

REPORT ON  
SEISMIC INVESTIGATIONS  
OF  
PROPOSED RELOCATION OF HIGHWAY NO. 2  
NEAR  
ANCASTER, ONTARIO

for the

DEPARTMENT OF HIGHWAYS - ONTARIO

by

HUNTING TECHNICAL AND EXPLORATION SERVICES LIMITED

Toronto, Ontario

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## INTRODUCTION

### GENERAL

Between November 4th. and December 24th. , 1958 , Hunting Technical and Exploration Services Limited carried out a seismic depth to bedrock investigation for the Ontario Department of Highways on the proposed Chedoke Expressway in the vicinity of Hamilton , Ontario.

From November 4th. to November 26th. , our seismic crew consisted of one geophysicist and one operator , using an MD-1 one-channel refraction seismograph. To improve the progress of the survey a second operator with another MD-1 instrument was added to the party from November 27th. to December 24th. Two local helpers were hired to assist in the field work. From November 4th. to December 12th. one or two of our engineers joined the seismic party to conduct geological observations , shallow probe holes and a limited amount of hand auger borings.

### PROCEDURE

The seismic survey consisted of a series of cross sections on a proposed relocation of Highway #2 between Mohawk Road and Longwood Road. The cross sections were 100 feet apart and extended 150 feet to either side of the centre line. Each cross section was marked in the field by a crew of the Ontario Department of Highways with three pickets , one picket at the centre line and one picket at each end of the cross sections. The cross sections were numbered from 205+00 at the Mohawk Road to 362+00 at the Longwood Road.

Wherever required and possible the seismic work was carried out in the following way: on each cross section four depth determinations were carried out, one determination at the left end of the cross section directed towards the centre line , one determination at the right end of the cross section also directed towards the centre line , and two determinations at the centre line , one directed towards the left and one towards the right. This procedure provided three actual depth determinations on each cross section and in most cases interpreted depth calculations between the actual determinations.

### ELEVATION SURVEY

An unfortunate delay in the report occurred because the surface elevations along the cross sections were not available. Finally , between May 22nd. and June 2nd. , 1959 , a survey party of Hunting Technical and Exploration Services Limited carried out a topographic survey of the investigated area.

## REQUIREMENTS

The requirements as stipulated by the Ontario Department of Highways can be summarized as follows:

UPPER PART - Between cross sections 205+00 and 249+00. This part comprised the area on top of the Niagara Escarpment. Here the thickness of the overburden was to be determined in cut sections. As a limited amount of drilling had already been carried out, no study of the overburden material was required.

CENTRAL PART - Between cross sections 250+00 and 321+00. This part comprised the area along the escarpment. In the first part of this area, between cross sections 250+00 and 302+00, it was important to determine the thickness of the overburden and its composition as well as the soundness of the bedrock in fill sections to ensure stability of the embankment. In the second part of this area, between cross sections 305+00 and 321+00, it was important to determine the thickness of the overburden in cut sections.

LOWER PART - Between cross sections 335+00 and 362+00. This part comprised the area below the escarpment on the Chedoke Civic Golf Course. Here depth of bedrock determinations were required on all cross sections.

## GEOLOGY

### GENERAL

The proposed Chedoke Expressway traverses the most striking topographic feature of the landscape in Southern Ontario, namely the Niagara Escarpment. This escarpment is an erosional feature which is due to the presence of a resistant layer of rocks underlain by soft, easily eroded shales. As the rock strata dip at a shallow angle into the escarpment, the weathering of the soft shales below undermines the harder upper layers which break off and preserve the steep front of the escarpment. Above the central part of that portion of the expressway route investigated, rock outcrops of dolomite form the upper vertical face of the escarpment, while the less resistant formations below form a slope, the steepness of which varies in accordance with the degree of resistance to erosion offered by the different rock layers.

The entire area traversed by the expressway has been subjected to glacial action and although the depth of overburden varies from place to place, the surface features above the escarpment appear to generally follow the bedrock features. Below the escarpment, however, the overburden appears to control the topography so that the present ground surface does not express the structure of the underlying rock.

TABLE OF FORMATIONS

SYSTEM	FORMATION	MEMBER	THICKNESS	CONTACT ELEVATION			
				Sta. 205+00	Sta. 255+00	Sta. 280+00	Sta. 300+00
Silurian	Guelph		150'	701±		726±	
		Eramosa	99'±	602±	630±	627±	
		"Undivided"	24'±		607±	603±	
		Gaspert	16'±		590±	587±	
		DeCew	7'±		583±	580±	
	Rochester		18'±		565±	562±	
	Clinton		8'±		557±	554±	
	Medina	Thorold	6'±		551±	548±	
		Grimsby	6'±		545±	542*	538±
		Cabot Head	81'±		464±	461±	457±
		Manitoulin	10'±		454±	451±	447±
		Whirlpool	10'±		444±	441*	437±
Ordovician	Queenston		340'±				

\* indicates elevation of this contact measured in the field

## BEDROCK STRATIGRAPHY

The route of the entire expressway is underlain by Palaeozoic sedimentary strata of the Silurian and Ordovician systems. The table of formations together with their thickness and elevation of contact encountered along the length of the highway is attached overleaf. Although the general dip of the Palaeozoic strata has been measured in gas and oil drill holes to be in the general order of 30 feet per mile to the southwest, field measurements taken on top of the Clinton formation indicate that the rocks dip locally at about 9 feet in 1,000.

As can be seen on the centre line profile, the Queenston red shale forms the base of the escarpment and underlies that part of the expressway which runs "below" the escarpment. The Lower Silurian (Medina Formation) rocks consist primarily of sandstone and shales and form the lower two-thirds of the escarpment. The Middle Silurian is composed essentially of dolomite and, with the exception of the Guelph formation and the Eramosa member of the Lockport formation, constitutes the upper part of the Niagara Escarpment and outcrops along its front. The Eramosa and Guelph dolomites underlie the "upper" part of the expressway.

### DESCRIPTION OF BEDROCK FORMATIONS

#### QUEENSTON FORMATION

"The strata consist of brick-red, thinly bedded, sandy and argillaceous shale, which is remarkably uniform in character showing little or no variation either vertically or from one locality to another. The shales are almost everywhere seamed by narrow greenish bands disposed both parallel and at right angles to the bedding planes. The vertical seams appear to lie along small joint fissures; the horizontal ones along what may be zones of greater permeability; and the colour is probably due to a bleaching by percolating water charged with organic acids in solution".

"The Queenston shale rapidly breaks down on exposure to the atmosphere and forms a fine, reddish, clay soil".

The Queenston shale is illustrated in figures 17, 18, and 19 in the appendix to this report. This formation is at least 450 feet thick.

#### MEDINA FORMATION

##### WHIRLPOOL MEMBER

"The Whirlpool member is a resistant, light grey, quartzose sandstone." It is about 12 feet thick and overlies the Queenstone shale. The contact between the Queenstone shale and the Whirlpool is exposed at centre line station 280+00, where figure 17 was taken. As seen in figure 16, this member occurs in beds of considerable thickness.

### MANITCULIN MEMBER

The Manitoulin member is a thin and irregularly bedded, grey to bluish, impure limestone with thin, grey, shale partings." This member overlies the Whirlpool sandstone. It is illustrated in figure 15.

### CABOT HEAD MEMBER

The Cabot Head member varies widely in its lithology from place to place. Primarily, in the vicinity of station 280+00, it consists of 80 feet of shales, predominantly grey with some red at the base. In addition, there are frequent interbeds of grey sandy limestone in the basal section. The thickness and variety of limestone or sandstone interbeds varies considerably throughout the remainder of the section.

There are only a few outcrops of the Cabot Head member along the proposed expressway route and these are concentrated at station 280+00. They are illustrated in figures 12 and 13. A more complete exposure of this member can be seen on the Number 6 highway cut south of Clappison Corner as shown in figure 14.

### GRIMSBY MEMBER

"The Grimsby member consists chiefly of reddish, or grey and red mottled sandstone, generally disposed in beds from 4 to 12 inches thick and separated by red, sandy shale partings". It is about 6 feet thick at station 280+00 and is illustrated in figures 11 and 12.

### THOROLD MEMBER

"The Thorold member is a light grey to whitish, hard sandstone in beds from a few inches to several feet in thickness." It is about 6 feet thick at station 280+00 and is illustrated in figures 11 and 12.

### ROCHESTER FORMATION

The 18 foot thick Rochester formation consists of dark grey, thinly bedded, sandy shale with frequent thin (1 to 5 inch) bands of grey limestone in the lower section. While this formation is not well represented by outcrop along the proposed highway, it can readily be examined in the Number 2 highway cut near Ancaster. This formation is illustrated in figures 4, 7, 8, and 9, which were taken at the above mentioned cut.

### LOCKPORT FORMATION

### DECEW MEMBER

"The DeCew beds consist of medium to dark grey, fine, dense, argillaceous limestone, commonly weathered dark grey or buff." These beds are about 7 feet thick and are illustrated in figure 4.

### GASPORT MEMBER

"The 16 feet thick Gasport horizon is occupied by a light grey to white, medium to coarsely crystalline dolomite in beds from 1 to 4 feet thick."

This member is about 16 feet thick where it intersects the highway route. Although it outcrops above the route, it can also be seen in the Number 2 highway cut near Ancaster. It is illustrated in figures 4 and 6.

### "UNDIVIDED" MEMBER

"Overlying the Gasport member, is about 24 feet of grey to brownish, dense, unevenly bedded dolomite in beds from 8 inches to 2 feet thick, with a profusion of chert nodules varying from 2 to 5 inches across. The chert is dense, hard and breaks with a conchoidal fracture, giving sharp splinters. On fresh surfaces it is dark grey or bluish, but on weathered surfaces it is light grey to almost white." These chert beds are known as "Undivided" Lockports and are illustrated in figures 4, 5, and 6.

### ERAMOSA MEMBER

Although half of the Eramosa member does not outcrop at Ancaster, the rock types can be seen in other localities. The Eramosa consists of a dense, brownish dolomite, in places weathered almost white, in beds from 1 to 3 feet thick. It is illustrated in figures 1 and 2.

### GUELPH FORMATION

The rocks of the Guelph formation are a light grey to brown crystalline dolomite which are very similar to the Lockport dolomites. These rocks outcrop in the creek bed in the vicinity of station 205+00 about 200 feet right.

### ENGINEERING GEOLOGY

While it is beyond the scope of this report to deal in great detail with the engineering geological aspects of the rock encountered along the expressway route, there are a number of features that became obvious during the course of this investigation which we consider to be worthy of mention at this time.

It is expected that one of the most useful tools of the designer will be the comparison with existing highway and railway cuts in the area. Very helpful information can be obtained by observing and studying the effects of previous construction practices on these local materials.

For purposes of this discussion, we have considered that part of the expressway investigated to be divided into three parts - the upper part, the central part and the lower part. The upper part refers to the section roughly



between Stations 205+00 and 249+00 which lies on top of the escarpment. The central part refers to between Stations 250+00 and 321+00 where the expressway runs along the steep part of the escarpment. The lower part refers to the section below the escarpment from Station 335+00 to Station 362+00.

The engineering features of the rock types encountered along the proposed route are considered in order of their occurrence along the chainage starting with the upper part of the route. While comments are made in general with reference to rock types encountered in a specific locality, these comments can be applied to any other locality where this rock type is encountered.

### UPPER PART

If the present grade line is maintained, rock will likely be encountered in the excavations between cross sections 206+00 and 213+00, 235+00 and 236+00, 241+00 and 243+00 as well as 244+00 and 249+00. It is in the latter area that the centre line of the proposed road runs over the edge of the escarpment.

The massive Eramosa and Guelph dolomites underlie that part of the expressway between chainages 205+00 and 213+00 and between 235+00 and 236+00 where rock cuts are envisaged. Figure 2 illustrates the type of rock to be encountered along this part of the route. Due to the massiveness of these strata this rock can be expected to break into large chunks when blasted. Depending upon the nature of the explosive charges and of the equipment used for excavation, this rock may require secondary blasting.

Between Stations 241+00 and 243+00, rock of the "Undivided" member of the Lockport formation will be encountered above the grade line. As shown in figure 5, this rock has many horizontal and vertical planes of weakness and should require only light charges of explosive. This rock will probably have a tendency to overbreak and will be difficult to scale. Figure 6 indicates the tendency for this rock to rubble which could contribute to ultimate constriction of drainage ditches and undermining of the earth slope on the right side of the expressway.

Between Stations 243+00 and 249+00, dolomite of the "Undivided" and Gasport members and limestone of the Decew member of the Lockport formation will be encountered above the grade line. In contrast to the "Undivided" member described above, the Gasport and Decew dolomites are more massively bedded. However, the Decew beds do have vertical planes of weakness as shown in figure 25 above the ice due to the argillaceous nature of the limestone. This should eliminate the necessity for secondary blasting. With reference to the high cuts on the right side of the highway, the tendency for the "Undivided" member to rubble may cause trouble. A certain amount of spalling due to freezing and thawing action is likely to be encountered in the rock of the "Undivided" and Decew members.

### CENTRAL PART

The central part of the route runs from Station 250+00 to Station 321+00 and consists of that section of the roadway which runs along the steep part of the Niagara Escarpment. The roadway as presently contemplated will consist partly of rock cut on the right and partly of rock fill on the left. The rocks which lie beneath the proposed grade line include all types between the Decew member of the Lockport formation and the Queenston formation whereas in the cut sections, all rocks above the Queenston formation to the "Undivided" member of the Lockport will be exposed. The talus slope which forms the major portion of the steep part of the escarpment has resulted from the weathering of the Rochester, Cabot Head and Queenston shales with subsequent undermining of the firmer strata above. Careful consideration will have to be given to the fill section of the roadway to determine the relationship between super-incumbent load (including talus), weathered shale and bedrock. As the in-situ shear strength of the weathered shale will be of critical importance in this section, an understanding of the diagenesis of the shale becomes of value.

Clays and silts are changed to shales through the process of compaction, or compaction and cementation. Compaction takes place as a result of the elimination of water under compressive forces exerted by overlying sediments. Compaction may proceed until the water films surrounding the shale particles have been removed and the particles brought into actual contact. When this degree of consolidation is reached, cementation may begin and solidification may then proceed until a comparatively high strength rock has developed.

Depending upon the character and degree of solidification, shales act differently when exposed to weathering. Those shales whose stage of development has reached to compaction stage only, revert to the original muds from which they were formed when subjected to drying and wetting. The rapidity with which they disintegrate is a function of their solidification development. Low grade clay shales of the compaction type undergo complete disintegration after several cycles of wetting and drying. Intermediate types of shale form chips instead of mud whereas the more fully developed types are more resistant to these changes.

The shales found along the proposed roadway are of the compaction type, thus they can be expected to disintegrate when exposed.

The presence of this shale and its disintegration characteristics suggest conditions which have a potential of creating trouble as follows:

- (1) Due to the presence of the shale beneath the talus slope, a potential landslide movement involving surficial material is envisaged if the present slope is disturbed to any great degree. The disturbance could be removal of material from the toe of the slope, addition of material at the top of the slope, changes in the ground water conditions.

(2) When shales are exposed on slopes in cuts slow disintegration can be expected to occur. This may in time lead to undercutting of firmer strata above, especially where ground water springs are involved (see figure 25). Some ravelling and spalling on the cut slopes can also be expected to occur.

(3) If water is allowed to run freely over the cut slopes or in rock cut drainage ditches without some sort of protection of the shale, rapid erosion can be expected to occur.

It is expected that a study of previous experience in the area will help determine the blasting and excavation characteristics of the shales and interbedded shales and limestones as well as the steps necessary to produce and maintain a stable highway section.

Due to the massiveness of the Clinton and Whirlpool beds, secondary blasting of these rocks may be required.

### LOWER PART

The lower part of the expressway has been considered between cross sections 335+00 and 362+00. In this area, cuts will intersect shale bedrock of the Queenston formation. As this shale is of the compaction type, problems associated with the disintegration feature described under the central part can be expected.

## SEISMIC SURVEY

### GENERAL

The results of the seismic survey are presented in the form of cross sections provided with this report on three separate rolls, each roll of cross sections corresponding to one of the three parts of the area. On each of the cross sections, which are drafted at the scale of 1 inch = 10 feet, the ground and bedrock surfaces are indicated. Points where the depth to bedrock is determined or interpreted are marked with different symbols. In addition, the actual velocities of the bedrock and of the various types of overburden are indicated.

Each cross section is furthermore discussed either separately or in combination with similar cross sections in the report. Bedrock profiles along the centre line are also included in the report on three separate sheets.

## UPPER PART

This area comprises the cross sections on top of the Niagara Escarpment, Cross Sections 205+00 to 249+00. The cross sections show a rather flat topography with the exception of the parts where the proposed road goes over the actual escarpment, and the overburden consisted mostly of a dry sand and/or clay overlain by a thin layer of loose topsoil. The bedrock consists of various types of dolomite belonging to the Guelph Formation or to the Eramosa to Gasport members of the Lockport Formation.

The seismic results indicate that some rock excavation will be necessary between cross sections 206+00 and 213+00 amounting locally to as much as 15 feet. Minor rock excavations will be required between cross sections 235+00 and 236+00 and between 241+00 and 243+00. A considerable amount of rock excavations will have to be carried out between cross sections 244+00 and 249+00. It is in this area that the proposed road cuts the escarpment.

### Cross Section 205+00

This section was rather flat and only slightly above the grade line. Depth to bedrock determinations were carried out at the centre line and at 150 feet left of the centre line. Some interpretation between these points was possible. Depth to bedrock varies between 6 1/2 and 9 feet. Overburden material shows a velocity of 900 - 1,100 ft./sec. indicating a very loose material, probably topsoil and organic material. Bedrock shows velocity of 11,500 - 14,000 ft./sec. and is composed of dolomites of the Guelph Formation. The depth as obtained by seismic methods was confirmed by a probe hole at the centre line, reaching a depth of 7 1/2 feet. In this cross section no bedrock is expected above the grade line.

### Cross Section 206+00

This section was slightly inclined towards the left. Depth to bedrock is around 11 1/2 feet in the left part of the section where only the low velocity layer overlies the bedrock. To the right another layer with a velocity of 2,400 ft./sec. appears between the loose topsoil and the bedrock. This layer is probably composed of sand and/or clay. The bedrock velocity varies between 12,000 and 16,000 ft./sec. Some bedrock excavation up to 4 feet might be necessary on the right part of the section but the bedrock level might be slightly lower than indicated. The bedrock is composed of dolomites of the Guelph Formation.

### Cross Section 207+00

This rather flat section is well above the grade line. Depth to bedrock however is increasing considerably compared with section 206+00 and is around 26 feet along the entire section. Overburden consists of a layer of loose topsoil 6 - 8 feet thick, and a layer with a velocity varying from 3,000 - 4,400 ft./sec. and probably composed of

sand and/or clay and silt. The bedrock shows a velocity of 12,000 - 16,000 ft./sec. and is composed of dolomites of the Guelph Formation. Some rock excavation, up to 4 feet in depth, will be necessary on the right part of this section.

#### Cross Section 208+00

This section has been investigated from 90 feet left of the centre line to 150 feet right of the centre line. Depth to bedrock varies between 9 and 12 feet. A probe hole at the centre line indicating a depth to bedrock of 11 feet confirms the seismic results. The overburden consists of loose topsoil. The bedrock shows a velocity of 10,000 - 17,000 ft./sec. and consists of dolomites of the Guelph Formation. Bedrock excavation up to 10 feet will be necessary over the entire cross section. A comparison between sections 206+00, 207+00 and 208+00 indicates that the little hill in this part is not reflected in the bedrock surface which remains rather flat.

#### Cross Section 209+00

This section also shows a shallow depth to bedrock varying from 5 to 8 feet. Overburden is composed of loose topsoil overlying dolomites of the Guelph Formation. The bedrock shows velocities varying from 10,000 to 18,000 ft./sec. A probe hole at the centre line did not penetrate below 3 1/2 feet. Bedrock excavation of 6 to 12 feet will be necessary over the entire section.

#### Cross Section 210+00

The results along this section are very similar to section 209+00. Overburden, consisting of loose topsoil is very thin, 4 - 7 feet. The bedrock, consisting of dolomites of the Guelph Formation shows velocities of 13,500 - 17,000 ft./sec. Probe holes at the centre line and at 150 feet to the right of the centre line penetrated respectively 3 and 4 1/2 feet. Bedrock excavation up to 15 feet will be necessary along this cross section.

#### Cross Section 211+00

The seismic results along this section indicate a depth to bedrock of 5 - 7 feet, which is confirmed by probe holes, (6 feet penetration at the centre line). The bedrock shows a velocity of 11,000 - 15,500 ft./sec. and consists of some remnants of dolomites belonging to the Guelph Formation directly underlain by dolomites of the Eramosa member of the Lockport Formation. Bedrock excavation amounts to a maximum of 9 feet, and includes the remnants of the Guelph Formation and the top of the Eramosa member.

#### Cross Section 212+00

One seismic depth determination on this section was carried out at 110 feet to the right of the centre line, indicating a depth of 4 feet.

Probe holes along the section indicated depths of 2 to 4 feet. Bedrock excavation in this section amounts to approximately 8 feet and includes remnants of the Guelph Formation and the top of the Eramosa member of the Lockport Formation. Figure 1 shows outcrops of dolomites of the Eramosa member at station 212+00, 100 feet right of the centre line.

#### Cross Section 213+00

Seismic determinations along the left part of this section showed depths of 6 1/2 feet. The bedrock, consisting of dolomites of the Eramosa member of the Lockport Formation, shows velocities of 13,000 - 15,000 ft./sec. The overburden consists of loose topsoil. Depths here were confirmed by probe holes which penetrated 6 feet at the centre line and 4 1/2 feet 150 feet left of the centre line. The right part of the section was investigated only by probe holes indicating depths of around 2 feet. Bedrock excavation is only around 1 foot in the right part of the section but increases to around 7 feet in the left part.

#### Cross Section 214+00

Probe holes on the right part of this section indicate depths of 3 to 6 feet and no bedrock excavation will be necessary here. No determinations were made in the left part of the section, however bedrock level will probably stay below the grade line through this part also.

#### Cross Section 215+00

No seismic work has been done on this section. Probe holes indicated depths of 2 to 4 1/2 feet with dolomites of the Eramosa member just below the grade line. No bedrock excavation on this section will be necessary.

#### Cross Section 216+00

No seismic work has been done here. At the right end of the section a probe hole penetrated 5 1/2 feet without hitting bedrock. Close to the centre line but off the railroad embankment a depth of 5 feet was encountered. At the left part of the section outcrops of Eramosa dolomite were found. This outcrop area is shown on figure 3. No bedrock excavation will be necessary in this section.

#### Cross Sections 217+00 to 222+00

These sections represent fill areas and no seismic determinations or probe holes were carried out here.

#### Cross Section 223+00

This cross section was partly investigated seismically. The bedrock, consisting of Eramosa dolomites, shows a velocity of around 12,500 ft./sec. It is overlain by 28 to 31 feet of overburden. The overburden consists of loose topsoil overlying a layer of sand and/or clay and silt. Excavation will be limited to the topsoil.

Cross Sections 224+00 to 226+00

The grade line in these sections lies above the surface level and therefore no work was done here.

Cross Sections 227+00, 228+00 and 229+00

In these three sections the grade line is partly below the surface level, however nowhere more than 10 feet. The depth to bedrock varies between 19 and 35 feet so that no bedrock excavation will be necessary here.

Cross Sections 230+00, 231+00 and 232+00

In these sections the grade line falls above the surface level.

Cross Sections 233+00 and 234+00

In these sections the grade line falls slightly below the surface level but the bedrock level falls at least 10 feet below the grade line.

Cross Section 235+00

A layer of 8 1/2 to 12 feet of overburden covers the bedrock here which consists of Eramosa dolomites. Overburden consists of loose topsoil and a layer of sand and/or clay and silt. Only in the extreme right end of the section does the grade line cut the bedrock surface and some bedrock excavation will be required here.

Cross Section 236+00

This section is very similar to section 235+00. Up to 10 feet of rock excavation will be necessary in the right half of the section.

Cross Sections 237+00 to 240+00

Of these cross sections only the part on top of the escarpment has been investigated. The sections show an increasing thickness of overburden from 237+00 towards 240+00. The level of the bedrock which is composed of Eramosa dolomites is just below the grade line. It is however possible that irregularities will bring the bedrock level locally slightly above the grade line. No rock excavation of any significance will however be necessary.

Cross Sections 241+00 to 245+00

These sections have all been investigated from 100 feet left of the centre line to 150 feet right of the centre line. In all these sections bedrock excavation is necessary in the right parts of the sections. The amount of excavation varies between a couple of feet in section 245+00 to 13 feet in section 241+00. In these cut parts the bedrock consists of dolomites belonging to the bottom part of the "Undivided" Lockport member.

or the top part of the Gasport member. The left parts of the sections show the bedrock level well below the grade line. In these sections no outcrops have been found within 150 feet from the centre line.

#### Cross Section 246+00

The part of this section on top of the escarpment, from 75 feet left to 150 feet right, shows the level of the bedrock up to 7 feet above the grade line. The bedrock consists here of dolomites of the Gasport member. The velocities are around 11,000 ft./sec. Down the slope of the escarpment some outcrops of fossiliferous dolomite of the Clinton Formation were found, at approximately 130 - 140 feet left of the centre line.

#### Cross Section 247+00

This section is very similar to section 246+00. A layer of 9 - 20 feet of mostly loose topsoil overlies dolomites of the Gasport member. Bedrock excavation of up to 15 feet will be necessary here. Bedrock velocities vary between 9,000 and 11,000 ft./sec. Figure 23 shows the slope of the left part of the section with outcrops of the Gasport dolomite and, at the bottom of the picture, outcrops of the Clinton Formation.

#### Cross Section 248+00

The part of the section on top of the escarpment is similar to section 247+00. Rock excavation varies between 10 and 20 feet. The down-slope is more gentle than usual and no sharp faces were observed. Bedrock seems to be overlain by about 10 feet of topsoil and talus. The velocity of the bedrock is around 10,000 ft./sec.

#### Cross Section 249+00

Very similar to the previous sections. Rock excavations vary between 20 and 35 feet on top of the escarpment. The part that has to be excavated consists of dolomites of the Lockport Formation. These formations can be observed on the cliff face at 5 feet left of the centre line. The velocity of the bedrock is 10,000 - 11,000 ft./sec. The slope on the left side of the section is covered by approximately 10 feet of topsoil and talus.

### CENTRAL PART

This area comprises the part along the Niagara Escarpment, cross sections 250+00 to 321+00. From 250+00 to 297+00 the bedrock is overlain by a thin layer of loose topsoil and talus blocks. The bedrock is mostly shales, limestone and sandstone of the Medina and the dolomites of the higher formation but at the left side of the cross sections the bedrock surface is built up by Queenston shales which occur at a level of approximately 440 feet. From 296+00 to 305+00 the bedrock level drops sharply



along the centre line mainly because the proposed road leaves the actual escarpment gradually and from 305+00 on the bedrock is entirely composed of Queenston shale. As the bedrock profiles show more and more shale at the bedrock surface, the overburden thickness increases and reaches values of around 40 feet.

#### Cross Sections 250+00 to 256+00

These cross sections are very similar to each other. They all go from the top of the escarpment down along the slope. Only the left part of these sections has been investigated seismically to determine the amount and nature of the overburden and the bedrock in the fill sections. The overburden consists of a layer of around 5 feet thickness composed of topsoil and talus blocks. The seismic work was rather difficult here on account of the steep slope and the results are therefore less accurate than normally. However, more than 10 feet of overburden is certainly not to be expected here. A few cross sections have been extended over the top of the escarpment and show overburden with a thickness of 14 - 22 feet. Figure 20 shows this general area viewed from the centre line of cross section 255+00. Outcrops can be observed along the cliffs and locally on the slopes. The rock formations range from the Cabot Head member of the Medina Formation up to the Eramosa member of the Lockport Formation. The velocities of the bedrock vary between 10,000 and 15,000 ft./sec.

#### Cross Sections 257+00 to 277+00

This series of cross sections all reach from just over the escarpment down the slope and could therefore not be seismically investigated over their full 300 foot length. The length of the seismic cross sections varies between 200 and 300 feet. Locally on cliff faces bedrock is exposed but mostly it is covered by around 5 to 10 feet of loose topsoil and talus blocks. The bedrock level of these cross sections reaches from a level of about 425 to 610 feet which comprises the top part of the Queenston Formation, the entire Medina Formation and the Lockport Formation up to the "Undivided" Lockport. Outcrops in the area belong mostly to the "Undivided" Lockport, Gasport or Clinton. The velocities of the bedrock vary between 8,000 and 16,000 ft./sec. but are mostly around 11,000 ft./sec. Figures 20 and 21 show typical cross sections in this area.

#### Cross Sections 278+00 to 281+00

These cross sections are all located in a stream gully. Cross sections 278+00 and 279+00 show an overburden coverage of 8 - 13 feet along the entire sections. The horizons belong to the Whirlpool, Manitoulin and Cabot Head members of the Medina Formations. Bedrock velocities vary between 9,000 and 10,000 ft./sec. Cross section 280+00 shows a shallow overburden cover at the left side and scattered outcrops of Manitoulin and Cabot Head. Cross section 281+00 shows scattered outcrops of the Queenston Formation with the lower members of the Medina Formation to the left part and a shallow overburden of around 8

feet on its right. In the last two sections the bedrock velocity is around 8,500 - 9,500 ft./sec. In the area of cross sections 270+00 - 281+00 only a minor amount of rock excavation has to be carried out.

#### Cross Sections 282+00 to 286+00

These cross sections were seismically investigated from 150 feet left of the centre line to as far right of the centre line as possible, which was usually around 80 feet. The bedrock along the entire cross sections is built up by the various horizons of the Medina Formation. At the extreme left of the cross sections the bedrock surface is formed by the very top layers of the Queenston Formation. Bedrock is overlain by loose topsoil and talus blocks usually to a thickness of around 5 feet. The thickness of the overburden increases slightly to about 8 feet where the underlying bedrock is composed of shale of the Queenston Formation. The velocity of the bedrock varies between 9,500 and 15,000 ft./sec.

#### Cross Sections 287+00 to 292+00

These cross sections were seismically investigated from the centre line to 150 feet left of the centre line. They show the same picture as the previous cross sections with their overburden coverage, on top of the Medina Formation, around 5 feet. Slightly more overburden is to be found at the left end of the sections, where Queenston shales form the bedrock surface, the thickness of the overburden increasing locally to 12 1/2 feet.

#### Cross Sections 293+00 to 296+00

On these cross sections seismic spot determinations have been made at the centre line and at 150 feet left of the centre line. The determinations along the centre line showed shallow overburden, 3 - 8 1/2 feet, overlying the various horizons of the Medina Formation. The determinations at the left end of the cross sections indicated around 12 feet of overburden overlying the Queenston shale.

#### Cross Sections 297+00 to 299+00

In these cross sections the bedrock is overlain only by loose topsoil and talus blocks, showing velocities of 1,000 to 1,800 ft./sec. The bedrock is composed of Queenston shale, and sandstone and limestone of the lower Medina Formation. These last rock types form the bedrock of the right part of the profiles and here a considerable amount of bedrock excavation will be necessary. In general, the bedrock is sloping down over these cross sections, as the projected highway turns away from the escarpment.

#### Cross Sections 300+00 to 302+00

In these cross sections the general bedrock elevation is still going down. The bedrock is overlain by two different layers of overburden,

a layer of loose topsoil with a maximum thickness of 10 feet having a velocity of around 1,000 ft./sec. and a layer of more dense material probably dry sand and/or clay showing velocities of 2,400 to 4,800 ft./sec. The total thickness of the overburden varies between 19 and 26 feet. Only at the extreme right of the cross sections is the bedrock still composed of rocks belonging to the lower Medina Formation.

#### Cross Sections 305+00 to 310+00

In these cross sections the bedrock is overlain by a layer of overburden varying in thickness from 19 to 38 feet, and probably composed of sand and/or clay overlain by a thin layer of topsoil. Bedrock is composed of Queenston shale, but in some of the cross sections the very bottom part of the Medina Formation might still be present. A considerable amount of bedrock excavation will be necessary at the right part of the cross sections.

#### Cross Sections 311+00 to 321+00

In these cross sections the underlying bedrock is definitely shale. Overburden varies in thickness between 15 and 30 feet but is usually around 20 feet. A layer, with a medium velocity of 2,300 - 5,000 ft./sec., probably composed of sand and/or clay is overlain by a thin layer of loose topsoil. Except for sections 315, 316 and 318 where, at the extreme right end of the sections, about 15 feet of excavation is necessary, the bedrock level falls below the proposed grade line.

### LOWER PART

This section which is located at the Chedoke Civic Golf Course comprises cross sections 335+00 to 362+00. The sections are topographically quite flat. Overburden is quite heavy and only minor amounts of rock excavation will be necessary. Over the first part, between cross sections 335+00 and 344+00, the bedrock was not detected but the unconsolidated overburden was found to be underlain by a till reaching well below the grade line.

#### Cross Sections 335+00 to 344+00

In these cross sections no bedrock has been detected but the unconsolidated overburden layers are underlain by a formation having a velocity of 6,000 - 7,000 ft./sec. This formation is probably composed of till. In most of the cross sections a layer of sand and/or clay is present between the till and the topsoil. The real bedrock surface, composed of Queenston shales is more than 30 feet below the surface and well below the proposed grade line.

Cross Sections 345+00 to 354+00

In these cross sections the bedrock surface is directly overlain by a layer of sand and/or clay. No till is present here. The bedrock is composed of Queenston shale showing a velocity of 9,000 - 11,000 ft./sec. The contact between the shale and the overburden is exposed in a creek at 354+50 (see figure 19). A drill hole at 345+80 penetrated 17 feet without hitting bedrock. A drilling report, dated July 2nd., 1957, showing four drill holes at location 349+00 approximately, indicated bedrock at an elevation of 312 - 318 feet which does not quite agree with the seismic results. However, as the drill logs indicate the bedrock to be composed of alternating red shale and limestone and it is known that the Queenston Formations, which forms the bedrock, do not contain any limestone, some doubt exists as to the exact location of these holes.

The seismic cross sections indicate a depth to bedrock varying between 15 and 35 feet. The bedrock surface is, in most cross sections, just below the grade line. Cross sections 346+00 and 352+00 indicate up to 8 feet of bedrock excavations.

Cross Section 355+00

This cross section has not been investigated seismically as the grade line falls above the surface here. Some outcrops of Queenston shale have been observed in the creek gully.

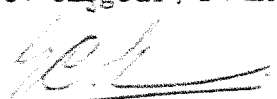
Cross Sections 356+00 to 362+00

These cross sections were seismically investigated from the centre line to 150 feet right of the centre line. The bedrock, Queenston shale, is overlain by 15 to 32 feet of overburden. Rock excavation up to 12 feet is required in sections 356+00 and 361+00. The other sections show the bedrock elevation to be just below the grade line or indicate a very small amount of rock excavation.

The seismic profiles in this part are slightly less reliable than normal on account of frost interference.

HUNTING TECHNICAL AND EXPLORATION SERVICES LIMITED

  
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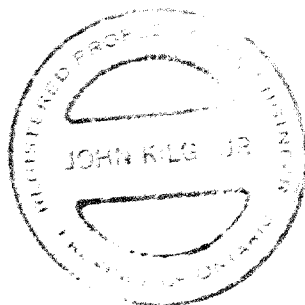


PHOTO APPENDIX



Fig. 1 - Taken at chng. 212+00 - 100' Rt. showing outcrop of Eramosa dolomite in abandoned house basement.



Fig. 2 - Taken off No. 2 highway near Ancaster showing outcrop of Eramosa beds.



Fig. 1 - Taken at chng. 212+00 - 100' Rt. showing outcrop of Eramosa dolomite in abandoned house basement.

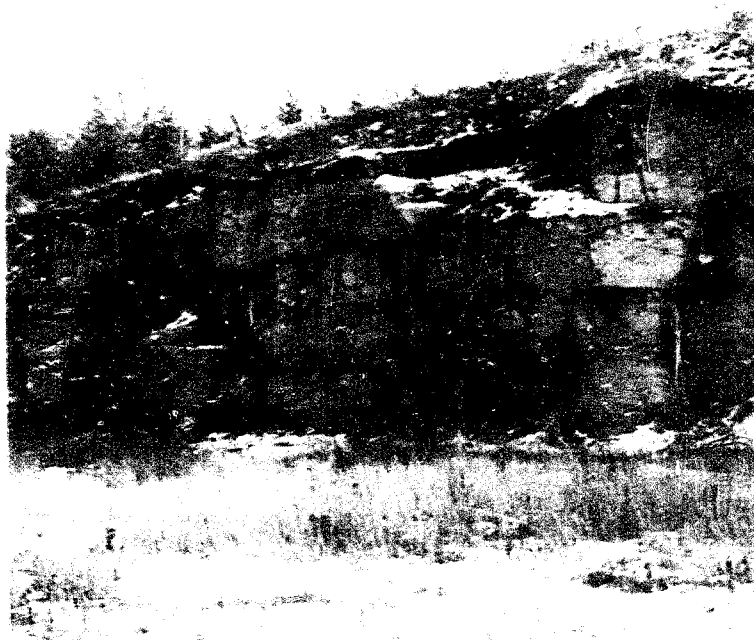


Fig. 2 - Taken off No. 2 highway near Ancaster showing outcrop of Eramosa beds.



Fig. 3 - Panoramic view of side hill from chng. 219+00. Outcrops of Eramosa beds are visible near top of slope.





Fig. 3 - Panoramic view of side hill from chng. 219+00. Outcrops of Eramosa beds are visible near top of slope.

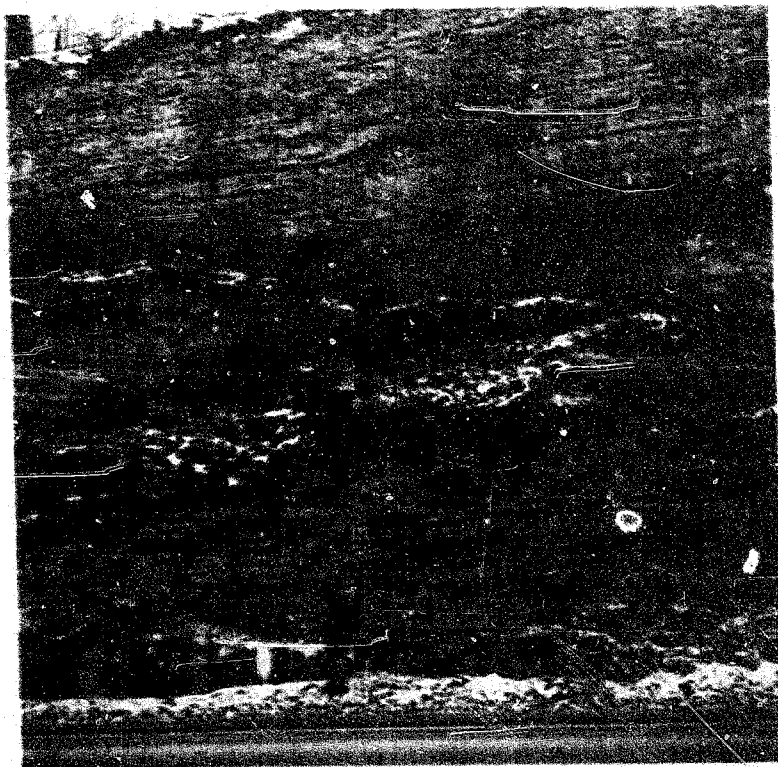


Fig. 4 - Taken in No. 2 highway cut near Ancaster. "Undivided" Lockport member is at top of cut, Clinton Formation is at bottom.



Fig. 5 - Taken in abandoned railway cut showing close-up view of "Undivided" Lockport member. Note beds of chert nodules.



Fig. 4 - Taken in No. 2 highway cut near Ancaster. "Undivided" Lockport member is at top of cut, Clinton Formation is at bottom.



Fig. 5 - Taken in abandoned rail way cut showing close-up view of "undivided" Lockport member. Note beds of chert in course.



Fig. 6 - Taken in abandoned railway cut showing "Undivided" Lockport and Gasport member. Note tendency of "Undivided" member to break down and form rubble at toe of cut.

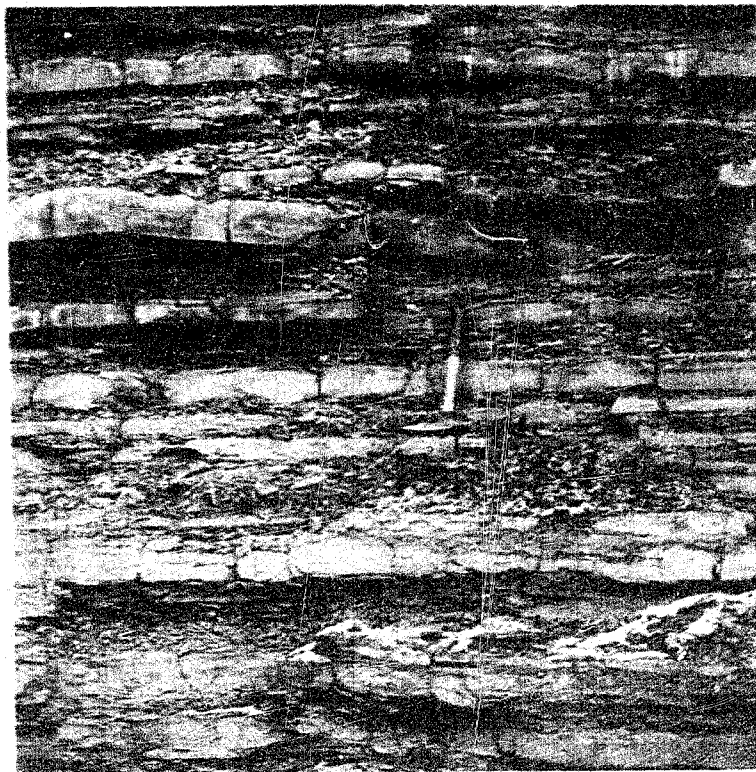


Fig. 7 - Taken in No. 2 highway cut near Ancaster showing close-up view of Rochester Formation.



Fig. 6 - Taken in abandoned railway cut showing "Undivided" Lockport and Gasport member. Note tendency of "Undivided" member to break down and form rubble at toe of cut.

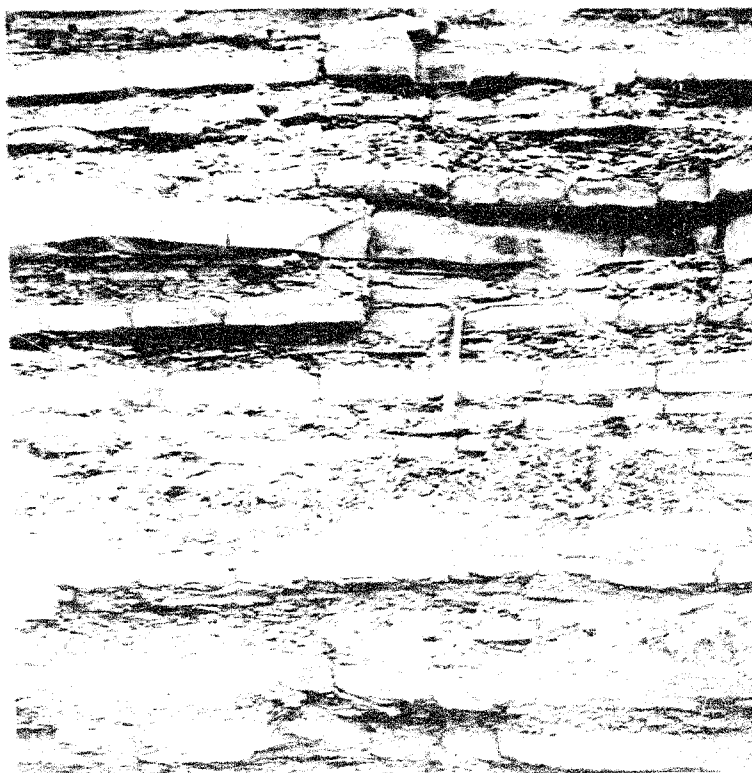


Fig. 7 - Taken in No. 2 highway cut near Ancaster showing close-up view of Rochester Formation.



Fig. 8 - Taken in abandoned railway cut showing Clinton Formation at bottom of cut. Note how breakdown and erosion of Rochester Formation has undermined overlying rock causing rock slumps in centre and rock falls at bottom of picture.

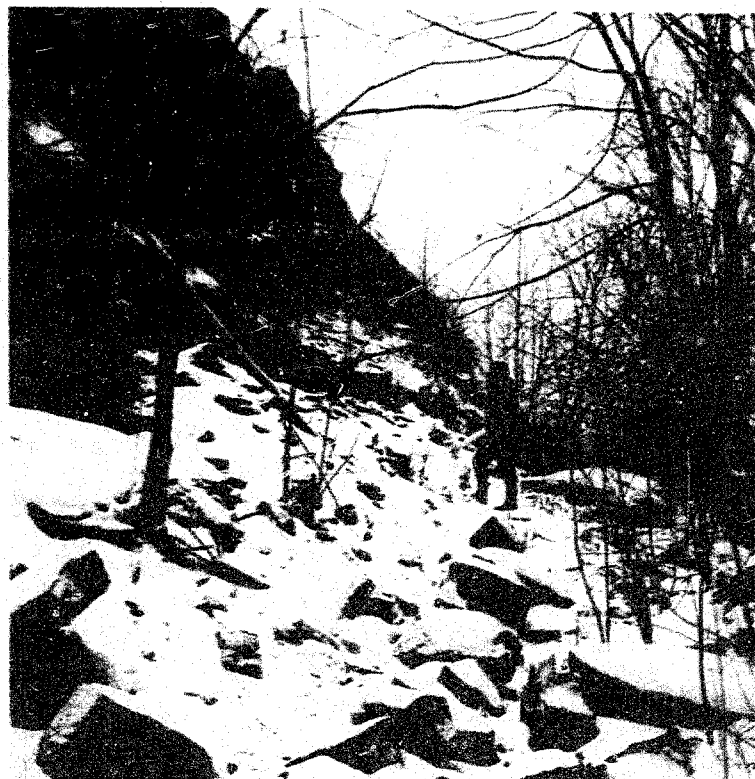


Fig. 9 - Taken in abandoned railway cut showing how rock falls resulting from disintegration of Rochester shale has completely covered the bottom of the cut.



Fig. 8 - Taken in abandoned railway cut showing Clinton Formation at bottom of cut. Note how breakdown and erosion of Rochester Formation has undermined overlying rock causing rock slumps in centre and rock falls at bottom of picture.

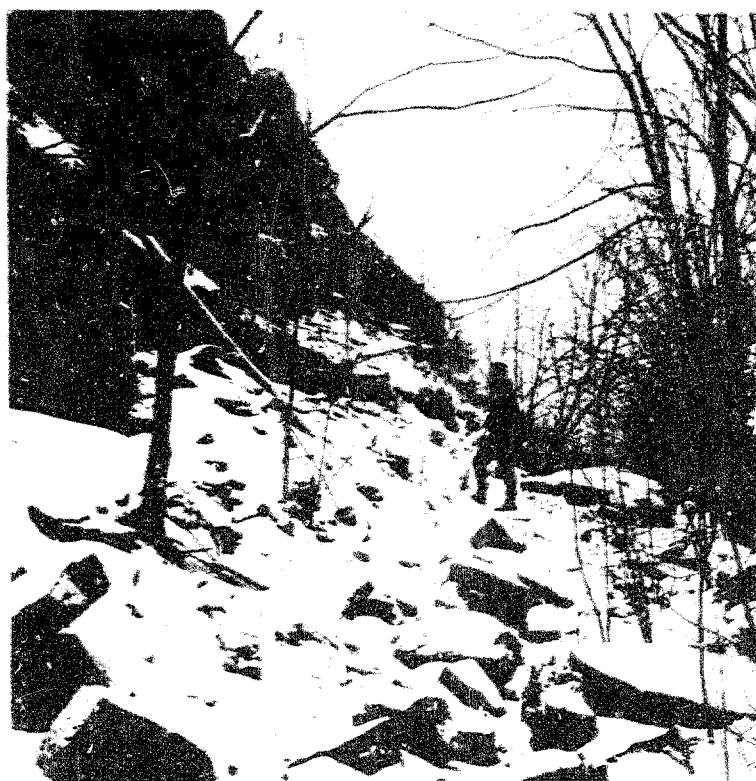


Fig. 9 - Taken in abandoned railway cut showing how rock falls resulting from disintegration of Rochester shale has completely covered the bottom of the cut.





Fig. 10 - Close-up view of Clinton Formation taken at chng. 238+50 - 180' L.



Fig. 11 - Taken in abandoned railway cut showing Clinton Formation and the Thorold and Grimsby members of Medina Formation.





Fig. 10 - Close-up view of Clinton Formation taken at chng. 238+50 - 180' L.

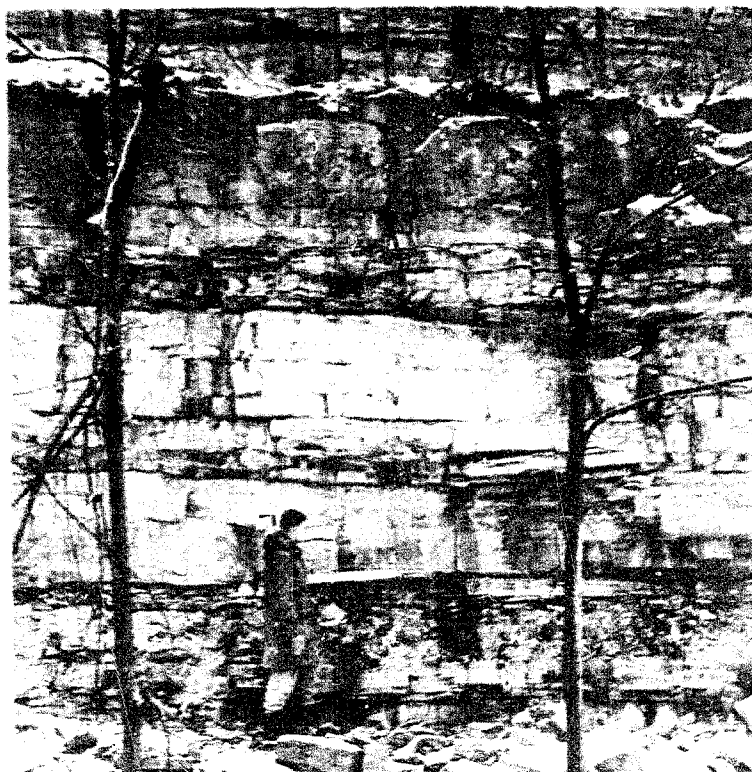


Fig. 11 - Taken in abandoned railway cut showing Clinton Formation and the Thorold and Grimsby members of Medina Formation.

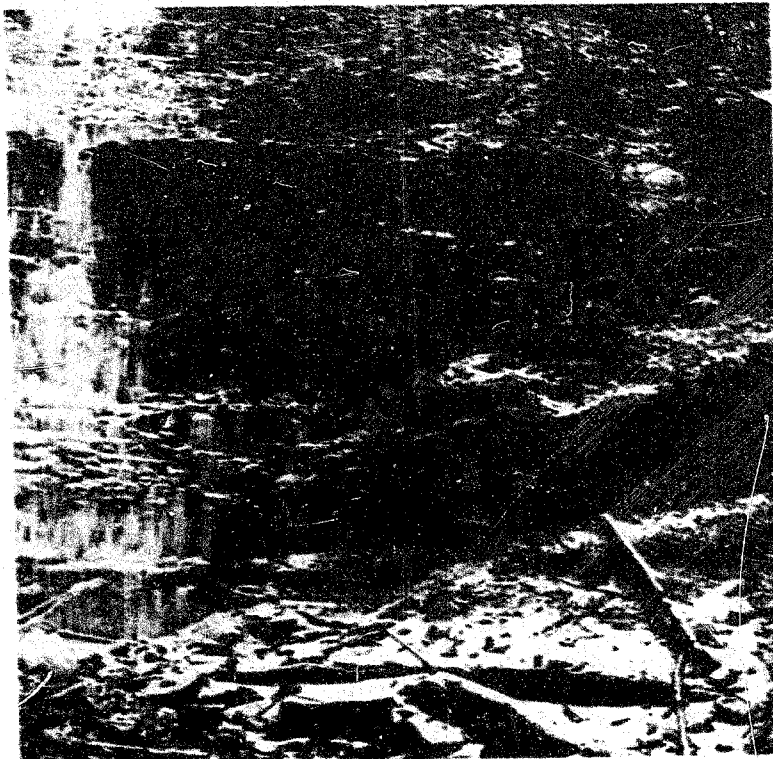


Fig. 12 - Taken in stream gully south of chng. 280+00 showing man standing on top of Clinton Formation. Thorold, Grimsby and Cabot Head members of Medina Formation are seen in succession below the Clinton.



Fig. 13 - Close-up of figure 12 showing Grimsby-Cabot Head contact.

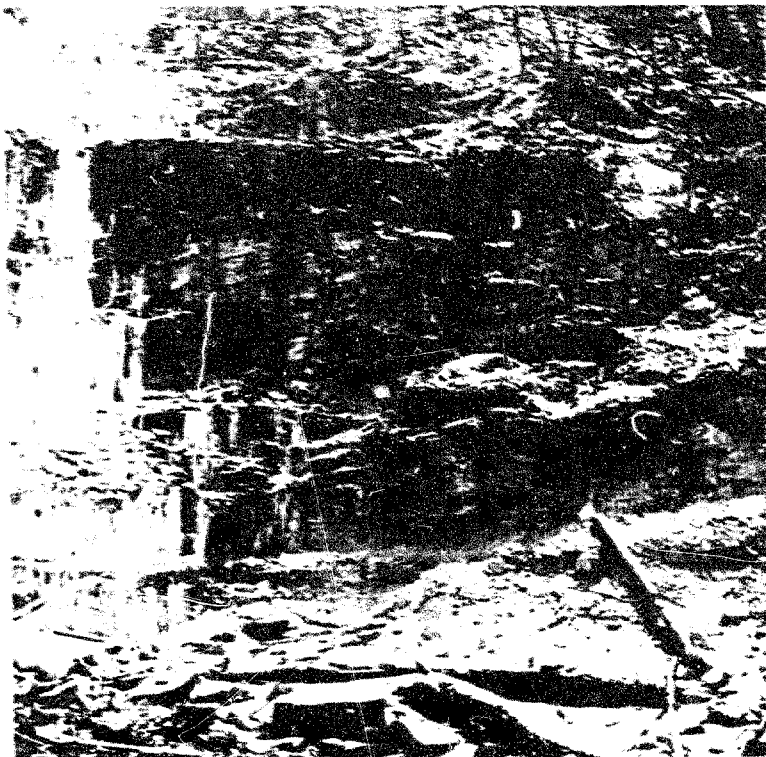


Fig. 12 - Taken in stream gully south of chng. 280-00 showing man standing on top of Clinton Formation. Therold, Grimsby and Cabot Head members of Medina Formation are seen in succession below the Clinton.



Fig. 13 - Close-up of figure 12 showing Grimsby-Cabot Head contact.

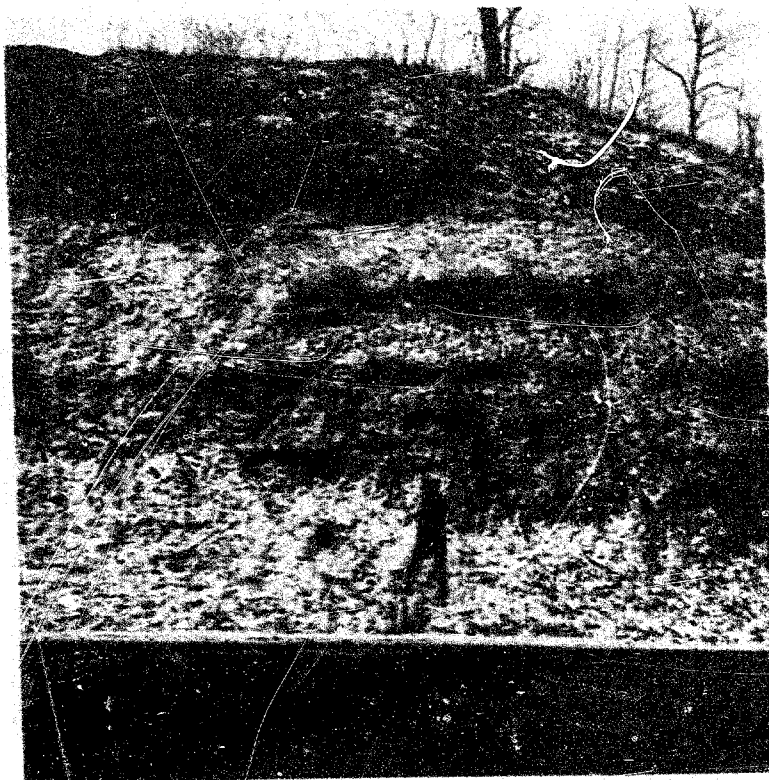


Fig. 14 - Taken in No. 6 highway cut south of Clappison Corner showing Cabot Head member.



Fig. 15 - Taken in stream gully near chng. 280+00 showing close-up of Manitoulin member of Medina Formation.



Fig. 14 - Taken in No. 6 highway cut south of Clappison Corner showing Cabot Head member.

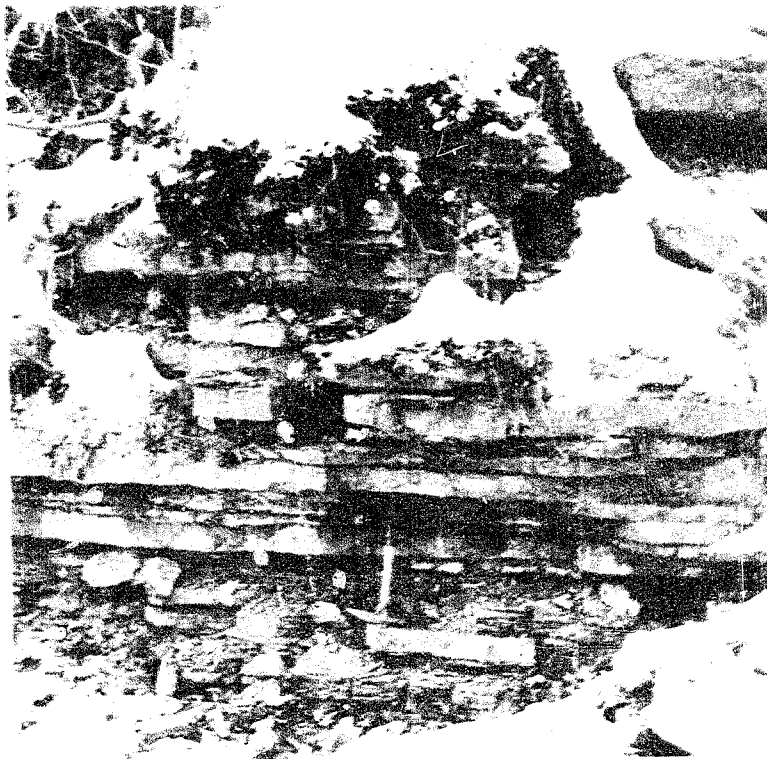


Fig. 15 - Taken in stream gully near chng. 280+00 showing close-up of Manitoulin member of Medina Formation.



Fig. 16 - Taken in stream gulley near chng. 280+00 showing massive beds of Whirlpool sandstone.



Fig. 17 - Taken in stream gulley near chng. 280+00 showing contact between Medina Formation (Whirlpool member) and Queenston Formation.



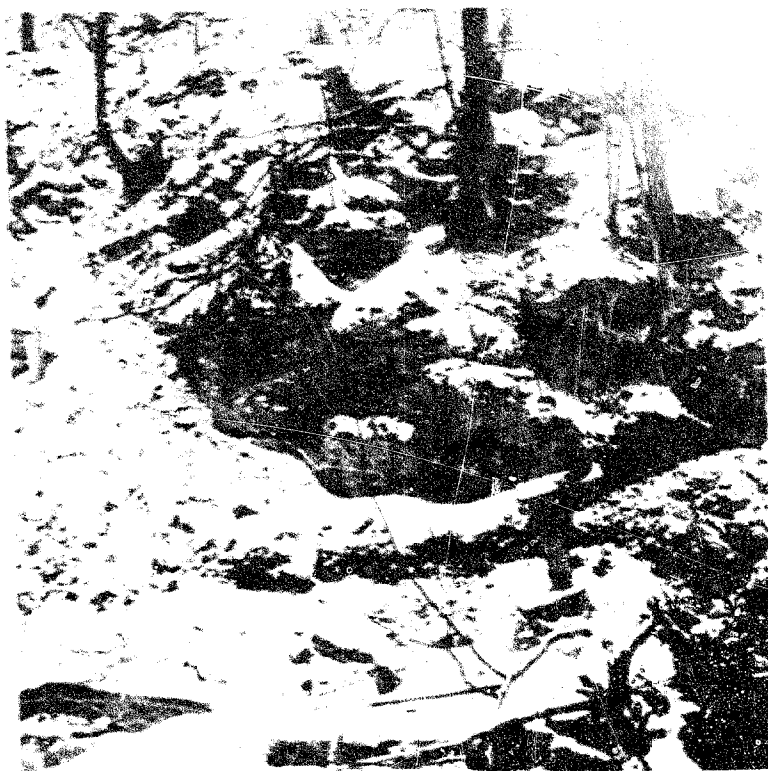


Fig. 16 - Taken in stream gully near chng. 260+ 00 showing massive beds of Whirlpool sandstone.



Fig. 17 - Taken in stream gully near chng. 260+ 00 showing contact between Medina Formation (Whirlpool member) and Greenston Formation.



Fig. 18 - Taken in stream gulley north of chng. 280+00. Top of hammer handle indicates overburden/Queenston shale contact.

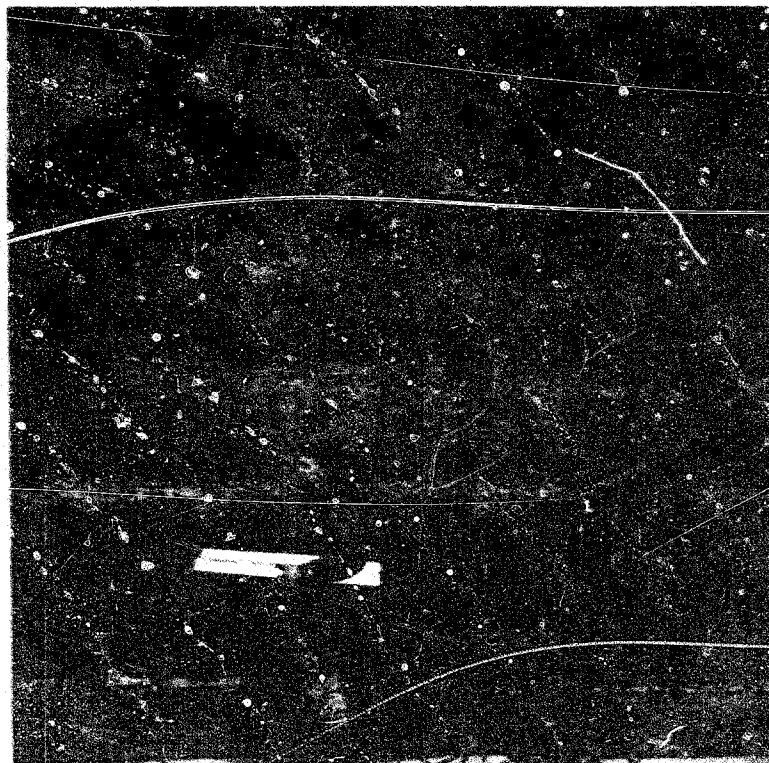


Fig. 19 - Taken in stream gulley near chng. 354+50 showing Queenston shale exposure. Overburden/shale contact is about 4 feet above the engineer's head.



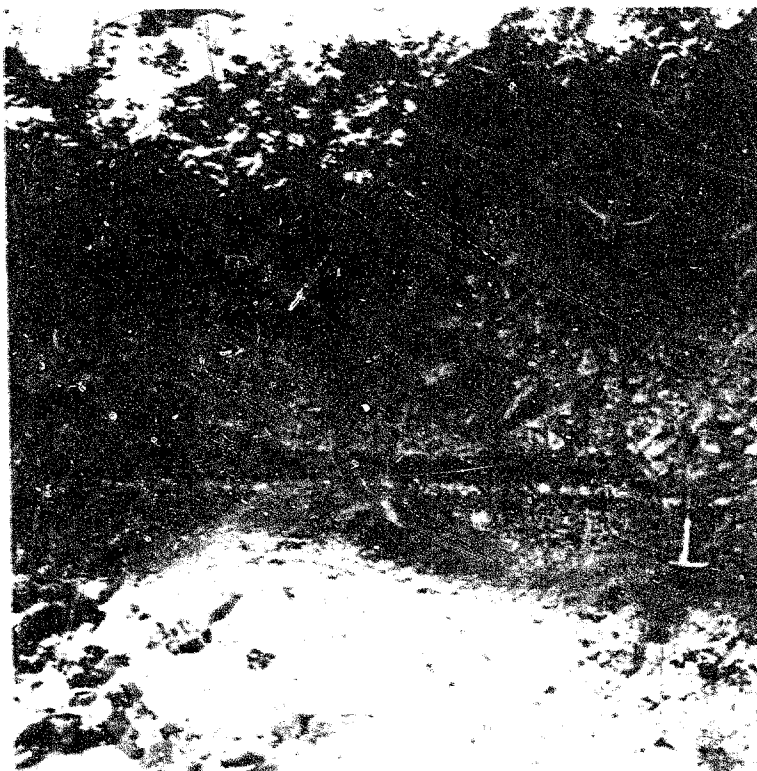


Fig. 18 - Taken in stream gully north of chng. 280+00. Top of hammer handle indicates overburden/Queenston shale contact.

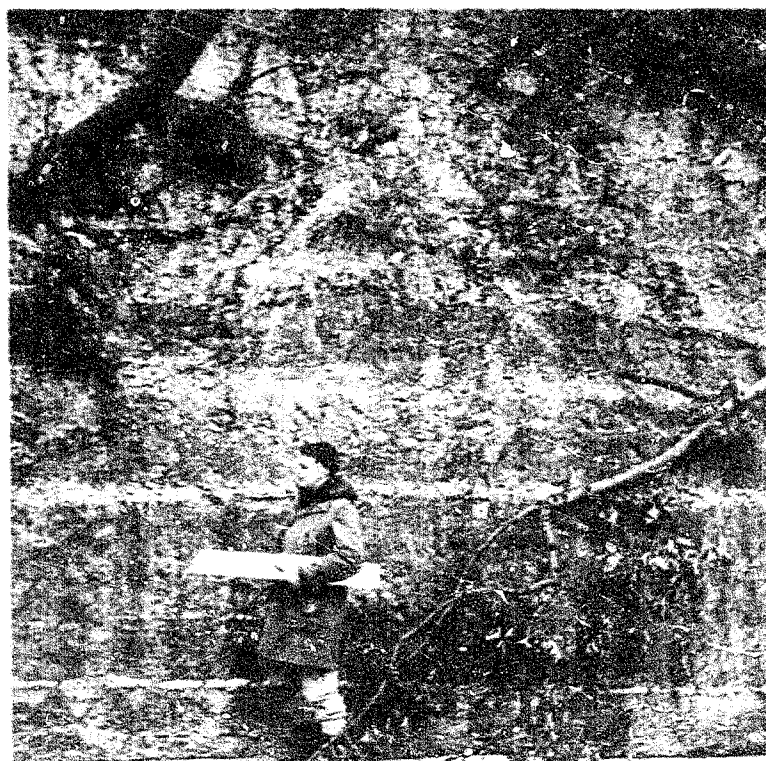


Fig. 19 - Taken in stream gully near chng. 364-50 showing Queenston shale exposure. Overburden/shale contact is about 4 feet above the engineer's head.

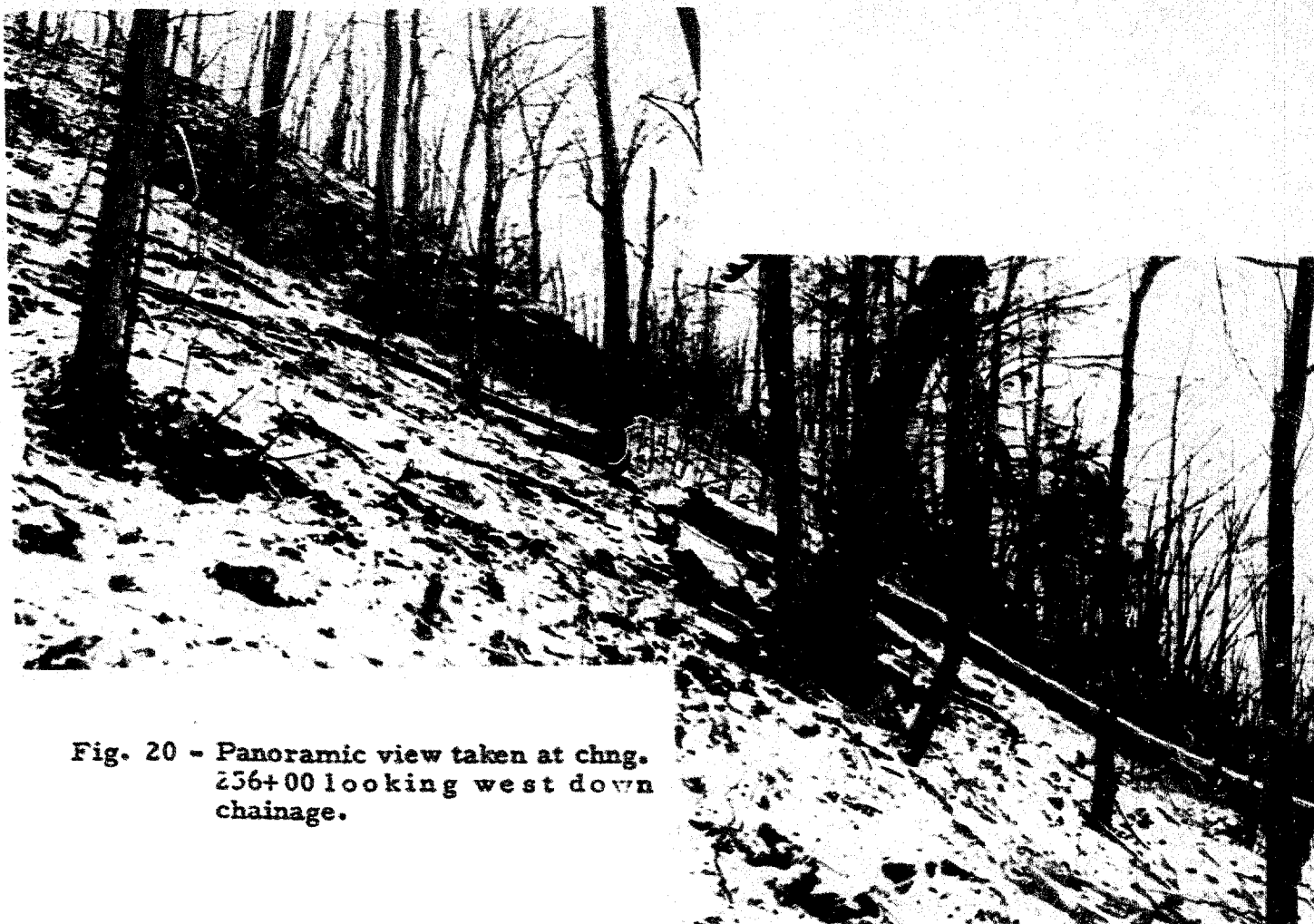


Fig. 20 - Panoramic view taken at chng. 256+00 looking west down chainage.



Fig. 21 - Taken at chng. 260+00 looking right from centre line. Note lack of vertical rock face marking top of escarpment.



Fig. 20 - Panoramic view taken at chng. 256+00 looking west down chainage.



Fig. 21 - Taken at chng. 260+00 looking right from centre line. Note lack of vertical rock face marking top of escarpment.



Fig. 22 - Taken at chng. 247+00 - 115' L. looking centre line showing nature of the terrain in this vicinity.



Fig. 23 - Taken at chng. 243+00 - 200' L. looking west showing ground water flowing over Clinton Formation.



Fig. 22 - Taken at chng. 247+00 - 115' L. looking centre line showing nature of the terrain in this vicinity.



Fig. 23 - Taken at chng. 243+00 - 200' L. looking west showing ground water flowing over Clinton Formation.



Fig. 24 - Taken in No. 2 highway cut near Ancaster showing how break down of shale by ground water percolation tends to undermine overlying formations.



Fig. 25 - Close-up view of fig. 24 showing weak vertical planes in limestone overlying eroded shale. Wedge and splinter shaped particles will soon fall here.





Fig. 24 - Taken in No. 2 highway cut near Ancaster showing how break down of shale by ground water percolation tends to undermine overlying formations.



Fig. 25 - Close-up view of Fig. 24 showing weak vertical planes in limestone overlying eroded shale. Wedge and splinter shaped particles will soon fall here.

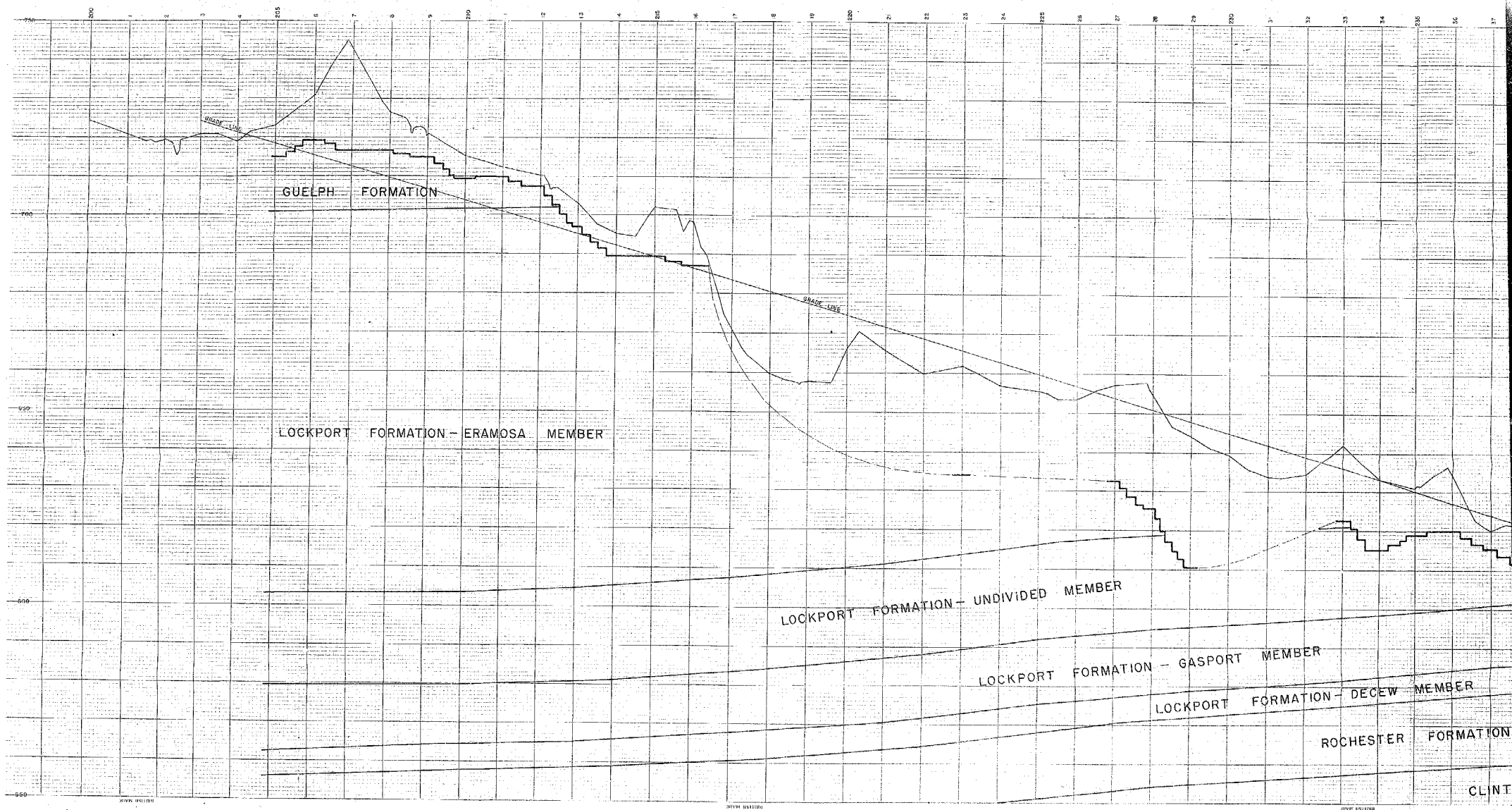
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W.P. 140-57

HWY. #2

ANCASTER





ONTARIO DEPARTMENT OF HIGHWAYS

RELOCATION HIGHWAY NO2

ANCASTER

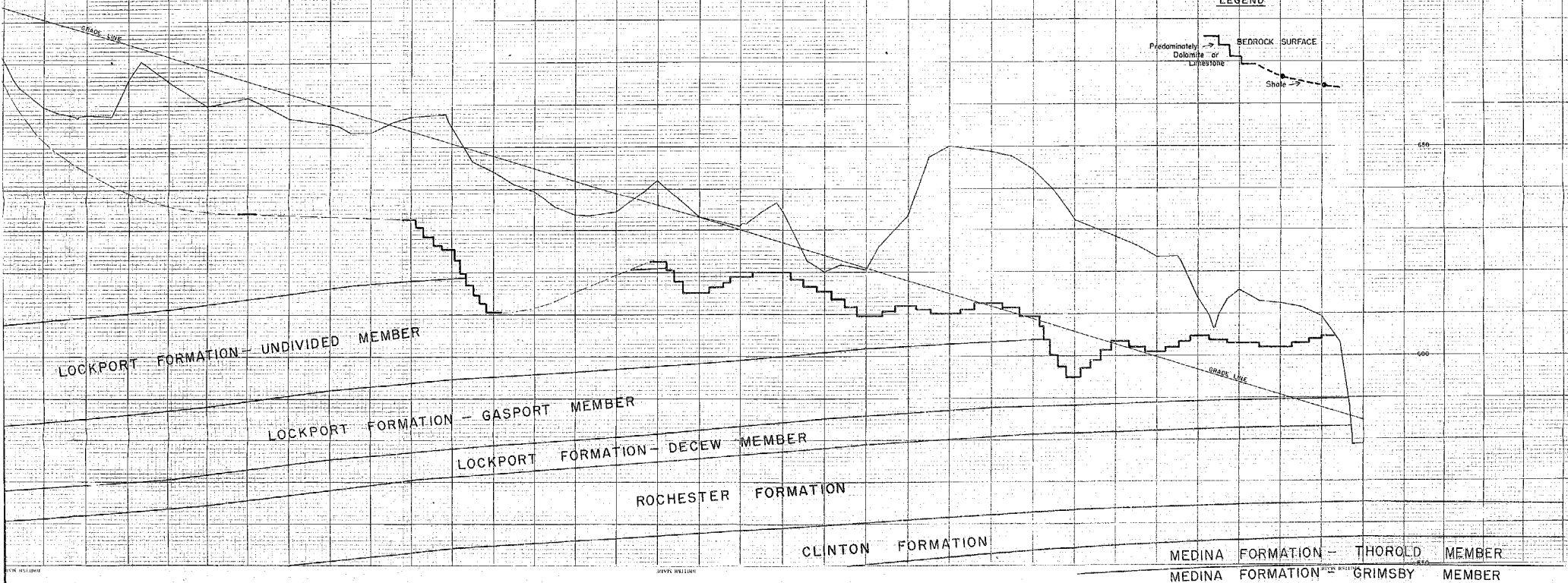
BEDROCK PROFILE ALONG CENTRE LINE  
BETWEEN STATIONS 205+00 and 249+00

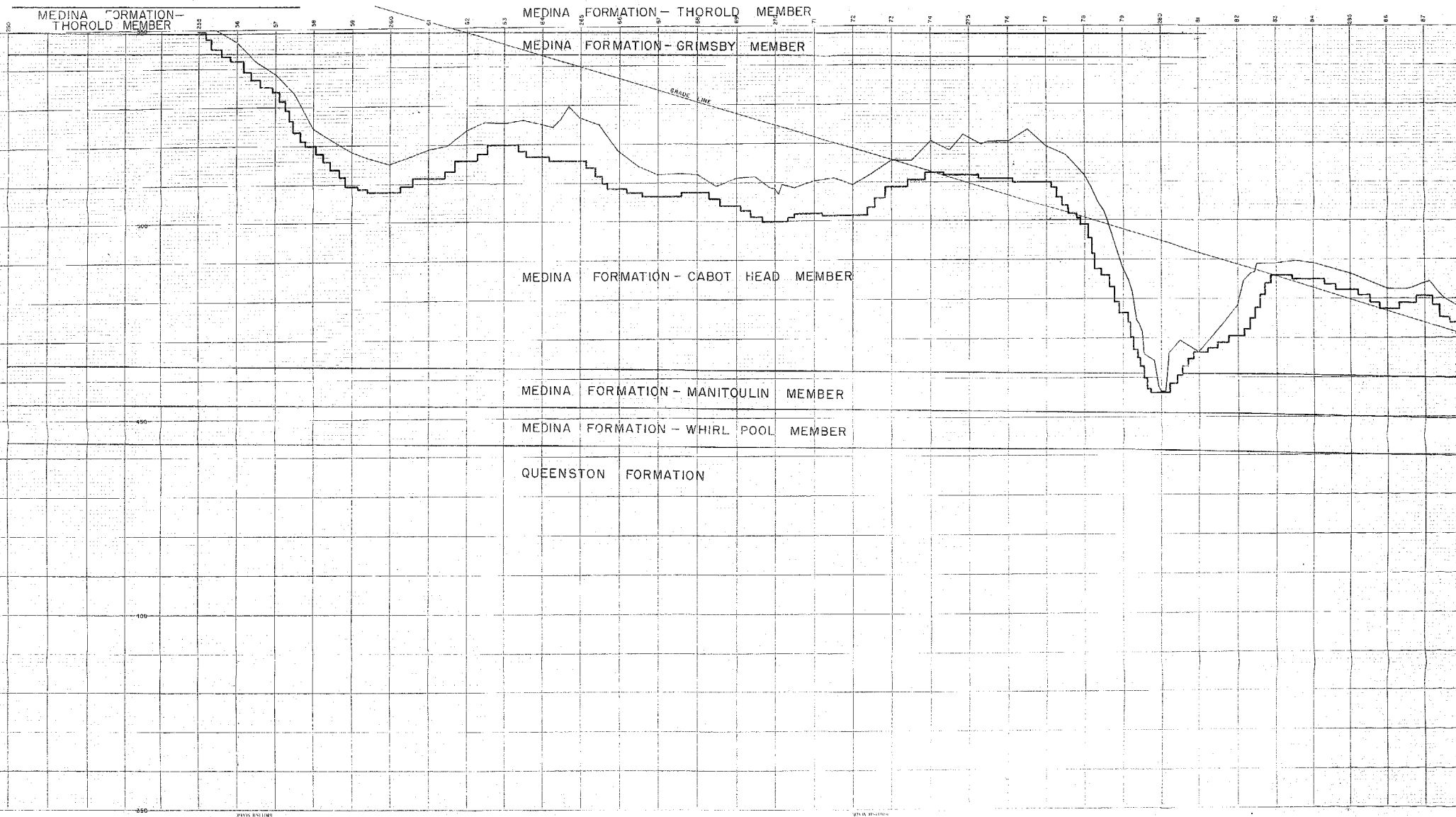
Horizontal Scale: 1" = 100'

Vertical Scale: 1" = 10'

LEGEND

Predominately Dolomite or Limestone → BEDROCK SURFACE  
Shale →





ONTARIO DEPARTMENT OF HIGHWAYS

RELOCATION HIGHWAY NO.2

ANCASTER

BEDROCK PROFILE ALONG CENTRE LINE  
BETWEEN STATIONS 255 + 00 and 321 + 00

Horizontal Scale: 1" = 100'

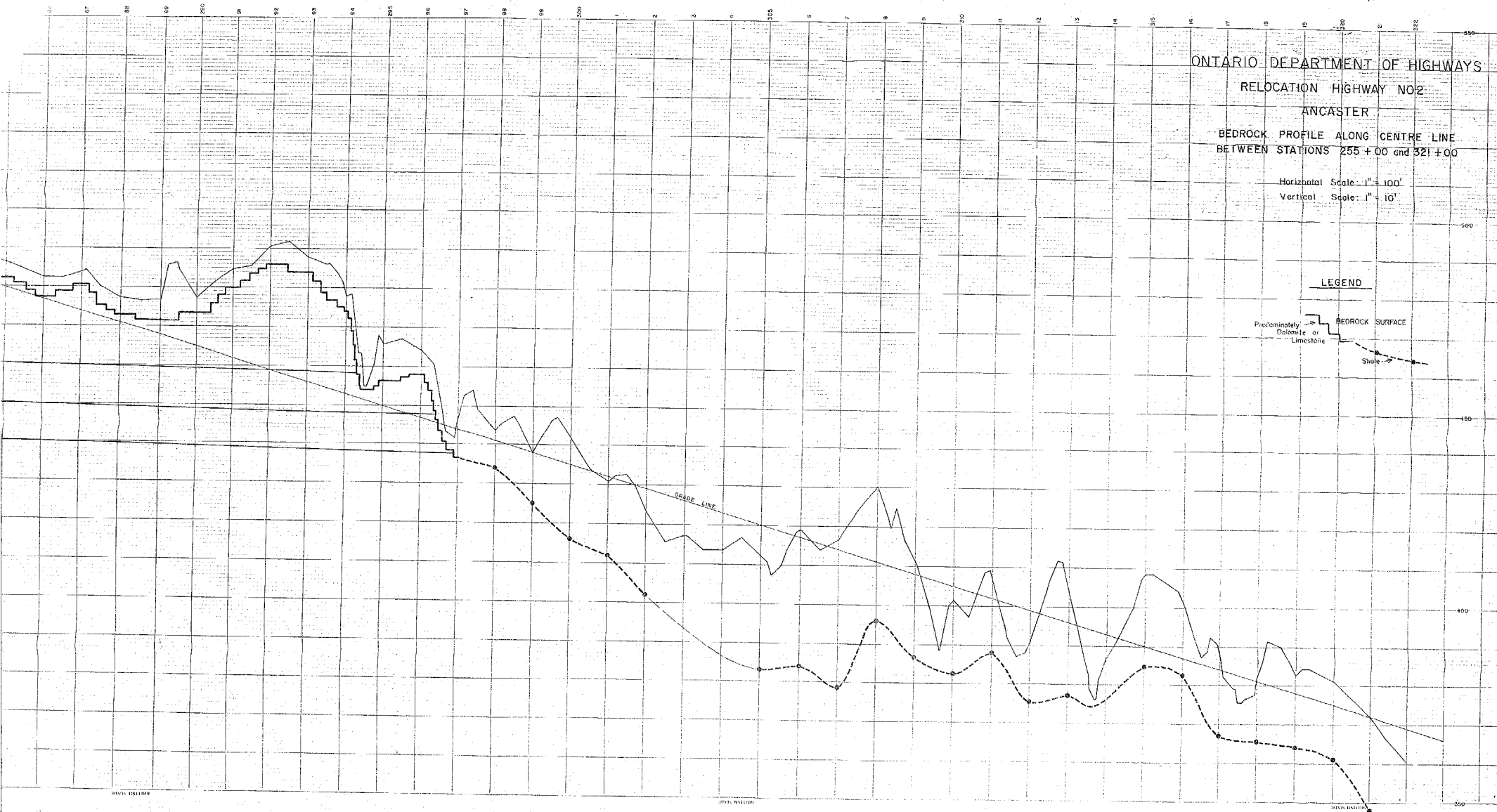
Vertical Scale: 1" = 10'

LEGEND

Predominately Dolomite or Limestone  
Shale

BEDROCK SURFACE

Shale



ONTARIO DEPARTMENT OF HIGHWAYS

RELOCATION HIGHWAY NO.2

ANCASTER

BEDROCK PROFILE ALONG CENTRE LINE  
BETWEEN STATIONS 335+00 and 362+00

Horizontal Scale: 1" = 100'

Vertical Scale: 1" = 10'

LEGEND

Predominately  
Dolomite or  
Limestone → BEDROCK SURFACE  
Shale →

