GEOLOGICAL SURVEY OF CANADA

PAPER 68-67

GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF ENERGY,
MINES AND RESOURCES

PLEISTOCENE GEOLOGY OF THE BURIED ST. DAVIDS GORGE, NIAGARA FALLS, ONTARIO: GEOPHYSICAL AND PALYNOLOGICAL STUDIES

(Report and 12 figures)

George D. Hobson and J. Terasmae

Price, $1.50

Indexed 10/2/69 MF

1969

GEOLOGICAL SURVEY
OF CANADA

PAPER 68-67

PLEISTOCENE GEOLOGY OF THE BURIED ST. DAVIDS GORGE, NIAGARA FALLS, ONTARIO: GEOPHYSICAL AND PALYNOLOGICAL STUDIES

George D. Hobson and J. Terasmae

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Available by mail from the Queen's Printer, Ottawa,

from Geological Survey of Canada,
601 Booth St., Ottawa,

and at the following Canadian Government bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
Æterna-Vie Building, 1182 St. Catherine St. West

OTTAWA
Daly Building, Corner Mackenzie and Rideau

TORONTO
221 Yonge Street

WINNIPEG
Mall Center Bldg., 499 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $1.50 Catalogue No. M44-68-67

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1969

CONTENTS

Illustrations

ABSTRACT

A stratigraphic drilling project was undertaken in the 1965-66 winter season, following geophysical studies designed to determine the location, width and depth of the buried ancient Niagara River valley leading from the 'whirlpool' of the present river to St. Davids and thence north towards Lake Ontario. J. W. W. Spencer in 1905 delineated a buried channel in the bedrock from the 'whirlpool' to St. Davids.

The geophysical studies consisted of a refraction seismic survey utilizing a portable hammer seismograph and delineated a bedrock depression extending northwestward from the Whirlpool Rapids to the St. Davids Gorge and northward below the Niagara escarpment to a point east of Virgil where the channel appears to bifurcate with one branch extending northward to Lake Ontario and the other northeasterly to the Niagara River. Depths below surface in excess of 150 feet have been calculated resulting in a channel approximately one mile wide incised into bedrock to a depth of about 80 feet. Subsequent drilling has verified the seismic picture.

No fossiliferous beds were found in the boreholes between St. Davids and Lake Ontario below the Niagara escarpment. In the St. Davids Gorge, however, borehole 5 revealed the presence of pollen and plant macrofossils in silt, clay and sand at a depth of 106-183 feet from surface. These beds are both overlain and underlain by glacial deposits. Wood from the 150-foot level was dated at 22,800 ± 450 years before present (GSC-816). Pollen assemblages in samples taken from the 80-foot sequence of nonglacial beds were dominated by spruce (Picea) and pine (Pinus banksiana) with small numbers of fir (Abies), birch (Betula) and several different types of non-tree pollen (including f. ex. Artemisia, Ambrosia, and Chenopodiaceae). Spores and ferns, fungi, and Selaginella were found in some samples and pre-Pleistocene spores were present frequently. Moss leaves, fragments of bark, leaf cuticle and conifer needles, and twigs indicate presence of local vegetation. Cold climatic conditions are inferred from the palynological evidence and a late mid-Wisconsin age has been assigned to the nonglacial beds. The St. Davids Gorge was cut either during the last interglacial (Sangamon) interval, or earlier.

PLEISTOCENE GEOLOGY OF THE BURIED ST. DAVIDS GORGE NIAGARA FALLS, ONTARIO: GEOPHYSICAL AND PALYNOLOGICAL STUDIES

INTRODUCTION

A seismic survey was undertaken to determine overburden thickness and thus directly the bedrock topography in an area north from the Whirlpool Rapids on the Niagara River to Lake Ontario. The purpose of the survey was to test the theory put forth by Spencer (1907) that a buried bedrock channel exists in the area. Such a channel has been found extending from the Whirlpool Rapids northwestward to the St. Davids Gorge and northward below the Niagara escarpment to a point east of Virgil where the channel appears to bifurcate with one branch extending northward to Lake Ontario and the other northeasterly to the Niagara River.

Lyell (1845) considered this buried channel to be the course of a preglacial Niagara River. Some years later, about 1881, Spencer suggested that "The Saint David Valley represents only the water course or water courses of local drainage before the ice age". His lengthy report and treatise of 1905-06 on the Falls of Niagara sets out his investigations and conclusions that the buried channel is interglacial rather than preglacial.

Acknowledgments

The authors are indebted to Mr. O. E. Johnston of the Hydro-Electric Power Commission of Ontario for his co-operation in facilitating access to the drilling sites near Whirlpool and his personal interest in the project, to Mr. Harold Robinson, driller with the Testing Laboratories of the Public Works Department, Ottawa, who contributed generously from his extensive experience towards obtaining satisfactory samples for this study, and to Mr. R. J. Mott, Geological Survey of Canada, who assisted with palynological analyses.

GEOLOGICAL SETTING

The bedrock geology of the area has been mapped by Caley (1940). The Niagara River at the Whirlpool cuts through the Silurian Lockport Formation, a light grey dolomite, exposing the Rochester, Clinton and Medina formations. Below the Niagara escarpment at the hamlet of St. Davids the

Project 640439
Manuscript received: November 19, 1968.

dolomite is completely absent whereas about three miles farther north, the Medina (also known as Queenston) Formation, at the top of the Ordovician, predominates and extends northward under Lake Ontario. The Queenston Formation is a brick red, thinly bedded, sandy and argillaceous shale. It underlies the Whirlpool sandstone which is basal Silurian in age. The red shales and infrequent sandstones of the Queenston Formation influence the surface soil colour near St. Davids.

The soil surveys of the area have been completed by the Federal and Provincial departments of Agriculture and the Pleistocene mapping program is underway at the time of writing.

THE SEISMIC SURVEY

The seismic survey consisted of single-ended refraction profiles at 97 locations carried out mainly along east-west trending roads with the intention that such a survey would yield cross-sections defining the buried channel. A portable hammer refraction seismograph, a Huntec Model FS-2, was used to record all seismic data. Seismic energy was generated by striking a 16-pound sledge hammer against a steel plate on the ground. In general, good data were obtained. Seismic locations and drillholes are shown in Figure 1.

Figure 2 is a histogram of all seismic velocities observed versus frequency of occurrence. These velocities are as observed and are uncorrected for dip because reversed seismic profiles were not surveyed. Good velocity contrasts are obvious as there are four distinct peaks on the histogram. The first peak is associated with the thin surficial layer of soil whereas the second and third are associated with the more compacted gravels, clays and glacial tills that generally cover the project area and infill the bedrock channel. Bedrock is identified with a velocity in excess of 10,000 feet per second and is an interbedded sequence of sandstones and shales, one or other of which may be bedrock under the project area.

THE DRILLING PROGRAM

Nine holes were drilled to bedrock at the completion of the seismic survey thus better defining the buried channel and supplying Pleistocene and fossil materials for examination.

PALYNOLOGICAL STUDIES

Samples for palynological studies were taken from the silt, clay and sand A-B (106-183 feet) as indicated in the drill log for borehole number 5 (Fig. 3). These samples were prepared by the standard extraction methods using hydrochloric and hydrofluoric acid, followed by the acetolysis treatment. Results obtained have been compiled in Table 1.

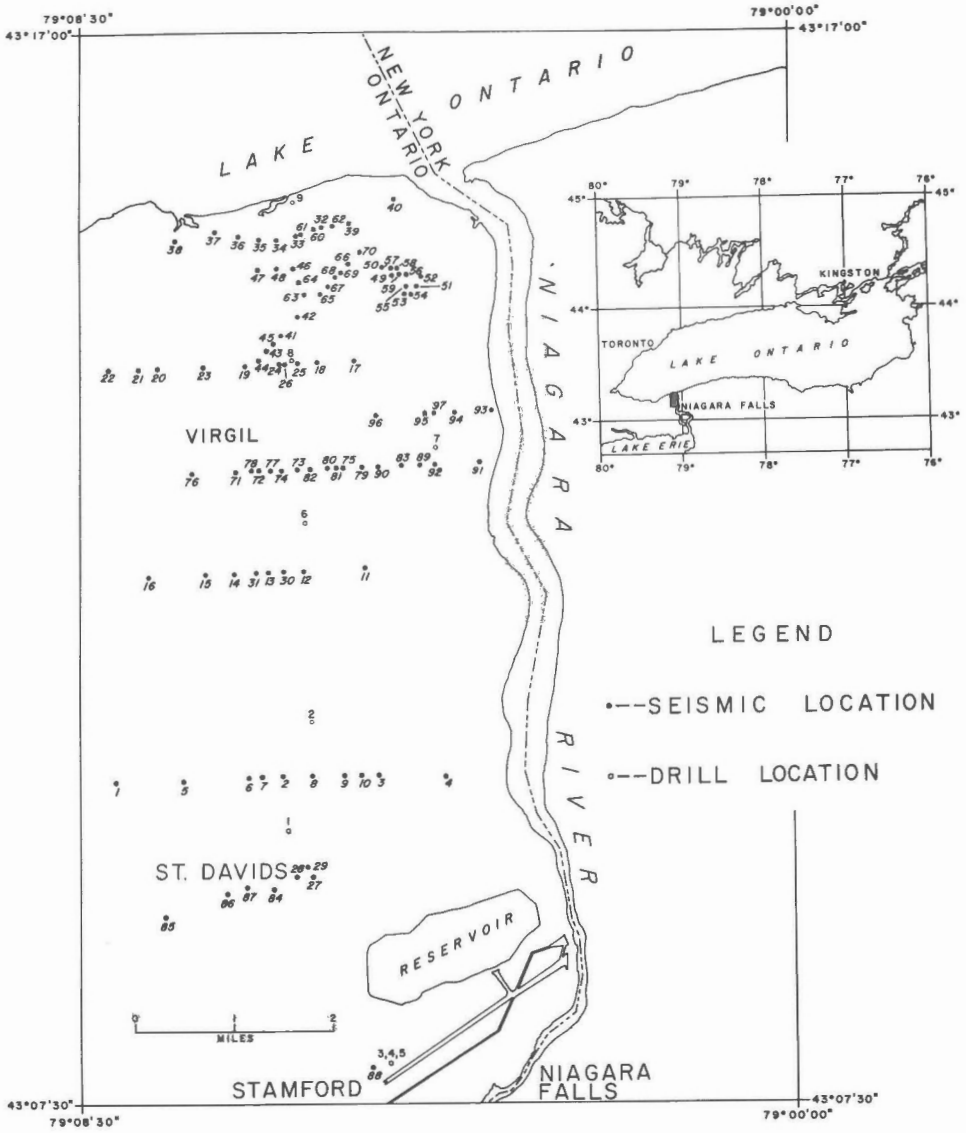

Figure 1. Whirlpool-St. Davids Gorge area.

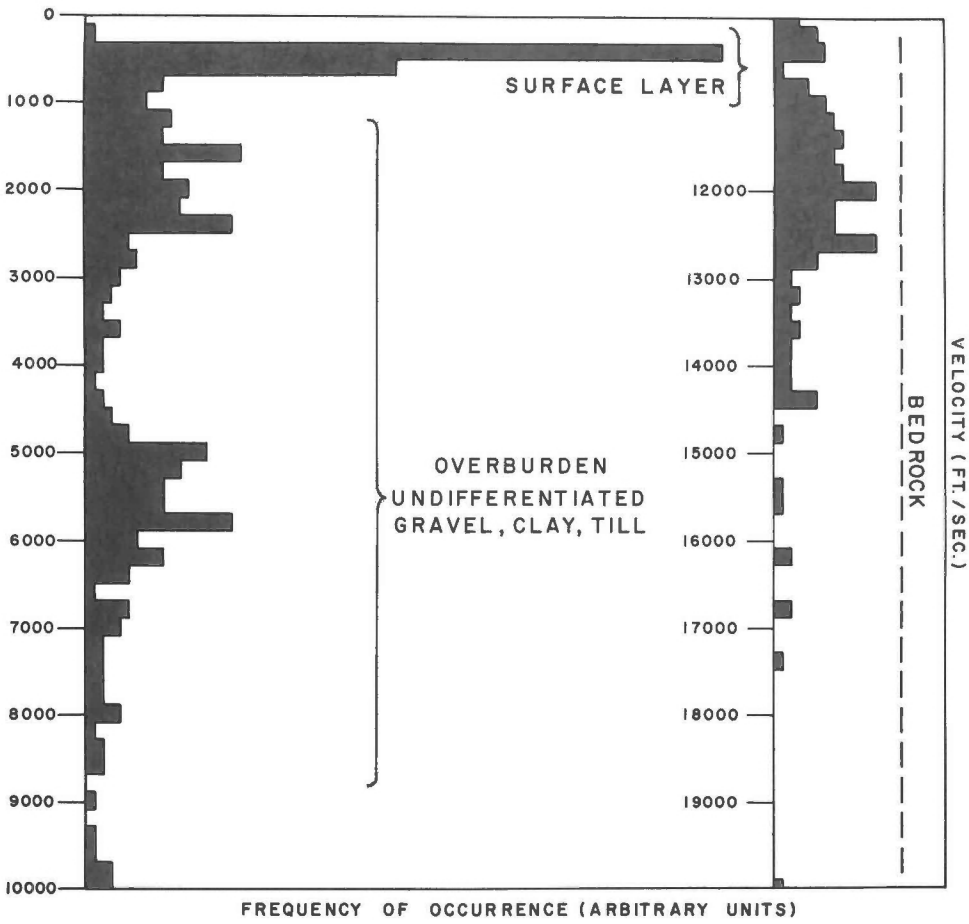

Figure 2. Histogram of boserved seismic velocities versus frequency of occurrence, Whirlpool-St. Davids Gorge area.

DRILL HOLE No.5

DETAILED DESCRIPTION	ELEVATION FEET	DEPTH FEET
CLAY	590	0
	588	12
SILT, SANDY	572	28
CLAY	567	33
SILT, SANDY	543	47
SANDY, GRAVELLY TILL	538	52
SILT, CLAYEY	532	58
SAND	520	70
CLAY	512	78
TILL WITH SAND, GRAVEL & COBBLES	496	94
GRAVEL & BOULDERS	484	106
A — POLLEN BEARING BEDS — SAND WITH SOME SILT & CLAY	452	138
SILTY SAND	445	145
CLAY WITH ORGANIC MATTER	441	149
SAND WITH TWIGS & WOOD	437	153
SAND FINE & MEDIUM	412	178
CLAY, SANDY		
B — SAND, FINE TO MEDIUM	407	183
GRAVEL, COBBLES, BOULDERS WITH LAYERS OF GLACIAL TILL	314	276
BEDROCK	305	285

RADIOCARBON DATE
22,800 ± 450 YEARS
(G.S.C. - 816)

DRILL HOLE No.8

DETAILED DESCRIPTION	ELEVATION FEET	DEPTH FEET
TILL (SOFT) WITH SAND & GRAVEL	290	0
	270	20
TILL (CLAYEY)	265	25
TILL SANDY, GRAVELLY	255	35
SAND, GRAVEL IN A CLAY MATRIX	252	38
SILTY SAND, GRAVEL & COBBLES	247	43
SAND, GRAVEL & COBBLES IN A CLAYEY MATRIX	238	52
TILL(?) GRAVEL & COBBLES (SILTY)	229	61
RED SHALE	219	71

Figure 3. Generalized drill logs, boreholes No. 5 and 8.

TABLE 1 Pollen assemblages from interstadial beds in the buried St. Davids Gorge. Numbers in brackets are relative percentages based on total tree pollen; otherwise the numbers of different pollen types counted in a sample are shown.

Sample number	83	85	87	89	91	93
Depth in feet	116	130	145	150	152	160
Tree pollen						
Spruce (Picea)	(39)	15	(25.5)	9	12	10
Pine (Pinus banksiana)	(50)	28	(65)	18	36	17
(Pinus sp.)	(6.5)	3	(3)	1	5	3
Fir (Abies)	(2)	-	(1)	1	-	-
Hemlock (Tsuga)	-	-	-	2	-	-
Birch (Betula)	(2.5)	6	(2)	2	2	2
Oak (Quercus)	-	1	(1.5)	-	-	-
Hickory (Carya)	-	1	(2)	-	3	1
Elm (Ulmus)	-	3	-	1	5	3
Non-tree pollen						
Artemisia	(0.6)	2	(1.5)	1	1	-
Ambrosia	(0.6)	8	(0.5)	1	8	7
Compositae	-	3	-	2	3	2
Gramineae	-	4	-	2	2	3
Cyperaceae	-	3	(0.5)	-	-	-
Ericaceae	-	-	-	-	1	-
Chenopodiaceae	-	-	-	2	1	-
Shepherdia canadensis	-	-	(0.5)	-	-	-
Unidentified	-	2	(1.5)	-	1	3
Spores						
Selaginella	-	-	(0.5)	-	-	-
Polypodiaceae	(0.6)	2	(2)	-	2	3
Sphagnum	-	-	-	-	-	1

Most samples of the fine-grained inorganic deposits contained pollen, although only in a few was pollen abundant enough to warrant calculating the relative percentages of the different pollen types. This was done when the number of tree pollen counted in a preparation exceeded 200.

The occurrence of pre-Pleistocene spores in most preparations was noted but no attempts have been made yet to determine their age more precisely or to locate the probable source of these spores.

The preservation of Pleistocene pollen commonly ranged from good to fair, and poorly preserved pollen grains were noted occasionally.

The nature of the deposits studied indicates the probable presence of redeposited pollen. However, experience gained from studies of similar sediments at other localities in southern Ontario suggests that the general characteristics of the primary pollen assemblages are still sufficiently well displayed and allow meaningful interpretation.

Taken collectively, all pollen assemblages obtained from the stratigraphic unit A-B (Fig. 3) are dominated by spruce (Picea) and pine (probably jack pine, Pinus banksiana), with small amounts of fir (Abies) and birch (Betula). The occasional pollen grains of hardwood species, e.g. oak (Quercus), elm (Ulmus), hickory (Carya), are attributed to either long-distance wind transport or possibly redeposition from older, interglacial beds. The relative abundance of tree pollen indicates that forested conditions prevailed near the site of deposition, and the presence of certain non-tree pollen types (including Artemisia, Ambrosia, Gramineae, Cyperaceae, Chenopodiaceae, and Shepherdia canadensis) permits the further conclusion that climatic conditions at that time were much colder than those presently obtaining in southern Ontario. The nonglacial interval during which the beds of unit A-B were deposited is given an interstadial rank because of the characteristic pollen assemblages extracted from it.

These assemblages are rather similar in many respects to those found in sediments of the Port Talbot Interstade (or the Plum Point interval) in southwestern Ontario (Dreimanis et al., 1966). This suggested palynological correlation is supported by the radiocarbon age of 22, 800 ± 450 years (GSC-816) obtained for a sample of wood detritus from the unit A-B (Fig. 3) in borehole No. 5.

On the basis of this correlation, and the stratigraphy of Pleistocene deposits in the buried St. Davids Gorge, it is concluded that this gorge was cut during the last interglacial interval (Sangamon) or earlier. On the other hand, one might argue against a pre-Pleistocene age for this gorge because it does not seem to join the system of preglacial valleys known to exist in southern Ontario. Furthermore, such valleys adjacent to the Lake Ontario Basin appear to be cut to a base-level which is lower than the present sea level, as indicated by available borehole data.

THE BURIED CHANNEL

Surface Indications

There are several surface indications of the buried channel at its southern extremity. The most obvious, of course, is the Whirlpool itself which was postulated as the entrance to a preglacial channel by Sir Charles Lyell as early as 1841. The extensive gravel pit near Whirlpool is in the channel, the surrounding country rock being dolomite (Lockport) of the type quarried in the nearby Queenston Quarries. There is also a very obvious slash in the Niagara escarpment at St. Davids due to the buried channel; the coarse infilling materials of the channel can be observed at this location.

North of St. Davids on the flats below the escarpment, the channel may be located by careful observation of the soil colour and type along the east-west roads. East and west of the channel, the surface soils are red and contain a large number of small pebbles. Over the channel the soil loses its red colour, the pebbles and stones are brown and in general, it is better soil for agriculture.

This suggests the use of colour air photography as a preliminary reconnaissance tool over such an area. The red soil is caused by the proximity to the surface of the red Medina shales in the area below and north of the escarpment. Farther north towards Lake Ontario such indications are slight, if present at all, probably because the overburden becomes thicker and the bedrock changes to the Queenston Formation thus making the effect of the red shales less evident. Differences in soil colour are difficult to observe on the ground but photography from the air may point up dissimilarities in soil conditions that may be useful to locate such a channel as is here described.

Specific Location of the Channel

Early drilling by the Hydro-Electric Power Commission accurately defined the channel for a distance of about 4,000 feet northwest from the Whirlpool. In this region it is only 1,000 feet wide. It then widens and bends slightly westerly where its location is determined by the gravel pits in the channel. From the gravel pits the channel extends across the Niagara escarpment at St. Davids; north of St. Davids the channel varies in width between one-half mile and one and one-half miles. It enters Lake Ontario about 1.5 miles west of the present outlet of the Niagara River after several gentle bends along its course.

The channel bifurcates at a point 3 1/4 miles south of Lake Ontario near Virgil with the east fork of the channel entering the Niagara River at a point which is indicated surficially by a shallow, narrow ravine. Well boring data have confirmed and more clearly defined the channel first defined by the seismic survey.

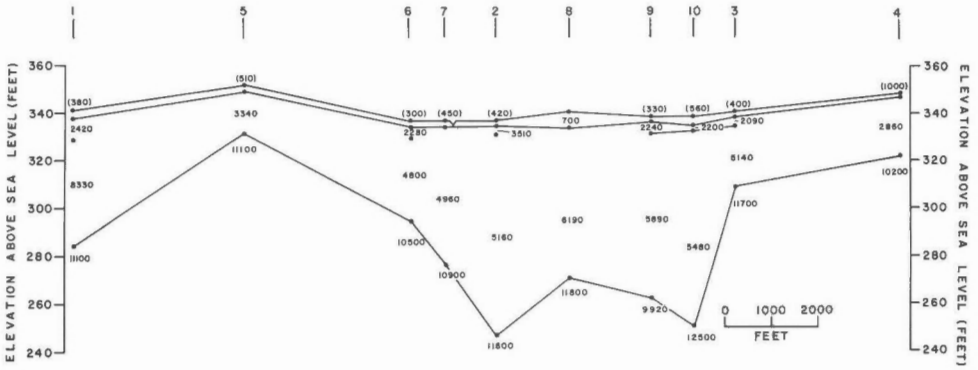

Figure 4. A cross-section, Whirlpool-St. Davids area.

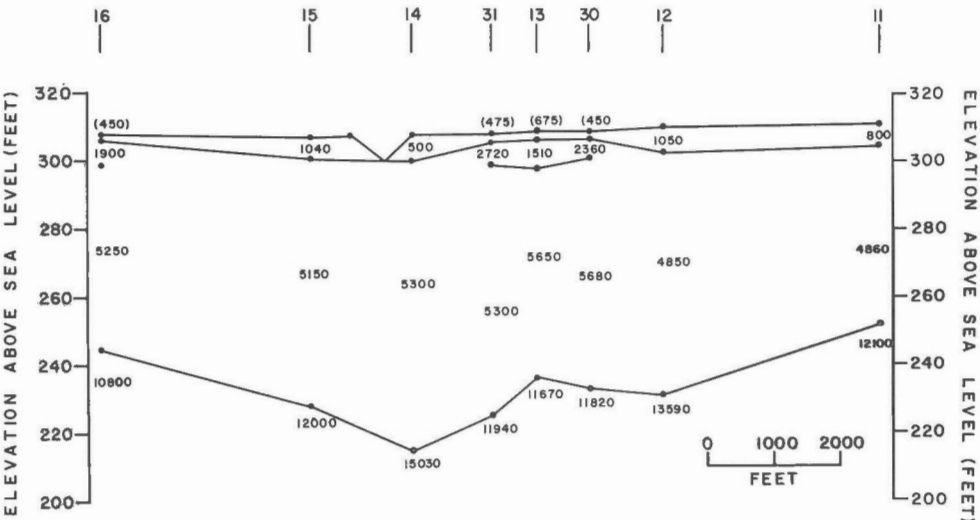

Figure 5. A cross-section, Whirlpool-St. Davids area.

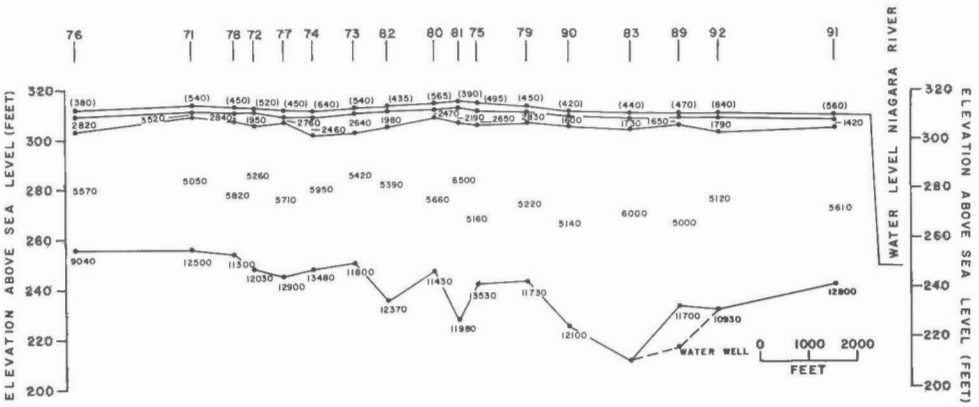

Figure 6. A cross-section, Whirlpool-St. Davids area.

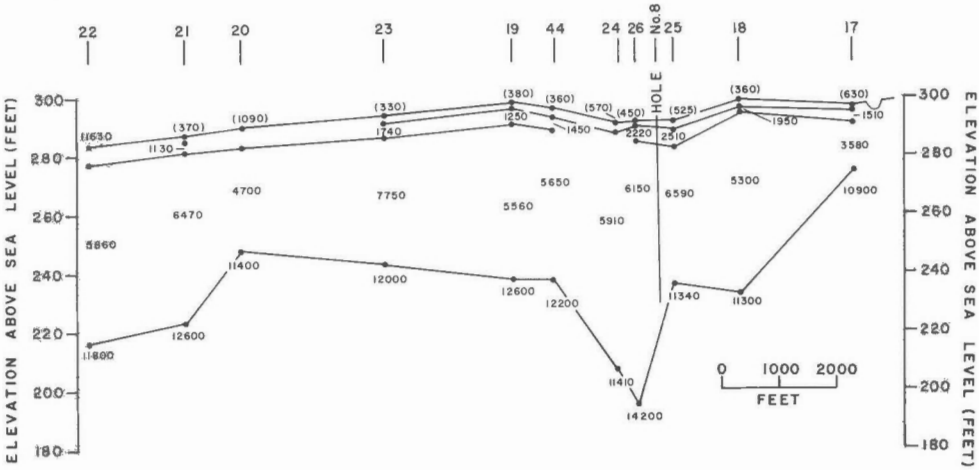

Figure 7. A cross-section, Whirlpool-St. Davids area.

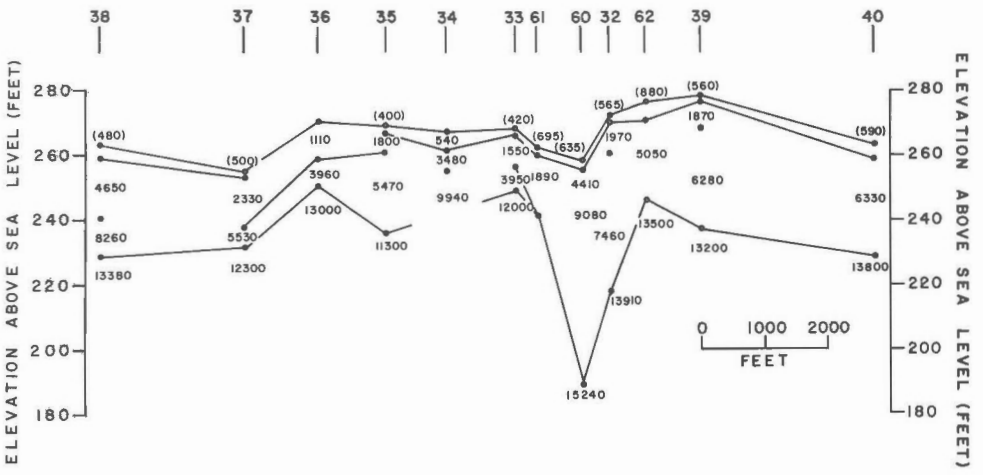

Figure 8. A cross-section, Whirlpool-St. Davids area.

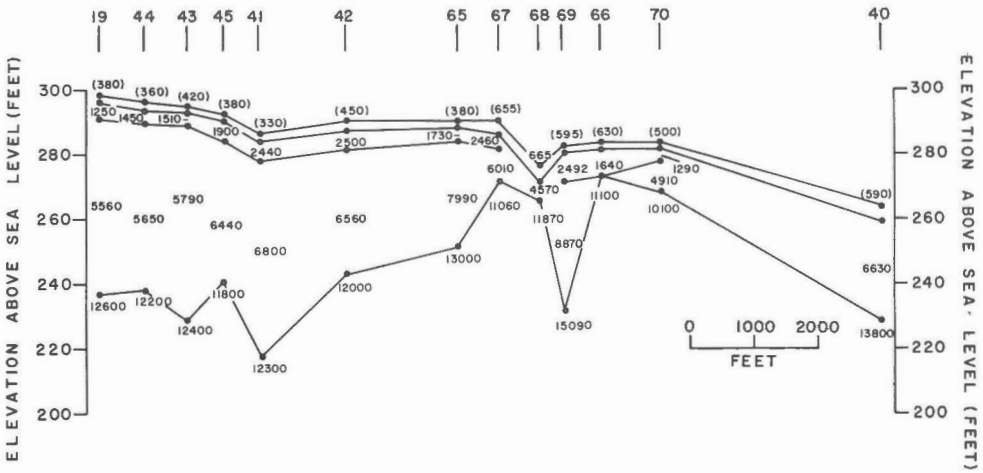

Figure 9. A cross-section, Whirlpool-St. Davids area.

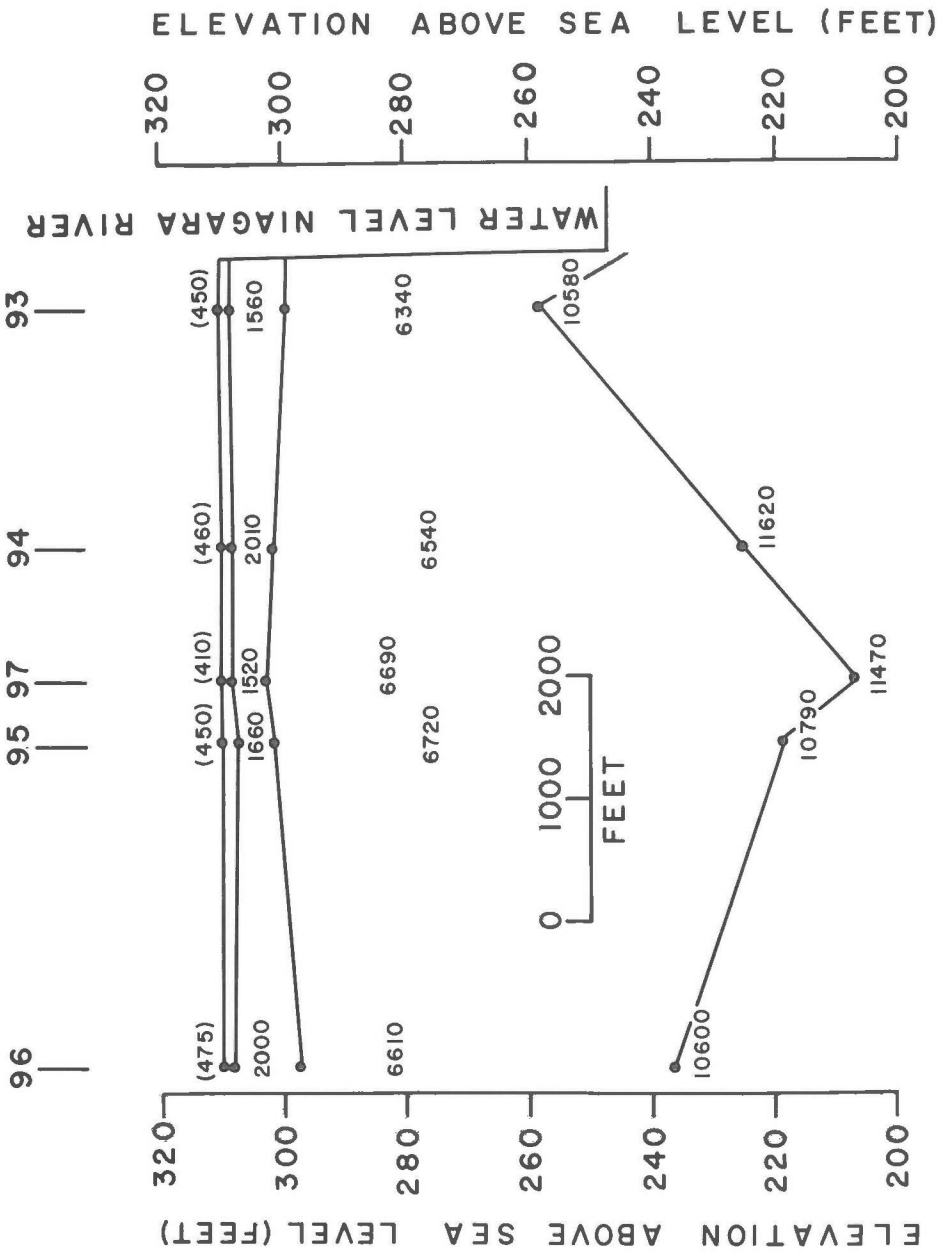

Figure 10. A cross-section, Whirlpool-St. Davids area.

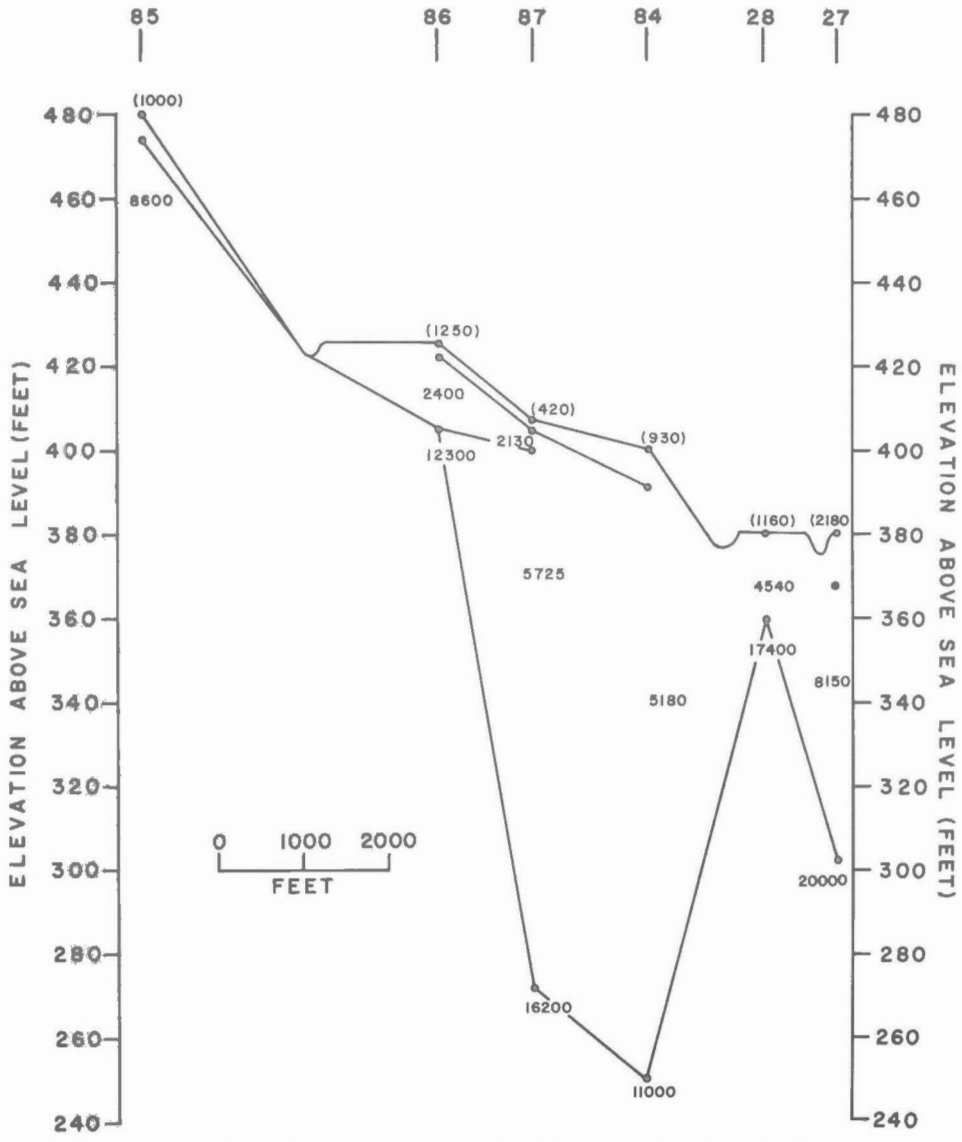

Figure 11. A cross-section, Whirlpool-St. Davids area.

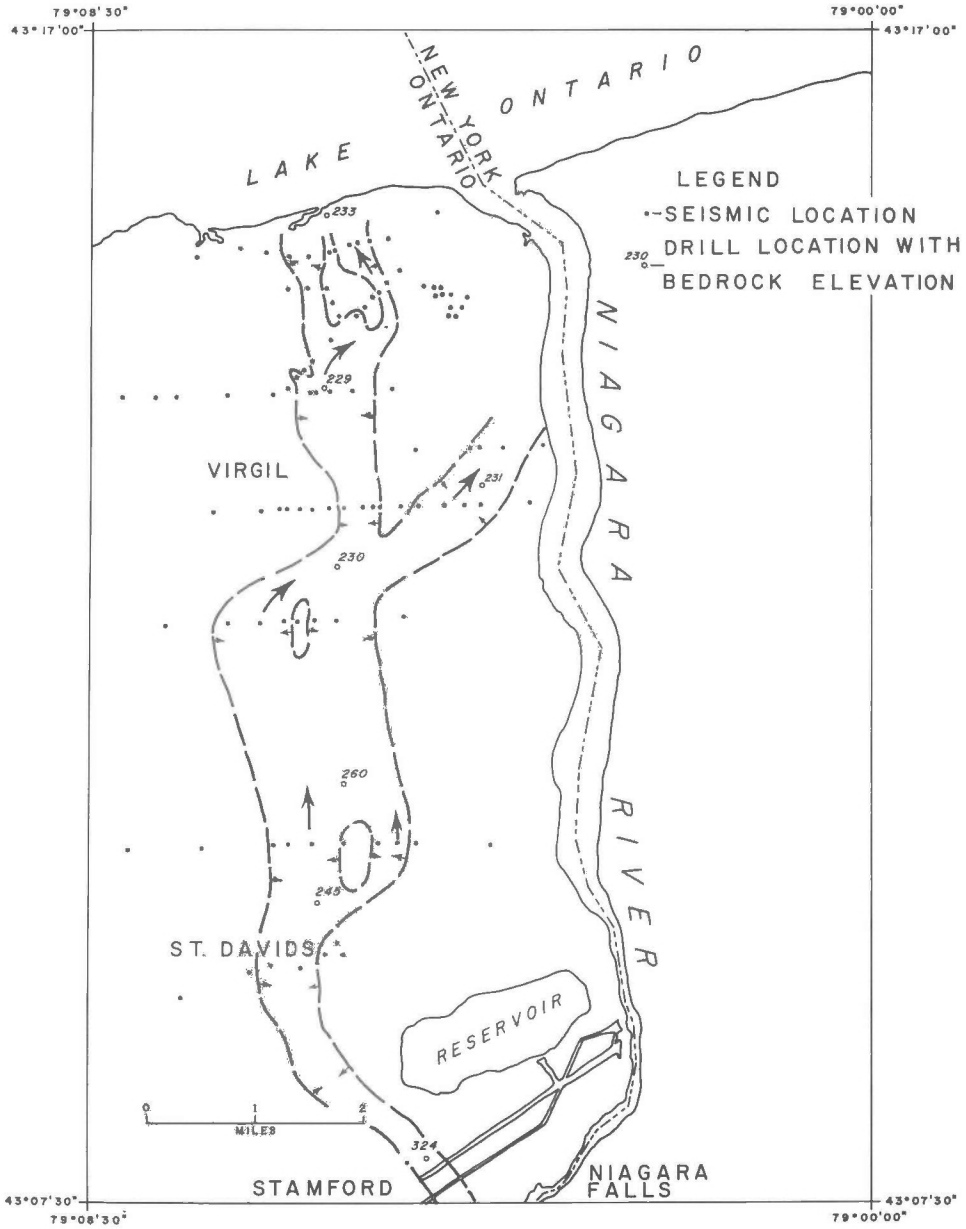

Figure 12. Plan of Whirlpool-St. Davids area buried bedrock channel.

Figures 4 to 11 are cross-sections, all oriented in a west-to-east direction except Figure 9, to show the thickness of the various surficial materials and the bedrock topography. Islands in the channel have been detected, especially on Figures 4, 5, 8 and 9. These may be similar to Goat Island and Navy Island in the present Niagara River immediately above the falls. The present river is about 5,000 feet wide at Goat Island and about 8,000 feet wide at Navy Island so that the widths indicated for the buried channel are not exorbitant.

Figure 12 is a plan of the buried channel as presently envisaged from seismic and drillhole control. In the case of the existence of a remnant island in the channel the main channel has been indicated. It is obvious even from the control available that this former river meandered to a certain degree.

Base Elevation of the Channel

At St. Davids, seismic data computes bedrock to be at an elevation of approximately 260 feet above sea level. In general the base elevation of the channel decreases northward towards Lake Ontario until at seismic location 60 bedrock has been calculated to be at an elevation of 187 feet above sea level. Bedrock in drillhole number 9 was reached at an elevation of 233 feet above sea level. The water level in Lake Ontario is +245 feet so that the base of the buried channel is well below the lake level. This represents a drop of 73 feet in about 6 1/2 miles.

Spencer (1907) calculated the base of the Whirlpool to be about +208 feet. This places the base of the channel found at the Hydro project significantly higher in elevation than the base of the Whirlpool; this is not a point for concern because the depths of the Whirlpool may well be due to its own action.

CONCLUSIONS

The Whirlpool-St. Davids Gorge suggested by Lyell and Spencer has been confirmed by seismic surveys and by drillholes. This gorge has been extended north of St. Davids and the Niagara escarpment to Lake Ontario to outline a broad buried channel. It has been infilled with glacial material and is therefore probably an excellent aquifer. Palynological studies coupled with the stratigraphy of the surficial deposits in the gorge confirm the postulated interglacial age of the buried channel.

REFERENCES

Caley, J. F.
1940: Palaeozoic geology of the Toronto-Hamilton area, Ontario; Geol. Surv. Can., Mem. 224.

Dept. Agriculture, Canada
1960: Soil survey of Welland County; Soil Map No. 5.

1963: Soil survey of Lincoln County; Report No. 34.

Dreimanis, A., Terasmae, J., and McKenzie, G. D.
1966: The Port Talbot Interstade of the Wisconsin Glaciation; Can. J. Earth Sci., vol. 3, pp. 305-325.

Lyell, C.
1845: Travels in North America in the years 1841-42; with geological observations on the United States, Canada and Nova Scotia; Wiley and Putnam, New York.

Spencer, J. W. W.
1907: The Falls of Niagara; Geol. Surv. Can., Publ. 970.