Art. XXI.—*The Stratigraphy and Geologic Relations of the Paleozoic Outlier of Lake Timiskaming;*[1] by George S. Hume.

Introduction.

The Paleozoic outlier of the Lake Timiskaming district is situated just a few miles northeast of the mining town of Cobalt, Ontario, and about 130 miles north of the eastern part of the north shore of Lake Huron. The area, which includes about 250 square miles, is restricted to a number of islands at the northern end of Lake Timiskaming and a strip of country not over 9 miles wide extending as far north as Englehart. This outlier is completely surrounded regionally by more elevated rocks of Precambrian age.

Previous work.—Paleozoic rocks were first reported from the Lake Timiskaming district in 1845. The first contribution of any importance on the geology was made by R. Bell in 1894 in a paper entitled "The pre-Paleozoic decay of the crystalline rocks north of Lake Huron." In it the conclusion is reached that the Paleozoic rocks are later in origin than the depression which now forms Lake Timiskaming. This view was also held by Barlow (1897), who made a more extensive study of the district, the report of which was published in 1897. The Paleozoic rocks were ascribed to the Clinton and Niagaran formations, and from loose fragments Trenton fossils were also obtained. It was concluded that Trenton was present though concealed.

The regional relationships of the district, with especial reference to the Precambrian, have been studied particularly by W. G. Miller (1913) on the western or Ontario side of the lake, and by M. E. Wilson (1918) on the eastern or Quebec side. They have shown that the Paleozoic sediments are older than the formation of the Timiskaming trench, which was also studied somewhat by both Bell and Barlow previously.

In a short reconnaissance trip M. Y. Williams (1915) found Ordovician sediments of Trenton age on the western side of Lake Timiskaming, and for the first time proved the existence of a fault along the straight western shore of the lake. Faulting had previously been sus-

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pected, although the actual proof was lacking. The discovery of Ordovician sediments stimulated interest in this outlier of Paleozoic rocks, and as the relationships of the younger to the older rocks gave promise of throwing much light on the history of the Laurentian plateau, the more detailed work was assigned to the writer, who undertook the present study in the following summer.

Scope of the work.—This paper is a synopsis of a report which will later be published in full by the Geological Survey of Canada. In the complete report the stratigraphic relations and faunal characteristics will be discussed in detail, and these, with the physiographic and structural features found in the area of Paleozoic rocks, will be applied to the regional history of the Laurentian plateau.

Acknowledgments.—The field work for this report was undertaken under the direction of Doctor M. Y. Williams of the Geological Survey of Canada, who gave valuable assistance on a short reconnaissance trip, and to whom the writer is further indebted for many helpful suggestions during the progress of the whole work.

In the preparation of the report, the work has been under the supervision of Professor Charles Schuchert of Yale University, to whom the writer wishes to acknowledge his thanks. Thanks are also due to Professors H. E. Gregory and Alan M. Bateman of Yale for helpful advice and criticisms.

Structure.

Regional relations.—It has been shown by Miller (1913) that there are three regional drainage systems along lines of fracturing or disturbance. The most pronounced of these water systems is in a northwest and southeast directions, including the drainage line of Lake Timiskaming and Long and Kinogami lakes farther north. This drainage system is parallel to many other water courses, among which the Montreal river is by far the most prominent.

The second system of drainage is in a northeast and southwest direction, and is best represented by a line through the northeastward extension of Lake Timiskaming at its northern end (see fig. 1). Continuing southwest, this line of water courses passes along the longer axis of Cobalt lake and about 4 miles of the Montreal river, where it turns sharply from a northwest and southeast direction to a northeast and southwest one between

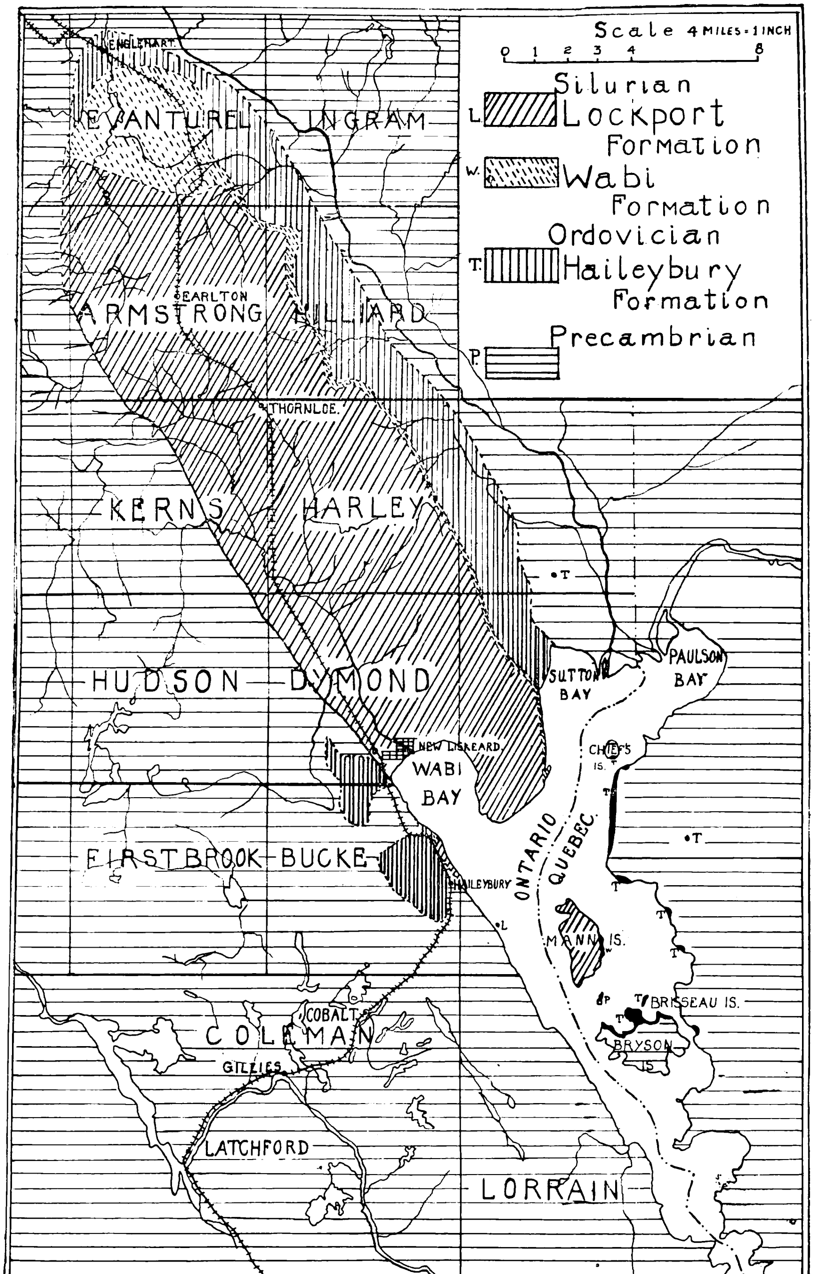

FIG. 1.—Map of the Paleozoic outlier of Lake Timiskaming area.

Latchford and Gillies. Various other lakes, including a line along the Matabitchuan river from the point where it enters Lake Timiskaming close to the outlet of the Montreal river, are parallel to this system.

The other system includes many lakes with longer axes in the north and south direction, and is best illustrated by the north and south part of Lake Timiskaming for about 10 miles north of the mouth of the Montreal river.

In the northern end of Lake Timiskaming it can be shown that the northwest and southeast system is conditioned by a large fault along the western shore of the lake, and the northeast and southwest system by warping, if not faulting. No definite information is available as to the north and south lines other than that which is suggested by their relationships to the other two systems.

Local evidence of faulting.—In regard to the northwest and southeast system of fracturing, a study of the Pale-

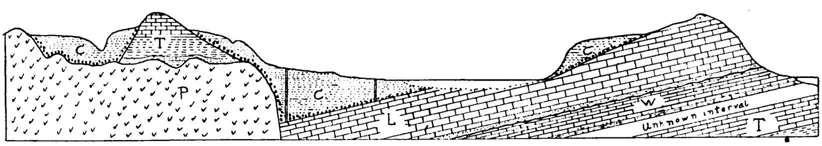

FIG. 2.—Section east and west through New Liskeard

Horizontal scale 2 miles = 1 inch
Vertical scale 800 feet = 1 inch

C, Post Glacial Clay.
L, Lockport formation. } Silurian.
W, Wabi formation. }
T, Haileybury formation—Ordovician.
P, Precambrian.

ozoic rocks has revealed the presence of a fault which is responsible for the straight western shore of Lake Timiskaming, and a fault-line scarp extending about 18 miles northwest from the head of the lake. The thickness of the various formations involved along this fault shows the displacement to be from 800 to 1000 feet, with the downthrow side to the east. The rocks on the eastern side of the fault are Silurian, with a westward dip, and near the fault at New Liskeard station a well boring has shown that they are covered by post-glacial deposits over 240 feet thick (see fig. 2). At an elevation of over 250 feet higher, on the west side of the fault, Ordovician occurs in flat-lying beds, while on the fault-line scarp itself, Silurian strata outcrop at various places, with beds tilted over 50°

to the east. North of the lake, at a higher elevation Precambrian rocks outcrop to the west of the fault-line, while Silurian occurs to the east, so that the faulting relationships are clearly evident. The scarp decreases in elevation to the north, due to the irregularities of the surface having been completely obliterated by the later deposits of post-glacial clay. South of Percy island, near Haileybury, no Paleozoic rocks are found on the western side of the lake. On the contrary, the lake is here bounded by Precambrian rocks in high cliffs which are in line with the fault-scarp shown in the Paleozoic rocks farther north.

In regard to the northeast and southwest fracture system, which includes the northeast extension of Lake Timiskaming at the northern end and its continuation southwest in a line through Cobalt lake and the Montreal river between Latchford and Gillies, it is known that a fault is present at Cobalt. This fault has a displacement of 400-500 feet, the downthrow side being to the northwest. A depression of the surface, which the railway follows, extends from Cobalt to Lake Timiskaming, and no Paleozoic rocks are found south of this line on the western side of the lake. On Mann island the rocks are Silurian, showing varying dips, mostly to the north and west. On Brisseau and Bryson islands to the south, Ordovician rocks occur, the sequence suggesting a northerly dip for the strata in this part of the lake. On Wabi peninsula the rocks have a southerly component to the dip, so that between Mann island and Wabi point there is at least a downwarped portion under the lake and faulting is not improbable.

Age of faulting.—Since the Silurian rocks have been broken by the faulting, and glacial and post-glacial materials are undisturbed, it is obvious that the faulting is post-Silurian and pre-glacial. The presence of a fault-line scarp, now over 150 feet high, which was over 400 feet high before the depression at its base was partly filled with post-glacial clay, is in favor of a date for faulting much nearer the Pleistocene than the Silurian. The fault-scarp is relatively slightly dissected by stream action, so that it is believed it could not have been earlier than the Cenozoic, and the probability is that it is late Tertiary, perhaps connected with the widespread crustal instability and accompanying earth movements which took place in Pliocene time.

The relationships of the northeast and southwest line of fracturing through Cobalt to the fault on the northwest and southeast line along the western shore of Lake Timiskaming, are not clear. Since a number of prospects and mines have been found near the general line of disturbance which includes Cobalt, it has been argued (Miller 1913) that mineralization has been connected with this fracture zone. At Cobalt the faulting is later than the Nipissing diabase, and it may be that shortly after the intrusion of the diabase sills, with which mineralization is connected, the fracture system was inaugurated, at least along the line here indicated. However, whatever the time of origin, the evidence is clear that there was crustal movement subsequent to the deposition of the Silurian about Lake Timiskaming. It is this later movement that has given rise to the renewed faulting now shown in the present fault-line scarp along the western shore of the lake and northwest of it.

Physiography.

Terraces and beaches.—Following the retreat of the continental glaciers, a lobe of ice blocked the southern drainage system through Lake Timiskaming and the Ottawa valley (Coleman 1909) causing the formation of a large glacial lake (south of the Continental Divide) which Wilson (1918) has called Lake Barlow. The deposits of Lake Barlow consist of very evenly stratified clays in which terraces were formed due to the subsidence of the lake in stages depending on the height of the outlet. These terraces now appear at 35, 110, and 140-170 feet above the level of the lake.

Beaches belonging to Lake Barlow are also known west of Haileybury and New Liskeard. The beaches to the south are at a slightly lower elevation than those farther north, the elevation being about 280-290 feet above the level of the lake.

Tilting to the south and post-glacial faulting.—Subsequent to the retreat of the ice, there seems to have been some response to isostatic readjustment, due to the release of load. Miller (1913) has stated that at Cobalt slight post-glacial faulting has taken place. No similar movement could be detected in the area of Paleozoic rocks, because of the weathered condition of the clays. However, the fact that Blanche river flows for many miles in a straight course parallel to the northwest and southeast system of fracturing suggests the influence of structural relations. Post-glacial faulting along an old fracture line, such as occurred at Cobalt, may have fractured the clay sufficiently to determine the position of the river course. However, as no proof of any movement in the clay could be found, the river may owe its present position to normal development on a gently sloping clay plain.

During this period of readjustment to isostatic equilibrium, with which post-glacial faulting is probably connected, there seems to have been a regional tilting to the south in this district. As has already been stated, the more northerly beaches are at a slightly higher elevation than those farther south. Also clay deposits are known in the vicinity of the Continental Divide at an elevation of about 1100 feet (Wilson 1918), while at Haileybury the highest reported occurrence is at an elevation of 775 feet (Coleman 1909). This represents a slope of approximately 5 feet per mile. The slope of the country from Englehart along the Blanche river to the north end of Lake Timiskaming is of the same order of magnitude. This does not mean a tilting of 5 feet per mile, because undoubtedly part of this was original slope, and until further detailed leveling work is done the amount of tilting can not be definitely stated.

Relation of Physiography to Structure.

Overdeepening of the Timiskaming trench.—A study of the regional map reveals that at about the mouth of the Montreal river there is an intersection of the three fracture systems. The great northwest and southeast line is represented by the straight course of the Montreal river, the northeast and southwest system by a line through the Matabitchuan river and a number of lakes to the southeast, and the north and south system by the straight north and south portion of Lake Timiskaming for 10 miles north of the mouth of the Montreal river. This point of intersection must therefore be a much disturbed and fractured part of the Timiskaming drainage system. Below the mouth of the Montreal river, soundings made in the lake show a maximum depth of 470 feet or an elevation for the bottom of the lake about 110 feet above sea level. The outlet at Mountain rapids has an elevation of about 415 feet, so that the portion of the lake south of the Montreal river has been much overdeepened. This is the more striking when it is considered that this portion of Lake Timiskaming represents a trench with rugged shores that rise 400-600 feet to the elevation of the Laurentian plateau.

Various theories such as warping (Pirsson 1910) and glacial scour have been advocated to explain this overdeepening, but no very satisfactory conclusions have been obtained. As the continental glaciers moved in a direction S. 7° W. to S. 18° W. (Barlow 1897), or across the Timiskaming trench, the theory of ice action has been rejected for the most part. However, lists of striæ made by Barlow clearly show that a subcurrent of ice was deflected down the Timiskaming trench, and it is suggested here that glacial scour on the fractured and broken materials south of the intersection of the three regional fracture systems at the mouth of the Montreal river has been responsible for the overdeepening that is now evident from numerous soundings. At the north end of Lake Timiskaming, the western shore is now known to be the result of a fault of 800-1000 feet displacement. It is therefore of some significance that the deepest soundings south of the Montreal river are invariably found towards the western side of the lake. However, as yet, faulting in this part of the Timiskaming trench has not been actually demonstrated.

Character of the Paleozoic Floor.

When the transgression of the middle Ordovician sea overspread the continent from the Arctic, it advanced over a land mass that had much the same sort of relief as is found on the present Laurentian plateau. The surface was very irregular and in the Timiskaming area knobs and ridges that were more than 200 feet high may have been islands during the early submergence. There is a fringe of Ordovician rocks on the north shore of Bryson island, where these rocks everywhere dip away from the island 10° to 12°. Precambrian rock, which forms the main portion of the island, rises 190 feet above the water level, the slope of the Precambrian surface on which deposition took place being responsible for the dip of the Ordovician strata. As Bryson island has been rounded off by glacial action, it is probable that the relief of the

Paleozoic floor was considerably over 200 feet at this place.

Brisseau island, just north of Bryson, shows Ordovician beds dipping away from the island on all sides from a nucleus of Precambrian quartzites which outcrops on the northeast corner. The relief indicated is over 50 feet. At many other places these irregularities of the Paleozoic floor are quite evident, the character of the floor being similar to what has been reported from other districts of the Laurentian shield where the contact of the Paleozoic and Precambrian rocks has been studied.

THE PALEOZOIC FORMATIONS OF LAKE TIMISKAMING.

Middle Ordovician: Haileybury formation.—The middle Ordovician in the Lake Timiskaming district is represented by rocks of Trenton age that are here called the Haileybury formation. From a diamond drill core obtained from west of Haileybury, the thickness of the whole formation is about 250 feet. In this diamond drill core, at the base of the Paleozoic there are 50 feet of red clay and shales resting on the Precambrian. This red material is thought to represent the reworked material of the old regolith encountered by the advancing sea and redeposited on protected portions of the Paleozoic floor. It is therefore only under exceptional conditions that the red clay has been preserved and it is now met with in but a few places. For the most part, the Haileybury formation begins with conglomerates and sandstones resting unconformably on Precambrian rocks. The conglomerates and sandstones are in the nature of a tangential deposit and therefore hold different time relations in the various places of their occurrence. As the sea advanced, the lower depressions were first filled by sediments, and later the transgression over the higher knobs and ridges resulted in the deposition of conglomerates at the base which are higher stratigraphically than those deposited on the lower parts of the old floor. The sandstones, which are coarse in the basal beds, or just above the conglomerate portion of the formation, grade upwards into finer calcareous sandstones, and these in turn are followed by red, green, and gray shales. The top member of the Haileybury consists of 40 feet of slightly magnesian limestone, and it is in this zone and as well in a few feet of the lower shales that most of the fauna was found.

Some of the more important fossils are as follows: *Receptaculites oweni, Streptelasma corniculum, S. angulatum, Columnaria alveolata, C. (Palæophyllum) stokesi, Halysites quebecensis, Plasmopora lambii, Pleurocystites squamosus, Dalmanella testudinaria, Platystrophia trentonensis, Rhynchotrema increbescens laticostatum, R. minnesotense, R. inequivalve, Strophomena emaciata, S. incurvata, S. trentonensis, S. trilobita, Fusispira* cf. *angusta, F. convexa, F. nobilis, Hormotoma gracilis, H. trentonensis, Liospira angustata, L. progne, Lophospira* cf. *elevata, Maclurina cuneata, M. manitobensis, Maclurites crassus, M. crassus macer, Trochonema umbilicatum, Narthecoceras crassisiphonatum, Ooceras cordatum, Orthoceras amplicameratum, Vaginoceras multitubulatum, Bumastus trentonensis, Ceraurus dentatus, Isotelus gigas.*

Of these, the corals are particularly common in the upper shales, and this level is suitably called the *Streptelasma corniculum* zone. The upper limestone is more especially characterized by large gastropods of the *Maclurea* type, after which the zone has been named.

The fauna shows close resemblances to that of the Nelson River limestone of Hudson bay (Savage and Van Tuyl 1919), and equivalent strata of Trenton age occur at Frobisher bay, Baffin land (Schuchert 1910), in Manitoba (Dowling 1898), and in Wisconsin, Minnesota, and Iowa. Several fossils suggesting a similar faunal association have also been reported from the Port Clarence limestone of Alaska (Kindle 1911). This fauna, then, belongs to a widespread transgression of the sea from the Arctic in Trenton time. Towards the base of the upper limestone member, or *Maclurea* zone, there is a fossil crinoid and cystid horizon having *Pleurocystites squamosus.* This fossil occurs in the Hull limestone of the Trenton of the Ottawa region, and it appears probable that its stratigraphic height is about the equivalent of the Kirkfield crinoid horizon of southern Ontario.

Upper Ordovician: Richmond.—No Richmond outcrops in this area, although it would be expected to occur from the known widespread marine transgression of this time. Between the top of the Haileybury formation and the lowest known Silurian, there is a stratigraphic interval calculated to be about 40 feet. This undetermined interval may possibly contain Richmond strata, but as it is completely covered by younger deposits, this supposition could not be established.

Silurian: Wabi formation.—The base of the Silurian system, or of what is here called the Wabi formation, is nowhere exposed in the Timiskaming area. The lowest strata are green shales with thin layers of limestone that contain a great many ostracods, particularly *Leperditia hisingeri fabulina,* after which the zone has been named. Higher up, these shales grade into thin-bedded magnesian limestones, the whole thickness of this formation being about 120 feet. In the limestone beds there is one horizon that contains a great many small Hormotomas, and consequently the upper limestone member has been designated the *Hormotoma* zone. Fossils are not plentiful in this formation, but among the most characteristic are: *Leperditia hisingeri fabulina, L. hisingeri, L. arctica, Zygobolbina williamsi, Hormotoma* sp., *Pterinea* cf. *brisa, P. elegans, P. occidentalis, Camarotœchia? winiskensis, Rhynchospira lowi,* and a number of other long-ranging brachiopods.

In other areas where a fauna similar to this has been found, *Virgiana decussata* occurs below the *Leperditia hisingeri fabulina* zone. In the Timiskaming area, the *L. hisingeri fabulina* zone is almost at the base of the exposed part of the section, and if the *Virgiana decussata* zone is present, it is in the unknown interval previously described.

A fauna similar to that of the Wabi formation occurs in the Port Nelson and Severn River limestones of Hudson bay (Savage and Van Tuyl 1919), and undoubtedly these strata are of equivalent age. In the Lake Timiskaming district, there are fewer species, although this may be due to the fact that exposures of the formation are not of great extent and the collecting places are very limited.

Savage and Van Tuyl (1919) have correlated rocks of this age in the Hudson Bay region with the lower part of the Stonewall formation of Manitoba and with rocks of equivalent age in eastern Wisconsin (the upper part of the Mayville limestone), and the northern peninsula of Michigan. In the Dyer Bay dolomite of the Lake Huron district, *Zygobolbina williamsi* was first found (Williams 1919). This is perhaps the only diagnostic fossil so far known common to the Wabi formation and to the Cataract of southern Ontario. If the strata in which this ostracod is found can be taken as about the same stratigraphic height in the two areas, then the lower beds of the Wabi are equivalent to the top part of the Cataract. This means that most of the Cataract of southwestern Ontario is not represented in the Timiskaming area, where 75 feet of deposits occur above the strata containing *Zygobolbina williamsi.*

The Wabi formation thus seems to belong to a transgression of the sea from the Arctic which spread also over the Hudson Bay district, Manitoba, eastern Saskatchewan, and south into eastern Wisconsin and northern Michigan. It probably united in part with the southern invasion of the sea at this time, but the slight intermingling of faunas in the two basins of deposition is opposed to any close connection between the two seas.

Silurian: Lockport formation.—The Lockport is the most extensive formation of the Lake Timiskaming area, and consists of magnesian limestones about 186 feet thick. It is separated at the base by a slight disconformity from the top of the Wabi formation, and although this break does not appear to be a great discordance, yet it represents the time of the Clinton and Rochester of New York.

The Lockport begins with a layer of sandstone 1-2 feet thick, but which very rapidly changes upwards into thin-bedded magnesian limestones. The top portion is marked by thicker bedded, more resistant strata which are an approach to dolomites in composition.

The fauna is marked by corals and cephalopods, although brachiopods are also common in parts. Among the more common fossils are: *Caninia stokesi, Cyathophyllum articulatum, Favosites favosus, F. gothlandicus, F. hispidus, F. niagarensis, Halysites catenularia, H. catenularia microporus, H. catenularia feildeni, H. labrinthicus, Heliolites megastoma, Strombodes pentagonus, Syringopora bifurcata, S. dalmani, S. verticellata, Clathrodictyon vesiculosum, Pentamerus oblongus, Orthis* near *davidsoni, Actinoceras backi, A. rotulatum, A. vertebratum, Discosorus conoideus, D. remotus, Huronia bigsbyi, H. distincta, H. minuens, H. obliqua, Orthoceras alienum, O. franklinense, Encrinurus ornatus, Calymene niagarensis.*

These fossils show a striking similarity to those of the Lockport of the Lake Huron district. Many of the corals in the Timiskaming area have been reported by Williams

(1919) from the Fossil Hill coral horizon on Manitoulin island, and many of the cephalopods have been found on Drummond island. From the Attawapiskat coral reef and Ekwan River limestone, Savage and Van Tuyl (1919) have reported many new species of which there are no representatives in the Timiskaming district. The fauna of the rocks of this age in the Hudson Bay region is decidedly dissimilar from that of Lake Timiskaming, and this probably means that there was a land barrier between the two basins of deposition for at least a part of Lockport time. Towards the top of the Timiskaming section, northern forms like *Cyathophyllum articulatum* and *Halysites catenularia feildeni* occur. These have not been recognized further south, and it would seem that there was a direct migration route from the north in late Lockport time.

It has generally been assumed that the Niagaran inundation of the continent from the Arctic was widespread over the western part of the Canadian shield, but the probable presence of a land barrier in early Lockport time shows that there were restrictions to this sea that have not been previously suspected. Savage and Van Tuyl (1919) have shown that the Niagaran rocks of Hudson bay have closer faunal relations with equivalent strata in Wisconsin than with those in Ontario and New York, and as the Timiskaming Lockport is very similar to that of Ontario, the barrier seems to have been responsible for this faunal distribution.

In the Timiskaming area, *Pycnostylus elegans* occurs. This, with *P. guelphensis* and some other forms suggesting Guelph time, occurs in the Hudson Bay region. However, Williams (1919) has shown that *P. elegans* and *P. guelphensis* occur also in the transition Eramosa beds between the Lockport and the Guelph. Hence these fossils alone can no longer be taken as indicating Guelph. It is surprising that none of the typical Guelph assemblage of fossils such as are so characteristic of the Guelph of southwestern Ontario and New York have been found in the north, and it seems certain that none of this typical Guelph occurs in the Timiskaming district or in the Hudson Bay region.

The presence of the European forms of crinoids and trilobites long ago reported by Weller (1900) from the Chicago series shows direct communication with Europe during Niagaran time, and the only possible connection seems to be by way of the Arctic. *Megalomus* has been reported from Alaska (Kindle 1907) and also occurs on the island of Gotland with *Trimerella*. These occurrences probably mean that the Guelph sea connected with the Arctic ocean, but that the waterway must then have been restricted to the western or Cordilleran geosyncline, while in Lockport time it transgressed more widely over the Canadian shield. *Pycnostylus guelphensis* has also been found in Manitoba, but none of the other typical Guelph fossils occur here, and hence it is not certain whether Guelph is actually present or whether this species comes from the equivalent of high Lockport beds such as the Eramosa beds of Ontario. It is possible that with further field work over suitable areas in the northwestern part of Canada, a Guelph fauna will yet be found and furnish a connecting link between the Arctic and the interior Guelph basin of Ontario and New York.

Devonian.—From the known paleogeography, it would be expected that rocks of late Middle Devonian time should occur in the Timiskaming area, but none are now present. It is possible that erosion may have completely removed them, but if so, that erosion must have taken place prior to the faulting that gave rise to the present fault-scarp along the west side of Lake Timiskaming. The downthrow side of such a fault would be a favorable place for preserval, but the highest rocks now found belong to the Lockport formation.

Post-Glacial Clay Deposits.

The clay deposits of Lake Barlow, which form a part of the northern Ontario Clay Belt south of the Continental Divide, have already been spoken of in connection with terraces. The clay is very evenly stratified in alternate light and dark bands each less than one half inch in thickness. Each two bands represent one complete cycle of deposition, and on the basis of De Geer's results in Sweden, are regarded as of one year. Over a great part of the Clay Belt, no thickness over 30 feet has been previously reported for the clay. However, at the head of Lake Timiskaming, where the clay has accumulated in the depression formed on the downthrow side of the northwest and southeast fault, a much greater thickness occurs. Even above the present surface level the clay is over 150 feet thick, and from calculations made on the average thickness of the bands, this represents at least 2000 years for deposition. In a well drilling at Uno Park 216 feet of clay were passed through, and at the town of New Liskeard near Wabi creek there was 100 feet. It is possible that this may not all be stratified clay, but as the New Liskeard well does not represent the maximum depth nearer the fault-line to the west, it is thought that 250 feet for a total thickness of the clays would be a very conservative estimate. This would mean at least 3600 years for the duration of Lake Barlow. It therefore appears certain that this lake lasted at least 2000 years, but the probability is that the larger figure of 3600 is more nearly correct.

Economic Geology.

Water supply.—The fault which has formed the straight western shore of Lake Timiskaming and its continuance seen in the fault-line scarp northwest of it, has brought about a tilting of the Paleozoic strata to the west in all of the area on the east side of the fault-line. Except for a ridge of rock extending northwest from Wabi peninsula, the whole surface is now covered by the clay deposits of Lake Barlow. These clays are relatively impervious to water, and the settlers have found that surface wells are for the most part unsuitable for human use. The problem of water supply is therefore very important to the agricultural development of this district, and in many places deep well boring has been done. In the final report a list of such well records will be published and a detailed account given.

In the low plain which includes the valley of Wabi creek and a strip of country to the west of Earlton and Thornloe and east of the Paleozoic boundary on the west, a great many wells have been obtained and artesian wells are not uncommon. The rocks under this plain dip west, but on the east they outcrop as a ridge stretching northwest from Wabi peninsula. It has been found that between the clay and the underlying westward dipping limestone there is a layer of bowlders which are the glacial materials left on the retreat of the continental ice sheets. This layer of bowlders is very favorable for the permeation of water along the upper surface of the limestone, and it has been found that good wells frequently develop as soon as the layer of bowlders is tapped.

On the ridge of rock extending northwest from Wabi peninsula, there is no possibility of obtaining artesian wells, and the chances for finding water close to the surface are not good. The top part of this ridge is of resistant rock, but at lower horizons shales occur, and the erosion on these less resistant strata has caused the ridge to be bounded on the east by a rather steep cuesta face which extends northwest from the west side of Sutton bay. East of this cuesta face, the country is very little above the level of the lake, but rises gradually towards the north. In this flat, extending as a narrow strip not more than 3 to 4 miles wide, there is again suitable structure beneath the clay for favorable water supply, and already one artesian well has been found. In the part of the Clay Belt underlain by Precambrian rocks there is a possibility of finding water on the contact of the Precambrian and clay deposits in the depressions between the knobs and ridges of rock.

Limestone.—Limestone of the Lockport formation is used in the manufacture of lime, and rock of both the Lockport and Haileybury formations has been used as building stone.

In the sulphite plant of the Abitibi Power and Paper Co., Iroquois Falls, limestone low in magnesium content is required in the manufacture of paper pulp. Rock of the Haileybury formation has been used for this purpose, but the present quarry is rather unsuitable on account of the alteration that has occurred in the top weathered portion. However, it is hoped that more favorable results can be obtained from a new quarry.

Clay.—The banded clay of Lake Barlow has been used in the manufacture of brick and tile. The clay contains too high a percentage of lime to make the best brick-forming material, but by the addition of finely ground diabase from the Cobalt mills, instead of sand, which is not available, a suitable quality of building brick is obtained.

There are red clays and shales at the base of the Haileybury formation that may be of future economic importance. These clays and shales in a diamond drill core from the west of Haileybury were 50 feet thick. Mr. Keele of the Department of Mines of Canada has investigated this material and finds it to be satisfactory, as it does not begin to soften below a temperature of about

2600° F. According to Mr. Keele's report, it would be suitable for cupola and stove lining, and also for the manufacture of vitrified wares such as paving blocks.

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