**CNWRA** *A center of excellence in earth sciences and engineering™*

Geosciences and Engineering Division
6220 Culebra Road • San Antonio, Texas, U.S.A. 78238-5166
(210) 522-5160 • Fax (210) 522-5155

June 26, 2008
Contract No. NRC–02–07–006
Account No. 14002.01.151
WM–00011

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Mrs. Deborah A. DeMarco
Division of High-Level Waste Repository Safety
Mail Stop EBB–2–BO2
11555 Rockville Pike
Rockville, Maryland 20852

Subject: AI 14002.01.151.803
Linking the Growth of the Lathrop Wells Scoria Cone, Nevada, and Pyroclastic Textures to Conditions of Magma Ascent

Dear Mrs. DeMarco:

The enclosed poster and Form 390A are being transmitted for programmatic review. Following NRC approval, the information discussed in the poster will be presented at the 2008 International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly in Reykjavik, Iceland, on August 18–22, 2008.

The poster outlines a study involving the use of pyroclastic textures, specifically those of the scoria found in the Lathrop Wells cinder cone in southern Nevada, to discern conduit dynamics during magma ascent. Textures have be characterized based on the vesicle and microlite populations present at a microscopic scale, and the results have be used to interpret transitions in eruptive behavior and flow regimes in the shallow conduit. The objective of this work is to gain a more integrated understanding of the processes that occur in the subsurface during conduit development and throughout an eruption of a water-rich basaltic magma, which can be used to consider consequences of igneous activity.

Washington Office
1801 Rockville Pike, Suite 105 • Rockville, Maryland 20852-1633

Please advise me of the results of your programmatic review. If you have any questions, please contact Nancy Adams at (210) 522-2161 or Dr. Philippe Dubreuilh at (210) 522-5085.

Sincerely,

Gordon W. Wittmeyer, Ph.D.
Assistant Director, Earth Sciences

GWW/slo
Attachment
cc:

**NRC**
L. Kokajko
B. Meehan
S. Kim
A. Mohseni
J. Davis
M. Shah
B. Hill
T. McCartin
J. Rubenstone
K. Stablein
J. Guttman
S. Self
M. Wong
E. Peters
S. Whaley

**CNWRA/GED**
W. Patrick (letter only)
B. Sagar(letter only)
N. Adams

CNWRA Dirs/EMs (letter only)
L. Gutierrez (letter only)

**SwRI**
Record Copy B, IQS

Attachment 1

**Checklist for Implementing the**
**Guidelines on Technical Publications and Presentations**

| Date | Initials | Action |
|---|---|---|
| **General Planning and Scheduling** | | |
| 06/23/08 | P.D. | CNWRA Manager (for CNWRA initiated publications) or NRC Branch-Chief (for NRC initiated publications) concurrence of no anticipated impact on assigned or anticipated tasks. |
| ↓ | P.D. | CNWRA Manager (for CNWRA initiated publications) or NRC Branch-Chief (for NRC initiated publications) approval of planned technical and programmatic scope of paper or presentation. |
| ↓ | P.D. | CNWRA manager/author Informally discusses with NRC Branch Chief or designee on planned scope; this may be done on telephone or via email. |
| ↓ | P.D. | Acknowledgment of staff member that paper or presentation may be later withheld from publication for programmatic reasons. |
| **Materials Generally Unsuitable for Inclusion** | | |
| 06/23/08 | P.D. | CNWRA Manager (for CNWRA initiated publications) or NRC Branch-Chief (for NRC initiated publications) review and determination that the document contains no information that is unsuitable for inclusion. [In most cases, the review will stop at this point.] |
| | | If needed, NRC programmatic review and determination that the document contains no information that is unsuitable for inclusion. |
| | | If needed, NRC OGC review and determination that the document contains no information that is unsuitable for inclusion. |
| **Decision and Agreement on Constraints** | | |
| 06/23/08 | P.D. | Acknowledgment of staff member that—despite approval—the paper or presentation may be later withheld for programmatic reasons. |
| ↓ | P.D. | Acknowledgment of staff member of any constraints imposed on discussions about and/or oral presentation of the document. |
| | | NRC Deputy Director or designee High-Level Waste Repository Safety |

G:\BSagar\HLWRS Board Meetings\Guidelines on Publications and Presentations Rev1.wpd

NRC Form 390A
(12-2003)
NRCMD 3.9

U.S. NUCLEAR REGULATORY COMMISSION

# RELEASE TO PUBLISH UNCLASSIFIED NRC CONTRACTOR SPEECHES, PAPERS, AND JOURNAL ARTICLES

*(Please type or print)*

1. TITLE (State in full as it appears on the speech, paper, or journal article)
Linking the Growth of the Lathrop Wells Scoria Cone, Nevada, and Pyroclastic Textures to Conditions of Magma Ascent

2. AUTHOR(s)
Nancy Adams

3. NAME OF CONFERENCE, LOCATION, AND DATE(s)
2008 International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly; Reykjavik, Iceland; August 18-25, 2008

4. NAME OF PUBLICATION
Proceedings of the IAVCEI General Assembly

| 5. NAME AND ADDRESS OF THE PUBLISHER | TELEPHONE NUMBER OF THE PUBLISHER |
|---|---|
| IAVCEI<br>PO Box 185<br>Campbell ACT 2612 AUSTRALIA | 61-2-6248-7403 |

| 6. CONTRACTOR NAME AND COMPLETE MAILING ADDRESS (*Include ZIP code*) | TELEPHONE NUMBER OF THE CONTRACTOR |
|---|---|
| Nancy Adams<br>Center for Nuclear Waste Regulatory Analyses<br>6220 Culebra Road<br>San Antonio, TX 78238 | (210) 522-2161 |

| YES | NO | 7. CERTIFICATION *(ANSWER ALL QUESTIONS)* | | |
|---|---|---|---|---|
| | X | A. COPYRIGHTED MATERIAL | – | Does this speech, paper, or journal article contain copyrighted material? If yes, attach a letter of release from the source that holds the copyright. |
| | X | B. PATENT CLEARANCE | – | Does this speech, paper, or journal article require patent clearance? If yes, the NRC Patent Counsel must signify clearance by signing below. |
| | | NRC PATENT COUNSEL *(Type or Print Name)* | SIGNATURE | DATE |
| X | | C. REFERENCE AVAILABILITY | – | Is all material referenced in this speech, paper, or journal article available to the public either through a public library, the Government Printing Office, the National Technical Information Service, or the NRC Public Document Room? If no, list below the specific availability of each referenced document. |
| | | SPECIFIC AVAILABILITY | | |
| X | | D. METRIC UNIT CONVERSION | – | Does this speech, paper, or journal article contain measurement and weight values? If yes, all must be converted to the International System of Units, followed by the English units in brackets, pursuant to the NRC Policy Statement implementing the Omnibus Trade and Competitiveness Act of 1988, Executive Order 12770, July 25, 1991. |

## 8. AUTHORIZATION

The signatures of the NRC project manager and the contractor official certify that the NRC contractor speech, paper, or journal article is authorized by NRC, that it has undergone appropriate peer review for technical content and for material that might compromise commercial proprietary rights, and that it does not contain classified, sensitive unclassified, or nonpublic information. (NRC MD 3.9, Part II(A)(1)(d))

| A. CONTRACTOR AUTHORIZING OFFICIAL *(Type or print name)* | SIGNATURE | DATE |
|---|---|---|
| Gordon Wittmeyer, Asst. Director | Gordon Wittmeyer | 6/26/2008 |
| **B. NRC RESPONSIBLE PROJECT MANAGER** *(Type or print name)* | OFFICE/DIVISION | MAIL STOP |
| | | |

| TELEPHONE NUMBER | E-MAIL I.D. | Did you place the speech, paper, or journal art cle in ADAMS? YES ☐ NO ☐<br>If so, provide the ADAMS Accession No<br>(Use Template OCIO 099) |
|---|---|---|
| | | |

| SIGNATURE | DATE |
|---|---|
| | |

# Linking the Growth of the Lathrop Wells Scoria Cone, Nevada, and Pyroclastic Textures to Conditions of Magma Ascent


Nancy K. Adams

Center for Nuclear Waste Regulatory Analyses - Southwest Research Institute®, San Antonio, TX, USA, nadams@cnwra.swri.edu


**OBJECTIVE:** Use pyroclastic textures of scoria from Lathrop Wells volcano to study magma ascent dynamics in the shallow conduit.

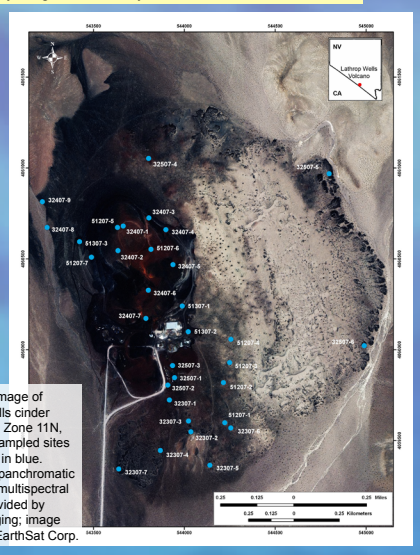
## 1. BACKGROUND

The ~80 ka eruption of Lathrop Wells volcano in Nevada, USA, of water-rich [~1.2 – 4.6 wt% $H_2O$ (Nicholis and Rutherford, 2004; Luhr and Housh, 2002)] trachybasalt was characterized by both effusive and explosive activity, resulting in two lava flow fields, fall deposits, and a 140-m [459-ft]-high scoria cone. Field observations suggest the emplacement of these three types of deposits overlapped in time.

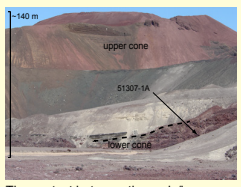
Excavation of the cone through commercial quarrying provides a unique opportunity to sample eruptive products that represent the duration of the cone-building process, and two distinct facies have been observed. The lower cone facies consists of partly welded, coarse lapilli and bombs indicative of a Strombolian-style eruption, and the upper cone facies is composed of nonwelded beds of vesicular scoria lapilli, consistent with the increase in eruption intensity and degree of fragmentation that characterizes violent Strombolian activity (Valentine, et al., 2007).

## 2. SAMPLING

Individual beds from the cone deposits in both facies were sampled in regular, vertical increments from the base to the summit. Each sample consisted of approximately 50 – 100 clasts of scoria 8 – 32 mm [0.3 – 1.3 in] in diameter. Inversely graded horizons in the upper cone indicate grain avalanching occurred as the cone grew, but beds exposed in quarry-cuts near the base of the cone were deposited earlier in the eruption than beds located near the top. Sample locations were chosen based on variations in clast size and character that represent transitions and/or pulses in activity that occurred during cone construction.

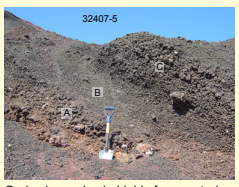



IKONOS® image of Lathrop Wells cinder cone (UTM, Zone 11N, NAD83). Sampled sites are marked in blue. One-meter panchromatic sharpened multispectral dataset provided by Space Imaging; image mosaic by EarthSat Corp.

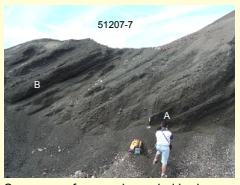



The contact between the early/lower cone and later/upper cone facies was exposed by quarrying operations in May 2007.

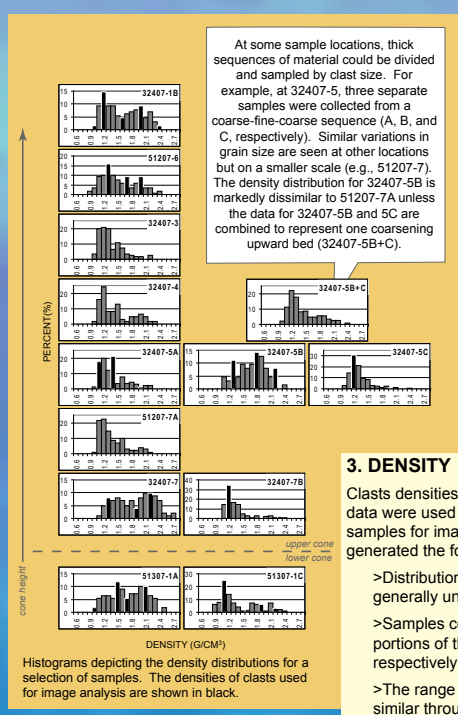

Lower cone deposits consist of partly welded coarse lapilli, ribbons, and bombs.




Grain size varies in highly fragmented, upper cone deposits; letters mark sampled horizons.



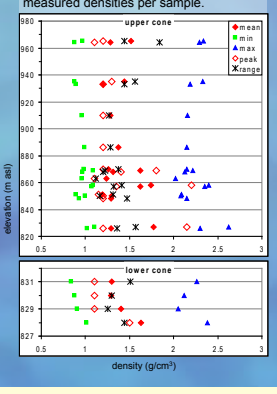

Sequence of reversely graded beds suggests grain avalanching occurred during upper cone construction; letters mark sampled horizons.




At some sample locations, thick sequences of material could be divided and sampled by clast size. For example, at 32407-5, three separate samples were collected from a coarse-fine-coarse sequence (A, B, and C, respectively). Similar variations in grain size are seen at other locations but on a smaller scale (e.g., 51207-7). The density distribution for 32407-5B is markedly dissimilar to 51207-7A unless the data for 32407-5B and 5C are combined to represent one coarsening upward bed (32407-5B+C).

Histograms depicting the density distributions for a selection of samples. The densities of clasts used for image analysis are shown in black.

Plot of sample densities against cone height. *Min* is the average of the three minimum density clasts, *max* is the average of the three maximum density clasts, and *range* is the difference between the highest and lowest measured densities per sample.




## 3. DENSITY

Clasts densities were measured per sample, and these data were used to select individual clasts from specific samples for image analysis. The density measurements generated the following results:

>Distributions appear somewhat irregular, but many are generally unimodal and peak at ~1.2 g/cm³ [74.9 lb/ft³].

>Samples collected from the lowermost and uppermost portions of the upper cone (32407-7 and 32407-1B, respectively) show bimodality.

>The range of density values present per sample is similar throughout the cone deposits, and with increasing cone height in both the lower and upper cone, the range first trends toward decreasing values, then holds somewhat steady, then increases with

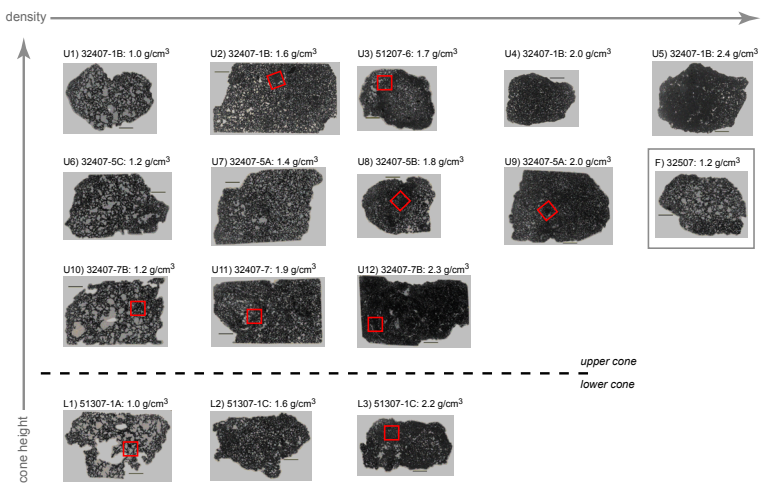
## 4. MICROTEXTURES

To characterize vesicle and microlite populations, low magnification images were collected by optically scanning thin sections on a flatbed scanner, and higher magnification, backscatter electron (BSE) images were captured using a scanning electron microscope (SEM).

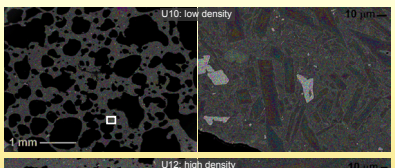
*Upper Cone*
Low density clasts are well vesiculated, have a significant population of large bubbles, and show abundant signs of bubble coalescence. High density clasts are poorly vesiculated and are dominated by small bubbles with shapes indicative of bubble collapse.

*Lower Cone*
Clasts show abundant signs of coalescence and collapse similar to upper cone samples, but low density clasts in the lower cone deposits have a population of large, outsized bubbles. Also, diktytaxitic textures occur throughout the cone deposits but are most pronounced in high density clasts from the lower cone.

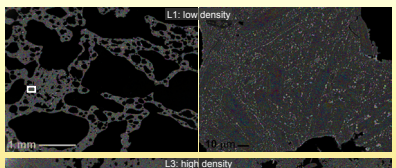
*Microlites*
Groundmass textures appear to be hypocrystalline to hypohyaline; plagioclase laths ≤100 μm [3.9 x $10^{-3}$ in] in length dominate the microlite assemblage, with minor amounts of olivine, clinopyroxene, and iron-titanium oxides (≤25 μm [9.8 x $10^{-4}$ in] in length). In both upper and lower cone clasts, microlite crystallization does not seem to be correlated to density or to textural domains defined by vesicles.




Optically scanned images of thin sections for selected clasts. *U* refers to upper cone, *L* to lower cone, and *F* to fall deposits. Scale bar is 5 mm [0.2 in] in length. Red boxes outline areas captured at higher magnifications. Many clasts with peak-to-mean densities found in the middle of the upper cone beds exhibit mid-level vesiculation (i.e., they are moderately vesiculated and dominated by medium-sized bubbles) and strongly resemble fall deposit clasts.



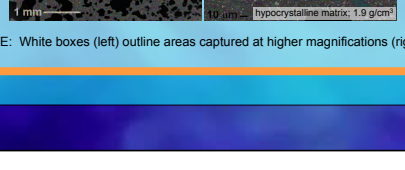

BSE images showing bubble coalescence in low density and bubble collapse in high density clasts from sample 32407-7B. White boxes (left) outline areas captured at higher magnification (right). Note: The low density clast has a glassier matrix than the high density clast.



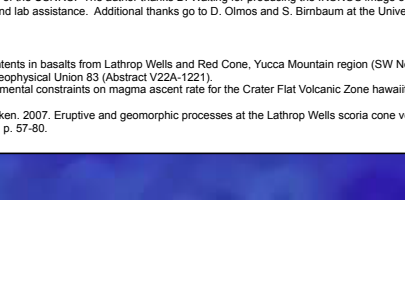

Textural features (signs of bubble coalescence, collapse) in lower cone clasts are similar to upper cone clasts. White boxes (left) outline areas captured at higher magnifications (right). Low density clasts in lower cone samples contain a population of outsized bubbles; this low density clast is hypocrystalline. Diktytaxitic textures appear prominently in the high density clast.

**Textural mingling** is apparent in Lathrop Wells scoria; images reveal regions with different dominant vesicle and/or microlite populations distinguishable by size and shape that are heterogeneously dispersed. These regions can sometimes be discerned by studying the microlites but are always identifiable by examining the vesicles. Mingling can be categorized into three types:

(i) distinct, smaller clasts are incorporated into a larger clast - boundaries are generally marked by large vesicles and changes in the microlites




(ii) domains dominated by smaller bubbles are ubiquitously interspersed in a clast occupied by larger bubbles - boundaries are not distinctly marked by vesicles, and only a subtle variation might be seen in the microlites




(iii) swaths of smaller bubbles cut through a matrix of larger bubbles - boundaries are not distinctly marked by vesicles and may or may not be distinct in the microlites.




NOTE: White boxes (left) outline areas captured at higher magnifications (right).

## 5. SALIENT POINTS

Field observations suggest Hawaiian-Strombolian behavior characterized the first phase of explosive activity at Lathrop Wells volcano and violent Strombolian the second, but density data and microtextures suggest more complicated conduit dynamics than simple slug flow and dispersed flow. The wide range in densities per sample, the population of outsized bubbles in some of the low density clasts, the population of very dense clasts in some samples, the textural mingling, and the simultaneous production of lava flows and/or a sustained eruption plume point toward lower cone growth during a transitional flow regime between slug flow and annular flow and upper cone growth during a flow regime characterized by an interplay between slug flow and dispersed flow.

Signs of bubble coalescence, bubble collapse, and textural mingling might be attributed to variations in ascent history for magma that ultimately reaches the same free surface. These variations might be caused by (i) the proximity within the dike/conduit to the wall and (ii) the transition between an eruption along a linear fissure to a focused conduit.


**6. ACKNOWLEDGMENTS**

This poster describes work performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA®) for the U.S. Nuclear Regulatory Commission (USNRC) under Contract Nos. NRC-02-02-012 and NRC-02-07-006. The activities reported here were performed on behalf of the USNRC Office of Nuclear Material Safety and Safeguards, Division of High-Level Waste Repository Safety. This poster is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the USNRC. The author thanks D. Waiting for producing the IKONOS image of Lathrop Wells volcano and M. Silver, S. Biswas, and S. Rubio for field and lab assistance. Additional thanks go to D. Olmos and S. Birnbaum at the University of Texas - San Antonio for their SEM guidance.


**7. REFERENCES**


Luhr, J.F. and T.B.Housh. 2002. Melt volatile contents in basalts from Lathrop Wells and Red Cone, Yucca Mountain region (SW Nevada): insights from glass inclusions. *EOS Transactions*, American Geophysical Union 83 (Abstract V22A-1221).

Nicholis, M.G. and M.J. Rutherford. 2004. Experimental constraints on magma ascent rate for the Crater Flat Volcanic Zone hawaiite. *Geology*. Vol. 32. p. 489-492.

Valentine, G.A., D.J. Krier, F.V. Perry, and G. Heiken. 2007. Eruptive and geomorphic processes at the Lathrop Wells scoria cone volcano. *Journal of Volcanology and Geothermal Research*. Vol 161. p. 57-80.