Sensitivity of glacier and climate reconstructions in high mountain regions to uncertainties of ^{10}Be surface exposure dating

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Reliable Late Quaternary glacier and climate reconstructions have long been challenging particularly in semi-arid high mountain regions, where organic material for radiocarbon dating is scarce. Surface exposure dating of glacial deposits using terrestrial cosmogenic nuclides, like 10Be, may enable establishing glacial chronologies more precisely, but geological and systematic methodological uncertainties need to be addressed. Here we compare 'virtual' exposure ages on global grids and along longitudinal transects in order to illustrate that systematic uncertainties due to the choice of the scaling system can result in age discrepancies more than 20%, depending on geographic location and exposure time. Particularly at high elevations in the subtropics and mid latitudes this prevents drawing paleoclimatic conclusions on millennial timescales. Provided that the recent developments in scaling are appropriate, our case study from the Central Andes illustrates that the local Last Glacial Maximum in the tropical Andes occurred at ~25 ka - roughly in-phase with the global LGM - and not at ~30 ka as inferred previously. Systematic uncertainties decrease further south, increasing confidence in interpreting Lateglacial moraines (16-13 ka) from ~15-30°S as evidence for an intensification of the tropical circulation, and pre-LGM moraines (~35 ka) from 30-40°S as evidence for stronger or more northerly westerlies. Our second case study from the Pamir Mountains shows that environments with long-lasting landscape instability are prone to geological uncertainties, which cause large scatter in exposure ages. Applying the 'oldest age model', we conclude that (i) the maximum glaciation at our study site near Lake Yashilkul occurred during MIS 4, (ii) glaciers were less extensive during MIS 2, likely due to increasing aridity over the course of the last glacial cycle, and (iii) an intensified monsoonal circulation was probably responsible for moraines being deposited during MIS 3.

Deposition of volatiles from Erebus volcano in Antarctic snow and ice

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The persistently degassing Erebus volcano (Ross Island, Antarctica) has a significant influence on the regional atmospheric and cryospheric chemistry. Its rare magma composition combines with ambient atmospheric conditions to produce unusual emissions released from the surface of its lava lake. We report analyses of volcanic deposition from Erebus collected during consecutive Antarctic field seasons (2005-2007). The deposits included: (i) snow from areas believed to be contaminated by the volcanic plume, (ii) snow containing ash; (iii) 'yellow ice' which are distinctive ice deposits of bright-yellow colour. All the plume-affected deposits have highly elevated concentrations of chloride and fluoride (≥1000 ppm), sulphate (≥240 ppm) and an array of metal cations (Al, Na, K, Fe, S, Ca, Mg and Pb being the most abundant). Abundances of Na, K and Al correlate strongly with those of halides; consistent with the known composition of aerosol particles emitted by Erebus. Yellow ice showed higher ionic concentrations than the snow. Ash-snow had elevated concentrations of selected ions (F, Cl, and certain metals), believed to be caused by hydrolysis of silicate minerals. Halide/sulphate molar ratios in the deposits are over an order of magnitude higher than in the gas phase. Dry deposition and/or snow scavenging of halide species is much more efficient than that of SO_2 and sulphate. The relative proportions of metals in the snow/ice were compared with those in the airborne plume to show that the lighter metals (Na, K, Mg, Ca, Fe) tend to be more enriched in the snow than heavy metals (Cr, Ni, Cu, Cd and In). It is proposed that the low ambient atmospheric temperature has a 'cold trap' effect causing selected ions to resist deposition.