Quantitative reconstructions of past lake level changes from tufas and paleoshorelines in the central Andes

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Paleoshorelines and tufa deposits of closed-basin lakes provide unequivocal evidence for past variations in the balance between precipitation and evaporation. Here we demonstrate the descriptive power of combining (1) precise uranium-thorium (U/Th) ages on tufa and other shoreline carbonate deposits with (2) geologic interpretations of depositional context at all scales—from outcrop to the microscale—and (3) elevational measurements of paleoshorelines. By integrating these data, we can pair the timing of past lake level variations with corresponding quantitative constraints on water volume changes.

To illustrate our process, we present new U/Th dating constraints on lake level variations from a north-south transect of closed-basin, high-altitude paleolakes in the central Andes (21-27°S, 3800-4400 masl). This region contains several small (<40 km^3) basins surrounded by well-preserved paleoshorelines and tufas that indicate previous periods of much wetter conditions. Recent advances in analytical techniques allow us to U/Th date single, small (<10 mg) aliquots of powder to avoid sampling detrital materials requiring large age corrections. With improved sample selection and high U concentrations, we can acquire U/Th dates on shoreline carbonates that are precise to within ±50 to 300 years.

Our initial ages suggest that these lakes were higher than present levels during these periods: 12–9 kyr BP, broadly coincident with the Younger Dryas (YD); 15.5–14.5 kyr BP, coincident with Heinrich Event 1 (HE1); and at some period before 100 kyr BP. These lake expansions correspond to 4- to 19-fold increases in lake surface area relative to modern. In addition, the depositional context of dated carbonates suggests that some of these wet periods are also associated with large magnitude lake level fluctuations occurring within sub-millennial timescales.

These data are the first precise shoreline ages for this broad section of the central Andes, significantly expanding the region of known wet conditions during HE1 and the YD in South America.