

6-1981

Reconnaissance Glacio-chemical Studies in the Indian Himalayas


Paul Andrew Mayewski

University of Maine, paul.mayewski@maine.edu

William Berry Lyons

Nasseruddin Ahmad

Follow this and additional works at: https://digitalcommons.library.umaine.edu/ers_facpub

 Part of the [Atmospheric Sciences Commons](#), [Climate Commons](#), [Glaciology Commons](#), and the [Hydrology Commons](#)

Repository Citation

Mayewski, Paul Andrew; Lyons, William Berry; and Ahmad, Nasseruddin, "Reconnaissance Glacio-chemical Studies in the Indian Himalayas" (1981). *Earth Science Faculty Scholarship*. 277.

https://digitalcommons.library.umaine.edu/ers_facpub/277

This Conference Proceeding is brought to you for free and open access by DigitalCommons@UMaine. It has been accepted for inclusion in Earth Science Faculty Scholarship by an authorized administrator of DigitalCommons@UMaine. For more information, please contact um.library.technical.services@maine.edu.

trajectory free from local sources of acidic pollutants. Both of these sites show a few low pH values but the majority are near the values expected in precipitation, unaltered by anthropogenic constituents. The pH profile of the Climax snowpit is typical of what one would find in the interior of the mountains away from any industrialization or major urbanization. Long Lake shows an acidic profile. It, however, does not indicate any pH values as low as some of those found by Lewis and Grant in the Como Creek watershed nearby. The most likely source of acidic contaminants to this site, as indicated by this study and that of Kelly and Stedman, is the Front Range Urban Corridor to the east. In lieu of the fact that only snowpack sampling sites near localized sources of acidic components showed acidic pH profiles, and since the Long Lake site has its acid pollutant source the Front Range Urban Corridor, the hypothesis of widespread acidification of precipitation in the Western United States, put forth by Lewis and Grant, is apparently invalid.

At the present time there seems to be no major threat from acid precipitation in Colorado. The economy of the state is, however, expanding. People are constantly moving into the Front Range area because of employment opportunities and the pleasant climate, leading to further pollution in this area. Large deposits of fossil fuels are presently being exploited for energy development in western Colorado. The combination of these two things can lead to the extension of what is now a minor problem. Pristine areas downwind from future development could well be significantly affected. This study has indicated a need for future monitoring and provided a baseline of data for comparison with future studies of this nature.

Acknowledgements

This research was funded by the Colorado State University Agriculture Experiment Station No. COL 00113.

References

- Brimblecombe, P., 1980: Search for acid snow in north-west Africa. *Weather*, **35**, 79-84.
- Clement, P., and J. Voudour, 1967: Observations on the pH of melting snow in the southern French Alps. *Arctic and Alpine Environments*, 205-213.
- Elgmork, K. A. Hagen, and A. Langeland, 1973: Polluted snow in southern Norway during the winters of 1967-1971. *Environ. Pollut.*, **4**, 41-52.
- Feth, J.H., S.M. Rogers, and C.E. Roberson, 1964: Chemical composition of snow in the Sierra Nevada and other areas. *Geological Survey Water-Supply Paper 1535-J*.
- Forland, E.J., and Y.T. Cjessing, 1975: Snow contamination from washout/rainout and dry deposition. *Atmos. Environ.*, **2**, 339-353.
- Hammer, C.U., 1980: Acidity of polar ice cores in relation to absolute dating, past volcanism, and radio-echoes. *J. of Glaciology*, **25**, 359-372.
- Hegg, D.A., and P.V. Hobbs, 1980: Measurements of gas-to-particle conversion in the plumes from coal-fired electric power plants. *Atmos. Environ.*, **14**, 99-116.
- Kelly, T.J., and D.H. Stedman, 1980: Effect of urban sources on acid precipitation in the western United States. *Science*, **210**, 1043.
- Likens, G.E., R.F. Wright, J.N. Galloway, and T.J. Butler, 1979: Acid Rain. *Scientific American*, **241**, 43-51.
- Lewis, W.M., and M.C. Grant, 1980: Acid precipitation in the western United States. *Science*, **207**, 176-178.
- Rhea, J.O., 1978: Orographic precipitation model for hydrometeorological use. *CSU Atmos. Sci. Paper*, No. 278.

RECONNAISSANCE GLACIO-CHEMICAL STUDIES IN THE INDIAN HIMALAYAS

Paul A. Mayewski
Wm. Berry Lyons

Department of Earth Sciences
University of New Hampshire
Durham, NH 03824 U.S.A.

and

Nasseruddin Ahmad

Geology Department
Aligarh Muslim University
Aligarh, India

ABSTRACT

Analysis of reactive silicate, ammonium, phosphate, iron and sodium from cores taken from three glaciers in the Kashmir portion of the Indian Himalayas are reported as the first in a series of glacio-chemical studies designed to produce proxy paleoclimatic data for this region. This study stresses the elevation dependency of such studies and for the chemical species analyzed which are most reliable for the purpose of the study.

Introduction

Glaciers in the temperate and tropical latitudes have the potential for providing paleo-climatological records unsurpassed by other storage mediums for time periods on the order of 10²-10⁴ years. The climatological record that evolves when ice cores are chemically analyzed includes information detailing source area of the precipitation as well as year and season in which it was deposited. Reconnaissance studies addressing the feasibility of using glacio-chemical studies on Himalayan glaciers as proxy indicators of climatic change were undertaken during the summer of 1979 in Kashmir India. Background information pertinent to recent (post AD 1812) glacier fluctuation history in this area and possible climatic links is addressed in Mayewski and Jeschke (1979) and Mayewski et al. (1980).

Core Locations

Three ice cores were collected during the reconnaissance study (Fig. 1). The first was a 2.90 m deep ice core from the highest part, 4427 m, of a small west-facing cirque. The snow surface at this site contained obvious signs of ablation in the form of large sun cups and surface-sorting of fine debris. The second core site, 4329m, was above the equilibrium line, and on the eastern side of a north-flowing alpine glacier, in the Kunyiraban Glacier system. Core 2 penetrated 4.63 m through a granular snow surface and then into alternating layers of nearly horizontal snow layers ranging in density up to solid firn intruded in places by nearly horizontal ice lenses and fine-textured debris layers. The highest core site, 4695 m, was situated above the equilibrium line of a south-west-flowing alpine glacier in the Khel Khod Glacier system. Core 3 began in granular snow and penetrated 4.50m through a sequence similar to that found at core site 2.

Proceedings of the Eastern Snow Conference, 38 Annual Meeting, Syracuse, N.Y., June 4-5, 1981

Methods

All cores were collected using a standard stainless steel SIPRE ice auger. The coring apparatus was cleaned thoroughly in distilled-deionized water prior to coring and wrapped in plastic while not in use. To alleviate contamination by the coring apparatus polyethylene scrapers were used to remove the outer 1-2 cm of each sample. Since the 1979 season we have changed to a Teflon-coated SIPRE auger and expect in future seasons to change to all plastic coring devices. All samples were handled with plastic gloves, sectioned in the field and placed in precleaned, acid-washed and several times rinsed with distilled-deionized water, plastic bags. Once in the securely sealed bags the samples were allowed to melt. Immediately upon melting the water was transferred to HCL cleaned 125 ml IPE bottles. Modified sample collection and handling techniques have been employed in our more recent studies to further reduce contamination, but within the scope of the reconnaissance study the 1979 techniques are believed to be suitable.

Upon return to our laboratory the melted samples to be analyzed for iron and reactive silicate were acidified with ultra-pure HNO₃ and allowed to set for at least 10 days. Reactive silicate, ammonium and phosphate were analyzed colorimetrically utilizing auto-analyzer techniques (Gilbert and Loder, 1977). Iron was determined manually using the method of Stookey (1970). Sodium analyses were conducted using atomic absorption spectrophotometry. The analytical precision of the reactive silicate, ammonium, phosphate, iron and sodium at the concentrations observed in these samples and reported as a coefficient of variation are $\pm 8\%$, $\pm 5\%$, $\pm 2\%$, $\pm 8\%$ and $\pm 4\%$ respectively.

Results and Discussion

Examination of the reactive silicate, ammonium, phosphate, iron and sodium values and their distribution in the three cores (Fig. 2) reveals that core site elevation closely controls the paleoclimatological usefulness of the samples. Core 1 collected in an obviously ablation affected area and core 2 collected at an even lower elevation both display relatively "washed-out" profiles compared with core 3. Cores 1 and 2 probably suffer from the redistribution of chemical species down core through leaching. Core 1 displays almost total leaching as evidenced by the relatively low concentrations of reactive silicate ($<2\mu\text{M}$), phosphate ($<0.1\mu\text{M}$), iron ($<2\mu\text{M}$) and sodium ($<30\mu\text{M}$; majority $10\mu\text{M}$). High ammonium values (range 18-67 μM) in core 1 suggest contamination in this core with respect to ammonium. Core 2 displays the general decay in concentration with depth for all chemical species analyzed noted by Ricq-de Bouard (1977) in his study of soluble ions from samples collected on Glacier Mont de Lans. Core 3 contains neither relatively low concentrations nor a decay in concentration with depth except perhaps in the case of sodium below 150 cm depth, because sodium is one of the most soluble of the chemical species analyzed. From the latter we conclude that core 3 may well contain a relatively undisturbed record of precipitation.

Matching peak alignments exist in the profiles of core 3 samples for all chemical species analyzed except phosphate. Peaks for reactive silicate, iron, ammonium and sodium are approximately 5, 4, 5 and 3 times respectively, the baseline values of these chemical species. Phosphate peaks are approximately 2 times the baseline value of phosphate.

Four surface samples collected at 3 m increments away from core site 3 were used as a check on the lateral variability of the down-core samples. Expressed as a standard deviation of the four surface samples (Fig. 2) phosphate and ammonium are seen to be unreliable as down-core indicators. Reactive silicate, iron and sodium have lateral variabilities, considerably lower than their peaks values.

Chemical analysis of the cores collected during the 1979 reconnaissance season suggest that the relatively insoluble chemical species such as reactive silicate and iron collected from elevations at or above 4696 m in this area may be used as time stratigraphic markers. In addition the Khel Khoo Glacier core chemistry reveals the probable source area and time of deposition of the precipitate entering the region and the net mass balance at the core site. The peak concentrations of reactive silicate and iron as well as those of sodium, although the latter is potentially leachable, are probably brought into the area during the summer season. During the summer reactive silicate and iron influxes increase due to an increase in snow-free tundra while sodium increases due to the increased influence of

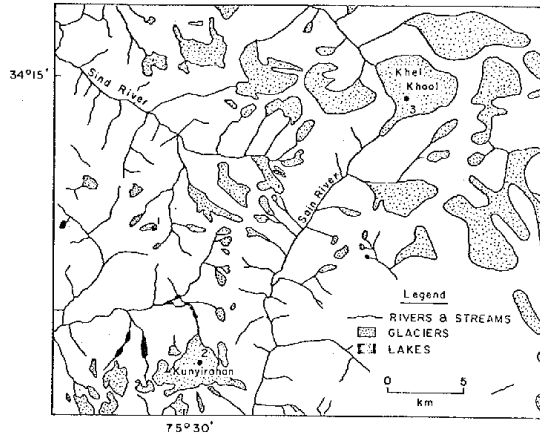


Figure 1. Location map

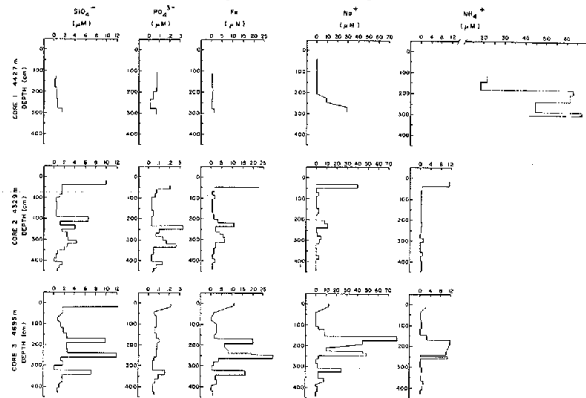


Figure 2. Chemical species distribution with depth for the 3 cores. Bar lengths on bottom of figure are standard deviations based on four surface samples

marine-based summer nonseasonal precipitation. Final validation of the source for the sodium contained in core 3 requires companion chloride data which are unfortunately unavailable from this core, but will be available for future cores from the region. If the peaks discussed are summer peaks then the total core age is 3 to 4 years, depending upon the species used. 4 years using reactive silicate and iron. Using the reactive silicate, iron and sodium peaks the net annual balance for the 1979 balance year is $+ .78 \text{ m H}_2\text{O}$ equivalent, the 1978 balance year $+ .29 \text{ m H}_2\text{O}$ equivalent and the 1977 balance $+ .38 \text{ m H}_2\text{O}$ equivalent, assuming an average core density of $.45 \text{ gm} \cdot \text{cm}^{-3}$. In addition at this site net winter mass balance appears to be roughly 2 to 3 times net summer mass balance. The only mass balance study comparable in the region was undertaken in 1974-1975 on Gara Glacier (Rania and others, 1977) some 450 km southeast of the Khel Khod Glacier system. Winter precipitation was also found to be the dominant component in the resultant positive net balance of that glacier.

In conclusion we feel that the glacio-chemical plot study discussed demonstrates great promise as a proxy tool for determining source area and time of deposition of precipitate entering high elevation portions of Himalayan glaciers. Future studies will emphasize the time-series capability of this type of investigation and should result in the production of paleoclimatic records for the Himalayas.

Acknowledgements

We would like to thank the Government of India for permission to conduct this project in India and we wish to thank all of the officials in Kashmir with whom we made contact for their support. P.A. Jeschke, UNH, provided invaluable field and laboratory assistance. G. Smith and T. Loder, UNH, offered appreciated laboratory advice. CREEL supplied the SIPA sugar used in the program. This research was supported by NSF grant ATM-791288.

References

- Gilbert, P.M. and Loder, T.C., 1977, Automated analysis of nutrients in sea water: a manual of techniques, Woods Hole Oceanographic Institution Tech. Rep. 77-47: 1-46.
- Nayewski, P.A. and Jeschke, P.A., 1979, Himalayan and Trans-Himalayan glacier fluctuations since AD 1812, Arctic and Alpine Research, 11, 267-287.
- Nayewski, P.A., Pregel, G.P., Jeschke, P.A. and Ahmad, N., 1980, Himalayan and Trans-Himalayan glacier fluctuations and the south Asian monsoon record. Arctic and Alpine Research, 12: 171-182.
- Raina, V.K., Kaul, M.K. and Singh, S., 1977, Mass balance studies on Gara Glacier, Journal of Glaciology, 18: 451-424.
- Ricq-de Bourard, M., 1977, Migration of insoluble and soluble impurities in temperate ice: study of a vertical ice profile through the Glacier du Mont de Lans (French Alps), Journal of Glaciology, 18: 231-238.
- Stokey, L.L., Ferrozine - A new spectrophotometric reactant for iron, Anal. Chem., 779-781.

ACIDITY OF RECENT HIMALAYAN SNOW

Wm. Berry Lyons
Paul A. Mayewski

Department of Earth Sciences
University of New Hampshire
Durham, NH 03824 U.S.A.

and

Nasseruddin Ahmad

Geology Department
Aligarh Muslim University
Aligarh, India

ABSTRACT

Surface snows collected at various elevations in the Indian Himalayas were analyzed in the field for pH as part of a broader study of the chemistry. The pH values are lower than the predicted ≈ 5.6 for unpolluted precipitation. Analysis of NO_3^- , NO_2^- , Cl^- , SO_4^{2-} and NH_4^+ indicate that these low pH values are not completely due to the presence of strong mineral acids. The strong correlation of pH with elevation (i.e. temperature) suggests that the low pH values are due to the snow being supersaturated with CO_2 .

Introduction

Precipitation in the Northern Hemisphere has recently been recognized to have hydrogen ion concentrations 10 to 500 times higher than expected for precipitation assumed to be in equilibrium with atmospheric CO_2 (i.e., $\text{pH} \approx 5.6$) (Likens and Bormann, 1974; Cogbill and Likens, 1974; Lewis and Grant, 1980). However there has been some controversy regarding the nature of the acidity of the precipitation sampled and if, indeed, the pH of North American precipitation has increased over time (Frothingham and Kane, 1975; Miller and Everett, 1979; Lerman, 1979; Stensland, 1980; Sequera, 1981). pH records have been constructed rather imperfectly in most locations due to differences in sampling, handling and analytical procedures used (Galloway and Likens, 1976, 1978; Galloway et al., 1979). It is thought that the lower pH's measured in Northern Hemisphere precipitation are due to the input of sulfur and nitrogen oxides from fossil fuel-burning (Likens and Bormann, 1974). Yet little data are available on the pH of precipitation in areas of the Northern Hemisphere remote from North American and European sources of anthropogenic sulfur emissions. This paper reports the pH of snow samples from the Indian Himalayas. It is hoped that the data presented will add to the information required to define baseline values of global pH in snow and ice and eventually add to the body of knowledge needed to correctly evaluate the pH of worldwide precipitation.

Methods

The snow samples come from within and adjacent to the Ladakh position of the Indian Himalayas (Fig. 1) and from an elevation range of 3400 to 5512 m. The samples are all surface snows (0-5 cm depth). Those from the Kangri and Sentik Glaciers were collected

Proceedings of the Eastern Snow Conference, 38 Annual Meeting, Syracuse, N.Y., June 4-5, 1981