SOME PHYSICAL AND CHEMICAL PROPERTIES OF TILL DERIVED FROM
THE MEGUMA GROUP, SOUTHEAST NOVA SCOTIA

Project 690095

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Abstract

Podolak, W.E. and Shilts, W.W., Some physical and chemical properties of till derived from the

Samples were collected from selected stratigraphic sections and other exposures of Quaternary
sediments in southeastern Nova Scotia in order to make a preliminary assessment of the value of till
sampling to enhance interpretation of results of a proposed lake sediment sampling project. Analyses
of the samples indicated weathering of economically important indicator minerals to depths of more
than 2 m. Trace element concentrations showed significant regional variations both within a till type
and among some of the major till types. These results confirm the premise that the extensive
sampling program carried out by Nova Scotia Department of Mines should provide data essential to
the proper interpretation of the results of regional lake sediment sampling.

A till sampling program was begun by the Nova Scotia
Department of Mines in 1977 in order to enhance interpreta-
tion of results of a planned regional geochemical lake
sediment sampling program. Modern lake sediments were
collected in 1977 over folded Paleozoic sedimentary rocks
and granitic intrusions of the Meguma Group in southern Nova
Scotia, east of Halifax.

At the beginning of the program, the authors visited the
study area briefly to sample selected till exposures and to
offer suggestions based on drift sampling work elsewhere in
the Appalachians (Shilts, 1973a, b, 1975, 1976; Shilts and
McDonald, 1975; Grant and Tucker, 1976). Profile samples
were collected through sections at Hartlen Point (near
Halifax), at Ecum Secum, along Musquodoboit River, and at
Cooks Cove; several individual samples were collected else-
where (Fig. 82.1). A number of geochemical and geotechnical
tests were performed on these samples in order 1) to
illuminate the differences in physical and chemical properties

Figure 82.1. Location of samples and generalized bedrock geology modified from Weeks (1965).
among the various lithological types of till described by Grant (1963) and Prest et al. (1972), 2) to define primary vertical sedimentological and stratigraphic variations in properties in sections through one or more till sheets; and 3) to define the depth and intensity of weathering of the more labile components of the various types of till. This latter study is particularly important in the extensive areas of red till where the primary hematitic colour tends to mask the secondary iron oxide/hydroxide deposits that usually indicate weathering.

**Techniques**

The trace element content of the clay (<2 μ) fractions and the fine sand-sized heavy mineral (specific gravity, s.g. >3.3) fractions were analyzed for all till samples. Analyses were carried out by Bondar-Clegg and Co., Ltd. using hot, mixed acid leach and atomic absorption and fluorescence techniques. In addition to the chemical tests, weight percentages of the fine sand-sized heavy mineral and magnetic fractions were measured, and complete grain size distributions (<2 mm >2 μ) and Atterberg limits were calculated.

**HARTLEN POINT SECTION**

![Graph showing vertical variations of selected chemical and physical parameters, Hartlen Point section.](image)

**ECUM SECUM SECTION**

![Graph showing vertical variations of selected chemical and physical parameters, Ecum Secum section.](image)

**EXPLANATION**

- **Cu, Pb, etc.** - Concentration of element in ppm, except for Fe (%)
- **Concentration of element in clay (<2 μ) fraction**
- **Concentration of element in heavy mineral (s.g. >3.3) fraction**
- **Concentration in silt fraction**
- **Concentration in heavy mineral fraction**
- **LL** - Liquid Limit
- **PI** - Plasticity Index
- **HM** - % Heavy Minerals in fine and very fine sand fractions
- **MM** - % Magnetic Minerals
- **Mdg** - Median grain size
- **σi** - Sorting

Figure 82.2. Vertical variations of selected chemical and physical parameters, Hartlen Point and Ecum Secum sections.
Previous work

The tills of Nova Scotia were first seriously studied by Grant (1963) who found that several types of till or related sediments could be found at the surface in southern Nova Scotia. In areas underlain by slates, quartzites, and granitic rocks of the Meguma Group, Grant noted the occurrence of several significant and distinct types of till among which he described 1) quartzite till; 2) granite till; 3) slate till; 4) red (clay) till; 5) compact grey till underlying red till; and 6) Bridgewater conglomerate. Grant noted that the first three types contained clasts eroded predominantly from quartzite, granite, or slate of the Meguma Group with very little exotic detritus from outside its outcrop area; furthermore, the distribution of these local till types was confined largely to outcrop areas of the rock that provided the dominant lithology with little, but predictable, overlap onto rock types down ice. The red till was found to replace, overlie, or underlie the first three types of till in many areas and occurred particularly commonly as drumlins in fields. The compact grey till was found to underlie red till in some exposures and was interpreted to have been deposited during an earlier glacial stade than the surface tills. Grant described the Bridgewater conglomerate as a till-like to stratified, iron and manganese cemented gravel, containing abundant slate fragments and erratics from outside the slate terrane. It was described as a glaciofluvial unit that was older than any of the tills because it always was found directly on slate bedrock and/or under till. However, because of the presence of erratics that could only have been transported by glacier, Grant ruled out earlier interpretations that described the Bridgewater conglomerate as a preglacial fluvial deposit.

**MUSQUODOBOIT RIVER SECTION**

**HALFWAY COVE SECTION**

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**EXPLANATION**

- Cu, Pb, etc. - Concentration of element in ppm, except for Fe (%)
- Concentration of element in clay (<2μ) fraction
- Concentration of element in heavy mineral (s.g. >3.5) fraction
- % Concentration in clay fraction
- % Concentration in heavy mineral fraction
- LL - Liquid Limit
- PI - Plasticity Index
- HM - % Heavy Minerals in fine and very fine sand fractions
- MM - % Magnetic Minerals
- Md₀ - Median grain size
- Gₛ - Sorting

Figure 82.3. Vertical variations of selected chemical and physical parameters, Musquodoboit River and Halfway Cove sections.
In the brief reconnaissance, most of the till types that Grant (1963) described were noted, both in sections that he studied and in new exposures. The authors noted, as did Grant, that some of the loose, coarse textured tills are difficult to place in either the lodgment or ablation classifications.

Two exposures of iron cemented slate till that overlies loose quartzite till and, possibly, red till were found near and east of Halfway Cove on the south shore of Chedabucto Bay. In cementation, texture, and clast composition, this material closely resembles the sediment that Grant described as Bridgewater conglomerate. The occurrence of the cemented till may be due to the presence of a permeable till with abundant pyritiferous slate fragments in a topographic situation where presently undefined local groundwater conditions lead to the characteristic cementation.

At Hartlen Point, south of Dartmouth, a section described by Grant (1963) as red till overlying grey compact till was examined. A boulder layer, which Grant described as a possible lag deposit separating two tills of different glacial stades, was found not to be confined to the contact, but to occur considerably above the base of the red till in some places (Fig. 82.4).

Results

Although the sampling was designed to provide preliminary trace element data on various types of till, some other parameters, such as texture, Atterberg limits, and magnetic mineral content, have been determined. These latter mineralogical and physical properties help give an impression of the variations of properties evident in the field. In addition, they can support the interpretation that compositional differences implied by trace element variations are related to till provenance rather than to local hydromorphic factors. The trace elements reported here were selected because they might reasonably be expected to be associated with various types of base metal or radioactive mineral occurrences thought likely to be present in the area. Figures 82.2 and 82.3 show the variations in selected trace element concentrations and in some other properties for four vertical sections through one or more till sheets.

Trace elements

Copper Copper concentrations range from 40-60 ppm and show little variation in the clay fraction of most samples, with the exception of two samples of quartzite till from a borrow pit in Musquodoboit (138-188 ppm), quartzite till samples from Liscomb (176 ppm) and Sherbrooke (136 ppm), and the only sample of iron cemented till from Halfway Cove (206 ppm).

In the heavy mineral fraction copper contents are generally low (6-50 ppm) in all but the samples collected from depths greater than 3 m below the surface. At depths of more than 2 m at Hartlen Point the lower grey till contains 228-296 ppm Cu, and the upper till contains 444-726 ppm (Fig. 82.4). In a wave cut cliff of red till at Ecum Secum, Cu in the heavy minerals in the top 2 m of the section ranges from 12-40 ppm but the lowermost samples, near and below sea level, contain 213-502 ppm.

Lead Lead in the clay fraction ranges from 20-40 ppm in all samples except for the quartzite tills at Liscomb (74 ppm) and Sherbrooke (51 ppm), red till over Triassic bedrock at Cooks Cove (56 ppm) and iron cemented till at Halfway Cove (211 ppm).

In the heavy mineral fraction lead is more variable, attaining levels at Hartlen Point of 260-336 ppm in the upper till and 228-296 ppm in the lower till; at Ecum Secum lead concentrations are as high as 339 ppm in a sample about 2 m below the surface. Samples of red till from Musquodoboit River (77-135 ppm) and a sample of quartzite till from Stillwater (122 ppm) have elevated lead values. Other samples generally have lead concentrations of 12-50 ppm in the heavy mineral fraction.

Zinc Zinc in the clay fraction of most till samples ranges from 120-170 ppm except for a sample of red till from over Triassic bedrock at Cooks Cove (91 ppm), the iron cemented till at Halfway Cove (68 ppm), two samples of quartzite till from Mushaboom (65-92 ppm), and the upper sample at Ecum Secum (91 ppm). The higher background values of zinc are similar to those for tills from the slate-granite-quartzite terranes of the Quebec Appalachians.

In heavy minerals, zinc concentrations are uniformly low (7-67 ppm) except for the lowest two samples at Ecum Secum (184-1135 ppm) and the lower (291-382 ppm) and upper (263-1070 ppm) till at Hartlen Point.

Cobalt Cobalt shows little variation in clay fractions (20-40 ppm) except in the iron cemented till, which has 83 ppm Co. In the heavy mineral fraction, cobalt is enriched in the lowermost sample at Ecum Secum (119 ppm) and in the lower grey till at Hartlen Point (121-144 ppm).

Nickel There is little variation in nickel in the clay fraction of all samples collected (33-69 ppm). In the heavy mineral fraction, Ni is enriched in the lower Ecum Secum samples (69-133 ppm), in the lower till at Hartlen Point (198-233 ppm), and in the lower part of the upper till at Hartlen Point (70-113); all other samples have a low content of Ni (10-46 ppm).

Chromium Chromium is uniformly low (10-22 ppm) in the heavy mineral fraction from which magnetic minerals were removed.

Molybdenum Molybdenum is uniformly low (1-4 ppm) in clay fractions of most tills except for the iron cemented till at Halfway Cove (20 ppm) and one sample at Mushaboom (12 ppm).

Manganese Manganese in the clay fraction of these tills commonly occurs in the 1000-3000 ppm range, a relatively high concentration for till that has not been intensely weathered. Exceptionally high values of 11 220 and 5790 ppm were recorded for the red till on Triassic rocks at Cooks Cove and in the iron cemented till, respectively. An exceptionally low Mn concentration (134 ppm) was found in the clay fraction of the lowest Ecum Secum sample. In contrast, a concentration of 10 320 ppm Mn was found in the heavy mineral fraction of the lowest Ecum Secum sample, whereas most other heavy mineral separates ranged from 1000-4000 ppm.

Cadmium All but four samples (three at 1 ppm, one at 3 ppm) have concentrations of 2 ppm Cd in the clay fraction. In heavy mineral fractions, Cd is not detectable in many samples and varies from 1-4 ppm in the rest, with two exceptions - lowest Ecum Secum sample (8 ppm) and lowest red till at Hartlen Point (6 ppm).

Uranium In the Clay fractions uranium is less than 3 ppm except in the quartzite till samples at Mushaboom (6.2-8.5 ppm), in the upper granite till samples on Musquodoboit River (6.4-9.0 ppm), and in the uppermost part of the lower grey till at Hartlen Point.

In the heavy mineral fraction, uranium is less than 3 ppm except for the two upper Musquodoboit River samples (4.3-4.5 ppm), the upper part of the lower till at Hartlen Point (6.5 ppm), and the Mushaboom samples (5.6-13.0 ppm).
Iron contents in the clay fraction are mostly between 4 and 5% the red tills containing no more iron than others. The iron cemented till contains 12.6% iron, and two of the three Mushaboom samples contain only 3% iron.

In the heavy mineral fraction, iron concentrations are less than 5% except in the Ecum Secum section (5-12%, top to bottom), in the lower till at Hartlen Point (9.4-12.4%), and the lower part of the upper till at the same site (6.8-8%).

Texture, Atterberg limits, magnetic mineral per cent, and heavy mineral per cent. These parameters are summarized for the sections in Figures 82.2 and 82.3, and are mostly self-explanatory. Magnetic minerals are present in far greater amounts (7-12%) in the heavy mineral fraction of the lower till at Hartlen Point than in the upper till (4-5%). At Ecum Secum they comprise up to 20% of the heavy fraction. Atterberg limits are fairly typical for Appalachian lodgment tills; they are distinctly different in the two tills at Hartlen Point, and the uppermost sample in the solum at Ecum Secum has a high liquid limit.

Heavy minerals were examined briefly under a binocular microscope. Compared to tills from the western Appalachians and in other areas of Laurentide glaciation, the variety of heavy minerals in any given sample is very limited, one, two, or three species predominating. Very few heavy mineral species were observed other than those expected to occur in the local bedrock. In tills containing high amounts of Cu, Pb, Zn, Co, and Fe in heavy mineral separates at Hartlen Point and at Ecum Secum, abundant unoxidized fragments of pyrite and, possibly, other sulphides were observed. Evidence of sulphides was not observed in other samples except for rare pseudomorphs of limonite after pyrite.

Discussion

While there are several potentially interesting aspects to the mineralogical and trace element distributions of these few samples, it is expected that the extensive till sampling program undertaken by Nova Scotia Department of Mines will provide many answers based on far more data. However, a few preliminary observations regarding stratigraphy, areal variations of parameters, provenance, and weathering can be made here, bearing in mind that they are based on very few samples.

Areal variation

Areal variations of parameters are related closely to the various types of till, which in turn are related to bedrock characteristics. The red till, however, which derives its colour and many other components from outside the Meguma basin, shows considerable variation from site to site. This variation is thought to be related to local components added to the till during its transport. The high levels of cadmium and zinc in the lowermost Ecum Secum till sample may indicate a nearby source of sphalerite, for example. Quartzite till appears to be enriched in copper and lead, probably reflecting a homogenization of zones in the Goldenville (quartzite) Formation that are rich in these elements. The Mushaboom quartzite till samples and the Musquodoboit granite till samples are enriched in uranium, suggesting that tills and derived postglacial sediments on or down ice from areas underlain by granite might have elevated uranium contents (granite comprises 23-30% of the coarse clasts in the Mushaboom samples). The areal variations suggested by these few samples seem to be potentially...
significant and when more accurately outlined by the till sampling program, should be used rigorously in evaluating other types of geochemical anomalies.

Stratigraphic variations

Variations of parameters that may occur where two types of till are exposed at one site are well illustrated by the Hartlen Point and Musquodoboit River sites. At these sites nearly all parameters measured vary significantly between tills (Figs. 82.2 and 82.3). It should be emphasized that these data do not indicate that these sites record two episodes of glaciation but may merely reflect two facies (i.e., subglacial and englacial) or shifts in ice flow direction during the same glaciation. Although there are no known outcrops of mafic rocks near or up ice from Hartlen Point, the relatively high ratio of Co-Ni-Fe to other trace elements sometimes is associated with tills with mafic rocks in their source areas. This element association stands in contrast to the Cu-Pb-Zn association in heavy minerals in the upper till, an association more typical of sedimentary sulphide mineralization.

As in the Appalachians of southeastern Quebec (Shilts, 1973, 1976), destruction of the more labile components (sulphides, carbonates, etc.) takes place to considerable depths and is reflected most sensitively by radial trace element decreases and by the disappearance of sulphide fragments upward in the sand-sized heavy mineral fractions. The transition from unweathered till upward into progressively more weathered till is well demonstrated in the profiles of heavy mineral chemistry of the red till at Hartlen Point and at Ecum Secum. The upward decreases of Cu, Pb, Zn, Co, Fe, Mn, and Cd in heavy minerals correspond with the disappearance of the abundant sulphide fragments found in the deeper, unweathered till samples. At all other sections and sample sites the heavy mineral fraction appears to have been stripped of labile components by weathering.

These observations confirm observations made elsewhere in the Appalachians (Shilts, 1976)—that labile components, which include many important indicators of mineralization, are destroyed to depths of several metres below the surface. Also, as observed elsewhere, the clay-sized portion of the tills fixes a portion of the cations released by weathering, with the result that concentrations of certain cations increase slightly in the clay fractions of tills that have been weathered. The compositional changes caused by the effects of weathering are superimposed on compositional variations related to varying bedrock sources.

Summary

Weathering of tills in Nova Scotia has destroyed many labile components (sulphides) to depths of 2 m or more below the surface. The clay-sized fraction of the tills probably is best to analyze for comparative purposes because 1) it is not affected by textural variations in the matrix of the widely varying types of till; 2) it is the fraction most likely to become part of lake sediments or to react with organic and other components that contribute to lake sediment, and 3) it probably scavenges cations released by weathering of labile components, as has been found elsewhere (Shilts, 1973). The effects of weathering are superimposed on stratigraphic, sedimentological, and areal variations and must be understood in order to understand regional and vertical compositional data.

Mapping of the distribution of types of till and their trace element geochemistry is essential to the interpretation of data obtained on sediments derived from the various types of till terrain. It is particularly important to map the distribution of the iron cemented till because of its high content of several cations scavenged by its iron-manganese rich matrix.

Maps of areal variations of chemical and mineralogical parameters and variations of those parameters in profile sampling of stratigraphic columns, along with soils maps and maps and information supplied by Grant (1963), should be carefully integrated into the regional lake sediment sampling program.

Acknowledgments

The authors would like to thank John Fowler of Nova Scotia Department of Mines and Ralph Stea and John Dickie, who carried out the till sampling program, for guiding us to the numerous exposures from which these samples were collected. Their hospitality and insights into local geology were much appreciated. This paper has been reviewed by R.N.W. DiLabio, J.S. Scott, and R.A. Klassen.

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