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# LETTER TO THE EDITOR

# Comment on "Late Holocene Lake Sedimentology and Climate Change in Southern Alberta, Canada" by Campbell

Campbell (1998) proposed that as the climate becomes moister the median particle size of sediment deposited in a lake will increase because the clay is removed in the water flowing from the lake. Sediment in Pine Lake, south of Edmonton, Alberta, was cored to 71 cm for $^{210}$Pb dating and to 3.75 m to study sediment sizes in the deepest part of the lake. Campbell indicated the lake is in a ". . . meltwater channel carved into fine-grained Paskapoo Formation (Tertiary sand and gravel)" and ". . . drains 150 km$^2$ of hummocky moraine, mostly by percolation through glacial deposits rather than direct overland flow." Thus, overland flow would transport sediment to the streams and lake, but most of the water must be ground water that maintains the two permanent streams and, indirectly, the lake.

Several factors need to be reconsidered to improve the climate estimates. Isobaths, usually used to show the depths of water, are confusing in Campbell's Fig. 1 because they apparently are elevations above sea level and increase rather then decrease from the lake edge to the center. They do not show the elevation of the lake bed and do not curve away from inflowing streams, as they should to show a delta. Deltas form where a stream empties into deep water. Gypsum and abundant $CaCO_3$ in the lake sediment would not be present unless calcium was the main cation in the water and on the clay exchange complex. The Ca-saturated clay would flocculate and settle to the bottom of the lake before the low energy outlet stream could remove it. Campbell's Fig. 2 was used to estimate the climate after 4,000 cal yr B.P. from the median particle sizes in the layers of the lake sediment. These estimates of climate are different from those suggested for western Nebraska (Brice, 1966), North Dakota (Blumle and Clayton, 1982), and South Dakota (White and Hannus, 1985), which are related to the average world temperature changes more recently proposed by Arnell (1996). The climate was warmer and valley filling occurred from 10,500 to 5,000 $^{14}$C yr B.P. and from 2,500 to 1,000 or 850 $^{14}$C yr B.P.; valley erosion occurred in cooler intervals from 5,000 to 2,500 $^{14}$C yr B.P. and intermittently after 1,000 $^{14}$C yr B.P. Campbell's Fig. 2 shows that the median grain size increased in the 2,100 to 1,300 cal yr B.P. interval which would be evidence the climate was more moist rather than drier. Laird *et al.* (1996) concluded that it was drier and droughts were frequent from 2,300 to 1,000 cal yr B.P.

Another explanation for the increase in grain size is the warmer drier climate caused the lake levels to decrease so inflowing drainage systems eroded their channels to adjust to a lower local base level. Sediment deposited in the valleys in earlier moist intervals was silty because the clay had already been carried into the lake. The increase in the amount of gypsum in the lower part of the lake sediment would be consistent with lower lake levels. Following this interval at Pine Lake, the climate became moister and the clay in the lake sediment increased. During short droughts in the last 700 yr, sediment-free ground water, which had accumulated previously in the swales between the morainal hummocks, could seep into the streams and erode the silty beds and banks. If the ground water had been depleted, thunderstorm runoff sediment would be mainly from the clay-containing soils on the steep slopes and small drainageways adjacent to the 13- or 14-km-long lake shoreline. Properties of the lake sediment would depend on the balance between the sources as well as the climate. The estimated dates shown in Fig. 2 probably should be adjusted to correspond more nearly to Arnell's proposed climates. Valley erosion in South Dakota about 800 to 1,000 $^{14}$C yr B.P. would be consistent with a moist climate interval during the Medieval Warm Period.

Using the tentative dates as given in Fig. 2 and the reinterpreted median particle size data, the climate was mesic from 4,000 to 2,000 cal yr B.P., xeric from 2,000 to 1,300 cal yr B.P., mesic from 1,300 to 700 cal yr B.P., and variable after 700 cal yr B.P., but more xeric than the preceding interval.

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