Exploring Lake Cahuilla's much larger predecessor lake: shorelines at ~50 m elevation

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Although Salton Sea is a well-known lake in the Salton Trough and many residents know of the older and larger Lake Cahuilla, few know that an even older and much larger lake once formed in the trough. We will describe this older lake, which formed shorelines close to 50 meters above sea level (masl), and explore the timing and causes for the lake as well as implications it holds for landscape evolution. The Salton Sea and Lake Cahuilla were sustained by inflow from the Colorado River. Highstand shorelines for Salton Sea are far below sea level, whereas Lake Cahuilla, which filled episodically over at least the last 2 thousand years, formed a highstand shoreline at ~13 masl. The Lake Cahuilla highstand coincides with the lowest part of a divide on the Colorado River fan near Cerro Prieto, Mexicali Valley. Evidently several fan-dammed lakes reached ~13 m and drained southward across the divide (sill) to the Gulf of California, which implies that the fan was stable and the overflow did not cause significant downcutting of the dam. The record of Lake Cahuilla before 2000 years is not well known, but it may have formed episodically for over ten thousand years.

Thomas (1963) and Stanley (1963, 1965) described shoreline deposits above those of Lake Cahuilla, at 48-50 masl, on both sides of the Salton Trough. These deeply eroded beach deposits locally bear freshwater fossils and tufa, which they dated by radiocarbon methods. Most samples yielded ages that approached or exceeded the limits of the method and are not interpretable but a few were in the 26-40 thousand years (kiloannum, ka) range. This lake with shorelines about 35 m above the modern divide at the Colorado River fan lacked a mechanism for impoundment. They attributed the deeper lake to an ancient sill on a larger Colorado River fan that was later downwarped to near the modern divide, invoking a tectonic cause for the absence of a dam. The proposed downwarping occurred in Mexico, as indicated by features interpreted as shorelines that descended southward along the northern Sierra Cucapah. This mountain range is cut by active faults, making it an attractive candidate for tectonic warping, but the numerous fault scarps also make identifying lacustrine wave-cut scarps difficult. We sought to better date this old high lake and to evaluate tectonic deformation of the highstand shoreline.

We identified several new exposures of the older lake deposits in the United States, linking discontinuous remnant shorelines longer than 100 kilometers (km) along both sides of the Salton Trough at ~50 masl. The deposits represent highstand beaches and nearshore deposits of sand, silt, and carbonate; they lie on old alluvial fan deposits, deformed Pleistocene to Pliocene mudstone and sandstone, and granite. The deposits are unconsolidated, unlike typical Brawley Formation rocks and more like the loose deposits of Lake Cahuilla. Beach stratigraphy is typically a simple coarsening upward sequence consistent with a single highstand. We observed consistent ~50 masl beach crest elevations in the U.S. that together point to negligible deformation along the margins of the Salton Trough. We could not find shorelines in the northern Sierra Cucapah, but did locate lacustrine sand and gravel in a gravel pit. The lack of descending shorelines along the northern Sierra Cucapah opens the possibility that a high barrier in Mexico once existed. Evidence for such a barrier is found at the modern Colorado River fan, which in its upper reaches near Yuma lies within 'shoulders' of a higher, older Colorado River fan that is undated. In addition, distal Colorado River fan deposits that aggraded to ~30 m above the modern fan along the eastern margins of Sierras El Mayor and southern Cucapah apparently represent this aggraded fan which may have been a barrier that dammed the high lake.

We used AMS radiocarbon, U-series, and luminescence dating methods to improve age control. Preliminary dates are varied but point to either a ~35 ka or ~65 ka highstand, or both. Armstrong et al. (2010) dated the high Colorado River fan deposits fronting the Sierras El Mayor and southern Cucapah by luminescence at 30-40 ka, consistent with many of our dates in the ~35 ka range. We propose that fan aggradation ~35 ka raised the divide over which a lake impounded in the Salton Trough must have flowed, causing stable lake levels and high shoreline deposits at ~50 masl. This lake was fed by Colorado River flow. This time period is late in marine isotope stage 3, which was a generally mesic time between glacial stages 4 and 2 at ~65 and ~20 ka respectively. Fan aggradation may have been driven by increasing discharge and sediment delivery to the Colorado River fan as climate became wetter following a long period of sediment accumulation on slopes. Because the fan crosses many of the most active strands of the transtensional plate margin in the Mexicali Valley, large-magnitude earthquakes may have disrupted fan aggradation and degradation processes. However, at present only minor pull-apart tectonic features can be seen in the fan near Cerro Prieto. We conclude that, despite the presence of the major plate-boundary San Andreas and Imperial faults in the Salton Trough's center and associated youthful volcanoes, its margins in the U.S. have been relatively stable for >35 ka. We suggest that the Colorado River fan is one of the most dynamic geomorphic features in the Salton Trough, aggrading and degrading on a time scale of thousands of years. The Colorado River fan controls lake levels in the Salton Trough.