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**Contents:** 3 page report

# *Mineralogy and Pore Water Chemistry of Presumpscot Clays*

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## INTRODUCTION

This report summarizes analyses of two suites of samples from borings of Presumpscot Formation carried out in Brunswick and Westbrook, Maine. These analyses included mineralogical and pore water chemistry determinations, as these properties are often related to the geotechnical properties of clays prone to slumping.

## METHODS

Samples of well cuttings were received from T. Sandford (of the University of Maine at Orono) following opening of the cores for geotechnical property measurements. The samples were stored in glass vials for a period of about three months at room temperature. Water contents were determined on the material by weighing the aliquots of the sediment before and after drying. As a result of this storage, partial desiccation of some of the samples, which ranged from 0-60% of the original water content as reported by T. Sandford's group.

Pore water salinity determinations were performed immediately upon opening the samples after storage. Distilled water was added to approximately 10 - 20 g of wet sediment to remove dissolved or easily soluble salts. The added water was then removed from the slurry by centrifugation, and its salinity measured by conductivity. A seawater standard was used to calibrate the conductivity meter, so that the resultant estimates of salinity - expressed in parts per thousand - assume a seawater composition for the dissolved salts.

Mineralogy was determined by X-ray diffraction analysis on the silt and clay fraction only. This fraction was isolated by passing the samples through a 63 micrometer sieve. The silt and clay material was then deposited from a water slurry onto a glass slide and dried at room temperature. These slides were subjected to X-ray diffraction on a Phillips unit, using Cu-K-alpha radiation. The presence of expandable clays was tested by adding ethylene glycol to the material dried onto the slide.

## RESULTS

The water contents of the material after three months storage ranged from 10 - 44% (wt water/wt dry sediment). These values are shown in Table 1, along with the determinations provided by T. Sandford.

The pore water salinities (Table 1) ranged from 0.02 - 2.1 ppt, as seawater equivalents. The assumption of seawater composition was predicated on the expectation that significant salinities would be found in these sediments. Given some of the low values found, this assumption is clearly inappropriate for some samples, particularly for those with salinities 0.5 - 1 ppt. The conductivity values are therefore also provided in Table 1. As typical surface water conductivities in coastal Maine range up to about 100  $\mu$ S, most of the salinity values reported here show a decided marine influence.

The size partitioning between silt-clay and sand size fractions are also reported in Table 1. The samples were all composed primarily of material in the silt and clay fraction. Only sample PO-8, the deep sample from the Westbrook site, showed a significant contribution of sand-sized material.

The mineralogical composition of the silt/clay fraction of these samples was quite homogeneous, showing a suite of major minerals common throughout northern New England soils and sediments. These minerals include quartz, feldspar, 10 Å mica minerals, chlorite, and small amounts of kaolinite. Carbonate minerals were specifically sought, on the hypothesis that they form cementing material, but not found. Ethylene glycol treatment of selected samples failed to show any evidence for expandable smectite clays. Variable but high 001:002 peak ratios of the 10 Å mica mineral suggest the presence of biotite and muscovite/illite compositions. No attempt was made to differentiate between illite (a relatively low temperature diagenetic mineral) and muscovite (a higher temperature metamorphic or igneous mineral). Kaolinite was identified in X-ray patterns on the basis of a small shoulder on the chlorite 004 peak, representing the kaolinite 002 reflection at 3.58 Å. The chlorite is likely an Mg-rich form, on the basis of high 004:002 and 003:002 peak ratios.

TABLE 1. DEPTH, WATER CONTENT (WT-WATER/WT-SOLIDS), SALINITY (NORMALIZED TO PRE-STORAGE WATER CONTENTS), AND PERCENT SILT/CLAY CONTENTS OF SAMPLES FROM BUNGANUC AND WESTBROOK SITES.

|                | Depth (ft) | Water content |              | ppt  | Salinity |      | %silt/clay |
|----------------|------------|---------------|--------------|------|----------|------|------------|
|                |            | Pre-storage   | Post-storage |      | $\mu$ S  |      |            |
| Bunganuc, B-1  |            |               |              |      |          |      |            |
| ST - 1         | 17         | 0.353         | 0.21         | 0.02 | 132      | 97.9 |            |
| ST - 2         | 32         | 0.282         | 0.14         | 0.96 | 1940     | 97.8 |            |
| ST - 3         | 47         | 0.304         | 0.17         | 1.01 | 2004     | 99.3 |            |
| ST - 4         | 62         | 0.338         | 0.36         | 0.77 | 1487     | 99.9 |            |
| ST - 5         | 72         | 0.239         | 0.10         | 2.06 | 4076     | 90.2 |            |
| Westbrook, B-2 |            |               |              |      |          |      |            |
| ST - 1         | 17         | 0.376         | 0.33         | 0.28 | 592      | 93.3 |            |
| PO - 1         | 52         | 0.45 (est.)   | 0.29         | 0.72 | 1486     | 99.9 |            |
| PO - 4         | 72         | 0.415         | 0.44         | 1.35 | 2422     | 100  |            |
| PO - 5         | 82         | 0.45 (est.)   | 0.38         | 1.10 | 2249     | 99.1 |            |
| PO - 7         | 102        | 0.39 (est.)   | 0.36         | 1.84 | 3431     | 99.8 |            |
| PO - 8         | 122        | 0.35 (est.)   | 0.17         | 1.87 | 3744     | 73.1 |            |

## DISCUSSION

The pore water salinities reported here are consistent with an original deposition of the clays in a salt or brackish water environment, with subsequent leaching of the clays by downwardly mixing fresh waters. Only the top sample at the Bunganuc site exhibits what may be a completely fresh water conductivity value, with some seawater influence found in all of the other samples. The increasing salinities downcore at the two sites are similar to those found by Torrance (1979) in his study of marine clays in the Ottawa, Canada area. These low salinities are in the range for which "quickness" has been observed (Torrance, pers. comm.). There were no significant differences between the two sites, except that the surficial sample salinity at the Bunganuc site was considerably lower than that at the Westbrook site. This low salinity sample was also highly weathered, as indicated by a reddish color (compared to the gray for all the other samples).

Accurate quantitation of the relative amounts of these minerals in the mixtures cannot be obtained from the X-ray diffraction patterns, for a number of reasons. The main problem is that a dried slurry on a glass plate, with a mixture of minerals, has crystals in varying degrees of preferred orientation on the slide. The orientation of minerals results in selective intensification of certain Bragg reflections; an unknown degree of orientation results in unknowable intensifications. In addition, lack of knowledge of the exact composition of minerals that have vari-

able compositions, such as chlorites, micas, and feldspars, result in ignorance of the correct X-ray scattering function. Both of these variables make quantitation impossible, without going into very involved analyses. However, both of these factors can be assumed, to a first approximation, to be equal among the samples analyzed here. This assumption allows determination of internally consistent, relative trends of mineral composition. These trends have been determined here by simple peak height ratios, with no attempt at correction for different scattering intensities among different minerals.

Some important trends in mineral composition are shown in Figure 1. I emphasize that the numerical values of peak ratios are arbitrary units, with no implication for actual compositions, and are meant only to show trends within and between the sites.

There is considerable homogeneity among the various samples. Among the more significant trends are an increase in the tektosilicate:phyllosilicate ratio (sum of quartz 3.33 Å and feldspar 3.19 Å peaks divided by the sum of mica 10.1 Å and chlorite 7.2 Å peaks in the surface horizon relative to the rest of each section. This increase may reflect greater weathering of the mineral assemblage, resulting in preferential loss of the clay minerals. The two sites have, otherwise, similar tektosilicate:phyllosilicate ratios. The Westbrook site show somewhat higher mica:chlorite and lower quartz:feldspar ratios than Bunganuc.

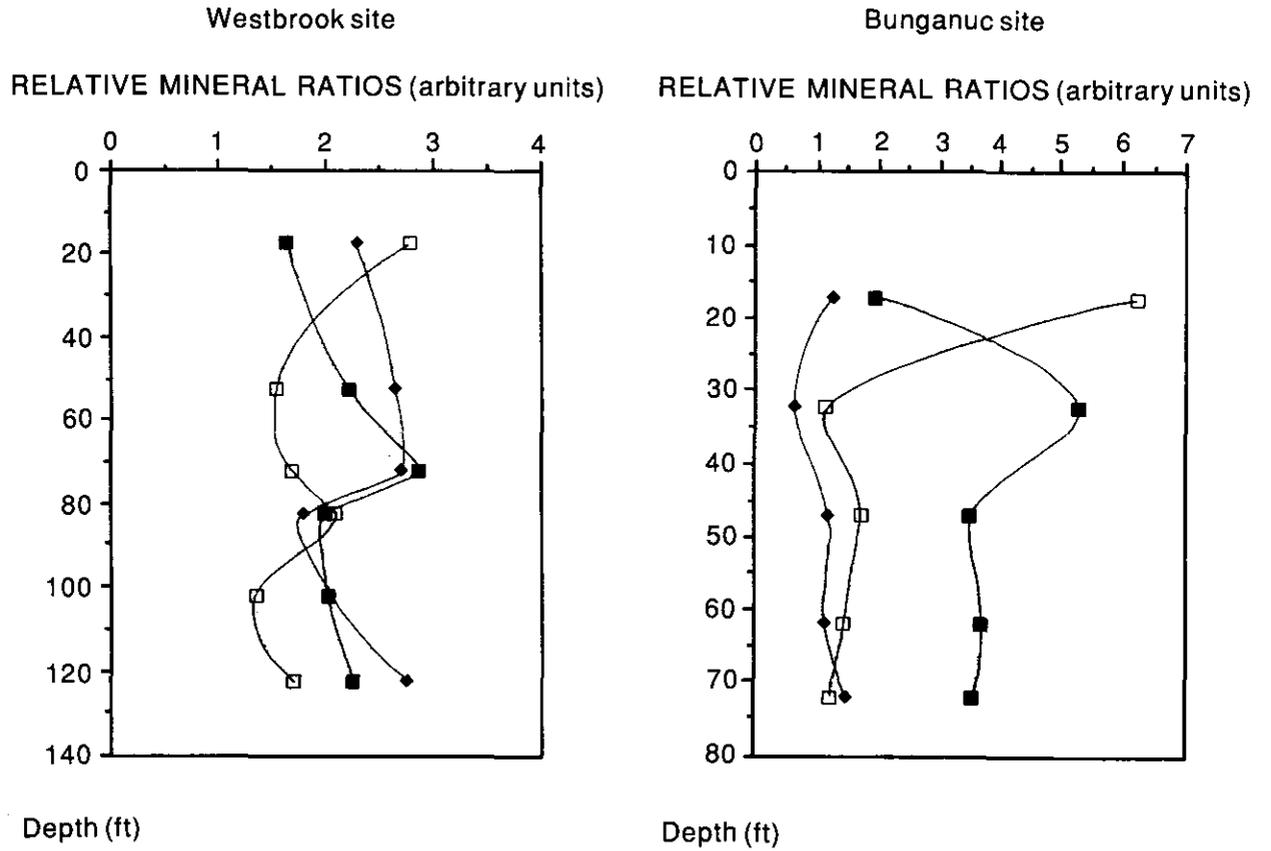


Figure 1. Relative mineral ratios of silt-clay fraction from the Westbrook and Bunganuc sites. Open squares are tektosilicate:phyllosilicate ratios, closed diamonds are the mica:chlorite ratios, and the closed squares are the quartz:feldspar ratios. These ratios are in arbitrary units and do not represent actual mineral ratios.