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LAKE VIDA, VICTORIA VALLEY, ANTARCTICA*

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ABSTRACT. Unlike the other large lakes in the ice-free valleys of southern Victoria Land, Antarctica, Lake Vida, in Victoria Valley, is probably frozen to its base. Sand layers in the uppermost 11 m. of ice on Lake Vida may indicate that this lake has a different history from the others. Summer-time ablation is about 50 cm. of ice.

RÉSUMÉ. *Lake Vida, Victoria Valley, Antarctique.* Contrairement aux autres lacs de la vallée libre de glace du sud de la Victoria Land, Antarctique, dans la Victoria Valley le Lake Vida est probablement gelé jusqu'au fond. Des strates de sable dans les premiers 11 m de la glace du Lake Vida peut témoigner d'une histoire différente de celle des autres lacs. L'ablation estivale est de l'ordre de 50 cm de glace.

ZUSAMMENFASSUNG. *Lake Vida im Victoria Valley, Antarktika.* Im Gegensatz zu den anderen grossen Seen in eisfreien Tälern von Süd-Victoria Land, Antarktika, ist Lake Vida im Victoria Valley vermutlich bis zum Grund gefroren. Sandschichten in den obersten 11 m des Lake-Vida-Eises lassen vermuten, dass die Geschichte dieses Sees von der der anderen verschieden ist. Die Sommer-Ablation beträgt ungefähr 50 cm Eis.

IN recent years many studies have been made of the chemical and physical characteristics of the lakes in the ice-free valleys of south Victoria Land, Antarctica (for example, Wilson and Wellman, 1962; Wilson, 1964; Shirtcliffe and Benseman, 1964; Hoare and others, 1964, 1965). Henderson and others (1966) have reported the existence of layers of water during the summer in the ice cover of Lake Fryxell in Taylor Valley (Fig. 1) and their work has prompted us to record some similar phenomena, and some marked contrasts, observed on Lake Vida.

Lake Vida is a permanently ice-covered lake, 3·5 km. long and 1 km. wide, at the east end of Victoria Valley (lat. 77° 24′ S., long. 162° E.). Its surface elevation is 390 m. The lake is fed to a minor extent by snow accumulation on its surface, and by melt water flowing from the local snow banks. During some summers melt-water streams flow into the lake from Victoria Upper and Lower Glaciers and from smaller glaciers in the St. Johns Range, but in other years these streams contribute little or nothing. Like Lakes Vanda, Bonney and Fryxell in the neighboring valleys, Lake Vida has no outflow, and losses occur only by evaporation, sublimation and by deflation.

In December 1961 several attempts were made with a coring auger to penetrate the ice cover near the middle of Lake Vida. Beneath a surface ice layer, 20–30 cm. thick, was a widespread water horizon, less than 1 m. thick, and this was underlain by cold ice which could not be penetrated because the auger was always trapped by the freezing of water percolating down the hole from the water layer above.

This melt-water horizon and the water-table on Lake Fryxell (Henderson and others, 1966) probably owe their existence to the "hothouse effect". Similar explanations have been used by Takahashi ([1960]) for the occurrence of puddles below unmelted snow on fresh-water ice at Syowa (lat. 69° S., long. 39° 45′ E.) and by van Autenboer (1962) to account for the ice mounds in the Sør-Rondane (lat. 72° S., long. 25° E.).

Early in October, when the sun is low and shines on the lake for only a few hours, the temperature of the surface ice is probably about −20°C., and it is likely to be lower at a

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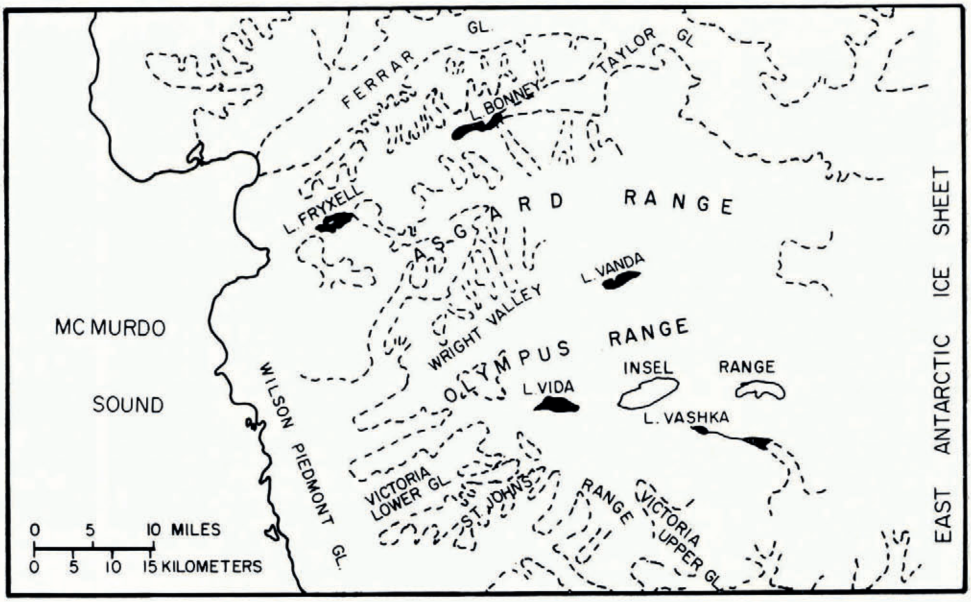

Fig. 1. Map of south Victoria Land (based on American Geographical Society 1 : 600,000 map, 1966)

depth of 2 or 3 m. (Cameron and Bull, 1962). During the spring the incoming short-wave solar radiation increases. About 50 per cent is reflected from the ice surface (which is kept relatively snow-free by the persistent winds) and most of the remainder is absorbed in the ice. Of the radiation incident on the surface, only 1 or 2 per cent passes through to the base of an ice layer 3–5 m. thick (Shirtcliffe and Benseman, 1964). No continued radiation measurements have been made in the ice-free valleys, but it may be assumed that the situation there is comparable with that at Scott Base (lat. 77° 52′ S., long. 166° 45′ E.) where year-round measurements have been made by Thompson and Macdonald (1961). Differences due to cloud cover and exposure have been discussed by Bull (1966). If there were no loss of energy from the uppermost 3 m. of ice, heated by the absorption of short-wave radiation, the temperature of this layer would rise by mid-December to 0°C. However, the air temperature at Lake Vida is lower than this, averaging about −11°C. for November and −3°C. for December (Bull, 1966), so that energy is lost from the ice surface. These losses may be very large at times owing to the constant and strong winds. Additional heat losses from the surface are due to the sublimation of ice, but data on humidities, wind speeds and the variations of temperature with height are too scanty to permit calculations. Energy losses also occur at the lower boundary of the heated layer by conduction to the colder underlying ice, but these are likely to be much smaller than at the upper surface. Nevertheless, by this conduction process the temperature at depth probably rises considerably before the water horizon forms. Obviously it would be worthwhile to obtain much more complete data on the temperature regime.

During the early summer, radiation and sublimation form dust pits, cusps and latticeworks of etched crystal boundaries on the surface of Lake Vida, but by February these have been replaced by new smooth ice. In part, this process is analogous to that occurring on Lake Fryxell, namely by the ablation of old ice above the new water-table. Some coating by water squeezed from the melt horizon to the surface through the expansion cracks of spring and early summer must also occur. However, near the edges of Lake Vida, the smoothing process is most clearly related to the flooding of the old ice surface from the bordering moat of open water.

This flooding may be much more significant on Lake Vida than on Lakes Fryxell, Bonney and Vanda, because Lake Vida alone appears to be frozen to its bottom so that the ice surface remains fixed, while on the others the ice cover can rise as the lake-water level increases during the summer. A hole augered 1 km. from the east end of the lake in November 1961 passed through hard blue ice with layers of sandy and silty ice at 3, 4, 10 and 11 m. to reach an impenetrable surface of frozen sand and gravel at 11·5 m. depth. Small pebbles of the local bedrock were recovered from this depth by blasting, and it seems certain that this surface is the lake bottom. The ice mounds in the north-central part of the lake (Cailleux, 1962) also indicate that the lake remains completely frozen, except for the narrow moat around the edges and the internal melt horizon.

On Lake Fryxell the newly formed ice surface is uplifted in late summer and early winter by the accretion of ice at the internal melt-water horizon and at the bottom of the ice column. This phenomenon has not been observed on Lake Vida and we believe that any regular annual raising of the surface due to this cause is very small. The vertical movements of the ice surface that do occur (a small rise during summer 1958–59; falls during summers 1960–61 and 1961–62) appear to be directly related to the balance between inflow (from melt-water streams and seepage from melting local snow) and outflow as evaporation, sublimation and deflation.

Whereas Lake Vida appears to be frozen to the bottom, the other large lakes in the area (Vanda, Bonney and Fryxell) all show elevated temperatures in the water beneath the ice cover. This has been explained (Shirtcliffe and Benseman, 1964) as being due to absorption and trapping of solar radiation in lower layers that are rendered non-convective by density gradients produced by increased saline concentrations at depth. The existence of sand layers in the ice at 3, 4, 10 and 11 m. beneath the surface of Lake Vida may indicate that its history is markedly different from that of the other lakes. Lake Vida may have built up slowly, perhaps yearly by the inflow of melt water, while the lake remained frozen to the bottom at least in some places. From time to time, the wind-carried sand and silt layer formed on the ice surface during the winter was much thicker than usual. By normal processes of differential absorption of radiation and melting, the thinner dust layers of other winters might be concentrated at these thicker horizons. This sequence would suggest that the lake now present has never completely melted and re-frozen.

The difference between Lake Vida and the other large lakes may be partly attributable to the different thermal environments. Lake Vida is at 390 m. elevation, compared with Lake Vanda at 123 m., Lake Bonney at 98 m. and Lake Fryxell at 70 m. During the summer 1958–59 the Onyx River, feeding Lake Vanda with melt water mainly from Wright Lower Glacier, carried a total volume of at least $1 \cdot 3 \times 10^6$ m.^{3}, and possibly three times as much, enough to raise the lake level by 18–54 cm., compared with the observed rise of 9·5 cm. In the same period the inflow into Lake Vida from Victoria Upper and Lower Glaciers was very small but the lake level did rise slightly. In summer 1961–62 discharges as large as 4·5 m.^{3} sec.$^{-1}$ were measured in the Onyx River while the only melt water reaching Lake Vida was from local snow banks, and during the season the lake level dropped by 50 cm.

This value is comparable with the 30–40 cm. reported as the average yearly net ablation on Lake Fryxell by Henderson and others (1966). However, it may be dangerous to assume that this is also the annual ablation on the local glaciers, as Henderson and others (1966) have done in their preliminary considerations of the mass balance of Canada and Commonwealth Glaciers in Taylor Valley.

The main terms in the mass budget of the glaciers in this area are the annual snow accumulation and the loss of material by sublimation. The annual accumulation varies greatly throughout the ice-free area and ablation varies from glacier to glacier, depending on its location and exposure to winds. For example, on Victoria Lower Glacier, where the annual snow accumulation may be relatively high, the ablation from stakes at 500 m. elevation in the period from early November 1961 to the end of January 1962 varied between only 0·3 and 2·5 cm. of ice. On the other hand, on Meserve Glacier on the south wall of Wright Valley, the ablation between about 25 November 1965 and about 13 February 1966, at 36 stakes at elevations from 400 to 550 m., averaged 19 cm. of ice. In the following winter, 13 February to 21 November 1966, the average ablation at these stakes was more than 11 cm. of ice. Thus, at this elevation on Meserve Glacier the annual ablation is comparable with that on Lake Fryxell, but on Victoria Lower Glacier it is very much less.

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