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GEOLOGICAL REPORT PETROLEUM EXPLORATION PERMITS, ANTICOSTI ISLAND

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GEOLOGICAL REPORT

PETROLEUM EXPLORATION PERMITS

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ANTICOSTI ISLAND - PROVINCE OF QUEBEC

W.A. Roliff, Ph.D.

Consulting Geologist

March, 1985

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EXPLORATORY WORK AND STUDIES RELATING TO OIL AND GAS EXPLORATION ANTICOSTI ISLAND - PROVINCE OF QUEBEC

INTRODUCTION

This report analyzes the work previously undertaken on the lands covered by oil and gas exploration licences on Anticosti Island.

Geologically, the island is underlain by rocks of Ordovician and Silurian age, mostly calcareous shales and carbonates that dip gently in a southerly direction and vary in thickness from 3,000 feet to over 12,000 feet.

A knowledge of the stratigraphy of the exposed upper Ordovician and Silurian rocks and the general areal distribution of the several lithologic units comprising this sequence was provided by the works of Bolton (1961), Twenhofel (1928) and the early explorations of Richardson (1857), Laflamme (1905) and Schuchert and Twenhofel (1910). A map indicating Twenhofel's subdivisions is shown in Figure 1. The studies of Twenhofel (1938) on the Mingan Islands, 20 miles to the north of Anticosti, and the spatial relationships, suggested the presence of several hundreds of feet, or more, of middle and lower Ordovician beneath the lowest rocks exposed on Anticosti.

Interest in the oil possibilities of Anticosti developed largely because of the presence of sediments believed to be capable of generating oil, the geographic location of the island in respect to possible markets, and the presence of free oil in corals in the Ordovician sediments exposed on the north shore.

In 1961, New Associated Developments Limited obtained an exploration license covering the entire island and subsequently subsidiaries of Imperial Oil Limited, Consolidated Paper Corporation and Atlantic Richfield acquired from New Associated exploration rights to 65% of the island. These companies carried out geological and geophysical studies and drilled 43,105 feet of hole. The location of areas held by the Imperial and Consolidated companies, the seismic lines and the holes drilled are shown in Figure 2.

These exploratory efforts were unsuccessful commercially, and most of the area held under license was surrendered.

As exploratory efforts expanded in the offshore region of Eastern Canada, interest was again revived in the oil and gas possibilities of Anticosti Island and early in 1970 Gamache Exploration and Mining Co. Ltd. applied for and was granted oil and gas exploration licenses comprising 838,000 acres covering approximately the northern one half of the island.

An airborne magnetic survey was made of the island surface and photogeologic studies were carried out to determine the attitude of the rocks and to improve the understanding of the distribution of the various units, and three stratigraphic test holes were drilled at about 25 mile intervals in the western one half of the island to obtain a knowledge of thicknesses, sediment character and lateral variations. The results of these activities were sufficiently encouraging to justify seismic surveys in an attempt to determine if traps are present of a size and character to contain quantities of oil that would be commercially attractive. Two such features were delineated and these were drilled and tested with a conventional rotary outfit. A further test was made by New Associated Developments Limited of the upper Ordovician formations, in close proximity to one of the stratigraphic test holes.

The pertinent data obtained and its possible significance is summarized

as follows:

(a) Airborne Magnetometer Survey

An airborne magnetometer survey was carried out over the island with lines flown in a north-south and east-west direction at intervals of 4 miles and a contour map of magnetic intensities was prepared. From this data the approximate thicknesses of the sediments was determined by the conventional method, and the results contoured on as shown on Figure 3. These indicate the sediments to have a thickness of 3,000 to 5,000 feet along the north side of the island and of 5,000 feet to more than 11,000 feet along the south shore of the island and that the Precambrian surface on which Paleozoic sedimentation took place was an uneven one with elevations varying as much as 1,000 feet or more and probably resembling the present-day Precambrian surface to the north of the St. Lawrence River.

(b) Seismic Surveys

Seismic profiling was carried out over practically all of the existing roads and a number of additional lines were cut. A total of 350 miles of line was run. In general, reflections were obtained from a horizon in the mid-upper Ordovician probably at or near the top of the English Head formation and from a horizon close to the top of the Trenton formation. Locally reflections were obtained from other horizons, but usually these had limited lateral extent. Cross sections based on the "English Head" and "Trenton" reflections are shown by the profiles A-B and C-D on Figure 4 and indicate post-Trenton, pre mid-upper Ordovician, tectonisms, and a thickening of the sedimentary section in a southerly direction. The extent and magnitude of the displacements indicated by "Trenton" reflection mapping is shown on Figure 5. There appears to be a northwesterly trending fault zone in the vicinity of the Anticosit No. 1 and Oil River holes with

displacements of as much as 1,500 feet, and eastwest trending major fault zone about 8 miles south of the Highcliff location with displacements up to 900 feet and northeasterly trending zone with displacements of the order of 300 feet to 400 feet in the Princeton Lake area. Adjustments along these fault zones about 8 miles south of the Highcliff location with displacements up to 900 feet and a northeasterly trending zone with displacements of the order of 300 feet to 400 feet in the Princeton Lake area. Adjustments along these fault zones continued in post mid-upper Ordovician time as is evidenced by reflections from the English Head horizon in the mid-upper Ordovician time. The displacements recognized and the magnitude of these are shown on Figure 6. A comparison of Figure 5 and Figure 6 shows the magnitude of the displacements on the mid-upper Ordovician horizon along the Oil River fault zone to be less than 200 feet compared with as much as 1,500 feet on the "Trenton" horizon. Similar relationships exist in regard to the respective displacements in the other fault zones mentioned.

(c) Explorary Drilling

A total of 7 explorary holes have been drilled on the island, 5 of these reached the Precambrian, 1 the lower part of the Beekmantown and 1 was completed just above the Macasty. The stratigraphic units penetrated are shown on Figure 7, and the following are indicated:

(1) The Vaureal and English Head formations thicken in a southwesterly direction suggesting deposition in a basin subsiding in the south and southwest.

(2) The relatively marked difference in the thickness of the Macasty formation suggests late-Trenton and/or post-Trenton uplift and erosion.

(3) The absence of the Chazy in the Carleton Point will indicates probably uplift and erosion at the close of Chazy time.

(4) The thinner section of Beekmantown in the Carleton Point well is probably due to erosion.

The generalized variations in lithologies are shown on Figure 9 and indicate an increase in shale and silt in the English Head towards the northeast. In regard to the other stratigraphic units there is no marked or well defined lateral variation in the lithologies.

Three of the exploratory holes are stratigraphic tests, and were cored. Numerous indications of oil and gas were observed in the cores. Many of these occurred in fractures. The occurrences may be summarized as follows:

(a) Showings above the Chazy formation were numerous in only two holes, Anticosti No. 1 and Jupiter No. 1 and occur mainly in fractures.

(b) The sands in the Chazy formation are oil stained in the Princeton Lake well, but not in the Anticosti No. 1 hole. The Chazy is not present in the Carleton Pt. Test.

(c) The most interesting showings and some visible porosity occur in the dolomites of the Beekmantown. In the Anticosti No. 1 test the cores between 5,240 - 5,350 feet, around 5,570 feet and 5,600 - 5,720 feet showed "weeping" or slight "bleeding" of oil. In the Princeton Lake hole a slight showing of oil occurred about 60 feet below the top of the Beekmantown in the Carleton Pt. hole a little oil staining and salt water occurred between 2,500 - 2,630 feet.

In the Oil River well a test of the Chazy sands yielded only 40 feet of slightly gas cut mud. Several drill stem tests of the Beekmantown yielded only salt water.

In the Highcliff well a drill stem test of the Chazy sands between 4,258 - 4,288 feet yielded 250 MCF of gas which in one hour declined to 27 MCF. A drill stem test in the Beekmantown between 4,795 - 4,832 feet, about 150 feet below the top of the formation, yielded 440 MCF gas which declined in one hour to 121 MCF.

Other tests at horizons approximately equivalent to the lower oil showings in the Anticosti No. 1 stratigraphic test yelded salt water.

The structural features on which the Oil River and Highcliff wells were located are shown on Figure 8 and were delineated by seismic surveys.

The Jupiter No. 1 cable tool well drilled close to the Anticosti No. 1 stratigraphic hole to test the upper Ordovician showings observed in the core of latter hole, failed to obtain commercial production.

A detailed study was made by J.W. Wishart of Imperials's research staff in Calgary of the cores of the Chazy formation from the Princeton Lake hole. This study indicated the Chazy to consist of an alternating series of sands, muds and carbonates which have been altered by the diagenetic effects of pressure solution and calcite cementation resulting in the loss of almost all of the original porosity.

Porosity and permeability tests were made on these portions of the cores of the Beekmantown formation from the Anticosti No. 1 and Carleton Pt. holes which, visually, appeared to have some porosity. The results of these tests are shown graphically on Figure 9. In regard to the Carleton Pt., a total of 78 feet of core was analyzed and resulted in a weighted average porosity of 5%. Ninety determinations of permeabilities were made and of those 18 representing a total sediment thickness of 15 feet had a weighted average permeability of less than 1 millidarcy.

2. SURFACE AND SUBSURFACE GEOLOGY

The areal distribution of the geological units underlying the region is shown on Figure 1. This map was prepared from various surveys, maps and reports in the files of the Quebec Department of Natural Resources, the Geological Survey of Canada and Consolidated-Bathurst Limited, from studies of air photos by the writer and from flights and field observations by the writer. It was possible to trace across the air photos of the area, many of the geological contacts established by ground traverses and much information on the strike and altitude of the beds is

observable on the air photos.

The Ordovician strata exposed on the island have been subdivided, in ascending order, into the Macasty, English Head, Vaureal and Ellis Bay Formations, and the exposed Silurian strata into the Becscie and Gun River Formations. Each of these formations is primarily a grouping of faunal zones and, hence, contacts are ill-defined.

The most easily recognized are the contact between the Vaureal and Ellis Bay and between the Becscie and the Gun River.

STRUCTURE

On the basis of surface geological evidence Anticosti Island consists essentially of a structurally undisturbed sequence of Ordovician and Silurian rocks with a northwest-southeast strike and dipping southward at angles averaging approximately 2^{o} to 3^{o}. There is little evidence in the outcrop information to suggest the presence of faulting. A study of the airphotos, however, reveal certain lineations suggesting faulting and the abrupt termination of key horizons in numerous localities support a suspicion of faulting. The seismic work carried out over the westerly one third of the island (Roliff 1968) reveals in the sub-surface, the presence of numerous faults with displacements varying from 200 feet to as much as 1,500 feet. Two well-defined reflecting horizons, the "Trenton Reflecting Horizon" and the "English Head Relfecting Horizon" (Figure 5 and 6) show most of the movement to have taken place in post-Trenton, pre-Vaureal time and thus explains the paucity of evidence of faulting in the exposed rocks on the island.

A time-structure map of the top of the "Trenton Reflecting Horizon" (Figure 10) was prepared from the seismic data. This interpretation shows two main fault bends affecting the Trenton and older rocks, one having a northwest-southeast trend and the other trending in a general northeast-southwest direction. Within this fault pattern a number of structural closures are present, some of which butt

against faults, and the Oil River well was located on this type of feature. A graben appears to be present to the northeast of the Princeton Lake hole in the northwestern extremity of the island. The region east of the permits appears to have been less affected by faulting, thus suggesting that the areally larger but less pronounced highs indicated to the east may be due to draping over pre-existing basement highs. It is a reasonable assumption, based on the foregoing, that in the region to the east, faulting in the Trenton and pre-Trenton rocks is probably less prevalent than in the Permits area and consequently that fewer features capable of providing traps for oil and/or gas accumulations are likely to be present.

Since the available geological and geophysical data relating to the region indicates in my opinion, that there is technical and economic justification for further exploration of the Permits I recommend that consideration be given to the drilling of a proposed location designated East Jupiter No. 1 approximately 12 miles northeast of the Arcan Anticosti No. 1 well near the southwest point.

In the only well, (Arcan Anticosti No. 1) drilled in the southwest point area, two showings of gas were reported, one at 6925'-6931' in the English Head Formation of the Upper Ordovician, necessitating an increase in mud weight to prevent a blow-out, and the other at 11220'-11232' in the Beekmantown Formation of the Lower Ordovician. Flow volumes were not reported. In the Beekmantown zone, porosity averaged 14%. Some faint oil staining was present in the Chazy Formation above the Beekmantown.

To the north and west of the Arcan well, six exploratory tests have been drilled. Each of these had showings of oil and/or gas (Figure 7).

The occurrences may be summarized as follows:

(a) Showings above the Chazy formation were numerous in only two holes, Anticosti No. 1 and Jupiter No. 1, and occur mainly in fractures.

(b) The sands in the Chazy formation are oil stained in the Princeton Lake,

but not in the Anticosti No. 1 hole. The Chazy is not present in the Carleton Pt. test. In the Highcliff well a drill stem test of the Chazy sands between 4258-4288 feet yielded 250 MCF of gas which in one hour declined to 27 MCF.

(c) The most interesting showings and some visible porosity occur in the dolomites of the Beekmantown. In the Anticosti No. 1 tests the cores between 5240-5350 feet, around 5570 feet and 5660-5720 feet showed "weeping" or "bleeding" of oil. In the Princeton Lake hole a slight showing of oil occurred about 60 feet below the top of the Beekmantown and in the Carleton Point hole oil staining and salt water occurred between 2500-2630 feet. In the Oil River well the zone between 5189-5292 feet had a net thickness of 54 feet averaging 7% porosity and the zone between 5509-5575 feet had a net thickness of 25 feet averaging 12% porosity, indicating that adequate porosity is present to provide reservoir for commercial hydrocarbons. Showings of oil, and salt water occurred in these zones.

Considerable seismic work has been done on the permits under consideration and several prospects have been interpreted. Of these, the most attractive feature, because of better structural control and greater possibilities of fracture porosity, is the East Jupiter anomaly located on permit 698. Aeromagnetic surveys have been carried out over all of the lands.

Seismic reflections obtained from a horizon in the mid-upper Ordovician probably at or near the top of the English Head Formation and from a horizon close to the top of the Trenton Formation indicated post-Trenton, pre mid-upper Ordovician movements and a thickening of the upper part of the sedimentary section in a southerly direction.

The recommended East Jupiter No. 1 location will test the possibilities of oil and/or gas accumulation in a large structural trap and has, as its principal

objective, the determination of the possibilities of accumulations of oil and/or gas controlled by such a feature and by fracture porosity.

EAST JUPITER NO. 1

This proposed test located at seismic station 20-1068 (Latitude 49°32'13" N and longitude 63°20'40" W) is situated on a seismic high bounded on the north by northeast by a large down-to-basin fault zone with up to 1200 feet displacement. Four hundred feet of critical northwest closure is provided by greater displacement (1600 feet) to the northwest where two seismic lines cross the fault again immediately south of the Anticosti No. 1 well (Figure 10). Because of this closure the recommended East Jupiter No. 1 well is considered a good prospect. Prospective horizons would be Trenton, Chazy and Beekmantown formations within the structure, plus wedging formations within the thickened Upper Ordovician section over the grossly displaced Trenton. This latter possibility is of particular interest in view of the occurance of gas in the English Head of the Upper Ordovician in the Arcan Anticosti No. 1 well, 12 miles to the southwest. Depth to basement would be 9000 feet.

RECOMMENDED WORK PROGRAM

Based on my appraisal of seismic and aeromagnetic data previouly performed on Permit 698 as well as correlation of information from 7 wells drilled on 3 sides of the East Jupiter No. 1 location. I recommend that an exploratory well be drilled to a depth of 9,000 feet at seismic station 20-1068 (Latitude 49°32'13" N and longitude 63°20'40" W).

The cost of this well, completed for production is estimated at $1,500,000.

W. A. Roliff

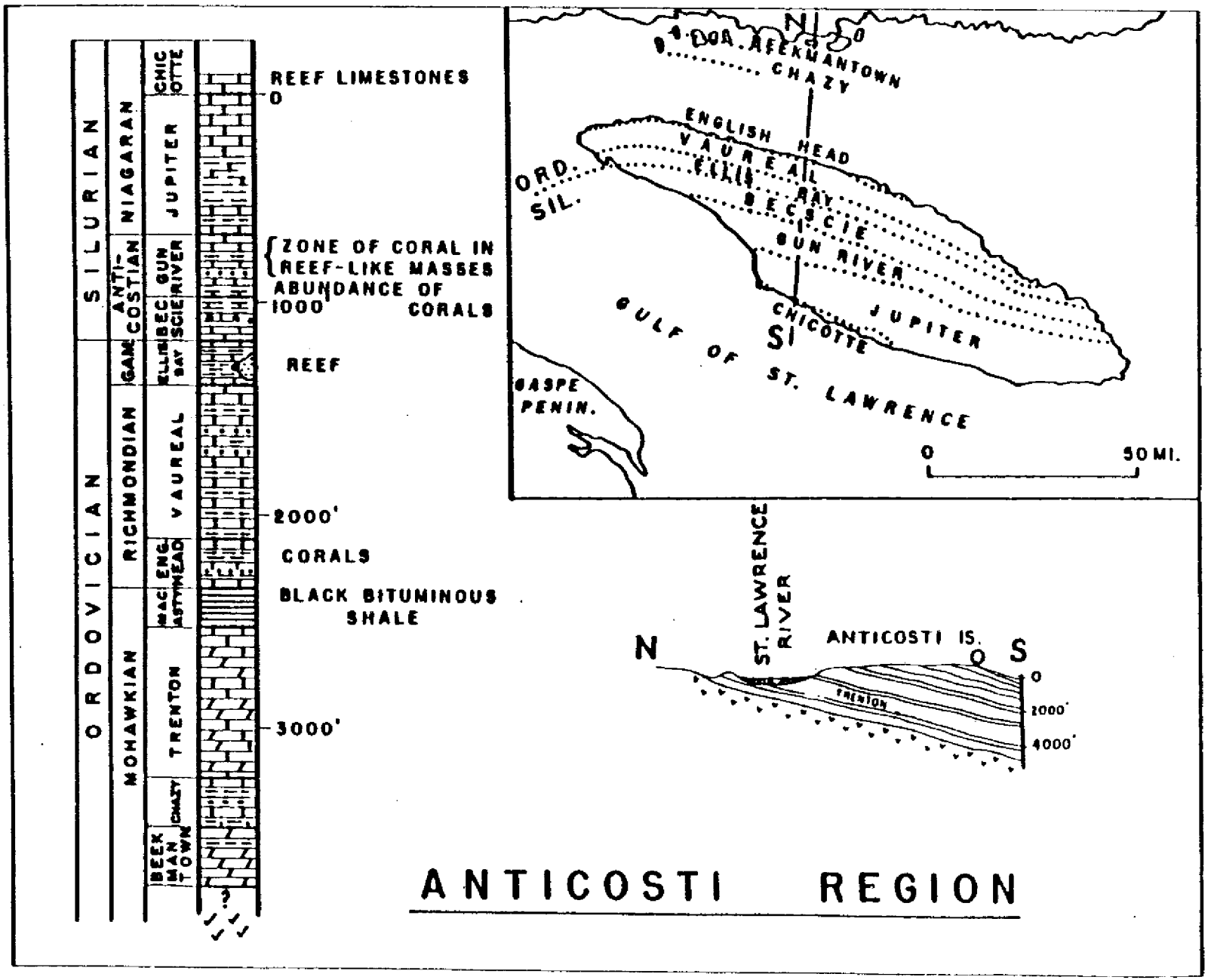

ORDOVICIAN
SILURIAN
MONAWKIAN
RICHMONDIAN
NIAGARAN
ANTI-COSTIAN
GAM
BEEK MAN TOWN
CHAZY
TRENTON
MACASTY HEAD
ENG.
VAUREAL
ELLIS BAY
BEC SCIE
GUN RIVER
JUPITER
CHIC OTTE
REEF LIMESTONES
0
ZONE OF CORAL IN REEF-LIKE MASSES
ABUNDANCE OF CORALS
1000
REEF
2000'
CORALS
BLACK BITUMINOUS SHALE
3000'
N
50
DOA. AFEKUANTOWN
CHAZY
ENGLISH HEAD
VAUREAL
ELLIS BAY
BEC SCIE
GUN RIVER
JUPITER
CHICOTTE
ORD.
SIL.
GULF OF ST. LAWRENCE
GASPE PENIN.
0
50 MI.
ST. LAWRENCE RIVER
N
S
ANTICOSTI IS.
TRENTON
0
2000'
4000'
ANTICOSTI REGION
W.A. ROLIFF

Figure 1

ANTICOSTI ISLAND

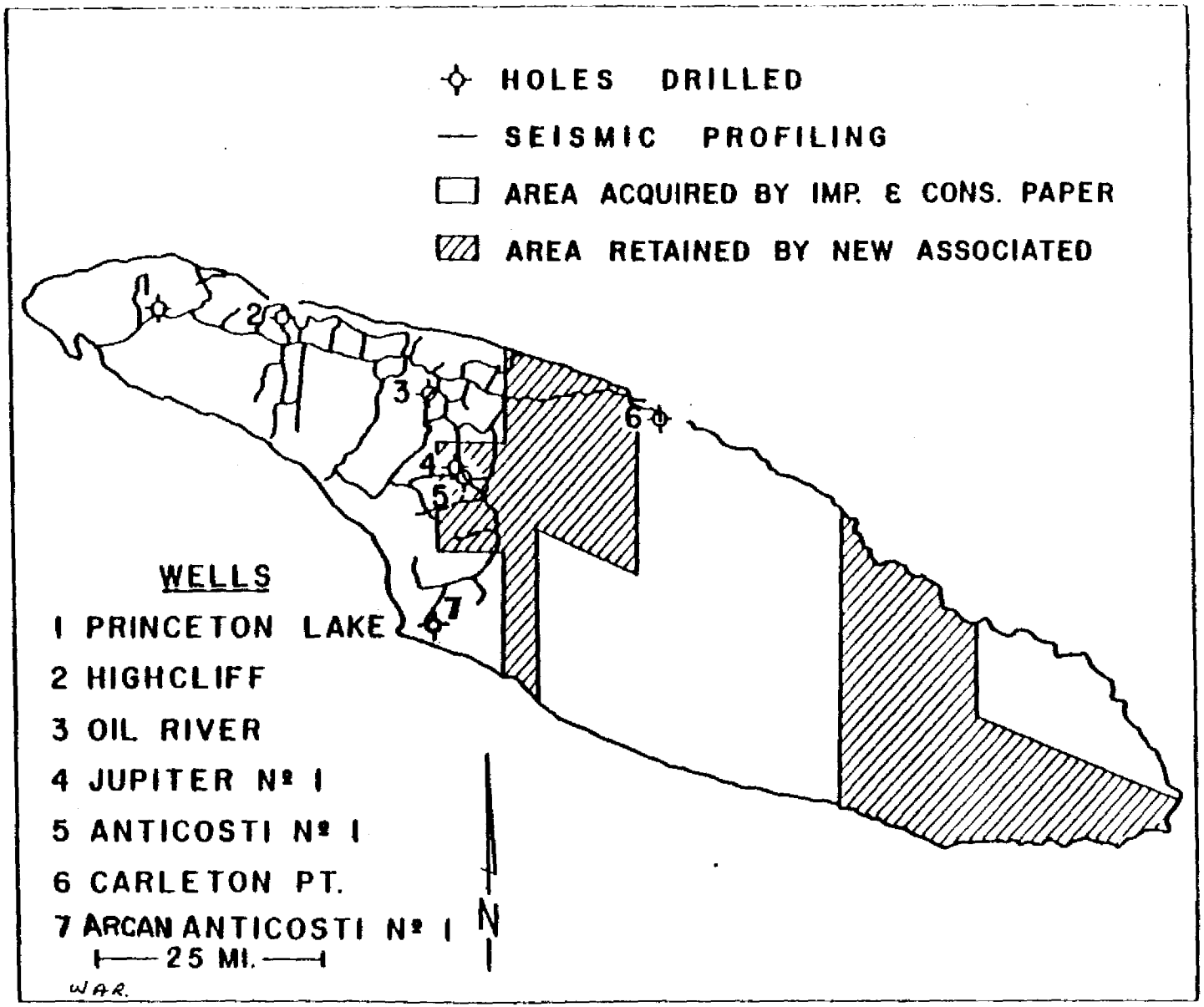


Figure 2

ANTICOSTI ISLAND

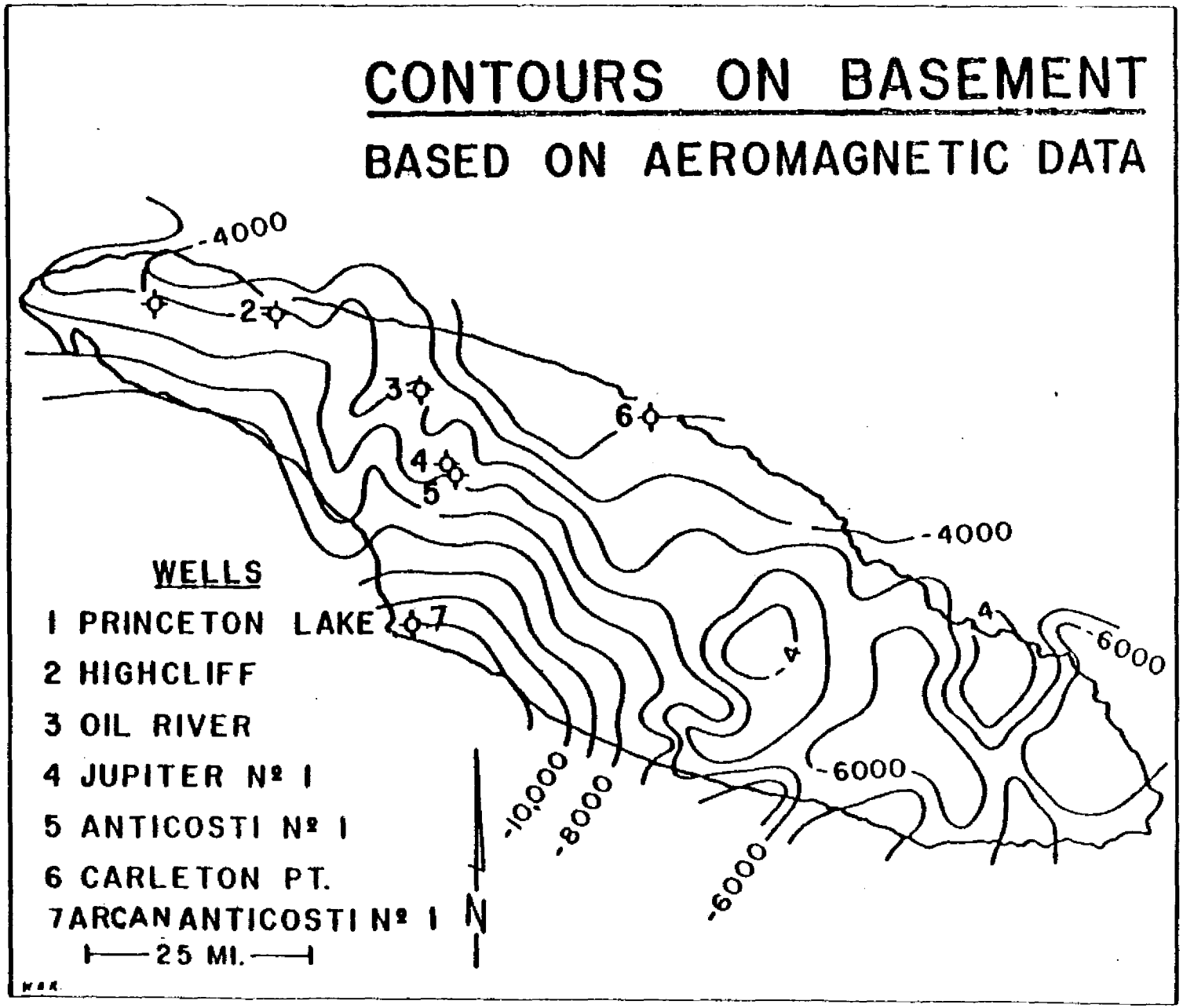
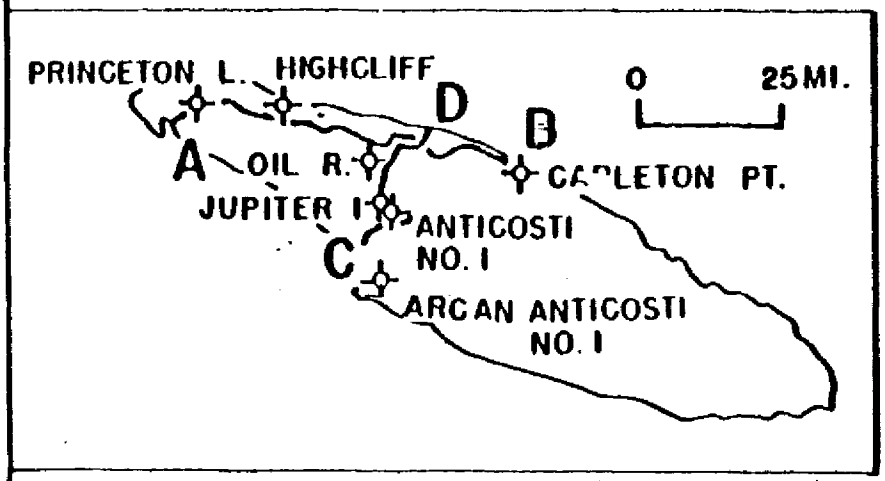
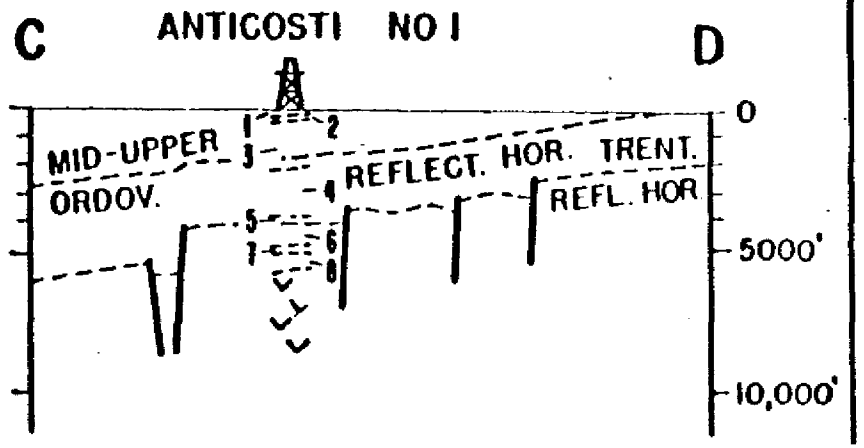
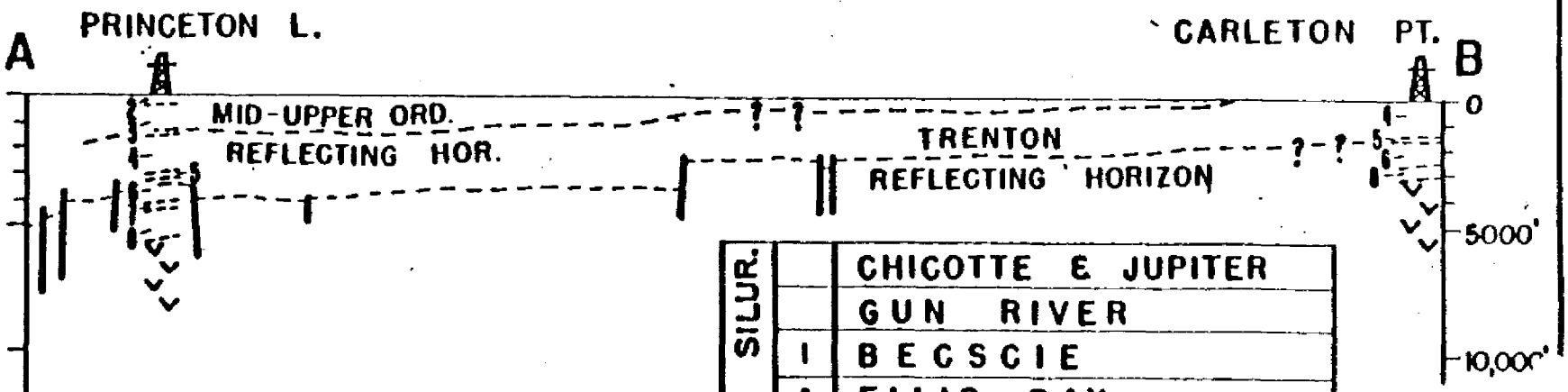


Figure 3







SILUR.		CHICOTTE E JUPITER
		GUN RIVER
ORDOVICIAN	1	BECSCIE
	2	ELLIS BAY
	3	VAUREAL
	4	ENGLISH HEAD
	5	MACASTY (UTICA)
	6	TRENTON
	7	CHAZY
	8	BEEKMANTOWN
PC	v v v v	PRECAMBRIAN

Figure 4

WESTERN ANTICOSTI ISLAND

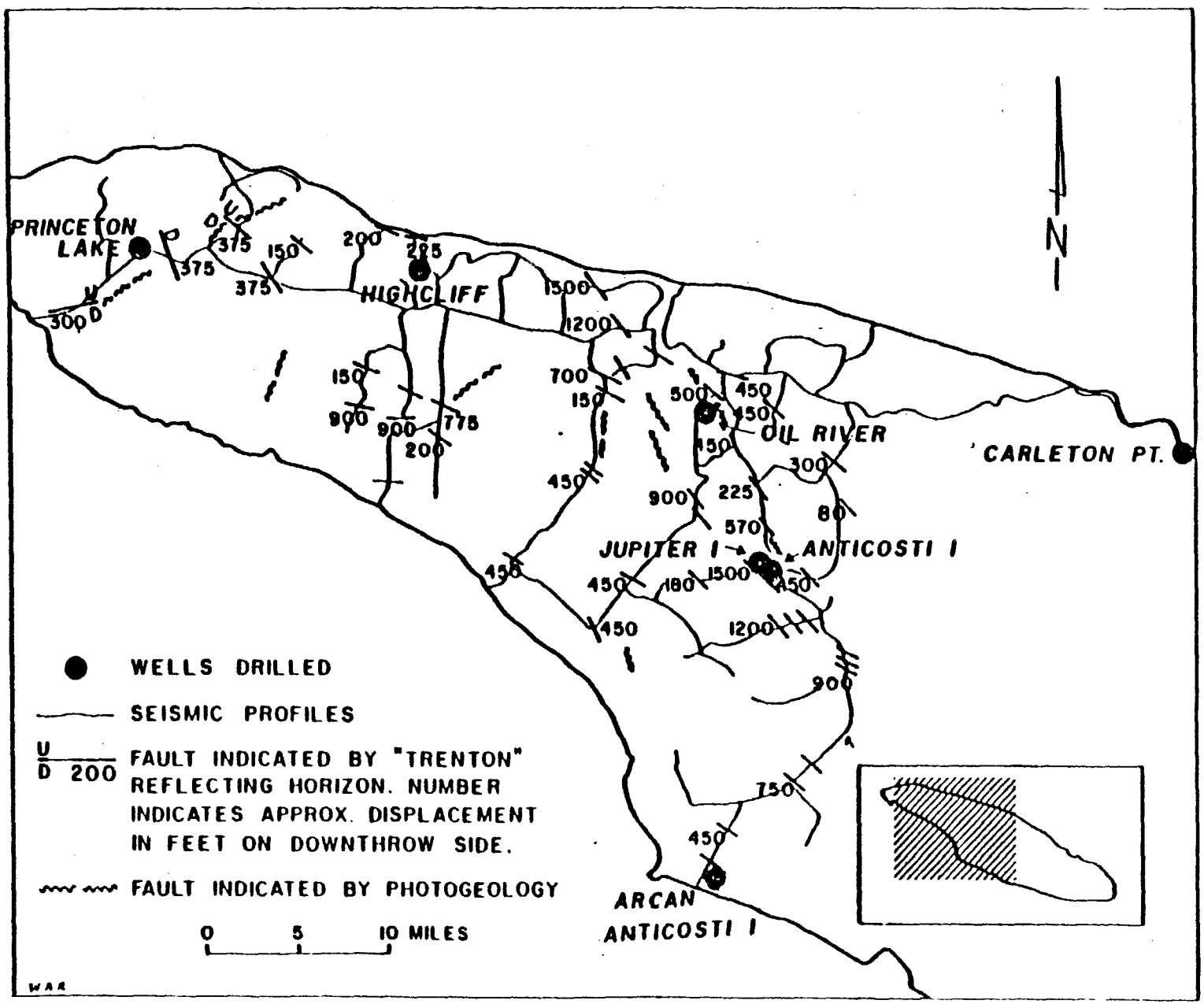


Figure 5

WESTERN ANTICOSTI ISLAND

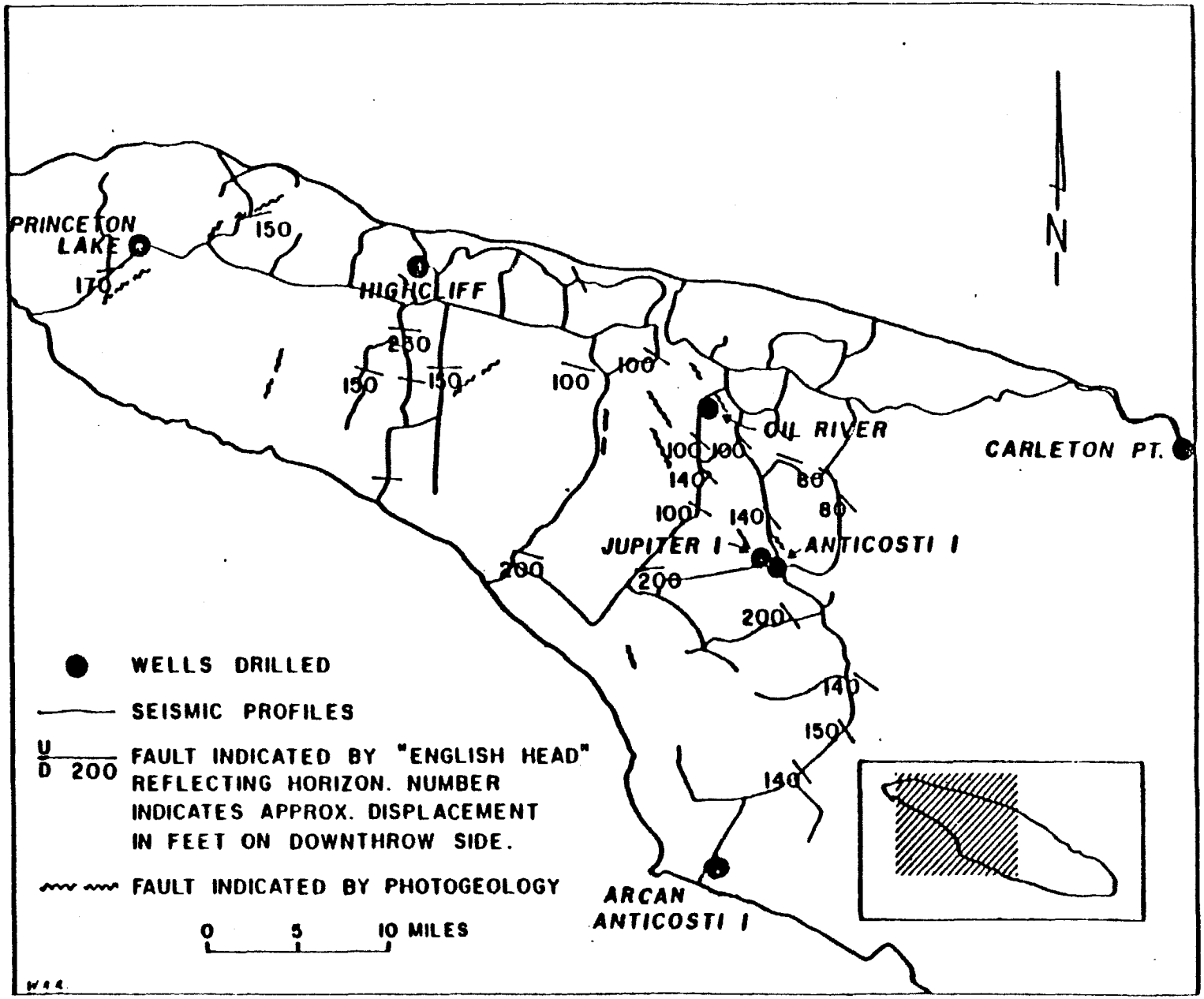


Figure 6

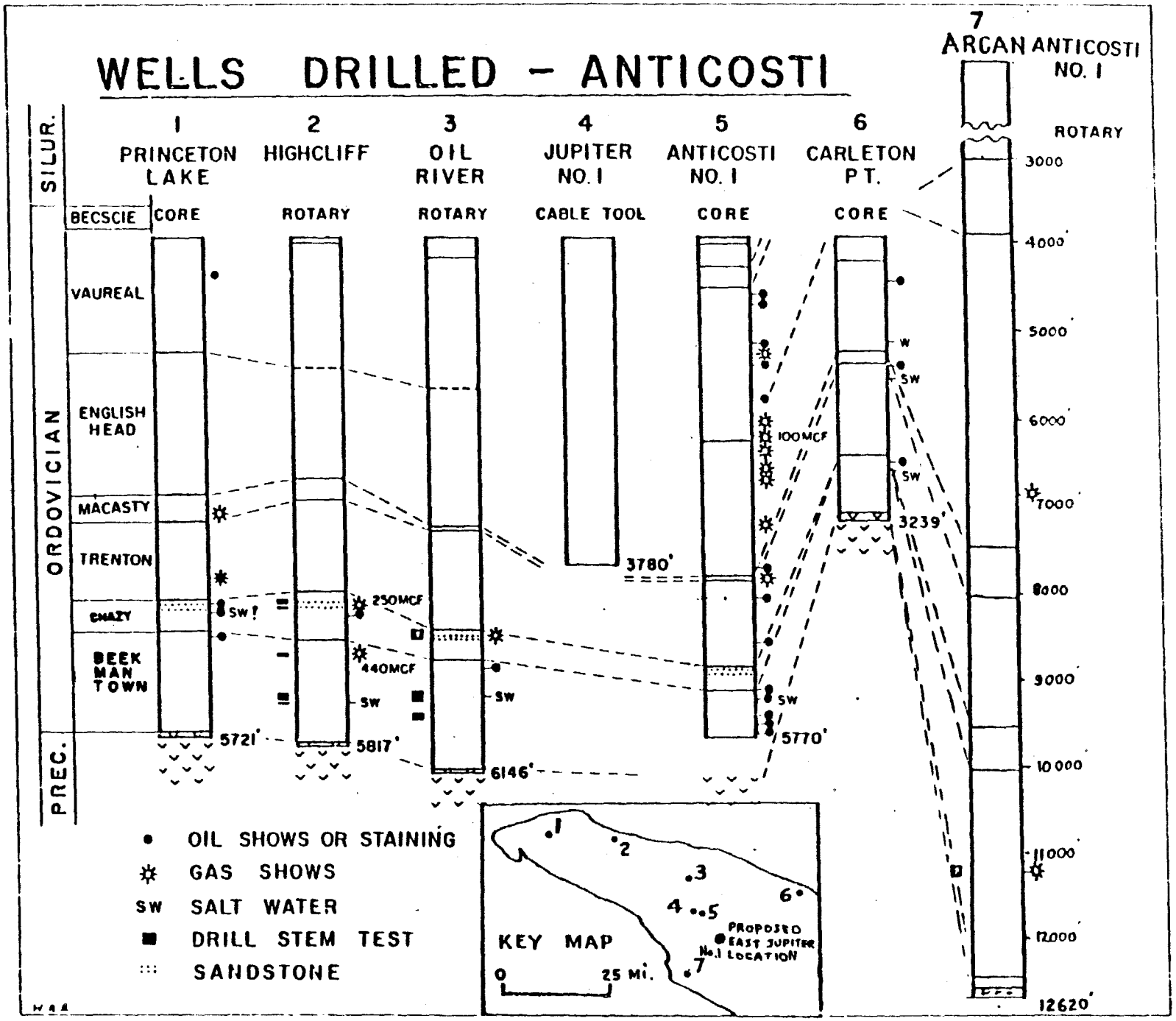

WELLS DRILLED - ANTICOSTI
1 PRINCETON LAKE
2 HIGHCLIFF
3 OIL RIVER
4 JUPITER NO. 1
5 ANTICOSTI NO. 1
6 CARLETON P.T.
7 ARCAN ANTICOSTI NO. 1
SILUR.
ORDOVICIAN
PREC.
BECSCIE
VAUREAL
ENGLISH HEAD
MACASTY
TRENTON
CHAZY
BEEK MAN TOWN
CORE
ROTARY
ROTARY
CABLE TOOL
CORE
CORE
ROTARY
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
100MCF
250MCF
440MCF
SW
3780'
3239'
5721'
5817'
6146'
5770'
12620'
OIL SHOWS OR STAINING
GAS SHOWS
SALT WATER
DRILL STEM TEST
SANDSTONE
KEY MAP
0
25 mi.
PROPOSED EAST JUPITER No.1 LOCATION

Figure 7

HIGHCLIFF Nº1 & OIL RIVER Nº1 LOCATIONS
CONTOURS ON TOP OF TRENTON

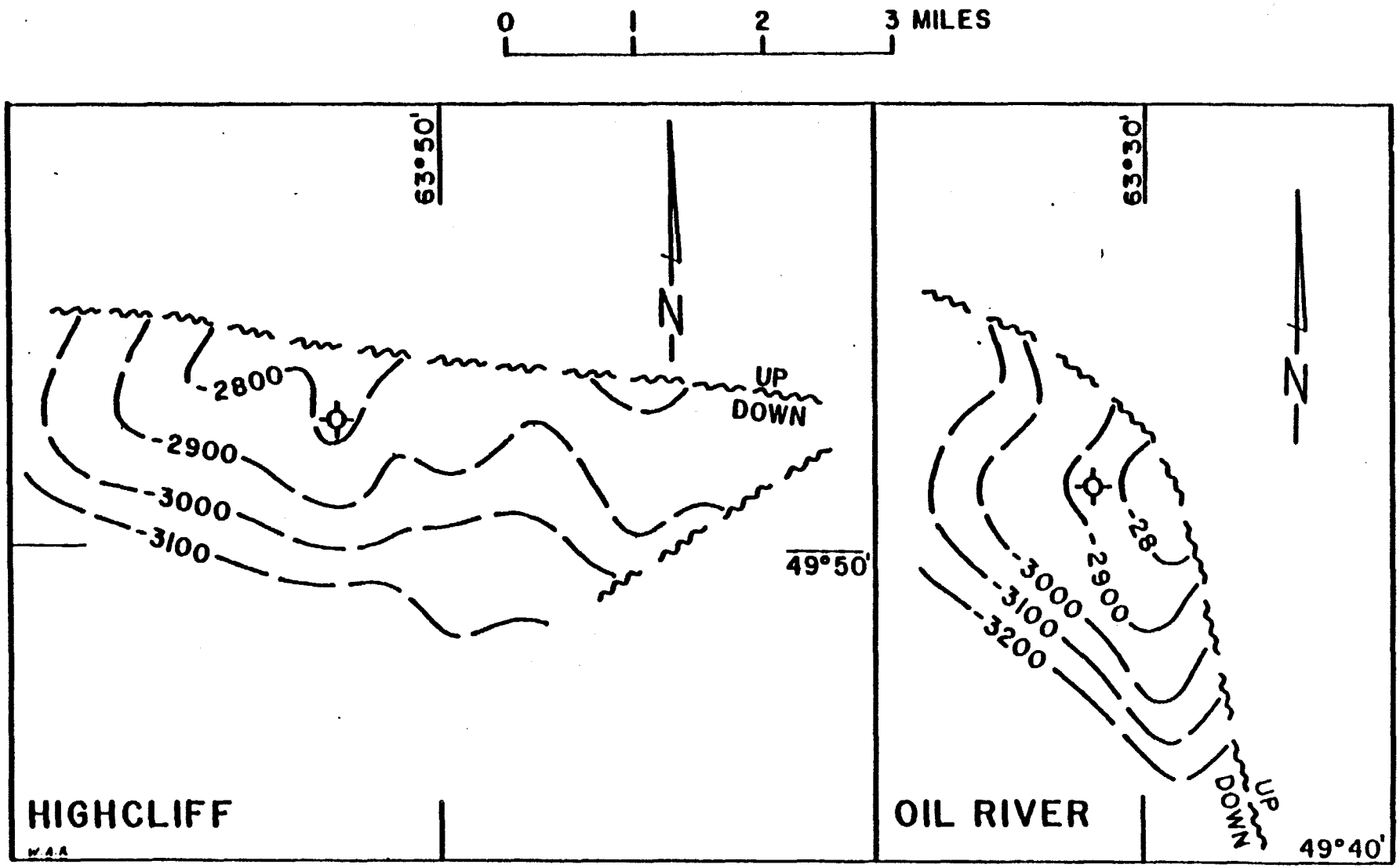


Figure 8

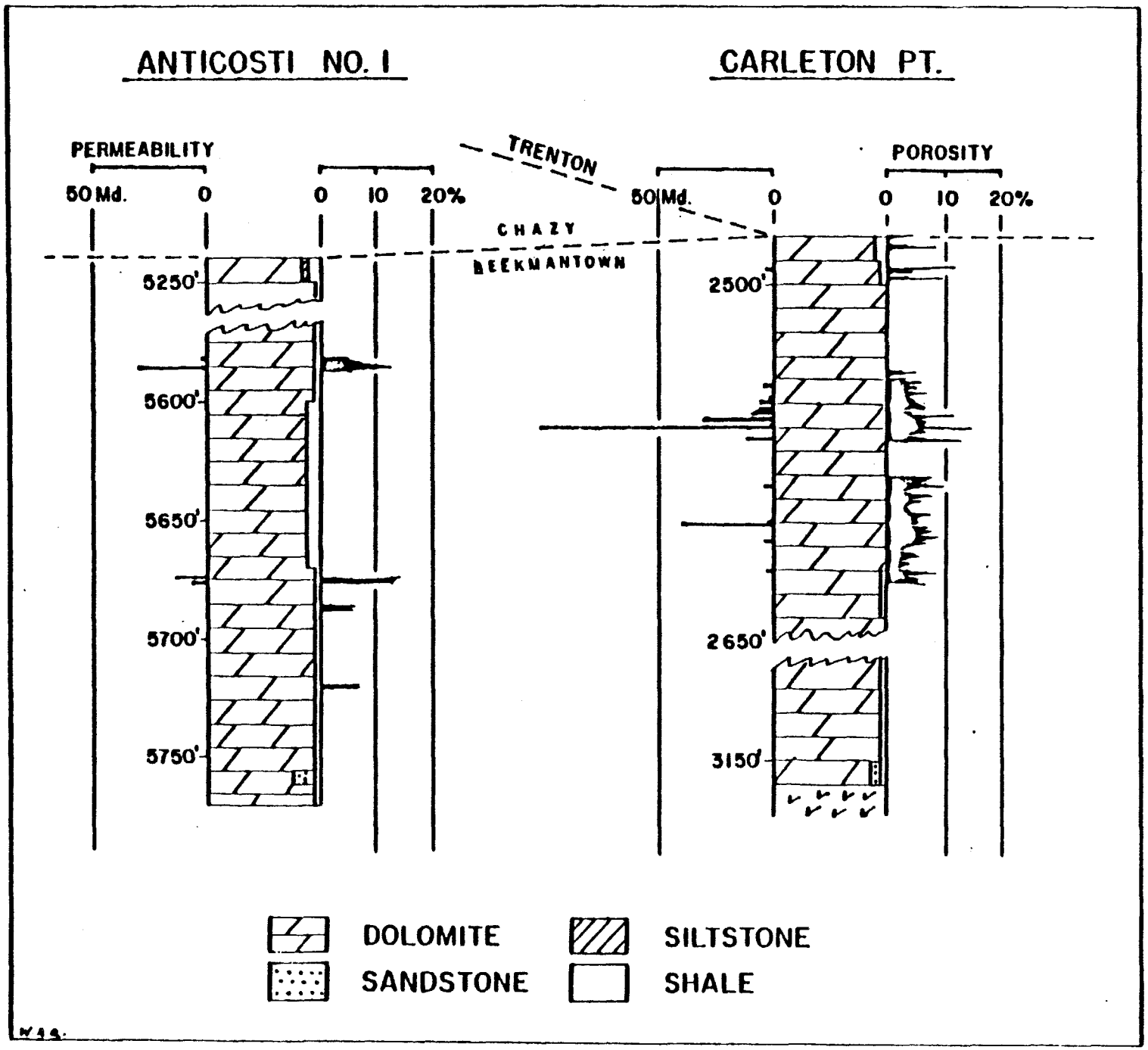
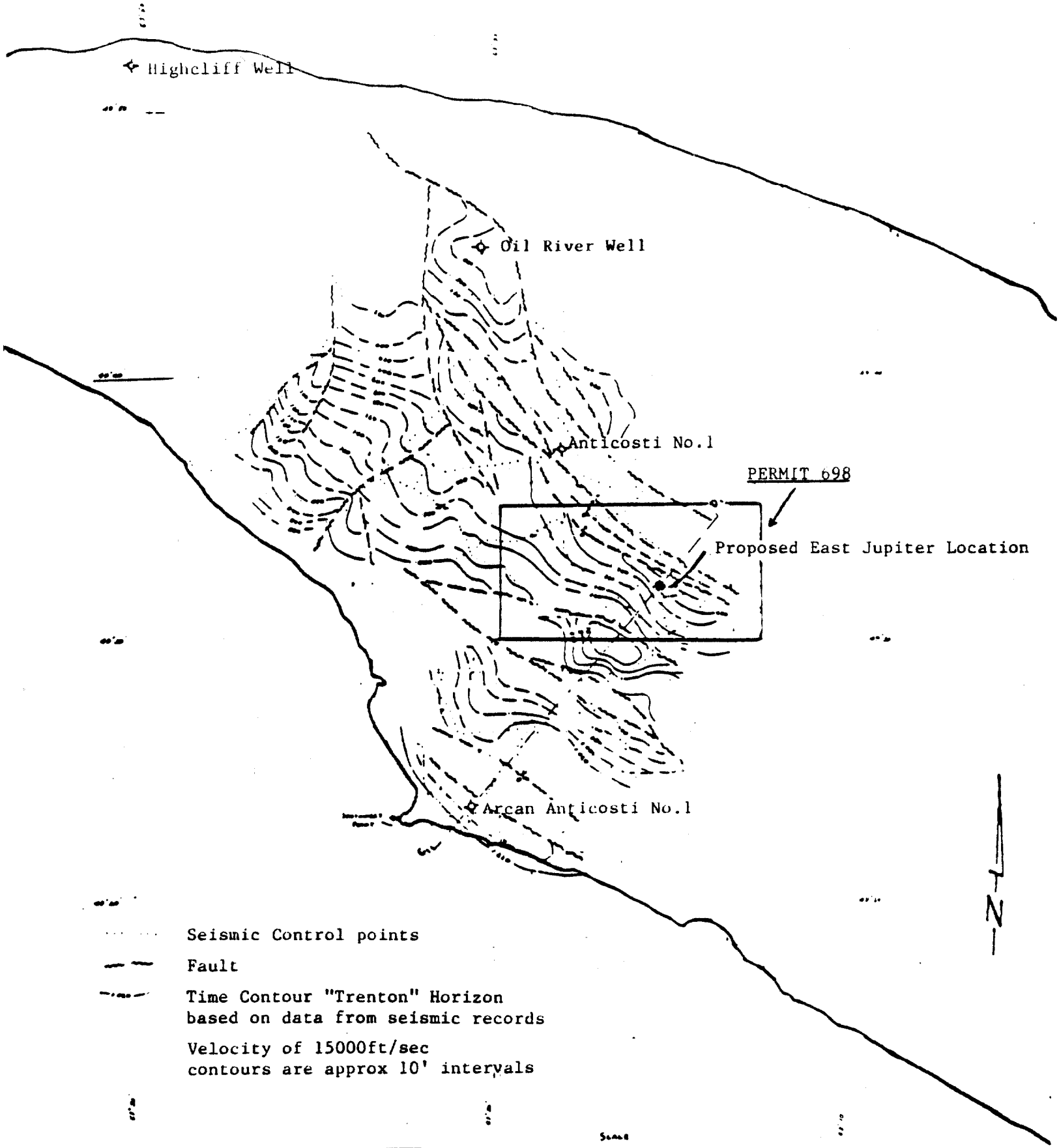

ANTICOSTI NO. 1
CARLETON PT.
PERMEABILITY
50 Md.
0
0
10
20%
TRENTON
CHAZY
BEEKMANTOWN
POROSITY
50 Md.
0
0
10
20%
5250'
5600'
5650'
5700'
5750'
2500'
2650'
3150'
DOLOMITE
SILTSTONE
SANDSTONE
SHALE

Figure 9

SEISMIC INTERPRETATION OF TRENTON HORIZON



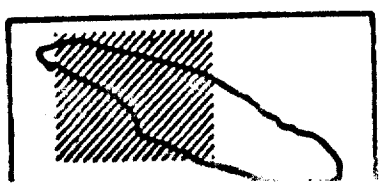


Figure 10

LONGITUDINAL CROSS SECTION

Arcan Anticosti No. 1 well to the proposed
East Jupiter No. 1 location
Reference Figure 10

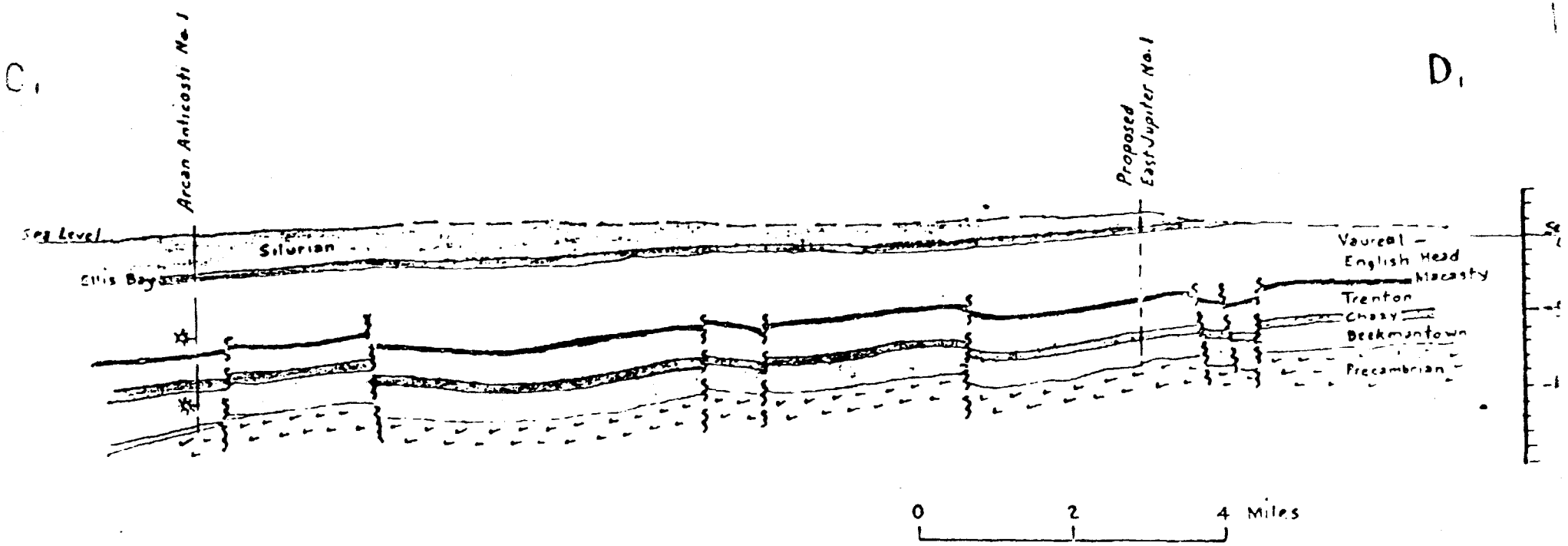


Figure 11

W.A. ROLIFF, Ph.D.

Petroleum Consultant

Telephone
(416) 423-2931

10 William Morgan Drive
Toronto, Ontario
M4H 1E7

I, William A. Roliff, of the City of Toronto, in the Province of Ontario, Canada, do hereby certify:-

1) that I am a Petroleum Consultant and reside at 10 William Morgan Drive, Toronto, Ontario, Canada;

2) that I am a fellow of the Geological Association of Canada;

3) that I have received from the University of London, England, the Bachelor of Science, Master of Science, and Doctor of Philosophy degree in geology;

4) that I have more than 25 years experience in the exploration for the production of oil and gas;

5) that I have no interest, direct or indirect in the properties discussed in this report;

6) that this report is based upon by study of maps and reports, related data in my files and an inspection of the site.

DATED this Second day of March 1985

W.A. Roliff

W.A. ROLIFF