NYE COUNTY NUCLEAR WASTE
REPOSITORY PROJECT OFFICE

TECHNICAL PROCEDURE

TITLE: PETROGRAPHY AND MODAL ANALYSIS PROCEDURE	Revision: 0 Date: 09-25-00 Page: 1 of 8
PROCEDURE No.: TP-8.5	SUPERSEDES: DRAFT, 02-23-95
APPROVAL [signature] 12.11.00 Project Manager Date	CONCURRENCE [signature] Principal Investigator Date [signature] 15 DEC 2000 Project Quality Assurance Officer Date

1.0 PURPOSE

The purposes of this procedure are to standardize the petrographic descriptions and to describe the modal point count method for determining the volume of identified mineral constituents in a thin section or polished section using a petrographic microscope.

2.0 SCOPE

This procedure covers all petrography and modal analysis performed on samples collected by the NWRPO independent oversight-drilling program.

2.1 APPLICABILITY

This procedure is applicable to mineralogic, whole rock, and/or textural descriptions, megascopic and/or microscopic made by standard optical methods. These include but are not limited to: unaided visual observation, hand lens, binocular microscope, petrographic or biological microscope, confocal microscope, color video camera magnified computer scanning system imagery with and without microscopic interface. This procedure also provides for modal point counting of volcanic, volcaniclastic, and other igneous and sedimentary rocks including volcanic glass, minerals, and associated constituents. The external procedure will be sent to GMI prior to making thin sections. A thin section request form will be filled out for samples that are sent out for preparation.

2.2 TRAINING

The Preparer will be trained to this procedure before conducting work, and will document they have read and understand this procedure. Documentation of training will be submitted to the NWRPO Quality Assurance Records Center (QARC). Advanced graduate school training in igneous, metamorphic and sedimentary petrography and petrology are required. The PI is considered trained to this procedure and may train other qualified personnel.

3.0 DEFINITIONS

N/A

4.0 RESPONSIBILITIES

4.1 The relevant NWRPO Principal Investigator is responsible for the preparation of this procedure.

4.2 The Project Quality Assurance Officer is responsible for oversight of the review, issuance, and change control of this procedure.

4.3 The principal investigator is responsible for the implementation of this procedure.

5.0 PROCESS

General - The principles of petrographic analysis and modal analysis are referenced in Williams, Turner, and Gilbert, 1954; Pettyjohn, 1949; Huang, 1962; Folk, 1968; Jones and Fleming, 1965; Tickell, 1965; Smith, 1960; Middlemost, 1985; Moorhouse, 1959; Ross and Smith, 1961; Kerr, 1977; and Hutchison, 1977.

Modal analysis is based upon a grid system with data point intercepts evenly spaced along parallel traverse lines across the sample. Lines can be spaced 0.5mm apart and points counted at 0.25-mm stops. The mineral or object under the cross hairs of the ocular is identified and counted. Other data is also collected from the mineral. It is possible to use different line spacing and point stops spacing along the line for different analyses. Minimum distances are 0.1 mm for each. Magnification used is the choice of the operator.

5.1 EQUIPMENT

Modal analysis is accomplished on any standard research petrographic microscope with a manual mechanical stage with mm-graduated x-y stage translation controls to move the thin section.

Petrographic descriptions can be obtained by unaided visual observations, by hand lens, binocular microscope, petrographic or biological microscope, confocal microscope, color video camera magnified computer scanning system imagery with and with out microscopic interface, among a variety of other techniques and situations. Photographs, diagrams, video camera tiff files, and videotape files can be used to support petrographic observations.

5.1.1 Calibration Requirements

Semi-quantitative calibration of the magnification of each microscope is done with the use of micron scale microscope slides. The scale for each magnification is taped to the microscope. Calibration is not required for the mechanical stage, but the semi-quantitative calibration is done to check the x and y scales on the stage. This is accomplished by measuring the size of an object under the microscope and then moving the stage by an increment and using that object as a scale of measurement. This only needs to be done when setting up the mechanical stage for the first time on the microscope. If there is a deviation of the scale it should be noted on the microscope itself and in the laboratory notebook. These calibrations are not as critical as the total number of points counted for calculating percentages of constituents. They are important for the grain size distribution data

5.2 PREPARATORY VERIFICATION

Sample tracking is handled by TP-8.2, "Thin section Preparation Procedure" and TP-8.3 Sample Collection, Identification and Control for Mineralogy-Petrology Studies.

There are no special environmental conditions specified.

5.3 DATA TO BE RECORDED

Petrographic descriptions are quantitative and in some situations descriptive. Photographs and other visual data can be used to map the thin section and to document identifications or other petrographic observations. Quantitative petrographic descriptions include, but not limited to, point counting (modal analysis), grain size for each mineral species, grain shape and or textural data for each mineral species, inclusions in the grains, overgrowths, intergrowths, and other morphological data including mineral associations, pore space, vugs, fractures, among other properties. Sedimentary grain mounts may be viewed in reflected light to observe the surface coating and textures of the grains. Weathered igneous rocks may be viewed in the same way. Thin sections with and without cover slips may be observed in plane light, plane polarized light and in cross nichols. Phase contrast may be used. In all descriptions, the conditions of the light will be described.

Petrographic descriptions are completed in a laboratory notebook. Description data are also collected on a Petrography Analysis Form. The purpose of a description analysis shall be noted at the start of the description. All documenting photographs, sketches and electronic tiff files will have a scale (metric) and a label giving the sample number. Ambiguous mineral identifications should be noted with a "?" after the identification. The location of that unknown mineral in the thin section should be noted in a foot note and a documenting picture and/or map tiff file should be taken.

Definitions of textural, mineralogical and morphological properties will be found in standard books (see references). For modal analysis a standard spacing for traverse lines and stops can be used as is described in section 5.0. It is also possible to determine the spacing of data collection based upon the median diameter of the phenocrysts (in tuffs) or mineral grains. For Tuffs from Yucca Mountain, phenocrysts smaller than 0.03 mm are considered as being groundmass. Therefore 0.03 maximum diameter and larger grains are counted. Groundmass is counted as groundmass to ascertain the percentage of phenocrysts in a rock. Traverse lines are taken at 0.50 mm apart and point counting locations on the traverses are spaced at 0.1 mm apart. These are standard settings for this program for Yucca Mountain Tuffs. Other rock types and sediments are point counted with different settings. In most cases the settings chosen are on the basis of median grain size and the purpose behind the description. The magnification used during point counting is the operator's choice. There should be sufficient magnification to acquire conoscopic images (optical interference figures) for mineral identification. This maybe difficult for phenocrysts in the fine sand to silt grain size range. Point counting analysis is started on one side of the thin section and point spacing is 0.1 mm apart. At the end of the first traverse the stage is moved 0.5 mm and the second traverse is started traveling along the x-axis in the opposite direction of the first traverse. During the point count it is common to acquire additional information such as phenocrysts size in mm, the presence of microcrystallites, grain shape among a variety of information. Data is therefore hand tabulated during the point count so that specific information is transferred to the logbook and to the Petrography Analysis form.

In many cases during modal analysis rare or accessory minerals are observed but they do not occur under the cross hairs and therefore they are not counted in the point count. Accessory minerals occur generally in Yucca Mountain tuffs as less than 0.5 mm in size. These minerals are allanite, apatite, perrierite, sphene, and zircon. In some cases the sphene and the allanite are larger. When these minerals are observed as being present and have not been point counted they are classified as trace constituents as long as they are in the phenocryst size range. If they are smaller than the phenocryst size range, they are described as being constituents of the groundmass.

Data processing is straightforward and is expressed as volume percent and as percentage ratios. The basic data recorded for modal analysis is as follows (additional data may also be collected):

a) Total number of points and spacing.
b) Mineral species volume percent of total phenocrysts.
c) Total phenocryst volume to groundmass.
d) Phenocryst species grain size distribution (as a histogram).
e) Grain shape distribution for each phenocryst species.
f) Tensile and shear fracturing observed.
g) Rare and accessory minerals observed and not counted.
h) Authigenic mineral coatings and stains on minerals and groundmass.
i) Vapor phase mineralogy
j) Megascopic description of specimen
k) Location of specimen
l) Specimen number
m) Stratigraphic depth and formation if possible.
n) Petrographer and date

5.3.1 Deviation from Procedure

Any deviation of methodology for optical petrography or modal analysis should be documented in the controlled laboratory notebook.

5.4 SAMPLE/SITE TRACEABILITY

Sample traceability is controlled by NWRPO Technical Procedures: TP-8.2 and TP-8.3.

Site location for field petrographic descriptions will be based upon records kept in the field notebook, associated maps and field photographs.

5.5 DATA ACQUISITION METHODOLOGY AND LIMITATIONS

Petrographic analysis requires a high level of skill and training, which can only be gained from extensive practice. Petrographic analyses are considered acceptable as descriptive data. Some mineral identifications are difficult and identifications may be in error.

Rejection of portions of a description or petrographic analysis (usually due to misidentification of a mineral) should result in the reanalysis by the same or another analyst. The reanalysis should refer to the original case and should revise that information. X-ray diffraction analysis, electron microprobe analysis, transition electron microscope electron diffraction analysis, and scanning electron microscopic analysis with dispersive or non-dispersive analysis can make confirmation of a mineral identification. Other equipment can be used to assist in obtaining a proper identification of a mineral.

6.0 REFERENCES

NWRPO Quality Assurance Program Plan

- Williams, H., Turner, F.J., and Gilbert, C. M. (1954) Petrography. W.H. Freeman and Co., San Francisco, 406 pp.
- Pettyjohn, F. J. (1949) Sedimentary Rocks. Harper &Row, New York, 718 pp.
- Huang, W. T. (1962) Petrology. McGraw-Hill, New York, 480 pp.
- Folk, R. L. (1968) Petrology of Sedimentary Rocks. Hemphill's, Austin, Texas, 170 pp.
- Jones, M. P., and Fleming, M. G. (1965) Identification of Mineral Grains.Elsevier, Amsterdam, 102 pp.
- Tickell, F. G. (1965) The Techniques of Sedimentary Mineralogy. Elsevier, Amsterdam, 220 pp.
- Smith, R. L. (1960) Zones and zonal variations in welded ash flows. U.S.Geol. Survey Prof. Paper 354-F, p.149-159.
- Ross, C. S. and Smith, R. L. (1961) Ash-flow tuffs: Their origin, geologic relations and identification. U.S.Geol. Survey Prof.Paper 366, 81pp.
- Middlemost, E. A. K.(1985) Magmas and Magmatic Rocks. Longman, London, 266 pp.
- Moorhouse, W. W. (1959) The Study of Rocks in Thin Section. Harper &Row, New York, 493 pp.
- Kerr, P. F. (1977) Optical Mineralogy. 4th Ed., McGraw-Hill, New York 492 pp.
- Hutchison, C. S. (1977) Laboratory Handbook of Petrographic Techniques. John Wiley & Sons, New York, 527 pp.

7.0 RECORDS

Petrographic and modal descriptions and data are recorded in the laboratory notebook. Field descriptions are noted in the field logbook. A Petrography Analysis Form is filled out for each and every petrographic analysis, either in the laboratory or in the field. Maps, photographs, and video tiff files are marked with sample number, location number, and date.

Petrographic Analysis Form

8.0 ATTACHMENTS

Petrographic Analysis Form

PETROGRAPHY ANALYSIS FORM

Sample No.:	**Date:**
Name:	**Organization:**
Field Sample Location:	**Formation:**
Core/Cuttings Sample:	**Depth:**

MEGASCOPIC DESCRIPTION:

MICROSCOPIC DESCRIPTION

Modal Analysis: Y___ N____ **Traverse Spacing:** **Spot Spacing:**

Total Number of Points Counted: **Tensile Fractures:**

Groundmass: % **Phenocryst: %** **Shear Fractures:**

Authigenic Mineralogy Remarks: carbonates:

oxyhydroxides:

clays: sulfides:

zeolites: sulfates:

opal CT opal A salts: Other:

Vapor Phase Mineralogy Remarks: Cristobalite Calcite

Accessory Minerals Observed: sphene allanite

Perrierite zircon apatite

Sedimentary Grains Remarks: Frosting on

Qtz rounded % Qtz angular % Qtz./Feld. Other:

Component	No. Grains	%	Max. Grain Size	GrainShape
Sedimentary Rock Fragment				
Metamorphic Rock Fragment				
Igneous Rock Fragment				
Quartz				
Plagioclase Feldspar				
Potash				
Feldspars				
Cristobalite				
Opal CT				
Volcanic glass				
Mica				
Clays				
Iron Oxyhydroxides				
Manganese Oxyhydroxides				
Clinoptililite-Heulandite				
Mordenite				
Analcime				
Calcite				
Hornblende				
Magnetite-titanomagnetite				
Other				