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PAPER 69-18

A SEISMIC RECONNAISSANCE SURVEY OF THE ATHABASCA FORMATION, ALBERTA AND SASKATCHEWAN (Part of 74)

(A co-operative venture with the Saskatchewan Department of Mineral Resources)

(Report and 18 figures)

G. D. Hobson and H. A. MacAulay

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ABSTRACT

The Athabasca Formation covers an area of approximately 40,000 square miles of northern Saskatchewan and Alberta. A reconnaissance seismic refraction survey has revealed that the thickness of sedimentary rocks in this area exceeds 5,000 feet. Basement structural trends have been recognized and related to known geological features. The regional topography of the basement rocks has been determined from the seismic data, but the spacing of data is too great to indicate local basement relief which may be considerable.

Both refraction and reflection surveys have been conducted. The refraction technique is a useful tool and the reflection technique, using a portable hammer seismograph, shows promise.

A SEISMIC RECONNAISSANCE SURVEY OF THE ATHABASCA FORMATION, ALBERTA AND SASKATCHEWAN

(PART OF 74)

INTRODUCTION

The Athabasca Formation underlies an area of approximately 40,000 square miles south and southeast of Lake Athabasca, principally in northern Saskatchewan but with the westernmost portion extending into Alberta.

Until recently, the Athabasca Formation or the Athabasca Sandstone area as it is frequently called, attracted very little economic interest. The area has been the subject of investigation for several geologists and more recently (1967) has become an area of interest for several companies involved in the search for uranium. Due to the earlier lack of economic interest, virtually no boreholes have been drilled in the area to probe either the Athabasca Formation or the pre-Athabascan surface. A seismic team of the Geological Survey of Canada was sent into the area during the summer of 1962, 1963 and more recently in 1968 to explore the subsurface composition of the Athabasca Formation, the thickness of the formation, the nature of the Carswell Lake structure and the topography of the pre-Athabascan surface. The program in 1968 was carried out as a co-operative venture with the Saskatchewan Department of Mineral Resources.

Acknowledgments

The authors wish to record their thanks for the courtesies and assistance extended by McMurray Air Services and by Eldorado Mining and Refining Company; this assistance facilitated and expedited field operations on several occasions. Mr. J. Barber, Saskair 1963, and Mr. G. Greening, Norcanair 1968, did more than just fly aeroplanes; they assisted in the field operations and maintained a sense of humour for the crew. The authors also wish to acknowledge the able assistance in this project of the following: J.E. Murray (1962), R.A. Hodge (1963), R.M. Youngman, R.W. Parker, F.K. Maxwell and R.M. Gagné (1968).

BRIEF DESCRIPTION OF GEOLOGY

The Athabasca Formation, whose surface composition is predominantly sandstone, covers an area of approximately 40,000 square miles and overlies, with great unconformity, older Precambrian crystalline and metamorphic rocks.

Tyrrell and Dowling (1896) and McConnell (1893) were among the first to visit this area to investigate and describe the geology. McConnell (1893) named the Athabasca Formation in which he included the red bed

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sequence of rocks found to the north of Lake Athabasca as well as the flat-lying sandstones south of the Lake. Blake (1956) and Fahrig (1961) restricted the term 'Athabasca Formation' to the sediments lying in a basin-like structure south of Lake Athabasca. It is in this latter sense that 'Athabasca Formation' is applied in this report. Alcock (1920, 1936), Blake (1956), Gussow (1959 and Fahrig (1961) have described the Athabasca Formation in detail; portions of the area and the environs have been described by Sproule (1938, 1940), Sproule and Downie (1940), Sproule et al. (1940), Christie (1953), Fraser (1954), Hale (1954), Bell (1959, 1961, 1962 a, b) and Tremblay (1968).

McConnell (1893) placed the Athabasca Sandstone in the Paleozoic Era, suggesting the Cambrian Period while Blake (1956) assigned it to the late Precambrian or Proterozoic. In surface outcrops the Athabasca Formation consists chiefly of white to buff coloured sandstone with minor amounts of interbedded shale and conglomerate. Shale chip fragments are common throughout the entire sequence. The sandstone is composed of well-rounded quartz grains and samples of the sandstone are hard and well cemented in some areas and weak and friable in others. The heavy mineral content of the rocks exposed at surface appears to be low (Fahrig, 1961).

The Athabasca Formation is locally underlain by the Tazin Group which is composed of folded and metamorphosed sediments including carbonate rocks, quartzites, argillites and conglomerates (Tremblay, 1968). The major unconformity between the Athabasca Formation and the underlying Tazin Group is marked locally by a thin layer of conglomerate comprising rounded quartzite fragments. At some localities, the basement rocks are highly weathered immediately below the unconformity and a regolith up to eight feet thick has been described (Fahrig, 1961).

The Athabasca Formation is essentially flat-lying and dips of three to five degrees are common. Blake (1956) believed that the formation extended as a flat-lying sheet between Black Lake southeast to Wollaston Lake. Deformation on a regional scale appears to be slight although local folding and faulting have been observed. Ripple-marks and crossbedding have been observed in sandstone outcrops suggesting that the Athabasca Formation is predominantly of fluvial origin. Fahrig (1961) stated that the features of much of the exposed parts of the Athabasca Formation are characteristic of sedimentation in a stable platform area.

THE SEISMIC METHOD

Seismic refraction and reflection theory are described by Nettleton (1940) and Dobrin (1960). The 'intercept method' of computing depths from refraction data was used throughout the reduction of the data obtained from field studies.

The refraction technique was generally used throughout these investigations in a modified reversed profile manner. Seismic lines were extended until an interface was detected that transmitted seismic compressional wave energy at approximately 19,000 feet per second.

Conventional seismic instrumentation

A model 7000 B 12-channel seismic system manufactured by Texas Instruments was used to record seismic data during the 1963 survey whereas in 1968, a model 8000 instrument with 24 channels and made by the same manufacturer was used. In both cases geophones with a natural frequency of 7 cycles per second were used to detect seismic energy.

Summer operations 1963

Ninety-three locations were investigated between July 21 and August 22, 1963. The instruments and all auxiliary equipment were installed in a de Havilland Otter (DH-3) float-equipped aircraft which was landed on selected lakes throughout the area covered by the Athabasca Formation. The aircraft was secured to the shore of the lake and the detector spread was set out on land to a distance of 660 feet to accommodate the spread of 12 geophones spaced at intervals of 60 feet. The instruments remained in the aircraft while on location.

Small charges of explosive were detonated at each end of the detector spread, one in the water near the shore (but at a safe distance from the aircraft) and the other in a shallow hole in the overburden at the other end of the spread. This arrangement yielded a reversed profile giving velocity through the overburden and velocity data through the bedrock immediately below the overburden. Arrivals of energy from the pre-Athabascan basement refracting surface were recorded from inline offset shots detonated on the bottom of the lake. Access to these offset shot points was provided by an 11-foot inflatable rubber boat equipped with a 3 1/2 horsepower outboard motor. The offset shot-instants were transmitted to the recording instruments by radio tone. The distance from spread to shot was calculated from angle data procured by a theodolite. A typical spread layout for summer operations is shown in Figure 1.

Winter operations 1968

Twenty-six locations were investigated between March 20 and April 20, 1968. The seismic instruments and all other shooting and recording gear were transported to selected lakes in a ski-equipped Otter aircraft. Once again, the aircraft housed the seismic instruments while the location was being investigated.

It had been found that the survey conducted during the summer months was somewhat restricted by the fact that the spread was laid out on land and by the fact that some of the locations investigated were on lakes that were too small to permit long enough offsets for the energy to penetrate the pre-Athabascan surface. Better data were obtained during the winter survey of 1968 than during the summer survey of 1963. Several additional locations were investigated during 1968 but many key locations were re-shot where penetration to the basement complex had not been achieved earlier.

A 24-channel seismic instrument with a 3,000-foot geophone spread was used. A typical spread layout for winter operations is shown in Figure 2. A motorized toboggan with trailing sled was used to lay out and retrieve the geophones and cables and to transport ice drilling and shooting equipment

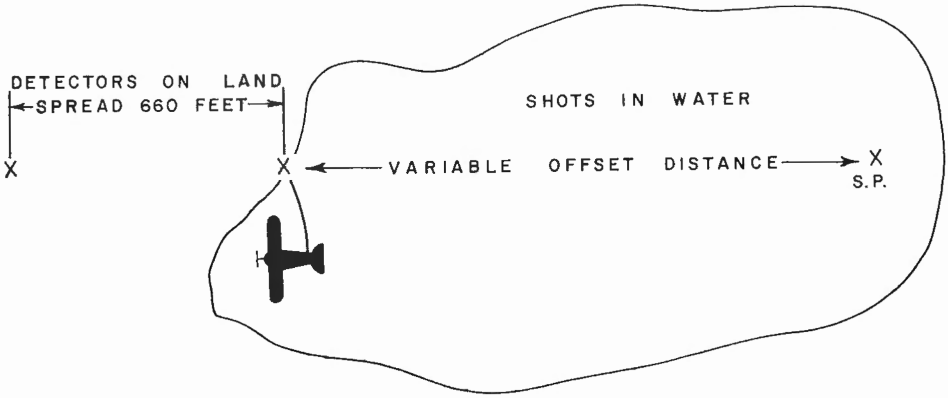

Figure 1. Typical spread layout for summer operation, detectors on land, shots in water.

along the profile. The aircraft was positioned on ice-covered lakes in a manner to provide adequate inline offset shot distances in at least one direction.

Arrivals of energy from the sandstone formation were recorded from shots usually located 1, 500 feet off both ends of the geophone spread. This offset of shot from spread was necessary in order to record the energy through the sandstone before the arrival of energy transmitted through the ice. Subsequent offset shots in one direction were placed generally at intervals of 3, 000 feet until a breakover into a high (pre-sandstone) velocity was recorded and observed. Wherever practicable, at least two shots were recorded at different distances beyond the breakover point.

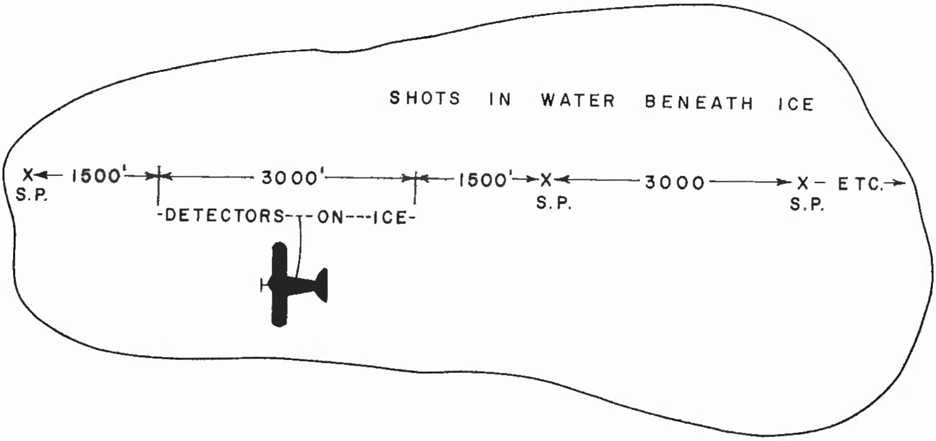

Figure 2. Typical spread layout for winter operation, detectors on ice, shots in water beneath ice.

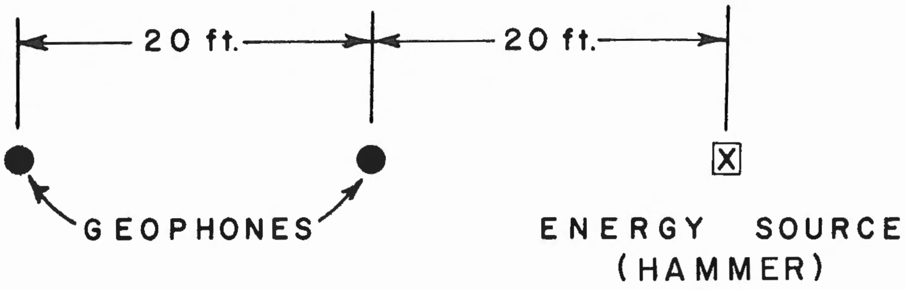

Figure 3. Configuration of energy source and geophones for reflection profiles utilizing FS-3 seismograph.

Useful secondary arrivals of energy were recorded only rarely so that almost total reliance was placed on the recording of first arrival energy from any refractor.

Charge sizes were mainly dependent upon shot-to-detector distance and depth of water in each lake, but rarely did shot size exceed 50 pounds of Geogel 60 per cent for offsets as great as 4 miles.

Hammer seismic instrumentation

Murray (1962), under sponsorship of the Geological Survey of Canada, participated in the first seismic project in the Athabasca area. His thesis reports on the use of an FS-2 facsimile seismograph built by Huntec Limited and a GT-2 seismograph built by Hall-Sears to investigate the seismic velocities associated with the Athabascan and pre-Athabascan rocks in the vicinity of the drillholes drilled in 1952 by Dee Explorations Limited. This survey was the forerunner to the surveys of 1963 and 1968 using conventional instrumentation.

In the period July 13 to 20, 1968 the senior author and a student assistant visited 8 locations in the sandstone area to investigate the feasibility of using a portable hammer seismograph in the reflection mode to detect interfaces, if such exist, within the Athabasca Formation and to determine the configuration of the pre-Athabascan surface. A model FS-3 seismograph by Huntec Limited was used. This instrument operates on the principle of a hot-wire recorder in which a stylus moves across electro-sensitive carbon-backed paper to record seismic energy as detected by two geophones. An 8-pound sledge hammer struck against a steel plate on the ground was adequate to supply energy detectable by the geophones as a reflected wave. The configuration of energy source and detectors is shown in Figure 3. These reflection experiments using the portable hammer seismograph were generally conducted over a distance of 1,000 to 1,400 feet along the shore of the lake. The frequent sand beaches provide an excellent location for carrying out such field investigations.

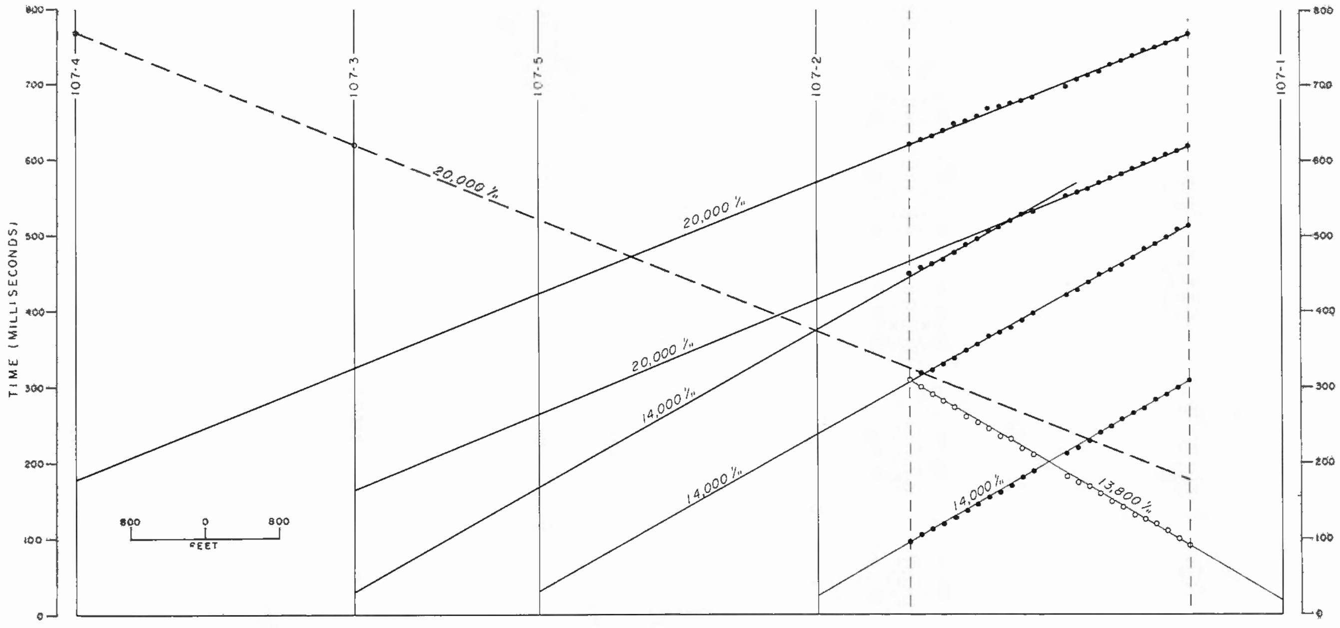

Figure 4. Time versus distance graph from profile 107.

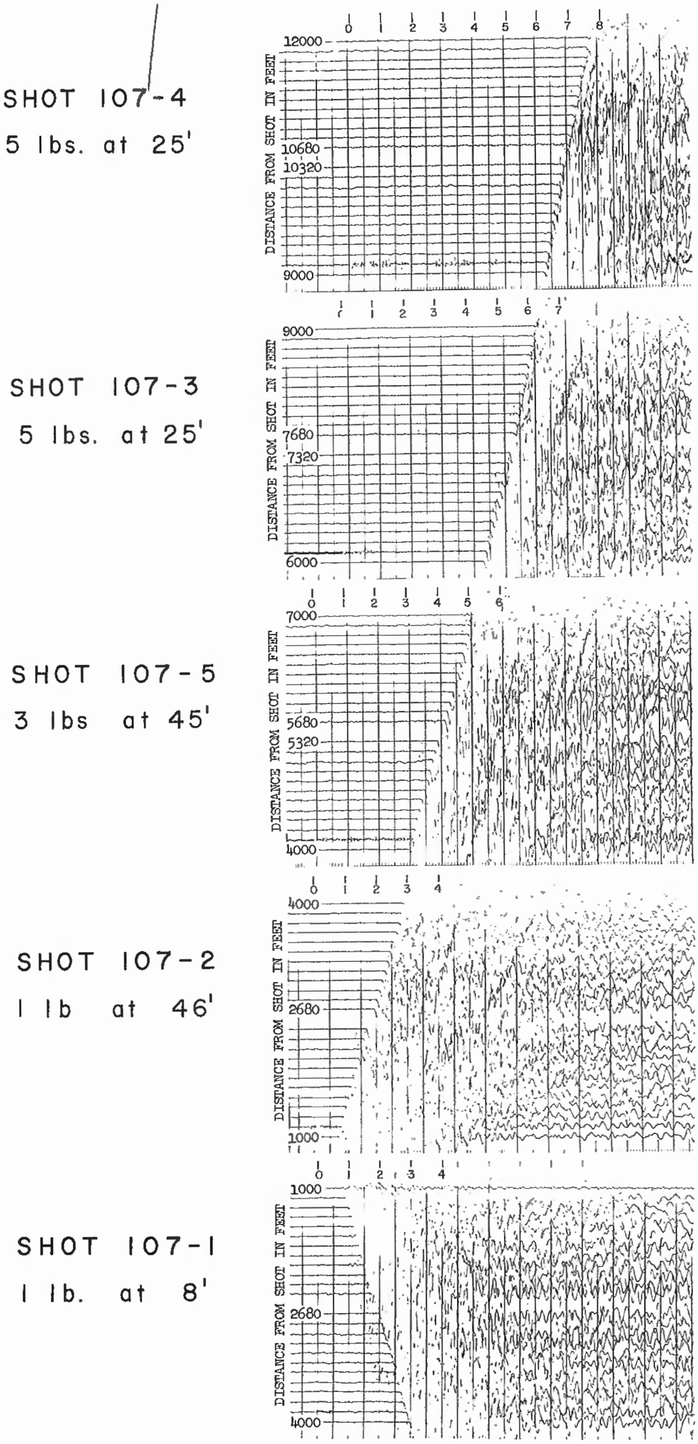

Figure 5. A typical suite of seismograms, profile 107.

RESULTS OF CONVENTIONAL REFRACTION SURVEYS

Velocities through the pre-Athabascan basement complex were determined at two locations north and south of the peripheral contact between the Athabasca Formation and the basement rocks. These velocity determinations, made on outcrops of granite gneiss, indicate a velocity of approximately 19,000 feet per second for the basement rocks. This value is an 'indicator' only and does not preclude the possibility of greater or lower values for velocity being observed for the basement complex refractor.

The profiles shot during the summer of 1963 were not reversed in respect to the basement complex refractor, therefore the depths calculated to this refractor are based solely on apparent velocities. If the apparent velocity observed on the time versus distance graphs were appreciably greater or less than the anticipated velocity of 19,000 feet per second, it was assumed that the discrepancy was induced by the slope of that lowest refractor. A mid-point depth to that refractor was determined using a time-intercept calculated on the basis of an assumed velocity of 19,000 feet per second. At locations where the offset shot distances were too short to permit observation of energy arrivals from the pre-Athabascan surface, minimum depths to that refractor were calculated using an assumed velocity of 19,000 feet per second.

The profiles shot during March-April, 1968 yielded better data from both the Athabasca Formation and the pre-Athabascan complex. Overlapping segments of energy arrivals from the 'sandstone' were consistently plotted. Arrivals of energy from the basement complex were usually recorded from two or three offset shots for each profile. With the geophone spread set in one location, the time from the shot to the most distant geophone could be plotted as a velocity segment in one direction and the reversed segment plotted at the spread position. The resulting segments do not overlap but if a plane refractor is assumed a measure of the true velocity and the slope of the refractor can be made. This is best illustrated by Figure 4, showing the time versus distance graph from data recorded at profile 107. Figure 5 shows the seismograms recorded at profile 107.

During the winter operations, the arrival of events transmitted at the water-bottom interface were obscured by the earlier arrival of energy transmitted through the surface layer of ice. It was therefore impossible to determine the velocity of seismic waves transmitted through the drift. A velocity of 5,000 feet per second was assigned to account for delay times associated with the water and unconsolidated subbottom material. This has no doubt led to errors in the depths calculated, but these errors should not be serious as the velocity through the subbottom materials probably varies in a range between 4,500 and 6,000 feet per second.

The velocity of seismic energy through the ice layer was observed to vary between 10,000 and 11,400 feet per second with a peak occurrence and average of 10,800 feet per second. The data from the summer survey indicates velocities for the Athabasca Formation that are less than this ice velocity. Therefore velocities for the 'sandstone' less than or equal to the ice velocity would not be observed. These low velocity values for the 'sandstone' observed during the summer survey were associated with the uppermost part of the Athabasca Formation and are probably attributable to weathering effects. Thus in some cases, part of the interval calculated as drift may in fact be upper sandstone beds; but delay times associated with this interval are small and cannot lead to large errors.

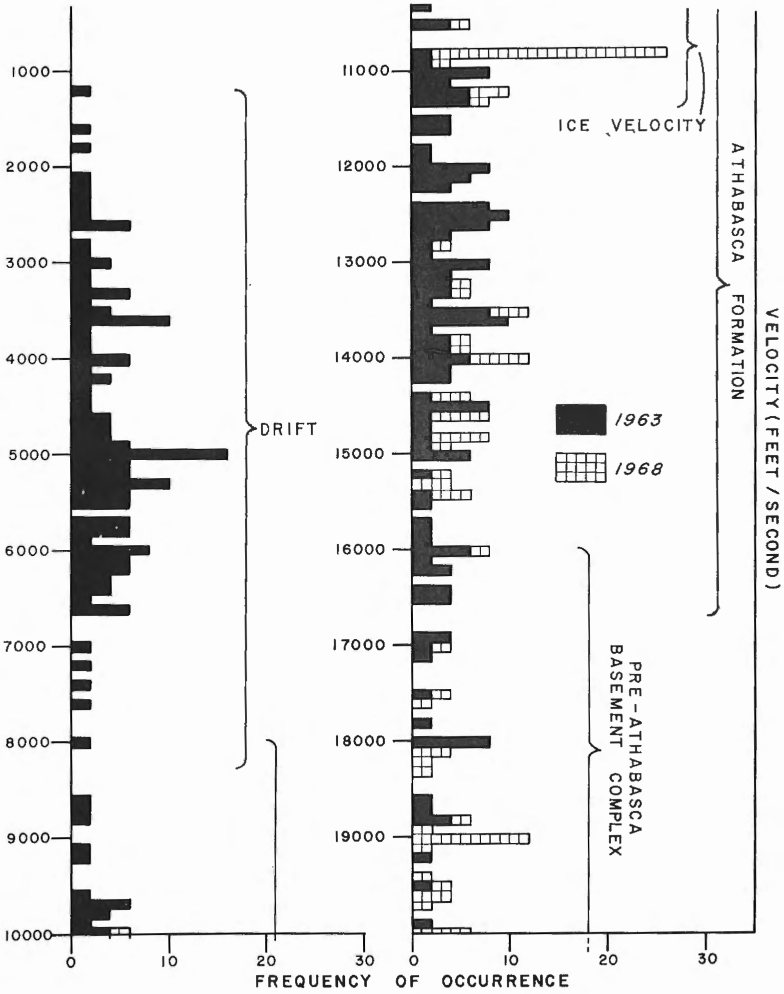

Figure 6. Histogram of velocities observed against frequency of occurrence, Athabasca Formation area.

For the reasons outlined above, a rigorous treatment of the seismic data was not possible or warranted. This approach does seem to be justified however when one considers the scope and the purpose of the survey.

Velocities

The velocity histogram of Figure 6 depicts the velocities observed and the interpreted velocity distribution. Velocities in drift, observed only during the summer operation, range from 1,200 to 8,100 feet per second. The sandstones of the Athabasca Formation display a wide velocity range, from 8,600 to possibly 16,500 feet per second with an average value of

13,300 feet per second. The range of velocities for the 'sandstone' during the winter operation is narrower because of the masking effect of the surface ice layer and is to be found in the high end of the Athabasca Formation velocity group.

Velocities in the range 16,000 to 21,000 feet per second are assigned to the rocks of the pre-Athabascan basement complex. Due to the apparent nature of the velocities shown on the histogram, there is an overlap of the velocities assigned to the Athabasca Formation and the pre-Athabascan basement complex. Incorrect assignment of velocities in this overlapping area may have led to errors in depth calculations at some locations. This was much less a problem with the data procured during the winter survey because essentially true velocities were observed and used in depth calculations.

As mentioned previously, it was the practice, where possible, to record arrivals of energy from the basement complex from at least two offset shots into the fixed geophone spread. At several locations the time versus distance graphs indicate a higher apparent velocity from the basement complex refractor for the more distant shots than from the closer shots which still penetrated and traversed the basement complex. In short, a velocity of 18,000 feet per second might be observed for a shot that supposedly penetrated the basement complex whereas the next shot, 3,000 feet farther from the geophone spread, yields data plotting up to a velocity of 20,000 feet per second. This perhaps suggests an increase in velocity with depth. It is uncertain from the data at hand whether this increase in velocity is discrete or is a gradual change. The difference in the calculated depth to the two apparent basement complex refractors is too great to be attributed to weathering of the uppermost part of the basement complex.

Pre-Athabascan topography

Figure 7 shows the general configuration of the pre-Athabascan surface topography referred to sea level. The contours are based mainly upon the total depths determined. Values, based on minimum depth calculations are also shown (in brackets) because they do point out that the pre-Athabascan surface must lie at least at, or probably below, the elevation indicated.

The lowest calculated elevation, 3,964 feet below sea-level, is located beneath profile 92 at Pasfield Lake in the east-central part of the area. A surface elevation at this profile of 1,347 feet above sea level indicates a total thickness of 5,260 feet for the Athabasca Formation.

The basement complex surface beneath the Carswell circular structure in the western part of the area has been contoured to conform to Fahrig's (1961, Fig. 5) hypothetical section across the circular structure. Seismic data from profile 98 on Carswell Lake and profile 95 on Cluff Lake in the southwest quadrant of the structure lend credence to this interpretation. At profile 95, the relatively low value of velocity from the basement complex as observed from shots southwest into the geophone spread, suggests that the pre-Athabascan surface is down slope toward the outer part of the feature marked by exposures of the Carswell Formation. Profile 98 crosses the exposed Carswell Formation; the depth to the basement complex calculated at this profile therefore includes Carswell Formation rocks. The velocity value

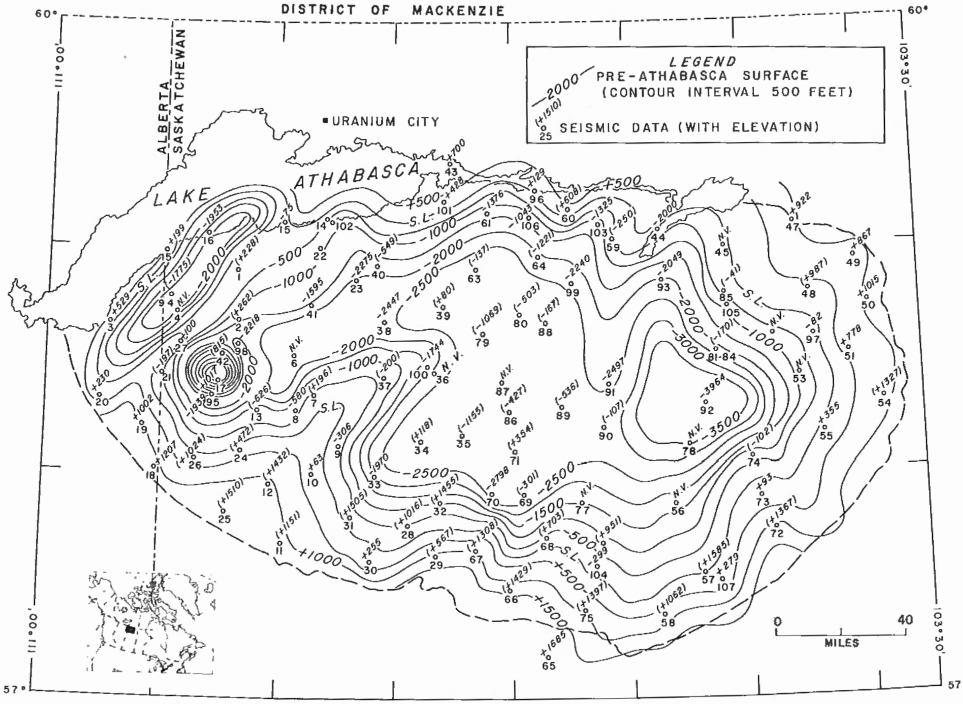

Figure 7. Pre-Athabascan topography, contour interval 500 feet, showing seismic locations and elevation of pre-Athabascan surface relative to sea level. Bracketed values of elevation are minimal values - the pre-Athabascan surface is probably deeper.

for the Carswell Formation appears to be within the range of velocities assigned to the Athabasca Formation thus preventing a reliable determination of the thickness of the Carswell dolomite. The velocities observed for this latter formation are lower than might be expected from dolomitic rocks but this may reflect deformation and brecciation due to structural stresses.

The contours outlining the elongated northeast-southwest trending trough north of the Carswell Lake circular structure are based mainly on data from profiles 16 and 94. At profile 16, the basement complex velocity was observed as a poorly defined secondary event. A minimum thickness for the Athabasca Formation was calculated at profile 94. However, if the interpretation is valid even in a general way some tectonic significance may be attached to the close alignment of this trough with the Black Bay Fault. This fault is shown on geological maps to be coincident with the Black Bay shoreline of the Crackingstone Peninsula on the north shore of Lake Athabasca.

An extension of the Black Lake Fault in the northeastern portion of the project area appears to coincide with a nosing feature on the pre-Athabascan surface. The proposed fault extension cannot be traced in detail with the seismic control available. However, closer seismic control may allow a definition of the fault in a southwesterly direction from Black Lake.

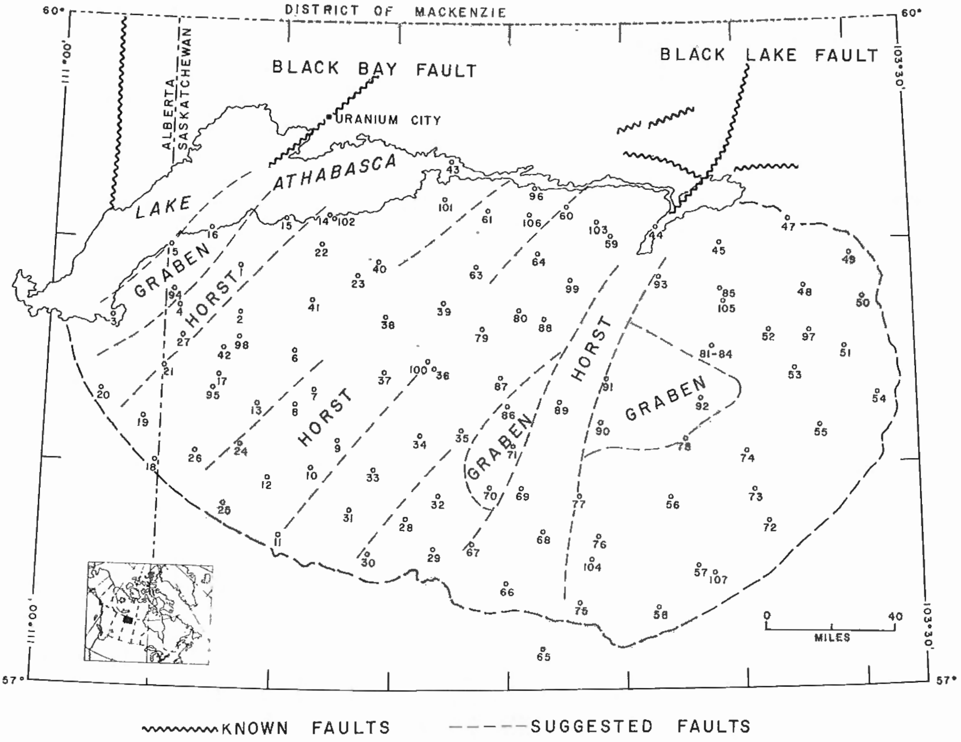

Figure 8. Geological implications of the seismic data, Athabasca Formation area.

The geological implications of the seismic data are suggested in Figure 8. Lineaments, suggested by sharp changes in direction of contour lines on Figure 7, may be faults in the pre-Athabascan basement complex. A graben may be present to the southeast of an extension of the Black Bay Fault whereas the nosing feature southwest from Black Lake may be a horst. The grabens may be infilled with Martin Formation. Indeed, the pre-Athabascan topography may be a series of horsts and grabens.

Athabasca Formation

Figure 9 is an isopachous map of the Athabasca sedimentary basin. The isopach indicates the thickness of the Athabasca Formation along with the possible underlying formations (Martin?) and local drift cover. Figures 7 and 9 display similar contour patterns for two reasons; there is relatively little surface relief over such an extensive area and the degree of control available permits only a general portrayal of the pre-Athabascan surface topography.

The cross-sections of Figure 10 indicate the thickness of the Athabasca Formation and, in a regional sense, the relief of the pre-Athabascan surface. The velocities indicated in cross-sections BB' and CC' for the

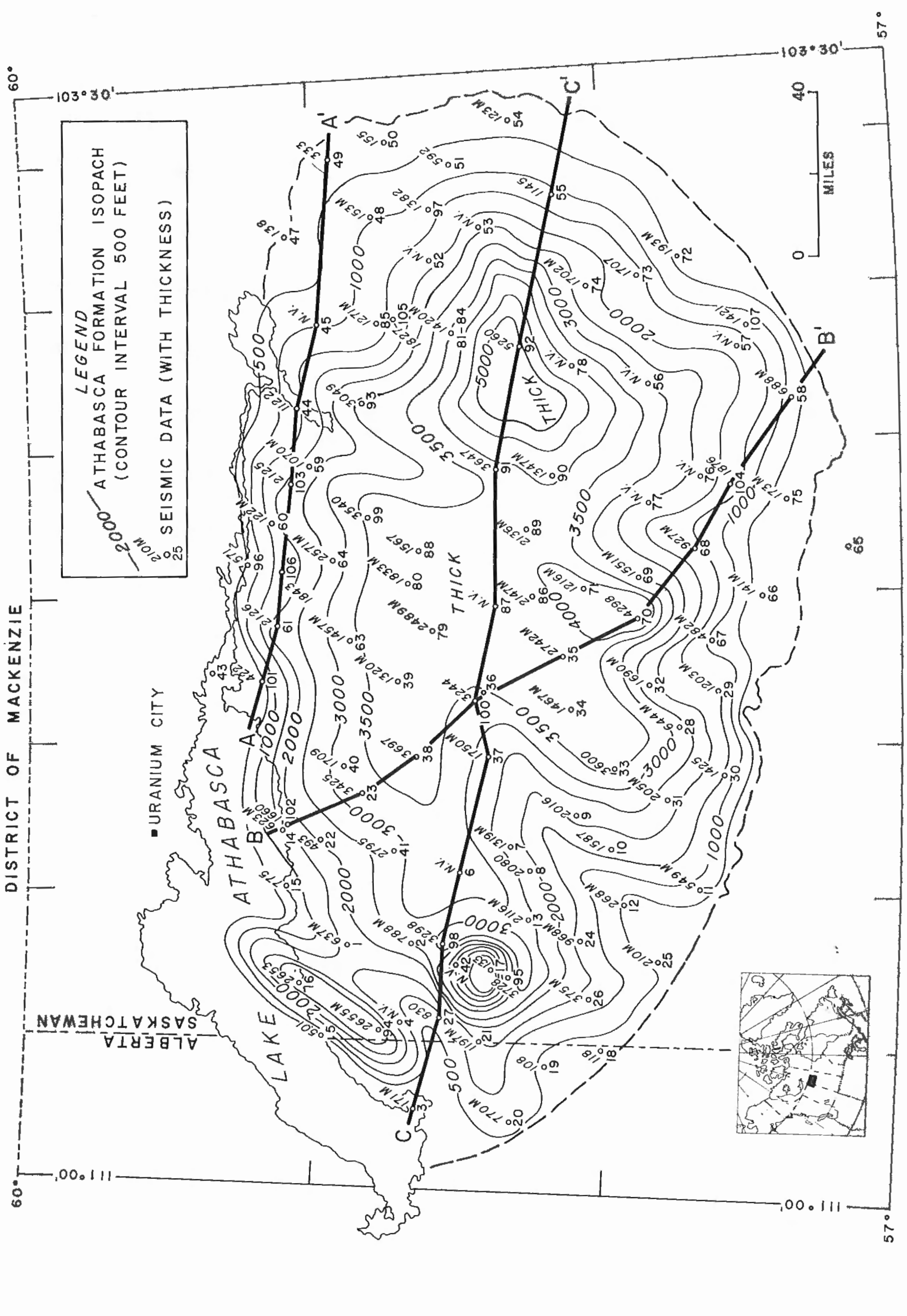

Figure 9. Thickness of Athabasca Formation, contour interval 500 feet, showing seismic locations and thickness of sandstone. M indicates computation of a minimum thickness.

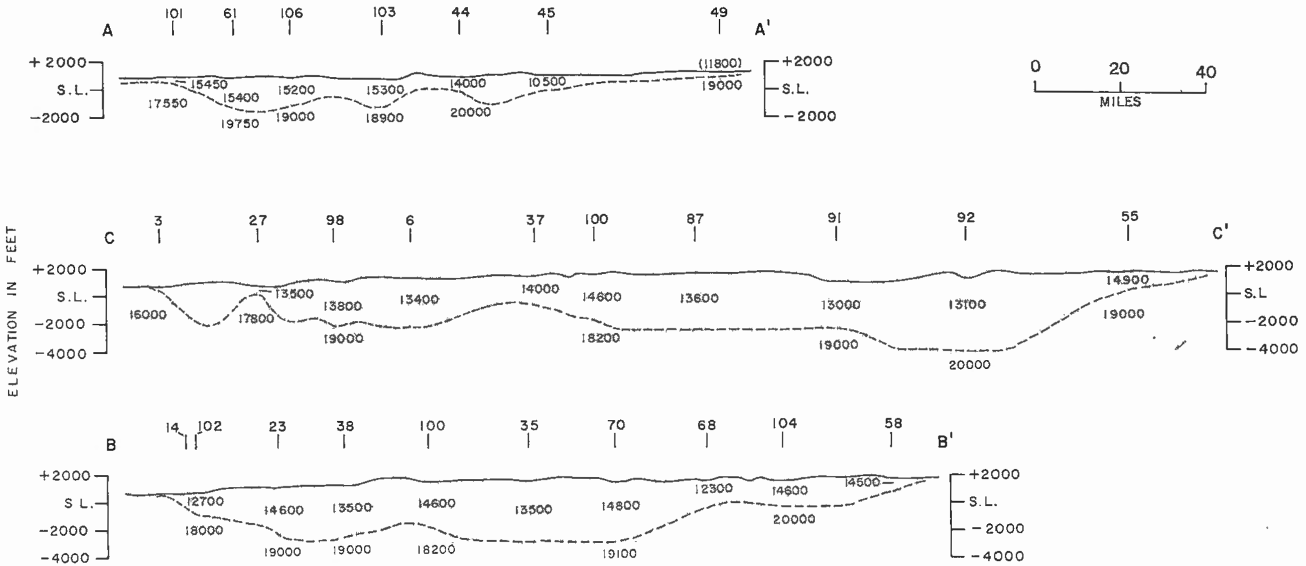

Figure 10. Cross-sections across Athabasca Formation.

Athabasca Formation do not vary greatly. However, those velocities associated with this formation beneath section AA' do vary considerably. It is noteworthy that between profiles 101 and 103 on section AA', velocities observed and assigned to the Athabasca Formation are relatively high and consistent when compared with the remainder of section AA' and the other sections. These higher velocities may be associated with lithologically distinctive lower beds of the Athabasca Formation or perhaps with the underlying Martin Formation which may extend beneath Lake Athabasca from the north to the south shore. Velocities of this order of magnitude were occasionally observed on records from offset shots in areas of thick section particularly in the north and northwest extents of the project area.

Martin Formation

The Martin Formation may underlie the Athabasca Formation in some parts of the sedimentary basin south of Lake Athabasca. If the Martin Formation does exist south of the lake it most likely will be found in basement lows. No seismic velocity data have been obtained over Martin Formation outcrops. Some of the observed velocities that are intermediate to those confidently assigned to either the Athabasca Formation or the basement complex may be associated with Martin rocks.

Drift

Drift thickness at most locations is generally less than 60 feet. Drift thicknesses greater than 100 feet were calculated at nine locations and at two of these it exceeded 200 feet.

RESULTS OF CONVENTIONAL REFLECTION SURVEYS

Events with normal but small moveouts were recorded at profiles 93 and 99. These events were recorded only from long offset shots and have two-way travel times in excess of three seconds. If these events are primary events they must originate from within the basement complex. They may also be multiples of primary reflections from the pre-Athabascan surface, the primary events not being recognized on these long offsets because they might be obscured by the arrival of refracted energy at the detectors at the same time. In short, the survey was not successful in recording reflections from the pre-Athabascan surface although efforts were made at 10 locations during April 1968.

RESULTS OF HAMMER SEISMIC REFLECTION SURVEYS

The reflection surveys conducted by the senior author at 8 locations during July 1968 yielded very interesting data. The following table sets out pertinent data known from the conventional refraction surveys before the reflection tests were conducted:

Location	horizontal sandstone velocity in feet per second	depth to pre-Athabascan surface in feet
44, Black Lake	14,000	1,122
55, Waterbury Lake	14,900	1,145
96, Shasko Bay	14,800	600
97, Durrant Lake	14,000	1,382
101, Helmer Lake	15,450	422
107, near Russell Lake	13,900	1,421
15, Catarra Lake	12,500	775
27, Bartlett Lake	12,500	830

Figures 11 to 18 are reproductions of the hammer seismograph reflection records for all locations. The profile at Black Lake, Figure 11, indicates an event at approximately 150 milliseconds which may be the pre-Athabascan surface. The event at 70 milliseconds is probably from within the Athabasca Formation.

The profile at Waterbury Lake, Figure 12, is poor in quality. Reflections are not distinguishable. The pre-Athabascan event should be present at approximately 150 milliseconds.

The profile at Shasko Bay, Figure 13, may show the pre-Athabascan reflector at about 100 milliseconds whereas the earlier events must be reflectors from within the 'sandstone'. The lowermost event is probably a multiple.

The excellent event at approximately 110 milliseconds on the Durrant Lake profile, Figure 14, must be from a reflector within the Athabasca Formation. This record exhibits an excellent direct wave through drift at 10 milliseconds.

The record at Helmer Lake, Figure 15, is probably the best example of an event associated with the pre-Athabascan surface. This event is that recorded at approximately 70 to 80 milliseconds.

The depth to the pre-Athabascan surface at Russell Lake (1,421 feet) is probably too deep to be recorded on the hammer seismograph without introducing the delay circuitry. The reflected events shown on this record at approximately 40 and 100 and 150 milliseconds (Fig. 16) must originate from within the Athabasca Formation.

Figure 17, Catarra Lake, probably shows the pre-Athabascan basement complex surface as the reflected event at 110 milliseconds. It is poorly defined in this example.

Reflected events are discernible on Figure 18 and these must originate from within the Athabasca sediments.

At all locations investigated the layout of geophones and source reduced the interference from the direct wave through the drift. The front end of all records could have been cleaner if the distance from source to geophones had been increased.

There is definitely an indication of considerable relief on the pre-Athabascan surface. The interpretation of the refraction data at several locations indicates the existence of a refracting interface or interfaces within the Athabasca Formation; this is supported by the reflection tests.

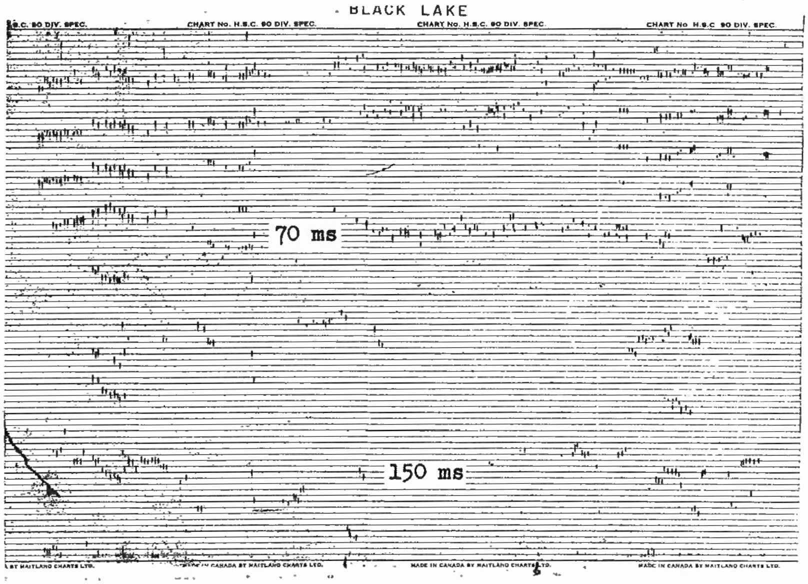

Figure 11. Reflection profile obtained by hammer seismograph, Black Lake.

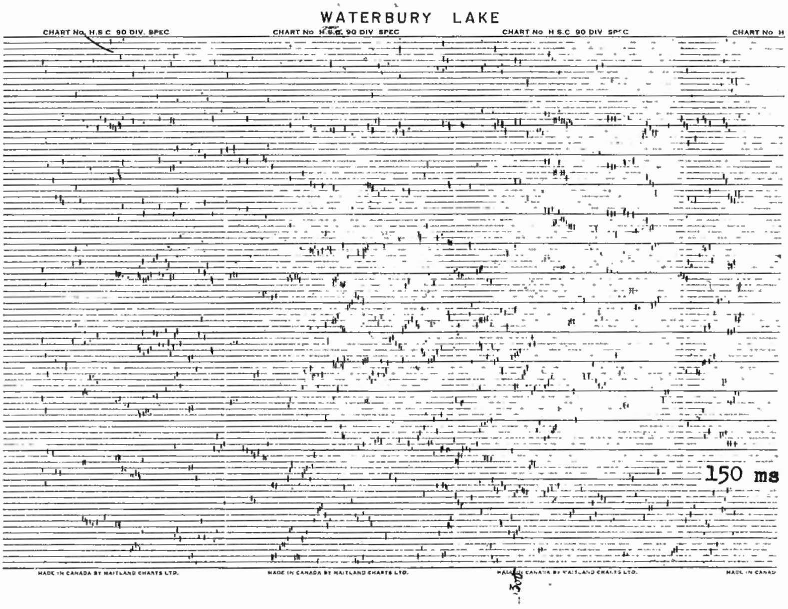

Figure 12. Reflection profile obtained by hammer seismograph, Waterbury Lake.

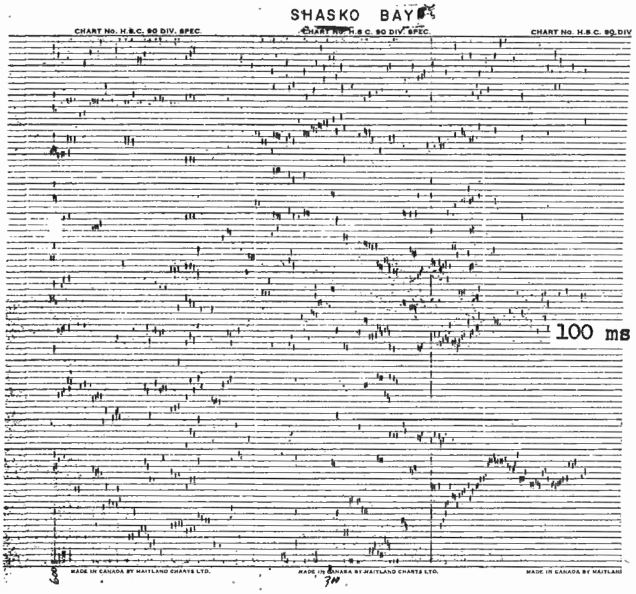

Figure 13. Reflection profile obtained by hammer seismograph, Shasko Bay.

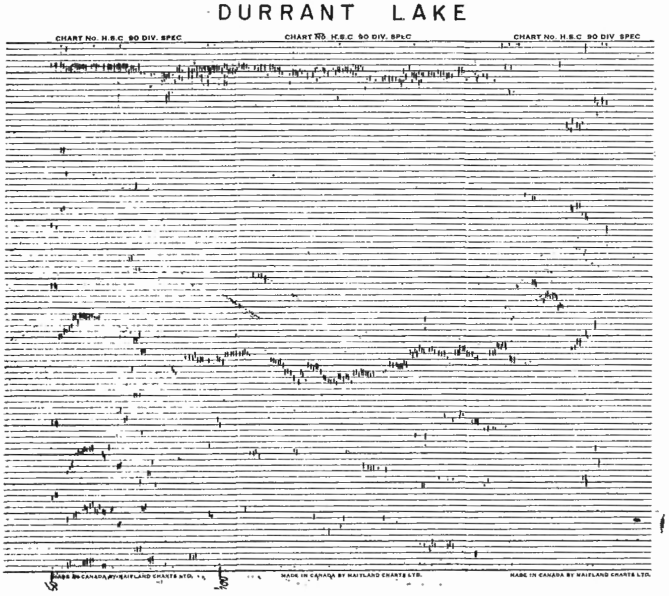

Figure 14. Reflection profile obtained by hammer seismograph, Durrant Lake.

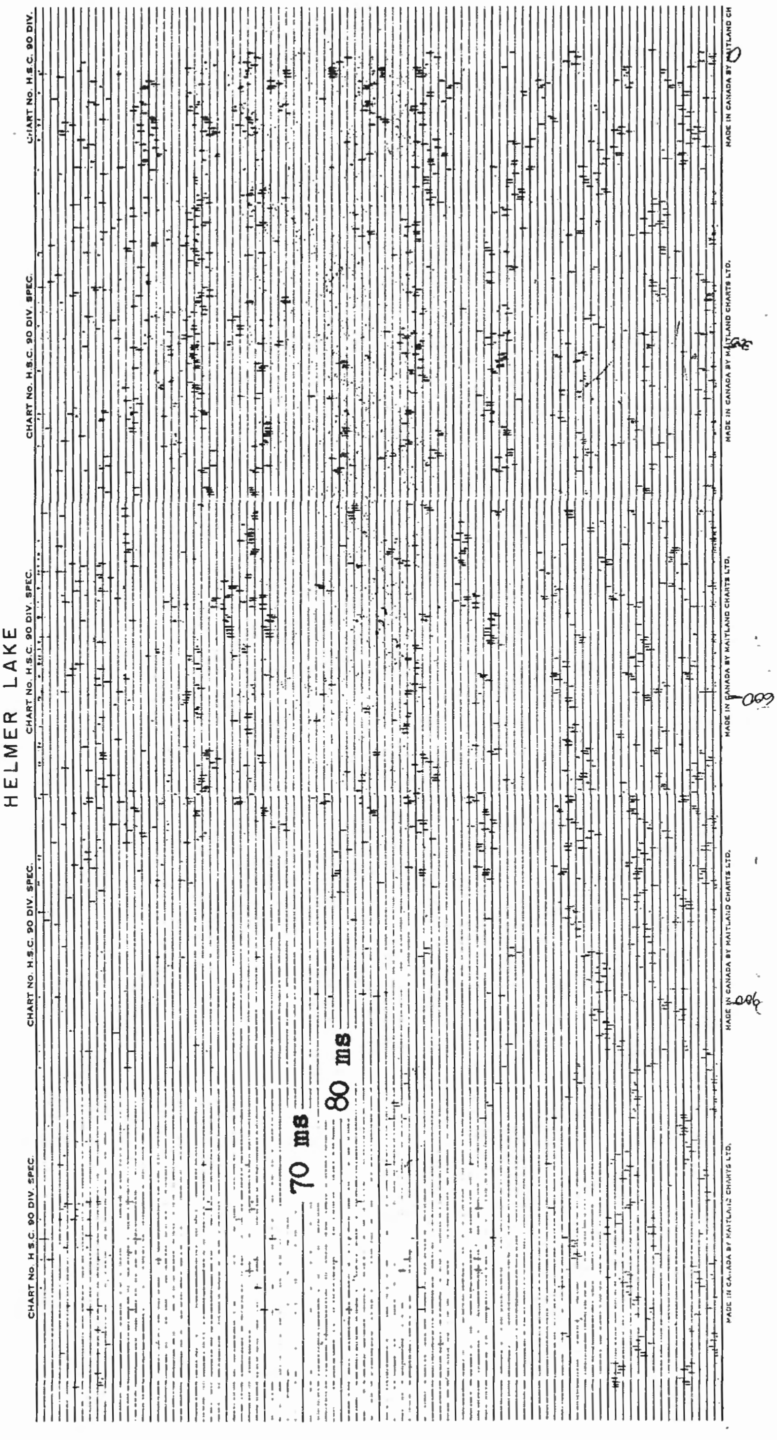

Figure 15. Reflection profile obtained by hammer seismograph, Helmer Lake.

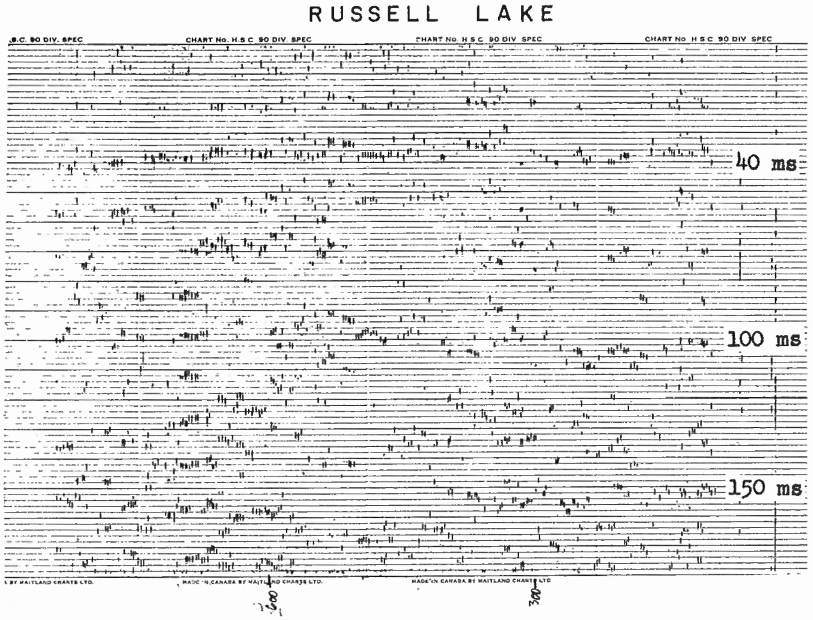

Figure 16. Reflection profile obtained by hammer seismograph, Russell Lake.

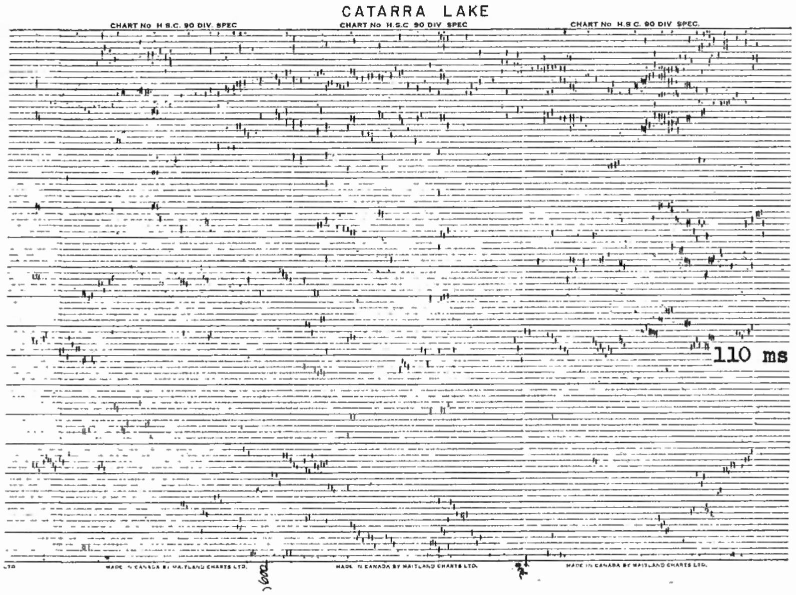

Figure 17. Reflection profile obtained by hammer seismograph, Catarra Lake.

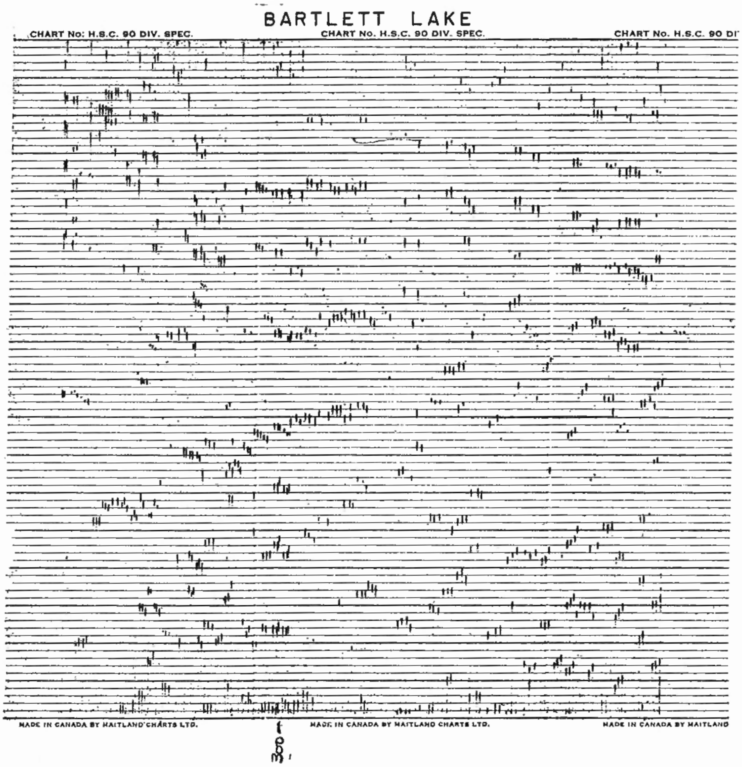

Figure 18. Reflection profile obtained by hammer seismograph, Bartlett Lake.

The feasibility tests of the portable hammer seismograph in this environment suggest that this instrument may be useful for mapping the pre-Athabascan basement topography to depths of approximately 1, 000 feet. It is anticipated that changes in relief on the basement surface of 50 feet could be mapped.

CONCLUSIONS

Seismic methods have been used to determine the thickness of the Athabasca Formation; if applied in detail, the topography of the pre-Athabascan surface probably could be defined. The seismic method should be considered in exploration programs in this area because of the good velocity contrast between the Athabasca Formation and the pre-Athabasca group of rocks.

A portable hammer seismograph used in the reflection mode has potential also as an exploration tool.

REFERENCES

Alcock, F. J.

1920: The Athabasca Series; Am. J. Sci., 4th series, vol. 50, No. 295, pp. 25-32.

1936: Geology of Lake Athabasca region, Saskatchewan; Geol. Surv. Can., Mem. 196.

Bell, C. K.

1959: Milliken Lake, sheet 1, Saskatchewan; Geol. Surv. Can., Map 38-1959.

1961: Milliken Lake, sheet 2, Saskatchewan; Geol. Surv. Can., Map 33-1961.

1962a: Milliken Lake, sheet 3, Saskatchewan; Geol. Surv. Can., Map 10-1962.

1962b: Milliken Lake, sheet 4, Saskatchewan; Geol. Surv. Can., Map 11-1962.

Blake, D. A. W.

1956: Geological notes on the region south of Lake Athabasca and Black Lake, Saskatchewan and Alberta; Geol. Surv. Can., Paper 55-33.

Christie, A. M.

1953: Goldfields - Martin Lake map-area, Saskatchewan; Geol. Surv. Can., Mem. 269.

Dobrin, M. B.

1960: Introduction to geophysical prospecting; McGraw-Hill, New York.

Fahrig, W. F.

1961: The geology of the Athabasca Formation; Geol. Surv. Can., Bull. 68.

Fraser, J. A.

1954: Crackingstone, Saskatchewan; Geol. Surv. Can., Paper 54-8.

Gussow, W. C.

1959: Athabasca Formation of western Canada; Bull. Geol. Soc. Am., vol. 70, pp. 1-18.

Hale, W. E.

1954: Black Lake map-area, Saskatchewan; Geol. Surv. Can., Paper 53-15.

McConnell, R. G.

1893: Report on a portion of the District of Athabasca; Geol. Surv. Can., Ann. Rept., vol. 5, Pt. 1D, 1890-91.

Murray, J. E.
1962: The application of the seismic refraction method in determining the thickness of the Athabasca Formation; unpublished B.Sc. thesis, Univ. Saskatchewan.

Nettleton, L. L.
1940: Geophysical prospecting for oil; McGraw-Hill, New York.

Sproule, J. C.
1938: Cree Lake, Saskatchewan; Geol. Surv. Can., Paper 38-9.

1940: Weitzel Lake, northern Saskatchewan; Geol. Surv. Can., Map 576A.

Sproule, J. C., and Downie, D. L.
1940: Brustad River, northern Saskatchewan; Geol. Surv. Can., Map 577A.

Sproule, J. C., Ells, S. C., and Downie, D. L.
1940: Upper Clearwater River, northern Saskatchewan; Geol. Surv. Can., Map 578A.

Tremblay, L. P.
1968: Geology of the Beaverlodge mining area, Saskatchewan; Geol. Surv. Can., Mem. 367.

Tyrrell, J. B., and Dowling, D. B.
1896: Report on the country between Athabasca Lake and Churchill River; Geol. Surv. Can., Ann. Rept. 1895, vol. 8, Pt. D.