Scientific Notebook 758E

Entry: Saurav Biswas
Date: February 8, 2006

Title: **Modeling of Aeromagnetic Anomalies in the Yucca Mountain Region to Support Evaluation of Event Probability.**

Personnel: John Stamatakos is the Principal Investigator for this project. Saurav Biswas is the lead investigator. Shannon Colton also provided input to technical work reported on in this scientific notebook. All entries in this scientific notebook were made by Saurav Biswas unless otherwise indicated in this text.

Project: This notebook document procedures, data, and modeling results used in evaluating magnetic anomalies under **20.06002.01. 352 — SUPPORT PRELICENSING TRANSITION TO LICENSE APPLICATION REVIEW - MSOP**. This text and supporting files are provided herein to meet the CNWRA requirements of QAP -001.

Data: CNWRA data contained in this report meet quality assurance requirements described in the CNWRA Quality Assurance Manual. Data used to support conclusions in this report taken from documents published by the U.S. Department of Energy (DOE) contractors and supporting organizations were generated according to the quality assurance program developed by DOE for the Yucca Mountain Project.

Codes: Maps and anomaly models were generated and plotted by the software Oasis montaj© ~~Version 5.1.8(A5) (Geosoft, 2000)~~ Version 5.1.8(A5) (Geosoft, 2000) and Version 6.3.1 (6G) (Geosoft 2006) (S.B. April 6, 2007), GM-SYS© (Geosoft) 4.8.45b (Northwest Geophysical Assoc., 2001), which are commercially available software codes that are maintained in accordance with CNWRA Technical Operating Procedure TOP–018.

Background: The total-field magnetic data for the current work was collected by the DOE using a helicopter-borne cesium-vapor magnetometer. The average elevation of the magnetic sensor was 30 m above ground. The primary flight lines were flown in an east-west direction, with a nominal flight-line spacing of 60 m. Secondary flight lines (tie lines) were flown in a north-south direction at a flight-line spacing of 600 m. The accuracy of magnetic data was ±0.01 nT. The measurement locations have horizontal accuracy of ±1 m and vertical accuracy of ±2 m. The total-field magnetic measurements were corrected for normal time variations in the earth's magnetic field with a base station magnetometer. Cogbill (2004) has summarized the aeromagnetic survey conducted to provide the data for this work.

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Entry 1.

a) ~~Background~~

~~The total-field magnetic data for the current work was collected by the DOE using a helicopter-borne cesium-vapor magnetometer. The average elevation of the magnetic sensor was 30 m above ground. The primary flight lines were flown in an east-west direction, with a nominal flight-line spacing of 60 m. Secondary flight lines (tie lines) were flown in a north-south direction at a flight-line spacing of 600 m. The accuracy of magnetic data was ±0.01 nT. The measurement locations have horizontal accuracy of ±1 m and vertical accuracy of ±2 m. The total-field magnetic measurements were corrected for normal time variations in the earth's magnetic field with a base station magnetometer. Cogbill (2004) has summarized the aeromagnetic survey conducted to provide the data for this work.~~
(S.B. March 5, 2007)

b) Prior evaluation of aeromagnetic data by Paul Landis

Data from the 2004 Department of Energy (DOE) was provided as two separate ASCII files, **FinalMagData-TieLines.dat** and **FinalMagData-TraverseLines.dat**. Both files were imported into Oasis Montaj and saved as .gdb files. The two flight line databases were merged into a single database using options under the 'Utility' menu in Oasis montaj (**flightlines.gdb**). The database consists of columns of UTM NAD 27 easting and northing, GPS elevation, radar altimeter data, and corrected total magnetic field data. The total magnetic field column was grided using the minimum curvature algorithm with a grid node spacing of 60 m (**aero_min_60**). The grid was displayed using a histogram equalization shading option that minimizes the distance between intervals and results in irregular spaced intervals. The elevation of the ground surface was calculated by converting the radar altimeter data into meters and then subtracting the altimeter data from the GPS elevation of the helicopter. The data were then grided using the minimum curvature algorithm in Oasis montaj. The grids for topography and magnetic anomaly are **aero_groundelev_200** and **aero_boomelev_200** respectively. The data is located in Bemore at **D:\sbiswas\Aeromag\paul\DOEaeromag05**. The locations of the boreholes for the respective anomalies are noted in the spreadsheet **usgsanom27.xls** Data folder.

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Entry 2. Magnetic Anomaly - Q

Steps for modeling magnetic anomaly Q:

(1) Define the location of the anomaly Q (Blakely et al., 2000; Hill & Stamatakos, 2002) on the total field aeromagnetic anomaly map around Yucca Mountain, Nevada – Figure 1.
(2) Define profile locations for magnetic anomaly – Figure 2.
(3) Export the extracted profile data into GM-SYS for modeling – Figure 3. The sequence of faulted lithologic units (Figure 3) for modeling the magnetic anomaly is based on stratigraphic section in Stamatakos et al. (2000). The depth of basalt in the model (Figure 3) at 141 m below ground surface is constrained by drill hole USW-VA-4a (Perry et al., 2005).
(4) Iteratively model the 2D subsurface geometry until the fit between observed and modeled magnetic profiles is optimized (e.g., small error).

Table 1 Source parameters for magnetic anomaly model for anomaly Q

Rock Type	Modeled Inclination	Modeled Declination	Remanent Magnetization Intensity (A/m)
Quaternary Alluvium (Qal)	-	-	0
Pliocene Basalt	-55°	170°	5
Basalt	-60°	180°	5
Ammonia Tanks (Tma)	59°	0°	0.58
Rainier Mesa (Tmr)	-55°	168°	4

The magnetic parameters of the sources are based on Brocher et al. (1998) and Stamatakos et al. (2000). The remanent magnetization intensity of Rainier Messa (Tmr) was increased from 0.8-2.7 A/m (Brocher et al., 1998; Stamatakos et al., 2000) to 4 A/m to better fit the observed anomaly. Further investigation of magnetic intensity of volcanic tuff is needed to decide the validity of the subsurface geometry of the sources.

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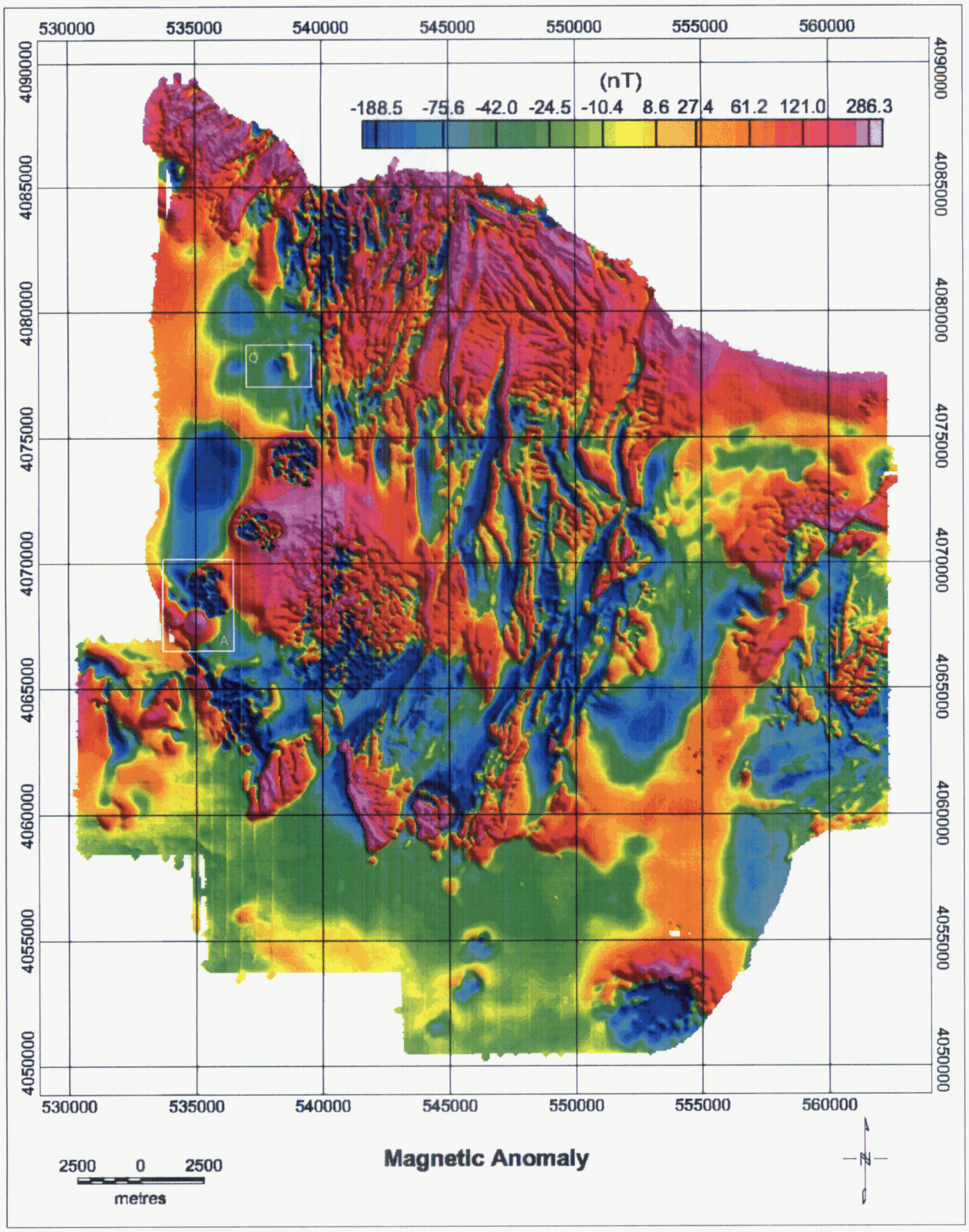

Figure 1 Total field aeromagnetic anomaly map around Yucca Mountain, Nevada compiled at approximately 30 m above the ground surface. The rectangles enclose the anomalies of interest chosen for further modeling. Coordinates are in Universal Transverse Mercator (UTM) Zone 11, using the North American Datum of 1927.

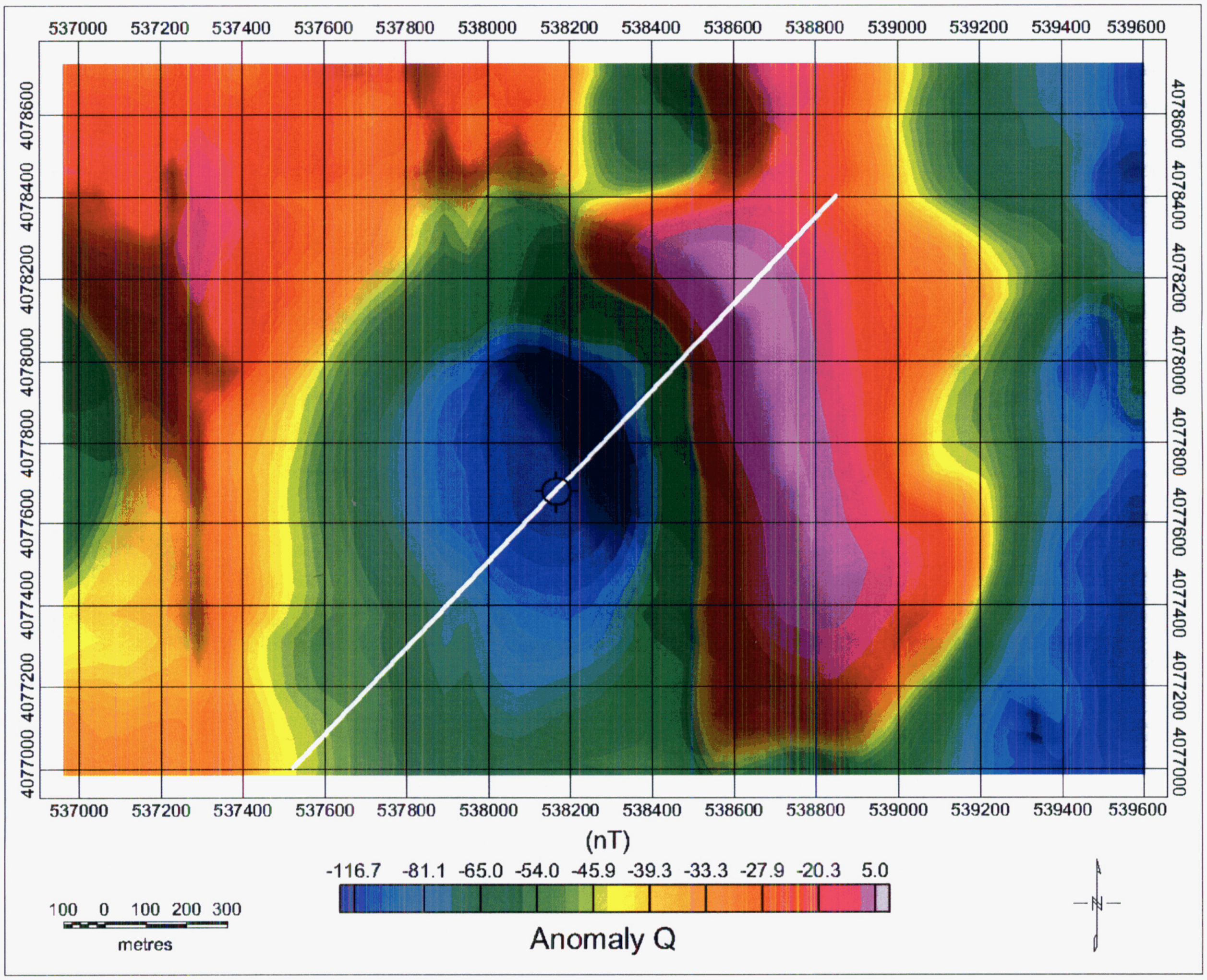

Figure 2 Total field aeromagnetic anomaly Q. Coordinates are in Universal Transverse Mercator (UTM) Zone 11, using the North American Datum of 1927. The white line shows the location of profile – Line2. Different profile termed Line 1 was modeled by Paul Landis and are not recorded in this Scientific notebook. ⌖ - borehole.

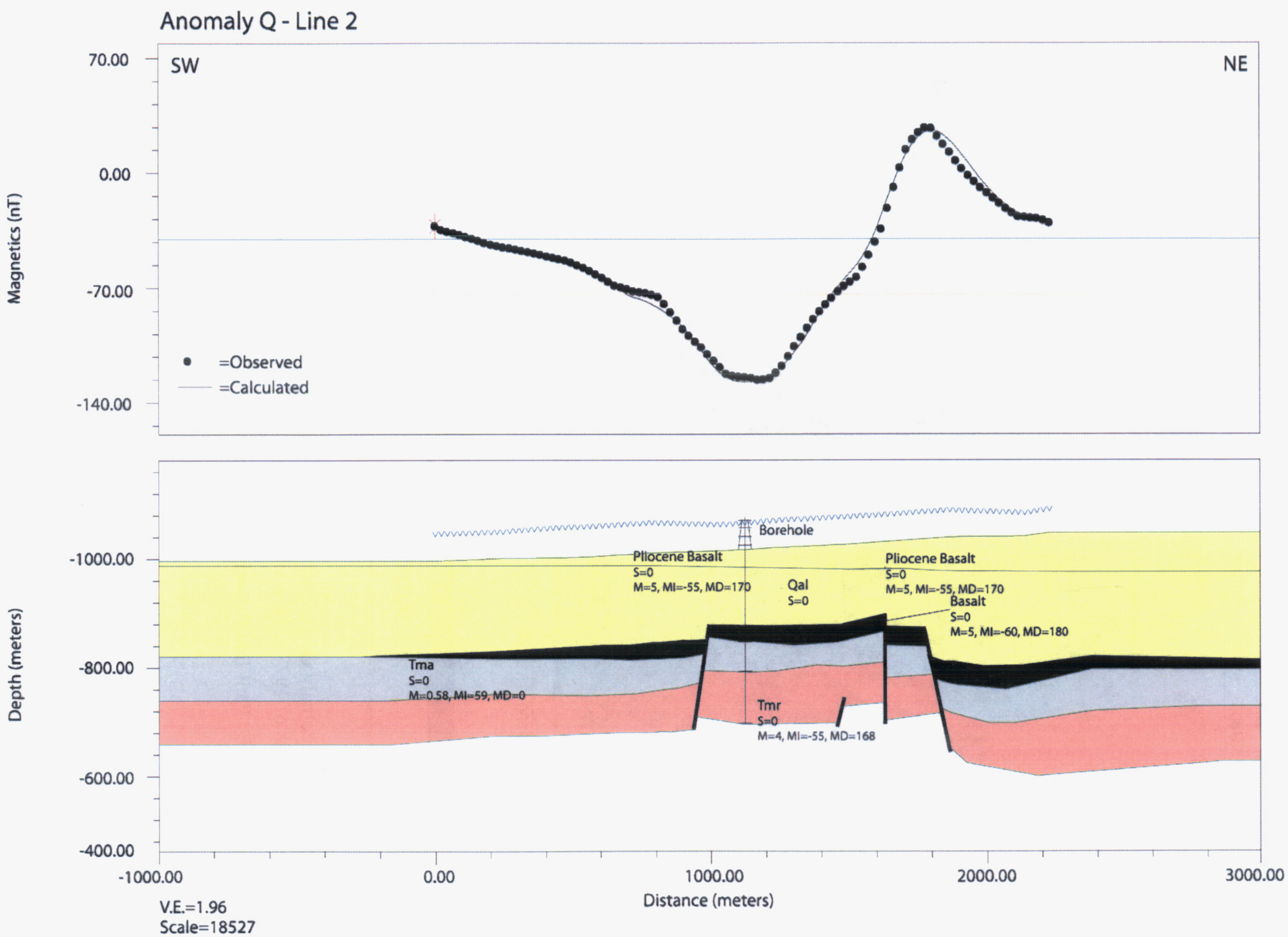

Figure 3 2D total field magnetic anomaly model for anomaly Q along profile – line 2. Qal – Quaternary alluvium, Tma – Ammonia Tanks, Tmr – Rainier Mesa.

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Reference:

Blakely, R.J., V.E. Langenheim, D.A. Ponce and G.L. Dixon. "Aeromagnetic Survey of the Amargosa Desert, Nevada and California; A Tool for Understanding Near-surface Geology and Hydrology." U.S. Geological Survey Open-File Report 00-188. 23p. 2000.

Brocher, T.M., and W.C. Hunter, and V.E. Langenheim. "Implications of seismic Reflection and Potential Field Geophysical Data on the Structural Framework of the Yucca Mountain-Crater Flat Region, Nevada." *Geological Society of America Bulletin*. Vol. 110. pp. 947-971. 1998.

Cogbill, A.H. "Aeromagnetic Survey Data Acquired near Yucca Mountain During 2004." Unpublished Report. October 5 2004.

Geosoft. "Online Manuals, Tutorials, and Technical Notes." Toronto, Canada, 2000.

Hill, B.E. and J.A. Stamatakos. "Evaluation of Geophysical Information Used to Detect and Characterize Buried Volcanic Features in the Yucca Mountain Region." CNWRA 02-97-009. San Antonio, Texas: CNWRA. 2002.

Perry, F., A. Cogbill, C. Lewis, M. Cline. "Preliminary Results and Interpretations of Drill Holes at Anomalies Q, A, and O." Unpublished Report. November 2005.

Stamatakos, J.A., B.E. Hill, D.A. Ferrill, P.C. LaFemina, D. Sims, C.B. Connor, M.B. Gray, A.P. Morris, and C.M. Hall. "Composite 13-Ma Record of Extensional faulting and Basin Growth of Crater Flat, Nevada." San Antonio, Texas: CNWRA. 2000.

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Entry: Saurav Biswas
Date: May 16, 2006

Entry 3. Receipt of shipment packet containing borehole core specimens from Sample Management Facility, Yucca Mountain Site Characterization Project

Dr. John Stamatakos has received the shipment packet containing 14 borehole core specimens today May 16, 2006 from:
Sample Management Facility (SMF)
Yucca Mountain Site Characterization Project
P.O. Box 617
Mercury, NV 89023-0617

The information related on specimen ID, type, top and bottom depths and parent boreholes of the specimen cores are provided in SMF Specimen Custody Receipt in Figure 4. The packet is stored in the office of Saurav Biswas until further action regarding rock magnetic laboratory experiments are undertaken. Address of Saurav Biswas' office:
Room B 240
Building 189
6220 Culebra Road
San Antonio, TX 78238

The borehole core specimens have a blue and red line drawn on the cylindrical surface. The blue line should be on the left and red line to the right to indicate the correct top and bottom directions of the core. Figures 5 and 6 show the pages 1 and 2 respectively from the Sample Overview Committee Specimen Removal Request form. Figure 5 documents the preliminary tests to be performed on the core specimens. Information on specimen source, specimen type, interval, amount and substitution acceptable remarks is documented in Figure 6. The nature of rock type of the borehole core specimen and associated magnetic anomaly is documented under the column heading Specimen Type in Figure 6.

BSC **SMF Specimen Custody Receipt** QA:QA

Requestor's Name:	Ship To (Recipient Name):	
John Stamatakos (ID#490) **Southwest Research Institute** **6220 Culebra Rd** **San Antonio , TX 78238-0000** **(210) 522-5247**	**John Stamatakos (ID#490)** **Southwest Research Institute** **6220 Culebra Rd.** **Bldg. 189** **San Antonio, TX 78238-0000** **(210) 522-5247**	Date Received: ____ Shipment ID: 01000850 Shipping Date: 11-may-2006 SMF Staff [signature] Date 5-11-06

Container ID: 01006944 Type: Borehole Specimens in this container: 14

Condition	Specimen ID	Type	Top	Bottom	Parent Borehole:
	02043322	WCSpec	273.2	273.5	UE-25 VA #10
	02043323	WCSpec	281.9	282.1	UE-25 VA #10
	02043324	WCSpec	307.2	307.4	UE-25 VA #10
	02043314	WCSpec	506.2	506.4	USW VA-1
	02043315	WCSpec	538.7	538.9	USW VA-1
	02043316	WCSpec	569.4	569.6	USW VA-1
	02043317	WCSpec	607.9	608.1	USW VA-1
	02043318	WCSpec	616.3	616.5	USW VA-1
	02043325	WCSpec	426.9	427.1	USW VA-2
	02043326	WCSpec	450.4	450.6	USW VA-2
	02043327	WCSpec	473.0	473.2	USW VA-2
	02043319	WCSpec	484.4	484.6	USW VA-4a
	02043320	WCSpec	512.7	512.9	USW VA-4a
	02043321	WCSpec	533.6	533.8	USW VA-4a

Please Sign this form and return to:
Sample Management Facility
Yucca Mountain Site Characterization Project
P.O. Box 617
Mercury, NV 89023-0617
SMF Verified: ____ **Date** ____

I hereby acknowledge the receipt of the Specimens listed above. I will return this form to the SMF within 10 business days of receipt.

Recipient [signature] Date 5/17/06

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Figure 4 Sample Management Facility Specimen Custody Receipt.

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Entry: Saurav Biswas
Date: May 16, 2006

BSC	Sample Overview Committee Specimen Removal Request *Complete only applicable items.*	QA: QA Page 1 of 2

Requester Name:	Organization:	Telephone:	Date:
JOHN A. STAMATAKOS	CNWRA (NRC CONTRACTOR)	210 522 5247	05/01/06

Address: SOUTHWEST RESEARCH INST., CNWRA (BLDG. 189), 6220 CULEBRA RD., SAN ANTONIO, TX 78238

Planning/Controlling Document Number:	Planning/Controlling Document Title:

Test or Analysis to be Performed/Performed By: JOHN STAMATAKOS / CNWRA

THERMAL AND AF DEMAGNETIZATION
SUSCEPTIBILITY (ROOM, LOW TEMPERATURE)
OTHER ROCK MAGNETIC EXPERIMENTS AS NEED TO CHARACTERIZE SAMPLES

CORES WILL BE CUT TO 1" SAMPLES FOR ANALYSIS

Comments/Directions:

SAMPLES OK AS IS.
SUBSTITUTES OK

FOR NON-QUALITY AFFECTING SAMPLES

The responsibility to adequately identify and control data from non-quality affecting samples (Ltr: January 12, 1988, Gertz to Technical Project Officers, NNA.19880113.0007) is assigned to you, the examiner, as the representative of our organization. Each Affected Organization shall ensure that these data re not used for primary license data or entered into documents or systems which are to contain qualified data only.

Circle one:
(A) Approved (D) Disapproved (T) Tabled

TCO Printed Name/Signature

Circle one:
(A) Approved (D) Disapproved (T) Tabled

SMF Printed Name/Signature

Circle one:
(A) Approved (D) Disapproved (T) Tabled

SOC Chairperson Printed Name/Signature

Circle one:
(A) Approved (D) Disapproved (T) Tabled

Date

PA-PRO-0803.2-r0

Figure 5 Sample Overview Committee Specimen Removal Request form page 1 of 2.

Entry: Saurav Biswas
Date: May 16, 2006

BSC	Sample Overview Committee Specimen Removal Request *Complete only applicable items.*	QA: QA Page 2 of 2

Requester Name:	Organization:	Telephone:	Date:
JOHN A. STAMATAKOS	CNWRA (NRC CONTRACTOR)	210 522 5247	05/01/06

Address: SOUTHWEST RESEARCH INST., CNWRA (BLDG. 189), 6220 CULEBRA RD., SAN ANTONIO, TX 78238

Planning/Controlling Document Number:	Planning/Controlling Document Title:

Specimen Source	Specimen Type	Interval	Amount	Substitution Acceptable/Remarks
USW-VA-1	BASALT CORE (A)	506.2 - 506.4	3"	YES, SIMILAR 3" SAMPLE
USW-VA-1	"	538 - 538.9	3"	"
USW-VA-1	"	569.4 - 569.6	3"	"
USW-VA-1	"	607.9 - 608.1	3"	"
USW VA1	"	616.3 - 616.5	3"	"
USW-VA-4a	BASALT CORE (Q)	484.4 - 484.6	4"	YES, SIMILAR 3" SAMPLE
USW-VA-4a	"	512.9 - 512.9	3"	"
USW-VA-4a	"	533.6 - 533.8	3"	"
UE-25-VA10	BASALT CORE (JFS)	273.3 - 273.6	4"	YES SIMILAR 3" SAMPLE
UE-25 VA10	"	281.9 - 282.1	3"	"
UE-25-VA10	"	307.2 - 307.4	3"	"
USW-VA-2	BASALT CORE (G)	426.9 - 427.1	3"	YES, SIMILAR 3" CORE SAMPLE
USW-VA2	"	450.4 - 450.6	3"	
USW-VA2	"	473.0 - 473.3	3"	

PA-PRO-0803.2-r0

Figure 6 Sample Overview Committee Specimen Removal Request form page 2 of 2. The nature of rock type of the borehole core specimen and associated magnetic anomaly is documented under the column heading Specimen Type

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Date: February 8, 2006

Entry 4. Sub-sampling of the 14 bore hole specimens and shipment to Institute of Rock Magnetism, Minneapolis, MN for rock and paleomagnetism experiments

Mr. Mark Silver was responsible for cutting each of the 14 borehole core samples into cubic specimens of 2 cm and identifying rock slices from leftover material for preparation of thin sections.

Table 2 Identification of borehole core numbers

Sample Bar Code	Well Identification	Depth Interval (ft.)	Depth Interval (m)	Associated Magnetic Anomaly	Borehole Core Numbers
02043314	USW-VA-1	506.2 – 506.4	154.3 – 154.4	A	A1
02043315	USW-VA-1	538.7 – 538.9	164.2 – 164.3	A	A2
02043316	USW-VA-1	569.4 – 569.6	173.6 – 173.6	A	A3
02043317	USW-VA-1	607.9 – 608.1	185.3 – 185.3	A	A4
02043318	USW-VA-1	616.3 – 616.5	187.8 – 187.9	A	A5
02043319	USW-VA-4a	484.4 – 484.6	147.6 – 147.7	Q	Q1
02043320	USW-VA-4a	512.7 – 512.9	156.3 – 156.3	Q	Q2
02043321	USW-VA-4a	533.6 – 533.8	162.6 – 162.7	Q	Q3
02043322	UE-25-VA-10	273.3 – 273.6	83.3 – 83.4	JF5	JF5-1
02043323	UE-25-VA-10	281.9 – 282.1	85.9 – 86.0	JF5	JF5-2
02043324	UE-25-VA-10	307.2 – 307.4	93.6 – 93.7	JF5	JF5-3
02043325	USW-VA-2	426.9 – 427.1	130.1 – 130.2	G	G1

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02043326	USW-VA-2	450.4 – 450.6	137.3 – 137.3	G	G2
02043327	USW-VA-2	473.0 – 473.3	144.2 – 144.3	G	G3

The borehole core specimens have a blue and red line drawn on the cylindrical surface. The blue line on the left and red line on the right indicates the correct top and bottom directions of the core. The borehole samples were cut into 2 cm cubic specimens. At least 8 cubes were made from each borehole. The cubes were numbered 1 - 8 from top to bottom. With Z vertically down and right handed coordinate system, the planes of the cubes perpendicular to X, Y and Z directions were marked respectively to preserve the orientation of the cubic specimens in the course of this study. One thin section was made from each borehole sample.

Table 3 Identification of cube and thin section numbers from borehole core samples

Borehole Core Numbers	Cube Sample Numbers	Thin section sample numbers
A1	A1-C1, A1-C2, A1-C3, A1-C4, A1-C5, A1-C6, A1-C7, A1-C8, A1-C9, A1-C10, A1-C11, A1-C12	A1-T1
A2	A2-C1, A2-C2, A2-C3, A2-C4, A2-C5, A2-C6, A2-C7, A2-C8, A2-C9, A2-C10, A2-C11, A2-C12	A2-T1
A3	A3-C1, A3-C2, A3-C3, A3-C4, A3-C5, A3-C6, A3-C7, A3-C8	A3-T1
A4	A4-C1, A4-C2, A4-C3, A4-C4, A4-C5, A4-C6, A4-C7, A4-C8, A4-C9, A4-C10, A4-C11, A4-C12	A4-T1
A5	A5-C1, A5-C2, A5-C3, A5-C4, A5-C5, A5-C6, A5-C7, A5-C8	A5-T1
Q1	Q1-C1, Q1-C2, Q1-C3, Q1-C4, Q1-C5, Q1-C6, Q1-C7, Q1-C8	Q1-T1
Q2	Q2-C1, Q2-C2, Q2-C3, Q2-C4, Q2-C5, Q2-C6, Q2-C7, Q2-C8	Q2-T1
Q3	Q3-C1, Q3-C2, Q3-C3, Q3-C4, Q3-C5, Q3-C6, Q3-C7, Q3-C8, Q3-C9, Q3-C10, Q3-C11, Q3-C12	Q3-T1
JF5-1	JF5-1-C1, JF5-1-C2, JF5-1-C3, JF5-1-C4, JF5-1-C5, JF5-1-C6, JF5-1-C7, JF5-1-C8, JF5-1-C9, JF5-1-C10, JF5-1-C11, JF5-1-C12	JF5-1-T1
JF5-2	JF5-2-C1, JF5-2-C2, JF5-2-C3, JF5-2-C4, JF5-2-C5, JF5-2-C6, JF5-2-C7, JF5-2-C8, JF5-2-C9, JF5-2-C10, JF5-2-C11, JF5-2-C12	JF5-2-T1

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JF5-3	JF5-3-C1, JF5-3-C2, JF5-3-C3, JF5-3-C4, JF5-3-C5, JF5-3-C6, JF5-3-C7, JF5-3-C8, JF5-3-C9, JF5-3-C10, JF5-3-C11, JF5-3-C12	JF5-3-T1
G1	G1-C1, G1-C2, G1-C3, G1-C4, G1-C5, G1-C6, G1-C7, G1-C8	G1-T1
G2	G2-C1, G2-C2, G2-C3, G2-C4, G2-C5, G2-C6, G2-C7, G2-C8	G2-T1
G3	G3-C1, G3-C2, G3-C3, G3-C4, G3-C5, G3-C6, G3-C7, G3-C8, G3-C9, G3-C10, G3-C11, G3-C12	G3-T1

Eight cubes from each borehole were shipped on 08/30/2006 to Institute of Rock Magnetism (IRM), Minneapolis, MN for rock and paleomagnetism measurements.

Table 3 Identification of cubes shipped to IRM

Borehole Core Numbers	Sample Numbers of cubes shipped
A1	A1-C1, A1-C2, A1-C3, A1-C4, A1-C5, A1-C6, A1-C7, A1-C8
A2	A2-C1, A2-C2, A2-C3, A2-C4, A2-C5, A2-C6, A2-C7, A2-C8
A3	A3-C1, A3-C2, A3-C3, A3-C4, A3-C5, A3-C6, A3-C7, A3-C8
A4	A4-C1, A4-C2, A4-C3, A4-C4, A4-C5, A4-C6, A4-C7, A4-C8
A5	A5-C1, A5-C2, A5-C3, A5-C4, A5-C5, A5-C6, A5-C7, A5-C8
Q1	Q1-C1, Q1-C2, Q1-C3, Q1-C4, Q1-C5, Q1-C6, Q1-C7, Q1-C8
Q2	Q2-C1, Q2-C2, Q2-C3, Q2-C4, Q2-C5, Q2-C6, Q2-C7, Q2-C8
Q3	Q3-C1, Q3-C2, Q3-C3, Q3-C4, Q3-C5, Q3-C6, Q3-C7, Q3-C8
JF5-1	JF5-1-C1, JF5-1-C2, JF5-1-C3, JF5-1-C4, JF5-1-C5, JF5-1-C6, JF5-1-C7, JF5-1-C8
JF5-2	JF5-2-C1, JF5-2-C2, JF5-2-C3, JF5-2-C4, JF5-2-C5, JF5-2-C6, JF5-2-C7, JF5-2-C8
JF5-3	JF5-3-C1, JF5-3-C2, JF5-3-C3, JF5-3-C4, JF5-3-C5, JF5-3-C6, JF5-3-C7, JF5-3-C8
G1	G1-C1, G1-C2, G1-C3, G1-C4, G1-C5, G1-C6, G1-C7, G1-C8
G2	G2-C1, G2-C2, G2-C3, G2-C4, G2-C5, G2-C6, G2-C7, G2-C8
G3	G3-C1, G3-C2, G3-C3, G3-C4, G3-C5, G3-C6, G3-C7, G3-C8

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Entry 5. Variation in helicopter boom elevation

Cogbill (2004) stated that the helicopter was nominally flown 60 m above the terrain with intended terrain clearance for the sensor package of 30 m. This suggests that boom would have a constant clearance above ground surface around 30 m. The ground surface elevation of the survey region was calculated by subtracting the radar data values in meter from the GPS elevation of the helicopter and stored in the column "realelev" in the database named flightlines.gdb. The magnetic 'bird' or the boom was flown 30 m below the helicopter. Consequently the elevation of the boom was computed by subtracting 30 m from the GPS elevation of the helicopter and stored in the column "elevboom" in the database. The clearance of the boom from ground surface was computed by subtracting "realelev" from "elevboom". Figure 7 shows the ground surface elevation and Figure 8 shows the clearance between the boom and the ground surface. The clearance of the boom varies between 30 and 70 m (Figure 8). In potential field surveys, line to line leveling problems can lead to significant leveling error in the data. However, since the dynamic range of the magnetic anomaly in this region varies between -200 to 300 nT it is possible that the small variation (between 30 – 70 m) in elevation of the boom would not have any significant impact on the source structures of the magnetic anomaly. Further case study is needed to test this hypothesis.

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Date: September 5, 2006

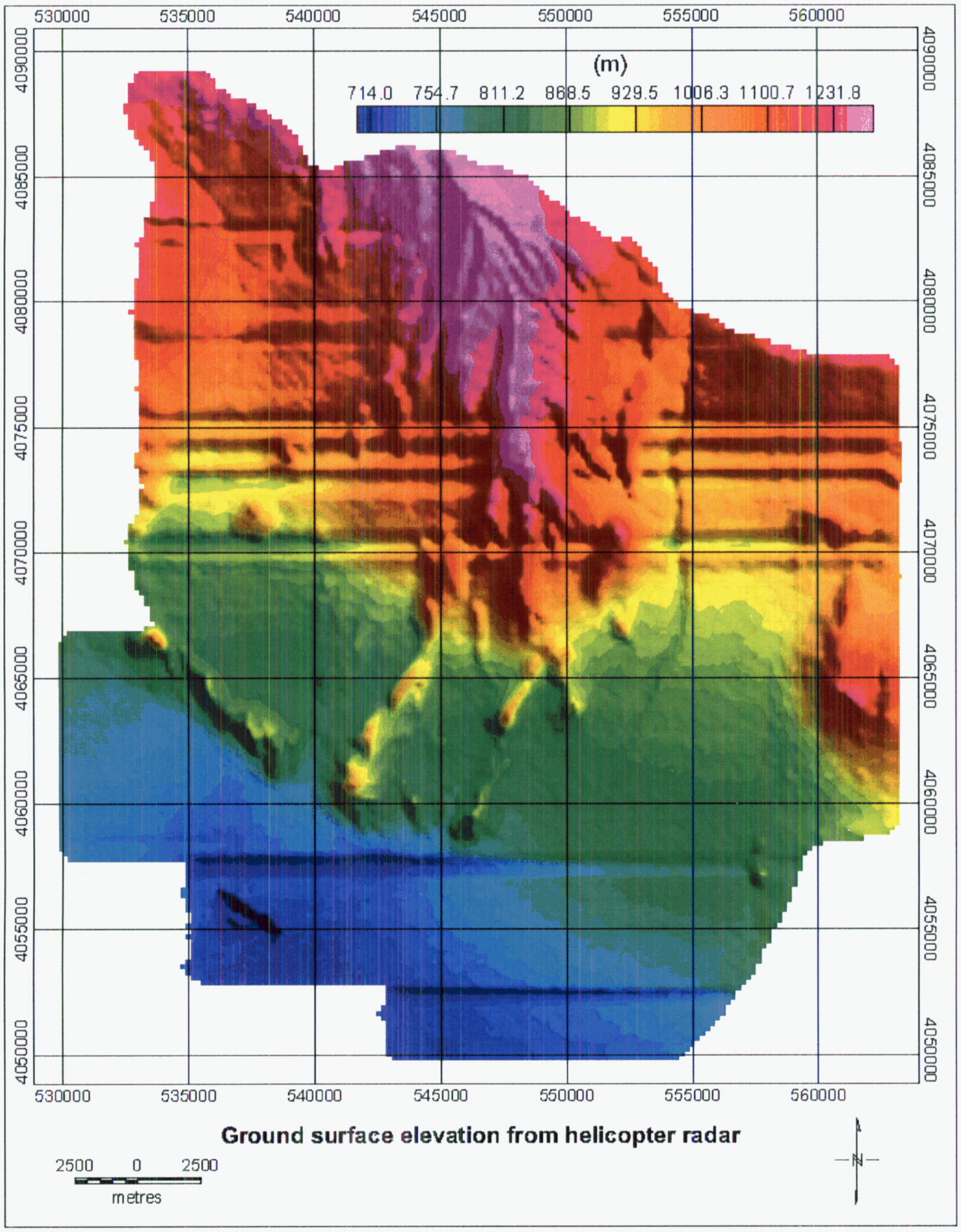

Figure 7 Ground surface elevation of the survey region derived from subtracting helicopter radar data from the GPS elevation of the helicopter.

Entry: Saurav Biswas
Date: September 5, 2006

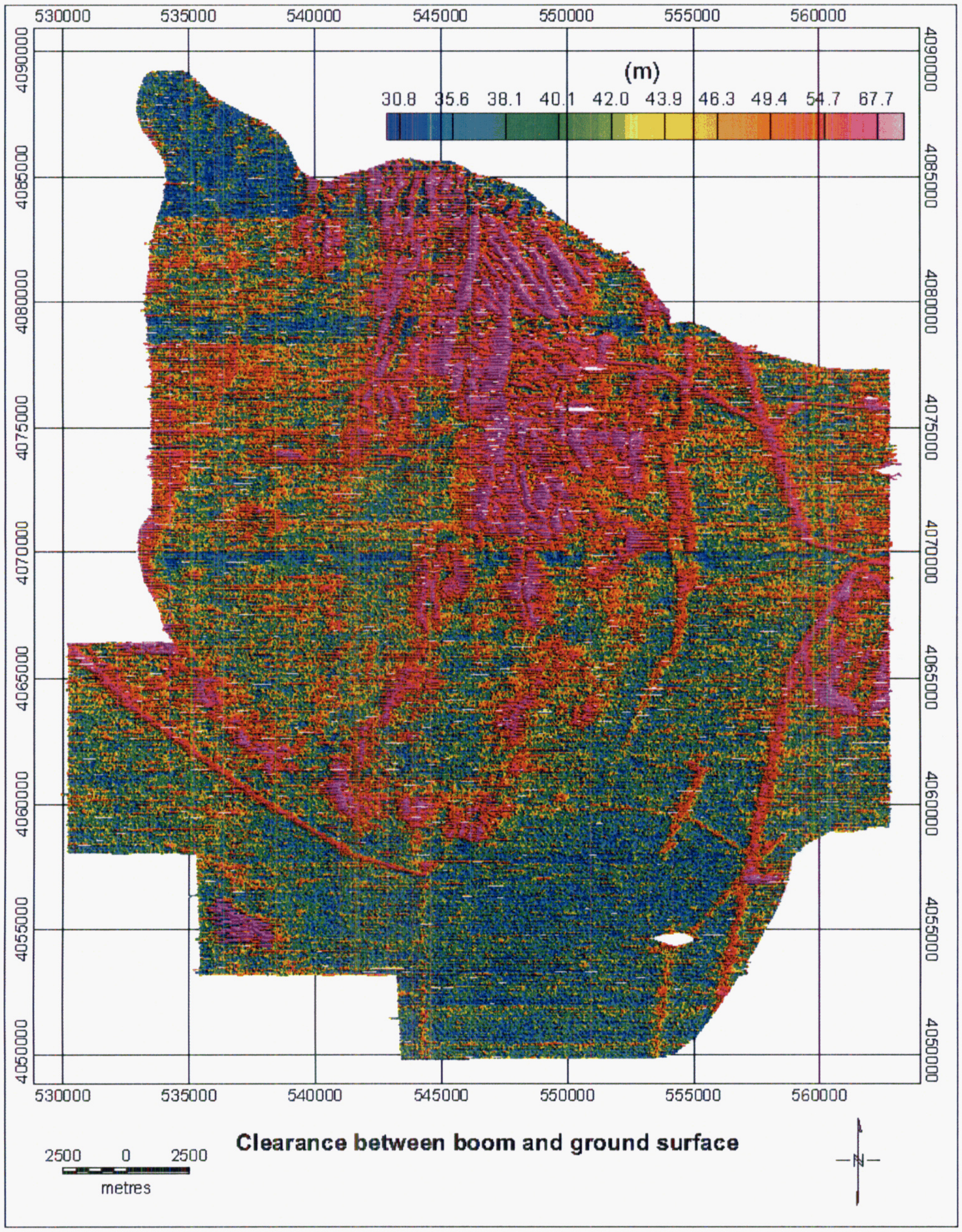

Figure 8 Clearance between the boom and ground surface computer by subtracting ground surface elevation from the boom elevation.

Entry: Saurav Biswas
Date: September 5, 2006

Reference:

Cogbill, A.H. "Aeromagnetic Survey Data Acquired near Yucca Mountain During 2004." Unpublished Report. October 5 2004.

Entry 6. Magnetic Anomaly - A

Figure 9 shows the magnetic anomaly A without any correction for leveling error. Figure 10 shows the leveling error computed using the De-corrugation filter in Oasis montaj with the MAGMAP feature. The parameters of the filter are mentioned in Table 4. Figure 11 shows the magnetic anomaly A after correcting for the leveling error. Comparing the dynamic ranges of the magnetic anomalies in Figures 9 and 10 illustrates that leveling error contributes to less than 10 % of the magnetic anomaly in Figure 9.

Table 4 Parameters for decorrugation filter.

de-corr., 60m line separation, N-S lines	
30	/sensor elevation
56	/magnetic inclination
14	/magnetic declination
55000	/total field strength
BTWR 0.00167 8 0	/high-pass butterworth
DCOS 0 0.5 1	/directional cosine

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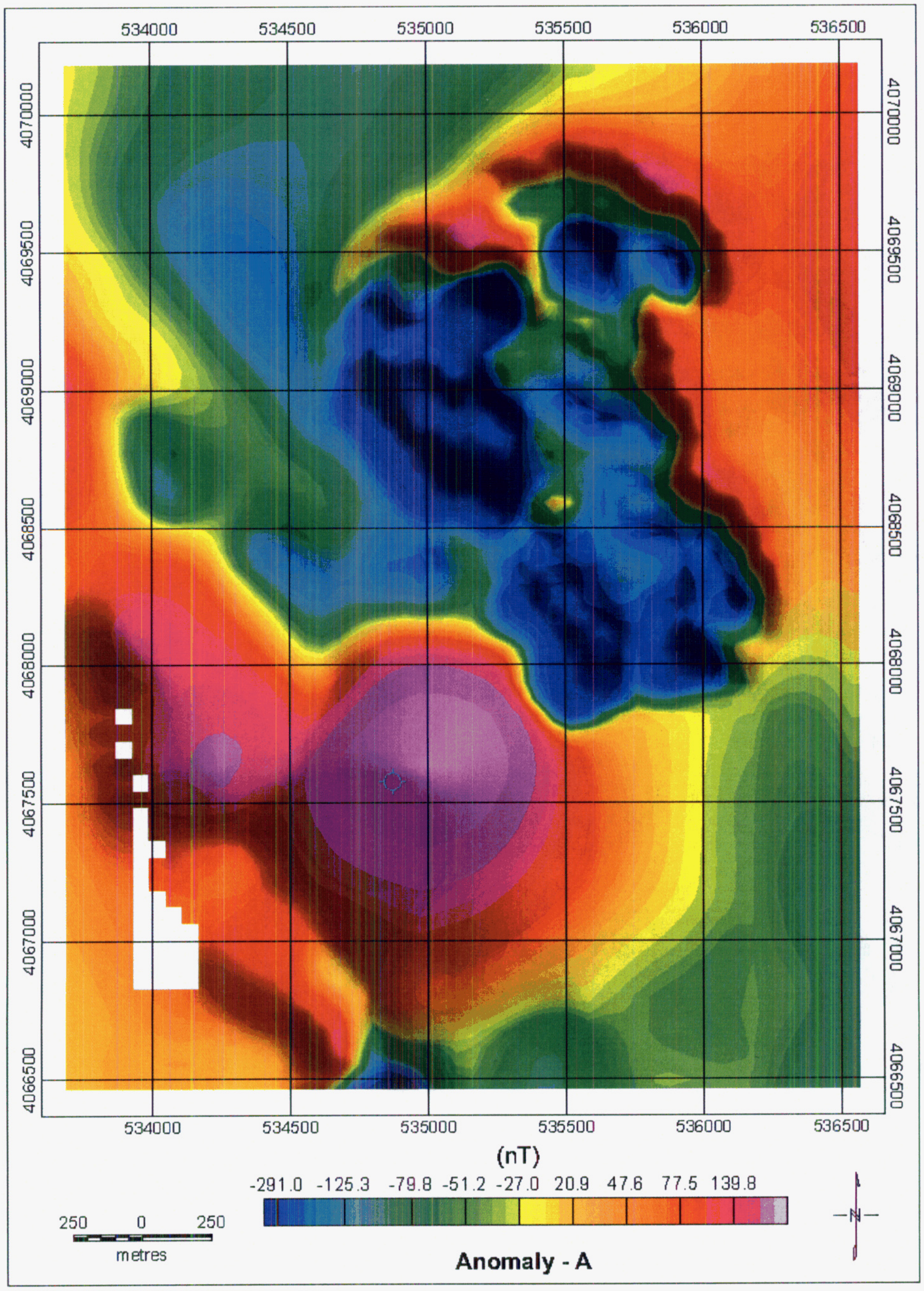

Figure 9 Magnetic anomaly A without correction for leveling error. ⌖ - borehole.

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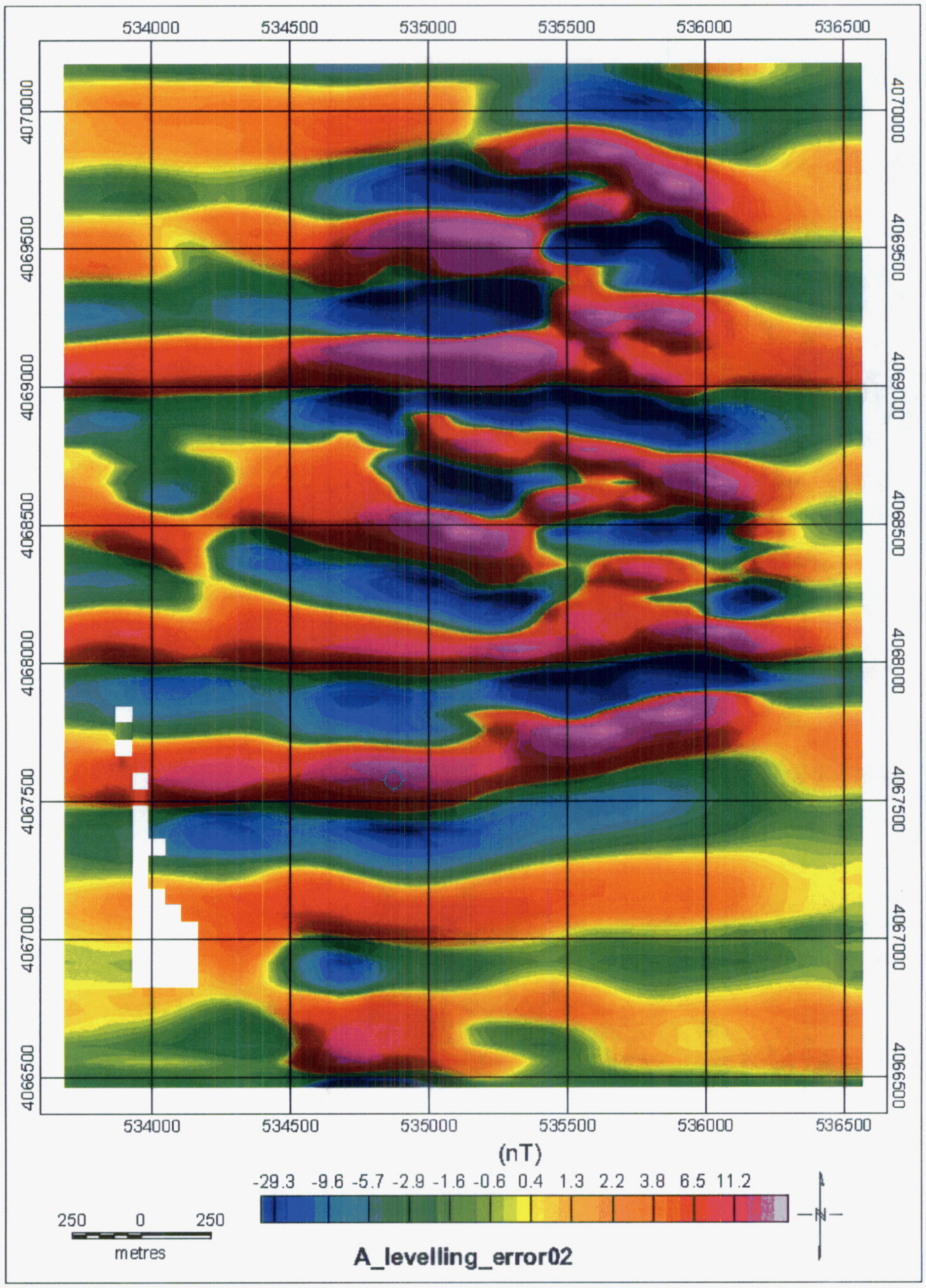

Figure 10 Leveling error in the magnetic anomaly computed using De-corrugation filter with parameters shown in Table 4. ⌖ - borehole.

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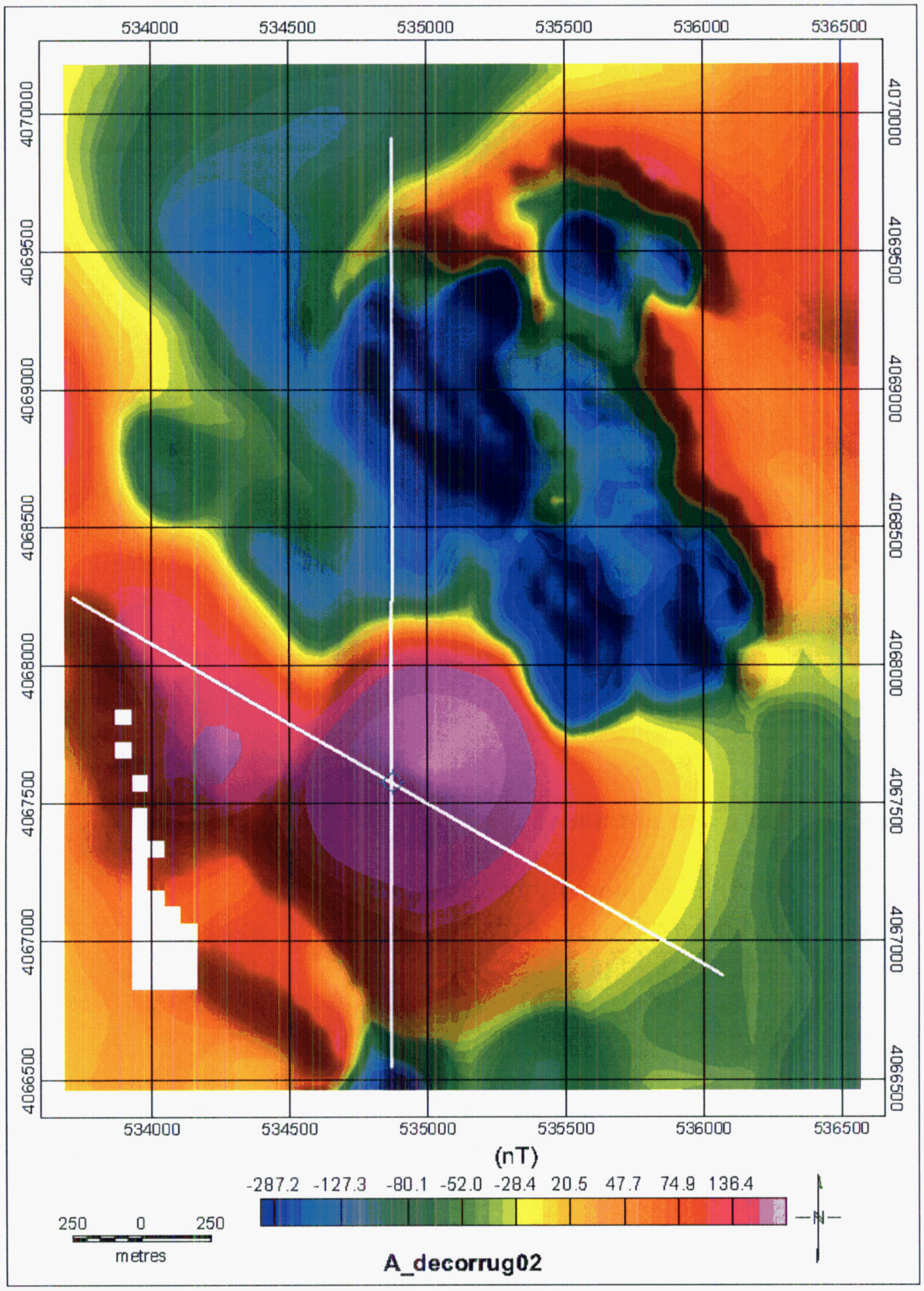

Figure 11 Total field aeromagnetic anomaly A after correction for leveling error. Coordinates are in Universal Transverse Mercator (UTM) Zone 11, using the North American Datum of 1927. The white line shows the location of profiles. NS profile – Line2. Oblique profile – Line 3. Different profile termed Line 1 was modeled by Paul Landis and is not recorded in this Scientific notebook. ⌖ - borehole.

Entry: Saurav Biswas
Date: September 5, 2006

Entry 7. Depth of basalt encounter in drill hole USW-VA-1, magnetic anomaly A

```
-----Original Message-----
From: Jack Parrott [mailto:JDP1@nrc.gov]
Sent: Wednesday, November 16, 2005 5:33 PM
To: sbiswas@cnwra.swri.edu; Brittain Hill; John Trapp;
Robert Latta
Cc: John Stamatakos
Subject: Re: Anomaly A - Basalt?

Anomaly A

Hit basalt at 487 feet.

The "as-planned" location for that borehole in Nevada State
Plane coordinates (feet) was Northing 729,818 and Easting
516,787. The "as-built" location surveys have not been
completed but they are typically within inches or feet of
the planned location.
```

```
487 ft = 148.44 m
```

Entry 8. Modeling NS profile – Line 2 of anomaly A

Two scenarios in modeling profiles of anomaly A are tested:

(a) Normal faulted sequence of basalt, Ammonia Tanks tuff and Rainer Mesa tuff with the basalt magnetized in normal direction – Model 1 (Figure 12).
(b) Reverse faulted sequence of basalt, Ammonia Tanks tuff and Rainer Mesa tuff with the basalt magnetized in reverse direction – Model 2 (Figure 13).

Steps for modeling magnetic anomaly A profiles:

(1) Define the location of the anomaly A (Blakely et al., 2000; Hill & Stamatakos, 2002) on the total field aeromagnetic anomaly map around Yucca Mountain, Nevada – Figure 1.
(2) Define profile locations for magnetic anomaly – Figure 11.
(3) Export the extracted profile data from the decorrugated grid - decorrug_A01_Out02.grd into GM-SYS for modeling – Figures 12 and 13. The sequence of faulted lithologic units in Figures 12 and 13 for modeling the magnetic anomaly are based on scenarios for Model 1 and Model 2

respectively. The depth of basalt in the model (Figures 12 and 13) at 148 m below ground surface is constrained by drill hole USW-VA-1 (Perry et al., 2005).

(4) Iteratively model the 2D subsurface geometry until the fit between observed and modeled magnetic profiles is optimized (e.g., small error).

Table 5 Source parameters for magnetic anomaly model for anomaly A

Rock Type		Modeled Inclination	Modeled Declination	Remanent Magnetization Intensity (A/m)
Quaternary Alluvium (Qal)		-	-	0
Pliocene Basalt		-55°	170°	15
Basalt	Model 1	60°	0°	20
	Model 2	-60°	180°	20
Ammonia Tanks (Tma)		59°	0°	0.58
Rainier Mesa (Tmr)		-55°	168°	4

The magnetic parameters of the sources are based on Brocher et al. (1998) and Stamatakos et al. (2000). The remanent magnetization intensity of Rainier Messa (Tmr) was increased from 0.8-2.7 A/m (Brocher et al., 1998; Stamatakos et al., 2000) to 4 A/m to better fit the observed anomaly. Further investigation of magnetic intensity of volcanic tuff is needed to decide the validity of the subsurface geometry of the sources. The magnetization intensities of basalts in anomaly A are stronger compared to anomaly Q. Paleomagnetic magnetic analyses of basalts from the drill cores will put better constraints on the remanent magnetic properties of basalts.

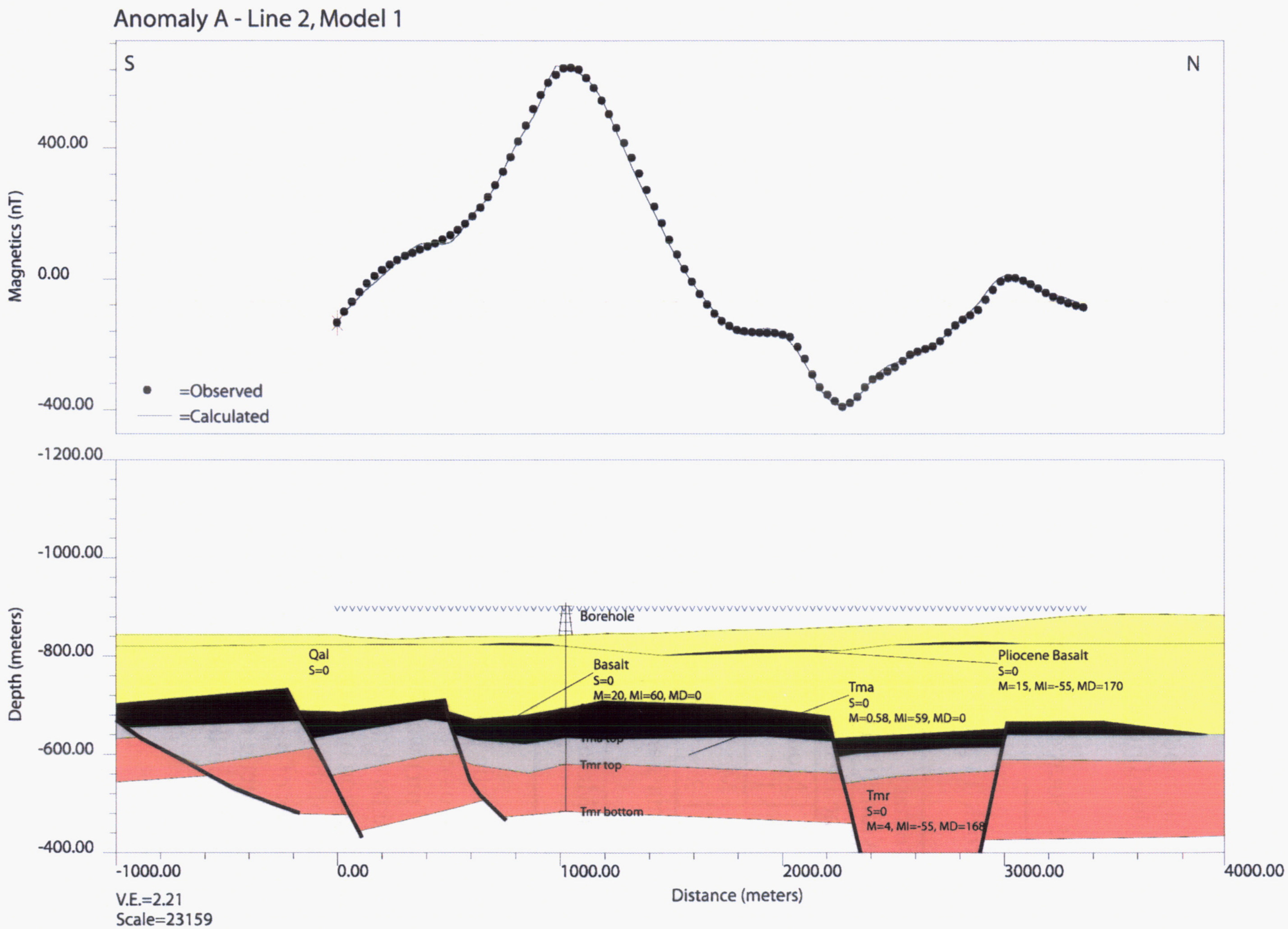

Figure 12 2D total field magnetic anomaly Model – 1 for anomaly A along NS profile – line 2. Qal – Quaternary alluvium, Tma – Ammonia Tanks, Tmr – Rainier Mesa.

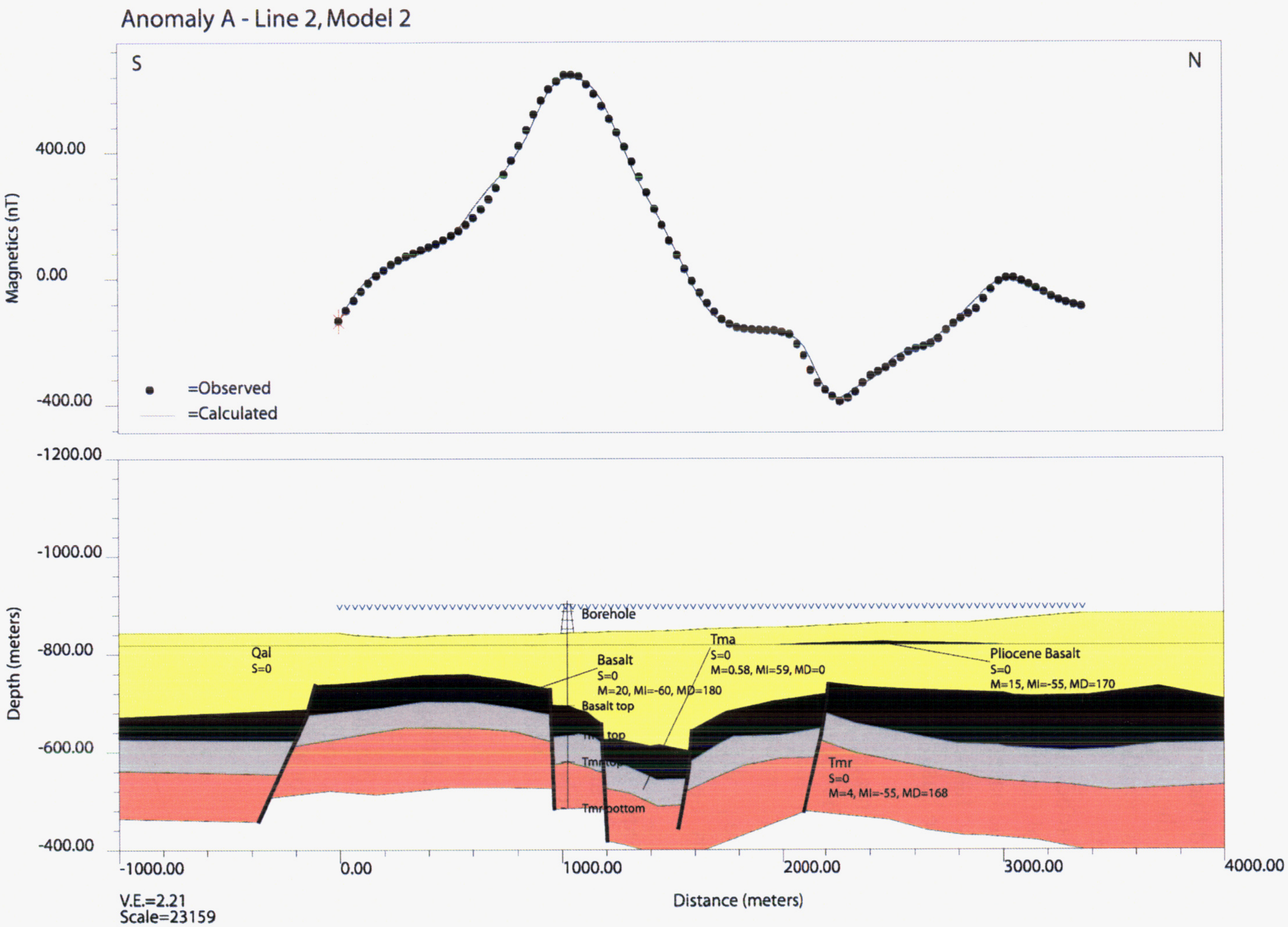

Figure 13 2D total field magnetic anomaly Model – 2 for anomaly A along NS profile – line 2. Qal – Quaternary alluvium, Tma – Ammonia Tanks, Tmr – Rainier Mesa.

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Modeling oblique profile – Line 3 of anomaly A

It should be noted that since it has been shown earlier that leveling error contributes to less than 10 % in the magnetic anomaly data, the oblique profile for anomaly A is extracted from the non decorrugated magnetic anomaly grid for anomaly A - aeromag_A01.grd.

Two scenarios in modeling profiles of anomaly A are tested:

(a) Normal faulted sequence of basalt, Ammonia Tanks tuff and Rainer Mesa tuff with the basalt magnetized in normal direction – Model 1 (Figure 14).

(b) Reverse faulted sequence of basalt, Ammonia Tanks tuff and Rainer Mesa tuff with the basalt magnetized in reverse direction – Model 2 (Figure 15).

Steps for modeling magnetic anomaly A profiles:

(1) Define the location of the anomaly A (Blakely et al., 2000; Hill & Stamatakos, 2002) on the total field aeromagnetic anomaly map around Yucca Mountain, Nevada – Figure 1.

(2) Define profile locations for magnetic anomaly – Figure 11.

(3) Export the extracted profile data into GM-SYS for modeling – Figures 14 and 15.
The sequence of faulted lithologic units in Figures 14 and 15 for modeling the magnetic anomaly are based on scenarios for Model 1 and Model 2 respectively. The depth of basalt in the model (Figures 14 and 15) at 148 m below ground surface is constrained by drill hole USW-VA-1 (Perry et al., 2005).

(4) Iteratively model the 2D subsurface geometry until the fit between observed and modeled magnetic profiles is optimized (e.g., small error).

There is significant difference between the computed and observed anomalies for the oblique profile corresponding to Model 2 (Figure 15). The source parameters of the magnetic anomalies for the oblique profiles are noted in Table 5.

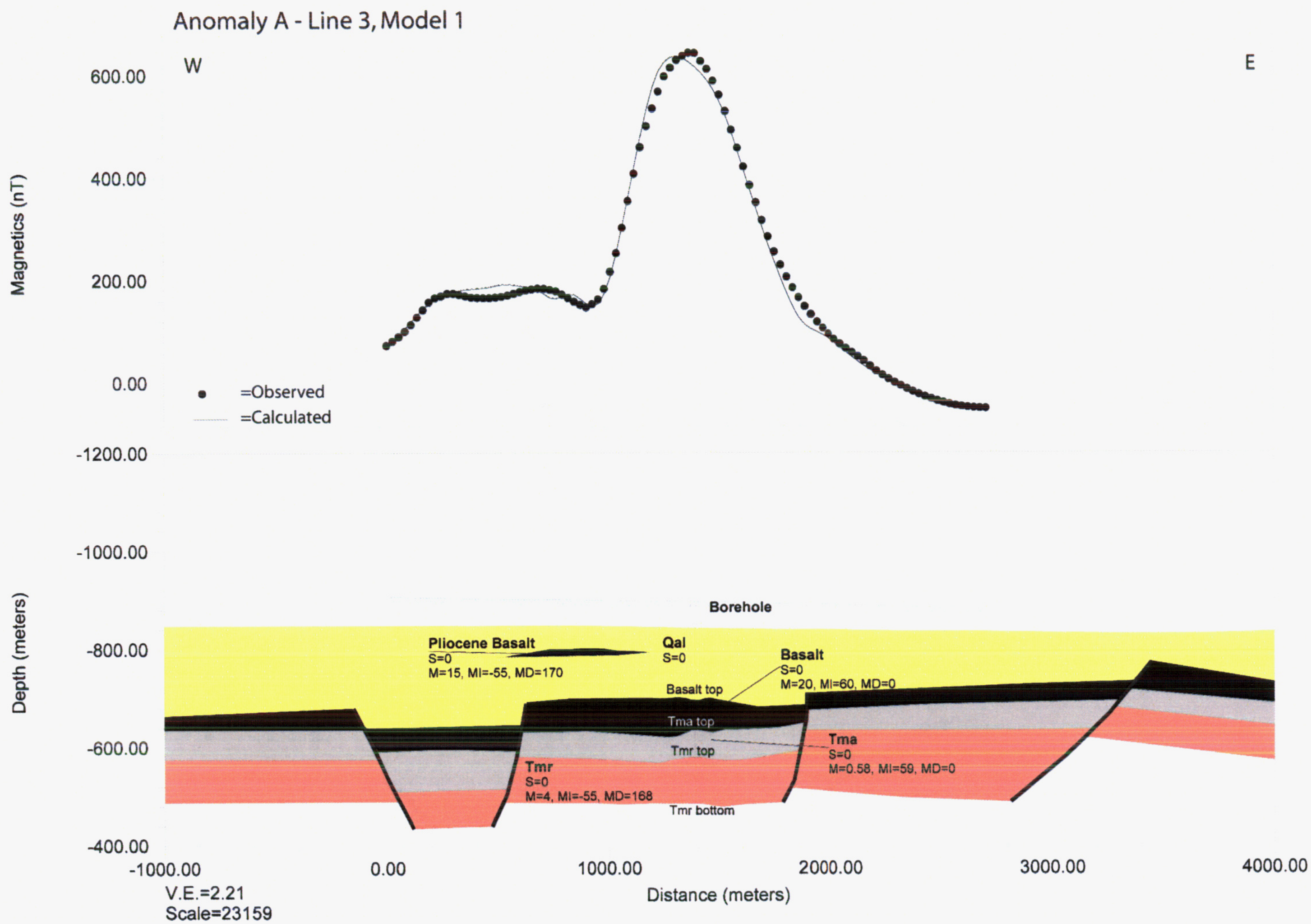

Figure 14 2D total field magnetic anomaly Model – 1 for anomaly A along oblique profile – line 3. Qal – Quaternary alluvium, Tma – Ammonia Tanks, Tmr – Rainier Mesa.

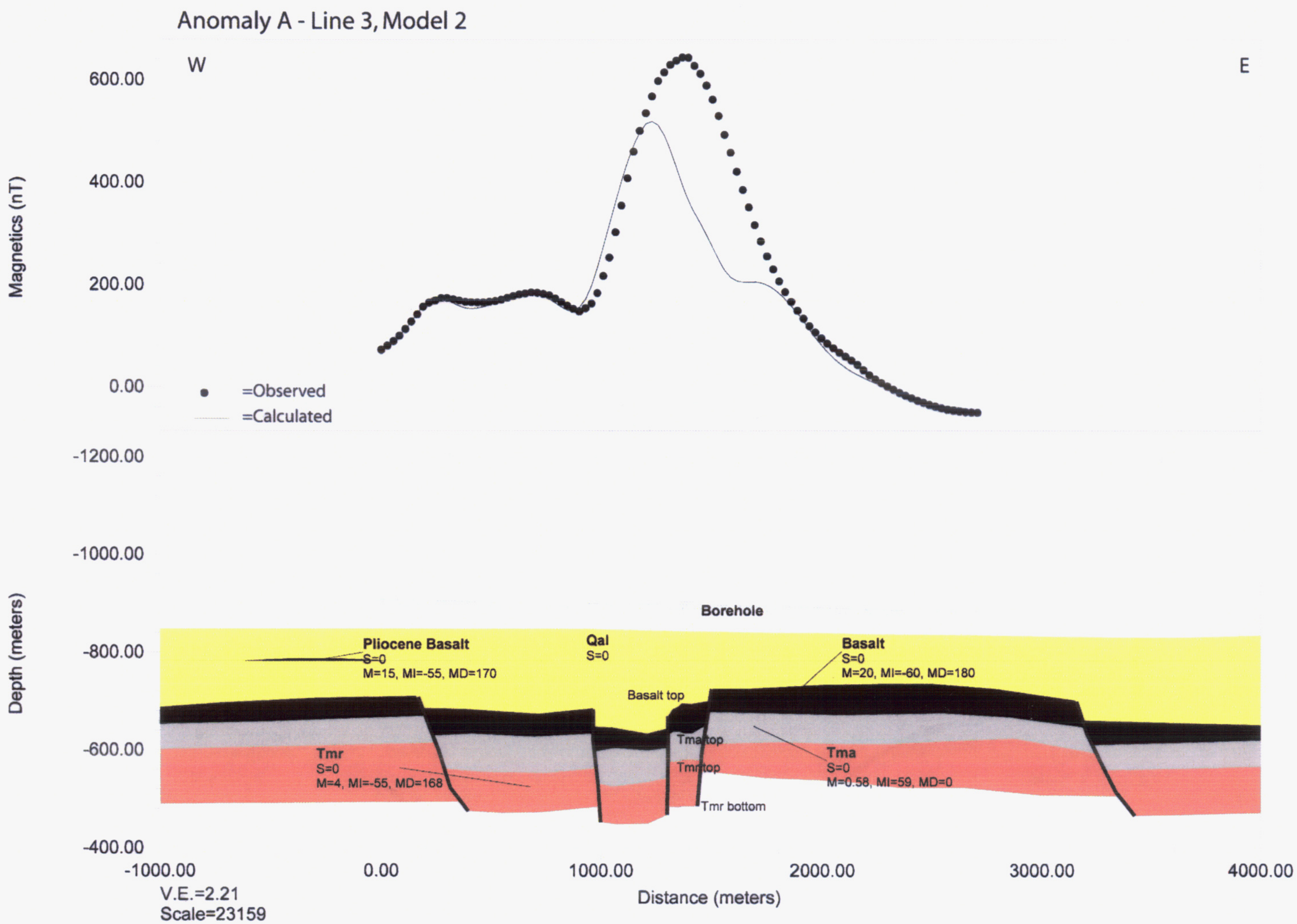

Figure 15 2D total field magnetic anomaly Model – 2 for anomaly A along oblique profile – line 3. Qal – Quaternary alluvium, Tma – Ammonia Tanks, Tmr – Rainier Mesa.

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Entry: Saurav Biswas
Date: September 5, 2006

Reference:

Blakely, R.J., V.E. Langenheim, D.A. Ponce and G.L. Dixon. "Aeromagnetic Survey of the Amargosa Desert, Nevada and California; A Tool for Understanding Near-surface Geology and Hydrology." U.S. Geological Survey Open-File Report 00-188. 23p. 2000.

Brocher, T.M., and W.C. Hunter, and V.E. Langenheim. "Implications of seismic Reflectionand Potential Field Geophysical Data on the Structural Framework of the Yucca Mountain-Crater Flat Region, Nevada." *Geological Society of America Bulletin*. Vol. 110. pp. 947-971. 1998.

Hill, B.E. and J.A. Stamatakos. "Evaluation of Geophysical Information Used to Detect and Characterize Buried Volcanic Features in the Yucca Mountain Region." CNWRA 02-97-009. San Antonio, Texas: CNWRA. 2002.

Perry, F., A. Cogbill, C. Lewis, M. Cline. "Preliminary Results and Interpretations of Drill Holes at Anomalies Q, A, and O." Unpublished Report. November 2005.

Stamatakos, J.A., B.E. Hill, D.A. Ferrill, P.C. LaFemina, D. Sims, C.B. Connor, M.B. Gray, A.P. Morris, and C.M. Hall. "Composite 13-Ma Record of Extensional faulting and Basin Growth of Crater Flat, Nevada." San Antonio, Texas: CNWRA. 2000.

Entry: Saurav Biswas
Date: March 5, 2007

Entry 9. Paleomagnetic investigations conducted at Institute for Rock Magnetism, University of Minnesota, MN between September 11 – 22, 2006.

The following measurements were taken on the cubic samples of basalts from the boreholes noted in Table 3, page 14:

1) Natural Remanent Magnetism (NRM)
2) Alternating field (AF) demagnetization and thermal demagnetization to determine the Characteristic Remanent Magnetism (ChRM)
3) High temperature susceptibility
4) Room temperature susceptibility
5) Hysteresis and coercivity measurements from Vibrating Sample Magnetometer (VSM) at room temperature

Description of the procedures and equipments are available in Scientific Notebook No. 099 titled "Field trip to review the structural and volcanic geology of Death Valley, CA and its relative similarities to the Yucca Mountain Region" (12/02/1993 through 05/16/2000) by Kathy H. Spivey and John A. Stamatakos, pages 59-62 and the websites of Institute for Rock Magnetism (http://www.irm.umn.edu/equipment/index.htm). Additional description of methods can be found in Dunlop and Özdemir (1997) and Evans and Heller (2003).

Objectives:
The motivations behind paleomagnetic measurements of the basalt samples from the boreholes located in the specific magnetic anomalies were to:

1) Characterize the associated magnetic anomalies with the paleomagnetic properties of the basalt.
2) Use the remanent magnetic properties of basalt to aide 2D modeling of the corresponding magnetic anomalies.

Results:

Table 6 List of paleomagnetic measurement datasets and associated Excel spreadsheets

Property	Figures	Excel spreadsheet	Location
All measured data	——	YM_IRM_data_all.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
NRM Intensities	16	YM_IRM_NRM_demag_data.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
NRM Inclination Angles	17	YM_IRM_Incl_Stat.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006

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ChRM Inclination Angles	18	ChRM_Incl_Stat.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006\05.1_Super-IAPD\PCA
Volume Susceptibility	19	YM_IRM_susc.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
Konigsberger Ratio (Q)	20	YM_IRM_susc.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
Day Plot	21	YM_IRM_data_all_Day_Plot.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
High temperature susceptibility measurements	22-35	YM_IRM_High_temp_susc.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006
Ordering temperatures	36	YM_IRM_High_temp_susc.xls	D:\01Projects\1.0_YMR_Mag\05_IRM_092006

Application of inclination only statistics:
Following the numerical example in appendix of McFadden & Reid (1982), ***YM_IRM_Incl_Stat.xls*** - a macro application in MS Excel was developed to compute inclination only statistics. To validate the macro we compared our results with the results in the numerical example.

Table 7 Comparison of calculated parameters between McFadden and Reid (1982) and YM_Incl_Stat.xls

Calculated parameters	**McFadden & Reid (1982)**	**YM_Incl_Stat.xls**
$\sum \cos\theta_i$	8.708	8.693
$\sum \sin\theta_i$	4.748	4.771
$\hat{\theta}_0$	27.7	27.8
C	9.917	9.915
S	-0.1560	-0.162
Estimated Inclination	61.4°	61.2°
K	54.2	52.66
α_{95}	5.7°	5.8°

The values of the calculated parameters closely match each other and validate the macro - ***YM_IRM_Incl_Stat.xls***. All the results of application of inclination only statistic to the NRM data are documented in ***YM_IRM_Incl_Stat.xls***.

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Principle Component Analysis (PCA):
The AF and thermal demagnetization results were treated through PCA with IAPD2000 to determine the ChRM. The results are documented in ***PCA_results.xls***. All the results of application of inclination only statistic to the ChRM data are documented in ***ChRM_Incl_Stat.xls***.

Note about IAPD2000:
IAPD2000 was acquired free of cost without any license from the author Professor Trond H. Torsvik, Team Leader, Center for Geodynamics, Geological Survey of Norway (NGU) for one time use for doing PCA on the thermal and AF demagnetization results. ~~The software will be controlled and validated according to TOP-018.~~ Scientific Notebook No. 099 (Spivey and Stamatakos, 2000, pages 63 - 65) document the validation of IAPD. (S.B. 10 April 2007).

The figures noted in Table 6 are included below.