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SUMMARY REPORT ON THE 1981 EXPLORATION PROGRAM IN THE JAMES BAY LOWLAND FOR ONTARIO ENERGY RESOURCES LIMITED

VOLUME I

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TABLE OF [illegible]

LIST OF TABLES

LIST OF FIGURES

MAPS

1. SUMMARY

The 1981 Ontario Energy Resources Limited (OERL) field program in the James Bay Lowland of northern Ontario centred largely on drilling for lignite in the eastern part of the exploratory licence area. The principal target areas included: the general area of the 1980 lignite discovery in the Mattagami River north of Grand Rapids; west of Portage Island near the confluence of the Missinaibi and Mattagami Rivers; along a surveyed line where an experimental ground resistivity survey was conducted; and farther west in the more central part of the basin where no previous work had been attempted. Secondary aims of the program involved: a systematic evaluation of heavy mineral concentrates of Pleistocene and Cretaceous clastic units, in an attempt to explore for diamonds, uranium, and precious and base metals; sampling and testing for possible oil shale units in the Devonian Long Rapids Formation; sampling and testing of silica sands and clay beds; and a very preliminary examination of peat occurrences in the eastern part of the licence area. Drilling was required due to lack of outcrop; and because of the very unconsolidated nature of the sediments in this region, a drilling combination consisting of a reverse-circulation system and triple-tube coring was used.

A significant lignite seam (approximately 5.2 m or 17 feet thick) was discovered in drillhole OEC-81-12 at relatively shallow depths (53 m). This discovery was a considerable distance from any previous lignite indications and has implications relevant to the entire central portion of the Cretaceous Basin. Certainly, it enhances the possibility of discovering major lignite reserves over a large area and at depths suitable for strip mining.

Minor but significant lignite occurrences were also noted in drillholes OEC-81-01, -03, -04, and -09.

A ground resistivity survey was attempted in order to evaluate its use as a tool for detecting the depth of the Pleistocene–Cretaceous contact. However, the resistivity contrasts were not sufficient to detect this contact and such surveys are unlikely to be useful for future lignite exploration in this area. On the other hand, the wireline logging system used in conjunction with the drilling proved very effective in locating lignite seams as well as providing geophysical signatures of sedimentary units. It also appears to be very useful for stratigraphic correlation and establishing sedimentary models.

The field and testing program indicated that the Cretaceous silica sands are quite pure and that there are substantial occurrences of fire clays that could have use as refractory material. The heavy mineral concentrates obtained from reverse-circulation drill cuttings did not indicate the presence of indicator minerals for diamonds nor other industrial or metallic commodities.

Analyses of selected shale samples from the Long Rapids Formation indicated total organic carbon contents consistently less than 5%. However, in drillhole OEC-81-05, near the Onakawana River, a 14.7 m intersection of shale averaged 6.1% total organic carbon, but yielded an average of only 3.1 gallons of organic condensates by Fischer assay. This suggests that hydroretorting is required for this portion of the formation to be at all economic.

Very preliminary testing of peat at the eastern end of the licence area indicates that there are large tonnages of good-quality peat located in several bogs, the thicknesses of which exceed 1.5 m over many hectares.

The results of the 1981 field program have clearly shown that the OERL licence area as well as areas north of the Missinaibi River have good potential for very large lignite reserves that may be at relatively shallow depths. It is strongly recommended that this potential be tested through an aggressive regional drilling program in conjunction with a detailed drilling program in the immediate vicinity of the major 1981 lignite discovery. Acquisition of additional land north of the Missinaibi River should be given serious consideration in view of the potential demonstrated by the 1981 discovery.

2. INTRODUCTION

2.1 GENERAL

This report summarizes the results of the 1981 field program in the James Bay Lowlands of northern Ontario (see Figure 1). This program was carried out in the period August 19 – November 11 and principally involved drilling in the eastern part of the OERL licence area.

2.2 LOCATION AND ACCESS

The OERL exploratory licence area covers 1,050,000 acres east of the Missinaibi River (see Map A in map folder). Land access is restricted to the Ontario Northland Railway line between Cochrane and Moosonee. This line, which includes two sidings at Onakawana, cuts across the most eastern corner of the licence area along the west bank of the Abitibi River. The ONR makes three weekly return runs throughout the year. During the summer months, additional daily return trips accommodate tourists visiting Moosonee.

An all-weather road to the Kipling Dam on the Mattagami River north of Smoky Falls provides access to areas very close to the southern boundary of the OERL licence area. In addition, a winter road was built in 1975 from Kipling Dam northwestward across the Missinaibi River to the north side of the Soweska River to facilitate a winter drilling program by the Geological Branch of the Ontario Division of Mines (now the Ontario Geological Survey); it cuts across the western end of the licence area. This road provides winter access to a large part of the area and would be of some use in the summer if all-terrain vehicles were used.

Both the Missinaibi and Mattagami Rivers are navigible by small craft.

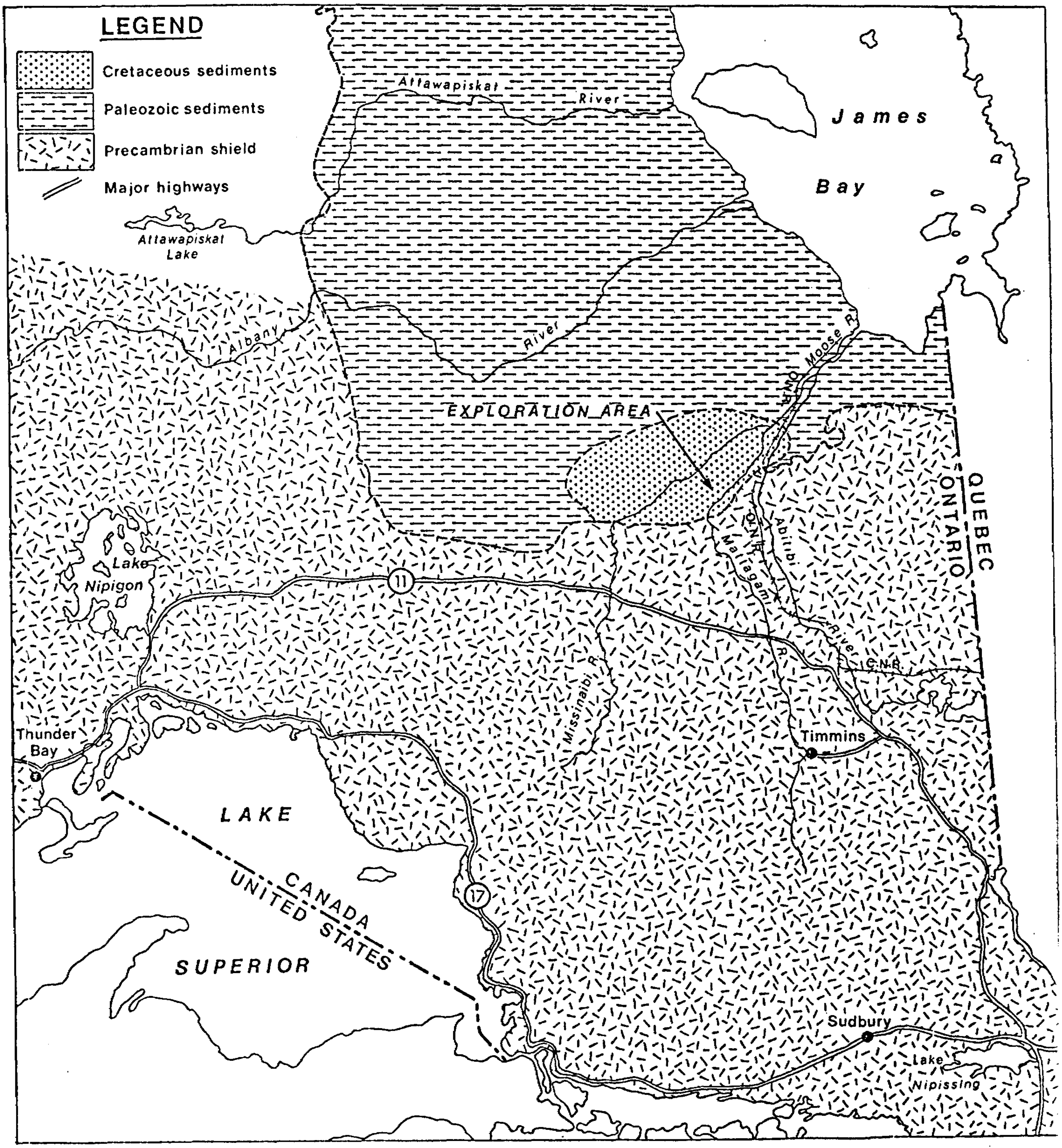


FIGURE 1: General location of the 1981 exploration area.

During the winter, most of the area would be accessible by all-terrain vehicles and snowmobiles. However, large all-terrain vehicles (such as Nodwells) would have difficulty crossing several of the rivers and ice bridges might be needed. In the summer, access is best provided by helicopters although small, shallow draft boats can be used on the major rivers.

2.3 GEOGRAPHY AND CLIMATE

The licence area is located along the southern edge of the James Bay Lowland, a plain bordering the west side of James Bay. Elevations reach maxima of approximately 150 m (500 feet) along the southern margin of the plain, whereas those in the northeastern part of the licence area, at the confluence of the Mattagami and Missinaibi Rivers, are approximately 60 m (200 feet) above sea level. This gives the plain a regional slope of approximately 1 m/km (see Figure 2). Most of the relief lies along stream channels, where moderately steep banks as high as 20 m occur along the major rivers (see Figure 3). These banks are usually capped by natural levees which are themselves a few metres above the flat, bog-covered areas (muskeg).

Vegetation in the licence area is sparsely distributed among extensive unconfined peat bogs (see Section 6.2.6 for further discussion of the peat deposits of the area). Most of these bogs contain stunted black spruce, although where drainage is good (usually along the edges of streams), much denser vegetation is present. Prevalent varieties of trees include spruce, pine, birch, and poplar, which in the fall provide a colourful contrast with the bog areas.

The average mean daily temperature in the lowlands is approximately 12°C (54°F). During the winter months, temperatures as low as -30°C (-22°F) are unexceptional; whereas during the summer months (early June to early September), temperatures of 25°–30°C (77°–86°F) are commonplace.

The mean annual precipitation is in the range 350–400 mm (approximately 15 inches), uniformly distributed throughout the year.

FIGURE 2: Grand Rapids on the Mattagami River. The area in the background is fairly typical of the eastern part of the licence area.

FIGURE 3: View along the Mattagami River. River banks are often steep and often quite high.

The 1981 field program was carried out from late August to early November. During this period the weather was generally good for effective field work. Very little time was lost due to poor weather, although small snowstorms occurred in October and November. Early morning ground fog occasionally delayed helicopter travel for several hours.

2.4 PREVIOUS WORK

Since the 1920s, the James Bay Lowlands have attracted considerable attention as a result of the known lignite occurences at Onakawana. No attempt will be made here to summarize work in the area, as this was discussed in the 1980 report by Watts, Griffis and McOuat Limited (WGM) as well as in several previously published reports — most of which are listed among the references at the end of this report. However, most of the previous work was focussed on the Onakawana occurrences at the east end of the Cretaceous sediments. Only limited reconnaissance drilling was done elsewhere in the basin (see Map A for previous drill sites) but by no means did this fully test the basin. Therefore, despite considerable literature on the region, very little is known about the regional geology. Certainly, very little has been done to test the potential for major lignite occurrences in areas other than part of the southern margin of the Cretaceous basin.

2.5 CONDITIONS AND RIGHTS OF THE EXPLORATION LICENCE

Exploration licence No. 14889 was issued to OERL in 1980. The licence is renewable annually for three years and covers an area of approximately 1,050,000 acres (≈425,000 ha) (see Figure 4). The permit requires exploration work expenditures acceptable to the Ontario Ministry of Natural Resources (OMNR) of $270,000 for the first year, $1.20/acre or $1,200,000 (whichever is greater) the second year, and the greater of $2.50/acre or $2,500,000 in the third year. Letters of credit must be posted by OERL each year for the exploration expenditures required that year. A $100,000 security must also be posted by OERL to ensure that obligations other than the

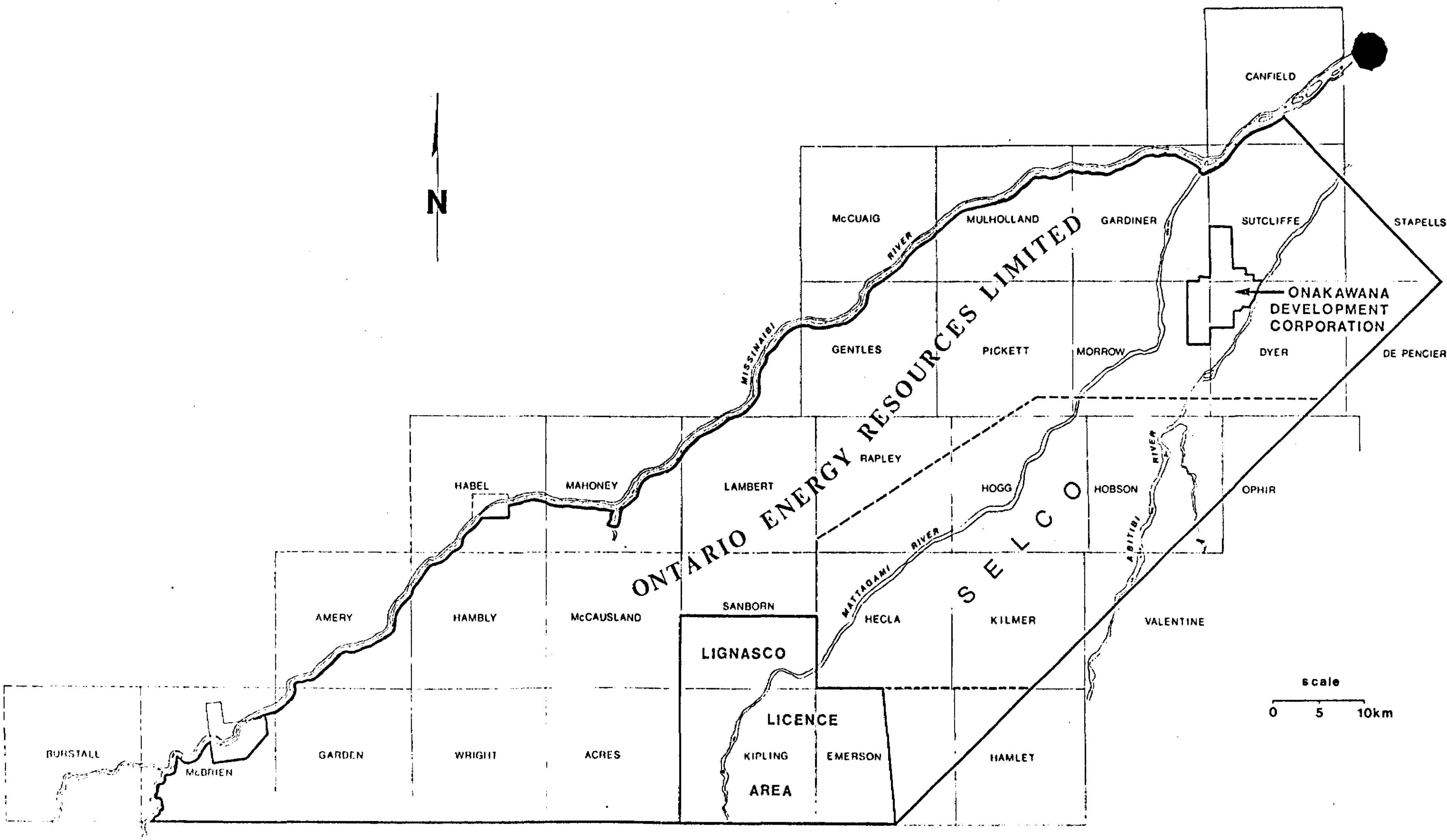


FIGURE 4: General outline of OERL licence area. A larger map is contained in the map pocket of this report.

exploration requirements are fulfilled. Finally, an annual licence fee of $1,000 is required.

The particulars of each year's exploration program must be submitted to the District Manager of the OMNR well before the start of each field season. Exploration expenditures and results must be fully explained and justified within 60 days of the annual exploration licence date. Representative core samples or drill cuttings must be taken on a regular basis and submitted to the OMNR. Any other core that is of no further use to OERL should also be submitted to the OMNR District Geologist in Timmins.

Exploration activity in the licence area must conform to regulations set out in a number of government acts covering various aspects of exploration and drilling.

The permit for exploration covers all minerals and includes the fossil fuels lignite, oil shale, and peat. Within the licence area held by Selco Inc. (a Canadian subsidiary of Selection Trust Ltd.), OERL has rights to carry out exploration for lignite and oil shale only.

In the 1981 program, all the necessary permits governing safety and environmental issues were granted by the OMNR. Senior OMNR personnel from both Timmins and Moosonee visited the work area on several occasions in order to ensure that all safety and environmental regulations were being strictly adhered to.

2.6 OBJECTIVES OF THE 1981 FIELD PROGRAM

The primary objective of the 1981 field program was to explore for lignite in three main areas:

(i) North of Grand Rapids on the Mattagami River where, in 1980, WGM field geologists reported a previously undiscovered exposure of lignite.

(ii) West of Portage Island, in an attempt to discover extensions of known occurrences on and near to Portage Island.

(iii) West of the Onakawana and Mattagami Rivers, where lignite was reported in Pleistocene units. A trial resistivity survey there was planned to test its effectiveness in detecting the Pleistocene–Cretaceous contract.

After testing the above target areas, it was intended that at least one drillhole be located near the Missinaibi River, well removed from any previous drilling.

Secondary aims of the exploration program included:

- Concentration and examination of heavy minerals to assess the possible occurrences of diamonds, gold, base metals, and uranium.
- Extension of several drillholes into the Devonian Long Rapids Formation to get fresh sample material for oil shale evaluation.
- Examination of Cretaceous units to discover and evaluate silica sand and clay occurrences.
- After the above program was underway, it was decided that a few of the larger peat bogs in the immediate vicinity of areas drilled would be examined briefly and sampled.

2.7 ACKNOWLEDGEMENTS

Wayne Brush, Manager of OERL, Project Officer Cara McCue, and Technical Co-ordinator Douglas McLean were most cooperative in assisting the project operations in all aspects of the 1981 program.

WGM personnel principally responsible for the 1981 drilling program included J. F. McOuat — senior consultant; R. J. Griffis — project manager; A. W. Stradling — project geologist; J. A. Rae — field engineer; and A. Aubé — field technician. This report was written principally by R. J. Griffis, A. W. Stradling, and R. H. Clayton.

Drilling was contracted to Bradley Brothers Limited of Timmins. The work was very effectively organized by G. Blais, and the drilling done by two first-rate drillers, R. Legault and R. Fournet. The drilling conditions commonly encountered in the James Bay Lowland are extremely difficult and the success of the 1981 program was to a large extent a result of the experience and efforts of the Bradley Brothers crew.

The helicopter contract was awarded to Viking Helicopters Limited of Ottawa, whose pilots, D. McCrea and J. Serpell, did outstanding jobs, often under very difficult flying conditions.

S. A. Averill of Overburden Drilling Management Limited (Ottawa) provided very good advice on problems related to reverse circulation drilling, and supervised the treatment and examination of heavy mineral concentrates.

Roke Oil Enterprises Ltd. (Calgary, Alberta) was awarded the contract for borehole geophysical logging. Keith Banks, K. Edwards, and D. Sim carried out the contract in an efficient and professional manner.

We would also like to acknowledge the cooperative efforts of various Ontario Ministry of Natural Resources personnel. These include: F. Wilson, W. Mackasey, and N. Luhta of Timmins; G. Wright in Cochrane; and B. Hutchinson at Moosonee.

3. LOGISTICS

3.1 FIELD CAMP AND SUPPLIES

The field camp (see Figures 5 and 6) was established on the west bank of the Mattagami River approximately 11 km west-southwest of the Onakawana railway siding and communications relay tower. Since most of the drilling was to be done west of the Mattagami River, returning to the base camp would be made easier without a river crossing if helicopter support were suspended. The west bank also offers greater protection from the prevailing northerly and westerly winds, which can be quite severe in the late summer and fall. The campsite was located fairly central to the planned drilling program to cut down on travel time to and from the various drillsites. The location turned out to be aesthetically pleasing and offered access to reasonably good drinking water as well as swimming in the early part of the field season.

The field camp consisted of ten framed canvas tents mounted on plywood floors and included one showering facility. The largest tents were rented from Bradley Brothers Limited, whereas the smaller ones had been previously purchased for the 1980 field program.

Bradley Brothers supplied a generator large enough to provide electricity for most tents as well as for refrigeration units. Heating and cooking facilities utilized propane gas purchased in Timmins and Cochrane. Several oil heaters were installed in late September, October, and November, when night temperatures frequently went below 0°C.

Food and hardware supplies were arranged through Carriere Supermarket in Cochrane, who not only supplied high-quality products but also expedited all supplies very efficiently. Supplies arrived at Onakawana on the regularly scheduled (Monday–Wednesday–Friday) trains and then were carried by helicopter to the field camp.

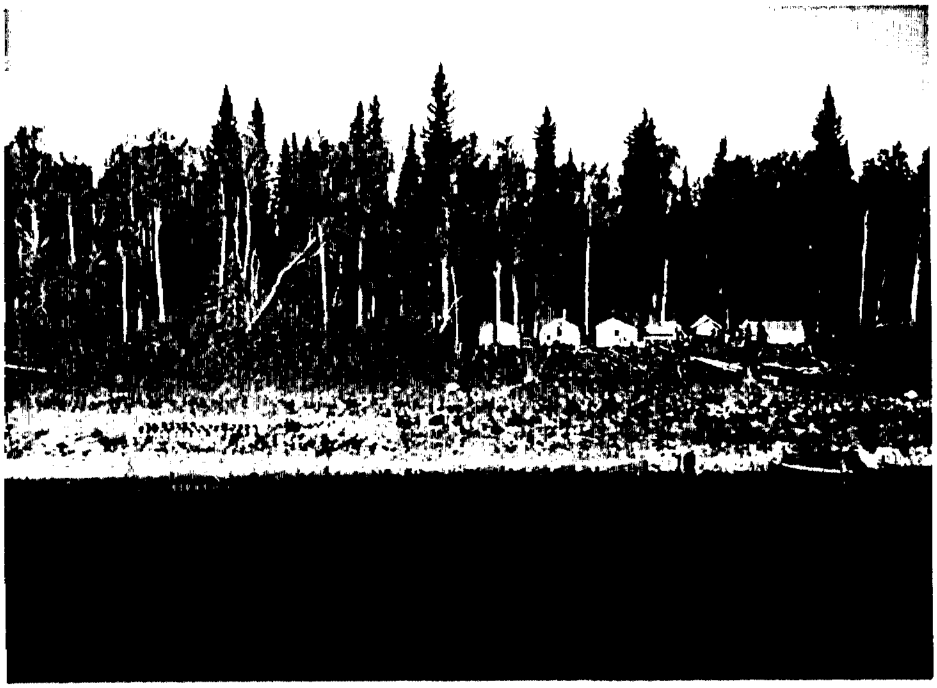


FIGURE 5: General view of the 1981 base camp.

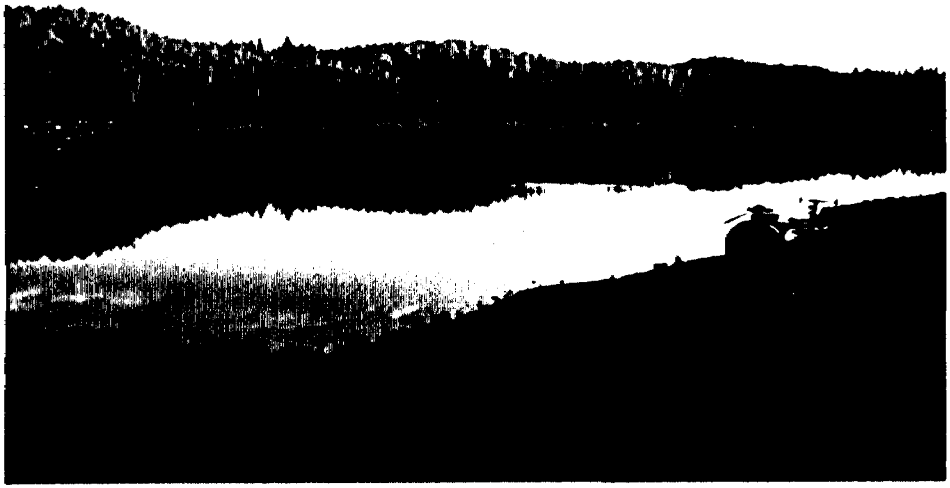


FIGURE 6: View from the base camp. Hughes 500D helicopter in right foreground.

3.2 HELICOPTER SUPPORT

The scope of the drill program indicated that the most cost-efficient method of moving drill rigs and supporting the field operations was to contract a small helicopter for the entire field season and to use a larger helicopter to assist during drill moves. The smaller helicopter was a Hughes 500D contracted from Viking Helicopters Limited of Ottawa. The 500D is a very rugged, high performance machine that is used extensively in Canada and Alaska to support drilling operations. The short blades permit it to land in tight spots and it has a good reputation for having few mechanical breakdowns. It has a drawback in that the cabin space is limited; it therefore is not often used solely for transporting personnel. In slinging equipment at low elevations, it consistently lifts as much as 1,400 lb (635 kg) when flying conditions are good (cool temperatures with a steady breeze).

Although the drilling contractor originally indicated that the heaviest drilling pieces would be less than 1,400 lb, the two largest items (pump and gears plus hoist drum) were in the weight range 1,450–1,700 lb. The 500D was unable to safely lift these, and therefore a larger aircraft was used to assist in drill moves. Selco, engaged in exploration nearby, kindly permitted us the use of an Astar 350 when it was not being used by them. For most of the drill moves, this worked out to our benefit: the aircraft was based at Onakawana, and there were minimal positioning charges. In addition, since the Astar was under long-term contract to Selco, there were no daily minimum charges. However, during much of October and November, the Astar was based in Timmins or Hearst and it was necessary to pay for considerable travel time. The Astar performed very well, although the heaviest piece (the water pump) was very close to its maximum lifting capability; in much warmer weather (i.e. mid-summer), it may have been unable to carry this item safely.

For one drill move when the Astar was unavailable, we chartered a Bell 206 Long Ranger from Timmins. This machine performed very well and seemed to have at least as good a lifting capability as the Astar.

FIGURE 7: Hughes 500D.

FIGURE 8: Astar 350D.

FIGURE 9: Loading the 500D at the Onakawana siding.

FIGURE 10: Slinging in auger equipment.

Preliminary field preparations were made over a period of five days in late July – early August. This consisted of chartering a Bell 206 Jet Ranger in Timmins, surveying the general lease area, and selecting and preparing a base campsite. Linecutting was also started, to provide accurate ground control for a resistivity survey to be carried out in late August. The Jet Ranger is a particularly reliable helicopter for such general field support operations, but its lifting capabilities and relatively long blades limit its use in hauling heavy drill equipment into and out of bushsites.

3.2.2 COST SUMMARY AND COMPARISON

A summary of data on the helicopters used in the 1981 program are presented in Table 1. Several points should be emphasized.

(i) The cost per hour for the Hughes 500D is surprisingly low because of the favourable contract offered by Viking Helicopters Limited. Work was carried out after the peak summer exploration season; the helicopter contracting business is in a lull period and therefore very competitive; and the contract was structured to include a substantial daily rental fee ($859 per day) and a minimal hourly charge ($87 per hour flown). This type of contract can be particulary beneficial if a lot of flying is necessary but will be relatively expensive if only a few hours are flown. On 1981 short-term contracts, the 500D was generally being charged at a rate of $350–375 per hour.

(ii) The Astar 350 helicopter used to assist in moving the heaviest drill equipment performed well. This French-built machine is fairly new on the North American market, and like any new high-performance machine, it has had mechanical problems that have given it a reputation for erratic performance and poor maintenance record. However, these limitations are being corrected and the machine shows much promise. It is particularly useful when a good range and a high cruising speed are needed (well over 400 miles with full fuel and cruising speed of 135 mph).

(iii) A Bell Long Ranger was used on one drill move because of the unavailability of a nearby Astar 350 and because we wanted to compare performance of the two aircraft under similar conditions. The Long Ranger proved to be very good, and if anything, may have a very slight edge in lifting capability over the Astar. It is also a very spacious helicopter, but has less range and lower cruising speed than the Astar. In the mining industry the Long Ranger has a very good reputation of high performance and an excellent low maintenance record. It is also slightly more expensive to charter than the Astar.

TABLE 1

SUMMARY OF INFORMATION ON HELICOPTERS USED ON 1981 EXPLORATION PROJECT

HELICOPTER	CONTRACTOR	LIFTING RANGE*	HOURS FLOWN	COST/ HOUR**	COMMENTS
Hughes 500D	Viking Helicopters, Ottawa	900–1,400 lb	360	$283.00 ✓	Very good performance machine. Cramped passenger space. Good maintenance records. Can get in and out of small landing spaces.
Aerospeciale Astar 350	North Star Helicopters, Hearst	1,200–1,700 lb	26	$445.00	Fast, spacious aircraft with great range capabilities. Poor maintenance record but improving.
Bell 206 Long Ranger	Huisson Aviation, Timmins	1,300–1,700 lb	7.4	$340.00	Spacious, rugged aircraft with limited range but very good performance and maintenance record.
Bell 206 Jet Ranger	Huisson Aviation, Timmins	1,300–1,700 lb	28.5	$480.00	Spacious aircraft with very good performance and maintenance record. Limited lifting capability. Needs relatively large landing area.

* Lifting range is very dependent on climatic and geographical conditions. The maximum lifts are only possible when the aircraft is low on fuel and the temperature and wind conditions are very favourable.

**These costs represent those incurred on this contract only. The Astar, Jet Ranger, and Long Ranger figures are fairly typical of short-term charter rates. None of the costs include fuel.

(iv) The Bell Jet Ranger is probably the most popular light helicopter in the western world and is used extensively in mineral exploration. It is used mostly to transport small crews and is considerably more comfortable to fly in than a Hughes 500. However, its lifting capabilities make it generally unsuitable for moving drill equipment. This helicopter has a very good maintenance and safety record. In 1981, long-term contracts for Jet Rangers included charges of $300-325 per hour.

(v) It would appear that over the next few years there will be a great deal of competition for helicopter contracts among the many Canadian helicopter companies. The trend towards structuring contracts on a daily rental charge plus minimal hourly charge will probably continue; in many programs, this can work out to the advantage of the exploration firm.

(vi) Because the Astar 350 is trying to establish a foothold in the Canadian mining industry, it is likely to be made available at modestly lower rates than it's main competion, the Long Ranger. To-date, its performance record in Canada has not been good, and for very remote operations where reliability is essential an improved maintenance record will matter considerably. For operations close to a major support base, such as in the James Bay Lowland, the Astar may prove considerably more economical than the Long Ranger.

(viii) Our experience in 1981 indicated that the three helicopter contractors dealt with were cooperative and the pilots, capable.

3.3 COMMUNICATIONS

Good communications are an essential part of modern-day field programs, especially those involving drilling, where mechanical breakdowns can be extremely costly or where accidents may necessitate immediate evacuation.

In the 1981 field program the following communications network was established:

(i) A portable telephone was rented from Ontario Northland Communications. This telephone operated through the Moosonee exchange and permitted generally good contact with the WGM office in Toronto as well as with the various contractors.

(ii) A portable radio in the base camp and at the drillsite were supplied by Bradley Brothers Limited, on the same frequency as a major receiver in their Timmins shop. This provided immediate contact with the shop if parts were needed.

(iii) The Viking helicopter had a radio that was able to contact nearby aircraft and, in some cases, the base stations nearby.

(iv) A telephone was available at the Onakawana railway siding that could be used if any of the above schemes were inoperable.

The communication system worked well, although for several weeks the portable telephone permitted only outgoing calls.

Additional communications would have been useful among geological field crews, the base camp, and the helicopter. Small portable field radios with a range of 30–50 km are available that would provide an important safety measure in the event of field emergencies such as injuries, fire, or the stranding of field crews by helicopter breakdown.

4. DRILLING TECHNIQUES

4.1 REVERSE CIRCULATION

Reverse circulation is a drilling system that came into use in the late 1960s, but only in the last few years has it been used extensively in Canada. This is a result of increased overburden drilling and sampling as an exploration tool in many parts of the Canadian Shield.

Reverse circulation utilizes drill rods with an inner and outer tube and, in most cases, a tricone bit (see Figure 11). Water is channelled down the outer tube, exits very close to the cutting face, and then enters the inner tube and back up the drill string. Any cuttings are carried up the inner tube and discharged at surface, usually at a high velocity. This system permits only very little fluid to pass up the outside of the drill string and consequently few cuttings are lost. Because the return water and cuttings are under high pressure, it is necessary to channel the returns into a cyclone before it is discharged into sample buckets (Figure 12) or settling tanks.

This system is most efficient for drilling through glacial overburden — tills, sands, and gravel. It is also effective when drilling through bedrock, although (as in almost any drill technique) hard rocks are penetrated slowly. Clay units are often difficult to penetrate, at least in part because they clog up the return tubes. The form of the return material is largely dependent on its original character and degree of consolidation (see Figure 13). Unconsolidated material returns as a muddy slurry, whereas competent bedrock returns as coarse angular fragments. The returns are usually passed through two coarse screens (6.3 mm and 1.70 mm) into the sample pails (see Figure 12). The material trapped on the screens permits rapid visual logging; after limited training, most geologists can make very accurate conclusions as to the character of the original material. Because of the velocity of the return, there is little lag between what is being drilled and what is being observed in the returns. Abrupt contacts can be logged easily and many sedimentary features inferred.

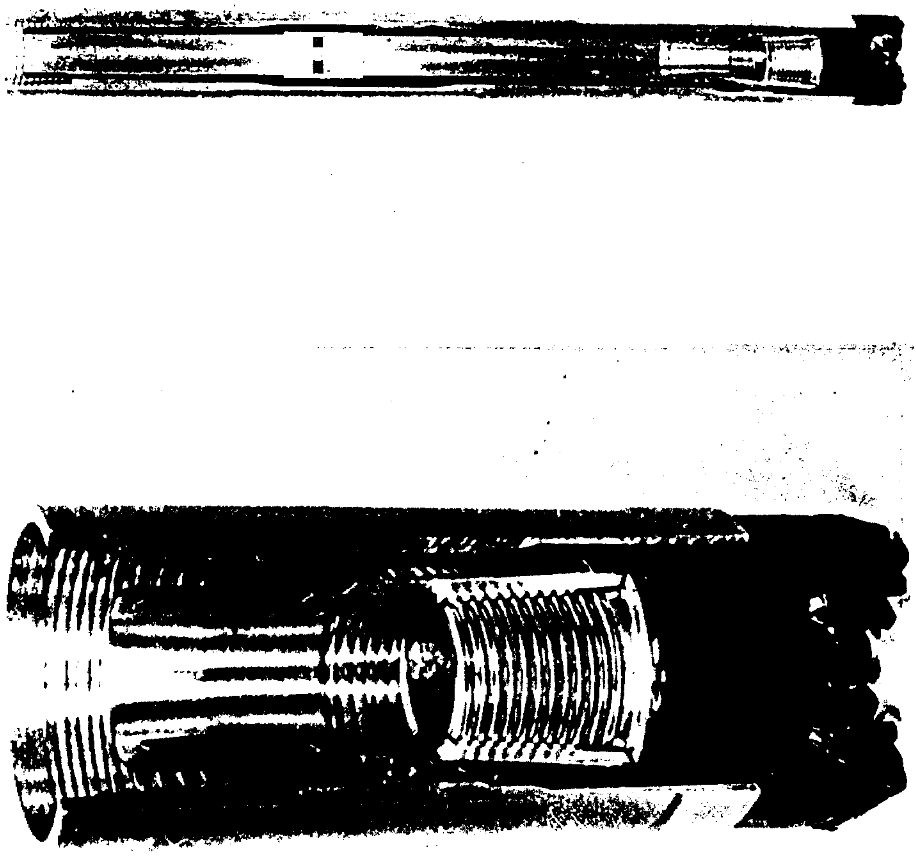


FIGURE 11: Reverse circulation drill rod and tricone bit (from Bradley Brothers).

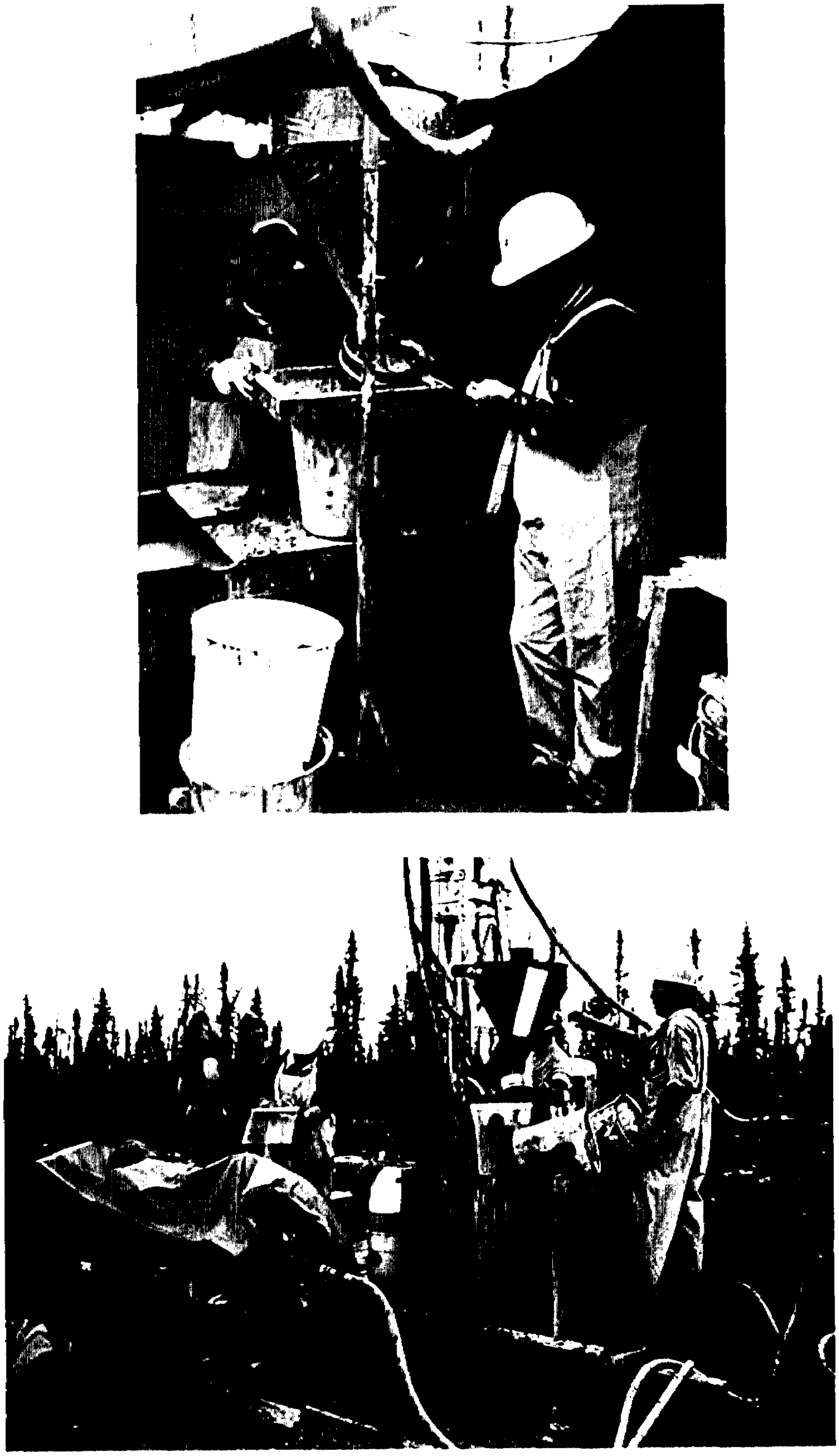


FIGURE 12: Reverse circulation sampling system. The discharge is slowed down by the cyclone and passed through one or two screens before emptying into plastic sample pails.

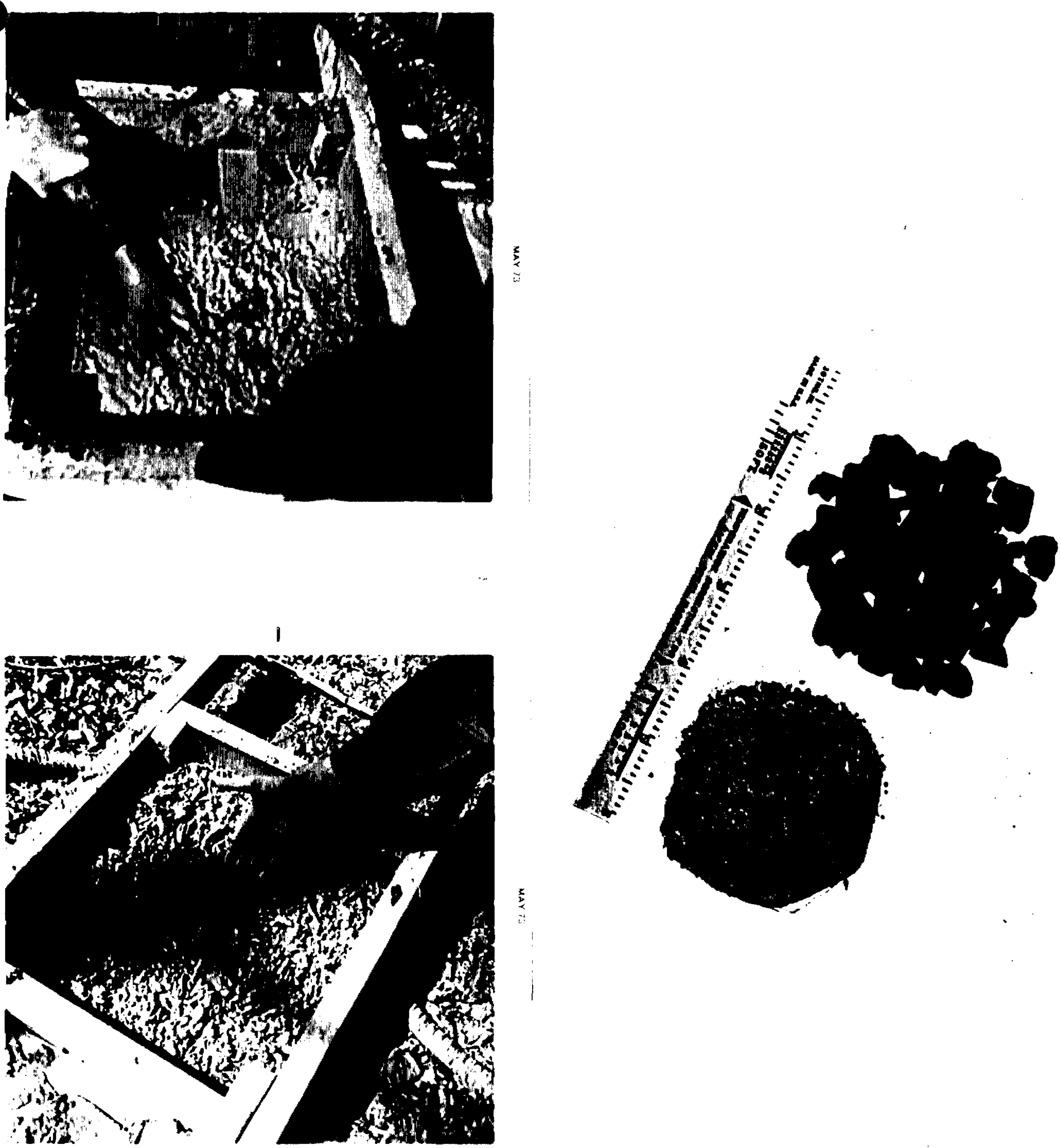


FIGURE 13: Sample material from reverse circulation drilling. Illustration at right shows character of sample cuttings for solid (black) and soft (grey) bedrock. At upper left the cuttings are being ejected through a coarse screen. At lower left the cuttings from a clayey unit.

Prior to the 1981 field program, it was recognized that the unconsolidated Cretaceous sediments would be almost impossible to core because the sands would simply fall out of the core barrel when it is retrieved. This prompted the decision to use the reverse circulation method because, almost always, sample returns are obtained and the drill equipment has been adapted so that it is possible to switch back and forth from reverse circulation to coring as geological conditions change.

Reverse circulation techniques require very experienced drillers; problems that arise can result in the loss of an entire drill string. Commonly, rapid drilling through the unconsolidated Cretaceous sands results in tight packing of the sands around the drill string. This eventually prevents the drill rods from being rotated or retrieved, and they then must be sheared off or left in the hole. Careful and patient drillers can usually avoid such problems.

In the James Bay Lowland, the Pleistocene deposits (marine clays and a variety of tills, sands, and gravel) are often competent enough to support open drillholes but the Cretaceous units, especially the sands and some clays, generally require some support. In some cases, heavy viscous muds (Quik Trol) can be pumped down the hole, packing the side walls enough to keep the holes from caving. In more extreme situations (usually when thick sands are encountered), it is necessary to sink metal casing past the point where serious caving occurs, retrieving the casing when the hole is completed.

4.2 TRIPLE-TUBE CORING

Under favourable circumstances, very soft sediments can be cored using standard diamond drilling techniques, augmented with a special core barrel. The advantage of having cores to sample are considerable if one is interested in obtaining geological information on small-scale sedimentary features. Such features can be important in defining the environments prevailing when the sediments were formed and can help to provide geological models that can be useful as exploration guides.

In the 1981 program, it was decided to core Cretaceous units whenever possible and to use reverse circulation when coring conditions were poor. This can be efficient, since virtually the same equipment is used other than the drill rods. To assist in coring, it was decided to use what is referred to as a triple-tube core barrel. This is a standard wireline core barrel with an additional thin metal inner tube that is split lengthwise. This inner tube protects the drilled core from disturbance. The core barrel produces a 4.76 cm diameter core (NQ size — equivalent to 1 7/8 inches) and proved to be very effective when drilling soft clays and even lignite. However, as expected, it was not possible to successfully core unconsolidated sands because the spring mechanism could not trap the loose sand.

When coring in Cretaceous units, drilling problems similar to those encountered in the reverse circulation system can occur. The most serious problem is likely to involve sanding-in of the drill string, which can result in losing the (expensive) core barrel and drill rods. To avoid such problems it is best to drive metal casing past any problem areas and to continually wash out the hole. This is necessary even after casing has been emplaced, because loose sands can get in between the drill string and the casing. This problem can be avoided by flushing the hole out regularly, drilling slowly through the loose sands, and advancing the casing systematically.

The soft Cretaceous and Paleozoic sediments are easily cored; thus, costs for drill bits and casing shoes are low.

4.3 AUGERING

In 1980, a J. K. Smit Winkie auger (model GW-15) was used to explore along many of the main rivers in and adjacent to the licence area. This preliminary investigation, to detect relatively shallow lignite beds, is described in the WGM report dated April 2, 1981. Although the method was used successfully in several areas, augering could not penetrate any of the Pleistocene or Recent deposits where boulders and cobbles were widespread. Because of these limitations, augering was restricted in the 1981 field program to areas where near-surface exposures were known. The augering was carried out along the banks of the Mattagami River, approximately 12 km southwest of the base camp (see Map B).

This Winkie drill (see Figure 14) is easily portable by small helicopter and can be operated by one driller, although it is more efficient and safer to have a drill assistant. A carbide auger bit is attached to 91 cm (3 feet) long vertical flight augers that are connected as the hole advances. A tripod is set up over the hole to pull the string of flight augers from the hole.

Augering is best used as a general exploratory method because of its depth limitations (maximum of 30–40 m) and because it is difficult to log accurately: sample contamination or mixing is unavoidable as the augers are removed from the hole. However, when drilling conditions are suitable, an experienced driller can produce results that can be very useful for geological interpretations. It certainly can reveal the presence and general character of lignite beds.

4.4 DRILL SUMMARY

Statistics on the 1981 drilling program are summarized in Tables 2, 3, and 4. A copy of the drill contract is included in the appendix of this report. The drill program was carried out generally as expected. The original goals (approximately 14 holes and 1,200 m) were not quite achieved, principally because serious drill problems encountered in hole OEC-81-02 caused a delay of one week. In addition, the length of time required to complete drill moves was slightly longer than expected. This resulted from having to set out long water lines, since many of the holes were not located adjacent to an adequate water supply. The program was terminated after the twelfth drillhole on November 7.

Consumable costs (Table 3) in the drill program were modest. In several holes metal casing could not be removed. All the plastic casing was left in the holes in anticipation of a decision to deepen the holes in a later drill program. Also, if plastic casing is left in a hole for more than a few days, it is likely that it will shear off at the connecting threads when removed, since the clays and sands will pack around the walls very tightly. The fact that more casing and drill rods were not lost in the drill holes is largely a reflection of the competence and patience of the drillers. For example, the

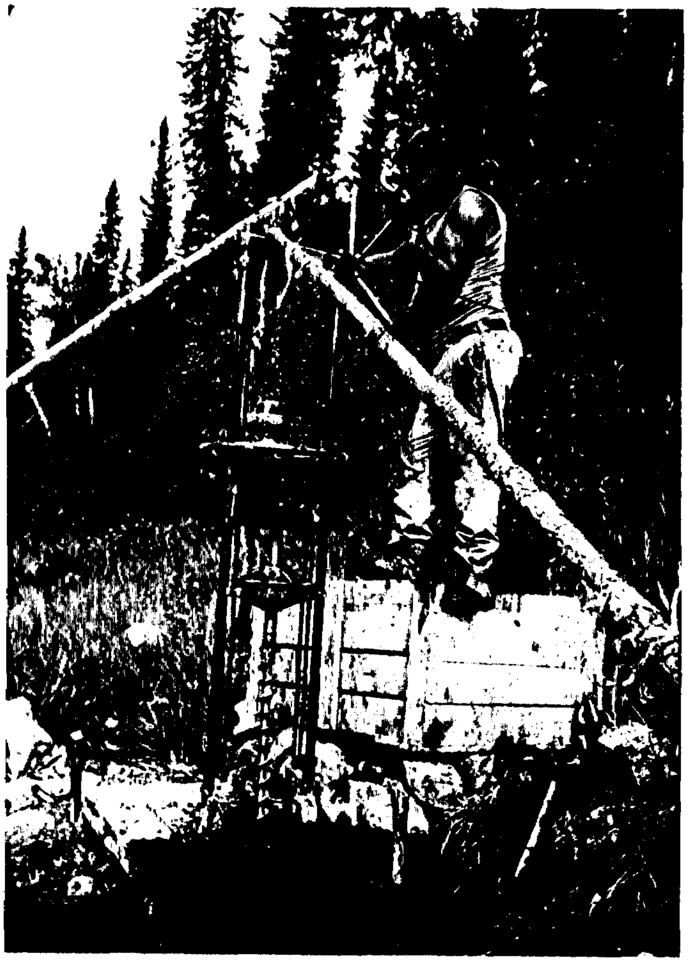


FIGURE 14: Winkie auger in operation. The auger is penetrating a black carbonaceous clay north of Grand Rapids on the Mattagami River.

difficulties met in hole OEC-81-02 would commonly result not only in serious mechanical problems but in the loss of a drill string.

Table 4 summarizes the costs of the drilling. It was hoped that the cost per foot drilled would be in the \$40–50 range; certainly, this would have been the case if not for the serious delays in the second drillhole. It should also be emphasized that in a one-drill program in which the budget cannot support a large helicopter to make drill moves, overall drilling efficiency decreases substantially — drill moves take time. A larger helicopter would permit moves to be completed in one shift, whereas with the Hughes 500D and Astar 350D, complete moves take at least two full shifts.

TABLE 2

SUMMARY OF DRILLING DATA

HOLE NO.	HOLE DEPTH	REVERSE CIRCULATION FOOTAGE	CORING FOOTAGE	OVERALL CORE RECOVERY (%)	HOURS DRILLING	HOURS MOVING	COMMENTS
OEC-81-01	117.9 m 386.8 ft	117.9 m 386.8 ft	—	—	33	20	
OEC-81-02	106.7 m 350.~~1~~0 ft	94.5 m 310.0 ft	12.2 m 40.0 ft	32.5	161.5	22	Numerous mechanical problems as a result of very difficult drilling in clays; several days lost.
OEC-81-03	83.3 m 273.~~3~~4 ft	83.3 m 273.3 ft	—	—	39.5	24	
OEC-81-04	94.0 m 308.4 ft	94.0 m 308.4 ft	—	—	68	28.5	
OEC-81-05	122.5 m 40~~1.9~~2.0 ft	70.7 m 232.0 ft	51.8 m 169.9 ft	87.1	88	36	Additional waterline hose necessary; loss of an 8-hour shift.
OEC-81-06	56.7 m 186.0 ft	48.8 m 160.1 ft	7.9 m 25.9 ft	74.6	20	15	Shallow hole: no Cretaceous units present.
OEC-81-07	71.8 m 235.~~6~~4 ft	71.8 m 235.6 ft	—	—	40.5	32	Very long move (30 km).
OEC-81-08	64.6 m 21~~1.9~~2.0 ft	46.3 m 151.9 ft	18.3 m 60.0 ft	88.2	44.5	17	
OEC-81-09	92.5 m 303.~~5~~4 ft	92.5 m 303.5 ft	—	—	24.5	18	
OEC-81-10	98.3 m 322.5 ft	48.8 m 160.1 ft	49.5 m 162.4 ft	90.5	28	10	
OEC-81-11	111.6 m 366.1 ft	25.9 m 85.0 ft	85.7 m 281.2 ft	68.8	54.5	13	
OEC-81-12	87.8 m 288.~~1~~0 ft	45.1 m 148.0 ft	42.7 m 140.1 ft	41.4	80	20.5	Mechanical problems at end of hole resulted in at least two shifts (24 hours) lost time.
TOTALS	1,107.7 m 3,634.~~2~~0 ft	839.6 m 2,754.6 ft	268.1 m 879.6 ft	71.8%	682	256	Total cost of drill program was $196,466.09.

TABLE 3

COSTS OF CONSUMABLES, 1981 DRILL PROGRAM

NW CASING	$ 6,693.92
NW CASING SHOES	2,494.35
TRICONE BITS	6,592.05
BIT ADAPTERS	2,277.00
NQ REAMING SHELL	463.30
PLASTIC CASING	7,641.61
DRILLING MUD	5,586.70
CORE TRAYS	550.00
NQ BITS (Diamond Replacement)	2,364.68
MISCELLANEOUS	120.58
TOTAL	$34,784.19

TABLE 4

DRILL COST SUMMARY

MOBILIZATION AND DEMOBILIZATION	$ 9,000.00	
DRILLING AND MOVING	152,681.00	
CONSUMABLE COSTS	34,785.09	
TOTAL	$196,466.09	
TOTAL FOOTAGE	3,633.9	(1,107.6 m)
COST PER FOOT (METRE)	$54	($177/m)
COST PER HOLE	$16,372	

5. GEOPHYSICAL SURVEYS

Outcrops are few and far between in the Cretaceous Basin, and drilling information is sparse, so that any subsurface information obtained by geophysical means would be very useful. Unfortunately the geological information that is available and the results from previous geophysical work have shown that there are unlikely to be any useful seismic contrasts and that gravity anomalies would show only variations in the Archean basement rocks. The only geophysical methods that held out any promise were resistivity, in the hope that there was a resistivity contrast between the Pleistocene and the Crectaceous, and well-logging methods, to enhance the information obtained from drilling. Both of these methods were used.

5.1 GROUND RESISTIVITY

5.1.1 GENERAL COMMENTS

Considerable data is available from previous resistivity surveys carried out by Scintrex Ltd., mainly over and around the Onakawana deposit, and Geoterrex Limited over a wider area of the Cretaceous Basin. Additional data is available from earlier work carried out on behalf of the Ontario Department of Mines and from work carried out by oil companies, although most of the latter is on too large a scale to be relevant.

These results show that there is no significant contrast between the resistivity of the lignite and the clays which usually (but not always) enclose it. There did, however, appear to be some contrast between the Pleistocene deposits and the Cretaceous; the resistivity in the Pleistocene was higher on average than the Cretaceous, although there were conductive layers in the Pleistocene and resistive layers in the Cretaceous. Since the Pleistocene deposits extend in places to depths below the known lignite and to depths below which strip mining would be impractical, the determination of the Pleistocene–Cretaceous contact by geophysical means could provide considerable help in placing drillholes. It was therefore decided to carry out a test program of resistivity work in order to test the hypothesis that there was an identifiable resistivity contrast between the Pleistocene and the Cretaceous.

5.1.2 FIELD WORK

The instrument used was a McPhar P-660 unit operating at a frequency of 5 cycles per second. A dipole–dipole configuration was used with a dipole width of 50 m and $n = 1$, 2, 3, 4, and 5. At six stations, spacings of $n = 6$ and 7 were used. Stations were at 50-metre intervals.

The survey was carried out along a line extending N10°W from the base camp on the north shore of the Mattagami River for a distance of 18,400 m, reaching almost to the Missinaibi River. A tie line extended 3,050 m from hole OEC-81-01 to cut the main line 3,170 m from its south end.

5.1.3 RESULTS

The survey could be checked against the known subsurface geology at four drillholes, OEC-81-01, -02, -09, and -11; the north end of the line reached almost to OEC-81-08 (see Map D in the map folder).

Resistivity contrasts are generally low and showed no discernable pattern. There is a slight tendency for till to have a higher resistivity than clay. For example, at hole OEC-81-11, which is mainly till, the average resistivity is nearly twice that at nearby OEC-81-09, where there is considerably more clay. However, on closer inspection, the correlation is poor. Hole OEC-81-11 has a thin marine clay layer on top of thick till but the resistivity decreases with depth; whereas at OEC-81-09, the till is close to the surface, but the resistivity increases with depth. No significant correlation was noted at any of the other holes.

The conclusion is, regrettably, that resistivity methods are not effective in this particular environment.

5.2 GAMMA-RAY AND NEUTRON WIRELINE LOGGING

5.2.1 GENERAL DISCUSSION

Geophysical logging involves the continuous recording of parameters of the strata penetrated by drilling with a small-diameter (32 mm) Sonde. Although numerous options are available for wireline logging in coal-related projects, the unconsolidated character of the Cretaceous sediments in the James Bay Lowland eliminated all but the gamma-ray detector and neutron emitter combination. Plastic casing was used to keep the holes open for the logging unit. Figure 15 is a schematic illustration of a wireline electric logging unit, whereas Figure 16 illustrates a typical electric log pattern.

The combined probe contains a gamma-ray detector and a neutron emitter, which consists of a 3-curie americium–beryllium source, a neutron detector, and all appropriate down-hole electronics. The complete unit is lowered to the bottom of the drillhole and preliminary checks made at the surface console.

Because of early caving, we were successful in inserting plastic casing in only eight of the twelve drillholes. The plastic PVC casing (outside diameter, 6.0 cm; inside diameter, 4.8 cm) could be inserted only if metal casing had been advanced through the most unconsolidated units, especially the Cretaceous sands. Once the drill rods were removed, the plastic casing would be lowered by hand inside the metal casing, after which the metal casing could be retrieved and the wireline probe lowered within the plastic casing. In the case of hole OEC-81-12, it was necessary to leave the metal casing in the hole and the probing carried out through the metal casing. This can be done successfully although detail can be lost.

During the last week of the drilling program, a two-member geophysical team from Roke Oil Enterprises Ltd., of Calgary, Alberta, arrived on-site. The complete unit was helicopter-lifted from site to site and set down on a small platform 5–10 m from each drillhole.

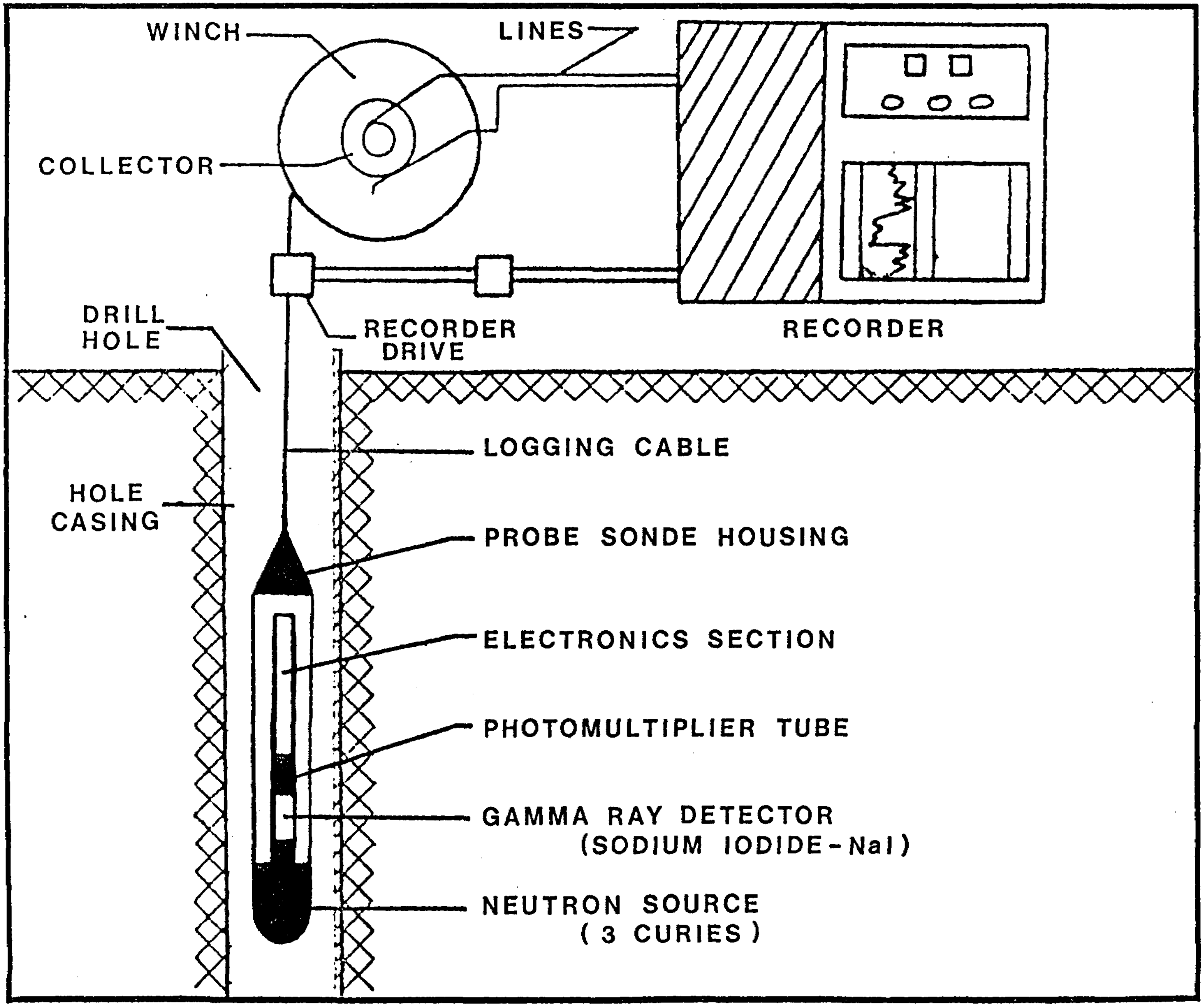


FIGURE 15: Diagrammatic illustration of a wireline electric logging system.

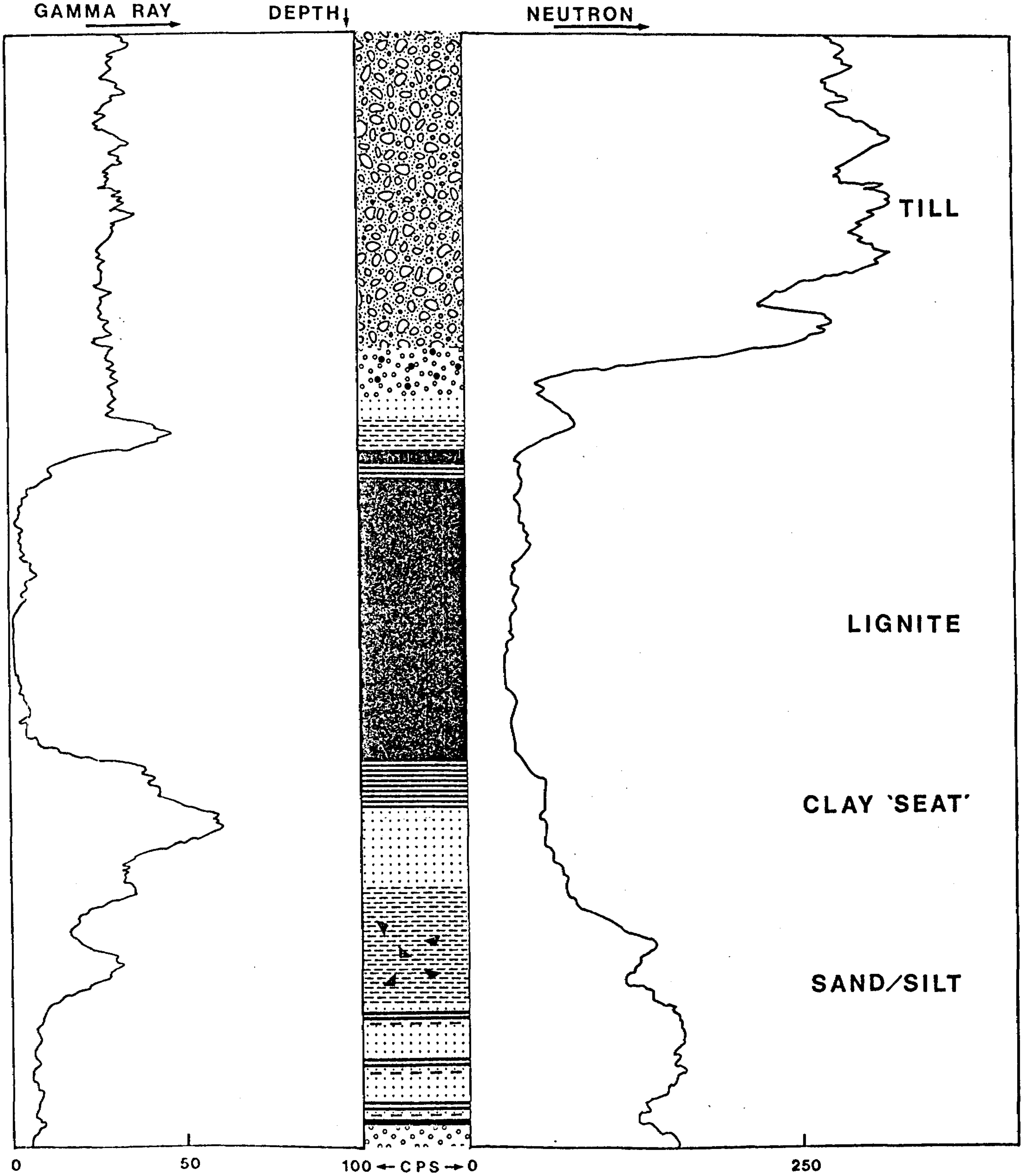


FIGURE 16: Typical gamma ray and neutron log pattern. This electric log shows how various lithologies produce quite different logging patterns.

Initial tests were carried out in drillhole OEC-81-04. Runs were made up the hole to the surface at rates of 2 m, 3 m, and 4 m per minute; the resulting logs were reviewed by the project geologist on-site. It was decided that the optimum logging velocity was 3 m per minute, for the best definition and signature distinction of the materials present. Scales in API units were adjusted accordingly, and each of the drillholes logged. The actual time taken to log each hole varied from 15 to 45 minutes; allowing for setting up and moving to the next hole, three drillholes could be logged comfortably during each of the short November days.

After the program was completed, Roke Oil Enterprises Ltd. conducted a number of experiments in test holes in Calgary. These experiments were designed to compare the sensistivity of results when using an open hole, a hole with PVC plastic casing, and a hole with metal casing. In all cases, even thin lignite or coal seams were clearly indicated by the Sonde instrumentation. Sensitivity is much reduced when using metal casing; but in the case of the PVC casing, very little sensitivity is in fact lost.

Since gamma-ray and neutron logging are carried out simultaneously, it is inadvisable to consider the results of each log trace separately. Gamma-ray–neutron logging entails the measurement of (a) naturally occurring gamma rays, and (b) artificially induced slow neutrons or capture gamma rays. The logs provide information that can be useful in correlation, lithology identification, and porosity measurements; for quantitative analyses to have any significant value, both logs must be considered.

The gamma-ray log is a continuous recording of the level of natural radiation emitted from rocks. Radioactive materials are present to some extent in all formations, depending on their chemical composition. The gamma radiation of shales (rich in clay minerals) is high compared with that of clean sand, clean limestone, or coal (see the respective logs in the appendix). An excellent visual contrast among formations is thus provided.

Neutron logging measures radioactivity artifically induced into the formation. A neutron log is the continuous recording of hydrogen concentrations in a rock. It uses the principle that high energy (fast) neutrons, emitted from the 3-curie americium–beryllium source, are slowed down by collision with hydrogen atoms because they have a very nearly identical mass to the neutron particles. Once they are slowed to thermal velocities, the neutrons can be captured by other atoms; this results in the release of gamma-rays, mostly with high energy. The neutron tool contains a neutron source, and a detector that measures the intensity of radiation scattered back to it. This detector indirectly records the hydrogen concentration whatever its mode of occurrence, but mainly, of course, as water. Rocks such as granite and limestone normally have a low response; clay, shale, and coal have somewhat higher (lignite, with more water, higher than that of hard coal); and saturated sands have the highest response.

5.2.2 RESULTS

The most obvious feature of the logging results is the distinctive trace of the Pleistocene beds. These are characterized by a consistent, relatively high percentage of clay material. Abrupt changes to sands or boulder/cobble units are well indicated, and water-deposited, graded interglacial, or interstadial sequences can be discerned. Great variations in unit porosity are also distinguishable. Notably, there remains the problem of correlating the Pleistocene tills across the area of exploration. Sharp jumps in the log readings were caused by granite boulders that had been penetrated during drilling: naturally-occurring radioactive materials are normally highly concentrated in granites that contain significant amounts of biotite and muscovite.

The most important and easily interpreted results were obtained from logs of the Cretaceous units. Clay, sand, and lignite facies become easily distinguishable, and a reliable record of sedimentological data can be inferred. This type of data is important for future exploration in that a start can be made in the construction of a sedimentary model for the Mattagami Formation. Distinctive signatures for each type of facies are now documented. In addition, sedimentation patterns can be discerned. Substantial thicknesses of vertically stacked, fining-upwards sand units have been noted in some of the drillholes.

Electric logging will also detect lignitic layers missed due to lack of core or of drill cuttings, and will help indicate seam thicknesses when using the reverse circulation drilling system. In the present program, electric logging confirmed what was inferred from the reverse-circulation returns and did not outline any lignite seams that were not indicated by drill cuttings.

For many years, fixing the lower boundary of the Cretaceous has been problematical, in both the field and the laboratory. Expensive, time consuming micropalaeontological studies to delimit the boundary with the underlying Lower Palaeozoic sediments have become necessary. This is particularly true where the Mattagami Formation rests directly on the Devonian Long Rapids Formation. The Lower Mattagami grey-green soft clays closely resemble the soft grey-green clays of the Long Rapids Formation — and reasonably so, since they are derived from the reworking of that formation. In the field, visual examination of the cores rarely resolves the problem, although a combined palynological and conodont study can help to define the contact. As an example, in drillholes OEC-81-05 and -11 (24 km apart), there is remarkable similarity in the gamma-ray and neutron logs across a relatively thick sequence of interbedded green and brown clay units. The upper sequence of green clays produces a relatively flat pattern in the gamma-ray and neutron logs, followed by a slow buildup in the gamma-ray responses deeper within the hole. It was originally suspected that the upper clay sequence represents a Cretaceous reworking of older, similar Devonian clay sequences. This possibility was further evaluated by studying the micropaleontological fauna of the various units (see Section 6.1.5), and this strongly suggested that the entire sequence is Late Devonian in age. However, it would seem likely that the similar geophysical patterns observed in each section indicate that the two sections are close stratigraphical equivalents; therefore, the electric log can be a very useful tool in making stratigraphic correlations that are not always obvious from looking at core samples or drill cuttings themselves. As additional drillhole geophysical data becomes available for this region, it will probably become an increasingly useful tool in assisting stratigraphic correlation as well as sedimentological modelling for the Cretaceous Basin.

6. GEOLOGY

6.1 SUMMARY

The Cretaceous Basin is part of the Moose River Basin, which itself forms part of the Hudson Bay sedimentary Basin. The Moose River Basin is west of the Abitibi River and north of the Precambrian escarpment, which lies east-west about 80 km north of the Trans-Canada Highway through Kapuskasing and Hearst. The basin is 150 km from east to west and 100 km from south to north, where it is bounded by the Cape Henrietta Maria Arch (see Figure 17).

The Cretaceous Basin occupies the southern and southwestern half of the Moose River Basin. The Cretaceous deposits may not be continuous, and their northern boundary is poorly defined. The outline of the Cretaceous Basin in Figure 17 represents the outer limit of the area in which Cretaceous rocks are likely to occur and is not intended to indicate the geological contact.

The whole sedimentary sequence is underlain by Precambrian rocks of the Canadian Shield. Little is known about these rocks. They are probably granitic, but airborne magnetic surveys indicate that they are not uniform, and that iron ore deposits and greenstone belts are possible. It is also possible that there are carbonatites in the area, as this general region contains numerous such intrusive complexes.

In the Cretaceous Basin the oldest sedimentary rocks appear to be the Lower-Middle Devonian Moose River Formation, although units as old as Cambrian overlie the Precambrian further north. This formation is overlain by the Abitibi River, Williams Island, and Long Rapids Formations, the last being Late Devonian in age. These sediments are generally limestones and shales. The Williams Island and Long Rapids Formations outcrop at Long Rapids on the Abitibi River, south of Onakawana. The upper member of the Williams Island Formation consists of relatively pure limestone, and the middle member of the Long Rapids Formation contains bituminous shale.

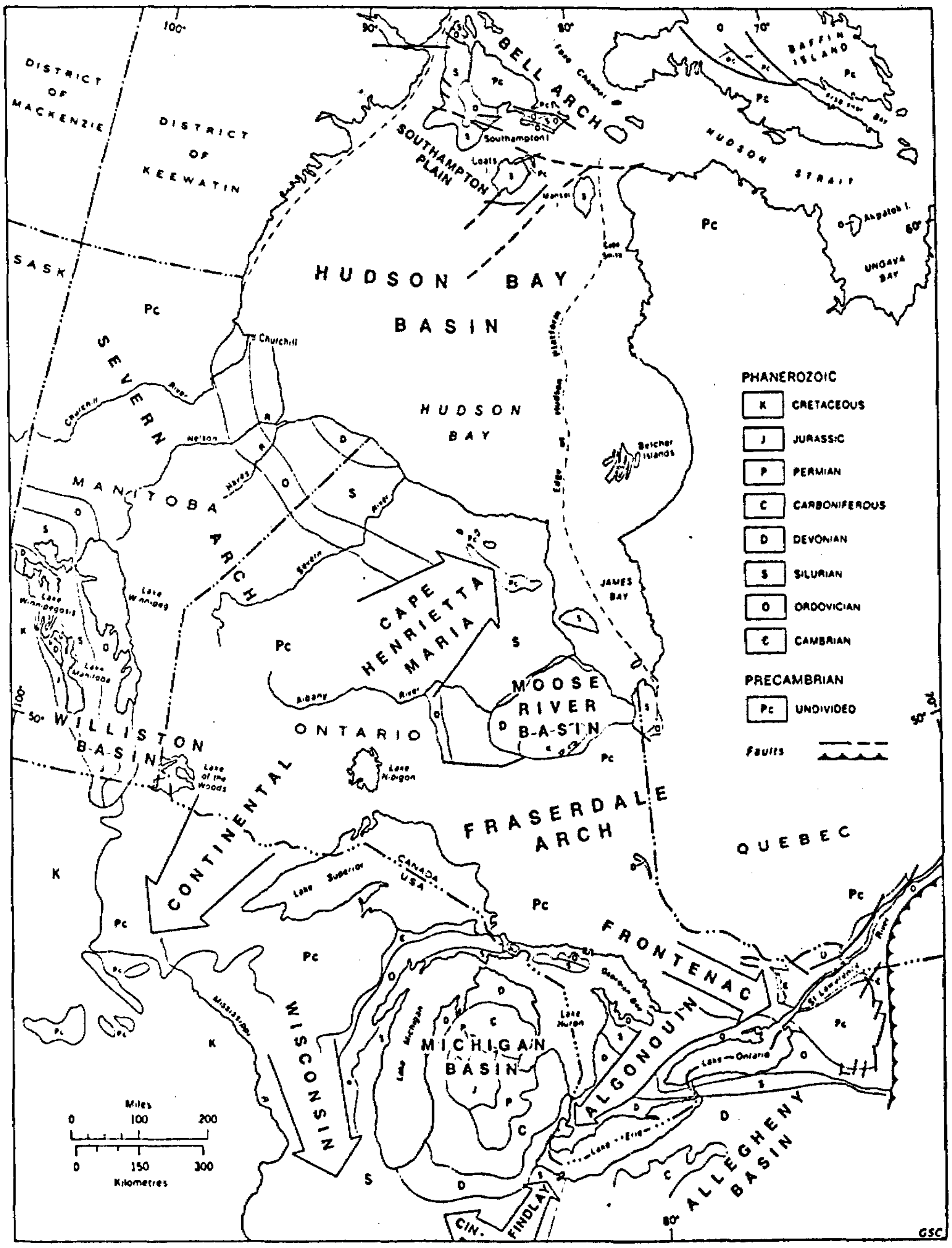


FIGURE 17: Sedimentary basins of east-central Canada and adjacent areas of the United States (from Sanford and Norris 1975).

No Mississippian, Pennsylvanian, or Permian rocks are known in the area. In some drillholes, poorly consolidated clays, limestone, and calcareous sands of the Middle Jurassic Mistuskwia Formation have been noted.

The Cretaceous rocks are all assigned to the Lower Cretaceous Mattagami Formation. They have been divided by Norris (1977) on palynological grounds into the lower Type A and upper Type B. They both consist of clays and sands with lesser silt, gravel, and lignite. The lignite appears to be confined to the lower Type A rocks.

The thickness of the Cretaceous is very variable. It can be over 150 m thick but in many places it is much less and may be missing altogether. This appears to be the result of riverbed erosion and/or scouring by ice sheets.

The overlying Pleistocene deposits are better correlated and have been divided into five units. They vary considerably in thickness, principally as a result of the variations in the Cretaceous. In places they are as deep as 150 m, but in a very few places they are absent altogether and Cretaceous rocks appear at the surface.

Lignite and peat occur in the Pleistocene. Most of the lignite appears to be detrital fragments, but in ODM hole 80, just west of the Mattagami River, 8 feet of lignite was reported. The core is unfortunately no longer available. However, in the present program, in drillhole OEC-81-01, located very close to the reported locality of the ODM drilling, only traces of lignite were noted in the Pleistocene units. Any noteworthy seams were observed only in what we would intrepret as Cretaceous sediments, but which may also include very minor lignite (reworked?) in early Pleistocene proglacial sediments.

6.1.1 RECENT

Recent beds form a thin mantle over the licence area and vary from 4 m to 16 m in thickness. Three distinct units are present — a glaciolacustrine unit, a marine unit, and a terrestial unit. The first consists of silt, clay, sands, sands and gravels, and silt-clay rhythmites (varves). The second comprises dark blue-grey silts and clays with occasional gravel or cobble layers. The third includes alluvium and thin sands. Peat deposits varying in thickness from approximately 0.5 m to 3 m blanket most of the region and were intersected by all of the twelve holes drilled in 1981.

6.1.1.1 Glaciolacustrine Unit

This unit directly overlies the upper member of the Pleistocene, the Kipling Till; and when complete, it contains the following sediments: (a) a silty diamicton; (b) sand and gravel; and (c) silty clay varved sequences. In only one location, OEC-81-01, is there evidence of an interval of sub-aerial weathering after deposition of the Kipling Till, where oxidized ochreous silty sands occur from 10.6 to 11.6 m; i.e., immediately on top of the till. The contact between these units tends to be quite sharp, but is gradational on occasion, e.g., in hole OEC-81-10.

This succession appears to be absent in holes OEC-81-04, -05, and -12, suggesting that the post-Kipling proglacial lake did not cover these areas at the time, or that any glaciolacustrine deposits formerly laid down have been subsequently eroded away and reworked by the advancing Tyrrel Sea. The most representative section of this unit is present in OEC-81-09, where a basal sandy cobble conglomerate passes up into a fining-upwards gravel and sand, and then into a finely layered or varved sequence of medium grey and blue-grey or black clays. The total thickness of the unit is 5.7 m. A less typical deposit in hole OEC-81-05 reaches a thickness of 6 m.

6.1.1.2 Marine Unit

Following the glaciolacustrine phase came the ingress of the Tyrrel Sea, which occupied the Hudson Bay Basin to the north as well as the Moose River Basin itself. The deposits associated with this marine incursion are the most widespread of the Recent units in the basin. They occur in areas below the present 475-foot elevation line and consequently can be expected to cover most of the present exploration area.

Again, three facies can be recognized: (a) a clay-pebble gravel; (b) clay and silt; and (c) beach and shallow-water sand and gravel. Skinner (1973) has established that the clay-pebble gravel is the oldest, whereas (b) and (c) types are really no more than lateral equivalents. In the 1981 drill program, marine fossils were present in all intersections of this unit.

The clay-pebble gravel was only observed in OEC-81-01. Elsewhere, this unit is characterized by 1 to 4 m of coarse, well rounded pebbles and cobbles passing upwards to coarse then fine sands and silts, and finally 1 to 8 m of soft, uniform, blue-grey, fossiliferous, calcareous marine clays. At times the clays are almost black with carbonaceous material. Rare pebbles are present throughout the unit — probably ice-rafted erratics.

Towards the top of the unit, the blue-grey clays become more silty, and at times sandy, and change colour to beige-grey, grey, or greenish grey. A very thick and complex marine unit was recognized in OEC-81-12, farther out in the centre of the basin. Here the sequence is 14 m thick and consists of a series of coarse fining-up units with silts, perhaps characteristic of a marine–deltaic interface. Near the base, an oxidized silt-bed packed with marine fossils probably represents a slight marine regression and temporarily exposed beach surface.

6.1.1.3 Terrestial Unit

The reverse-circulation method of drilling did not allow regular sampling of specimens of this unit. However, a nearly complete core was collected in OEC-81-12 from 0 to 5 m depth in a triple-tube core barrel, simply by allowing the barrel to fall slowly, by its own weight, through the unit without using the usual water flush. Beyond this depth, in the soft sediments, the hole had to be cased, using water, so that core recovery became very difficult and at times impossible. In general, a thin alluvium or silt layer is present and is often overlain by a thin grey soil before passing up into peat. During the whole field program the muskeg was waterlogged.

6.1.2 PLEISTOCENE

According to Skinner (1973), the oldest Pleistocene deposits are three tills of pre-Wisconsin age in the southwestern portion of the Moose River Basin. The next oldest compose the Missinaibi Formation, which is probably of Sangamonian age, also pre-

Wisconsin. It was laid down during an interglacial period. The lowest member is marine; it is followed by river deposits and a peat member formed from burned soil. Lake sediments form the top of the Missinaibi Formation and mark the end of the inter-glacial period. The Adam Till, of Wisconsin age (about 50,000 years BP), overlies the Missinaibi Formation and is overlain in places by the Friday Creek sediments, laid down in a period of glacial retreat. Finally, the Kipling Till generally tops the Pleistocene sequence.

The surface of the Cretaceous is very irregular, apparently from gouging by ice sheets and possibly from stream erosion. The depth to the Cretaceous varies from 0 to 150 m of Pleistocene and Recent sediments. In the deeper zones, the older tills can be identified; but later deposits are more difficult to correlate as the lateral facies changes are considerable even over short distances.

In the 1981 drilling the thickness of the Pleistocene deposits varied from 8.0 m in OEC-81-09 to 86.5 m in OEC-81-01.

6.1.3 CRETACEOUS

No Tertiary deposits are known in the Moose River Basin. Pleistocene or Recent deposits lie unconformably on the Cretaceous. The Cretaceous deposits consist only of the Mattagami Formation, of early to middle Albian age. Since Albian time is limited to the middle Cretaceous, an unconformity presumably lies at the base of the Cretaceous as well as at the top. The Albian age is indicated through the evaluation of pollen and spores by Legault and Norris (1982), as well as by Fasola (this study — see Appendix VI), who examined 30 species of terrestrial palynomorphs from clay beneath the thick lignite seam in hole OEC-81-12.

Within the Cretaceous area in Figure 18, the Cretaceous is generally present at depth, but it is by no means continuous; and because of the relative paucity of drillholes in the area, its actual extent is not yet clear. There appear to be three reasons for discontinuities in the Cretaceous: subsurface ridges in the Archean basement; ridges in the Devonian (which may be associated with the Archean ridges); and removal of the

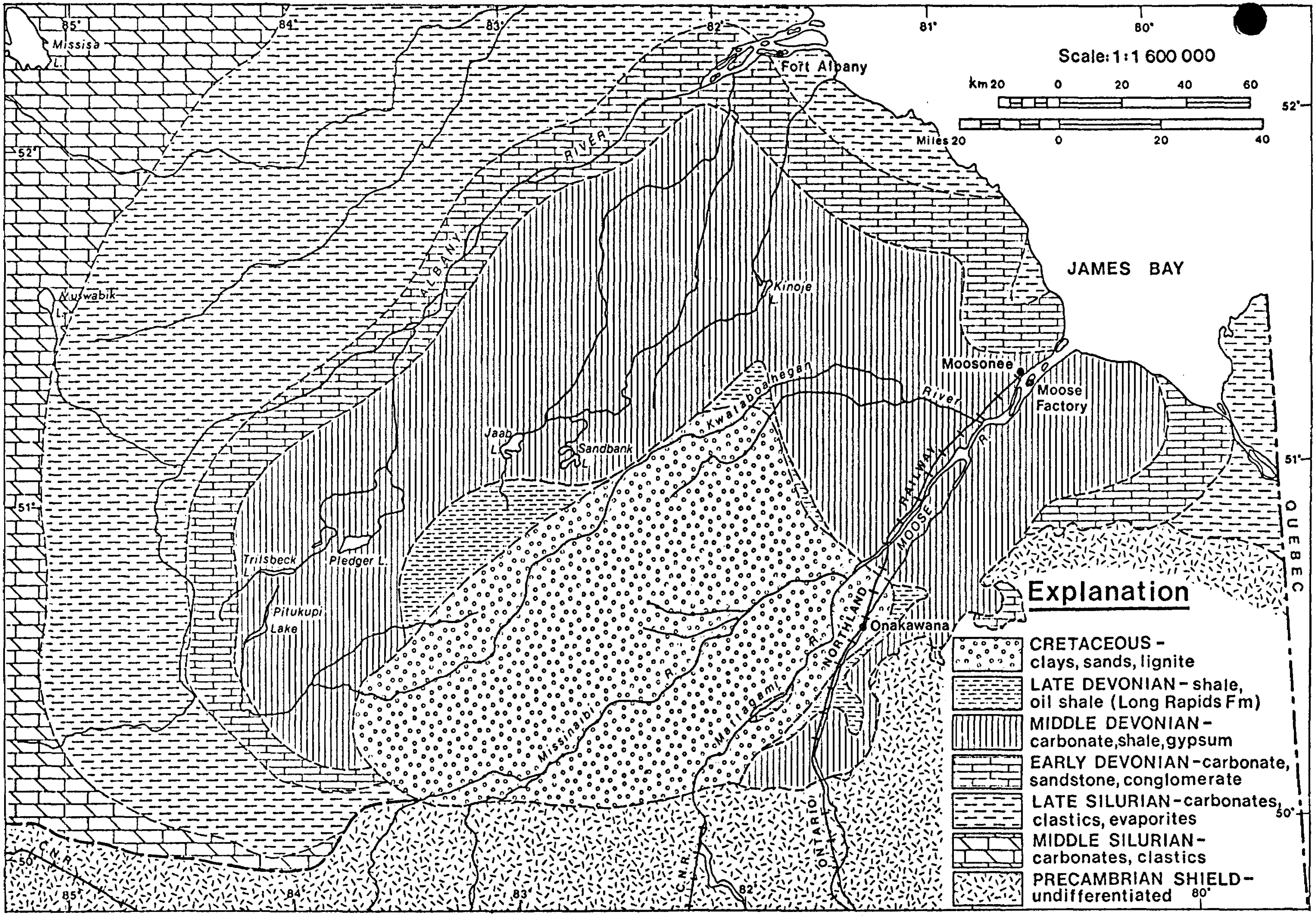


FIGURE 18: General geology of the Moose River Basin.

Cretaceous, through gouging by ice sheets or by river erosion in the Late Cretaceous or Cenozoic. Those holes in which the Cretaceous is absent (i.e., OEC-81-02, OEC-81-06, OEC-81-11, ODM-75-3, and ODM-78-7) were not on magnetic highs, which makes ridges in the Archean basement unlikely. In OEC-81-02 and -11, the Pleistocene is deep, suggesting gouging. In OEC-81-06, the Pleistocene is relatively shallow and the absence of the Cretaceous probably results from a pre-Cretaceous ridge, which may be an extension of the nearby arch at Grand Rapids on the Mattagami River.

The Mattagami Formation can be divided into an upper member and a lower member. The upper member consists of sandy gravel, fine gravel, and sand, in clay, interbedded sand and clay, and clay. The clay is generally light in colour and lacking in carbonaceous material.

The lower member appears to contain all the potentially commercial lignite presently known in the region. The lowermost section of the member is a dark green to grey clay. Past paleontological and palynological studies have indicated that some of the clay in this zone, formerly thought to be Cretaceous, actually belongs with the topmost Long Rapids Formation, which it closely resembles. The rest of the formation consists of interbedded quartz sand and clay, dark grey to black carbonaceous clay, and lignite. The black clay grades into lignite, and some burns when dried and ignited. It frequently contains fragments of lignite. The lignite is generally woody, with a matrix of organic mud, although the upper seam at Onakawana is mainly earthy lignite.

Development of the Mattagami Formation appears to have started with the deposition of clay on the bottom of a large lake, followed by the development of deltaic conditions in which the sediments were being eroded and re-deposited in changing stream channels, while dense vegetation established itself on those areas above stream levels. This hypothesis accounts for the frequent lateral facies changes and the non-continuous nature of the lignite.

6.1.4 DEVONIAN

Devonian sediments of the Hudson Platform are represented by two formations — the Upper Devonian Long Rapids Formation and the Middle Devonian Williams Island Formation.

No attempt is made here to detail the Mesozoic stratigraphy of the Moose River Basin, which has been well documented by Sanford and Norris (1975). The general distribution of the various Devonian and Silurian units is illustrated in Figure 18 and the regional stratigraphy summarized in Table 5.

The most important Devonian formations in the general vicinity of the OERL licence area are the Long Rapids and Williams Island Formations of Late and Middle Devonian age, respectively. The Long Rapids Formation is of potential economic importance as a source for oil shale.

6.1.4.1 Long Rapids Formation

This formation is equivalent in age to the Antrim shale of the Michigan Basin, the New Albany shale of the Illinois Basin, and the Ohio and Chattanooga shales of the Appalachian geosyncline. All of these formations have received considerable attention in recent years for their oil shale potential. The Long Rapids Formation is also age-equivalent the Kettle Point Formation of the Great Lakes Lowland in southwestern Ontario.

The formation is present in two areas on the Hudson Platform. In the Hudson Bay Basin the Long Rapids Formation consists of red evaporitic mudstone, shale, claystone, and sandstone, indicating a shallow restricted evaporitic environment. However, further south in the Moose River Basin the beds assigned to the Long Rapids Formation consist mainly of dark shales, siltstones, and clays interbedded with grey-green mudstones and clays, as well as minor bands of limestone and dolomite. The dark brownish-black to grey shales and siltstones contain pyrite and occasional clay-ironstone nodules. These sediments were deposited under reducing conditions and in deeper waters than those of the Hudson Bay Basin. The lithology is very similar to the

TABLE 5

SUMMARY OF THE DEVONIAN AND LATE SILURIAN STRATIGRAPHY IN THE MOOSE RIVER BASIN

(from Sanford and Norris 1975)

PERIOD	FORMATION	THICKNESS DATA (feet)			CHARACTERISTIC LITHOLOGY
		MOOSE RIVER BASIN	ONAKAWANA 'A'		
			Interval	Thickness	
Upper Devonian	Long Rapids	0 - 285	250 - 535	285 (86.9 m)	Dark grey to black, non-calcareous, commonly bituminous shale interlayered with thin, soft, green mudstone beds. Thin calcarenites and siderite nodules. Fossils include <u>Lingula</u>, the spore <u>Tasminites</u>, and Conodonts.
					PARACONFORMITY
Middle & Early Upper Devonian	Williams Island	301 max.	535 - 682 682 - 836	147) 301 154 }(91.7 m)	Alternating thin to medium bedded argillaceous limestone and calcareous shale. Grey shales, calcarenites, limestones, some evaporitic limestone.
					PARACONFORMITY
Middle Devonian	Murray Island	20 - 65	836 - 873	37 (11.3 m)	Calcareous dolomite, calcarenitic limestone.
					EROSIONAL UNCONFORMITY
	Moose River	94 - 291	873 - 967	94 (28.6 m)	Limestone, argillaceous ls, dolomitic ls, dolomite, gypsum, minor anhydrite. Some shale and secondary selenite.
					RECESSIVE TRANSITIONAL CONTACT
	Kwataboahegan	13 - 251	967 - 980	13 (4.0 m)	Brown, calcarenitic, bituminous, macrofossiliferous limestone. Minor dolomite.
					UNCONFORMITY
Lower Devonian	Sextant	0 - 298	980 - 1019	39 (11.9 m)	Continental wedge of arkosic sandstone, pebbly sand, micaceous shale, plant fragments.
					RECESSIVE TRANSITIONAL CONTACT
	Stooping River	8 - 469	1019 - 1027	8 (2.4 m)	Calcarenitic limestone, dolomitic ls, dolomite, quartzose in part, minor anhydrite, oolitic limestone.
					PARACONFORMITY AND OTHER CONTACTS
	Kenogami River (Upper)	0 - 173	Missing		Calcitic dolomite, oolitic dolomite, evaporites, chert.
					TRANSITIONAL AND EROSIONAL CONTACTS
Silurian	Kenogami River (Middle)	No Data	Missing		Red, evaporitic, clastic beds.

NOTE: Onakawana 'A' refers to the hole drilled at the south end of the Onakawana lignite deposit in 1930.

Kettle Point Formation and the Upper Devonian shales of the eastern United States basins (Sanford and Norris 1975).

The probable areal extent of the Long Rapids Formation is shown in Figure 18. The total thickness of the formation is not known but probably exceeds 90 m in the Moose River Basin.

The contacts between the Long Rapids Formation and the underlying Williams Island Formation have not been seen in outcrop in the area. During the 1981 drilling program, the Long Rapids was intersected in nine of the twelve drillholes and cored in four of these holes. Six of the holes showed that the Long Rapids Formation is overlain unconformably by sands and clays of the Cretaceous Mattagami Formation. The top 10–15 m of the Long Rapids consists of grey-green non-calcareous clays interbedded with minor dark chocolate brown silty clays. As the darker clays become predominant with depth, they also become indurated and grade into shales and siltstones. Originally it was thought that the top 10–15 m of the sediments could have been reworked clays derived from older units nearby. To test this possibility, samples were selected from drillholes OEC-81-05 and -11 from portions of the section that underlie sediments of fairly definite Cretaceous age and overlie other units of probable Devonian age (Long Rapids Formation). Dr. A. Fasola from the University of Toronto examined these samples for palynomorphs and discovered assemblages of spores and microplankton that are consistent with a Late Devonian (Frasnian–Fammenian) age. Dr. Peter von Bitter from the Royal Ontario Museum in Toronto examined samples from the same sequence and identified a conodont assemblage that was also indicative of a Late Devonian age. These findings suggest that, at least in the holes sampled, and perhaps in most of the other drill intersections, post-Devonian reworking was not very extensive. Details of the above investigations are included in Appendices VI and VIII of this report.

The contact between the Long Rapids Formation and the underlying Williams Island Formation may be seen in Ontario Hydro drillhole No. LX-7A, which was drilled in 1980 near the Abitibi River just south of the Williams Island anticline. In this hole the dark shales of the Long Rapids Formation are interbedded with greyish-green calcareous clays, which in turn phase into limestones toward the base of the formation. The contact cited lies between the carbonates of the Williams Island Formation and the dark shales of the Long Rapids Formation.

6.1.4.2 Williams Island Formation

The Middle Devonian Williams Island Formation underlies the Long Rapids Formation and overlies the Murray Island Formation. The sediments consist of oolitic and argillaceous limestones interbedded with bluish-grey calcareous shales. The complete thickness of the Williams Island Formation is nowhere exposed in the area but is suspected to be greater than 150 m (Sanford and Norris 1975). During the recent drilling program, some 15 m of carbonates and bluish-grey clays of the Williams Island Formation were intersected in drillhole OEC-81-06.

6.1.5 PRECAMBRIAN

Part of the southern margin of the Moose River Basin is marked by a prominent Precambrian escarpment, suggesting faulting and uplift of the Precambrian relative to the rocks of the basin. Evidence for a fault origin of this mainly subsurface escarpment is the apparent truncation of rocks of Ordovician, Silurian, Devonian, and Lower Cretaceous ages along part of its length. Drilling has indicated downwarping and increased thickness of the sedimentary rocks adjacent to the fault.

Of the Precambrian rocks to the south and those forming the undermass and local highs in the basin, the oldest are Archean volcanic and sedimentary quartzose rocks. These have been intruded by granites, to a lesser extent by mafic intrusives, and by diabase dykes. In the immediate vicinity of Coral Rapids (on the Abitibi River, next to the Ontario National Railway line), there are known kimberlitic rocks and the region as a whole contains several large carbonatite complexes. (Kimberlites are the primary source of commercial diamonds.)

6.2 ECONOMIC GEOLOGY

6.2.1 INTRODUCTION

A detailed review of this subject is covered in the 1981 WGM report to OERL as well as in several other reports, notably Telford and Verma 1978, Telford 1979, Guillet 1979, and Rodgers et al. 1975.

The specific aims of the 1981 drill program were:

a) Drilling on both sides of the Mattagami River in the general area of the 1980 lignite discovery, north of Grand Rapids.

b) Drilling those areas west of Portage Island to test possible extensions of known lignite occurrences.

c) Drilling several holes along an experimental ground resistivity survey line to evaluate ground resistivity for detecting the Pleistocene–Cretaceous contact.

d) Should time permit, the drilling of one or more holes in the basin a considerable distance from any previous drilling.

e) Extension of several of the above holes well into the Upper Devonian Long Rapids Formation to evaluate its oil shale potential.

f) Systematic sampling of Pleistocene tills and clastics and Cretaceous clastics, and concentration and examination of the heavy minerals. These heavy mineral concentrates would permit some evaluation of potential for diamonds, precious and base metals, and uranium.

g) Examination and sampling of Cretaceous units for quartz sands and clays that could be of economic significance.

Late in the field season, it was also decided to sample several areas for peat and to have a number of the peat samples analysed.

The geological units, the principal economic commodities, and the approach to their evaluation are summarized in Table 6. The results of the program are discussed in the sections following.

TABLE 6

ECONOMIC COMMODITIES IN THE JAMES BAY LOWLAND

GEOLOGICAL UNIT	AGE	LITHOLOGY	ECONOMIC COMMODITY	SAMPLING AND TESTING
UNNAMED	QUATERNARY	Peat; clays and sands; variety of glacial (tills) and interglacial sediments (sands, gravels, etc.).	Peat	Peat sampled directly. Heavy minerals concentrated from most non-clay units to evaluate metallic and non-metallic commodities present in older units.
MATTAGAMI FORMATION	EARLY CRETACEOUS	Clays Sands Lignite	Lignite Quartz sand 'Fire clay' (in several forms) Secondary gold and/or diamond concentrations Uranium	Drilling and augering for lignite: geophysical verification of lignite seams. Sampling and testing of drill cuttings for sands and clays. Concentration of heavy minerals from clastic units for the evaluation of gold, diamonds, and uranium; geophysical detection of possible uranium mineralization.
UNNAMED	JURASSIC	Clays Sands	Sand and/or clays — very unlikely, based on present knowledge.	No clearly Jurassic units indicated in the 1981 drill program.
KIMBERLITES	POST-DEVONIAN	Usually an altered peridotite breccia.	Diamonds	Evaluated indirectly through an examination of heavy minerals from Cretaceous and Quaternary clastic units.
LONG RAPIDS FORMATION	LATE DEVONIAN	Clay Shale Silt Oil shale	Oil shale Possibly clay	Oil shale sampled from core and analysed for total organic carbon and condensate yield by pyrolysis.
WILLIAMS ISLAND FORMATION	LATE DEVONIAN	Limestone Minor gypsum	Limestone Gypsum	Not considered economic in the forseeable future and therefore not evaluated.
'BASEMENT'	PRECAMBRIAN	A great variety of granitic and metamorphic units: possible iron formation.	Base and precious metals Uranium	Evaluated only indirectly through concentration of heavy minerals in younger clastic units. No basement rocks sampled directly in this program.

6.2.2 LIGNITE

6.2.2.1 General Occurrences in the James Bay Lowland

Map A indicates most of the known major and minor lignite occurrences in the general region. Over the past 50 years, deposits at Onakawana have been studied in detail, and lignite reserves of 180–200 million tons at shallow depths have been outlined. Drilling in nearby areas has indicated that sizeable extensions are unlikely in the immediate vicinity of the main deposit.

A significant discovery was made in the 1978 OMNR drill program (Guillet 1979): In the southwest corner of Sanborn Township, approximately 6 km from the Mattagami River, an 18-foot thick lignite seam at a depth of 310–328 feet was found. This same drill program indicated numerous thin lignite beds farther south along Adam Creek on the east side of Kipling Township. These latter occurrences had a cumulative thickness of approximately 29 feet between depths of 250–410 feet, but the maximum thickness on any individual bed was only 3.6 feet. The general area of these discoveries is now part of an exploratory licence area issued to Lignasco Limited, a Toronto-based company attempting to evaluate the area as an in-situ gasification project. Lignasco has undertaken (January–February, 1982) a drill program in this area to better define the size of the 1978 discovery in Sanborn Township (Lignasco Limited, private communication, 1982).

In McBrien Township, at the far west end of the OERL licence area, minor lignite occurrences have been reported in the vicinity of Coal Creek. Some occurrences in this area appear to be allochthonous (displaced from original site), possibly as a result of glacial action, but several thin Cretaceous lignite seams do occur in-place just north of Coal Creek (see WGM 1981 and Guillet 1979).

Lignite seams have also been reported in the vicinity of Portage Island, at the confluence of the Missinaibi and Mattagami Rivers. Early drilling by the Ontario Department of Mines (1932) indicated fairly thick (up to 2.5 m) seams in two holes, but subsequent holes nearby contain very little. Substantial lateral extensions of these seams could be present west and north of Portage Island, but drilling south of the area has been unproductive.

In 1980 the OERL regional ground examination and augering program discovered a seam of lignite along the east bank of the Mattagami River, in the southwest corner of Morrow Township (see Map B). Augering in the vicinity of the 1.5 m thick exposure was unsuccessful due to boulder till and alluvium. This area was also the target for substantial drilling and augering in the 1981 field program. South of this area, numerous minor lignite intersections were reported in one drillhole (Hole 74-8 by Aquitaine: see the April 1981 WGM report) very close to the eastern contact of the Cretaceous units.

6.2.2.2 Lignite Occurrences Discovered in the 1981 Drill Program

The principal lignite occurrences indicated by the 1981 drill program are summarized in Table 7. The detailed drilling logs (see Appendix I) also describe the character of the occurrences. Drillsites are indicated on Map B.

Drillholes OEC-81-01 and -02, near the 1981 base camp west of Onakawana, verified that the Pleistocene deposits are thick in this area and that no more than thin lignite seams (which appeared only in OEC-81-01) are present.

Drilling in the vicinity of the 1980 lignite discovery north of Grand Rapids (holes OEC-81-03, -04, and -05) did not outline thick extensions of lignite but did indicate the presence of a relatively thick Cretaceous section with numerous thin lignite seams at moderate depths.

West of Portage Island the drilling was disappointing in that known seams were not intersected in either of drillholes OEC-81-07 and -08. The discoloration in the sediments and the lack of a substantial Cretaceous section suggest that this area may have been a 'paleo high' and therefore would not represent an area where thick vegetation would accumulate and be preserved. It is also possible that Pleistocene glaciers have scoured some of the Cretaceous units, removing some lignite.

TABLE 7

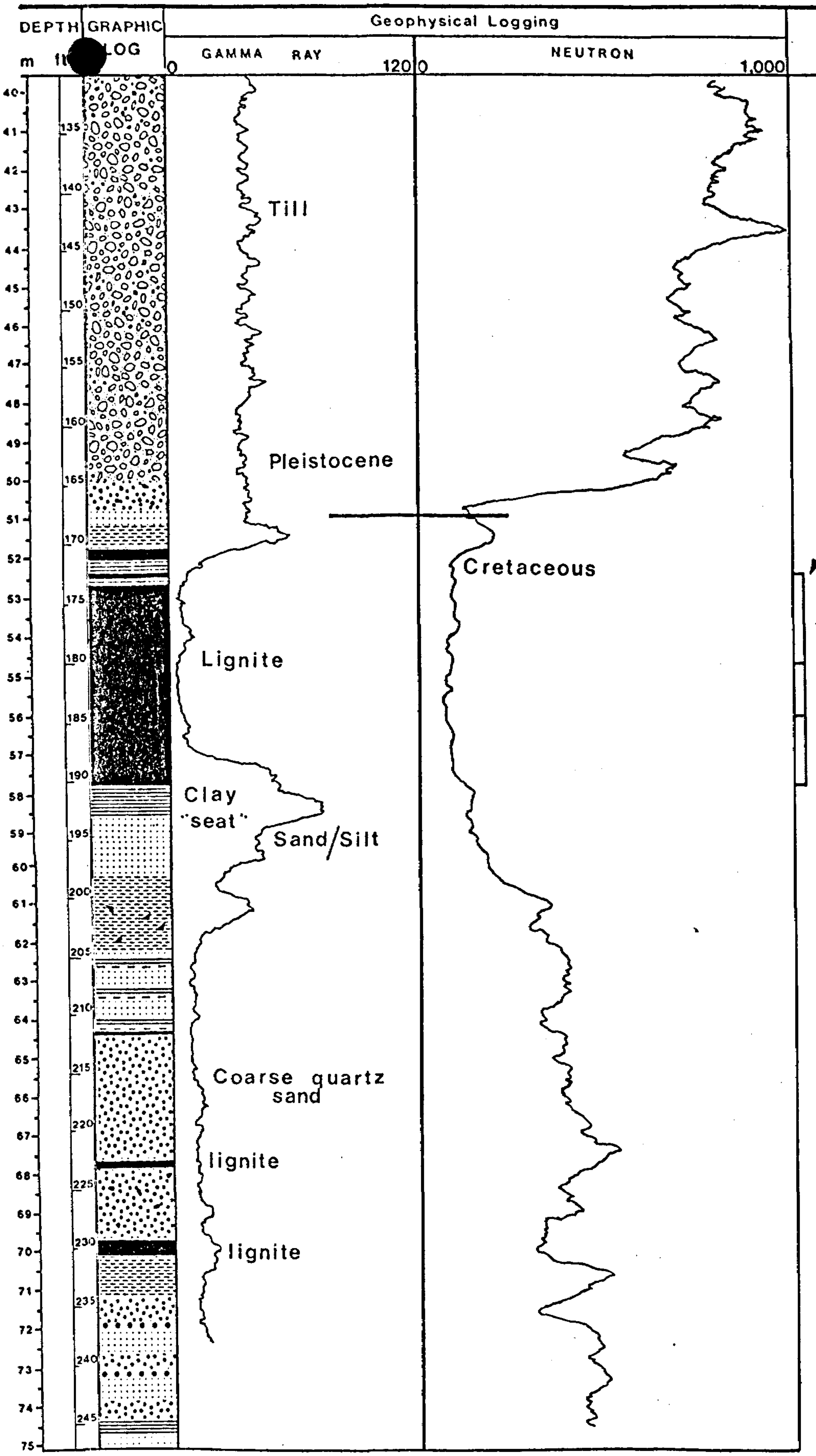
SUMMARY OF LIGNITE OCCURRENCES INDICATED IN THE 1981 DRILL PROGRAM

DRILLHOLE No.	LIGNITE OCCURRENCES AND COMMENTS
OEC-81-01	1.4 m of relatively good lignite at a depth of 101.2–102.6 m: see analysis 4521-81 in the following summary of analytical results. Several other minor occurrences between depths of 78–105 m. The lignite is interpreted to be in a sequence of Cretaceous clastics and clays although previous work had suggested that nearby lignite occurs in a Pleistocene sequence.
OEC-81-02	No significant indications but traces of lignite chips in a pebbly, mature sand and clay at 66–68 m. Hole had to be abandoned at a depth of 106.5 m and does not appear to have penetrated the Cretaceous units. Additional lignite may occur at the base of the Cretaceous units, below 106 m.
OEC-81-03	Only very thin seams (usually <20 cm) and detrital lignite chips between depths of 36–75 m. A character analysis of the lignite chips is shown in the following analytical summary table. This hole was located about 1 km from the 1980 discovery on the east side of the Mattagami River.
OEC-81-04	Detrital lignite in quartz sands and numerous thin lignite seams (up to 40 cm) interbedded with clay between depths of 46–78.5 m. Three character analyses of lignite–clay summarized in analytical table. This hole is approximately 2.5 km west of the 1980 discovery on the east bank of the Mattagami River.
OEC-81-05	Only detrital lignite in sands and poorly sorted gravel at depths of 25–30 m. Clay with finely comminuted lignite chips at depth of 42–43 m. This hole is approximately 3 km east of the lignite seam discovered in 1980 on the east bank of the Mattagami River.
OEC-81-06	No lignite. This appears to have intersected no Cretaceous units. The Pleistocene occurs to a depth of approximately 40 m and is underlain by limestone and clays that are Middle Devonian in age (Williams Island Formation).
OEC-81-07	No lignite. Sequence of variegated clays and silts are probably Cretaceous in age. This hole is located 2–3 km west of known occurrences in the vicinity of Portage Island. The colouration in the clays and silts may be due to in-situ weathering along a Cretaceous ridge.
OEC-81-08	No lignite. Either no or very little Cretaceous present in this hole which is located very close to the Missinaibi River.
OEC-81-09	1.4 m of lignite at a depth of 51.2–52.6 m. Minor clay partings and visible FeS_2 present. The analysis in the following table includes substantial clay mixed in with the lignite. Hole collapsed before plastic casing was inserted so it was not possible to confirm thickness using electric logging.
OEC-81-10	No lignite. Extent of the Cretaceous is not well established, but it appears to consist of about 50 m of variegated clays, marls, and silts.
OEC-81-11	No lignite. A thick clastic sequence (33.5–64 m) appears to be largely Pleistocene gravels and sands that are underlain by Late Devonian clay units. This hole is only about 60 m south of OEC-81-09, where 1.4 m of lignite was indicated.
OEC-81-12	5.2 m lignite seam at depth of 52.7–57.9 m. A 1 m section immediately above the main seam contains interbedded clay and lignite. Five analyses shown in the following analytical table. The lignite contains considerable visible FeS_2, negligible clay partings, but some detrital quartz grains. Between depths of 61–70 m there are a variety of carbonaceous clays and thin lignite seams (<30 cm thick). The hole had to be terminated at a depth of 88 m (288 feet) and may not have completely penetrated the Cretaceous section. The drillhole is located on the east edge of Gentles Township, approximately 6 km from the Missinaibi River and 33 km from Onakawana.

The 1.4 m seam indicated in drillhole OEC-81-09 must represent an extension of the Portage Island occurrences. If so, then there may be considerable chance that sections in-between may be considerably thicker. The Pleistocene in this area is generally not very thick and there appears to be a substantial Cretaceous section (approximately 45 m). As is commonly the case in other lignite occurrences in the region, the lignite in OEC-81-09 is close to the base of the Cretaceous units. Drillhole OEC-81-11 was drilled only 600 m south of OEC-81-09 in order to retrieve some lignite core, since hole OEC-81-09, drilled only with the reverse-circulation system, had collapsed to the point that electric logging to better define the lignite occurrence was impossible. Surprisingly, no lignite was found in OEC-81-11, and possibly none of the sediments are Cretaceous in age. To a depth of 32 m, the Pleistocene was dominantly till overlain by marine(?) clay and underlain by about 47 m of sandy and pebbly clastics. The very poor recovery of sample material from this section makes interpretation difficult, but this thick clastic sequence could well represent a major Pleistocene fluvial (river) channel. The units could represent a Cretaceous sequence except that close to the base of the clastics there are two thin sections that appear to be very much like tills, and they in turn are underlain by a sequence of clays very similar to those of the Long Rapids Formation in nearby areas. In any case, it points up the fact that lateral changes can be quite abrupt in this region as a result of either Cretaceous sedimentary characteristics or as a result of Pleistocene fluvial erosion or glacial scouring.

Drillhole OEC-81-10 in Mulholland Township intersected no lignite whatsoever. The Pleistocene in this hole was not very deep (approximately 35 m), and consisted largely of sandy and pebbly clastics overlying a fairly thick sequence (approximately 50 m) of variegated clays of probable Cretaceous age. The Pleistocene clastics probably represent a major fluvial system, whereas the variegated clays may represent a 'paleo high' where lignite would not be preserved.

Drillhole OEC-81-12 in Gentles Township, near one of the major creeks running into the Gardiner River, was essentially a wildcat effort, far removed from previous drilling. The hole intersected a very substantial lignite seam (approximately 5.2 m thick) at reasonable depths (52–57 m or 173–190 feet). Figure 19 indicates the general character of this discovery as well as other features of the Cretaceous section.



reverse circulation sample: clay contamination: dry BTU 7315
(Anal. No. 4519-81)
duplicate sample from same interval yielded: dry BTU 8144
(Anal. No. 4527-81)
reverse circulation sample: dry BTU 8641
(Anal. No. 4528-81)
core sample: dry BTU 974
(Anal. No. 4520-81)

FIGURE 19: The main lignite seam in drillhole OEC-81-12, Gentles Township.

The analytical results from hole OEC-81-12 (see Table 8) bear some explanation. All but one sample were from reverse-circulation cuttings and, at least in the top part of the lignite, there appears to have been considerable clay contamination — not always evident in reverse-circulation material. In reverse-circulation samples, the clay may actually be from thin clay partings within the lignite or from clay initially trapped in the drill-bit and later blown clear with lignite to become a contaminant. One core sample (analysis 4520-81) yielded the highest BTU value (9,743 BTU on a dry basis) ? 2nd highest from the seam. The high sulphur content (in the range 3–8 wt.% on a dry basis) is evident from examining either the drill cuttings or core, because relatively fresh iron sulphide (presumably the mineral marcasite — FeS_2) is plainly visible in many samples. The yellowish-green iron sulphide occurs in narrow lenses and in what appears to be cross-cutting veinlets within the lignite. To examine the character of the sulphur present, two samples from the main lignite seam in hole OEC-81-12 were analysed. One had a total sulphur content of 6.98% (as received), made up of 0.43% sulphate sulphur, 3.83% pyritic sulphur, and 2.72% organic sulphur. The second sample contained less overall sulphur (5.42%), but considerable pyritic sulphur (4.36%), modest organic sulphur (1.03%), and negligible sulphate sulphur (0.03%).

All of the samples from the main seam have high ash contents; this is quite typical of lignites from the region. The in-situ moisture content of the lignite is difficult to evaluate because in either reverse-circulation or core drilling, water is used, and the samples cannot be properly sealed. Certainly, samples 4527-81 and 4528-8 (see Table 8) show moisture contents considerably above the in-situ values, whereas sample 4520-81 was partially dried from sitting in open air. An in-situ moisture content of 45–50% is probably reasonable, and consistent with the moisture content of the Onakawana lignite.

In addition to the reverse-circulation and core drilling, eight auger holes were drilled along the Mattagami River, in the vicinity of the 1980 discovery. Map B indicates the locations of these holes; the auger logs are included in the appendix of this report.

The augering did not find direct equivalents to the lignite seam discovered in 1980 — the only place where the auger could penetrate was probably stratigraphically lower than the lignite bed. However, several of the holes did intersect substantial

TABLE 8 RESULTS FROM THE 1981 JAMES BAY LOWLAND DRILL PROGRAM

Analysis Number	PROXIMATE ANALYSIS							ULTIMATE ANALYSIS										CALORIFI	
	Moisture	Ash		Volatile		Fixed Carbon (by difference)		Carbon		Hydrogen		Sulphur		Nitrogen		Oxygen (by difference)		Calories per gram	
	As Received	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry
4517-81	30.54	53.82	77.48	9.04	13.01	6.60	9.51	9.65	13.89	0.53	0.76	1.19	1.71	0.09	0.13	4.18	6.03	812	**1,169**
4518-81	40.15	38.55	64.41	14.83	24.78	6.47	10.81	11.88	19.85	1.05	1.75	0.63	1.05	0.15	0.25	7.59	12.69	1,029	**1,719**
4519-81*	14.00	31.43	36.55	29.51	34.31	25.06	29.14	37.91	44.08	1.88	2.19	5.13	5.97	0.33	0.38	9.32	10.83	3,495	**4,064**
4520-81*	41.31	10.48	17.86	26.49	45.14	21.72	37.00	33.13	56.45	2.40	4.09	4.77	8.13	0.23	0.39	7.68	13.08	3,176	**5,411**
4521-81	6.74	16.73	17.94	40.80	43.75	35.73	38.31	—	—	—	—	5.06	5.43	—	—	—	—	5,056	**5,421**
4522-81	6.70	19.18	20.56	37.38	40.06	36.74	39.38	—	—	—	—	1.22	1.31	—	—	—	—	4,842	**5,190**
4523-81	51.68	23.74	49.13	14.39	29.78	10.19	21.09	—	—	—	—	0.55	1.14	—	—	—	—	1,545	**3,197**
4524-81	39.38	30.06	49.59	17.70	29.20	12.86	21.21	—	—	—	—	1.07	1.77	—	—	—	—	1,736	**2,864**
4525-81	30.54	58.03	83.54	7.74	11.14	3.69	5.32	—	—	—	—	0.49	0.71	—	—	—	—	549	**790**
4526-81*	42.48	43.71	75.99	8.88	15.44	4.93	8.57	—	—	—	—	1.30	2.26	—	—	—	—	661	**1,149**
4527-81*	62.87	11.45	30.84	12.97	34.93	12.71	34.23	—	—	—	—	1.18	3.18	—	—	—	—	1,680	**4,525**
4528-81*	62.19	10.75	28.43	14.56	38.51	12.50	33.06	—	—	—	—	2.23	5.90	—	—	—	—	1,815	**4,800**

*These samples are all from the main lignite discovery in Hole No. OEC-81-12

ULTIMATE ANALYSIS								CALORIFIC VALUE				Comments
ydrogen		Sulphur		Nitrogen		Oxygen (by difference)		Calories per gram		BTU per pound		
s ived	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	
53	0.76	1.19	1.71	0.09	0.13	4.18	6.03	812	**1,169**	1,461	**2,103**	No. OEC-81-04; from 62–64 m: lignite and clay interbeds.
05	1.75	0.63	1.05	0.15	0.25	7.59	12.69	1,029	**1,719**	1,852	**3,094**	No. OEC-81-09; from 49–52 m: interbedded clay and lignite.
38	2.19	5.13	5.97	0.33	0.38	9.32	10.83	3,495	**4,064**	6,291	**7,315**	No. OEC-81-12; 173–180' reverse circulation interval: some contamination from top clay units.
40	4.09	4.77	8.13	0.23	0.39	7.68	13.08	3,176	**5,411**	5,718	**9,743**	No. OEC-81-12; from core sample. **Note:** the real moisture is probably ≈50%; the high S content is due to granular iron sulphide.
—	—	5.06	5.43	—	—	—	—	5,056	**5,421**	9,101	**9,759**	No. OEC-81-01; character sample of 1.4 m section of lignite at depth of 101 m. **Note:** the low moisture content is in part due to drying at room temperature.
—	—	1.22	1.31	—	—	—	—	4,842	**5,190**	8,716	**9,342**	No. OEC-81-03; character sample of lignite chips in quartz sand.
—	—	0.55	1.14	—	—	—	—	1,545	**3,197**	2,781	**5,755**	No. OEC-81-04; lignite and interbedded clay: character sample.
—	—	1.07	1.77	—	—	—	—	1,736	**2,864**	3,126	**5,157**	No. OEC-81-04; character sample of lignite and interbedded clay.
—	—	0.49	0.71	—	—	—	—	549	**790**	989	**1,424**	No. OEC-84-04; reverse circulation sample of 2.5 m of lignite, clay, and sand.
—	—	1.30	2.26	—	—	—	—	661	**1,149**	1,190	**2,069**	No. OEC-81-12; 3 ft reverse circulation sample of clay and lignite.
—	—	1.18	3.18	—	—	—	—	1,680	**4,525**	3,024	**8,144**	No. OEC-81-12; 7 ft reverse circulation sample largely of lignite.
—	—	2.23	5.90	—	—	—	—	1,815	**4,800**	3,267	**8,641**	No. OEC-81-12; 4 ft reverse circulation sample. **Note:** because water is used in drilling, it is not likely that the 62.19% moisture is representative of the lignite in-situ.

mples are all from the main lignite discovery in Hole No. OEC-81-12 thicknesses (up to 8 m) of black carbonaceous or lignitic clay. The weight of this material suggested that it was largely clay rather than the lighter lignite. Nevertheless, several samples of the material, when ignited with a blowtorch, gave off a strong asphalt odor and remained ignited for some time. A sample of this material was sent to CanMet for detailed analyses (see Table 9). Clearly the sample is largely clay, although the dry BTU content (3,670) indicates the presence of a substantial amount of organic material. This carbonaceous clay represents the proper sedimentary environment for lateral equivalents to occur as lignite horizons.

6.2.2.3 Comparative Sedimentary Models

Coal deposits occur in a variety of nonmarine and marine sedimentary environments (see Flores and Ethridge 1981) of deposition. Within the Cretaceous basin of the James Bay Lowland, there are few indications that the sediments accumulated in a marine environment; most of the sequences are clearly nonmarine. In nonmarine depositional models, coal deposits are commonly associated with fluvial (river), alluvial (fans), and lacustrine (lake) settings. Studying the sedimentary associations of coal or lignite can lead to the recognition of indicators for such characteristics as deposit thickness, form, and composition. Therefore, recognizing the particular sedimentary environment may be helpful in selecting drillsites in exploration programs.

In a review of the Mesozoic sediments and Onakawana coal deposits, Price (1978) made a number of observations concerning sedimentary features of the areas. Some of these observations are highlighted below:

> *The silica sand appears to be the weathered residue of a series of coalescing river channel arkosic deposits and, although very little evidence is available to determine the distribution of environmental associations, it should be pointed out that the sediments of the Mattagami Formation encountered so far contain no sign whatever of salt or brackish water sediments that would indicate the presence of any lower deltaic or tidal channel facies.*
>
> *The exposed lignitic beds are related to lacustrine sediments filling depressions along the front of the Precambrian escarpment. Whether this ponding was structurally controlled, that is by a reversal of the general slope by a slight upwarp within the basin to the north, or was the result of aggrading of downstream sediments below an upper deltaic or fluvial plain*

TABLE 9

ANALYSIS OF A CARBONACEOUS CLAY

Sample No. 3909-81 from AW-1 taken along the east bank of the Mattagami River, southwest corner of Morrow Township

ANALYSES	As Received	Dry
PROXIMATE ANALYSIS		
Moisture	37.36%	—
Ash	37.08	59.20%
Volatiles	17.50	27.94
Fixed Carbon (by difference)	8.06	12.86
ULTIMATE ANALYSIS		
Carbon	15.63%	24.95%
Hydrogen	0.82	1.31
Sulphur	0.29	0.46
Nitrogen	0.15	0.24
Ash	37.08	59.20
Oxygen (by difference)	8.67	13.84
CALORIFIC VALUE		
Calories	1,277/g	2,039/g
BTU	2,299/lb	3,670/lb
FREE SWELLING INDEX	NA	NA
ASH ANALYSIS		
Component		
SiO_2	53.50%	
Al_2O_3	12.81	
Fe_2O_3	3.87	
TiO_2	0.46	
P_2O_5	0.09	
CaO	16.40	
MgO	3.68	
SO_3	2.21	
Na_2O	1.77	
K_2O	1.91	
BaO	0.06	
SrO	0.04	
LOF	0.75%	

> *of the river system that drained the Cretaceous surface toward the north, or a combination of both, is not known.*
>
> *Carbonaceous deposits, as presently known, would result from swampy depressions close to the faulted Precambrian escarpment on the south and parallel with the eastern Precambrian margin of Moose River Basin on the east. The depressions are related in part to basinward aggrading of fluvial plain or upper deltaic deposits of a northward-flowing drainage system to the west of Onakawana.*

Figure 20 illustrates models of deposition from sedimentological studies in areas of non-marine coal deposits that could apply to the James Bay Lowland. Although these models are relatively simple, they can lead to rather complex sedimentary successions. For example, Flores (1981) illustrates lithogenetic models for facies that may be dominated by fluvial channels (Figure 21) or by fluvial lakes (Figure 22).

The lacustrine model may well apply to the Onakawana deposit (see Price 1978, above) and may also apply to the area north of the Mattagami Grand Rapids. For example, in the auger holes as well as in drillholes OEC-81-03, -04, and -05, there are relatively thick sequences of brown to black carbonaceous clays, interbedded thin lignite seams, and fine-grained sands. These sequences may represent an overbank crevasse and lake system similar to those modelled in several of the preceding illustrations. A similar system could also apply to the region that includes drillhole OEC-81-09, where 1.4 m of coal are contained in a sequence dominated by a variety of clays, silts, and minor sand units.

The Adam Creek occurrences have features that may represent a fluvial–lacustrine environment of deposition, especially in drillholes ODM-78-01 and -05. However, the thick seam encountered in drillhole ODM-78-06 is associated with a thick sequence of fine- to coarse-grained sands and silt as well as thin carbonaceous clays. This sequence could be more representative of an overbank-fluvial channel system.

The thick seam discovered in Gentles Township is difficult to evaluate because the lignite is within 2–3 m of overlying Pleistocene till. However, the Cretaceous sediments underlying the main lignite seam are dominated by fining upward sequences of very coarse to fine sands with relatively minor silt and clay units. Thus, the lignite

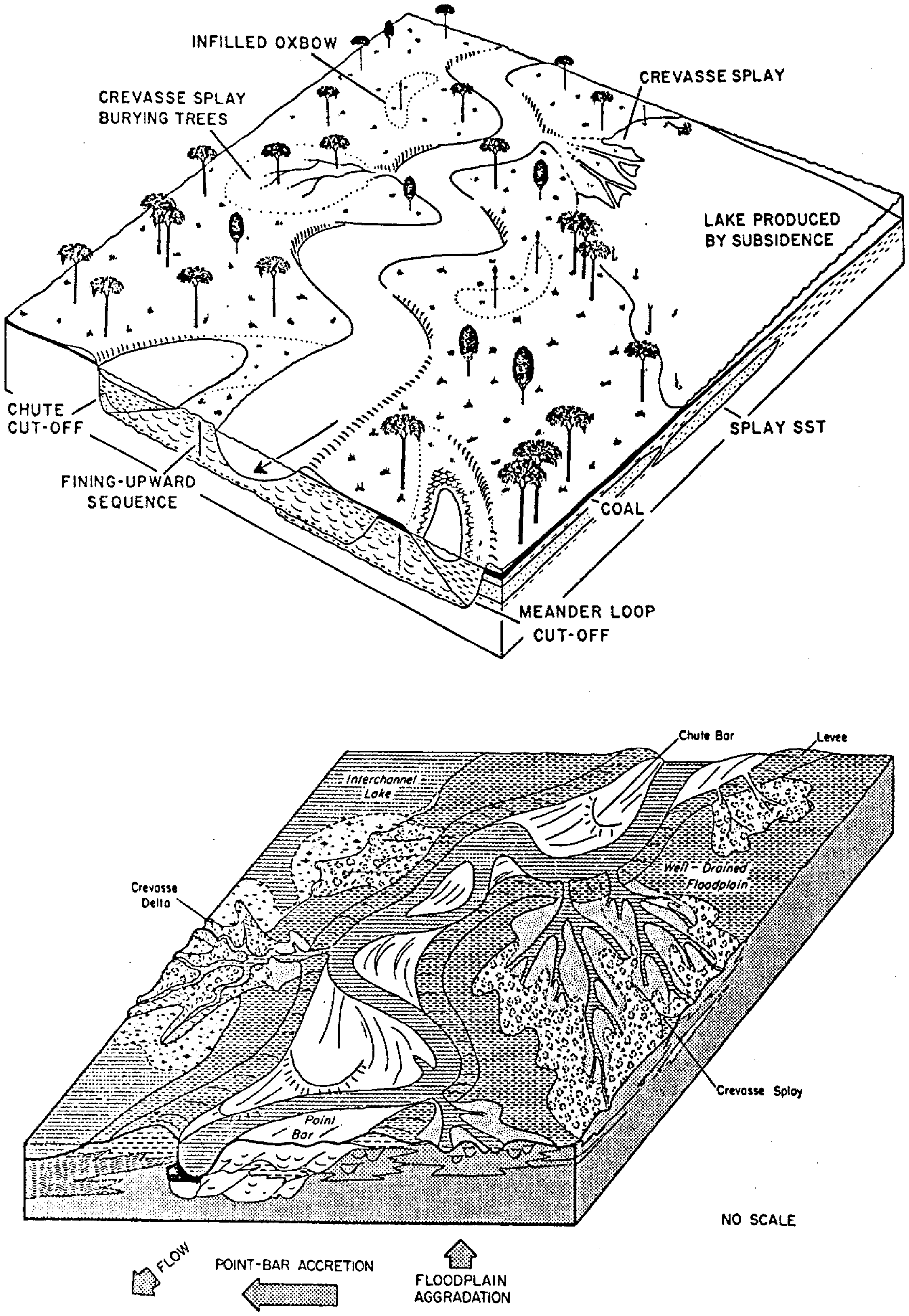


FIGURE 20: Simplified fluvial depositional models. The top model is a reconstruction of the coal-bearing sediments of the Port Wood Formation (Late Carboniferous age) in Nova Scotia by Gersib and McCabe (1981). Whereas the lower model applies to the fluvial systems in the Gulf Coast in the Cenozoic and is from Galloway (1981).

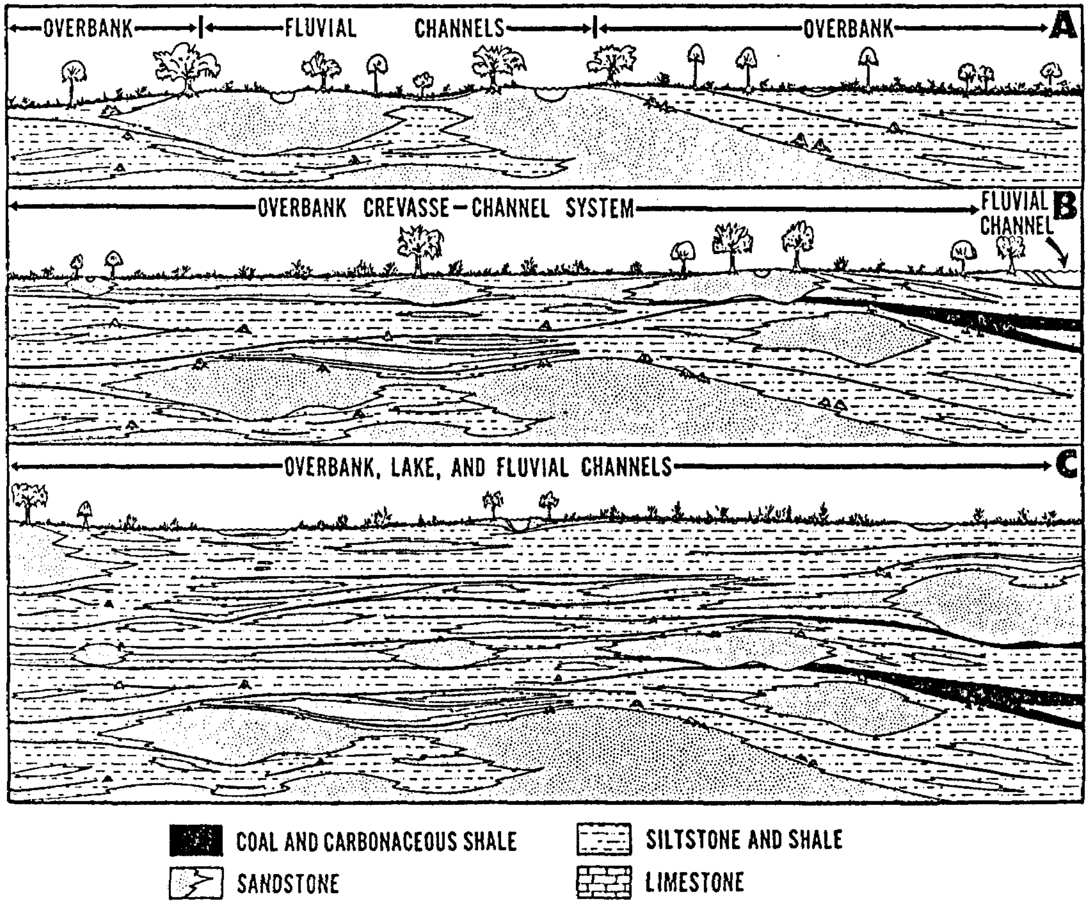


FIGURE 21 : Lithogenetic model for the fluvial–channel–dominated facies, portraying sequences of depositonal events (taken from Flores 1981).

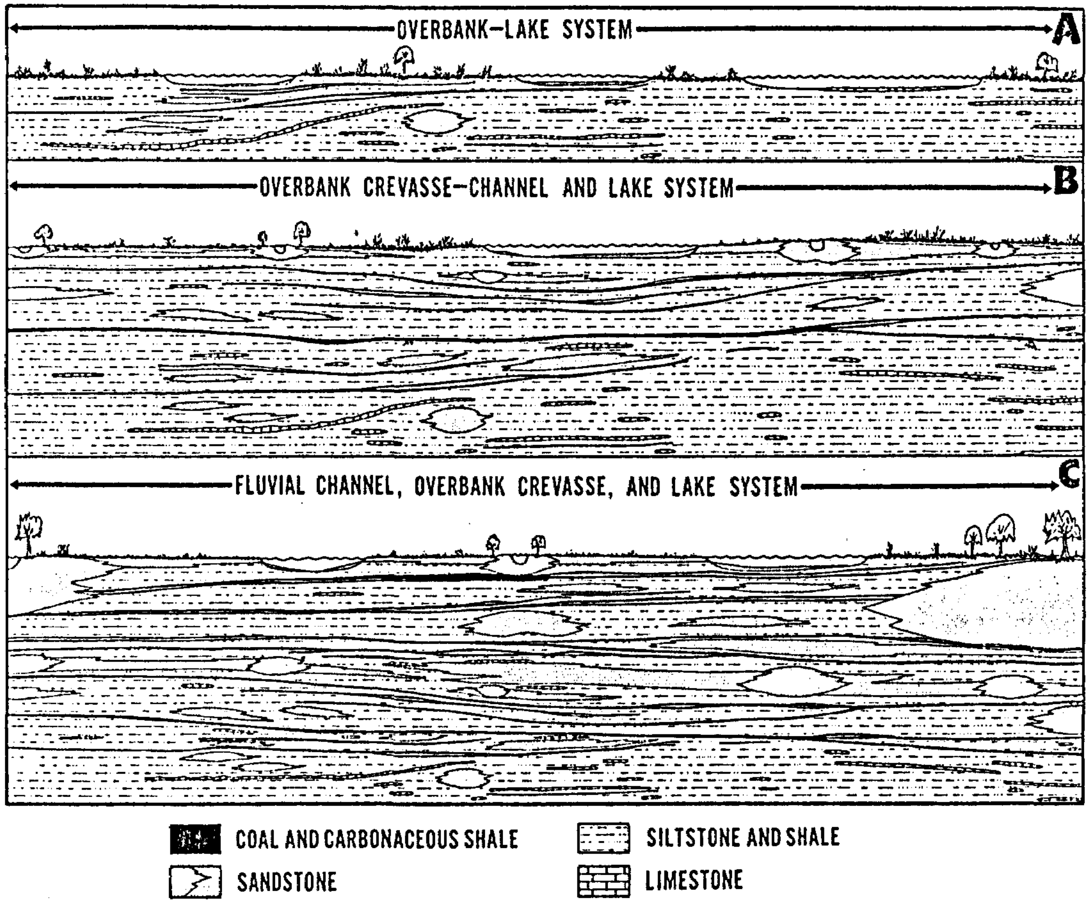


FIGURE 22 : Lithogenetic model for the fluvial–lake facies, showing sequences of depositional events (taken from Flores 1981).

may have accumulated in poorly drained swamps behind levees of a major fluvial channel. Much more information is needed before such comparisons can be considered anything but speculation.

Ethridge and his co-authors (1981) have provided an interesting summary of coal-bearing non-marine sediments in the southern Powder River Basin of Wyoming; general features of this region could apply to the James Bay Lowland. Figure 23 illustrates the size, paleogeography, and inferred depositional systems of this early Tertiary intermontane basin. Figure 24 illustrates a simplified depositional model and the lithologies, structures, and other sedimentological features that generally define the Powder River nonmarine sequences. Significant coal deposits occur in two varying settings within the basin. The most important type, which averages 24 m thick in the area studied, is laterally extensive, occurs in areas peripheral to major north–south trunk streams, has relatively low (but highly variable) ash and sulphur contents, and contains negligible shale partings. The second type is much thinner (usually 0.3–2 m), has limited areal extent, contains shale partings, and often sits atop crevasse splays or channel sands and silts. The latter deposits are believed to be more restricted to the tributary subsystems. Ethridge and others (1981) have speculated that the thick coals have accumulated in part because the vegetation was receiving nutrients in the groundwater discharge area, thus flourishing so as to develop topographic platforms that were not inundated by the nearby channels. Figure 25 illustrates this model.

Many observations of the Powder River Basin could be applicable to features in the James Bay Lowland. However, we presently have only limited knowledge of the paleogeography and sedimentology of the Cretaceous Basin in this region. Most of our information is derived from small areas along the southern and southeastern margins of the former basin. Elsewhere, little is known; certainly, the major paleochannels have not been defined, and fundamental sedimentary information is lacking for most of the area. Analogies with better-known coal-bearing areas in nonmarine sediments clearly indicate the regional potential for discovering significant lignite occurrences in large parts of the James Bay Lowland where no testing has been done to-date.

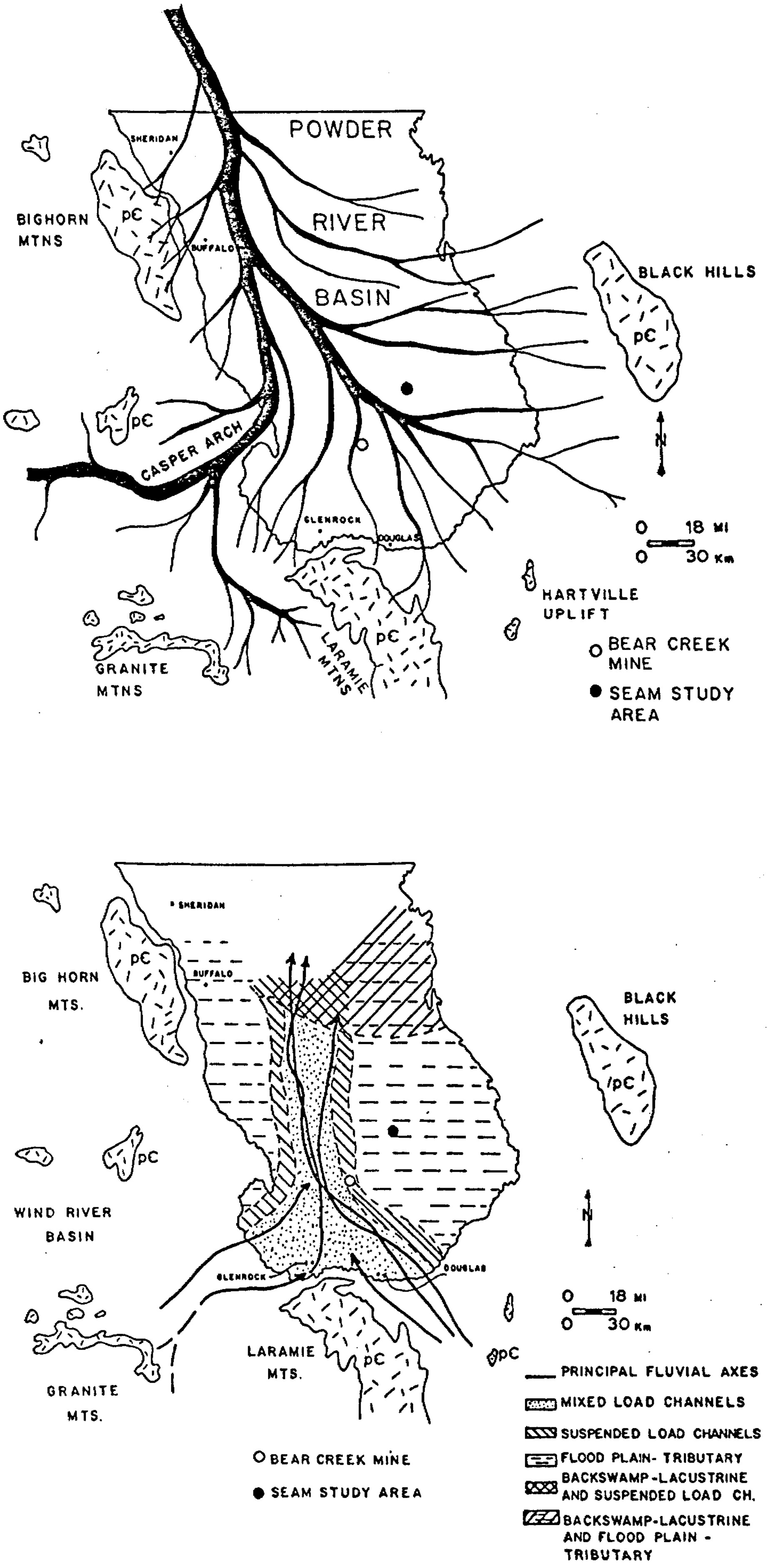


FIGURE 23: Coal-bearing non-marine sediments in the Powder River Basin, Wyoming (after Ethridge and others, 1981)

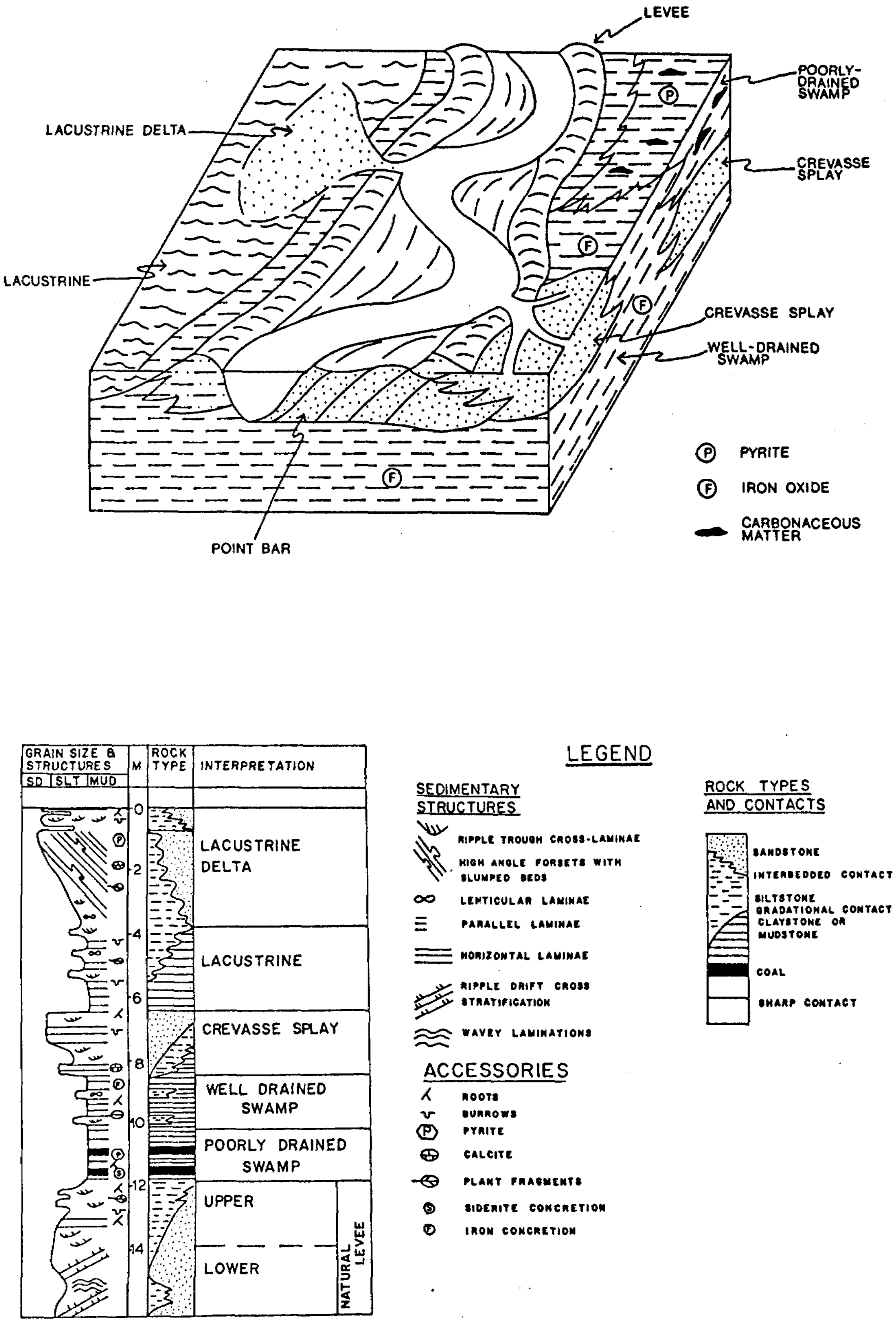


FIGURE 24: Simplified depositional model for the Powder River coal occurrences (after Ethridge and others, 1981).

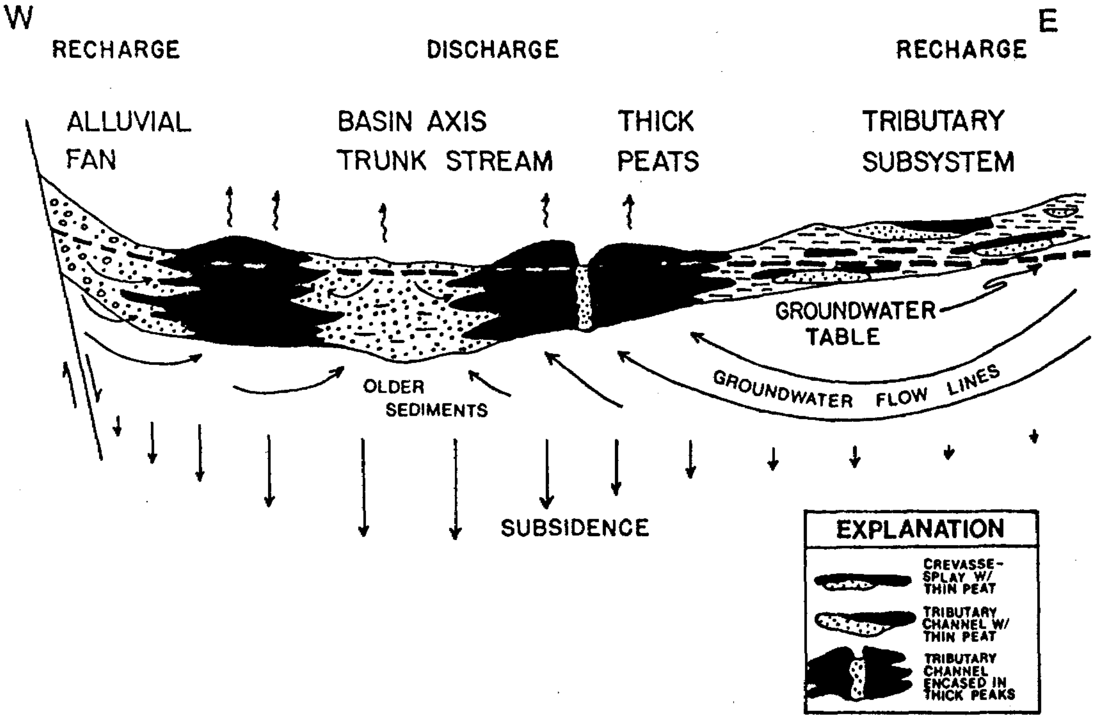


FIGURE 25: Possible origin for the thick coal deposits in the Powder River Basin, Wyoming. Thick vegetation can grow as a result of receiving abundant nutrients in areas where there was extensive groundwater discharge. The thick vegetation created topographic platforms that were secure from periodic flooding and inundations by nearby channels (after Ethridge and others, 1981).

6.2.3 OIL SHALE

This section will discuss those aspects of the 1981 exploration program designed to evaluate the oil shale potential of the Long Rapids Formation in the OERL exploratory licence area. A 1982 WGM report, 'Pilot Study on the Evaluation of Ontario Oil Shale' by P. Lalande and M. C. Ward, also covers numerous aspects of the oil shale potential of the Long Rapids Formation and reports the results of tests in this general region. 'A Review of Oil Shale Potential in Eastern Canada' was submitted to OERL by WGM in May, 1980.

For present purposes, we can define an oil shale as a fine textured sedimentary rock containing substantial organic matter in the form of kerogen, from which significant amounts of oil can be extracted. It has been known for 70 years that the Long Rapids Formation contains oil shale units that have yielded oil under pyrolysis. The 1981 lignite drill program offered the opportunity to test a number of areas for oil shale since the Long Rapids Formation underlies most of the Mesozoic sediments in the Moose River Basin. Where possible most of the 1981 drillholes were extended into the Long Rapids Formation, and several of these holes were cored to obtain fresh material for testing purposes.

Four main drill intersections were sampled in detail. These included drillholes OEC-81-05, -08, -10, and -11 (see Map B). The material sampled was taken from 1 7/8 inch diameter cores that were cut in half with a rock saw and one half crushed and submitted to Bondar–Clegg & Company Ltd. (Ottawa) for analysis. Most sample lengths are in the 1–2 m range. The analytical procedure involved a hydrochloric leaching stage followed by a carbon determination on the acid residue. Analytical precision and accuracy are generally within 5% of the organic carbon content.

Table 10 summarizes all the analytical results of samples obtained in the 1981 drill program. There is a wide variation in the results, from approximately 0.5% organic carbon to approximately 7.2%. In general, the medium grey, more clay-rich sections have relatively low carbon values (usually <3%), whereas the higher values apply largely to the dark brown clay-silt units. Certainly when the drilling was being carried out, the drill cuttings and return water almost always left an oily coating on the

TABLE 10

SUMMARY OF TOTAL ORGANIC CARBON ANALYSES

(FROM BONDAR-CLEGG & CO. LTD.)

LAB NO.	SAMPLE LOCATION			SAMPLE DESCRIPTION						Organic Carbon (%)
	General	Township	Hole No.	Supplied By	Sample Type	Geol. Form.	From (m)	To (m)	Length (m)	
0941	M.R.B.	Hobson-Morrow	OEC-81-05	WGM	CO	DLR	71.0	74.0	3.0	0.78
0942	"	"	"	"	"	"	74.0	77.0	3.0	1.96
0943	"	"	"	"	"	"	77.0	80.0	3.0	1.08
0944	"	"	"	"	"	"	80.0	85.0	5.0	0.98
0945	"	"	"	"	"	"	85.0	86.0	1.0	1.47
0946	"	"	"	"	"	"	86.0	87.0	1.0	2.25
0947	"	"	"	"	"	"	87.0	88.0	1.0	3.62
0948	"	"	"	"	"	"	88.0	89.0	1.0	2.74
0949	"	"	"	"	"	"	89.0	89.4	0.4	2.54
2059	"	"	"	"	"	"	89.4	90.4	1.0	1.25
2060	"	"	"	"	"	"	90.4	91.7	1.3	4.33
2061	"	"	"	"	"	"	91.7	93.3	1.6	4.72
2062	"	"	"	"	"	"	93.3	94.5	1.2	4.72
2063	"	"	"	"	"	"	94.5	95.7	1.2	5.30
2064	"	"	"	"	"	"	95.7	96.9	1.2	4.53
2065	"	"	"	"	"	"	96.9	98.1	1.2	4.14
2066	"	"	"	"	"	"	98.1	99.3	1.2	4.82
2067	"	"	"	"	"	"	99.3	100.6	1.3	6.36
2068	"	"	"	"	"	"	100.8	101.8	1.0	5.30
2069	"	"	"	"	"	"	101.8	103.0	1.2	5.97
2070	"	"	"	"	"	"	103.0	104.2	1.2	5.68
2071	"	"	"	"	"	"	104.2	105.4	1.2	6.74
2072	"	"	"	"	"	"	105.4	106.6	1.2	4.72
2073	"	"	"	"	"	"	106.6	107.8	1.2	6.55
2074	"	"	"	"	"	"	107.8	109.1	1.3	6.26
2075	"	"	"	"	"	"	109.1	110.3	1.2	7.13
2076	"	"	"	"	"	"	110.3	111.5	1.2	5.78
2077	"	"	"	"	"	"	111.5	112.7	1.2	7.22
2078	"	"	"	"	"	"	112.7	114.0	1.3	5.39
2079	"	"	"	"	"	"	114.0	115.2	1.2	3.18
2080	"	"	"	"	"	"	115.2	116.4	1.2	2.31
2081	"	"	"	"	"	"	116.4	117.8	1.4	1.93
2082	"	"	"	"	"	"	117.8	119.0	1.2	2.02
2083	"	"	"	"	"	"	119.0	122.5	3.5	2.89
2084	"	Gardiner	OEC-81-08	"	"	"	45.7	48.8	3.1	1.48
2085	"	"	"	"	"	"	48.8	50.3	1.5	2.07
2086	"	"	"	"	"	"	50.3	51.8	1.5	3.64
2087	"	"	"	"	"	"	51.8	53.0	1.2	2.17
2088	"	"	"	"	"	"	53.0	54.0	1.0	2.07
2089	"	"	"	"	"	"	54.0	55.0	1.0	1.97
2090	"	"	"	"	"	"	55.0	56.0	1.0	3.94
2091	"	"	"	"	"	"	56.0	57.0	1.0	2.36
2092	"	"	"	"	"	"	57.0	58.0	1.0	3.25
2093	"	"	"	"	"	"	58.0	59.0	1.0	3.54
2094	"	"	"	"	"	"	59.0	60.0	1.0	4.24
2095	"	"	"	"	"	"	60.0	61.0	1.0	3.74
2096	"	"	"	"	"	"	61.0	62.0	1.0	4.93
2097	"	"	"	"	"	"	62.0	63.0	1.0	3.25
2098	"	"	"	"	"	"	63.0	64.3	1.3	2.46
2099	"	"	OEC-81-10	"	"	"	84.2	85.2	1.0	1.28
2100	"	"	"	"	"	"	85.2	86.2	1.0	1.08
2101	"	"	"	"	"	"	86.2	87.2	1.0	1.38
2102	"	"	"	"	"	"	87.2	88.2	1.0	0.89
2103	"	"	"	"	"	"	88.2	89.2	1.0	1.58
2104	"	"	"	"	"	"	89.2	90.2	1.0	1.97
2105	"	"	"	"	"	"	90.2	91.2	1.0	2.96
2106	"	"	"	"	"	"	91.2	92.2	1.0	1.48
2107	"	"	"	"	"	"	92.2	93.2	1.0	0.49
2108	"	"	"	"	"	"	93.2	94.2	1.0	2.07
2109	"	"	"	"	"	"	94.2	95.2	1.0	0.79
2110	"	"	"	"	"	"	95.2	96.2	1.0	2.17

TABLE 10

(continued)

LAB NO.	SAMPLE LOCATION			SAMPLE DESCRIPTION						Organic Carbon (%)
	General	Township	Hole No.	Supplied By	Sample Type	Geol. Form.	From (m)	To (m)	Length (m)	
2111	M.R.B.	Gardiner	OEC-81-10	WGM	CO	DLR	96.2	97.2	1.0	1.08
2112	"	"	"	"	"	"	97.2	98.2	1.0	2.66
2113	"	"	OEC-81-11	"	"	"	70.6	71.6	1.0	1.08
2114	"	"	"	"	"	"	71.6	72.6	1.0	0.79
2115	"	"	"	"	"	"	72.6	73.6	1.0	0.30
2116	"	"	"	"	"	"	73.6	74.3	0.7	0.49
2117	"	"	"	"	"	"	74.3	75.9	1.6	0.49
2118	"	"	"	"	"	"	75.9	77.4	1.5	1.18
2119	"	"	"	"	"	"	77.4	78.2	0.8	1.58
2120	"	"	"	"	"	"	78.2	79.6	1.4	1.08
2121	"	"	"	"	"	"	79.6	80.8	1.2	0.89
2122	"	"	"	"	"	"	80.8	82.0	1.2	1.18
2123	"	"	"	"	"	"	82.0	83.2	1.2	1.18
2124	"	"	"	"	"	"	83.2	84.4	1.2	2.56
2125	"	"	"	"	"	"	84.4	85.6	1.2	2.27
2126	"	"	"	"	"	"	85.6	86.6	1.0	2.86
2127	"	"	"	"	"	"	86.6	87.2	0.6	0.59
2128	"	"	"	"	"	"	87.2	88.2	1.0	1.77
2129	"	"	"	"	"	"	88.2	89.0	0.8	1.58
2130	"	"	"	"	"	"	89.0	90.0	1.0	1.97
2131	"	"	"	"	"	"	90.1	91.0	0.9	2.56
2132	"	"	"	"	"	"	91.0	92.0	1.0	1.38
2133	"	"	"	"	"	"	92.0	93.0	1.0	4.14
2134	"	"	"	"	"	"	93.0	94.0	1.0	4.04
2135	"	"	"	"	"	"	94.0	95.0	1.0	3.84
2136	"	"	"	"	"	"	95.0	96.0	1.0	3.15
2137	"	"	"	"	"	"	96.0	97.0	1.0	4.43
2138	"	"	"	"	"	"	97.0	98.0	1.0	4.93
2139	"	"	"	"	"	"	98.0	99.0	1.0	2.27
2140	"	"	"	"	"	"	99.0	100.0	1.0	2.27
2141	"	"	"	"	"	"	100.0	101.0	1.0	3.05
2142	"	"	"	"	"	"	101.0	102.0	1.0	3.05
2143	"	"	"	"	"	"	102.0	103.0	1.0	5.32
2144	"	"	"	"	"	"	103.0	103.8	0.8	4.90
2145	"	"	"	"	"	"	104.1	105.1	1.0	4.21
2146	"	"	"	"	"	"	105.1	106.1	1.0	3.04
2147	"	"	"	"	"	"	106.1	107.1	1.0	4.31
2148	"	"	"	"	"	"	107.1	108.1	1.0	4.61
2149	"	"	"	"	"	"	108.1	109.1	1.0	6.51
2150	"	"	"	"	"	"	109.1	110.1	1.0	3.75
2151	"	"	"	"	"	"	110.1	111.1	1.0	1.96
2152	"	"	"	"	"	"	111.1	111.6	0.5	0.98

floorboards of the drill platform, whereas the cuttings from the lighter-grey clays were easily washed away, leaving no residue behind. The difference in the organic content of these two principal lithologies is best demonstrated in drillhole OEC-81-05, located very close to the southeastern boundary of the Cretaceous units. At depths of approximately 89–98 m, the section consists of interbedded grey-green and dark brown claystone/shale/siltstone in approximate proportions of 4 : 6 (grey : brown). At about 98 m, the brown units become more abundant (approximately 1 : 10 grey : brown). At about 99 m, the analyses show an abrupt jump from 4–5% organic carbon to levels consistently close to 6% and 7%. In fact, from 99.3 to 114.0 m (14.7 m), the average organic content is 6.1%. Farther north (holes OEC-81-08, -10, and -11 are all near the Missinaibi River), the organic content of samples of the Long Rapids Formation are considerably lower than those from OEC-81-05. In the northern area, organic carbon levels rarely exceed 5% and most are less than 3%. In hole OEC-81-11, the values vary widely, again as a result of the relative proportions of organic-rich brown units and organic-poor green-grey units.

There are insufficient data to make very meaningful regional comparisons of the organic content in the Long Rapids Formation. However, the values reported from hole OEC-81-05 are consistently 1–2% lower than comparable analyses of Ontario Hydro cores from Hobson Township (Abitibi River); but they are 2–3% higher than samples from near the Missinaibi River. Considerably more regional testing would be required to establish whether this indicated trend is meaningful.

A selected suite of core samples from drillholes OEC-81-05, -08, and -11 was submitted to the Colorado School of Mines Research Institute (CSMRI) for Fischer assaying. The results are reproduced in Table 11.

To quote from the 1980 WGM oil shale report:

> *Traditionally the shale oil yield of oil shale has been determined using the Fischer test. This test is executed by heating a sample of oil shale in a retort to 500°C at which point pyrolysis takes place. A portion of the carbonaceous material (kerogen) undergoes a chemical change and part of it is vaporized. The vapour following condensation is separated into gaseous and liquid hydrocarbons and a portion of the kerogen remains in the spent shale as solid hydrocarbon and as coke(?).*

TABLE 11

FISCHER ASSAY RESULTS

Drillhole No.	Sample No.	Bondar–Clegg Organic Carbon (%)	H_2O (g/t)	Oil (g/t)	Specific Gravity	Gas + Loss (%)	ANALYSES ON SPENT SHALE			Carbon Percent Removed in 'Oil'
							Carbonate Carbon (%)	Total Carbon (%)	Organic Carbon (%)	
OEC-81-05	2067	6.36	22.7	5.18	0.910	1.93	0.35	4.89	4.54	1.82
	2068	5.30	22.6	1.83	0.910	0.60	0.49	4.29	3.80	1.50
	2069	5.97	22.5	1.92	0.910	1.74	0.20	4.51	4.31	1.66
	2070	5.68	14.4	4.66	0.910	1.63	0.18	4.59	4.41	1.27
	2071	6.74	21.5	5.23	0.910	2.10	0.04	5.44	5.40	1.34
	2072	4.72	20.1	2.05	0.910	1.98	0.26	4.09	3.83	0.89
	2073	6.55	23.6	2.91	0.910	1.46	0.19	5.21	5.02	1.53
	2074	6.26	24.5	3.21	0.910	1.51	0.11	4.89	4.78	1.48
	2075	7.13	17.9	3.18	0.910	1.89	0.21	5.44	5.23	1.90
	2076	5.78	22.6	2.06	0.910	2.78	0.20	4.78	4.58	1.20
	2077	7.22	22.7	2.81	0.910	3.52	0.24	5.92	5.68	1.54
	2078	5.39	19.0	1.67	0.910	3.03	1.71	5.49	3.78	1.61
OEC-81-08	2090	3.94	22.7	N.D.	—	2.98	0.53	4.10	3.57	0.37
	2091	2.36	22.4	2.36	0.910	0.19	1.52	3.78	2.26	0.10
	2092	3.25	20.0	1.37	0.910	1.25	1.15	4.14	2.99	0.26
	2093	3.54	22.1	N.D.	—	1.02	0.21	3.20	2.99	0.55
	2094	4.24	28.0	N.D.	—	1.27	0.22	4.11	3.89	0.35
	2095	3.74	21.9	N.D.	—	2.61	0.34	4.24	3.90	0.16
	2096	4.93	22.7	2.07	0.910	1.30	0.21	4.78	4.57	0.36
	2097	3.25	22.2	0.90	0.910	1.32	0.74	4.42	3.68	0.43
	2098	2.46	13.1	1.99	0.910	1.43	1.48	3.51	2.03	0.43
OEC-81-11	2143	5.32	12.9	3.90	0.910	1.07	0.34	4.02	3.68	1.64
	2144	4.90	13.2	2.19	0.910	1.27	0.42	4.16	3.74	1.16
	2145	4.21	19.1	2.68	0.910	1.87	0.54	4.91	4.37	0.16
	2146	3.04	16.7	N.D.	—	1.37	0.46	3.65	3.19	0.15
	2147	4.31	15.5	2.28	0.910	0.83	0.30	4.14	3.84	0.47
	2148	4.61	15.3	2.51	0.910	1.21	0.18	3.88	3.70	0.91
	2149	6.51	14.0	4.32	0.910	1.56	0.27	5.47	5.20	1.31
	2150	3.75	14.3	0.60	0.910	1.07	0.10	3.08	2.98	0.77

N.D. = None Detected

> *The Fischer test does not measure the absolute content of kerogen in the oil shale. It determines only that content of carbonaceous material which can be converted to gaseous or liquid hydrocarbons by the retort process, an amount which is restricted by the available hydrogen content of the kerogen. Left behind and not measured is a residue which is a carbonaceous sludge or coke which, under the proper conditions, can be converted to additional amounts of hydrocarbon.*

Despite these limitations, Fischer assay does indicate that portion of the organic material that is likely to be most easily recovered in the form of oil or gas. The licence area oil yields (in U.S. gallons per ton) are quite low relative to the organic carbon content. The 14.7 m section in hole OEC-81-05 that averaged 6.1% organic carbon had an average yield of approximately 3.1 gallons per ton. In general, the samples with more organic carbon yielded more oil, but there are numerous exceptions where samples with relatively high organic carbon have low oil yields and samples with lower amounts of organic carbon have yielded relatively larger amounts of oil.

In the final column of Table 11, we have tabulated the percentage of organic carbon removed by the Fischer assay. This figure is the difference between the organic carbon in the spent shale (CSMRI analysis) and the organic carbon content in the original sample (Bondar–Clegg analysis). Most of the oil was derived from 0.5–2% organic carbon. This suggests that the Fischer conversion is about 5–30% efficient.

If we doubled the efficiency of conversion of several samples, there would still remain a substantial amount of organic carbon left in the shale. For example, in Sample 2067, 5.18 gallons of condensate were yielded from approximately 1.5% organic carbon, which represents a conversion efficiency of close to 30%. Theoretically, a 60% conversion would yield 10 gallons of condensate; and 90% conversion, 15 gallons. The greatest ultimate yield could be expected from Sample 2071, in which the indicated yield of 5.2 gallons of condensate (per ton of rock) was apparently derived from 1.34% of organic carbon. This conversion efficiency is approximately 20%. Therefore, under ideal conditions, the ultimate yield from this particular material would range 20–25 gallons of organic condensate per ton. Although these figures are entirely speculative, they indicate the general range in yields that could be expected from the oil shales sampled in the 1981 drill program.

6.2.4 HEAVY MINERAL CONCENTRATES

All clastic units were analyzed for heavy minerals. A total of 269 samples were taken, among all twelve holes drilled in 1981. The samples were analyzed by Overburden Drilling Management Limited; a report by F. J. Thompson with comments by S. A. Averill is included in Appendix III. The flowsheet for the sample processing is shown in Figure 26.

Minerals of economic interest were sparse; there were only traces of chalcopyrite, molybdenite, and ilmenite. Most of the heavy minerals were judged to be derived from Archean igneous rocks. The only diamond-indicator minerals found were kyanite and zircon; the more important indicators — green chrome diopside, purple pyrope (magnesian garnet), and picroilmenite — were absent.

In several areas along the Mattagami River, alluvial samples were panned and in most cases traces of gold were indicated. However, none of these occurrences could be considered to be of economic significance. In fact, at one location (at the west bank of the Mattagami River in between auger holes 4 and 5), a 7-cubic-foot alluvial sample was concentrated; from this, 1.75 mg of gold (887 fineness) was recovered. This is equivalent to 0.00022 troy ounces (approximately 0.007 grams) per cubic yard. If the price of gold is $350 Canadian per ounce, the above yield would be worth only about 8¢ per cubic yard.

6.2.5 CLAYS AND SANDS

The main industrial mineral possibilities comprise good quality kaolin and silica sand. The Algoma Central Railway has developed substantial tonnages of silica sand in the area, but no operation has been attempted. High quality kaolin would be marketable, but the kaolin found to-date has not been of marketable grade; the best sample of clay analyzed in 1981 contained only 27% kaolinite.

A suite of typical clay samples were selected for mineralogical determination and sent to the X-ray Section, Department of Geology, University College of Swansea in Wales.

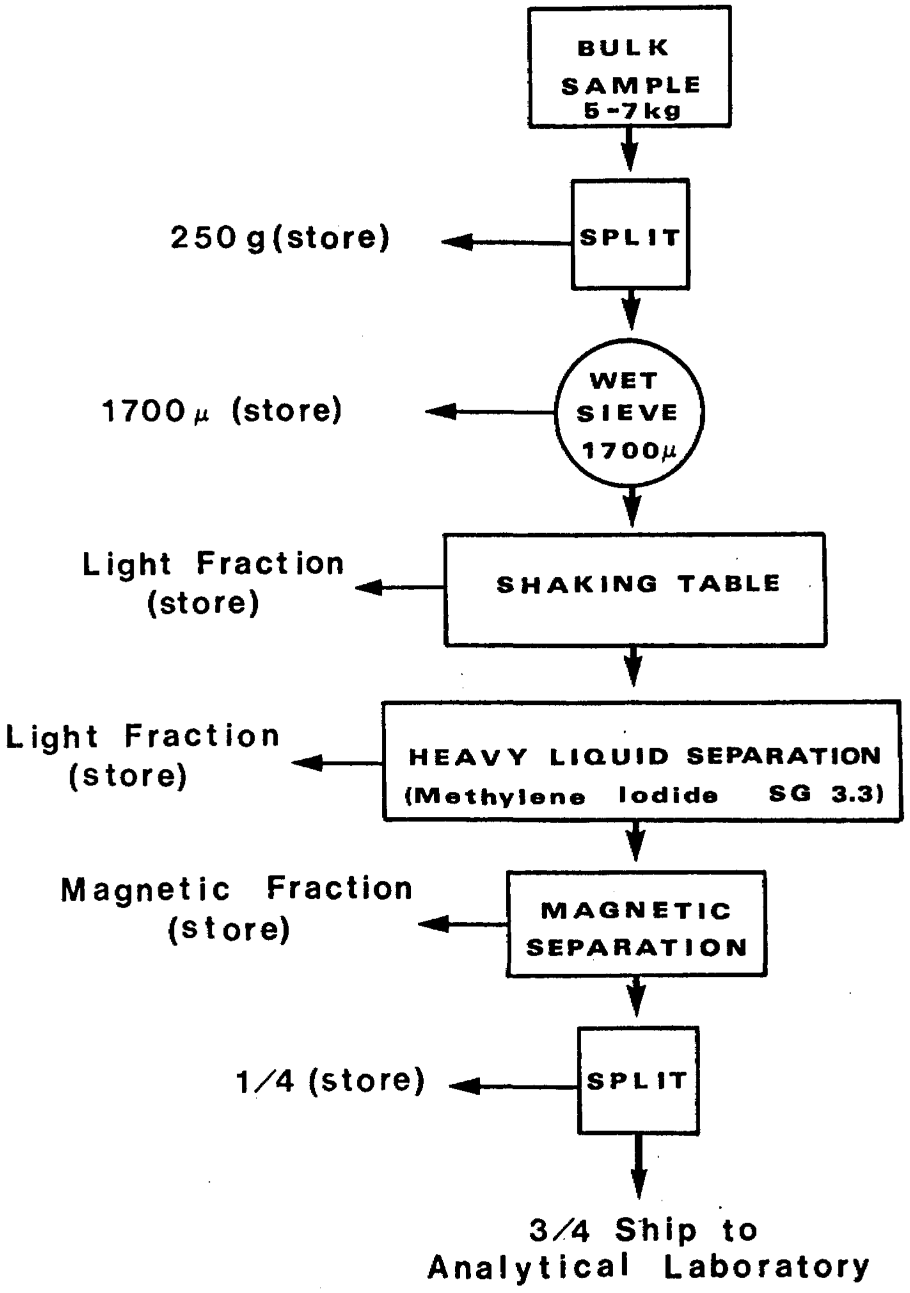


FIGURE 26: Sample processing flowsheet for heavy mineral concentrates (from Overburden Drilling Management Ltd.)

TABLE 12

PRINCIPAL MINERAL CONSTITUENTS OF SELECTED CLAY SAMPLES

(Modal %)

Sample No.	Dolomite (%)	Quartz (%)	Kaolinite (%)	Illite (%)	Chlorite (%)	Montmorillonite (%)	Others* (%)
OEC-81-02 #81 dup.	—	34	15	44	5	—	2
OEC-81-03 46 m dup.	—	62	22	12	—	2	2
OEC-81-03 67.1 m	—	54	27	9	7	trace	3
OEC-81-03 74 m	—	26	18	47	6	—	3
OEC-81-04 66 m	—	68	15	5	9	trace	3
OEC-81-05 #162	—	46	26	15	5	6	2
OEC-81-10 #250	27	50	trace	20	—	—	3
OEC-81-11 235.6'	—	33	16	40	9	—	2
OEC-81-07 57 m	—	19	18	52	6	1	4
OEC-81-09 #224	—	76	12	trace	9	—	3

*Minor constituents present in all samples included calcite, feldspar, and gypsum. Other minor minerals present in most samples included hornblende, siderite, hematite, goethite, and lepidocrocite.

Mineral identifications were made with a Philips X-ray diffractometer utilizing the spacings between the basal atomic planes for clay-size fractions. Since clay-mineral particles are usually flake-like, the planar surfaces parallel to (001) samples were sedimented so that reflections observed were specifically those diffracted from the atomic layers parallel to (001).

Ten selected clay samples were subjected to this method of investigation (see Table 12). They were first powdered with an agate mortar and pestle, and three specimens prepared from each sample. For each clay sample, one specimen was left untreated; one heated in a moffle furnace at 550°C for one hour; and the third glycolated above ethylene glycol for one hour at 60°C in an oven. All thirty specimens were then run on the Philips XRD equipment, comprising a PW1130 generator, a PW1050 diffractometer, a PW1965 detector, a PW4620 amplifier, and graph charts recorded on a PM8220 recorder. A cobalt anode X-ray tube was used and power applied at 35 kV, 25 mA.

To examine the character of the silica sands and clays encountered in the drill program, routine industrial chemical and size analyses were carried out on selected samples. Two silica sand samples were submitted for chemical and sieve analysis. Twenty clay samples were submitted for sieve analysis, differential thermal analysis, and five colour tests. Three clay samples were also submitted for chemical and particle-size analysis. This work was done by the Ontario Research Foundation and the detailed results are reproduced in Appendix VIII of this report. Briefly, this testing indicates that the sands are very high in silica content (98.8% SiO_2) and that the remaining impurities could be removed inexpensively. These sands are quite similar to others reported elsewhere in the Cretaceous Basin, although they tend to be somewhat finer-grained than many examples in the region.

The clay samples tested are largely of a plastic fire-clay type, many of which fire a white to light natural colour. The most obvious impurities include organic material, iron and, in some samples, considerable silica. As would be expected from largely clay material, the particle size is very fine. Again, the presence of these fire-clay materials is consistent with previous work in the region and attests to the regional abundance of industrial clays.

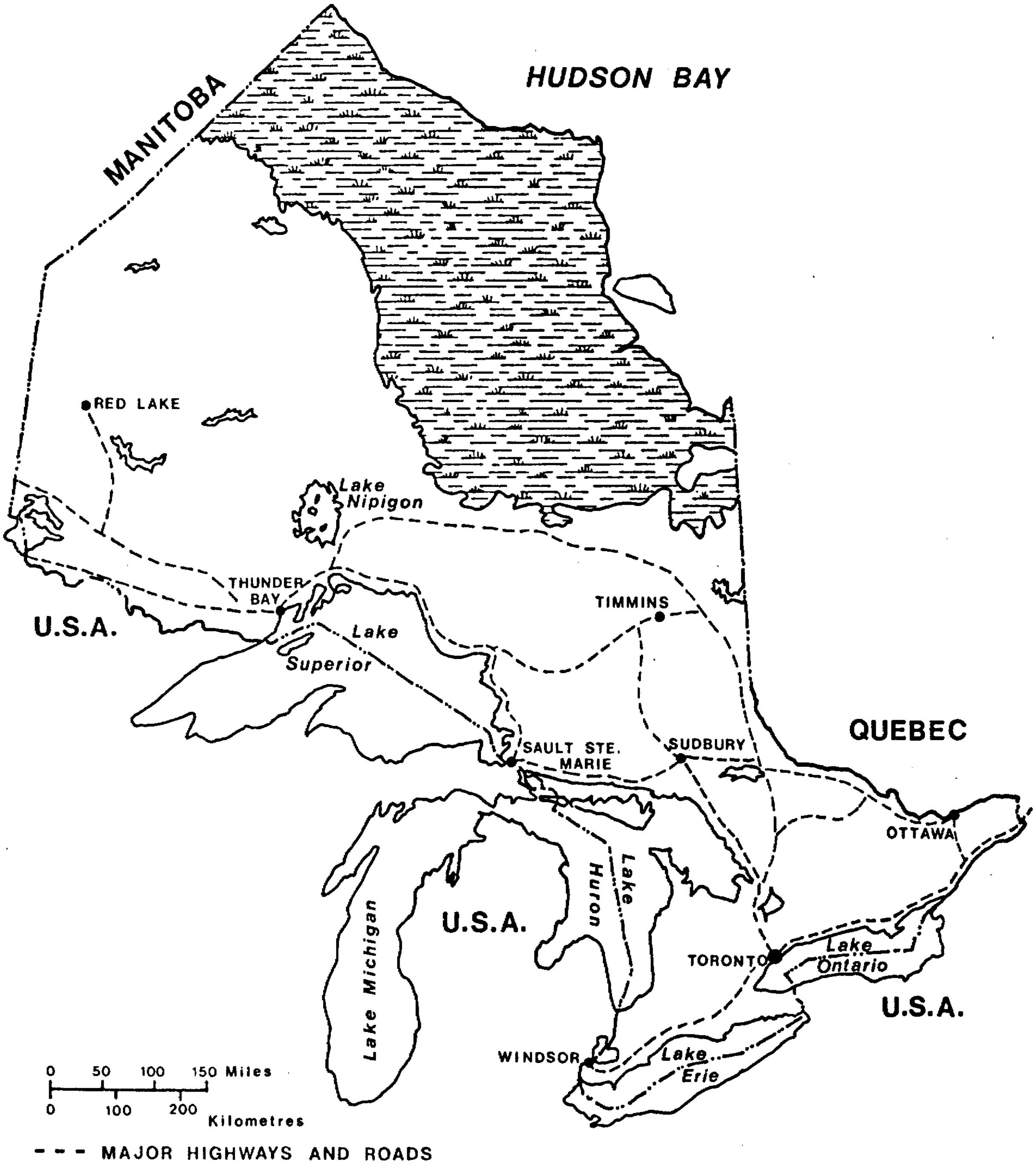


FIGURE 27: Continuous peatlands of northern Ontario (modified from the 1981 Monenco report).

6.2.6 PEAT

The James Bay Lowland is almost completely covered with peatlands as indicated in the 1981 Monenco report titled 'Evaluation of the Potential of Peat in Ontario'. Figure 27 illustrates the vast area occupied by these peatlands; geomorphologically, it coincides closely with the boundary of the Canadian Shield and the flat-lying Paleozoic sediments that border James and Hudson Bays. Figures 28 and 29 illustrate typical peatland areas in the OERL licence area. Although most of the peatlands are sparsely covered with stunted black spruce, much denser forests border the major streams and rivers, where drainage is better and where the peat cover is quite thin (usually <100 cm).

In the 1981 field program, no attempt was made to systematically evaluate the peatlands of the licence area; but fairly late in the season, it was decided at least to determine the depths and general character of several peatland areas near the Mattagami River, in the vicinity of areas being drilled for lignite. Map B indicates where most samples were taken.

Thanks to Maureen Kershaw of the OMNR Forestry Branch, we were able to borrow a MacCauley sampler to test the peat and to obtain samples from various depths within a peat section.

Along the geophysical baseline, samples were taken in three main areas: (i) near drillhole OEC-81-02; (ii) close to drillholes OEC-81-09 and -11; and (iii) at the very end of the baseline. In the first case, the peat depths are approximately 100 cm; in the second area, approximately 120–140 cm; and up to 200 cm at the north end of the baseline.

In the area of drillhole OEC-81-03, the peat is generally less than 60 cm thick; whereas at hole -06, it is 120–140 cm thick. Farther north, the area around OEC-81-07 has peat thicknesses of 80–100 cm.

Substantially thicker peat was indicated in a large area north of hole OEC-81-05, between the Mattagami and Onakawana Rivers. Here, thicknesses are in the range of

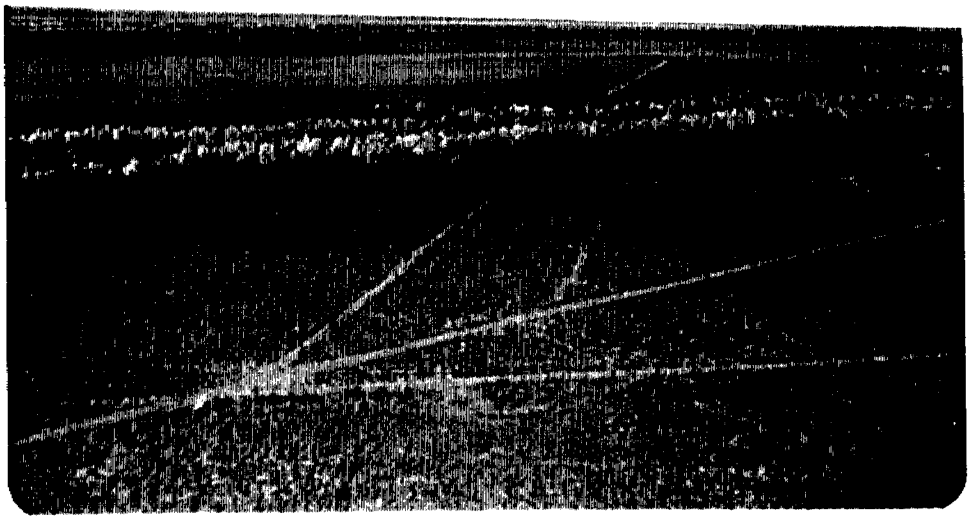


FIGURE 28 : Area along the Mattagami River. Areas with dense trees contain thin peat, whereas the more open areas contain thicker peat.

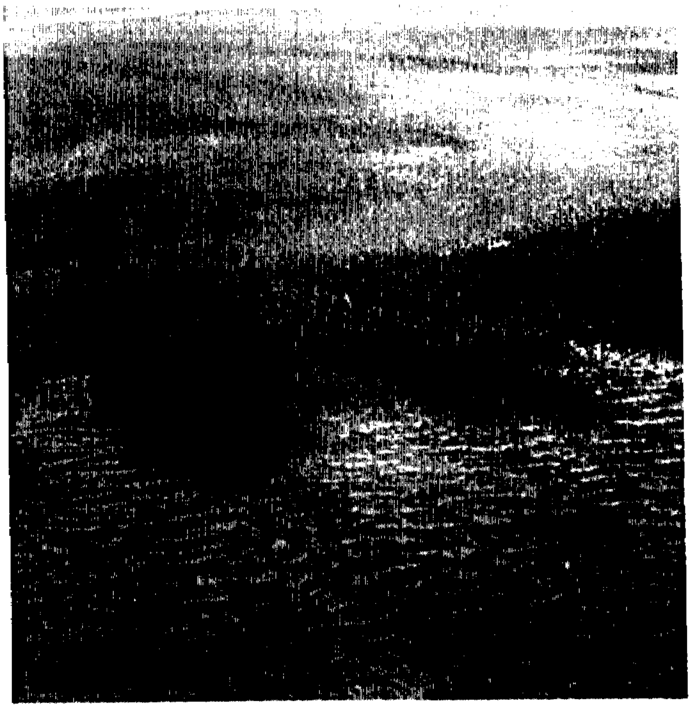


FIGURE 29 : Area immediately west of Onakawana. The sparsely treed areas probably contain relatively thick peat deposits.

160–225 cm. Several samples in another large, open area approximately 6 km north of the base camp (on the east side of the Mattagami River) has peat thicknesses of 170–200 cm.

From such sampling, it is clear that the peat is quite thin (50–100 cm) in wooded areas and thicker in places where the vegetation is dominated by small bushes and a variety of mosses. Within most sections, the character of the peat changes from being relatively fibric (high percentage of fibrous plant residue) at surface to noticeably more humic (substantial amorphous as well as fibrous plant residue) at depth. Five peat samples were selected for analysis (Table 13). All of the samples yielded relatively high calorific values and contain low ash. The proximate analysis (Sample P-1) also indicated very low sulphur. Moisture values range 88–95%. These characteristics are typical of peat from other parts of Ontario; certainly, the calorific values are typical of peat analyses (see 1981 Monenco report, p. 19).

7. CONCLUSIONS

The following are the most important conclusions from the 1981 field program.

1. The lignite discovery in drillhole OEC-81-12 must be considered very significant in that it indicates the potential for establishing large lignite reserves at shallow depths suitable for large-scale surface mining. The area where such reserves may exist covers a large untested region in the OERL licence area as well as in entirely untested areas north of the Missinaibi River. Analogies with similar types of nonmarine coal fields indicate that reserves in the range 0.5–2 billion tons are certainly possible.

2. The only way to fully evaluate the lignite potential of the region is to drill the region systematically on a grid pattern to ensure that deposits the size of Onakawana will not be missed.

3. The ground resistivity system does not seem to hold much promise as a regional prospecting tool capable of detecting the Cretaceous–Pleistocene contact. On the other hand, down-the-hole geophysical logging techniques can be of considerable use in any lignite exploration drilling program.

4. The combined drilling technique, utilizing both reverse circulation and triple-tube coring, appears to be the most effective system for drilling the unconsolidated sediments in the Cretaceous Basin.

5. Although study of the heavy minerals did not indicate the presence of buried industrial or metallic mineral deposits, this may still be the most effective tool in regional exploration for such commodities.

6. Silica sands and refractory clay deposits appear to be of a quality and size that could be of economic significance.

7. Preliminary testing of shales for total organic content and organic condensate yield through Fischer assaying has not outlined any high grade oil shale horizons in the Long Rapids Formation. However, only a very small part of the area underlain by this formation has been tested; a more regional drill program is needed for a meaningful evaluation of the oil shale potential of the Long Rapids Formation.

8. Sizeable tonnages of good quality peat are present over large parts of the OERL licence area.

8. RECOMMENDATIONS

Results from the 1981 field program prompt the following recommendations:

1. A systematic drill program for the regional evaluation of lignite is clearly warranted. It is recommended that a grid pattern at approximately 5 km centres be used in order to have a high degree of confidence that a lignite deposit of commercial interest will be discovered. Approximately 80–90 holes are proposed.

2. More drilling in the vicinity of the major 1981 lignite discovery is recommended to better define this occurrence and to obtain detailed sedimentological data that may be pertinent to interpreting other lignite occurrences in the region.

3. Serious consideration should be given to obtaining a sizeable parcel of land north of the Missinaibi in order to cover possible major lignite extensions north of the river.

4. The regional drilling program should be helicopter-supported, utilizing combination reverse-circulation/triple-tube coring techniques that have proven successful under the very difficult drilling conditions to be expected in this region. The more detailed drill program could be incorporated in the above operation or could be conducted the following winter, in which case a sonic drill system should be considered. Every attempt should be made to recover drillcore from the new lignite discovery, to better evaluate the sedimentary environment of the deposit and to obtain sample material for a variety of tests. Initially, the detailed drilling should be carried out on 1–2 km centre spacings, although this distance may be increased according to early results. It is expected that this program will entail approximately 20 holes.

5. Well logging geophysical techniques should be used in any drill program. This will necessitate implanting heavy-duty plastic casing in all of the drillholes.

6. In the above regional drill program it is recommended that approximately 15–25 drillholes be extended well into or through the Long Rapids Formation to obtain a regional representation of material from this oil shale formation.

7. In the course of carrying out the above programs, it is also recommended that a regional evaluation of the peat resources be carried out. This evaluation should attempt to locate and define the peat bogs of most significance, should any development of other natural resources of the region be called for.

8. The regional drill program should also include a systematic appraisal of heavy mineral concentrates from Pleistocene and Cretaceous units, in order to evaluate the possible presence of diamonds, uranium, and precious and metallic minerals in the region. This appraisal should also include sampling and evaluating of silica sands and clays where found.

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SUMMARY REPORT ON THE 1981 EXPLORATION PROGRAM IN THE JAMES BAY LOWLAND

FOR

ONTARIO ENERGY RESOURCES LIMITED

VOLUME II

Toronto, Canada
April 21, 1982

Watts, Griffis and McOuat Limited
Consulting Geologists and Engineers

TABLE OF CONTENTS

APPENDICES

MAPS

APPENDIX I

DRILL LOGS

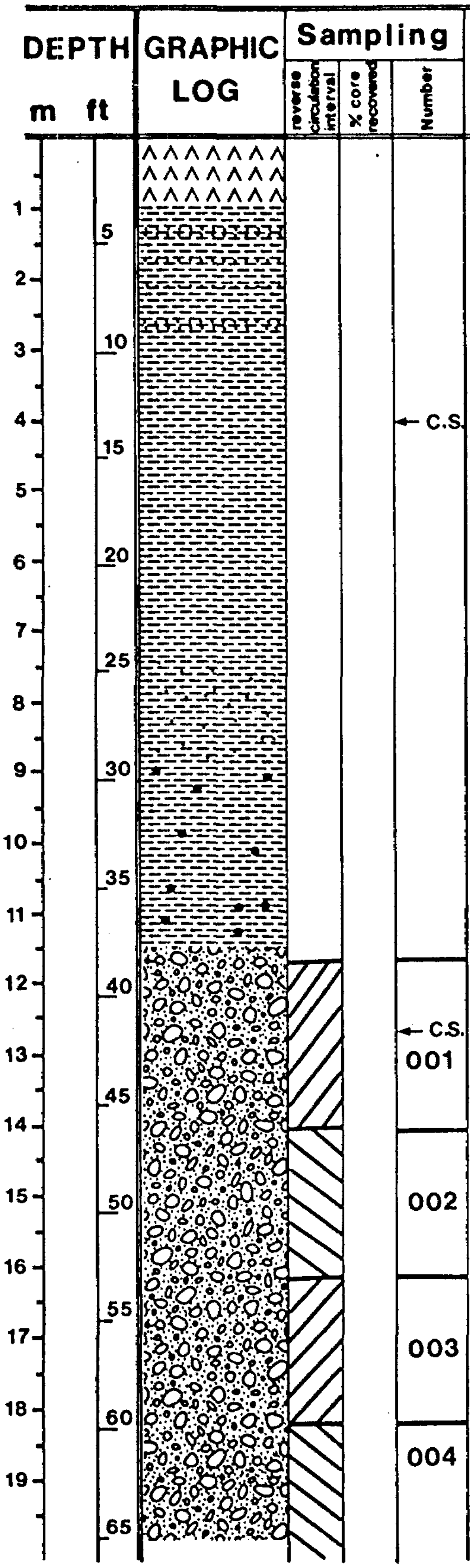
EXPLANATION FOR DRILL LOG SYMBOLS

⋀⋀⋀	Muskeg
▤	Clay (may include siltstone and shale)
▩	Till
⠿	Fine to Medium Sands
⁘	Medium to Coarse Sands
●	Pebbles and/or Cobbles
☰	Black Carbonaceous Clay
■	Lignite-Relatively Massive
◢	Lignite Chips
⊥	Marl
▦	Limestone

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01 **Location:** MORROW TWP.-B.L. 0+300m

Elev. of collar: 180.0' **Sheet** 1 **of** 6 (lat. 50°33.7' long. 81°35.1')



Description

MUSKEG: 0–3.3'
CLAY: 3.3–38.4'
Pale grey–beige clay with silt and fine sands. Dark steel grey with fine (less than 1 mm) beige laminations. Contains black siltstone or basal sandstone from 7.5–9.0', rounded black pebbles and small (2 mm) marine shell from 29.5–38.4'.
Oxidized ochre beds.

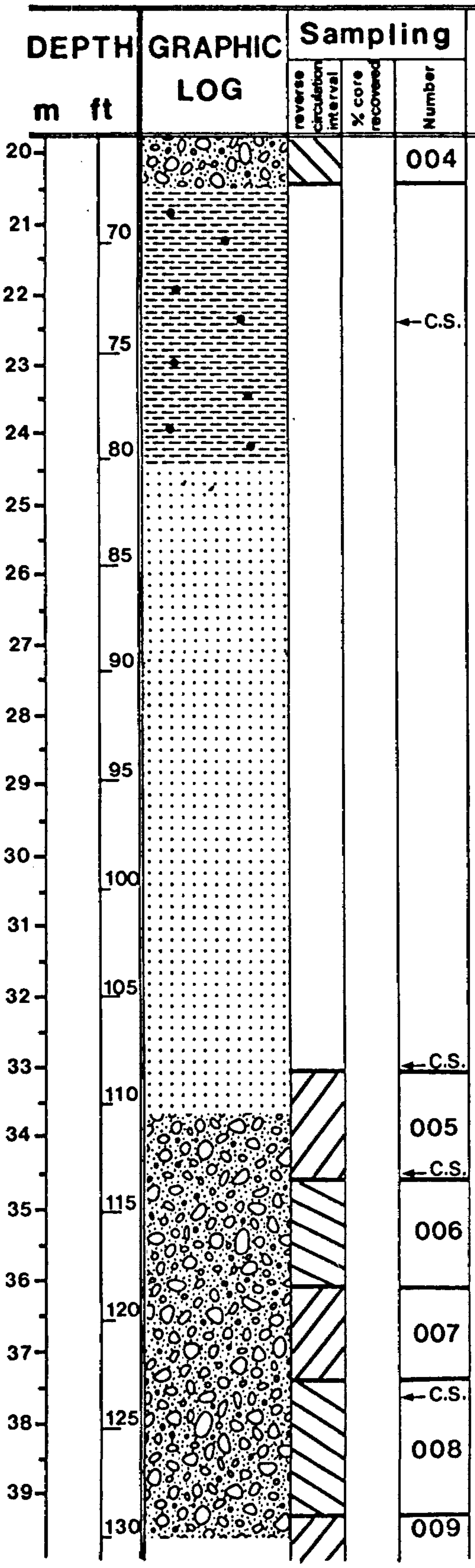
TILL: 38.4–67.3'
Beige clayey and pebbly with 60% limestone, 20–30% basement (gneiss, volcanics), and 10–20% black siltstone or basalt to 55.1'.

Change in composition of till to cobbly with greyer matrix; lithologies as above.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01

Sheet 2 of 6



Description

CLAY AND SAND: 67.3–110.9'
Soft, smooth, grey, non-gritty with occasional pebbles.

Coarsely layered (1–18", possibly varved) blue clay, beige clay, and fine beige sand.

Uniform fine sand with abundant wood chips (approximately 2") at 95.1'. No shells.

TILL: 110.9–118.8'
Very slightly clayey (beige) to fine sandy (beige). Very pebbly; 60% limestone, 10% green–black sandstone/basalt, 30% basement. Single lignite fragment 2–5" at top of till.

GRAVEL: 118.8–122.4'
Pebbly with coarse granular matrix. Pebble suite as above.

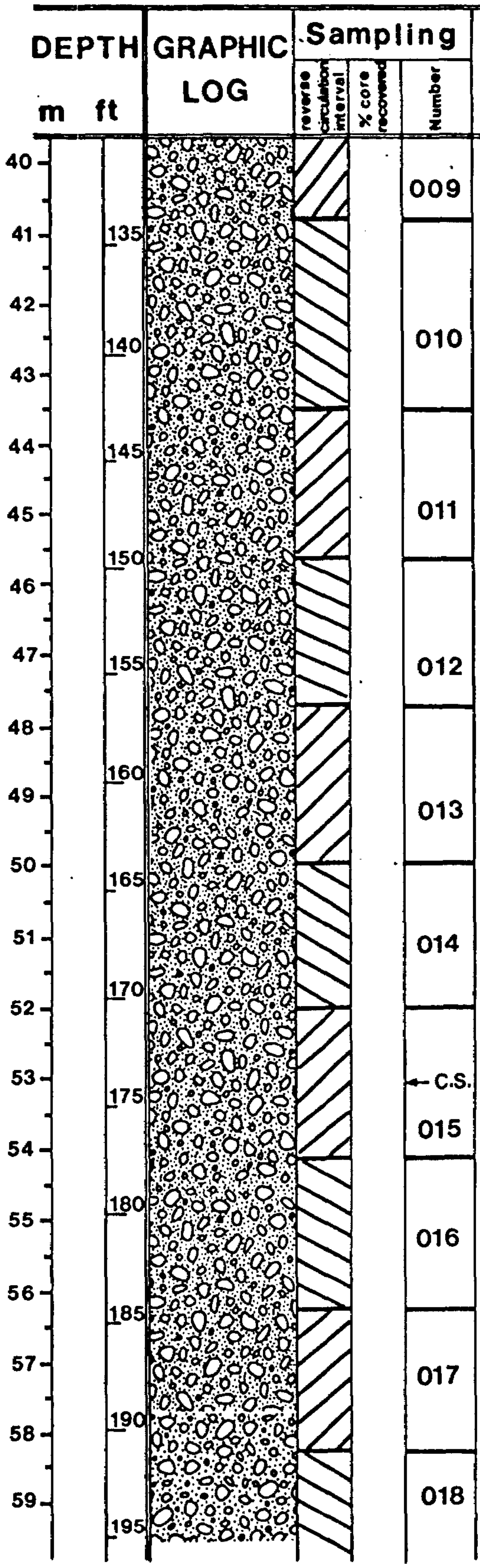
TILL: 122.4–173.6'
Dark brown grading to medium brown carbonaceous, calcareous, gritty tough clayey matrix. Pebbly, lithologies as above tills but pebble content less than 10%.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01

Sheet 3 of 6

Description



145.7–173.6': Abrupt change to pale/medium grey clayey matrix. Clay less stiff. Trace lignite or wood at 156.0'. Lithologies as above with addition of 3–5% white chert.

As above with clasts of cream limestone, lesser amounts of chert. At 178.4' chert becomes more abundant.

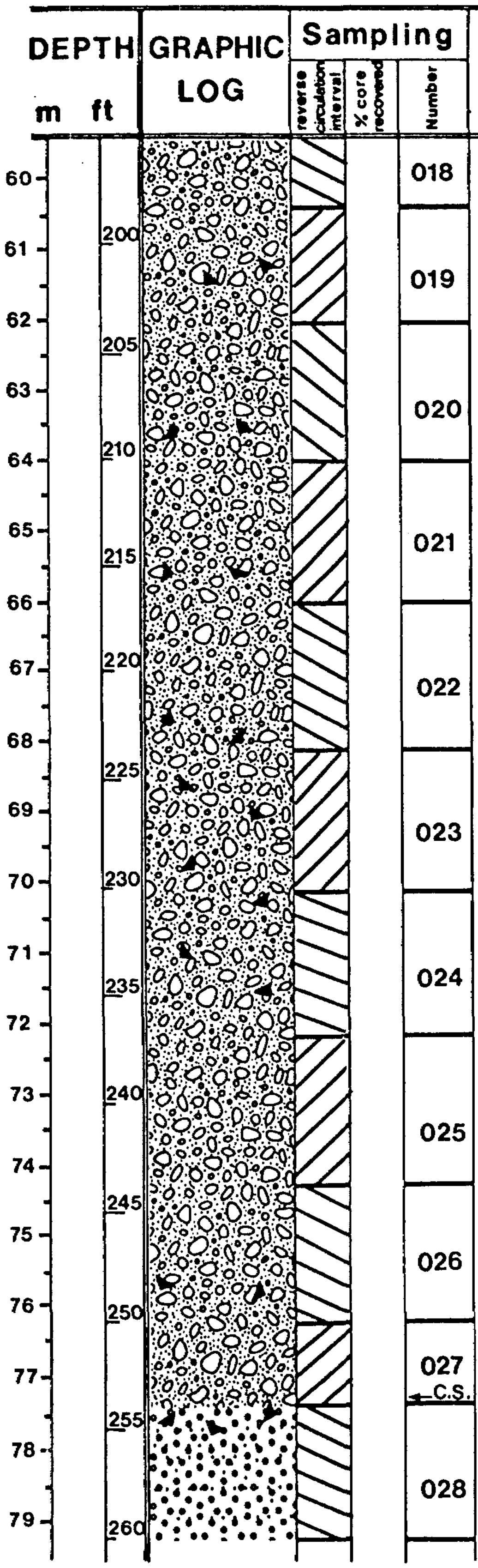
Matrix pale grey clay, maximum clast of buff chert up to 1/4". Chert 60% and limestone 10%, matrix still calcareous.

Pebbles as before; limestone, chert, and basement material.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01

Sheet 4 of 6



Description

202.4': Lignite trace.

209.3': Lignite trace.

215.9': Lignite trace.

223.4–235.2': Diabase and quartzite pebbles; more cobbles now. Lignite traces increase in volume to 20% clasts.

Clay very stiff, becoming dark grey downwards.

Very stiff dark brown/grey clay matrix.

248.7': Lignite trace.

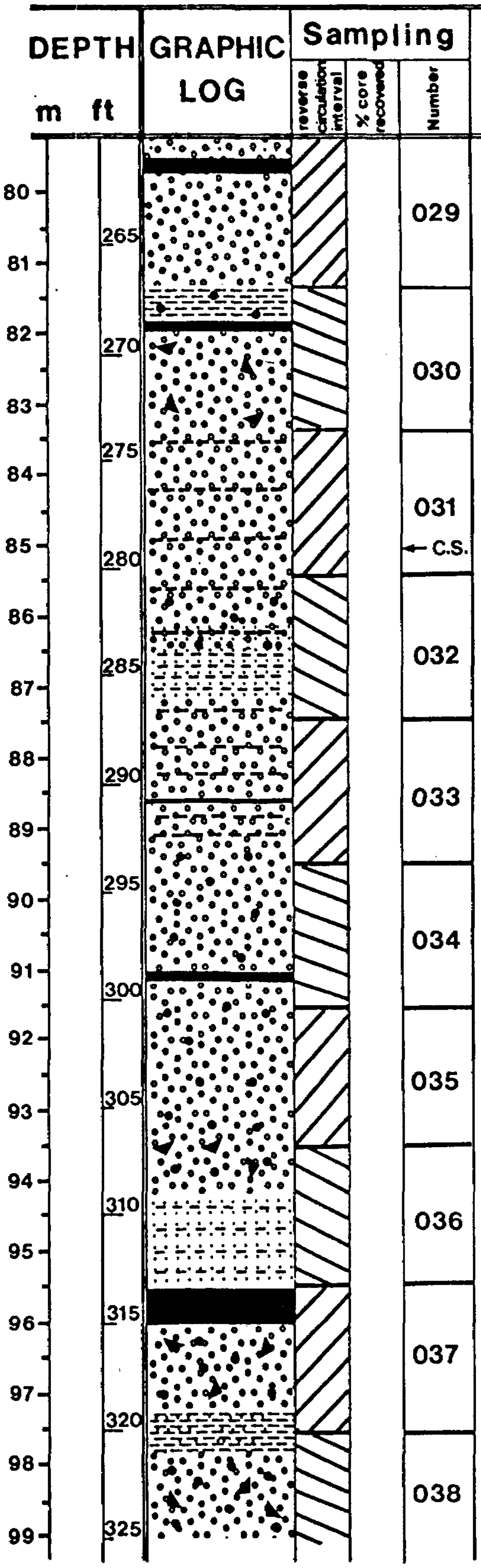
Light grey medium stiff clay matrix.

COARSE CLASTICS: 253.3–335.0'
Lignite in sandy gravel; coarse granular texture. Pebble clasts: 40% limestone, 20% chert, 10% quartz.
256.6': Less than 20% of clasts are lignite (less than 1 1/4").
261.2–261.8': Lignite with limestone pebbles and medium to coarse sand matrix.
Medium to coarse, quartzitic sand with limestone grains.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01

Sheet 5 **of** 6



Description

White–grey silty clay with pebbles.

268.4–268.7': Lignite.
Gravel and sand, with clasts of limestone, chert, quartz, and basement; less than 20% of the clasts are lignite.

White clayey medium to coarse sand.

As above with rounded pebbles of limestone, chert, lignite, and basement.

Alternating layers of white silty clay and white clayey/silty sand.

Varve-like laminations of green/grey/white sand and clay.

291.0': Thin lignite bed.
Varved as above.
Gravel with clasts of limestone, quartz, basement, and chert; white clay also present.
Percentage of quartz clasts decreases downwards.
Medium/coarse sand matrix.
297.6': Lignite trace.
298.6–298.9': Lignite bed.

Gravel with lignite.

Kaolinitic clayey, white, very coarse sand with lignite traces.

Alternating kaolinitic sand and white silty kaolinitic clay.

313.3–315.0': Lignite bed.

Coarse sandy gravel with lignite.

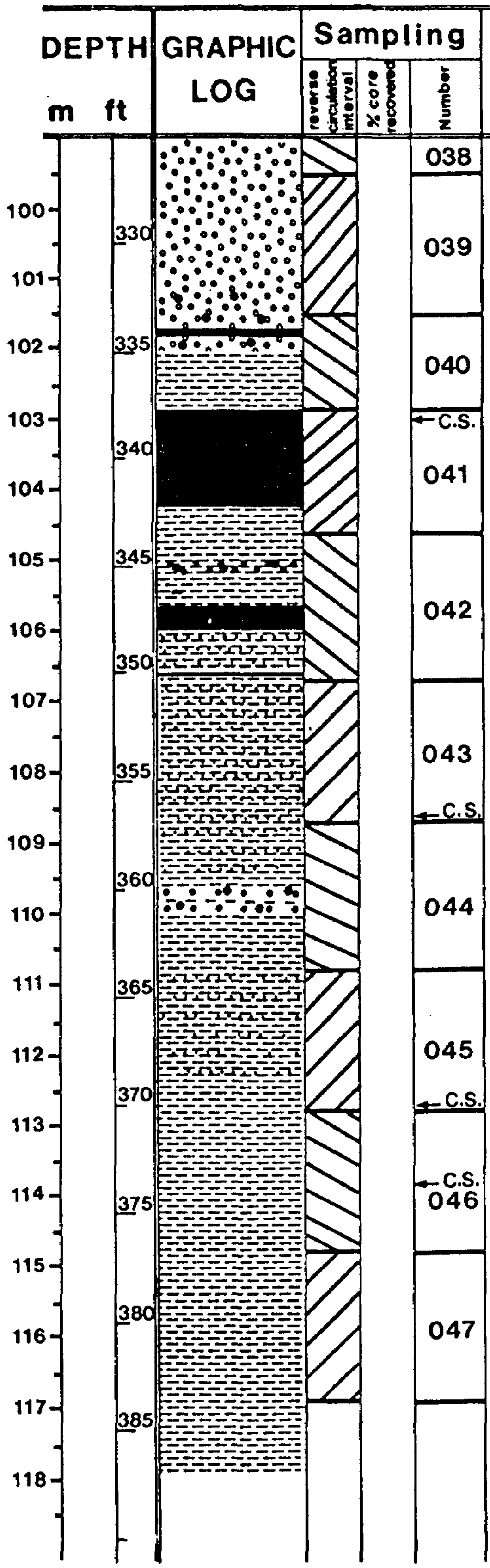
White silty sandy clay.
Very coarse pebbly gravel.
Medium brown/grey stiff lignitic clay.
Very coarse pebbly gravel.
White clayey coarse sand.

Coarse gravel with sandy matrix.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-01

Sheet 6 of 6



Description

334.0–334.3': Lignite bed. Fine white clay. Coarse gravel.
CLAY AND LIGNITE SEQUENCE: 334.0–350.7'
337.3–341.9': Lignite bed.
Medium brown/grey clay.
As above with lignite fragments.
Coarse pebbly gravel.
Grey silty clay with thin lignite beds; calcareous.

346.8–347.8': Lignite bed.
Fine pale grey/white silty sand with kaolin clay matrix.

350.4–350.7': Two thin lignite beds.
SANDSTONE/SILTSTONE SEQUENCE: 350.7–368.4'
Fine pale grey/white silty sand with kaolin matrix and thin lignites.

Coarse pebbly gravel with very fresh basement clasts less than 1".
Thin gravel and large quartz boulder/pebble.

363.5': Light grey clay gradually becoming dark green/brown clay; slightly calcareous.
Pale grey/white silty sand with kaolin matrix.
Very angular, embayed sand grains.
CLAY SEQUENCE: 368.4–386.8'
Pale green silty clay alternating with dark brown stiff clay. Clays become less stiff with greater depth.

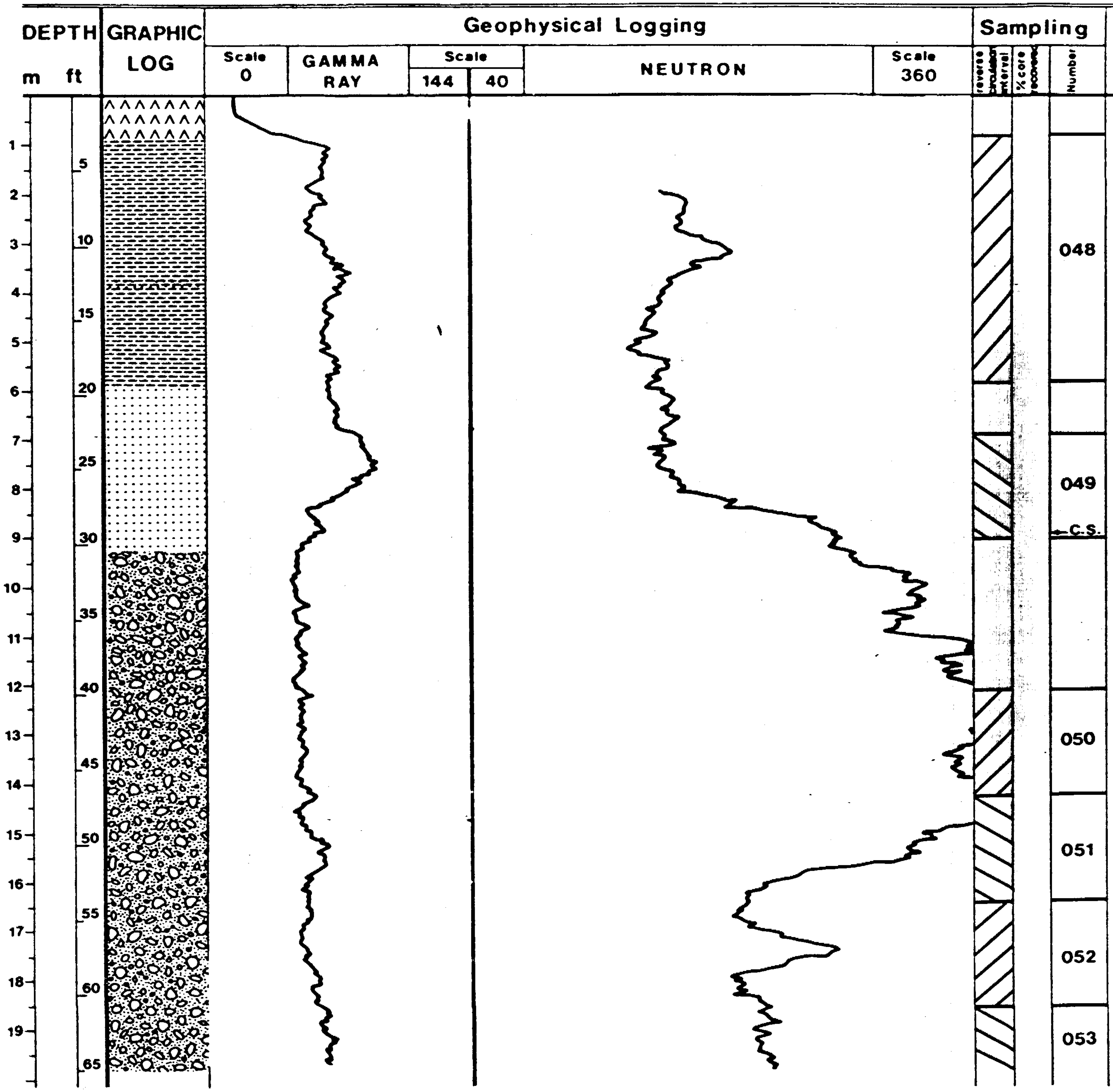
380.2': A few twinned aggregates of pyrite octahedran.

386.8': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 02 Location: MORROW TWP. - B.L. 5 + 740 m

Elev. of collar: 170.0′ Sheet 1 of 6 (lat. 50°36.5′ long. 81°34.8′)



Description

MUSKEG: 0–3.3′

CLAY: 3.3–23.3′
Soft, medium blue-grey, calcareous clay with occasional thin silt and sand.

10.0–26.7′: Sands become more pronounced.

SAND: 23.3–26.7′
Silty pale grey mature sand.

26.7–28.3′: Pale grey silty sand with some granules.

TILL: 28.3–48.3′
Sandy with rounded granules and pebbles. 60% limestone, 20–30% basement (granites, basalts, diabase, gneiss), 5% white chert, clay matrix calcareous.

LIMESTONE: 41.5–48.3′
Limestone and white chert pebbles increasing in frequency.

TILL: 48.3–58.8′
As above, with red jasper pebble at 54.0′.

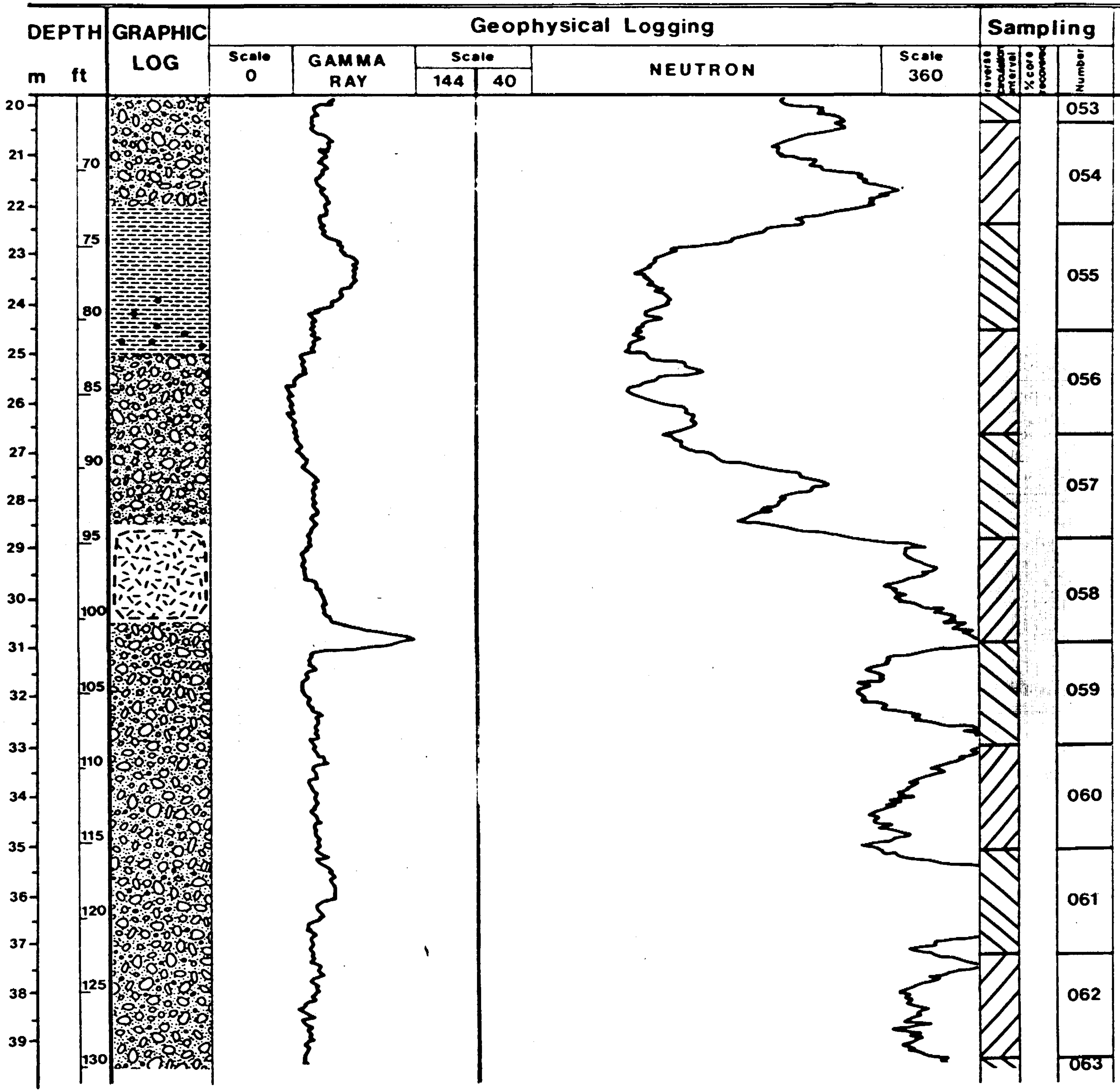
TILL: 58.8–72.4′
Beige-grey, silty to gritty, at times gravelly or pebbly, clayey till, matrix calcareous.

63.3–64.0′: Red jasper pebbles.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-02

Sheet 2 of 6



Description

67.5': Wood fragment.

67.5–72.4': Beige–grey silty, gravelly, clayey till.

CLAY: 72.4–79.0'
Alternating thin laminae of light beige–grey and dark grey fine calcareous clay.
CLAY: 79.0–82.7'
As above with well rounded pebbles of basement suite increasing downwards.
TILL: 82.7–83.7'
Light grey, clayey, silty, very coarse, gravelly till; 60% limestone, 20% basement, 5% chert, 5% quartz.

TILL: 83.7–109.3'
Grey–beige, clayey, silty, gravel till alternating with sandy, pebbly till, calcareous. Pebble suite starts 60% limestone, 20% basement, 5% chert, 5% quartz, and changes downwards to 30% limestone, 50% basement, 5% chert, 5% quartz. All pebbles well- to sub-rounded.
94.2–101.0': Pink granite boulder.

TILL: 109.3–130.3'
Dominantly clayey matrix beige–grey with gravels and pebbles.

120.0–121.0': As above but non-gravel till.
120.2–130.3': Dominant, still calcareous.

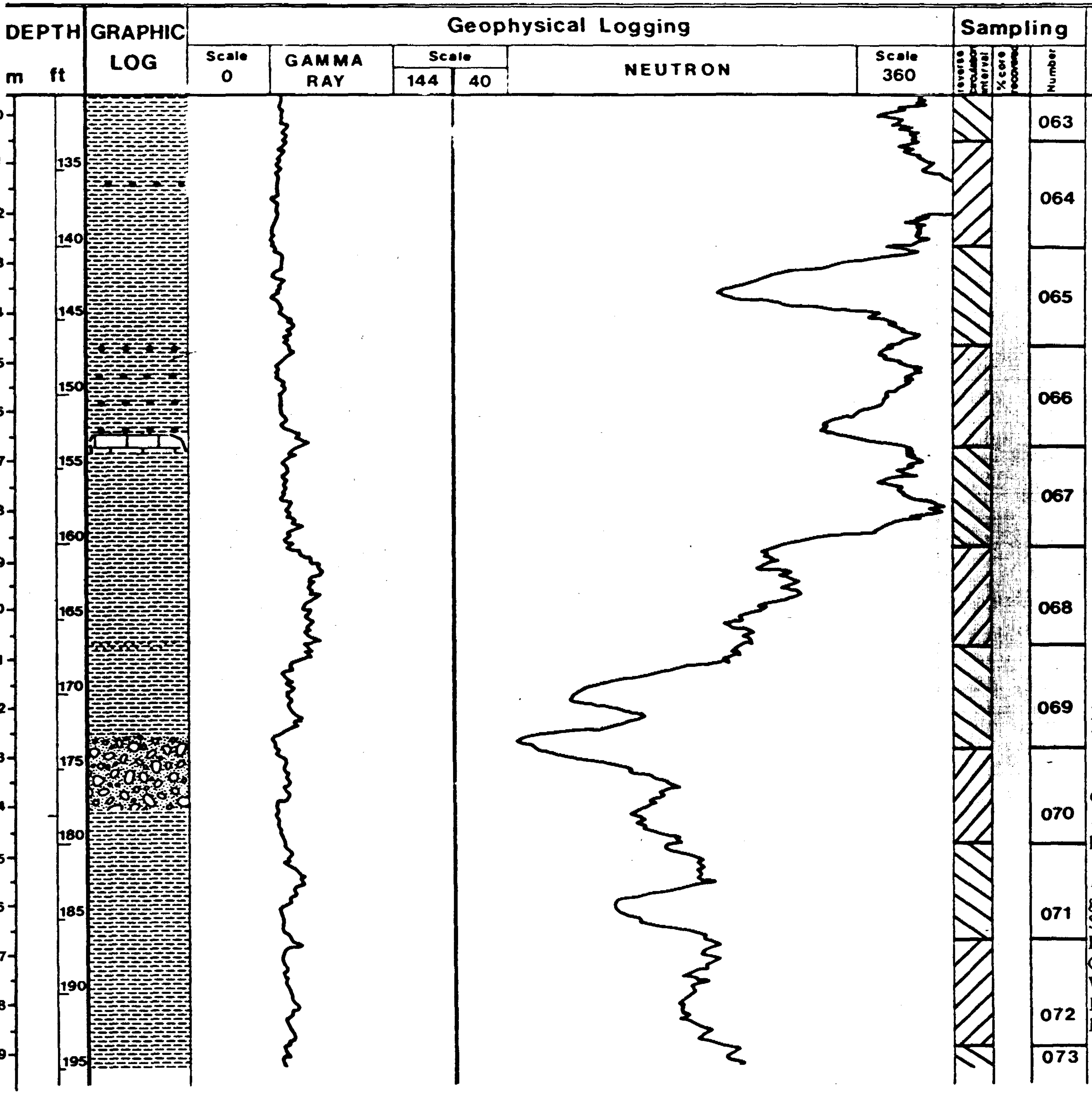
CLAY: 130.3–173'
Dark mid-grey clay with white chert clasts.
130.4–133.4': Beige–grey clays, with orange, white, and pale green clay chips.

133.4': Large limestone boulder.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-02

Sheet 3 of 6



Description

133.4–157.0': As above, becoming more gritty and pebbly downwards.

136.0': Blue–white and white chert pebbles.

138.3': Granules less than 4 mm, with white and orange clay chips.

147.7': Rare limestone and chert cobbles.
149.0': Pebbles more common.
149.3': Brownish, medium grey with more pebbles; 30% limestone, 50% basement, 10% chert, 5% quartz.
150.7': Beige clay.
153.3–154.2': Limestone boulder.

157.0–158.4': Medium to very stiff alternate beige and medium grey.

160.4–163.4': Varved beige grey and medium blue–grey, very fine clays.

166.0': Beige clay, gritty.

TILL: 173.0–178.0'
Light beige–grey clayey, silty gravel till with lignite traces, 60% limestone, 25% basement, etc. as before.

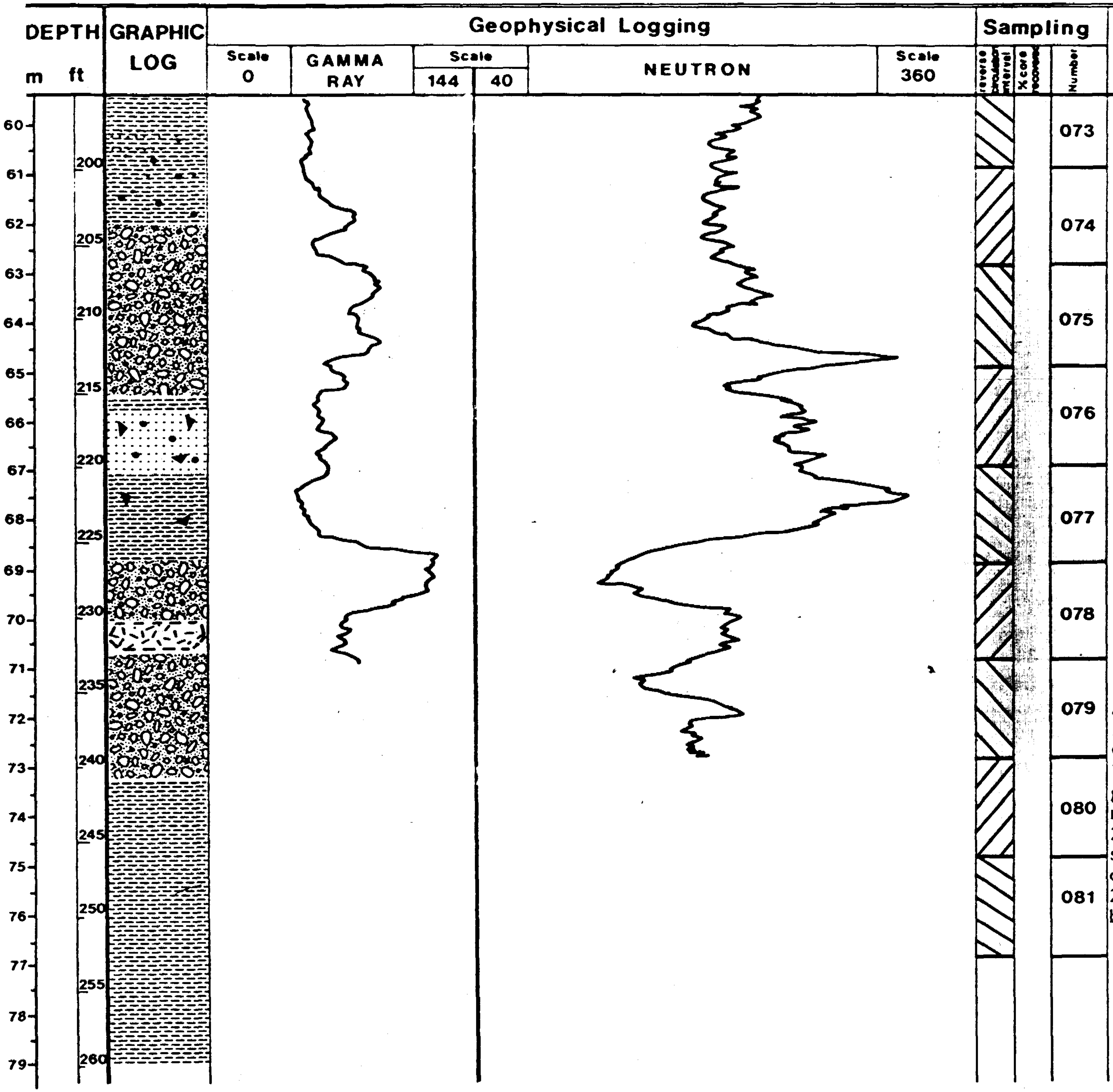
178.0': Fine grey sand.
CLAY: 178.2–183.7'
178.2': Stiff beige grey clay, gritty with rare limestone pebbles.

180.7': Varved beige grey and blue grey fine clay; non-gritty, calcareous.
SAND: 183.7–184.0'
Fine, clayey, silty, pale grey sand.
CLAY: 184.0–204.0'
Varved clays as before, very stiff.
195.0': Lignite trace.
198.8': Limestone pebbles in stiff blue grey clay.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-02

Sheet 4 of 6



Description

201.3': As above, varved but more gritty.

202.7': Varved but more sandy/gritty.

203.1': Pebbles, usual suite, less than 1 cm.

TILL: 204.0–215.0'

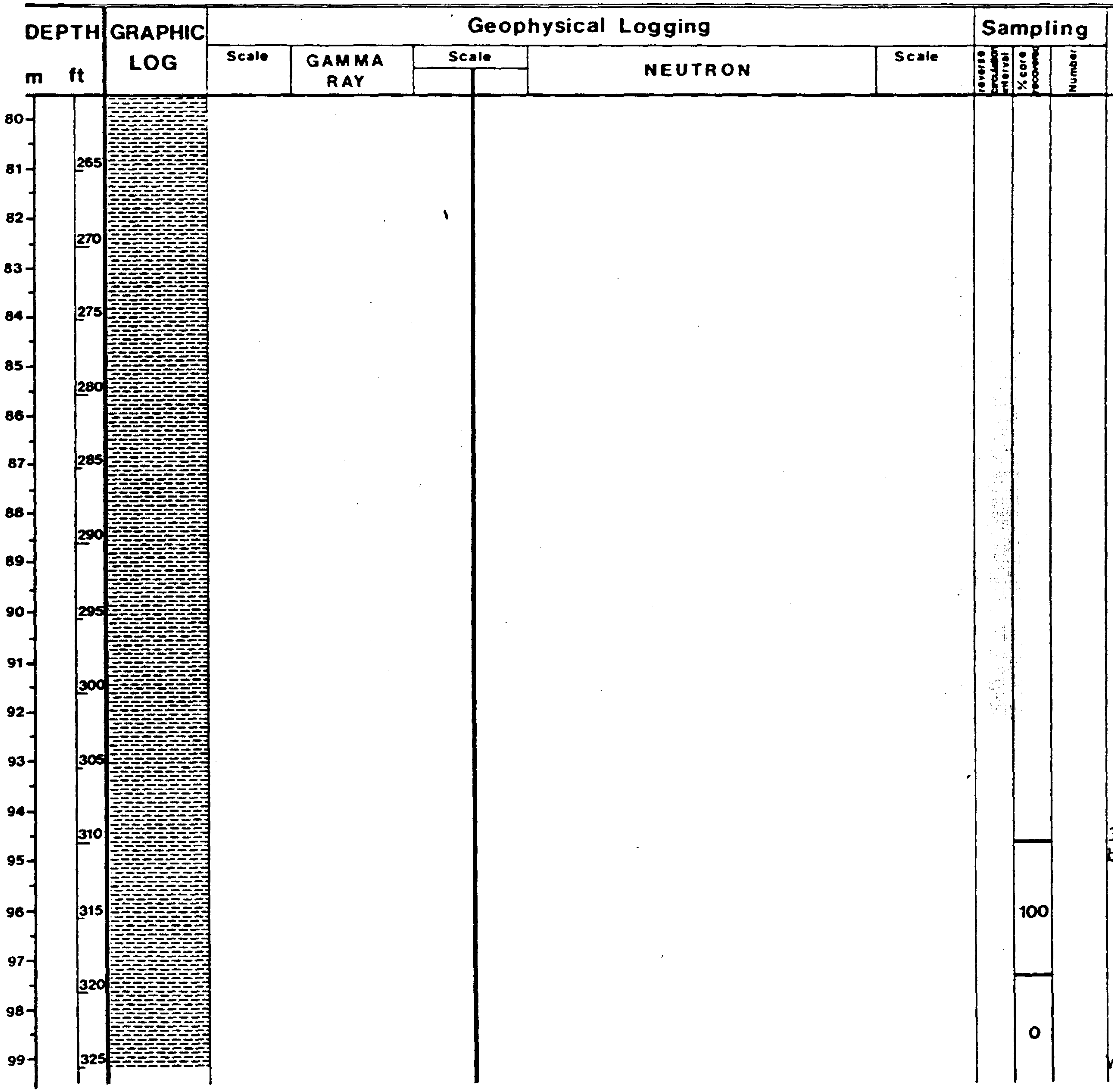
210.0–211.1': Non-calcareous matrix now.

CLAY: 215.0–216.0'
Beige grey non-calcareous gritty clay becoming brownish medium grey downwards.
SAND: 216.0–220.3'
Fine grey matrix sand, with pebbles and lignite fragments.
CLAY: 220.3–226.0'
Alternating (varved?) fine pale grey–green clay and dark brownish grey clay; non-calcareous with lignite fragments.
225.4': Limestone boulder.
TILL: 226.0–241.4'
Grey with greenish grey clayey, silty, gritty till or very coarse pebble. Till, non-calcareous at first, but becoming calcareous at 235.0'. Lignite at times. Pebbles and grit well rounded. 70% limestone, 30% basement.
230.1–232.7': Diabase boulder.
233.3–238.3': Till alternating with medium-course sands and grey silty/gritty clays.
240.4': Clay matrix slightly calcareous.
CLAY: 241.4–350.0'
Very fine-grained alternating (varved?) layers of pale grey green and dark brownish grey clays; non-calcareous and rare limstone and basement granules.
245.0–250.5': Alternating/laminated clays as above; very stiff; no grit or pebbles and some disseminated pyrite in clay lumps; non-calcareous.
250.5–266.7': Mottled pale green and dark brown clays becoming predominantly pale green clays.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-02

Sheet 5 of 6



Description

As above.

271.5–273.3': Mostly dark brownish grey stiff clay.

273.4–293.3': Medium stiff grey–green clay with some chips of very stiff dark brown clay, less than 1 cm.

293.3': Predominantly grey–green stiff clay, with thin dark brownish grey, very stiff clays up to 1.0' at times. Average thickness 2–4" approximately.

310.0–320.0': Pale grey–green soft clay, with chips of dark brownish-grey clay less than 1".

Very wet and soft clay, as above. Too wet for recovery.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-02

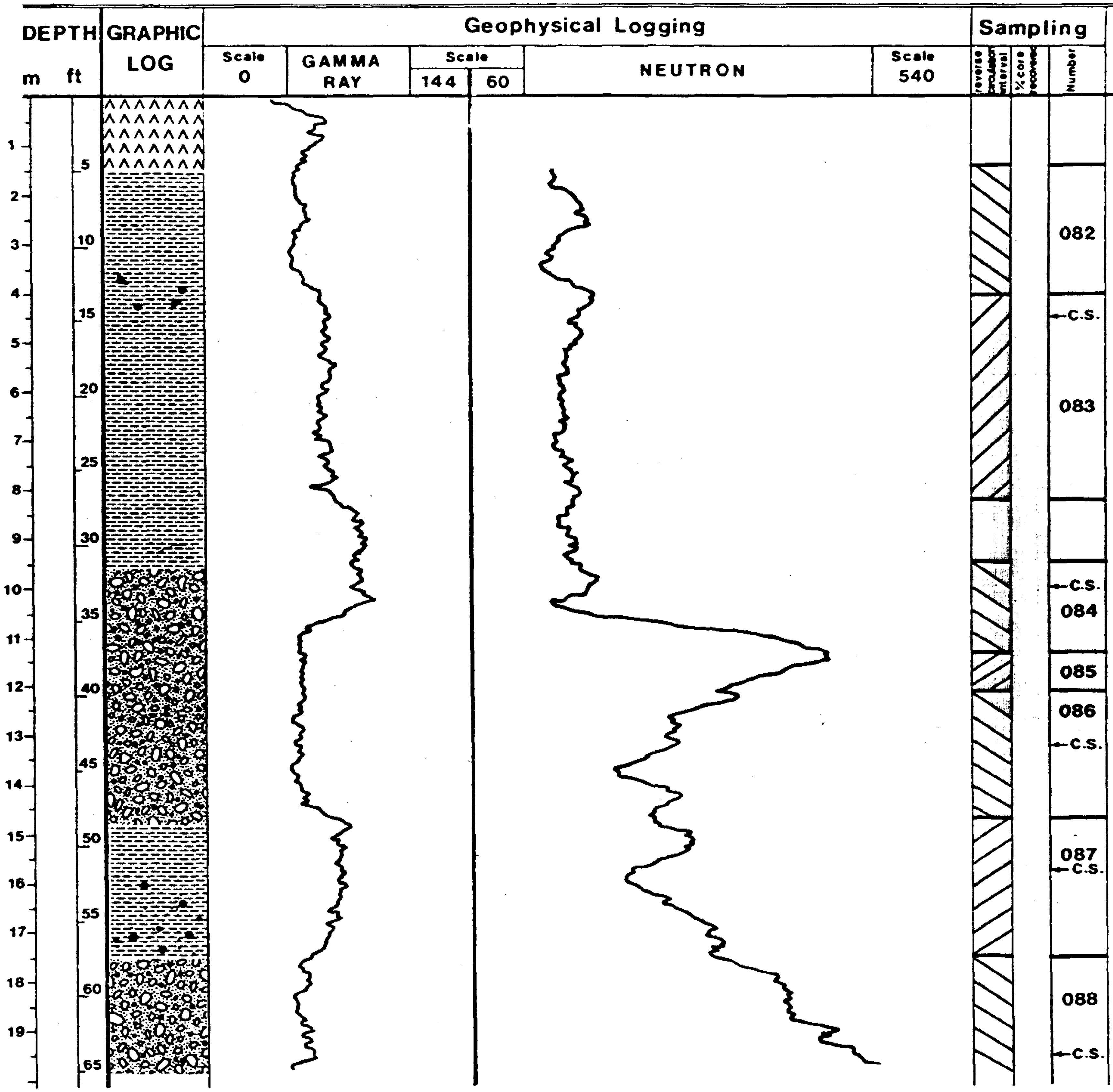
Sheet 6 of 6

DEPTH m	DEPTH ft	GRAPHIC LOG	Geophysical Logging: Scale	GAMMA RAY	Scale	NEUTRON	Scale	Sampling: reverse circulation interval	% core recovery	Number	Description
									0		As above, but too wet for recovery.
100											
	330										
101											
102	335								16.6		Soft, wet pale grey–green clay, with large fragments/pellets of dark brownish grey shale less than 2".
103											
	340										
104											
105	345								13.3		Pale grey–green, very hard compacted mudstone shale.
106											
	350										350.0': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-03 Location: MORROW TWP.

Elev. of collar: 200.0′ Sheet 1 of 5 (lat. 50°29.8′ long. 81°40.6′)



Description

MUSKEG: 0–5′

CLAY: 5.0–31.1′
Beige, silty, and calcareous; alternating with blue-grey, calcareous clay.

12.7′: Black and brown wood fragments.
13.7′: More rounded basement pebbles less than 1 cm.
14.5′: Blue-grey clay; only minor silt; calcareous.

23.3–26.7′: Pale blue-grey clay with thin layers of black clay.

26.7′: Traces of marine bivalves; less than 1/4″.

TILL: 31.1–32.5′
Beige, silty, sandy, pebbly clay; calcareous; 65% sedimentary clasts, 35% basement.
CLAY: 32.5–48.3′
32.5–37.7′: Alternating layers of pale blue-grey and beige clay.
37.7–40.0′: Beige-grey clay, silty, sandy, and pebbly; dominantly sedimentary clasts, including some chert.

40.0–41.0′: Beige-grey gravelly sand.

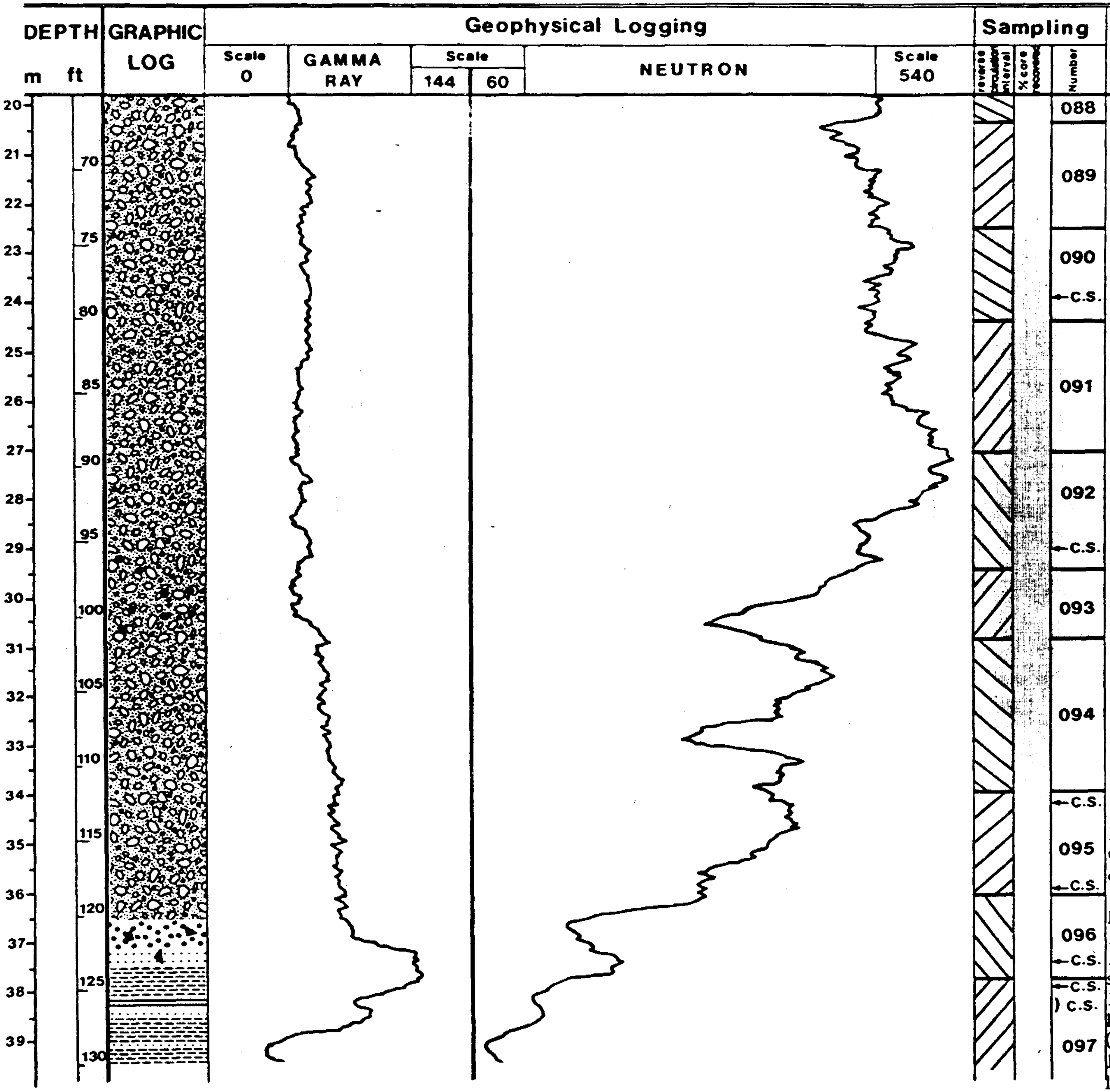
45.0–48.0′: Abundant diabase clasts.
48.0–48.3′: Beige-grey till; very coarse; clayey, sandy, pebbly.
CLAY: 48.3–56.7′
Pale grey-green; silty, sandy, and calcareous.
52.3′: Minor sedimentary pebbles in clay; becoming increasingly silty and sandy by 56.7′.
TILL: 56.7–98.5′
Light green-grey, clayey, sandy, pebbly; dominantly sedimentary clasts; calcareous matrix; in places conspicuously sandy.

63.3′: Trace of woody lignite clasts.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-03

Sheet 2 of 5



Description

76.7': Dominant buff coloured sedimentary pebbles.
78.2': Traces of woody lignite chips.

85.5': Possible traces of gypsum(?).

CONGLOMERATE: 98.5–102.0'
Sandy, pebble; dominantly sedimentary clasts; sharp contacts with till above and below.

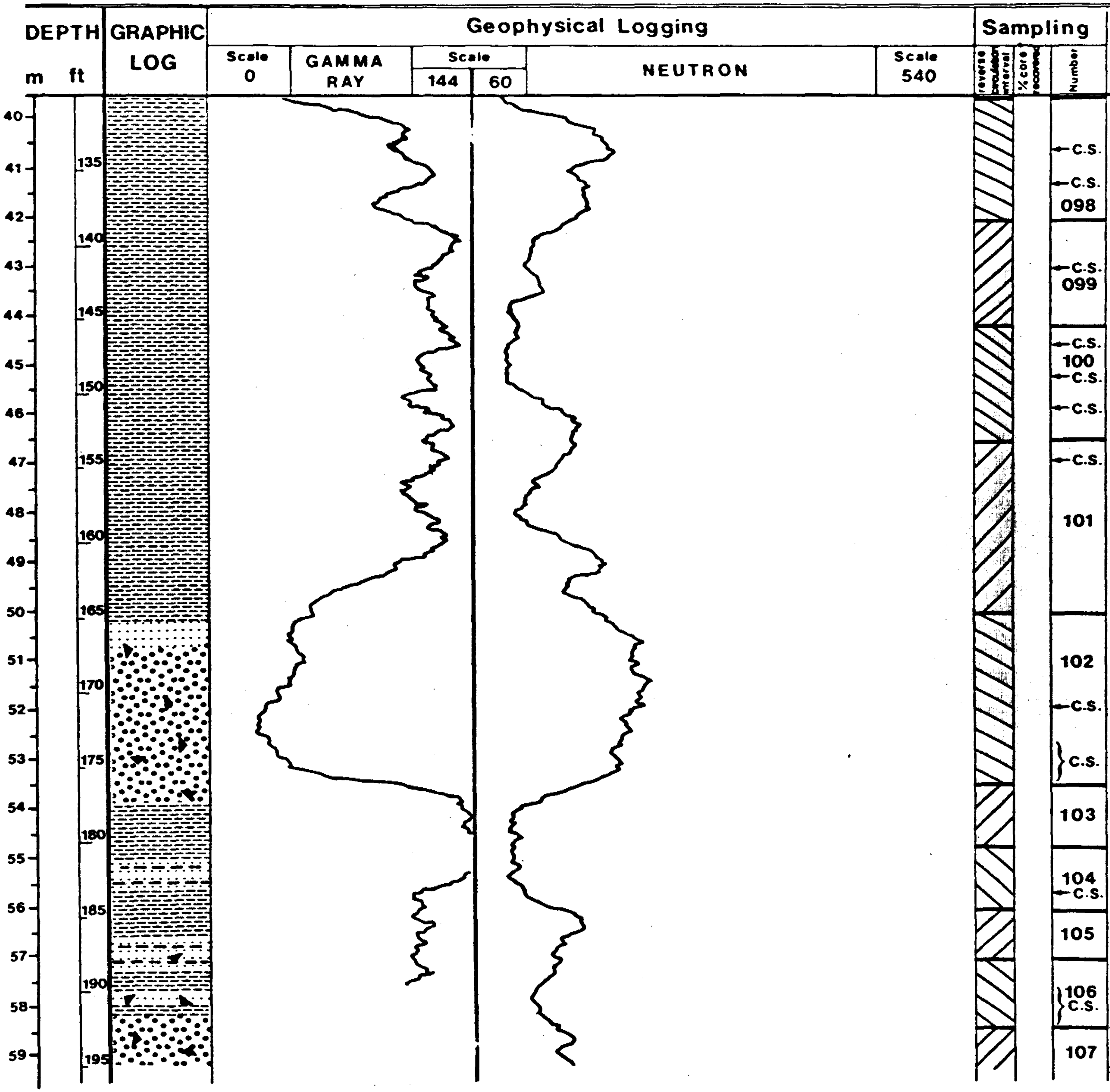
TILL: 102.0–120.3'
Medium to dark grey; calcareous; very clayey but considerable sand; sporadic pebbles of dominantly sedimentary lithologies but significant basement clasts as well.

LIGNITE IN SANDS AND CLAYS: 120.3–133.3'
Quartz sands and abundant lignite chips; angular, coarse quartz grains; some brown clay, non-calcareous.
122.0–122.5': Fine quartz sands with lignite clasts underlain by light grey clay, followed by dark brown clay.
122.5–125.0': Light grey clay.
125.0–125.3': Lignite and grey clay; considerable quatz sand mixed in; non-calcareous clays.
125.3–133.3': Largely clay interbeds; dark grey-brown and light grey varieties; non-calcareous, considerable sand (quartz).
129.0': A narrow bed of light grey clay, quartz sand and lignite chips approximately 4" thick.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-03

Sheet 3 of 5



Description

CLAY: 133.3–165.0'
Medium dark grey; silty and non-calcareous; in places becoming dark grey and occasionally (141.7') containing abundant fine-grained carbonaceous material.

145.3–148.3': Dark grey clay with noticeable silt-sand and fine-grained carbonaceous clasts.

150.6–165.0': The clay is light grey/brown; non-calcareous.

LIGNITE IN SAND: 165.0–177.0'
Fine-grained, quartz sand; traces of woody lignite.
166.7–177.0': Coarse quartz sand and abundant lignite chips; minor impurities, considerable kaolin(?) coatings.

CLAY: 177.0–183.3'
Medium light grey; non-calcareous; minor silt sand and fine carbonaceous material.
181.0–183.3': Light grey sand, silt, and clay.

CLAY: 183.3–188.0'
Brown-grey clay plus lignite chips changing to quartz sand, silt, clay interbeds with minor lignite.

CLAY: 188.0–193.5'
Grey; silt sand interbeds; non-calcareous; traces of lignite.

SAND-SILT: 193.5–201.0'
Fairly coarse; considerable woody lignite and in places substantial fresh pyrite.

TABLE 13 PEAT ANALYSES

	PROXIMATE ANALYSIS							ULTIMATE ANALYSIS										CALORIFIC	
Sample Numbers	Moisture	Ash		Volatile		Fixed Carbon (by difference)		Carbon		Hydrogen		Sulphur		Nitrogen		Oxygen (by difference)		Calories per gram	
	As Received	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry
P-1	89.69	1.01	9.80	6.55	63.53	2.75	26.67	5.36	51.99	0.60	5.82	0.01	0.10	0.21	2.04	3.12	30.25	501	**4,859**
P-2	91.45	0.36	4.21	5.93	69.36	2.26	26.43	—	—	—	—	0.01	0.12	—	—	—	—	427	**4,994**
P-3	90.13	0.62	6.28	6.60	66.87	2.65	26.85	—	—	—	—	0.01	0.10	—	—	—	—	491	**4,975**
P-4	94.55	0.27	4.95	3.88	71.19	1.30	23.86	—	—	—	—	0.02	0.13	—	—	—	—	253	**4,642**
P-5	88.38	0.86	7.40	7.50	64.54	3.26	28.06	—	—	—	—	0.02	0.17	—	—	—	—	581	**5,000**

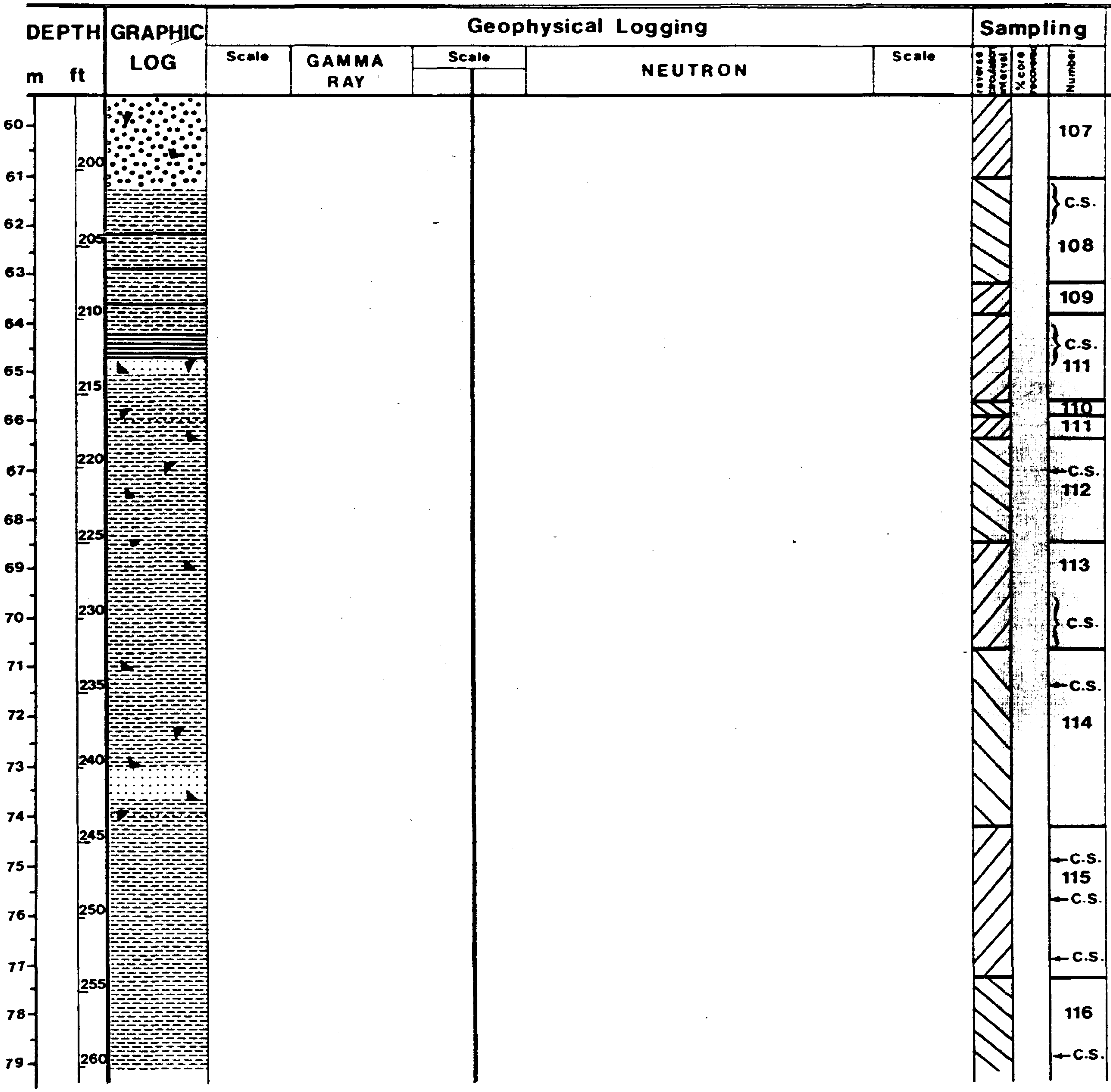
LE 13 PEAT ANALYSES

ULTIMATE ANALYSIS							CALORIFIC VALUE				Location and Comments
en	Sulphur		Nitrogen		Oxygen (by difference)		Calories per gram		BTU per pound		
Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	As Received	Dry	
5.82	0.01	0.10	0.21	2.04	3.12	30.25	501	**4,859**	901	**8,739**	Southwest corner of Morrow Township: from 0–2.24 m (88 inches).
—	0.01	0.12	—	—	—	—	427	**4,994**	769	**8,994**	North part of Gardiner Township, south of Missinaibi River: from 0–1.02 m (40 inches).
—	0.01	0.10	—	—	—	—	491	**4,975**	884	**8,956**	Same location as No. P-2: from 1.02–2.03 m (40–80 inches).
—	0.02	0.13	—	—	—	—	253	**4,642**	455	**8,349**	Southwest corner of Morrow Township, just north of drillhole No. OEC-81-05: from 0–1.02 m (0–40 inches).
—	0.02	0.17	—	—	—	—	581	**5,000**	1,045	**8,993**	Same location as No. P-4: from depth of 1.02–2.03 m (40–80 inches).

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-03

Sheet 4 of 5



Description

CLAY: 201.0–220.7'
Black to dark grey; minor silt sand interbeds and in places thin seams of lignite (less than 4").

211.3–213.0': Black carbonaceous clay with considerable lignite.
213.0–214.7': Black carbonaceous clay, considerable quartz sand interbeds and minor lignite chips in the clays.
214.7–218.5': Light grey clay; minor quartz sand, lignite.
218.5–220.7': Light brown-green clay; minor quartz sand, lignite.

CLAY: 220.7–273.3'
Variable colour; non-calcareous; in places minor lignite chips.
220.7–225.8': Light grey and, in part, light brown-green colour.
225.8': Thin interbed of quartz sand lignite.

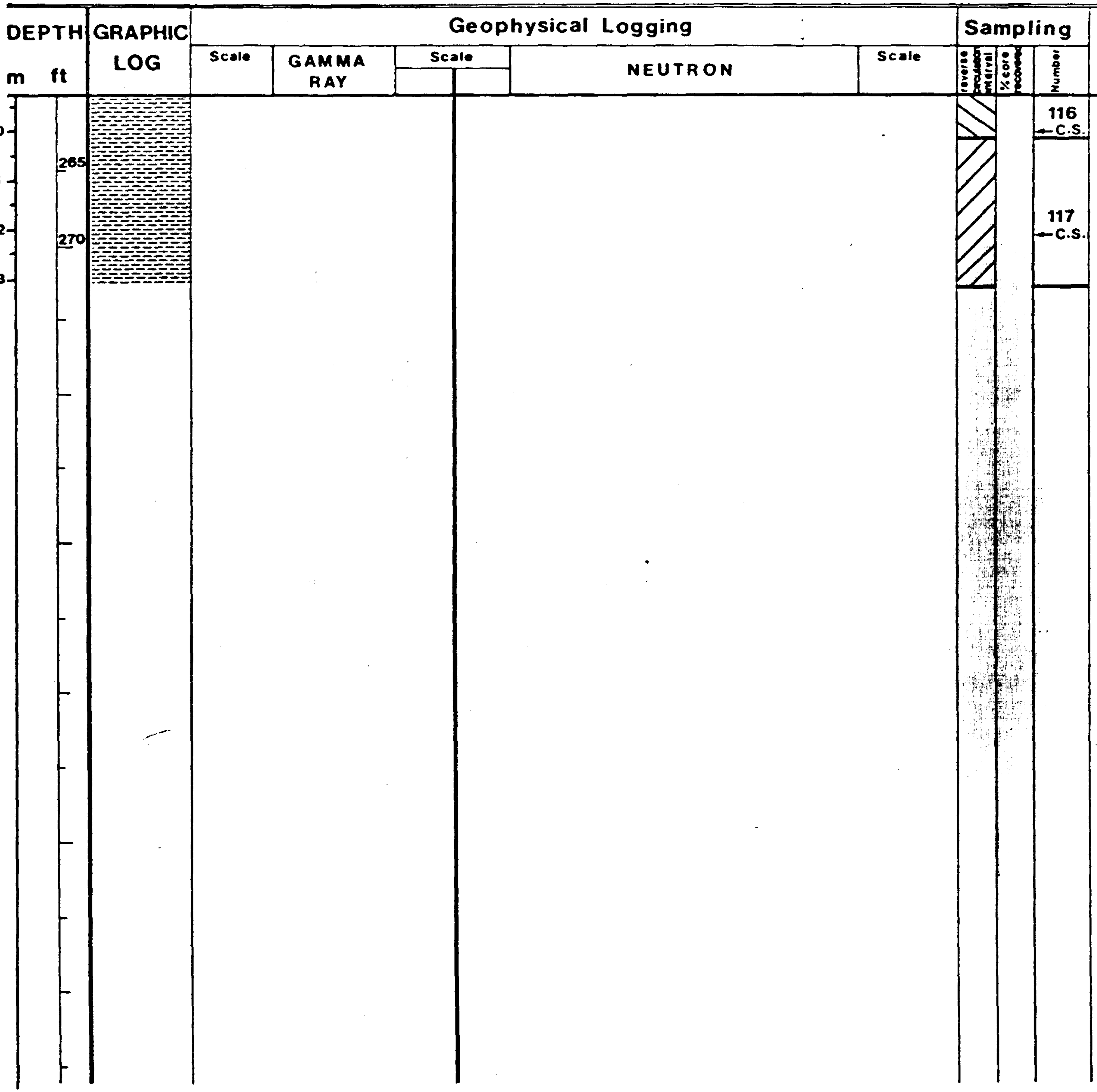
240.0–242.7': Quartz sand with lignite chips.
242.7–244.7': Brown clay with 4" of quartz sand, lignite chips at 244.4'.

244.7–273.3': Interbedded dark brown-grey and light green clay; no traces of lignite after approximately 75 m; all are non-calcareous; most beds are 15–50' thick; in places the green clays predominate whereas in others the grey-brown clay interbeds are more abundant.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-03

Sheet 5 of 5



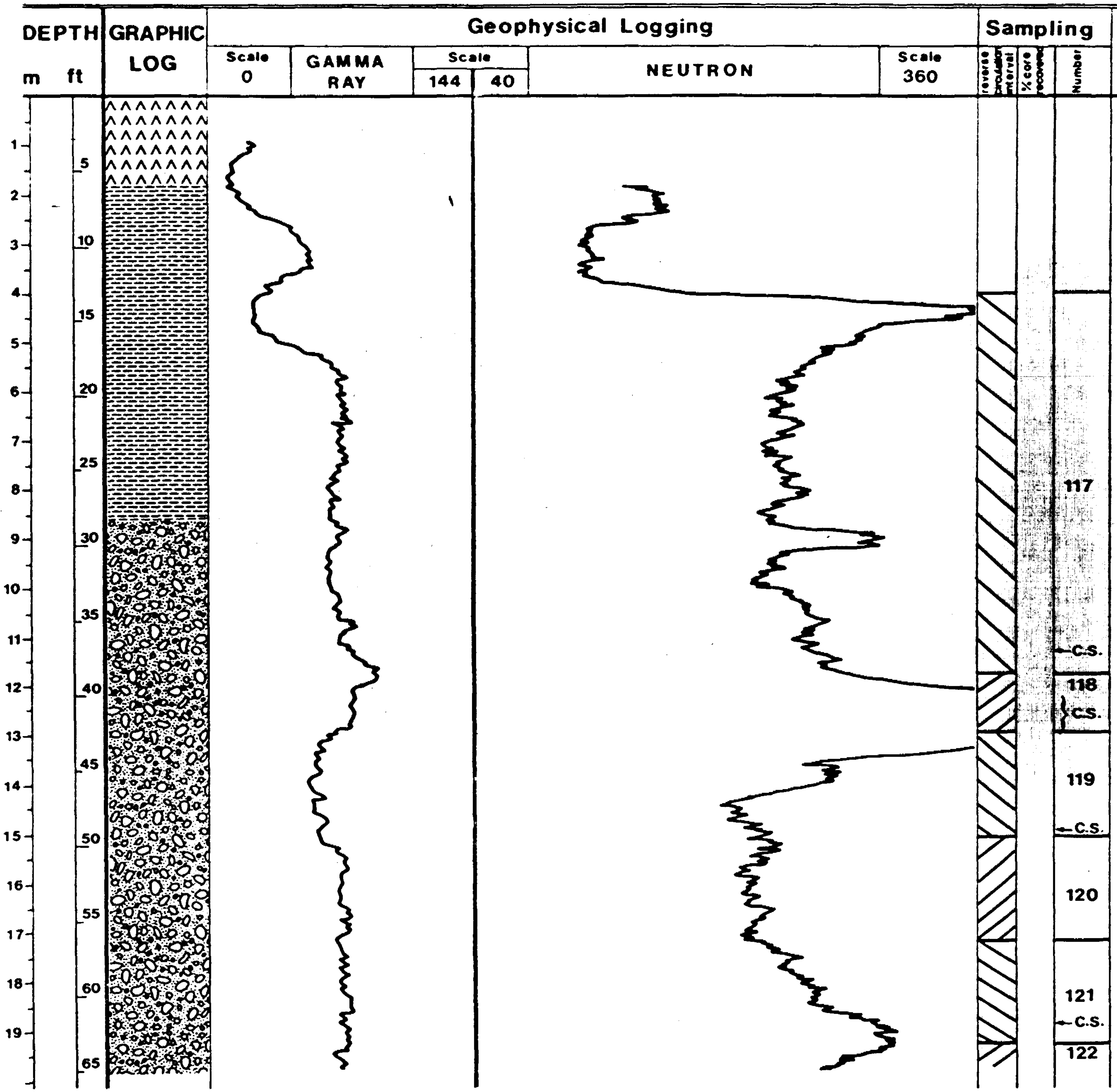
Description

273.4': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-04 Location: PICKETT TWP.

Elev. of collar: 205.0′ Sheet 1 of 5 (lat. 50°29.7′ long. 81°42.0′)



Description

MUSKEG: 0–6.0′

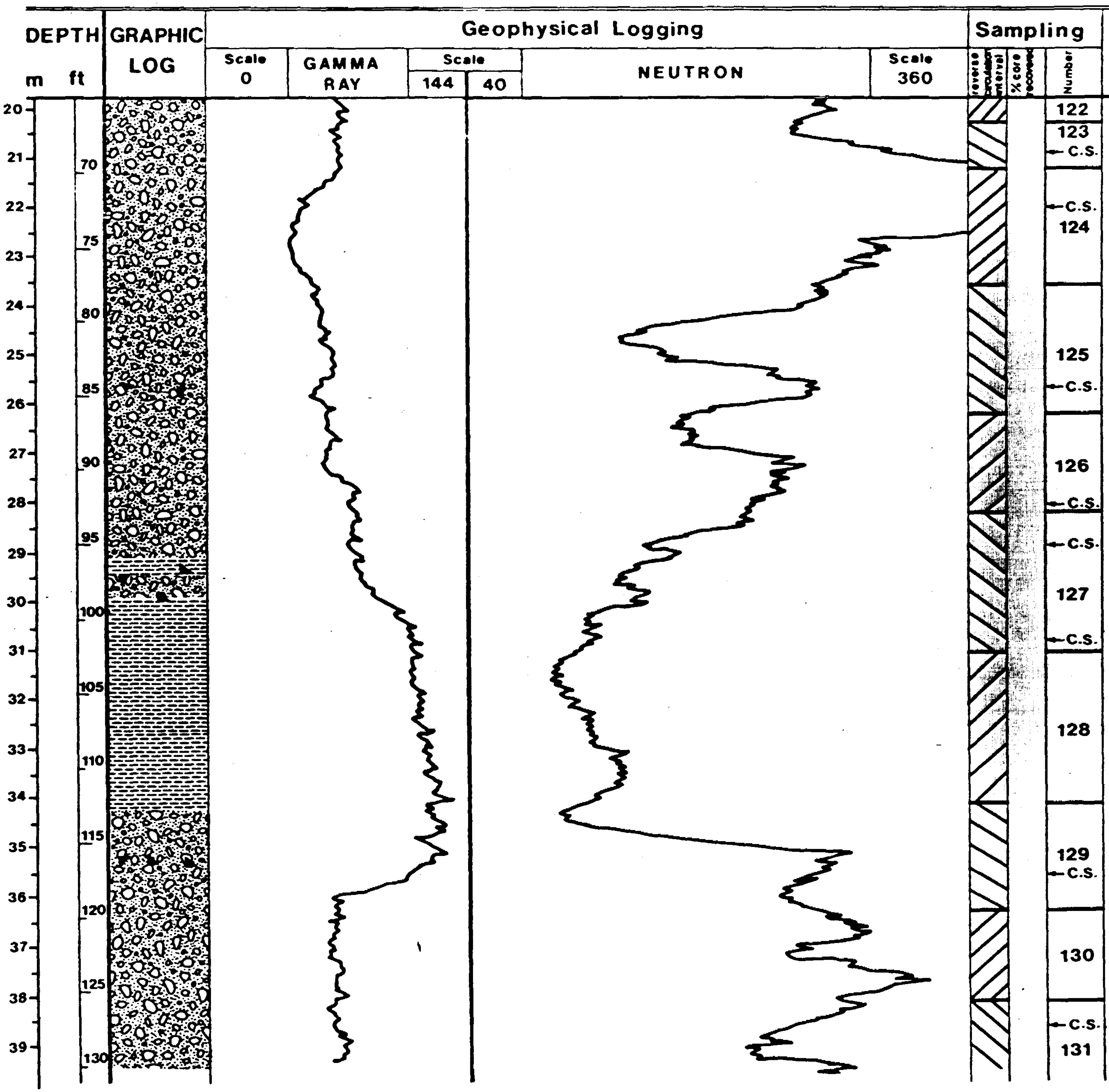
CLAY: 6.0–28.3′
Medium to medium-dark bluish grey; minor clasts; calcareous; soft.

TILL: 28.3–95.0′
Largely medium-grey clayey, sandy-silty matrix; calcareous; in places pebbly (usually more than 50% sedimentary clasts, but also considerable non-sedimentary basement lithologies).

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-04

Sheet 2 of 5



Description

84.6–85.0': Abundant, coarse lignite chips.

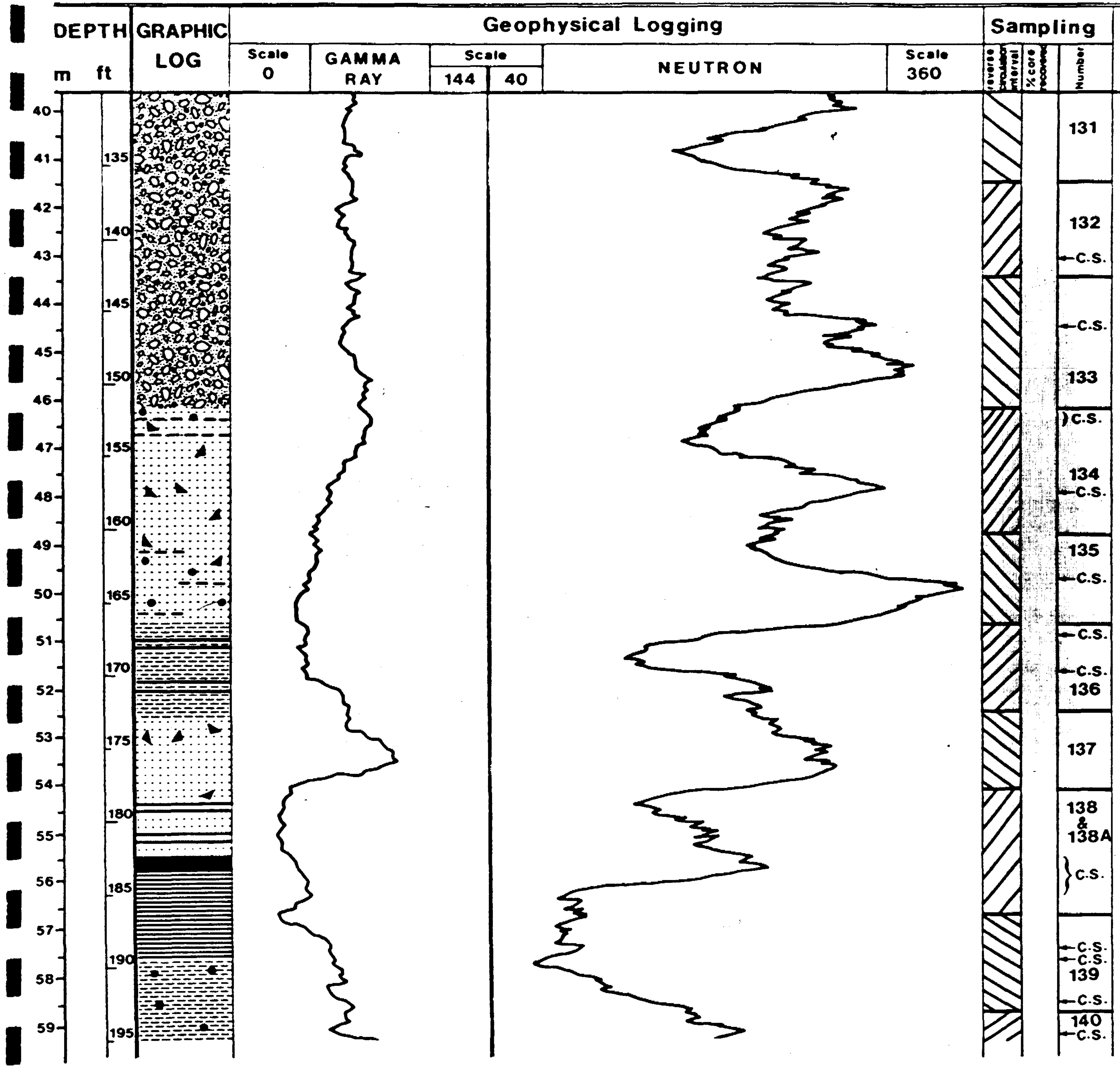
TILL: 95.0–96.0'
Light grey clayey-sandy.
CLAY: 96.0–97.3'
Medium-grey.
TILL: 97.3–99.3'
Medium dark grey clayey, sandy till; traces of lignite chips.
CLAY: 99.3–113.3'
Medium and light grey; fine-grained carbonaceous material; weakly calcareous.

TILL: 113.3–163.3'
Dark to medium grey, clayey, sandy, pebbly (abundant sedimentary and basement clasts); calcareous, abundant lignite chips at 117.0'; occasional cobbles.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-04

Sheet 3 of 5



Description

133.8': Numerous lignite chips; most of the pebbles (more than 70%) are sedimentary.

140.0–144.0': A few red chert clasts.

144.0': The till becomes a lighter grey (clayey, sandy, pebbly); over 4–8".
146.7': Conspicuous lignite chips.

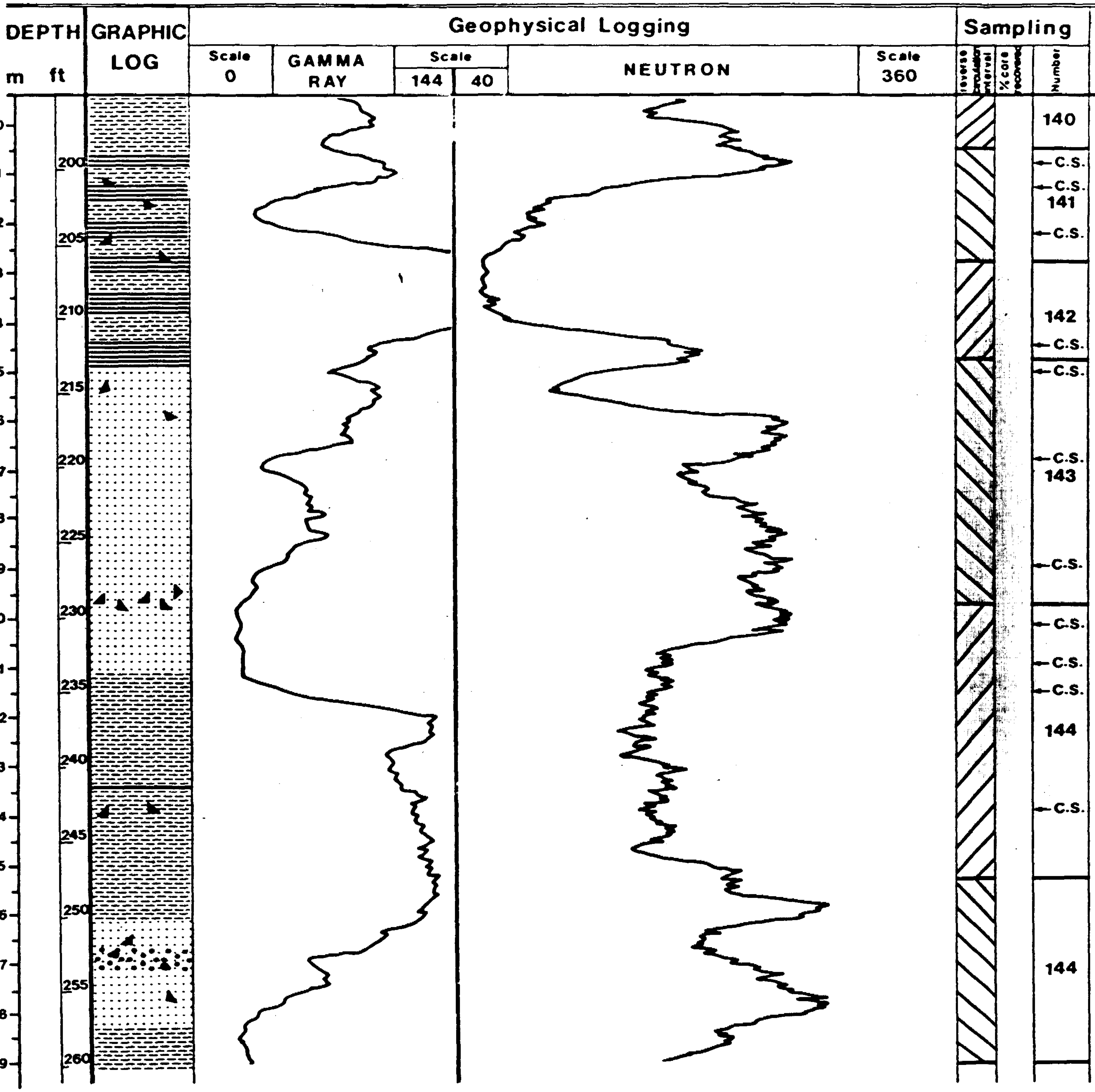
151.9–153.3': Mixture(?) of quartz, arkosic sand, heterogeneous pebbles, as well as a dark brown and light grey clay (could be the offset of glacier overriding?).
153.3–163.3': Polymictic conglomerate; sandy, largely sedimentary clasts; numerous lignite chips.

SAND: 163.3–166.3'
Poorly sorted, but largely rounded clasts; polymictic, and, in places, abundant pebbles as well as minor clasts(?) of dark grey clay.
CLAY: 166.3–173.0'
Dark grey–brown to black; carbonaceous; in places sandy and containing traces of lignite; non-calcareous.
QUARTZ SAND: 173.0–178.7'
Minor lignite chips although at 175.0' quite coarse lignite chips.
CLAY: 178.7–183.0'
Carbonaceous clay with sand followed by more quartz sand with abundant lignite chips in places.
LIGNITE AND CLAY: 183.0–189.7'
183.0–184.3': Lignite, minor clay; fairly massive.
184.3–185.5': Carbonaceous clay with lignite; some blebs of pyrite.
185.5–189.7': Lignite and black clay interbeds.
CLAY: 189.7–197.8'
Medium brown–grey; minor pyrite; fine-grained carbonaceous clasts abundant in some sections, but not throughout; at 197.0' coarse lignite chips and blebs of quartz sand cemented with pyrite, all in a matrix of medium dark brown–grey clay.
QUARTZ SAND: 197.8–199.2'
Some lignite chips and minor clay; pyrite cement in places.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-04

Sheet 4 of 5



Description

CLAYS AND LIGNITE: 199.2–213.7'
Lignite and interbedded brownish grey to black coloured clays; overall the clay is more abundant, but some sections contain woody lignite chips, whereas others appear to contain soft, massive lignite; most of the clays contain much fine-grained carbonaceous clasts; all clays non-calcareous.

QUARTZ SANDS: 213.7–234.0'
In places fairly fine-grained and containing considerable clay as well as lignite chips; after 220' essentially all quartz sand quite pure.

229.0': Thin bed (4") of quartz sand and coarse lignite chips.

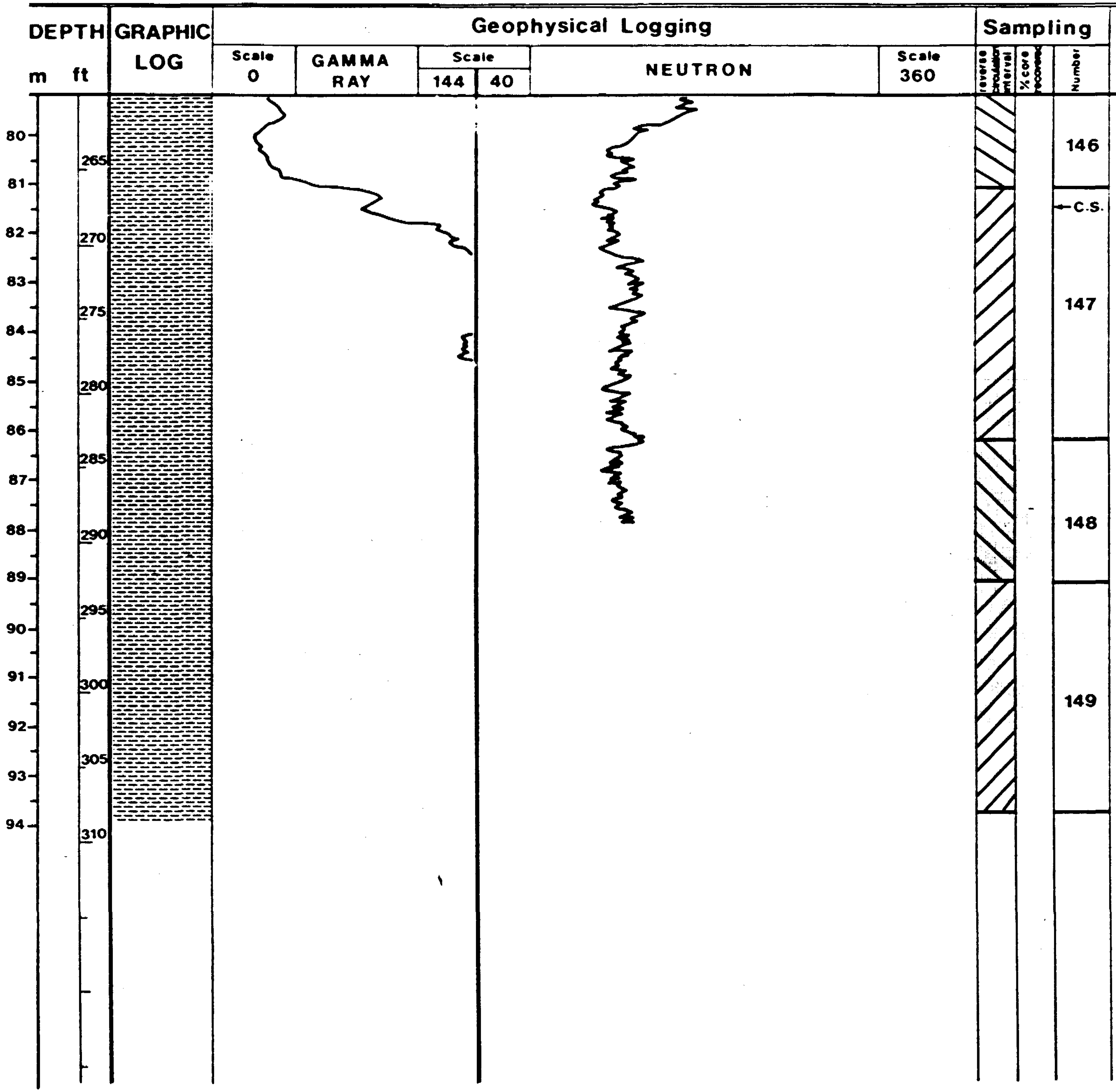
CLAY: 234.0–250.3'
Thinly interbedded sequence of light grey, light greenish-grey, beige, medium grey, and occcasional dark grey clay beds; all are non-calcareous.

241.5': Thin interbed of soft lignite.
243.3': Abundant small lignite chips.
244.7–247.0': Clay with aggregates of euhedral pyrite (less than 0.2 mm).
247.0–250.3': Light grey clay becoming quite silty.
SAND: 250.3–258.3'
White quartz sands; silty at top and in places containing significant lignite chips.
252.5–254.0': Coarse sandy gravel and lignite; angular quartz clasts and containing some white clay (kaolin?).
CLAY: 258.3–267.0'
Largely interbedded pale grey; medium grey, pale green–grey and occasional band of dark brown clay; all are non-calcareous and frequently in beds that appear to be 4_12" thick.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-04

Sheet 5 of 5



Description

CLAY: 267.0–308.3'
Alternating layers of soft to medium stiff pale grey–green clay and medium stiff to hard layers of dark chocolate brown clay; non-calcareous. The laminae are thin at first, but increase to 2" downwards.

291.8–302.3': As above, non-calcareous, medium stiff to hard alternating layers of green and dark brown clays and siltstones, mostly thinly layered.

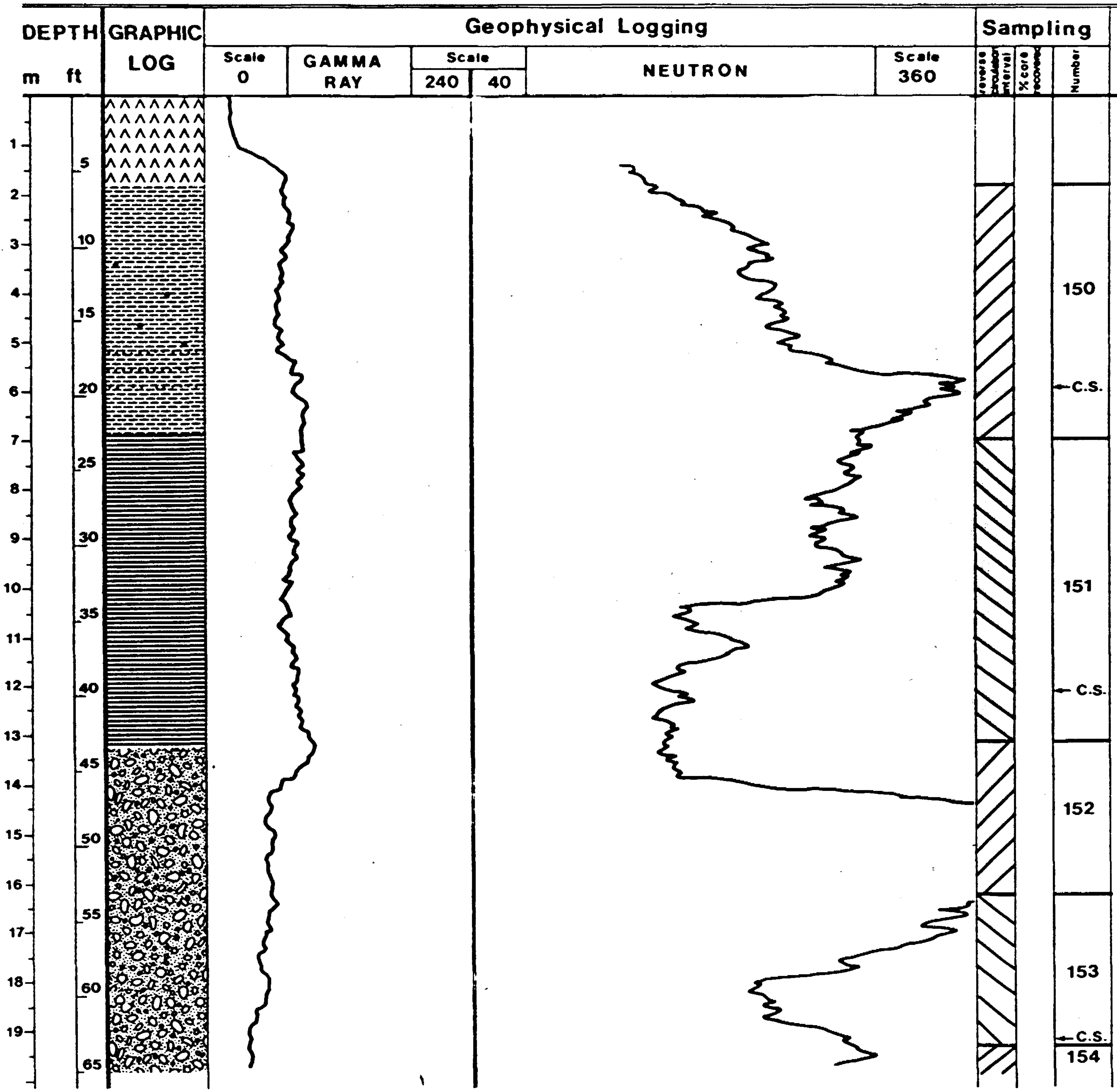
302.3–308.3': Very hard, finely laminated fissile, dark chocolate brown clay/shale, and siltstone with rare thin hard fissile pale grey–green clay/shales.

308.4': END OF HOLE.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05 Location: MORROW-HOBSON TWP. LINE

Elev. of collar: 220.0′ Sheet 1 of 7 (lat. 50°29.5′ long. 81°38.5′)



Description

MUSKEG: 0–5.7′

CLAY: 5.7–43.7′
5.7–6.7′: Pale grey, soft, calcareous.
6.7–11.5′: Pale blue grey, soft, calcareous clay.

11.5–17.3′: As above but becoming silty, and containing bivalves, and small very rounded pebbles of diabase, dark shale, and buff limestone, and soft brown wood fragments.

17.3–20.7′: As above but becoming very sandy. Bivalves and layers of black lignitic sand, dust.

20.7–23.3′: Dark blue grey gritty, very calcareous.

22.5–23.3′: Very thinly varved pale grey and dark blue grey, calcarous clay.
23.3–43.3′: As above but finely striped with black soft clay (Carbonaceous?).

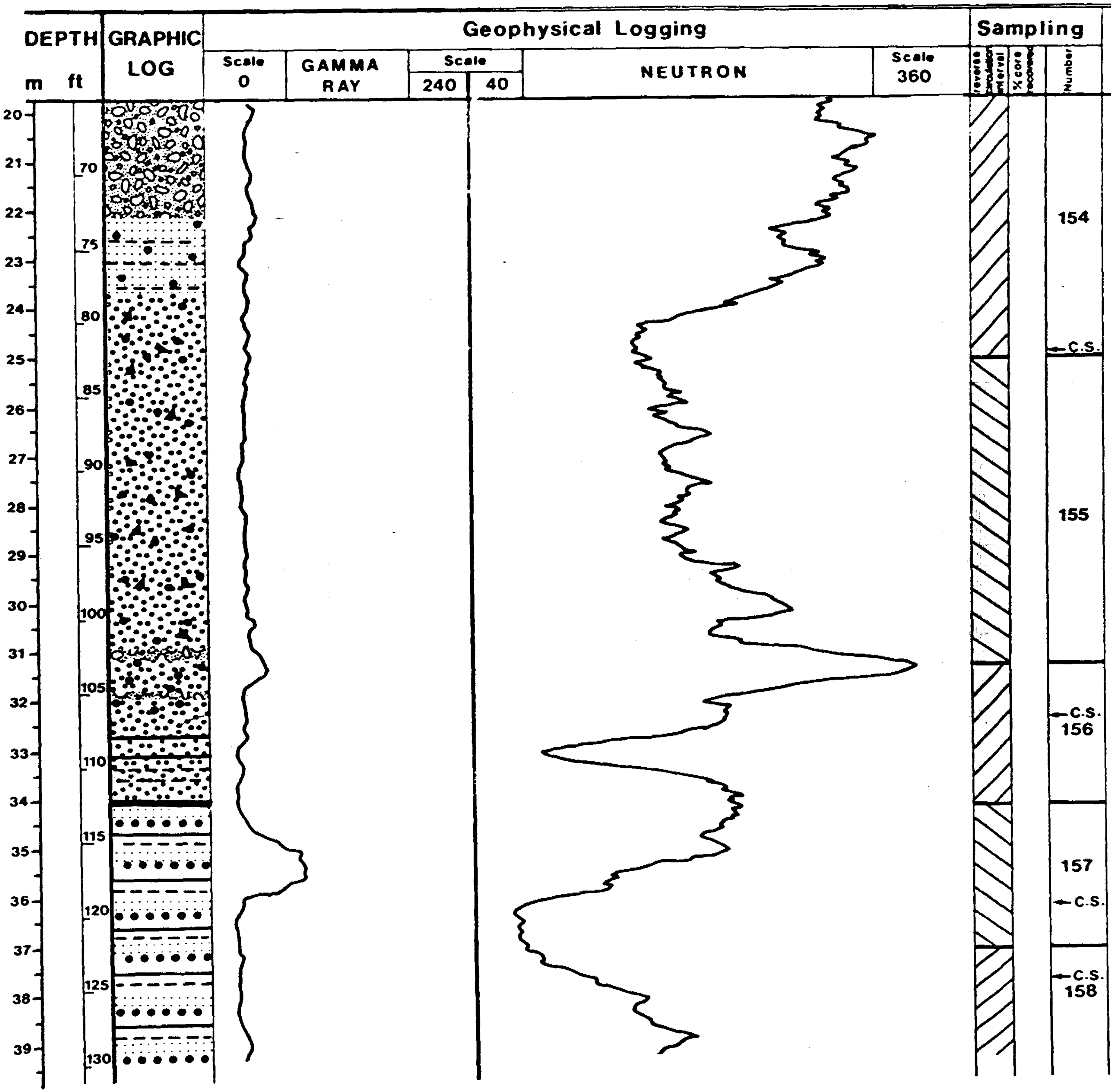
41.7′: Soft lignite fragments.
TILL: 43.7–61.0′
Pale grey at first, but beige grey by 14.8 m. Predominently beige, clayey, silty, gritty, pebbly till. At times gravel, pebble with cobble layers, calcareous, beige clasts predominantly (60%), buff limestone, with basement pebbles comprising 30%. Some white chert and red jasper pebbles.

CLAY: 61.0–61.9′
Beige silty clay, no gravel or pebbles.
TILL: 61.9–66.7′
Beige grey, silty, sandy clay till, with occasional pebbles of usual suite.
63.0′: Fresh lignite fragments.
63.7–66.7′: Boulder.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 2 of 7



Description

TILL: 66.7–73.3'
Clayey, beige grey, gravelly, pebbly, and cobbly. 60% limestone clasts, 30% basement pebbles and cobbles.

SANDS, GRAVELS AND CLAYS: 73.3–78.1'
Alternating beige clays, pale grey sands and gravels.

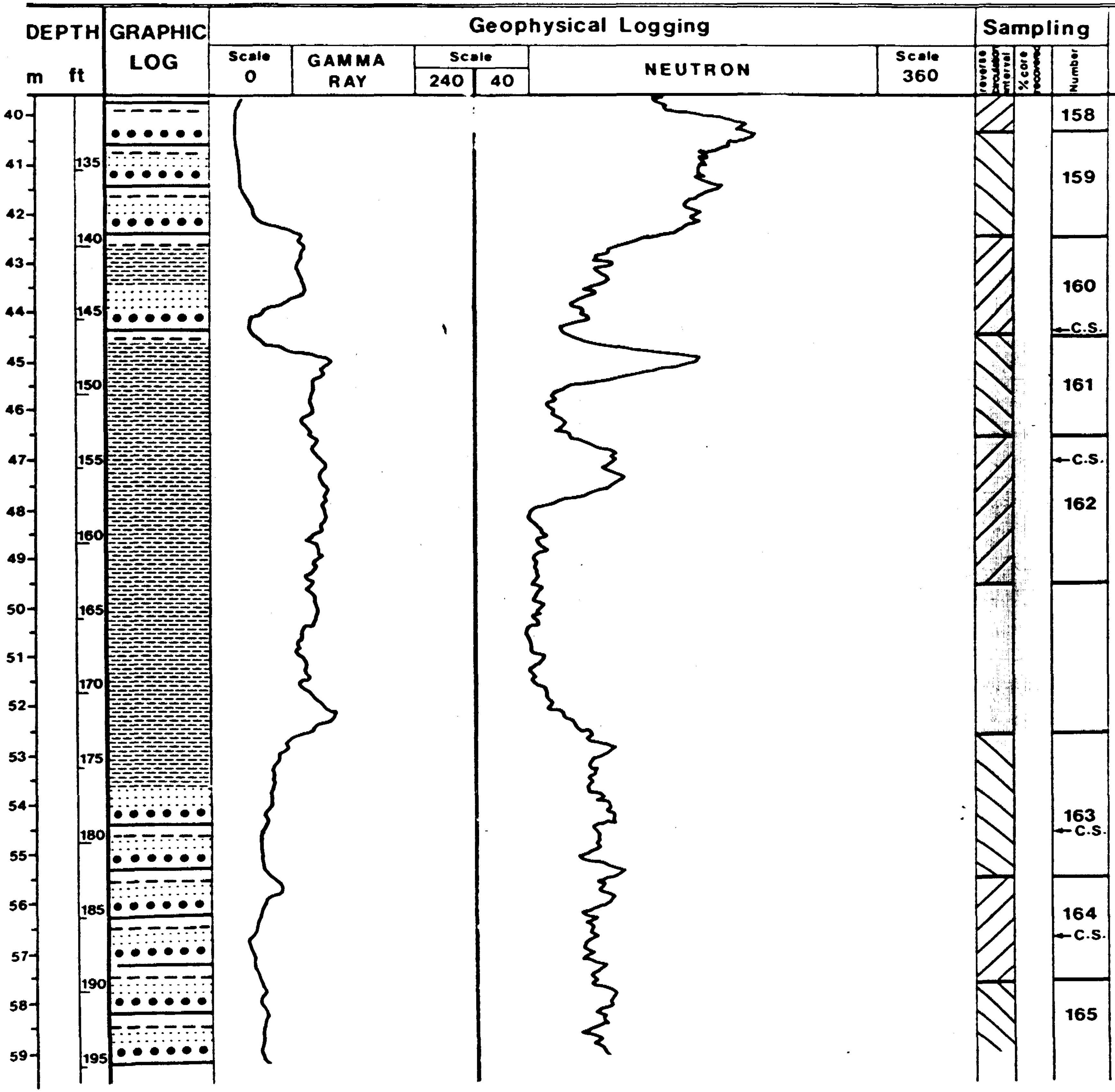
GRAVELS, SANDS WITH LIGNITE: 78.1–101.7'
Rapidly alternating coarse and pebbly gravels, and sands with much fragmental lignite. Rare stiff brown or grey clays.

TILL: 101.7–102.3'
Stiff, dark brown clayey, silty, sandy with lignite fragments.
GRAVEL: 102.3–104.0'
Very coarse gravel with silt and sand matrix and lignite fragments.
TILL: 104.0–104.4'
Stiff, brownish grey clayey, gritty till.
SAND AND GRAVEL: 104.4–106.7'
Coarse gravel passing down into dirty medium grained sand.
GRAVELS AND CLAYS: 106.7–111.7'
Very coarse angular white quartz gravel passing into lignite and then into a thin soft white kaolinitic clay, and then dark brown silty, sandy clay and lignite.
REPEATED CYCLIC UNITS: 111.7–140.0' (each ≈3')
Sequence fine silt, fine, medium, and coarse white quartz angular sand, white very angular very coarse gravel (quartz grains and rare pink feldspar), and then sudden transition into thin lignite resting on grey or white soft clays or brown clays. There are usually thin layers of pyrite (1/2–1") cementing fine or medium sands (Sample VI) and some coarse sands/gravels also. At times thin pyrite layers are present in fine dark clay layers. Some darker clay bands contain finely disseminated, discrete cubes of pyrite.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 3 of 7



Description

CLAYS: 140.0–143.7'
Very stiff, brownish grey, at times gritty clay with thin fissile lamellae and fine grains of lignite, non-calcareous.

CYCLIC UNITS: 143.7–146.7'
As before.

VARIEGATED CLAYS: 146.7–176.0'
146.6–152.5': Stiff pale grey/white kaolinitic clay with numerous pyrite layers 1", non-calcareous.
152.5–159.3': Mottled and thinly laminated yellow, brown, ochre, red, and reddish orange, with frequent pyrite layers.
159.3–169.3': Very stiff medium grey clay.

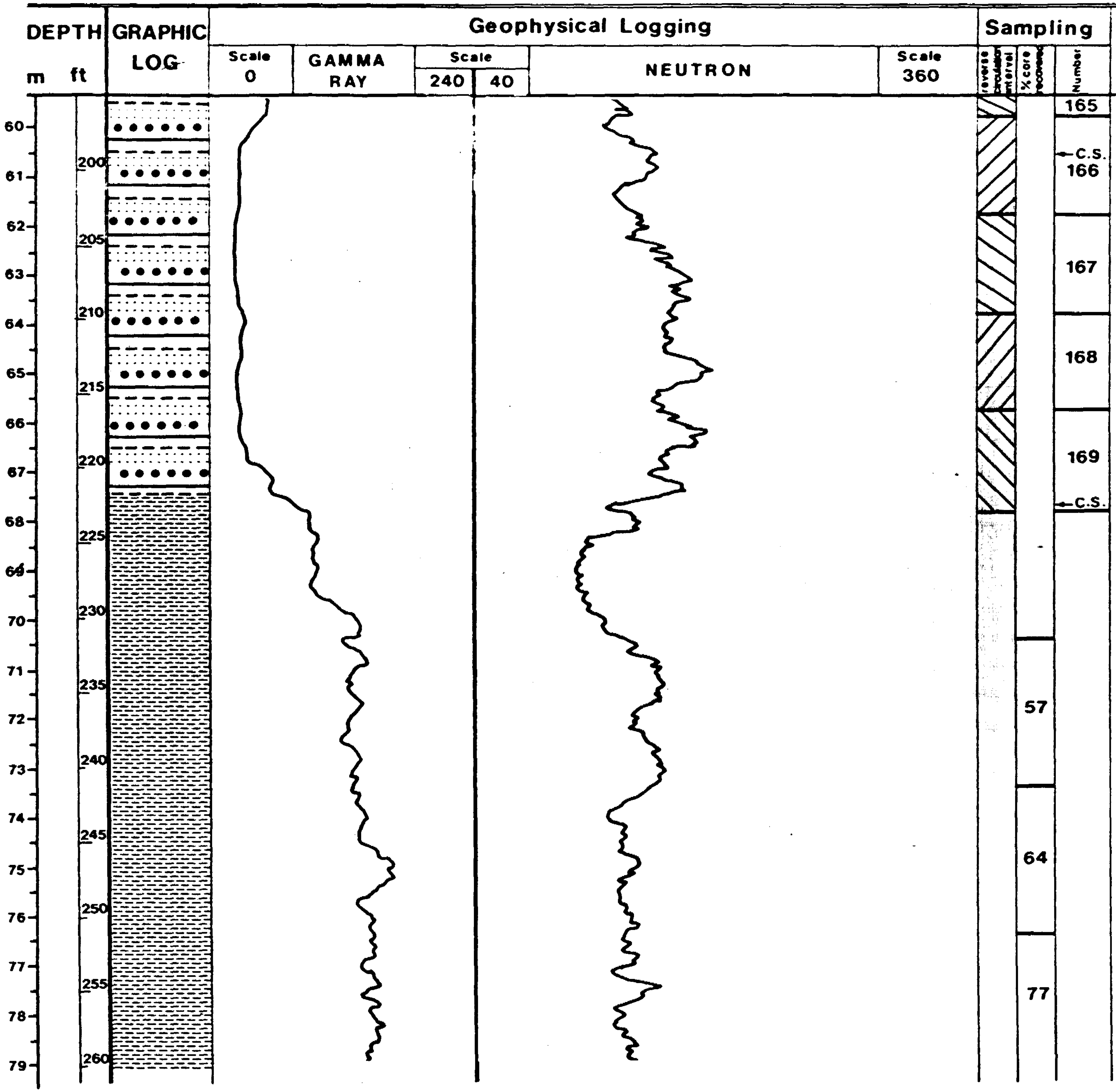
169.3–176.0': Pale olive green/grey clay, with slight orange mottling. From 170' becoming silty.

REPEATED CYCLIC UNITS: 176.0–222.0'
As before. Pyrite layers in sands and clays.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 4 of 7



Description

As above. Many pyrite layers, 1/2–1" in sands and clays. Clays now pure white, with angular lignite clasts less than 1 cm and down to silt size. Lignite seams getting thinner, 1/2–1" downwards. Clays now white and dark grey. Lowest three gravels are pebble sized, angular, and of basement suite.

CLAYS, SHALE, AND SILTSTONES: 222.0–400.3'
222.0–222.1': Mottled light grey, and dark grey clay.

Pale grey green and dark chocolate brown clays and siltstones. To 286.7' predominantly soft to medium stiff grey green clays alternating with lesser bands of chocolate brown siltstones. Frequent thin layers (or laminae) of pyrite.

232.0–242.0': Soft and stiff, pale grey green clays alternating with thinner layers of dark chocolate brown and grey, very hard indurated shale or siltstones (60/40 ratio green clays to brown siltstones). Frequent pyrite in layers 1/4".

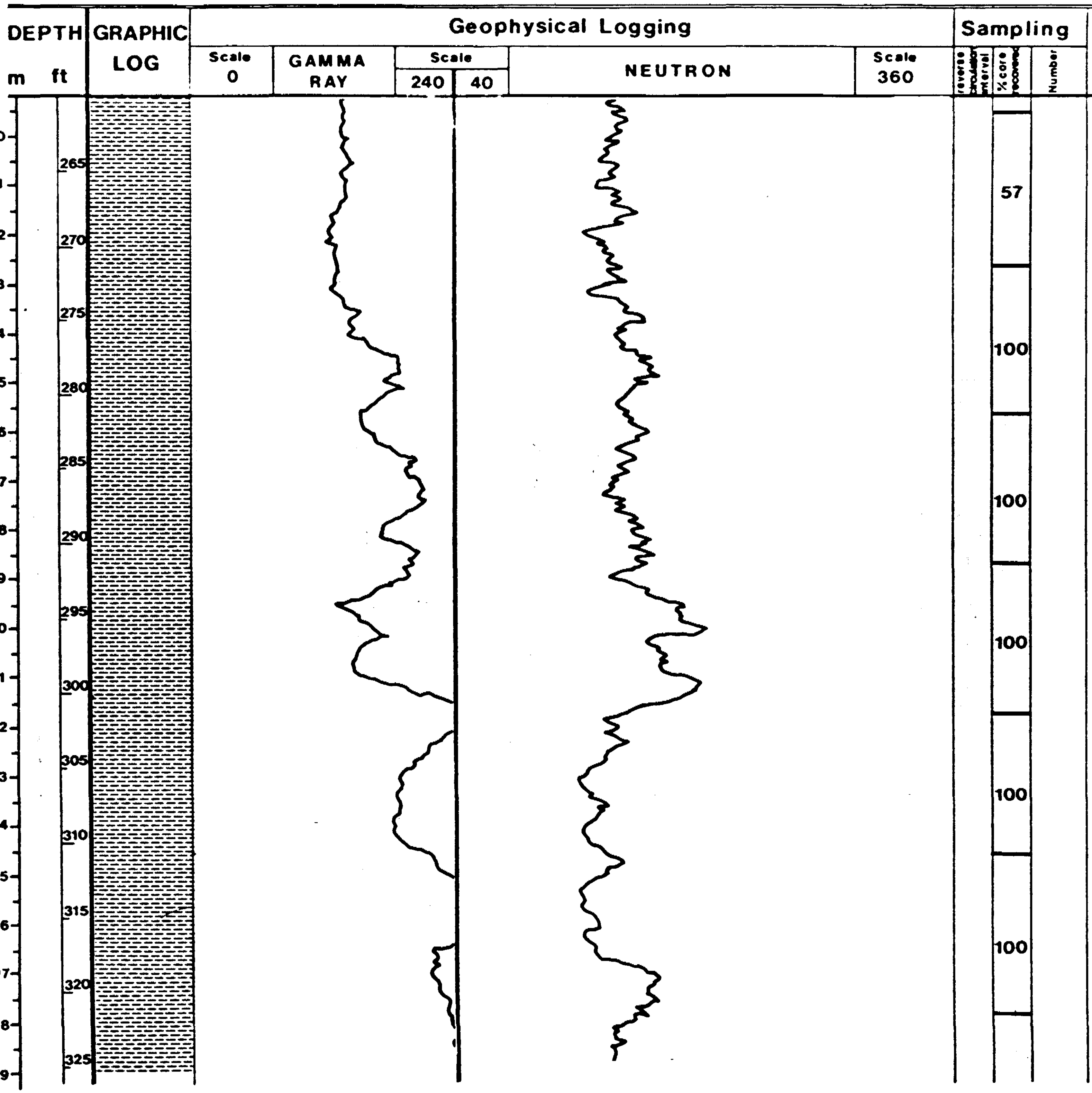
242.0–252.0': As above, ratio green to brown 70/30. Siltstones very hard, fissile and green clays becoming very stiff by 220.8'. Pyritiferous as above. Dark brown siltstones now thicker, less than 3".

252.0–262.0': As above but green clays now compact and dominant. Very hard indurated brown siltstones vary between 1/4–4" thick. Ratio green/brown 90/10.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 5 of 7



Description

262.0–272.0': Compact green/grey, fissile, finely laminated claystone/mudstone with rare dark brown fissile shale/siltstone laminae from 1/4–1" (green/brown 93/7).

272.0–282.0': As above, very compact claystone/shales–siltstones green beds softer than dark brown layers. Dark brown layers vary from 1/2–5" and becoming more frequent (30%).

282.0–292.0': As above, ratio 60% brown, 40% green. Bands vary from 1/4–30".

292.0–302.0': As above, but both types very compact mudstone, shale or siltstones. Dark brown banding varies from 1/8–28".

302.0–312.0': As above, now very compact indurated dark brown to black shale/siltstone with rare grey green shale?/claystone. Green layers vary from 1/16–2 1/2". Ratio grey/green to dark brown 15/85.

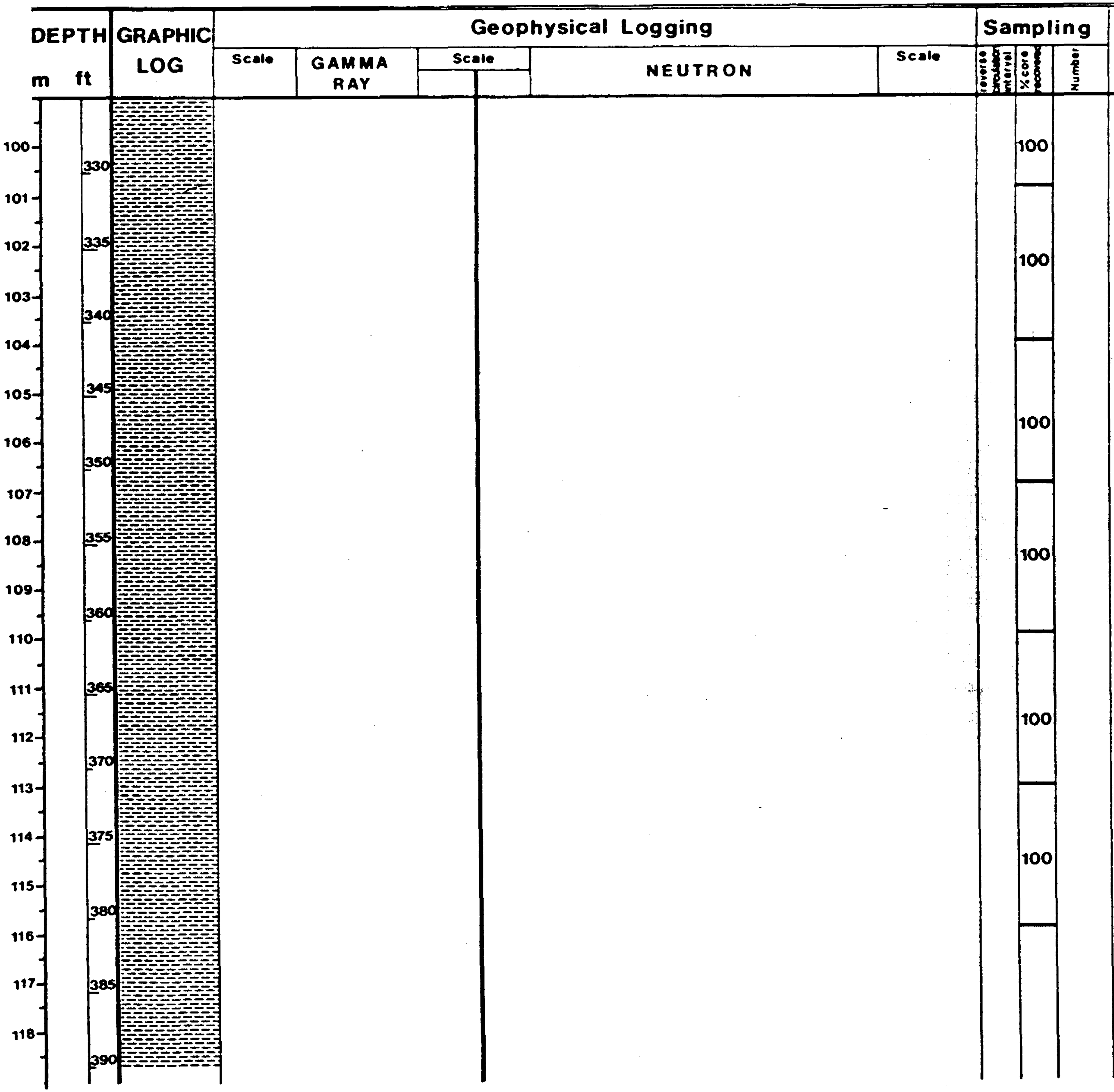
312.0–322.0': Very compact indurated dark chocolate brown, fissile claystone or very fine siltstone with rare thin layers of green softer clay, average 1/2", but over at 4". Sedimentary structures visible, giving low bedding dip 5°–10°. Elusive contact at top of thicker dark brown horizons, with mudstone and green clay 'rip-up' clasts. Dark brown siltstones very thinly laminated, ≈1/32". Ratio 5/95 grey/brown.

322.0–332.0': Very fine laminae of dark chocolate brown mudstone/shale and light brown very hard siltstone. Rare layers of green shale, mudstone. Some structures as above. Some green clasts show recumbent slump structures, and slump rotations. Ratio 3/47 grey/brown. Penecontemporaneous slumping.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 6 **of** 7



Description

332.0–342.0': As above, but from 332.7–334.0' pale greenish grey to light blue/grey calcareous siltstone/fine-grained arenite with voids, vugs containing small encrusting gypsum crystals and large, 1/2" crystals of iceland spar. Usual intervals of small flattened, ovate mud clasts (green), some distorted and penecontemporaneous slumping, etc. Sharp erosional contacts with top of brown siltstones. Ratio 5/95 green/brown.

342–352.0': As above. All material contains much very finely disseminated pyrite crystals and fine layers of the same. Rare euhedral Xtals of pyrite less than 1/2".

352.0–362.0': As above. Very compact and indurated. Only one green layer now 2 1/2" thick. Sedimentary structures as before. All fine lamellae horizontal.

362.0–372.0': As above, but no grey/green layering.

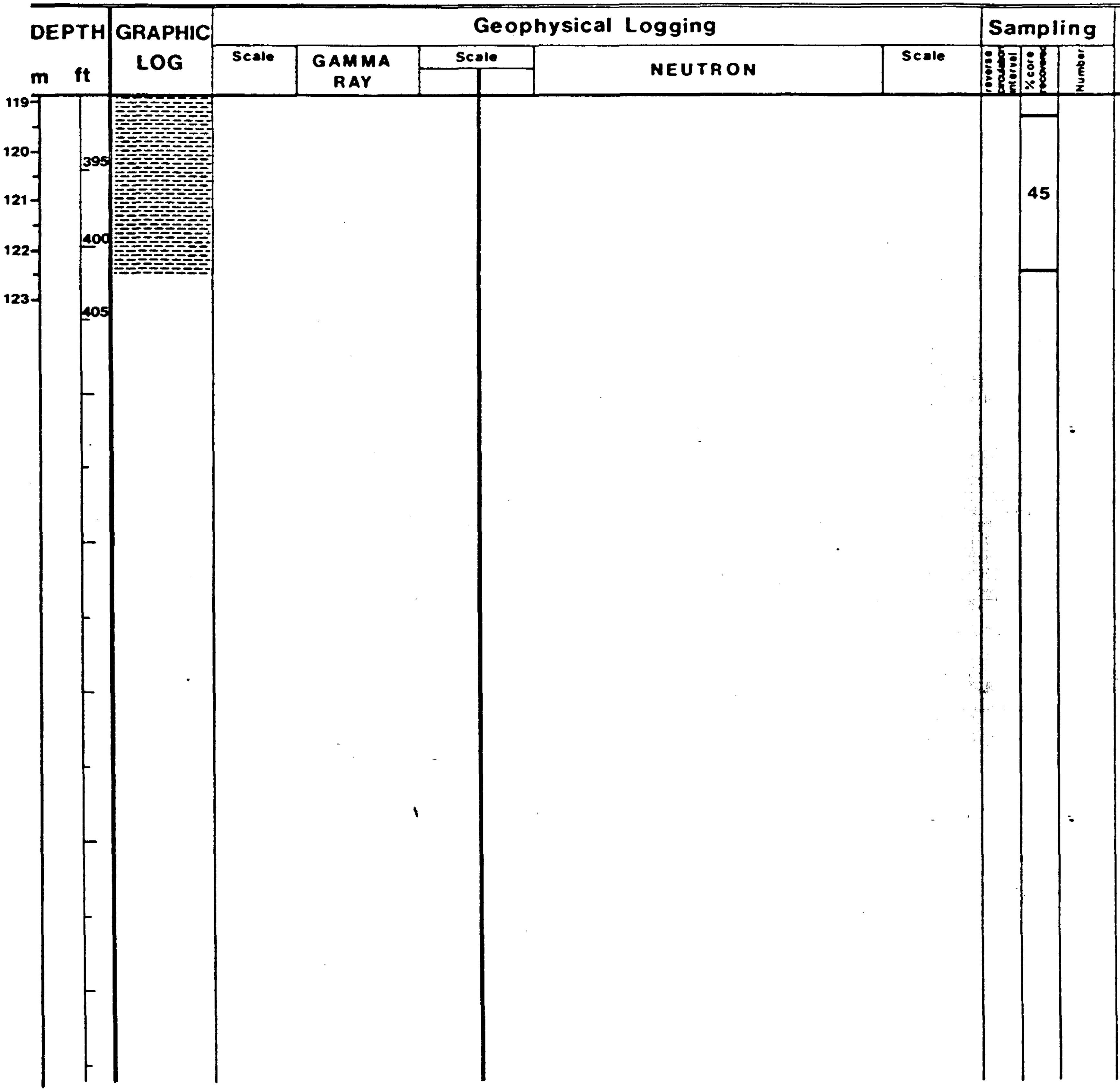
372.0–382.0': As above. At 383.9' a pale green slightly calcareous siltstone, with a thin 1 mm diagonal white vein. Possible evidence of bioturbation of thin lamellae or possible alteration zone.

382.0–392.0': Predominantly finely laminated medium brown and pale greyish brown siltstones and mudstones with one 4" layer of calcareous green or blue/grey calcareous siltstone with possible bioturbation or psendo-brecciation. Fine white mica visible and soft buff grey clay (6").

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-05

Sheet 7 of 7



Description

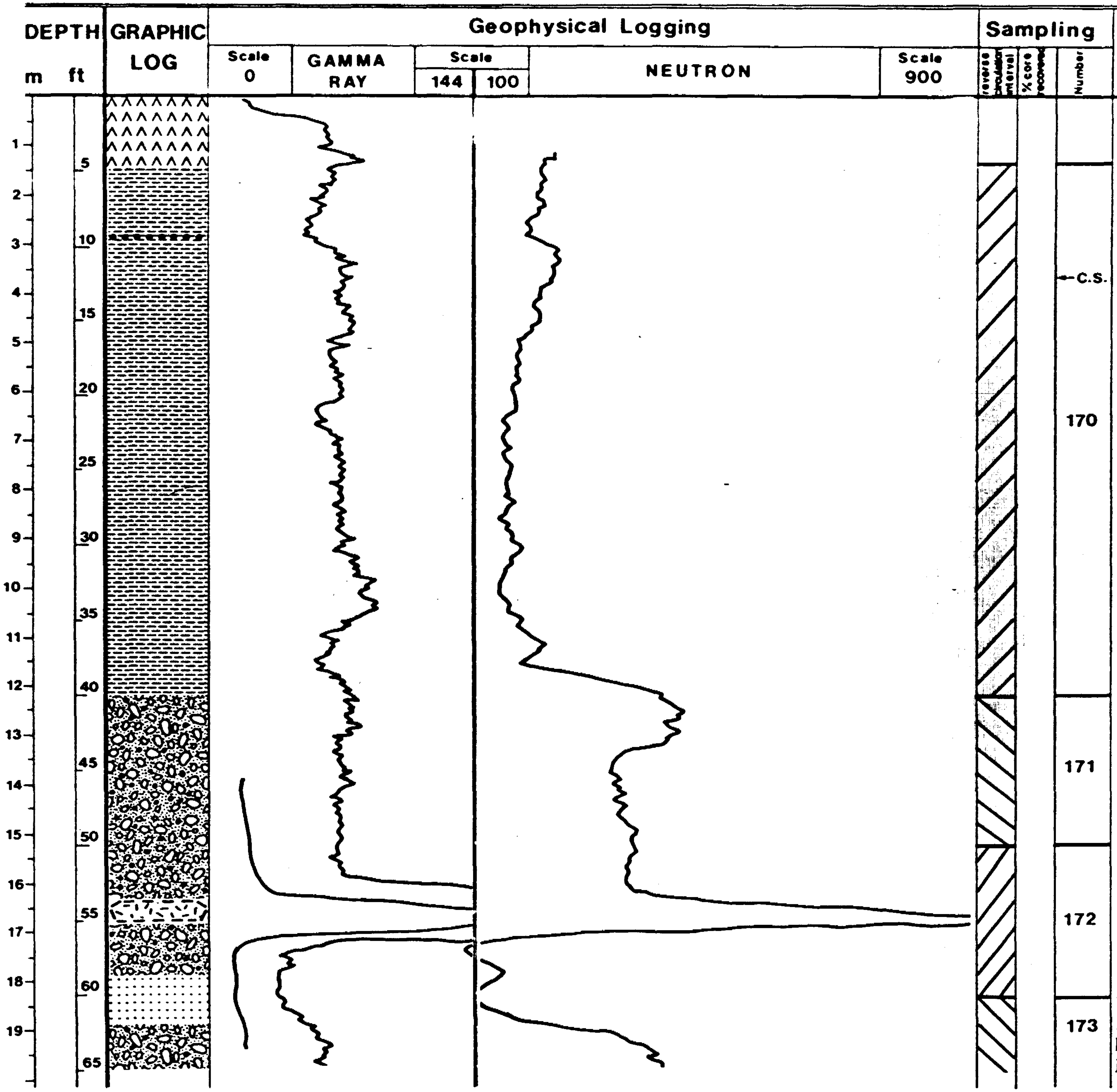
392.0–402.0': As above.

402.0': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-06 Location: PICKETT TWP.

Elev. of collar: 200.0' Sheet 1 of 3 (lat. 50°29.7' long. 81°43.5')



Description

MUSKEG: 0–4.7'

MARINE CLAYS, etc: 4.7–40.0'
Pale grey clay, then for 1.7 cm blue grey clay. At 1–4" rounded pebbles of limestone and basement less than 1 cm. Clay becomes silty and gritty. Small bivalves common. Very calcareous.

TILL: 40.0–50.0'
Beige grey, clayey, silty, gritty, gravelly till, with small pebbles (limestone 60%, basement suite 25%, red jasper), and thin shelled bivalves less than 1 1/2" with white chert pebbles. Very calcareous.
14.1 m: Limestone cobbles.
15.2 m: Limestone cobbles.

TILL: 50.0–56.3'
Pale green, clayey, gritty, pebbly till.
53.7–55.7': Pink biotite–granite boulder.

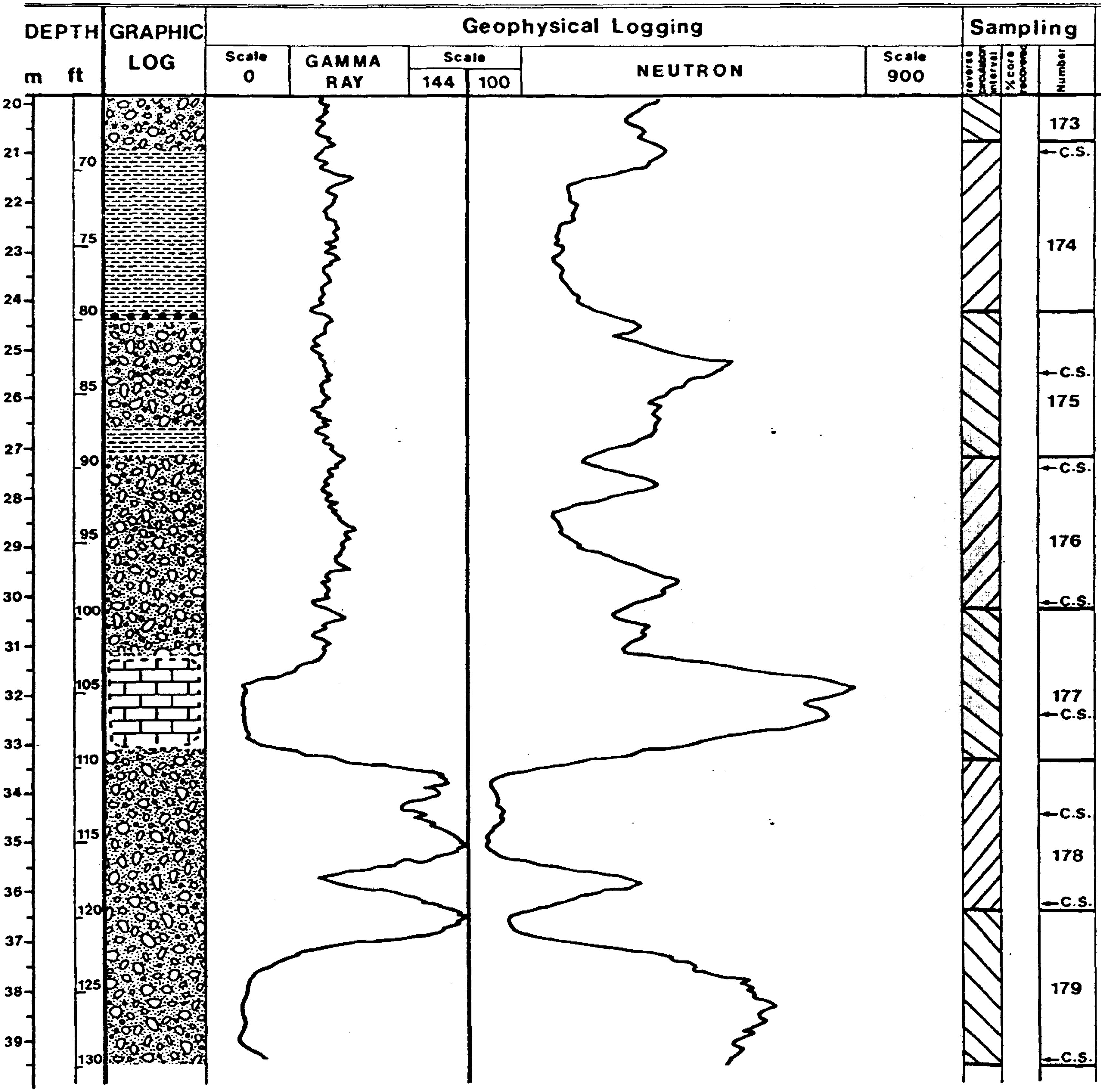
TILL: 56.3–62.6'
Grey, clayey, silty, gravel till.
59.3–62.6': Fine/medium-grained sand.

TILL: 62.6–69.7'
Pale grey, silty, gritty, clay–till. Very calcareous with blue-grey chert less than 1/2" and rare small pebbles of limestone.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-06

Sheet 2 of 3



Description

CLAY: 69.7–80.0'
As above. Pale grey and stiff.

73.4–73.7': Gritty.

77.4–77.7': Gritty.
79.0': Pebbles of limestone and basement suite.
79.3–80.0': Pink biotite–granite cobble.
TILL: 80.0–87.6'
Grey, clayey, gritty, pebbly/cobbly till.

CLAY: 87.6–89.3'
Medium grey, stiff, gritty to 88.2', then pure clay.
TILL: 89.3–131.7'
Grey to dark grey, rarely brown, clayey, silty, gritty till, at times pebbly or cobbly. Rare lignite fragments, soft white gypsum clasts and limestone.

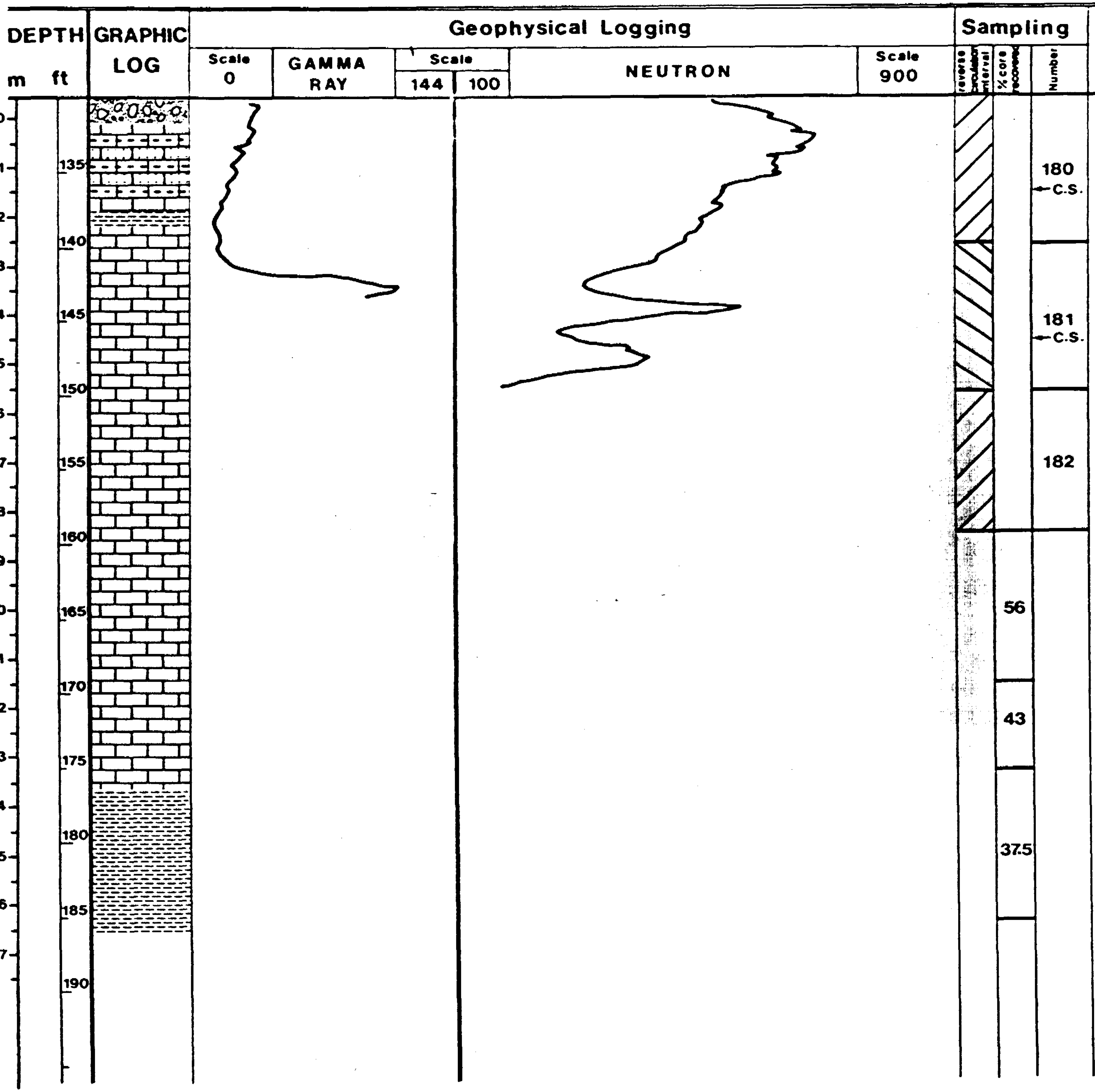
103.1–108.5': Limestone boulder.

LIMESTONE AND CLAYS: 131.7–137.6'
Limestone and silty to sandy clays, minor gypsum fragments.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-06

Sheet 3 **of** 3



Description

CALCARENITE: 137.6–138.3'
With clay bands (light green).
LIMESTONES: 138.3–160.0'
Light, medium, and dark blue grey limestones, thin buff calcarenite horizons, with thin light blue grey clays, silty or sandy at times.

148.7–149.7': Strong H_2S gas escape.

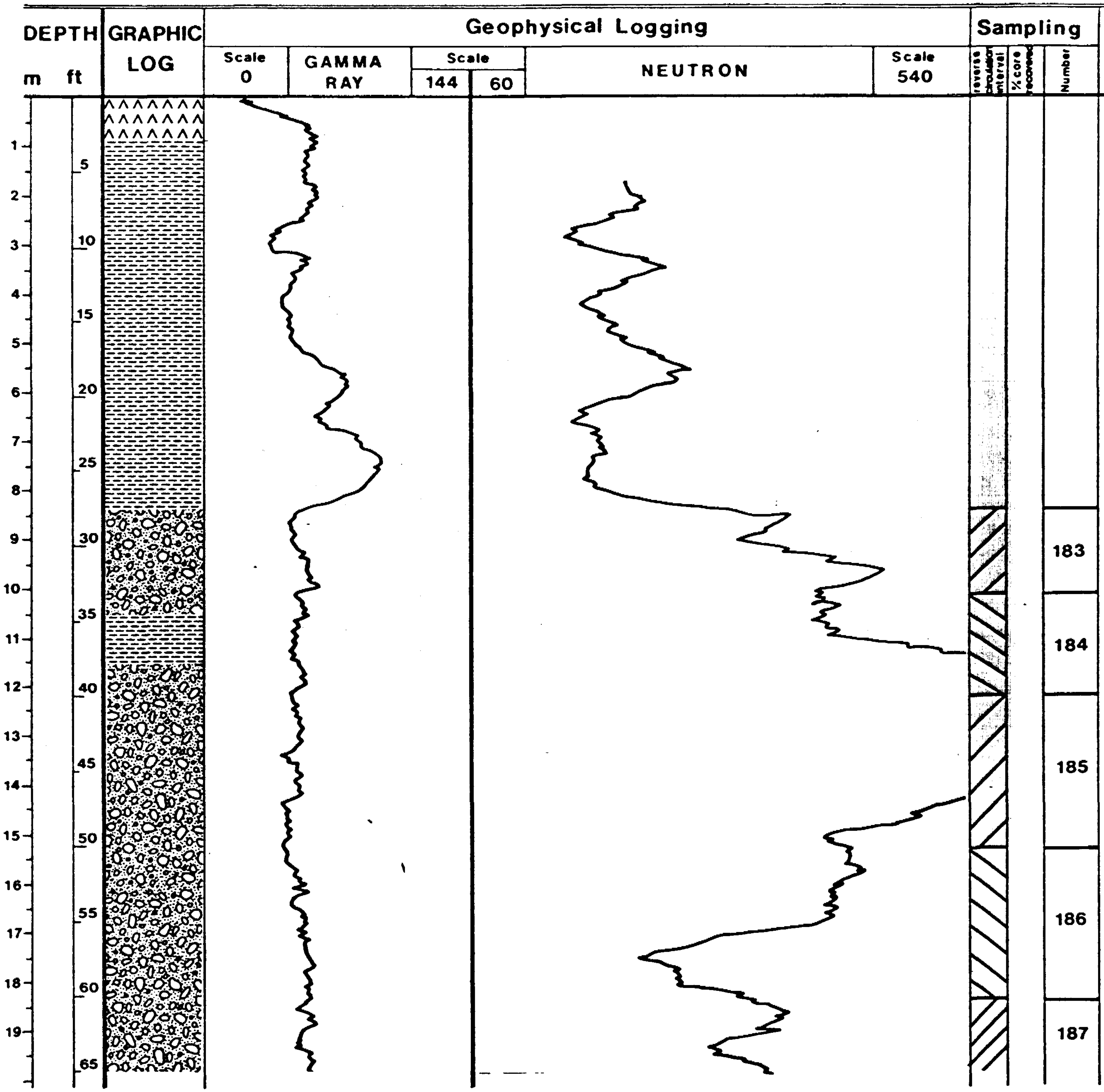
LIMESTONES, CALCARENITES, SANDSTONES AND BRECCIAS: 160.0–170.0'
~~Cavitated and vugated.~~ Rapidly alternating sequence of pale grey, and buff fine and coarsely grained limestone, dark grey biomicrite; very porous buff medium-grained sandstones, finely laminated buff and grey calc-arenites; honeycombed sandstone, slump breccia (coarse) with dips varying between 45° and 65°. Stylolites, and thin calcite veining.
LIMESTONE, CALCARENITE, AND DOLOSTONES: 170.0–176.0'
Finely layered buff calcarenite with distorted laminae; dark blue grey, finely layered fragmental limestone; calcite veins, slump breccias, dark fine-grained biomicrite. Stylotic. Distorted bedding varying from 65° to vertical.
CLAY: 176.0–180.0'
4-foot sequence of soft, plastic, dark blue green clays, calcareous (possibly cavity infill??).
180.0–186.0': Same breccia as before.
186.0': END OF HOLE.

Vuggy

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-07 Location: GARDINER TWP.

Elev. of collar: 150.0′ Sheet 1 of 4 (lat. 50°44.1′ long. 81°30.6′)



Description

MUSKEG: 0–3.0'

MARINE CLAYS, etc.: 3.0–27.7'

3.0–3.6': Pale grey green clay.

3.6–20.6': Blue grey clay with bivalves and soft brown wood fragments. Becoming more silty and sandy by 17.4'.

20.6–27.7': Medium stiff, dark blue grey and thinly striped with black clays. Some wood fragments.

TILL: 27.7–56.7'

Mostly a beige grey, clayey, silty, sandy, pebbly till, at times becoming less clayey and more pebbly or cobbly.

34.7–37.4': Soft beige silty/gritty clay, becoming clay by 36.0'. Rare white ochre/white chert pebbles.

TILL AND GRAVEL/SANDS: 56.7–64.3'

Blue grey clayey, silty, gravel, pebbly till becoming a sand or coarse sand and gravel downwards with little clay.

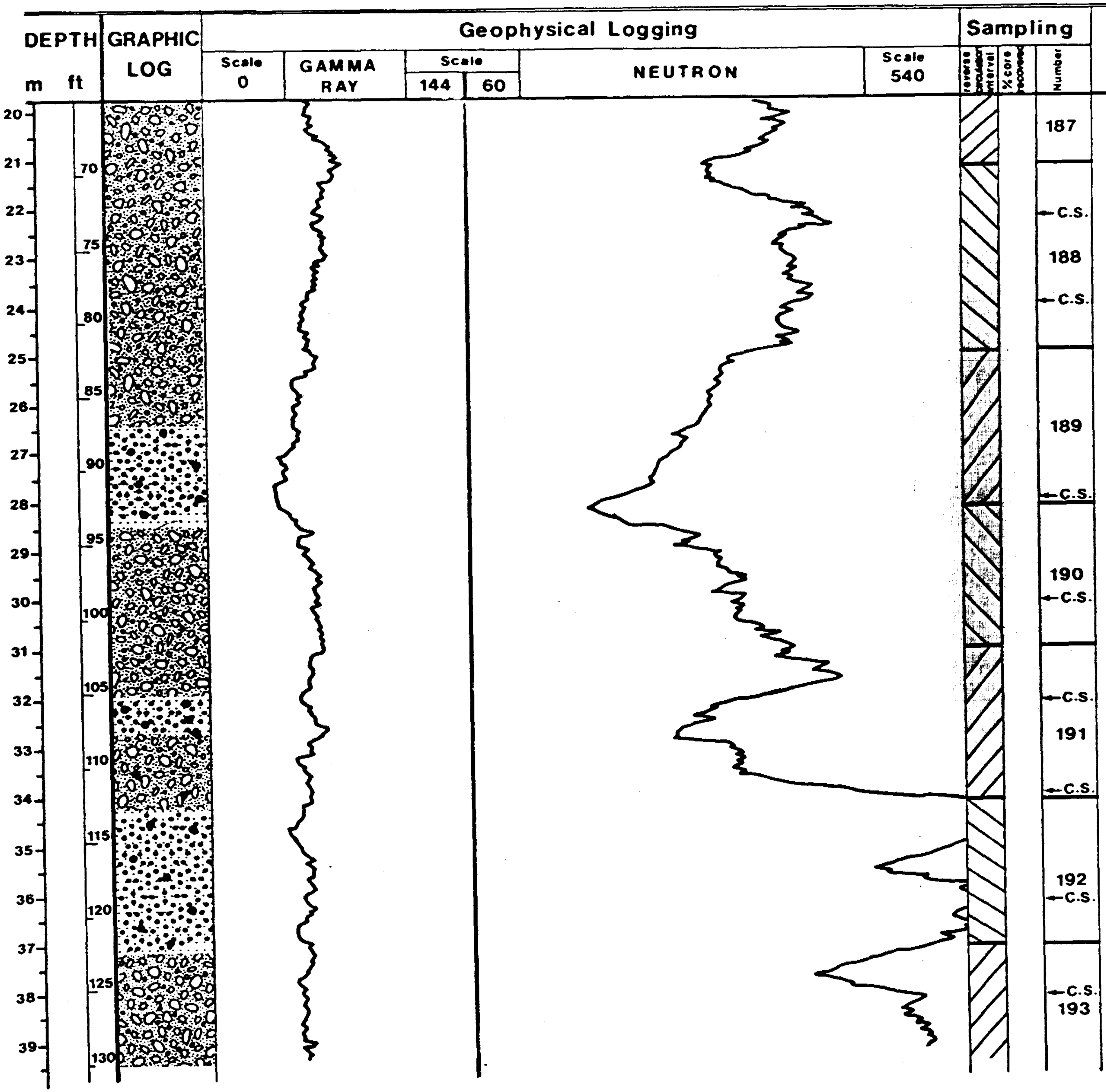
TILL: 64.3–87.3'

Medium to dark grey clayey, silty, gritty, pebbly and rare cobbly till.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-07

Sheet 2 of 4



Description

As above.

PEBBLY, SANDY GRAVEL: 87.3–93.9'
With minor amounts of dark grey, sandy clay till.

TILL: 93.9–105.0'
Dark grey clayey, silty, sandy till.

PEBBLY GRAVEL: 105.0–107.6'
Some red jasper pebbles, some wood fragments.

TILL: 107.6–112.7'
Dark grey clayey, silty, sandy clay till, passing into dark grey calcareous clay. Lignite framents.

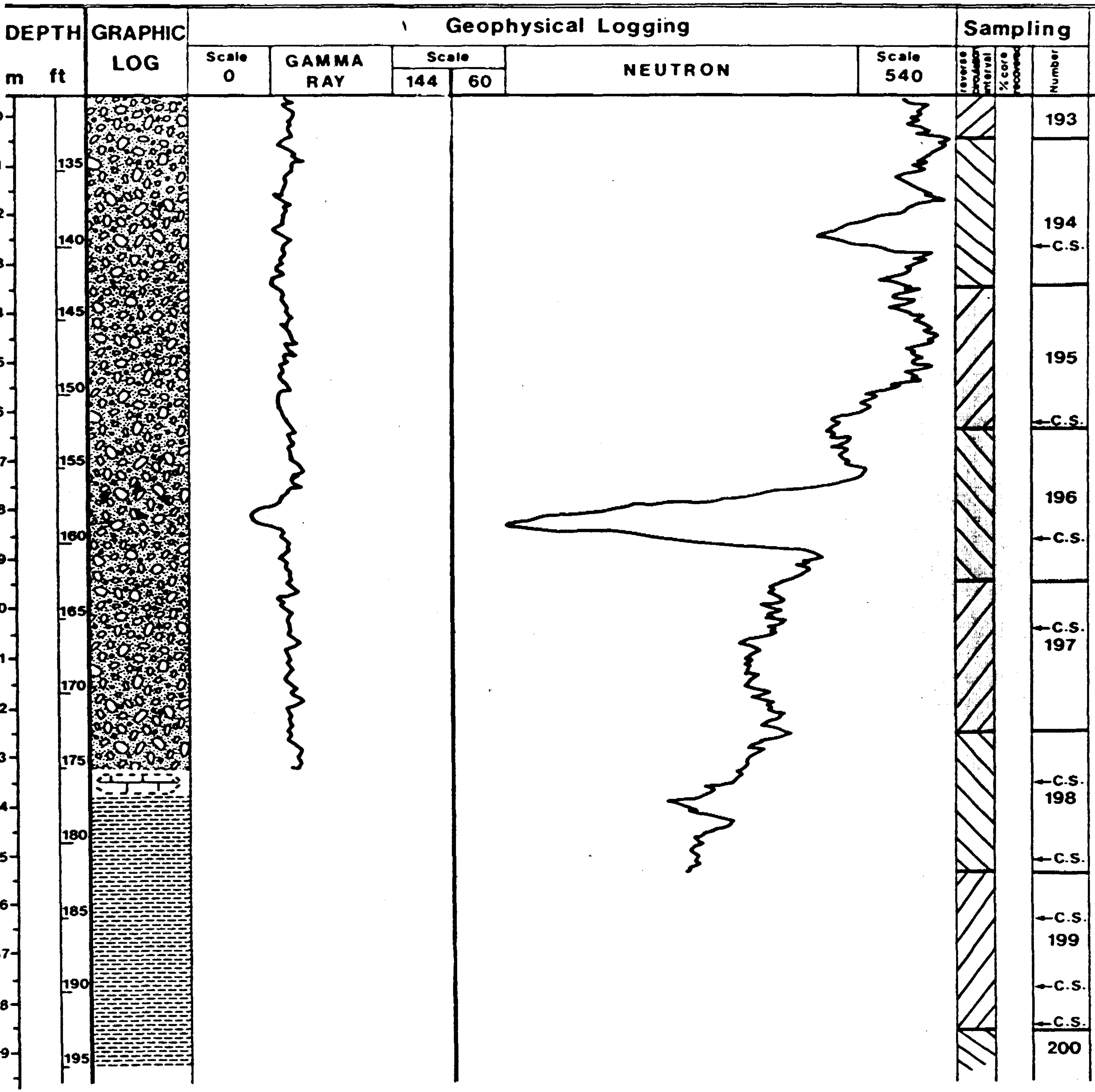
PEBBLE GRAVEL: 112.7–123.3'
Mostly sandy, pebbly gravels, with minor amounts of clay till.

TILL: 123.3–176.7'
Dark grey, clayey, silty, sandy clay-till. Calcareous. Usual pebble and cobble suite.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-07

Sheet 3 of 4



Description

As above.

157.5': Woody lignite fragments.

172.0': Red jasper pebble.

175.0–176.7': Fine-grained cherty dolomitic limestone boulder.

CLAYS: 176.7–184.3'

Silty and gritty; dirty white, dark grey, light green, and pinkish brown alternating clay layers. Non-calcareous.

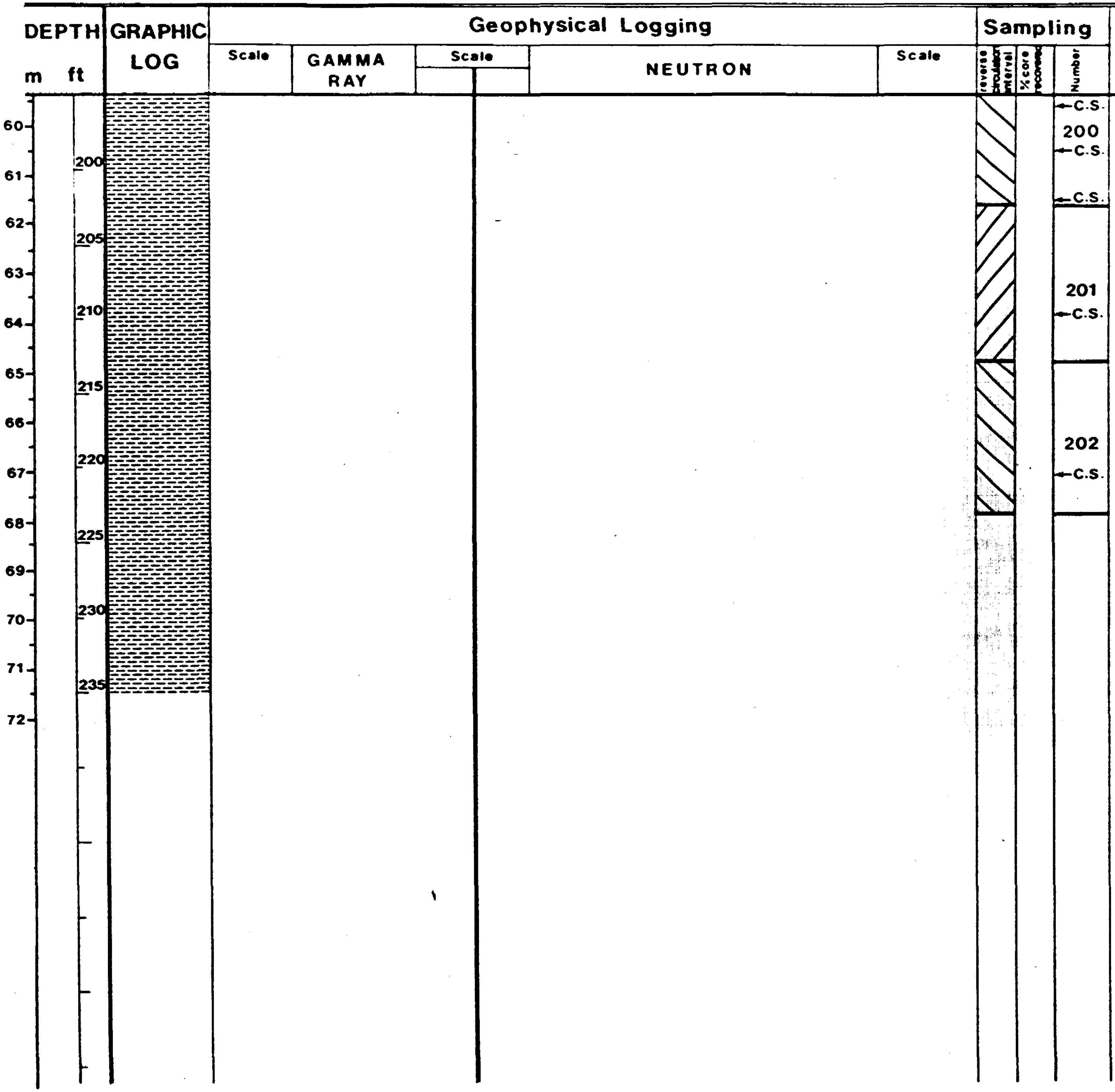
VARIEGATED CLAYS: 184.3–200.0'

Thinly layered and laminated bright coloured clays varying from light green, yellow, brown, purple, red, pink, dark grey, and black. Non-calcareous. At times slightly silty or even gritty.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-07

Sheet 4 of 4



Description

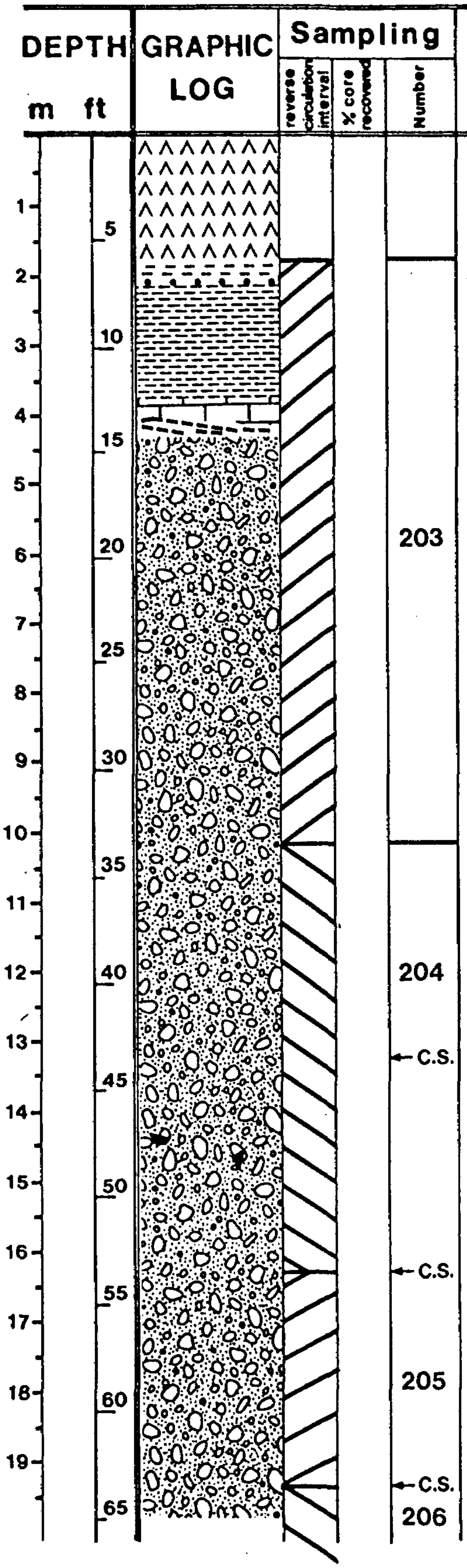
CLAYS: 200.0–235.3'
Non-calcareous, medium stiff to stiff multicoloured clays, varying from light green, grey, black, but becoming more stiff and silty downwards and rapidly alternating pale grey green and dark brown silty clays and siltstones. Laminations within clay bands becoming finer downwards.

235.4': END OF HOLE.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-08 Location: GARDINER TWP.

Elev. of collar: 180.0' Sheet 1 of 4 (lat. 50°43.7' long. 81°36.9')



Description

MUSKEG: 0–5.9'

CLAY: 5.9–6.7'
Beige grey on very course gravel.
SILTY CLAY: 6.7–13.0'
Beige grey with frequent small chips of gypsum.
12.8–13.1': Limestone cobble.
13.3–13.6': Gneiss boulder.
TILL: 14.4–104.0'
Light to medium grey, calcareous, sandy, silty, pebbly, clay till. Minor gypsum clasts. 60/40 (60% sedimentary, 40% basement suite).

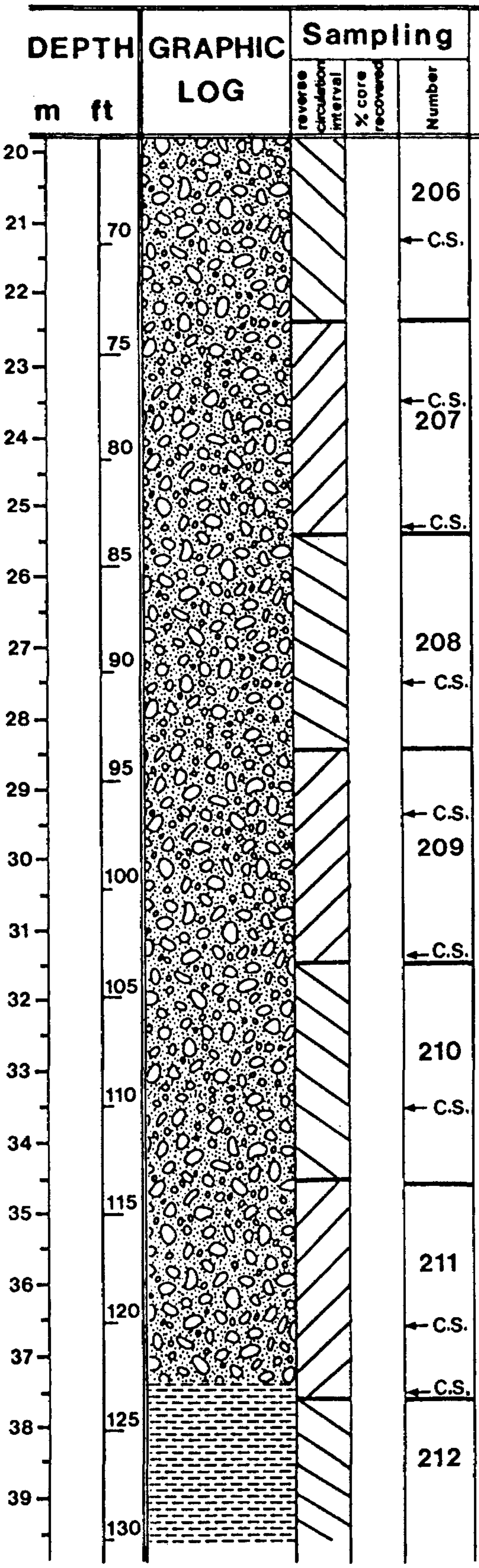
48.3': Minor woody lignite fragments over 1.5".

50.2': Minor red jasper pebbles.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 08

Sheet 2 **of** 4



Description

67.0': Limestone and chert cobbles.

87.4': Pink granite boulder.

92.7': Basement cobble (melonocoutic)

95.0': Basement cobble (melonocoutic)

98.7': Minor yellow chert.
99.7': Thin layer of white gypsum/clay.

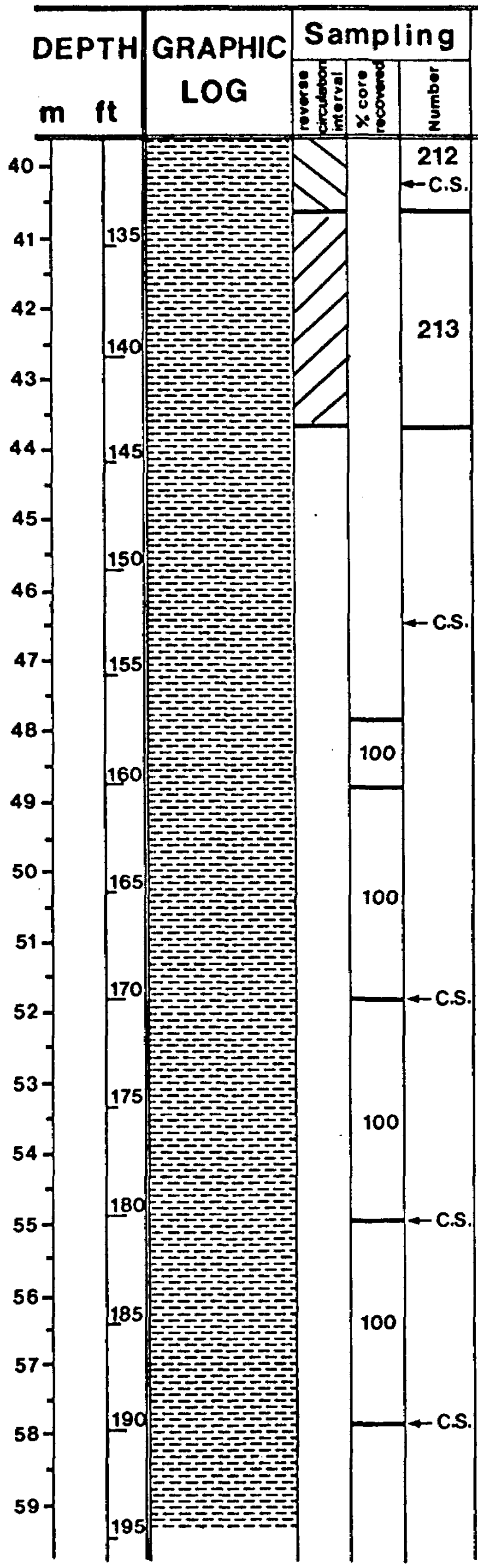
TILL: 104.0–104.7'
Dark grey, stiff, gritty, silty, clay till, with usual pebble suite, calcareous.
TILL: 104.7–122.1'
Stiff, calcareous, medium grey, clayey, silty, gritty, gravelly, and pebbly till.
107.7': Yellow oxidized layer.
110.7': Layer of gypsum pebbles.
113.4–120.0': Increased percent of gypsum pebbles — pebble suite 50% gypsum, 25% limestone, 25% basement, jasper clasts.

120': No gypsum clasts.
CLAY: 122.1–124.0'
Gritty, non-calcareous, soft pale green and medium grey clay with chips of harder dark brown siltstone, becoming rapidly alternating green and medium grey clays (approximately 1–1.5") by 123.0'. Dominantly grey green from 126.6'.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 08

Sheet 3 of 4



Description

CLAYS: 133.3–152.0'
Pale grey green non-calcareous clays with thin, silty, dark brown clays, up to 2" thick. Dark clays increasing in thickness and frequency downwards.

CLAYS: 152.0–160.0'
Medium to medium stiff pale grey–green clays, with 34% grey–chocolate brown stiff silty clay/shale varying from 1–9 cm thick. Some micro-laminae of green and brown clay.

160.0–170.3': Indurated, hard dark chocolate brown siltstone/clay, finely laminated with very stiff pale green clay bands varying from 1.5–26 cm. Sedimentary structures visible at the top of the brown layers: flat, lenticular mud 'rip-up' clasts/chips less than 6 cm. Some showing slump flows and some arranged diagonally and cutting across fine and continuous thin laminae. Penecontemporaneous slumping.

170.3–180.1': As above, increasing brown siltstones.

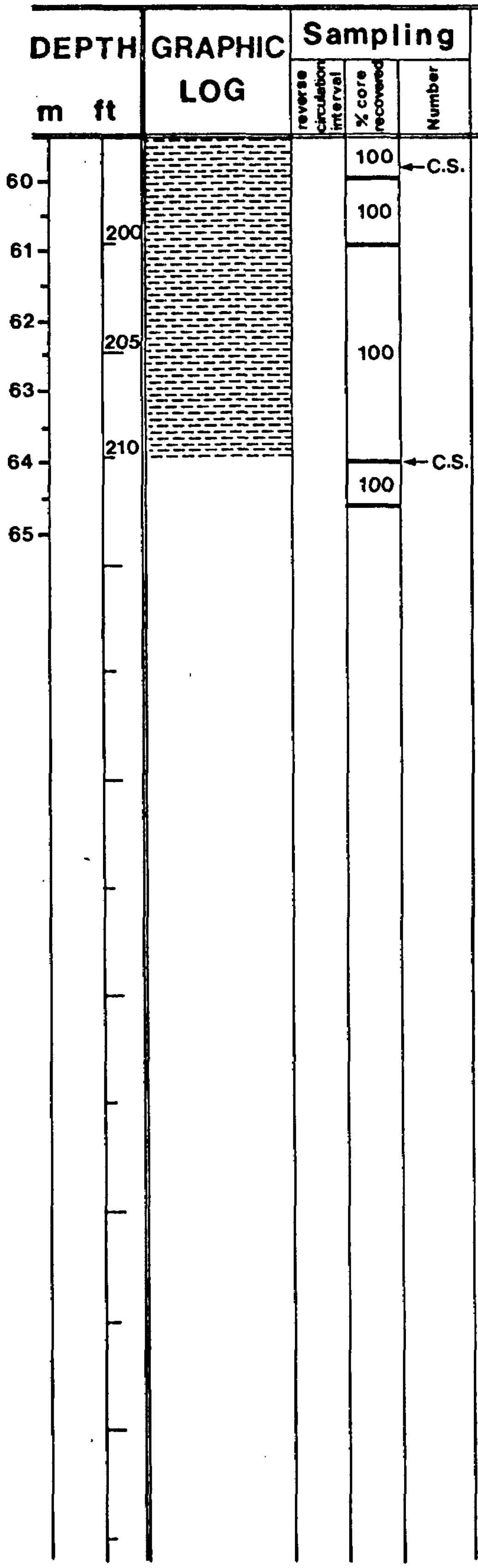
180.1–193.4': As above, but predominantly dark, chocolate brown, very compact siltstones.

193.4–196.9': As above.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 08

Sheet 4 of 4



Description

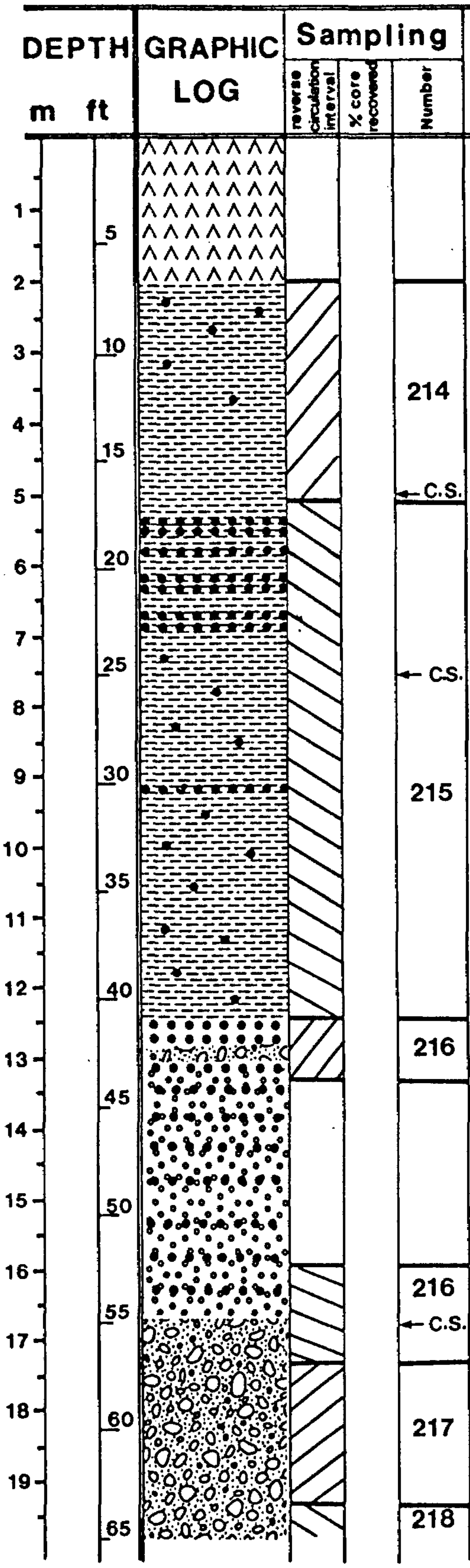
196.9–212.0': As above, but some thin calcite laminae and diagonal calcite veins, 0.5 mm. Siltstones very hard now.

212.0': END OF HOLE.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole №: OEC-81-09 Location: GARDINER TWP.-B.L. 16+450 m

Elev. of collar: 175.0′ Sheet 1 of 5 (lat.50°42.1′ long.81°36.8′)



Description

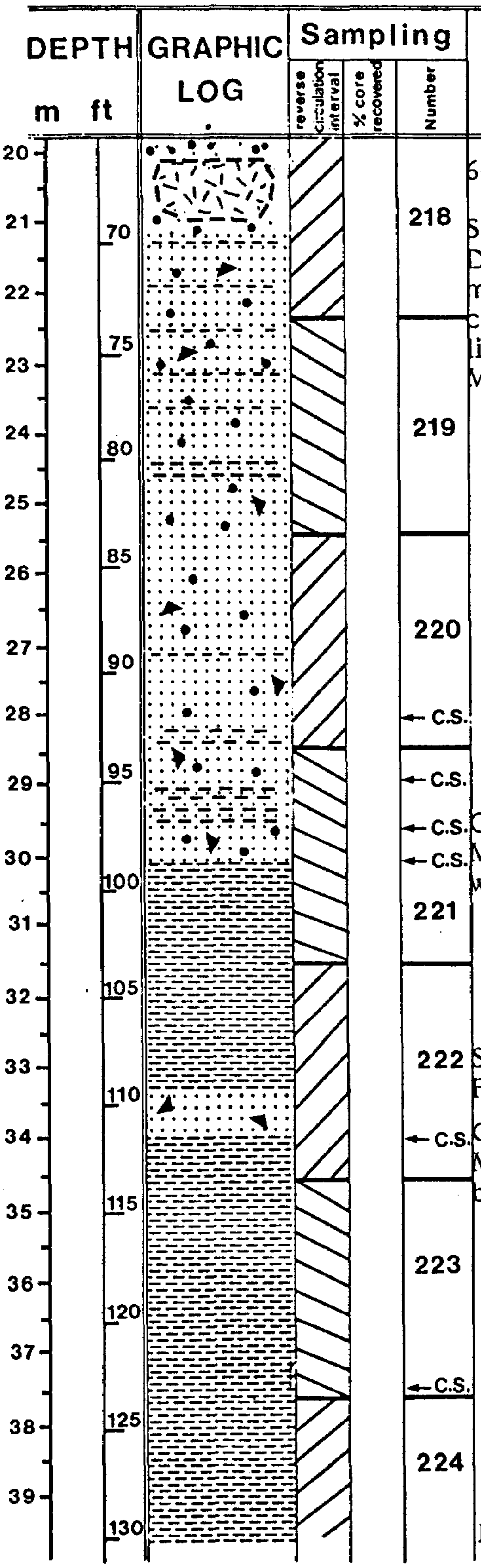
MUSKEG: 0–6.7'

CLAY: 6.7–7.1'
Soft blue/grey clay.
CLAY: 7.1–12.3'
Soft, beige clay, slightly silty and gritty, at times with rare well-rounded pebbles 0.5". Bivalves common.
CLAY: 12.3–14.3'
Medium grey gritty clay becoming medium stiff blue grey, with bivalves and limestone cobbles.
CLAY: 14.3–17.2'
Stiff, dark beige clay, with oxidized layer and layers of soft comounated brown peat.
COBBLE BED: 17.2–18.3'
Very rounded and polished gravel, pebble cobble conglomerate in blue clay.
CLAYS AND GRAVELS: 18.3–22.3'
Alternating dark bluish grey and grey clays, at times silty and gritty with well-rounded pebble and gravel and bivalves at 20.7'.
CLAYS AND GRAVELS: 22.3–38.3'
Very dark blue grey and thin light grey clays with pebbles and bivalves, at times striped with thin black carbonaceous layers. At times buff grey clay horizons occur.
30.4': Many basement and limestone cobbles.
32.8': 4.5 m clays now medium grey and blue grey alternating.
CLAYS: 38.3–40.7'
As above but becoming gritty downwards with increasing basement pebbles.
COARSE GRAVELS: 40.7–41.3'
Rounded gravel and cobbles.
TILL: 41.3–42.0'
Beige grey, gritty clay till.
COARSE COBBLY GRAVELS AND SANDS: 42.0–54.0'
Very coarse, well-rounded gravelly cobbles with little or no clay; dirty grey, fine, medium, and coarse sands with pebbles at times; coarse gravelly cobbles downwards.
54.0': Wood and peat ffragments; white chert pebbles.
TILL: 54.0–66.7'
Beige grey clay till at first becoming gritty and gravelly beige clay till by 59.0'.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-09

Sheet 2 of 5



Description

66.7–69.3': Granite boulder.

SAND AND GRAVEL WITH THIN CLAYS: 69.3–98.7'
Dirty white/grey fine, medium, and coarse sands and gravels, mostly angular, with thin grey or white clays, beige, dark rown clays, pyrite layers and much fragmented and finely laminated lignite throughout. Sands at times very rich in white sericite? Mica-non-calcareous throughout.

CLAYS: 98.7–109.7'
Medium or stiff, dark mauve grey, beige, dark grey to black clays with much fine lignite grains.

SANDS: 109.7–111.3'
Fine, medium, and coarse dirty white sand with lignite and pyrite.

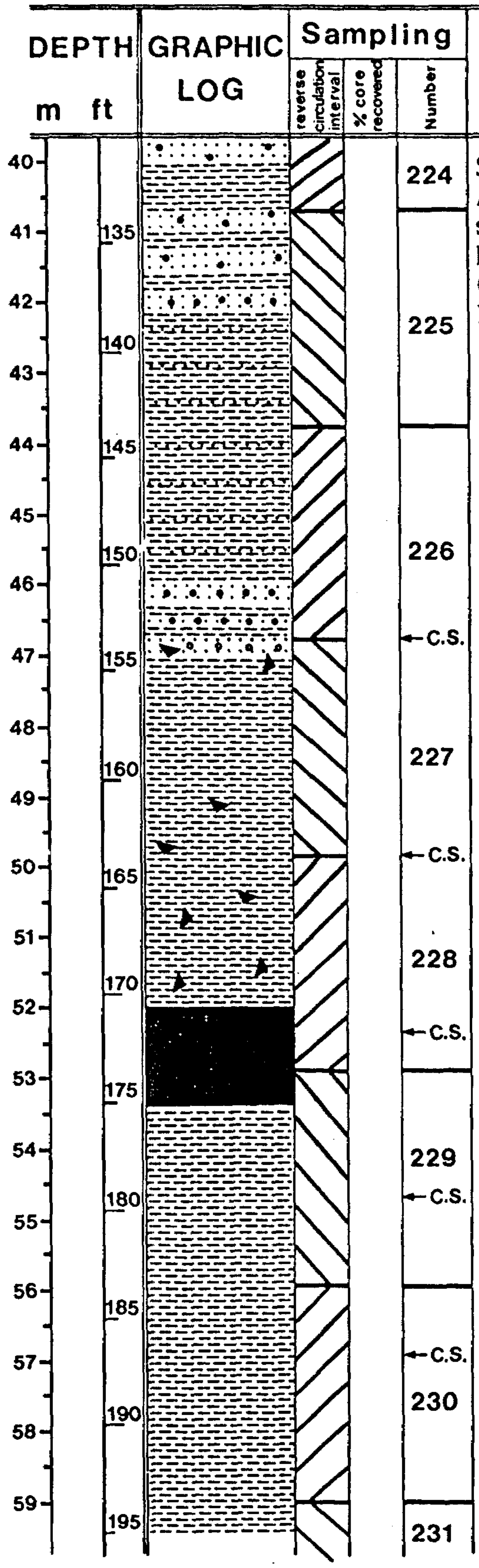
CLAYS: 111.3–133.3'
Mostly stiff, dark grey/black, mauve, thin buff and medium grey, brown, and beige clays with much finely laminated lignite.

130.7–131.7': Dirty grey, medium-grained sand with lignite.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 09

Sheet 3 of 5



Description

SANDS AND CLAYS: 133.3–134.3'
Alternating, mica rich, dirty grey, fine, medium, and coarse sands, with pyrite layers and thin clays (dark grey, brown, and buff) and much micro-lignite.

CLAYS: 134.3–151.6'
Dark grey to black (mauve tinge) clay, with pure thin sands.
135.0': Dark/medium brown oxidized fine silt/sand layer.

151.6–154.7': Alternating thin beds of beige grey silty clays and dirty brownish grey, micaceous, very fine silt and sand with much fine lignite material.

SILTY CLAYS AND CLAYS: 154.7–178.7'
Non-calcareous, medium stiff, medium grey silty clays and pure lignite fragments with dirty fine to coarse, thin sand layers. Clays become more pure after 160.0' and darker with much lignitic material.

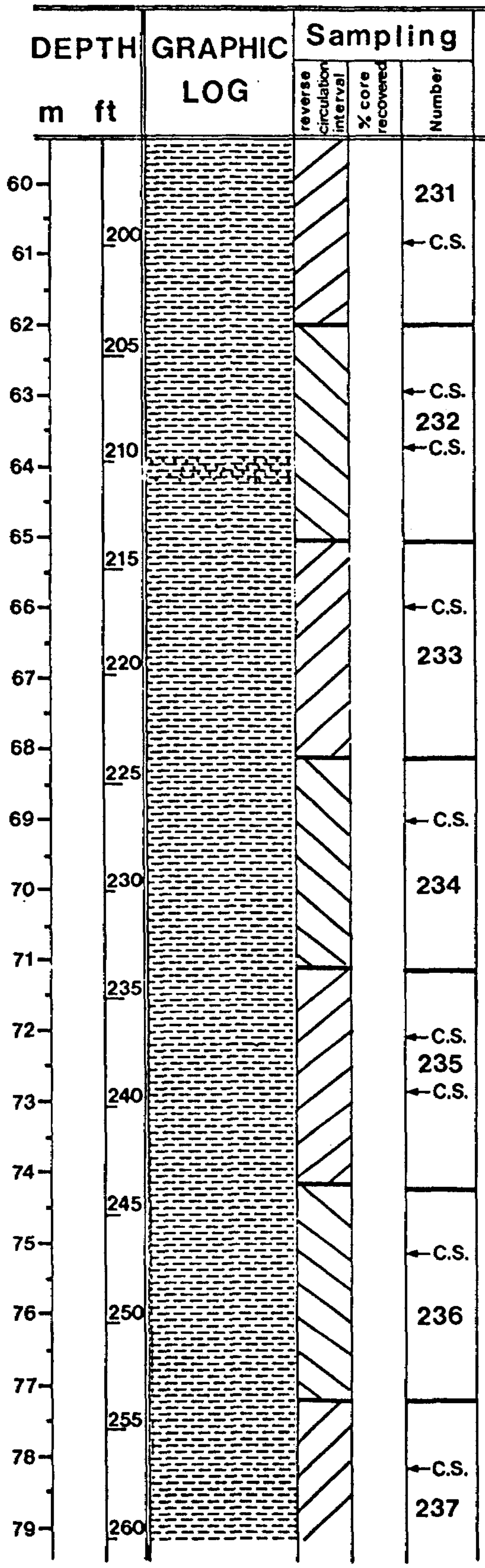
LIGNITE: 170.4–175.4'
Thick seam with some thin light brown to grey clay lenses. Black and brown woody lignite with layers of pyrite and yellow sulphur on cleavage surfaces.
177.7': Beige grey silty clay plus 1 cm pyrite layer.

CLAYS: 178.7–200.0'
Pale grey, becoming greenish grey, at times white kaolinitic clay, medium stiff. Non-calcareous, becoming rapidly alternating light grey green and dark grey to black, medium stiff clays by 181.8'.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 09

Sheet 4 of 5



Description

CLAYS: 200.0–233.3'
Alternating layers of soft to medium stiff pale green and dark stiff, clay/siltstones. Dark brown siltstones increase in thicknes and frequency downwards. Thin bands of each occur at burden fo full sequence. Non-calcareous sequence.

208.7–209.0': Medium grey soft sandy clay.

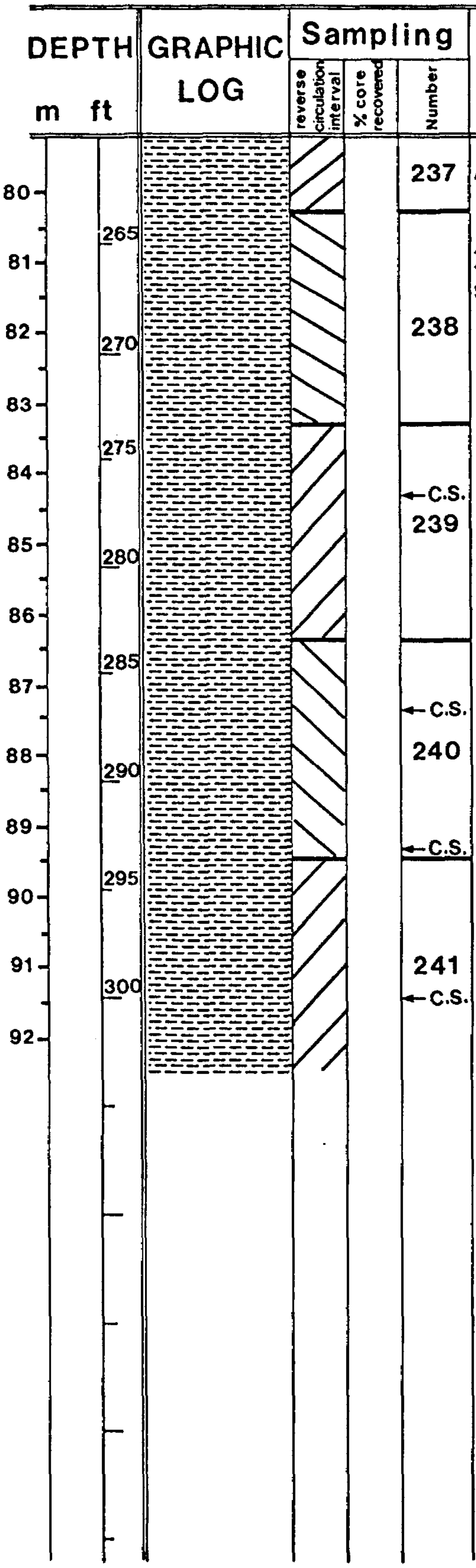
As above.

As above.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 09

Sheet 5 of 5



Description

As Above.

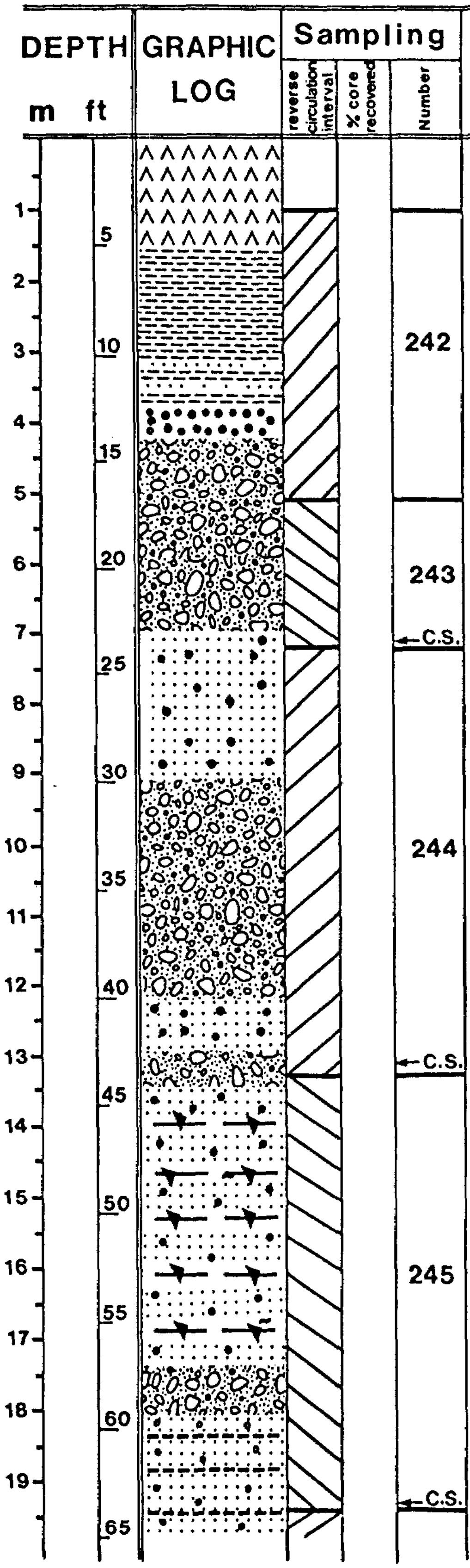
266.7–303.3': Alternating pale green and dark chocolate brown stiff clay/siltstones.

303.4': END OF HOLE.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-10 Location: MULHOLLAND TWP.

Elev. of collar: 205.0' Sheet 1 of 5 (lat. 50°40.6' long. 81°43.1')



Description

MUSKEG: 0–5.0'

MARINE CLAYS: 5.0–13.0'
At first beige then light blue grey, soft, calcareous, silty clay with frequent small bivalves. Becoming more silty downwards and eventually a fine sand with a well-rounded gravel layer at 12.8'.

GRAVEL/PEBBLE BEDS: 13.0–14.3'
Well-rounded gravel passing down to very coarse, well-rounded pebble/cobble bed.
TILL: 14.3–23.3'
Pale grey then medium grey, clayey, silty, gravel, pebbly, calcareous till.
18.3–19.7': Fine micaceous sandy layer (senicite mica).
19.7–20.3': Diabase boulder.
20.3–23.0': Less clayey, becoming medium sand, creamy and clay.
SAND AND GRAVEL: 23.3–28.5'
Fine to medium sandy, well-rounded gravel, cobbles, and pebbles.
TILL: 28.5–40.0'
Pale blue grey, clayey, gritty, pebbly to cobbly till.

34.0–37.0': Clayey, sandy till. Slightly calcareous.

37.0–40.0': Beige grey clayey, gritty, pebbly to cobbly till.

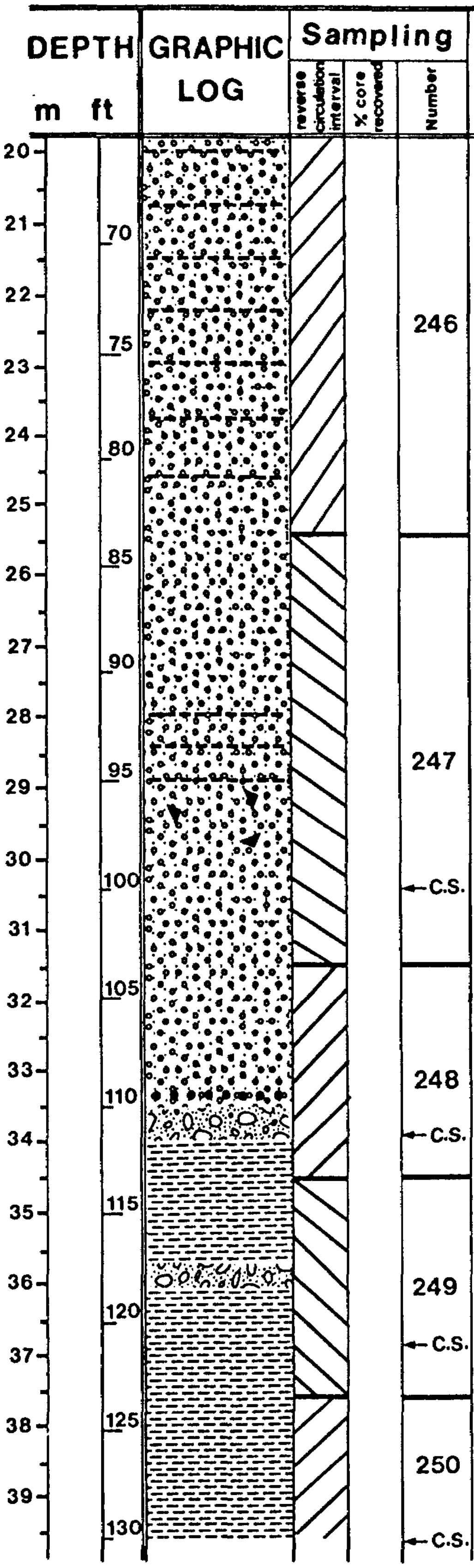
SAND AND GRAVEL: 40.0–42.8'
Grey, very micaceous, angular coarse sands and gravel with well-rounded pebbles.
TILL: 42.8–44.3'
Pale medium grey, clayey, sandy, pebbly till with brown wood and peat.
SANDS: 44.3–57.0'
Fine, medium and coarse, micaceous sands with thin peat (lignite?) layers and brown wood chips. Some thin white clay seams and mud fine lignite 'dust' in zones.

TILL: 57.0–58.8'
Medium to dark grey, clayey, sandy, pebbly till.
SANDS: 58.8–65.0'
Fine, medium, and coarse sands, with much lignite dust and small wood fragments. Light and medium grey clay lenses less than 1".
CLAYS: 65.0–67.3'
Blue grey and pale grey silty clays with wood fragments.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC - 81 - 10

Sheet 2 **of** 5



Description

SANDS, GRITS, AND GRAVELS: 67.3–109.7'
Fine, medium, and coarse sands, grits, at times micaceous, occasional pebbles and cobbles, with gravel, pebble, cobble bed base. Rare thin clays.

76.7–84.0': As above, but coarse gritty sands with thin blue grey clays.

84.0–87.4': Fine, micaceous sands.

87.4–109.4': Coarse grey grit, alternating with fine, medium and coarse sand.

93.4': Bivalves; some rounded pebbles.
94.7': Very coarse gritty grey sand and thin bluish green/grey clays.
97.1': Sands with lignite fragments.

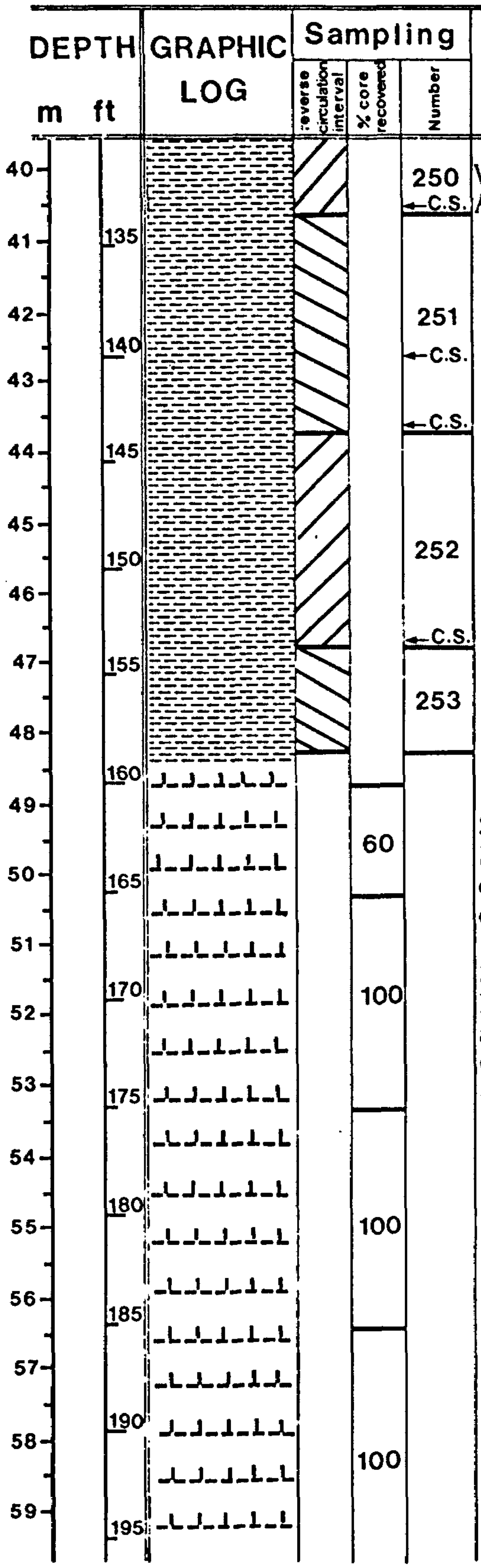
100.0–103.4': Very coarse grey sands all with fine and medium sands.

Bivalves, white agate pebbles.
109.4': Well rounded gravelly pebble bed with sand matrix.
CLAY: 109.7–110.0'
Pale bluish green/grey stiff clay.
TILL: 110.0–112.2'
Beige grey clayey, gritty, at times pebbly till, with sand and rounded gravel, pebble layers and variegated clays; calcareous.
CLAY: 112.2–116.7'
Beige, with very hard pale green claystone clasts less than 1/8".
TILL: 116.7–118.0'
Coarse pebble conglomerate on beige, clayey, gravelly, pebbly till; calcareous.
CLAYS: 118.0–120.3'
Variegated, tan brown, green, kahki, and ochre with frequent well-rounded pebbles from 1/8–1".
VARIEGATED CLAYS: 120.3–133.3'
Repidly alternating layers of stiff orange brown, tan, bright pale green, light brown, greyish brown, and chocolate brown clays. At times very stiff. One band rounded pebble (1/8") of basement and soft brown woody fragments up to 1/8" long.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-10

Sheet 3 of 5



Description

VARIEGATED CLAYS: 133.3–158.3'
As above, non-calcareous.

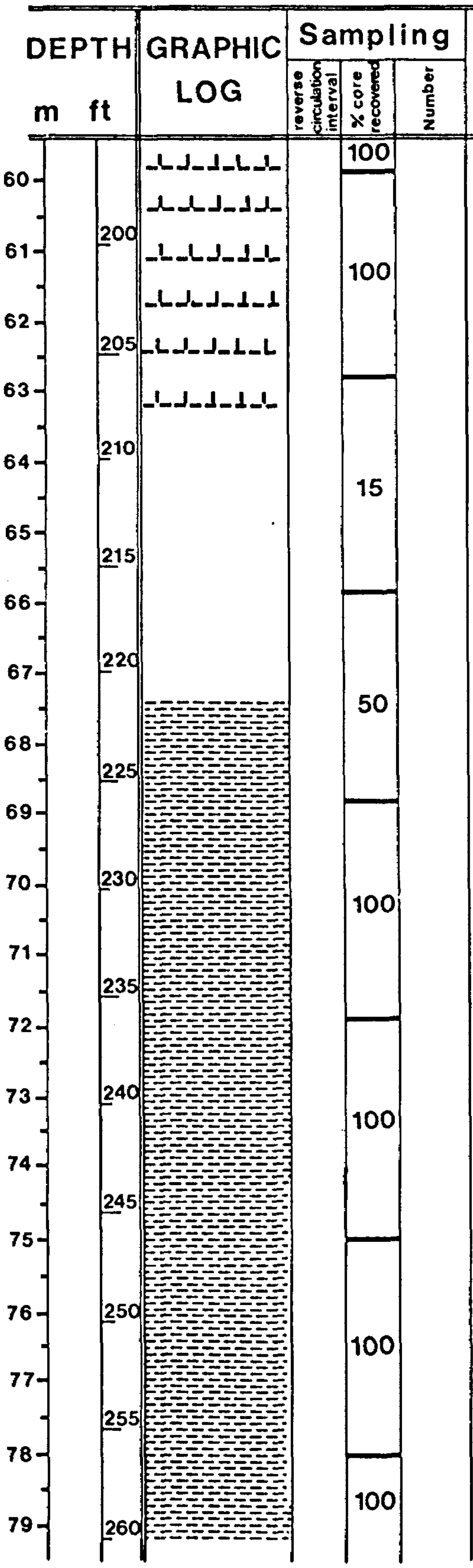
SILTY CLAYS AND MARLS: 163.0–167.2'
Mostly red brown, less pale grey/green, clays, silts, and marls, all calcareous with some thin pure carbonate layers. Some green reduction spots and mottling.

SILTY MARLS: 167.2–200.0'
Reddish brown silty marls, with frequent green reduction spots and mottling. Some thin pale grey green beds are highly calcareous. Calcite veins. Rare softer red/brown clays. Marls becoming very compact.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-10

Sheet 4 of 5



Description

RED MARLS, etc: 200.0–211.0'
As above.

63.14 m: Soft calcareous marl.
63.2 m: Very light honeycombed tufa.

211.0–224.1': No recovery — possible cavity or sofft clay/marls, or fine sands?

VARIEGATED CLAYS: 224.1–262.4'
Mostly non-calcareous stiff clays, reddish brown, green, yellow, brown, purple, pale green. Rare pale green layers up to 10 m, which are very calcareous and silty.
225.0': 2" layer of pale buff sediment containing coarse, rounded (0.5 mm) quartz grains and white plant fragments in a calcite matrix/cement.

254.6–256.4': Pale grey green soft, calcareous clay/marl.

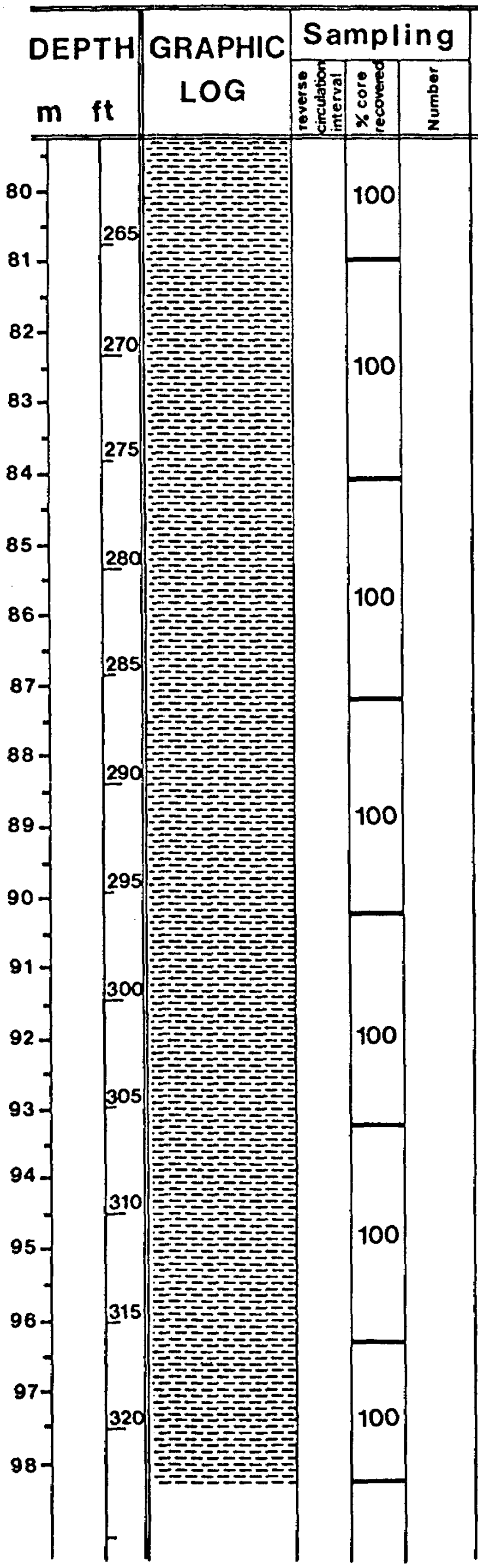
256.4–258.4': Variegated clays as above.

CLAYS: 262.4–266.7'
Pale green, non-calcareous clays.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-10

Sheet 5 of 5



Description

CLAYS: 266.7–290.5'
Non-calcareous, pale grey green, soft to medium stiff clays, with occasional dark grey harder siltstone/clays ranging from 1/32–3" thick.

As above but more compact, few dark siltstones, but up to 41 cm thick at times.

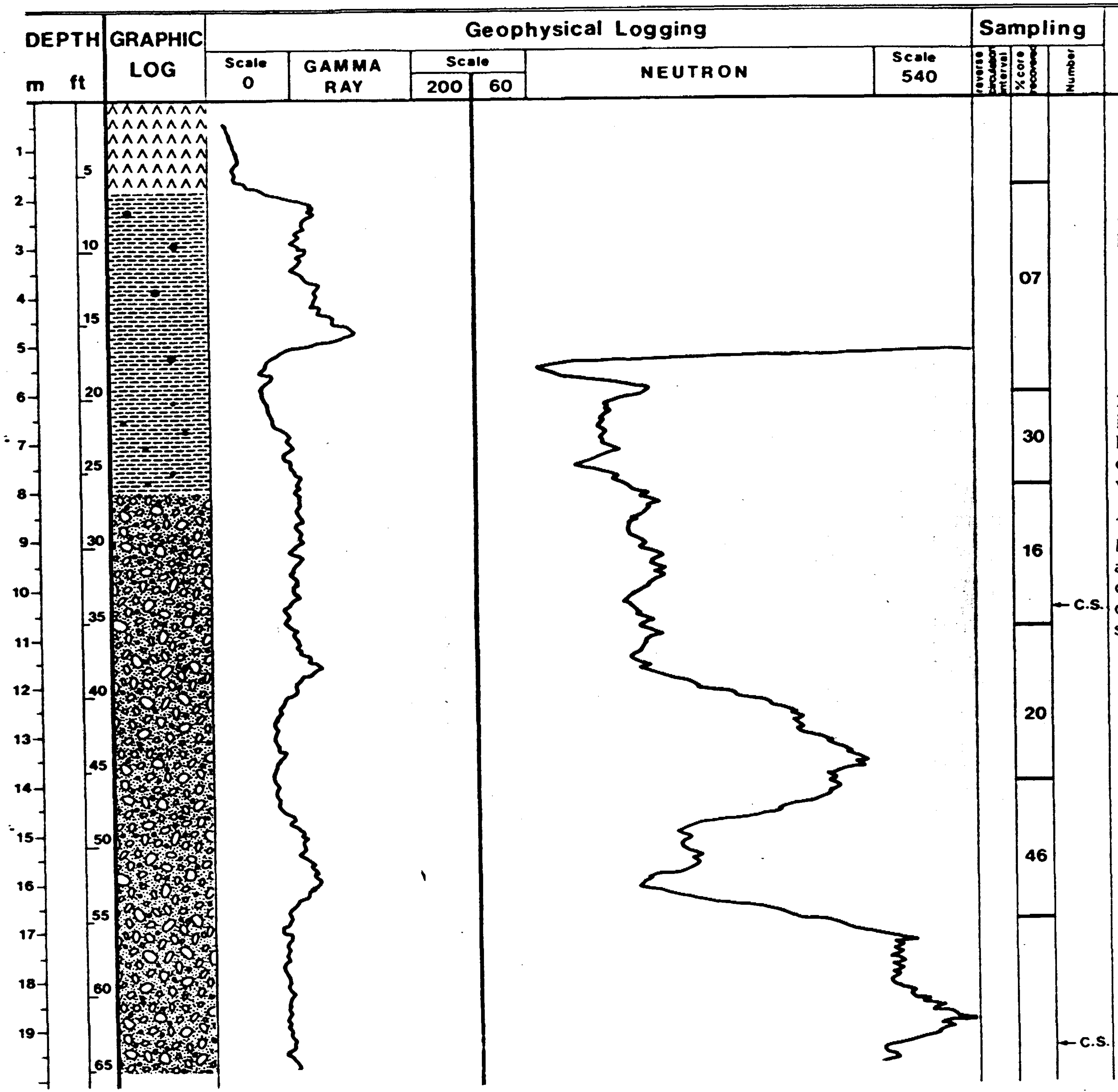
HARD CLAY/SHALE AND SILTSTONES: 290.5–322.5'
Indurated hard, thinly laminated, at times fissile green clays and dark grey, black, or chocolate brown siltstones. At the top of the dark siltstones there are erosional surfaces, penecontemporaneous slumps and eroded angular/lenses of green clay chips. Darker layers increasing downwards.

322.5': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11   Location: GARDINER TWP.

Elev. of collar: 175.0′   Sheet 1 of 6   (lat. 50°42.1′ long. 81°36.8′)



Description

MUSKEG: Very wet peat; organic debris not highly decomposed at surface.

Very poor recovery, therefore difficult to log properly: appears to be largely medium-dark grey clay with minor pebbles; very calcareous.

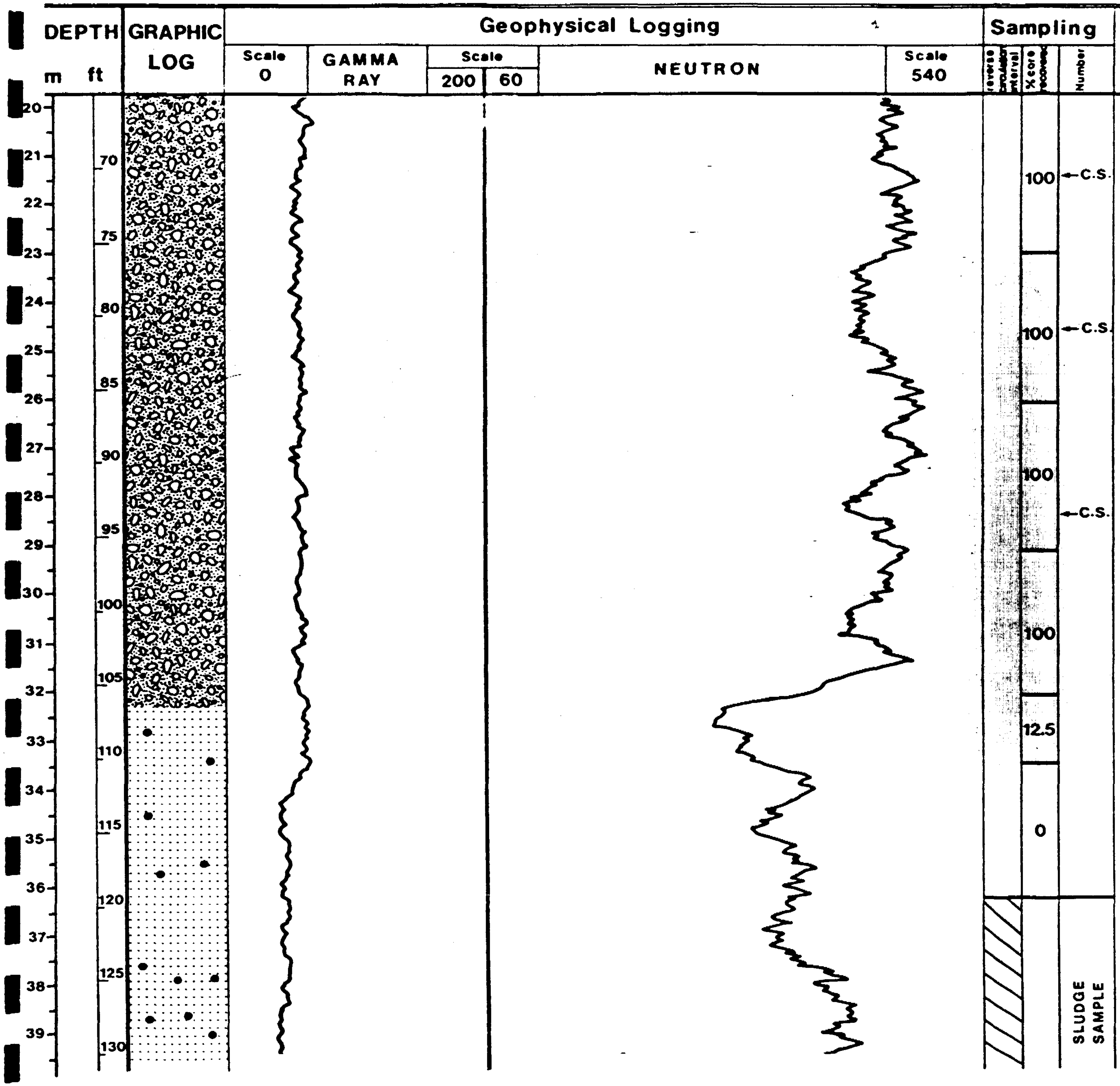
20.3–26.9′: As above except the clays have a few sandy interbeds that are 1–4" thick; becoming increasingly sandy by approximately 26.9′ where abundant coarse sand-sized clasts are widespread and very much like till; everything is very calcareous.

TILL: 26.9–106.0′
Medium to light grey (partly beige); very calcareous; sandy and pebbly with only modest amount of clay; sedimentary clasts are dominant (60–70%) but basement clasts quite conspicuous; traces of bright red–orange jasper (usually sand-sized); a few cobbles up to 6" in maximum dimension.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11

Sheet 2 of 6



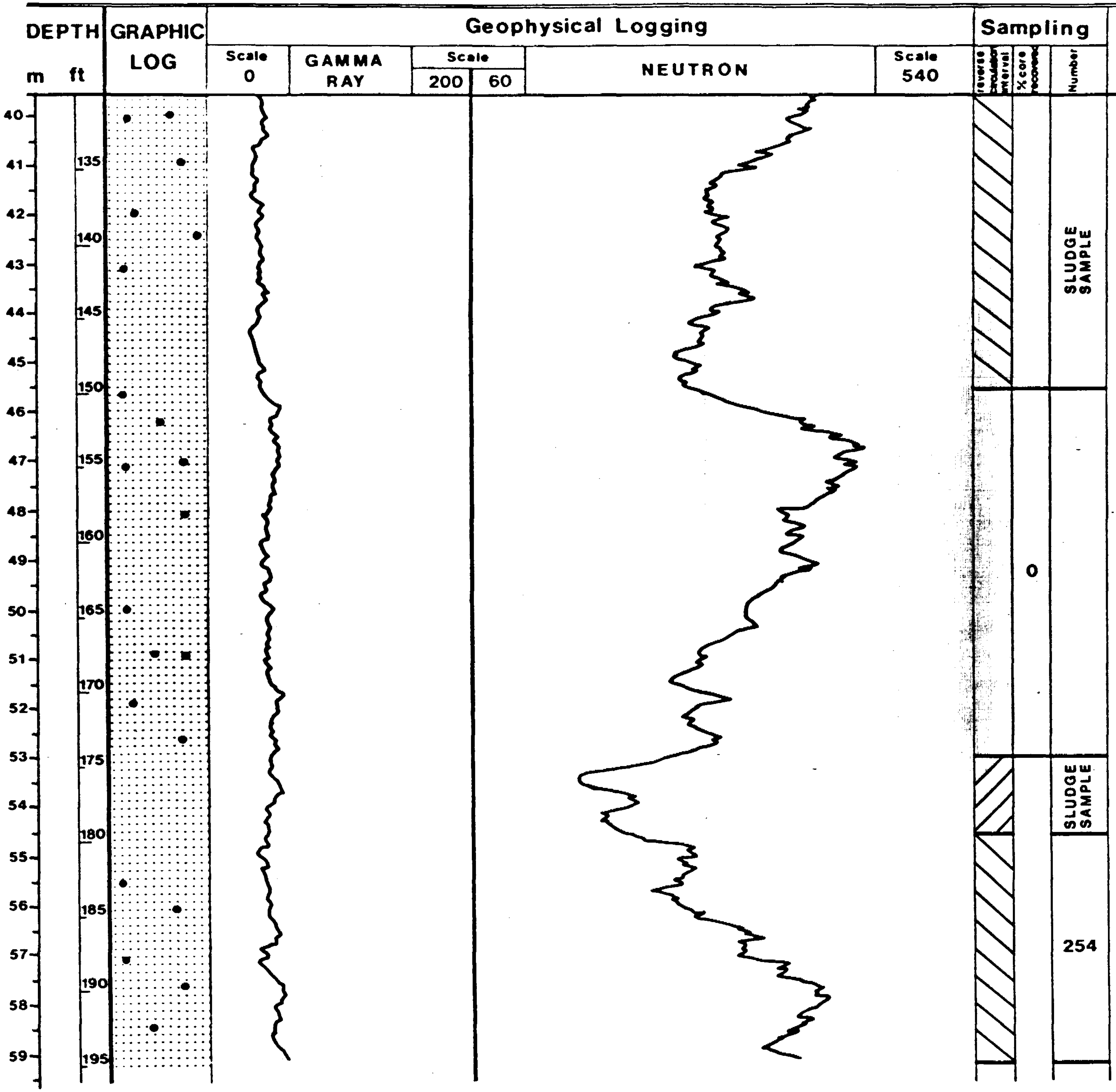
Description

SAND: 106.0–110.0'
Relatively fine-grained, heterogeneous clasts, moderately mature: appears to be gradational at base into thin band of till (8" thick) that is sandy, pebbly, and, in part, clayey (calcareous and medium-grey colour).

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11

Sheet 3 of 6



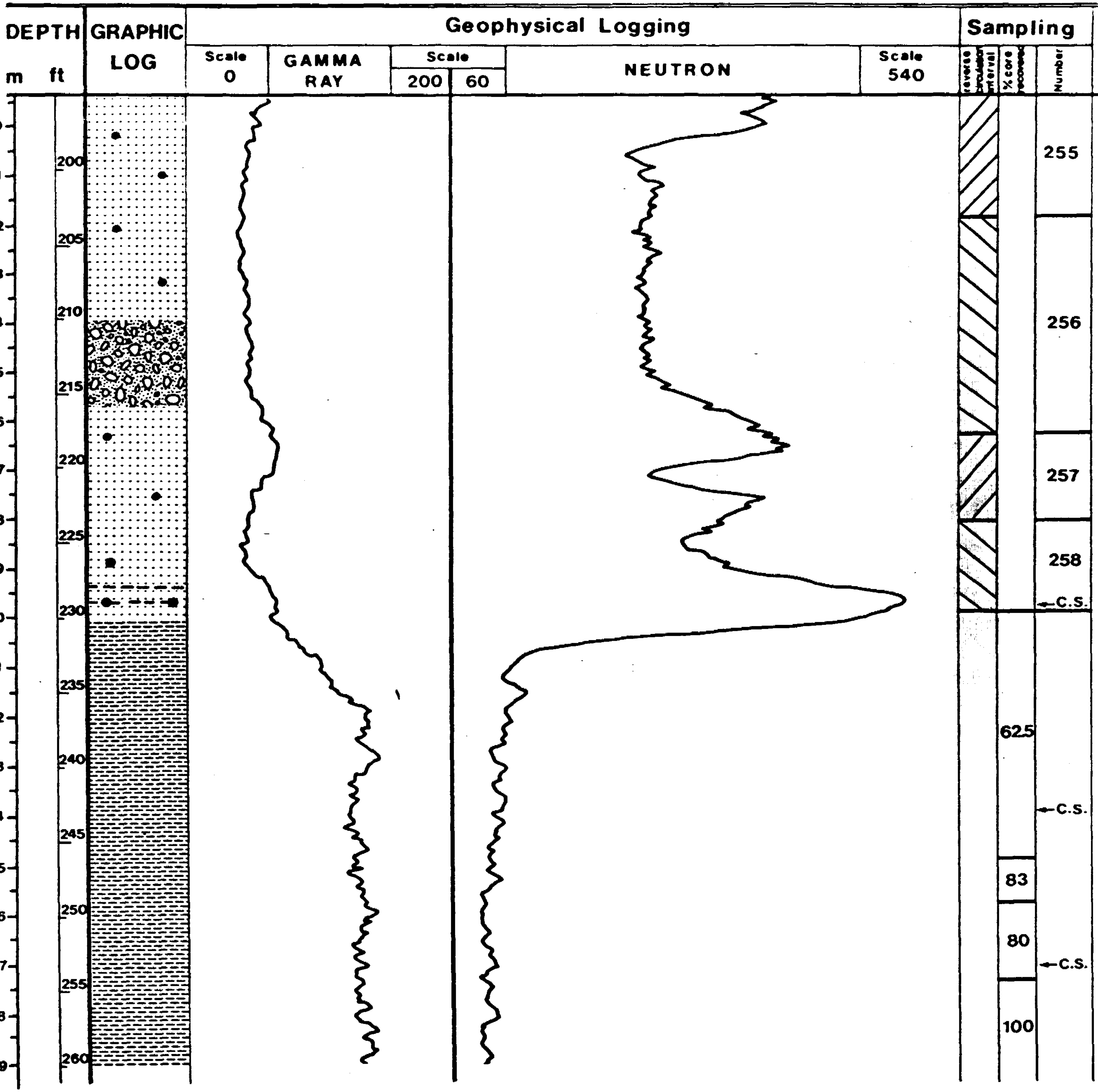
SAND AND CONGLOMERATES: 110.0–230.0'

Very poor recovery from this section makes detailed interpretation very tentative; most appear to be poorly sorted, moderately mature sands and pebble conglomerates; some are distinct beds of well-sorted sand, but most appear to be mixed; sedimentary clasts are dominant, but basement lithologies are also quite widespread. Unable to define coarsening-upward and/or fining-upward cycles, but these may well be present.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11

Sheet 4 of 6



Description

210.0–215.9': The material appears to be a medium-light grey clay, sand, pebbly till(?).

215.9–223.8': Back into a sandy, pebbly conglomerate as above.

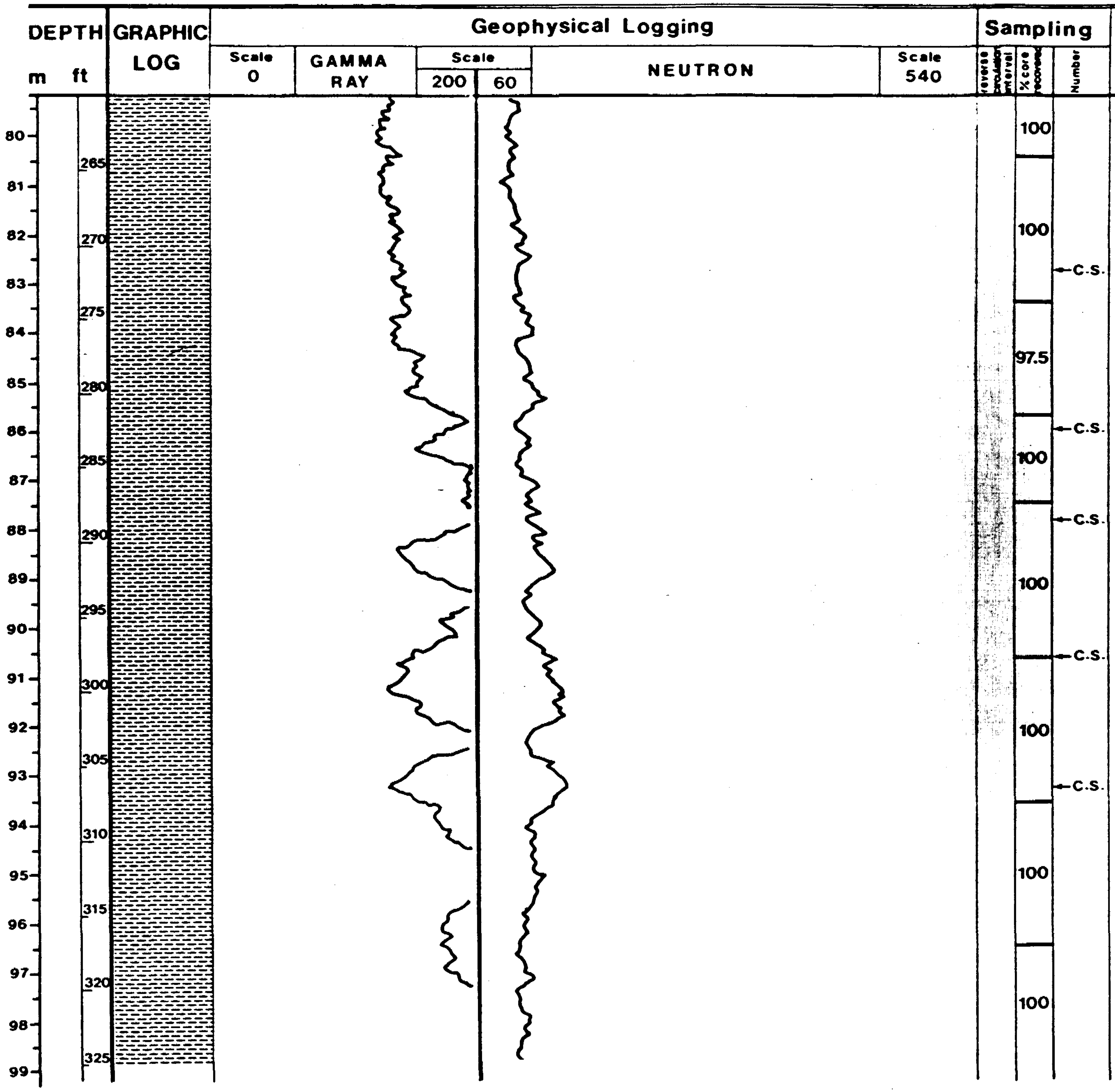
223.8–230.0': The material appears to be a gritty, clay till(?) again.

CLAY AND SHALE: 230.0–366.1'
Interbedded pale green clay and dark brown to grey-black shale: abrupt contact with overlying units.
228.0–269.4': It is dominantly light grey clay, non-calcareous, soft: contains well-defined interbeds of darker shale/clay in units up to 6" thick; traces of pyrite in both types of units: contacts invariably sharp.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11

Sheet 5 of 6



Description

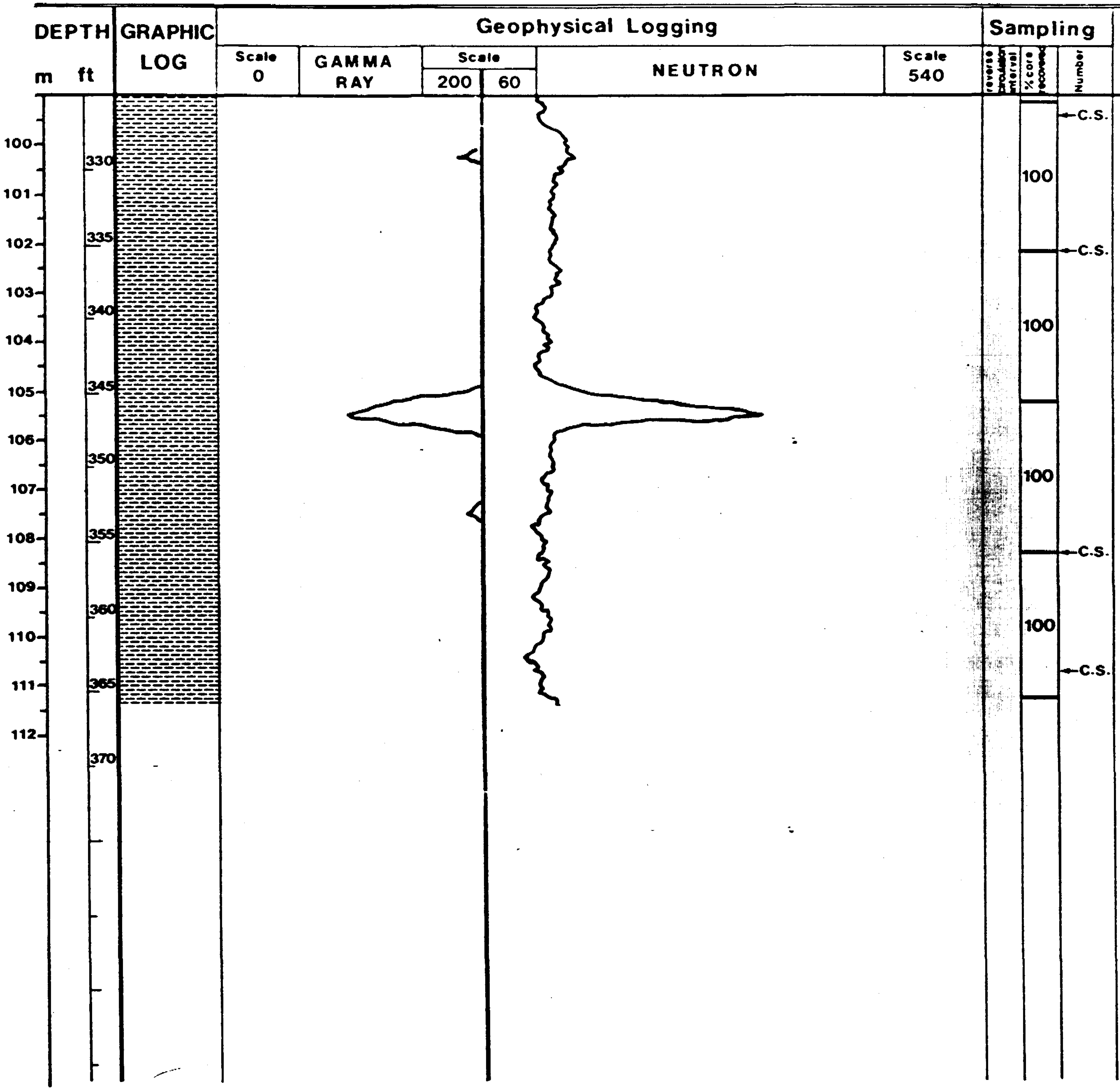
269.4–300.9': Dark brown–black shale/clay with interbedded light green clays: all units are non-calcareous and most are more than 8" thick; approximately 60% of the section is the darker shale; the dark units sometimes contain fine laminae of fresh pyrite; generally sharp contacts.

300.9–359.9': The dark brown–black shale/clay is overwhelmingly dominant in beds up to 9.8' thick: minor interbeds of light green clay (usually less than 6"); sharp contacts.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-11

Sheet 6 of 6



Description

340.6–341.2': Light green clay-rich carbonate (limestone) that is much like the green clays in colour but contains very abundant calcite.

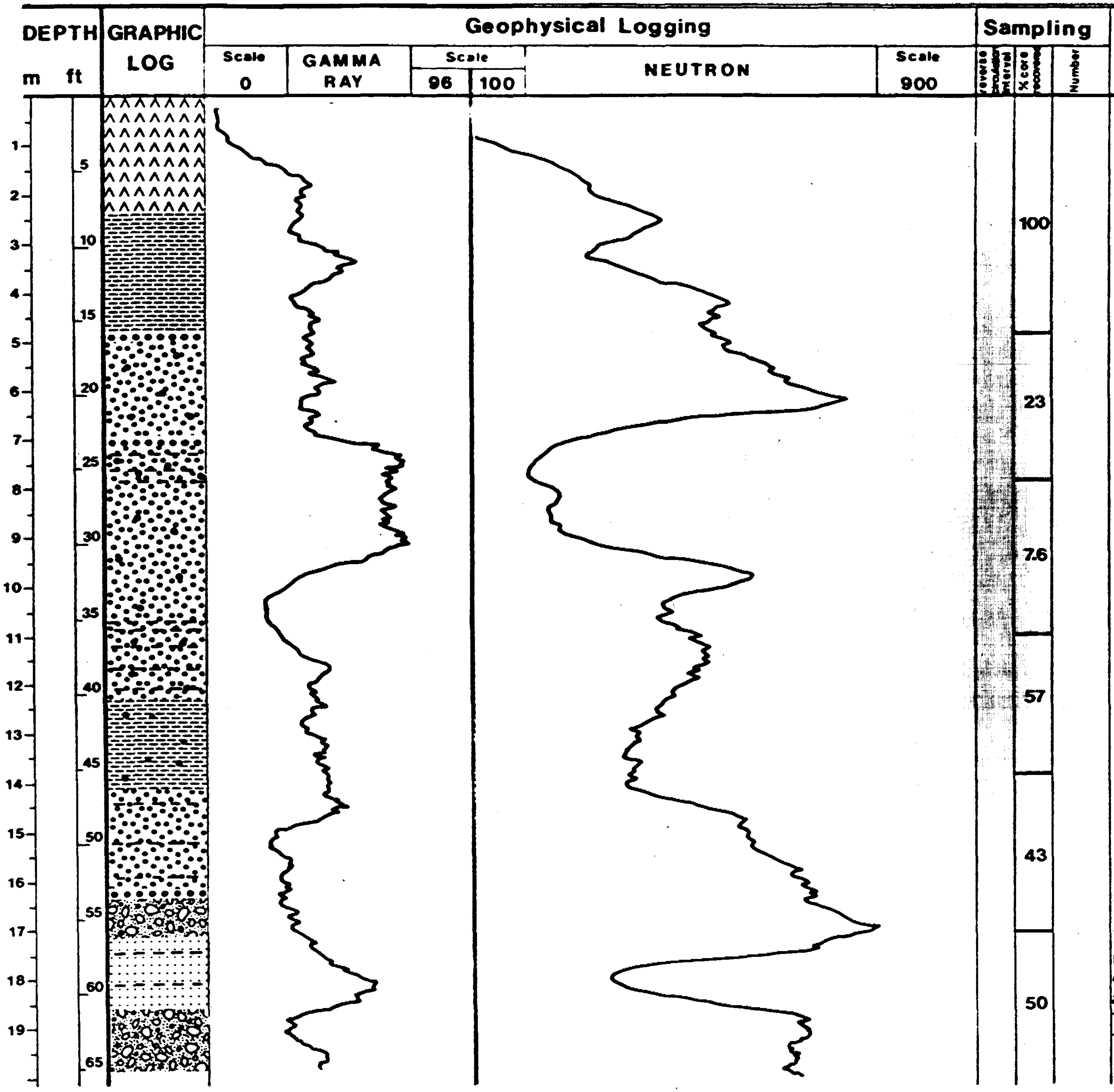
359.9–366.1': Green clay and dark shale units are in almost equal proportions in beds commonly 4–12" thick: sharp contacts.

366.1': END OF HOLE.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-12 Location: GENTLES TWP.

Elev. of collar: 250.0′ Sheet 1 of 5 (lat. 50°35′ long. 81°54′)



Description

MUSKEG: 0–8.4′

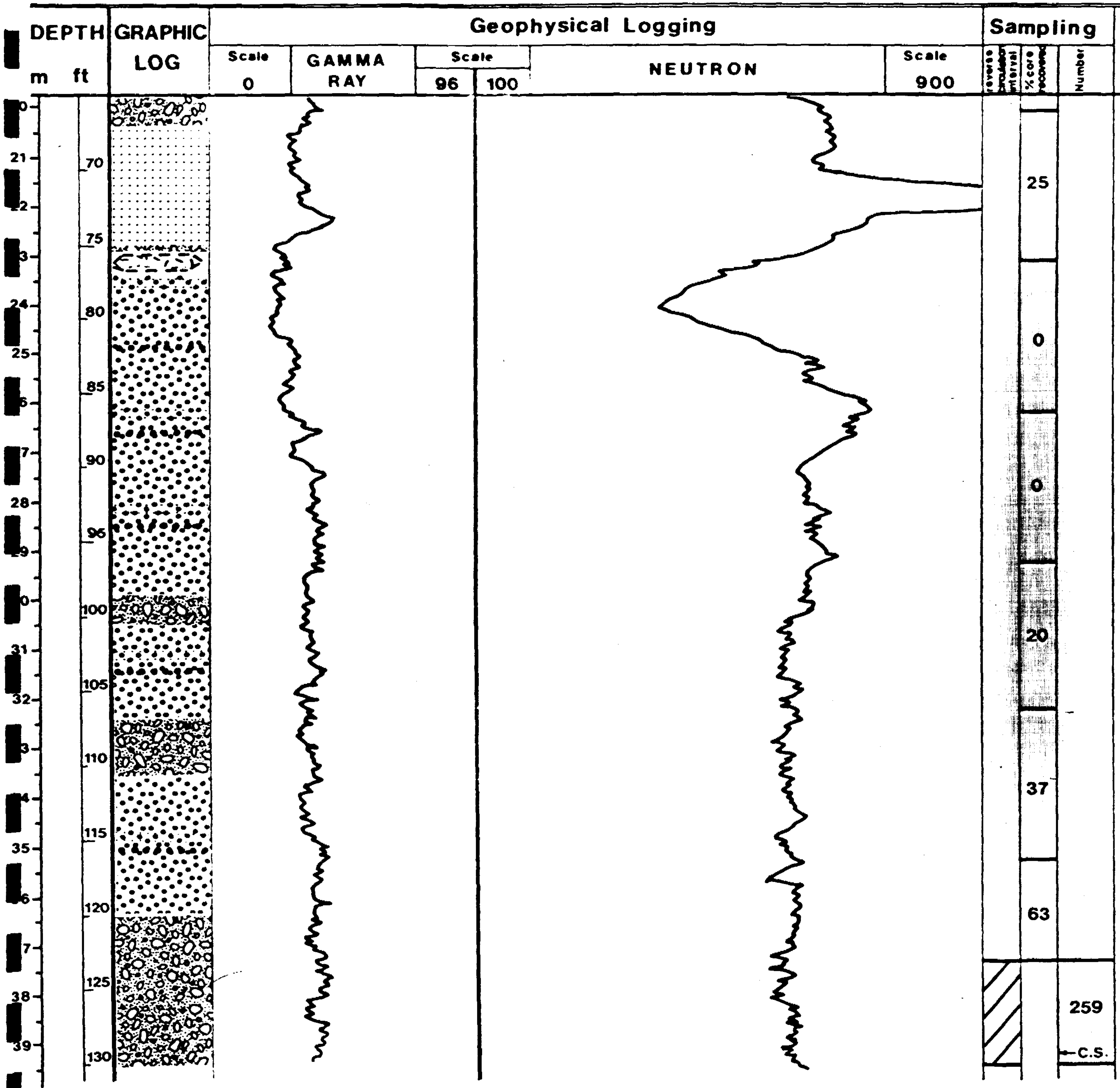
MARINE SEQUENCE: 8.4–52.8′
CLAYS:
10.0–15.9′: Soft blue/green/grey calcareous clays; silty in places, with frequent bivalves.
Very coarse, well-rounded conglomerate with predominantly basement cobbles.
Dirty grey, fine-grained, very micaceous sands and coarse sands, and gravel/pebble.
Grey/green stiff calcareous clays; may be silty, sandy, gravelly or pebbly. Pebbles sub-rounded, buff limestone, and basement pebbles up to 1".
Dirty grey, fine, medium, and coarse sands and gravels.
Green calcareous sand/pebbly clays.
Thin dark brown silty clay or grey/green clay with bivalves in a thin buff silty layer (1/2").
Fine sands showing coarsening downward sequence.
Very coarse, sub-well rounded pebble/cobble conglomerate.
Dark green/grey stiff clay; may be silty, sandy, or pebbly.
Very coarse, calcareous dark grey-green angular to subrounded sandstone, alternating with fine or coarse sands.
At 51.7′ a similar coloured, very stiff clay with abundant bivalves and bivalve fragments concentratged in thin layers, in places silty and gritty. Basal cobble layer.

TILL: 52.8–56.6′
Pebble ratio (sedimentary/basement) 70/30. Beige-grey, silty, gritty, pebbly, cobbly, calcareous till.
TILL: 56.6–66.7′
Fine to medium grey/green sand with clay matrix. Pebble ratio 80/20. Beige/grey silty, gritty, pebbly, and cobbly; calcareous. Grey calcareous, very coarse gritty sand, angular to subrounded.
TILL: medium to dark grey, very stiff, calcareous clay.
Till at times sandy, pebbly, or cobbly.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-12

Sheet 2 of 5



Description

SANDSTONE SEQUENCE: 66.7–74.4'
Fine and medium grey/green sands, coarse sandstone and gravel.

TILL: 74.4–76.0'
Medium grey, cobbly, pebbly clay till with 1' boulder of pink granite.
Sequence of fine, medium, and coarse sands, gravels, pebble and cobble beds.

TILL: 98.0–100.0'
Pebble ratio 70/30.
Medium grey, sandy, pebbly, and cobbly clay till; calcareous.
MEDIUM/COARSE SANDS AND GRAVELS: 100.0–106.4'

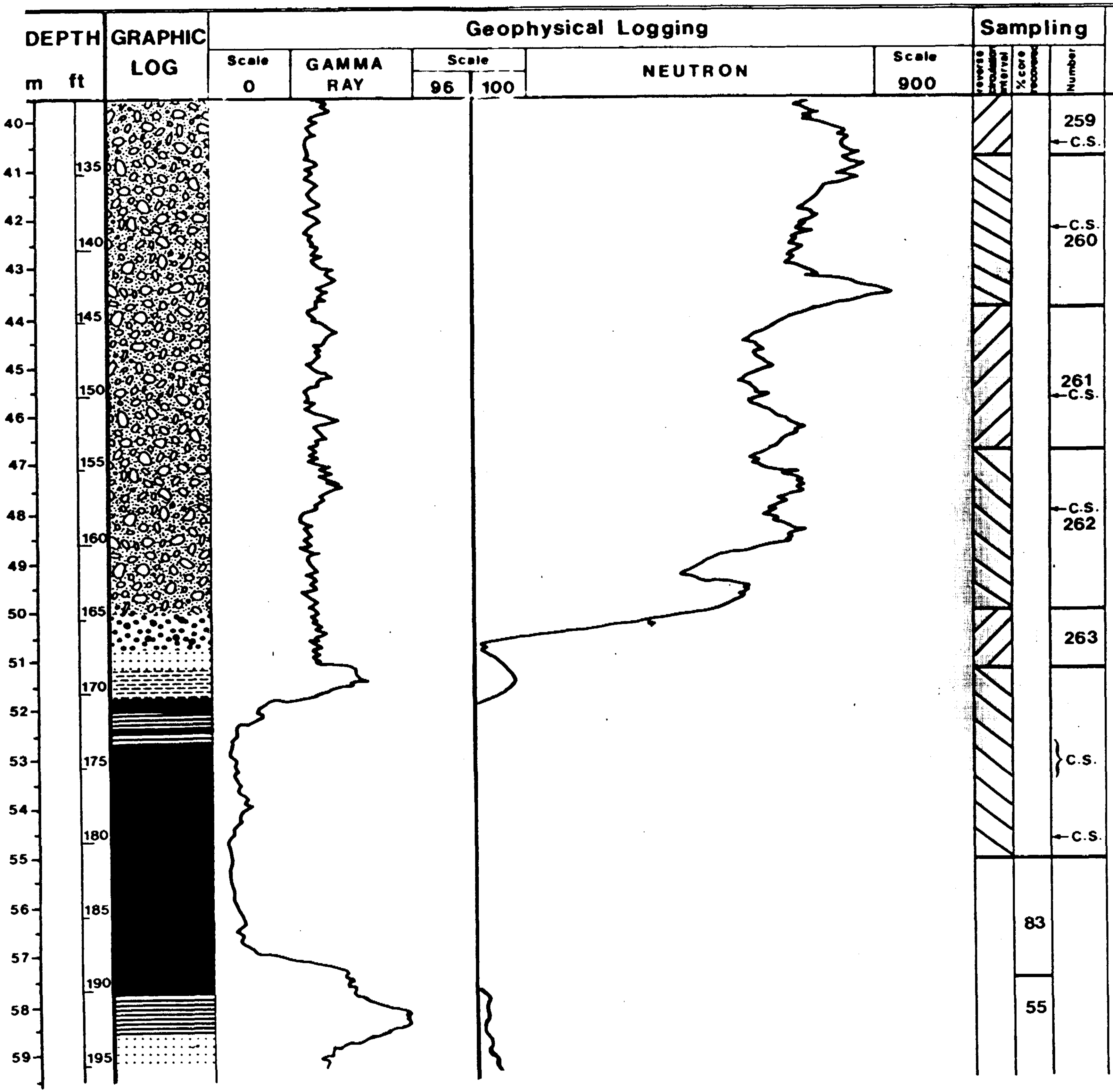
TILL: 106.4–110.0'
Medium grey clay till as above.
MEDIUM/COARSE SANDS AND GRAVELS: 110.0–119.0'

TILL: 119.0–163.0'
Peble ratio 80/20.
Medium grey, sandy, pebbly clay till.
Gypsum pebbles occur frequently.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-12

Sheet 3 of 5



Description

VERY COARSE PEBBLY/COBBLY CONGLOMERATE: 163.0–168.0'

CLAY: 168.0–170.0'
Dark grey at first, but then black and lignitic.

LIGNITE SEQUENCE: 170.0–190.0'
Black wooden lignite with soft black or grey carbonaceous clays.
Thick, hard, black lignite with occasional thin dark clay horizons. Frequent pyrite. In places hard and woody or softer with fine-grained structure and dull appearance (vitrain and fusain).

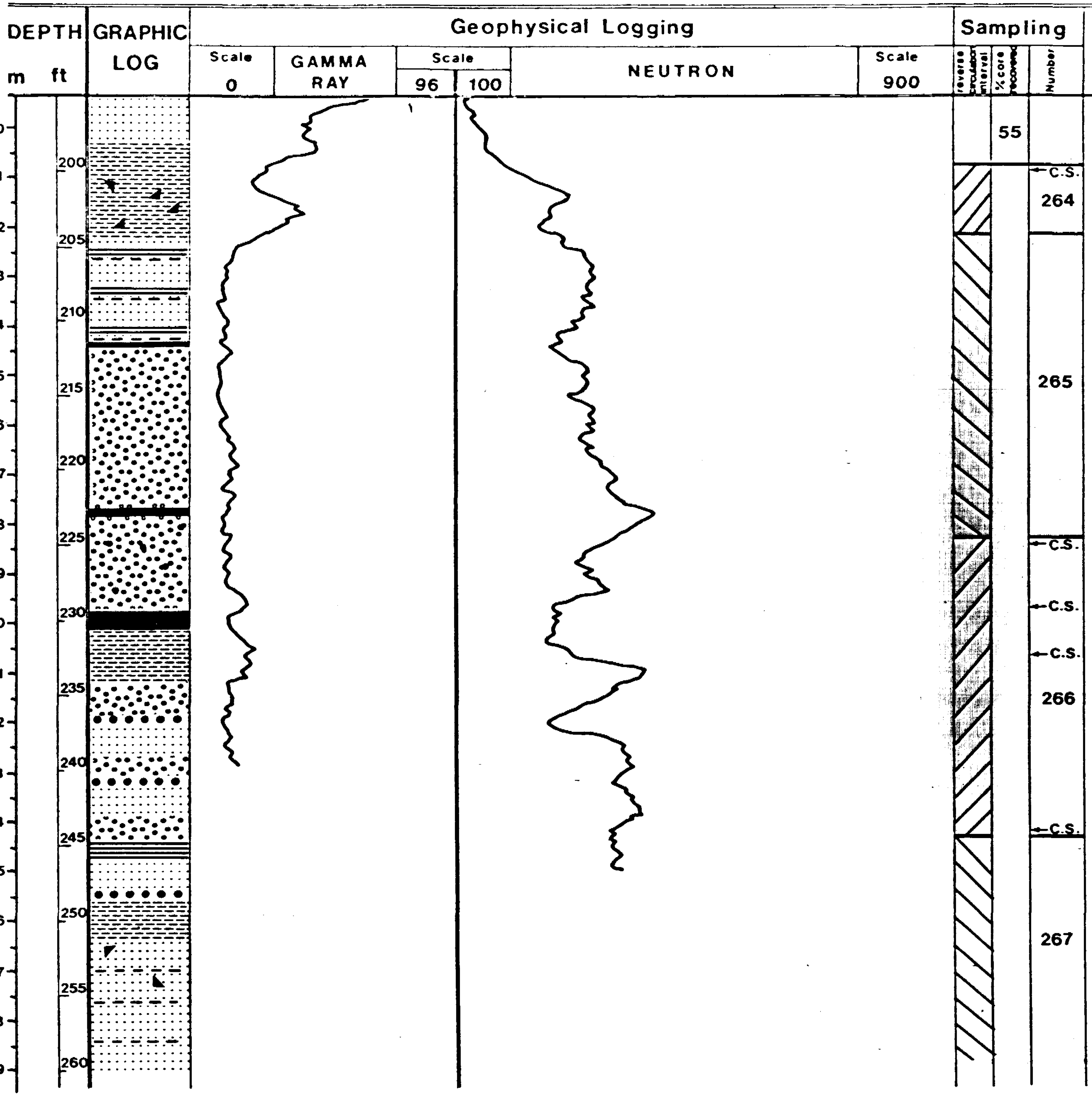
CLAYS: 190.0–192.1'
Soft black, lignitic clay, then dark grey stiff to medium stiff silty clay with pyrite, with a thin buff brown micaceous silt at base.

SANDS: 192.1–197.2'
Fine to medium, very micaceous (sericite), grey/white sand.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole No: OEC-81-12

Sheet 4 of 5



Description

CLAYS: 197.2–204.0'
Very stiff dark grey to black clay, with thin silt layers and varved light and dark grey laminae at 199.0'.
Micaceous brown clay with lignite fragments.

SANDS WITH LIGNITES: 204.0–212.0'
Rapidly alternating sequence of fine, medium, and coarse sands, and thin lignites on thin dark grey clays.

SANDS: 212.0–222.0'
Very coarse angular white quartz sands, with minor fresh feldspars, but abundant white mica (sericite), mostly coarse sized up to 0.25" average.

Very coarse angular dirty grey quartz sands.

LIGNITE SEQUENCE: 222.0–224.0'
Thin lignite on thin white clay passing down to grey clay, coarse sand, coarse sanstone, and rounded pebble conglomerate of usual pebble suite (limestone and basement).

SANDS: 224.0–229.0'
Very coarse angular white sands.

LIGNITE AND CLAY: 229.0–233.6'
Thick 2–5", layer of pyrite (sample) on lignite seam passing down to very stiff dark brown/grey clay on sands coarsening downwards to a coarse rounded gravel.

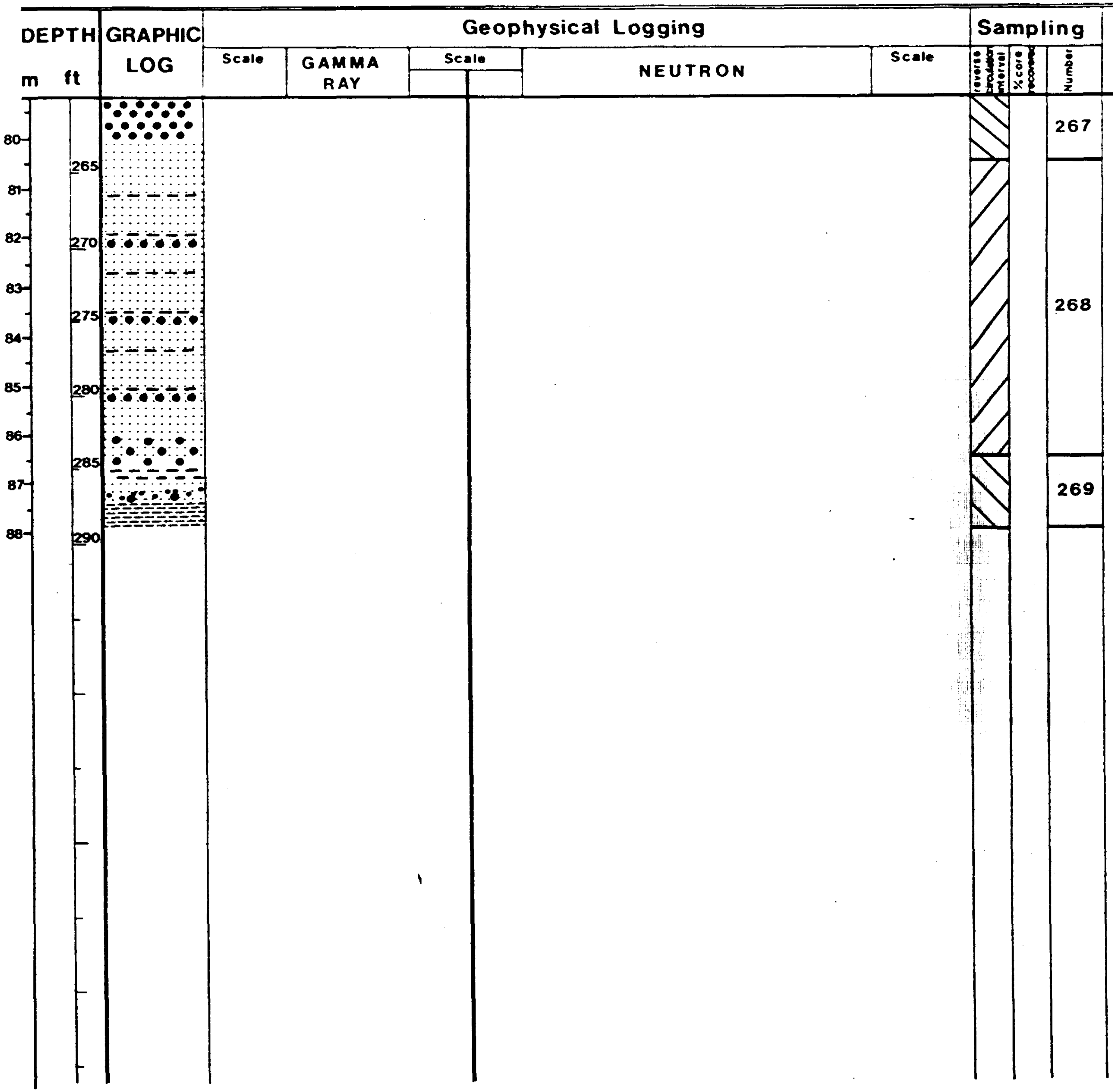
CLAY: 233.6–237.5'
Light grey clay.

GRAVELS, CONGLOMERATES AND SANDS: 237.5–250.0'
Very coarse, well-rounded pebble conglomerate with sandstone/gravel matrix (average pebble size 0.5"). Pebbles are buff carbonates and basement suite. Cyclic sequences coarsening downwards from fine-, medium-, to coarse-grain sand and then gravel on pyrite layer on thin lignite (4"). Basal unit of cycle may be a pebble conglomerate underlain by a thin lignite seam. The sands become cleaner and quartzitic downwards with thin white clays (lens-shaped). Thin dark brown clays occur beneath the lignite and are highly sulphurous. Dirty grey/brown silts on stiff sulphurous dark clays.

1981 DRILLING PROGRAM - JAMES BAY LOWLANDS

Drill Hole Nº: OEC-81-12

Sheet 5 of 5



Description

SANDS, GRAVELS AND CONGLOMERATES: 250.0–284.0'
Very fine grained dirty silts; fine sands with lignite fragments.
By 253.9', the sands become white quartzitic with frequent white clay lenses. Frequent fresh feldspars.
By 259.9', the sands have coarsened to a very coarse, rounded gravel/conglomerate. Cyclic pattern is evident.

CLAYS: 284.0–288.0'
Stiff grey/white clay passing down into a fine silt.
Fine/medium/coarse sand and gravel to conglomerate, coarsening downward. Pale medium grey gritty clay becoming pure clay and stiff by 285.4'.
END OF HOLE 288.0'.

APPENDIX II

AUGER DRILL LOGS

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

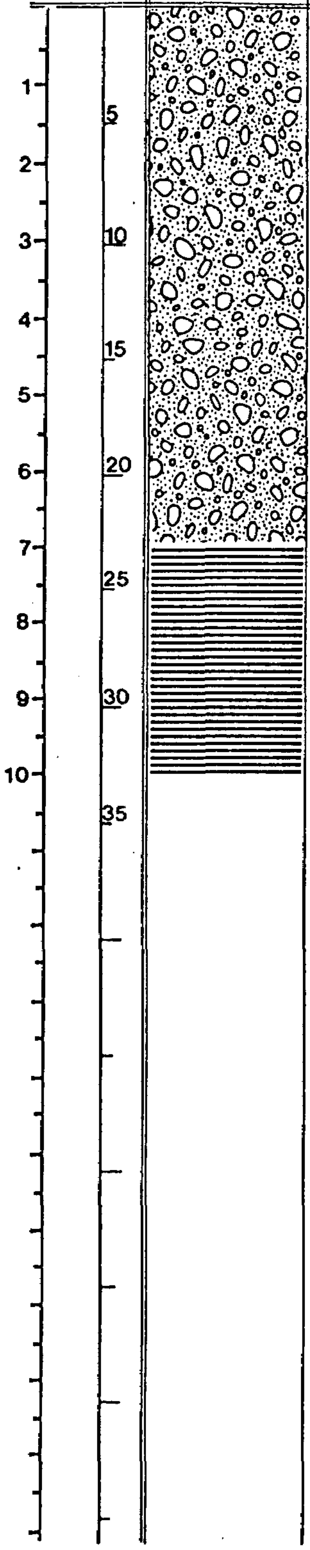
Drill Hole Nº: AUGER AW1

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS EAST SIDE OF MATTAGAMI R.

Elev. of collar: 175.0'

Sheet 1 of 1

DEPTH m ft	GRAPHIC LOG	Sampling reverse circulation interval	 % core recovered	 Number	Description



TILL: 0–23'
Sandy, gravelly, clayey.

CLAY: 23–33'
Black carbonaceous (lignitic?) clay that is fine-grained and contains no coarse woody lignite.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

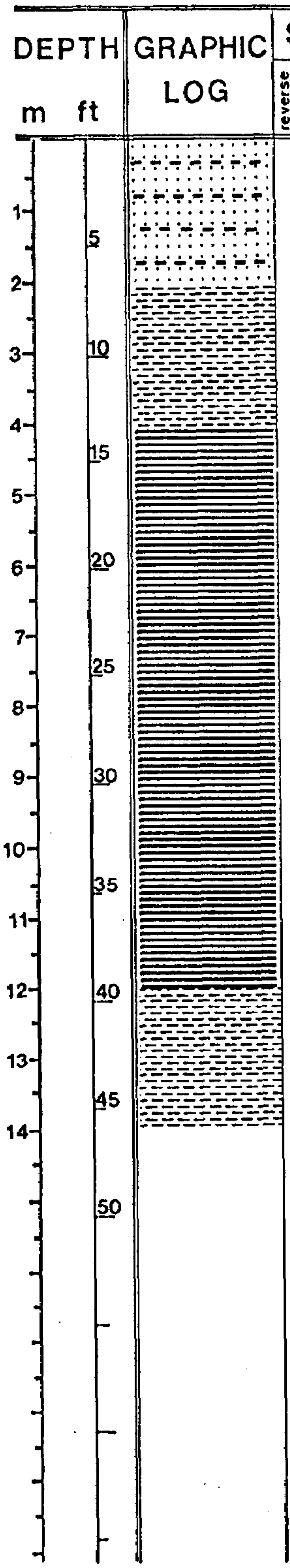
Drill Hole Nº: AUGER AW2

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS

Elev. of collar: 175.0'

Sheet 1 of 1

EAST SIDE OF MATTAGAMI R.



Sampling

reverse circulation interval

% core recovered

Number

Description

CLAY: 0–6'
Reddish brown and ochreous sandy clay.

CLAY: 6–12'
Black soft/plastic clay.

CLAY: 12–36'
Black soft plastic lignitic clay.

CLAY: 36–42'
Brown, medium stiff clay.

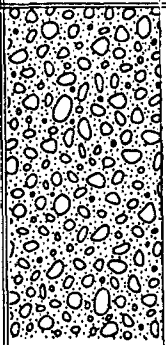
1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW3

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS EAST SIDE OF MATTAGAMI R.

Elev. of collar: 175.0'

Sheet 1 of 1

DEPTH		GRAPHIC LOG	Sampling			Description
m	ft		reverse circulation interval	% core recovered	Number	
1 2 3 4 5	5 10 15					TILL: 0–15' Pale grey silty/sandy gravel alternating with stiff light grey gritty clay with frequent pebbles, cobbles, and boulders of limestone and basement suite rocks.

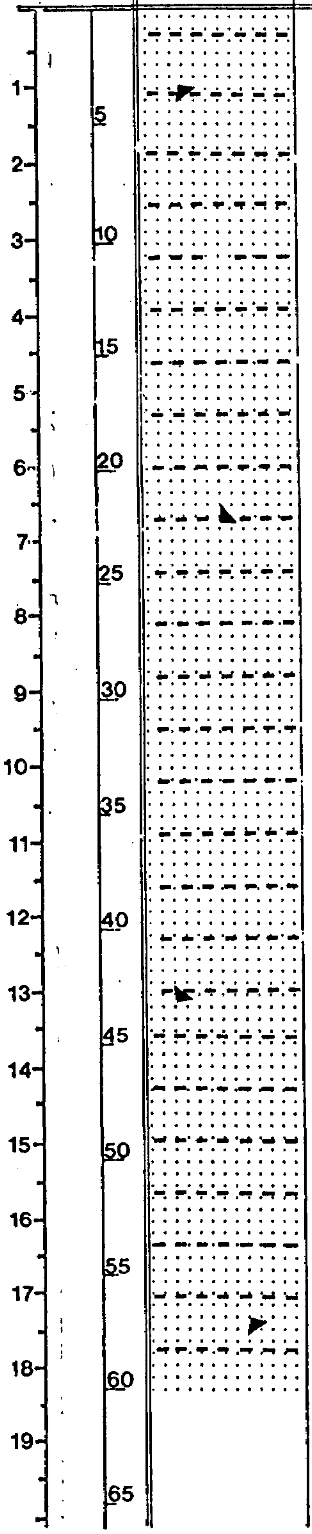
1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW4

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS WEST SIDE OF MATTAGAMI R.

Elev. of collar: 150.0′

Sheet 1 of 1



DEPTH m ft	GRAPHIC LOG	Sampling reverse circulation interval	Sampling % core recovered	Sampling Number	Description
					0–60′: Pale grey silty clayey fine to medium sand, with rare small traces of lignite.

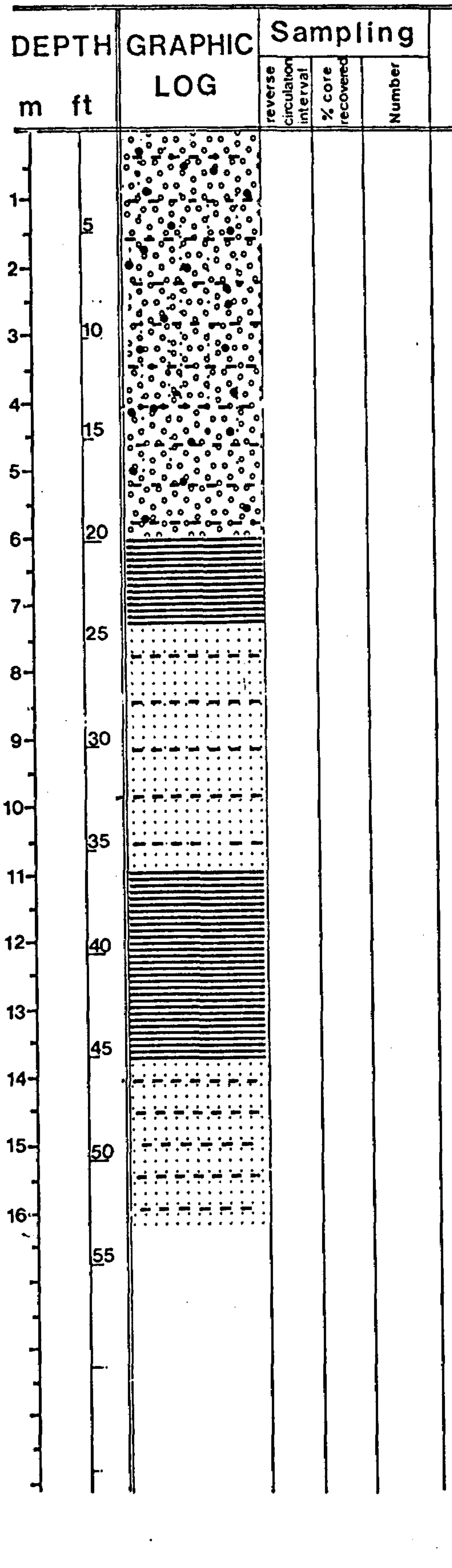
1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW5

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS WEST SIDE OF MATTAGAMI R.

Elev. of collar: 150.0′

Sheet 1 of 1



Description

0–20′: Grey sandy gravelly clay.

20–24′: Black soft lignitic clay.

24–36′: Pale grey sandy/gritty clay.

36–45′: Black soft lignitic clay.

45–53.5′: Light greyish green sandy clay.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

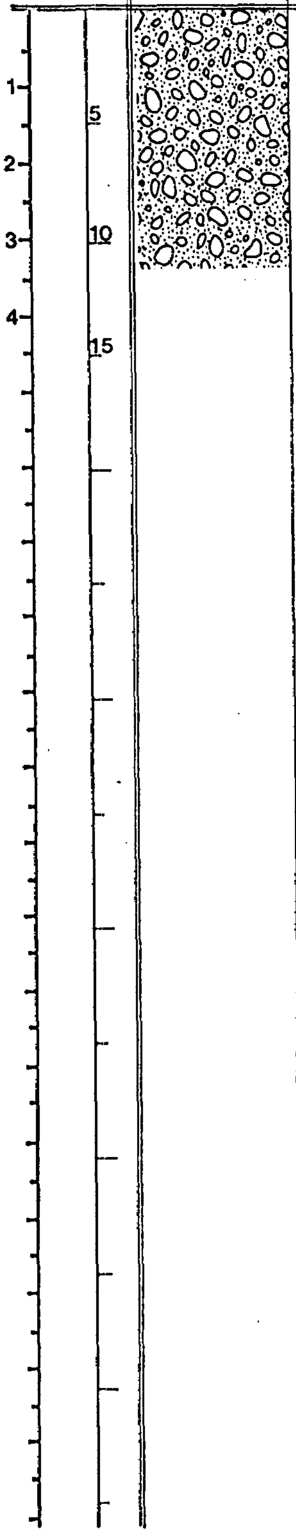
Drill Hole Nº: AUGER AW5A

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS WEST SIDE OF MATTAGAMI R.

Elev. of collar: 150.0′

Sheet 1 of 1

DEPTH m ft	GRAPHIC LOG	Sampling reverse circulation interval	Sampling % core recovered	Sampling Number	Description



TILL: 0–11.2'

0–4.9': Light brown sandy medium stiff clay.

4.9–5.9': Light grey clayey gravelly coarse sand.

5.9–6.8': Black soft lignitic clay.

6.8–7.9': Grey, soft/medium clay.

7.9–11.2': Light grey gravelly clay.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

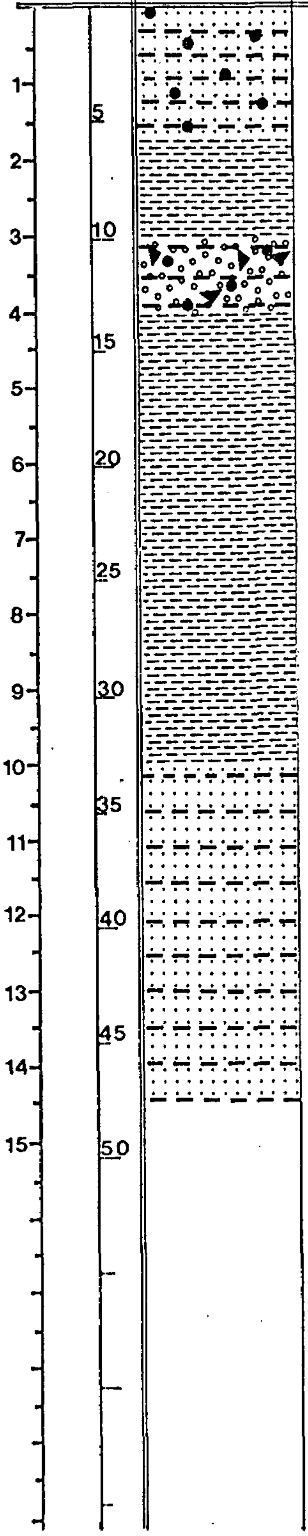
Drill Hole Nº: AUGER AW6

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS WEST SIDE OF MATTAGAMI R.

Elev. of collar: 150.0'

Sheet 1 of 1

DEPTH m ft	GRAPHIC LOG	Sampling reverse circulation interval	Sampling % core recovered	Sampling Number	Description



CLAY: 0–5.3'
Light greenish grey medium stiff gravelly/sandy silty clay.

CLAY: 5.3–9'
Beige grey medium stiff/soft clay, with black clay chips.
SAND: 9–12'
Dark grey clayey gravelly sand, with less than 25% lignite fragments.
CLAY: 12–15'
Beige grey medium stiff clay, with lignite fragments.
CLAY: 15–27'
Dark beige grey medium stiff clay, with lignite fragments.

CLAY: 27–30'
Light beige grey medium stiff clay.
CLAY: 30–40.5'
Light greenish grey sandy clay, medium stiff.

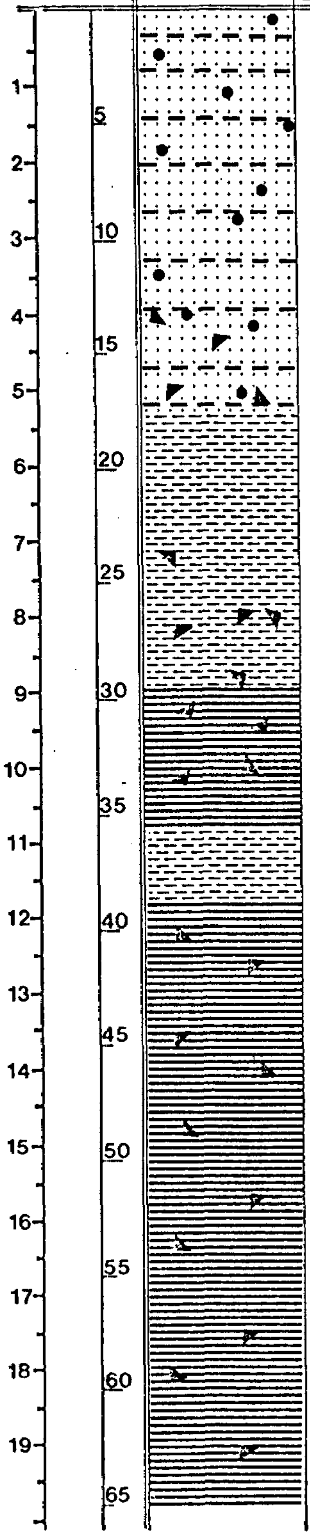
CLAY: 40.5–43.5'
Light green fine silty sandy soft clay.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW7 Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS

Elev. of collar: 150.0′ Sheet 1 of 2 WEST SIDE OF MATTAGAMI R.

DEPTH m ft	GRAPHIC LOG	Sampling reverse circulation interval	Sampling % core recovered	Sampling Number	Description



CLAY: 0-2'
Light brown silty sandy clay, medium stiff.
CLAY: 2-12'
Light grey silty sandy gravelly clay.

CLAY: 12-16'
Dark grey silty gravelly sandy clay, with soft lignite fragments.

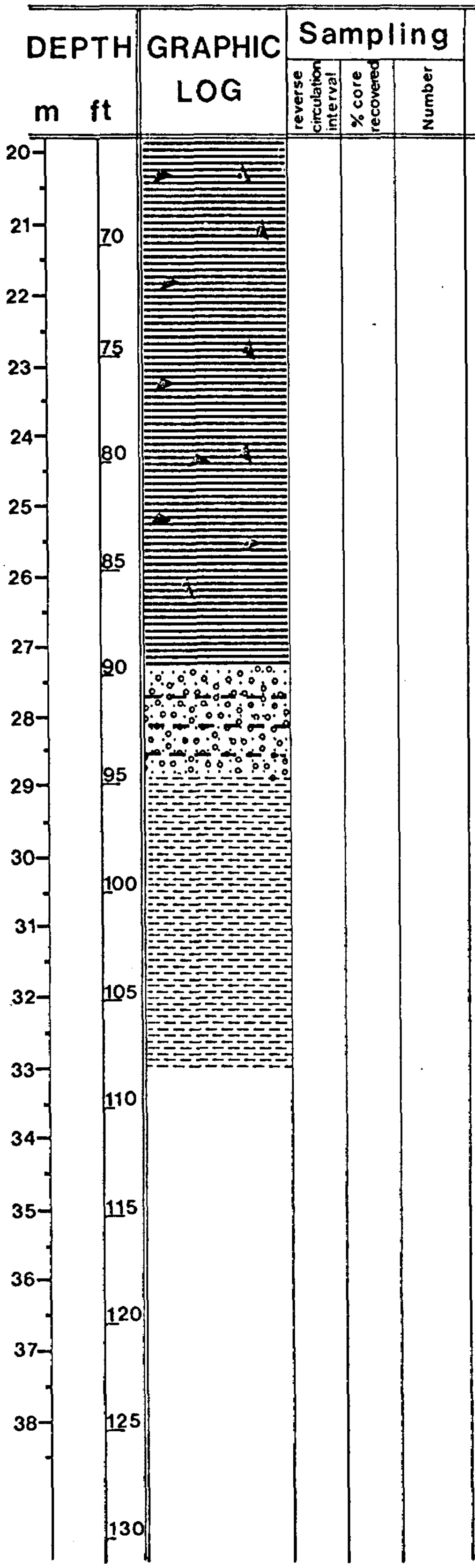
CLAY: 16-22'
Medium grey medium stiff clay.

CLAY: 22-25.5'
Medium grey stiff clay, with lignite fragments.
CLAY: 25.5-26'
Medium grey medium stiff clay, less than 25% lignite fragments
CLAY: 26-27'
Medium grey medium stiff clay, less than 10% lignite fragments
CLAY: 27-32'
Black plastic (carbonaceous lignitic?) clay, with large lignit fragments.
CLAY: 32-35.5'
Dark grey medium stiff clay, with beige clay chips.
CLAY: 35.5-87.6'
Black soft (carbonaceous lignitic?) clay, with lignite fragments.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW7

Sheet 2 of 2



Description

CLAY: 80.1–82'
Black carbonaceous (lignitic?) soft clay.
SAND: 82–87'
Grey coarse silty beige sand, with thin clay bands.
CLAY: 87–99'
Beige silty clay, becoming orange brown medium stiff sandy clay (white mottling).

CLAY: 99–105'
Reddish brown mottled (grey/green and orange brown) very stiff clay, with gritty greenish-black soft clasts less than 1".
GRAVEL: 105–108'
Coarse sandy gravel.
CLAY: 108–113'
Reddish brown (orangey) mottled (as above) very soft plastic clay, gritty green black clasts less than 1".

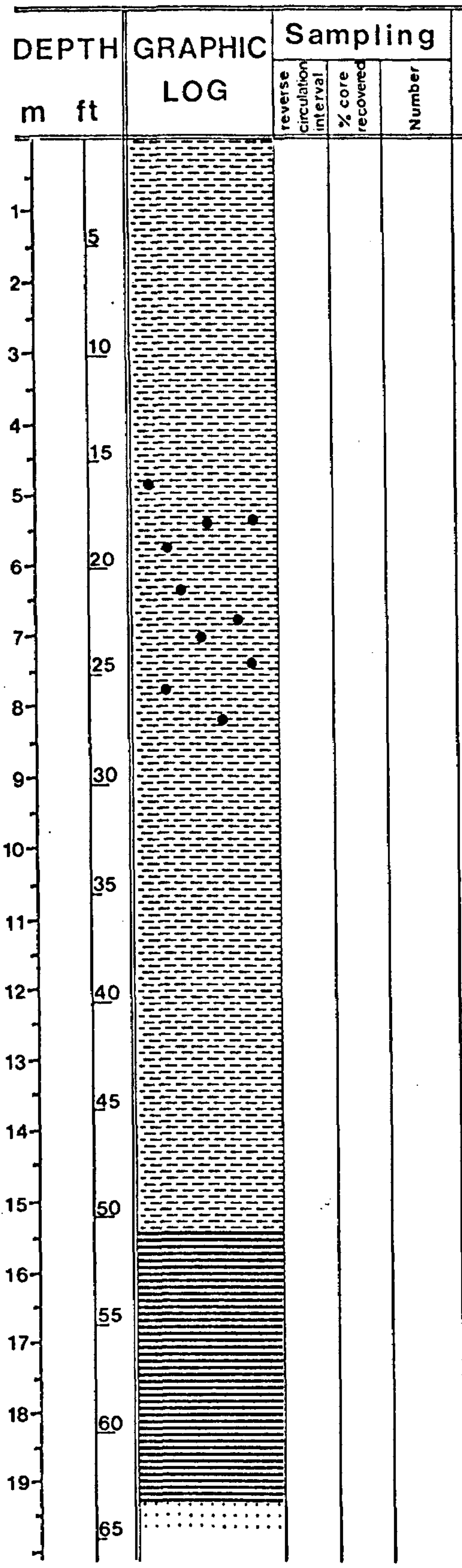
1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW8

Location: INTERSECTION OF PICKETT, MORROW AND HOGG TOWNSHIPS WEST SIDE OF MATTAGAMI R.

Elev. of collar: 150.0′

Sheet 1 of 2



Description

CLAY: 0–9'
Reddish brown and grey (mottled) silty and at times gritty, medium stiff clay.

CLAY: 9–15'
Beige brown/grey and reddish brown, mottled, medium stiff sandy clay.

CLAY: 15–27'
Mottled orange red brown and pale grey green soft clay with basement pebbles (mafics) up to 8".

CLAY: 27–30'
Orange brown, with lesser pale grey green mottling, soft clay.
CLAY: 30–35'
Soft orange brown (with blue black mottling clay).

CLAY: 35–51'
Soft light beige grey/brown sandy clay.

CLAY: 51–54'
Very stiff dark grey/black carbonaceous clay.
CLAY: 54–64'
Very stiff dark grey/black carbonaceous clay.

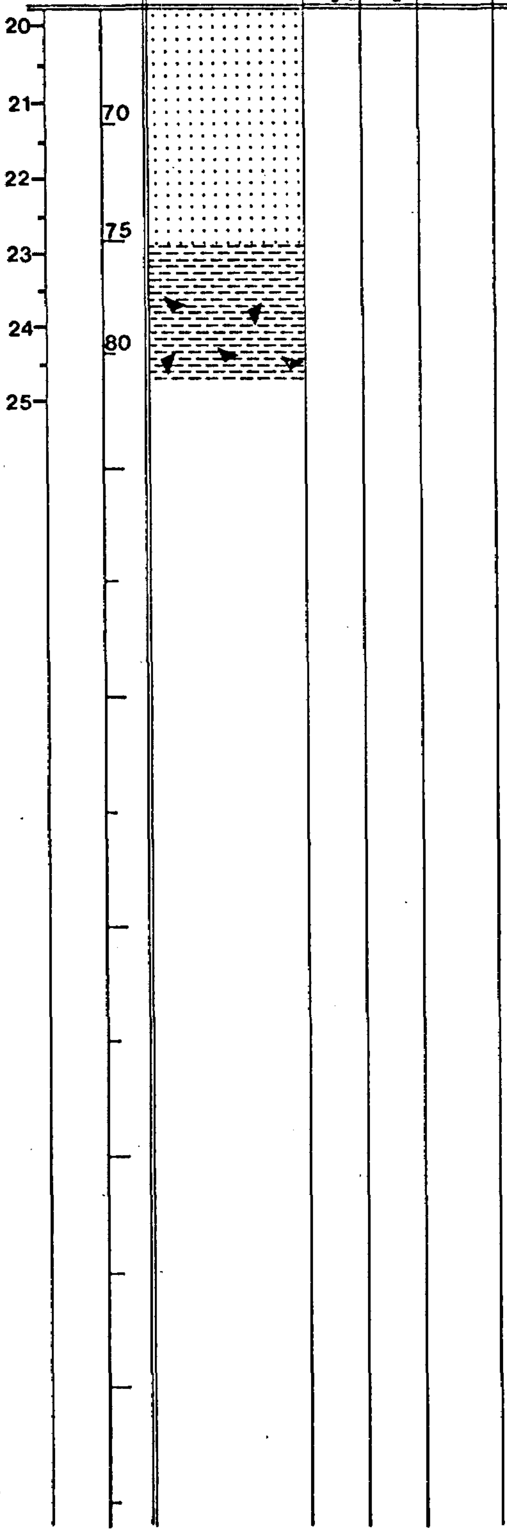
SAND: 64–75'
Soft running brownish grey sand.

1981 DRILLING PROGRAM-JAMES BAY LOWLANDS

Drill Hole Nº: AUGER AW8

Sheet 2 of 2

DEPTH m ft	GRAPHIC LOG	Sampling: reverse circulation interval	Sampling: % core recovered	Sampling: Number	Description



CLAY: 75-78'
Medium stiff mottled pale grey green and dark grey/black clay.
CLAY: 78-81'
Medium stiff very dark brownish black clay, with pale grey green clay chips less than 1/8", with large lignite fragments.

APPENDIX III

SUMMARY OF HEAVY-MINERAL CONCENTRATE DATA

SUMMARY OF LABORATORY DATA OF HEAVY MINERAL CONCENTRATES TABLE

Sample Number		WEIGHT (kg wet)			WEIGHT (grams dry)				DESCRIPTION	
		Table Split	+10 Rock Chips	-10 Table Feed	Table Concentrate	M.I. Lights	Non-Magnetic	Magnetic	+10	Matrix
OEC-81-01-	01	6.3	0.9	5.4	88.5	77.0	8.4	3.1	Pebs 70% lst. 5% gr. 10% v/s	Unsorted grey with white clay
	02	6.9	0.6	6.3	147.6	142.4	3.7	1.5	Cobs 65% lst. 10% gr. 10% v/s	Unsorted grey-beige with white clay
	03	5.6	0.5	5.1	113.6	105.8	6.2	1.6	Cobs 70% lst. 20% basement	"
	04	6.1	0.5	5.6	81.2	72.6	7.2	1.4	"	"
	05	5.0	0.6	4.4	38.8	28.8	8.6	1.4	Cobs 50% lst. 40% basement	"
	06	6.2	1.4	4.8	140.3	120.6	16.5	3.2	Cobs 60% lst. 30% basement	Unsorted grey-beige with little white clay
	07	4.9	1.8	3.1	234.9	223.4	8.9	2.6	"	"
	08	6.0	0.4	5.6	114.9	102.2	10.4	2.3	Pebs 40% lst. 50% basement	Unsorted grey with clay
	09	5.5	0.3	5.2	91.8	75.0	14.3	2.5	"	"
	10	6.5	0.4	6.1	81.1	68.2	10.8	2.1	Pebs 45% lst. 50% basement	"
	11	7.1	0.3	6.8	112.6	97.1	13.5	2.0	"	"
	12	6.4	0.2	6.2	166.1	155.8	8.8	1.5	Pebs 60% lst. 30% basement	Unsorted grey with white clay
	13	6.6	0.2	6.4	111.1	99.4	9.6	2.1	"	"
	14	6.3	0.2	6.1	123.2	108.5	12.0	2.7	"	"
	15	6.1	0.3	5.8	135.5	127.6	6.3	1.6	"	"
	16	6.8	0.2	6.6	100.4	84.2	12.5	3.7	Pebs 50% lts. 40% basement	"
	17	6.3	0.2	6.1	89.7	76.5	9.9	3.3	"	Unsorted grey-beige with white clay
	18	6.5	0.3	6.2	96.7	80.9	11.1	4.7	"	"
	19	5.8	0.3	5.5	95.3	79.7	12.3	3.3	"	"
	20	6.4	0.3	6.1	95.7	78.7	14.0	3.0	Pebs 40% lst. 50% basement	Unsorted grey-beige with grey clay
	21	5.9	0.3	5.6	101.2	87.4	11.1	2.7	"	"
	22	6.1	0.4	5.7	134.9	116.9	15.7	2.3	Pebs 30% lst. 60% basement	Unsorted grey with clay
	23	6.7	0.4	6.3	140.0	117.7	19.3	3.0	Cobs 40% lst. 50% basement	"
	24	6.0	0.5	5.5	136.9	112.8	20.7	3.4	Cobs 60% lst. 30% basement	"
	25	6.6	0.3	6.3	170.9	144.2	24.6	2.1	Cobs 50% lst. 40% basement	"
	26	6.8	0.4	6.4	94.2	60.0	30.8	3.4	"	"
	27	3.5	0.2	3.3	72.6	55.9	15.2	1.5	"	"
	28	6.5	0.6	5.9	105.0	74.1	26.1	4.8	"	Unsorted grey-beige with clay
	29	6.8	0.2	6.6	116.9	86.0	26.9	4.8	Cobs 70% lst. (lignite) 25% basement	"
	30	5.9	0.3	5.6	273.9	241.3	30.1	2.5	Cobs 30% lst. 60% basement	"
	31	5.7	nil	5.7	166.0	137.9	26.9	1.2	nil	Sorted medium-fine grey-white with little clay
	32	4.6	few pebs	4.6	97.5	77.1	18.6	1.8	Pebs 50% lst. (lignite) 50% basement	"
	33	6.4	0.2	6.2	188.4	150.0	35.6	2.8	"	Unsorted grey-white with grey clay
	34	6.1	3.0	3.1	226.8	208.8	17.5	0.5	Cobs 60% lst. (lignite) 30% basement	Unsorted grey-beige with clay
	35	6.5	2.2	4.3	66.5	50.9	14.3	1.3	Cobs 50% lst. (lignite) 40% basement	"
	36	6.0	0.5	5.5	152.5	129.3	22.2	1.0	"	Unsorted grey-beige with silt
	37	5.9	0.9	5.0	121.1	106.6	13.7	0.8	Cobs 70% lst. (lignite) 25% basement	"
	38	6.8	1.8	5.0	187.2	143.8	39.8	3.6	"	Unsorted grey-beige with clay
	39	6.4	0.1	6.3	163.7	132.8	28.9	2.0	Pebs 70% lst. 25% basement	Sorted medium-fine grey with silt
	40	2.6	0.1	2.5	67.6	54.2	12.9	1.4	"	"
	41	2.4	0	2.4	55.3	45.5	9.2	0.6	Organics	Sorted fine grey with silt
	42	2.2	few pebs	2.2	37.1	29.9	6.7	0.5	Pebs 80% lst. 10% basement	"
	43	1.9	0	1.9	65.1	58.2	6.0	0.9	nil	"
	44	2.0	0.05	2.0	69.1	59.5	9.3	0.3	Cobs 60% lst. 30% basement	Unsorted grey with silt
	45	1.8	0	1.8	78.0	58.3	18.8	0.9	nil	Sorted fine grey with silt
	46	1.2	0	1.2	17.7	15.5	2.2	few grains	nil	Unsorted grey-white with grey-brown clay
	47	1.2	0	1.2	17.5	17.3	0.2	"	nil	Unsorted grey-brown with clay

Sample Number	WEIGHT (kg wet)			WEIGHT (grams dry)				DESCRIPTION	
	Table Split	+10 Rock Chips	-10 Table Feed	Table Concentrate	M.I. Lights	Non-Magnetic	Magnetic	*+10*	Matrix
OEC-81-02- 48	2.8	few pebs	2.8	83.0	82.7	0.3	few grains	Pebs 80% basement 15–20% lst.	Unsorted grey with grey-brown clay
49	5.0	0.4	4.6	155.6	152.0	2.7	0.9	Pebs 50% basement 40% lst.	Unsorted beige with white clay
50	6.0	0.7	5.3	211.9	206.0	4.7	1.2	Pebs 25% basement 70% lst.	"
51	4.1	0.3	3.8	64.9	60.1	3.9	0.9	Cobs 40% basement 50% lst.	"
52	6.3	0.6	5.7	138.8	132.2	5.3	1.3	Cobs 30% basement 60% lst.	"
53	5.6	0.3	5.3	108.6	101.8	5.7	1.1	"	"
54	6.0	0.2	5.8	99.6	92.7	5.8	1.1	"	"
55	3.7	<0.1	3.7	29.0	28.4	0.6	few grains	Pebs 30% basement 65% lst.	"
56	5.0	0.6	4.4	72.2	59.7	10.0	2.5	Cobs 38% basement 60% lst.	Unsorted grey with white clay
57	6.6	1.3	5.3	214.9	200.7	9.9	4.3	Cobs 30% basement 65% lst.	"
58	7.1	1.9	5.2	279.1	264.9	10.3	3.9	Cobs 45% lst. 50% basement	"
59	6.8	1.8	5.0	157.5	138.2	15.3	4.0	"	Unsorted beige with white clay
60	6.5	1.6	4.9	159.7	136.4	16.8	6.5	Cobs 50% lst. 45% basement	"
61	6.3	1.3	5.0	92.6	68.7	18.6	5.3	Cobs 55% lst. 40% basement	"
62	6.8	1.4	5.4	123.4	111.4	9.9	2.1	Cobs 50% lst. 45% basement	"
63	6.9	0.2	6.7	96.6	90.3	4.7	1.6	Cobs 90% lst. 5% basement	"
64	6.2	0.1	6.1	170.8	165.2	4.5	1.1	Cobs 85% lst. 10% basement	"
65	6.0	<0.1	6.0	124.3	117.6	5.1	1.6	Cobs 65% lst. 25% basement	"
66	6.0	0.2	5.8	74.9	69.2	4.5	1.2	"	"
67	5.9	0.1	5.8	101.2	93.6	6.2	1.4	Cobs 70% lst. 25% basement	"
68	7.0	<0.1	7.0	55.9	53.7	1.9	0.3	Cobs 65% lst. 30% basement	Unsorted grey-beige with white clay
69	6.0	0.1	5.9	67.5	53.9	10.6	3.0	Cobs 85% lst. 10% basement	"
70	6.6	0.1	6.5	46.1	40.0	5.2	0.9	Cobs 75% lst. 20% basement	"
71	6.0	<0.1	6.0	46.8	39.0	6.7	1.1	Pebs 45% lst. 45% basement	"
72	3.4	<0.1	3.4	35.5	34.1	1.3	0.1	Pebs 45% lst. 45% basement	"
73	6.0	<0.1	6.0	67.0	55.6	10.0	1.4	Cobs 65% lst. 30% basement	"
74	6.3	0.4	5.9	85.0	62.6	20.8	1.6	Cobs 35% lst. 60% basement	Unsorted beige with grey clay
75	6.9	1.1	5.8	96.5	60.6	31.3	4.6	Cobs 55% lst. 40% basement	Unsorted grey-beige with grey clay
76	6.2	2.5	3.7	102.7	67.4	33.6	1.7	"	"
77	5.9	0.4	5.5	70.3	39.6	29.6	1.1	"	Unsorted beige with grey clay
78	9.0	0.4	8.6	106.2	61.8	38.6	5.8	Cobs 80% lst. 15% basement	"
79	6.7	0.4	6.3	177.4	138.5	34.5	4.4	"	"
80	6.1	0.1	6.0	53.5	31.3	21.7	0.5	Cobs 55% lst. 40% basement	"
OEC-81-03- 82	5.3	few pebs	5.3	43.9	37.4	4.9	1.6	Pebs 45% basement 50% lst.	Unsorted grey with clay
83	6.2	"	6.2	30.7	29.8	0.7	0.2	Pebs 45% lst. 50% basement	Unsorted dark grey with clay
84	4.4	0.1	4.3	47.1	44.6	1.8	0.7	"	Unsorted beige with grey clay
85	4.9	0.3	4.6	82.0	75.5	5.3	1.2	Pebs 80% lst. 15% basement	"
86	6.7	0.7	6.0	147.8	143.9	3.2	0.7	"	Unsorted grey-beige with grey clay
87	5.4	0.1	5.3	40.1	35.5	3.7	0.9	Pebs 60% lst. 35% basement	"
88	6.3	0.3	6.0	62.5	53.3	7.4	1.8	Cobs 80% lst. 15% basement	Unsorted beige with grey clay
89	6.9	0.2	6.7	64.6	54.6	8.4	1.6	"	"
90	6.3	0.3	6.0	82.4	70.4	10.2	1.8	Cobs 70% lst. 25% basement	Unsorted grey-beige with clay
91	6.7	0.4	6.3	71.2	59.7	9.4	2.1	Cobs 80% lst. 15% basement	"
92	6.9	0.6	6.3	72.5	56.5	13.2	2.8	Cobs 70% lst. 25% basement	"
93	6.8	2.4	4.4	113.5	106.7	6.1	0.7	"	Unsorted beige with grey clay
94	6.9	0.3	6.6	61.9	52.1	8.7	1.1	Pebs 70% lst. 25% basement	Unsorted beige with clay
95	6.1	0.2	5.9	52.2	46.0	5.6	0.6	Cobs 70% lst. 25% basement	"
96	5.4	0.4	5.0	96.8	90.6	6.1	0.1	Pebs Tr. lst. 95% basement	Unsorted white-grey with clay
97	6.2	1.3	4.9	142.2	139.7	2.5	few grains	"	"

Sample Number	WEIGHT (kg wet)			WEIGHT (grams dry)				DESCRIPTION	
	Table Split	+10 Rock Chips	-10 Table Feed	Table Concentrate	M.I. Lights	Non-Magnetic	Magnetic	+10	Matrix
OEC-81-03- 98	5.4	<0.1	5.4	96.1	86.1	10.0	few grains	Pebs 90% ss. Tr lst.	Unsorted beige-white with clay
101	5.2	0.1	5.2	77.4	72.6	4.8	"	"	Sorted medium white with clay
102	5.4	1.0	4.4	140.9	135.1	5.8	"	Pebs 95% qtz with lignite Tr. lst.	Sorted coarse white with brown clay
104	5.9	0.1	5.8	94.0	90.7	3.3	"	Pebs 60% qtz 40% lignite	Sorted coarse grey with brown-grey clay
105	4.5	0.7	3.8	49.8	46.5	3.3	"	Pebs 95% qtz Tr. lignite Tr. lst.	Sorted coarse grey-white with clay
107	6.2	0.4	5.8	211.2	201.2	10.0	"	Cobs 20% ss. Tr. lst. 40% lignite 35% qtz	Unsorted grey-white with clay
108	5.0	<0.1	5.0	59.8	43.5	16.3	"	Cobs 10% ss. Tr. lst. 15% qtz 70% lignite	"
111	5.4	0.2	5.2	150.5	130.6	19.8	0.1	Cobs 10% lst. Tr. ss. 25% qtz 60% lignite	"
112	5.2	<0.1	5.2	171.6	157.8	13.8	few grains	Pebs 10% qtz 10% ss. 80% lignite	Sorted grey-white with clay
113	6.0	0.2	5.8	270.2	263.8	6.4	"	Pebs 30% qtz 5% ss. 60% lignite	"
114	6.3	0.7	5.6	91.9	74.9	16.0	"	Pebs 40% lignite 50% qtz 2% v/s	Sorted coarse grey
OEC-81-04-119	5.5	0.8	4.7	66.0	52.5	11.4	2.1	Pebs 80% lst. 15% basement	Unsorted grey-green with grey clay
120	6.7	0.4	6.7	78.0	66.8	9.3	1.9	Cobs 75% lst. 15% basement	"
121	6.9	0.3	6.6	88.9	77.5	9.6	1.8	Cobs 75% lst. 15% basement GCI's	Unsorted grey with clay
122	6.0	0.3	5.7	109.5	100.0	7.9	1.6	Cobs 85% lst. 10% basement	"
123	3.3	0.3	3.0	59.1	50.0	7.1	2.0	Pebs 85% lst. 10% basement	"
124	5.5	0.2	5.3	108.3	100.2	6.3	1.8	"	"
125	6.5	0.2	6.3	102.7	90.8	10.9	1.0	Pebs 50% lst. 40% basement	Unsorted light grey with dark grey clay
126	4.9	0.1	4.8	108.7	89.1	18.5	1.1	Pebs 60% lst. 25% basement 2% lignite	"
129	5.4	0.4	5.0	101.2	93.2	6.5	1.5	Pebs 70% lst. 25% basement 2% lignite	"
130	5.6	0.5	5.1	108.4	97.8	7.7	2.9	Cobs 60% lst. 30% basement 2% lignite	"
131	6.5	0.5	6.0	100.4	89.3	8.7	2.4	Cobs 70% lst. 20% basement 2% lignite	"
132	5.3	0.5	4.8	69.7	59.2	8.8	1.7	"	"
133	6.5	0.6	5.9	91.6	88.2	1.7	1.7	Cobs 50% lst. 40% basement 2% lignite	Unsorted grey-white with clay
134	7.4	1.0	6.4	111.3	78.6	29.5	3.2	Cobs 70% lst. 20% basement 2% lignite	Sorted coarse grey-white with dark grey silt
135	5.8	1.0	5.8	194.2	167.4	23.0	3.8	Cobs 80% lst. 10% basement 2% lignite	Unsorted grey-white with dark grey silt
136	5.3	0.3	5.0	105.8	95.3	10.4	0.1	Cobs 30% lst. 60% basement 2% lignite	Sorted coarse white with dark grey silt
137	5.2	0.3	4.9	136.8	123.2	13.5	0.1	Pebs 30% lst. 60% basement 2% lignite	Sorted coarse white with black silt
138	5.6	1.1	4.5	67.1	42.3	24.8	few grains	Pebs 5% lst. 85% basement 2% lignite	"
139	5.0	0.7	4.3	95.6	83.7	11.7	0.2	Pebs 10% lst. 80% basement 2% lignite	"
140	5.3	few pebs	5.3	164.4	157.5	6.9	few grains	Pebs 20% lst. 70% basement 2% lignite	"
143	4.9	0.2	4.7	227.7	174.3	53.5	0.1	Pebs Tr. lst. 95% basement Tr. lignite	Sorted coarse white with silt
145	6.2	0.7	5.5	58.2	52.3	4.3	1.6	Pebs Tr. lst. 80% basement Tr. lignite	"
OEC-81-05-150	5.7	<0.1	5.7	49.4	37.6	9.6	2.2	"	Unsorted grey with clay
151								PURE CLAY	
152	6.3	0.4	5.9	247.4	225.4	18.6	3.4	Pebs 70% lst. 25% basement	Unsorted beige-grey with white clay
153	6.0	0.8	5.2	78.4	55.9	19.1	3.4	Cobs 60% lst. 30% basement	Unsorted beige-grey with white silt
154	6.3	0.9	5.4	108.0	79.3	22.8	5.9	Cobs 50% lst. 40% basement	Unsorted beige-white with silt
155	6.9	1.2	5.7	181.5	176.1	5.2	0.2	Pebs 70% lst. 25% basement Tr. lignite	"
156	6.2	1.1	5.1	151.1	140.7	10.4	few grains	Pebs 30% lst. 60% basement Tr. lignite	Sorted coarse white with silt
157	7.6	1.7	5.9	119.0	111.2	7.5	0.3	Pebs 90% qtz 10% lignite	"
158	7.2	0.6	6.6	141.4	135.2	6.1	0.1	Pebs 85% qtz 10% lignite	"
159	7.2	0.9	6.3	181.0	173.2	7.7	0.1	"	"
160	5.3	0.2	5.1	55.2	53.8	1.4	few grains	Pebs 80% qtz 15% lignite	Unsorted white with grey clay
161	5.0	0.6	4.4	44.2	41.4	2.8	"	Pebs Tr. lst. 85% qtz 10% lignite	Unsorted white with yellowish clay

Sample Number	WEIGHT (kg wet)			WEIGHT (grams dry)				DESCRIPTION	
	Table Split	+10 Rock Chips	-10 Table Feed	Table Concentrate	M.I. Lights	Non-Magnetic	Magnetic	+10	Matrix
OEC-81-05-163	6.0	<0.1	6.0	102.5	89.4	13.1	few grains	Pebs Tr. qtz 95% lignite	Sorted medium coarse white with little clay
164	6.9	0.6	6.3	168.9	159.5	9.4	"	Pebs 90% qtz 5% lignite	Sorted coarse white with silt
165	6.7	0.4	6.3	158.1	154.3	3.8	"	Pebs 95% qtz 5% lignite	"
166	6.2	0.1	6.1	97.1	94.3	2.8	"	"	"
167	6.8	0.9	5.9	138.9	137.2	1.7	"	Pebs Tr. lst. 95% qtz Tr. lignite	"
168	6.9	1.9	5.0	113.2	107.8	5.4	"	Pebs 90% qtz 5% lignite	"
169	6.5	1.0	5.5	144.9	131.5	13.3	0.1	"	"
OEC-81-06-170	2.2	<0.1	2.2	91.1	88.4	2.3	0.4	Pebs 90% basement Tr. org.	Unsorted grey with clay
171	3.4	0.3	3.1	123.9	117.9	5.0	1.0	Pebs 60% lst. 40% basement	Unsorted beige-grey with grey clay
172	5.7	0.4	5.3	85.2	56.5	18.7	10.0	Pebs 35% lst. 60% basement	Unsorted orange-grey with white clay
173	5.0	0.1	4.9	102.9	93.4	7.8	1.7	"	Unsorted beige-grey with white clay
174	6.2	<0.1	6.2	68.9	62.9	4.4	1.6	Pebs 30% lst. 65% basement	"
175	7.3	0.6	6.7	80.7	67.4	11.4	1.9	Cobs 70% lst. 30% basement	Unsorted grey with light grey clay
176	6.0	0.2	5.8	52.0	44.1	6.8	1.1	Pebs 50% lst. 50% basement	"
177	6.6	2.5	4.1	77.2	24.2	52.9	0.1	Cobs 95% lst. 5% basement	Unsorted light brown with grey clay
178	6.7	0.6	6.1	115.1	37.3	77.7	0.1	Cobs 95% lst. Tr. basement	Unsorted light brown with brown-grey clay
179	5.6	2.4	3.2	131.6	127.9	3.7	few grains	Cobs 95% lst.	"
OEC-81-07-183	4.2	1.0	3.2	81.2	72.0	6.8	2.4	Cobs 50% lst. 50% basement	Unsorted grey with clay
184	4.0	0.4	3.6	59.6	56.6	2.4	0.6	Cobs 60% lst. 25% basement	Unsorted brown with light brown clay
185	7.1	0.8	6.3	89.9	83.9	5.3	0.7	Cobs 70% lst. 25% basement	Unsorted brown with clay
186	8.0	1.7	6.3	101.7	90.1	8.2	3.4	Cobs 60% lst. 30% basement	Unsorted grey-brown with brown clay
187	6.0	0.8	5.2	108.2	97.7	8.5	2.0	Cobs 40% lst. 55% basement	Unsorted grey-green with grey clay
188	6.3	0.5	5.8	102.4	91.4	8.4	2.6	"	"
189	6.1	1.4	4.7	107.4	96.9	7.4	3.1	Cobs 65% lst. 35% basement	"
190	7.1	0.7	6.4	111.8	103.6	5.7	2.5	Cobs 60% lst. 35% basement	"
191	7.4	1.3	6.1	107.2	91.4	12.4	3.4	Cobs 40% lst. 55% basement	"
192	7.2	1.5	5.7	108.3	87.4	16.8	4.1	"	"
193	7.2	0.9	6.3	79.6	57.3	17.9	4.4	"	"
194	6.7	0.7	6.0	73.9	57.6	12.8	3.5	Cobs 50% lst. 45% basement	Unsorted brown-green with light brown clay
195	6.5	0.7	5.8	111.5	95.7	12.6	3.2	Cobs 60% lst. 35% basement	"
196	7.0	0.6	6.4	160.2	125.0	30.0	5.2	Cobs 45% lst. 50% basement	Unsorted grey-green with gray clay
197	6.4	0.8	5.6	84.7	65.7	16.0	3.0	Cobs 35% lst. 65% basement	"
198	6.6	0.4	6.2	167.2	143.6	23.1	0.5	Cobs 10% lst. 90% basement	Unsorted white with orange clay
OEC-81-08-204	6.5	0.4	6.1	100.8	93.0	6.1	1.7	Cobs 30% lst. 65% basement	Unsorted grey-green with light clay
205	6.9	0.6	6.3	91.6	82.6	7.2	1.8	"	"
206	6.1	0.4	5.7	92.3	85.1	5.6	1.6	"	"
207	6.0	0.2	5.3	77.1	71.6	3.7	1.8	"	"
208	6.2	0.4	5.8	103.0	96.9	4.1	2.0	Cobs 20% lst. 80% basement	"
209	6.4	0.4	6.0	117.6	105.3	10.5	1.8	"	Unsorted grey-green with brown clay
210	6.3	0.2	6.1	109.4	97.0	10.7	1.7	"	"
211	6.3	<0.1	6.3	51.8	40.4	9.7	2.0	Cobs 20% lst. 75% basement	"
OEC-81-09-214	3.5	0.2	3.3	66.0	62.7	2.6	0.7	Pebs 60% lst. 30% basement	Unsorted grey-green with light clay
215	6.4	0.3	6.1	119.4	114.3	3.7	1.4	Pebs 50% lst. 45% basement	"
216	5.7	1.8	3.9	136.9	121.2	11.9	3.8	Cobs 50% lst. 50% basement	Unsorted grey-green with grey-white clay
217	5.5	0.7	4.8	78.0	68.6	7.4	2.0	Cobs 40% lst. 60% basement	Unsorted grey-green with light clay
218	7.6	0.4	7.2	73.1	47.2	19.3	6.6	Pebs 50% lst. 50% basement	Sorted fine beige-green with light clay
219	5.5	few pebs	5.5	69.5	45.9	19.8	3.8	"	Sorted fine beige-green
220	7.3	0.4	6.9	95.6	74.1	20.0	1.5	"	Unsorted beige-green with light clay
221	5.5	0.1	5.4	78.0	63.4	14.4	0.2	Pebs 55% lst. 40% basement	Unsorted white with dark grey clay

Sample Number	WEIGHT (kg wet)			WEIGHT (grams dry)				DESCRIPTION	
	Table Split	+10 Rock Chips	-10 Table Feed	Table Concentrate	M.I. Lights	Non-Magnetic	Magnetic	+10	Matrix
OEC-81-09-222	4.5	0.2	4.3	51.8	23.3	28.4	0.1	Cobs 95% lst. Tr. basement	Unsorted white with dark grey clay
223	------	------	------	------	------	------	------	------PURE CLAY------	------
225	4.3	0	4.3	75.9	67.1	8.5	0.3	nil	Unsorted white with dark grey clay
226	4.3	0	4.3	70.6	64.0	6.3	0.3	nil	"
227	4.3	0	4.3	93.3	76.4	3.8	0.2	nil	"
OEC-81-10-242	5.0	1.0	4.0	151.4	138.3	9.3	3.8	Cobs 60% lst. 40% basement	Unsorted grey-green with light clay
243	4.5	1.0	3.5	106.5	94.1	9.8	2.6	"	"
244	7.0	0.3	6.7	129.9	87.1	34.3	8.5	Pebs 60% lst. 40% basement	"
245	6.0	few pebs	6.0	182.7	137.7	35.2	9.8	"	Sorted beige-green with beige clay
246	6.3	"	6.3	178.8	146.0	27.2	5.6	"	"
247	6.0	0	6.0	214.0	204.3	7.4	2.3	nil	Sorted fine beige-green
248	6.4	<0.1	6.4	140.4	104.6	30.1	5.7	Pebs 50% lst. 50% basement	Sorted medium fine beige with white clay
249	6.4	0.1	6.3	54.6	43.3	10.0	1.3	"	Unsorted grey with orange clay
OEC-81-11-254	4.0	0	4.0	163.7	152.8	6.7	4.2	nil	Sorted fine beige-grey with silt
255	5.3	2.5	2.8	80.6	73.7	5.2	1.7	Pebs 50% lst. 50% basement	Sorted coarse beige with silt
256	4.6	1.1	3.5	60.8	54.2	4.8	1.8	"	Unsorted grey with clay
257	5.2	3.0	2.2	94.6	88.8	4.6	1.2	"	"
258	5.7	0.1	5.6	77.2	70.8	4.3	2.1	"	"
OEC-81-12-259	5.3	0.3	5.0	62.0	54.3	5.4	2.3	"	"
260	6.4	0.5	5.9	83.6	70.1	10.1	3.4	Pebs 60% lst. 40% basement	"
261	7.0	0.9	6.1	100.1	88.4	8.2	3.5	Cobs 60% lst. 40% basement	"
262	7.2	1.5	5.7	90.4	77.5	9.9	3.0	Cobs 50% lst. 50% basement	Unsorted grey-green with grey clay
263	6.9	1.6	5.3	85.9	75.3	8.5	2.1	"	"
264	3.8	<0.1	3.8	100.3	82.9	17.3	0.1	95% lignite	Sorted white fine with light grey clay
265	5.7	0.5	5.2	36.3	17.2	19.0	0.1	Pebs 55% basement 45% lignite	Unsorted light grey with clay
266	5.5	0.9	4.6	107.3	15.4	91.8	0.1	Pebs 10% lst. 60% basement 30% lignite	Unsorted light brown with little clay
267	6.3	1.4	4.9	131.7	101.1	30.5	0.1	Pebs Tr. lst. 90% basement 5% lignite	Unsorted light grey with dark grey clay
268	5.4	1.7	3.7	188.0	167.4	20.5	0.1	Pebs Tr. lst. 95% basement	"
269	2.9	0.2	2.7	49.2	27.3	21.8	0.1	"	Unsorted grey with light grey clay

APPENDIX IV

REPORT ON THE EXAMINATION OF HEAVY-MINERAL CONCENTRATES

OVERBURDEN DRILLING MANAGEMENT LIMITED
192 POWELL AVENUE, OTTAWA, ONTARIO K1S 2A5 — (613) 822-0202

COMPANY: [illegible]
ATTENTION: T.S.
READ:
PROJECT:
FILE:
DEC 16 1981

REFERRED TO	ON	READ BY	ON

NOTES:

December 15, 1981

Watts, Griffis and McQuat Limited
Suite 911 - 159 Bay Street
Toronto, Ontario
M5J 1J7

Attention: Mr. A. Strading

Dear Mr. Strading:

Re: James Bay Lowland Project, 1981

Enclosed find one copy of a report describing the distribution of heavy minerals in the glacial debris on your Onakawana area property. This report has been prepared by Frank Thompson, Consulting Geologist, under our direction.

I have personally reviewed the report and wish to add the following comments:

1. As discussed in the field in October I consider the complexly layered basal sediments that occur immediately above the Devonian rocks in Hole 01 to be preglacial sediments that were deposited as the first Pleistocene ice sheet advanced toward the area. The concentrates are deficient in foreign heavies because only half of the beds in the sediment section are derived from glacial debris; the others are recycled Cretaceous lignite, kaolinite and quartz sand.

2. Re Table 2. - I question whether any detrital ilmenite is present in the weathered Cretaceous sediments; however, this mineral may be present in the clastic Devonian sediments.

3. The apparent concentration of kyanite in the locally derived tills is puzzling. Frank feels that this trend is real although he admits that kyanite is more difficult to identify in concentrates that are enriched in other foreign minerals such as garnet. I suggest that kyanite, like rutile, zircon, and ilmenite occurs as a detrital mineral in either the Cretaceous or Devonian clastic sediments.

...2

4. The kimberlite indicator minerals that are stated to be absent are green chrome diopside, purple pyrope garnet and picroilmenite.

Should you require any additional information do not hesitate to contact the undersigned.

Yours truly,

S. A. Averill
President

WATTS, GRIFFIS AND McOUAT LIMITED

JAMES BAY LOWLAND PROJECT, 1981

DISTRIBUTION OF HEAVY MINERALS IN GLACIAL DEBRIS

by

F. J. THOMPSON

DECEMBER, 1981

AS DIRECTED BY OVERBURDEN DRILLING MANAGEMENT LIMITED

INTRODUCTION

The report describes the distribution of heavy minerals in the glacial debris of twelve reverse circulation drill holes in the Onakawana area. The objective of the study was to determine if minerals of economic significance -- particularly diamond indicator minerals -- are present in the glacial debris. The interpretation is based on binocular logs of non-magnetic heavy minerals with specific gravity greater than 3.3 and on x-ray confirmation of selected minerals (Table 1). The heavy minerals are described in Table 2.

INTERPRETATION AND OBSERVATIONS

Stratigraphy

The samples were divided into five stratigraphic categories based on the composition and character of the heavy mineral concentrates (Table 1). The sample processing logs (Table 3) and the overburden drill logs were utilized to supplement this stratigraphic information. The distribution of the heavy minerals is shown in Table 4. The stratigraphic categories are described below.

Bedrock - Heavy mineral concentrates were prepared from several bedrock samples. These concentrates are primarily cuttings of pyrite with variable siderite, hematite, ilmenite, zircon and rutile. The pyrite occurs as cement in sandstone, pyritized wood and clusters of fine crystals.

Local Till - The local till overlies bedrock or local sand/gravel throughout the drill area. The concentrates are unsorted and are comprised, in part, of heavy minerals - siderite, hematite and pyrite (as described in bedrock section) -- derived from the Cretaceous and Devonian rocks. Rogers et al. (1975) note pyrite in Cretaceous and Devonian rocks, and Skinner (1973) notes siderite in Devonian rocks. The local till is ice deposited and provides the most representative test of the underlying and up ice bedrock. This till is most likely the pre-Missinaibi till described by Skinner (1973). Skinner indicates that the direction of ice flow was from the north-east.

Local Sand and Gravel - Local sand and gravel overlie bedrock in holes OEC-01 and 04. The concentrates are sorted and commonly contain less than 15% of Archean-derived garnet, hornblende, pyroxene and epidote. These sands and gravels are most likely pre-Missinaibi interglacial/interstadial deposits. The thin local sand and gravel deposits intercalated with local till in holes OEC-04, 09 and 11 are similar in composition to the local till and reflect short periods of glacial recession. The local sand and gravel concentrates reflect the composition of the Cretaceous and

Devonian rocks but are water deposited and consequently, distance and direction of transport are uncertain.

Foreign Till - Foreign till overlies local till or foreign sand/gravel throughout the drill area. The concentrates are unsorted and are comprised primarily of heavy minerals - garnet, hematite, hornblende, pyroxene and crystalline pyrite - derived from the Archean granites, volcanics and sediments over 200 km glacially up ice (north-east) from the drill area. Consequently, this horizon does not provide a test of the underlying bedrock. These tills are most likely the Adam and Kipling tills described by Skinner (1973). Skinner indicates that the direction of ice flow was from the north-east.

(Note: The upper samples in holes OEC-11 and 12 were not submitted for concentrate preparation.)

Foreign Sand and Gravel - Late glacial foreign sand and gravel deposits overlie foreign till in most holes. The foreign sand and gravel section underlying foreign till in holes OEC-02 and 10 may be a part of the Missinaibi sediments described by Skinner. The foreign sand and gravel concentrates are sorted and are similar in composition to the foreign till. These deposits do not provide a test of bedrock in the drill area.

Economic Potential

A late Devonian kimberlitic dike has been observed in the vicinity of Coral Rapids 50 km south-west of the drill area (Sanford et al., 1968). However, kimberlite/diamond indicator minerals were not observed in the glacial debris in the drill area, indicating that kimberlites are not present in the bedrock underlying the drill area. Kyanite - a mineral found in kimberlites, eclogites and metamorphosed pelites -- is present in minor amounts (<3%) in the local till. The low levels of kyanite in the glacial debris and the lack of other kimberlite minerals would suggest a distant non-kimberlitic source.

The scattered occurrences of base metal minerals observed in the glacial debris are not indicative of significant mineralization in the underlying bedrock. These occurrences are summarized below.

OEC-81-02-50 - A trace of molybdenite occurs in foreign till 60 metres above bedrock. A distant sub-economic source is indicated.

OEC-81-04-123 and 125 - Traces of chalcopyrite occur in two local till samples 27 and 30 metres above bedrock. A sub-economic Cretaceous/Devonian source of minimum of one kilometre north-east of the drill hole is indicated.

OEC-81-06-172 - Molybdenite (0.1%) occurs in foreign till 16 metres above bedrock. This molybdenite is most likely derived from sub-economic levels of molybdenite in the granite boulder in the sample. A distant source is indicated.

OEC-81-10-243 - A trace of chalcopyrite occurs in foreign till 30 metres above bedrock. A distant, sub-economic source is indicated.

The rare earth minerals associated with carbonatite deposits were not observed in the concentrates. However, low concentrations of minerals of the niobium/tantalum group would be difficult to identify in concentrates with similar looking iron oxides.

DISCUSSION

The lack of minerals of economic significance in the glacial debris would strongly suggest that bedrock in the drill area has a low diamond/base metal/rare earth potential. However, it should be noted that -- because the primary objective of the drill program was to evaluate the Cretaceous lignite deposits -- the holes are widely spaced and large areas between the drill holes remain untested. In addition, the sand and gravel deposits overlying bedrock in holes OEC-01 and 04 shield part of the drill area from glacial erosion.

Frank Thompson

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Table 1 - Heavy Mineral Concentrate Logs

Notes

1. Samples are unsorted unless otherwise indicated.
2. L 5 means "less than 5".
3. * denotes x-ray identification (Carleton University, Ottawa).

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
Oec-81-01- 01	30	-	10-15	10	10-15	15-20	5	Foreign Till	
02	40-50	-	15	5-10	5-10	10-15	15	"	Coarse Pyrite
03	40	-	10	5-10	5-10	20	8	"	
04	30-40	-	5	5	5-10	15	25	"	
05	30	15	5	10	5	20	8	"	
06	50-60	3	5	5	5-10	10-15	4	"	Coarse
07	50	2	10-15	3-5	10-15	10-15	8	Foreign Gravel	Sorted - coarse
08	5	60-70	15-20	L 5	L 3	3-5	5	Local till	Sandstone with pyrite cement Pyrite pseudomorphs of wood
09	5	60	15	L 5	L 5	3-5	5	"	
10	10-15	50-60	15-20	L 5	L 5	3-5	8	"	Coarse siderite cuttings
11	10	40	20	5	5	5-10	8	"	
12	10	40-50	15	5	5	15	5	"	
13	10	35	15	5-10	L 5	5-10	15	"	10% sandstone with pyrite cement (cuttings)
14	15	30	20	5-10	L 5	10	10	"	

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-01-15	15	15-20	20	5-10	5-10	20	10	Local till	Coarse pyrite pseudomorphs of wood
16	10	20	15-20	10	5	20	5	"	
17	10-15	30	5-10	15-20	5-10	20	3	"	Pyrite pseudomorphs of wood. 1% amber garnet.
18	10-15	25	5-10	20	5-10	20	3	"	1% kyanite
19	5	60	5	15	L 5	5-10	5	"	Coarse siderite
20	5	60	5-10	10	L 5	5	12	"	Pyrite pseudomorphs of wood 3% sandstone with pyrite cement
21	5-10	60	5-10	10-15	L 5	5	8	"	Coarse siderite cuttings
22	3-5	75	5	10	L 5	L 5	3	"	Coarse siderite cuttings Pyrite pseudomorphs of wood
23	L 5	85	3-5	5	L 3	L 5	5	"	Coarse siderite cuttings Pyrite pseudomorphs of wood
24	L 5	70	5	5	L 3	L 5	10	"	Coarse siderite cuttings
25	L 5	70	5	5-10	L 3	L 5	15	"	Pyrite pseudomorphs of wood
26	L 5	60	5	5	L 3	L 5	25	"	Pyrite pseudomorphs of wood
27	L 3	65	5	5	L 3	L 3	25	"	
28	5	65	5	5	L 5	5-10	15	Local sand/gravel	Finer than above, siderite rounded

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-01-29	5-10	50	10-15	5	L 5	5-10	10	Local sand/ gravel	Finer than above, siderite rounded.
30	5	70	5	L 5	L 3	L 5	15	"	Sorted - coarse. Siderite rounded. Blue iridescent film on pyrite. 3% sandstone with pyrite cement.
31	3-5	70-80	5	L 5	L 3	L 5	15	"	Well sorted- medium. Siderite rounded.
32	3-5	70	5	5	L 5	5	10	"	As OEC-31. Trace kyanite.
33	5	70	5	L 3	L 5	L 5	20	"	Sorted - medium to coarse.
34	L 5	65	L 5	L 3	L 3	L 5	30	"	Coarse pyrite and siderite cuttings. Pyrite pseudomorphs of wood. 5% sandstone with pyrite cement.
35	3-5	50-60	5-10	L 5	L 3	L 5	30	"	
36	L 5	70	L 5	L 3	L 3	L 5	20	"	Sorted - coarse.
37	5	50-60	5	L 5	L 3	L 5	30	"	Poorly sorted - coarse. Pyrite pseudomorphs of wood.
38	L 5	60-70	5	L 5	L 3	L 5	25	"	Coarse pyrite and siderite cuttings.
39	3-5	70	5	L 5	L 3	L 5	20	"	Sorted - medium. Rounded siderite. Trace kyanite.
40	3-5	60	5-10	5	L 5	5-10	12	"	Poorly sorted - medium to fine. 1% kyanite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-01-41	L 5	60-70	10-15	L 5	L 5	5	8	Local sand/ gravel	Sorted - medium.
42	L 5	60	10	10	L 5	5	5	"	Sorted - fine. 2% kyanite. *
43	L 5	60	10	10	L 5	3-5	10	"	Poorly sorted - fine. 2% kyanite. Pyrite pseudomorphs of wood. 3% sandstone with pyrite cement. Trace staurolite.
44	L 5	70	5-10	5-10	L 5	L 5	10	"	Pyrite pseudomorphs of wood. 3% sandstone with pyrite cement. 1% kyanite.
45	L 5	60	10-15	10-15	L 5	3-5	8	"	Poorly sorted- fine. 1% kyanite.
46	L 5	25	L 5	L 5	-	L 5	70	Bedrock	Well sorted - very fine. Pyrite/quartz aggregates (delicate pseudomorphs of wood).
47	L 5	3-5	2-3	L 3	-	L 5	70-80	"	Sorted - very fine. Pyrite pseudomorphs of wood and crystalline pyrite. 8% barite. *
OEC-81-02-48	15	-	10-15	10-15	10-20	25	15	Foreign sand	Sorted - fine. Coarse pyrite with calcite crust.
49	35	-	15	10-20	10-20	15-20	10	Foreign till	
50	30	-	10-15	10-20	10-20	10-20	10	"	One flake molybdenite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-02-51	30	-	10	15	10-20	20-30	5	Foreign till	
52	35-40	-	5	10-15	10-20	20-25	10	"	
53	35	-	5-8	10-15	10-20	20-30	5	"	Finer than above.
54	30	-	5	15	10-20	30	3	"	3% leucocratic accessories.
55	30	-	5	15-20	10-20	30	3	Foreign sand	Poorly sorted - fine. 2% leucocratic accessories.
56	20-30	-	5	20	10-20	30	3	Foreign till	
57	50	1-2	10-15	5	10	10-20	5	"	
58	40	L 2	15-20	5	10	10-20	5	"	
59	50	L 2	10	5-10	5-10	20	8	"	
60	40	-	20	5	5-10	15	10	"	
61	40-50	Tr.	15	5	5-10	20	5	"	
62	30-40	Tr.	10-15	5	5-10	20-30	20	"	Pyrite with quartz.
63	30	1-2	5-10	10-15	5-10	30	8	Foreign sand/ gravel	Poorly sorted - fine. Rounded garnet. 2% leucocratic accessories.
64	30	3	15	5-10	10	30	10	"	Rounded garnet. 2% limonite. 2% leucocratie accessories.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-02-65	20-30	3	10-15	5	5-10	20	25	Foreign sand/ gravel	Rounded garnet. Pyrite with calcite crust.
66	30	3	15-20	5	5-10	20	10	"	
67	20	10	5-10	10	10-15	20	10	"	
68	20-30	2	5-10	5-10	10-15	15-20	30	"	Pyrite with calcite crust. 1% kyanite.
69	20-30	1	10-15	10-15	5-10	20	10	"	Sorted - fine.
70	20-30	1	5-10	15	5-10	20-30	10	"	Sorted - fine. 3% leucocratic accessories.
71	20-30	Tr.	5	20	5-10	30	10	"	Sorted - fine to medium. 3% leucocratic accessories.
72	20-30	1	5	20	5-10	30-40	3-5	"	Sorted - fine to medium. 3% leucocratic accessories.
73	5-10	30	5	10	L 5	5	35	Local till	Pyrite pseudomorphs of wood.
74	5	30-40	5	10	L 3	L 5	35	"	Coarse pyrite. Hornblende cuttings.
75	10-20	10-15	5-10	10	5	15	25	"	Coarse pyrite and siderite. Trace kyanite.
76	L 5	10-20	3-5	L 5	L 3	L 5	60-70	"	Coarse pyrite. Fine siderite. Pyrite/white carbonate aggregates (pseudomorphs of wood).

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-02-77	5	20	3-5	5	L 3	L 5	60	Local till	Coarse delicate pyrite (pseudomorphs of wood). Fine siderite. Difference in size of pyrite & siderite may reflect source.
78	15	5-10	3-5	5	L 3	3-5	50	"	Pyrite pseudomorphs of wood. Trace kyanite.
79	5	20	3-5	3-5	L 3	L 5	40-50	"	Pyrite/carbonate aggregates (pseudomorphs of wood). Trace kyanite.
80	L 3	50-60	L 5	L 5	-	-	40	Bedrock	Bimodal - medium pyrite. Fine siderite.
OEC-81-03-82	20	-	5	20-30	10	20-30	Tr.	Foreign sand	Well sorted - very fine. 5% leucocratic accessories.
83	20	-	5-10	10-20	10	30-40	2	"	Fine. 3% leucocratic accessories.
84	20	-	10	5	20-30	20	2	Foreign till	5% leucocratic accessories.
85	30	-	5-10	10	10-20	20-30	5	"	
86	40	-	10	10	10-15	15-25	8	"	Coarse pyrite.
87	30-40	-	5-10	5-10	25-30	20-25	1	"	15% vitreous dark brown diopside/augite. *
88	25-30	2	5	10-15	10-15	25	8	"	
89	20-30	3	5	15	5-10	20	20	"	20% coarse cuttings (sandstone with pyrite cement).

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-03-90	30-40	2	5	15	5-10	20-30	10	Foreign till	
91	30	3	5-10	10-15	10-15	20-30	15	"	
92	25-30	3-5	5-10	20	5-10	20	15	"	
93	20-30	5-10	5-10	10	10-15	20	15	Local till	Coarser than above. Pyrite pseudomorphs of wood.
94	25	10-15	5	15	5-10	15-20	10	"	
95	20-30	10	10	15	10	20	10	"	
96	3	30	30	L 5	-	L 3	25	Bedrock	Bimodal - fine to medium grained with coarse pyrite. Pyrite pseudomorphs of wood. 2% zircon.
97	5-10	20	30-40	-	-	-	30-40	"	Bimodal - fine to medium grained with pyrite/lignite aggregates (pseudomorphs of wood).
98	L 3	30	30	-	-	-	-	"	Bimodal - fine to medium with 30% coarse cuttings (sandstone with pyrite cement).
101	-	10	40	-	-	-	2	"	Well sorted- medium to fine. 40% waxy brown rutile * 3% zircon.
102	5-10	15	25	-	-	-	50	"	3% rutile. Pyrite pseudomorphs of wood.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-03-104	10	5	5-10	-	-	-	70	Bedrock	3% rutile. Pyrite pseudomorphs of wood. Grey film on pyrite.
105	30	5	20	-	-	-	40-50	"	
107	L 5	L 5	15	-	-	-	-	"	Primarily cuttings (sandstone with pyrite cement). Hematite and siderite occur with sandstone.
108	L 3	-	L 3	-	-	-	98	"	Coarse pyrite pseudomorphs of wood.
111	L 3	L 3	L 5	-	-	-	95	"	As OEC-108.
112	L 3	10-15	10-15	-	-	-	75	"	As OEC-108. 20% sandstone with pyrite cement.
113	L 3	L 5	5	-	-	-	90	"	Pyrite/ligniteaggregates (pseudomorphs of wood).
114	10	L 2	15-20	-	-	-	70	"	Pyrite pseudomorphs of wood. 10% sandstone with pyrite cement. L 2% zircon.
OEC-81-04-117	50	-	5	10	5-10	15	3	Foreign till	
120	50	-	5-10	10-20	5-10	15-20	5	"	
121	50	-	5-10	5-10	5-10	15	5	"	Coarse pyrite with iron oxide film. Trace pyrrhotite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-04-122	50-60	1	10	5	5-10	15	3	Foreign till	Coarse pyrite as OEC-121.
123	20-30	20	5-10	10	5-10	20-25	5	Local till	Pyrite pseudomorphs of wood. Rare trace chalcopyrite.
124	20-30	20-30	5-10	5-10	5-10	20	8	"	
125	5-10	50-60	20	L 3	L 3	L 5	20	"	Pyrite pseudomorphs of wood. 3% sandstone with pyrite cement. Rare trace chalcopyrite.
126	L 5	80	5	L 5	L 3	L 3	8	Local gravel	Poorly sorted. Rounded siderite.
129	20	20-25	10-15	5-10	5-10	15	15	Local till	Trace pyrite with calcite. Rare trace staurolite.
130	20	30	5-10	5-10	10	20	12	"	Pyrite pseudomorphs of wood. 1% amber garnet. Trace staurolite.
131	15	40	15	L 5	5	10-15	15	"	Pyrite pseudomorphs of wood. Rare trace kyanite.
132	15	30	10	L 5	5	15	15	"	Pyrite pseudomorphs of wood. Sandstone with pyrite cement.
133	5-10	70	5-10	L 5	L 3	L 5	8	"	Coarse siderite cuttings. 0.1% staurolite.
134	3	70-80	5-10	L 5	L 5	L 5	15	"	Pyrite pseudomorphs of wood.
135	3	70	5	5	L 5	5	10	"	Pyrite pseudomorphs of wood. Trace kyanite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-04-136	L 5	50	L 5	-	-	-	45	Local sand/ gravel	Pyrite pseudomorphs of wood.
137	L 5	90	3	-	-	L 5	5	"	Poorly sorted - coarse.
138	L 5	25	L 5	-	-	-	70	"	Pyrite pseudomorphs of wood and pyrite as clusters of fine crystals Trace composite pyrite siderite grains.
139	L 3	30	L 3	-	-	-	70	Bedrock	Delicate pyrite (pseudomorphs of wood).
140	-	L 5	20	-	-	-	60	"	Bimodal. 20% coarse cuttings (sandstone with crystalline pyrite cement). 15% leucocratic accessories- mainly zircon.
143	L 5	-	L 5	-	-	-	95	"	Pyrite pseudomorphs of wood. 10% sandstone with pyrite cement.
145	30	-	5	15	10	20-30	1	Foreign sand	Sorted - very fine. Composition indicates sample labelled incorrectly. Should be an upper sample in OEC-05 not a bedrock sample in OEC-04.
OEC-81-05-150	30	-	5	15	10	30	3	"	Sorted- fine. Trace pyrrhotite.
152	30	3	5	L 5	20	15	3	Foreign till	3% green pyroxene/ilmenite aggregates. 15% ilmenite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-05-152 continued									15% brown hypersthene Trace sphene.
153	35	5	10	10	5-10	20	5	Foreign till	
154	50-60	3-5	10-15	3-5	5	15	5	"	Pyrite pseudomorphs of wood.
155	5	-	45	-	-	-	45	Local till	Pyrite pseudomorphs of wood and pyrite in clusters of fine crystals. 3% rutile. 3% leucocratic accessories.
156	3	-	35	-	-	-	60	"	5% leucocratic accessories (primarily zircon). 3% rutile.
157	5	-	40	-	-	-	35	Bedrock	Pyrite pseudomorphs of wood. 5% leucocratic accessories (primarily zircon). 15% rutile.
158	15-20	1	40	-	-	-	20	"	Pyrrhotite in magnetic split. Pyrite pseudomorphs of wood. 3% leucocratic accessories (primarily zircon). 15% rutile.
159	10-15	10-20	30-40	-	-	-	20	"	Pyrite pseudomorphs of wood. Bimodal - pyrite coarse. 5% leucocratic accessories (primarily zircon). 10-20% rutile.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-05-160	5	3	20	-	-	-	60	Bedrock	Poorly sorted. Delicate pyrite cuttings (pseudomorphs of wood). 3% leucocratic accessories (primarily zircon). 5% rutile.
161	L 5	50-60	20-30	-	-	-	15	"	Bimodal - coarse pyrite pseudomorphs of wood. 3% rutile.
163	L 5	15-20	50-60	-	-	-	12	"	Sorted - fine. 2% zircon. 5-10% rutile.
164	15	3-5	50	-	-	-	30	"	Poorly sorted. Pyrite as clusters of fine crystals. 2% zircon. 2% rutile.
165	5	15-20	35	-	-	-	35	"	Bimodal. Pyrite as clusters of fine crystals. Pyrite/quartz and pyrite/hematite aggregates. 5% rutile.
166	5	5	40	-	-	-	40	"	Pyrite pseudomorphs of wood and pyrite as clusters of fine crystals. Pyrite/hematite complexes. 2% zircon. 2% rutile.
167	5-10	2	10-15	-	-	-	70-80	"	Pyrite pseudomorphs of wood.
168	5-10	-	20-30	-	-	-	60-70	"	Pyrite as clusters of fine crystals. Pyrite/hematite aggregates.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDCTE	PYRITE		
OEC-81-05-169	L 5	-	20-30	-	-	-	60-70	Bedrock	10% pyrite as clusters of fine crystals. Pyrite pseudomorphs of wood. 20% sandstone with pyrite cement. 2% rutile.
OEC-81-06-170	60	2	10-15	5	5	10-15	3	Foreign sand/ gravel	Poorly sorted - fine.
171	30-40	30-40	10	L 5	5	10	3	Foreign till	5% pyrrhotite in magnetic split.
172	40	-	10	L 5	5	10-15	2	"	Boulder cuttings. 5-10% red garnet cuttings. 3% idocrase. 0.1% molybdenite.
173	50	-	5-10	L 5	10	15	2	"	5% sandstone with magnetite. 1% idocrase.
174	30	3	5	5	5-10	20-30	8	"	Coarse cuttings. 5% sphene. Trace idocrase. Pyrite with calcite film.
175	40	5-10	5	5-10	5-10	15-20	8	Local till	1% sphene.
176	10	40	10	5-10	L 5	5-10	20	"	7-10% ilmenite.
177								Bedrock	Primarily cuttings (pyrite/calcite aggregates).
178								"	As OEC-177

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-06-179								Bedrock	As OEC-177
OEC-81-07-183	30	-	10-15	5-10	10-15	20-30	3	Foreign till	Trace black garnet. Trace idocrase.
184	30	-	5-10	10	10-15	20-30	5	"	Garnet rounded.
185	30	-	5	5-10	15-20	40	8	"	Trace zircon.
186	30-40	Tr.	5-10	3-5	10	20	20	"	Poorly sorted - coarse.
187	50	Tr.	5-10	5	5-10	15-20	8	"	
188	40-50	1	5	10	10	15-20	8	"	3% sandstone with pyrite cement.
189	20-30	-	5	5	10	20-30	15	"	3% ilmenite. Trace kyanite.
190	20-30	1	10	5	10	15-20	35	Local till	Coarse pyrite. Trace kyanite. 3% red garnet (grossularite). *
191	15-20	20-30	15	3-5	L 5	5	30	"	Trace kyanite. 3% grossularite.
192	10	20-30	10	3-5	L 5	3-5	35	"	Coarse pyrite. Trace kyanite. 10% sandstone with pyrite cement.
193	10-15	35	5-10	3-5	L 5	3-5	30	"	Trace kyanite.
194	15-20	20-30	5	5	5	10	20	"	Trace kyanite. 3% grossularite.
195	15	30	5	5	L 5	10	25	"	5% pyrite pseudomorphs of wood. 5% sandstone with pyrite cement. 0.1% kyanite. 3% grossularite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-07-196	5-10	40	5	3	L 5	3	40	Local till	0.1% kyanite. Trace sphene.
197	5-10	35	3	5	L 5	3	45	"	Trace kyanite. 3% grossularite.
198	20	50-60	3	-	-	-	20	"	Garnet well rounded and pitted. Crystalline pyrite. 5 - 10% grossularite.
OEC-81-08-204	60	-	5	5-10	10	15	2	Foreign till	
205	60	-	5	10	10	15	3	"	
206	60	-	5-10	5-10	10-15	15	3	"	
207	15-20	-	5	5-10	50	10-15	3	"	Trace sphene. 3% ilmenite.
208	10	10	30	5-10	10	10	10	Local till	Coarse hematite and hematite/quartz cuttings. 15% "hitchhiking" light minerals. 0.5% pyrrhotite.
209	5	30-40	3-5	3-5	L 5	3	35	"	10% sandstone with pyrite cement.
210	5	40-50	L 5	L 5	L 5	L 5	25	"	Trace kyanite. 3% grossularite.
211	10	30	5-10	5	L 5	15	20	"	3% pyrite pseudomorphs of wood. 3% sandstone with pyrite cement. 0.1% kyanite.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-09-214	20-30	1	10	10	20	20	2	Foreign till	3% black garnet. 3% vitreous brown augite/diopside* Trace barite.
215	20	-	10	5	10-20	20	0.5	"	3-5% black garnet. 3% vitreous brown augite/diopside.
216	60	2	15	3-5	5-10	15-20	3	"	Coarser than above.
217	30-40	2	5	L 5	10-15	20	8	"	5% "hitchhiking" light minerals.
218	15	35	5	5	5	15	10	Local sand/ gravel	Poorly sorted. 0.1% kyanite.
219	10	50	5-10	5	L 5	10	8	"	Well sorted - fine to medium. 2% kyanite. 1% grossularite. Trace staurolite.
220	5	60-70	5	5	L 5	3	15	Local till	5% sandstone with pyrite cement. 3% ilmenite. 0.1% kyanite. 1% grossularite.
221	L 2	L 2	-	-	-	L 5	-	Bedrock	Primarily cuttings (sandstone with pyrite cement). 3% ilmenite with cuttings.
222	L 1	90	-	-	-	L 2	8	"	2% ilmenite.
225	-	45	-	-	-	5	-	"	45% sandstone as OEC-221.
226	-	3	-	-	-	3	-	"	Primarily sandstone as OEC-221. 5% ilmenite. 1% zircon. 5% pyrite pseudomorphs of wood.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-09-227	1	60	-	-	-	2	10	Bedrock	Sorted - fine. 20% ilmenite. 3-5% pyrite pseudomorphs of wood. 3% rutile. 1% kyanite.
OEC-81-10-242	50	1	5-10	3-5	10	20	3	Foreign till	Trace
243	60	-	5	3	5	10	3	"	Trace chalcophyrite. 3% vitreous brown pyroxene.
244	60-70	-	5	3	5	10	2	Foreign sand/ gravel	Poorly sorted. 1% vitreous brown pyroxene.
245	60	1	5	5-8	5	10	8	"	Poorly sorted. 1% vitreous brown pyroxene.
246	60	3	3-5	3-5	5	15	10	"	Well sorted - medium. 2% vitreous brown pyroxene.
247	50	3	L 5	L 5	L 5	3-5	35	"	Sorted - medium. 1% vitreous brown pyroxene. Magnetic split contains magnetite with oölitic pyrite film.
248	60	3	3-5	L 5	5	5-10	10	"	Sorted - medium. Oölitic pyrite as OEC-247.
249	5	60-70	L 5	L 5	L 5	L 5	15	Local till	

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-11-254	20	5	10-15	L 5	L 5	15	25	Local till	Coarse cuttings (sandstone with pyrite cement). 0.5% kyanite. 5% "hitchhiking" light minerals. 3% grossularite.
255	15	30	10	L 5	15	15	10	"	Pyrite pseudomorphs of wood. Trace kyanite.
256	15	20-30	10	5-10	10-15	20	15	"	5% pyrite pseudomorphs of wood.
257	15	30	5	L 5	L 5	5	35	Local gravel	Sorted - coarse. 5% sandstone with pyrite cement.
258	15-20	5	15	3-5	10	25	15	Local till	3% oölitic pyrite. Trace kyanite. 3% vitreous brown augite/diopside. 3% grossularite.
OEC-81-12-259	30-40	3-5	10	5	5-10	20	5	Foreign till	
260	30-40	3	10	5-10	10	20-30	3	"	Trace kyanite.
261	40	3-5	10	5	10-15	20	8	"	
262	30	5-10	10	5	5-10	15	10	Local till	3% pyrite pseudomorphs of wood. 3% sandstone with pyrite cement. Trace kyanite.
263	20-30	10	5-10	5-10	5	10-15	25	"	Coarse pyrite. Trace kyanite.
264	2	10-15	10-15	-	-	-	70	Bedrock	Sorted - medium. Pyrite/quartz aggregates. Trace rutile.

SAMPLE	VOLUME %							STRATIGRAPHIC HORIZON	REMARKS
	GARNET	SIDERITE	HEMATITE	HORNBLENDE	PYROXENE	EPIDOTE	PYRITE		
OEC-81-12-265	-	-	-	-	-	-	-	Bedrock	Primarily cuttings (sandstone with pyrite cement and 1-3% hematite/ ilmenite.)
266	-	-	-	-	-	-	-	"	Cuttings as OEC-265.
267	2	-	-	-	-	-	-	"	Cuttings as OEC-265.
268	2	-	-	-	-	-	-	"	Cuttings as OEC-265. Trace zircon.
269	-	0.5	-	-	-	-	97	"	Poorly sorted. Pyrite as clusters of fine crystals 2% ilmenite.

MINERAL	SPECIFIC GRAVITY	COLOUR	REMARKS
Garnet	3.5 - 4.3	Pink	Primarily pink almandite with minor red grossularite and black andradite. Derived from Archean granites, volcanics and sediments north-east of the drill area.
Siderite	4.0	Brown	Earthy, non-crystalline. Derived primarily from the Cretaceous and Devonian rocks.
Hematite	5.3	Grey-black	Derived from Archean granite, volcanics and sediments north-east of the drill area and the Cretaceous and Devonian rocks.
Hornblende	3.0 - 3.4	Black to dark green	Derived from Archean granites, volcanics and sediments north-east of the drill area.
Epidote	3.3 - 3.5	Pistachio-green Grey-green	Derived from Archean granites, volcanics and sediments north-east of the drill area.
Pyroxene	3.2 - 3.6	Brown to dark green	Derived from Archean granites, volcanics and sediments north-east of the drill area.
Pyrite	5.0	Brass yellow	Fresh. Crystalline pyrite derived from Archean granites, volcanics and sediments north-east of the drill area. Sandstone with pyrite cement, pyrite pseudomorphs of wood and clusters of fine crystals derived from the Cretaceous and Devonian rocks.
Ilmenite	4.7	Black	Derived from the Cretaceous and Devonian rocks.
Rutile	4.2	Brown to beige	Waxy, earthy. Derived from the Cretaceous and Devonian rocks.
Zircon	4.7	Colourless to brown	Stubby crystals. Derived in part from the Cretaceous and Devonian rocks.

Table 2 - Descriptions of the Common Heavy Minerals

MINERAL	SPECIFIC GRAVITY	COLOUR	REMARKS
Staurolite	3.7	Red-brown	Dull,earthy. Most likely derived from Archean granites, volcanics and sediments north-east of the drill area.
Kyanite	3.6	Colourless	Fine crystals. Most likely derived from Archean granites, volcanics and sediments north-east of the drill area.

Table 2 - Descriptions of the Common Heavy Minerals

APPENDIX V

PALYNOLOGICAL REPORT

PALYNOLOGICAL REPORT ON SAMPLES COLLECTED FROM CORES FROM HOLES OEC-81-05 AND OEC-81-11

by Armando Fasola

ABSTRACT

Palynological analysis of cored samples obtained from hole OEC-81-05 between the depths of 71.39 and 86.05 m, and from hole OEC-81-11 between the depths of 75.30 and 85.07 m indicate an Upper Devonian age for the samples in both holes.

INTRODUCTION

Palynological assemblages from twelve samples obtained from cores in the holes OEC-81-05 and OEC-81-11 were studied in order to determine an age for the sediments involved. The samples were collected above and below the 82 metre deep geophysical marker in both holes, since it was suggested that the marker could indicate the boundary between the Devonian sediments below and the Cretaceous sediments above. Figures 1 and 2 show the location of the samples on the hole logs; their actual depths in the holes in metres is as follows:

hole OEC-81-05	hole OEC-81-11
71.39 m	75.30 m
73.68 m	77.76 m
77.25 m	80.28 m
80.53 m	81.38 m
82.91 m	83.77 m
86.05 m	85.07 m

The processed samples were dark-grey shales, most of them non-calcareous; only samples OEC-81-05 82.91 m and OEC-81-11 77.76 m and 81.38 m were slightly calcareous. All the twelve samples yielded palynomorphs.

METHODS

The procedure followed for the recovery of the palynomorphs from these samples was the standard in palynological research which includes the disaggregation of the sample, the elimination by acids of the mineral part, and the recovery and mounting of the acid-insoluble residue (palynomorphs and other organic debris) for eventual study under the microscope. A summary of the method used follows:

Five to 6 grams of the sample were crushed with mortar and pestle into small pieces of uniform size. The crushed sample was then treated with HCl, followed by treatment with hot HF for 3 to 4 hours, until the minerals were dissolved. The organic rich residue thus obtained was then treated with Schulze Solution, an oxidant solution formed by HNO_3 and $KClO_3$; K_2CO_3 was used for the elimination of the oxided, soluble organic compounds. Following sieving of the residue through a 20 microns mesh, and staining with Safranin, 3 slides from each sample were prepared for subsequent study.

RESULTS AND DISCUSSION

(a) OEC-81-05.

The stratigraphic distribution of the species in the sampled interval is shown in Fig. 3, where an M before the species name indicates a microplankton element.

Following there is a list of the spores (palynomorphs produced by terrestrial plants) and microplankton elements (palynomorphs of marine origin, namely acritarchs and tasmanitids) which have been identified in the samples from this hole; the species with a + sign also occur in hole OEC-81-11.

Spores:

+Apiculiretusispora nitida
A. plicata
+Calamospora atava
Cyclogranisporites amplus
Dibolisporites echinaceus
D. eifeliensis
+D. cf. D. quebecensis
Divietipollis robusta
+Geminospora plicata
+Hymenozonotriletes denticulatus
Hystrichosporites gravis
+Leiotriletes microdeltoidus
Perotriletes minor

Retusotriletes dubiosus
+R. pychovii
+Rhabdosporites micropaxillus

Microplankton:

+Goniosphaeridium sp.
Gorgonisphaeridium evexispinosum
+G. sp.
+Leiosphaeridia sp.
+Lophosphaeridium sp.
+Multiplicisphaeridium amitum
+M. anastomosis
+M. trunculum
+Solisphaeridium apodasmion
S. spinoglobosum
Stellinium comptum
+S. micropolygonale
+Tasmanites spp.
+Unellium piriforme
+Veryhachium downiei

(b) OEC-81-11.

The stratigraphic distribution of the species in the sampled interval is shown in Fig. 4, where an M before the species name indicates a microplankton element.

The spores and microplankton elements identified in the samples from this hole are listed below; the species with a + sign also occur in hole OEC-81-05.

Spores:

Apiculiretusispora gaspiensis
+A. nitida
+Calamospora atava
+Dibolisporites cf. D. quebecensis
Emphanisporites rotatus
+Geminospora plicata
G. svalbardiae
+Hymenozonotriletes denticulatus
Leiotriletes confertus
+L. microdeltoidus
+Retusotriletes pychovii
+Rhabdosporites micropaxillus

Microplankton:

Cymatiosphaera labyrinthica
+Goniosphaeridium sp.
Gorgonisphaeridium ohioense
+G. sp.
+Leiosphaeridia sp.
+Lophosphaeridium sp.
Micrhystridium adductum
M. crassiechinatum
+Multiplicisphaeridium amitum
+M. anastomosis
+M. trunculum
+Solisphaeridium apodasmion
+Stellinium micropolygonale
+Tasmanites spp.
Unellium cornutum
+U. piriforme
+Veryhachium downiei

The palynologic assemblages of the intervals 71.39 m to 86.05 m in hole OEC-81-05, and 75.30 m to 85.07 m in hole OEC081-11 suggest a close correlation of the two sequences because of the similarity (of the assemblages) measured in the number of species in common. The following discussion of age for the intervals involved then applies similarly to both holes.

Microplankton species present in the samples and which have been reported from Frasnian and Famennian (Upper Devonian) sediments in North America and Europe are Cymatiosphaera labyrinthica, Gorgonisphaeridium evexispinosum, G. ohioense, Multiplicisphaeridium amitum, M. anastomosis, M. trunculum, Unellium piriforme, and Solisphaeridum apodasmion; S. spinoglobosum and Stellinium micropolygonale have a longer range which includes the Upper Devonian nevertheless. The rest of the species are known from Devonian deposits elsewhere.

Although there are species with long ranges in the assemblages, such as Veryhachium downiei, most have been reported up to now only from the Devonian; further, only from Frasnian-Famennian strata in North America. The microplankton then suggests an Upper Devonian (Frasnian-Famennian) age for the intervals.

Among the species of spores present in these intervals, the following have been previously reported from Devonian sequences in the indicated areas: Dibolisporites cf. D. quebecensis from Lower and Middle Devonian in N. America; Hystrichosporites gravis and Rhabdosporites micropaxillus from late Middle and early Upper Devonian (Frasnian) in the N.W. Territories; Apiculiretusispora nitida, A. plicata, Geminospora plicata, and Leiotriletes microdeltoidus from U. Devonian (Frasnian) in the N.W.T. and the Arctic; Hymenozonotriletes denticulatus and Retusotrletes pychovii from the U. Devonian (Famennian) in the N.W.T. and Ontario.

The spores, then, seem to suggest an Upper Devonian age, perhaps Frasnian, for the intervals studied; this being in agreement with the age suggested by the microplankton.

Most of the spores, acritarchs and tasmanitids present in the samples studied are in good state of preservation, not being destroyed or degraded. They seem to be indicating a site of deposition near the place of origin; reworking of the material into these shales is excluded.

All the spores and microplankton species of these samples are Devonian in age; no evidences of Cretaceous or other post-Devonian palynomorphs were found.

Since the palynologic assemblages above the 82 m marker horizon do not contain Cretaceous or other post-Devonian palynomorphs, and since the Devonian assemblages above and below the 82 m marker do not show signs of reworking, being instead similar in content and state of preservation, it is concluded that the intervals analyzed in both holes are entirely Devonian.

		depth (in metres)					
		86.05	82.91	80.53	77.25	73.68	71.39
M	Veryhachium downiei	+	+	+	+	+	+
M	Leiosphaeridia sp.	+	+	+	+	+	+
M	Tasmanites spp.	+	+	+	+	+	+
	Divietipellis robusta						+
M	Stellinium comptum						+
	Rhabdosporites micropaxillus	+	+	+	+	+	+
M	Multiplicisphaeridium trunculum	+		+		+	
M	Unellium piriforme					+	
M	Gorgonisphaeridium evexispinosum					+	
	Dibolisporites cf. quebecensis	+	+	+	+	+	
	Apiculiretusispora nitida	+		+	+	+	
M	Stellinium micropolygonale					+	
	Geminospora plicata	+				+	
M	Multiplicisphaeridium amitum	+				+	
	Retusotriletes pychovii	+	+		+	+	
	Leiotriletes microdeltoidus			+	+	+	
	Calamospora atava	+	+	+	+	+	
	Hymenozonotriletes denticulatus	+				+	
M	Solisphaeridium apodasmion					+	
	Cyclogranisporites amplus				+	+	
M	Gorgonisphaeridium sp.	+		+	+	+	
	Hystrichosporites gravis					+	
	Perotriletes minor				+		
M	Multiplicisphaeridium anastomosis			+			
M	Solisphaeridium spinoglobosum			+			
	Dibolisporites echinaceus			+			
	Apiculiretusispora plicata		+				
M	Goniosphaeridium sp.		+				
M	Lophosphaeridium sp.		+				
	Retusotriletes dubiosus	+					
	Dibolisporites eifeliensis	+					

Fig. 3. Distribution of palynomorphs in hole OEC-81-05

		depth (in metres)					
		85.07	83.77	81.38	80.28	77.76	75.30
M	Veryhachium downiei	+	+	+	+	+	+
M	Leiosphaeridia sp.	+	+	+	+	+	+
M	Tasmanites spp.	+	+	+	+	+	+
	Leiotriletes confertus						+
M	Multiplicisphaeridium trunculum	+	+				+
M	Unellium piriforme		+	+		+	+
M	Micrhystridium crassiechinatum						+
M	Cymatiosphaera labyrinthica						+
M	Micrhystridium adductum						+
	Hymenozonotriletes denticulatus	+		+	+		+
M	Multiplicisphaeridium amitum						+
M	Stellinium micropolygonale						+
M	Solisphaeridium apodasmion					+	
	Retusotriletes pychovii	+	+			+	
	Rhabdosporites micropaxillus	+	+	+		+	
	Geminospora svalbardiae					+	
	Dibolisporites cf. quebecensis	+	+	+		+	
M	Gorgonisphaeridium sp.	+	+	+		+	
M	Lophosphoridium sp.				+		
	Apiculiretusispora gaspiensis				+		
M	Tasmanites sp.				+		
	Emphanisporites rotatus		+				
	Apiculiretusispora nitida	+	+				
M	Gorgonisphaeridium ohioense		+				
M	Unellium cornutum		+				
M	Multiplicisphaeridium anastomosis		+				
	Geminospora plicata	+					
	Leiotriletes microdeltoides	+					
	Calamospora atava	+					
M	Goniosphaeridium sp.	+					

Fig. 4. Distribution of palynomorphs in hole OEC-81-11

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PALYNOLOGICAL CONTENT OF 3 SAMPLES FROM A LIGNITE SEAM AND SEAT EARTH IN CORED DRILL HOLE OEC-81-12

by Armando Fasola

ABSTRACT

Two lignite samples and one seat earth sample from hole OEC-81-12 yielded 30 species of terrestrial palynomorphs which suggest an Albian age for the sequence.

INTRODUCTION

Two samples from a lignite seam and one sample from the seat earth underneath the seam in cored drill hole OEC-81-12 were analyzed in order to determine their palynological content.

The depth of the samples is as follows:

185 feet	lignite
188 feet	lignite
190.5 feet	dark-grey shale

The lignite samples were prepared using the Schulze solution - K_2CO_3 technique followed by staining, sieving in 20 micron mesh sieves, and mounting on slides for microscopic study. The shale sample was prepared using the standard HF - HCl - Schulze solution - K_2CO_3 technique followed by staining, sieving in 20 micron mesh sieves, and mounting on slides.

RESULTS AND DISCUSSION

The three samples yielded abundant palynomorphs of exclusive terrestrial origin: briophyte and pteridophyte spores and gymnospermic pollen; angiospermic pollen, however, was not present in the assemblages.

The assemblages in the three samples are composed of the same species, although there are slight variations in their proportions from sample to sample.

The species identified in these samples are:

spores:

Appendicisporites potomacensis
Baculatisporites comaumensis
Biretisporites potoniaei
Cicatricosisporites australiensis
Cingutriletes clavus
Cyathidites australis
Cyathidites minor
Deltoidospora hallei
Gleicheniidites senonicus
Impardecispora apiverrucata
Laevigatosporites ovatus
Osmundacidites wellmanii
Stereisporites antiquasporites
Verrucosisporites sp.

gymnospermic pollen:

Alisporites bilateralis
Alisporites grandis
Araucariacites australis
Cerebropollenites mesozoicus
Classopolis torosus
Eucommiidites minor
Eucommiidites troedssonii
Ginkgocycadophytus nitidus
Parvisaccites radiatus
Perinopollenites elatoides
Phyllocladidites microreticulatus
Pityosporites alatipollenites
Pityosporites constrictus
Podocarpidites multesimus
Taxodiaceaepollenites hiatus
Vitreisporites pallidus

These assemblages are Albian, by comparison with other spores and pollen assemblages described from the Atlantic Coastal Plain, Alberta, and western and northern Canada. Further, they are evidently similar to assemblages identified in the Moose River Basin by Legault and Norris (1982) and which are believed to be early middle Albian in age.

APPENDIX VI

MICROPALEONTOLOGY — CONODONT REPORT

Royal Ontario Museum

100 Queen's Park
Toronto, Ontario
Canada M5S 2C6
Cables: ROMA Toronto

ROM

416:978-4059

February 19th, 1982

Watts, Griffis and McQuat Limited,
Suite 911,
159 Bay Street,
Toronto, Ontario
M5J 1J7

Attention: Dr. Bob Griffis

MICROPALAEONTOLOGICAL REPORT ON PORTIONS OF HOLES
OEC-81-11 and OEC-81-05, JAMES BAY LOWLANDS.

Portions of Hole OEC-81-11 sampled as six samples labelled A-F and taken in relatively unconsolidated green siltstone in the interval requested by A. Stradling.

A 280'1" to 278'3"
B 278'3" to 276'4"
C 276'4" to 274'11"
D 274'11" to 273'2.5"
E 273'2.5" to 271'6"
F 271'6" to 270'

Portions of Hole OEC-81-05 sampled as nine samples labelled as G-O and taken in relatively unconsolidatedgrey to green siltstone in the interval requested by A. Stradling.

G 284' to 282'8"
H 282'8" to 280'9"
I 280'9" to 279'
J 279' to 277'8.5"
K 277'8.5" to 275'11"
L 275'11" to 274'1.5"
M 274'1.5" to 273'3.5"
N 273'3.5" to 271'4.5"
O 271'4.5" to 269'8.5"

N.B. Note that the footages are taken from the core boxes and are apparently at variance with those given on the graphic logs.

... over

All fifteen samples contained abundant marine fauna in the form of conodonts belonging to species of Palmatolepis, Polygnathus and rarely Polylophodonta associated with abundant, less diagnostic nonplatform conodonts.

The abundance, the glassy unaltered preservation, and the taxonomy of the conodonts indicates an Upper Devonian age for the sediments and their contained fauna. (Species of Palmatolepis were found in all fifteen samples. Species of this genus are restricted to the Upper Devonian). Only in sample H was there any indication of alteration, an overall whitening of the normally transparent conodonts; however, this was not severe enough to be considered indicative of reworking into younger strata. Similarly rounding of conodonts was not observed; again indicating that reworking into younger strata has not taken place.

No microfossils indicative of a younger age were recovered.

I conclude that the portion of the cores examined are below the Devonian-Cretaceous Boundary in the Upper Devonian and that the boundary picked on geophysical criteria is incorrect.

P. H. von Bitter,
Curator in Charge,
Department of Invertebrate Palaeontology,
Royal Ontario Museum.

Associate Professor,
Department of Geology,
University of Toronto.

2 Core boxes of partially quartered core may be picked up from our laboratory at your convenience; please phone 978-4370 or 4059 to advise when you will pick them up.

APPENDIX VII

ANALYSES OF SAND AND CLAY SAMPLES

ONTARIO RESEARCH
FOUNDATION

SHERIDAN PARK RESEARCH COMMUNITY
MISSISSAUGA, ONTARIO, CANADA L5K 1B3 • (416) 822-4111 • TELEX 06-982311

DEPARTMENT OF MATERIALS CHEMISTRY

THE ANALYSIS OF TWO SILICA SAND SAMPLES, TWENTY CLAY SAMPLES AND ONE WATER SAMPLE FROM NORTHERN ONTARIO

Industrial Minerals Services
Report No. 82-63421

I.H. Joyce
March 15, 1982

for

Watts, Griffis & McOuat Ltd.
Suite 911, 159 Bay Street
Toronto, Ontario
M5J 1J7

Attention: Dr. R. Griffis

1. INTRODUCTION

Mr. A. Stradling of Watts, Griffis and McOuat Ltd. submitted two silica sand samples, 20 clay samples and one water sample to the Ontario Research Foundation for analysis as follows:

Two silica sand samples	- chemical analysis and sieve analysis
All 20 clay samples	- wet sieve analysis, differential thermal analysis and fired color tests
Three selected clay samples	- Chemical analysis and particle size analysis
Water sample	- Chemical analysis as considered suitable

2. SAMPLE IDENTIFICATION

All of the samples received were identified by a coding system devised by Watts, Griffis and McOuat Ltd. The samples were identified as follows:

Silica sand samples	- #81-04-68
	#81-05-56
Clay Samples	- #81-02, 81
	81-03, 46m
	81-03, 65
	81-03, 67.1
	81-03, 74
	81-03, 75.9
	81-04, 66
	81-04, 69.2
	81-04, 70.6
	81-04, 80.5
	81-05, 162

Clay Samples - #81-07, 57
81-07, 63
81-08, 212 dupl.
81-09, 56
81-09, 65
81-09, 224
81-10, 250
81-10, 252
81-11 235.6

Water Sample - Mattagami River Sample, Morrow Twp.

3. EXPERIMENTAL WORK

3.1 Silica Sand Samples

The "as received" samples were air dried and split into representative samples for analysis by means of a riffle (sample splitter). The representative samples obtained were submitted for chemical analysis and dry screen analysis. The results obtained are shown in Tables I and II.

3.2 Clay Samples

The majority of the clay samples were in a soft sticky condition when received; they were left to air dry under ambient conditions and lightly ground by mortar and pestle to a free-flowing powder form for analysis. Representative samples were prepared for analysis by sample-splitting in a riffle.

A sample of each clay was subjected to a wet screen analysis, (to determine the percentage of material plus 325 mesh), a fired-color test at $1050^{\circ}C$ (after soaking at temperature for two hours) and to differential thermal analysis (to indicate presence of organic impurities and other mineral impurities).

The results of the wet screen analysis and the fired color tests are shown in Table III. The differential thermal analysis charts are shown in Figures 1 to 20.

The following samples were selected for more detailed particle size analysis and chemical analysis:

Nos. 81-03-46
81-03-75.9
81-04-69.2

The samples were chosen on the basis of physical appearance and fired color as being typical of the variety of materials supplied.

The chemical analysis data obtained is shown in Table IV, while the particle size data is contained as a separate entity in Appendix I.

3.3 Water Sample

A small quantity of Mattagami River water was supplied for analysis. No instructions were given on the species for analysis, however, discussion with the analytical group at Ontario Research suggested that because of the limited quantity of water available, the following should be considered:

(a) Multi-Element Analysis including Cobalt, Zinc, Cadmium, Phosphorus Silicon Iron, Manganese, Calcium, Magnesium Copper, Aluminum, Lead, using D.C. plasma techniques.

(b) Total Organic Carbon by Beckman Carbon analyzer.

(c) Chloride, Sulphate, Fluoride, Nitrate and Phosphate by ion chromatography.

The results obtained are shown in Table V.

4. DISCUSSION OF RESULTS

4.1 Silica Sand Samples

4.1.1 The chemical analysis results indicate that the two silica sand samples are of 98.8% purity with approximately 0.5% of Alumina impurity. The only other impurities of any significance are the iron and titania components, which, if they are typical of other sands from the James Bay Lowlands, are jointly contained as a "ilmenite-type mineral". This material should be readily removed by magnetic separation or flotation if the deposit is to be exploited.

4.1.2 The sand samples are relatively fine compared to other sands from the area which generally contain large proportions of +20 mesh material. In these particular samples, the particles are predominantly contained in the size range -40 mesh +100 mesh.

4.2 Clay Samples

4.2.1 All of the clay samples appeared to be very plastic despite the fact that some of them contained high proportions of grit (probably sand). The samples containing high levels of grit were:

81-03-75.9
81-04-66
81-04-69.2
81-04-80.5
81-05-162
81-09-65
and 81-09-224

4.2.2 The firing tests would suggest that the majority of the materials were fire clay-type material, however, the light natural color and white fired color of samples:

81-03-46m
81-03-65
81-03-67.1
81-04-66
81-04-69.2
81-05-162

suggest the presence of large quantities of kaolinitic material.

4.2.3 Differential Thermal Analysis indicated the presence of large quantities of organic matter in samples:

81-02-81
81-03-74
81-03-75.9
81-04-30.5
81-09-56
81-09-65
81-09-224

and lesser quantities in samples:

81-04-69.2
81-07-63
81-08-212 dupl.

Some of these exothermic peaks were of sufficient strength that they masked any possible dehydroxylation endotherms at ∿570°C which might be attributed to the clay mineral.

The presence of Quartz was detected in samples:

81-03-46m
81-03-65
81-03-67.1
81-04-66
81-04-69.2
81-04-70.6
81-05-162

Sample No. 81-10-250 and No. 81-10-252 showed endotherms at ∿800°C possibly due to the presence of carbonates.

4.2.4 The chemical analysis data was typical of what would be expected of clays, the white clay Sample No. 81-03-46 exhibited lower impurity levels then the other two. Sample No. 81-03-75.9 exhibited high iron contents and high loss on ignition (due to the presence of large quantities of organic matter). Sample No. 81-04-69.2 exhibited medium levels of iron and increased levels of calcium-bearing minerals.

4.2.5 The particle size data on the three clay samples:

81-03-46m
81-03-75.9
81-04-69.2

indicate that the material is very fine as one would expect for a clay fraction; Sample No. 81-04-69.2 being the finest with an average particle size of 1.4 μ.

4.3 Water Sample

The chemical analysis data for the water sample gives only elemental or radical group analysis. The possible presence of active bacteria, etc. could not be evaluated due to the small volume of water supplied.

I.H. Joyce

Ivan H. Joyce
Assistant Director

E C Brown

Earle C. Brown, Director
Department of Materials Chemistry

/gb

TABLE I

CHEMICAL ANALYSIS DATA FOR TWO SILICA SAND SAMPLES

Sample	Sample #81-04-68	Sample #81-05-56
SiO_2	98.78%	98.86%
Al_2O_3	0.58%	0.41%
Fe_2O_3	0.12%	0.17%
TiO_2	0.14%	0.21%
CaO	0.059%	0.047%
MgO	0.020%	0.018%
K_2O	0.041%	0.075%
Na_2O	0.084%	0.050%
P_2O_5	0.023%	0.025%
LOI	0.45%	0.25%

TABLE II

DRY SCREEN ANALYSIS OF TWO SILICA SAND SAMPLES

Mesh	Sample #81-04-68	Sample #81-05-56
+10	0.1%	0.0%
-10 +20	0.5%	0.3%
-20 +30	1.1%	1.7%
-30 +40	3.3%	5.8%
-40 +50	18.7%	31.3%
-50 +60	22.4%	25.6%
-60 +70	17.4%	15.4%
-70 +80	11.3%	7.9%
-80 +100	16.9%	8.4%
-100 +120	4.8%	2.4%
-120 +140	1.6%	0.7%
-140 +200	1.1%	0.4%
-200	0.8%	0.3%
TOTAL	100.0%	100.2%

TABLE III

FIRED COLOR AT 1050°C AND WET SCREEN ANALYSIS DATA FOR TWENTY CLAY SAMPLES

Sample #	Natural Color	Fired Color at 1050°C	Wet Screen Analysis % +325 Mesh
81-02-81	Light grey	Red	3.61%
81-03-46m	Light brown/beige	White	2.91%
81-03-65	Off white/brown	White	3.02%
81-03-67.1	Yellow	Orange and white	5.82%
81-03-74	Grey	Red	3.56%
81-03-75.9	Black	Red	19.17%
81-04-66	Off white	White	67.27%
81-04-69.2	Off white/red	Beige	8.08%
81-04-70.6	Yellow/brown	Orange	0.12%
81-04-80.5	Brown/grey	Red	20.35%
81-05-162	Pinky grey	White	8.79%
81-07-57	Red/Salmon	Red	0.49%
81-07-63	Green/grey	Red	0.94%
81-08-212 Dupl.	Grey	Orange/red	4.33%
81-09-56	Green/grey	Brown	1.21%
81-09-65	Grey	Red	13.41%
81-09-224	Brown/black	Creamy-pink	51.05%
81-10-250	Rusty orange	Red	3.02%
81-10-252	Salmon	Cream-red streaks	6.78%
81-11-235.6	Light grey	Red	3.91%

TABLE IV

CHEMICAL ANALYSIS DATA OF THREE CLAY SAMPLES

Element	Sample #81-03-46	Sample #81-03-75.9	Sample #81-04-69.2
SiO_2	64.70%	56.64%	61.81%
Al_2O_3	18.97%	17.20%	19.86%
TiO_2	1.38	0.96	1.02
Fe_2O_3	2.26	7.06	5.55
MnO	1.014	0.037	0.036
CaO	1.26	1.61	2.03
MgO	0.55	3.22	1.42
K_2O	2.07	0.81	0.69
Na_2O	0.24	0.36	0.28
LOI	8.74	11.10	7.53

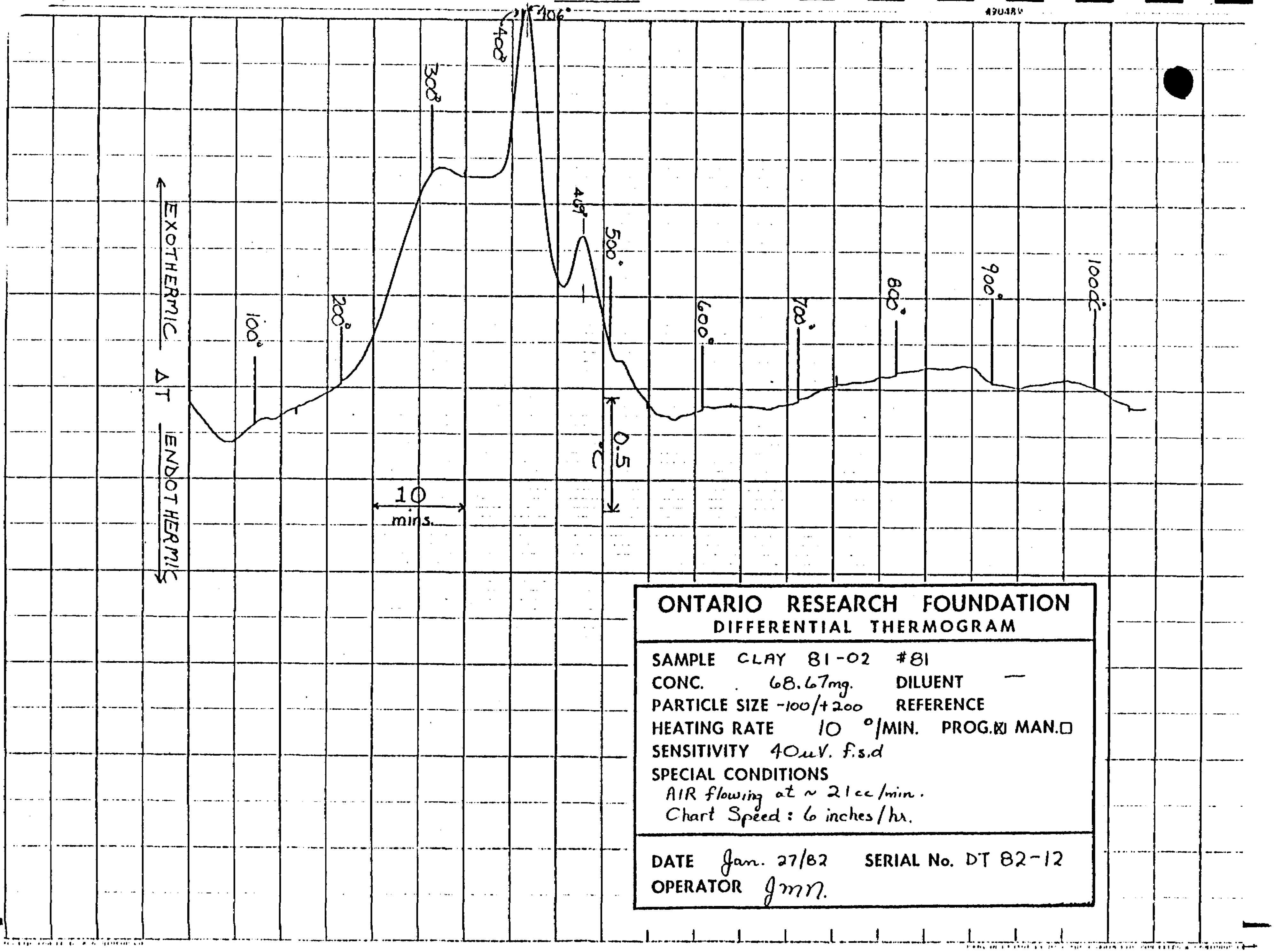
TABLE V

CHEMICAL ANALYSIS OF WATER

Element/Radical	Concentration (μg/mL Sample)
Cobalt	<0.05
Zinc	<0.05
Cadmium	<0.05
Phosphorus	<0.05
Silicon	1.6
Iron	0.10
Manganese	<0.05
Calcium	24
Magnesium	4.9
Copper	<0.05
Aluminum	0.07
Lead	<0.05
Nickel	<0.05
Chromium	<0.05
Sodium	3.0
TOC*	69
Chloride (Cl^-)	2.9
Sulphate ($SO_4^=$)	5.5
Fluoride (F^-)	0.1
Nitrite (NO_2^-)	<0.1
Phosphate ($PO_4^{\equiv}$)	<0.5
Nitrate (NO_3^-)	<0.1

*Total Organic Carbon

Fig 1

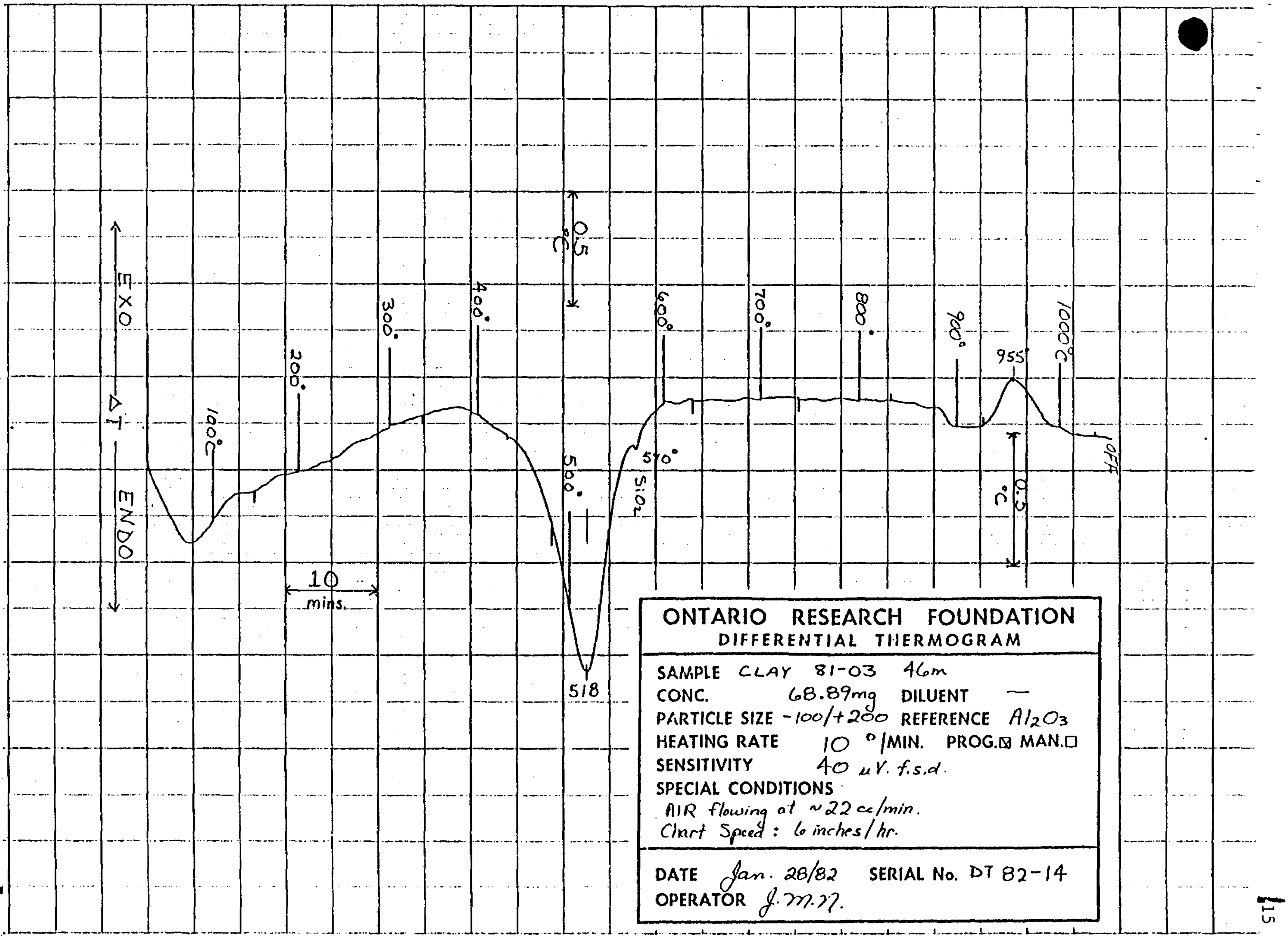


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-02 #81
CONC. 68.67mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40uV. f.s.d
SPECIAL CONDITIONS
AIR flowing at ~ 21cc/min.
Chart Speed: 6 inches/hr.

DATE Jan. 27/82 SERIAL No. DT 82-12
OPERATOR JMN.

Figure 2



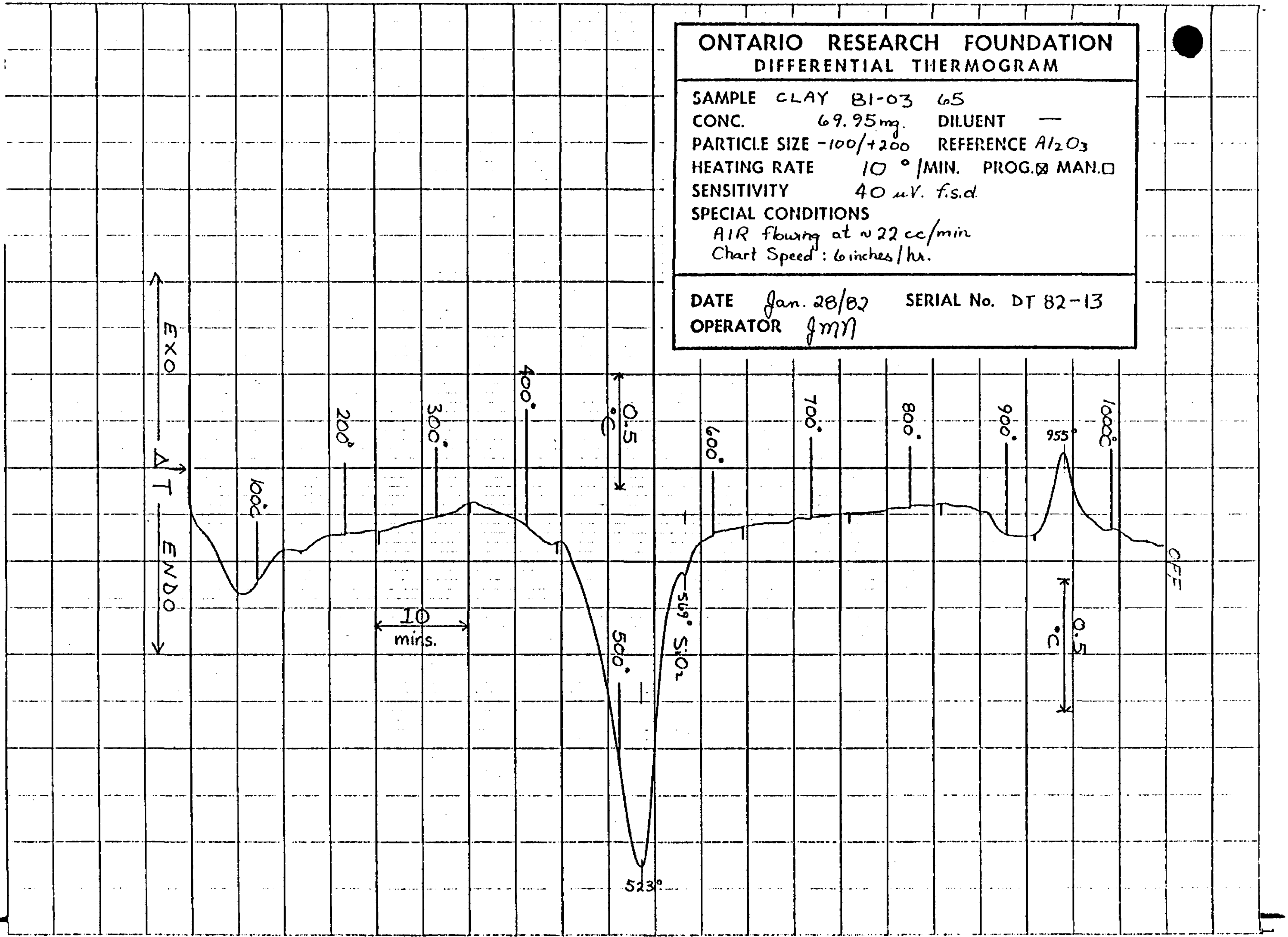
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-03 46m
CONC. 68.89mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 μV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~22 cc/min.
Chart Speed : 6 inches/hr.

DATE Jan. 28/82 SERIAL No. DT 82-14
OPERATOR J.M.M.

Figure 3

490489



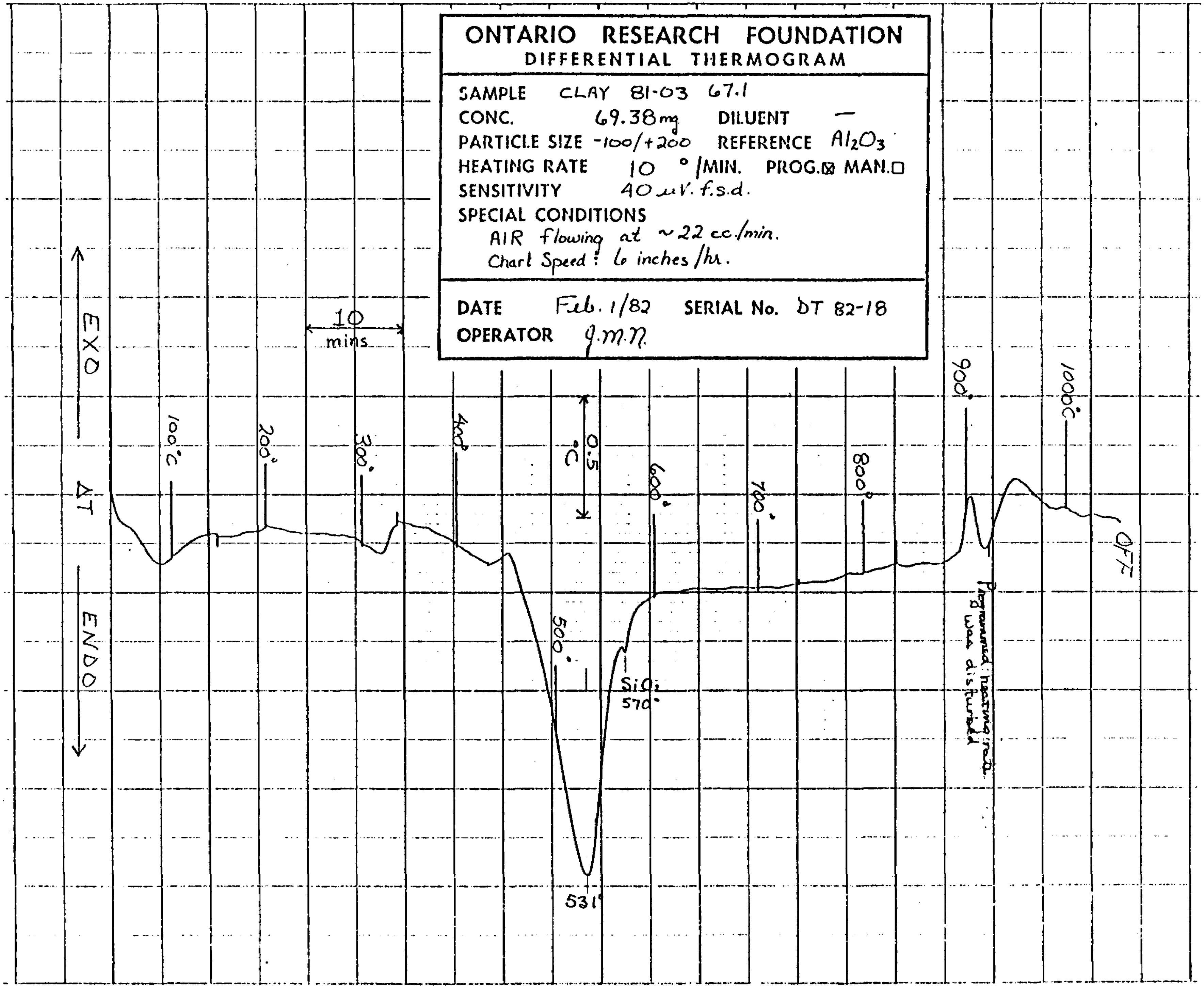
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-03 65
CONC. 69.95 mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 40 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 22 cc/min
Chart Speed: 6 inches/hr.

DATE Jan. 28/82 SERIAL No. DT 82-13
OPERATOR JMN

490489

Figure 4

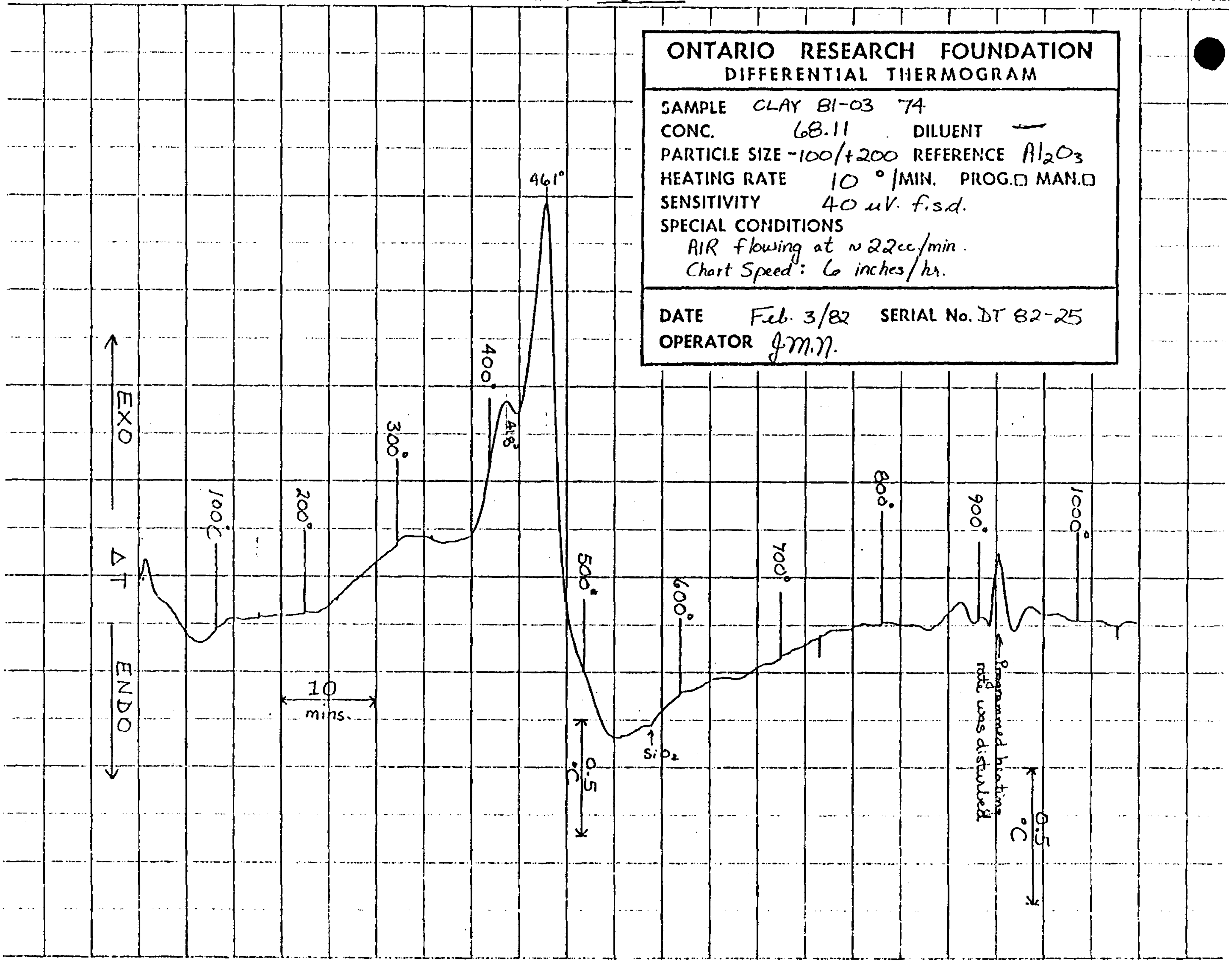


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-03 67.1
CONC. 69.38 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~22 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb. 1/82 SERIAL No. DT 82-18
OPERATOR g.m.n.

490489 Figure 5

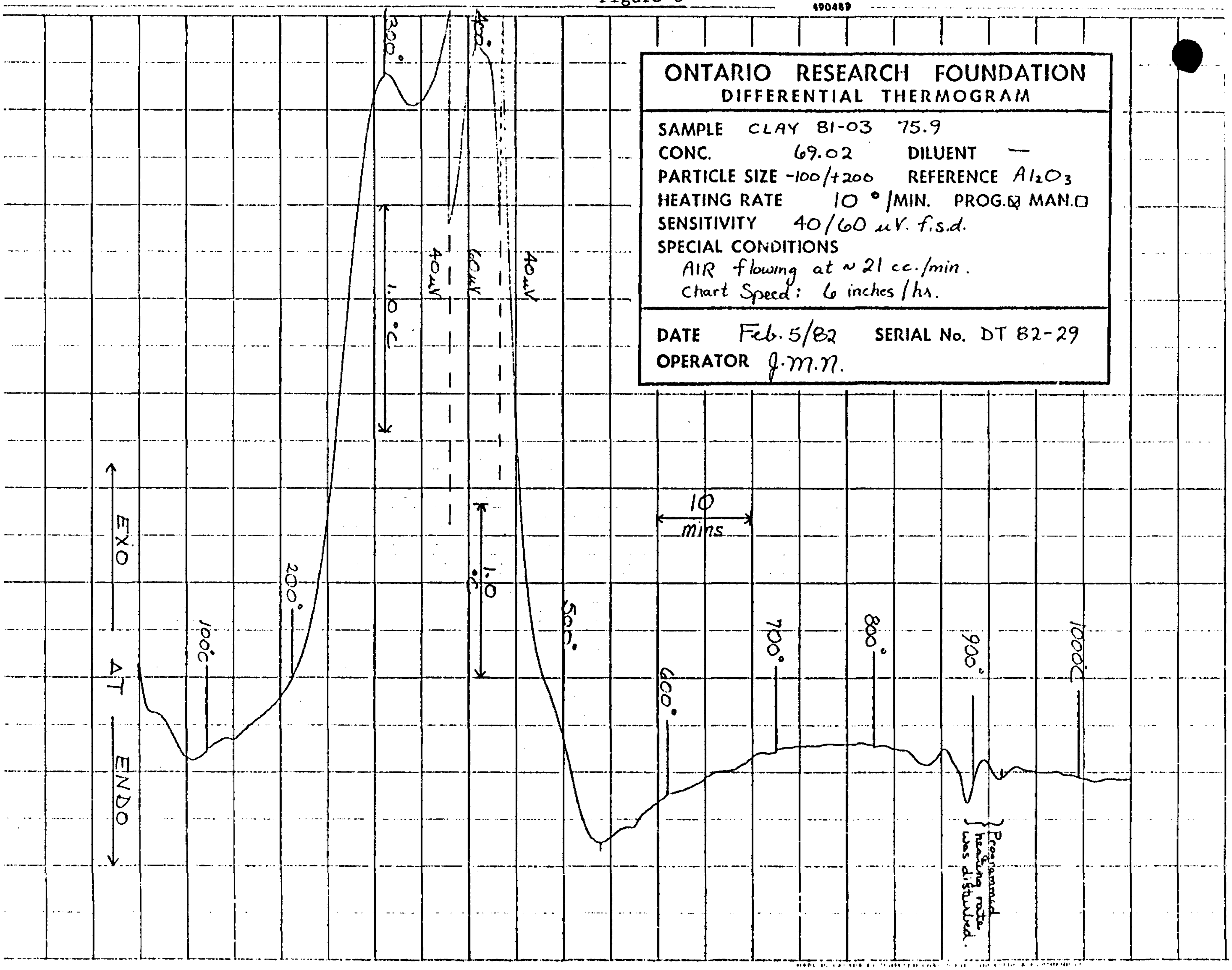


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-03 74
CONC. 68.11 DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☐ MAN.☐
SENSITIVITY 40 uV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~22cc/min.
Chart Speed: 6 inches/hr.

DATE Feb. 3/82 SERIAL No. DT 82-25
OPERATOR J.M.N.

Figure 6

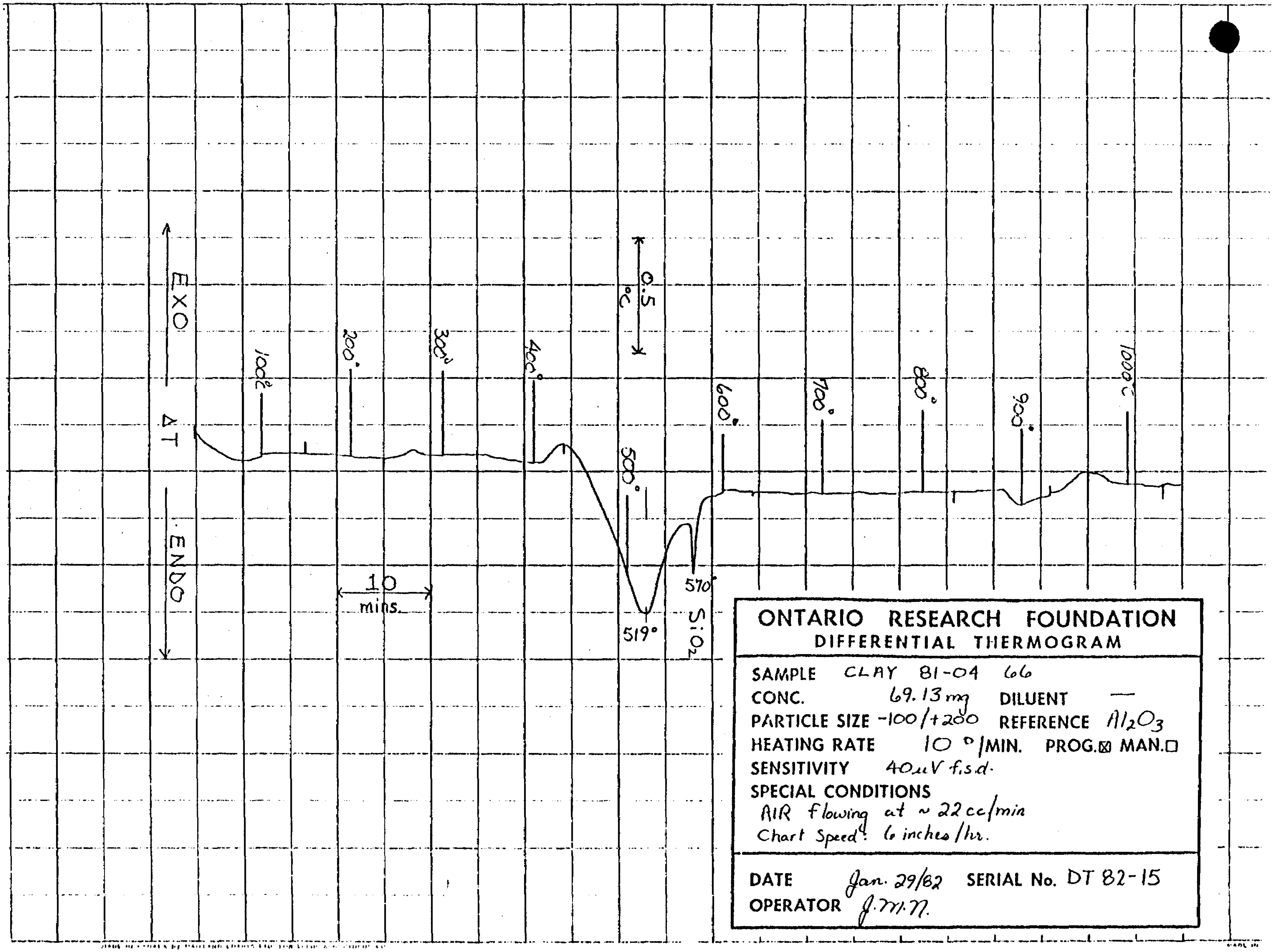


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-03 75.9
CONC. 69.02 DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40/60 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb. 5/82 SERIAL No. DT 82-29
OPERATOR J.M.N.

Figure 7

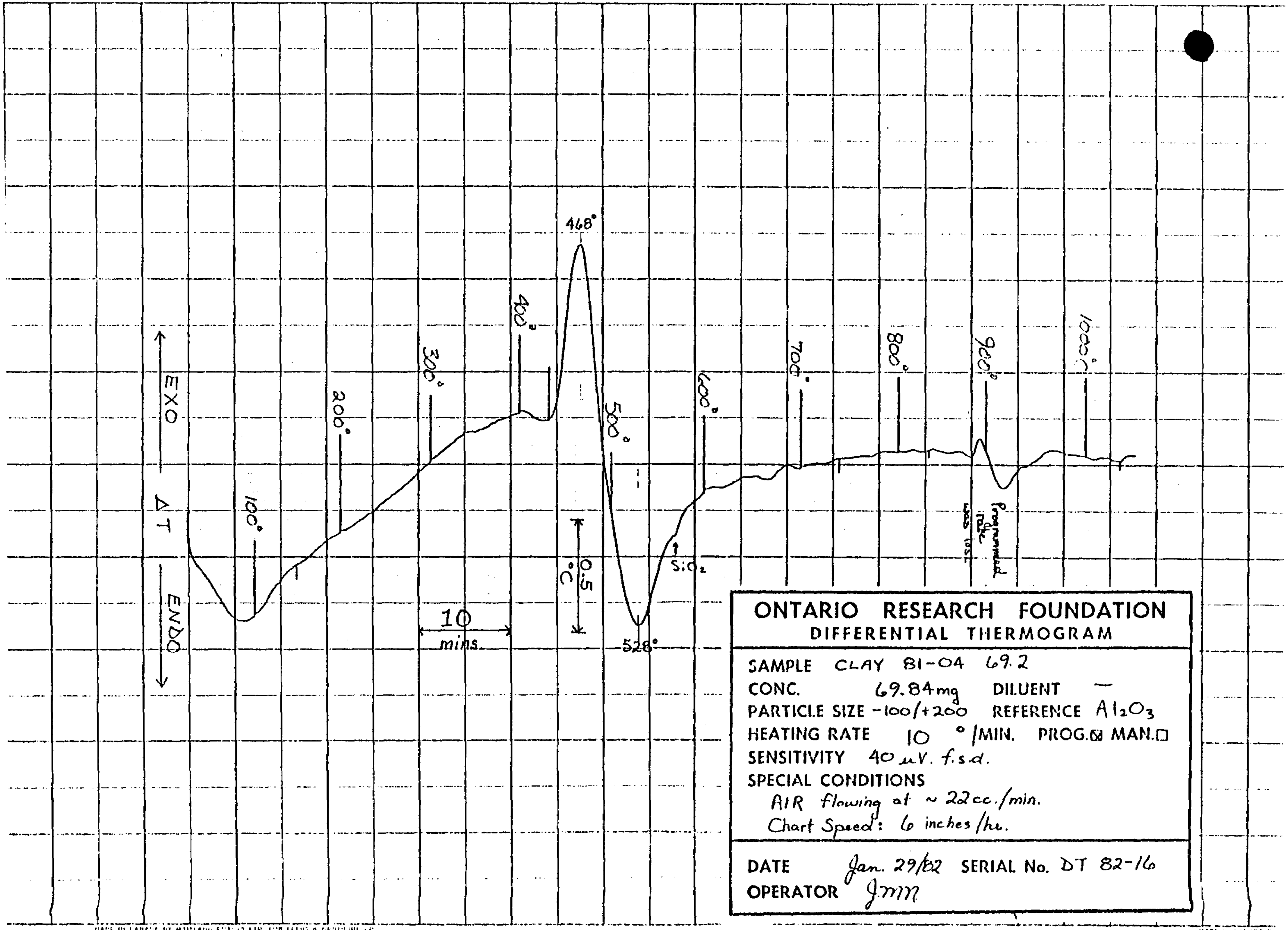


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-04 66
CONC. 69.13 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40μV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 22 cc/min
Chart Speed: 6 inches/hr.

DATE Jan. 29/82 SERIAL No. DT 82-15
OPERATOR J.M.N.

Figure 8



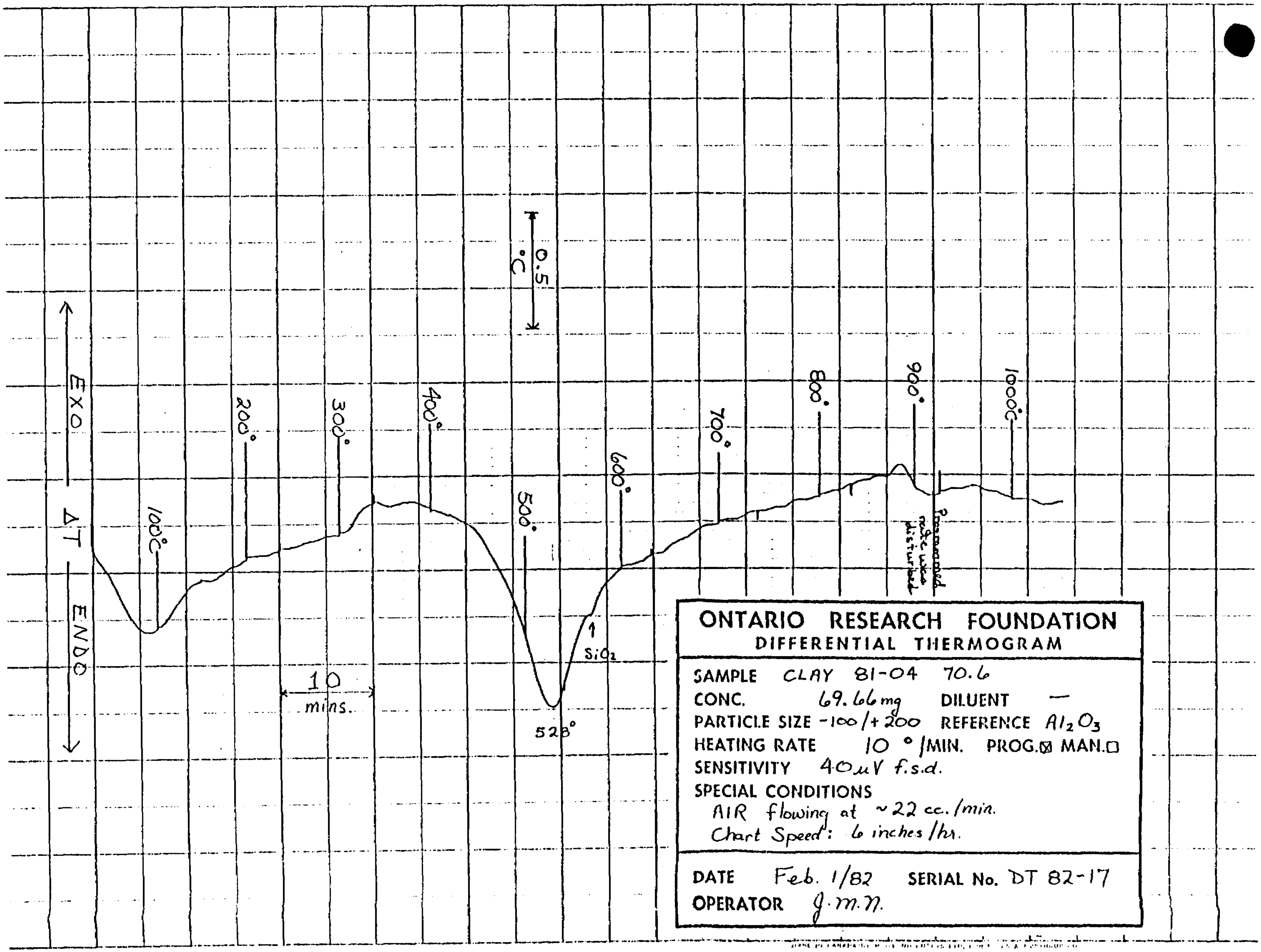
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-04 69.2
CONC. 69.84 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 40 μV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 22 cc./min.
Chart Speed: 6 inches/hr.

DATE Jan. 29/82 SERIAL No. DT 82-16
OPERATOR JMM

Figure 9

490489

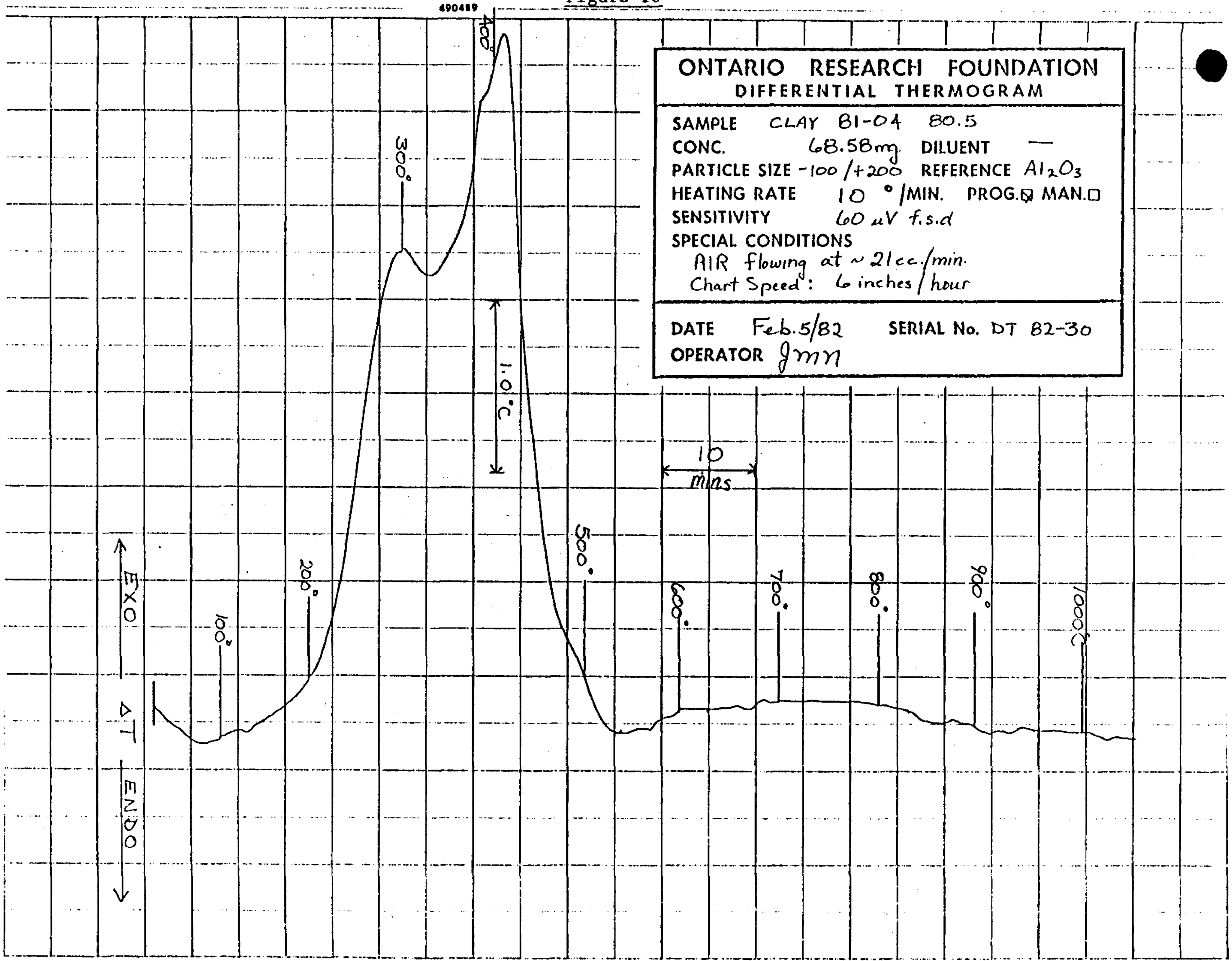


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-04 70.6
CONC. 69.66 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 40 µV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~22 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb. 1/82 SERIAL No. DT 82-17
OPERATOR J.M.N.

Figure 10

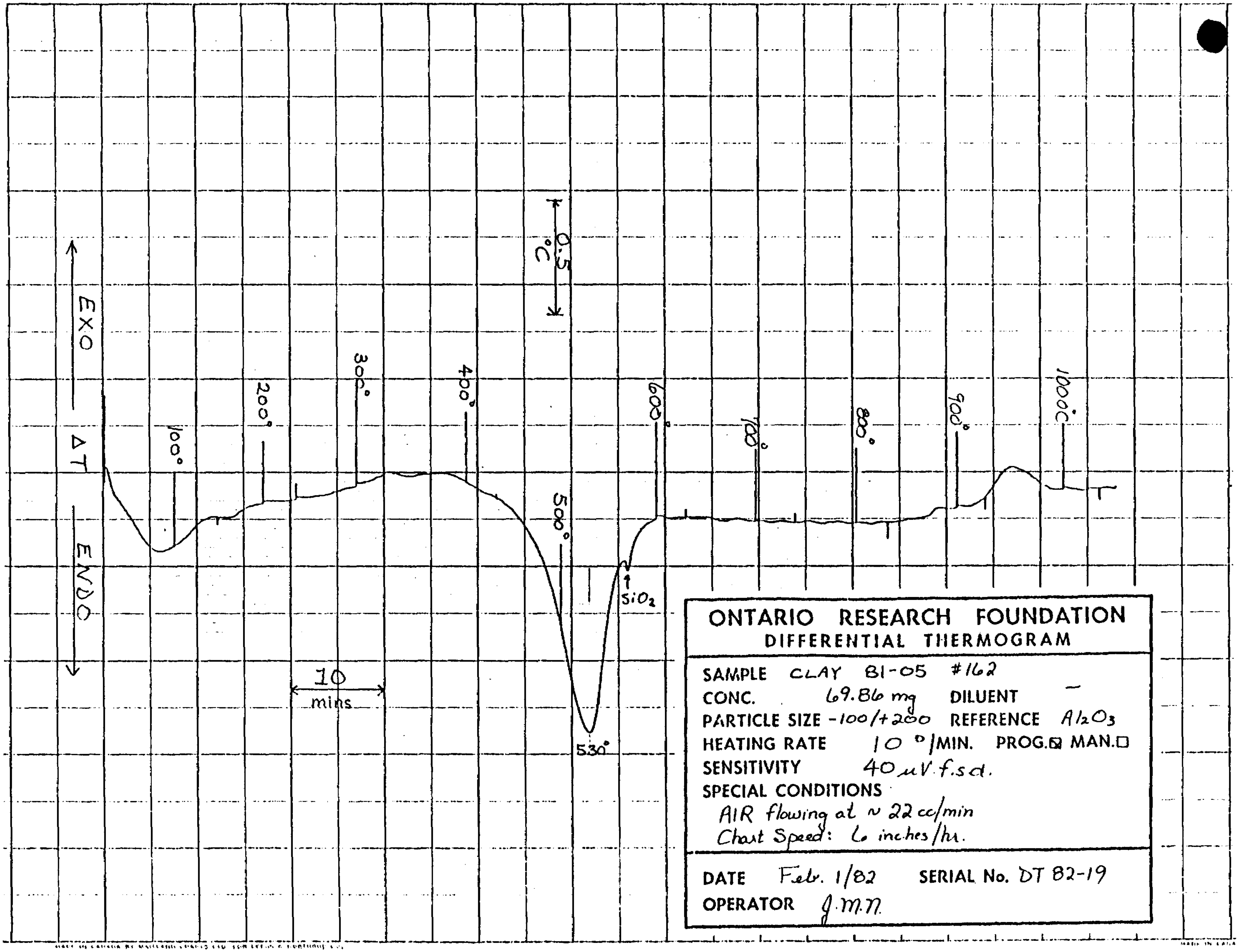


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-04 80.5
CONC. 68.58mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 60 µV f.s.d
SPECIAL CONDITIONS
AIR flowing at ~21cc./min.
Chart Speed: 6 inches/hour

DATE Feb.5/82 SERIAL No. DT 82-30
OPERATOR Jmn

Figure 11

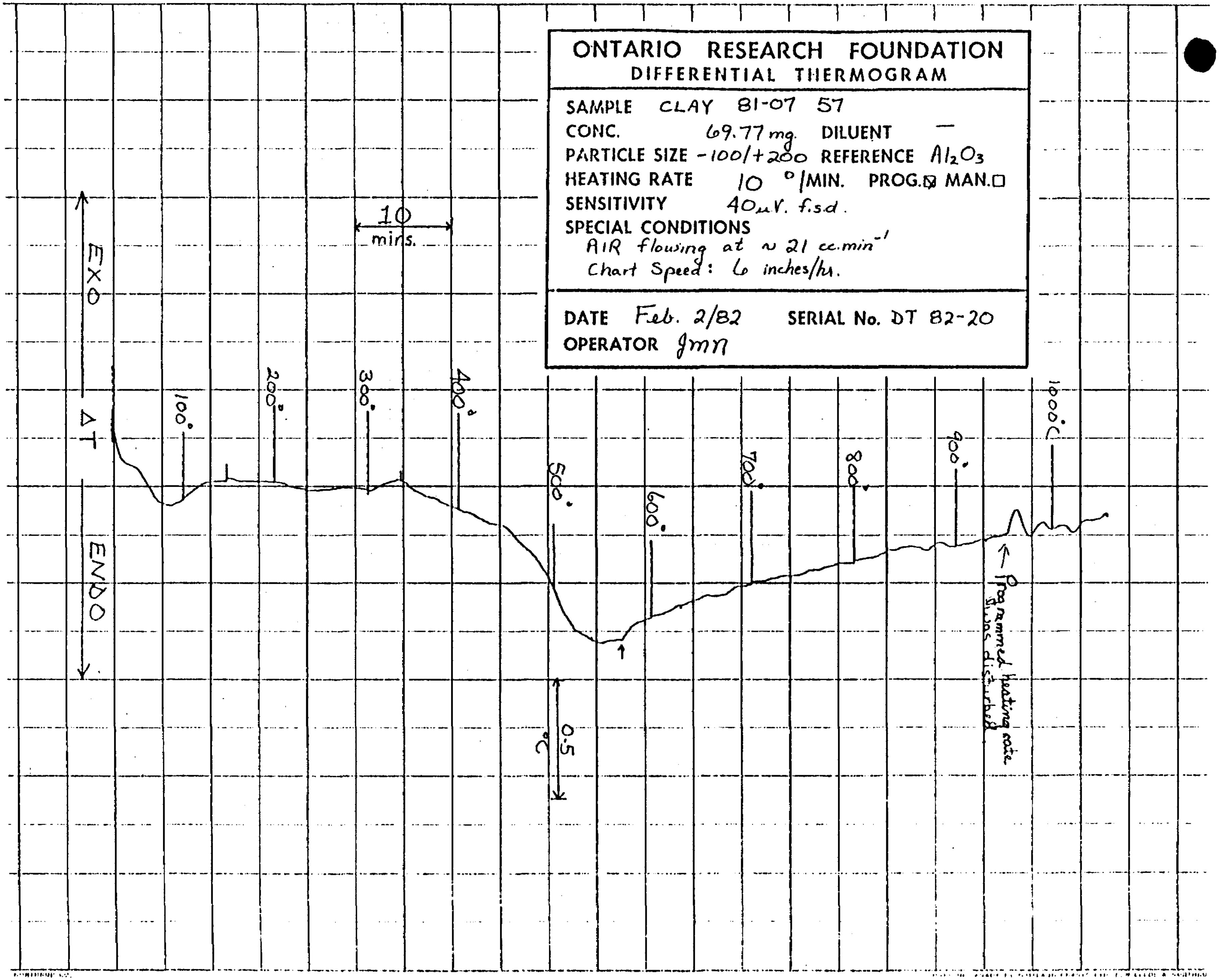


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-05 #162
CONC. 69.86 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 μV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 22 cc/min
Chart Speed: 6 inches/hr.

DATE Feb. 1/82 SERIAL No. DT 82-19
OPERATOR J.M.N.

Figure 12



ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-07 57
CONC. 69.77 mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21 $cc.min^{-1}$
Chart Speed: 6 inches/hr.

DATE Feb. 2/82 SERIAL No. DT 82-20
OPERATOR Jmn

Figure 13

ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-07 63
CONC. 68.56 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 µV. f.s.d
SPECIAL CONDITIONS
AIR flowing at ~ 21 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb 4/82 SERIAL No. DT 82-26
OPERATOR J.M.M.

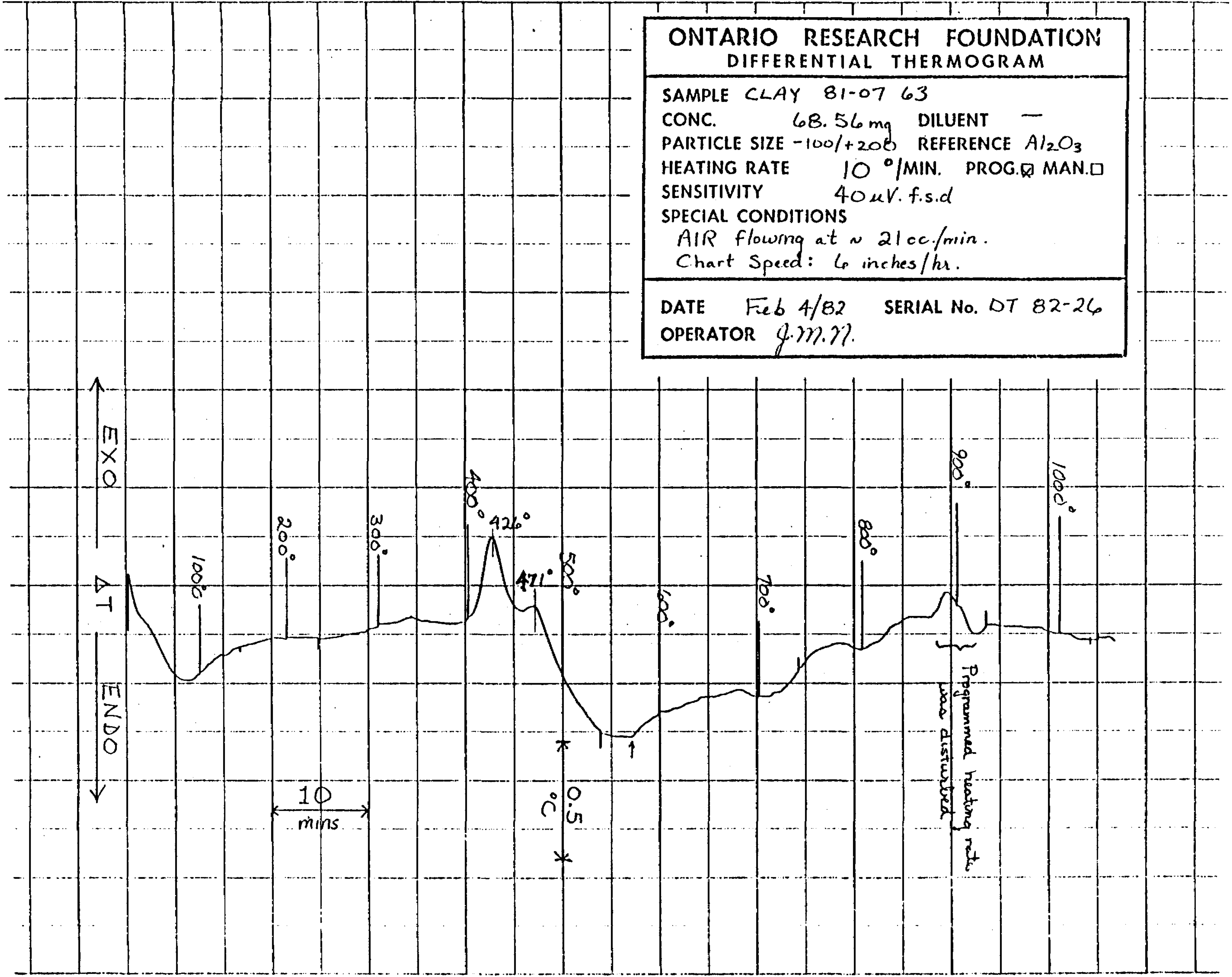
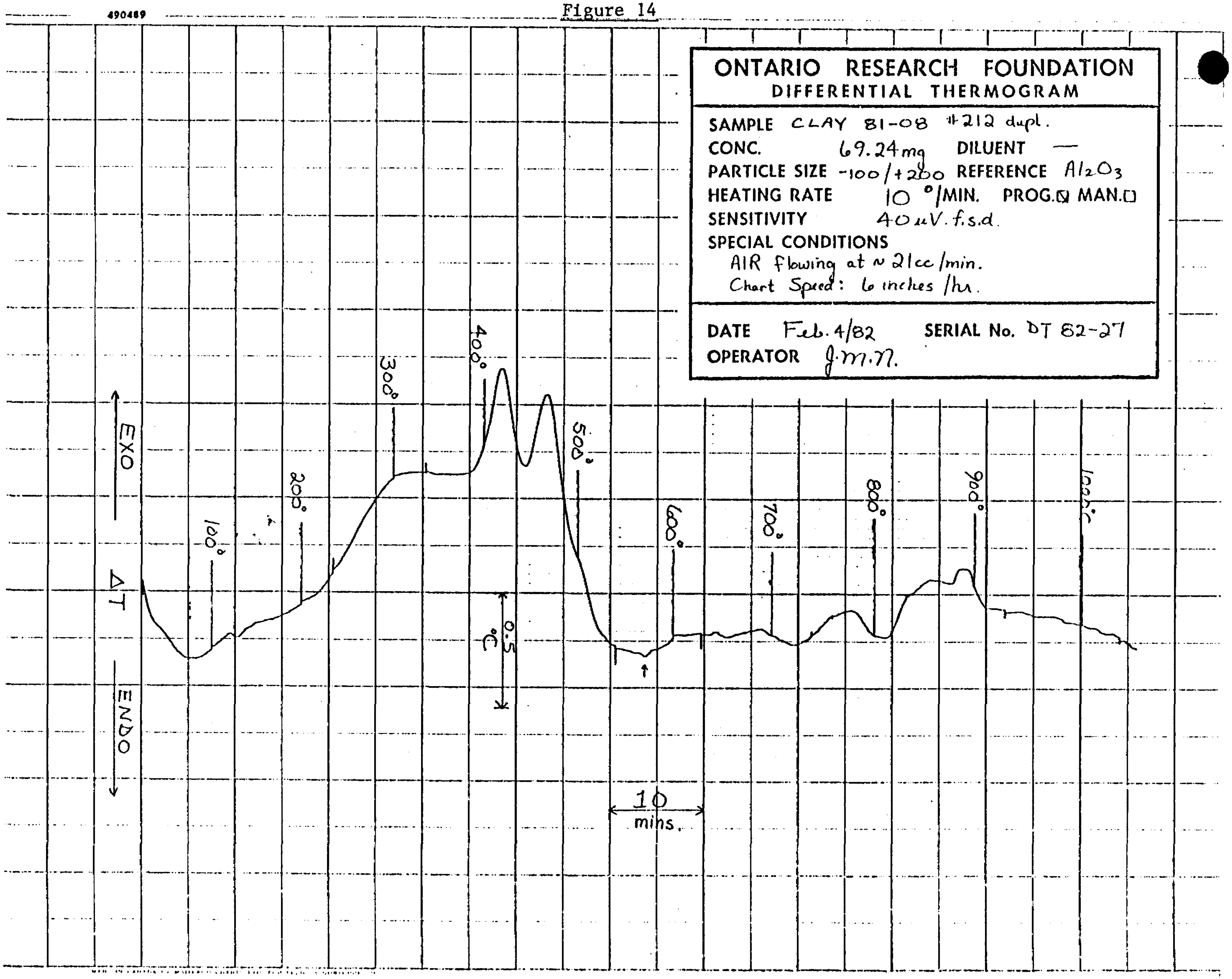


Figure 14



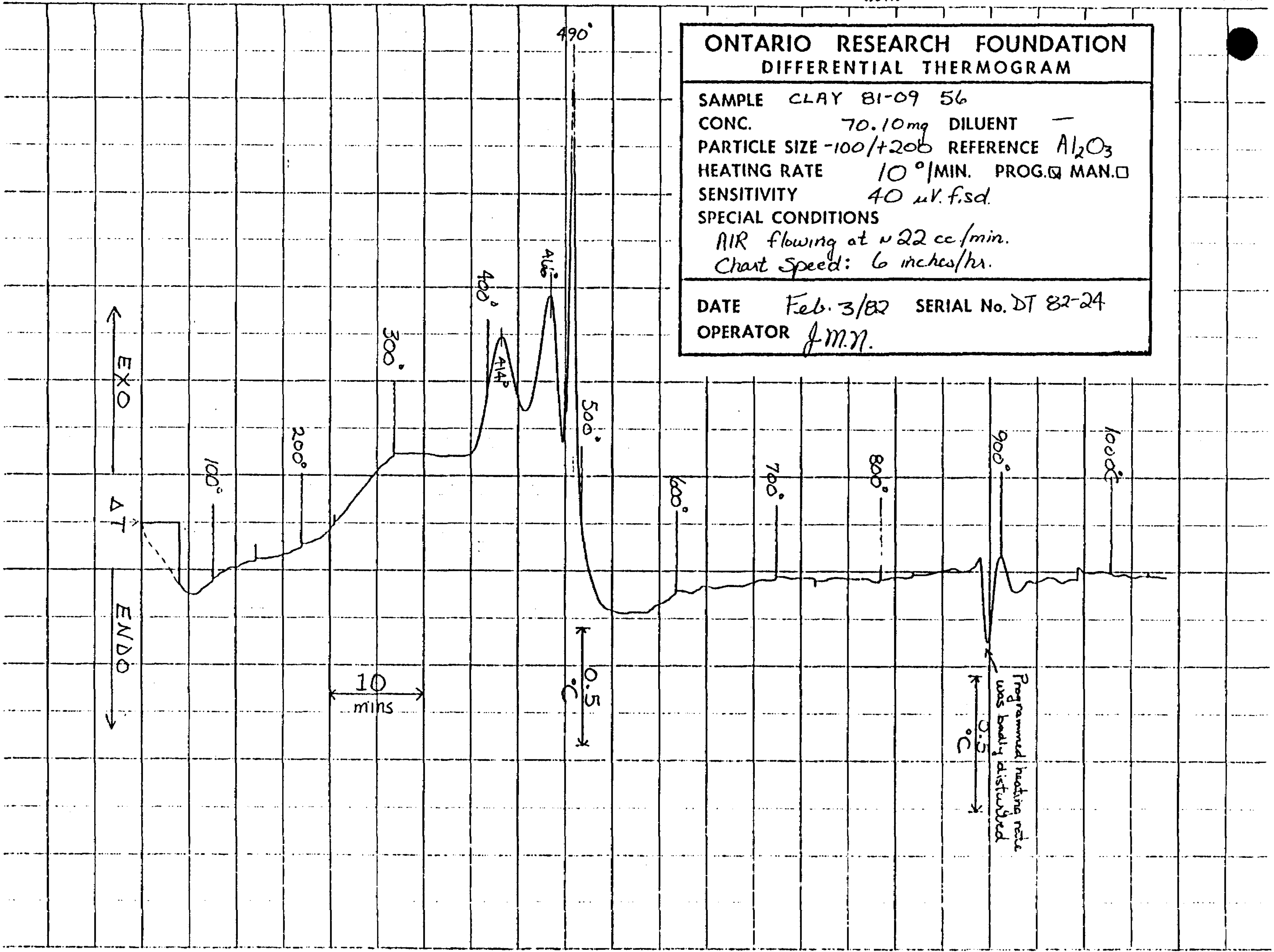
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-08 #212 dupl.
CONC. 69.24 mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21cc/min.
Chart Speed: 6 inches/hr.

DATE Feb. 4/82 SERIAL No. DT 82-27
OPERATOR J.M.N.

Figure 15

490489

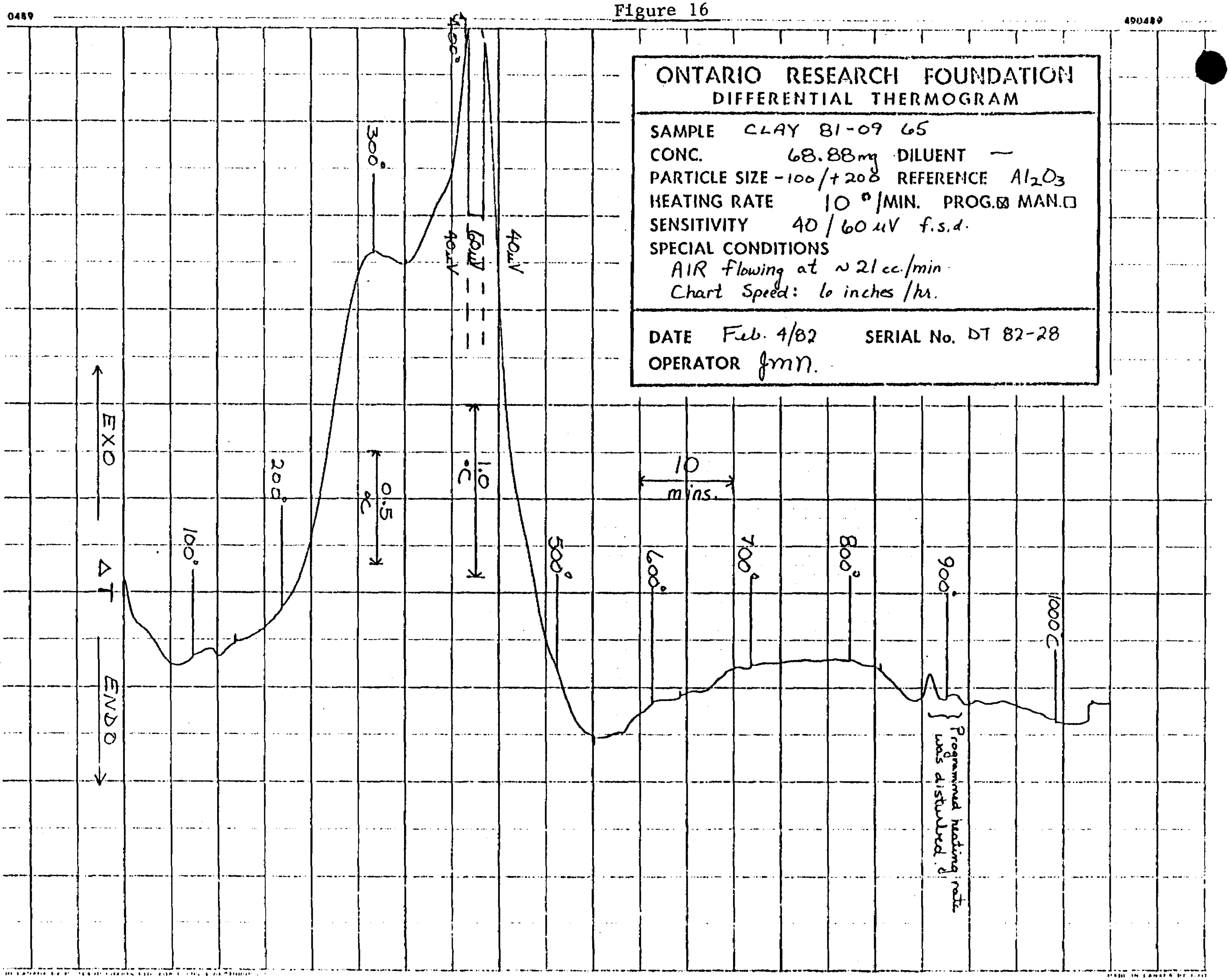


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-09 56
CONC. 70.10mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10°/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 µV. f.sd.
SPECIAL CONDITIONS
AIR flowing at ~22 cc/min.
Chart Speed: 6 inches/hr.

DATE Feb. 3/82 SERIAL No. DT 82-24
OPERATOR J.M.N.

Figure 16

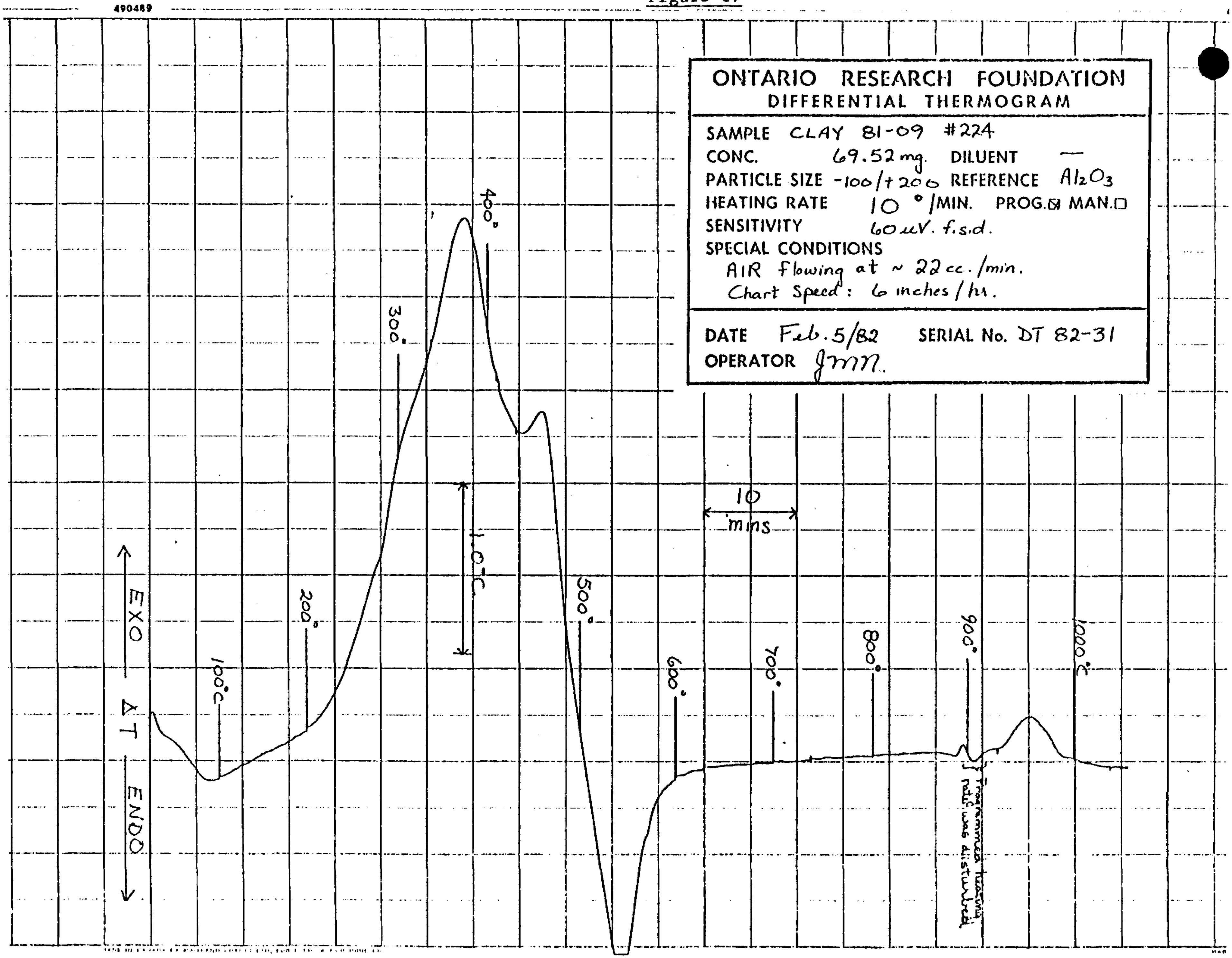


ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-09 65
CONC. 68.88mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG.☒ MAN.☐
SENSITIVITY 40 / 60 µV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21 cc./min
Chart Speed: 6 inches /hr.

DATE Feb. 4/82 SERIAL No. DT 82-28
OPERATOR JMN.

Figure 17



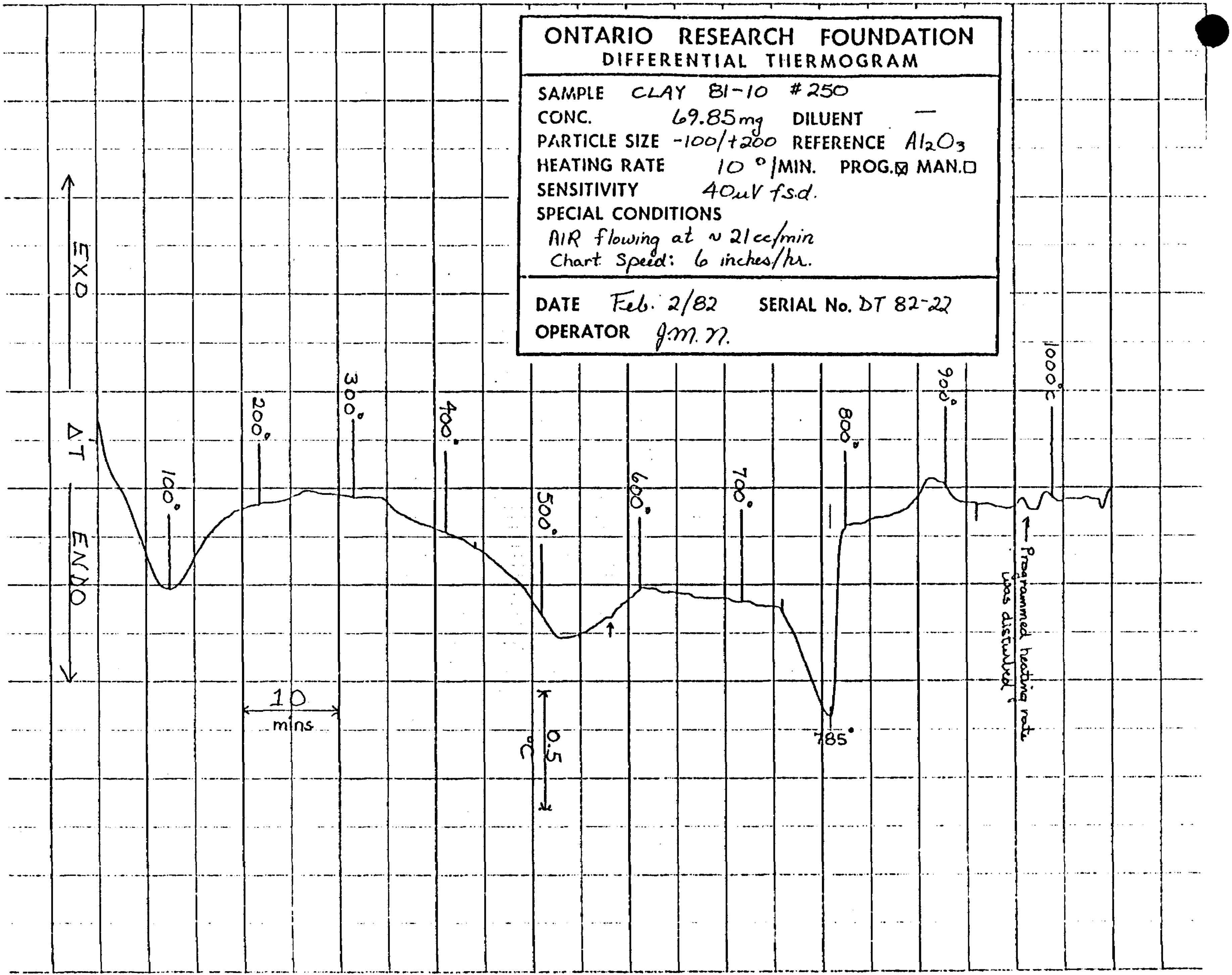
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-09 #224
CONC. 69.52 mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 60 µV. f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 22 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb. 5/82 SERIAL No. DT 82-31
OPERATOR JMN.

490489

Figure 18



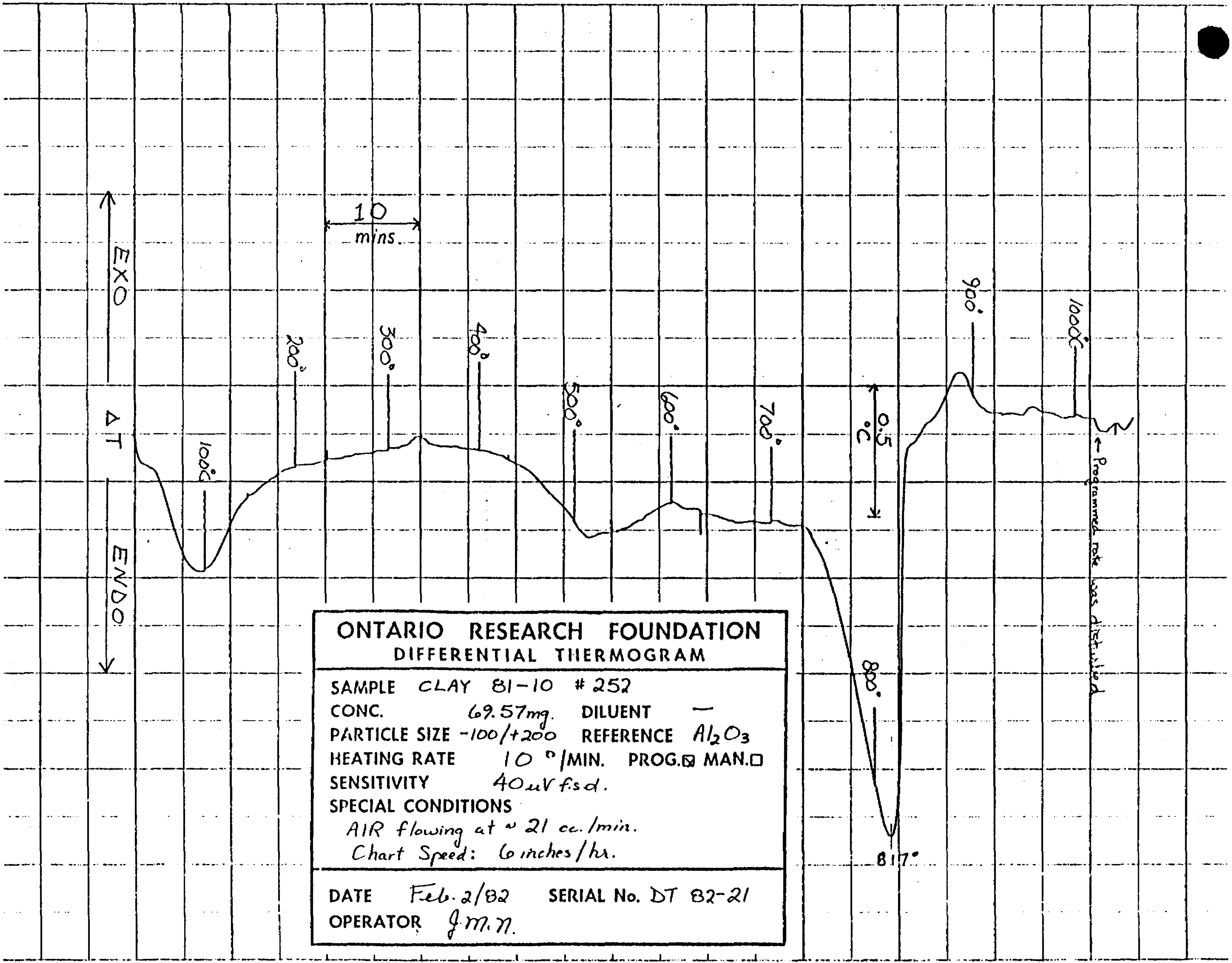
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-10 #250
CONC. 69.85mg DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 40uV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21cc/min
Chart Speed: 6 inches/hr.

DATE Feb. 2/82 SERIAL No. DT 82-22
OPERATOR J.M.N.

Figure 19

490489



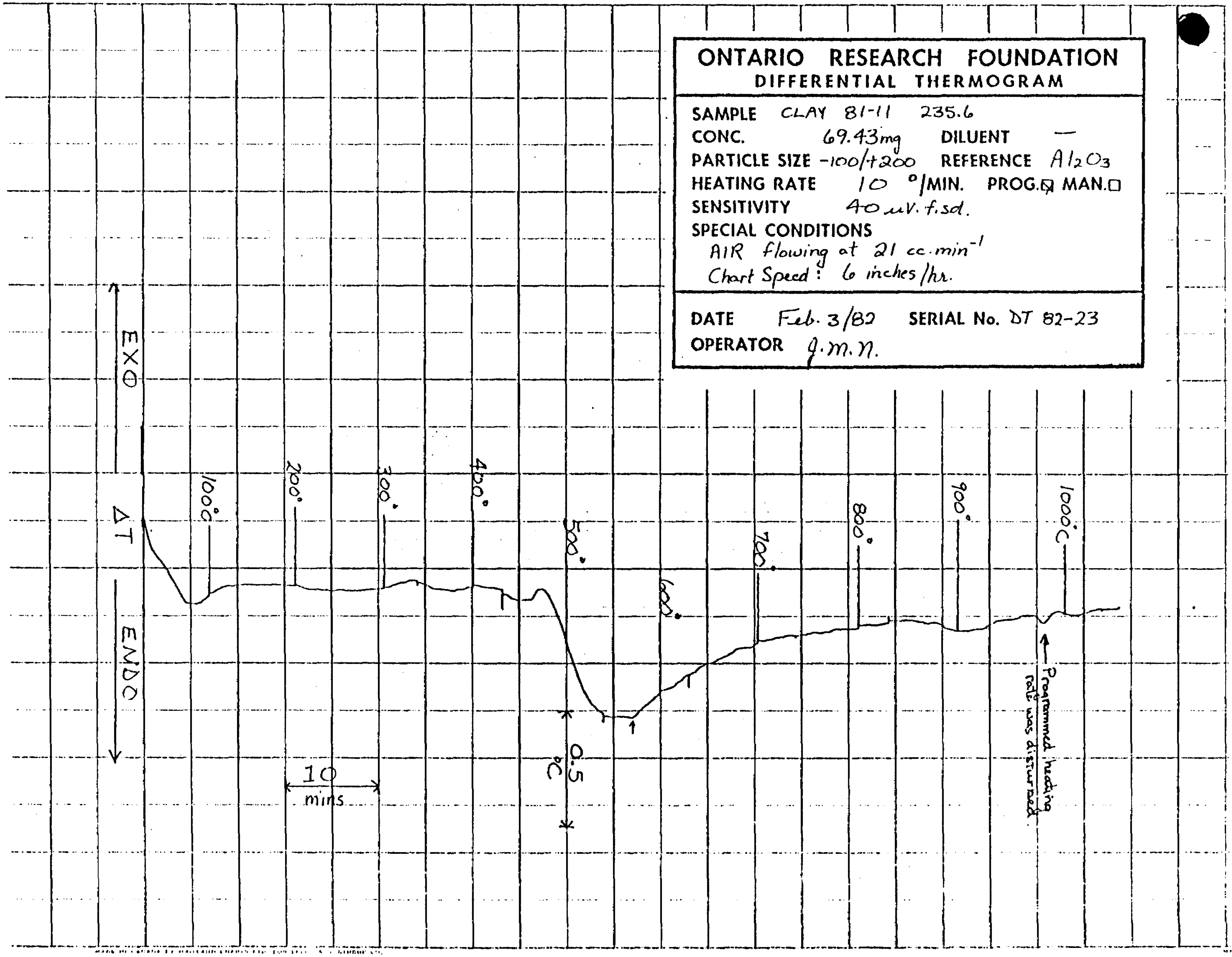
ONTARIO RESEARCH FOUNDATION
DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-10 # 252
CONC. 69.57mg. DILUENT —
PARTICLE SIZE -100/+200 REFERENCE Al_2O_3
HEATING RATE 10 °/MIN. PROG. ☒ MAN. ☐
SENSITIVITY 40 μV f.s.d.
SPECIAL CONDITIONS
AIR flowing at ~ 21 cc./min.
Chart Speed: 6 inches/hr.

DATE Feb. 2/82 SERIAL No. DT 82-21
OPERATOR J.m.n.

Figure 20

490489



ONTARIO RESEARCH FOUNDATION

DIFFERENTIAL THERMOGRAM

SAMPLE CLAY 81-11 235.6

CONC. 69.43mg DILUENT —

PARTICLE SIZE -100/+200 REFERENCE Al_2O_3

HEATING RATE 10 °/MIN. PROG.☒ MAN.☐

SENSITIVITY 40 µV. f.sd.

SPECIAL CONDITIONS

AIR flowing at 21 cc.min^{-1}

Chart Speed: 6 inches/hr.

DATE Feb. 3/82 SERIAL No. DT 82-23

OPERATOR g.m.n.

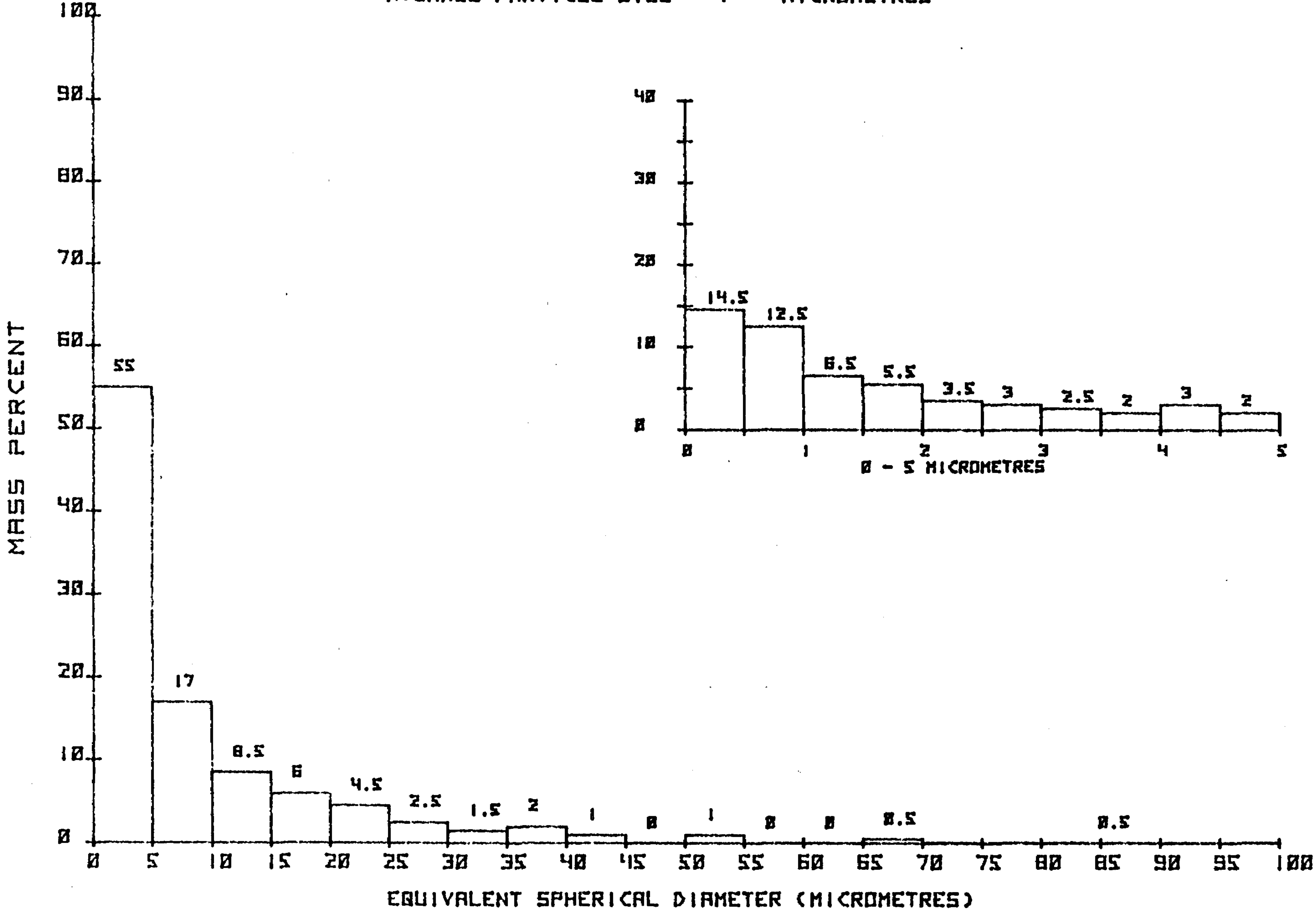
APPENDIX I

PARTICLE SIZE DATA FOR THREE CLAY SAMPLES

#81-03-46m
#81-03-75.9
#81-04-69.2

HISTOGRAMS FOR CLAY SAMPLE 81-03 46.0M

AVERAGE PARTICLE SIZE = 4 MICROMETRES



NUMBER DISTRIBUTION OF PARTICLES FROM WEIGHT DATA FOR CLAY SAMPLE 81-03 46.0M

CLASS INTERVAL (MICRONS)	AVERAGE RADIUS (MICRONS)	WEIGHT PERCENT	NUMBER OF PARTICLES PER GRAM	NUMBER PERCENT
0.0- 0.5	0.125	14.5	7.1E+12	96.4
0.5- 1.0	0.375	12.5	2.3E+11	3.1
1.0- 1.5	0.625	6.5	2.6E+10	0.3
1.5- 2.0	0.875	5.5	7.9E+09	0.1
2.0- 2.5	1.125	3.5	2.4E+09	0.0
2.5- 3.0	1.375	3.0	1.1E+09	0.0
3.0- 3.5	1.625	2.5	5.6E+08	0.0
3.5- 4.0	1.875	2.0	2.9E+08	0.0
4.0- 4.5	2.125	3.0	3.0E+08	0.0
4.5- 5.0	2.375	2.0	1.4E+08	0.0
5.0- 10.0	3.750	17.0	3.1E+08	0.0
10.0- 15.0	6.250	8.5	3.3E+07	0.0
15.0- 20.0	8.750	6.0	8.6E+06	0.0
20.0- 25.0	11.250	4.5	3.0E+06	0.0
25.0- 30.0	13.750	2.5	9.2E+05	0.0
30.0- 35.0	16.250	1.5	3.4E+05	0.0
35.0- 40.0	18.750	2.0	2.9E+05	0.0
40.0- 45.0	21.250	1.0	1.0E+05	0.0
45.0- 50.0	23.750	0.0	0.0E+00	0.0
50.0- 55.0	26.250	1.0	5.3E+04	0.0
55.0- 60.0	28.750	0.0	0.0E+00	0.0
60.0- 65.0	31.250	0.0	0.0E+00	0.0
65.0- 70.0	33.750	0.5	1.2E+04	0.0
70.0- 100.0	42.500	0.5	6.2E+03	0.0

SURFACE AREA DETERMINATION FOR CLAY SAMPLE 81-03 46.0M

CLASS INTERVAL (MICRONS)	AVERAGE RADIUS (MICRONS)	WEIGHT PERCENT	AREA FRACTION (CM↑2)
0.0- 0.5	0.125	14.5	13975.9
0.5- 1.0	0.375	12.5	4016.1
1.0- 1.5	0.625	6.5	1253.0
1.5- 2.0	0.875	5.5	757.3
2.0- 2.5	1.125	3.5	374.8
2.5- 3.0	1.375	3.0	262.9
3.0- 3.5	1.625	2.5	185.4
3.5- 4.0	1.875	2.0	128.5
4.0- 4.5	2.125	3.0	170.1
4.5- 5.0	2.375	2.0	101.5
5.0- 10.0	3.750	17.0	546.2
10.0- 15.0	6.250	8.5	163.9
15.0- 20.0	8.750	6.0	82.6
20.0- 25.0	11.250	4.5	48.2
25.0- 30.0	13.750	2.5	21.9
30.0- 35.0	16.250	1.5	11.1
35.0- 40.0	18.750	2.0	12.9
40.0- 45.0	21.250	1.0	5.7
45.0- 50.0	23.750	0.0	0.0
50.0- 55.0	26.250	1.0	4.6
55.0- 60.0	28.750	0.0	0.0
60.0- 65.0	31.250	0.0	0.0
65.0- 70.0	33.750	0.5	1.8
70.0- 100.0	42.500	0.5	1.4

TOTAL SURFACE AREA = 22126 CM↑2/G

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION 8 [illegible]

DATE [illegible]

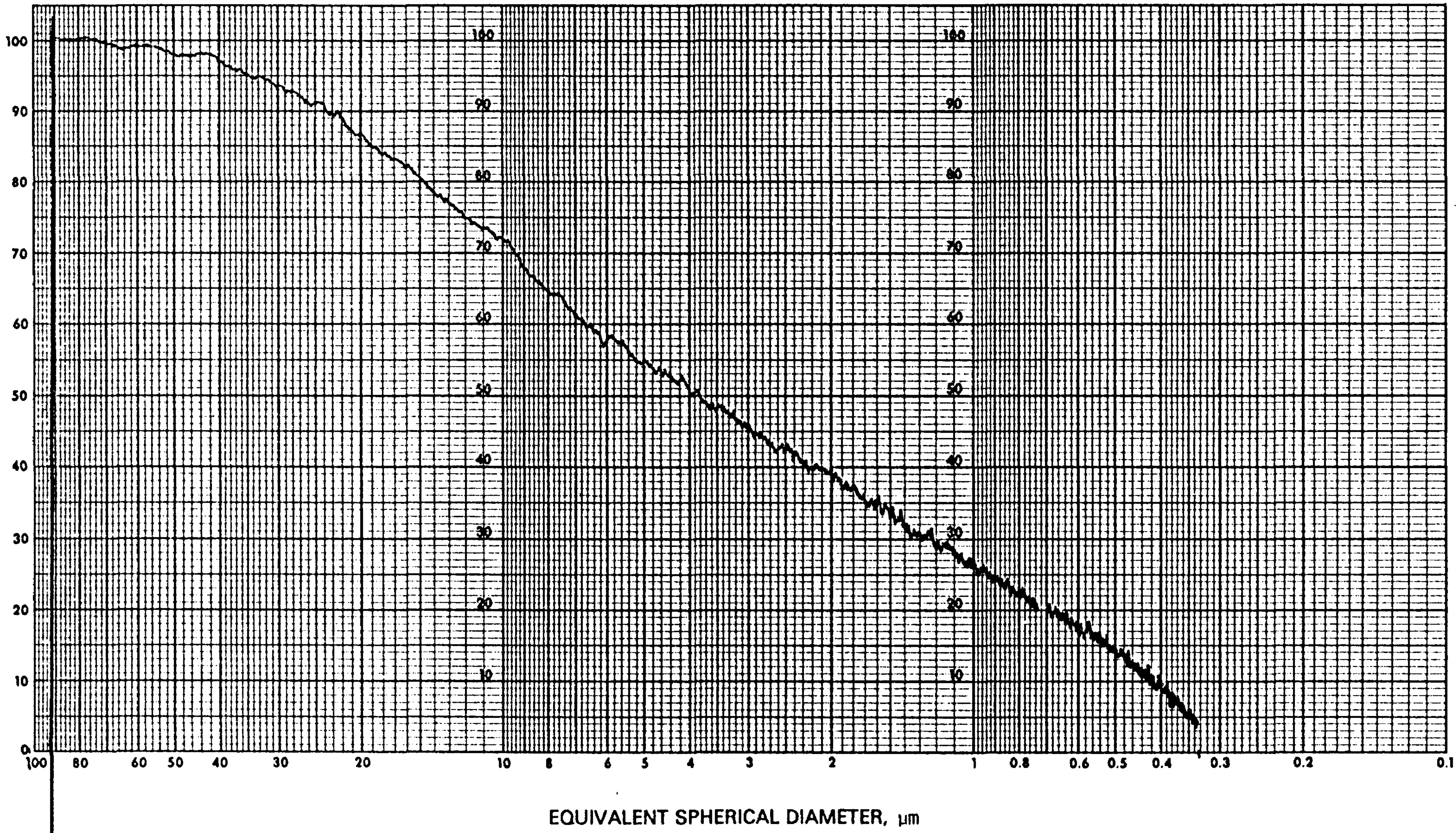
Density ______ g/cc LIQUID ______ Density ______ g/cc Viscosity ______ cp

BY [illegible]

Preparation 7 [illegible]

TEMPERATURE ______ °C

RATE ______ START DIA. ______ µm



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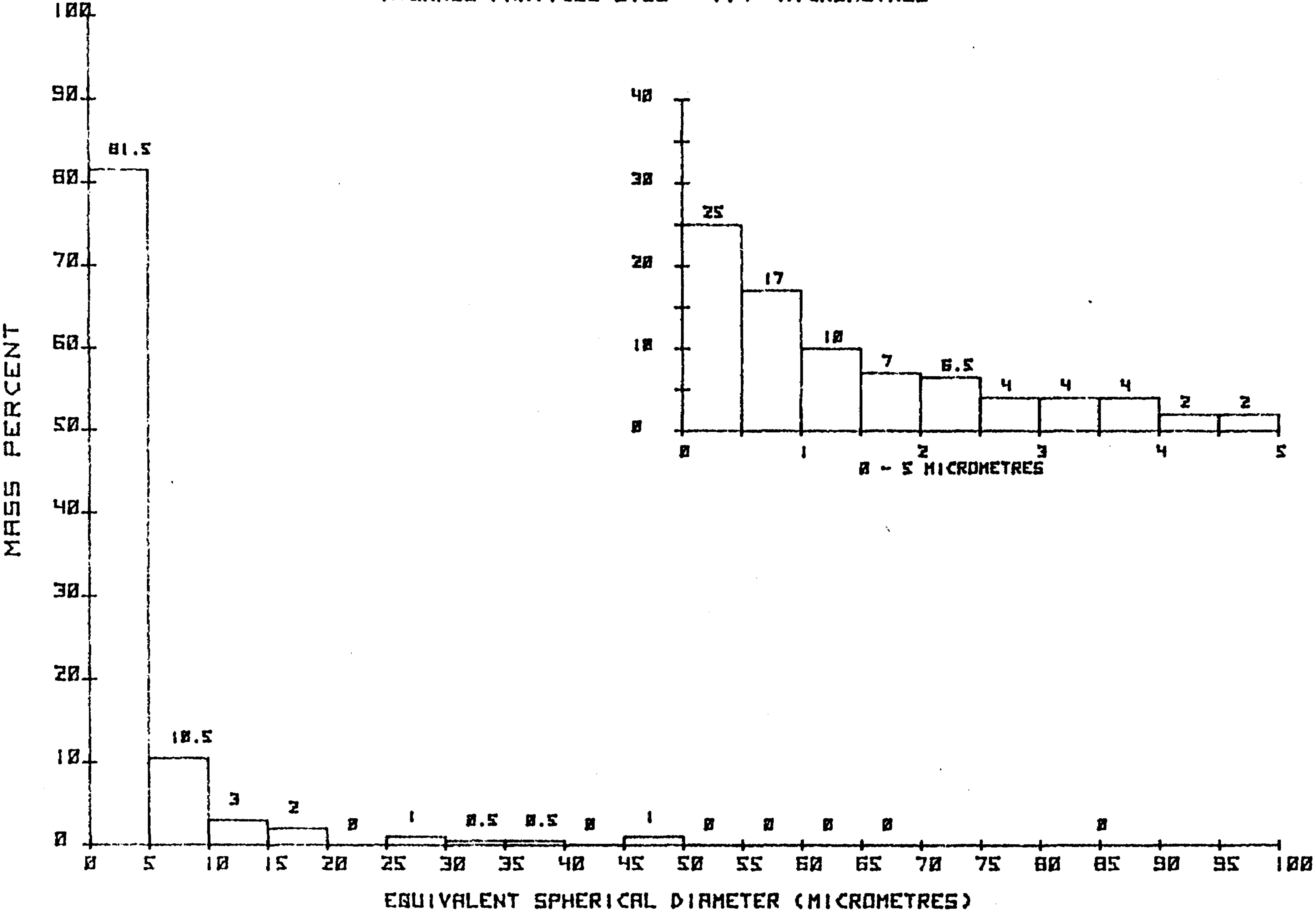
HISTOGRAMS FOR CLAY SAMPLE 81-04 69.2

AVERAGE PARTICLE SIZE = 1.4 MICROMETRES



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NUMBER DISTRIBUTION OF PARTICLES FROM WEIGHT DATA FOR
CLAY SAMPLE 81-04 69.2

CLASS INTERVAL   AVERAGE RADIUS  WEIGHT  NUMBER OF PARTICLES   NUMBER
  (MICRONS)         (MICRONS)     PERCENT       PER GRAM          PERCENT
  0.0-    0.5        0.125        25.0        1.2E+13          97.1
  0.5-    1.0        0.375        17.0        2.9E+11           2.4
  1.0-    1.5        0.625        10.0        3.7E+10           0.3
  1.5-    2.0        0.875         7.0        9.6E+09           0.1
  2.0-    2.5        1.125         6.5        4.2E+09           0.0
  2.5-    3.0        1.375         4.0        1.4E+09           0.0
  3.0-    3.5        1.625         4.0        8.5E+08           0.0
  3.5-    4.0        1.875         4.0        5.6E+08           0.0
  4.0-    4.5        2.125         2.0        1.9E+08           0.0
  4.5-    5.0        2.375         2.0        1.4E+08           0.0
  5.0-   10.0        3.750        10.5        1.8E+08           0.0
[illegible]0.0-   15.0        6.250         3.0        1.1E+07           0.0
 15.0-   20.0        8.750         2.0        2.7E+06           0.0
[illegible]0.0-   25.0       11.250         0.0        0.0E+00           0.0
[illegible]5.0-   30.0       13.750         1.0        3.5E+05           0.0
 30.0-   35.0       16.250         0.5        1.1E+05           0.0
 35.0-   40.0       18.750         0.5        6.9E+04           0.0
[illegible]0.0-   45.0       21.250         0.0        0.0E+00           0.0
[illegible]5.0-   50.0       23.750         1.0        6.8E+04           0.0
 50.0-   55.0       26.250         0.0        0.0E+00           0.0
[illegible]5.0-   60.0       28.750         0.0        0.0E+00           0.0
[illegible]0.0-   65.0       31.250         0.0        0.0E+00           0.0
 65.0-   70.0       33.750         0.0        0.0E+00           0.0
 70.0-  100.0       42.500         0.0        0.0E+00           0.0


SURFACE AREA DETERMINATION FOR CLAY SAMPLE 81-04 69.2

CLASS INTERVAL    AVERAGE RADIUS    WEIGHT       AREA
  (MICRONS)          (MICRONS)       PERCENT  FRACTION (CM↑2)
   0.0-    0.5         0.125          25.0      22988.5
   0.5-    1.0         0.375          17.0       5210.7
   1.0-    1.5         0.625          10.0       1839.1
   1.5-    2.0         0.875           7.0        919.5
   2.0-    2.5         1.125           6.5        664.1
   2.5-    3.0         1.375           4.0        334.4
   3.0-    3.5         1.625           4.0        282.9
   3.5-    4.0         1.875           4.0        245.2
   4.0-    4.5         2.125           2.0        108.2
   4.5-    5.0         2.375           2.0         96.8
   5.0-   10.0         3.750          10.5        321.8
  10.0-   15.0         6.250           3.0         55.2
  15.0-   20.0         8.750           2.0         26.3
  20.0-   25.0        11.250           0.0          0.0
  25.0-   30.0        13.750           1.0          8.4
  30.0-   35.0        16.250           0.5          3.5
  35.0-   40.0        18.750           0.5          3.1
  40.0-   45.0        21.250           0.0          0.0
  45.0-   50.0        23.750           1.0          4.8
  50.0-   55.0        26.250           0.0          0.0
  55.0-   60.0        28.750           0.0          0.0
  60.0-   65.0        31.250           0.0          0.0
  65.0-   70.0        33.750           0.0          0.0
  70.0-  100.0        42.500           0.0          0.0

TOTAL SURFACE AREA = 33113    CM↑2/G
```

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION 81-01 64 2

DATE Jan. FEB 1, 1982

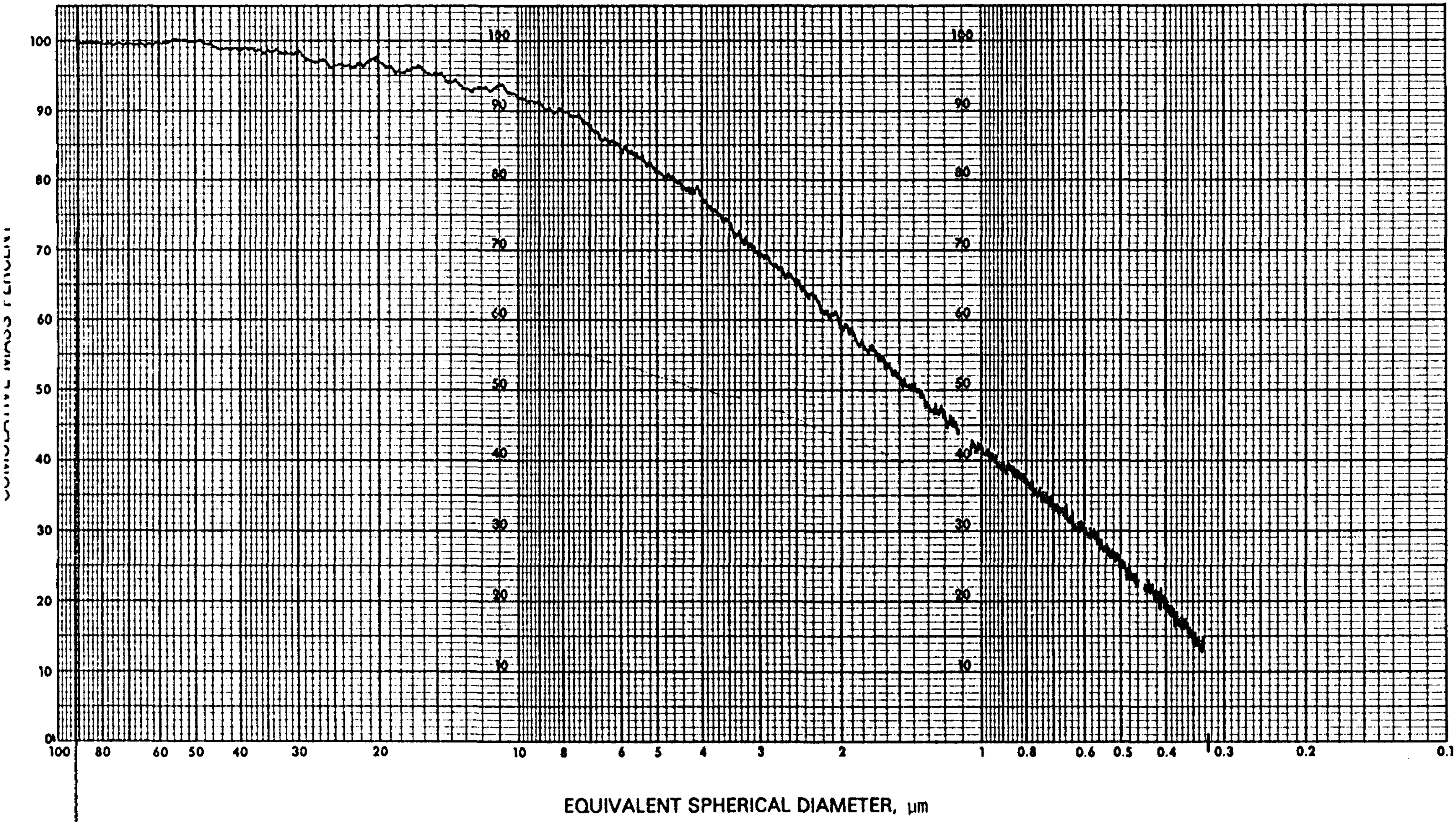
Density 2.61 g/cc LIQUID A-11 Density .749 g/cc Viscosity 1.323 cp

BY Bill Gautsch

Preparation 7 minute sonic bath

TEMPERATURE 32 °C

RATE 90.5 START DIA. 90 µm



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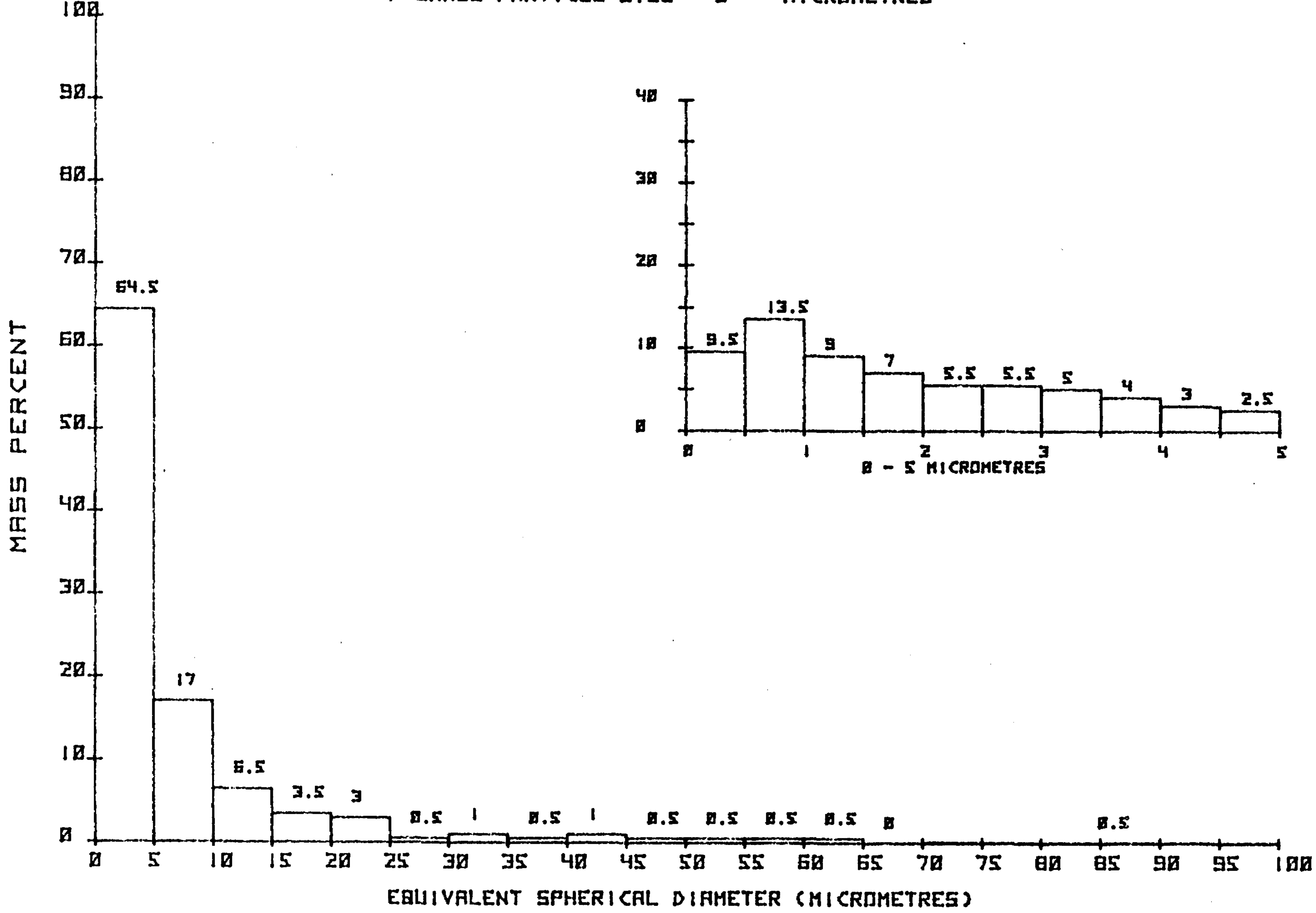
HISTOGRAMS FOR CLAY SAMPLE 81-03 75.9

AVERAGE PARTICLE SIZE = 3 MICROMETRES



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NUMBER DISTRIBUTION OF PARTICLES FROM WEIGHT DATA FOR
CLAY SAMPLE 81-03 75.9

CLASS INTERVAL   AVERAGE RADIUS   WEIGHT   NUMBER OF PARTICLES   NUMBER
  (MICRONS)        (MICRONS)      PERCENT       PER GRAM         PERCENT
  0.0-    0.5        0.125          9.5         4.6E+12           94.0
  0.5-    1.0        0.375         13.5         2.4E+11            4.9
  1.0-    1.5        0.625          9.0         3.5E+10            0.7
  1.5-    2.0        0.875          7.0         9.8E+09            0.2
  2.0-    2.5        1.125          5.5         3.6E+09            0.1
  2.5-    3.0        1.375          5.5         2.0E+09            0.0
  3.0-    3.5        1.625          5.0         1.1E+09            0.0
  3.5-    4.0        1.875          4.0         5.7E+08            0.0
  4.0-    4.5        2.125          3.0         2.9E+08            0.0
  4.5-    5.0        2.375          2.5         1.7E+08            0.0
  5.0-   10.0        3.750         17.0         3.0E+08            0.0
 10.0-   15.0        6.250          6.5         2.5E+07            0.0
 15.0-   20.0        8.750          3.5         4.9E+06            0.0
 20.0-   25.0       11.250          3.0         2.0E+06            0.0
 25.0-   30.0       13.750          0.5         1.8E+05            0.0
 30.0-   35.0       16.250          1.0         2.2E+05            0.0
 35.0-   40.0       18.750          0.5         7.1E+04            0.0
 40.0-   45.0       21.250          1.0         9.8E+04            0.0
 45.0-   50.0       23.750          0.5         3.5E+04            0.0
 50.0-   55.0       26.250          0.5         2.6E+04            0.0
 55.0-   60.0       28.750          0.5         2.0E+04            0.0
 60.0-   65.0       31.250          0.5         1.5E+04            0.0
 65.0-   70.0       33.750          0.0         0.0E+00            0.0
 70.0-  100.0       42.500          0.5         6.1E+03            0.0
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SURFACE AREA DETERMINATION FOR CLAY 81-03 75.9

CLASS INTERVAL    AVERAGE RADIUS    WEIGHT      AREA
  (MICRONS)         (MICRONS)      PERCENT  FRACTION (CM↑2)
   0.0-    0.5        0.125          9.5       8941.2
   0.5-    1.0        0.375         13.5       4235.3
   1.0-    1.5        0.625          9.0       1694.1
   1.5-    2.0        0.875          7.0        941.2
   2.0-    2.5        1.125          5.5        575.2
   2.5-    3.0        1.375          5.5        470.6
   3.0-    3.5        1.625          5.0        362.0
   3.5-    4.0        1.875          4.0        251.0
   4.0-    4.5        2.125          3.0        166.1
   4.5-    5.0        2.375          2.5        123.8
   5.0-   10.0        3.750         17.0        533.3
  10.0-   15.0        6.250          6.5        122.4
  15.0-   20.0        8.750          3.5         47.1
  20.0-   25.0       11.250          3.0         31.4
  25.0-   30.0       13.750          0.5          4.3
  30.0-   35.0       16.250          1.0          7.2
  35.0-   40.0       18.750          0.5          3.1
  40.0-   45.0       21.250          1.0          5.5
  45.0-   50.0       23.750          0.5          2.5
  50.0-   55.0       26.250          0.5          2.2
  55.0-   60.0       28.750          0.5          2.0
  60.0-   65.0       31.250          0.5          1.9
  65.0-   70.0       33.750          0.0          0.0
  70.0-  100.0       42.500          0.5          1.4

TOTAL SURFACE AREA = 18525    CM↑2/G
```

PARTICLE SIZE DISTRIBUTION

SAMPLE IDENTIFICATION 81-03 75.9

DATE Jan 21 1983

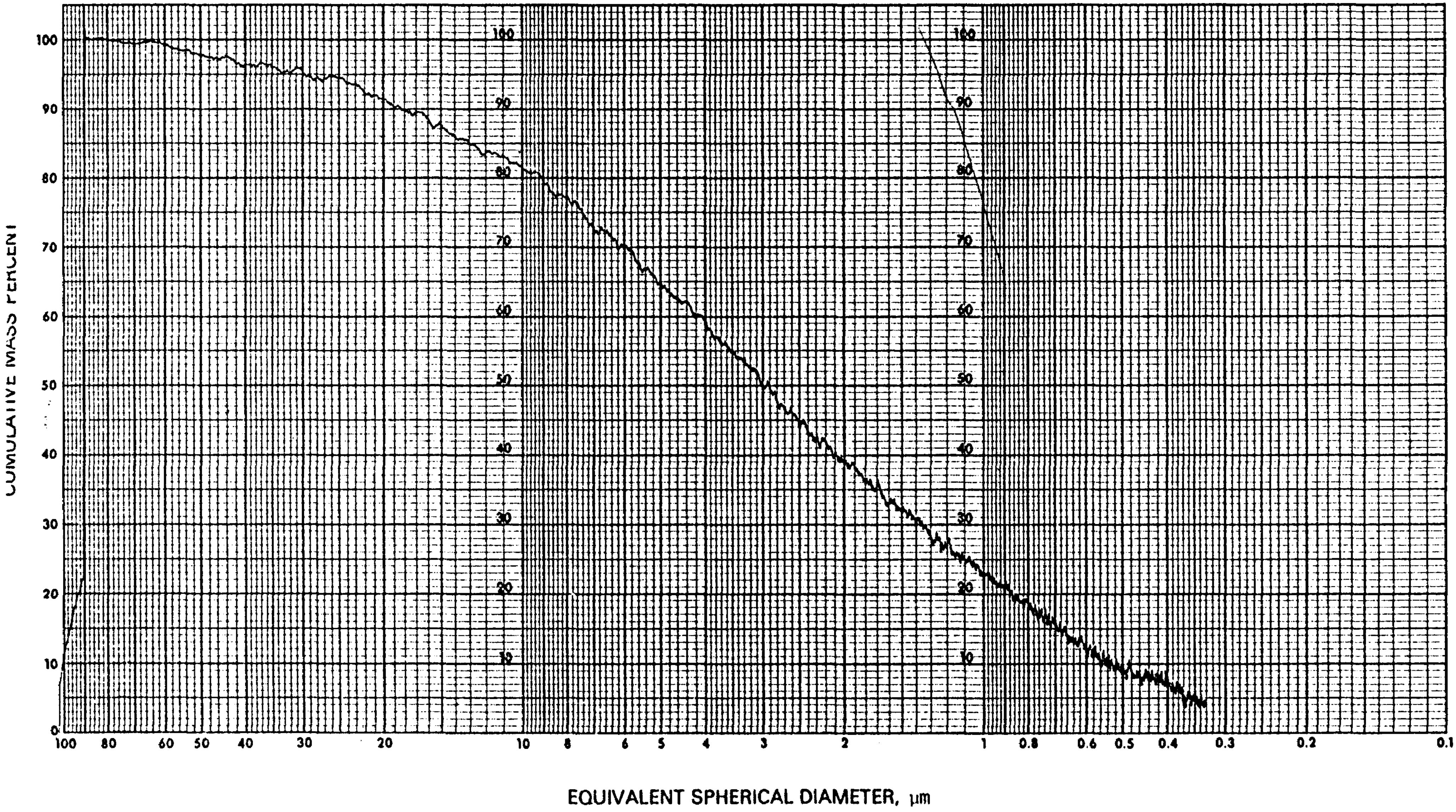
Density 2.55 g/cc LIQUID A-11 Density .744 g/cc Viscosity 1.323 cp

BY Bill Zinbeck

Preparation 2 min ult son bath

TEMPERATURE 32 °C

RATE 733 40 START DIA. 90 μm



micromeritics® instrument corporation

APPENDIX VIII

DRILL CONTRACT

AGREEMENT

BETWEEN

WATTS, GRIFFIS & McOUAT LIMITED

AND

BRADLEY BROS. LIMITED

MEMORANDUM OF AGREEMENT made in Noranda, Quebec, this 21st day of July, 1981.

BETWEEN:

WATTS, GRIFFIS & McOUAT LIMITED
Consulting Geologists & Engineers
Suite 911 - 159 Bay Street
Toronto, Ontario
N5G 1J7
Hereinafter called the Company.

AND:

BRADLEY BROS. LIMITED
P.O. Box 367
Noranda, Quebec
J9X 5A9
Hereinafter called the Contractor.

The Contractor agrees to sink by reverse circulation and by NQ triple tube such grounds as designated by the Company in the Onakawana area in the Province of Ontario at the following prices:

Charge per hour while outfit is operating: - $160.00
This rate includes a three man crew, a foreman, a drill and a compressor.

Charge per hour while moving in from the railroad siding in Onakawana to the first drill hole which includes setting up of drill and camps: - $135.00 per hour

Charge per hour while moving between holes: - $135.00 per hour

Charge per hour while moving out from the final drill hole to the railroad siding in Onakawana which includes dismantling of drill and camps: - $135.00 per hour

The drill outfit will be employed on a 10 hour a day basis, 7 days a week.

In addition to the above charge, all "down the hole" consumable items will be charged at cost plus 15% for handling. These consist of:

Button bit
Heavy duty dual-tube rod
Adapter for heavy duty dual-tube
Rods
Mud

Reaming casing, if necessary, and NQ triple tube drilling will be charged at the following prices:

a) $135.00 per hour
b) All down the hole consumables
c) Plus 15% on b)

The Contractor agrees to supply the necessary drill outfit together with the men and supplies to carry on this work and to carry Workmen's Compensation in conformity with the Workmen's Compensation Act of Ontario.

The Company shall at its own expense provide all rights of way, all rights of ingress or egress and all real property that may be required in connection with said work including real property upon which all necessary temporary buildings may be erected, and other facilities required, and shall also warrant the quiet and peaceful possession of all such real property.

Page 2 ...

Any extra labour required over and above the four men will be charged at cost. Labour shall be charged at $19.00 per man hour.

The Company agrees to pay the Contractor $2,300.00 plus 21% fringe benefits per month for the cook and also agrees to pay the cost of all groceries required during this project. The Contractor shall order and handle all grocery orders, however the Company agrees to be billed direct for these purchases. Should the Company's representatives board at the cookery, there would be no charge made to the Company.

For any equipment breakdown, the Company agrees to pay the Contractor $135.00 per hour. However it is understood that the Contractor's equipment will arrive on the project in good working condition.

Mobilization of the drill outfit from Timmins, to the Onakawana railroad siding shall be charged at $4,500.00 per outfit.

Demobilization of the Contractor's drill outfit from the Onakawana Railroad siding to Timmins shall be charged to the Company at $4,500.00 per outfit.

The Company agrees to pay as follows for probing the holes: $135.00 per hour.

For all time the rig operations are suspended for the convenience of the Company, the Company agrees to pay the Contractor $135.00 per hour.

The Company agrees to pay the Contractor all costs of servicing the outfit from Timmins, Ontario.

The Company agrees to pay the Contractor $400.00 per month per tent for all such facilities required during this project for both the Company and Contractor's employees.

Page 3 ...

The Company agrees to pay the Contractor the cost of all propane and heating fuel required during this project.

If necessary, the Company agrees to pay from Timmins all air charges incurred while performing this work and agrees to be billed direct by the Air Transport Company. Should there be delays due to bad weather conditions in the area of the drill project or lack of availability of aircraft, the Company agrees to pay the Contractor $135.00 per hour while operations are so suspended.

The Company agrees to pay $150.00 per month per radio for use of the radio communication system, if same is deemed necessary.

If the Company desires the Contractor to supply the core boxes, the Company agrees to pay $5.50 per NQ core tray.

Should the Contractor be awarded this work, the Contractor will do its utmost to commence the program when so directed by the Company. However the Contractor will begin operations no later than August 24, 1981.

The Contractor reserves the right to repudiate the terms of this Agreement if it is not accepted by the Company before August 15, 1981.

The Contractor agrees to carry Comprehensive General Liability insurance written foran inclusive limit of no less than $2,000,000.00 to cover all operations of the contract referred to herein. The Contractor specifically represents that, in performing its obligations under this contract, its status if that of an independent Contractor, and that its employees and the employees of its sub-contractor are not the employees of Watts, Griffis & McOuat and/or Ontario Energy Corporation for any purpose whatsoever.

Page 4 ...

The Contractor will render its accounts to the Company on a monthly basis and the Company agrees to pay the Contractor's invoices within thirty days of their receival dates.

In complying with the obligations of this Agreement, neither Party shall be held responsible for any damage or loss sustained by the other resulting from strikes, floods, fires, war, acts of God or any cause beyond its control.

IN WITNESS WHEREOF the parties hereto have set their hands and seals.

WATTS, GRIFFIS & McOUAT LIMITED

Per

Per

BRADLEY BROS. LIMITED

Per Wallace Bradley

63.4111

Watts,Griffis & McOuat Limited

ONTARIO ENERGY RESOURCES LTD.

GEOLOGICAL MAP

JAMES BAY LOWLANDS

SCALE: 1: 250 000

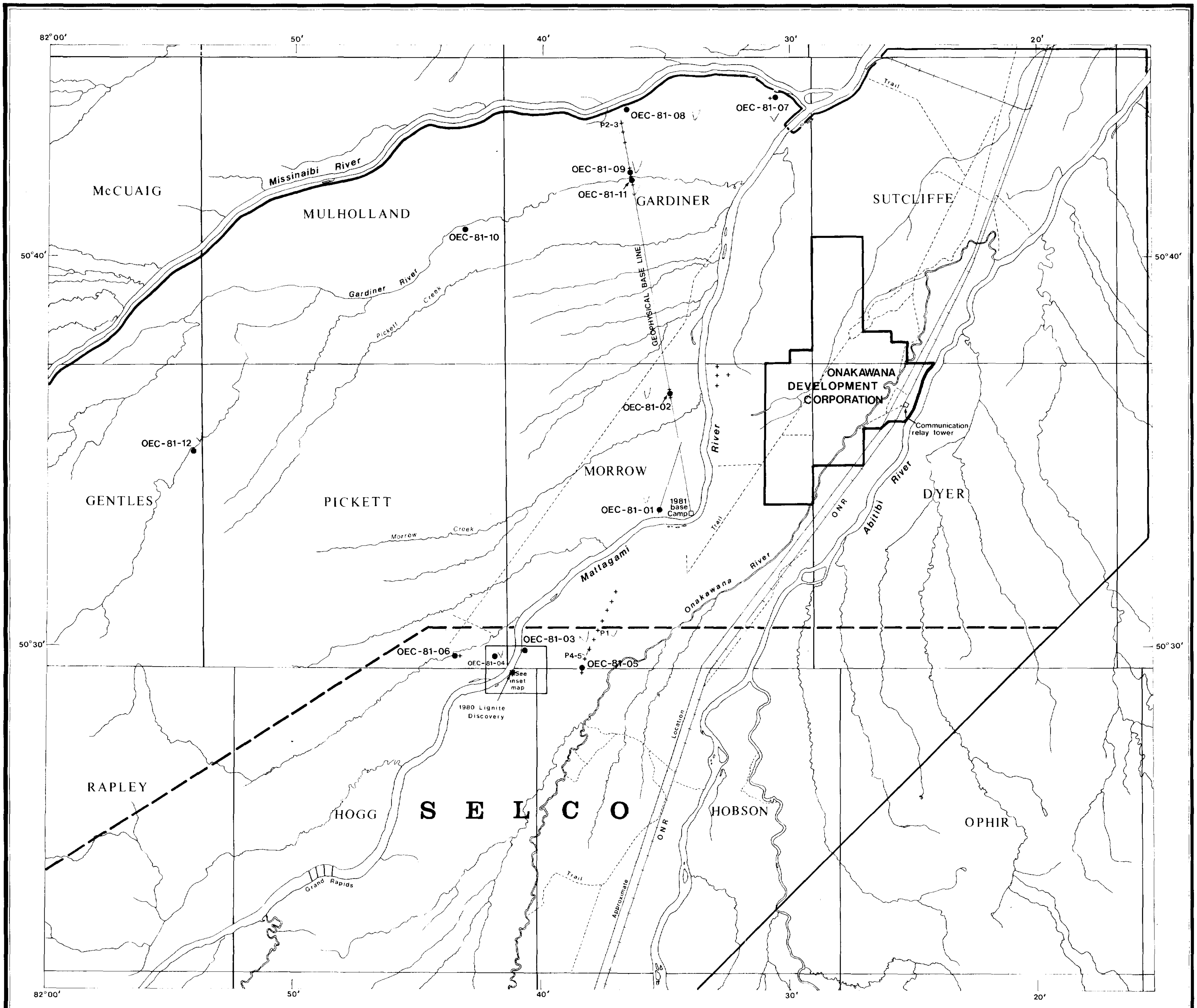
DATE: JANUARY 1982

DWN BY: JAN

APPROVED: R.J.G.

DWG Nº: A

200



EXPLANATION

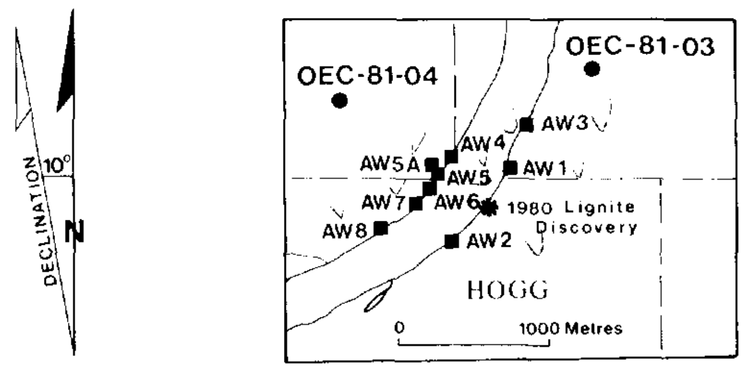
● OEC-81 DRILL HOLE

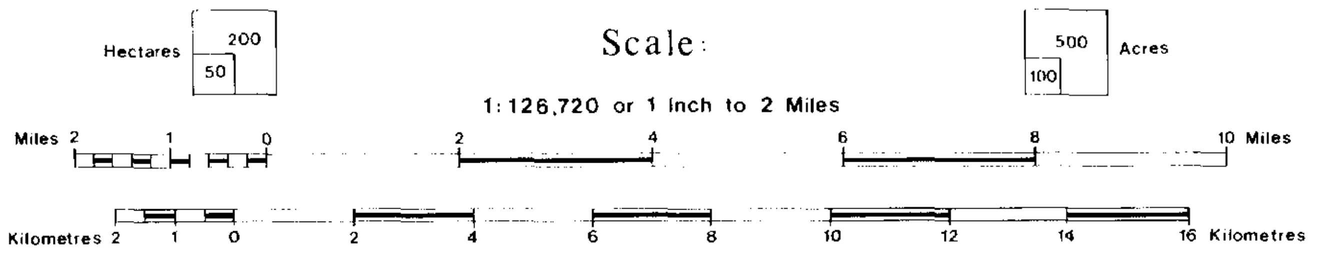
■ 1981 AUGER HOLE

\+ PEAT SAMPLE

—— LICENCE AREA BOUNDARY

– – – APPROXIMATE LICENCE AREA BOUNDARY





63.4111

Watts,Griffis & McOuat Limited

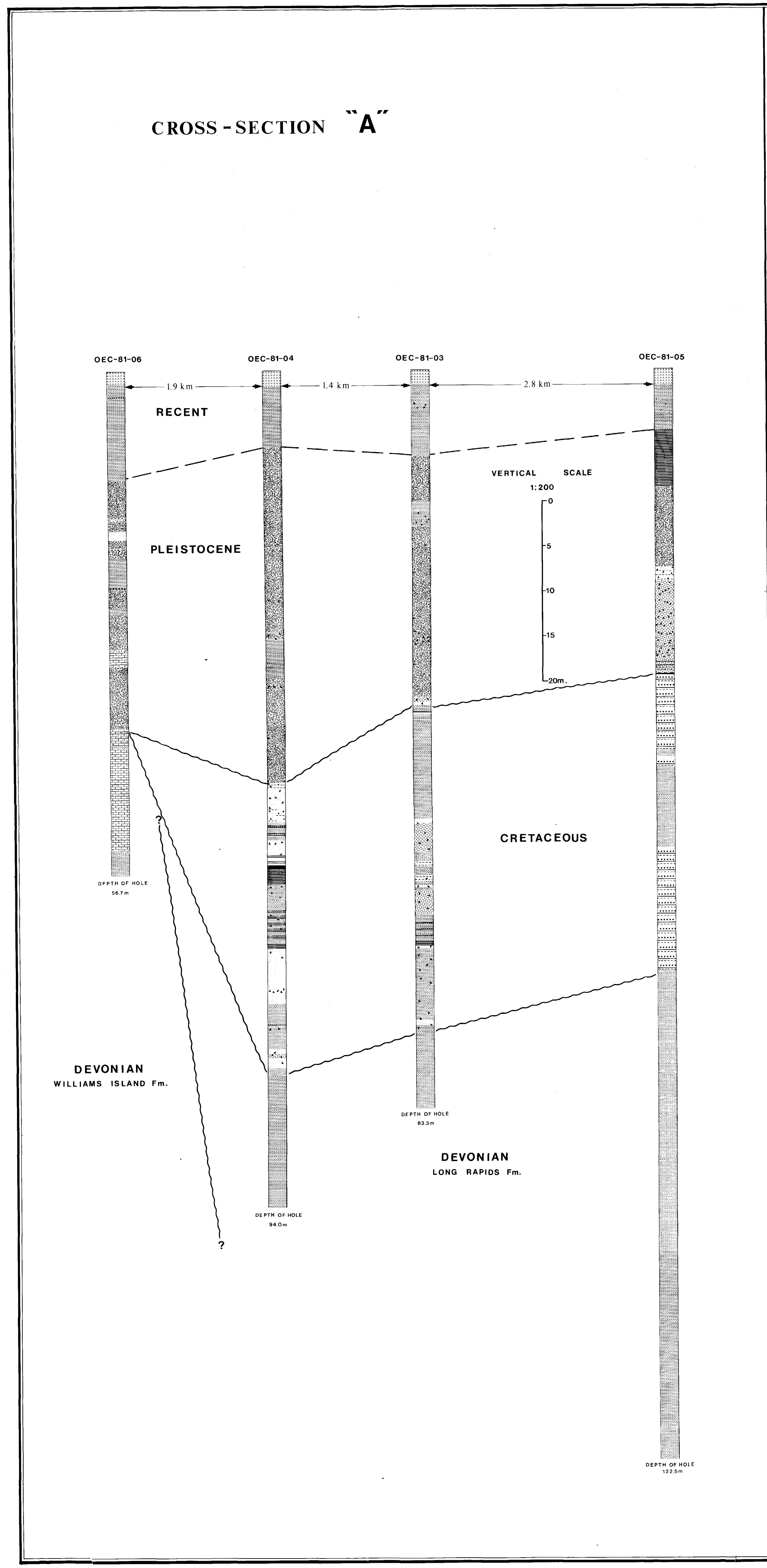
ONTARIO ENERGY RESOURCES LTD.

PLAN SHOWING

1981 FIELD PROGRAM

JAMES BAY LOWLANDS

SCALE: 1:126,720	PREPARED: J.R.	APPROVED: R.J.G.
DWN BY: JAN	DATE: FEBRUARY 1982	PROJECT Nº: 618-1 DWG Nº: B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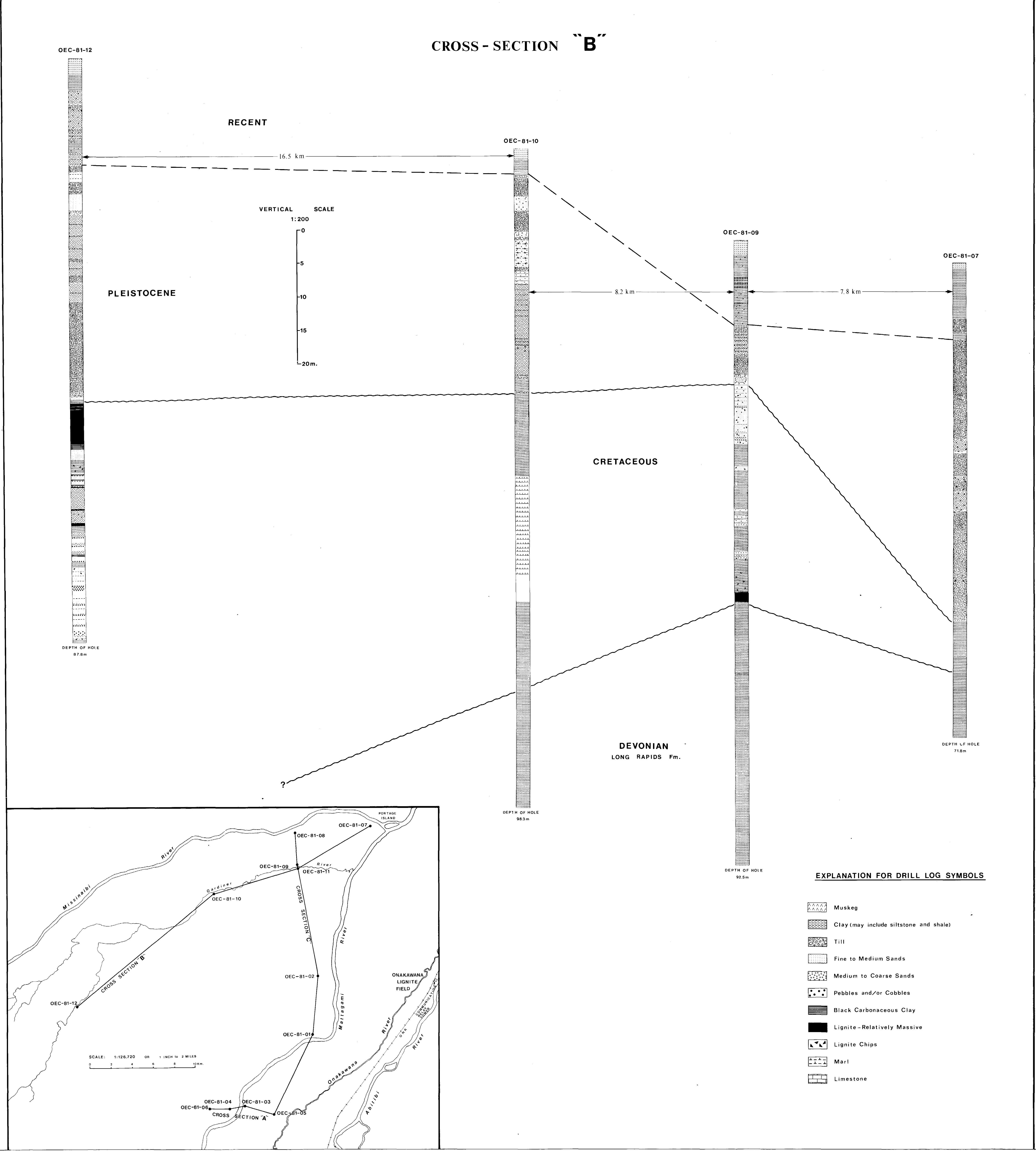
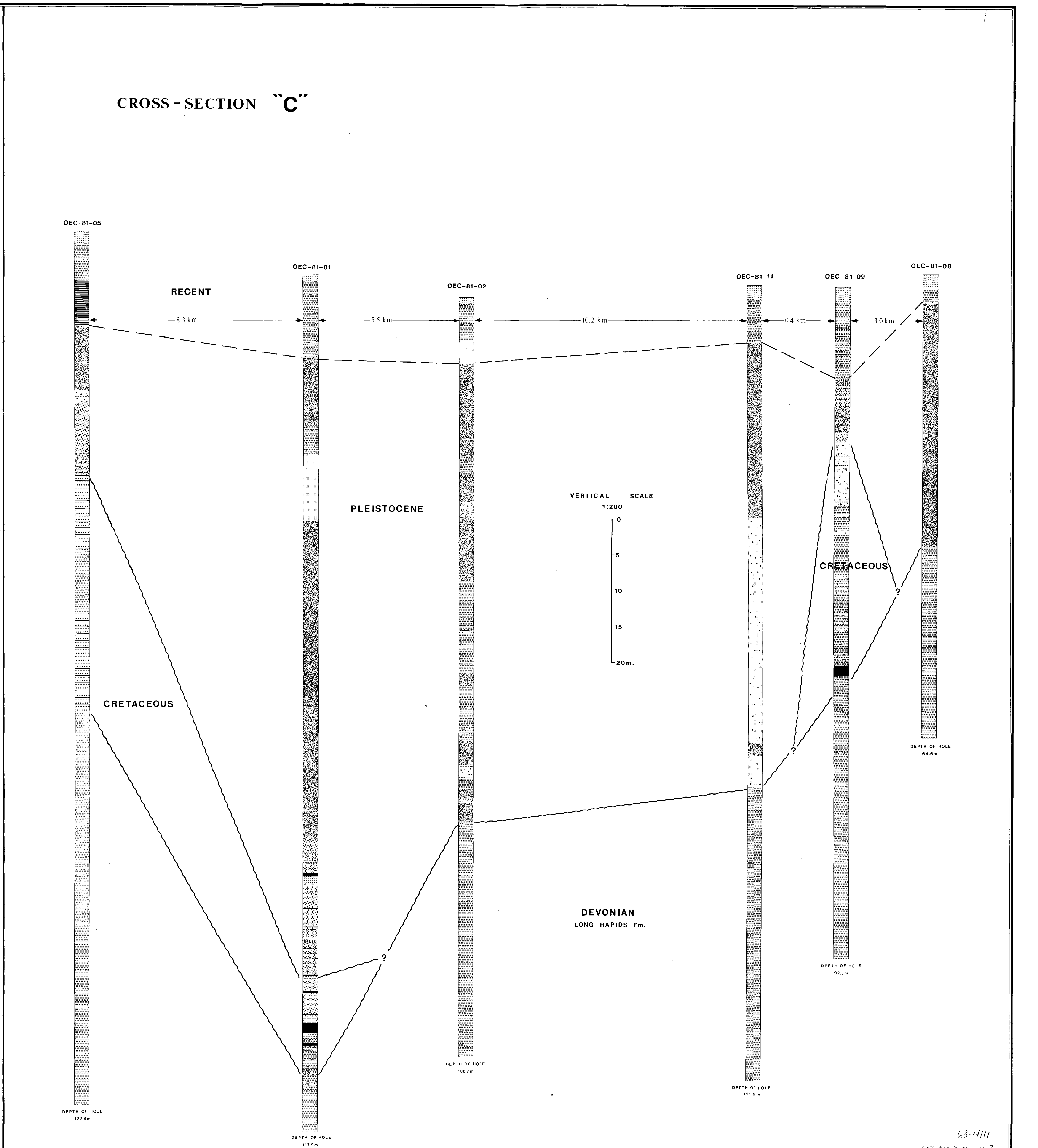

CROSS-SECTION "B"

EXPLANATION FOR DRILL LOG SYMBOLS

⋀	Muskeg
▤	Clay (may include siltstone and shale)
▨	Till
⋯	Fine to Medium Sands
∘	Medium to Coarse Sands
●	Pebbles and/or Cobbles
☰	Black Carbonaceous Clay
■	Lignite-Relatively Massive
▲	Lignite Chips
┴	Marl
▦	Limestone


CROSS-SECTION "C"

63·4111
OM 81-5-C-107

Watts, Griffis & McOuat Limited
ONTARIO ENERGY RESOURCES LTD.

DRILL HOLE SECTIONS
JAMES BAY LOWLANDS

PREPARED: J.R.	SCALE: As Indicated	APPROVED: R.H.C.
DRAFTING: J.R.	DATE: MARCH 1982	PROJECT Nº: 618-1 DWG Nº: C

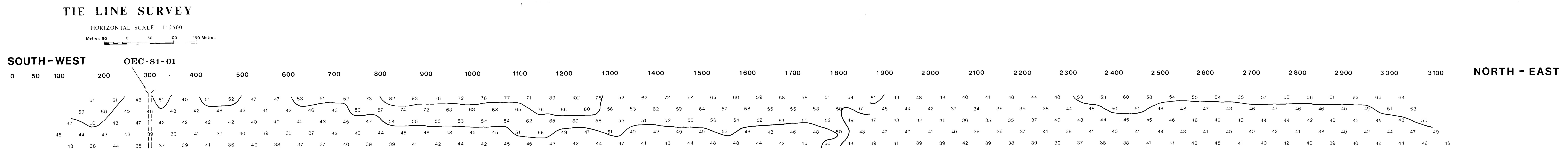
220

BASE LINE SURVEY

HORIZONTAL SCALE · 1:2500

TIE LINE SURVEY

HORIZONTAL SCALE · 1:2500



EXPLANATION

Equipment used was a McPhar P-660 I.P. unit
Frequency - 5 c.p.s.
Dipole-dipole configuration.
Readings taken every 50 metres.
Survey carried out by C. Beuden: field consultation provided by R. Mertens.

63-4111

Watts, Griffis & McOuat Limited
ONTARIO ENERGY RESOURCES LTD.

GROUND RESISTIVITY SURVEY

SCALE: 1 : 2500
APPROVED: R.J.G.
DWN BY: JAN
DATE: MARCH 1982
PROJECT Nº: 618-1-700
DWG Nº: D