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MCMURDO LTER: PALEOLIMNOLOGY OF TAYLOR VALLEY, ANTARCTICA

Although much information has been gathered on the climatological and glaciological histories of the dry valleys (e.g., Stuiver et al. 1981, pp. 319-436; Denton et al. 1989), relatively little is known about the physicochemical and biological state of past lakes in the region. For a recent review of paleolimnology in the McMurdo Dry Valleys, see Doran, Wharton, and Lyons (1994). The main objectives of this research are

- to put the present lake environments into historical perspective,
- to trace environmental change (e.g., changes in lake productivity, chemistry, sedimentology, and so forth) through recent time using lake-bottom sediments,
- to confirm and extend this record by using paleolake sediments left by high lake stands (e.g., perched deltas left by Glacial Lake Washburn between approximately 12,000 to 24,000 years ago), and
- to investigate new dating techniques to overcome carbon reservoir effects.

Short cores [less than 35 centimeters (cm)] collected from Lake Hoare in Taylor Valley (figure 1) have been analyzed for character and amount of carbonates and organic matter, siliceous algal remains, geochemistry, mineralogy, and texture. Carbonates in the short cores are sporadic, usually occurring in the fine-grained strata (figure 2; table), and so far have all been determined to be calcite with varying calcium-to-magnesium ratios. For the 31 oxic samples measured to date (strata from cores taken from DH1 and DH2), carbonates range from 0.3% Omicron (This character cannot be represented into ASCII Text.) to 8.4% Omicron (This character cannot be represented into ASCII Text.) isotopic carbon-13 (delta^{13}C), with a mean value of 5.6% Omicron (This character cannot be represented into ASCII Text.). This is remarkably close to the 5.4% Omicron (This character cannot be represented into ASCII Text.) value that Aharon (1988) predicts for antarctic lakes precipitating calcite in equilibrium with atmospheric carbon dioxide (CO_2) at 0 degrees C. Lake Hoare sediment delta^{13}C values reported here are heavier than those of its nearest neighbor, Lake Fryxell (Lawrence and Hendy 1989), by approximately 5% Omicron (This character cannot be represented into ASCII Text.).

According to Green, Angle, and Chave (1988), Lake Hoare surface waters are supersaturated with respect to calcite whereas waters below 20 meters depth are undersaturated. Mass-balance calculations further showed that calcium carbonate ($CaCO_3$) is precipitated in the shallow regions of the lake, the area from which our core was extracted. This, coupled with the relatively heavy Lake Hoare dissolved inorganic carbon values resulting from the lack of surface water inflow and mixing (Wharton, Lyons, and Des Marais 1993), helps to explain the isotopically heavy sedimentary carbonate. Sedimentary carbonate delta^{13}C increases with core depth to approximately 30 cm in the core depicted in figure 2, suggesting a change in lake hydrology and/or productivity over recent time.

Organic matter delta^{13}C is relatively light. This may be related to the findings of Rau, Takahashi, and Des Marais (1989), who suggest that increased solubility of CO2 in colder water favors isotopic discrimination by phytoplankton. The relatively heavy organic delta^{13}C values in the coarser material reflect an allogenic source for the material.

These preliminary results suggest that

- solution/dissolution of calcium carbonate is an important process in the lake;
- carbon dynamics have not been stable over recent time; and
- organic matter is primarily derived from allocthonous input during periods of high sedimentation rates, and during low sedimentation periods, autochthonous organic input is dominant.

More than 30 freshwater diatom taxa have been documented from a Lake Hoare core (from DH2#4). Total number of diatom valves per milligram of dry weight sediment varies from less than 1,000 to 117,000 (figure 3). Total abundance is greatest at 17-18 cm depth. Although benthic cyanobacterial mats are clearly evident within the core, the 17-18-cm section is not associated with mat material. Additional analyses will determine whether diatom abundance is consistently negatively correlated to total organic material. Chrysophyte cysts and fragments of marine diatoms are also present. Marine diatom fragments are not as common in Lake Hoare sediments as in Lake Fryxell. The marine fragments are likely to have entered the lake from terrestrial deposits, possibly transported by streamflow.

Samples of perched deltas left from Glacial Lake Washburn were collected during the 1993-1994 field season and will undergo the same types of analyses as the lake sediments. Results so far indicate that calcite is the only carbonate present in the delta samples. The amount of carbonate and organic matter per unit volume of perched delta sediment is extremely variable and seems to decrease with delta size.

During the 1994-1995 field season, we will continue collecting perched delta samples and attempt to collect long cores from the lakes using a modified Nesje corer (Nesje 1992). Ideally, we would like to penetrate Lake Hoare sediments and obtain Lake Washburn sediments lying below. One of the key questions that could be answered with the long cores is whether Lake Hoare evaporated to dryness 1,200 years ago during a prolonged dry period that drew other dry valley lakes down to brine ponds. Furthermore, we may have the opportunity to compare sediments below Lake Hoare with perched delta sediments of the same age.

A suite of dating techniques is being tested and tried on the sediments retrieved from the dry valleys. These include thermoluminescence, uranium/thorium, and paleomagnetism.

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Percentages of calcium carbonate ($CaCO_3$) and organic matter (CH20), and delta^{13}C values (in %*(This character cannot be represented into ASCII Text.)) for selected strata in Lake Hoare core DH2#4. Sample numbers correspond to those found in figure 1. (IC=insufficient carbon.)

Legend for chart:

A - Sample
B - Depth (cm)
C - %$CaCO_3$
D - %$CH_2$0
E - Delta$^{13}C_{carb}$
F - Delta$^{13}C_{org}$

A	B	C	D	E	F
1	0.0-1.0	5.4	0.8	6.7	-23.2
2	1.0-2.0	2.0	1.2	6.4	-22.1
3	2.0-3.0	0.1	0.2	6.0	-17.4
4	8,0-10.0	0.0	0.1	IC	-14.6
5	12.0-13.0	0.0	0.1	IC	-14.8
6	14.0-15.5	16.4	0.2	6.4	-15.5
7	17.0-19.0	0.0	0.1	IC	-14.5
8	20.5	21.4	1.8	7.5	-25.7
9	21.5	14.2	3.5	7.2	-25.7
10	24.0-26.0	0.0	0.1	IC	-14.7
11	27.0-29.0	4.6	0.2	8.4	-1.9
12	30.0-32.0	0.1	<0.1	3.2	-14.8

MAP: Figure 1. Map showing locations of dive holes (DH) on Lake Hoare.

GRAPH: Figure 2. Core log of Lake Hoare core DH2#4.

GRAPH: Figure 3. Absolute abundance of diatom valves (10^4 valves per milligram dry weight sediment) in Lake Hoare sediment core from dive hole 2 (DH2) (different from that depicted in figure 2).

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