Pollen Records of Andean Ice Cores

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Abstract

Ice cores are an important archive of long-term, high-resolution paleoclimatic information. Recent developments in ice-core palynology have shown that pollen in tropical and subtropical ice cores can provide sensitive records of vegetational and climatic changes that complement the paleoenvironmental records derived from other ice-core proxies. The potential of pollen--the only biological proxy consistently present in ice core--is demonstrated by a high-resolution ice-core pollen record from the Dunde Ice Cap in the Tibetan Plateau, which documents sensitively vegetational response to the early Holocene summer monsoon maximum, as well as century-scale climatic oscillations such as the Little Ice Age and Medieval Warm Period (Liu et al., 1998).

Ice cores retrieved from several tropical Andean ice caps—Quelccaya, Huascaran, Sajama—offer excellent opportunities for producing high-resolution pollen records of vegetational response to late-Quaternary climatic changes. Detailed pollen analysis of the seasonal ice layers for a 17-year period from 1980 to 1997 in the Sajama ice core shows significant differences in pollen deposition between the wet season and the dry season. In general, grass (Gramineae) pollen are more abundant in the meltwater samples of the wet summer season, while tree and shrub pollen (e.g., *Polylepis*, Compositae) tend to characterize the deposition during the dry winters. This pattern of seasonal pollen deposition, if confirmed by more work in the future, may provide some clues for deciphering the climate signals from long-term pollen records from Andean ice cores.

A preliminary study of stratigraphic meltwater samples from the Sajama ice core reveals striking differences in pollen composition between the Late Glacial Stage (LGS) and the Holocene. The LGS pollen samples are dominated by Gramineae with little or no Compositae, but the Holocene samples contain significant xerophytic shrubs and forbs including Compositae, Chenopodiaceae, *Artemisia*, and *Ephedra*. Since high Gramineae pollen percentages are characteristic of the superpuna and grasses are also dominant in relatively humid herbaceous communities on the eastern slope of the high Andes (Graf, 1981), the dominance of Gramineae pollen in the LGS samples suggests a cold and wet glacial climate on the Altiplano. Conversely, the abundance of Compositae and other xerophytic

shrubs in the Holocene samples suggests a warm and dry climate consistent with reconstruction from other ice-core parameters from Sajama (Thompson et al., 1998). Pollen concentration values in ice cores are primarily a function of vegetation density and pollen productivity, but also modulated by geographical and meteorological factors such as proximity to vegetation sources and wind direction. In the Sajama ice core, extremely low pollen concentrations during the LGS may be due to greater distance between the ice cap summit and the vegetation source, as LGS snowlines on the Andes in southeastern Peru and western Bolivia were 500-800 m lower than that of today (Klein et al., 1999). Higher pollen concentrations (up to 2000 grains/liter) in the Holocene samples suggest greater vegetation density and productivity under a warmer climate. The much greater abundance of microscopic charcoal particles in the Holocene samples also suggests higher frequency of fires in the Altiplano. This is consistent with the scenario of a greater supply of fuel (due to higher vegetation density) and a warmer, drier climate during the middle Holocene.

Research is currently in progress to better understand the patterns and processes of pollen dispersal and deposition on Andean ice caps. Discovery of pollen clumps and tetrads in ice core samples suggests that pollen deposition on an ice cap may not be entirely attributable to aolian processes, and indeed a complex array of mechanisms and vectors such as insects, thunderstorms, and wet deposition may be involved. Surface snow samples have been collected from the Quelccaya Ice Cap to study the spatial variability of pollen deposition on the ice cap surface. An expedition is being undertaken to collect pollen surface samples from the Bolivian Altiplano in an effort to document the pollen-vegetation-climate relationships around the Sajama Ice Cap.