Standard Operating Procedure No. 42

Porosity

REVISION LOG		
Revision Number	Description	Date
42.0	Original SOP	11/26/03
42.1	Revisions by PJP	1/15/04
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42v1	Edits by LMK	10/11/05
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1. PURPOSE AND SCOPE

This Standard Operating Procedure describes the method for determining porosity, which is the volume of void space in a sample of porous media. Porosity is a measure of the maximum volume of water a sample of porous media can contain. Effective porosity, a related concept, is the pore volume (proportion of porosity) through which significant flow and transport occur, that is, total porosity minus the volume of very small and "dead end" pores. Knowledge of porosity and/or effective porosity is critical for calculating other important parameters, e.g., volumetric moisture content (SOP 35), bulk density (SOP 32), and degree of saturation, as well as modeling flow and solute transport under saturated or unsaturated conditions.

A large variety of methods exist for measuring porosity in the wide array of earth materials, see Danielson and Sutherland [1986] for examples. This SOP describes a method for determining porosity (as opposed to effective porosity) using a relatively simple laboratory gravimetric method suitable for sample volumes of 20 cm^3 or more of sedimentary material of any grain size. Knowledge of the sample's total volume (obtained in SOP 32 using the wax clod method) or its bulk density (SOP 32) is needed to calculate porosity using this method.

2. RESPONSIBILITIES AND QUALIFICATIONS

The Team Leader and Characterization Team will have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate staff to implement this SOP and for ensuring that the procedures are followed accurately.

All personnel performing these procedures are required to have the appropriate health and safety training. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP, and to receive specific training regarding these procedures if necessary.

All environmental staff and assay laboratory staff are responsible for reporting deviations from this SOP to the Team Leader.

3. DATA QUALITY OBJECTIVES

This SOP address objectives 1 and 7 in the data quality objectives outlined by Virginia McLemore for the "Geological and Hydrological Characterization at the Molycorp Questa Mine, Taos County, New Mexico".

- Determine how the hydrogeochemistry and water balance dynamics influence rock pile weathering and stability.
- Determine if pyrite oxidation, moisture content, and microbe populations affect rock pile weathering and stability.

4. RELATED STANDARD OPERATING PROCEDURES

The procedures set forth in this SOP are intended for use with the following SOPs:

- SOP 1 Data management (including verification and validation)
- SOP 2 Sample management (including chain of custody)
- SOP 4 Taking photographs
- SOP 5 Sampling outcrops, rock piles, and drill core (solid)
- SOP 32 Bulk Density
- SOP 35 Volumetric moisture content
- SOP 40 Gravimetric moisture content

The procedures set forth in this SOP are also intended for use with the drill plans and sampling plans.

5. EQUIPMENT LIST

The following materials are required to measure porosity in the laboratory:

- Scale or balance, capable of measuring to within .01 grams
- Weights to calibrate scale
- Aluminum weighing tares
- Saturation chamber
- Dessication chamber (a dry vacuum saturation chamber will also work)
- Vacuum pump
- Water de-aerator
- Tubing and valves to connect the saturation chamber to the de-aerator and the vacuum pump.
- Water with the appropriate ionic composition. Do not use deionized or distilled water.

6. SAMPLE PROTECTION

Each samples must be protected during porosity measurements so that it does not lose mass or void volume, will allow easy ingress and egress of air and water, and can be weighed accurately. The sample must be protected on its sides and on the bottom to prevent loss of sample integrity by disaggregation or slumping during measurements.

The sample's sides must be enclosed in a lightweight, nonporous material that is fairly rigid, such as a coring cylinder, metal ring, or epoxy sheath. The weight of the enclosure should be known to within 0.01 g. Measuring the volume of the enclosure may also be necessary for other measurements such as bulk density (SOP 32).

The sample bottom should be enclosed by a filter mesh or similar material which prevents sediment loss, allows water to enter, and does not hold a significantly volume of water relative to the pore volume. Filter papers can hold a relatively large volume of water and so should be used with care or not at all. The saturated weight of the filter mesh should be measured several times and the values averaged.

Sample volume and shape must be rigorously maintained throughout the collection, transport, and laboratory analysis steps.

Refer to SOPs 1, 2, 32, 35, and 40 for relevant requirements regarding the collection, labeling, preservation, and transportation of samples.

7. PROCEDURES

1. Calibrate scales using standard weights.
2. Log samples into laboratory, following Chain of Custody procedures, SOP 2.
3. Measure the weight of the sample sleeve, holder, expoxy sheath or other protection used to within 0.01 g.
4. Measure and record the oven-dry weight of the sample and container to within 0.01 g by drying it in an oven at 105 degrees C for 24 hours (see SOPs 32, 35, or 40).

5. Cool sample to room temperature in a dessication or vacuum chamber.
6. Place the sample on the tray within the dry saturation chamber.
7. Evacuate the saturation chamber with the vacuum pump.
8. De-aerate a sufficient quantity of water (do not use de-ionized or distilled water for this procedure) according to the de-aerator manufacturer's directions.
9. Slowly introduce the deaerated water into the bottom of the evacuated saturation chamber to prevent splashing.
10. Continue to introduce water into the chamber until the water level is roughly 1 cm above the sample bottom. Do not allow the water level to reach the top of the sample.
11. Re-evacuate the saturation chamber with the vacuum pump and allow the sample to saturate. Sandy samples may saturate within an hour or two whereas finer-grained materials may require 24 hours or more to saturate.
12. Carefully weigh the saturated sample to within 0.01 g. Subtract weight of water in saturated filter mesh. Record the weight as container + sample saturated weight.
13. Calculate water volume:
    (sample saturated weight – sample dry weight) * water density
14. Porosity (cm^3/ cm^3) = water volume / sample volume.
    or water volume / (sample dry weight / bulk density)

8. QUALITY ASSURANCE/QUALITY CONTROL

Verify accuracy of thermometer and scale. Laboratory scales should be calibrated using standard weights prior to measuring. Oven temperature should be checked and maintained to within 5 degrees C. Minimize sample handling and record all losses of sample mass (spalled grains, sample tipped and spilled, etc.)

9. DOCUMENTATION

Data fields to be captured using a form in the database should include the following

Hole_ID
Test_pit_ID
Sample Field_ID
Elevation (ft)
Depth (m)
Date sample collected
Time sample collected
Collector's initials
Location (feature ID, UTM coords, description, etc.)
Sampling method description
Disturbed or undisturbed sample?
Repacked sample? Y/N
Container+sample dry weight (g)
container+sample saturated weight (g)
sample dry weight (g)

sample saturated weight (g)
container weight (g)
sample water weight (g)
sample volume (cm^3)
source of volume (indicate measured in lab, estimated from bulk density, etc.)
sample porosity (cm^3/cm^3)
Lab ID
Date analyzed
SOP number
Deviation from SOP
Analyzed by (initials)
Comments
Reference

10. REFERENCES

Danielson, R.E. and P.L. Sutherland, 1986, Porosity, in *Methods of Soil Analysis Part 1. Physical and Mineralogical Methods*, Agronomy Monograph no. 9, Soil Science Society of America, Madison, WI, USA, p. 443-461.

Hillel, D., 1998, *Environmental Soil Physics*, Academic Press, New York, p.12-15.

Jury, W.A., W.R. Gardner, and W.H. Gardner, 1991, *Soil Physics*, John Wiley and Sons, New York, p.29.