

## Remarkably extensive early Holocene glaciation in Turkey

**M. Zreda** (1), A. Ciner (2), S. Bayari (2), M.A. Sarikaya (1)

(1) Dept. of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, USA (marek@hwr.arizona.edu / Phone: +1 520 621-4072), (2) Dept. of Geological Engineering, Hacettepe University, Ankara, Turkey (aciner@hacettepe.edu.tr / Phone: +90 312-297-77-47)

We conducted a detailed glacial-geological study in Hacer Valley (Aladaglar, in the High Taurus, central Turkey, 37°45'N, 35°15'E). We mapped and dated six large, well-preserved moraines in Hacer Valley (1510-2580 m, see the table), and one on the summit plateau (3080 m), and calculated changes in the equilibrium line altitude ( $\Delta$ ELA, a measure of the extent of glaciation) and temperature. The large sizes and low elevations of the lowest moraines suggest that they were deposited during the Last Glacial Maximum (LGM), at the end of the Pleistocene, about 20 ky ago. But cosmogenic  $^{36}\text{Cl}$  dating of boulders from tops of these moraines has yielded surprising results: all moraines, from the most extensive to the least, have early Holocene ages, ranging from  $9.3 \pm 0.4$  ky (calendar years) for the lowest moraine in the valley, to  $7.4 \pm 1.2$  ky for the highest, and  $7.6 \pm 0.1$  ky for the plateau moraine. The positions of the moraines indicate a decrease of the ELA by up to 1 km and the corresponding decrease of temperature by up to  $7^\circ\text{C}$ . [We note, however, that these calculations are preliminary and may have to be revised.] This result is important and surprising because: (1) the moraines have similar ages, but different  $\Delta$ ELAs, which indicates a fast climate change; (2) these  $\Delta$ ELAs are typical of LGM times, which indicates a big climate change; and (3) all moraines have early Holocene ages, which suggests that the contemporary glacial climate was as severe as that of the LGM elsewhere. These findings prompt an important question: Is this an isolated occurrence or a regional pattern? An isolated occurrence could be explained by anomalous local climatic or glaciological conditions. But ubiquitous extensive and young glacial deposits would imply that the early Holocene regional climate was much more severe than previously thought. And our results may have important implications for the study of human evolution in this 'cradle of civilization'. An extensive early-Holocene glaciation implies that paleoclimate might have played an important role in the evolution of early human civilizations. The deglaciation ages reported here coincide broadly with the transition from nomadic to settled life style, with the spread of agriculture, and with the dispersal of early Indo-European languages.

Elevation (m)	$^{36}\text{Cl}$ age (ky)	$\Delta$ ELA (m)	$\Delta T$ ( $^\circ\text{C}$ )
3080	$7.6 \pm 0.1$	---	---
2580	$7.4 \pm 1.2$	510	3.3
2310	$7.8 \pm 0.8$	610	4.0
1920	$8.7 \pm 0.3$	---	---
1745	$8.7 \pm 0.4$	900	5.8
1636	$9.1 \pm 0.6$	950	6.2
1510	$9.3 \pm 0.4$	1060	6.9
ca. 1200	not dated	1190	7.7