.

REFERENCES CITED

Byrne, K., 2014, Gust or 'freak dust devil' throws bounce house in air, injures three kids in NY: AccuWeather, Inc.: http://www.accuweather.com/en/weather-news/wind-bounce-house-ny-children/26883142.

Benison, K.C., 2017, Gypsum gravel devils in Chile: Movement of largest natural grains by wind?: Geology, v. 45, p. 423–426, doi:10.1130/G38901.1.

Criado, C., and Dorta, P., 2003, An unusual "blood rain" over the Canary Islands (Spain): The storm of January 1999: Journal of Arid Climates, v. 55, p. 765–783.

de Silva, S.L., Bailey, J.E., Mandt, K.E., and Viramonte, J.M., 2010, Yardangs in terrestrial ignimbrites: Synergistic remote and field observations on Earth with applications to Mars: Planetary and Space Science, v. 58, p. 459–471, doi:10.1016/j.pss.2009.10.002.

Heavens, N.G., 2017, Of kangaroo rats and gypsum gravel: Probing the extremes of aeolian transport in the present and the past: Geology, v. 45, p. 479–480, doi:10.1130/focus052017.1.

Ives, R.L., 1947, Behavior of dust devils: Bulletin of the American Meteorological Society, v. 28, p. 168–174.

Lorenz, R.D., 2017, Gypsum gravel devils in Chile: Movement of largest natural grains by wind?: Geology: Comment, v. 45, p. e423, doi:10.1130/G39216C.1.

Norris, R.D., Norris, J.M., Lorenz, R.D., Ray, J., and Jackson, B, 2014, Sliding rocks on Racetrack Playa, Death Valley National Park: First observation of rocks in motion: PLoS One, v. 9, p. e105948, doi:10.1371/journal.pone.0105948.

Wang, Z., Ren, S., and Huang, N., 2014, Saltation of non-spherical sand particles: PLoS One, v. 9, p. e105208, doi:10.1371/journal.pone.0105208.