# THE ORIGIN, GEOCHEMISTRY AND MORPHOLOGY OF WEAVER AND YOUNG LAKES, HERKIMER COUNTY, N.Y.

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## INTRODUCTION

This work is part of a broader study involving an analysis of Glaciation and the development of karst systems in the northwestern section of the Otsego Lake watershed.

This paper discusses possible mechanisms of origin of Weaver and Young Lakes based on the morphology and aqueous geochemistry, and the stratigraphy and glacial landforms in the area. These mechanisms include: solutional development of a karst system; plucking during advance of the ice sheet in combination with stagnant ice upon retreat; and a variation of the dead-ice sink method of development.

## GEOGRAPHY AND TOPOGRAPHY

Weaver and Young Lakes lie in thick glacial deposits (Rickard and Zenger, 1964) in the southeastern corner of Herkimer County along State Route 20 in the hamlet of Warren (Fig. 1). Weaver Lake, northwest of Young Lake, lies partially above the Onondaga Limestone and the Carlisle Center Sandstones and Esopus Shales. Young Lake lies completely in the Onondaga. A drumlinoid feature separates the two lakes and is breached by a stream which drains Weaver Lake into Young Lake.

The surface areas of the lakes are shrinking. A look at aerial photographs (Fig. 2, USDA, 1992) and topographic maps of this area show former shorelines of both lakes. This may indicate lowering of lake level due to drainage of the lakes or increased sediment deposition within them.

## GEOMORPHIC PROCESSES

In this area two major geomorphic processes have modified and developed the surficial landforms; glaciation and karst processes. Glaciation, by far, is the most significant of the two.

Thick Pleistocene glacial sediments extend from the Helderberg-Onondaga escarpment on the southern flank of the Mohawk Valley to the upland divide separating Otsego and Canadarago Lakes. Drumlins formed during the retreat of the Mohawk Lobe (≈14,500 BP) extend across these sediments in an east-west trend, indicating the direction of ice movement (Fig. 3). This east-west trend is indicated in the basin morphology of both Young and Weaver Lake. Retreat of the ice margin in this region seems to have been characterized by rapid downwasting rather than stagnant-ice retreat.

The sediments end in a distinct line at the brink of the escarpment. This indicates that the portion of sediment deposited north of the esearpment has been fluvially transported down the scarp face into the Mohawk Valley.

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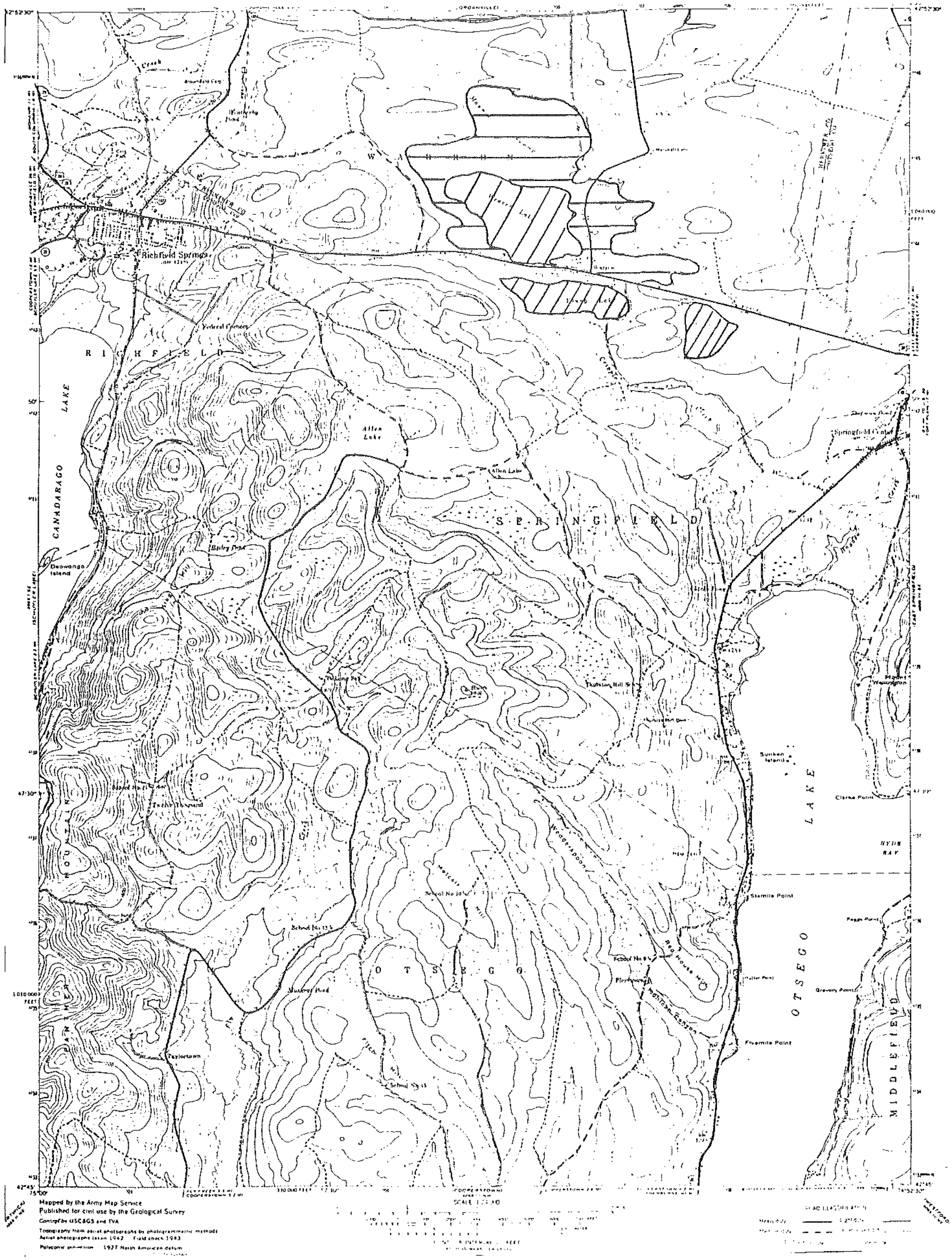
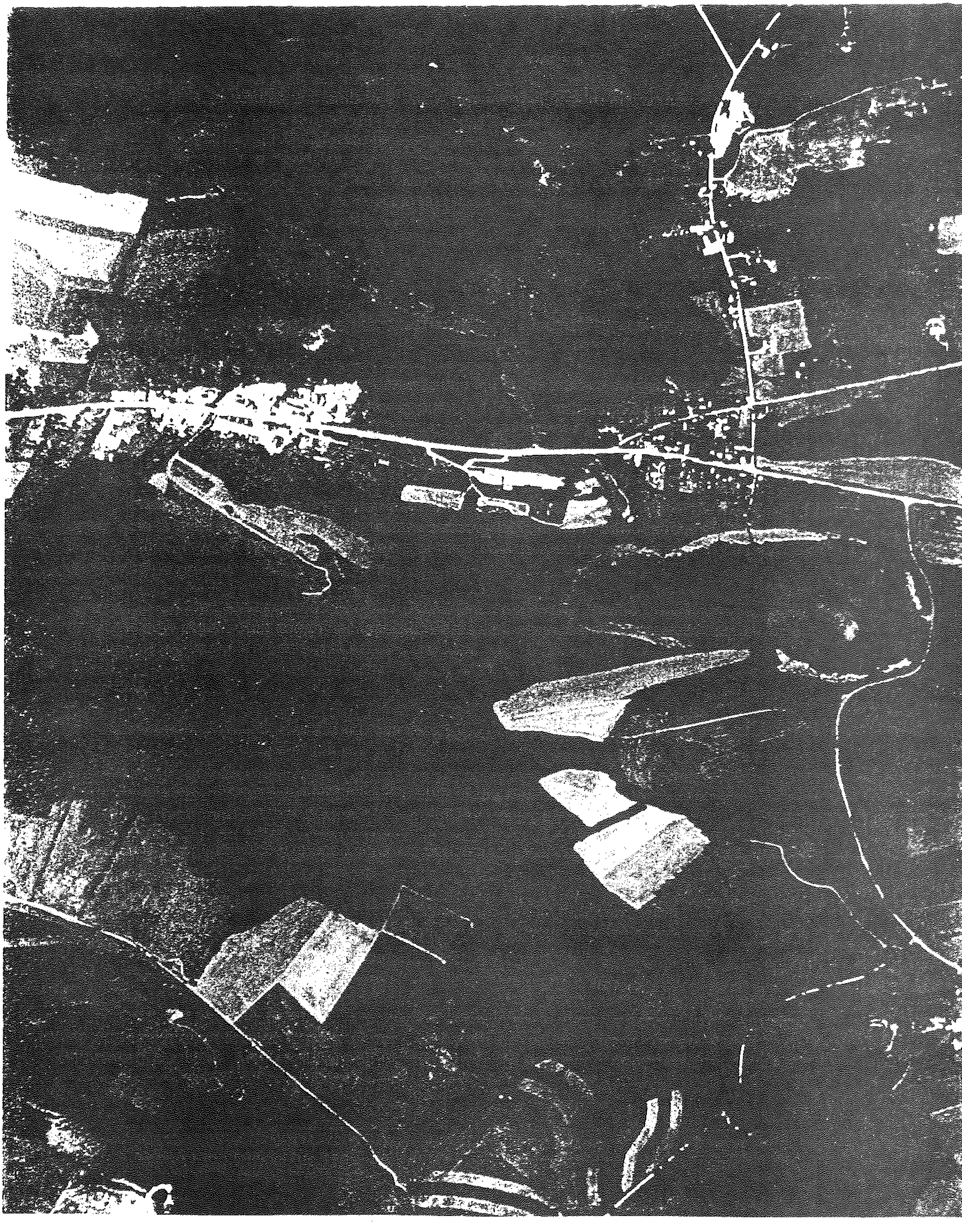



*Fig. 1 – Outlined areas indicate possible dimensions of stagnant ice in this area.*



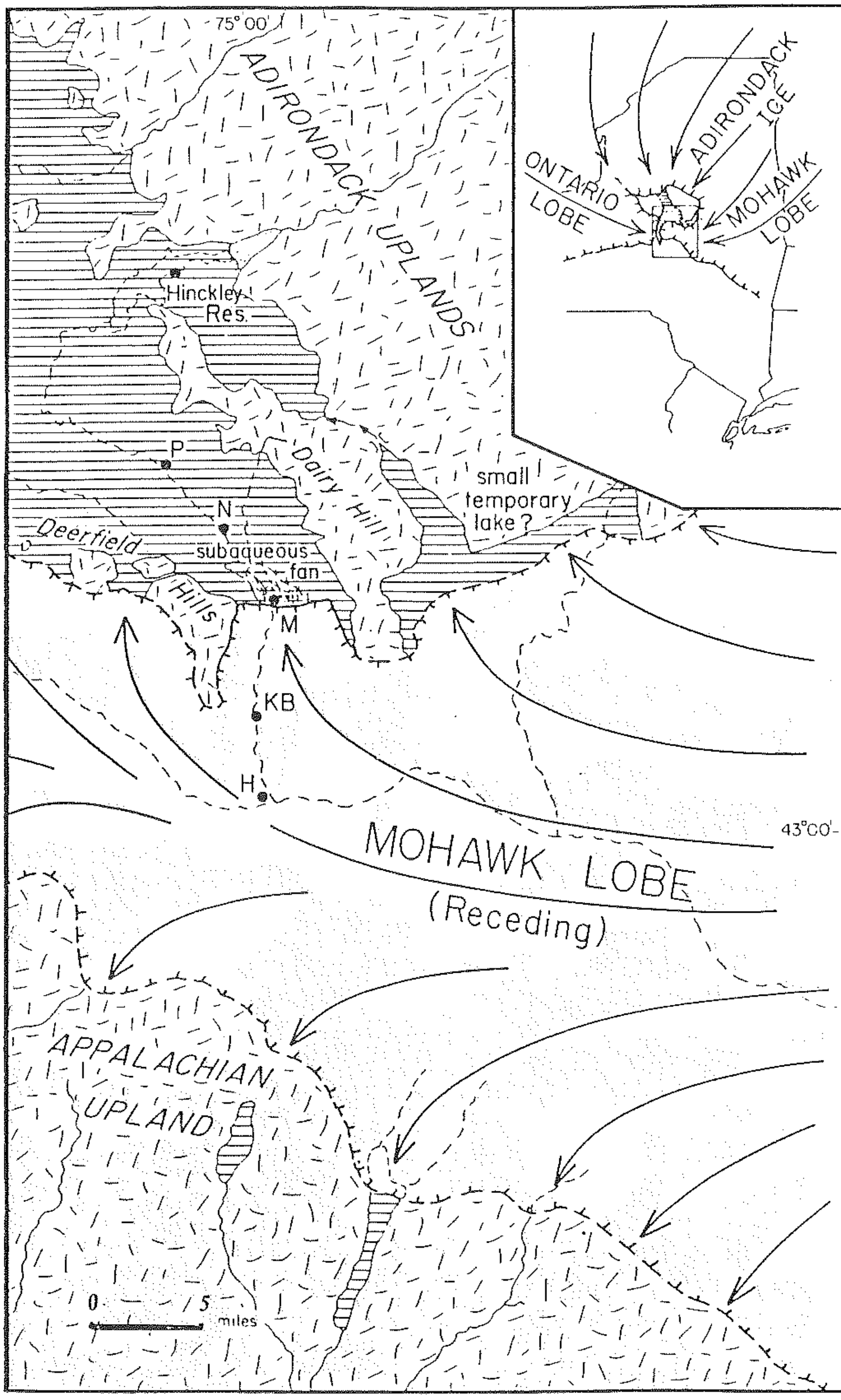



*Fig. 3 -- General location of the Mohawk Lobe ice margin during retreat (Ridge, 1991).*

Karst topography is normally illustrated by typical surface expressions, including sinkholes, disappearing streams and springs. In this area, mappable surface expressions of karst are rare. There are far more sinkholes and smaller swallow holes in this area than the map depicts.

Well-developed karren topography also exists across this entire area. Karren topography results from widening of joints by chemical weathering and glacial loading and unloading (Palmer, 1991). Like many of the sinkholes, karren topography isn't illustrated on topographic maps because it is a small scale feature.

## LAKE BASIN MORPHOLOGY

### Weaver Lake

Having the largest surface area of the two lakes, $3.35 \times 10^6$ $ft^2$, Weaver Lake has a mean depth of 7.1 feet and a maximum depth of 11 feet. The total volume of the lake is $2.38 \times 10^7$ $ft^3$.

Weaver Lake has three streams draining into it, one located at the northwestern corner and two in the northeast. Drainage out of the basin is through a small southeasterly flowing stream emptying into Young Lake. These streams transport sediment and possibly high nutrient loads into the lake from adjacent farms.

Bathymetric maps (Fig. 4) were produced using a Ross depth recorder secured to a john-boat. The boat was powered by a 16 H.P. outboard, which was driven at a constant speed. Several times transects in Weaver Lake had to be shortened because of extremely thick vegetation which prohibited reaching the shore. In these cases the depth of the lake was extrapolated from that point to the end of the transect.

Subsurface profiles across the lake (Fig. 5) indicate a flat-bottomed basin with relatively steep walls along the north-south line of section and progressive changes of elevation in an east-west line of section (steeper along the eastern slope of the basin).

### Young Lake

The surface area of Young Lake covers $8.36 \times 10^5$ $ft^2$ (Greeson and Robison, 1970) with a mean depth of 10.11 feet and a volume of $8.46 \times 10^6$ $ft^3$.

Stratigraphically, Young Lake lies completely within the Onondaga Limestone (Rickard and Zenger, 1964). The same equipment and procedure was used in mapping this lake. The low concentration of vegetation made complete transects possible. Bathymetrically, Young is similar to Weaver, in that it is flat bottomed and has fairly widely spaced contours both in the eastern and western portions of the map (Fig. 6). In addition, the trough of each lake is narrow.

However, the change in depth in Young Lake is much more rapid than in Weaver, appearing topographically to be nearly vertical along the trough walls, particularly in the eastern and southern fringes of the trough (Fig. 7).

The surface area of Young Lake is also being reduced by sedimentation, precipitation of calcareous marl and subsequent encroachment of vegetation. This is evident from topographic maps and aerial photographs. This is seen primarily in the northwest corner of the lake. Little sedimentation is taking place in the eastern portion of the basins, evidenced by the presence of large glacial erratics seen in shallow waters in this area and a solid substrate.

## LAKE CHARACTERISTICS

Sediments in these lakes, particularly Weaver Lake, consist primarily of marl. Bathymetric maps of the lakes indicate benches of marl deposited along the shore of the lakes.

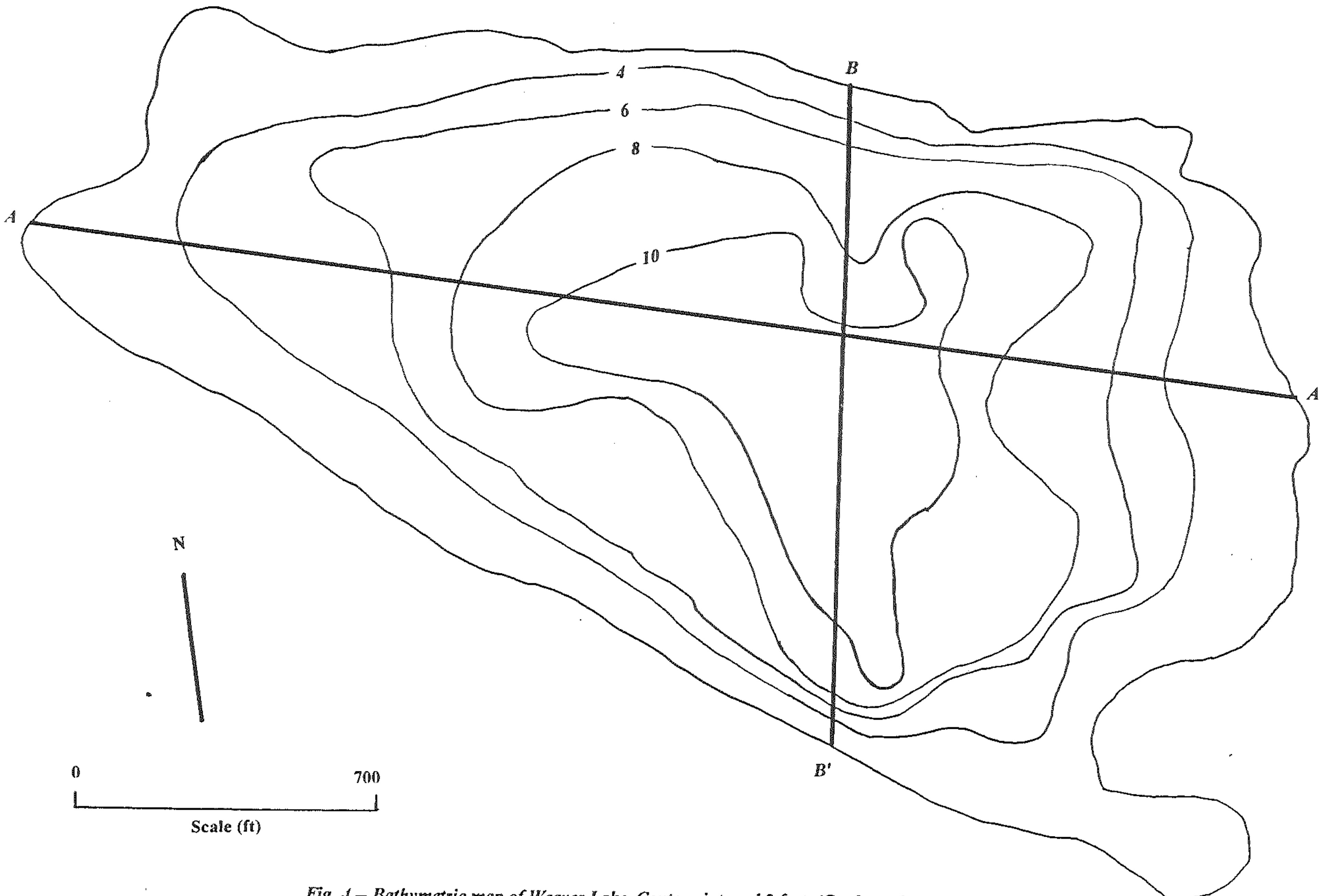
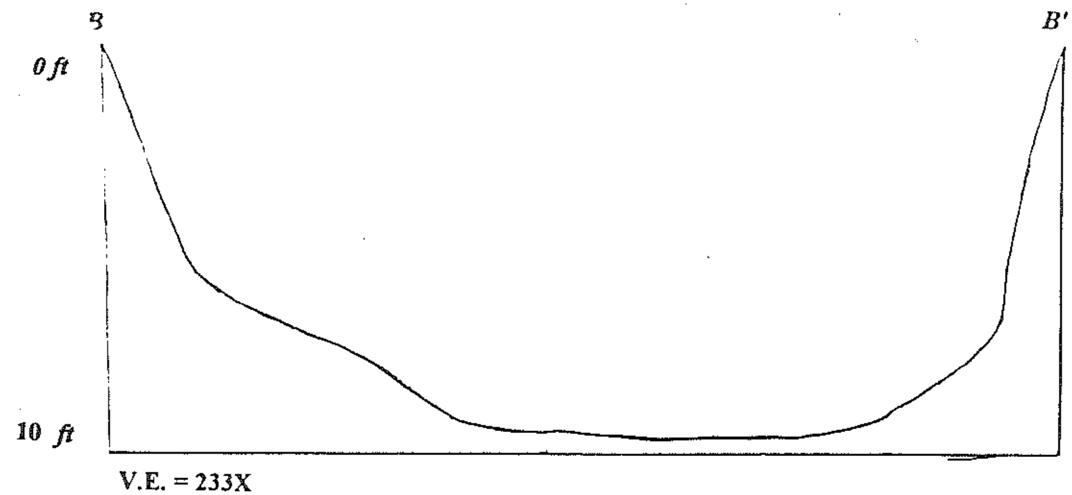



*Fig. 4 – Bathymetric map of Weaver Lake. Contour interval 2 feet. (Gardner, Graham, 1992)*




**Weaver Lake (9/13/92)**

| | |
|---|---|
| ZMean | 7.1 ft |
| ZMax | 11 ft |
| Area | $3.35 \times 10^6$ $ft^2$ |
| **Vol.** | $2.38 \times 10^7$ $ft^3$ |
| DO | 6.08-9.23 |
| Cond. | .288-.337 |
| Temp. (C) | 16.66°-18.98° |
| pH | 7.34-7.84 |

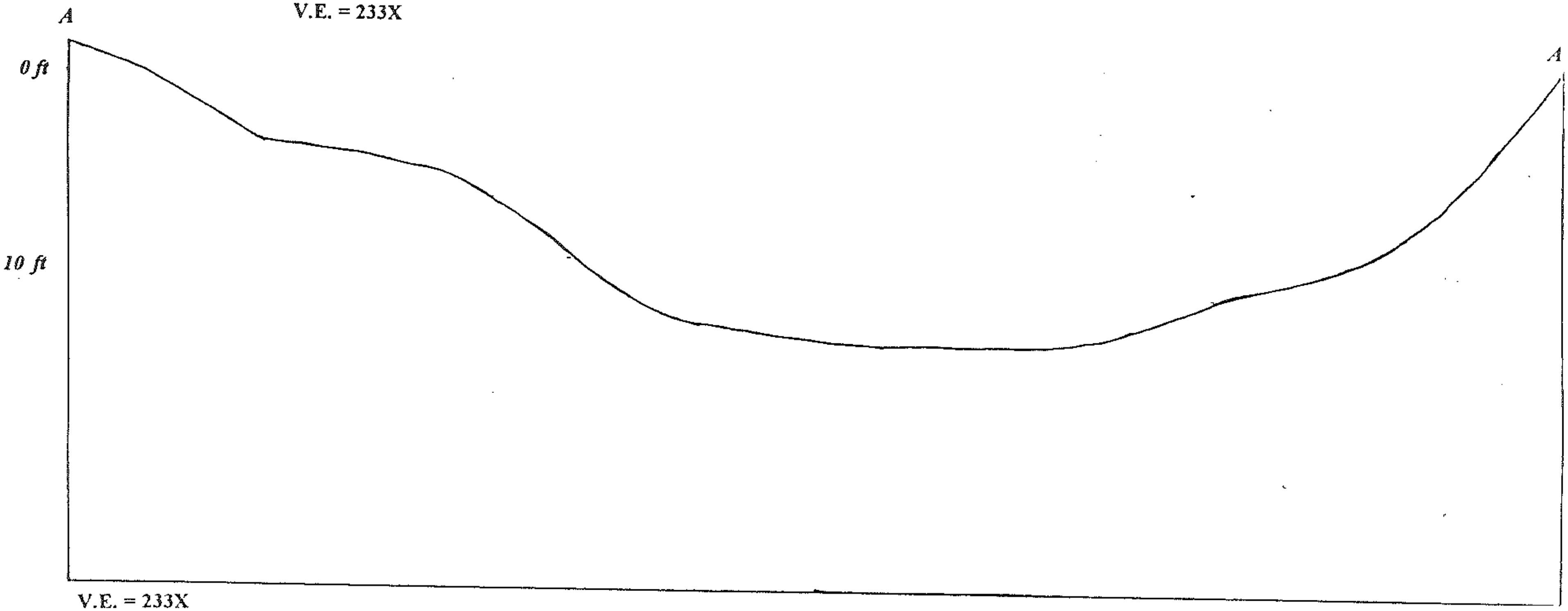



*Fig. 5 – Profiles of Weaver Lake.*

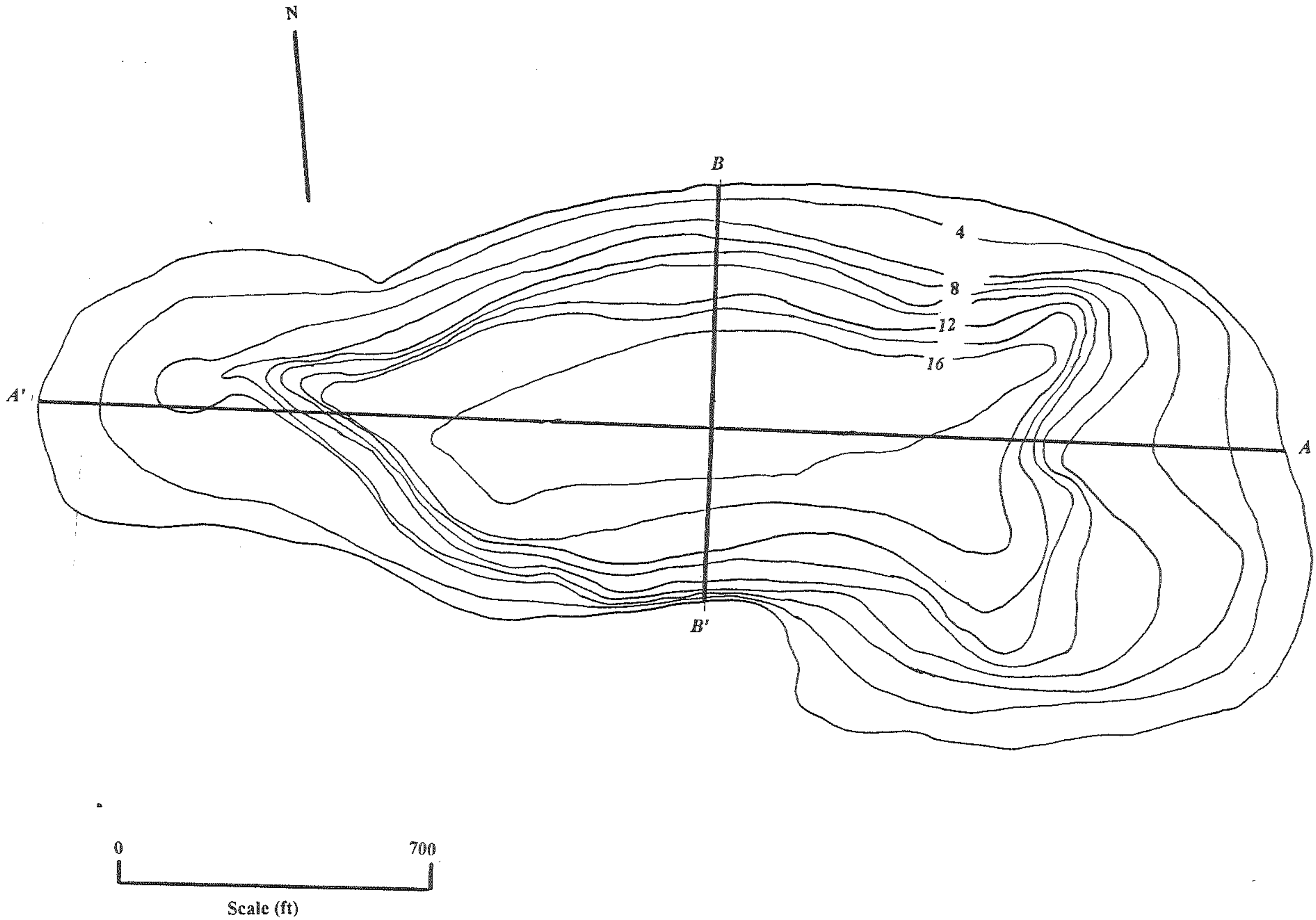
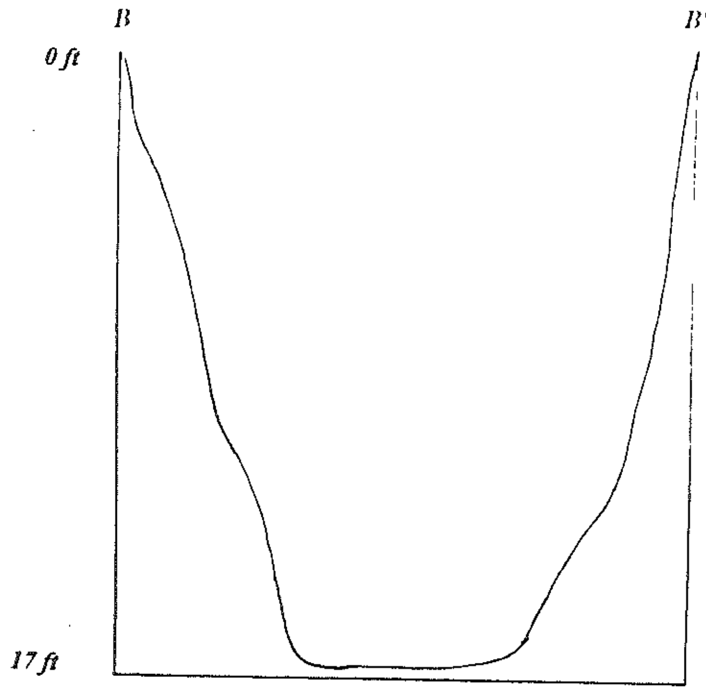



*Fig. 6 – Bathymetric map of Young Lake. Contour Interval 2 ft. (Gardner, Graham 1992).*

**Young Lake (10/7/92)**

| | |
|---|---|
| Zmean | 10.11 ft |
| Zmax | 17 ft |
| Area | $2.79 \times 10^5$ ft$^2$ |
| **Vol.** | $8.46 \times 10^6$ ft$^3$ |
| DO | 10.01 |
| Cond. | .278 |
| Temp (C) | 11.43°-12.90° |
| pH | 7.73 |



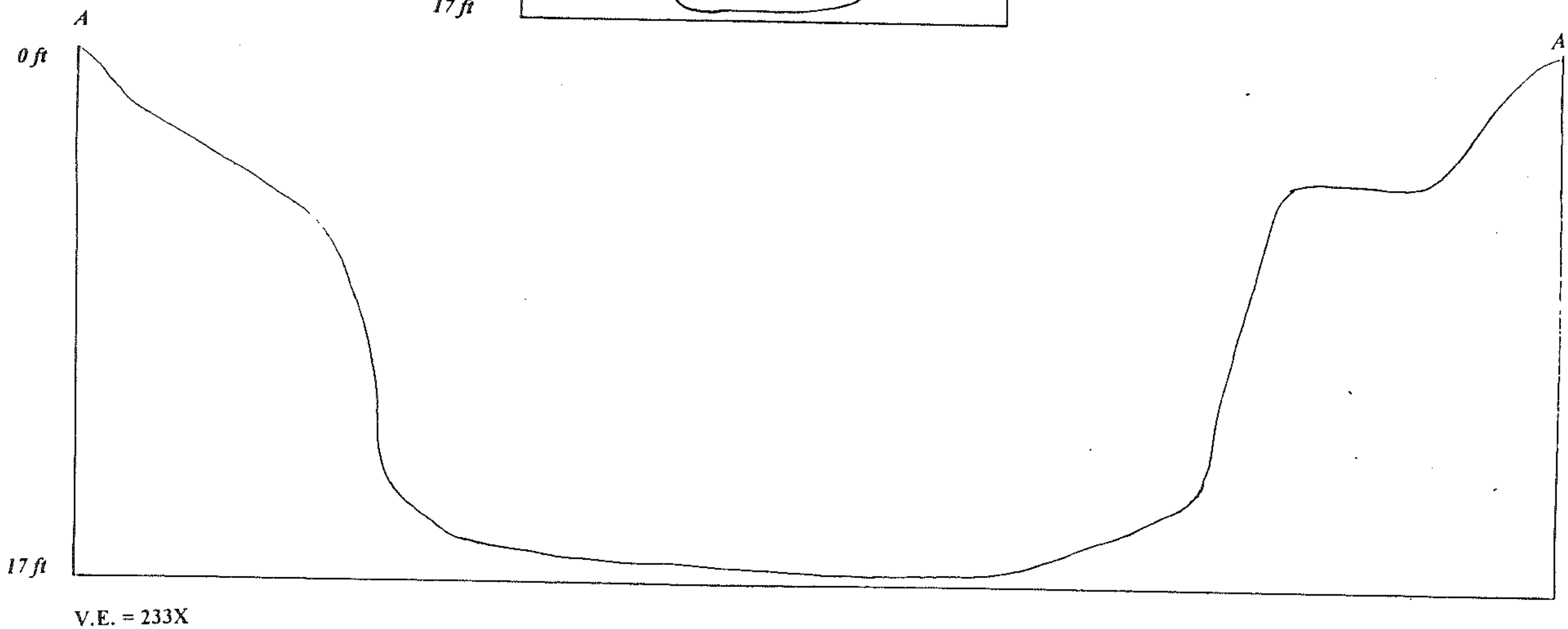




*Fig. 7 – Profiles of Young Lake.*

Calcium carbonate was found on aquatic plants laying near the shore line. This type of precipitation removes available carbon dioxide from the system. Additional $CO_2$ is absorbed by plants reducing the amount of carbonic acid available to dissolve the calcium carbonate again. Therefore, these benches of precipitates will remain.

Physical and chemical appearance of the lakes indicates that they fit the profile of a less productive, eutrophic lake (Table 1).

The thickness of the vegetation indicates that there are potentially high levels of nutrients available to the lakes. Streams flowing into Weaver Lake drain agricultural areas including tilled fields and barn yards. The streams would act as excellent transportation vehicles for dissolved nutrient loads.

The density of vegetation in Young Lake is much less than Weaver. This may be the result of reduced nutrient load entering Young Lake. These streams cross fallow fields and may not have access to high amounts of nutrients.

| **Factor** | **Eutrophic Productive** | **Eutrophic Less productive** |
|---|---|---|
| Nutrients | High supply rates and often high winter levels of all major and minor nutrients | Often high levels of nutrients year-round. |
| $O_2$ | Great variation from saturation. Depression in hypolimnion (0-100%) and mostly supersaturation in epilimnion. | Similar to oligotrophic. |
| Biota | High densities and yields of phytoplankton and zooplankton, zoobenthos and fish. | Similar to oligotrophic. |
| Light | Water not very transparent, light penetration relatively low, often not reaching thermocline or lake bed. Secchi depth .1-2m. | a. Water often cloudy; low light penetration due to peat fragments or humic acids or to suspended sediments.<br>b. Water clear but acid, pH <4. |
| Basin Shape and watershed | Lakes shallow with gently sloping sides. Often unstratified. Cultivated, disturbed, or naturally fertile watershed. WL ratio high. | Lakes usually small and shallow. Watershed with peat wetlands, coniferous forest or easily eroded soils. Acid rain or muddy inflows. WL ratio variable. |

*Table 1 -- Characteristics of productive and less productive eutrophic lakes. (After Goldman and Horne, 1983)*

The ability of light to penetrate the water is limited by the high amount of suspended material (peat?) in the water. An additional factor which indicates that these lakes are eutrophic is their basin morphology. These are shallow lakes with small surface areas and a portion of their watersheds draining into the lakes enters from peat bogs.

Temperature-depth profiles (Fig. 8) indicate that there is no thermal stratification in these lakes. Temperature variations are very small from the surface to the bottom in either lake and therefore don't fit a stratified lake profile. Temperature changes in lakes indicate changes in density of the water. These density changes result in thermal layering of the water. Mixing seems to occur from top to bottom indicating that these lakes are holomictic.

## ORIGIN OF WEAVER AND YOUNG LAKES

Using geochemical and bathymetric data collected and mechanisms proposed for the development of other basins in the area, two hypothesis for the origin of these lakes: glacial plucking; and sinkhole development.[1]

### Option 1 -- Stagnant-Ice Basins vs Dead-Ice Sinks

Similar to dead-ice sinks hypothesized by Fleisher (1986), the stagnant-ice basins at the head of this through valley are associated with different landform assemblages and method of formation. Dead-ice sinks and moats are areas of stagnant ice deposition during glacier retreat.

Sinks are developed from the melting of buried or partially buried ice-masses detached from the ice margin during retreat. Burial of this stagnant ice insulates it and causes it to melt at a slower rate than exposed ice, leaving a closed depression once it has melted.

This mode of development is exactly like kettle development but on a significantly larger scale. Ice blocks involved in this type of sink development may be thousands of meters across, extending from one valley wall to another, and 100 meters deep. Other differences between kettles and dead-ice sinks include: sinks are part of the flood plain and not restricted to higher stratified drift surfaces; and these are sites of continuous sedimentation by through-flowing meltwater and post-glacial streams.

Topographically, dead-ice sinks are recognized by their characteristic landform assemblages. Extremely broad flood plains bounded up valley and down by outwash terraces or eroded valley-train deposits are one indication of stagnant ice. Secondly, sinks can be separated by several different landforms -- eskers, kame terraces, low relief outwash, valley-train deposits, and outwash terraces.

The potential for a dead-ice sink method of development is limited because of several factors. Geographically, Young and Weaver Lakes are situated in essentially lowrelief terrain at the head of a through valley, rather than within the confines of a valley.

Although the lakes are located topographically in broad flood-plain-like areas, the lake basins are neither bound up-valley or down by landforms typically associated with dead-ice sinks. The two most favorable topographic settings for dead-ice sinks are preglacially incised, tight valley meanders and valleys oriented parallel with the ice margin.

The Young and Weaver Lake stagnant-ice basins differ from dead-ice in both formation and associated landforms.

Initial formation of the basins possibly began as a sublobe of the Mohawk Lobe advanced southward toward and what is now Otsego Lake. Subglacial plucking occurred when ice and meltwater were in contact with jointed bedrock. For plucking to occur, meltwater penetrates joints and

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1These are initial interpretations of data collected. Additional field work will need to be completed to confirm or disprove these options.

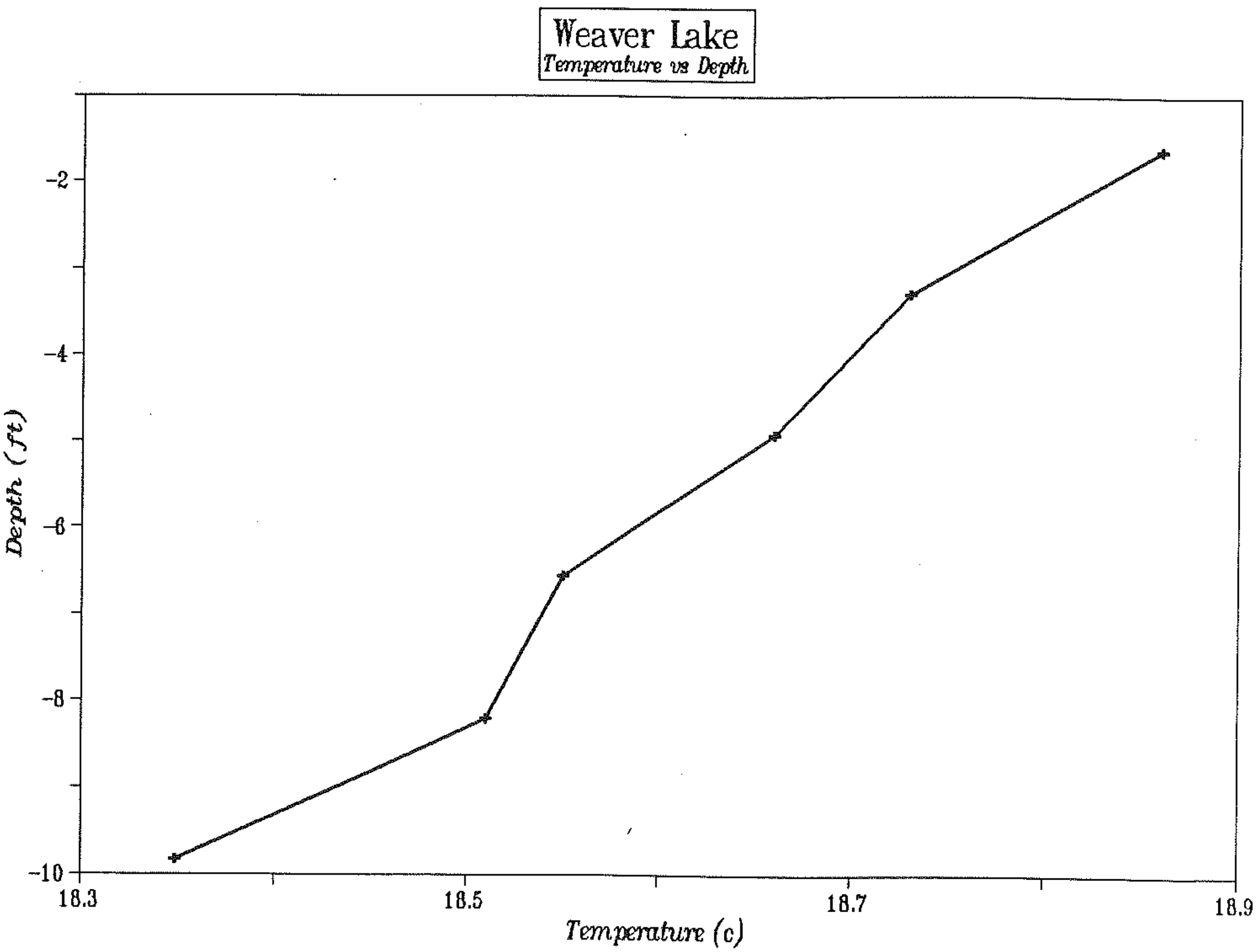



*Fig. 8a -- Temperature vs depth profiles for Weaver Lake.*

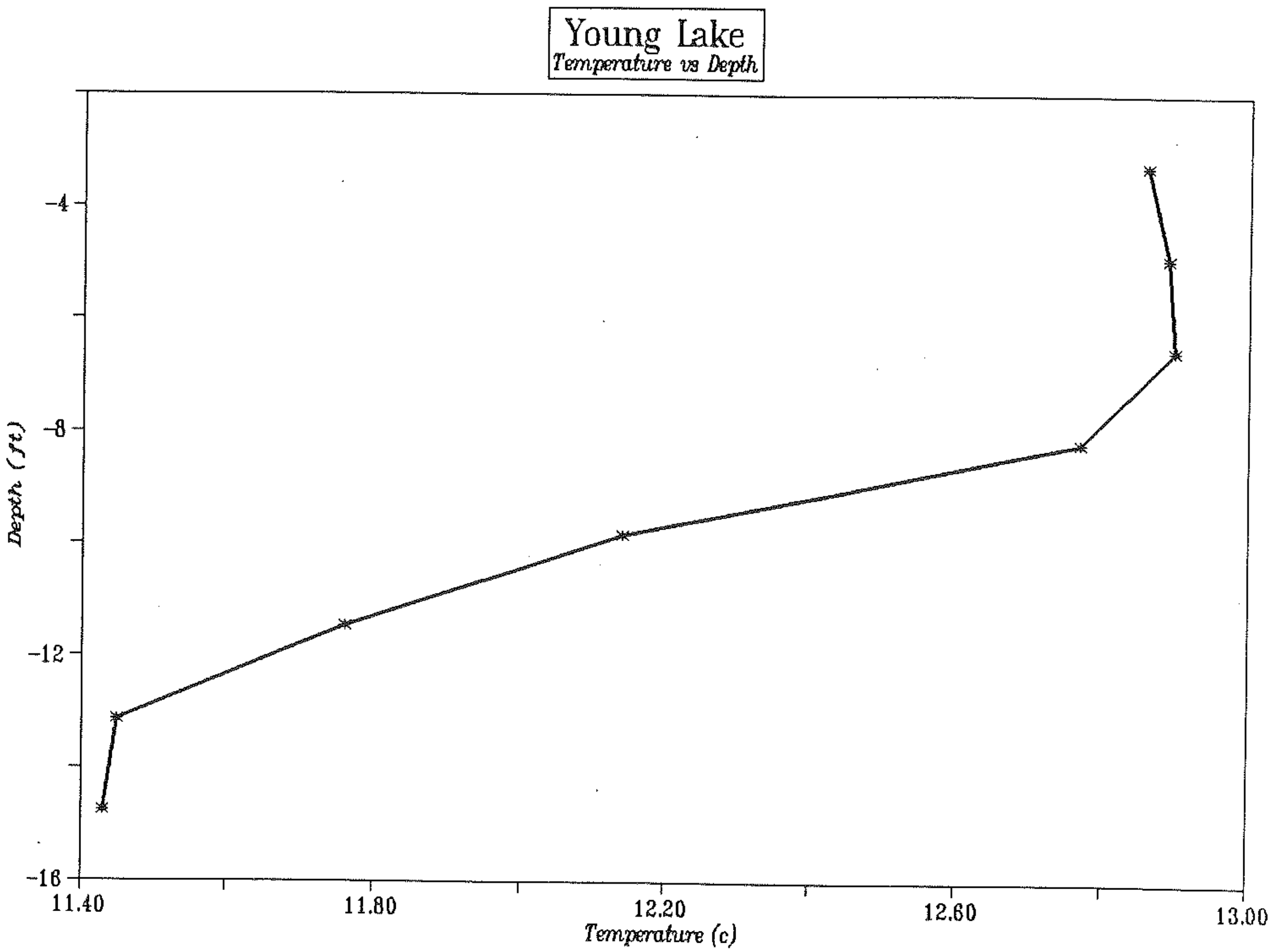
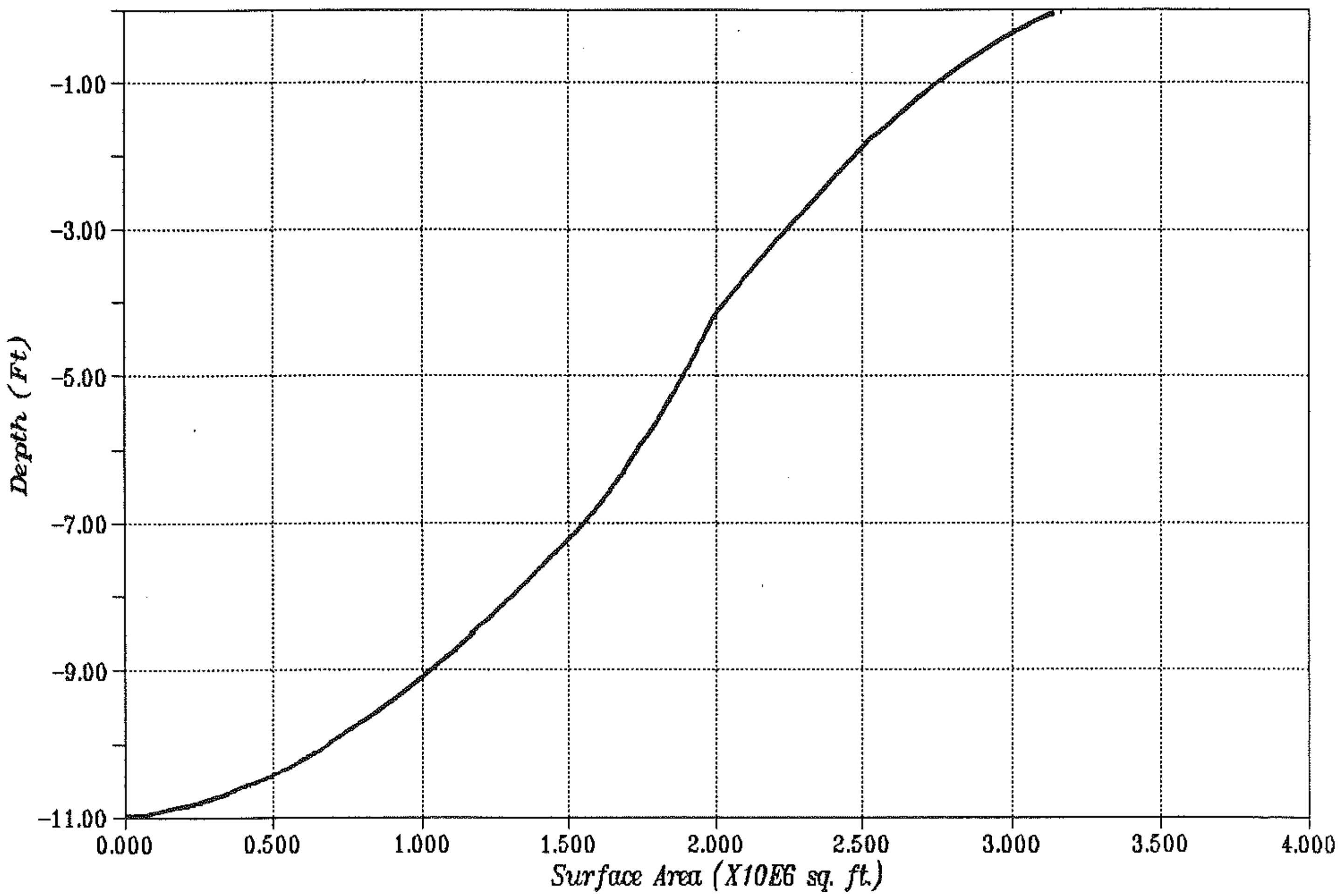
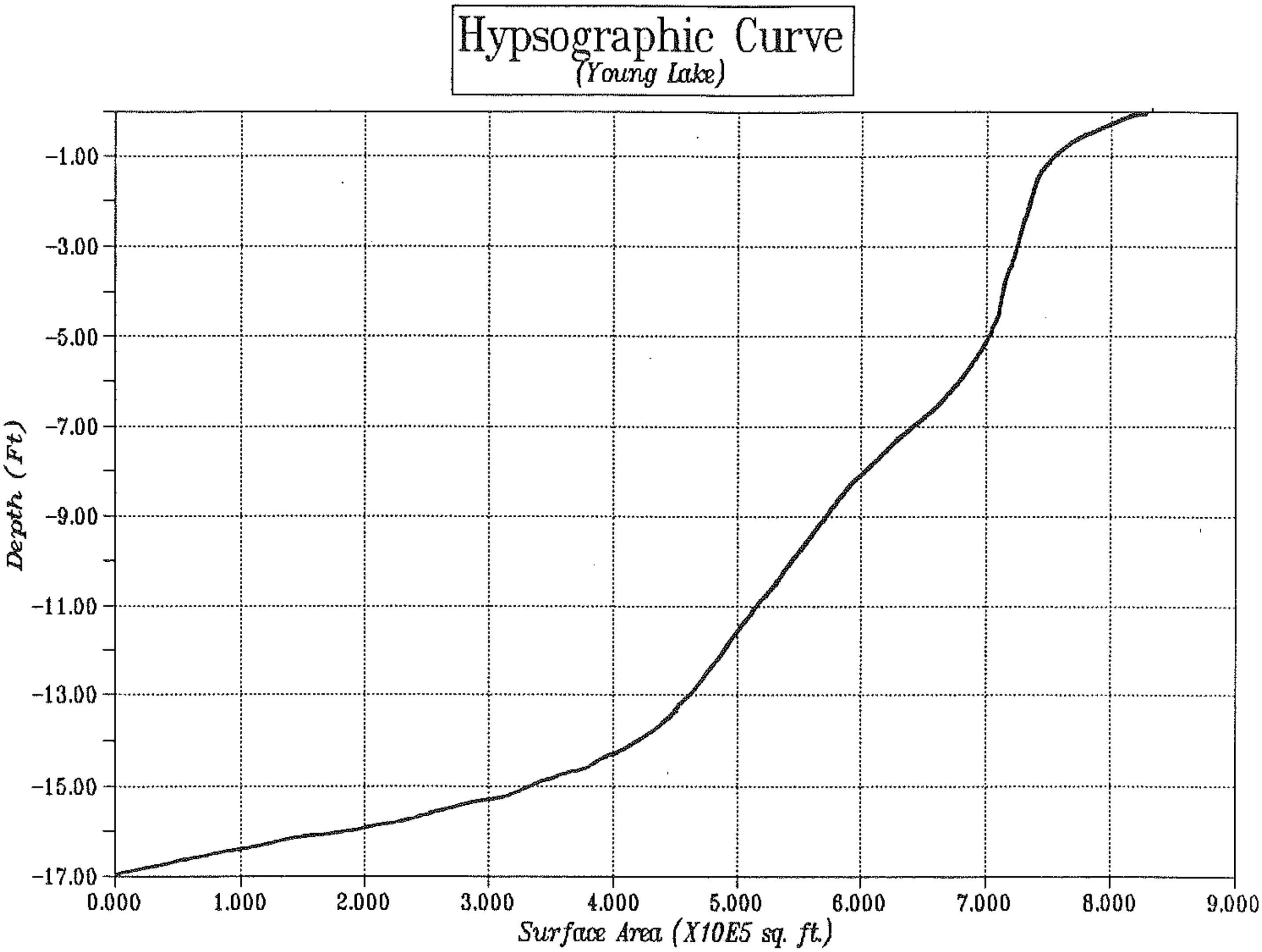



*Fig. 8b -- Temperature vs depth profiles for Young Lake.*

# Hypsographic Curve
*(Weaver Lake)*





Hypsographic Curve
(Young Lake)
-1.00
-3.00
-5.00
-7.00
-9.00
-11.00
-13.00
-15.00
-17.00
Depth (Ft)
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
9.000
Surface Area (X10E5 sq. ft.)

freezes. The expansion of the ice separates the rock from its surroundings and it becomes part of the glacial bedload. This is the process suggested for the modification of the Susquehanna River and the deepest portions of the Otsego Lake basin. The uniform, narrow and steep bottom morphology of both Young and Weaver Lakes suggest this type of development (Shoemaker, 1986).

As the ice advanced through this area, basal ice remained in contact with the rock in the plucked basins. Upon retreat, large ice blocks remained anchored in these basins, cut off from sources of meltwater and sedimentation (Fig. 1). Stagnation occurred as the ice margin retreated north of the Mohawk Valley divide. Being in the head of a through valley, and near the escarpment (less than five miles), ice in this area acted similar to ice in the upper reaches of a non-through valley (Fig. 9). The lack of sedimentation, or high enough volume of sediment (leaving some portions of the ice exposed), during this period reduced the amount of insulation normally provided by overlying sediments. This lack of insulation may have been somewhat subdued by the position of these lakes on the northern face of the Otsego-Canadarago Lake divide, causing a lack of melting from direct sunlight.

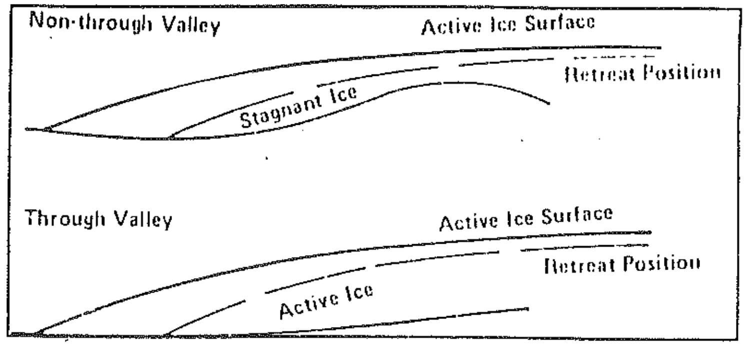



*Fig. 9 -- Ice in this region stagnated in the same manner as ice in the upper reaches of a non-through valley because of the close proximity of the Onondaga-Helderberg escarpment (Fleisher, 1986).*

During the advance of the Mohawk Lobe, a large amount of sediment was deposited in the till shadow south of the escarpment. This sediment was formed into drumlins as the ice advanced through the area. Ice in contact with the bedrock in the basins prevented sedimentation in these areas, creating rock-basin lakes after retreat.

Sediment in dead-ice sinks is typically extremely thick. Well logs in the thick glacial cover have casing depths up to 100 feet (Randall, 1972) and local well drillers have indicated depths exceeding 200 feet (verbal communication D. Bosc 1992). Shallow seismic work in the area of the basins would indicate accurate thicknesses of the sediments in the area.

<u>Option 2 -- Karst Mechanisms</u>

Karst features in this area are subtle with few exceptions. Sinkholes, swallow holes and springs are the primary medium-scale expressions of the solution of the underlying limestones. Regionally, small-scale features include solutionally widened joints which form the upper reaches of the epikarstic zone. Although many sink holes are found in the area, the majority are formed in the Helderberg Group limestones, stratigraphically down from the Onondaga. Karst development in the Onondaga is limited by chert beds which control the movement of ground water.

There may be input into the lakes through springs. Because of the shallowness of the lakes, this would be indicated by bottom water temperatures from 8 to 10 degrees Celsius. This was not indicated in either lake (Fig. 8). Karst systems haven't been a significant factor in the development of these lakes, either as sinkholes or large springs.

## PHYSICAL CHEMISTRY OF WEAVER LAKE

Aqueous geochemical analysis of Weaver Lake was completed using a Van Dom sampler and a Hydrolab, Surveyor II, to measure pH, temperature, dissolved oxygen, depth and conductivity.

Samples were titrated for calcium and magnesium. The molar concentrations were then input into the Saturation Indices program (Palmer, 1987). This program calculates saturation indices using log (IAP/K); where IAP is the ion activity product and k is the solubility product constant. A value greater than zero indicates supersaturation, values equal to zero indicate saturation, and values less than zero indicate undersaturation with respect to a given ion. Table 2 illustrates the results of this chemical analysis.

| Sample | $PCO_2$ (atm) | SI calcite | SI aragonite | SI dolomite |
|---|---|---|---|---|
| Site 1 | .0081 | -0.13 | -0.28 | -0.58 |
| Site 2 | .0036 | +0.35 | +0.20 | +0.07 |
| Site 3 | .0027 | +0.38 | +0.23 | -0.15 |
| Site 4 | .0030 | +0.32 | +0.17 | -0.27 |
| Site 5 | .0027 | +0.45 | +0.30 | -0.13 |
| Site 6s | .0054 | +0.07 | -0.08 | -0.66 |
| Site 6b | .0045 | +0.16 | +0.01 | -0.51 |
| Site 7 | .0032 | +0.31 | +0.16 | -0.32 |
| Site 8 | .0027 | +0.38 | +0.23 | -0.29 |
| Site 9 | .0070 | -0.02 | -0.17 | -0.70 |
| Site 10 | .0055 | +0.03 | -0.12 | -1.07 |
| Site 11 | .0036 | +0.26 | +0.11 | -0.48 |

*Table 2 -- Calculated values for the saturation indices of calcite, aragonite and dolomite in Weaver Lake. This chart also indicates the partial pressures of carbon dioxide in each of the samples. (S and B indicate surface and bottom samples).*

Many of the samples were supersaturated with calcium ions. This is not unusual in surface water in carbonate terrains. An additional factor in this area are the alkaline sediments. Sediments in the area have a high concentration of calcium carbonate which can be dissolved by carbonic acid in surface and ground water.

High carbon dioxide partial pressure values also indicate the presence of large amounts of available carbon dioxide to form carbonic acid and dissolve calcium carbonate.

Temperature is the most important limiting factor in the amount of oxygen and carbon dioxide available. Other factors include photosynthesis, respiration of organisms, aeration of water, the presence of other gases and any chemical oxidations that may occur (Goldman and Horne, 1983).

## CONCLUSIONS

Formations of these lakes is the result of blocks of stagnant ice anchored in plucked bedrock basins. Sedimentation and landform development primarily occurred during the advance of the ice through this area, forming drumlins (the dominant glacial landform in the area). The position of the ice in the basins prohibited the deposition of sediments within them. Deposition of sediments in the basins was prohibited because of the presence of the ice. The ice then stagnated and was cut off from meltwater and sediment sources, leaving large, open basins as it melted.

The method of development for dead-ice sinks, at least in the large sense, doesn't seem to fit the geographic and topographic location or the type of glacial landforms in the area. This may be the result of the low-relief in the area which may affect the type of landforms deposited. This is in part indicated by the lack of in-valley glacial landforms in the area.

Initial physical interpretation of these lakes is that they are well-mixed, less productive eutrophic lakes, that are glacial in origin rather than having a karst form of development. Young and Weaver Lakes also seem to be reaching an end point in their succession. The size of the lakes is being reduced by encroaching vegetation and precipitation of calcareous deposits.

There are many areas of possible geologic study available in this region. An application of geophysics, particularly gravity and seismic work, plus a concentration of well-log data would help to prove or disprove the origin of these lakes. Seismic and gravity work on the drumlins in the area could indicate whether they are rock cored or molded glacial sediments.

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