Eureka Valley Sand Dunes

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Abstract

The Eureka Valley sand dunes, the tallest in California, occupy the southeastern corner of Eureka Valley in the Basin and Range province of eastern California. The alluviated valley floor is both extensive and sandy enough to generate sufficient sand to build the dunes in a period of 500,000 years at most.

The symmetrical form of the dunes and their location suggests that they occupy the site of a persistent, orographically controlled wind eddy where the sand moves to and fro, but does not advance in any consistent direction.

Introduction

In the southeastern corner of Eureka Valley is California's tallest sand dune, a mountainous ridge of sand that rises 208 m (682 ft) above its base. Its dimensions are about 5.3 by 2.4 km (3.3 by 1.5 mi). The Eureka dune is dominated by a single high ridge, in contrast to the Kelso Dunes farther south in the central Mojave Desert (Fig. 1). The Kelso Dunes, California's second highest, have four distinct parallel east-west ridges. On the other hand, the main ridge in the Eureka Dunes lies more or less north-south, roughly parallel to the west face of the nearby Last Chance Range.

It has been suggested from time to time that very high dunes like those in the Eureka Valley and at Kelso are only rocky hills entirely covered by dune sand rather than hills wholly of sand. So far as is known, no bedrock core has revealed itself either at Kelso or in Eureka Valley, and it is probable that any account of an origin for these large dunes would need to provide enough sand to build a dune group exclusively from wind-blown material.

Discussion

Though no systematic study has ever been published on the Eureka Dunes, the alluviated Eureka Valley seems to be large enough to supply the necessary sand. Not only do numerous broad, sandy washes lead from the surrounding mountains to the playa lake just northwest of the dunes, but the lower part of the valley floor between stream channels is also very sandy, and vegetation is sparse enough to allow strong winds to pick up considerable sand. Further, the dunes probably have been in existence since at least the Late Pleistocene, maybe even longer, so it is likely that as much as 100,000 years has been available to produce the

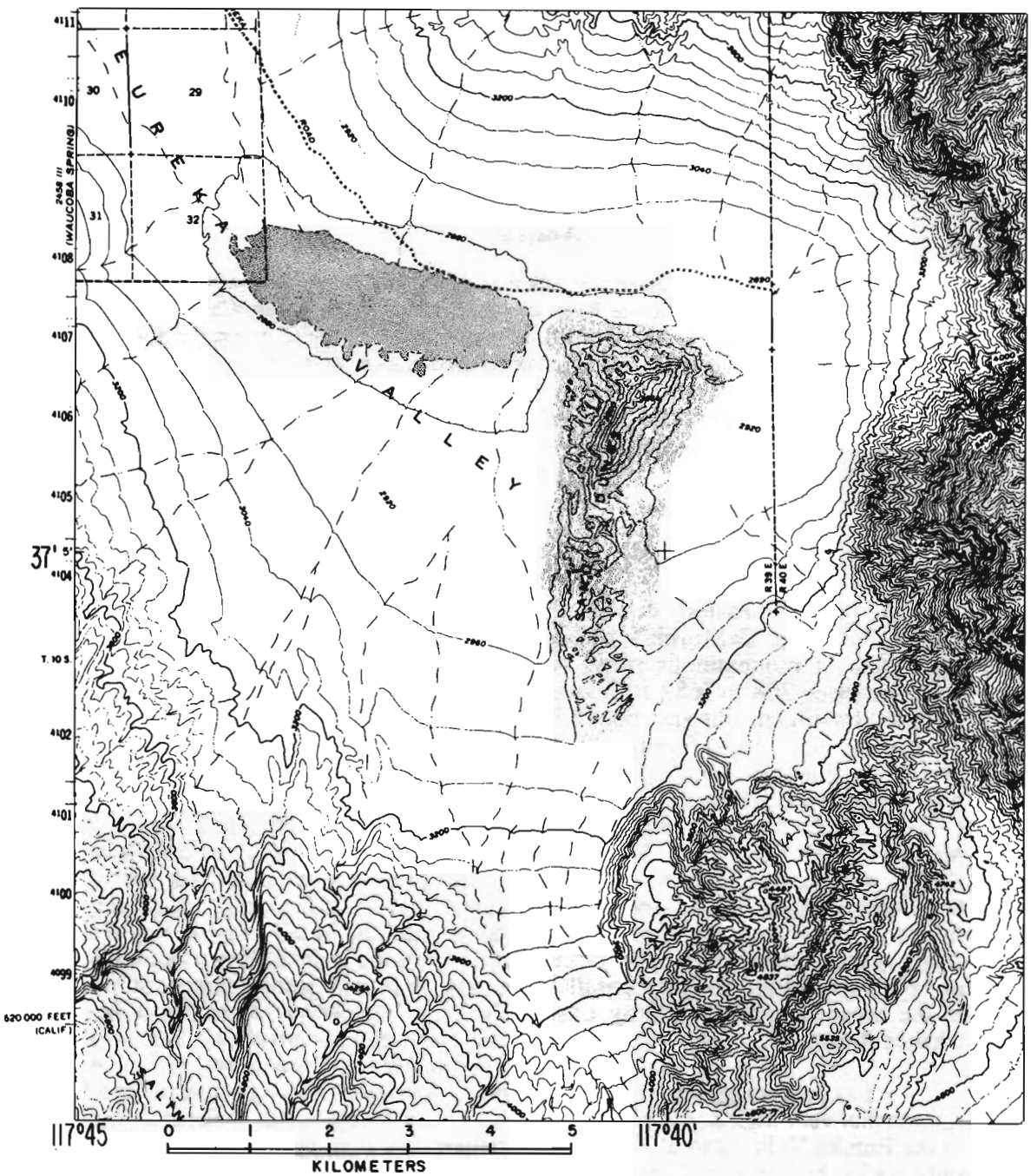

Figure 1. A portion of the U.S. Geological Survey 1:62,500 Last Chance Range Quadrangle, California, showing the form and location of the dunes.

dunes we see today. If the dunes are 100 percent sand, they contain, very roughly, 1.38 cubic km (about 0.33 cubic mi) of sand. If we were to assume the dunes are about 500,000 years old, hardly an unreasonable figure, this would require that something like 6,900 cubic meters of new sand be added annually to create the dunes of today. Is this too much? Are the dunes younger or older than 500,000 years? We really don't know; there are no measurements of sand flux in the Eureka Valley. We do know that the floor of Eureka Valley occupies at least 350 sq km (135 sq mi), and an annual contribution of 6,900 cubic meters would require an average of only about 20 cubic meters from each square kilometer of valley floor. These figures seem very conservative indeed in view of the author's study of a single, much smaller Imperial Valley dune that frequently showed an increase or loss in sand volume of between 10,000 and 70,000 cubic meters in a single month [Norris, 1966].

Admittedly, this is speculation piled upon speculation, but it nevertheless appears reasonable to conclude that the Eureka Dunes are some hundreds of thousands of years old and that the sand present within them could quite easily have been supplied by desert-floor alluvium in Eureka Valley during that time, however long that might have been.

Why are the dunes located in the southeastern corner of the the Valley? Again, we have no weather information from Eureka Valley to guide or constrain us. We do not know the frequency, strength, direction, or duration of the sand-driving winds that rake the Valley and dunes. On the coast and in the larger valleys of California, there is a tendency for the stronger (sand-driving) winds to blow from the northwest; but in the deep, enclosed valleys of the Basin Ranges, this pattern may be much modified by the shape and plan of the surrounding mountains. Nevertheless, Eureka Valley is elongated in a northwest-southeast direction, and the dunes lie near its southern end; northwesterly winds are probably important in forming them.

Although the dunes are located in the southern part of the Valley, they are not plastered against the steep face of the Last Chance Range (Fig. 2). In some places, such as on the Malibu coast, dunes have developed right against a mountain face; but in other situations, like the Panamint Valley, dunes have developed some distance away from the mountain barrier but nevertheless in a location influenced by the mountain wall.

The Eureka Valley dunes seem to have a more-or-less symmetrical cross section from east to west, which suggests that they are governed by winds whose direction is quite variable, but which blow mainly from east or west. Winds of constant direction develop gentle slopes on the windward side and steep slopes (slip faces) on the lee side. This geometry is very obvious in Imperial Valley's Algodones dunes, which have steep slip faces facing southeast owing to the influence of strong winds from the northwest [Norris and Norris, 1961]. The Eureka dunes lack well-defined slip faces, so winds of constant direction cannot be important.

Having said this, however, it should be made clear that the sand in the Eureka dunes was not necessarily derived solely from the near vicinity of the present dunes. Indeed, it is probable that northwesterly winds

swept sand from much of the Valley into this little corner where the configuration of the mountains produces some sort of persistent eddy in the wind pattern. The eddy might result in sand deposition at the site of the dunes where sand may move to and fro without developing well-defined slip faces. Unfortunately, there are no meteorological data to lend credence to this story; only the form and location of the dunes can inform us.

Even small dunes -- perhaps initiated by a desert shrub that causes a tiny dune to develop on its lee side (sand shadow or accretion dune) -- tend to attract more sand. Whenever a steady sand supply is available, dunes often respond by growing larger because the leaps of the wind-transported saltating sand grains shorten across sandy surfaces (and lengthen over hard or rock surfaces). Much sand travels by saltation or jumping. When sand grains strike a yielding, loose sandy surface, they tend not to bounce back into the air column, but instead are added to the sand dune. However, when a saltating grain strikes a hard rock, it immediately leaps or bounds back into the air. (It has long been known that the easiest way to destroy a dune is to scatter pebbles and rocks on its surface in order to increase the number of saltating grains.) As for the large Eureka Dunes, they probably started as a small sandy patch during an arid interlude, perhaps in the Middle Pleistocene. As more sand was brought into this favorably situated location, the Eureka dunes gradually grew to their present size.

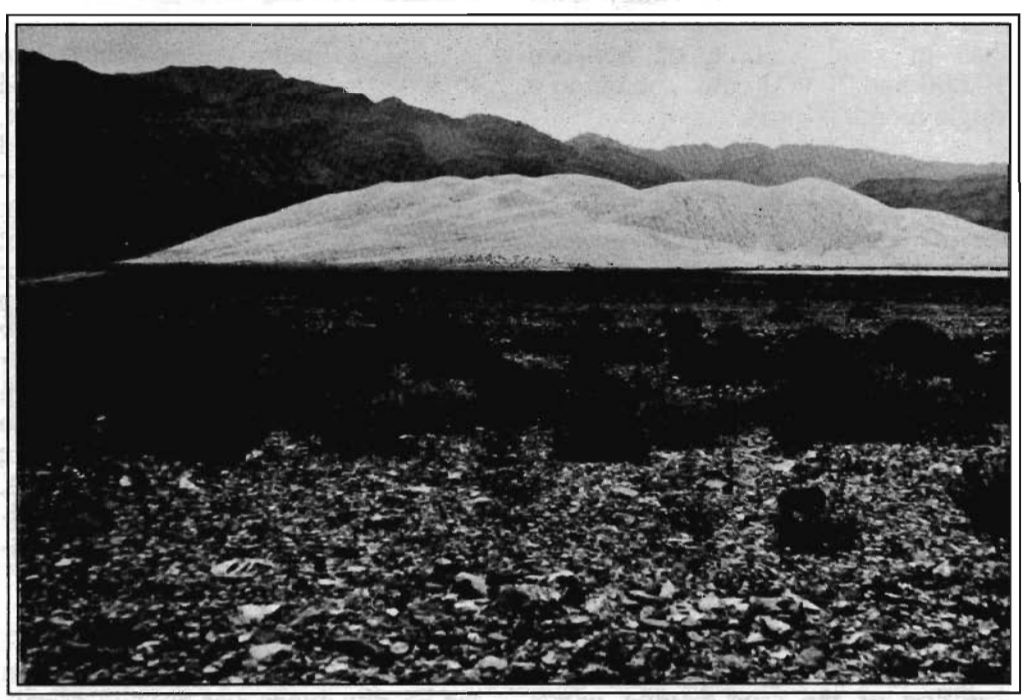

Figure 2. The Eureka Valley sand dunes seen from the northwest. The Last Chance Range, a tilted fault block composed of Paleozoic marine sedimentary rocks is in the background. Photography by Robert M. Norris.

In conclusion, we must admit that our knowledge of the Eureka Valley Dunes is very limited. We do not have any weather or wind records from the area on which to rely; we must deduce the entire story by comparison with other, more closely studied dune groups and what the form and location of the Eureka Dunes can suggest about their origin and history. For these reasons, it would be well to accept this story with caution, lest we validate Mark Twain's comment: "There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

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