LOS ALAMOS NATIONAL LABORATORY

YUCCA MOUNTAIN PROJECT
CHANGE REQUEST

CHANGE REQUEST NO. 135
DATE 3/26/90

UNCONTROLLED COPY
NO. ______

PROCEDURE No. TWS-ESS-DP-102, R2

CHANGE REQUESTED:

Add a signature line for the Principal Investigator on the cover page. (An amended cover page is included as Attachment 1.)

REASON FOR CHANGE:

To conform to CR 088, QP 5.2, R2.

Since the Principal Investigator is D. Vaniman, who also is the Technical Reviewer, this change should be considered minor.

CHANGE REQUESTED BY Stephen Bolivar DATE 3/26/90

REVIEWED BY refer to attachment 1 DATE 4/19/90

QAPL APPROVAL [signature] DATE 4/19/90

TPO APPROVAL [signature] DATE 4/23/90

EFFECTIVE DATE 4/23/90

ENCLOSURE 2

PROCEDURE FOR DETERMINATION OF VOLUME CONSTITUENTS IN THIN SECTIONS OF ROCKS

Effective Date 4/24/90

David Broxton for F. M. Byers, Jr.	3/28/90
Preparer Frank M. Byers, Jr.	Date
David T. Vaniman	3/28/90
Technical Reviewer David T. Vaniman	Date
Lloyd W Schempp	3-28-90
QA Reviewer L. W. Schempp	Date
David T. Vaniman	3/28/90
Principal Investigator D. T. Vaniman	Date
HPNunes	4/23/90
Quality Assurance Project Leader H. P. Nunes	Date
R J Herbst	4/23/90
Technical Project Officer R. J. Herbst	Date

PROCEDURE FOR DETERMINATION OF VOLUME CONSTITUENTS IN THIN SECTIONS OF ROCKS

Effective Date 3/5/90

F. M. Byers, Jr. — 2/15/90
Preparer
Date

D. T. Vaniman — Feb. 15, 1990
Reviewer, EES-1
Date

L. W. Schempp — 3-5-90
Reviewer, MEE-9, for Quality Assurance
Date

H. P. Nunes — 3/5/90
Quality Assurance Project Leader
Date

R. J. Herbst — 3/5/90
Technical Project Officer
Date

PROCEDURE FOR DETERMINATION OF VOLUME CONSTITUENTS IN THIN SECTIONS OF ROCKS

1.0 PURPOSE

This procedure describes a petrographic modal point count method for determining the volume fractions of identifiable constituents in a slide (thin section), using a petrographic microscope.

2.0 SCOPE

This procedure applies to modal point counting of petrographic slides of porphyritic volcanic and volcaniclastic rocks.

3.0 APPLICABLE DOCUMENTS

Petrographic studies within Work Breakdown Structure (WBS) element 1.2.3.2.1.1 (Mineralogy-Petrology) are defined in the Site Characterization Plan (SCP) and its updates. Thin sections are prepared following procedure TWS-ESS-DP-04. Other applicable documents are TWS-QAS-QP-03.5, TWS-QAS-QP-15.1, TWS-ESS-DP-03, TWS-ESS-DP-07, TWS-ESS-DP-101, and TWS-ESS-DP-112, which are cited later under appropriate sections of this procedure.

4.0 RESPONSIBILITIES

The PI for each subtask, such as petrography, within WBS element 1.2.3.2.1.1 has the responsibility for organizing and overseeing petrographic studies for that subtask, and for stating the plan of research in the SCP. The individual analyst is responsible for recording his petrographic observations and data in a controlled laboratory notebook.

5.0 PRINCIPLES

This procedure for Yucca Mountain Project (YMP) rocks is based on principles and methods in standard textbooks on optical mineralogy and petrography (e.g., Williams, Turner, and Gilbert, 1954; Hutchison, 1974; and Kerr, 1977). General principles are also outlined in ASTM-E 562 83, Standard Practice for Determining Volume Fraction by Systematic Manual Point Count.

The fraction of points within a rectangular grid superimposed on a two-dimensional planar section through a specimen provides an estimate for the volume fraction of an identifiable constituent (Chayes, 1949; Hutchison, 1974). This technique assumes that a statistically adequate number of sample points are taken on the plane of section (Weibel, 1980; Byers and Moore, 1987). Although Chayes' (1949) theory and proof relating point count on a planar section to volume percent of constituents was based on a square grid of points, volume percentages for correlation purposes have been determined from points counted along parallel traverse lines separated as much as 10 times the distance between point along the traverse (Byers et al., 1976; Byers and Warren, 1983; Byers, 1985). This approach is an extension of the Rosiwal intercept method (Nelson and Nelson, 1967, p. 320). In this method, prior to development of point counting, a series of evenly spaced continuous line traverses were made along a rock slab or a thin section and linear intercepts were recorded for each constituent. The total linear intercept distance for each constituent along all the traverse lines was summed by a millimeter scale on a drum translating the stage for that constituent. An electrically driven adaptation was the Hurlbut stage and console, which summed up the Rosiwal proportional intercepts of each constituent.

The point count method described herein is similar to the Rosiwal system of counting mineral (or other constituent) intercepts, insofar as the number of successive points tallied on a mineral could increase without limit and become infinitesimally close together to form a continuous line or intercept through the mineral. The Rosiwal method is based on the reasonable assumption that the lengths or percentages of the mineral (constituent) intercepts are proportional to its sectional area, which in turn is proportional to its volume percentage in the rock (see also discussion in Byers and Moore, 1987, p. 47). Stoyan (1979) makes similar assumptions based on line segment portions of traverse lines that intersect a given constituent. Inasmuch as the point counts are relatively close together (~0.1 mm), the percentage of the total line segment representing the constituent is approximated. Volume percentages of constituents based on point counts described herein are consistent and comparable with prior published petrographic modal data of volcanic rocks relevant to YMP studies (e.g., Byers et al., 1976; Byers and Warren, 1983; Byers, 1985; W. J. Carr et al., 1986; Byers and Moore, 1987).

6.0 DEFINITIONS

LANL = Los Alamos National Laboratory; NTS = Nevada Test Site; WBS = Work Breakdown Structure; SCP = Site Characterization Plan; EA = Environmental Assessment; RPC = Records Processing Center; SEM = Scanning Electron Microscope; YMP = Yucca Mountain Project.

7.0 PROCEDURE

7.1 Adequate and appropriate equipment

Any standard research petrographic microscope with an electrically automated or manual mechanical stage with mm-graduated x-y stage translation controls to move the thin section may be used. The slide is placed in the stage holder parallel to the x translation, which is either (1) electrically power-driven and is connected to a main console that has keys individually assigned to a constituent identifiable in the point count) or (2) traversed manually with intercepts in mm read off the x translation or "clicks" recording translations of ~0.1 to ~0.5 mm, depending on setting (original point counter; Chayes, 1949), the "clicks" being tallied with the other hand on a mechanical counter (e. g. Clay-Adams blood counter). The electrically driven mechanical stage moves ~0.1 to 0.5 mm per count (depending on the setting) and the console sums the points tallied for each constituent and converts to percentages. Precise calibration of the 0.1 to 0.5 translation settings of the mechanical or manual stage is not critical, inasmuch as approximate spacing of translation steps or "clicks" is adequate for calculation of percentages of constituents. The y translation of either automated or manual stage is controlled manually and determines the spacing between traverses, generally 1 mm, and need not be calibrated for the simple arithmetic calculation of percentages of constituents.

7.2 Preparatory verification

Adequate sample tracking is necessary (Procedure TWS-ESS-DP-101). Thin sections are prepared in accordance with TWS-ESS-DP-04.

7.3 Controlled conditions and data requirements

No control of the environment is necessary. Other specific instructions, as necessary, shall be detailed on the Thin Section Request Form.

7.3.1 Orientation of plane of thin section with respect to fabric:

In the case of pumice-foliated welded tuff (flattening or foliation nearly perpendicular to gravitational force) or other rock type with horizontal fabric, the thin section should be cut close to vertical with the long dimension running perpendicular to the foliation (Hutchison, 1974, p. 47, fig. 3.2). This provides the longest traverse lines nearly normal to foliation. Also, in sampling nonfoliated silicic volcanic rocks, especially where the attitude (strike and dip) is unknown, the long dimension of the slide may be cut vertical for consistency. The drill core, surface outcrop or mine exposure should be marked with a down arrow prior to sampling. The thin section preparer should cut the long dimension (30 mm) of the slide parallel to the arrow and show the direction of the arrow on the slide, following procedure TWS-ESS-DP-04. Exception: In sectioning of a horizontal cylindrical core plug (e.g., paleomagnetic samples), the thin section is cut perpendicular to the core axis (circular section). Down is marked on the section from the down arrow marked on either end of the core plug by the original sampler.

7.3.2 Additional thin sections from specimens:

Where a sample site is critical, two or three thin sections may be cut from a single specimen of core or mine wall. The purpose is to provide a larger area to count for better statistics on a critically located sample for which the stratigraphic position is unknown. The first section should be cut vertical and perpendicular to foliation in accordance with the standard procedure above (7.3.1). The second thin section should also be cut vertical and as close to perpendicular as possible to the first section (the second section would not necessarily be perpendicular to the foliation unless it were horizontal), and the third should be at an angle of 45 degrees to the other two and vertical. The third section may, under exceptional circumstances, be cut horizontally perpendicular to the other two but must carefully avoid any large pumice, which might not be representative of the groundmass.

7.4 Data to be recorded

7.4.1 Set-up:

The general background for recording thin section data is given in TWS-ESS-DP-03. The procedure described herein results in quantitative petrographic descriptions (Hutchison, 1974). No two petrographers will generate identical data but they should be similar (cf. Moore et al., 1989). Definitions of phenocrysts (minerals), textures, and fine-grained "groundmass" will depend on the thin section being analyzed. The cut-off size for phenocrysts or microphenocrysts must be judged by the petrographer before the modal analysis is begun. For example, in the devitrified rhyolitic Topopah Spring Member, the lower median diameter for microphenocryst (mineral) or fine textural constituent to be recorded is taken at about 0.1 mm, and therefore the step-wise movement on traverse lines parallel to the long dimension of the slide (x dimension) is generally selected at ~0.1 mm for phenocryst-poor rocks. This close spacing is selected not only for phenocrysts but also for microscopic textures. Constituents that are smaller than the 0.1 mm cutoff, even though they are recognizable, are included with categories of groundmass. The distance between traverses is generally selected at 1.0 mm, giving about twenty 30-mm traverses per slide. This rectangular grid spacing of 1.0 x ~0.1 mm is generally sufficient to quantify phenocrysts and textures that have abundances of 1% or more.

In volcanic rocks with less than 1% of critical constituents, additional traverses may be required to quantify these constituents. For volcanic rocks with macrophenocrysts and/or coarse textures greater than 0.1 mm that make up more than 1% of the rock, the point spacing along the traverse may be wider than 0.1 mm, depending on size and concentration. Other point-count spacings may be used for other rock types; the spacing should be recorded by the petrographer.

7.4.2 Use of photographs:

For any thin section that may be used for SEM/microprobe analysis or may be essential to identify stratigraphic position, an enlarged photo of the entire section may be made before the section is point counted. This photo can then be used to record the location of features of interest, some of which may be phenocrysts or textures for later examination by microprobe (TWS-ESS-DP-07) and/or SEM (TWS-ESS-DP-112). Photographs may also be taken to record fields containing exemplary phenocrysts or textures by 35-mm or polaroid camera attached to the microscope as standard equipment. These photographs may be numbered and stored as separate records or they may be attached to the petrographer's laboratory notebook.

7.4.3 Counting:

The counting procedure described below is modified to fit YMP rocks from descriptions given in a standard text by Hutchison (1974, p. 44-61). A petrographic microscope with a Swift automated point counter is also shown (Hutchison, 1974, Figure 3.6). Magnification selected for point-counting will depend on the grain size of features being analyzed. If features less than 0.1 mm are to be quantitatively determined, then reflected light identification may be preferred (with transmitted light to aid in identification). A constituent beneath the point defined by the intersection of cross hairs within the ocular is tallied by depressing the key corresponding to that constituent on the console or tally recorder, and the stage is simultaneously advanced to the next point. This is repeated until the end of the traverse. If a ~0.1 mm point spacing is used, about 300 points will have been tallied in one traverse on a 30-mm-long slide. As an example, in modal counting of thin sections of devitrified phenocryst-poor Topopah Spring, a 10X ocular and a 10X or 20X objective, may be used on the petrographic microscope in transmitted light. The substage converger may be engaged, to enhance the color of groundmass textures. A 40X or higher objective should be available for optical interference figures (conoscopic images) as an aid for positive identification of phenocrysts (Kerr, 1977, p. 108-133).

After completion of the first traverse, the stage is moved (usually 1 mm) on the y axis and the second traverse is begun, following the above procedure. After about 20 traverses, depending on the width of the slide, the point count is completed. The points in each constituent are read off the manual counter or off the automated console display.

In the rare event that a point should fall on the boundary of two constituents, the constituent with the most area in SE quadrant of the cross hairs will be tallied.

7.4.4 Visual count of accessory minerals:

Rare to sparse accessory minerals, mostly of average diameters less than 0.5 mm may be simply enumerated rather than point counted. Accessory minerals in rhyolites include sphene, allanite, perrierite, zircon, and apatite. The first two are larger, occasionally up to 1.5 mm and may be hit during the point count. The others, however, are generally less than 0.2 mm in long dimension and are rarely hit during a traverse.

7.4.5 Calculation of Percentages:

The number of points accumulated for each constituent, C_i, is divided by the total number of points in all constituents, C_T, is expressed as the volume percent of that constituent, V_i in the thin section:

$$V_i = C_i \times 100/C_T$$

Phenocrysts are expressed as volume percentage ratios, V_p, in which the number of points accumulated for each phenocryst, P_i, is divided by the total number of phenocryst points, P_T, in the thin section.

$$V_p = P_i \times 100/P_T$$

7.4.6 Recording of data:

The following data should be recorded in the appropriate laboratory notebook:

(a) Total number of points and spacing.
(b) Volume % of each constituent. Individual phenocrysts may also be represented as percent of total phenocrysts.
(c) Specimen location, identification, brief thin section description, and stratigraphic assignment if possible.
(d) Petrographer and date.
(e) The maximum and minimum (cut-off) dimension of each type of phenocryst, if desired.

7.5 Sample/site traceability

Sample traceability is described in procedure TWS-ESS-DP-101. Site traceability for field petrographic descriptions will be recorded in a field notebook; field descriptions will be referenced to appropriate map(s) or photograph(s) as necessary. Copies of maps and photographs will be maintained by the investigator using them; upon task completion or departure of the investigator from the project, all records will be placed in the resident file and copied to the RPC.

7.6 Verification of key actions

Key actions for this procedure are those that result in completion of site characterization milestones. Completion of required milestones constitutes verification. The analyses resulting from this procedure shall be reported in LANL reports as necessary. This procedure shall be referenced as appropriate to substantiate the analytical process.

7.7 Acceptance/rejection criteria

There are few known potential sources of error in this procedure as far as operation and functioning of equipment. There is, however, a subjective observer element, especially in counting textures where there is a size cutoff; two operators are not likely to get precisely the same results (Moore et al., 1989). If more than one operator is involved, they should check on percent of groundmass textures within 20 percent of error (e. g., 50% ± 10%) within the same thin section; if not, they should discuss differences of observation and repeat the point counts. Phenocryst (including microphenocrysts >0.1 mm) counts in a phenocryst-poor thin section (~1% phenocrysts), such as from the Topopah Spring Member, should check within 20 percent of error of the total phenocrysts for major constituents, such as feldspars, and within 50 percent on minor constituents, such as biotite, that constitute less than 10 percent of the total phenocrysts (<0.1% of the total rock). Mafic and accessory phenocrysts that occur at less than about one percent of the total phenocrysts (~0.01% of the Topopah Spring) should be tallied rather than point counted, as the chance occurrence of hitting such very minor constituents in a point count is highly variable. In volcanic rocks with greater percentages of phenocrysts than in the Topopah Spring Member, correspondingly greater accuracies should be attainable.

8.0 QUALITY ASSURANCE REQUIREMENTS

8.1 Handling, shipping, and storage

Handling, shipping, and storage requirements are described in TWS-ESS-DP-101.

8.2 Records

Petrographic modal descriptions and data are recorded in controlled laboratory or field notebooks. Maps or photographs should be dated and marked with sample or locality numbers that can be be uniquely related to a notebook entry (sample numbering requirements are described in Procedure TWS-ESS-DP-101). These notebooks and maps should be copied periodically or at the end of the investigation, based on the judgement of the investigator. Interim copies should be kept in the EES-1 Resident File during the active stage of the investigation. Original photographs with inked sample points and other inked data are treated as one-of-a-kind records and are kept in the EES-1 locked sample storage room or the EES-1 Resident File when not in use by the investigator during the active stage of the investigation. Following conclusion of the investigation, all records will be transferred to the Los Alamos YMP Records Processing Center.

8.3 Training

Successful completion of college-level courses in petrography and petrology are required to use this procedure. Researchers using this procedure must also certify that they have read and understood it, as well as procedures TWS-ESS-DP-03 and TWS-ESS-DP-101.

8.4 Calibration requirements

Calibration is not required for the microscopic <note: microscope> equipment covered by this procedure. Magnification scales and mm spacing on the mechanical stages described herein are commercial grade. Calibration of the mechanical stage is not required, because the absolute spacing between points is not as critical as the total number of points counted for calculating percentages of constituents.

8.5 Deviations and nonconformances

Any special optical petrographic methods that might deviate from this procedure shall be documented in a controlled laboratory notebook, following the requirements of TWS-QAS-QP-03.5. Any nonconformances will be handled according to TWS-QAS-QP-15.1.

8.6 Standards

Petrographers using this procedure should be competent and follow guidelines in Hutchison (1974, p. 44-61) and American Standard for Testing Materials, ASTM-E 562 83, Standard Practice for Determining Volume Fraction by Systematic Manual Point Count.

9.0 REFERENCES

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5. Chayes, F., "A Simple Point Counter for Thin Section Analysis," Am. Mineralogist, v. 34, p. 1-11 (1949).

6. Carr, W. J., F. M. Byers, Jr., and Paul P. Orkild, "Stratigraphic and Volcano-tectonic Relations of Crater Flat Tuff and Some Older Volcanic Units, Nye County, Nevada," U. S. Geo. Survey Prof. Paper 1323, 18 p. (1986).

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11. Stoyan, D., "On the Accuracy of Lineal Analysis," Biometrical J., v. 21, 439-449 (1979).

12. Weibel, E. R., Stereological Methods, v. 2: Theoretical Foundations, Academic Press (1980).

13. Williams, H., Turner, F. J., and Gilbert, C. M., Petrography, W. H. Freeman & Co., San Francisco, 406 p. (1954).