unique in its spatial collocation with a massive pile of subducted lithosphere.

Ying Zhou's[3] observations are thus intriguing because they suggest the existence of a semi-deep upwelling within a deep subduction setting. Her proposed explanation, of passive, wet mantle upwelling in reaction to sudden slab foundering, opens a window to explain surficial plume indicators and will hopefully motivate the broader geoscience disciplines to reconsider the physical source mechanism of Yellowstone volcanism. ❐

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ANNIVERSARY RETROSPECTIVE

Fingerprints of the thermal equator

Drylands cover nearly 50% of Earth's present-day land surface and are home to more than two billion people. Population growth coupled with continued climate-driven changes in water availability will have significant implications for vulnerable socioeconomic and ecological systems. Securing a resilient future for dryland regions hinges on an understanding of the controls on past hydroclimates.

Geomorphic and stratigraphic signatures preserved in dryland landscapes record past variation in water availability. In the Great Basin of western North America, regional extension and uplift have produced an alternating basin and range topography. Lying at the floors of many basins are closed lakes. With no outlet to the sea, these lakes are natural rain gauges: they expand and contract with climatically induced changes in precipitation, run-off and evaporation. Shorelines constructed by persistent lake levels are etched into the landscape, and lake transgressions and regressions are preserved in the stratigraphic record. Sedimentary deposits including tufa, shells and charcoal provide age constraints on the timing and duration of lake-level oscillations.

Wallace Broecker (*J. Clim.* **23**, 6669–6683; 2010) argued that the size and distribution of lakes across the globe reflect the position of Earth's thermal equator — the annually migrating belt of hottest surface temperatures — and thereby the position of tropical rain belts and mid-latitude storm tracks. This idea motivated me to use closed-basin lake systems to estimate the magnitude of past and future climate changes in dryland regions. So, during my PhD research, I reconstructed changes in the late Holocene climate of the closed Walker Lake Basin that spans the boundary between California and Nevada.

Relict Jeffrey pine tree stumps of medieval age found in the present-day West Walker River. Image taken by B. J. Hatchett, edited by E. Drake/1L1T.

Specifically, I pursued the link between estimated changes in runoff under past and present climatic conditions, and plausible changes in atmospheric circulation. I found that the lake level responds strongly to changes in winter storm track activity and moisture flux, but persistent climatic change on a decadal time scale is needed to elicit large lake-level fluctuations (Hatchett et al. *Geophys. Res. Lett.* **42**, 8632–8640; 2015).

In the West Walker River, which drains into Walker Lake, sub-fossilized stumps of submerged Jeffrey pine trees provide the starkest geomorphic indicator of shifts in the thermal equator and centennial-scale drought in the region. Scott Stine (*Nature* **369**, 546–549; 1994) dated these trees and found that their demise corresponded with medieval megadroughts and lowstands of most Great Basin lakes. The stumps show that the spectre of extreme and persistent drought that looms over the western United States has been very real in the past.

The construct of a thermal equator also provides a framework to interpret future hydroclimatic change under continued global warming. During glacial terminations, increased winter sea ice in the Northern Hemisphere pushes the thermal equator southward, which enhances moisture flux into the boreal subtropics and weakens the Asian monsoon. Deglaciation is then followed by abrupt warming. Putnam and Broecker (*Sci. Adv.* **3**, e1600871; 2017) argue that this scenario provides an analogue for ongoing warming today, as the Northern Hemisphere is warming faster than the Southern Hemisphere. In the past, such differential warming shifted tropical rain belts northward, increasing aridity in many dryland regions while making tropical regions wetter.

Broecker's work argues for a global hydroclimate perspective. The geomorphic fingerprints left by migrations of the thermal equator must be traced across Earth's landscapes. Solving mysteries of the past will not answer all remaining questions regarding the future of dryland hydroclimate. However, doing so will provide critical insight into how these regions respond to natural climate variability, and hopefully inform adaptive management strategies that are necessary to sustain both ecosystem functions and human consumptive demands. ❐

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