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Iranian speleothems: Investigating Quaternary climate variability in semi-arid Western Asia

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Rapid population growth and limited water supply has highlighted the need for vigorous water resource management practices in the semi-arid regions of Western Asia. One significant unknown in this discussion is the future change in rainfall amount due to the consequential effects of today's greenhouse gas forcing on the regional climate system. Currently, there is little paleoclimate proxy data in Western Asia to extend climate records beyond the limits of the instrumental period, leaving scant evidence to investigate the system's response to various climate forcings on different timescales.

Here we present a synthesis of speleothem climate records across northern Iran, from the wetter climate of the Alborz and Zagros mountain ranges to the dry northeast, in order to investigate the magnitude of past climate variability and the forcings responsible. The stalagmites collected from the west and north-central mountain ranges, areas with ∼200-400mm mean annual precipitation mostly falling within the fall-winter-spring months, all demonstrate growth limited to the interglacial periods of the Quaternary. We present overlapping Holocene stable isotope records with a complementary trace element record to assist in interpreting the isotopic variability. One of the records is sampled at <4yr resolution and spans 3.7-5.3 kyBP, a contested period of catastrophic droughts that allegedly eradicated civilizations in areas of the near East. Imposed upon decadal-scale variability, the record reveals a 1,000-yr gradual trend toward enriched stable oxygen isotope values, interpreted as a trend toward drier conditions, which ends with an abrupt 300-yr cessation in growth beginning at 4.3 kyBP, coincident with the so-called 4.2 kyBP drought event. From the northeast Iranian plateau, we present a new stalagmite record that spans the penultimate deglaciation and Stages 5e-5a. This region presently receives limited rain annually (∼100-300mm/yr, regularly falling between November and May), and the record presented is one of the first speleothem climate records to span a deglaciation in West Asia.

To improve our interpretation of the speleothem climate proxy timeseries, we use multiple decades of Tehran GNIP data, meteorological data, and isotope-equipped climate model outputs to investigate the large-scale mechanisms forcing isotopic variations in rainwater across northern Iran. We also examine possible transformation of water isotopes during the transition through the karst aquifer based on site properties, measured dripwater isotopes, and simple model experiments.