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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 52

SEISMIC AND RESISTIVITY RECONNAISSANCE SURVEYS AT TROIS RIVIERES, QUEBEC

BY

GEORGE D. HOBSON AND J. E. WYDER

OTTAWA

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Illustration

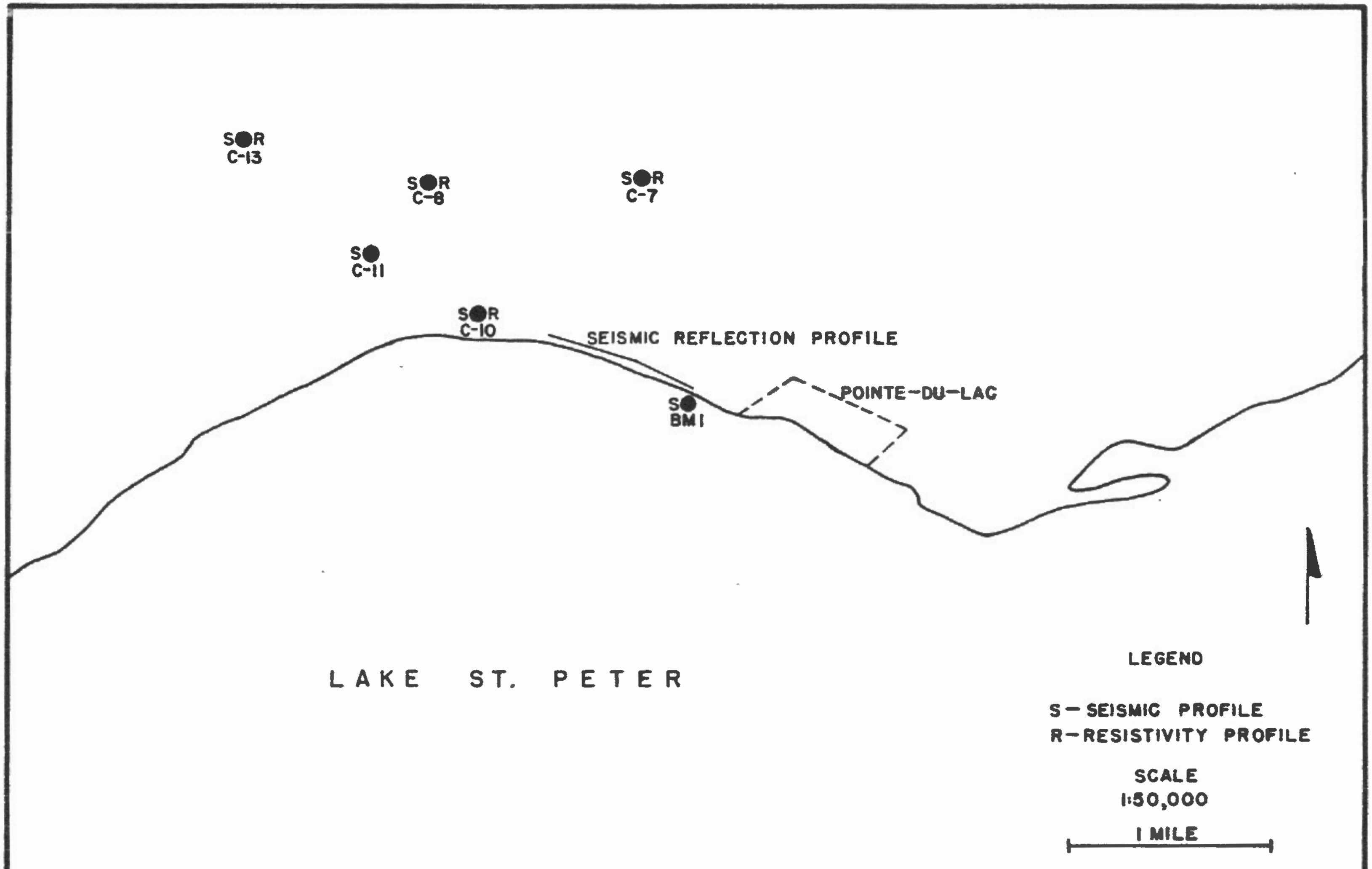
S●R
C-13
S●R
C-8
S●R
C-7
S●
C-11
S●R
C-10
SEISMIC REFLECTION PROFILE
S●
BM1
POINTE-DU-LAC
LAKE ST. PETER
LEGEND
S — SEISMIC PROFILE
R — RESISTIVITY PROFILE
SCALE
1:50,000
1 MILE

FIGURE 1

SEISMIC AND RESISTIVITY RECONNAISSANCE SURVEYS

AT

TROIS RIVIERES, QUEBEC

Introduction

The shallow gas field near Trois Rivieres, Quebec, has recently received much publicity in the trade journals as a geological oddity of considerable economic importance. Hammer seismic and D.C. resistivity geophysical surveying methods were applied to the problem of delineating this surficial-type gas field during the period October 20-24, 1961. The purpose of this field work was to evaluate the effectiveness of these geophysical methods and their associated interpretation techniques to determine the major geological features in this known geologic environment.

The area of interest is known as the Pointe-du-Lac gas field and is located on the north shore of Lake St. Peter in the St. Lawrence River some 8 miles west of Trois Rivieres, Quebec. Hammer seismic equipment, model FS-2 manufactured by Hunting Survey Corporation Limited, was used for determinations of depth to bedrock by seismic refraction techniques. A continuous reflection profile was also surveyed along the shore of the lake between five known wells using this same equipment. Seismocaps and primacord were used as a source of energy when the distance between source and detector became extensive. The resistivity equipment, developed by the Saskatchewan Research Council, is truck mounted. The locations of seismic and resistivity profiles are shown on the accompanying map, figure 1.

Local Geology

The subsurface geology has been interpreted mainly from the logs of holes[1] drilled during the early development of the Pointe-du-Lac gas field. The lack of physical descriptions of the various materials encountered in the holes has seriously thwarted attempts to interpolate the geology between drill holes.

In general, the geologic column consists of recent alluvial material overlying Pleistocene sediments that rest unconformably on a bedrock of Ordovician shales. A major pre-Pleistocene bedrock fault of uncertain attitude is thought to exist between drill holes C-10 and C-7[2]. This fault trends northeast - southwest.

Bedrock, which ranges in depth between 250 feet and 325 feet below surface, is thought to be Lorraine shale. However, in drill hole C-13 a bedrock of limestone (which may be a lens in the shale) was encountered at a depth of 325 feet. A layer of sand 10 feet to 50 feet thick rests unconformably on the bedrock. It is from this layer that most of the gas is recovered. The drill logs describe as "clay" the material immediately above this sand layer. This "clay", ranging from 50 feet to 150 feet in thickness, may be the Gentilly till. A second but gas-barren "sand" layer separates this "till" from Champlain Sea deposits. These latter sediments are 25 feet to 150 feet thick and are overlain by the High Terrace sands[3]. Some recent alluvial deposits occur along the shore of Lake St. Peter.

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[1] Drill logs submitted to Quebec Department of Mines.
[2] Personal communication R.D. Howie.
[3] N.R. Gadd, 1960, Surficial Geology of the Bécancour map-area, Quebec, Geol. Surv., Canada, paper 59-8.

The Seismic Method

The seismic velocity in the surficial sand layer is 3,000 - 3,500 feet/second. The velocity in the surficial clay is 4,300 - 5,300 feet/second. Bedrock in the area changes as evidenced by the logs of the deeper holes drilled within the gas field and its environs. The seismic velocity in the Lorraine shale is approximately 15,500 feet/second while the limestone encountered in hole C-13 appears to have a velocity of about 18,000 feet/second. It is customary practice in seismic interpretation to utilize first arrivals of seismic energy at a detector to determine the graph of time vs. distance and so determine the velocity of the seismic wave in various media. However, in the Trois Rivieres area, extensive use had to be made of later phases of energy. The recognition and use of these later phases tempers any statement of definitive velocities.

The following tabulation of the seismic data indicates the accuracy of the refraction survey:

Hole	Calculated depth to bedrock	Known depth to bedrock	% error
BM-1	?	238	
C-7	254	251	1.2
C-8	267	305	12.5
C-10	212	306	
C-11	271	302	10.3
C-13	319	321	0.6

The seismic profile at BM-1 was extended along the shore of the lake generally within 10 feet of the water. It was not extended to sufficient length to permit a reliable depth determination of bedrock because of the necessity of using large charges of explosive at energy sources near inhabited dwellings. The data from location C-10 is unreliable due to a poor velocity graph; bedrock was probably not penetrated. It is interesting to note that these two locations are near the water and geological or general near-surface conditions may not permit a reliable interpretation.

The reflection profile shot along the shore between the 5 adjacent Bald Mountain Oil Company wells, BM-1 to BM-5, was not as successful as the refraction profiles. This profile substantiates the previous statement that geological or general near-surface conditions along the shore may not be conducive to the use of the seismic method. Intervals of 200 feet between reflection data locations was used but it is now suggested that an interval of between 50 and 100 feet would give closer control and perhaps allow better correlation of the data. A tentative interpretation of the profile has been attempted and it would appear that the first clay-sand contact and the first sand-clay contact can be mapped by the reflection technique. Bedrock is not positively identifiable on the profile record. This is probably due to the fact that in the extensive sand layers at depth there is too great an attenuation of the energy initiated at surface to permit the recording of strong events at the detector. This may possibly be overcome by shooting small charges instead of using the hammer as an energy source.

The Resistivity Method

Resistivity depth probes using an expanding Wenner configuration and direct current equipment were completed at well sites C-7, C-8, C-10, and C-13. The data has been difficult to interpret. The sharp breaks in the apparent resistivity vs. "a" span plot preclude the use of a theoretical analysis of the curves. Therefore, the curves should be interpreted on an empirical basis.

The development of a good empirical method of interpretation for any given area requires data from many vertical resistivity profiles and correlatable geological control. An insufficient number of these profiles are available for the Trois Rivieres area. The empirical methods of interpretation developed for other areas have been applied to the field curves of this survey but none of these yield an interpretation that fits the known geology at each site.

Conclusions

1. Seismic methods can be used on land with confidence to determine the bedrock topography and perhaps two of the upper near-surface interfaces between clay and sand strata.

2. The seismic refraction technique is adaptable to the problem except in locations adjacent to the shore of the lake. This limit has not been defined.

3. The seismic reflection technique is probably applicable to the "inland" problem.

4. The percentage error computed in the above table indicates that reliable determinations of depth to approximately 300 feet can be made in the Trois Rivieres area using portable hammer seismic methods.

5. Both refraction and reflection seismic techniques will be more expensive than the conventional hammer seismic survey since seismocaps and small explosive charges are required for penetration of the seismic energy to the depths of interest.

6. An average of 4 refraction profiles could be completed in one day by three men using hammer equipment and a hand auger to drill shot holes.

7. The area of interest is well populated and therefore would be a difficult area in which to acquire complete coverage by refraction techniques.

8. Further attempts to outline the field by seismic methods should employ the reflection technique with spacings of 50 to 100 feet between stations.

9. The resistivity profiles obtained to date are not amenable to correct interpretation by standard interpretational methods.

10. The A.C. resistivity equipment presently under consideration for development should be field tested in this area in direct comparison with the data from the D.C. survey. Since good geological control is available, a method of interpretation may arise from a different technique.

11. The seismic sparker method could be employed offshore to delineate the structure associated with this gas field. The swells from the wakes of lake and ocean-going freighters may present operational problems.