



UNITED STATES
NUCLEAR REGULATORY COMMISSION

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January 27, 1997

MEMORANDUM TO: Michael Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management, NMSS

FROM: Abou-Bakr Ibrahim, Geophysicist
Philip Justus, Senior Geologist
Engineering and Geosciences Branch
Division of Waste Management, NMSS

SUBJECT: DEPARTMENT OF ENERGY WORKSHOP NUMBER 3: SEISMIC SOURCE
CHARACTERIZATION FOR YUCCA MOUNTAIN PROJECT, NOVEMBER 18-21,
1996, AMARGOSA, NEVADA, TRIP REPORT.

OBJECTIVE: The goal of the workshop was to discuss
alternative models, hypotheses, and
interpretations that are important to the
characterization of seismic sources. These
sources will be used as the bases for estimating
the ground motion and fault displacement hazards.

INTRODUCTION: The Department of Energy (DOE) is carrying out a probabilistic seismic hazard analysis (PSHA) for Yucca Mountain, Nevada. The aim of this study is to provide the annual probability with which different levels of vibratory ground motion and fault displacement will be exceeded at the site. The PSHA process involves development by two panels. One panel addresses characterization of seismic sources and fault displacement, while the other panel deals with vibratory ground motion. This Number 3 workshop deals with the seismic source characterization (see list of attendees, attached). The workshop had two principle goals: (1) 2.5 days of field review and discussion focusing on the behavior of faults in the Yucca Mountain and its vicinity; the characteristic of faulting in the repository block; and the behavior of the Bare mountain fault zone; and (2) workshop sessions at which the experts presented their tectonic models and interpretation of the geophysical data. To accomplish these goals, the experts, accompanied by the observers, visited several trenches (See agenda attached) and identified issues of most significance to seismic hazard at Yucca Mountain and tried to link these issues with data collected that are most important to addressing the seismic hazard. In the workshop session, the experts presented their tectonic models and implications. The seismic source experts and observers visited the Exploratory Studies Facility and examined the fractures and faulting underground. At the end of the workshop, NRC staff provided closing remarks, addressing the inconsistency in the geophysical data interpretation provided by the different organizations, and stressed the fact that the modelers should support their modeling effort by using more of the available geophysical data. Copies of the different presentations are available in SDS KTI file.

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OBSERVATIONS:

- * The experts proposed several tectonic models (Detachment, Pull Apart, Strike-Slip, Rolling Hinge, and Caldera) and identified the pros and cons of each model. There is some uncertainty about which of these models will provide the best representation of Yucca Mountain. Will all the models mentioned be given equal weights or will different weights be assigned to each?
- * There is still uncertainty in the number of events observed in the trenches and the amount of slip estimated.
- * The ages of faulting in some trenches were not constrained.
- * Spatial and temporal distribution of volcanic-related events and seismicity were considered, but not resolved.
- * Discussion of variation of the fault rupture with magnitude issue was not conclusive. The different interpretations of geophysical data were not reconciled.
- * Some of the experts did not rely on the available geophysical data to support their models.
- * The slip on the fault is estimated from only the vertical component of the slip vector.
- * More discussion is needed on how the experts will treat faults that are unmapped, mapped but not characterized, and characterized with different interpretations.

ISSUES PLANNED TO BE ADDRESSED BY THE EXPERTS:

- * What tectonic models are appropriate to explain observations in the Yucca Mountain region?
- * What are the potential seismic sources, their geometries, and their uncertainties?
- * What are the maximum magnitude associated with these sources?
- * What are the recurrence rates of fault displacements and of ground motion?
- * How much of the observed seismicity is background and how much is associated with mapped faults?
- * How representative is the earthquake catalog of the historical data?
- * Are more data needed to clearly define the appropriate tectonic model for Yucca Mountain?

M. Bell

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NEXT WORKSHOP: In the next workshop the experts will address and will try to provide answers to these and other related issues. It is clear that there will be some uncertainties in these sources and tectonic models and these uncertainties need to be discussed and clearly defined.

Attachments: Agenda of the Meeting
List of Attendees

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A T T A C H M E N T S

FINAL AGENDA
SEISMIC SOURCE CHARACTERIZATION
WORKSHOP ON ALTERNATIVE MODELS AND INTERPRETATIONS

November 18-21, 1996

GOAL OF THE WORKSHOP:

The primary goal of the workshop is to discuss alternative models, hypotheses, and interpretations that are important to the characterization of seismic sources for vibratory ground motion hazard and fault displacement hazard. The discussions will allow for all of the members of the panel to gain a better understanding of the technical bases for each model, to hear the pros and cons of the alternatives, and to better understand the uncertainties associated with each model.

APPROACH:

The approach to be taken in this workshop is to provide a forum, both in a meeting setting and a field-trip setting, for structured debate of the alternative models and interpretations of importance to the seismic source characterization (SSC). Various individuals, including some members of the expert panel, will play the role of "proponents" in presenting the arguments in favor of a particular model or interpretation. The experts on the panel, as "evaluators", will probe and technically challenge the proponent positions in an effort to better understand the positions, the available supporting data for each position, and the associated uncertainties. The field trip will include 2½ days of field review and discussion focusing on : the behavior of faults in the Yucca Mountain vicinity, the nature of faulting in the potential repository block, and the behavior of the Bare Mountain fault zone. The workshop discussions entail presentations and discussions centered around five key issues of importance to the ground motion and fault displacement hazard: tectonic models, three-dimensional geometry of faults, definition and synchronicity of faulting events, characterization of faulting in the repository, and maximum background earthquakes.

MONDAY, NOVEMBER 18, 1996

Field Trip - Day 1

6:00 AM	<i>Breakfast buffet at Long Street Inn (Colorado Room 1)</i>
7:00	<i>Depart from Long Street Inn</i>
7:45	<i>Arrive Steve's Pass (Fridrich)</i>
8:00	<i>Leave Steve's Pass</i>
8:35	<i>Arrive Southern Crater Flat fault trenches (Taylor)</i>
9:35	<i>Leave Southern Crater Flat trenches</i>
9:55	<i>Arrive 3.7 Ma basalt flow (Whitney)</i>
10:10	<i>Leave basalt flow</i>
10:45	<i>Arrive Windy Wash trenches, CF2 and CF3 (Whitney)</i>
11:45	<i>Leave Windy Wash trenches</i>
12:20 PM	<i>Lunch (boxed lunches supplied by Long Street Inn) and Solitario Canyon fault trench T3, walk along fault scarp to trench T8 (Ramelli)</i>
1:40	<i>Leave trench T8</i>
1:55	<i>Arrive Solitario Canyon fault trench T4 (Ramelli) and outcrop geology (Potter and Day)</i>
3:00	<i>Leave trench T4</i>

3:40 Arrive Northern Crater Flat fault trench CFF-2a (time permitting) (Whitney)
 4:30 Return to Long Street Inn
 6:00 Buffet dinner at Long Street Inn (Colorado Room 1 - beer available starting at 5:45 PM)

Monday Evening Workshop Session (Colorado Room 2)

7:00 - 9:00 Tectonic Models and Their Implications (Issues: tectonic history; listric faulting, rolling hinges, and pull-aparts; fault displacement histories; kinematics and implications to contemporary geometries and rates)
 7:00 - 7:30 Tectonic History of the Yucca Mountain Region (C. Fridrich)
 7:30 - 8:00 The Amargosa Desert Fault System: A Right-Lateral Fault System in the Yucca Mountain Region (R. Schweickert)
 8:00 - 8:30 The Rolling Hinge Tectonic Model for the Yucca Mountain Region (W. Hamilton)
 8:30 - 9:00 The Bare Mountain Breakaway (D. Ferrill)

TUESDAY, NOVEMBER 19, 1996

Field Trip - Day 2

5:30 AM Depart from Long Street Inn
 6:15 Mercury -- NTS badging
 6:30 Breakfast in Mercury
 7:15 Leave Mercury from the cafeteria parking lot separated into two equal groups
 8:00-11:30 Group 2 takes ESF tour
 11:30-3:00 Group 1 takes ESF tour

Group 1 Group 2

8:00	11:40	Arrive Bow Ridge fault trench 14d at Exile Hill (Menges) (Group 2 eats lunch [boxed lunches supplied by Long Street Inn])
8:30	12:30	Leave trench 14d
8:35	12:35	Arrive NRG#4 to observe "imbricated fault zone," hanging wall deformation on the Bow Ridge fault (Day and Potter)
8:50	12:50	Leave NRG#4
9:00	1:00	Arrive Split Wash--Ghost Dance fault trenches 4, 4a and 4b in (Taylor) and bedrock exposure of the Ghost Dance fault (Potter and Day)
9:30	1:30	Depart Split Wash
9:40	1:40	Arrive Ghost Dance fault exposures in Antler Wash--Antler Ridge pavement (Day and Potter) and trenches 5 and 5a (Taylor and Whitney)
10:10	2:10	Depart Antler Wash Brief stop at "imbricated fault zone" exposed near UZ-16 (time permitting)
10:15	2:15	Arrive UZ-7a drill pad and walk to the Whale Back Ridge trench exposure of the Ghost Dance fault (Taylor, Whitney and Menges) (Group 1 eats lunch [boxed lunches supplied by Long Street Inn])
11:20	3:20	Leave UZ-7a for ESF (Group 1) or rendezvous (Group 2)

- 3:15-3:30** **Groups 1 and 2 rendezvous on road to Busted Butte on the west terrace above Fortymile Wash**
- 3:30** Visit either (1) Paintbrush Canyon fault exposures at the Busted Butte sand ramps (Whitney) or (2) the Abandon Wash fault exposed in bedrock (Day and Potter)
- 4:15** Rendezvous at the Crest of Yucca Mountain
- 5:30** Surrender temporary badges at Gate 510
- 6:30 PM** *Free tour and wine tasting at Pahrump Valley Vineyards in Pahrump*
- 7:00 PM** *Dinner at Pahrump Valley Vineyards*

WEDNESDAY, NOVEMBER 20

Morning Workshop Session (Colorado Room 2)

- 7:00-8:00** *Breakfast (on your own - Long Street Inn's Coffee Shop opens at 6:00 AM)*
- 8:30 - 12:30** **Constraints on Tectonic Models** (Issues: three-dimensional geometry of faults; seismic reflection interpretations; connections at depth/along strike; balanced cross sections, boundary element models; implications to fault rupture length, downdip width)
- 8:30 - 9:00** Structural Constraints on Tectonic Models, Including Deformation History (D. O'Leary)
- 9:00 - 9:30** Geological and Geophysical Constraints on Interpretations of Bare Mountain, Including Balanced Cross Sections (J. Stamatakis)
- 9:30 - 10:00** The Case for High-Angle Faulting Based on Geophysical Data; Interpretations of Seismic Reflection Data (T. Brocher)
- 10:00 - 10:15** *Break*
- 10:15 - 10:45** Other Faults Important for Yucca Mountain Tectonic Models (J. Bell)
- 10:45 - 11:15** Thoughts on the Seismotectonics of Normal Faults (B. Smith)
- 11:15 - 11:45** Discussion of Implications of Tectonic Models to Source Characterization (All)
- 11:45 - 12:00** Comments from Observers
- 12:00 - 1:00** *Lunch buffet at Long Street Inn (Colorado Room 1)*

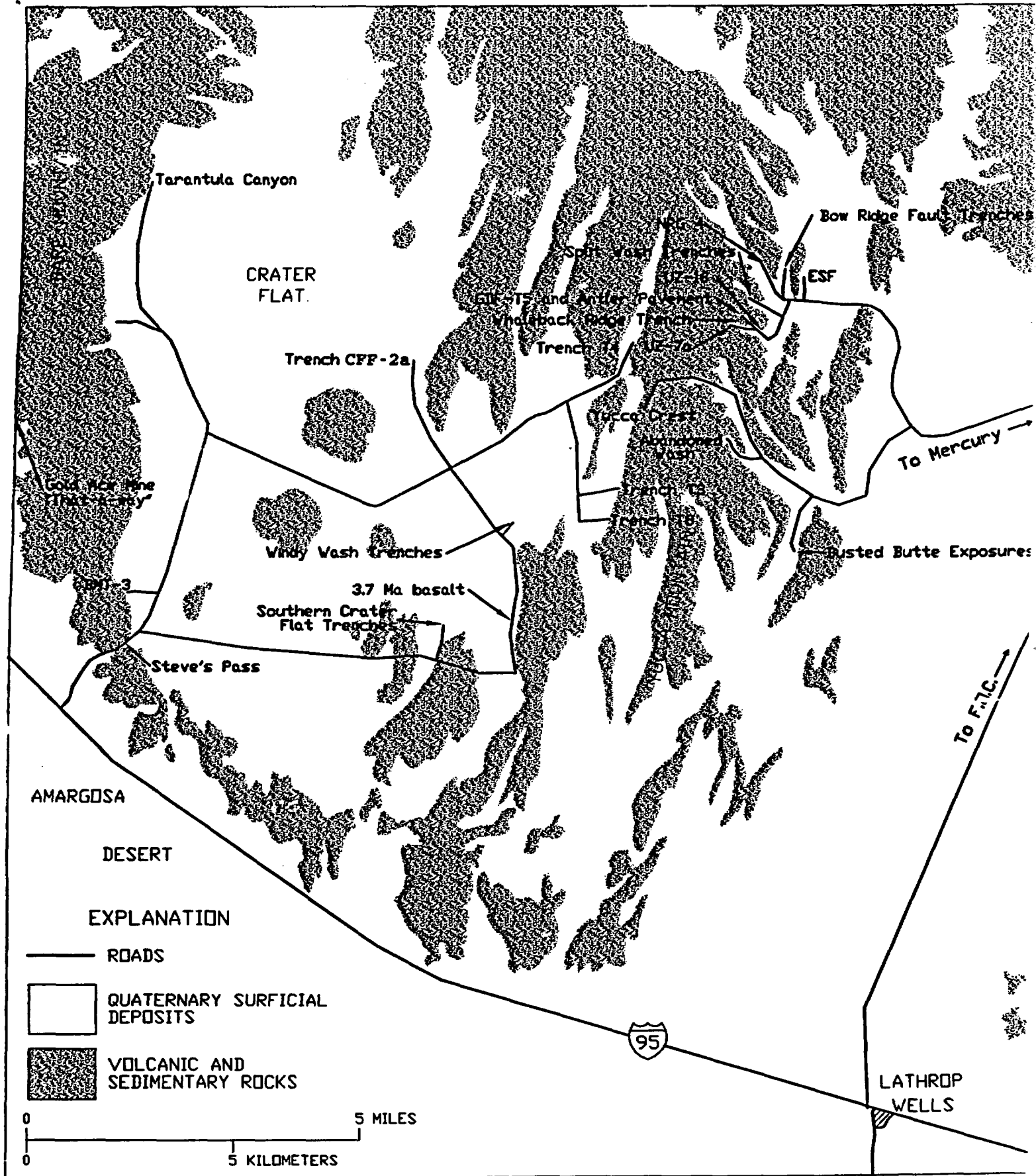
Wednesday Afternoon Field Trip

- 1:00 PM** Depart Long Street Inn
- 2:00 PM** Bare Mountain fault, Tarantula Canyon trench site-- discuss trench and Bare Mountain fault history (Anderson, Bell)
- 3:30 PM** Bare Mountain fault, southern trench site -- discuss paleoseismic interpretation and buried volcanic flow (Anderson, Stamatakis)
- 4:30 PM** Gold Ace Mine -- discuss significance of fault to seismic hazards at Yucca Mountain (Stamatakis)
- 6:00 PM** *Dinner in Beatty at The Burro Inn*

Workshop Sessions - All Day (Colorado Room 2)

- 6:30-7:30 am Breakfast (on your own - Long Street Inn's Coffee Shop opens at 6:00 AM)**
- 8:00 - 9:00 Synchronicity of Faulting Events (Issues: definition of 'event;' evidence for synchronous ruptures [distributive events] vs. separate events; implications to recurrence, slip rate, and Mmax)**
- 8:00 - 8:30 The Ash-related Event (A. Ramelli)**
- 8:30 - 9:00 Event Scenarios and Implications to Recurrence and Mmax (J. Whitney)**
- 9:00 - 2:15 Characterization of Future Faulting in Repository (Issues: resolving power of various datasets; predictability of displacement on major faults, minor faults, other locations; geometry of displacement [length, width, sense])**
- 9:00 - 9:30 Coseismic Displacement Models: Characteristic Slip, Variable Slip, Slip Rate Constraints on Successive Displacements, etc. (D. Schwartz)**
- 9:30 - 10:00 Nature of Fault Interactions at Yucca Mountain (C. Potter)**
- 10:00 - 10:15 Break**
- 10:15 - 10:45 The Fracture Network at Yucca Mountain and Correlation of Surface and Subsurface Deformation (D. Sweetkind)**
- 10:45 - 11:15 Midway Valley Observations; Fault Displacement Analysis (B. Swan)**
- 11:15 - 11:45 Amounts and Geometries of Coseismic Displacement (S. Pezzopane)**
- 12:00 - 1:00 Lunch buffet at Long Street Inn (Colorado Room 1)**
- 1:00 - 1:30 Fault Displacement Hazard Methodologies: Skeletal Advice (Fault Displacement Working Group)**
- 1:30 - 2:30 Maximum Background Earthquake (MBE) (Issues: random source of earthquake ground motions; threshold of surface faulting; historical seismicity)**
- 1:30 - 2:00 Size of the MBE; Magnitudes of some Basin and Range Earthquakes; Definition of Primary and Secondary Faulting (C. dePolo)**
- 2:00 - 2:30 Magnitude of the Threshold of Surface Faulting; Implications to Estimating MBE (K. Coppersmith)**
- 2:30 - 2:45 Minimum Faulting Earthquake and a Model for Background Earthquake (S. Pezzopane)**
- 2:45 - 3:15 Constraining the MBE Using Historical Seismicity (I. Wong)**
- 3:15 - 3:45 What Happens Next (K. Coppersmith)**
- 3:45 - 4:00 Comments from Observers**

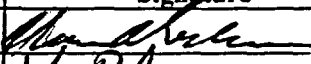
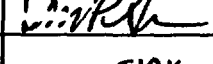

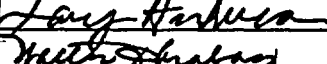
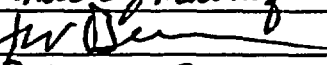
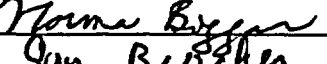
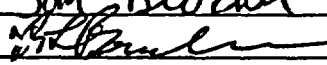
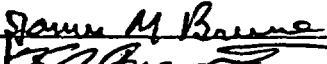
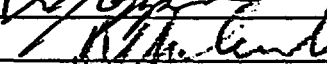
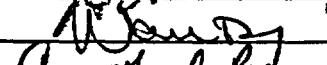
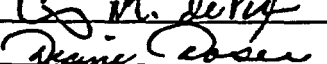
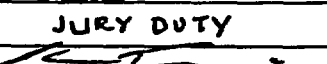
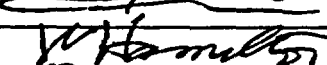
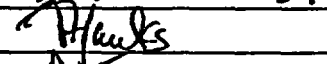

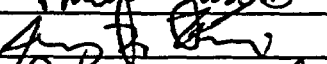
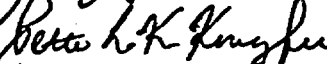
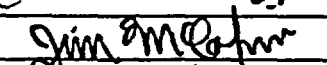
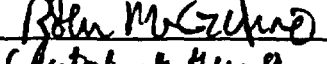

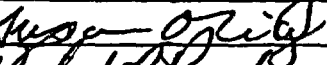
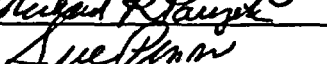
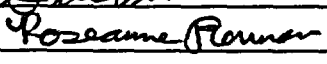




Seismic Source Characterization Field Trip Stops



**YUCCA MOUNTAIN SEISMIC SOURCE CHARACTERIZATION
WORKSHOP ON ALTERNATIVE MODELS AND INTERPRETATIONS**

November 18-21, 1996

Attendance List

Name	Signature	Affiliation
1. Abrahamson, Norm		Consultant
2. Ake, Jon		U.S. Bureau of Reclamation (USBR)
3. Allen, Clarence	SICK	Nuclear Waste Technical Review Board (NWTRB)
4. Anderson, Ernie		U.S. Geological Survey (USGS)
5. Anderson, Larry		USBR
6. Arabasz, Walter		University of Utah (UU)
7. Bell, John		UNR
8. Biggar, Norma		WCFS
9. Brocher, Tom		USGS
10. Bruhn, Ron		UU
11. Brune, James		UNR
12. Coppersmith, Kevin		Geomatrix
13. Cornell, Allin		Consultant
14. Day, Warren		USGS
15. dePolo, Craig		UNR
16. Doser, Diane		University of Texas, El Paso
17. Ferrill, David	JURY DUTY	CNWRA
18. Fridrich, Chris		USGS
19. Hamilton, Warren		Colorado School of Mines
20. Hanks, Tom		USGS
21. Ibrahim, Bakr		U.S. Nuclear Regulatory Commission (NRC)
22. Justus, Phil		NRC
23. King, Jerry		M&O/SAIC
24. Knuepfer, Peter		State University of New York at Binghamton
25. McCalpin, Jim		GEO-HAZ Consulting, Inc.
26. McGuire, Robin		Risk Engineering
27. Menges, Chris		USGS
28. O'Leary, Dennis		USGS
29. Olig, Susan		Woodward-Clyde Federal Services (WCFS)
30. Parizek, Richard		Technical Review Board
31. Penn, Sue		WCFS
32. Perman, Roseanne		Geomatrix

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**YUCCA MOUNTAIN SEISMIC SOURCE CHARACTERIZATION
WORKSHOP ON ALTERNATIVE MODELS AND INTERPRETATIONS**

November 18-21, 1996

Attendance List

Name	Signature	Affiliation
33. Pezzopane, Silvio	<i>Silvio Pezzopane</i>	USGS
34. Pomeroy, Paul	<i>Paul Pomeroy</i>	Advisory Committee on Nuclear Waste
35. Potter, Chris	<i>Chris Potter</i>	USGS
36. Quittmeyer, Richard	<i>R. C. Quittmeyer</i>	WCFS
37. Ramelli, Alan	<i>Alan Ramelli</i>	UNR
38. Reiter, Leon	<i>Leon Reiter</i>	NWTRB
39. Rogers, Al	<i>Al Rogers</i>	EQE International
40. Savino, John	<i>John Savino</i>	SAIC
41. Savy, Jean	<i>Jean Savy</i>	Lawrence Livermore National Laboratory
42. Schwartz, David	<i>David P. Schwartz</i>	USGS
43. Schweickert, Rich	<i>Richard Schweickert</i>	UNR
44. Slemmons, Burt	<i>Burt Slemmons</i>	WCFS
45. Smith, Ken	<i>Ken Smith</i>	UNR
46. Smith, Robert	<i>Bob Smith</i>	UU
47. Soeder, Daniel	<i>Dan Soeder</i>	USGS
48. Stamatakos, John	<i>John Stamatakos</i>	CNWRA
49. Stepp, Carl	<i>Carl Stepp</i>	WCFS
50. Stuckless, John	<i>John Stuckless</i>	USGS
51. Sullivan, Tim	<i>Tim Sullivan</i>	DOE
52. Swan, Bert	<i>Bert Swan</i>	Geomatrix
53. Sweetkind, Don	<i>Don Sweetkind</i>	USGS
54. Taylor, Emily	<i>Emily Taylor</i>	USGS
55. Toro, Gabe	<i>Gabe Toro</i>	Risk Engineering
56. Tynan, Mark	<i>Mark Tynan</i>	DOE
57. Engelbrecht von Tiesenhausen	<i>E. von Tiesenhausen</i>	Clark County Nuclear Waste Division
58. Whitney, John	<i>John Whitney</i>	USGS
59. Wong, Ivan	<i>Ivan Wong</i>	WCFS
60. Youngs, Robert	<i>Robert Youngs</i>	Geomatrix
61. Yount, Jim	<i>Jim Yount</i>	UNR
62.		
63.		
64.		
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