possibility that this ash fell not only on the unglaciated area, but also on the ice itself and on ground recently abandoned by the ice, encourages search for further occurrences and age determination by radiocarbon methods (*12*).

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12. Publication authorized by the director, U.S. Geological Survey. We are indebted to many persons for stratigraphically documented samples of ash, for collections of lump pumice from recently active Cascade volcanoes, and for helpful discussion of the field and laboratory problems.

30 January 1964

Temperature Regime of Deep Lakes

Abstract. *New data concerning the temperature of maximum density of fresh water under pressure have been obtained in Great Bear Lake, in the Northwest Territories of Canada. Previous theoretical determinations are discussed; Strøm's empirically determined figures are in agreement with these data.*

In the north of Canada, Great Bear Lake is situated with its northern arms cutting across the Arctic Circle; it is the fourth largest lake in North America, and also the fourth deepest. It is still comparatively little known limnologically, although a comprehensive survey, with the motor vessel *Radium Gilbert*, was started in the summer of 1963. The greatest depth recorded was 427 m (1410 feet) in McTavish Arm, 8.5 km west of Port Radium in an extensive region of very deep water. The water is extremely clear in this locality, a Secchi disc reading of 30 m (98.5 feet) having been obtained; the dissolved solids amounted to 78 parts per million.

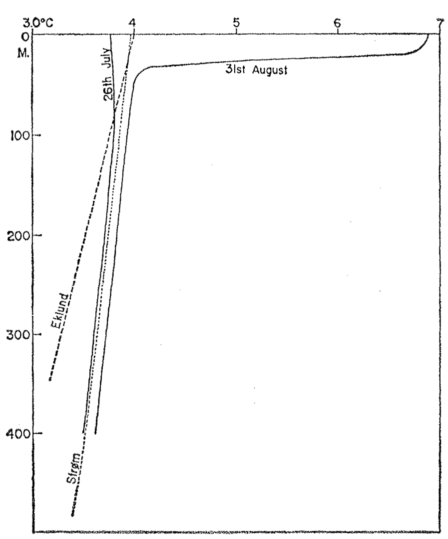

Fig. 1. Temperature series, Great Bear Lake, Canada.

The conditions in Great Bear Lake appear to come as close as possible to the requirements stipulated by Strøm (*1*) for a lake in which to measure the temperature of maximum density: "If a holomictic lake (a lake with seasonal circulations extending to the bottom) is cooled sufficiently down before vernal full circulation, temperatures in the deep must immediately after the establishment of incipient summer stratification very nearly correspond to the temperature of maximum density at the various depths."

Two temperature series were taken in the area of deep water with protected reversing thermometers in Nansen water bottles. The thermometers were calibrated by the National Research Council of Canada within 3 months of the time the readings were made. Bathythermograph traces were obtained at the same time. The first series was taken at the end of July as the surface waters approached their temperature of maximum density (3.94°C), and the second recordings were made at the end of August at about the time of maximum heat absorption. The surface temperature at this time was 6.87°C; the corresponding temperature at 50 m was 3.97°C. These series are plotted in Fig. 1; also included on the graph are the lines deduced by Strøm and Eklund (*2*). Strøm's line appears to provide an exceptionally good fit to the data; neither the early nor the late profile crosses the theoretical line; at 400 m on 26 July the observed value of 3.48°C is almost identical with that of 3.49°C deduced by Strøm, and this is well within the standard deviation of the instrument used (± 0.02°C).

Although minimum winter temperatures are not yet available, it appears that Great Bear Lake is dimictic in this deep-water region. In July there appeared to be no trace of stagnation in the deepest water, the *p*H, nitrate, and phosphate values being very close to those obtained on the surface. Miller and Kennedy (*3*) found that the water was between 85 to 91 percent saturated with oxygen at depths up to 346 m (1134 feet). It can therefore be assumed that circulation is taking place, probably at a temperature slightly below that of maximum density. When the bottom temperature reaches 3.48°C relative stability is attained. This stability is largely maintained until the fall. Its maintenance is doubtless assisted by the relatively narrow and deep section of McTavish Arm and the calm weather at this time of the year. Unfortunately no chemical data are available for the August temperature series. Such data might have indicated summer stagnation, although biological activity is so slow, even on the surface, that very sensitive methods might be required to determine any effects of this deep stagnation.

The theoretical values deduced in a most ingenious manner by Eklund from the compressibility of water have no relationship to the data from Great Bear Lake, although there is a very slight point of inflection on the bathythermograph slide at about the depth at which Eklund's line would cross the trace.

It seems apparent that Strøm's "envelope" has some physical reality, and it must therefore be connected in some way with density relationships. Eklund's statement that there is no physical reason why the temperature profile of a stable column of water cannot cross the line of maximum density surely needs challenging. If two points on a profile that is crossed by the line of maximum density are considered, one point on each side of the line, then the water at the point to the right will be too warm for maximum density and that on the left of the line will be too cold. As the points approach the line the system will gain entropy by mixing in such quantities as are necessary to achieve the temperature of maximum density. If no external forces are present the "reshuffling" process will proceed until stability is attained along the temperature curve for maximum density. The example provided by Eklund of a lake isothermal at 3.9°C having a temperature profile crossing the line of maximum density is by no means convincing unless it can be shown that this condition does in fact occur under calm conditions. Lussana, whose work is quoted by Dorsey (4) and by Eklund in support of his calculations, deduced a figure of 197 atm as the pressure at which the temperature of maximum density is 0°C. This work is not referred to by Strøm, who considered that Pushin and Grebenshchikov had fixed this point with great certainty as 600 atm. It is unfortunate that the discrepancy between physical determinations should be so great.

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12 March 1964

Cariostatic Effect of Phosphates

Abstract. *The caries-preventive effect of phosphate additives in cariogenic diets fed to white rats has been further demonstrated. Diammonium phosphate, β-glycerol phosphate, and sodium phytate again were shown to be caries-inhibiting, as was a 1,6-fructose diphosphate. The caries-inhibiting action of organic phosphates may coincide with a caries-protective factor presumed lost in the refining of sugar and in the processing of certain cereal foods.*

Previous publications have presented numerous results and reviewed data demonstrating unusual cariostatic effects of phosphates in experimental rats and hamsters (*1*). This report presents data on an anticaries property of a fructose phosphate, and adds to previous evidence of cariostatic effects of sodium phytate, β-glycerol phosphate, and diammonium phosphate (*1*). The data prompted speculation regarding the identity of caries-preventive organic phosphates with a so-called "caries-protective factor," presumed lost during the refining of sugar and in the processing of certain cereal foods (*2, 3*).

As discussed by Shaw (*4*), a low incidence of caries among certain populations often occurs where the oral environmental effect of the food is regarded as a dominant caries-preventing factor. Osborn, Noriskin, and Staz postulated in 1937 that crude cereals and sugars contain substances which inhibit dental caries but are removed during the refining process (see *2*). Osborn (*3*) reported a reduction in decalcification of teeth in vitro by cooked brown flour. The inhibitory effect of unrefined sugars, various hexose-phosphates, calcium phytate, and calcium glycerol phosphate was investigated (*2, 3*). Jenkins *et al.* (see *2*), in extensive experiments on white and brown flour, confirmed the evidence of Osborn *et al.* "that cooked brown flour contains a substance which reduced the solubility of teeth *in vitro*," and concluded "that certain organic phosphates, including phytate, reduce the solubility of calcium phosphate and teeth." These may be active substances in brown flour.

It is of interest that oat hulls (*5, 6*), as well as rice, pecan, peanut, and cotton seed hulls (*7*), have a cariostatic property. While efforts have been made to isolate an anticaries factor from such seed hulls, so far as is known such a factor has not been identified as an organic phosphate, for example, phytin. The major effort has been to identify an ether, alcohol, or acid water extract as a caries-preventive, brought about by an effect on the oral flora (*5*).

The experimental regimen of this type of study has been described (*1*). Dry ground bread, prepared by a local bakery, constituted 67 to 73 percent of the diet, together with 18 percent glucose (commercial cerelose) and 4 to 8 percent corn starch. Essential vitamins (Nutritional Biochemical Company vitamin mix), 1.09 percent L-lysine·hydrochloride, 0.5 to 2.0 percent NaCl, and 1.37 percent $CaCO_3$ were added. Phosphorus supplements replaced an equivalent quantity of corn starch. The diets contained 10 to 12 percent protein, and cariogenicity was not dependent on an excessive quantity of sugar. The animals were killed after a 60- to 90-day experimental period, and the lower molar teeth were examined for caries, essentially all the smooth surface type (*1*).

In the first series of experiments (1a, 1b, 1c, 1d in Table 1) the cariostatic effects of 0.55 percent, 1.11 percent, and 3.33 percent of $(NH_4)_2HPO_4$ were compared. In the second series (2a, 2b, 2c) the primary objective was to study a hitherto uninvestigated sugar phosphate, namely, the trisodium salt of fructose 1,6-diphosphate. In a third series the cariostatic effects of $(NH_4)_2HPO_4$ and sodium phytate were compared. Both the phytate and phosphate were evaluated in previous studies (*1*). Anticaries effects of the various additives are measured by comparison of control and corresponding test groups, in terms of percent of carious rats, carious molar teeth, and caries severity scores. That all control groups do not develop identical caries experiences is not unexpected in experimental caries research. Results can be evaluated, therefore, only by comparison of a test group with its specific control group. Rats of all comparable experimental groups are littermates.

As shown in Table 1, the cariostatic effect of $(NH_4)_2HPO_4$ was again demonstrated. Three different concentrations of $(NH_4)_2HPO_4$ reduced the incidence of caries from 91.4 percent to 20.5, 34.3, and 20.3 percent, respectively. A severity score of 13.2 was reduced to 1.0, 1.8, and 0.8. Under these conditions as little as 0.55 percent $(NH_4)_2HPO_4$ was very cariostatic, concomitant with a low concentration of 0.24 percent phosphorus in the diet. This effect of $(NH_4)_2HPO_4$ stands in striking contrast to results of previous