FIELD TRIP TO THE GATINEAU AREA, QUEBEC, CANADA, HELD IN CONJUNCTION WITH THE ELEVENTH CLAY CONFERENCE

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PRECAMBRIAN GEOLOGY

The Gatineau Hills are stumps of former mountains. These mountains, which extended over much of Ontario and Quebec, were produced by the Grenville orogeny perhaps 1000 million years ago. Metamorphic rocks appear to have been squeezed into tight trough-like folds between granite and syenite masses. The mountains were eroded away before the Paleozoic sediments were deposited.

The only possible Precambrian rocks of this district that were formed after the Grenville orogeny are the diabase dykes of the Buckingham swarm, a group of basic rocks of insignificant volume.

The Eardley Escarpment forms a clean boundary with the hills of Precambrian rock on the north and the Ottawa valley plain underlain by Ordovician sediments to the south. It is generally believed that the escarpment is a fault line scarp. These features are shown in Plate 1.

Excellent exposures of Precambrian rocks are located in the Gatineau region. Notable are the fresh roadcuts of the Gatineau Parkway where typical igneous and metamorphic rocks may be easily examined.

Of the metamorphic rocks, gneisses are perhaps the most abundant. They consist mainly of biotite gneiss in the Hull–Kingsmere region, pyroxene gneiss in the Black Lake–Camp Fortune region and again biotite gneiss near Wakefield. Good exposures of biotite gneiss occur on the Mine Road just south of the Hull Iron Mine and pyroxene gneiss intersected by a network of pegmatite dykes occurs in a roadcut of the Gatineau Parkway just north of Black Lake.

Marble is common in the Hull–Kingsmere region and along the Gatineau River above Wakefield. The very white rockcuts on the Gatineau Parkway

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about 2 miles north of Fairy Lake are composed of this rock. Pyroxene-rich marble is transitional into pyroxenite—a favourable host for mica and apatite veins.

The hilly country around Meach and Harrington Lakes is largely concerned with the Wakefield complex. The Wakefield complex extends for 20 miles from Lac Lapêche towards St. Pierre de Wakefield. Syenite, monzonite and diorite are transitional and appear to belong to a single consanguineous unit. A distinctive feature of the complex is the prevalence of aplite and pegmatite. Most of these rock types can be observed in the Fortune Lake section of the Gatineau Parkway.

Rocks of irrefutable igneous origin are comparatively uncommon. We may mention diabase and diorite dykes. The diabase dykes consistently strike east–west. They rarely attain a width of 200 ft but can sometimes be traced for miles. One of these dykes is exposed near the entrance of the Mud Lake parking lot on the Gatineau Parkway. Diorite is very rare.

These igneous and metamorphic rocks generally show little alteration but a few exceptions to this generalization will be mentioned. The coarse pyroxene–plagioclase gneiss south of Kingsmere has been scapolitized as have the feldspars of many mica veins in the region. The pyroxenites often display retrograde amphibolitization especially in the vicinity of mica veins. The plagioclase of diorite dykes has been intensely sericitized but that of diabase is comparatively fresh. Limestone in the southern part of the Gatineau Park contains abundant serpentine (at least in part after pyroxene) and locally mixed-layer vermiculite. A breccia with vermiculite–apatite matrix occurs near Fortune Lake.

Of particular interest to the mineralogist are the mica–apatite veins. Those on the west side of the Gatineau River often have cores of pink calcite containing large, well-formed crystals of phlogopite (either the normal type or anomite) and fluorapatite. Often projecting into the veins are pyroxene (salite) crystals. Notable is the Chapute–Payne vein, below the Champlain Lookout on the Gatineau Parkway, whose upper portion was tested for mica and lower portion for molybdenite.

NOTE: Additional information may be obtained from the following references.

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PLEISTOCENE GEOLOGY

The post-Pleistocene history of the Ottawa area may be summarized by the following excerpt from N. R. Gadd's publication entitled "Surficial Geology of the Ottawa Area, Geological Survey of Canada, Paper 61–19, 1961". Further references on the subject may be obtained from this publication.

"The history of the Ottawa area seems quite simple, at least from the time of the last major glaciation. As the ice-front receded from the area, glacial lakes formed and probably drained southward into the St. Lawrence system just as other lakes formed in the St. Lawrence valley (MacClintock, 1958; Gadd, 1960; Terasmae, 1960). Marine invasion closed off the late Wisconsin glacial-lake events locally, but probably was contemporaneous with continuing glacial activity in nearby highland areas. The marine invasion may have occurred well within Wisconsin time, perhaps as early as the Two Creeks interval. Antevs' hypothesis of two marine invasions cannot be dismissed yet, but there appears to be no valid evidence of more than one marine invasion. Therefore the writer accepts as an alternative working hypothesis that the land was submerged only once and was uplifted gradually and more or less continuously after the maximum marine invasion, and that the uplift continues to the present. This sequence is thought to be supported by field studies in the adjacent St. Lawrence valley areas (MacClintock, 1958; Terasmae, 1960; Gadd, 1960). In the last stages of uplift, when sea-level stood somewhere below 300 feet present elevation in this area, fresh-water drainage was initiated and broad estuarine, fluvial, and lacustrine terraces were formed. Fine sediments derived from erosion of older glacial and marine sediments were deposited on terraces below this limiting elevation. Modern drainage is cutting its way into these sediments and the underlying bedrock and is producing an alluvium that may have many properties in common with the earlier sediments, but probably will differ from them through admixture of sediments derived from erosion of local bedrock."

SOIL PROFILES

(a) *Regosol–Rideau Clay*

The Rideau clay is a moderately well-drained soil developed on the marine or reworked marine clays, and is regosolic since the profile is weakly developed and lacks distinct pedogenic horizons. The solum differs from the underlying material in having an accumulation of organic matter in the surface A_1 horizon and in the slight development of structure in the B horizon directly under the A_1.

Mineralogical analysis of a typical profile (Brydon and Patry, 1961) revealed that weathering was limited. Quartz, feldspar, amphibole, mica and chlorite occurred in all size fractions, and amphibole existed in the less than 0.08 micron clay fraction.

The fine size of the material and the young age appear to be factors responsible for the lack of weathering. The fine particle size prevents rapid percolation and hence leaching of hydrolyzed metallic ions is rather weak. Radiocarbon dates of 10,000 years (Gadd, 1961) suggest that this slow process has been operating for a relatively short period of time.

(b) *Acid Brown Wooded, Brown Podzolic, or Sol Brun Acide–Gatineau Loam*

This group of forested soils characteristically (Tamura *et al.*, 1959) has a profile with a thin leaf mat, A_0, over a bright colored B horizon. The underlying dull colored C horizon is usually acidic, as is the B horizon, and may have a pH of 5.0. The soils appear to represent a stage of soil development between the Regosol and the Podzol, and the incipient podzolization is often shown by a thin *AB* horizon just beneath the leaf mat.

Mineralogical analysis of a profile similar to the profile exposed at Stop *D* revealed that there was a slight amount of weathering. Amphiboles were present in the less than 1.4 micron fraction of the *B* and *C* horizons but not in the thin *AB* horizon directly under the leaf mat.

The phyllosilicate minerals in the *B* and *C* were interstratified mixtures of vermiculite, chlorite and possibly illite components. The material gave broad diffuse peaks which did not expand to 17 Å with glycol. On heating, a 10 Å peak developed with a series of weak, broad diffraction effects between 10 and 14 Å.

On the other hand, in the *AB* material there was a 12.2 Å peak which split to give 10, 14 and 17 Å peaks on glycol treatment, and which collapsed completely on heating to give a broad peak at 9.7 Å.

There are two possible explanations of this behavior:

1. The interstratified mixture of clay minerals may have been inherited and the interlayer material and coatings removed in the *AB* horizon during the podzolization process, thus freeing the montmorillonite, vermiculite and illite components (Whittig and Jackson, 1956).

2. Chloritization, the formation of partial or complete aluminum hydroxide interlayers, may have taken place in the *B* and *C* horizons (Pawluk, 1961). It is not known, on the basis of preliminary results, which of these alternatives is the correct one.

(c) *Podzol–Ste. Agathe*

Podzols typically have an organic A_0 surface layer underlain by an ashy eluviated A_2 horizon which has lost relatively more sesquioxides than silica. The A_2 is in turn underlain by a darker colored illuvial *B* horizon in which the major products of accumulation are sesquioxides and organic matter. The solum is acidic and the base-exchange complex is unsaturated (Stobbe and Wright, 1959).

The diffraction patterns of the less than 1.4 micron clay from a Podzol profile from a site not far removed from Stop *E* are shown in Fig. 1. Amphibole and feldspar are present in the clay fractions of the horizons below the A_2.

The A_2 horizon clay fraction consists largely of montmorillonite which collapses to 9.9 Å on heating. The *C* horizon clay fraction consists of illite and chlorite with a predominance of vermiculite which does not expand with glycol and collapses readily on heating to give a sharp 10 Å peak. The *B* horizon clay is similar in many respects to the *C* except that the 14 Å peak shows impeded collapse to 10 Å.

Presumably, there is a fundamental difference in the expanding 2:1 layer lattice minerals of the *C* and A_2 horizons. The illite and chlorite of the *C* horizon appear to have been altered to a montmorillonite product in the *A* horizon. Partial chloritization of the expanding layer minerals in the *B*

PLATE 1.—View from the Champlain Lookout. The highland and escarpment are composed of syenite and other Precambrian rocks; the lowland is underlain by Ordovician rocks.

PLATE 2.—Landslide scar near Ottawa. Courtesy City of Ottawa.

(Facing p. 4)

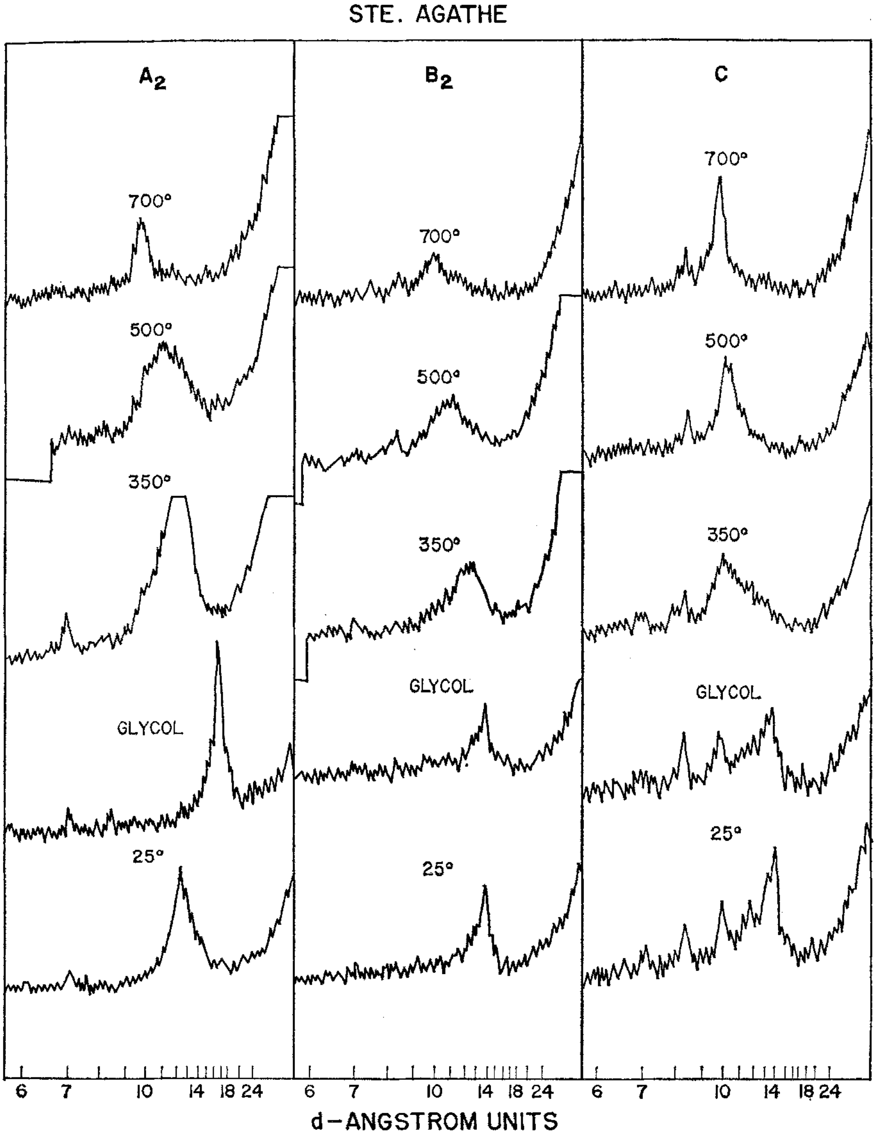

FIGURE 1.—X-ray diffraction patterns of Podzol clays.

horizon may be responsible for the impeded collapse of the structure on heating to 700°C. There is abundant evidence in the literature that these mineralogical differences are genetic and are related to the podzolization process

(Brydon, 1958; Camez *et al.*, 1960; Gjems, 1960; McCaleb, 1954; Pawluk, 1961; Tedrow, 1954; Whittig and Jackson, 1956).

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LANDSLIDES IN LEDA CLAY

The Ottawa river valley is scarred with recent and old landslides. They vary in size from a few acres to as much as 15 square miles. The largest recorded landslide is located on the south bank of the Ottawa river a few miles west of Hawkesbury, Ontario. These landslides range from small rotational bank failures to large retrogressing flow slides. The flow-type failures are characteristic of sensitive marine clays. They have occurred extensively in Scandinavia where marine clays similar to the Leda clays are found.

The structural properties of these so-called sensitive clays is a subject of extensive study both in Canada and in Scandinavia. The term "sensitivity" refers to the loss of strength of a soil when it is remolded. In the Ottawa area it is not uncommon to find clays whose remolded strength is less than 1 per cent of the undisturbed strength. Because of this, when the clays are disturbed they liquefy and when a flow slide occurs large blocks of undisturbed clay float away on the liquefied portion.

A classical example of a flow slide exists just at the eastern limits of the city of Ottawa. This slide probably occurred two or three hundred years ago but its actual age is not known. In this case about 30 acres of a 90 ft high bank flowed out over a fairly level plain, covering about 80 acres of bottomland to a depth of 15 to 20 ft. About two million cubic yards of soil were deposited on this plain. An aerial view of the earth flow is shown in Plate 2.

The first recorded landslide in the Leda clay occurred on the Maskinongé river, a few miles west of Trois-Rivières, Province of Quebec. It was described in the Proceedings of the Geological Society of London in 1842 by Sir William Logan, the first Director of the Geological Survey of Canada. The most serious recorded landslide occurred at the little village of Notre-Dame de la Salette on the Lièvre River about 20 miles north of Ottawa. This slide, in 1908, destroyed the village and killed 33 people. A recent flow slide to receive wide attention occurred in November 1955 at the village of Nicolet near Trois-Rivières. The slide caused several millions of dollars in damage and the loss of three lives. Less than three months ago, on 23 May 1962, nine loggers were killed by a landslide on the Toulnustouc River, 30 miles north of Baie Comeau.

During this tour it is not convenient to visit any of the well-documented landslides but in order to illustrate their nature a stop will be made near the village of Ironside, Province of Quebec, to see a typical landslide crater. Several craters exist in the immediate vicinity and, although their history is unknown, they demonstrate the influence of these movements on the present topography.

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BRUCITE DEPOSIT AND PROCESSING PLANT, WAKEFIELD, QUEBEC (ALUMINUM COMPANY OF CANADA, LIMITED)

History

Wakefield Works is located on the west bank of the Gatineau river, about twenty miles north of Ottawa. Previous to 1939 the district was supported mainly by farming and lumbering. In that year brucite was identified by M. F. Goudge of the Bureau of Mines, Ottawa, on samples of limestone from the Wakefield area. The brucite (magnesium hydroxide) occurs as granules in the limestone. By the following year Mr. Goudge had developed a process for extracting magnesia from the ore. By 1941 Aluminum Company of Canada, Limited (Alcan) had acquired some deposits, the rights to the process, and had constructed a plant. The Wakefield plant is the only magnesia producer in Canada and one of the very few in the world to make magnesia from the mineral brucite.

Process

In its present form the process serves to extract the brucite, as magnesia, and to produce lime from the limestone.

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The rock is removed from the quarry in the common manner of blasting on various advancing levels. Preliminary sorting of ore from waste is carried out by selective loading by power shovel. The mill feed is trucked to the crushing plant where a further waste rock is removed and the ore is crushed to a maximum size of $1\frac{7}{8}$ in. and is screened to four uniform sizes to assure uniform calcining.

Two oil-fired rotary kilns $7\frac{1}{2}$ ft in diameter by 152 ft long calcine the rock at a temperature of about 2100°F. From 50–55 per cent of the kiln feed is recovered as calcines, the balance being carbon dioxide gas driven off the limestone, water driven off the brucite, and dust loss. In the calcines the granular form of the original brucite is retained.

The calcined material is handled in such a way as to yield from the fines a quicklime of controlled quality sold as Alcan Quicklime, and used as a raw material in glass manufacturing or for neutralization of acidic effluents. The balance of the calcines is fed to a hydrator under carefully controlled conditions. In the hydration stage magnesia granules are not significantly affected while the lime hydrates to a fine powder, mostly finer than 325 mesh. This powder is removed by air separators, yielding Alcan Hydrated Lime. Where required, the proportion of particles larger than 325 mesh, or of undesirable color, are controlled. Wakefield hydrated lime exhibits the characteristic of relatively consistent composition, and is suited for various applications in the chemical industry, as well as mason's lime and for the preparation of agricultural sprays.

The oversize from the air separator, consisting mainly of magnesia granules with some adhering lime, is fed to a rotary wet hydrator. The material is further passed through a series of three classifiers in order to wash off the adhering fine particles. In the next step the material is wet screened to separate the granules of higher purity from the undersize. These two streams of material are dried in separate rotary dryers heated with steam.

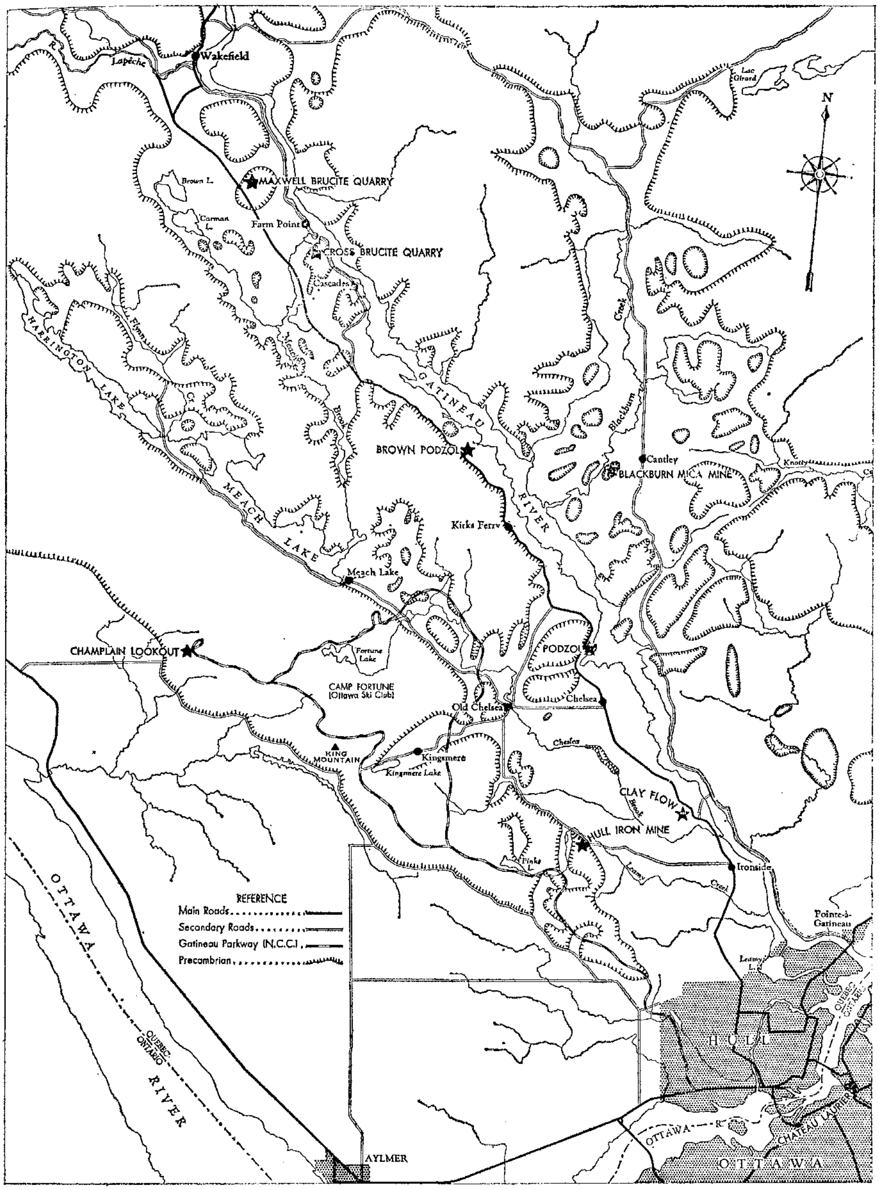
The dry materials are further screened to separate various size fractions present. At this stage the granules are channelled in major groups based on the MgO content: e.g. (a) over 90 per cent, (b) about 95 per cent, (c) about 75 per cent.

The material containing more than 90 per cent MgO is passed over parallel air tables, one screen fraction on each. In this operation, which is based on different specific gravities of pure and siliceous granules, further differentiation takes place. The final products contain approximately 94 and 90 per cent MgO respectively. Either of these is beneficiated to a higher quality as required.

Various grades of magnesia are made by mixing products described above according to customer requirements. Grinding facilities are available for the requirements of those customers who prefer ground products.

The major outlets for magnesia are the following industries:

(a) Refractories
(b) Agriculture
(c) Uranium production



ELEVENTH ANNUAL CLAY-MINERALS CONFERENCE

FIELD EXCURSION MAP

OTTAWA-GATINEAU DISTRICT

FIGURE 2.—Field excursion map, Ottawa–Gatineau district.

These products, as well as quicklime and hydrated lime, are shipped in bulk or bagged form by truck or rail. Continued development of new and improved products for new and existing applications is maintained. Technical service in the use of Wakefield products is constantly at the service of the customer.

LOG OF FIELD TRIP

(See Fig. 2)

MILES

0.0 Depart east door of Chateau Laurier Hotel. Proceed west across the Chaudière Bridge and north on Quebec Highway 11.

7.7 Charles Hendrick farm (stop A), site of landslide (page 6) and site of Regosolic soil profile (page 3). Proceed north on Highway 11 and turn right on the Farm Point River Road.

22.1 Brucite quarry and plant of the Aluminum Company of Canada, Limited (page 7) (stop B). Proceed north on the River Road to the Wakefield Inn.

24.3 Lunch—Wakefield Inn (stop C).
Depart Wakefield via Highway 11, towards Ottawa.

31.3 Site of Brown Podzolic soil profile (page 3) (stop D).

36.3 Site of Podzol soil profile (page 4) (stop E).

37.2 Village of Chelsea. Turn right and proceed through Old Chelsea to Fortune Lake Parkway.

39.4 Turn right on Fortune Lake Parkway and proceed to Gatineau Parkway.

44.4 Turn right on Gatineau Parkway.

46.1 Stop at Champlain Lookout to examine land forms and igneous rock formations (stop F). Proceed towards Ottawa via Gatineau Parkway.

50.2 Stop at Kingsmere to examine metamorphic rock formations (stop G).

63.5 Chateau Laurier Hotel.

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