The Stratigraphy of the Stony Brook University Campus

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Stony Brook University is located in central Suffolk County on the north shore of Long Island (Figure 1), and overlies some 900 feet of Pleistocene and Cretaceous unconsolidated sediments, which overlie early Paleozoic and Precambrian bedrock. Well logs available at the New York State Department of Conservation for water wells and borings for engineering purposes as well as logs from Suffolk County Water Authority were used to evaluate the underlying strata. Ten boreholes penetrate the Magothy Formation as well as the Pleistocene sediments; in addition five shallow boreholes and a cliff face exposed during construction give a more detailed description of the Pleistocene sediments. Lithologic logs for each of the boreholes and an exposed cliff face on campus are in the appendix.

Fig. 1 Map of Long Island.
Jensen and Soren (1974) mapped the hydrological units beneath Suffolk County, Long Island based on well logs from municipal water well borings. Smolensky, Buxton and Shernoff (1989) remapped the hydrologic units. Fig. 2 is a north-south cross-section from Long Island Sound to the Atlantic Ocean that goes through Stony Brook University modified from Jensen and Soren (1974). According to Jensen and Soren (1974) and Smolensky, Buxton and Shernoff (1989), the basement is early Paleozoic and Precambrian bedrock which is overlain by the Lloyd Sand and Raritan Clay Members of the Raritan Formation, these are overlain by Magothy Formation and the Pleistocene sediments. The type of sediment found in each geologic unit and their thickness are shown in Table 1. The Cretaceous sediments and the top of the basement dip about 1° to the south (Jensen and Soren, 1974).

Krulikas and Koszalka (1983) describe a lacustrine clay known informally as the Smithtown clay, found within the Pleistocene sediments. The clay is mainly found between the Ronkonkoma and Harbor Hill Moraines in north-central Suffolk County. They suggested that the lake resulted from the damming of water by the Ronkonkoma Moraine upon the retreat of the glacier that formed the Ronkonkoma Moraine. The clay was then buried by sediments associated with the next glacial advance that created the Harbor Hill Moraine. Most of the Stony Brook University campus is on the Harbor Hill Moraine. The Stony Brook portion of the Harbor Hill Moraine was formed by glacial tectonics. Tzakas and others (2002) describe how pushing of unconsolidated sediments in front of the glacier formed the moraine. Tingue and others (2004) have use ground penetrating radar to show that underlying sediments in the Ashley Schiff Preserve have features typical of a fold and thrust terrane.

<table>
<thead>
<tr>
<th>Geological Age</th>
<th>Geological Unit</th>
<th>Thickness (ft)</th>
<th>Description of Sediment Deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary-</td>
<td>Upper Pleistocene</td>
<td>0-150</td>
<td>Unsorted and unstratified clay, silt, sand, gravel and boulders;</td>
</tr>
<tr>
<td>Pleistocene</td>
<td></td>
<td></td>
<td>tan brown, and brownish-gray</td>
</tr>
<tr>
<td>Era</td>
<td>Deposits</td>
<td>Outwash</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Smithtown Clay</td>
<td>0-150</td>
<td>Lacustrine deposits consist of clay and silt, brown, brownish gray and gray.</td>
</tr>
<tr>
<td></td>
<td>Magothy Formation</td>
<td>0-1000</td>
<td>Gray to white fine to coarse sand with clay, silt and lignite interbedded.</td>
</tr>
<tr>
<td></td>
<td>Raritan Clay Member</td>
<td>0-250</td>
<td>Clay, silty clay, and clayey and silty fine sand, light to dark-gray, brownish-red, red, pink, and grayish-white. Beds and lenses of lignite, pyrite and sand.</td>
</tr>
<tr>
<td></td>
<td>Lloyd Sand Member</td>
<td>0-550</td>
<td>Fine to coarse sand and gravel, grayish-whit, light to medium-gray and yellowish-gray, with intercalated beds and lenses of light to dark gray clay, silt, clayey and silty sand and some lignite and pyrite.</td>
</tr>
<tr>
<td>Precambrian-</td>
<td>Bedrock</td>
<td>Unknown</td>
<td>Crystalline rocks mainly granite, gneiss and schist</td>
</tr>
<tr>
<td>Early Paleozoic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
While no bore holes penetrate the bedrock on campus, it is most likely that the basement is part of the Avalon Terrane exposed in eastern Connecticut and thought to underlie Long Island Sound immediately to the north (Pacholik and Hanson, 2001). The Avalon Terrane consists of 600 to 700 Ma old dominantly leucocratic gneisses and 300 Ma granitic intrusions. In many places the top of the basement rocks consists of a regolith of residual clay. The Magothy Formation, which is part of the Matawan Group, is separated from the Raritan Formation by an unconformity. Near the base of the Magothy Formation is a coarse basal zone which is overlain by a fining upward sequence consisting mainly of fine sands and clay, typical of a delta environment (Smolensky, Buxton and Shernoff, 1989). The Magothy Formation is overlain by Pleistocene sediments. During the Pleistocene, continental glacial advance and retreat occurred many times. It is not clear how many times this area was glaciated. Glacier scour and melt water valleys have created an irregular surface between the glacial sediments and the Magothy Formation.

Ten deep wells (hundreds of feet) and five shallow wells (less than 100 feet) were chosen for analysis based on quality of the logs and their location. A stratigraphic column was also constructed based on a section on campus that was exposed during construction of a recharge basin (see Appendix). Figure 3 locates the wells, with letters A through J for the deep wells, ESS gives the location of a shallow borehole near the Earth and Space Sciences Building, S shows the location of a shallow borehole on South Campus and Cliff marks the location of the sedimentary section exposed during construction of a recharge basin. Suffolk County Water Authority (SCWA) well A is the northern most well which is on Mud Road, followed by wells at the Student Union (B), Arts and Science Center (C), Old Chemistry (D), Daniel Webster Drive SCWA Well 1 (E), Daniel Webster Drive SCWA Well 2 (F), Javits Lecture Hall (G), Heavy Engineering (H), Henry Clay Drive SCWA (I) and the southern most well, Oxhead Road SCWA (J). The driller’s information is presented in Table 2; this includes well location, contractor, date, drill type, depth, elevation and reason for drilling. The shallow borehole information is provided in Table 3 and the stratigraphic columns are found in the appendix)

![Fig. 3 Map showing locations of the boreholes. See text for descriptions.](image)

<table>
<thead>
<tr>
<th>Well Letter</th>
<th>Location</th>
<th>UTM Zone 18 NAD83</th>
<th>Owner</th>
<th>Driller</th>
<th>Date</th>
<th>Type of Drill</th>
<th>Well Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mud Road</td>
<td>657969E 453215N</td>
<td>SCWA Strata Well Co.</td>
<td>September 2, 1981</td>
<td>Reverse Rotary</td>
<td>Municipal Water Supply</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Student Union Building</td>
<td>658147 E 4531137N</td>
<td>NY State Lauman Co.</td>
<td>April 4, 1973</td>
<td>Rotary</td>
<td>Cooling</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Arts and Science Center</td>
<td>657793E 4531137N</td>
<td>NY State Lauman Co.</td>
<td>July 27, 1960</td>
<td>NS</td>
<td>Construction Test Well</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Old Chemistry Building</td>
<td>658047 E</td>
<td>NY Lauman Co.</td>
<td>October</td>
<td>NS</td>
<td>Cooling</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Drilling Information for Shallow Boreholes drilled by Land Air and Water Environmental Services

<table>
<thead>
<tr>
<th>Locations</th>
<th>Date</th>
<th>Drill Type</th>
<th>Depth (ft)</th>
<th>Elevation (ft)</th>
<th>Reason for Drilling</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS 1</td>
<td>October 2000</td>
<td>Hollow Stem Auger</td>
<td>20</td>
<td>120</td>
<td>Educational</td>
</tr>
<tr>
<td>ESS 2</td>
<td>October 4, 2001</td>
<td>Hollow Stem Auger</td>
<td>12</td>
<td>120</td>
<td>Educational</td>
</tr>
<tr>
<td>ESS 3</td>
<td>October 31, 2002</td>
<td>Hollow Stem Auger</td>
<td>15</td>
<td>120</td>
<td>Educational</td>
</tr>
<tr>
<td>ESS 4</td>
<td>October 2003</td>
<td>Hollow Stem Auger</td>
<td>9</td>
<td>120</td>
<td>Education</td>
</tr>
<tr>
<td>South Campus 1</td>
<td>October 23, 1997</td>
<td>Hollow Stem Auger</td>
<td>82</td>
<td>190</td>
<td>Educational</td>
</tr>
<tr>
<td>South Campus 2</td>
<td>October 15, 1998</td>
<td>Hollow Stem Auger</td>
<td>52</td>
<td>120</td>
<td>Educational</td>
</tr>
</tbody>
</table>

Results

For each deep borehole, the driller provided the depth of the well relative to land surface, however, the surface elevation was not always provided. Elevation for these wells was determined based on located the site on a topographic map and interpolating the elevation. The depth to the water table relative to the land surface was provided in all logs, except the one at Henry Clay Drive. The depth of the well and elevation of water table are provided in Table 4. In some logs the driller or geologist noted the upper surface of Magothy Formation. When this information was not provided, or its placement was not consistent with the description of the sediments, the upper surface of the Magothy Formation was determined by comparing the sediment descriptions in the logs to descriptions in the literature. Generally the Pleistocene sediments are tan, whereas the Cretaceous sediments are a variety of brighter or more distinct colors, such as red, black, white, gray etc.

Based on the stratigraphic columns of the deeper borehole, the depth of specific units relative to mean sea level were determined and displayed in Table 5. The logs of the Student Union Building (B) and Daniel Webster Road 1 (E) include a gravelly unit that the loggers call the “basal unit”; Table 5 gives the elevation of the “basal unit” described by the drillers of logs B and E, but in the Table 5 it is identified as gravelly which was also identified in boreholes A, C, D, F, I, and J. The surface of the gravelly units in boreholes B and E differs by 85 ft. The position of the gravelly unit within the other boreholes does not show a trend, suggesting that this describes channel fill in multiple channels and not a well-defined stratigraphic unit.

Lignite was identified in the Magothy Formation in boreholes B, C, D, F and J. The elevation of these units, displayed in Table 5, range from –155 to –377 ft relative to mean sea level. In addition to the elevation of the lignite layers, the thickness of each layer is provided in Table 5. In borehole B, Student Union building, the lignite is found in two units. The deeper unit is 12 ft thick with lignite located in fine to medium gray sand, with pieces of clay. The 8 ft thick unit directly above consists of sandy gray clay, pyrite and lignite. To summarize, the sediments found with the lignite are gray, fine to coarse sands and clays, and occasionally pyrite probably representing overbank deposits formed in a swampy environment. Lignite is deposited in an environment that is...
humid and wet, allowing the preservation of organic material.

Table 4. The Elevation of the land surface, the elevation of the bottom of the bore hole and the elevation of the groundwater table relative to mean sea level.

<table>
<thead>
<tr>
<th>Borehole ID</th>
<th>Location</th>
<th>Elevation of Location (ft)</th>
<th>Elevation of bottom of hole (ft)</th>
<th>Elevation of water table (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mud Road</td>
<td>116</td>
<td>-464</td>
<td>26.5</td>
</tr>
<tr>
<td>B</td>
<td>Student Union Building</td>
<td>120</td>
<td>-377</td>
<td>57</td>
</tr>
<tr>
<td>C</td>
<td>Arts and Science Center</td>
<td>135</td>
<td>-500</td>
<td>37</td>
</tr>
<tr>
<td>D</td>
<td>Old Chemistry Building</td>
<td>135</td>
<td>-521</td>
<td>27</td>
</tr>
<tr>
<td>E</td>
<td>Daniel Webster Drive 1</td>
<td>125</td>
<td>-428</td>
<td>46</td>
</tr>
<tr>
<td>F</td>
<td>Daniel Webster Drive 2</td>
<td>107</td>
<td>-380</td>
<td>31</td>
</tr>
<tr>
<td>G</td>
<td>Javits Lecture Hall</td>
<td>140</td>
<td>-210</td>
<td>30</td>
</tr>
<tr>
<td>H</td>
<td>Heavy Engineering</td>
<td>130</td>
<td>-217</td>
<td>15</td>
</tr>
<tr>
<td>I</td>
<td>Henry Clay Road</td>
<td>226</td>
<td>-449</td>
<td>NA</td>
</tr>
<tr>
<td>J</td>
<td>Oxhead Road</td>
<td>145</td>
<td>-420</td>
<td>35</td>
</tr>
</tbody>
</table>

NA – Not applicable

Table 5. The elevation and thickness of geological layers and features according to the boreholes

<table>
<thead>
<tr>
<th>Borehole</th>
<th>Location</th>
<th>Elevation of Upper surface of Gravelly Magothy* (ft)</th>
<th>Elevation of Upper Surface of Layers containing Lignite (ft)*</th>
<th>Thickness of Magothy Lignite (ft)</th>
<th>Elevation of the Base of Glacial Sediments* (ft)</th>
<th>Elevation of upper surface of Pleistocene Clays (ft)*</th>
<th>Thickness of Pleistocene Clay (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mud Road</td>
<td>-374</td>
<td>NA</td>
<td>NA</td>
<td>-29</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>B</td>
<td>Student Union Building</td>
<td>-307●</td>
<td>-272</td>
<td>20</td>
<td>-49</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>Arts and Science Center</td>
<td>-371</td>
<td>-240</td>
<td>5</td>
<td>-54±15</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>E</td>
<td>Daniel Webster Drive 1</td>
<td>-370●</td>
<td>NA</td>
<td>NA</td>
<td>-8±19</td>
<td>29</td>
<td>12</td>
</tr>
<tr>
<td>F</td>
<td>Daniel Webster Drive 2</td>
<td>-355</td>
<td>-156</td>
<td>16</td>
<td>-27±18</td>
<td>36</td>
<td>14</td>
</tr>
<tr>
<td>G</td>
<td>Javits Lecture Hall</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>-38</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>Heavy Engineering</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>-50±11</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>I</td>
<td>Henry Clay Road</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>41</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>J</td>
<td>Oxhead Road</td>
<td>NA</td>
<td>-369</td>
<td>8</td>
<td>-100</td>
<td>17</td>
<td>11</td>
</tr>
</tbody>
</table>

*Elevation Relative to Mean Sea Level
● The basal unit in the Magothy Formation identified by in the borehole logs.

NA – Not applicable
**Figure 4.** North-south stratigraphic cross section across the Stony Brook Campus.

The data in Table 5 were used to construct a cross-section of the strata below the Stony Brook University campus. The cross-section, Figure 4, extends from borehole A, at Mud Road, located north of campus, to borehole J, located south of the campus. Moving south from borehole A the elevation of the upper surface of the Magothy Formation decreases from -29 to -61 ft at location H. However, Henry Clay Drive (I) borehole, located on the Moraine, the upper surface of the Magothy is at an elevation of 41 ft above sea level. South of the Moraine at location J, the upper Magothy surface is lower at -100 ft. Thus, the upper surface of the
Magothy Formation is higher under the Harbor Hill Moraine which may be a result of differential erosion by the glaciers or perhaps the Cretaceous sediments were pushed up by the advancing glacier that formed the Stony Brook portion of the Harbor Hill Moraine.

![Long Island Sound]

**Figure 5.** Contour map showing the elevation of the top of the Smithtown clay from Krulikas and Koszalka (1983) and the elevation of the top of the clay in boreholes on or near the Stony Brook University campus.

Within boreholes D, E, F and J is a layer of lacustrine clay similar to the Smithtown clay found by Krulikas and Koszalka (1983) in northwestern Suffolk County. Figure 5 is a contour map showing the elevation of the top of the Smithtown clay south of Stony Brook University. The Smithtown clay is up to 170 feet thick, but more typically on the order of 20 to 50 feet thick. The elevation of the top of the five- to fourteen-foot thick lacustrine clay found underlying the Stony Brook University campus is fairly consistent with the elevation of the clay found by Krulikas and Koszalka (1983). The clay on campus is found both north and south of the moraine, but not under the highest part of the moraine. If the rise in the Magothy Formation under the moraine were present during the deposition of the Smithtown clay in a proglacial lake, this area may have been above the level of the lake. Or, if the bulge is due to glacial tectonics, the clay may have been removed by the pushing of the glacier. A lacustrine clay was noted near the surface on campus at an elevation of about 140 feet during the construction of the Student Activity Center. If this clay were the Smithtown Clay, this would suggest that the clay had been transported by glacial tectonics to a much higher elevation.

The reported depth to the water table ranges from 15 to 57 ft above mean sea level. Since the logs were completed at different times of the year and in different years, some of the differences in the elevations may result from seasonal or annual variations in precipitation as well as variations in the elevation of the water table with distance from Long Island Sound. In Figure 4, the elevation of the water table is approximated based on the borehole logs.

The sediments found in the shallow borehole and the cliff face are similar to each other (see Appendix for details). Located near the land surface is silty sand and sandy silt probably loess (Zhong et al., 2002) which
generally overlies till. In the shallow bore holes and exposed cliff, the till consisted of a 3ft thick layer near the top of the sections. Six feet of till was identified in the boreholes at Student Union, and about eight feet of till was found in the Old Chemistry bore hole. Below the till are usually alluvial sands and gravels showing plane or cross bedding.

**Figure 6.** Photograph of the exposed cliff located near the west campus recharge basins. The cliff composes mainly of alluvial sands and gravels, with 3 ft of till near the top. The black box illustrates the section photographed in **Figure 7**.
Figure 7. Close up of the exposed cliff strata in Fig. 6. The sections in the photograph are the stratified layers of gravel, deposited a layer of finer sand with cross stratification. The cross-bedding and finer sediments deposited indicate a low energy, unidirectional flow of the outwash material. The environment changed to a high energy, unidirectional flow of melt water indicated by the gravelly sandy layers.
Discussion

The deepest geological formation penetrated by the boreholes in this study is the Magothy Formation. Found near the base of the boreholes is a layer of gravelly sands with some clay which was identified as the “Basal Magothy” in two locations. However, a comparison of sediments found in the other boreholes indicates that the Magothy Formation is found at deeper elevations and the Raritan clay was never penetrated. Based on these boreholes the “Basal Magothy” described by the loggers is actually a gravelly unit indicating channel deposits found within the Magothy Formation. The upper surface of the gravelly unit is irregular, which is typical of a delta environment. The presence of gravel at the lower sections of the formation suggests that the deposition of the Magothy Formation began in a high-energy delta environment, which decreased in energy over time.

Deposited in the lower energy environment are mainly clays and fine sands. The lignite recognized in the finer layers of the Magothy Formation is found at a variety of depths, suggesting there is no continuous layer of lignite within the Magothy Formation. However, in boreholes located at the Student Union, the Art and Science building and the Old Chemistry building the lignite is found in similar sediments and depths. The elevation of the lignite layers are −240 ft, −270 ft and −277 ft, and the thickness of the layer varies from 5 ft thick at the Art and Science Center to 12 ft thick at the Student Union. Since these boreholes are in close proximity to one another, the lignite layer may extend beneath this entire area.

The cross-section of the entire Stony Brook University, Figure 4, shows the upper surface of the
Magothy Formation is extremely irregular. The elevation of the Magothy Formation rises considerably beneath the Harbor Hill Moraine. This rise may have glacial tectonic implications based on the location. As the glacier moved into the Long Island region and made contact with the unconsolidated sediments, the glacier could have pushed the Magothy Formation. However, the clay unit found, also plotted in the Figure 5, poses an issue for this theory. If the Magothy Formation was tectonically altered, the deposition of the clay could not be related to the clay found south of the moraine; the clay would also be tectonically altered. The clay found beneath Stony Brook University could possibly relate to the clay unit discussed by Krulikas and Koszalka (1983) according to the map. The clay north of the moraine may have been pushed into its location by the glacier. To further investigate the rise of the Magothy formation beneath the moraine, well boreholes logged from different locations on the moraine need to be obtained to see if this is trend within the moraine.

The shallow boreholes provided the majority of the detailed information on the glacial sediments. The sediments described in the borehole logs were mainly sandy silt, silt sand, sand and gravelly sands. The exposed cliff provided a more detailed analysis of the sediment associated with the glacier (Figure 6). Soil is found at the top of the cliff and is commonly formed on loess. The exposed cliff had about 3 ft of glacial till. The sediments found within the till layer are similar to the outwash sediments, however the till is unsorted and unstratified, while the outwash beneath is stratified. The loggers of the shallow or deeper boreholes rarely identify a layer of till. The method of sediment extraction makes distinguishing till and outwash difficult; the layers were not preserved or not identified. Only two of the deep boreholes recognized a layer that has the distinct features of till, these units were 6 to 8 ft thick. Figure 8 shows a more distinct boundary between till and outwash found near the location of the cliff. Beneath the till in the exposed cliff is outwash containing cross-stratified sands and stratified gravel. Layers of sand and gravel are similar to the sediments described by the loggers of the shallow boreholes. The cliff also exposed sedimentary structures (Figure 7). The structures reveal details about the depositional environment. The alternating of stratified sands and stratified gravels indicate deposition was rapid and inconsistent. The melt water deposited the sediments quickly in a stream, and then as sediments pile melt water creates or deposits sediments to a new stream. This may explain why the sediment sizes were not consistent in the ESS boreholes, which were drilled within feet of each other. In addition to the melt water inconsistence, glacial tectonics may have altered the sediments layers. Figure 9 is a photograph of the sediments found beneath the SAC. The fine sediments and the coarse gravel are folded, most likely due to the glaciotectonic forces as the glacier advanced forward.

References


Pacholik, W., and Hanson, G.N., 2001, Boulders on Stony Brook Campus reveal geology of Long Island Sound basement, Geology of Long Island and Metropolitan New York, Long Island Geologists, Program with Abstracts, Volume 8: Stony Brook, New York, Long Island Geologist, Department of Geosciences, State University of New York at Stony Brook, p. p. 28-34.

