Catena 134 (2015) 41–49

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Owens Lake dune fields: Composition, sources of sand, and transport pathways

Nicholas Lancaster [a,*], Sophie Baker [a], Steven Bacon [a], Grace McCarley-Holder [b]

[a] Desert Research Institute, Reno, Nevada; Bishop, CA, United States
[b] Great Basin Unified Air Pollution Control District, Bishop, CA, United States

ARTICLE INFO

Article history:
Received 3 July 2014
Received in revised form 2 December 2014
Accepted 4 January 2015
Available online 22 January 2015

Keywords:
Sand dunes
Mineral composition
Particle size
Owens Valley
California

ABSTRACT

In this paper, we describe the mineral and grain size compositions of sand from the major dune areas adjacent to the now dry Owens Lake, California and compare them 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 semi-quantitative mineral compositional data indicate that the dune sands are all very similar and are composed of approximately 47% quartz, 33% plagioclase and 13% potassium 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 via the Owens River from the north as well as from granitic rocks in the Coso Range to 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 Dirty Socks Dunes. The source of sand for the South Sand Sheet area is hypothesized to be the adjacent Vermillion Canyon wash system draining the Coso Range.

1. Introduction

Dune fields in arid and semi-arid regions typically form part of local to regional scale sand transport systems, which comprise source areas, transport pathways, and depositional sinks. The dynamics of these systems are controlled by the supply of sand-sized sediment, the availability of this sediment for transport by the wind, and the transport capacity of the wind (Kocurek and Lancaster, 1999). Identifying and characterizing the components of such systems can be challenging, but 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 on the Great Plains (Muhs et al., 1996), the Mojave and Sonoran Deserts (Muhs et al., 2003; Scheidt et al., 2011), as well as Namibia and the Arabian Peninsula (Garzanti et al., 2012, 2013). The results of such analyses can also be used to constrain the conditions in which dune construction occurred (e.g. Muhs et al., 2003).

Areas of sand dunes in this study occur adjacent to the northeastern and southern shores of the now dry Owens Lake, California. The composition and sources of sand for these dune areas have not been previously studied in any detail, but are important for understanding the relationship between the formation of dunes in response to changes in lake level, either by natural or anthropogenic forcing (e.g., as a result of water diversion).

In this paper, we describe the mineral and grain size compositions of sand from the major dune areas and compare its mineral composition with potential sources of sand including the Owens River and streams draining the Sierra Nevada, which lie to the west of Owens Valley and Lake, as well as ephemeral washes around the Owens Lake basin that drain the Inyo Ranges to the east and the Coso Range south of the basin.

2. Study area

Owens Lake lies at the southern end of Owens Valley, a 200-km long north–south trending fault graben that is bounded to the west by the Sierra Nevada and to the east by the White and Inyo Mountains. The Coso Range bounds the basin on its southern end (Fig. 1). The primary inflow to the lake is the Owens River, the watershed of which includes a large area of the Sierra Nevada to the west and north of the Owens Valley. There is also minor input from perennial streams draining from the Sierra Nevada immediately west of Owens Lake. Streams draining the Coso Range and Inyo Mountains are ephemeral and reach the lake only after heavy local precipitation (e.g., Goodridge, 1996).

* Corresponding author.
E-mail address: nick.lancaster@dri.edu (N. Lancaster).

http://dx.doi.org/10.1016/j.catena.2015.01.003

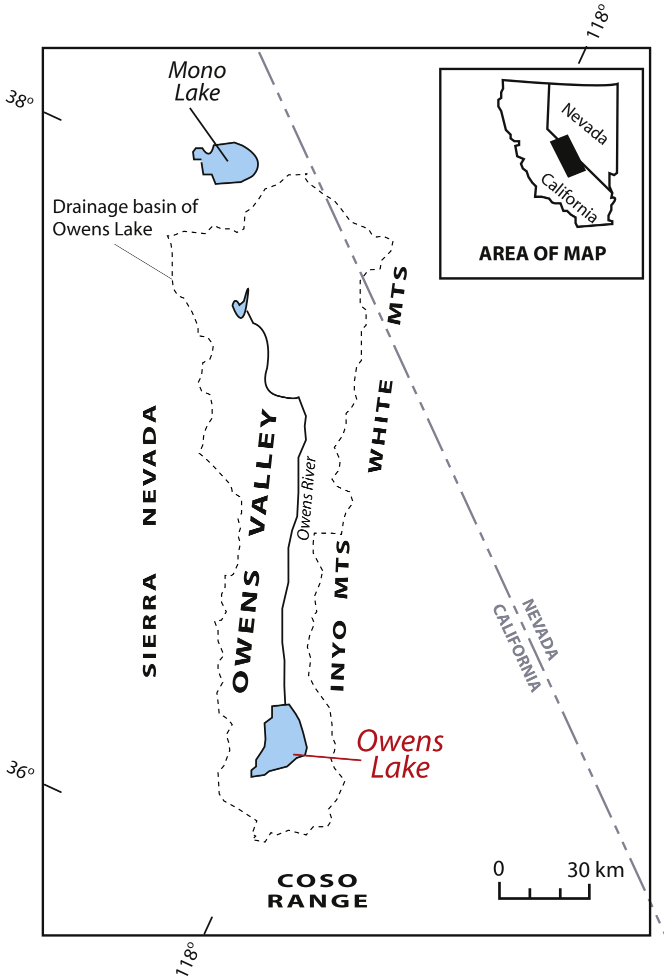

Fig. 1. Location map showing Owens Lake in relation to major topographic and hydrologic features.

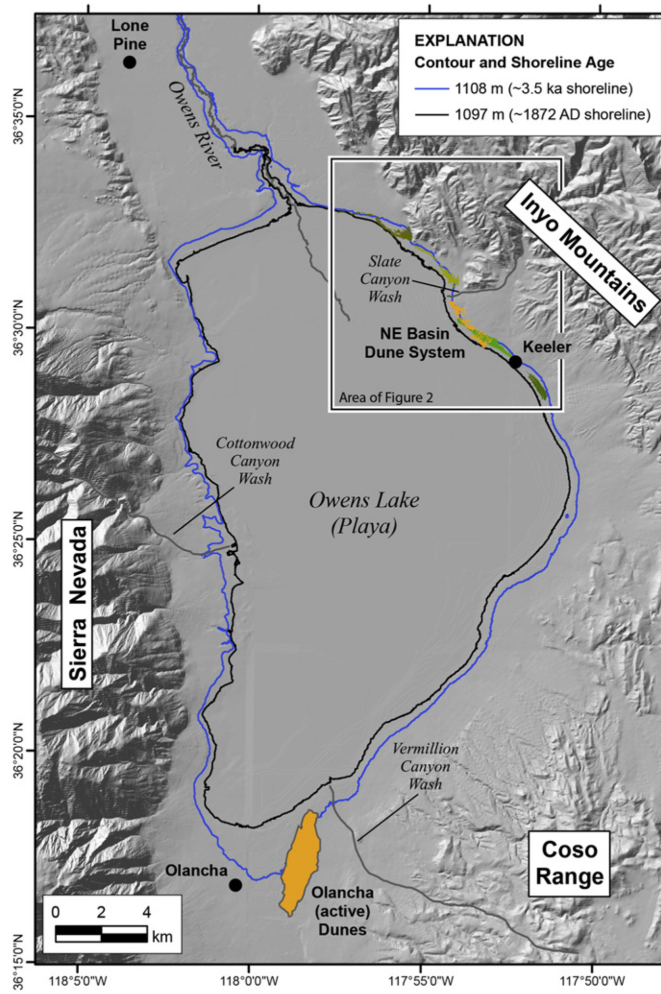

Fig. 2. The Owens Lake basin, showing areas of sand dunes. Box indicates area of Fig. 3.

Water of the Owens River and tributary streams draining the Sierra Nevada have been diverted to the Los Angeles Aqueduct beginning in 1913. As a result, the lake has lowered from its historical water level in ~1872 AD at an elevation of 1096 m above mean sea level to a largely dry playa (elevation ~1085 m) by the 1930s (Gill, 1996). After its desiccation, the bed of Owens Lake has been a major source of wind-blown dust (Gill, 1996), generated by the saltation of sand across the exposed lake bed (Gillette et al., 1997), until dust control measures were implemented from 2002 onwards.

In addition to the late Pleistocene to early Holocene shorelines that extend from as high as ~1160 m to near 1120 m (Bacon et al., 2006; Orme and Orme, 2008), there are several lower late Holocene erosional and constructional shoreline features at elevations of 1108, 1103, 1101, and 1099 m that provide evidence for significant fluctuations in lake level as a result of regional climate change (Bacon et al., 2013; Reheis et al., 2014).

3. Distribution and morphology of dune fields adjacent to Owens Lake

Dunefields and associated sand sheets occur in two main locations adjacent to Owens Lake (Fig. 2): (1) the northeastern section of the lake basin in the area between the Owens River and the Sulphate Road location, comprising from northwest to southeast: the Lizard Tail Dunes, Swansea Dunes, Keeler Dunes, and Keeler-Sulphate Dunes (Fig. 3); 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.

The Lizard Tail Dunes (Fig. 4A) occupy an area of 0.43 km^2 and comprise two NW–SE trending, symmetrical and vegetated sub-parallel ridges that are 50–100 m apart and 5–6 m high. These ridges, together with an area of vegetated sand sheets, extend to the east to the base of the Inyo Mountains within the north portion of the "Swansea Embayment". The dune ridges lie below the 1103 m shoreline; whereas wave-cut notches occur at 1101.7 and 1099.5 m on the landward (outer) ridge and at 1097.3 m on the lake-ward (inner) ridge.

The Swansea Dunes (Fig. 4B) occupy an area of 0.37 km^2 near the historical mining settlement of Swansea and comprise two parts: (1) a northwestern area of low vegetated linear ridges, with a morphology and trend similar to the Lizard Tail Dunes; and (2) a southeastern area that comprises a sparsely vegetated area of rolling dunes up to 4 m in height, with a very sharp eastern margin. The morphology of these features resembles a transgressive coastal dune area.

The Keeler Dune field (Fig. 4C) covers an area of 0.73 km^2 with a further 4 km^2 consisting of thin to discontinuous sand sheets overlying late Holocene alluvial fan deposits near the town of Keeler. The dune field consists of two parts: (1) the northern dunes, which includes sand sheets on the far northwestern or trailing margin of the dune field; together with three linear dune ridges up 3 m high and up to 500 m long; as well as sand sheets and nebkhas adjacent to these dune ridges; and (2) the southern dunes, which comprise as many as 15 crescentic