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LGM glaciers on Mount Lebanon? New insights from 36Cl exposure dating of moraine boulders

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In situ-produced 36Cl has been used to determine the exposure age of boulders located below the top of Mount Lebanon (3088 m asl) at the Cedars locality (2000 m asl, 34.25°N). Morphological and geological evidence such as horseshoe- shaped cirques, U-shaped valleys and coarse and chaotic Quaternary deposits suggest the presence of former glaciers. Detailed field mapping allow identifying different moraine ridges. Sampling of the topmost centimeters of surfaces of large, flat-topped, stable carbonate blocks, protruding from the moraine crests have been performed. To constrain parameters such as possible inheritance in moraine material or erosion of the glacial deposits, samples have also been collected along a depth profile (0 to 1100 cm depth) in the center of a moraine ridge. 36Cl and Cl concentrations have been measured in collected samples by isotope dilution accelerator mass spectrometry at both CAMS-LLNL (US) and ASTER-CEREGE (France). Those analysis have been completed by radiocarbon dating of charcoal sampled in a pit deposit located a few meters from the depth profile between two ridges.

The exponential decrease of the measured 36Cl concentrations as a function of depth along the profile is best explained by a surface exposure age ranging between 18-20 ka, negligible inheritance and an erosion rate ranging from 50 to 100m/Ma (density measured on site of 1.3 g/cm3 at 120 cm depth). Exposure ages yielded from surface samples spread between 19 and $\sim$130 ka when using the range of erosion rates deduced from the depth profile. Radiocarbon ages range from 0 to 8.3 ka in stratigraphic order and in agreement with vegetation and soil development after glacial retreat during the Holocene.

To further constrain the paleoclimatic conditions (temperatures and precipitations) prevailing during the formation of these glacial deposits, we used a numerical ice–flux model on a high resolution (100 m) digital elevation model. Ice ablation is computed using a positive-degree-day model. To account for the presence of a glacier at Cedars, preliminary results suggest annual temperature decrease from 10 to 14°C, for x2 to x0.5 precipitation change respectively, during the LGM.

Although the Quaternary deposits of Mount Lebanon have been interpreted as massive rockfalls, questioning their glacial origin, our results favor emplacement at least 18 ka ago, in agreement with the presence of a glacier during the LGM in this area.