Sediments and Structures of Part of Glacial Lake Agassiz in Grand Forks County, North Dakota

Louis D. Smith

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SEDIMENTS AND STRUCTURES OF PART OF GLACIAL LAKE AGASSIZ IN GRAND FORKS COUNTY, NORTH DAKOTA

by

Louis D. Smith

A senior thesis submitted to the faculty of the Geology Department at the University of North Dakota in partial fulfillment of the requirements for the Bachelor of Science in Geology Degree

Grand Forks, North Dakota
July 23, 1970
This Thesis submitted by Louis D. Smith in partial fulfillment of the requirements for the Degree of Bachelor of Science in Geology from the University of North Dakota is hereby approved by the Faculty Advisor under whom the work has been done.

[Signature]
(Advisor)
ABSTRACT

Eastern Grand Forks County lies within the glacial Lake Agassiz plain (Fig.2). The lacustrine sediments, as exposed in a drainage ditch along the east edge of sections 16, 21, and 28, T. 154 N., R. 52 W., northwest of Manvel, North Dakota, have been divided into two main groups: the lower bedded clays overlain by bedded, silty clays and silt. Separating these units is a limonite hardpan.

During the late receding stage of Lake Agassiz, tributary drainage developed cut and filled channels within the silt directly underlying the lake plain. Several such channels occur within the outcrop area in the upper three feet of Lake Agassiz sediments. Folding of these sediments by isostatic rebound accounts for the distorted sediments noted in the outcrop.

Size analyses prove these sediments are of lacustrine origin and that the channel structures are fluvial. Buried wood suggests an erosional interval during the closing stages of Lake Agassiz.
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SEDIMENTS AND STRUCTURES OF PART OF GLACIAL LAKE
AGASSIZ IN GRAND FORKS COUNTY, NORTH DAKOTA

INTRODUCTION

The purpose of this paper is to present data collected from the sediments and structures of glacial Lake Agassiz as exposed in a drainage ditch in northern Grand Forks County, North Dakota (Fig. 1), and to compare them with other data.

This study was completed, at the suggestion of Dr. Lee Clayton, as a senior thesis in partial fulfillment of the requirements for the Bachelor of Science Degree at the University of North Dakota. I also want to thank Dr. Frank R. Karner of the Geology Department at U.N.D. for constructive criticism of the content and style of this paper.

The glacial Lake Agassiz deposits marked the close of Wisconsinan glaciation. Lake Agassiz, with an area of approximately 110,000 square miles, was probably the largest body of fresh water in the world (Upham, 1896). This study will correlate sediments and sedimentary structures with other studies and present data not previously reported.

GEOLOGICAL SETTING

The outcrop is located along the north edge of sections 20 and 21, and the east edge of sections 16, 21 and 28, T. 154 N., R. 52 W., approximately five miles northwest of Manvel, Grand Forks County, North Dakota. The region lies within the Red River Valley (Fig. 2), and the lacustrine deposits are underlain by ice-carved glacial till of Pleistocene age (Freers and Carlson, 1963). The drainage ditch, originally excavated in 1923 and enlarged in 1963, exposes approximately 20 feet of lacustrine deposits (Fig. 3).
Figure 1. Grand Forks County, North Dakota, showing the location of the outcrop.
As early as 1875, Dawson interpreted the origin of soil in this area to be fluviatile or lacustrine. Upham's classical work (1896) is the standard reference for Lake Agassiz. Working in northern Minnesota and southern Manitoba, Johnson (1916) found evidence for two stages of Lake Agassiz. Laird (1944) found evidence for a disconformity between the laminated clays and overlying silts east of the Grand Forks Air Force Base east gate. Rominger and Rutledge (1952) also recorded evidence for a disconformity, and they noted dessication surfaces in the lower laminated clays. Laird (1964) summarized the literature and indicated problem areas where data is needed for a more complete history of the events of glacial Lake Agassiz. Hanson and Kume (1970) give the detailed geology of Grand Forks County and conclude Lake Agassiz originated as a small proglacial lake that expanded in area and receded and drained in steps. They reported the upper silt as extensive but discontinuous in the eastern part of the county.
METHODS OF INVESTIGATION

Field Data

After becoming familiar with the area by walking the outcrop and observing the lithology and sediments, three locations for measured sections were chosen. The outcrop along the north side of sections 20 and 21 is badly slumped. This study was confined to the outcrop along the east edge of sections 16, 21, and 28. The location of samples for size analyses are: 1-east edge of section 28, 300' south of the ½ section line; 2-east edge of section 28, 300' north of the ½ section line; 3-east edge of section 21, 0.25 mile south of field access bridge at the ½ section line.

Figure 3. View looking south along the east edge of section 21, T. 154 N., R. 52 W., Grand Forks County, North Dakota.

Measured sections

The lithology was recorded and samples taken at three locations along sections 21 and 28. When the ditch was enlarged in 1963, according to Bill Schmidtke, Forester Construction, Manvel, and a local farmer, the topsoil along the edge was partially removed and clay dredged
from the bottom of the ditch was deposited in its place. The sections were measured in areas where the topsoil was in place and the outcrop slumping was minor (Fig. 4).

Figure 4. View of a typical outcrop.

Figure 5. Cross-sections of Lake Agassiz sediments along sections 21 and 28, T. 154 N., R. 52 W., Grand Forks County, North Dakota.

The sections reveal the above lithology (Fig. 5).
<table>
<thead>
<tr>
<th>UNIT</th>
<th>DESCRIPTION</th>
<th>THICKNESS (FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Topsoil, developed in place, black loam.</td>
<td>1.0 to 1.5</td>
</tr>
<tr>
<td>4</td>
<td>Sandy silt; brown; some faint bedding; appears to be eolian.</td>
<td>0.8 to 1.4</td>
</tr>
<tr>
<td>3</td>
<td>Sand, silt, and clay; laminated; brown, yellow-orange, and gray, respectively.</td>
<td>0.5 to 0.7</td>
</tr>
<tr>
<td>2</td>
<td>Silty clay; gray-green, limonite-stained; bedded, 1/4&quot; to 3/4&quot; with limonite-stained interbedded sand along bedding planes; limonite concretions, microscopic to one foot in diameter (see figures 6 and 7); limonite increases downward to a hardpan at base of unit.</td>
<td>5.0 to 6.0</td>
</tr>
<tr>
<td>1</td>
<td>Clay; blue-gray; bedded, thinner at top with interbedded (ripple-marked?) sand along bedding planes (see figures 8 and 9). Numerous areas of wood on upper contact.</td>
<td>10.0 - ?</td>
</tr>
</tbody>
</table>

The thickness of lake sediments in this area is approximately 70 feet (Hanson and Kume, 1970, p. 54).

Figure 6. Limonite concretions in Unit 2 of Lake Agassiz sediments. Sample bag for scale is 4 x 6 inches.
Figure 7. Limonite concretions in Unit 2 of Lake Agassiz sediments. Sample bag for scale is 4 x 6 inches.

Figure 8. Limonite hardpan between Units 1 and 2 of Lake Agassiz sediments.
Buried wood

An eight-foot tree with an intact root system from 2 to three was found lying parallel to the top contact of Unit 1 (see fig. 10). Another tree segment was found just to the left of the first one, and samples of both were taken.
Structures

Cut and filled channels occur within the upper three feet of Lake Agassiz sediments at several places along the outcrop at sections 21 and 28. One large channel (145 feet wide) clearly shows fluvial bedding, ripples and dunes (Figs. 11 and 12). This channel is located approximately 400 feet south of the junction of sections 21 and 28. Other smaller channels occur throughout sections 21 and 28. One of these shows contorted bedding (Fig. 13). This channel is located one-quarter mile north of the junction of sections 21 and 28.

Figure 11. Fluvial bedding in cut and filled channels in Lake Agassiz sediments. White ruler is six inches long.

About 600 feet north of the contorted channel is a structural feature that also occurs within the upper three feet of Lake Agassiz sediments. This feature was photographed (Fig. 14) and drawn for later analysis.

Within a few feet north of the buried wood in section 28, ripple-marked sand was found along the bedding planes of Unit 1 clays about
one foot below the limonite hardpan (see fig. 15).

Figure 12. Fluvial bedding in cut and filled channels in Lake Agassiz sediments. White ruler is six inches long.

Figure 13. Contorted fluvial bedding in cut and filled channels in Lake Agassiz sediments. Ruler is six inches long.
Figure 14. Contorted Lake Agassiz sediments.

Figure 15. Contorted bedding in Lake Agassiz Unit 1 clays. The sand on the right is limonite-stained.
Size analyses

Samples taken from the measured sections were analyzed for sand, silt, and clay percentages following Standard Procedure A-65 (North Dakota Geological Survey, 1965). This procedure is out of print and is included as an appendix. Samples A, B, C, and D are located on the measured sections (Fig. 5).

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.06</td>
<td>2.68</td>
<td>25.93</td>
<td>71.33</td>
</tr>
<tr>
<td>B</td>
<td>0.26</td>
<td>1.64</td>
<td>58.90</td>
<td>39.20</td>
</tr>
<tr>
<td>C</td>
<td>----</td>
<td>2.00</td>
<td>59.44</td>
<td>39.68</td>
</tr>
<tr>
<td>D</td>
<td>----</td>
<td>0.30</td>
<td>26.68</td>
<td>73.36</td>
</tr>
</tbody>
</table>

Figure 16. Size analyses percentages of selected samples of Lake Agassiz sediments.

Figure 17. Textural classification triangle (from Krumbein and Sloss, 1963).

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>NOMENCLATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>SILTY CLAY</td>
</tr>
<tr>
<td>B</td>
<td>CLAYEY SILT</td>
</tr>
<tr>
<td>C</td>
<td>CLAYEY SILT</td>
</tr>
<tr>
<td>D</td>
<td>CLAY</td>
</tr>
</tbody>
</table>
The material retained in the #10 and #230 mesh sieves were microscopically examined. The only material removed by the #10 sieve, from samples A and B, were pieces of limonite concretions showing center-holes lined with dark stains. The concretions appear to have formed around root or plant stems which have since been decomposed and removed. The #230 mesh sieve fractions from samples A to D are:

A - Gypsum crystals (80%), limonite concretions, biotite and muscovite flakes, and quartz sand.

B - Limonite concretions (50%), angular to well rounded quartz grains (40%), limonite hardpan, rounded shale fragments (1%).

C - Limonite concretions and sand (90%); well rounded to angular quartz grains (5%), rounded shale fragments (1%).

D - Rounded shale fragments (50%); well rounded to angular, red and transparent quartz grains (40%); biotite flakes; gypsum crystals with clay coatings; limonite-coated quartz grains; fresh-water ostracods.

Other samples

Samples taken from the interbedded sand of Lake Agassiz Unit 1 clays (Fig. 15) are clean, washed quartz sand. The sand on the left of figure 15 is gray from the clay, and the sand on the right is limonite-stained. Samples from the cut and filled channels are composed completely of clean quartz sand.

Summary of data

Lake Agassiz deposits in this area can clearly be divided into two sediment types: silts and silty clays overlying bedded clays. This conforms to reports by Laird (1944) and Rominger and Rutledge (1952).

Streams entered Lake Agassiz when the water level was near this area, or to the Red River after the lake receded.

The contorted channel sediments (Fig. 13), the sand in Unit 1 (Fig. 15), and the contorted sediments in figure 14 are probably due
to folding of the sediments by isostatic rebound after retreat of the glacial ice.

The limonite hardpan can be attributed to a shallow lake that covered several square miles around the outcrop site. A local farmer reports hunting ducks on the lake in the 1920's. The hardpan could be a limonite precipitation layer above the more impermeable clay of Unit 1.
DISCUSSION

Hansen and Kume (1970, p. 58) found several exposures of silt directly underlying the lake plain that indicates the silt is fairly extensive, but may not be continuous. There is no doubt the silt was deposited during a receding lake stage as the waves reworked the glacial till.

They also reported a "sedimentary flow structure" similar to figure 14. The folded sediments in their areas were probably also due to isostatic rebound after glacial retreat.

Size analyses of the sediments correlate them with other reports (Laird, 1944 and Rominger and Rutledge, 1952), and are clearly lacustrine sediments (Fig. 17).

Several exposures of wood occur along the outcrop. One of these is a tree (Fig. 10) with attached roots and a segment of a second tree nearby. Smaller samples of wood outcrop at the same stratigraphic level along the ditch. Radiocarbon dates were not available on the wood, consequently correlation with other worker's erosional intervals was not possible.

Suggested future work in the area would be to date the wood samples (stored in the ice vault at the University of North Dakota) and to core the outcrop area. Time and expense prevented this writer from gathering this additional data.
APPENDIX

Tentative
Gravel-Sand-Silt-Clay Analysis

N.D.G.S. Standard Procedure A-65
November 1965


2. Use.--This procedure is to be used in the analysis of unlithified sediment containing less than 30 percent gravel, the non-gravel part being at least 10 percent silt and clay. Equipment to be used is listed in paragraph 11.

3. Sample size.--About \( \frac{1}{2} \) pint of sediment is needed for the analysis.

4. Disaggregate sample.--The air-dried sample is broken up with the fingers or in a mortar with a large rubber stopper until aggregations remain. Avoid smashing up individual grains.

5. Split sample.--Thoroughly mix sample. Using a Jones Sample Splitter, divide the sample into a "larger subsample" and a "smaller subsample". The larger subsample will be used for gravel and sand analysis and the smaller subsample for silt and clay analysis. The smaller subsample should contain 15.0 gm of silt plus clay (see paragraph 12). The larger subsample is what remains of the \( \frac{1}{2} \) pint sample after the smaller subsample has been removed. Weigh the larger subsample to nearest gram; enter weight in column AA of data sheet. (Be sure the subsamples are split properly; each should contain the same proportions of moisture, gravel, sand, silt, and clay.)

6. Sand and gravel analysis.--Oven dry (100 degrees Centigrade for 24 hr) the larger subsample and let cool in weighing room for several hours, until the subsample comes to equilibrium with the moisture conditions of the air in the room. Weigh to the nearest gram; enter weight in column A of data sheet. Soak the subsample over night in about a pint of dispersant solution (see paragraph 14). Nest together a 2mm sieve and a 0.0625 mm sieve; place in a sink. Using a spray-hose attached to a water faucet, wash out (and discard) all of the silt and clay from the subsample until the water runs clear and no silt or clay aggregations remain on the lower sieve; do not add sediment to sieves so fast that the lower sieve becomes clogged and overflows (see paragraph 13). Using a wash bottle, wash each
sieve fraction onto a filter paper in a small funnel. Air dry each sieve fraction. Weigh to nearest gram; enter in column A of data sheet.

a) Amount of gravel.--The weight of gravel in the larger subsample is the weight of the fraction on the upper (2 mm) sieve; enter weight in column B of data sheet.

b) Amount of sand.--The weight of sand in the larger subsample is the weight of the fraction on the lower (0.0625 mm) sieve; enter weight in column C of data sheet.

c) Amount of silt plus clay.--The weight of silt plus clay in the larger subsample is the total weight of the larger subsample (paragraph 6) minus the weight of gravel (paragraph 6a) and sand (paragraph 6b) in the larger subsample; enter weight in column D of data sheet.

7. Preparing for pipette analysis.--The smaller subsample will be used for a pipette analysis. It should never be oven dried.
   a) Water.—All water used in the pipette analysis should be distilled.
   b) Temperature.—Throughout the pipette analysis the suspension of sediment should be kept at 20 degrees ±10 C. (68 degrees±1 degree F). The thermostat of the room in which the analysis is to be run and in which the distilled water and dispersant solution are stored should be permanently set at 68° F. Use a water bath, if available, to maintain constant temperature. (Sediment settling velocity varies 2.3 percent for each degree centigrade change.)
   c) Soak subsample.—Place the smaller subsample in a 250-ml jar with 100 ml of the dispersant solution. Stir with a rod until all of the sediment is thoroughly wetted; crush all lumps. Put cap on jar and shake vigorously. (Do not lose any material.) Soak at least 18 hr.
   d) Remove sand and gravel.—Nest a 0.0625 mm and a 2 mm sieve in a large funnel over a mixing cup. Wash the sample through the sieves with a wash bottle, using no more than 500 ml of distilled water (see paragraph 13). (Do not lose any of the silt and clay). If all of the silt and clay has been washed into the cup from the sand, gravel, and sieves, discard the sand and gravel; if not, dry the sand and gravel and remove the remaining silt and clay with a 0.0625 mm dry sieve, and add this silt and clay to the suspension.
   e) Mix.—Mix the contents of the mixing cup for 5 min with the electric mixer.
   f) Cylinder.—Transfer contents of mixing cup to 1000 ml cylinder. (Be careful not to lose any sediment, such as that sticking to the stirrer or the cup baffles.) Add distilled water until volume is exactly 1000 ml.
   g) Stir.—Using the 22 in. stirring rod, stir the suspension vigorously and let stand for a day in the 68° F room. If it shows no signs of flocculation (see paragraph 15) it is ready for pipette analysis; if it starts to flocculate, redisperse (see paragraph 16) or discard.

8. Pipette analysis.—Use a 20 ml pipette with 10 cm depth marked on its stem (see paragraph 17).
   a) Stir.—Using the stirring rod, stir the cylinder vigorously until all of the sediment has been loosened from the bottom; then stir
for another 60 sec. until all of the material is distributed uniformly throughout the column. End up with long, smooth strokes the full length of the column, from the very bottom until the stirrer base breaks the surface. This is important. As soon as the stirrer emerges for the last time, start the timer.

b) Withdrawal.---At 3 hr 12 min insert the pipette (see paragraph 18) to a depth of 10 cm and withdraw exactly 20.0 ml of suspension. Remove the pipette; expell the suspension into a 50 ml glass beaker; suck up about 10 ml of additional water, distilled, to rinse out the pipette, and expell the water into the same beaker. (A sample for x-ray analysis could be withdrawn at this point)

c) Dry.---Evaporate the beaker to dryness in an oven at approximately 90° C. Remove from oven and let cool in weighing room for several hours, until the sample comes to equilibrium with the moisture conditions of the air in the room. (Take care no dust gets into beaker.)

9. Silt and clay in cylinder.---Make calculations with a sliderule.
   a) Material in beaker.---Weigh the material in the beaker (dried sediment plus dispersant) to nearest 0.001 gm (see paragraph 19); enter weight in column F of data sheet.
   b) Amount of dispersant.---The weight of dispersant in the beaker is (20 ml/1000 ml) (100 ml) (40 gm/liter) = 0.08 gm.
   c) Amount of sediment.---The weight of sediment in the beaker is the total weight of beaker contents (paragraph 9a) minus 0.08 gm, the weight of dispersant in the beaker (paragraph 9b); enter weight in column H of data sheet.
   d) Amount of clay.---The weight of clay in the cylinder is found by multiplying the weight of sediment in the beaker (paragraph 9c) by 50; enter weight in column J of data sheet.
   e) Amount of silt.---The weight of silt in the cylinder is found by subtracting the weight of clay (paragraph 9d) from the total silt plus clay (15.0 gm); enter weight in column K of data sheet.

10. Sample size composition.---The percentages of gravel, sand, silt and clay in the sample is calculated (to two significant figures) as follows:
   a) Gravel.---Divide the weight of gravel in the larger subsample (paragraph 6a) by the total weight of the larger subsample (paragraph 6) and multiply by 100; enter weight in column L of data sheet.
   b) Sand.---Divide the weight of sand in the larger subsample (paragraph 6b) by the total weight of the larger subsample (paragraph 6) and multiply by 100; enter weight in column M of data sheet.
   c) Silt.---Multiply the weight of silt plus clay in the larger subsample (paragraph 6c) by the weight of silt in the smaller subsample (paragraph 9e) times 100 divided by the weight of silt plus clay in the smaller subsample (15.0 gm) times the weight of the larger subsample (paragraph 6); enter weight in column N of data sheet.
   d) Clay.---Multiply the weight of silt plus clay in the larger subsample (paragraph 6c) by the weight of clay in the smaller subsample (paragraph 9d) times 100 divided by the weight of silt plus clay in the smaller subsample (15.0 gm) times the weight of the larger subsample (paragraph 6); enter weight in column P of data sheet.
11. Equipment needed
   Mortar and large rubber stopper
   Jones Sample Splitter
   Scale, accurate to 0.1 gm.
   Scale, accurate to 0.001 gm.
   Oven
   Beakers (1-500 ml, 1-100 ml, and 1-50 ml per sample)
   2 mm sieve (No. 9 Tyler or No. 10 U.S.)
   0.0625 mm (62.5 microns) sieve (No. 250 Tyler or No. 230 U.S.)
   Spray-hose faucet attachment
   Sink with cold-water faucet
   Distilled water (about a liter per sample)
   Wash bottle
   Small (about 4 in.) funnel with small funnel stand
   Large (about 10 in.) funnel with large funnel stand
   Filter papers
   Sodium hexametaphosphate (4 gm per sample)
   Thermometer, wet
   Small (about 250 ml) glass jar with tight cap
   Short glass stirring rod
   Electric malt mixer and mixing cup with baffles conforming
to sec. 2 (b) of American Society for Testing Materials, 1958, p. 83, 84
   1000 ml glass cylinder, 18 in. high, 2½ in. diameter, with
   a 1000 ml mark (1 per sample)
   22 in stirring rod with a 2 in multiholed rubber stopper
   for plunger
   20 ml volumetric pipette (with valved rubber bulb) with 10
   cm depth marked on stem
   Watch with second hand
   Sliderule
   Datasheet

12. Size of smaller subsample.--Determine the correct size of the
   smaller subsample (so that it contains exactly 15.0 gm of silt
   plus clay) as follows: In paragraph 5, split out a smaller
   subsample that is obviously too large; set it aside to be
   reduced to the correct size after the larger subsample has
   been analyzed (paragraph 6), then, the correct size (in grams)
   of the smaller subsample can be calculated by multiplying the
   moist weight of the larger subsample (paragraph 5) by 15.0 and
   dividing by the weight of silt plus clay in the larger subsample
   (paragraph 6c); enter weight in column E of data sheet.

13. Care of screens.--Great care should be taken in handling the
   screens. They are precision instruments and are useless if
   the wire mesh size is altered in any way. After using them,
   they should be carefully cleaned and returned to their cabinet.
   A wet screen can be cleaned by spraying water through both
   sides; warm soap and water may be necessary. A dry screen can
   be cleaned by brushing with a paint brush or by gently tapping

Datasheet
the frame diagonal to the mesh direction. Never use fingers to force material through a screen and avoid placing gravel-sized fragments on the 0.0625 mm sieve.

14. **Dispersant solution.**—Dispersant solution is prepared by adding sodium hexametaphosphate (NaPO₃ or (NaPO₃)₆; "Calgon") to distilled water. The concentration should be 40.0 gm per liter of dispersant solution. New solutions should be dated and should be kept no longer than 1 month.

15. **Flocculation.**—Flocculation is recognized by curdling and rapid settling of clumps of particles, or by the presence of a thick soupy layer which passes abruptly into relatively clear overlying water and assumes a level position when the cylinder is tilted.

16. **Redispersion.**—Redispersion may be attempted by remixing the suspension, varying the amount of dispersant added to the suspension, varying the suspended-sediment concentration, or washing the sediment in suspension. If the suspended-sediment concentration is varied, "15.0" in paragraphs 12, 9e, 10c, and 10d and column K, N, and P of the data sheet should be changed accordingly. If the amount of dispersant added (paragraph 7c) is varied, the middle term (100 ml) in the expression in paragraph 9b must be altered accordingly, as must "0.08 gm" in paragraph 9c and column H of data sheet. Washing of sediment consists of: a) removal of all the sediment from suspension by centrifuging; b) decanting off the clear water (which may contain ions that caused flocculation); c) adding distilled water; d) repeating steps a, b, and c; and e) adding another 100 ml of dispersant solution.

17. **Pipette size.**—If a 25 ml, rather than a 20 ml, pipette is used, "50" in paragraph 9b and column J of the data sheet should be changed to "40".

18. **Withdrawal procedure.**—Grasp the rubber bulb with the left hand; with the right hand, insert the glass stem of the pipette to the proper depth and steady it by resting the right hand on the rim of the cylinder. Then release the rubber bulb with the left hand until the suspension is at the 20 ml mark.

19. **Weighing beaker contents.**—Weight of beaker contents (paragraph 9a) can be determined by using preweighed beakers: the beaker is first thoroughly cleaned and rinsed with distilled water; it is then weighed to the nearest 0.001 gm, and the weight of the beaker or code number is written on the beaker. The weight of the beaker contents is the weight of the preweighed beaker subtracted from the weight of the beaker plus contents. Alternatively a balance with an adjustable zero reading can be used.
20. References


This is a tentative procedure; please note any errors, alterations or improvements.
<table>
<thead>
<tr>
<th>PARAGRAPH</th>
<th>MATERIAL</th>
<th>CALCULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>total moist</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>gravel</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>sand</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>silt &amp; clay</td>
<td>A-B-C</td>
</tr>
<tr>
<td>E</td>
<td>total moist</td>
<td>15(AA)/D</td>
</tr>
<tr>
<td>F</td>
<td>contents of beaker</td>
<td>F-.08</td>
</tr>
<tr>
<td>H</td>
<td>sediment in beaker</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>clay</td>
<td>50H</td>
</tr>
<tr>
<td>K</td>
<td>silt</td>
<td>15.0-J</td>
</tr>
<tr>
<td>L</td>
<td>gravel</td>
<td>100 B/A</td>
</tr>
<tr>
<td>M</td>
<td>sand</td>
<td>100 C/A</td>
</tr>
<tr>
<td>N</td>
<td>silt</td>
<td>100DK/15A</td>
</tr>
<tr>
<td>P</td>
<td>clay</td>
<td>100DJ/15A</td>
</tr>
</tbody>
</table>

DATA SHEET—NDGS STANDARD PROCEDURE A-65
GRAVEL-SAND-SILT-CLAY ANALYSIS
REFERENCES CITED


