The Paleoclimatic Significance of Ice Margin Fluctuations During the Younger Dryas in the Peruvian Andes.

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Dozens of published radiocarbon dates provide minimum-bracketing ages for late glacial moraines in the tropical Andes. However, the development of a well-dated late glacial chronology in the tropical Andes is hindered by a scarcity of maximum-bracketing ages and/or ambiguities over stratigraphic interpretations. This has frustrated attempts to compare rigorously the glacial geologic record from the tropical Andes with events in extra-tropical regions.

Recent radiocarbon dates on lacustrine sequences in Perú show that the chronology of glaciation during the late glacial in the tropical Andes was significantly out-of-phase with the record of glaciation in the North Atlantic region (Rodbell and Seltzer, 2000). Radiocarbon dates from peat stratigraphically bounding a glacial outwash gravel in the Cordillera Blanca, central Peru indicate that a glacier advance culminated there between ~11,280 and 10,990 ^{14}C yr B.P.; rapid ice recession followed. A basal radiocarbon date of ~10,870 ^{14}C yr B.P. from a lake within 1 km of the Quelccaya Ice Cap in southern Perú and upvalley from a moraine that was deposited <11,460 ^{14}C yr B.P. indicates that ice readvanced between ~11,500 and 10,900 ^{14}C yr B.P. By the latter date, the ice front had retreated to nearly within the modern limit of the Quelccaya Ice Cap.

These glaciers advanced and retreated in near lock-step with one another, and much of the Younger Dryas (YD) interval in the Peruvian Andes was apparently marked by rapidly retreating ice fronts. However, the climatic forcing that drove the strongly negative glacier mass balances during the YD remains enigmatic. One hypothesis, which hinges on the interpretation of cool YD conditions from the ∂^{18}O record of Sajama and Huascarán ice (Thompson *et al.*, 1995, 1998), is that the YD was marked by a substantial reduction in precipitation. Currently, glacier equilibrium line altitudes in much of the tropical Andes descend steeply eastward toward the westward-blowing, moisture-bearing trade winds from the Amazon Basin. This slope reflects the importance of precipitation in controlling the extent of ice cover in the tropical Andes. Thus, if early in the YD interval, conditions became suddenly drier—even if temperatures were invariant—glacier mass balances would have become negative and ice front retreat would have followed.

The hypothesis of a relatively dry YD interval in the Peruvian Andes is consistent with several other proxy paleoclimatic indicators. The difference between the ∂^{18}O of authigenic calcite in Lake Junin, Perú (~11°S) and Huascarán (~9°S) ice reflects the relative degree of evaporative ^{18}O enrichment of Lake Junin (Seltzer *et al.*, 2000). This time series, which is highly dependent on an accurate chronology in both the ice and lake records, reveals an increase in relative aridity in the central Peruvian highlands at about the same time as the Peruvian paleoglaciers described here began to retreat rapidly. A reduction in effective moisture during the YD in the tropical Andes is also apparent in the reconstructed record of Amazon River discharge, which is inferred to have been reduced by at least 40% during the YD (Maslin and Burns, 2000), and in the record of riverine

discharge from northern South America as preserved in Cariaco Basin sediments (Peterson *et al.*, 2000).

An alternative hypothesis holds that the retreating ice fronts were driven by warm but relatively moist conditions. This hypothesis requires reinterpretation of the relatively ^{18}O-depleted YD ice to reflect precipitation amount rather than temperature. A moist YD is consistent with recent proxy paleoclimatic evidence from the southern altiplano (Betancourt *et al.*, 2000) and with the emerging sediment record from Lago Titicaca (Baker *et al.*, submitted). A third hypothesis, which accepts all records at face value, posits that there was a considerable difference in hydrologic conditions south and north of ~15°S during the YD, with drier conditions to the north and wetter conditions to the south.

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