Slow and steady drop of the Atacama water table from ~15 Ma constrained by (U-Th)/He dating of hematite

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The western margin of the Central Andes in northern Chile and southern Peru has an arid climate that is thought to have persisted for at least 15 Ma [1–3]. The onset of aridity has been linked to uplift of the Andes, which blocked moisture from the Amazon, creating a rain shadow [1]. However, the timing of this uplift and its potential effect on regional climate is poorly understood, with uplift estimates ranging from slow and steady since ≥25 Ma to recent and rapid between ~10 and 6 Ma [4 & refs therein].

A direct consequence of both tectonic uplift and climate dessication is the downward migration of the water table [5] [6]. Therefore, the timing and rate of water table drop can help to discern between uplift and aridity models.

Here, we directly track the temporal downward migration of the Atacama water table using (U-Th)/He dating of hematite [7]. The hematite (Fe_2O_3) formed by reaction of oxygenated groundwater with ferrous-bearing minerals above the redox interface [8]. Thus, the depth of hematite precipitation as a function of time can be used to constrain the relative movement of the water table.

Nine samples were collected in drill core from an active mine in northern Chile, providing precise depth profiles through the top few 100 m beneath the surface. Our results imply a slow and steady lowering of the water table from ~15 Ma to the present day at a rate of ~11 m/m.y. This change at ~15 Ma could reflect the onset of climatic dessication, or could be a response to uplift and fluvial incision along the western Andean margin. Whatever the cause, the steady rate of lowering of the water table implied by our data suggests that the driver has been constant over the last ~15 Ma.

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