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Stalagmite record of Last Glacial Maximum to early Holocene climate change in southwest Iran

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Iran is a country with large climate contrast and thus highly vulnerable to climate change. The two major mountain ranges, Alborz in the north and Zagros in the west, impede the penetration of Mediterranean and Caspian winds to the central plateau, leading to precipitation on the topographical highs as well as deserts in the center of the country. Semi-arid southern Iran has struggled with severe droughts for several decades, and destructive floods in recent years underscore the vulnerability to ongoing climate change.

Records of paleoclimate in the Middle East, useful for improving our knowledge about the natural variability of atmospheric circulation patterns in this region, are sparse in comparison to other regions. In particular, there are currently no paleoclimate studies based on speleothem archives in Iran which span the transition from the Last Glacial Maximum (LGM) to the Holocene.

Here we report a well-dated, high-resolution stalagmite proxy record from the foothills of the Zagros Mountains, SIB-4, which for the first time covers the LGM as well as parts of the deglaciation and reaches into the early Holocene. SIB-4 oxygen isotope ($\delta^{18}O$) values are ~4‰ higher in the LGM relative to the early Holocene. Other stalagmite records in the Middle East also show higher $\delta^{18}O$ values in the LGM relative to the Holocene, such as from Soreq cave in Israel[1] ($\Delta\delta^{18}O$ = +3‰), Jeita cave in Lebanon[2] ($\Delta\delta^{18}O$ = +2.5‰), Dim cave in Turkey[3] ($\Delta\delta^{18}O$ = +6‰), and Moomi cave in Oman[4] ($\Delta\delta^{18}O$ = +2‰). A large portion of the $\Delta\delta^{18}O$ of SIB-4 was likely caused by colder and drier conditions in the LGM. This interpretation is supported by the SIB-4 carbon isotope ($\delta^{13}C$) values, which are ~7‰ higher in the LGM relative to the early Holocene. These high $\delta^{13}C$ values, which approach the values of the marine host rock, are attributed to sparse vegetation (steppe type) and related reduced soil bioproductivity.

SIB-4 contains three growth hiatuses during the deglaciation, 17.8-17.2 ka, 15.1-14.7 ka, and 13.4-11.7 ka, all coincident with millennial- to centennial-scale dry periods previously identified by a dust record from a peat bog in Southeast Iran[1]. Dry conditions during the youngest SIB-4 hiatus are also supported by the $\delta^{18}O$ and $\delta^{13}C$ values which increase sharply immediately before the hiatus. SIB-4 $\delta^{18}O$ and $\delta^{13}C$ values decrease sharply at 14.7 ka, marking more humid conditions coincident with the onset of the last interstadial known from many records across the Northern Hemisphere.

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