How to Identify and Properly Classify Drill Cuttings

(Creating Useful Borehole Logs)

Dave Larson
Hydrogeology and Geophysics Section

ILLINOIS STATE GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Accurate information about the borehole location and a careful description of the geologic materials encountered and their depths make a borehole log useful.

- Information can be retrieved long after the borehole has been drilled
- Performance of a closed-loop geothermal system can be linked to the subsurface geology
- Information can be shared with others – drillers, geoscientists. Commonly accepted terms to describe geologic materials helps in sharing information.
Background

Education
BA, Geology, 1970; Fredonia State College (SUNY); Fredonia, New York
MS, Geology, 1976; University of Nebraska; Lincoln, Nebraska

Experience
1991-present, Hydrogeologist, Illinois State Geological Survey; Champaign, Illinois
1974-1976, Research Hydrogeologist, Conservation and Survey Division, University of Nebraska
Drilling in North Dakota
Drilling in central Illinois
Drilling a borehole is an exploration of the unknown.

Some insight about what geologic materials might be found at a drill site can be gained from available information, but surprises should be expected (flowing borehole or lost circulation)

Some sources of available information:

Results of drilling that’s been done in an area (ILWATER for water-well records).

Searching the Illinois State Geological Survey’s website (www.isgs.illinois.edu) by county, for example.

ISGS statewide maps:

A) Drift thickness map – shows the thickness of deposits overlying bedrock.

Provides information about the depth to bedrock; the information should be verified for specific locations of interest.

Available online as a PDF file.
B) Bedrock geology map – shows the type of rock that’s at the bedrock surface and the formation name associated with the rock.

The information can be used to look into the thickness of bedrock at locations of interest.

Available online as a PDF file.

Hard copy can be purchased
Information that’s more site-specific is available from water-well records; accessed online through ILWATER at www.isgs.Illinois.edu
Record for a water well located in Tazewell County

Driller’s description of geologic materials encountered in the borehole with depths

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>black dirt</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>brown sandy clay, some gravel</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>brown dirty sand, some clay &amp; boulders</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>soft blue clay, some sand</td>
<td>11</td>
<td>62</td>
</tr>
<tr>
<td>very dirty sand, some gas</td>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>blue clay, soft &amp; sandy</td>
<td>65</td>
<td>85</td>
</tr>
<tr>
<td>dry gray sand &amp; gravel, very coarse</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>gray wtr s.coarse w/gvl &amp; med/f sand</td>
<td>87</td>
<td>98</td>
</tr>
<tr>
<td>med to coarse sand</td>
<td>98</td>
<td>103</td>
</tr>
<tr>
<td>med to coarse sand with fine gravel</td>
<td>103</td>
<td>109</td>
</tr>
<tr>
<td>sandy green clay</td>
<td>109</td>
<td>114</td>
</tr>
<tr>
<td>shale at</td>
<td>114</td>
<td>114</td>
</tr>
</tbody>
</table>

Total Depth: 114 feet

Casing: 4" STANDARD BLACK from 4' to 106'

Screen: 3' or 3.75" diameter 35 slot

Water from sand & gravel at 106' to 109'.

Static level 88' below casing top which is 1' above GL

Pumping level 88' when pumping at 12 gpm for 2 hours

Driller's Log filed

Owner Address: 201 S. Louisiana Morton, IL

Location source: Location from permit

Permit Date: December 17, 1968

| COMPANY | Ebert, Robert H |
| FARM    | Benbow, George L |
| DATE DRILLED | February 1, 1969 |
| ELEVATION | 0 |
| LOCATION | 400'S line, 200'W line of NE |
| LATITUDE | 40.576272 |
| LONGITUDE | -89.578681 |
| COUNTY | Tazewell |
| API | 121790047800 |
The goal of identifying, describing, and classifying drill cuttings is to understand the subsurface geology – the sediments or bedrock present at the site, and the depth and thickness of the layers of sediment or rock.

Do the cuttings accurately represent the geologic materials encountered?

Soft silt and clay may dissolve into the drilling mud

Hard clay may appear as small cuttings

Very fine to fine sand will be entrained in the drilling mud

Coarser sand and gravel can be broken into smaller pieces

Sediment may become sorted during travel to the top of the borehole

Sediment already drilled through can continue to be present in the samples from deeper in the borehole

Drilling practices affect the size and presence of cuttings
Drill cuttings are usually identified, described, and classified by touch and sight. Field aids are commercially available that can help with selecting commonly used terms and identifying a systematic process for describing cuttings. The goal is to have consistent logs from one borehole to the next.

- Sand gauge available online
- Grain sizes with samples
- Terms for thickness

Terms used to describe clastic geologic materials refer to grain size; grain size is the basis for classification.

**Unconsolidated materials**
- Clay
- Silt
- Sand
- Gravel
- Cobbles
- Boulders

Grain size increases.

**Bedrock**
- Shale
- Claystone
- Siltstone
- Mudstone
- Sandstone
- Conglomerate

Grain size increases.

Other types of bedrock include limestone, dolomite, and coal.
- Limestone consists of calcium carbonate and fossils.
- Dolomite is magnesium calcium carbonate.
<table>
<thead>
<tr>
<th>Geologic Material</th>
<th>Grain Size</th>
<th>Bedrock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>&gt;10.08&quot;</td>
<td></td>
</tr>
<tr>
<td>Cobble</td>
<td>2.52&quot; – 10.08&quot;</td>
<td></td>
</tr>
<tr>
<td>Very coarse gravel</td>
<td>1.26&quot; – 2.52&quot;</td>
<td></td>
</tr>
<tr>
<td>Coarse gravel</td>
<td>0.63&quot; – 1.26&quot;</td>
<td></td>
</tr>
<tr>
<td>Medium gravel</td>
<td>0.31&quot; – 0.63&quot;</td>
<td></td>
</tr>
<tr>
<td>Fine gravel</td>
<td>0.16&quot; – 0.31&quot;</td>
<td></td>
</tr>
<tr>
<td>Very fine gravel</td>
<td>0.08&quot; – 0.16&quot;</td>
<td></td>
</tr>
<tr>
<td>Very coarse sand</td>
<td>0.04&quot; – 0.08&quot;</td>
<td>Sandstone</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>0.02&quot; – 0.04&quot;</td>
<td></td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.01&quot; – 0.02&quot;</td>
<td></td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.005&quot; – 0.01&quot;</td>
<td></td>
</tr>
<tr>
<td>Very fine sand</td>
<td>0.002&quot; – 0.005&quot;</td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td>0.0002&quot; – 0.002&quot;</td>
<td>Siltstone, Mudstone</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt;0.0002&quot;</td>
<td>Shale, Claystone</td>
</tr>
</tbody>
</table>

Classification by grain size
Identifying the type of geologic material:

Sand and small gravel can be seen

Large gravel, cobbles, and boulders typically show up as freshly broken, angular pieces

If they survive the trip up the borehole, clay cuttings are typically smooth, silt cuttings less so; clay and silt typically occur as clayey silt or silty clay.

Ease and smoothness of drilling can help identify the geologic material - clay and silt vs sand and gravel or unconsolidated sediment vs bedrock
Quarries, sand and gravel pits, and outcrops show that geologic materials usually consist of a variety of grains sizes and several types. In order to describe geologic materials more completely, other terms are added to those that refer to grain size.
Additional terms used to describe drilling cuttings

Sand and gravel may have a range of grain sizes because it was deposited by flowing water. The range is identified by size end members. The most abundant size is also specified. Sorting describes the distribution and relative abundance of grain-size intervals; sorting varies from very poorly to very well sorted.

Very poorly sorted = many grain sizes
Very well sorted = few grain sizes
Well sorted to moderately well sorted sand
directly overlying poorly sorted sand and gravel

Cuttings of clay if they can be found in the drilling fluid are usually described in terms related to consistency:

- soft
- hard
- smooth
- gritty
- stiff
- cohesive
- plastic

Determined by feel – squeezing the cutting between thumb and forefinger

http://scienceisgrowing.blogspot.com/2011/06/agbcs-s-is-for-sensational-soil.html
Geologic materials commonly are found as combinations of grain sizes: clay, silt, sand, gravel, cobbles, and boulders.

Terms in classification systems based on grain size provide names for these combinations.

Example: Folk’s classification system for clay, silt, and sand; note that the size of sand is not part of the system.

Terms such as clay and sand, gravel and clay, etc. can be ambiguous. Do they refer to layers or mixtures? If it’s layers, what is the thickness of the layers? How abundant is each sediment type?

http://geology.about.com/od/sediment_soil/ss/Folk-Sediment-Classification.htm
Other commonly used terms for mixtures of geologic materials:

Till - an unsorted mixture of clay, silt, sand, gravel, cobbles, and boulders; proportions typically vary from till to till

http://anconafamily.com/gallery/main.php?g2_itemId=3710
A useful borehole log describes the geologic materials encountered when the borehole was drilled, and provides the depth and thickness of each layer of geologic material.

Thermal conductance is the capacity of geologic materials to transmit heat. It is related to the type, porosity, and degree of saturation of material.

The estimate of thermal conductance for a borehole based the geologic materials found in the borehole (descriptions of cuttings) may be more representative than applying an average thermal conductance value for the entire borehole. Incorporating the more representative value into the design of the geothermal system may improve efficiency of the system while helping to reduce costs.

Which of the variety in range of values and averages available better reflect the thermal conductance of the geologic materials found in Illinois? Would having values specific to Illinois benefit the geothermal industry in Illinois?

What information can the ISGS provide to geothermal industry in Illinois?
Using ILWATER
www.isgs.Illinois.edu

2015 Naturally Illinois Expo
The Prairie Research Institute presents the sixth Naturally Illinois Expo on a new date this year and at a new location: April 17-18, 2015 at the University of Illinois Research Park. [...]
Illinois Water Well (ILWATER) Interactive Map

The ISGS is an official repository for records of wells drilled in the state of Illinois. Paper records are archived for over 700,000 wells. Some of these records go back as far as the late 1800s. Water and related well data can be accessed for private water wells, engineering borings, and stratigraphic borings. Contact Bill Dey, by email (wdley@illinois.edu) or phone 217-244-2779, with any questions about water well records, and for assistance using the ILWATER application.

Illinois Water and Related Wells Web Mapping Applications (ILWATER)

NEW ArcGIS Server-based Web Mapping Application - The new ILWATER application was built using Esri ArcGIS for Server version 10.1, Esri’s ArcGIS API for Flex version 3.3, and the Adobe Flex SDK 4.6.0. The application software and hardware are updated as necessary to provide greater stability and more functionality for our users.
<table>
<thead>
<tr>
<th>Private Water Well</th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>clay</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>clay and sand</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>gray mud</td>
<td>15</td>
<td>31</td>
</tr>
<tr>
<td>gray slate</td>
<td>31</td>
<td>45</td>
</tr>
<tr>
<td>coal</td>
<td>45</td>
<td>49</td>
</tr>
<tr>
<td>gray slate</td>
<td>49</td>
<td>55</td>
</tr>
<tr>
<td>lime</td>
<td>55</td>
<td>57</td>
</tr>
<tr>
<td>gray slate</td>
<td>57</td>
<td>78</td>
</tr>
<tr>
<td>coal</td>
<td>78</td>
<td>82</td>
</tr>
<tr>
<td>dark slate</td>
<td>82</td>
<td>113</td>
</tr>
<tr>
<td>lime</td>
<td>113</td>
<td>116</td>
</tr>
<tr>
<td>gray slate</td>
<td>116</td>
<td>180</td>
</tr>
</tbody>
</table>

**Total Depth**

Casing: 5" PVC from 2' to 180'

Size hole below casing: 0"

Water from sand at 5' to 120'.

Static level 16' below casing top which is 2' above GL

Pumping level 160' when pumping at 2 gpm for 0 hours

Permanent pump installed at 160'

on September 8, 1986, with a capacity of 5 gpm

Owner Address: R.R.#2 Belle Rive, IL

Location source: Location from permit

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**Permit Date:** August 27, 1986  
**Permit #:** 126429

**COMPANY:** Specht, James

**FARM:** Dulany, Vernon

**DATE DRILLED:** September 5, 1986

**ELEVATION:** 0

**LOCATION:** NE NE SW

**LATITUDE:** 38.263256  
**LONGITUDE:** -88.712995

**COUNTY:** Jefferson  
**API:** 120812445500  
**13 - 3s - 4E**
Statewide information available from the Illinois State Geological Survey

Geology of Illinois

Published in celebration of the Survey’s Centennial (1905-2005)
GLACIAL DRIFT IN ILLINOIS:
THICKNESS AND CHARACTER

Kemal Piskin
Robert E. Bergstrom

Revision of Circular 416

ILLINOIS STATE GEOLOGICAL SURVEY
Jack A. Simen, Chief
Urbana, Ill. 61801
CIRCULAR 490 1975
Geothermal Alliance of Illinois
2015 Conference
Thank You