U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Summary of Issues Associated With KTI Agreement IA 1.02

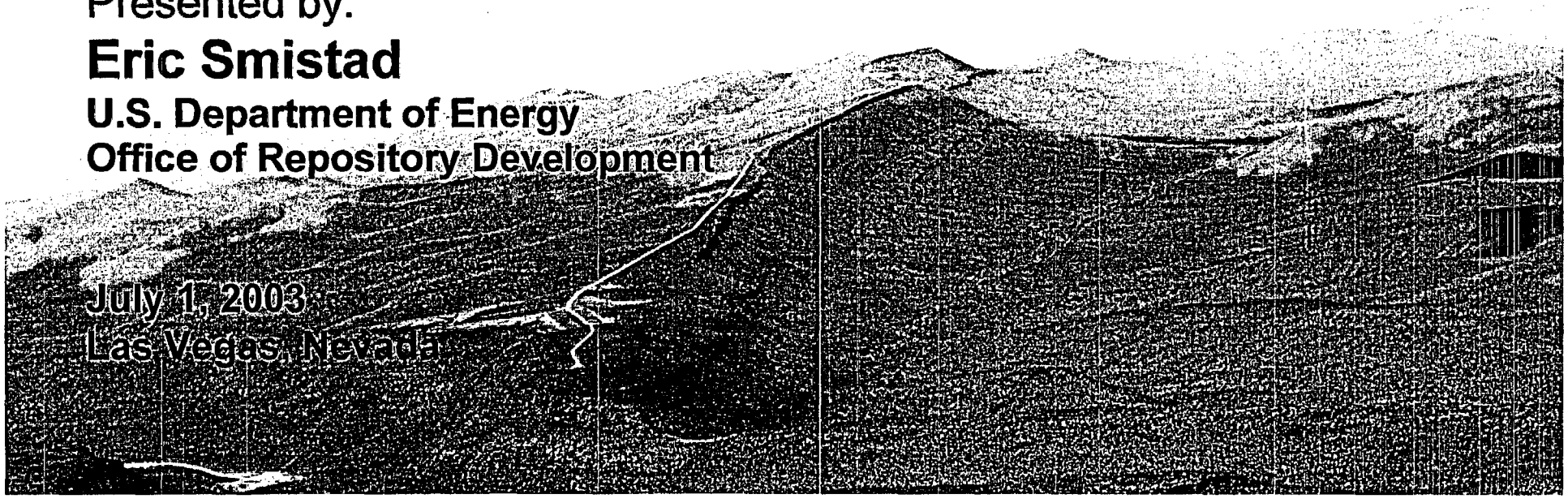
Presented to:

DOE-NRC Technical Exchange

Presented by:

Eric Smistad

U.S. Department of Energy
Office of Repository Development



Attachment 3

Outline

- Background
- Status
- Path Forward
- Summary

Background

KTI Agreement IA 1.02

- "Examine new aeromagnetic data for potential buried igneous features and evaluate the effect on the probability estimate. If the survey specifications are not adequate for this use, the action is not required"
- "DOE agreed and will document the results of the evaluation in an update to the AMR, *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* expected to be available in FY 2003"

Background (Continued)

DOE letter to the NRC (9/26/02, Ziegler to Schlueter) addressed KTI agreement IA 1.02

- Transmitted report that evaluated the effect of the new aeromagnetic data (USGS Open File Reports 00-188 and 02-020) on the probability of a dike intersecting the repository
- Two sensitivity cases showed increases of approximately 22% and 40% in mean probability of intersection (1.6×10^{-8}/yr)
- Results to be documented in update of AMR, *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada*

Background (Continued)

NRC letter to DOE (12/19/02, Schlueter to Ziegler) requesting additional information stated that the 9/26/02 response does not provide an adequate technical basis to evaluate the likely effects on probability

- **Provide a technical basis to constrain the number and age of volcanic events in vicinity of YM**
- **Provide evaluation of how new information would change conceptual models considered by the PVHA experts**

Status

DOE letter to NRC (06/03, Ziegler to Schlueter) committed to additional field investigations and analyses

- States that the technical basis that will be presented in the LA provides a reasonable representation of the volcanic framework and hazard of the Yucca Mountain region
- Support for LA includes
  - Technical basis based on PVHA
  - Recalculation of probability of intersection using LA repository footprint
  - Analyses of sensitivity of frequency of intersection based on evaluation potential buried volcanic centers
  - Dose sensitivity to single point frequency at 10^{-7}/yr (per agreement IA 1.01)

Path Forward

- DOE is implementing a program to address the request for additional information stated in the NRC letter of 12/23/02
- Program implements studies to identify and characterize potential buried volcanic centers
  - Low altitude, high resolution aeromagnetic/electromagnetic (EM) survey
  - Phased drilling
  - Data analysis and documentation
  - Update to PVHA based on new information

Path Forward (Continued)

Schedule for Planned Program

- **FY 03**
  - Recalculate igneous event frequency of intersection for LA footprint (Complete)
  - Assess need to proceed with PVHA update (Complete)
  - Document sensitivity analyses
  - Plan aeromagnetic survey and drilling program

Path Forward (Continued)

Schedule for Planned Program

- **FY 04**
  - Initiate drilling
  - Complete aeromagnetic survey, analyze data and document results.
  - Sample analysis (if needed)
  - Initiate PVHA update planning

Path Forward (Continued)

- **FY 05**
  - Continue drilling contingent on results of aeromagnetic/EM survey
  - Continue sample and data analyses
  - Initiate PVHA update
- **FY 06**
  - Document data analyses
  - Document PVHA update

Summary

- DOE's letters of 9/26/02 and 6/03 address
  - KTI Agreement IA 1.02
  - Request for additional information for IA 1.02
- Technical basis related to frequency of intersecting the repository complies with the requirements of 10 CFR Part 63 and acceptance criteria of the draft Yucca Mountain Review Plan
- Multi-phased program of field investigations and analyses has been initiated to increase confidence in the technical basis and address the request for additional information

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Office of Civilian Radioactive Waste Management

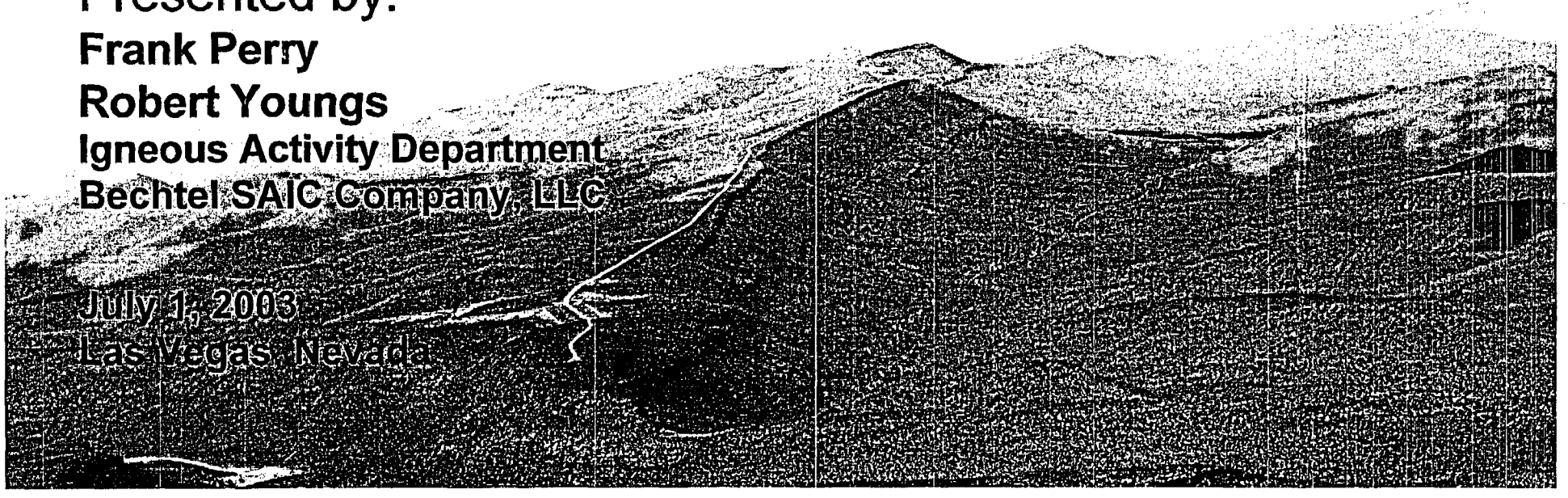
YUCCA MOUNTAIN PROJECT

Frequency of Intersection of Volcanic Events and Sensitivity Studies

Presented to:
DOE-NRC Technical Exchange

Presented by:
Frank Perry
Robert Youngs
Igneous Activity Department
Bechtel SAIC Company, LLC

July 1, 2003
Las Vegas, Nevada

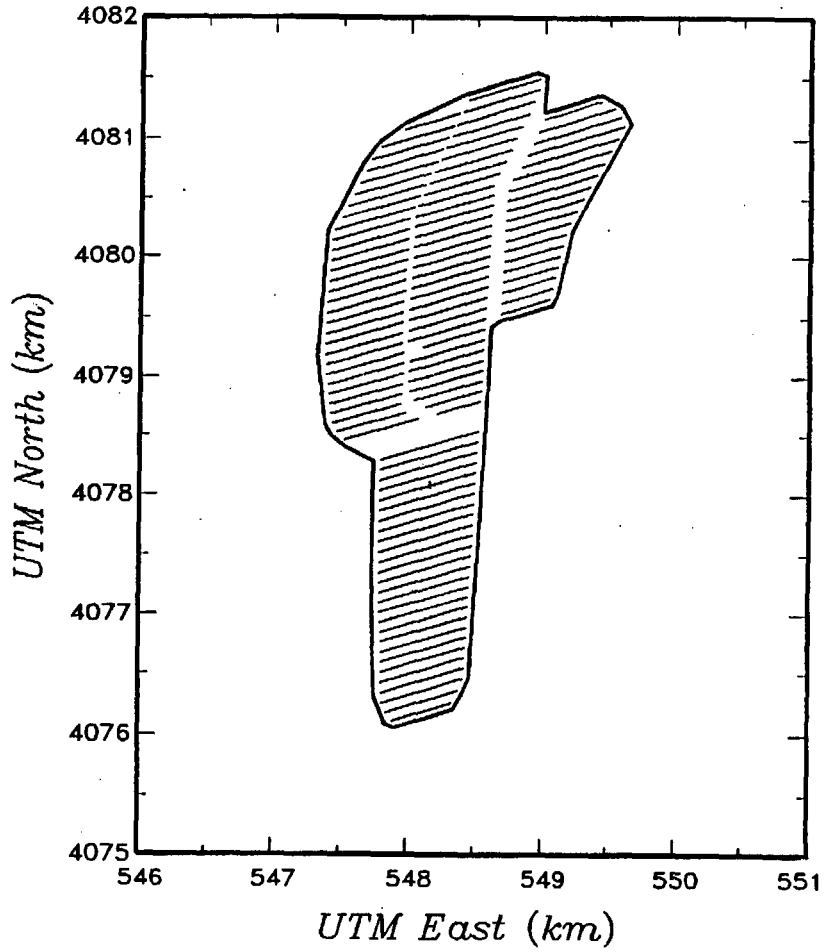


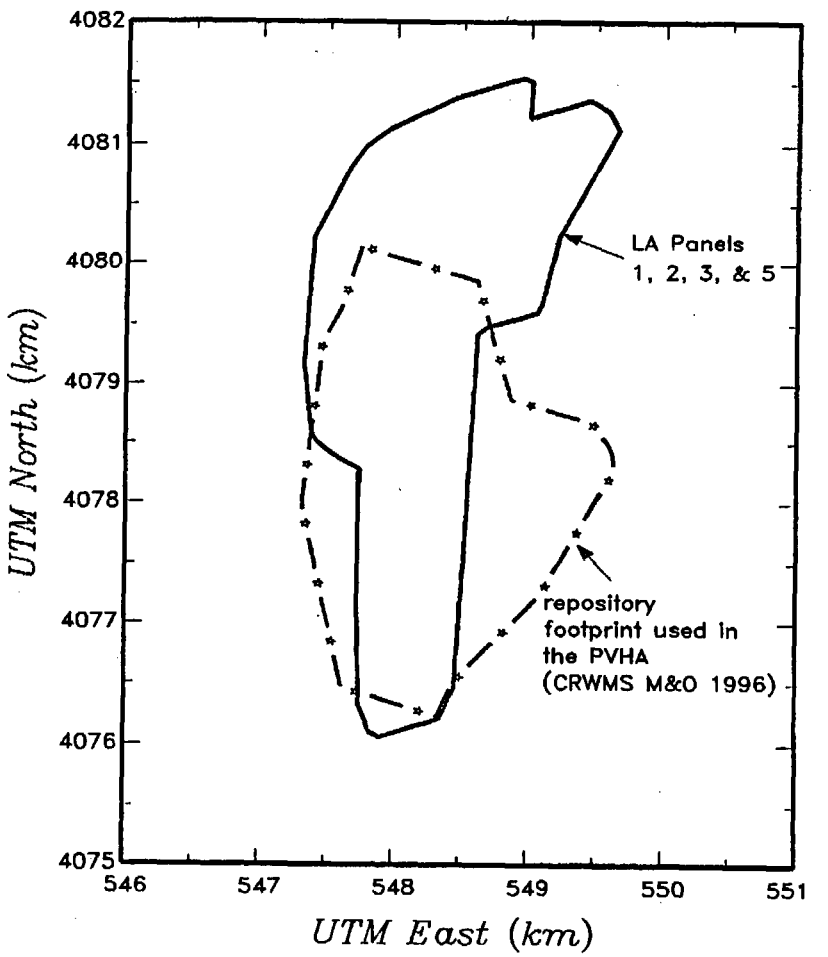
Topics

- Recalculation of the frequency of intersection of volcanic events based on the LA repository footprint
- Significance of potential volcanic events in Crater Flat and western Jackass Flats

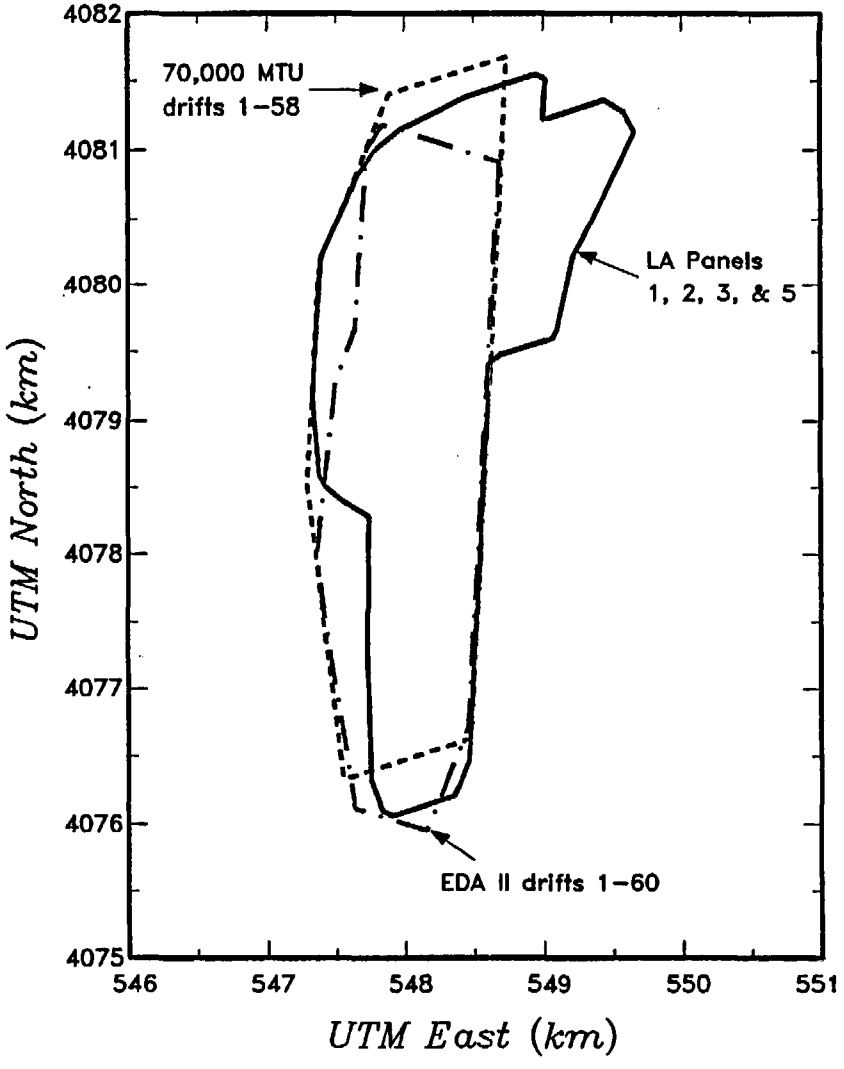
Recalculation of the Frequency of Intersection

Comparison of LA and PVHA Footprints





Comparison of LA Footprint to EDA II and 70,000 MTU SR Footprints



Comparison of Summary Frequencies of Disruptive Volcanic Events

Repository Footprint	Hazard Level	Annual Frequency of Intersection of Repository Footprint by a Dike	Final Composite Conditional Probability of At Least One Eruptive Center	Annual Frequency of Occurrence of One or More Eruptive Centers within Repository Footprint
PVHA	5th	5.4×10^{-10}	NA	NA
	Mean	**1.5×10^{-8}**	NA	NA
	95th	4.9×10^{-8}	NA	NA
EDA II Primary + Contingency Blocks[1]	5th	7.6×10^{-10}	0.44	3.3×10^{-10}
	Mean	**1.6×10^{-8}**	0.50	**7.7×10^{-9}**
	95th	5.0×10^{-8}	0.49	2.5×10^{-8}
70,000 MTU Primary + Contingency Blocks[2]	5th percentile	7.9×10^{-10}	0.74	5.9×10^{-10}
	Mean	**1.6×10^{-8}**	0.77	**1.3×10^{-8}**
	95th	5.2×10^{-8}	0.76	4.0×10^{-8}
LA Footprint[3]	5th	7.4×10^{-10}	0.75	5.6×10^{-10}
	Mean	**1.7×10^{-8}**	0.78	**1.3×10^{-8}**
	95th	5.5×10^{-8}	0.77	4.3×10^{-8}

[1] ANL-MGR-GS-000001, Rev 00
[2] ANL-MGR-GS-000001, Rev 00, ICN 1
[3] ANL-MGR-GS-000001, Rev 01

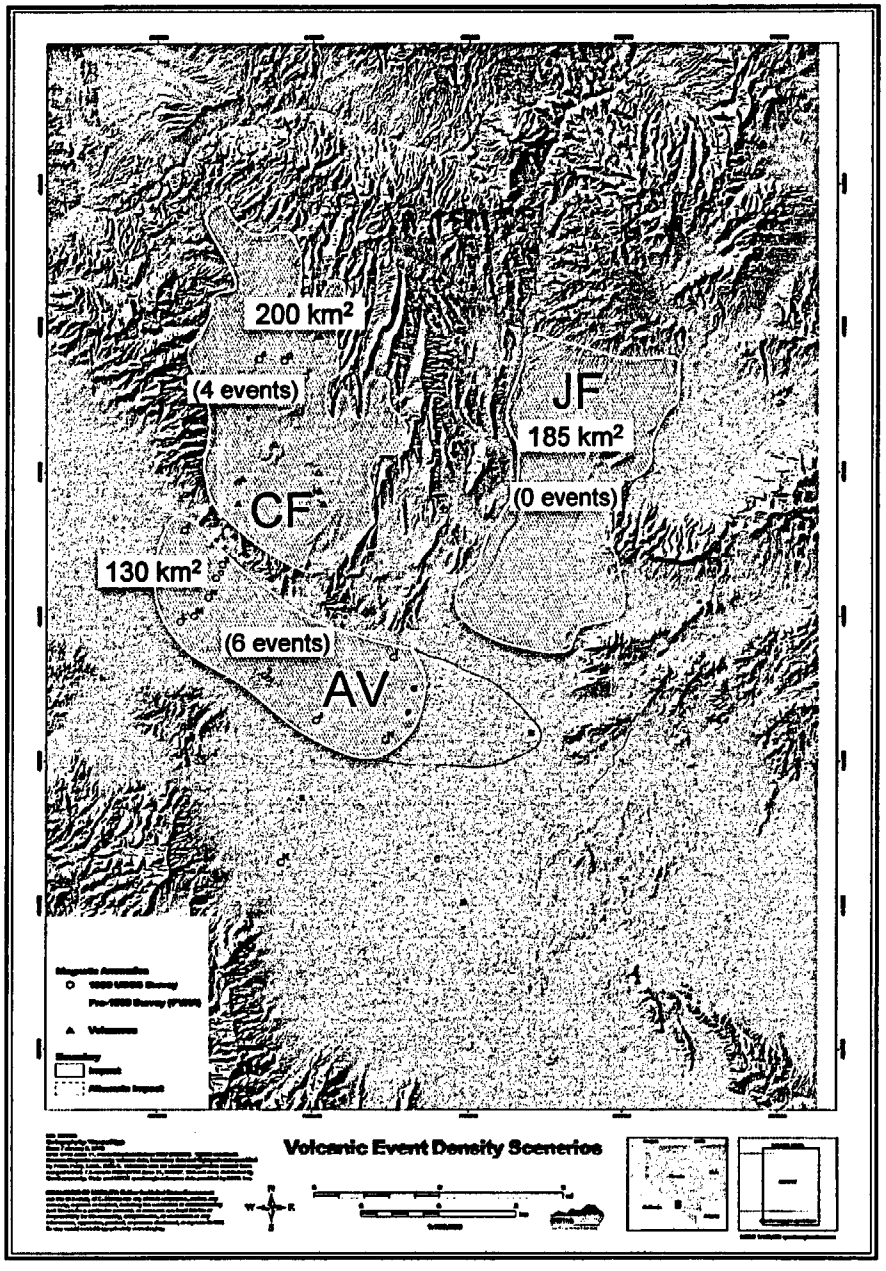
Significance of Potential Volcanic Events in Crater Flat and Western Jackass Flats

Background

- Magnetically complex bedrock beneath Crater Flat and Jackass Flats leaves open the possibility that buried and undetected volcanic events in these basins cannot be resolved by existing aeromagnetic surveys
- To significantly impact the results of the 1996 PVHA, the presence of buried volcanic events would need to produce a change in the mean of PVHA probability distribution of half an order of magnitude or greater (Brocoum 1997)
- Sensitivity studies were conducted to examine this possibility
- Sensitivity results reflect a hypothetical scenario of undetected events, not new data

Assumptions

- Potential event density based on "most likely" event counts in Amargosa Valley (AV), Crater Flat (CF) and Jackass Flats (JF)
- Most likely Pliocene events: AV = 12, CF = 4, JF = 0
- A reasonable "maximum" volcanic event density in AV = 1 event per 22 km^2, based on 6 most likely events in northern AV
- AV event density applied to CF and JF
- All potential buried volcanic events are of Pliocene age (~2-5 Ma)



Areas used in northern Amargosa Valley, Crater Flat and western Jackass Flats used to define most likely and potential Pliocene event counts

Red = number of "most likely" Pliocene events

Methods

- Applying event density from northern AV to defined areas of CF and western JF demands 5 additional events in CF and 9 additional events in western JF, after taking into account the most likely event counts in both areas
- Additional events randomly located in CF and JF (10 simulations)
- Intersection probability was calculated using two equally weighted nonhomogeneous spatial density models (bivariate Gaussian[1] and fixed kernel density)
- PVHA Hidden Event Factor was included in calculations

[1]Assumed all events are part of the same field

Sensitivity Results

- Base case (most likely events only) using equally weighted spatial density models results in weighted probability of 1.5×10^{-8}/year, consistent with PVHA mean
- Sensitivity case with hypothetical additional events in Crater Flat and Jackass Flats results in weighted mean probability of 8.0×10^{-8}/year
- Resulting mean probability is ~5 times the mean of the PVHA distribution, indicating a potentially significant change to the results of the PVHA

Sensitivity Results

- Results depend primarily on the assumed presence of 9 undetected events in western Jackass Flats, a possibility that is considered extremely unlikely by DOE, but testable through additional data collection
- Results of sensitivity study are bounded by the results of the 10^{-7}/year case

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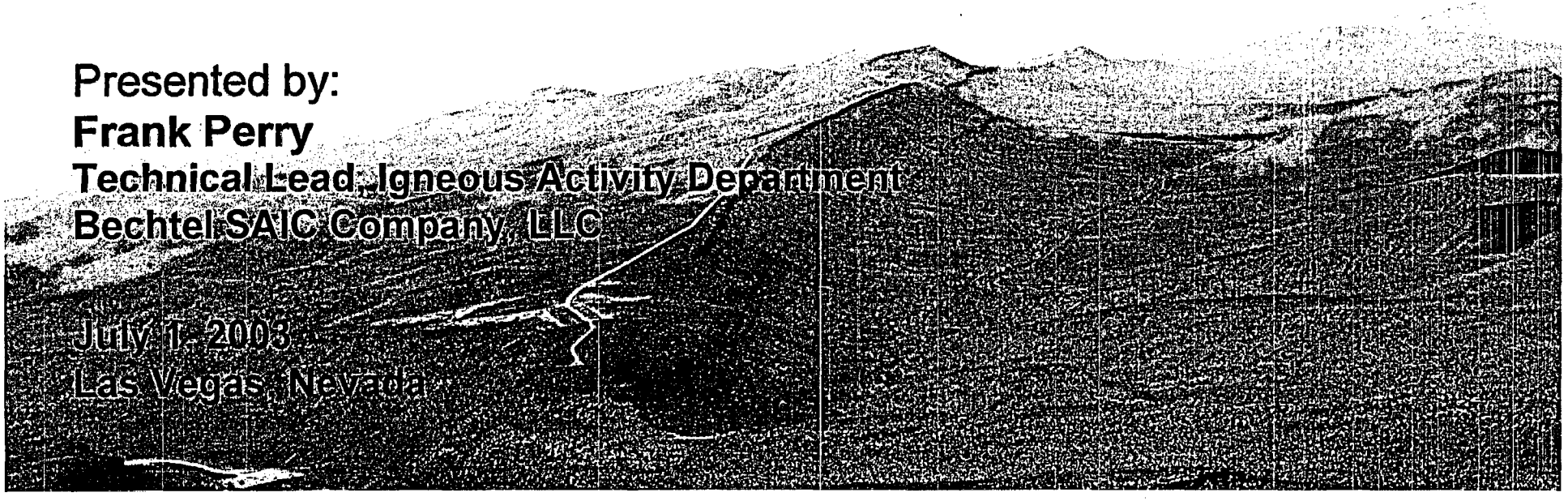
YUCCA MOUNTAIN PROJECT

Field and Laboratory Program to Constrain the Number and Ages of Volcanic Events: Outline of Path Forward

Presented to:
DOE-NRC Technical Exchange



Presented by:
Frank Perry
Technical Lead, Igneous Activity Department
Bechtel SAIC Company, LLC

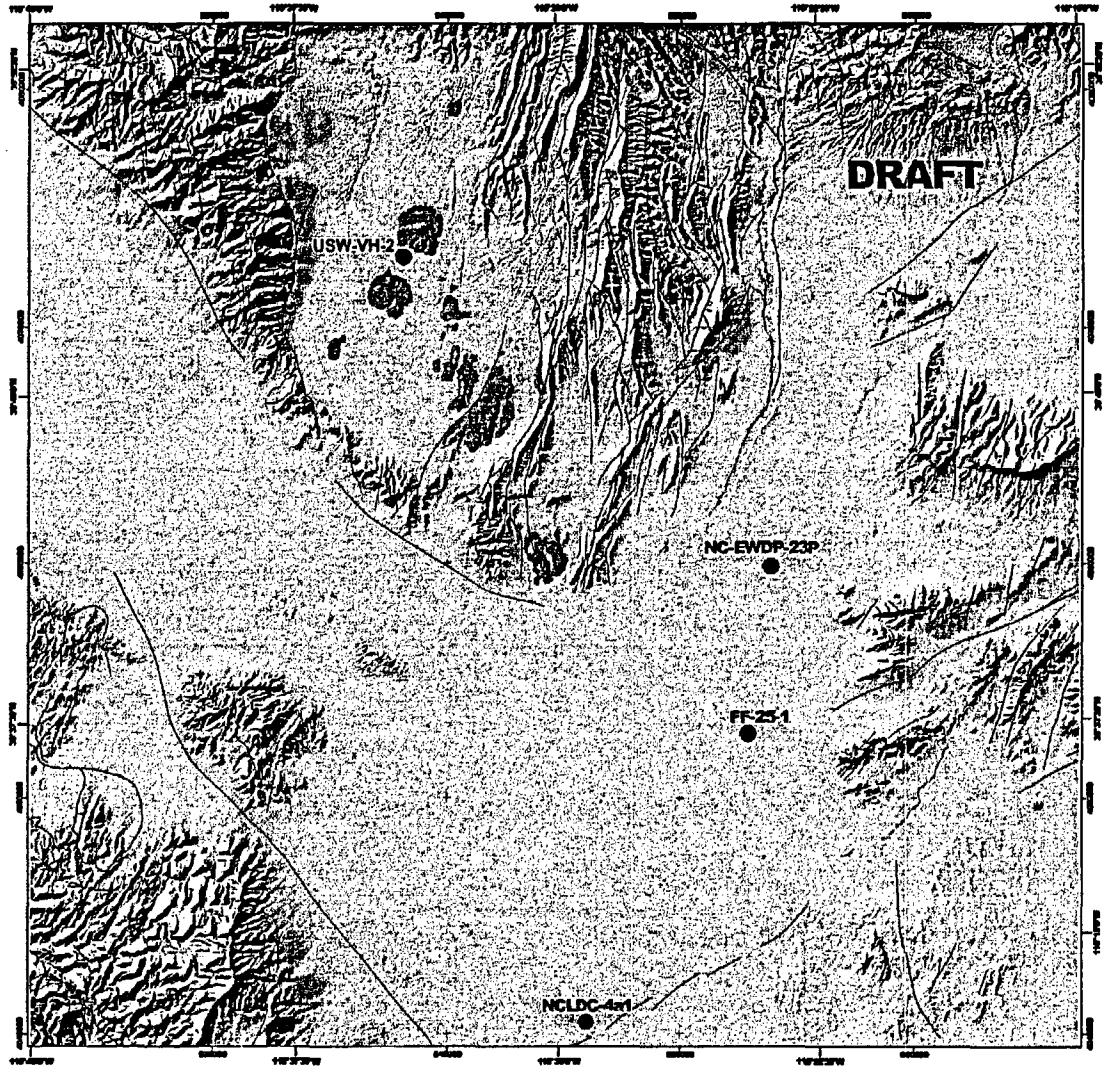
July 1, 2003
Las Vegas, Nevada

Goal of Additional Data Collection

Provide additional data to better constrain the number and age of volcanic events, reduce uncertainty, and facilitate consideration of alternative conceptual models for PVHA update

- High-resolution aeromagnetic/electromagnetic (EM) survey
- Drilling of selected anomalies
- Age and geochemistry of sampled buried basalt

Post-Miocene Volcanoes in the Yucca Mountain Region



Legend

- Yucca Mountain Repository
- Quaternary Basalt
- Pliocene Basalt
- Faults
- Drillholes

MN 200606
Cartography by: Roger Faulkt
Date: May 15, 2003
Grid: UTM Zone 11, North American Datum 1927 (NAD27). 10,000 m interval.

N
W E
S

1:100,000

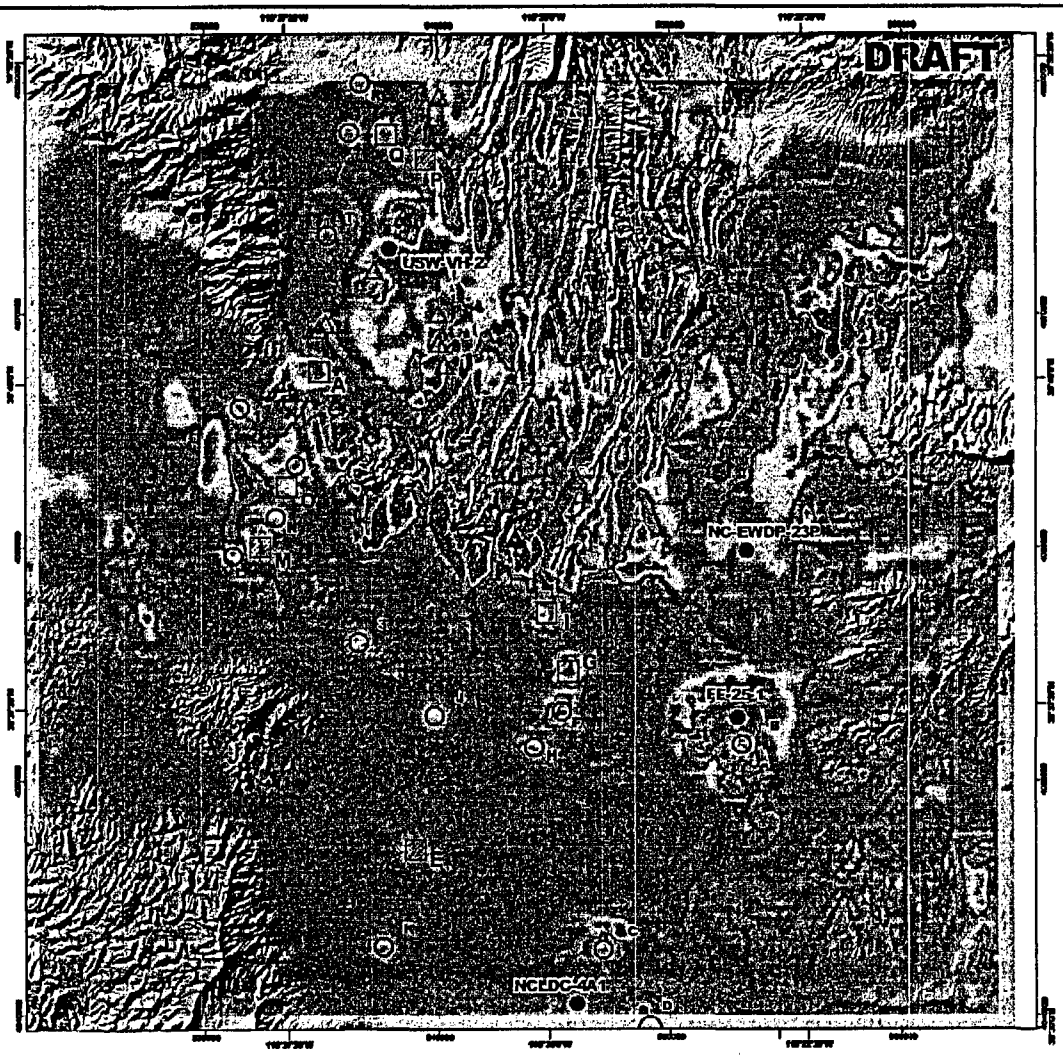
5,000 2,500 0 5,000 10,000 Meters

5 0 5 mi

GISLab
Los Alamos National Laboratory

USGS 1:100,000 quadrangle reference

1999 USGS Aeromag Survey in the Yucca Mountain Region



Legend

TYPE

- Volcanoes
- Survey

Mag Survey Flight 60m Arc

Flight Paths (linear distance sum)

60 m (6794.55 km)

600 m (678.14 km)

Drillholes

- Drillholes (Preexisting Bsmt)

Magnetic Anomalies

- 1999 USGS Survey
- Confirmatory Drill Holes
- Planned Drill Holes
- Yucca Mountain Repository

1999 USGS Aerial Mag Survey-Filtered Value

High : 233.6

Low : -113.3

10 Meter Shaded Relief Value

MR 2000000
Cartography by: Roger Prunill
Date: May 15, 2003
Grid: UTM Zone 11, North American Datum 1927 (NAD27). 10,000 m interval.

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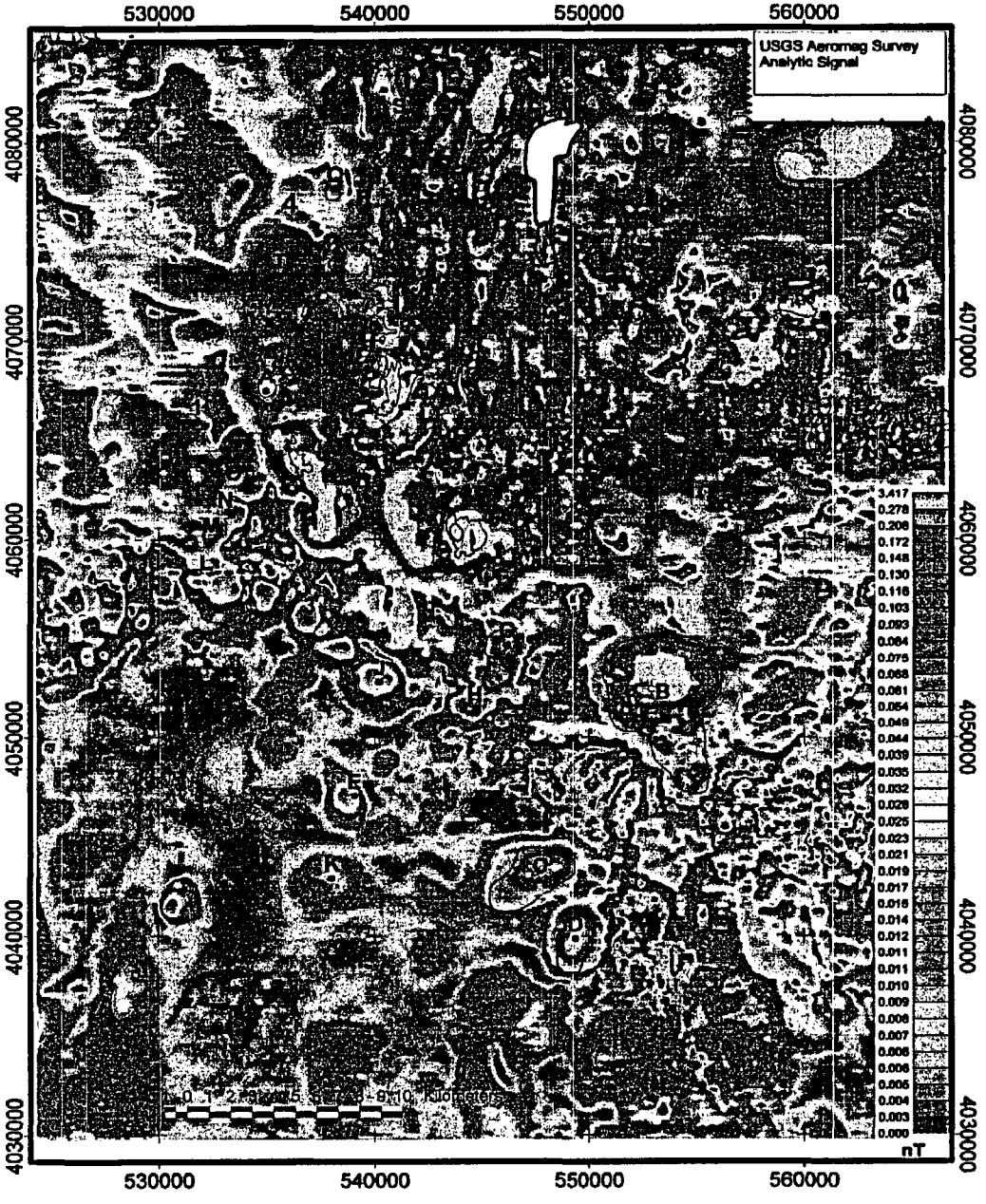
GISLab
Los Alamos National Laboratory

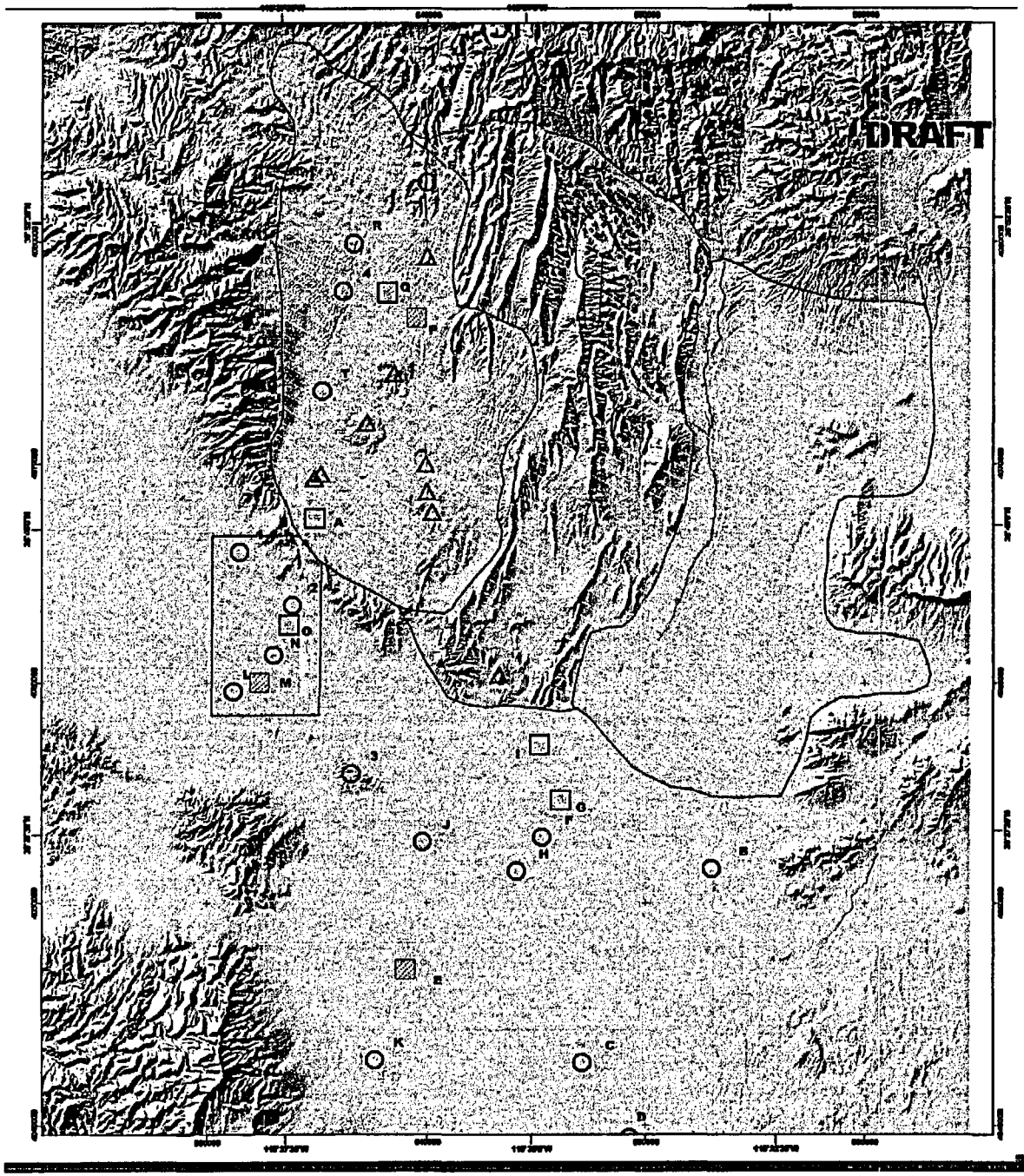
USGS 1:100,000 quadrangle reference



Total Magnetic Signal

(Hill and Stamatakos 2002)

Repository lies within "noisy" region of high amplitude, short wavelength magnetic signal



Design of new aeromagnetic/EM survey emphasizes detection of basaltic features in magnetically noisy areas surrounding Yucca Mountain

- Survey area used to estimate costs, actual survey area may be slightly different
- Diagonal flightlines are for illustration purposes only; 600 meter spacing shown, 60 meter spacing planned

△ Volcano

○ 1999 USGS Survey

□ Planned Drill Hole

▨ Contingency Drill Hole

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Selection Criteria for Drilling Anomalies

- **Location as it pertains to impact on probability estimates (e.g., distance from repository, impact on event lengths)**
- **Sample each major cluster or alignment of anomalies**
- **Range of potential ages based on differences in burial depth, magnetic polarity**
- **Balance of "high confidence" vs "low confidence" anomalies**

Planned Phase I Drillholes

Anomaly	Polarity	Est. Depth (m)	Comments
A	N	150	Aligned with 1 Ma centers in Crater Flat, normal polarity
G	R	150	Northernmost of 3 aligned anomalies
O	N	50	One of 5 aligned anomalies, shallow burial depth
Q	R	400	One of four grouped anomalies in northern CF
I	N	250	NE of "G", greater depth
(M)	N	150	Contingent on results of "O"
(P)	R	150-200	Contingent on results of "Q"
(E)	N	150	Contingency target

1999 USGS Aeromag Survey in the Yucca Mountain Region

Legend

TYPE

△ Volcanoes

▭ Survey

Mag Survey Flight 60m Arc

Flight Paths (linear distance sum)

60 m (8794.55 km)

600 m (878.14 km)

Drillholes

Magnetic Anomalies

1999 USGS Aerial Mag Survey-Filtered

Value

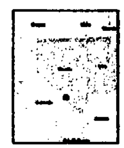
High : 253.6

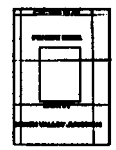
Low : -113.3

10 Meter Shaded Relief

Value

1:100,000





GISLab

Los Alamos National Laboratory

USGS 1:100,000 quadrangle reference

Phase II Drillholes

Selection of targets will depend on:

- **Results of new aeromagnetic/EM survey**
- **Phase I drilling results**

Planned Sample Analysis

- Age determinations – $^{40}Ar/^{39}Ar$ dating
- Major and trace-element geochemistry
- Isotopic data – Sr, Nd, and Pb

Summary

- Program of field and laboratory investigations
- Field program
  - High resolution Aeromagnetic/EM survey to identify additional anomalies and determine nature of source
  - Drilling of high and low confidence targets to locate buried basalts and obtain samples
- Laboratory program
  - Rock chemistry
  - High precision ages
- Update PVHA

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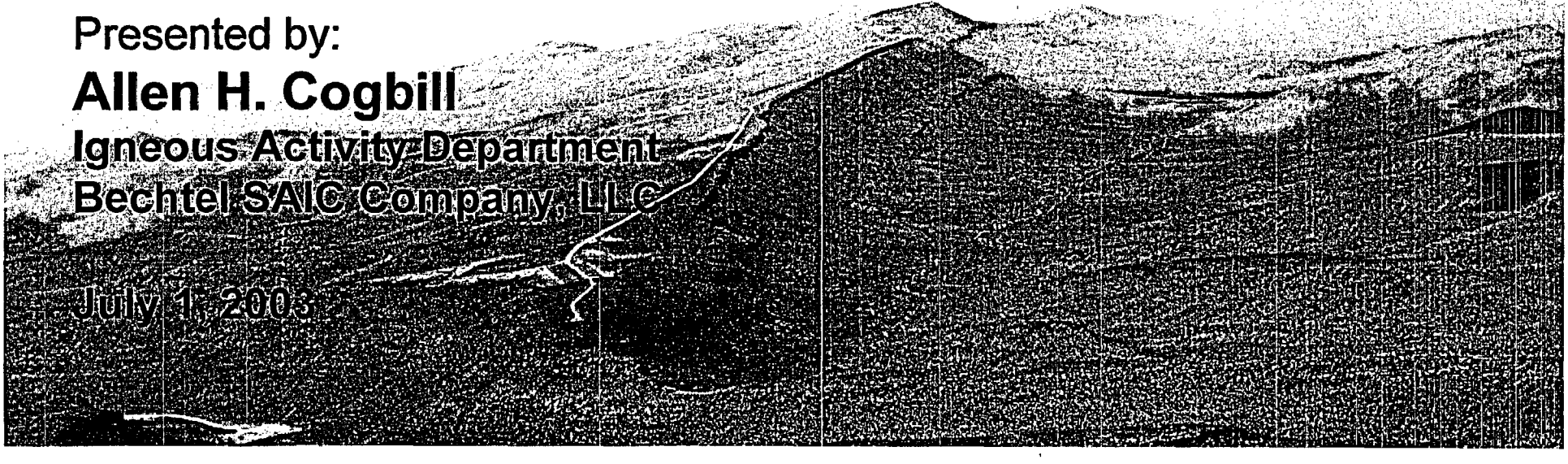
YUCCA MOUNTAIN PROJECT

Aeromagnetic Survey Design

Presented to:
DOE-NRC Technical Exchange



Presented by:
Allen H. Cogbill
Igneous Activity Department
Bechtel SAIC Company, LLC

July 1, 2003

Survey Objectives

- Reliably map possible basaltic rocks within the upper 400 m of section
- Distinguish between magnetic tuffs and basalts
- Provide uniform, unaliased coverage of the area of interest

Magnetic Properties

- The measured magnetic field is influenced by the magnetization of the underlying rocks
- Broadly speaking, rock magnetization is a combination of
  - Remanent (i.e., permanent) magnetization
  - Induced magnetization (due to an applied field)

Magnetic Properties (con'd)

- Both basalts and portions of certain older tuff units (*e.g.*, Topopah Spring) are characterized by high remanent magnetization
- The basalts seem to have rather typical high magnetic susceptibility, whereas the tuff units have susceptibilities 5-10 times smaller. Thus, the basalts should have much higher induced magnetization
- A method of measuring only induced magnetic field may distinguish the types of two rocks

Low-level Airborne Surveys

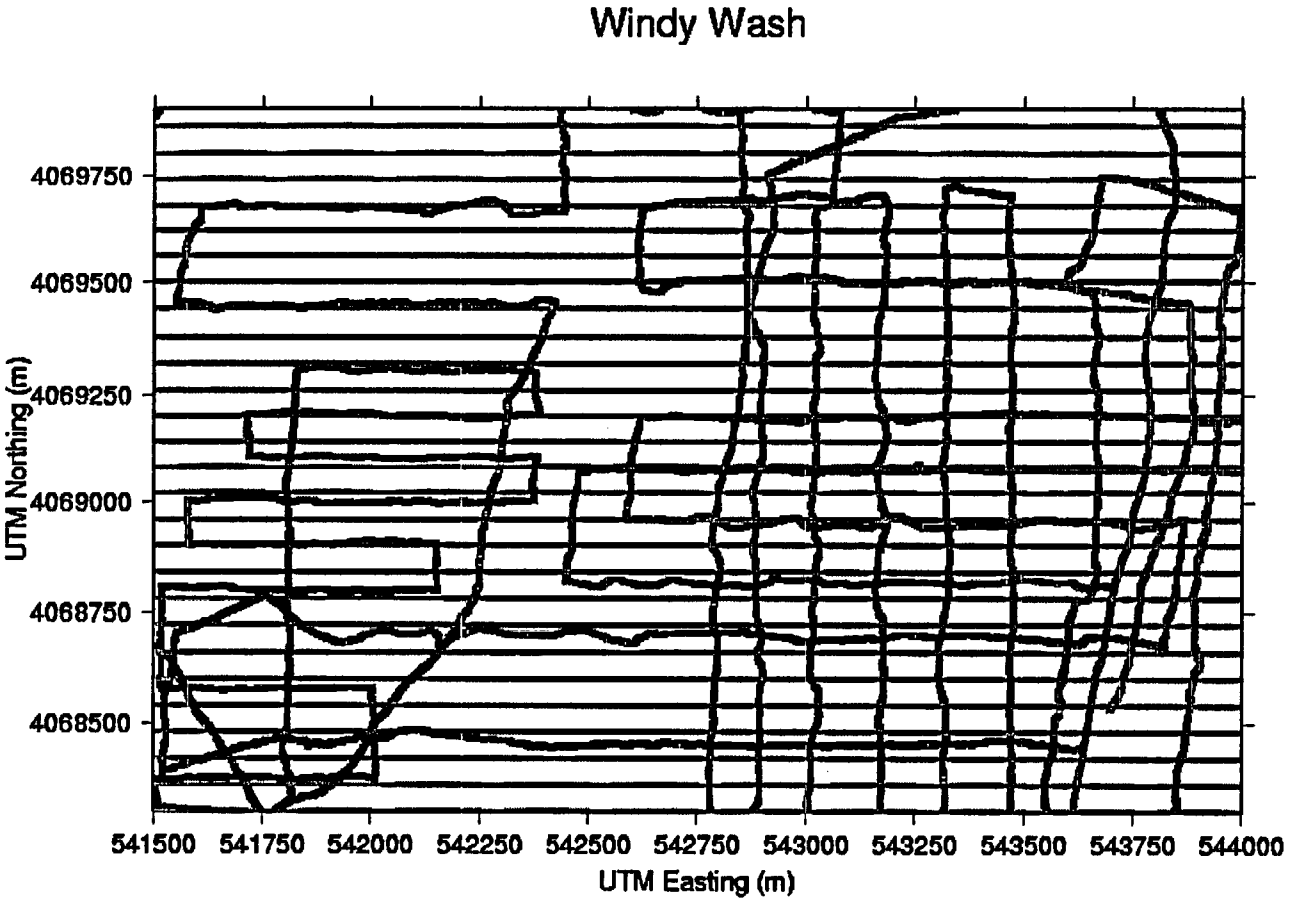
- Offer greatly-improved spatial resolution compared to typical airborne surveys
- Are much less affected by cultural noise and potentially severe aliasing than ground surveys
- Provide uniform data coverage even in rugged terrain
- Airborne EM surveys utilize much larger EM sources than ground EM surveys

Magnetic & EM Survey

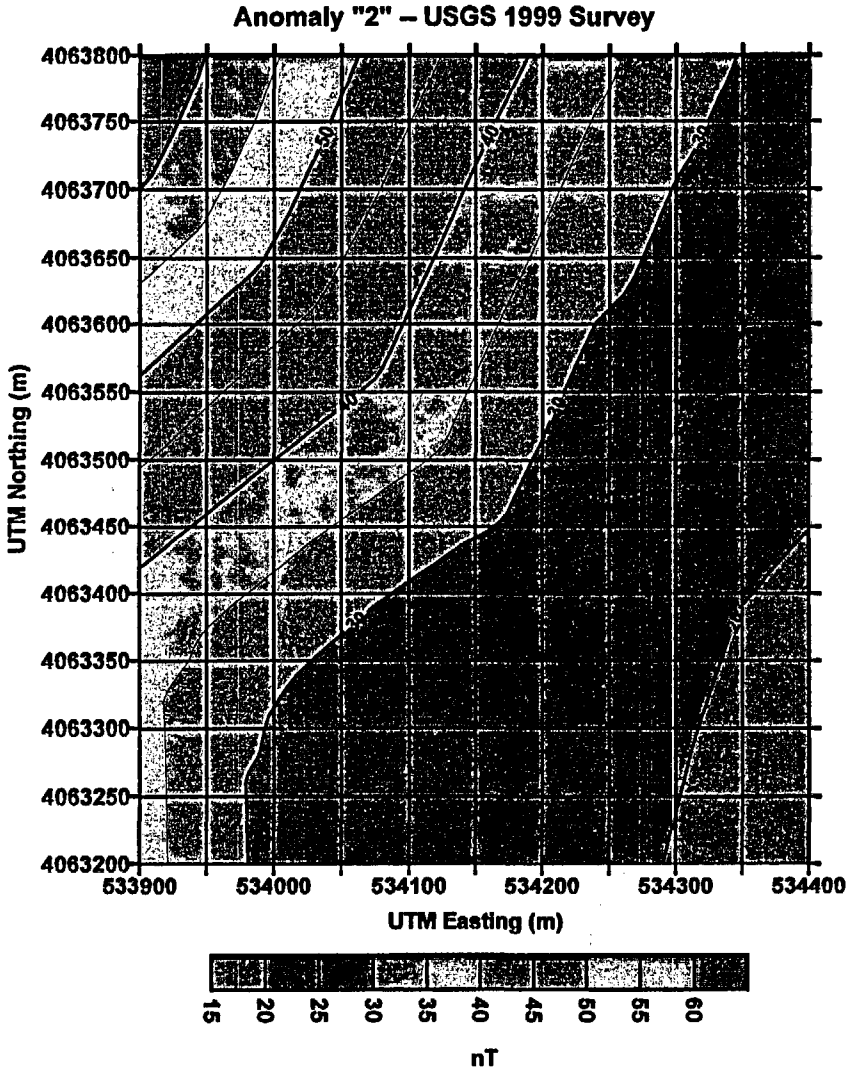
- Multi-frequency (300 Hz - 100 kHz) EM survey uses a vertical magnetic dipole source
- At low frequencies (< 1 kHz), the EM source is similar to the Earth's field, although smaller in magnitude
  - Primarily the induced magnetic field is measured
  - Data can be processed to provide a magnetic susceptibility map

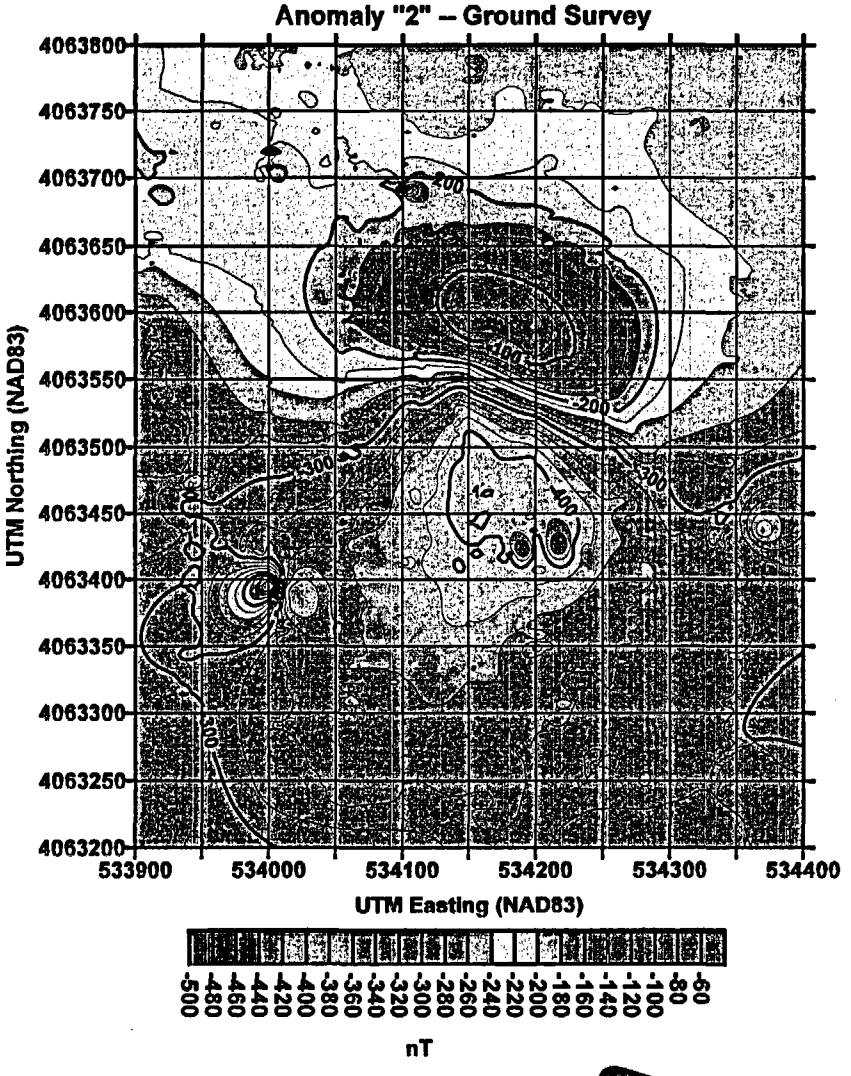
Uniform Data Coverage

Proposed HEM survey lines, shown in blue, would provide more uniform coverage compared to ground surveys.

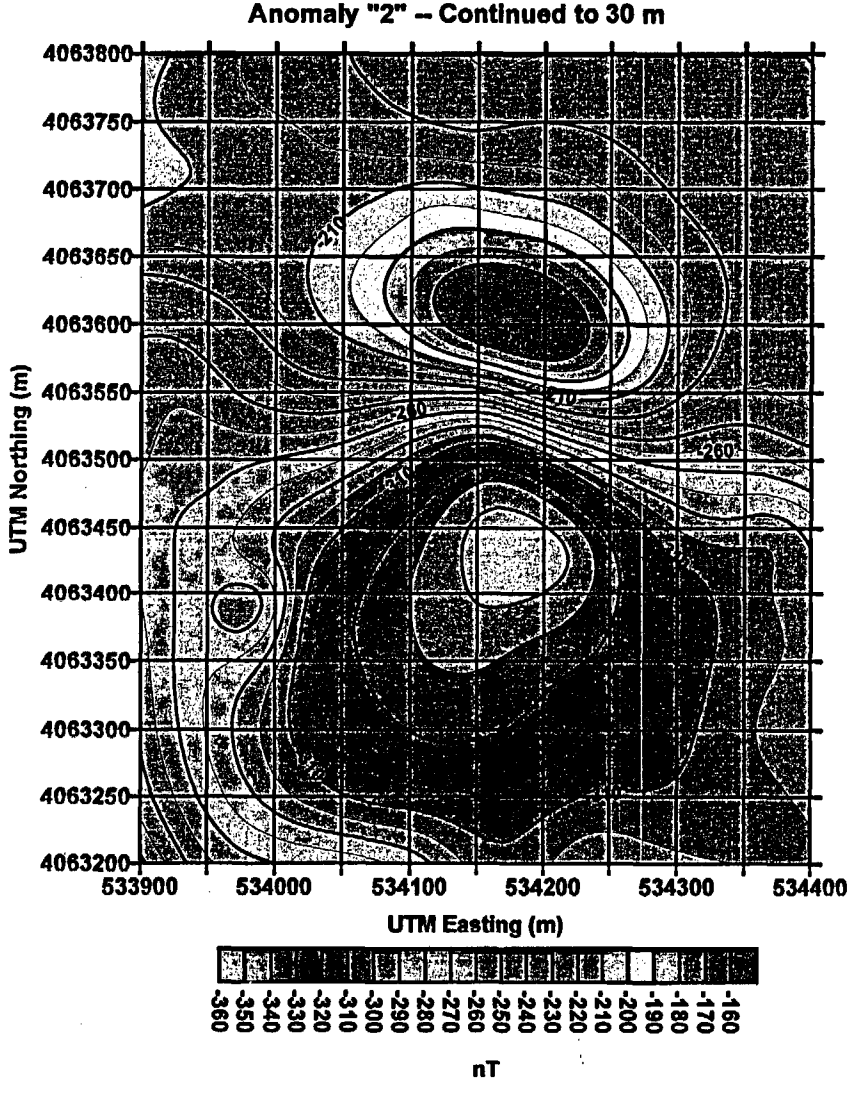


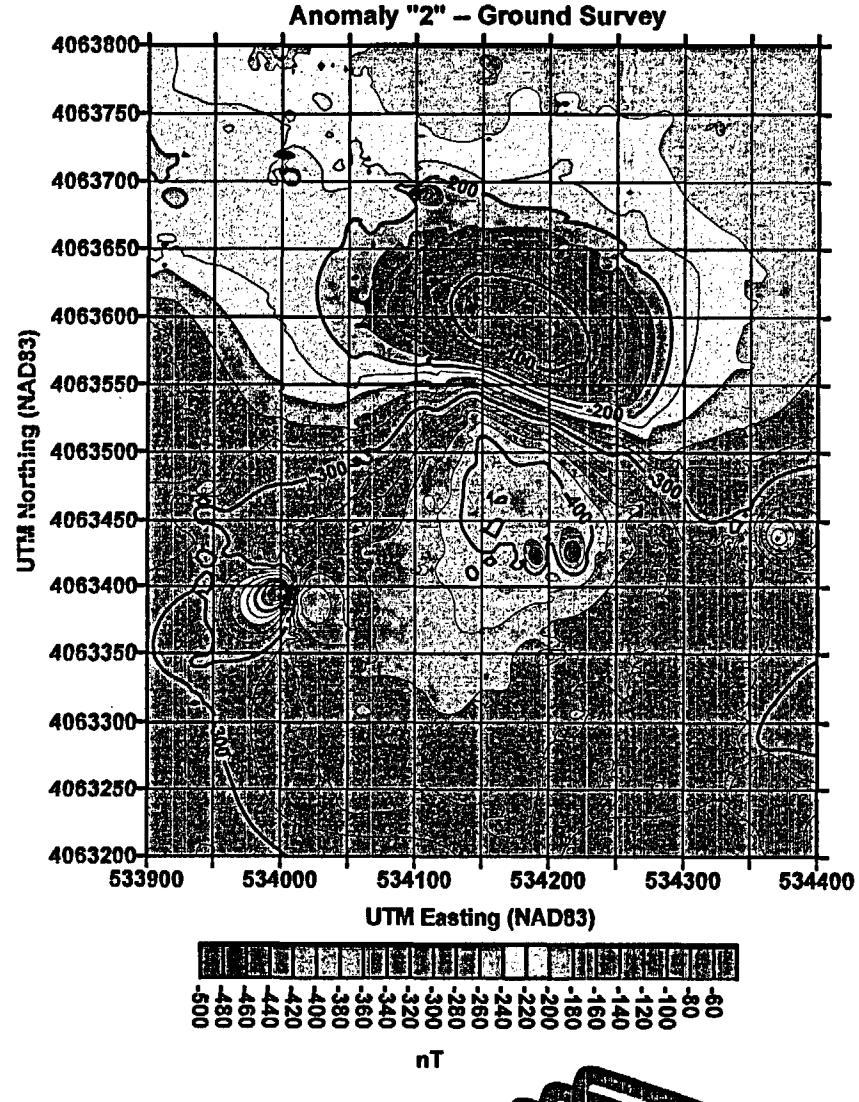
Better Spatial Resolution





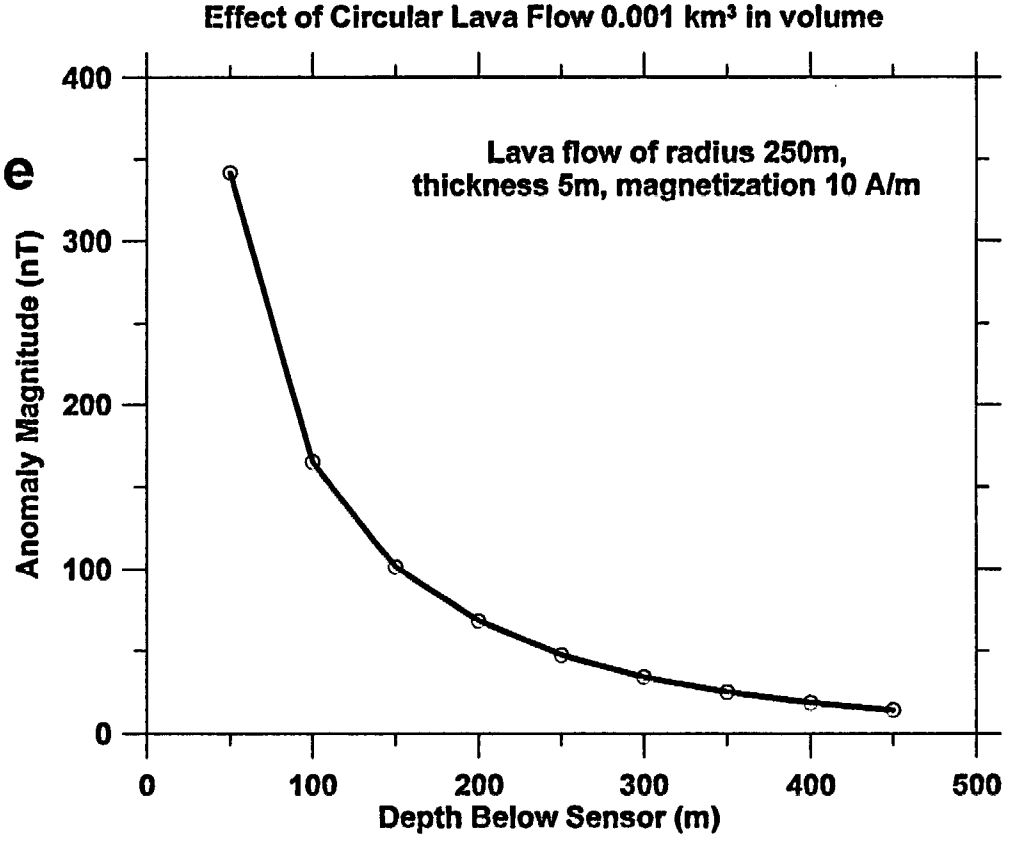
Good Resolution at 30 m





Small Sources Detectable

- Small magnetic sources embedded in alluvium are detectable to depths of about 400m
- A small (0.001 km^3) magnetic source produces 15-nT anomaly even 430m below sensor

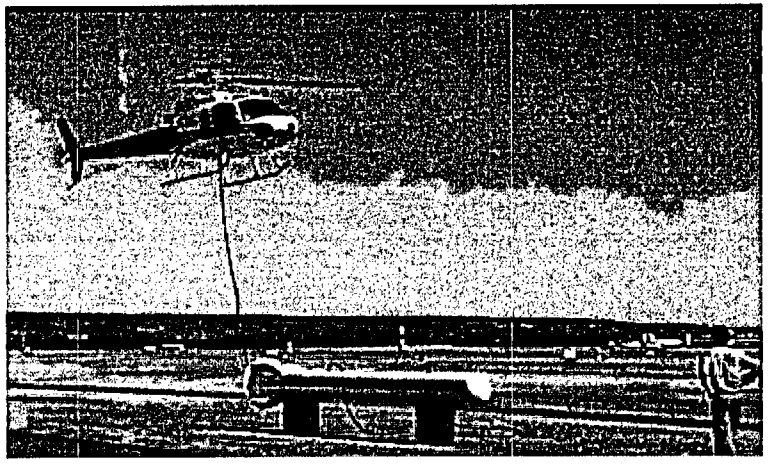


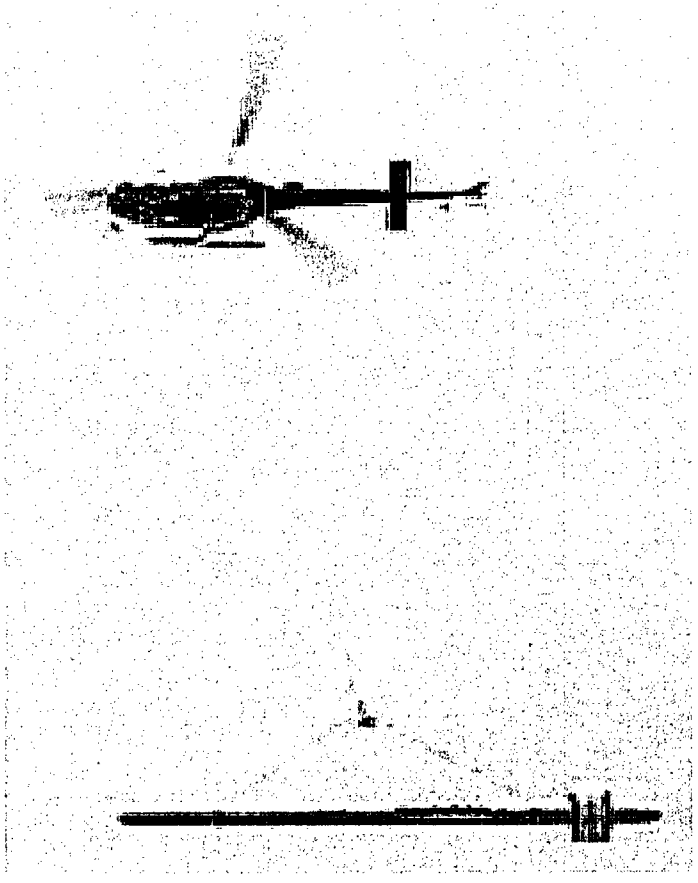
Helicopter Mag/EM Surveys

- Total-field magnetic data and multi-frequency EM data acquired concurrently, in the same instrument package
- Spectral gamma-ray data may also be acquired concurrently
- Typical sensor altitude is 30 meters, constrained by EM requirements
- Flight-line spacing is twice the sensor height (typically 60 meters), due to EM source "footprint" and anti-aliasing

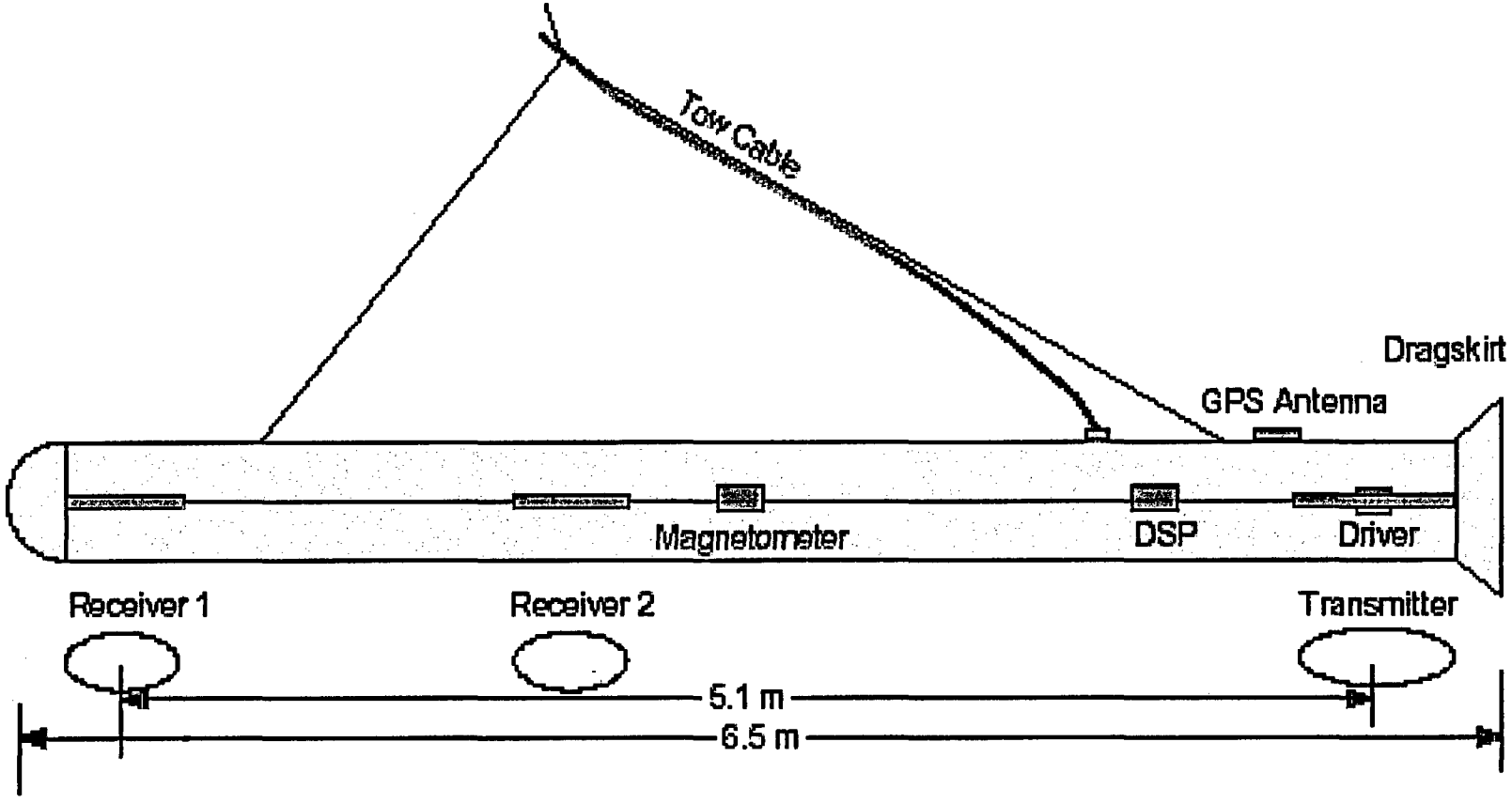
HEM Instrument Package

- **Bird towed about 30 meters below helicopter**



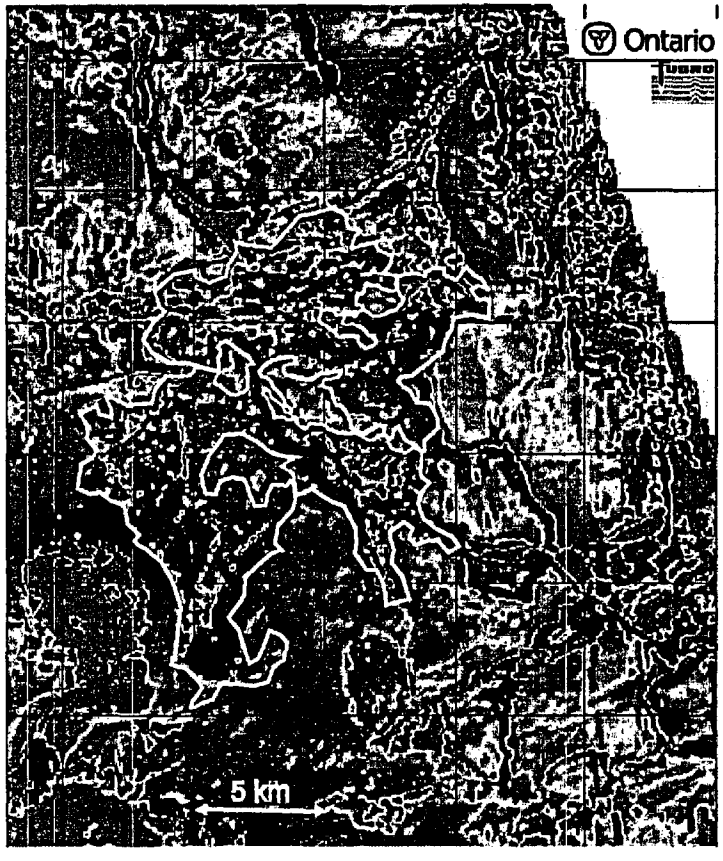


Instrumentation in Package

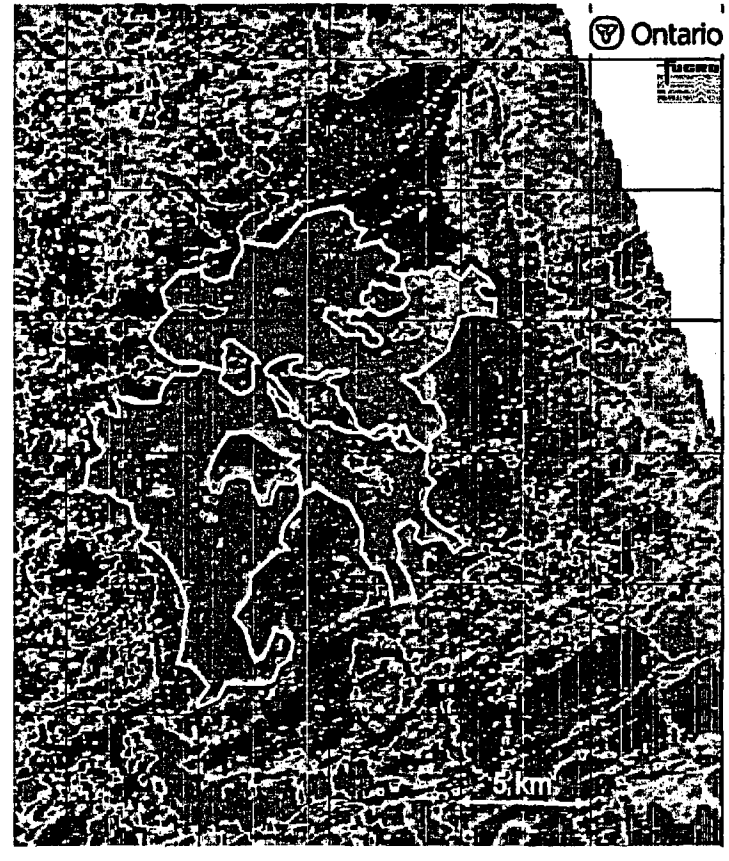


Field Example from Ontario

Total Magnetic Field



Apparent Susceptibility



Summary

- A helicopter EM and total-field magnetic survey offers very high spatial resolution, uniform data acquisition, and the ability to detect small magnetic sources.=
- Additionally, the ability to process the EM data to produce a magnetic susceptibility map helps distinguish basalt from tuff in the shallow section

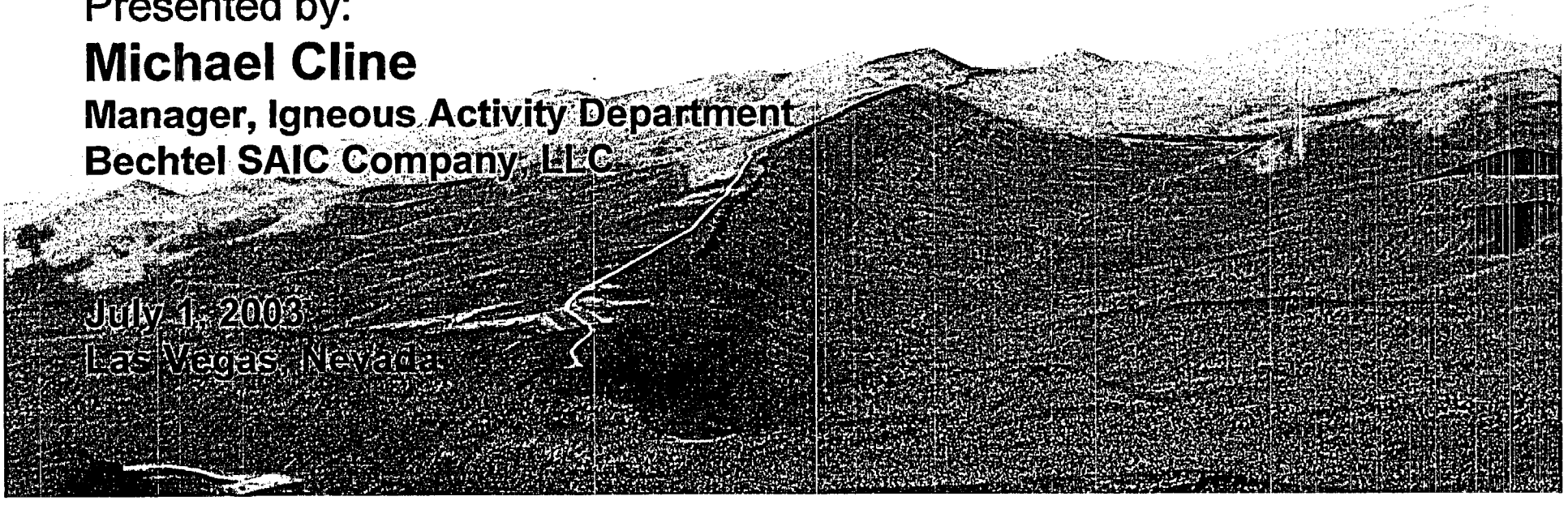
U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Status of Responses to Igneous Consequences Peer Review Comments

Presented to:
DOE-NRC Technical Exchange

Presented by:
Michael Cline
Manager, Igneous Activity Department
Bechtel SAIC Company, LLC



July 1, 2003
Las Vegas, Nevada

Igneous Consequence Peer Review (ICPR)

- Conducted (6/02 – 2/03) to address specific issues related to consequences of a potential igneous event intersecting the proposed repository
- Review was thorough and complete
  - Final report issued February 2003
  - Overall view of the ICPR

    "...overall conceptual model (...rising dike intersecting several drifts into which magma flows, followed by ... pyroclastic strombolian eruption along a conduit) is both adequate and reasonable."

    "...unreasonable to expect major advances in understanding ...within the next three years... do not recommend any alteration to present overall model"
  - 29 Comments included in report

ICPR Final Report

- **ICPR addressed eight questions related to**
  - Adequacy of the models being used to represent the initiating events and associated processes
  - Ability of the models to quantify uncertainties
  - Level of analysis necessary to adequately address the issues given the limitations of science
- **ICPR focused on recommendations related to reducing uncertainty**
  - Restricting range of magma properties and eruptive scenarios
  - Better understanding of dike propagation mechanics
  - More realistic treatment of waste entrainment

Status of DOE Response to ICPR

- DOE's evaluation of the comments consider a risk informed approach
- Responses will address comments in one of two ways
  - Discussion with no additional work planned
  - Description of ongoing work or planned work to support the technical basis for repository licensing
- ICPR's 29 comments have been grouped into summary topics to minimize repetitions in the DOE responses
- Responses available within 60 days

Major ICPR Comments

- General conceptual model for an igneous event is adequate and reasonable
  - ICPR recognizes the limitations of scientific understanding and computational capabilities for developing more sophisticated mechanistic models for igneous events, particularly as they relate to
    - Damage to waste packages from magma flowing into drifts
    - Pyroclastic conduit flows past waste packages

Major ICPR Comments

- Future modeling should focus on developing a 3-D model for dike propagation, dike/drift interaction, and quantifying the "dog leg" scenario
- This will require more sophisticated software and modeling to address
  - Gas/vapor evolution
  - Gas/vapor cavity length
  - 3-D coupled models for unsteady dike/drift flow
  - Gas pressure loss through rock permeability

ICPR Recommendations Addressed in Planned Work

- Approach giving more weight to Plio-Pleistocene igneous events near YM is reasonable; however, additional age dating should be performed
  - Age dating included in current work plan
- Recommended a number of repository design modifications to minimize impacts of Igneous events that the Project is considering
  - Backfill plug to impede magma flow being evaluated for inclusion in the design

Additional ICRP Recommendations

- **Additional work to reduce uncertainties**
  - **Laboratory experiments to**
    - **Address transition between bubbly magma and gas-filled cavity**
    - **Chemical/mechanical effects on waste packages**
  - **Compare ASHPLUME predictions to ASHFALL and RAMS/HYPACT predictions using fixed set of data**
- **Work would be confirmatory in nature and DOE is evaluating it in the context of the risk informed approach**

Summary

- ICPR viewed overall conceptual model of dike-drift intersection to be adequate and reasonable
- ICPR presented recommendations for future work to address uncertainties
- DOE responses consider a risk informed approach in addressing comments one of two ways
  - Discussion with no additional work planned
  - Description of ongoing work or planned work to support the technical basis for repository licensing
- Responses expected to be available within 60 days

July 24, 2003

Mr. Joseph Ziegler, Acting Director
U.S. Department of Energy
Office of Repository Development
P.O. Box 364629 M/S 523
North Las Vegas, NV 89036-8629

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF ENERGY TECHNICAL EXCHANGE ON IGNEOUS CONSEQUENCES PEER REVIEW REPORT RECOMMENDATIONS AND IGNEOUS ACTIVITY PROBABILITY

Dear Mr. Ziegler:

Enclosed is the meeting summary of the July 1, 2003, Technical Exchange, between the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE). The purpose of the meeting was to discuss NRC's response to Igneous Consequences Peer Review Report Recommendations and Igneous Activity Probability.

The technical exchange was held at DOE offices in Las Vegas, Nevada and via telecon to the NRC office in Rockville, Maryland, and at the Center for Nuclear Waste Regulatory Analyses in San Antonio, Texas. The bridge number for the telecon was also provided for others interested in participating in the meeting. If you have any questions regarding this letter, please contact Greg Hatchett, Senior Project Manager. He can be reached at 301-415-3315 or via e-mail at gxh@nrc.gov.

Sincerely,

/RA/

Janet R. Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

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