Owens Lake dunefields: composition, sources of sand, and transport pathways

Nicholas Lancaster[1], Steven N. Bacon[1], Sophie Baker[1], and Grace A. McCarley Holder[2]

[1]Division of Earth and Ecosystem Sciences, Desert Research Institute, 2215 Raggio Parkway, Reno, Nevada, 89512

[2]Great Basin Unified Air Pollution Control District, 157 Short Street, Bishop, CA 93514-3537

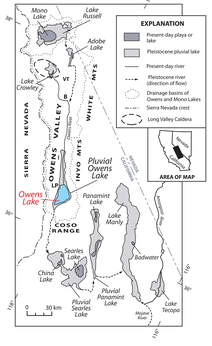
Abstract

Analysis of the mineral and chemical composition of aeolian sands, as well as those from potential fluvial, alluvial, or lacustrine sources can provide valuable information on sand sources and transport pathways, as demonstrated for dune fields in many areas. The results of such analyses can also be used to constrain the conditions in which dune construction occurred. We describe the mineral and grain size composition of sand from the major dune areas adjacent to the now dry Owens Lake, California and compare it with sand from potential sources including washes draining the Inyo and Coso ranges to the east and south of the basin, as well as to the Owens River and washes draining the Sierra Nevada, which lies to the west of the Owens Valley and Owens Lake.

The compositional data indicate that the dune sands are all very similar and are composed of an average of 47% quartz, 33% plagioclase and 13% K-feldspar, with minor amounts of calcite and other minerals. The relative proportions of quartz, plagioclase, and K-feldspar indicate that the sands are derived from granodioritic source rocks. It is therefore considered that the primary source of sand for dune fields in the Owens Lake basin is sediment derived from the Sierra Nevada Mountains, via the Owens River from the north and the Coso Range from the south.

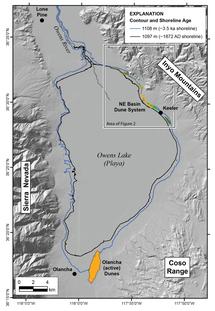
Sediment from fluvial and alluvial sources reached the dune fields in the northeastern sector of the basin by wind transport across the exposed bed of Owens Lake during periods of low lake levels. The pathway by which sand reached the Olancha Dunes located to the south of the lake is less clear, but probably involved transport from the South Sand Sheet, via the former Dirty Socks Dunes. The source of sand for the South Sand Sheet area is hypothesized to be the adjacent Coso Wash system draining the Coso Range.

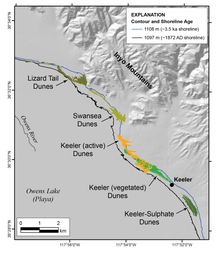
Study Area

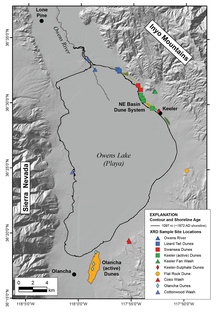


Owens Lake Dunefields

Dunefields and associated sand sheets occur in two main locations adjacent to Owens Lake: (1) the northeastern section of the lake basin in the area between the Owens River and the southeast of Keeler, comprising from northwest to southeast: the Lizard Tail Dunes, Swansea Dunes, Keeler Dunes, and Keeler-Sulphate Dunes, and (2) the Olancha Dunes in the southwestern margin of the basin. Additional small dune areas and sand sheets occur in the southern part of the lake basin on the piedmont of the Coso Range. The dunes and sand sheets overlie late Pleistocene and Holocene distal alluvial fan deposits, as well as lacustrine deposits and shoreline features associated with late Holocene transgressions of Owens Lake to elevations of up to 1108 m.



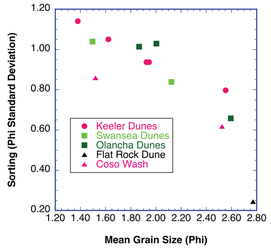




Sand samples were collected from representative dunes in all parts of the dune areas and from potential source sediments that included fluvially-transported sand adjacent to the Owens River; two washes on the Keeler fan; Cottonwood Wash on the western margin of the basin; and the Coso Wash to the south.

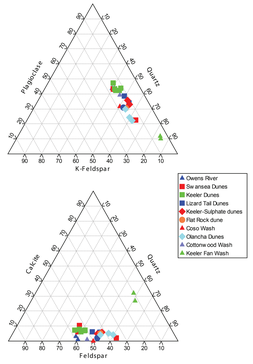
Sediment grain size composition and mineralogy

Particle size and sorting



The sampled sands range widely in their mean particle size from medium to very fine sand (Wentworth scale). Mean grain size ranges from 1.38 to 3.07 phi (511-133 µm). Sorting coefficients range between 0.24 (very well sorted) to 1.16 (poorly sorted). The majority of sands are moderately well to poorly sorted, with well-sorted sand being exceptional. In general, sorting improves as mean particle size decreases. Sands exhibited a range of skewness values from strongly-fine skewed (tail of coarse grains) to strongly-coarse skewed (tail of fine grains).

Bulk mineralogy



Bulk mineralogy was determined using semi-quantitative XRD (X-ray Diffraction).

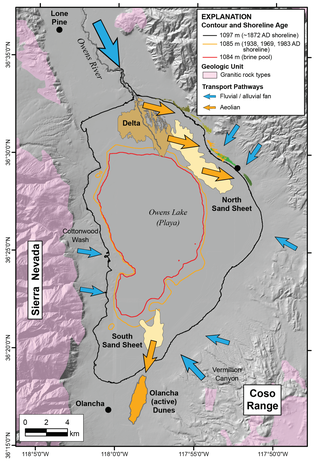
All the dune samples are quite similar, containing major quartz (mean 47%) and plagioclase (33%) with minor K-feldspar (e.g. orthoclase) and minor or trace amounts of both calcite and amphibole.

With one exception, sands from the Swansea Dunes and Keeler Dunes are almost identical, with a quartz content of 37-38% and total feldspar content of 40%. The sands from the Lizard Tail and Keeler-Sulphate Dunes, as well as those in the southern parts of the basin, however, are slightly richer in quartz (48-55%) and lower in total feldspar (39-40%).

Sands from fluvial, alluvial, and deltaic sources on the north, west, and south of the basin are similar with a quartz content of 38-40%, 42-43% plagioclase, and 15-16% K-feldspar, with trace calcite.

In contrast, the sand from the Keeler Fan washes is distinctly different - quartz is the dominant mineral (>50%), and calcite (as lithic fragments) is the only other major mineral (>20%) present.

Sand sources and transport pathways



Based on the compositional data presented here, it is considered that the primary source of sand for dune fields in the northeastern sector of the Owens Lake basin is sediment derived from the Sierra Nevada, via the Owens River. Sand in the southern part of the basin, especially the Olancha Dunes was likely sourced from ephemeral washes draining the Coso Range.

Sediment from fluvial and alluvial sources reached the various dune fields by wind transport from the exposed bed of Owens Lake during periods of low lake levels. Following the desiccation of Owens Lake as a result of anthropogenic water diversions, the Keeler Dunes were sourced from sediment transported by wind from the area of the Owens River delta across the dry bed of Owens Lake (Lancaster et al., 2013). During previous climatically controlled periods of low lake levels, sands exposed in distal delta areas and on fringing lake plains were deflated by NW winds to form the Lizard Tail and Keeler-Sulphate dunes.

The pathway by which sand reached the Olancha Dunes is less clear, but probably involved transport from the South Sand Sheet, via the former Dirty Socks Dunes (northeast of the Olancha Dunes). The source of sand for the South Sand Sheet area is hypothesized to be the adjacent and well-developed Coso Wash system.

The results of these studies indicate the close connections that exist in this area between sediment supply from alluvial and fluvial sources and dune construction. We are currently seeking to define the relationships between Holocene changes in lake level and periods of dune construction.

We thank Sondra Grimm for collecting samples to add to the database and Scott Stine for discussions on the paleohydrology of Owens Lake during low lake levels

This project was funded by a contract from the Great Basin Unified Air Pollution Control District to DRI