Borehole Logging from Sample Collection to Borehole Geophysics

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Type of Activity: Hands-on sample identification and geophysical correlation lab.
Lab Activity: Borehole Logging from Sample Collection to Borehole Geophysics
Brief Description of Lab Activity: Drilling the borehole is only the beginning. Data collection, handling and interpretation are the most important aspects to the field hydrogeologist. This session will use an exercise that combines both physical soil samples and borehole geophysical logs to build an interpretation of the subsurface.

Context

Type and level of course in which I use this activity: Entry level hydrogeology course for both major and non-majors; pre-requisites include Geology 101 lecture and lab.

Skills and concepts that students must have mastered before beginning the activity: Students should have had basic mineralogy and physics so that they can begin to understand borehole geophysics and its relationship to both grain size and mineralogy.

How the activity is situated in my course: This lab activity is one of many field/laboratory exercises that students conduct over the course of a semester.

Goals of the Activity or Assignment

Concept(s) goal(s) for this lab activity:

1. Accurate description of logged soil samples, especially of features with which the students are unfamiliar.
2. Recognition of grain size variation, texture, color and mineralogy as it changes with depth.
3. The integration of sample description/classification to porosity and permeability measurements or observations.

Higher order thinking skills and goals for this lab activity:

1. In many cases the use of samples involves descriptive analysis and, in some cases, may involve problem solving through the integration and synthesis of previously presented material – Thinking!
2. Formulation of hypotheses, especially multiple hypotheses that might explain the features described.

Other skills and goals for this lab activity:

1. Note taking and sketching: How to carefully make a written description with a logical organization.
2. May include oral communication of ideas and working in groups.

Description of Lab Activity:

In January of 2003, CSUF drilled and completed a deep multiport-monitoring well on the north side of campus. This was done in order to gain a better understanding of the local subsurface geology and groundwater conditions in and around CSUF. Samples were collected from the drill hole (boring) every 5-feet. The total depth of the well is 870 feet below ground surface (grade). Borehole geophysical data (E-log) information was collected from the boring prior to the installation of the well pipe. As you describe the soil samples, compare and contrast your findings to those of the geophysical signature (gamma-ray log) found in the accompanying "E-log" for the boring.

1. Complete a boring log with sample description for all samples collected.

    a) Use Mussel Color Charts to describe the color.
    b) Use a grain size ruler to describe the make up of the samples.
    c) Use the Unified Classification Scheme to describe samples.

2. Describe the samples based on porosity and permeability.

    a) Use your best judgment to describe the variability in permeability with depth.
    b) Describe how water would move through the soil column (your sample).

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

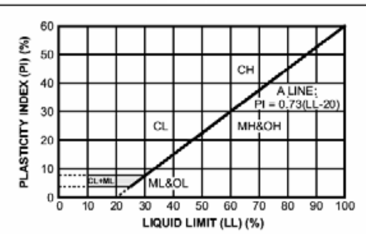
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

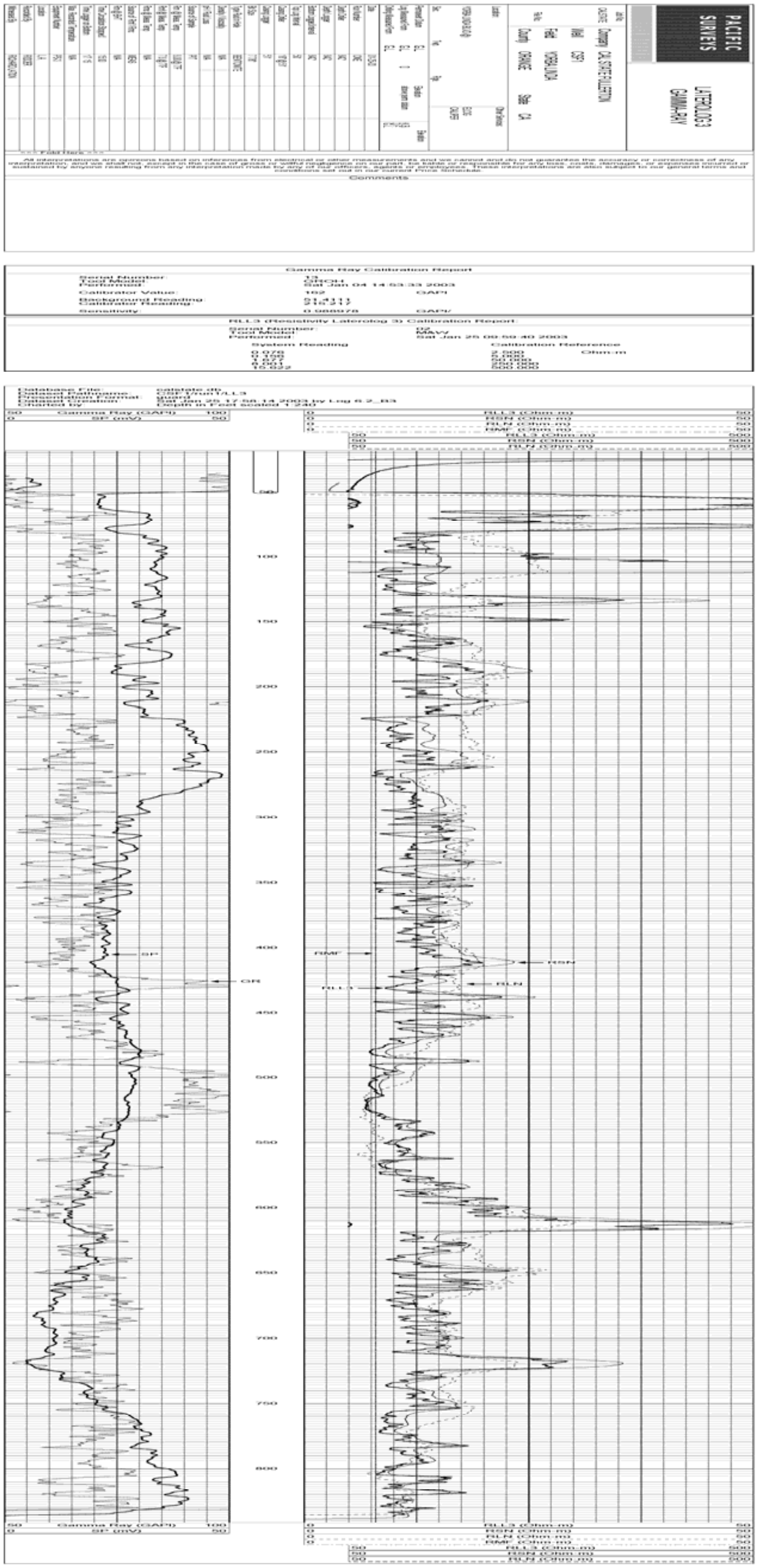
Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent .... GW, GP, SW, SP
More than 12 percent .... GM, GC, SM, SC
5 to 12 percent .... Borderline cases requiring dual symbols

PLASTICITY CHART



Type up your report and include the well log(s) and comparison of your description to those of the geophysical "E-log".



Geophysical Log of CSUF-1 well.

BORING / WELL LOG DATA SHEET

PROJECT:	**WELL/BORING NO.:**
LOCATION:	**DATE DRILLED:**
DRILLING METHOD:	**TOTAL DEPTH DRILLED:**
GROUND ELEVATION:	**REMARKS:**
DEPTH TO WATER:	
WATER LEVEL ELEVATION:	

LOGGED BY: **[PAGE of]**

PHYSICAL DESCRIPTION

Depth	USCS	Color	FORMATION DESCRIPTION	Well Diagram

Evaluation

The students construct a complete well log including descriptions of each hand sample. For each identified unit, students are to describe the geophysical response to the unit and explain its physical properties as they are related to permeability. This description is written into a short narrative.

Supporting references / URL's:

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