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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 70-34

QUATERNARY GEOLOGY OF THE STRATFORD-CONESTOGO AREA, ONTARIO

(Report, 1 figure, Maps 26-1970; 27-1970; 28-1970 and 29-1970)

P.F. Karrow

GEOLOGICAL INFORMATION
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Figure 1. Distribution of surface tills in the Stratford-Conestogo area. 5

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ABSTRACT

The Stratford-Conestogo area is mid-way between Lakes Huron and Ontario in southwestern Ontario, and lies between the cities of Stratford and Kitchener. Because of its central location, it was subject to the action of the Huron, Georgian Bay, Ontario, and Erie ice lobes at various times and when the glacier was at its maximum, ice flowed across the area from the northeast. Tazewellian Catfish Creek Till (sandy texture) is found throughout the area under as many as three or four Cary tills, usually of a clayey or silty texture. As many as three pre-Tazewell tills (probably all of Wisconsinian age) occur in the eastern part of the area. Till sheets are often thin and landforms, particularly end moraines, are often palimpsest. Several end moraines and interlobate moraines cross the area. Most moraines are related to the activity of the Huron and Georgian Bay ice lobes. Minor moraines and eskers occur in the northwest and northeast parts of the area.

Sand and gravel are derived from the kame deposits in the Easthope, Waterloo, and Elmira moraines, from eskers west of Milverton, and from outwash gravel terraces along the Nith and Conestogo Rivers. Chert is abundant in the northwestern deposits but rare in the southeast. Glaciolacustrine silt and clay are worked for tile manufacture near Elmira.

RÉSUMÉ

La région de Stratford-Conestogo se trouve à mi-chemin entre les lacs Huron et Ontario, au sud-ouest de l'Ontario, et s'étend entre les villes de Stratford et Kitchener. Du fait de sa situation centrale, elle a été soumise à diverses reprises à l'action des lobes glaciaires du lac Huron, de la baie Georgienne, du lac Ontario et du lac Érié et, lors de l'avancée maximum de la nappe glaciaire, les glaces ont traversé toute la région depuis le nord-est. Dans toute la région, on trouve le till tazewellien de Catfish Creek, à texture sableuse, sous-jacent à trois ou quatre couches de till de Cary, d'une texture généralement argileuse ou limoneuse. Dans le partie est, on trouve jusqu'à trois couches de till antérieur au Tazewell, probablement toutes du Wisconsin. Les couches sont souvent peu épaisses et les formes du relief, en particulier les moraines terminales, sont fréquemment résiduelles. Plusieurs moraines terminales et interlobaires traversent la région. La plupart des moraines proviennent de l'action des lobes glaciaires du lac Huron et de la baie Georgienne. Des moraines moins importantes et des eskers, s'étendent au nord-est et au nord-ouest de la région.

Le sable et le gravier résultent de kames des moraines d'Easthope, de Waterloo et d'Elmira, des eskers sis à l'ouest de Milverton et des terrasses de gravier fluvioglaciaire situées le long des rivières Nith et Conestogo. Le chert est abondant dans les dépôts du nord-ouest, mais rare au sud-est. Le limon et l'argile glacio-lacustres servent à la fabrication de tuiles près d'Elmira.

QUATERNARY GEOLOGY OF THE STRATFORD-CONESTOGO AREA, ONTARIO

INTRODUCTION

Location and access

The Stratford-Conestogo area is located in the interlake peninsula of southern Ontario between lakes Ontario, Erie, and Huron. It has an area of about 850 square miles and is bounded by latitudes 43°15' and 43°45' and longitudes 80°30' and 81°. The cities of Stratford, Waterloo and Kitchener and the towns of Listowel, Elmira, New Hamburg and Tavistock are within the area. Maps of the National Topographic Series 40 P/7 and 40 P/10 cover the area at a scale of 1:50,000.

Provincial highways 7, 8, 19, 23, 59, 85, 86, 97, and 401 serve parts of the area. Almost all the area is readily accessible by township or county roads, several of which are paved.

Topography and drainage

Elevations in the area vary from a low of 900 feet along the Nith River in the southeast part of the area, to a high of 1,575 feet in the northeast part of the area. Rolling sand and till hills extend through much of the eastern half or quarter of the area, while nearly level till and clay plains dominate the western portions. Local relief along the river valleys and in the more rugged moraine areas is often 100 to 200 feet.

Most of the area drains to Lake Erie via tributaries of the Grand River. The north central and northeast parts are drained by the Conestogo River, which joins the Grand at the village of Conestogo at the eastern edge of the area. The central and southeastern parts of the area drain via the Nith River to the Grand at Paris, several miles southeast of the area. In its southwestern part, the area is drained by tributaries of the Thames River, which eventually flow into Lake St. Clair. The northwestern part is drained by branches of the Maitland River, which flows into Lake Huron at Goderich, west of the area.

Previous work

The bedrock of the area has been studied by Caley (1941). Preliminary bedrock topography maps have been prepared by Davies and McClymont (1962). The general physiography and description of major landforms has been presented by Chapman and Putnam (1966). Very little detailed geological work has been undertaken in the area at any time previous to this study although the areas adjacent to the east have been described by Karrow (1963, 1968b)

Original manuscript submitted by author: 9 July, 1969
Final version approved for publication: 3 November, 1970

Present work

Field mapping was carried out in the summers of 1965, 1966, 1967, and 1968. Stratigraphic drilling was carried out by the Department of Public Works in the winters of 1966-67 (6 holes) and 1968-69 (3 holes). Supporting seismic surveys and palynologic sampling were carried out in the summer of 1968 but results are not yet available. In the course of regular mapping, over 500 samples of till were collected for laboratory study of grain size and carbonate content. At selected sites clay minerals, heavy minerals, pebble composition, and pebble orientation (till fabric) have been studied. All analyses have not yet been completed but should be available for inclusion in the final report. Only partial synthesis and interpretation of the analyses have been undertaken as yet.

The accompanying geological map shows the surface distribution of deposits three or more feet in thickness; thinner deposits are not shown. Along the valleys, individual units are often too thin or too numerous to be shown separately. Where this problem arises, several units may be grouped together or only the most important may be shown.

ACKNOWLEDGMENTS

The author wishes to thank B.H. Feenstra who served very capably as senior assistant all four summers of field work (1965-68). Junior assistants on the project were: R.A. Fisher and W.L. Johnston in 1965; W.D. Corstorphine, K.H. Livingston and J.S. Hancock in 1966; T.J. McManus, R. Van der Linde, B.D. Bornhold and F.W. Schwartz in 1967; and R.W. May and A.C. Bartlett in 1968.

BEDROCK GEOLOGY

The bedrock formations are of Silurian and Devonian age and extend as belts trending almost north-south under the area. The rocks consist predominantly of dolomite and limestone with some shale and chert. These rocks have been classified as Salina, Bass Island, Bois Blanc, and Detroit River (Sanford, 1958) in order of decreasing age from east to west. They have a gentle dip westward toward the Michigan Basin. Nowhere in the area does the bedrock outcrop but it has been penetrated by many wells.

The bedrock surface is broadly level over large areas, with a system of buried valleys incised into it in a pattern somewhat similar to the modern valley system. The buried Onondaga Escarpment enters the area from the south near Bright but becomes blurred and lost northward. The bedrock surface is concealed by a cover of Quaternary deposits commonly ranging from 100 to 300 feet in thickness, with depths as great as 400 feet in parts of the eastern moraine complex.

GEOMORPHOLOGY

A variety of landforms are present in the area, most of which reflect the action of glaciers either directly or indirectly. Many of the landforms reveal a complex history of origin and often can be seen to have originated during events preceding the last ice advance in the area. Because of its location, the area has been subjected to glaciation by four different ice lobes which acted independently or in pairs at various times. The lobes involved were the Huron lobe from the west, the Georgian Bay lobe from the northwest, the Ontario lobe from the east, and the Erie lobe from the southeast.

An extensive interlobate moraine, the larger part of which is known as the Waterloo moraine, extends between Plattsville in the south and St. Clements in the north. While the early history of the sandy feature is obscure, it appears to have been overridden most recently from the east by the Ontario lobe. Extending northward almost to Alma is a smaller and less complex interlobate ridge known as the Elmira moraine, most recently overridden from the northwest by the Georgian Bay ice lobe, but shortly thereafter approached closely from the east by the Ontario lobe.

Southeast of the Waterloo moraine is the outermost identified moraine of the Erie lobe (Ingersoll moraine). This moraine has a substantial core of kame sand and gravel but has a capping of younger silt till. Several spurs of kame sand extend west and northwest of the Waterloo moraine, overridden by advances of the Georgian Bay and Huron glacial lobes.

An irregular kame moraine complex (Easthope moraine) also exists north of Shakespeare. Of unknown origin, it was overridden by the Huron lobe.

The outermost distinguishable till moraine of the Huron lobe is the Macton moraine (Karrow, 1968a). This subdued hummocky clay till moraine swings in an arc convexly eastward from southeast of Listowel, near Glen Allan, Macton, and Hawkesville, becoming lost in overridden kame moraine west of St. Clements. The Milverton moraine trends southward from the northwest end of the Macton moraine through Milverton and Brunner and swings southwestward out of the area. North of Brunner it consists, in part or entirely, of silt till deposited by the southward-flowing Georgian Bay lobe, while to the south and west, a clay till ridge extends out from under the silt till.

Numerous minor moraines occur in the area. Small ridges trending southwest-northeast occur between Tavistock and the Milverton moraine. To the southeast they consist of silt till while to the northwest they are capped by a younger sandy silt till; it is believed all the ridges may have originated in the earlier (silt till) advance, the more westerly ones being capped by, but not destroyed by, a later readvance. A few till ridges mark the retreat of the Georgian Bay lobe south of Listowel. They trend north of east, approximately perpendicular to eskers in the area.

Eskers are usually associated with silty to sandy till sheets. Several have been identified as deposited during the retreat of the Ontario lobe (southeast of Elmira) and the Georgian Bay lobe (south and east of Listowel). One of the longest is the Atwood esker, whose outermost end is southwest of Milverton; most of this esker lies to the west of the area.

Till plains are very extensive west of the interlobate moraine tract. The plains are underlain by till sheets of several ages, varying in texture from clayey to sandy silt. Well fluted surfaces occur north of Conestogo Lake and poorly formed drumlins occur near Listowel, all trending east of south. Vague drumlin-like rolls and flutings also occur southeast of Tavistock and apparently represent a northward extension of the Woodstock drumlin field, later modified and overridden by the Huron lobe which deposited a silt till on top of them. The Woodstock drumlins are probably the oldest in the Province. Extensive portions of the Waterloo moraine are veneered by a till sheet which inherited the irregular topography of the surface on which the till was deposited; they are thus a peculiar kind of till plain.

Overlying the till in numerous individual patches and more extensive sheets are shallow lacustrine deposits, predominantly of silt. The more

extensive lake plains between Stratford and Milverton probably were formed by temporary glacial lakes standing at an elevation of about 1,215 feet

During the retreat of the ice, much dissection by meltwater occurred. Till sheets were extensively dismembered in areas of higher relief, such as the Waterloo moraine. Some valleys were major temporary meltwater channels. The lower reaches of the Nith River, for instance, were flooded by westward-flowing waters at about the time the Paris moraine was formed to the east. Deep gravel deposits now flank the valley. With the retreat of the ice, meltwater was diverted down the Grand Valley and drainage down the Nith was reversed and changed to the east. Low-lying portions of the old meltwater terraces are now covered by deep organic deposits and swamps.

QUATERNARY STRATIGRAPHY

There are few outstanding high stratigraphic sections in the area, such as have been described from other map-areas in southern Ontario. Nevertheless, because till sheets are often relatively thin over large areas, even sections of very modest height often expose several superimposed till sheets. The widespread occurrence of thin traceable tills is an impressive feature of the area. Intervening stratified beds are often lacking, or thin, contributing to the general thinness of stratigraphic sequences. Much stratigraphic information has come from road-cuts and other man-made exposures. River bank sections were available principally along the Conestogo and Nith Rivers, Smith Creek, and Canagagigue Creek.

Catfish Creek Till (A)

The most useful stratigraphic marker throughout the area is an almost ubiquitous, relatively thick sheet of stony, sandy to silty, olive to buff till, commonly found low in stratigraphic sequences (Fig. 1). This till is considered to be the northward extension of the Catfish Creek Till of Tazewellian age (Goldthwait et al., 1965). It is a dolomitic till in both pebble and matrix composition and has a fabric indicating ice movement from the north or northeast. It is interpreted as having been deposited by the Late Wisconsinan ice sheet, during the time of maximum thickness and extent, when ice flow was not differentiated into separate lobes in each lake basin. This till occurs in this map-area both east and west of the interlobate moraine complex and is presumed to pass beneath it. The till is hard and dense, and is commonly encountered at depth by well-drillers and called "hardpan". Comparable till has been recognized throughout much of the area covered by the Erie ice lobe, both north and south of Lake Erie. Mapping in this area also has revealed its extensive occurrence in the area later covered by advances from the Huron and Georgian Bay ice lobes.

South of Bright there is an area of a few square miles where the Catfish Creek Till forms the surface till, and was presumably deposited by the latest ice advance. This area extends southward into the Woodstock map-area and is probably continuous with the sandy till drumlins of the Woodstock drumlin field. If this interpretation is correct, this is an area of exposed Tazewellian drift, and perhaps the oldest glacial surface in southern Ontario! Other areas south of Tavistock mapped as exposed Catfish Creek Till are actually inliers, surrounded by younger till and overridden by a later ice advance which did not cover the older till everywhere.

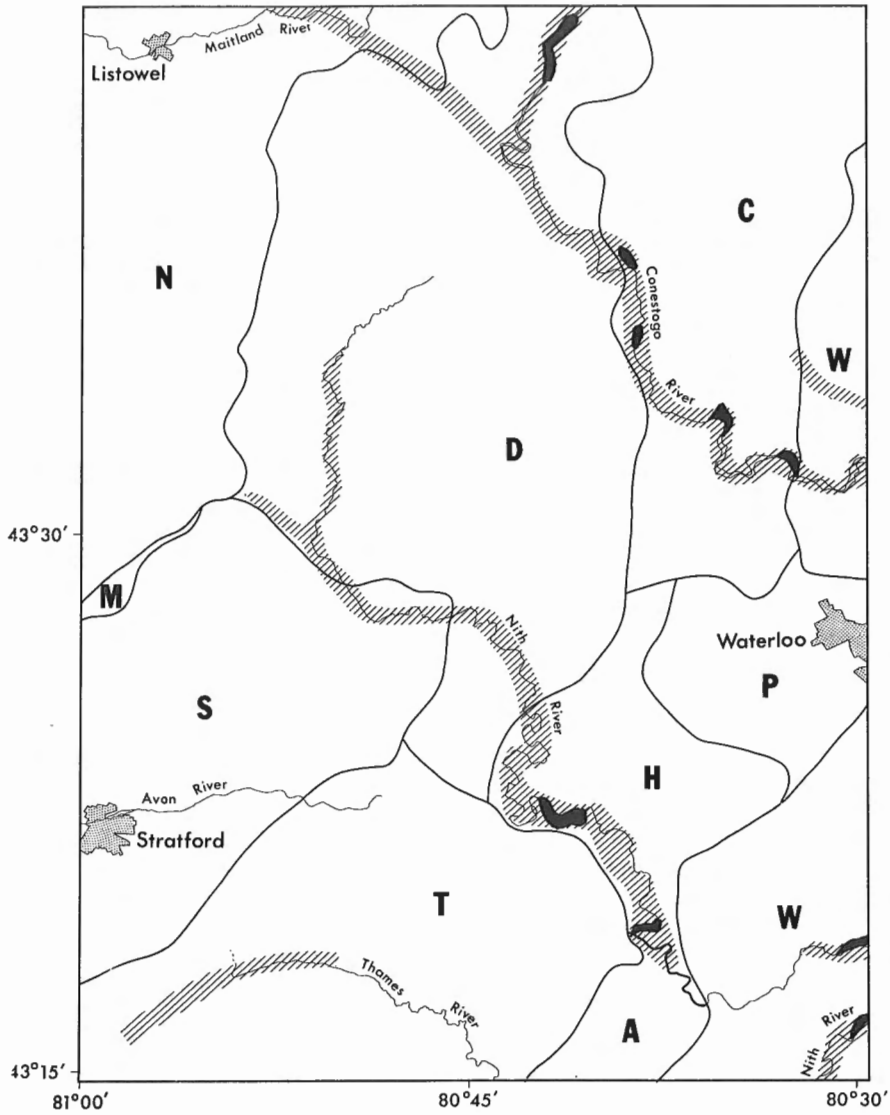

Figure 1. Distribution of surface tills in the Stratford-Conestogo area. Boundaries of till sheets are somewhat generalized and interpretive. Areas of pre-Catfish Creek tills exposed along valleys shown in solid black. Areas along valleys where Catfish Creek Till commonly occurs are cross-hatched.

Pre-Catfish Creek Till

Pre-Catfish Creek tills occur in several places in the eastern half of the area (Fig. 1). Generally speaking, these tills are silty in the Conestogo map-area and clayey in the Stratford map-area. The southern occurrences may correlate with the Canning Till of the lower Nith River (Karrow, 1963). Sequences of at least three pre-Catfish Creek tills occur at the north end of Conestogo Lake. They are, in descending order: stonefree, massive to sub-stratified silt till interbedded with stratified silt; gravelly silt till which, to the casual eye, resembles Catfish Creek Till; and reddish brown clayey silt till. A complex sequence occurs some three miles southeast of Glen Allan which includes a possible paleosol and organic matter, possibly of pre-Catfish Creek age. Although occurrences of pre-Catfish Creek tills are known from other widely scattered sites such as Stratford and St. Mary's, their relatively great abundance in or near the interlobate zone (Westgate and Dreimanis, 1967) is thought to be significant. This implies reduced glacial erosion in such zones. Old tills near St. Jacob's are believed equivalent to similar tills along the Grand River in the Guelph and Galt map-areas (Karrow, 1963, 1968b).

In most parts of the map-area, one to three younger tills overlie the Catfish Creek Till. Several till sheet margins have been located in the area, but in some cases it has been difficult or impossible either to identify the till or to draw boundaries between similar tills derived from different advances of the same ice lobe or of different lobes. These problems have been most severe in flat terrain with poor vertical exposure or in the rough sandy moraine belts where facies changes obscure till identification. Thus, for the present, most till units are referred to by informal letter designations and some are not correlated with designated tills. It is hoped that, with further analysis of accumulated data, greater refinement will be possible and that it will also be possible to apply a formal set of names to the tills of the area.

Till P

East of the "interlobate line", tills probably deposited by the Ontario-Erie lobe form a westward extension of the deposits described in the Galt and Guelph areas. Thus, from Kitchener northward, the Catfish Creek Till is overlain by silty to clayey till, low in stones, and having calcite exceeding dolomite in the till matrix. This has previously been referred to as Port Stanley Till (Karrow, 1963) or "middle till" (Karrow, 1968b). Doubt as to its eastern or western derivation remains, which may be resolved by mineralogical studies now in progress. On balance, I still feel it is an eastern till and that it extends approximately as far as the Elmira moraine; it may form the core of the till ridge portion of the moraine which swings convexly westward southwest of Elmira. West of Kitchener, silty to clayey till caps the Waterloo moraine. It is all or partly derived from the east but its relationship to the Port Stanley Drift is uncertain. Erratics of Grenville marble are a notable feature of this till.

Till W

North of Kitchener, the youngest till is a sandy till previously called Wentworth Till (Karrow, 1968b). It often becomes more silty near its western margin and is then difficult to identify; the same problem was encountered north of Fergus in the Guelph area. South of Kitchener, a silty to sandy till extends westward to the interlobate line and caps part of the Waterloo moraine and all of the Ingersoll moraine; to the southeast it was previously mapped as

Port Stanley Till. This till may also be a later part of the Catfish Creek Drift (A. Dreimanis, pers. comm.). White (1968) has presented evidence of a significant ice retreat between deposition of the sandy till in front of the Paris moraine and of the sandy till of the Paris moraine itself; I have previously classed both tills as Wentworth Till on the basis of appearance. Additional evidence of a time break occurring at this time has been presented from the Erie Basin (Wall, 1968). I have been troubled previously by the peculiar extension of the Wentworth Till for many miles west beyond the Paris moraine north of Kitchener, while in the Brantford area it apparently stopped at the Paris moraine. If the silty to sandy till southwest of Kitchener is the southward equivalent of the pre-Paris-moraine Wentworth, this problem is much alleviated, although the age of the advance remains uncertain. One critical relationship remains to be established to determine whether the silty till overlies clay till (Port Stanley Till), as is suspected, or whether it overlies Catfish Creek Till yielding, in one case, two units of Port Stanley Drift and, in the other case, two units of Catfish Creek Drift. In the vicinity of Plattsville and Bright, in some exposures, this till is difficult to distinguish from Catfish Creek Till.

Till H

West of the interlobate line, clay till (till H) overlies the Catfish Creek Till and is exposed as the surface till between New Hamburg and Petersburg. A few till fabrics suggest deposition from the southwest. The matrix is higher in calcite than dolomite. This till extends southwestward a few miles under till T but forms isolated caps on top of sand along the western flank of the Waterloo moraine. Its relationship to clay till east of the interlobate line is unknown but it is believed to be at least equivalent in age.

Till T

Till T is a gritty clayey silt till deposited from the northwest. Along its eastern margin it overlies till H but, between Tavistock and Stratford, it rests directly on Catfish Creek Till. It is the surface till west from the Nith River to near Stratford. Its outer limit has been mapped near Bright and is believed to continue southwest into the Woodstock sheet. Northward, the margin follows the west side of the Nith River to New Hamburg, then swings westward into the Easthope moraine complex. Calcite slightly exceeds dolomite in the till matrix. The till surface forms several small subparallel moraine ridges trending southwest-northeast between Tavistock and Stratford.

Till S

This till is a moderately stony, sandy silt till whose margin has been traced from Harmony (south of Stratford) to Wellesley, and then northwestward along the Nith River to the lake plain south of Milverton. Where the till margin passes through the Easthope moraine, till identification is uncertain. Till fabrics indicate ice motion was south of east. Calcite is roughly equal to, or slightly less than, dolomite in the till matrix. As with till T, till S forms a series of subparallel till ridges trending southwest-northeast in the belt of land between Harmony and the Milverton moraine. Because of the general thinness of till S, it is thought these till ridges are inherited from the underlying till T.

Till M

South of Brunner, the Milverton moraine is formed of stonefree clay till M. Calcite considerably exceeds dolomite in the till matrix. Because of the limited area of occurrence and a lack of stratigraphic information, the correlation of till M is uncertain. Lenses of stone-bearing clay on top of till S in areas of lacustrine sedimentation may be an extension of till M a few miles east of the Milverton moraine, but the materials are usually thin and thoroughly weathered. Clay till overlying till similar to till S west of the map-area (near St. Mary's) suggests at least that till M was the deposit of a later ice advance over till S.

Till B

In the central and northern parts of the Conestogo sheet, silty to clayey till, relatively high in calcite, directly overlies the Catfish Creek Till. This is till B of the Conestogo Dam area. To the north it is silty, but to the south it is clayey. Till B may correlate with till H of the New Hamburg area but nothing is directly known of the relationship. Aside from this possibility, till B is not known to occur anywhere at the surface. Till B does not apparently extend east as far as the interlobate complex; if it did, it would be difficult to distinguish from the "middle" clay till of Kitchener.

Till C

Till C, a gritty clayey silt till, was deposited from the northwest and is an extensive and major unit through much of the Conestogo sheet. It forms the surface till over much of the area east of Conestogo Lake and, as a surface till, extends south probably as far as Waterloo. Where it becomes sandy, it is distinguished with great difficulty from the Wentworth Till which overlies it along its eastern edge between Waterloo and Elmira. Till C was referred to as "northern till" in the Guelph area north of Fergus (Karrow, 1968b). It is known to overlie the "middle" clay till east of the Elmira moraine. The Elmira moraine itself was overridden by the ice which deposited till C, leaving a cap of till C on top of the moraine sands. The southern limit of the till has not been determined because of the problem of till identification in the Waterloo moraine. It bears some resemblance to till T but no direct correlation has been possible. Both overlie clay tills (H and B) which rest on Catfish Creek Till. Generally, till C has more calcite than dolomite in the matrix although, near Alma, in the northeast part of the area, dolomite exceeds calcite, adding to the difficulty of distinguishing it from Wentworth Till. At the other end of its facies variation, finer material becomes somewhat difficult to distinguish from coarser facies of the "middle" till and overlying clay till of the Conestogo Dam area. Small chips of red Queenston shale are encountered throughout the area in all the tills, but are particularly abundant in till C.

Till D

Overlying till C, and forming the surface till between the Milverton moraine and the Conestogo River, is clayey till D. This till appears to form the bulk of the Macton moraine. It was apparently deposited from the northwest but the ice margin retreated westward. Clay till extends northward along both sides of Conestogo Lake and may have been deposited by a different advance from the northwest; it is strongly fluted by ice moving southeast. The southern limit of the till is also uncertain, becoming difficult to recognize in overridden kame moraine east of Wellesley. Surface clay till south of

Wellesley may also be till D. Calcite exceeds dolomite in the matrix. Both till D and M were overridden by an ice advance from the north which deposited till N, but the relationship between D and M is only inferred. The northeastern margin of till S apparently laps over on top of till D near Wellesley, and is in turn overlain by till M.

Till N

Till N was the latest till deposited in the western part of the area. It is silty in the south near Milverton but sandy in the north near Listowel. Where it is silty, dolomite exceeds calcite in the matrix, but where it is sandy, dolomite strongly predominates (calcite-dolomite ratios of 0.1 to 0.3). A few small morainic ridges trend north of east, perpendicular to esker trends and surface lineaments. The Milverton moraine was enlarged by marginal accumulation of till N, whose limit closely follows the moraine north of Brunner but, farther southwest, swings westward away from it. West of Conestogo Lake, a silty facies is difficult to distinguish from till C.

Problems of till correlation

The many tills west of the interlobate line substantially exceed the number of tills east of it and present a puzzling phenomenon. The Paris moraine to the east has been correlated with the Wyoming (Port Huron) moraine to the west (Chapman and Putman, 1966) but the stratigraphic information at hand indicates that the Huron lobe fluctuated many more times than the Ontario lobe did in what appears to be the same time interval. Most of these fluctuations are of Caryan age and must have occurred in an interval of three or four thousand years. The evidence at hand continues to throw into question the moraine correlations in southern Ontario. Only by continued and extensive detailed mapping can we hope to resolve these problems.

Kame and outwash deposits

Extensive kame sands and some gravels, usually overridden by later ice advances, occur in the Easthope, Waterloo, Elmira, and Ingersoll moraines. Their relationship to the various tills is usually unknown. Outwash sand and gravel is most abundant along the lower Nith valley and along the Grand valley east of Elmira, although other limited deposits occur along the Nith valley near Wellesley and New Hamburg, and in a few places along the Conestogo River. Eolian sand and silt (loess) occur thinly and sporadically in the Waterloo moraine, occasionally overlying buried soil profiles on till; all associated profiles are thin and apparently young.

Lacustrine deposits

Shallow pond and lake deposits, consisting mostly of silt with some clay and sand, occur as depression fillings in many places throughout the area but are particularly abundant on tills S, D, and N. Some of the more extensive deposits south of Milverton appear to have shallow water facies suggesting a shoreline near 1215 feet elevation. Some of these facies are also fossiliferous, with several species of aquatic molluscs and ostracods identified. These sediments form generally poorly drained soils, a situation which has given rise to extensive tile drainage installations and ditching.

Bog and swamp deposits

Numerous deposits of peat and muck of varying extent and depth occur in the area. They occur as kettle hole fillings in the moraine belts, as meltwater channel fillings in outwash channels, such as along the Nith Valley west of Wolverton, and in residual depressions in lake basins such as west and south of Milverton. Most bogs are less than 10 feet deep but the Nith Channel bog is over twenty feet deep and some kettle bogs are even deeper. Palynological study and radiocarbon dating are under way in several of the bogs. A study of a kettle bog west of Waterloo was recently completed by Sreenivasa (1968).

ECONOMIC GEOLOGY

In former years, clays have been used for the manufacture of pottery at Conestogo and brick at Conestogo, Elmira, and Stratford. In some cases the clay used was stonefree clay till but, in most cases, shallow lacustrine deposits were used. Similar lake deposits are now being used in an active tile industry west of Elmira at Wallenstein. The deposits, their properties and exploitation have been described recently by Guillet (1967).

Numerous pits, abandoned and active, occur throughout the area in kame, esker, and outwash sand and gravel. Chert is commonly present in the gravels of the area, being particularly abundant (over 15%) in esker gravels east of Listowel. The Nith terrace gravels in the southeastern part of the area have been derived from the east, are generally free of chert and are of high quality. Some of the operations have been described by Hewitt and Karrow (1963). Sand and gravel deposits are particularly lacking in the area underlain by clay till D and, to a lesser extent, in areas of tills C and T.

Peat and muck resources are large but are not commercially exploited at present. Marl beds were formerly worked west of Milverton (Guillet, 1969).

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