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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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SURFICIAL GEOLOGY OF SMOOTH ROCK COCHRANE DISTRICT, ONTARIO

(Preliminary Report and Map)

By

O. L. Hughes

OTTAWA
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Introduction

Smooth Rock map-area lies within that part of the Barlow-Ojibway clay plain that was overridden by ice during a late Wisconsin ice advance (the Cochrane ice advance). The area mantled by Cochrane till is a gently undulant plain, interrupted only by broad ridges that coincide with the position of buried glacio-fluvial deposits, and by occasional knobs of bedrock.

The area is drained by three major northward flowing rivers, Abitibi, Mattagami, and Groundhog, and by major tributaries such as Frederickhouse, North Driftwood, and Poplar Rapids Rivers. These are cut 50 or more feet below the till plain, and their longitudinal profiles are interrupted by numerous falls and rapids at points where downcutting has been arrested by bedrock.

Secondary drainage is but weakly developed. Interstream areas are consequently poorly drained, and much of the area is covered by bog.

General Geology

The substratified drift (1) consists of partially sorted glacial debris which locally contains interstratified gravel, sand, and silt. It is distinguished from glacio-fluvial deposits principally by its low degree of sorting and by lack of well defined bedding. Particle size ranges from silt size to cobbles and boulders, the latter constituting as high as 40 per cent of the total volume. Whereas glacio-fluvial gravel is loose and free-running, the substratified drift is moderately compact, though not as compact as the basal till with which it is closely associated in exposures outside the map-area. It is in part ablation till laid down during the ice retreat that preceded the Cochrane ice advance, and in part morainal debris of marginal moraines built during the same ice retreat.

Within Smooth Rock map-area, substratified drift is exposed in several road-cuts and pits in an area that includes parts of Glackmeyer and Clute townships. This area is topographically high, lying 50 to 200 feet above the general level of the Cochrane till plain, and, in contrast to the gently undulant till plain, has a local relief of 50 to 100 feet. Substratified drift is exposed in thicknesses up to 35 feet, and may be much thicker. In this area it appears to constitute a segment of pre-Cochrane marginal moraine.

There are further exposures of the substratified drift, one on the east bank of Mattagami River at Island Falls, where it is overlain by 14.5 feet of Barlow-Ojibway varved sediments, 2 feet of Cochrane till, and 1.5 feet of post-Cochrane sediments; another is on the west bank of Mattagami River at Davis Rapids, where it is overlain by about 3 feet of Cochrane till.

On the west bank of Frederickhouse River, 500 feet below Frederickhouse dam, compact sandy boulder till with inter-stratified sand is exposed up to 13 feet above river level, and is overlain by about 25 feet of varved Barlow-Ojibway sediments and about 35 feet of Cochrane till. Substratified drift is exposed 650 feet below the dam, also overlain by varved clay and Cochrane till. The substratified drift differs from the till only in being less compact, and is interpreted as ablation till produced during the latest pre-Cochrane ice retreat.

From the close spatial and stratigraphic relationship of the substratified drift and the sandy boulder till, they may be considered as two phases of a single stratigraphic unit. Within and adjacent to the map-area, this single unit represents the whole of the pre-Cochrane part of the Wisconsin stage. The wide distribution of its exposures and reports from well-drillers of bouldery layers at depths of 60 to 150 feet below the Cochrane till plain suggest that the unit is rather continuous in the subsurface.

The glacio-fluvial sand and gravel (2) varies from coarse boulder gravel to fine sand. Rude foreset bedding, with dips up to 35 degrees to the south, is common in the gravel; minute foreset bedding, also dipping south, is common in the sand. Locally deposits of this unit may be predominately gravel or predominately sand, with rapid changes over short distances, both horizontally and vertically.

These deposits occur as low broad ridges with numerous kettles, and may be termed esker complexes. One esker complex, marked by a chain of kettle lakes, may be traced from 1 mile north-east of Island Falls, Abitibi River, to the west side of Frederick-house Lake, a distance of 72 miles. Others are traceable for lesser distances, of the order of 10 miles.

The kettle lakes are situated more or less medially in the esker complex, and are elongated parallel to its trend. The lakes commonly occur in pairs, with a central ridge of gravel separating the two. In some lakes the central ridge may be partially submerged, forming a point or points of land projecting into the lake. The former type is exemplified by Parks and Paradise Lakes, at the corner common to Colquhoun, Leitch, Clute, and Calder townships, the latter type by Commando Lake, within the town of Cochrane, and by a lake 3 miles northeast of Moonbeam Lake in Alexandra township.

Very similar glacio-fluvial deposits have been reported by Norman (1938 and 1939) from Chibougamau district, Quebec and Mistassini Lake region, Quebec respectively, and by Wilson (1938) from the region between Turgeon and Bell Rivers, Quebec.

Norman (1938, p. 78) describes two types of large sand and gravel ridges which he terms retrogressive eskers and sand-plains. The former consists of "a central sharp-crested ridge (is) bordered on each side by a continuous series of kettles and depressions that separate the ridge from the lateral outwash aprons on the outside parts of these eskers". The sandplains "resemble the large eskers in having wide aprons of outwashed sand, but instead of a prominent sharp-crested central ridge have a central chain of kettle holes. The sand plains vary in width from 1,500 to 10,000 feet. .... A double row of kettle holes separated by a small sharp-crested ridge occurs along parts of some sand plains, in other parts kettle holes may be lacking or widely separated. ...... Some of the photographs when examined with a stereoscope suggest very clearly that if the chains of kettle holes had not been formed the profile across the sand plains would be perfectly smooth curves, having wide flat crests and steep sides that flatten out laterally".

Norman considers both types to be deltaic deposits, formed in glacial Lake Barlow-Ojibway in successive annual increments by subglacial streams emerging from a retreating ice margin. As such they might be termed attenuated deltas. The kettle lakes are attributed to melting out of ice that was buried at the margins of subglacial streams during simultaneous lateral cutting and aggradation of the channel.

Probably both of Norman's categories of large sand and gravel ridges occur within the esker complexes of Smooth Rock map-area. These were, however, overridden by ice in the Cochrane advance so that their original form is not readily discernible. Nevertheless, the form of the kettle lakes is almost identical to that of the kettle lakes studied by Norman and Wilson, and when the esker complexes are traced southward beyond the limits of the Cochrane advance, they are found to duplicate closely the forms described by these authors. The kettle lakes and central ridges could not have survived continental glaciation during Cochrane time had they developed prior to the Cochrane advance. Therefore, it is postulated that the buried ice masses to which they owe their origin remained essentially unmelted until and throughout the Cochrane advance, so that, although the ice masses were pre-Cochrane, the melting and slumping that produced the kettles took place after retreat of the Cochrane ice.

The Barlow-Ojibway deposits (3) include all of the fine-grained sediments deposited in glacial Lake Barlow-Ojibway. In general, the lower part of the unit consists of bedded silt. Upward in the section clay laminae 1/2 inch to 2 inches thick appear. At first these laminae are at intervals of several feet, but the interval decreases more or less regularly until the layers become typical varves consisting of alternating laminae of silt and clay, the varve thickness ranging from 1/2 inch to 1 1/2 inches. Most of the varves show a fairly regular gradation from silt of the summer layer to clay of the winter layer, with a sharp break between the clay and the silt of the succeeding varve. Within the silt layers and less markedly within the clay layers there is lamination due to alternation between finer and coarser sediment. This is particularly true of the thicker basal varves. Such laminations are doubtless an expression of day to day change in the influx of sediment to Lake Barlow-Ojibway, and thus of day to day changes in the rate of ice melting. The thick silty basal varves were deposited in closer proximity to the ice front than thinner more clayey varves above, and, therefore, more subject to the effects of such short term changes.

Varved clay and silt appears to form a more or less continuous stratigraphic unit throughout the area. The maximum observed thickness is 27 feet (east bank of Driftwood River, 3.5 miles from mouth, at crossing of Island Falls-Hunta power line). The actual maximum thickness may, however, exceed this by several tens of feet. The varved sequence thins on the flanks of buried glacio-fluvial deposits, and in most cases is absent over these deposits. Probably detailed examination would show interfingering between fine sand on the flanks of esker complexes and the bedded silt and thick silty varves at the base of the Barlow-Ojibway deposits. Throughout the area the upper few feet of Barlow-Ojibway deposits are strongly contorted as a result of having been overridden by Cochrane ice.

The Cochrane till (4) comprises both basal till (lodge moraine) and ablation till. The former is a bluish grey, clay-rich till, which, near the surface, is weathered to dull reddish brown and has blocky columnar structure. Coarse clastics (greater than 2 mm.) constitute from 1 to 6 per cent of the total weight, of which 35 to 75 per cent is limestone derived from James Bay Lowland, the remainder igneous and metamorphic rocks.

In many exposures the basal till is overlain by ablation till. This is tan-brown, in contrast to the dull reddish brown of oxidized basal till and has weakly developed platy structure. Coarse clastics constitute 1 to 14 per cent of the total weight, of which 75 to 88 per cent is limestone. Where ablation till can be recognized with certainty it has a thickness of 2 to 4 feet. It is not recognizable in all till exposures, possibly because it is locally so thin that it is lost in the soil profile.

Cochrane till overlies Barlow-Ojibway deposits, or where these are locally absent, lies directly on glacio-fluvial sand

and gravel, on substratified drift and associated till, or on bedrock. The thickness in most exposures ranges from 5 to 15 feet; the maximum observed thickness within the map-area is 22 feet. The till thins on the flanks of the esker complexes, and on the crests of these occurs as thin discontinuous patches.

The post-Cochrane deposits (5) consist of laminae of silt 1 inch to 8 inches thick separated by thin clay laminae, and are regarded as annual deposits or varves. Maximum observed thickness is 15 feet, the average thickness being about 2.5 feet. The unit is consistently present at the top of exposures in the eastern half of the map-area, except in topographically high areas underlain by substratified drift or glacio-fluvial deposits. In the western half of the map-area it has been recognized only within 1 1/2 miles of Mattagami and Groundhog Rivers. The distribution and thinness suggest that it was deposited in several separate, shallow lakes during the retreat of the Cochrane ice.

The bog deposits (6) consist of dark brown to black, partly humified organic material containing trunks, roots, and branches of spruce and other trees. Locally the lower 1 foot to 3 feet of this unit contains abundant shells of fresh water and terrestial gastropods, and fresh water pelecypods. Recent highway construction west of Cochrane has exposed a thickness of as much as 14 feet of this material in small bogs overgrown with spruce and tamarack. Probably the greatest depth of the larger open bogs greatly exceeds this figure.

The flood plain deposits (7) consist of fine-grained sand and silt, although locally, as on the west bank of Frederickhouse River 3/4 mile below Carter Rapids, the flood plain deposit is gravel with a thin cover of silt.

Flood plain surfaces lie 10 to 13 feet above the July 1954 water-level, and appear to flood only during years of extremely high water. Similar fluviatile deposits occupy abandoned channel segments situated above the level of highest floods.

Glacial Lineations and Striae

Glacial lineations, as used here, include fluting and elongate drumlins on the surface of Cochrane till, and crag-and-tail structures. The glacial fluting consists of broad shallow grooves and intervening low ridges developed on the upper surface of Cochrane basal till. Where best developed the flutings measure 300 to 700 feet from crest to crest, with relief of from 5 to 10 feet between crest and trough. Individual flutings are persistent for distances up to 5 miles. The fluted surface is thinly mantled by Cochrane ablation till and the grooves may be partly filled by bog deposits. The fluting is best developed west of Mattagami River but less distinct fluting occurs east of Frederickhouse and Abitibi Rivers. Possibly fluting is concealed beneath post-Cochrane deposits and bog in some parts of the map-area where it has not been recognized. Locally the fluting gives place to elongate drumlins and, where bedrock is present, to crag-and-tail structures.

The fluting is not readily recognizable in the field, but shows as well-marked lineations on air photos. In Alexandra and Machin townships it exerts control on the secondary drainage, which is expressed in parallelism of northward flowing streams.

Well preserved glacial striae and grooves are found on the few exposures of volcanic rocks within the area, but on outcrops of granitic and gneissic rocks weathering has removed all but the deeper grooves. Wherever striae and grooves are found in close proximity to glacial lineations, the two agree in direction, and both may be attributed to the latest movement of Cochrane ice.

Pleistocene History

Pleistocene history, as evidenced by deposits within and adjacent to Smooth Rock map-area, begins with the advance of the Wisconsin ice-sheet, which deposited the sandy boulder till exposed on Mattagami and Frederickhouse Rivers. The area apparently was not affected by the fluctuations of the Wisconsin ice margin that permit subdivision of the Wisconsin stage south of the Great Lakes; rather, it remained covered by ice, until with general deglaciation, the ice margin retreated northward at least to latitude 49°35' N. When the ice margin had retreated north of the height of land dividing the St. Lawrence and Hudson Bay drainage basins, Lake Ojibway and the northwestern part of Lake Barlow-Ojibway were impounded between the height of land and the ice margin, and expanded northward as the ice retreated. At first the lakes must have drained southward, into the upper Great Lakes basin, but later, when Lakes Barlow and Ojibway merged into a single body of water, drainage was through the Ottawa Valley.

Poorly sorted glacial debris, the substratified drift, was deposited as ablation till over the sandy boulder till, or as marginal moraines marking halts or minor readvances in the general retreat. Where subglacial streams debouched into Lake Ojibway, attenuated deltaic deposits of sand and gravel (esker complexes) were deposited. At the same time, varved clay and silt, the Barlow-Ojibway deposits, were deposited on the lake floor, and on the flanks of the esker complexes.

The extent of northward ice retreat prior to the Cochrane advance is not known. Varved Barlow-Ojibway deposits are found at least as far north as Island Falls, Abitibi River, (lat. 49°35'N), but whether or not James Bay Lowland became ice-free cannot be decided from present evidence. Certainly there is no evidence of warm interglacial or even interstadial climate just prior to the Cochrane advance, either in the form of organic remains or weathering of the upper surface of Barlow-Ojibway deposits. Quite possibly the Cochrane advance began when the ice margin had retreated to about the southern periphery of James Bay Lowland.

During the Cochrane advance the ice pushed southward over the Barlow-Ojibway deposits to within at least 4 miles of Sandy Falls (near Timmins). This is the southernmost exposure of Cochrane till overlying disturbed varved clay seen by the writer. Thus an advance of at least 70 miles is recorded, that being the distance between Island Falls and Sandy Falls in the direction of glacier movement. On the northern fringe of the map-area, the latest movement of the Cochrane ice, as recorded by glacial lineations and striae, was south by east; in the western half of the area the lineations diverge strongly to the southwest, suggesting a lobate expansion of the ice margin. No marginal moraine marking the southern limit of the Cochrane ice has been recognized. The term 'Cochrane moraine', widely used conversationally by Pleistocene geologists, is misleading, and should be dropped in favour of 'Cochrane till', for the Cochrane till is a stratigraphic unit recognizable over a considerable area.

No glacio-fluvial deposits are known that can be related with certainty to the retreat of Cochrane ice. Two lines of reasoning combine to explain this; firstly, Cochrane ice, advancing over Barlow-Ojibway deposits, had access to little coarse clastic material, the glacio-fluvial deposits being largely covered by varved clay and silt; and secondly, progressive retreat which permitted accumulation of huge volumes of sand and gravel in esker complexes during the earlier retreat appears not to have occurred. Rather, it appears that the ice-sheet in its last stages of activity became very thin, to the point where it stagnated and dropped its debris as ablation till with little or no sorting.

If a counterpart of Lake Barlow-Ojibway followed upon the wastage of the Cochrane ice, it must have been short-lived, for the post-Cochrane deposits appear to have been deposited in several separate shallow lakes. Additional evidence is found in the abandoned beaches that mark the progressive lowering of Lake Barlow-Ojibway. Series of these beaches are found on the flanks of bedrock knobs in Iroquois Falls map-area to the southeast. Although three examples of these are found 8 miles or less south of exposures of Cochrane till, not a single example is known from north of the limit of the Cochrane advance, despite the presence of favourable bedrock knobs. Evidently the Cochrane ice destroyed any beaches within the limits of its advance, and if there was a post-Cochrane counterpart of Lake Barlow-Ojibway, it gave place to several small lakes before beaches could be formed.

Since final deglaciation, the main rivers of the area have cut channels to depths of 50 feet or more below the Cochrane till plain, but have made negligible progress in cutting through bed-rock barriers in their channels. Consequently all stream gradients are interrupted by numerous falls and rapids. Abandoned channel segments above the present flood levels of the rivers indicate that minor shifting occurred during cutting of the channels. Secondary streams have made little progress in dissecting interstream areas, which remain poorly drained and favour development of bog deposits.

Economic Geology

Gravel is the only important product derived from the surficial deposits. Except for a few small pits in substratified drift, and a pit in fluviatile gravel in the flood plain of Frederickhouse River, all the actively worked pits are in glacio-fluvial deposits. Chains of lakes marking the trends of esker complexes are valuable guides to the presence of sand and gravel, which may be covered by a thin layer of Cochrane till and thus not exposed at the surface. In general, the coarsest material will be found in the central ridges separating paired lakes, which mark the former positions of sub-glacial channels.

Varved glacial clay has been used at New Liskeard in the manufacture of red brick. Bricks produced from varved clay at Matheson are reported to have weathered and disintegrated rapidly, possibly because of difficulty in mixing the clay and silt parts of the varves to a homogeneous paste. The varved clays of the upper part of the Barlow-Ojibway deposits are fairly fat and plastic, and may prove to be suitable for the manufacture of common extruded products.

The economic possibilities of the bog deposits have not been investigated. Humified peat is used locally in small quantities to increase the humic content of garden soil.

During the summer of 1955 gas was encountered at a reported depth of 58 feet on a farm near Frederickhouse Station, in the course of driving a pipe for water. The gas is reported to have had a pressure of 12 lbs. per sq. in., and to contain about 30 per cent methane and 70 per cent nitrogen. The gas is almost certainly derived from the decay of organic matter and is unlikely to prove of much commercial importance.

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