UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Magnetometric Resistivity Survey Near Forty Mile Wash,

Nevada Test Site, Nevada

by

David V. Fitterman

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Introduction

This report describes the results of a magnetometric resistivity (MMR) survey near Forty Mile Wash, Nevada Test Site, Nevada. The work was performed to determine if the method is useful in locating faults. The field location is near some mapped faults in the vicinity of the Yucca Mountain waste disposal study area.

Description of Method

The magnetometric resistivity (MMR) method consists of injecting current of a known magnitude and frequency into the ground, and recording the resulting magnetic fields. The magnetic fields recorded will be produced by three sources: 1) the current in the wire between the two electrodes, 2) the effect of the ground surface, and 3) the effect of any conductivity boundaries in the ground. The first two sources represent corrections which must be made to the data, whereas the third source produces anomalous fields if conductivity boundaries are present. Discussions of the method can be found in several papers including Edwards (1974), Edwards and Howell (1976), Edwards *et al.* (1978), and Gomez Trevino and Edwards (1979).

In general, the magnitude of the anomalous magnetic field is proportional to the conductivity reflection coefficient $k_{ij}=(\sigma_j-\sigma_i)/(\sigma_j+\sigma_i)$ across conductivity boundaries and the current flowing parallel to the conductivity boundary, and inversely proportional to the distance from the conductivity boundary where σ is the conductivity. In view of these considerations, one tries to locate the two current electrodes on strike with the presumed conductivity boundary or fault.

The depth of investigation of the MMR method is controlled by the distance between the current electrodes and the conductivity structure of the ground. A *very* crude estimate of the depth of investigation is about one-third the distance between the current electrodes. When the conductivity structure has no natural scale, as in the case of a vertical contact, the width of the anomaly is controlled by the electrode separation. However, if the conductivity structure contains a feature of finite width, such as a vertical dike, the anomaly width is controlled by the width of the feature.

Figure 1 shows a typical field geometry. Current is transmitted between two electrodes connected by a wire. The wire is placed to the side of the measurement area to help minimize its effect. All measurement points are described in terms of an electrode-centered, right-hand coordinate system. For comparison purposes, the measured magnetic anomalies (B_m) are normalized by the transmitted current (I). The normalized fields are noted by lower case letters. From the geometry of the transmitter wire and the orientation of the measurement plane, the normalized primary field b_p is computed. The difference between the normalized measured and normalized primary fields gives the normalized anomalous or secondary field ($b_s=b_m-b_p$). These three quantities are computed for all three field components. The percentage MMR anomaly is computed for each observation point as follows:

$$\%MMR_i = \frac{b_{si}\ (x, y, z)}{b_{py}\ (x, o, z_p)} \times 100\%$$

where i is the field component, (x, y, z) is the observation point coordinates, and (x, o, z_p) is the projection of the observation point onto the line between the current sources and sink (in a least squares sense). The observation point plane is determined by fitting a plane to the surveyed observation points and the end points of the transmitter wire segments. This normalization provides an easy way of comparing measured anomalies with computed anomalies. The data are then presented as traverses in the y-direction.

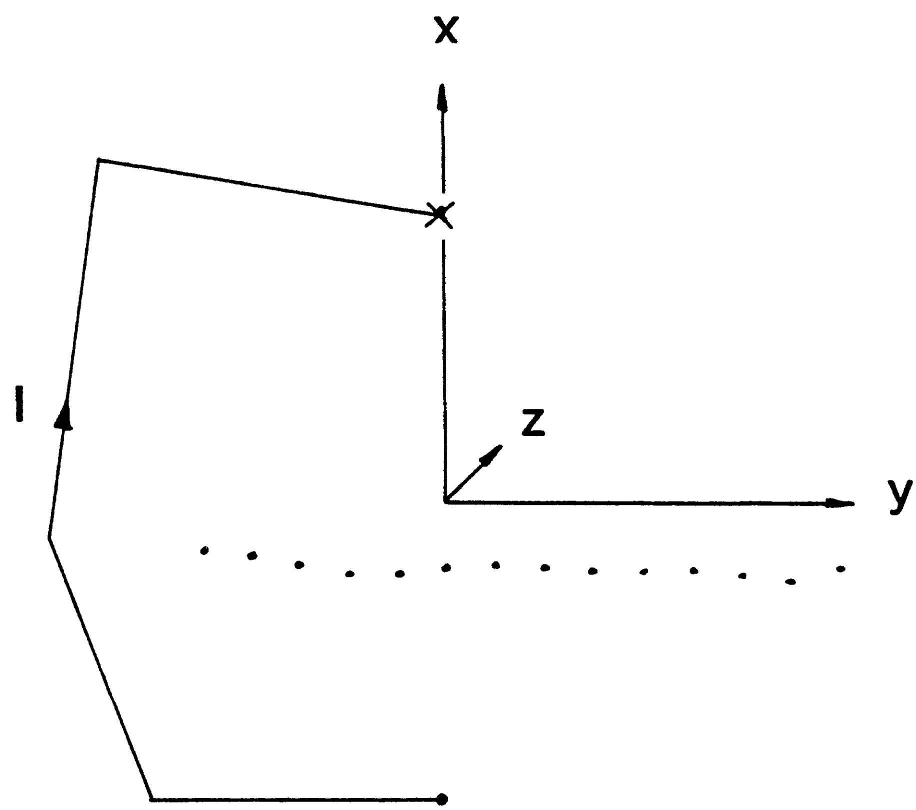


Figure 1. Electrode centered, right-hand coordinate geometry. Current flows in the wire in the direction shown by the arrow, entering the ground along the +x-axis. The dots represent a typical measurement traverse.

Estimates of conductivity contrasts and conductive zone width for the case of vertical contacts and vertical dikes can be made using published interpretation curves (Edwards et al., 1978). Although this technique is not as good as a forward modelling and anomaly matching technique, it is considered to be the most appropriate technique for a preliminary interpretation. This type of procedure was used to make the interpretations presented in this report.

Equipment

A block diagram of the field equipment used is shown in Figure 2. A motor generator provides power to a Geotronix EMT-5000 resistivity transmitter. The frequency of the transmitter (1 hz) is controlled by the TX box by means of a crystal oscillator which is synchronized with another oscillator in the RX box. The transmitter provides current to the electrodes through a shunt resistor which is monitored by the TX to obtain the transmitter current.

A S.H.E. Corp. Model 330 SQUID magnetometer was used to measure the magnetic field. The appropriate component is selected, filtered (Ithaco Model 4211 filter) and amplified, before being detected by the RX. The RX determines the inphase and quadrature components of the signal. Corrections are applied to the data for the transfer function of each instrument. The signals are predominantly inphase at 1.0 Hz unless the signals are close to the noise level at which point the phase is quite variable.

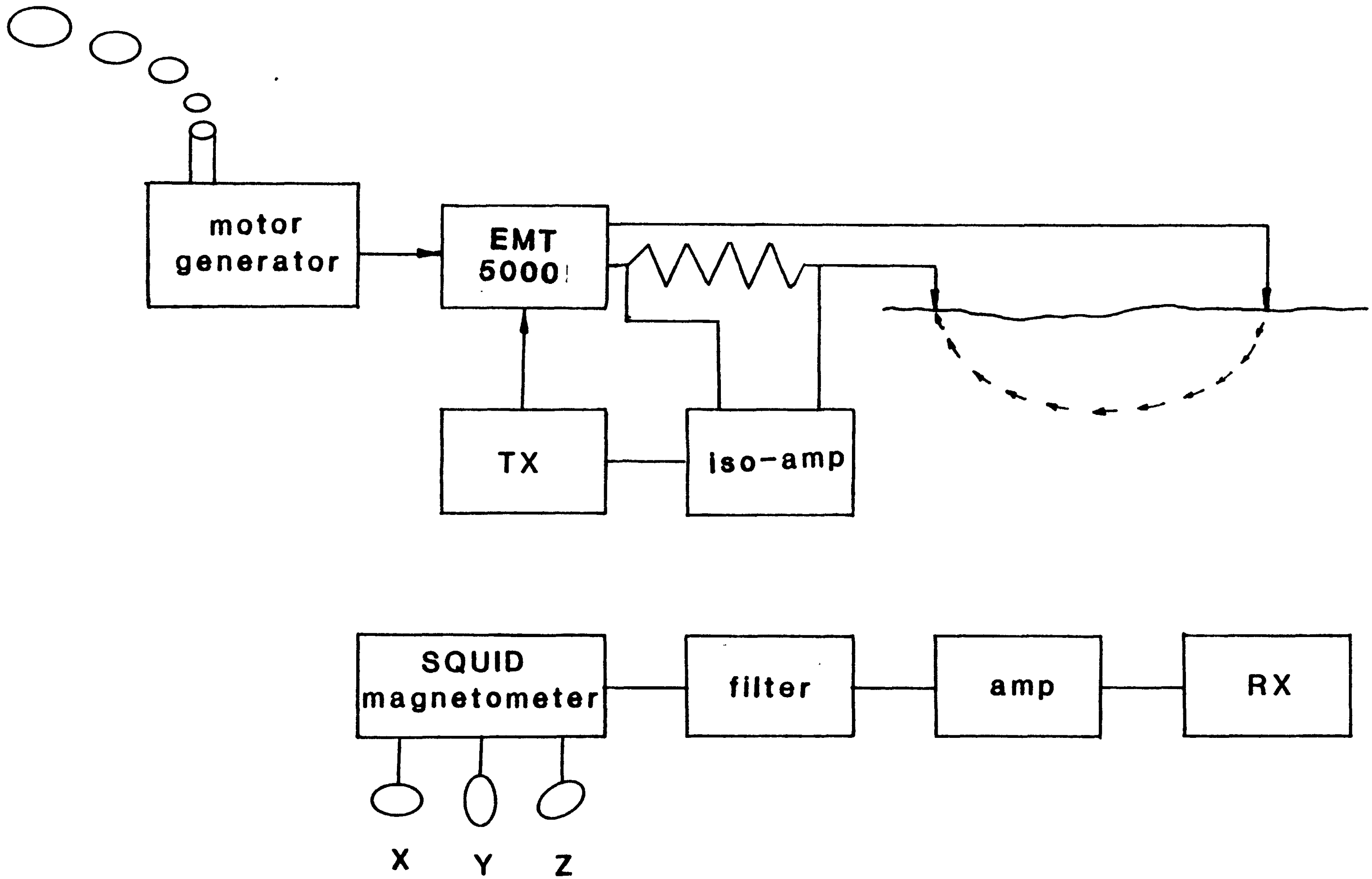


Figure 2. Measurement system block diagram.

Figure 2

Results

The location of the Forty Mile Wash survey site is shown in Figure 3. The transmitter wire forms a broad "V" shape with the electrodes roughly on strike with the mapped fault labelled "A", which runs in a general north-south direction (Lipman and McKay, 1965). The field site is covered by Quaternary alluvium and colluvium and underlain by various members of Paintbrush Tuff which is a Tertiary bedded tuff interlayered with ash-flow tuffs.

The survey was made along two lines, the more northerly being called NTS-1 and the more southerly NTS-2. The lines run roughly perpendicular to the strike direction. Figures 4 and 5 show the NTS-1 and NTS-2 results respectively. The normalized primary (P), measured (M), and secondary (S) fields are shown as functions of y. The MMR anomaly (%) is also shown. The vertical scale for the primary and measured fields are the same, while the secondary field scale is to the left and the MMR anomaly scale is to the right. The minimum and maximum values for the scales are displayed. The squares refer to the left-hand scale, and the x's refer to the right-hand scale. There is a separate display for each field component.

The z-component MMR anomalies are characterized by a positive peak near y=470 m on line NTS-1 and near y=330 m on line NTS-2 indicating a conductivity boundary. The y-component MMR anomaly shows an asymmetric transition from a small negative value to a larger positive value in the direction of decreasing y. From these two curves, we can determine that the region to the west of this boundary is more conductive. (See Figure 6 for a schematic representation of the excess currents and the resulting MMR anomaly.)

The west edge of this conductive zone is not seen because the line was not continued far enough. However, based on the continued decrease of the z-anomaly on line NTS-1, we can estimate the conductor to be at least 800 m

Figure 3. Forty Mile Wash location map taken from the Topopah Spring SW Quadrangle. Faults are from Lipman and McKay (1965).

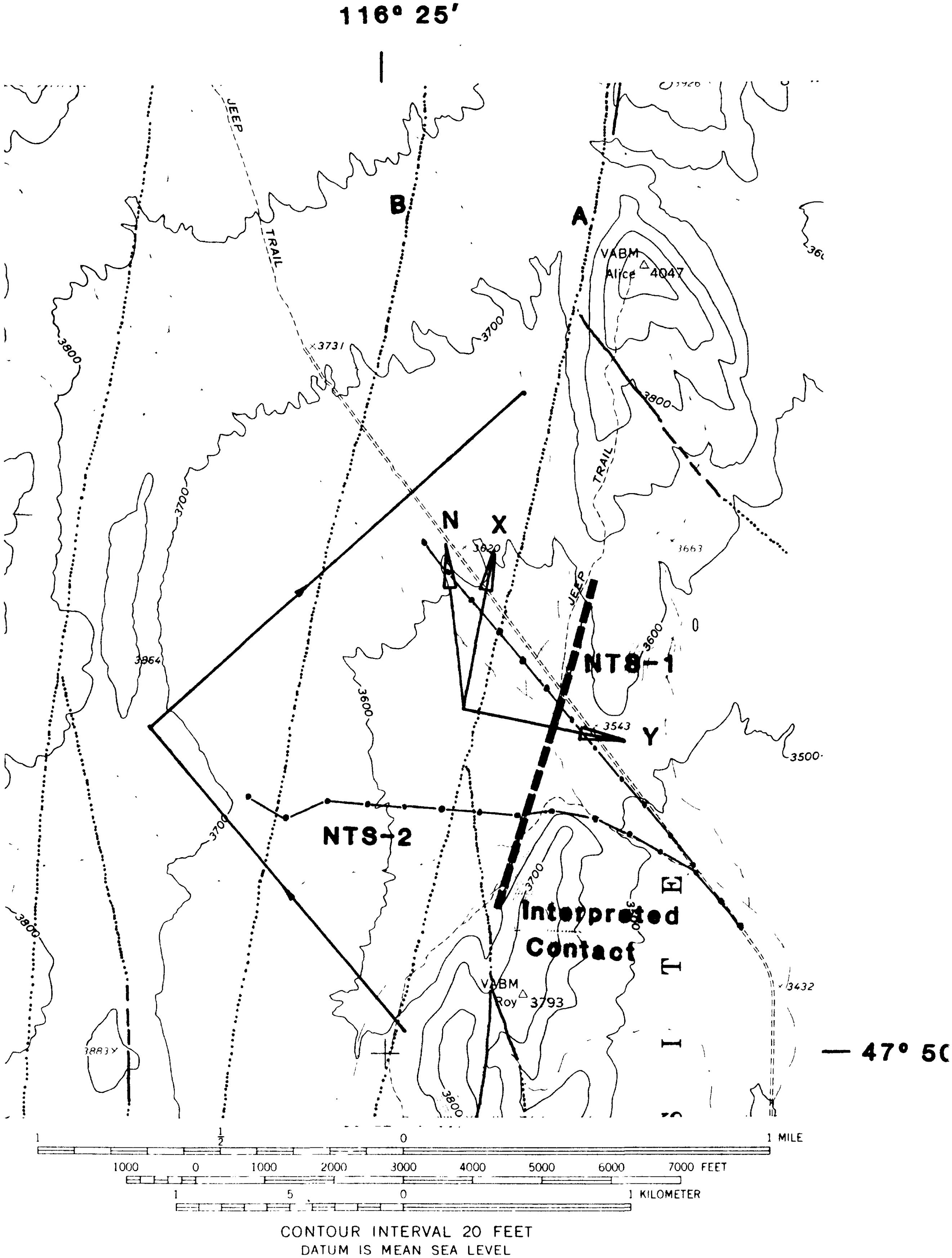
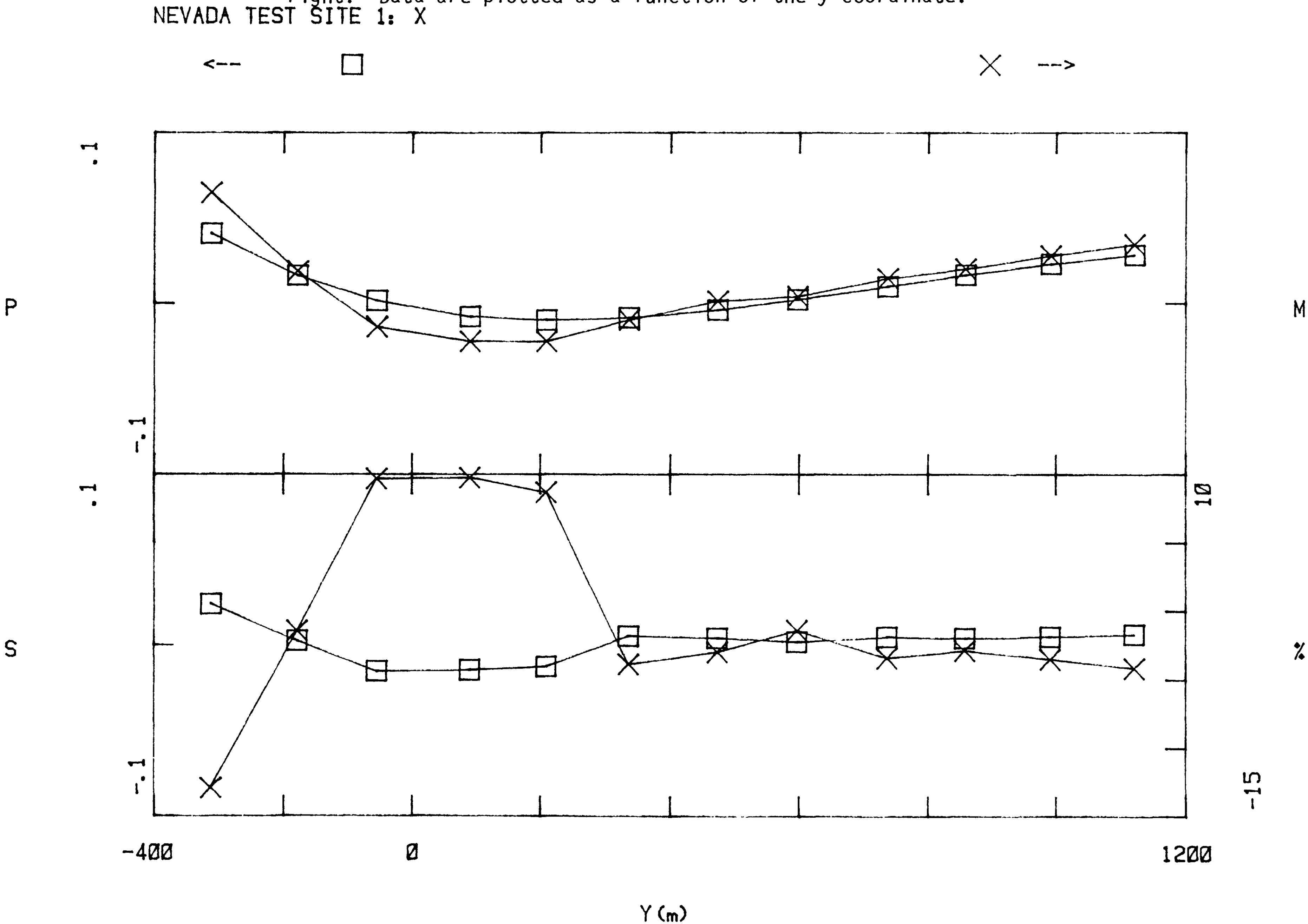
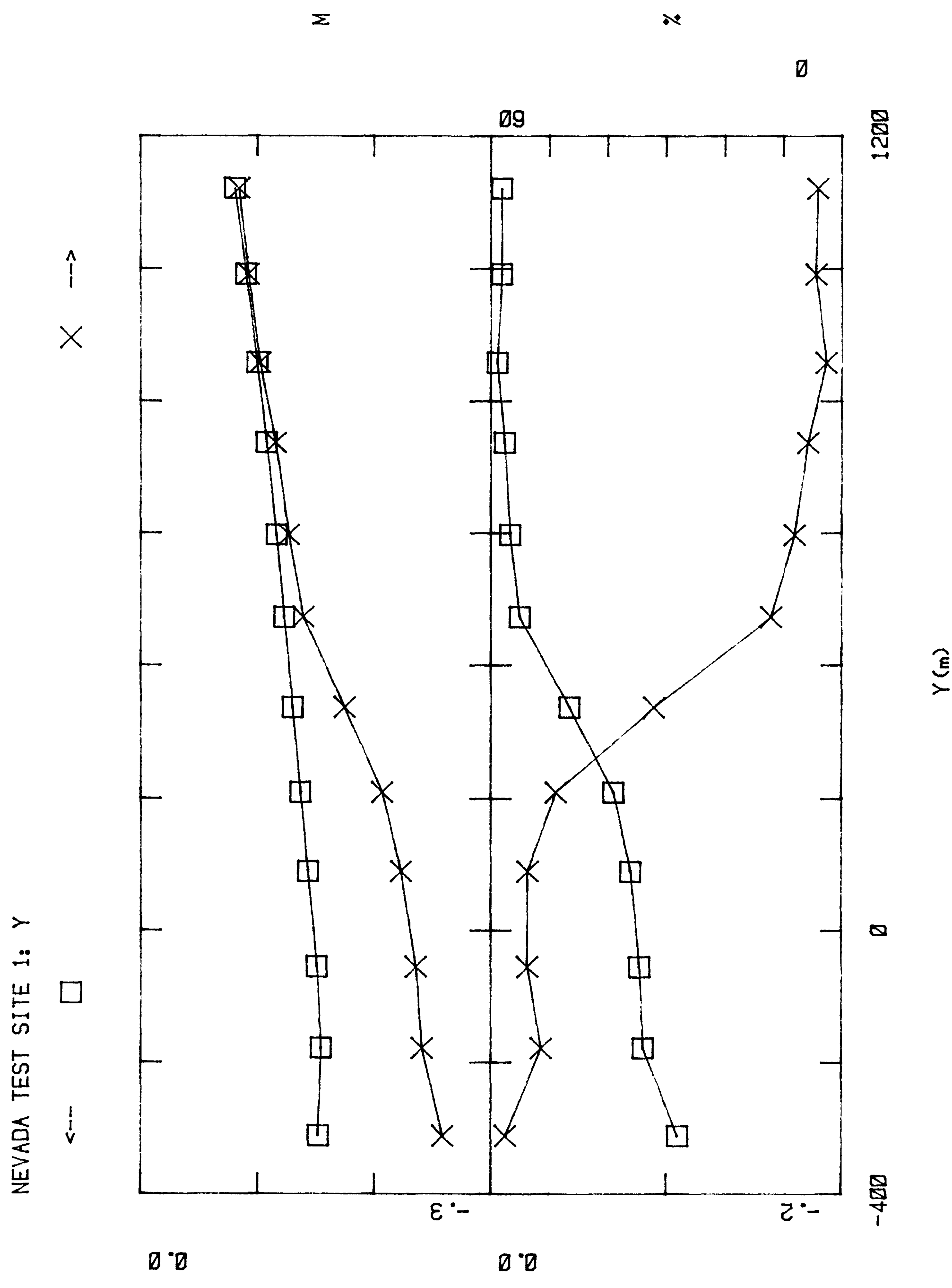


Figure 4. Nevada Test Site 1 MMR data. The upper plot shows the normalized primary (P) and normalized measured (M) fields. The scales are the same for both curves. The lower plot shows the normalized secondary (S) field to the left, and the MMR anomaly (%) to the right. Data are plotted as a function of the y-coordinate.




NEVADA TEST SITE 1: Y
<---
--->
P
S
M
%
0.0
-.3
0.0
-.2
60
0
-400
0
1200
Y(m)

NEVADA TEST SITE 1: Z

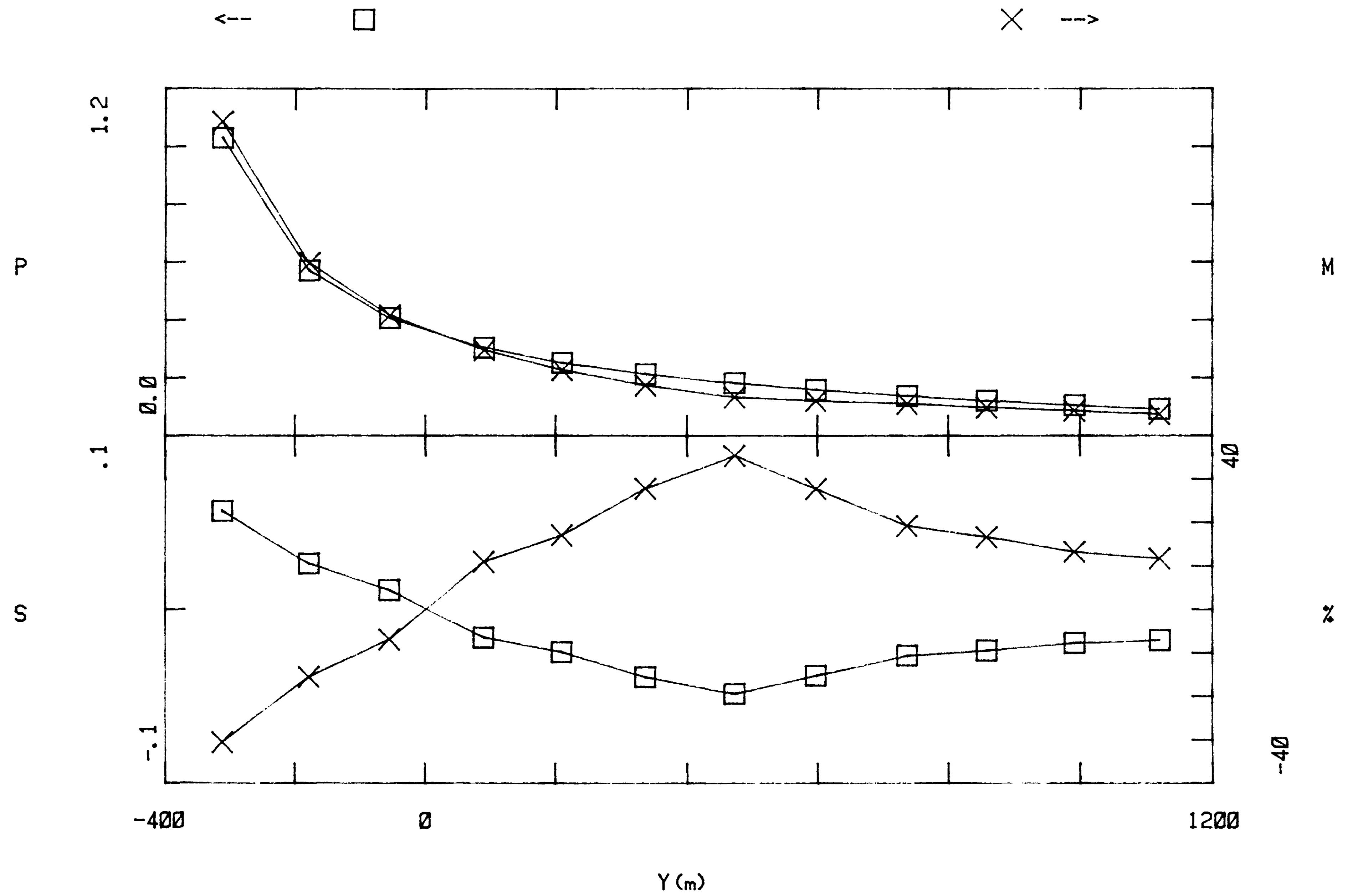
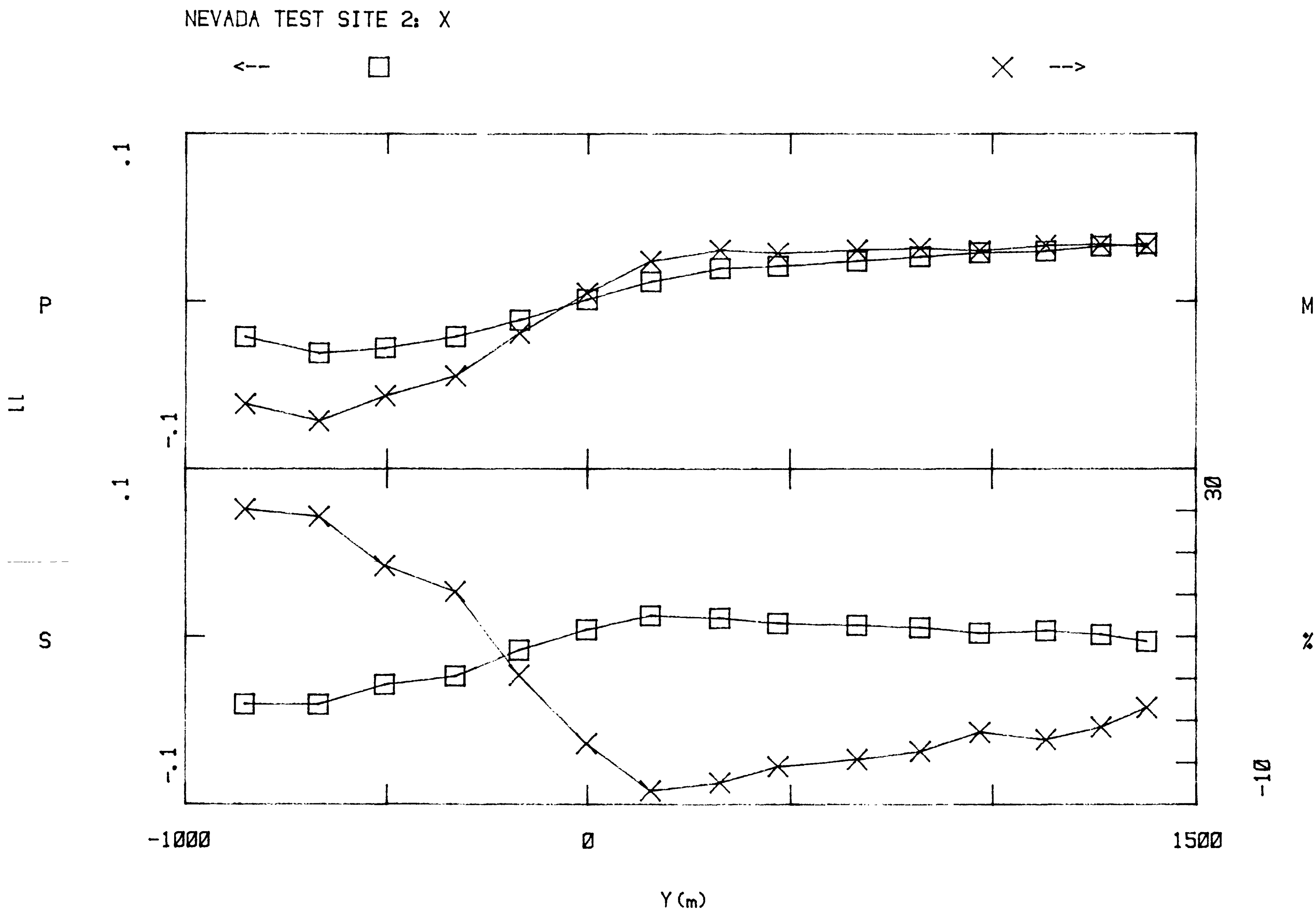
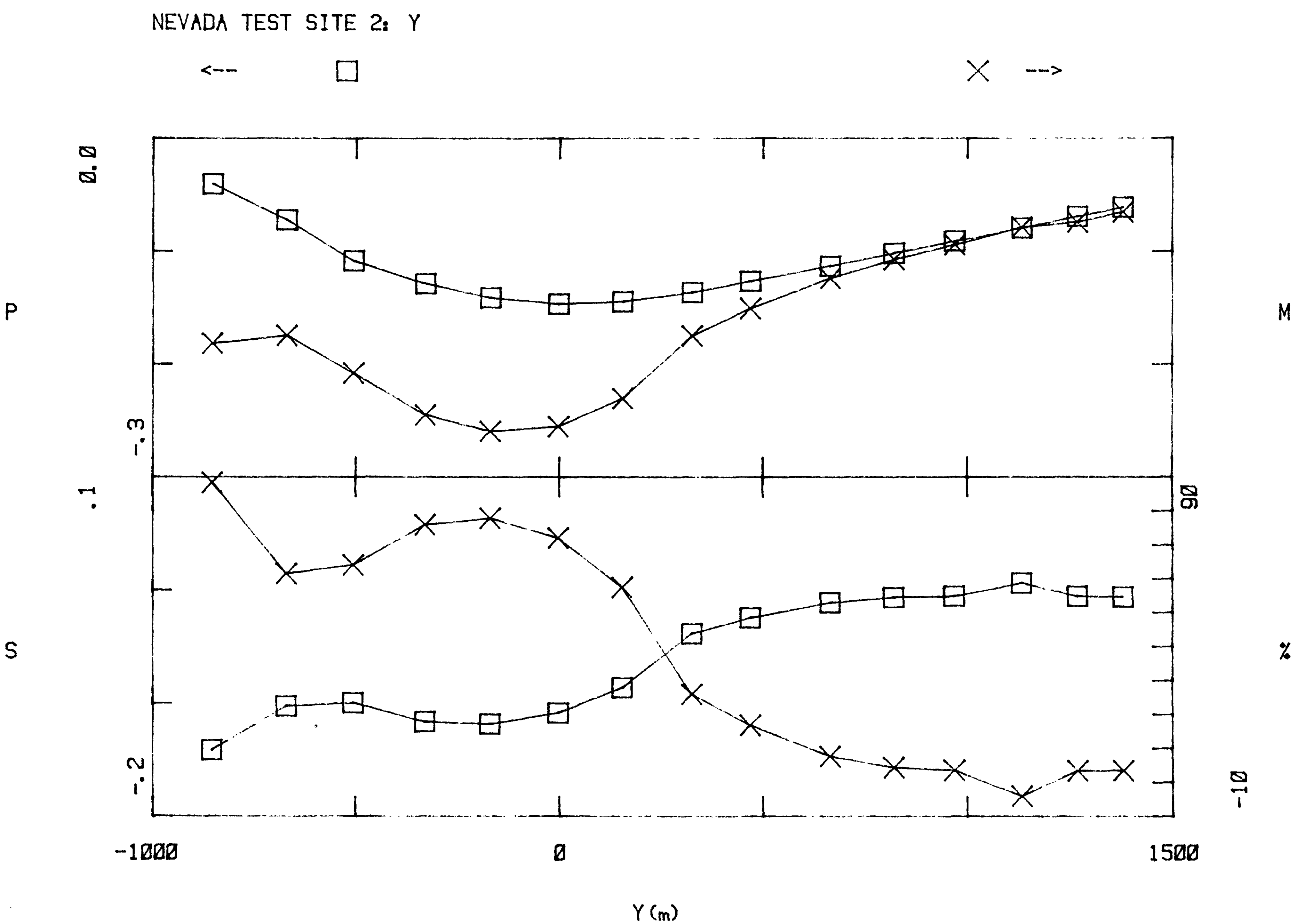
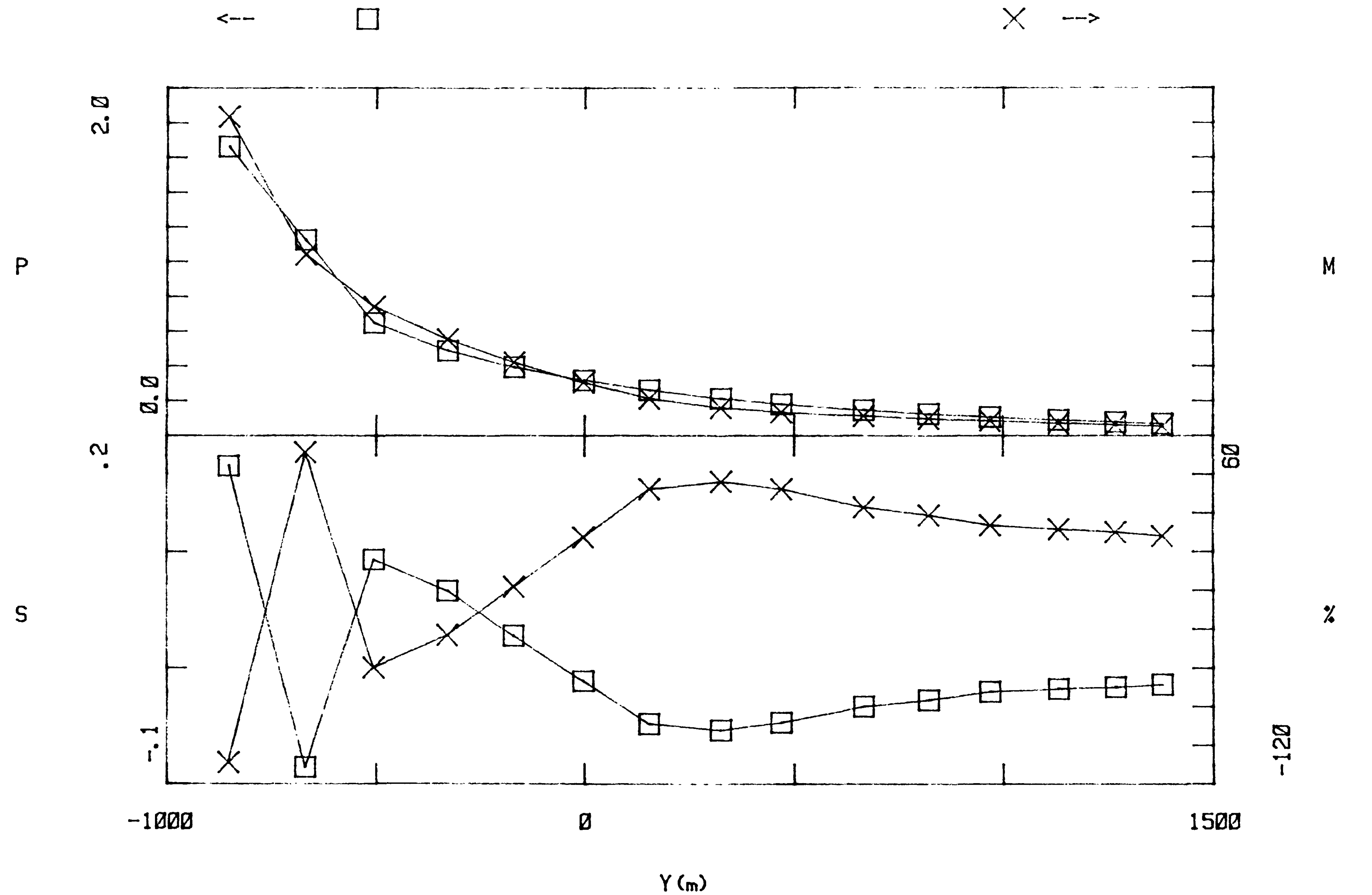


Figure 5. Nevada Test Site 2 MMR data. See Figure 4 for a description of the plots.




NEVADA TEST SITE 2: Y
<---
-->
P
S
M
%
0.0
-.3
.1
-.2
90
-10
-1000
0
1500
Y (m)

NEVADA TEST SITE 2: Z



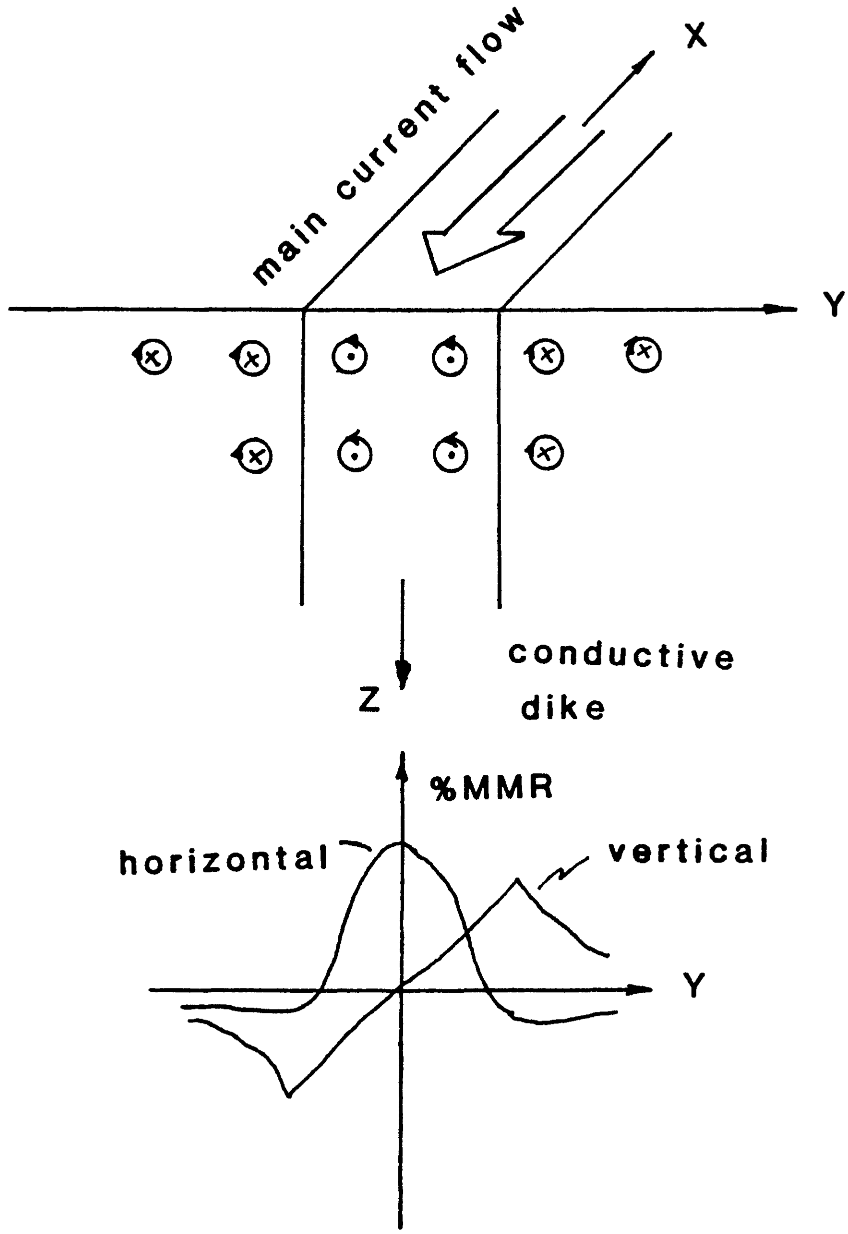


Figure 6. Schematic representation of MMR anomaly for a conductive dike.

wide. Line 2 data shows an anomalous z-value at y=-670 m. There is also an anomalous value in the y-component in this region, possibly indicating thewestern edge of the conductor. The width of the conductor would then be about 1000 m. This boundary corresponds with the location of fault "B" in Figure 3.

Using published interpretation curves for a vertical dike (Edwards et al., 1978) estimates of the conductivity contrast and dike width can be made from the magnitude of the vertical anomaly. Using a maximum vertical anomaly of about 35%, a resistivity contrast of about 5 is obtained for a dike width of from 700-1400 m. A dipole-dipole resistivity line run parallel NTS-2 found a conductive region roughly between y=200 m and y=-800 m with a resistivity ratio of between 3 and 8. (D. B. Hoover; U.S.G.S.; oral commun., 1981). The interpreted eastern edge of the conduction lies about 300 m to the east of the concealed fault "A" and about 200 m to the east of the dipole-dipole resistivity boundary. The agreement between the two interpretations is in general good. The resistive region to the east corresponds to a horst block, while the conductive zone is a down-dropped block covered by conductive sediments.

Conclusions

A field test of the MMR method over a concealed fault was able to detect a conductivity boundary associated with the fault. Interpretation of the resistivity ratio is in general agreement with the value obtained from a dipole-dipole resistivity survey. While the presence of a conductive zone could be detected, the western boundary of the feature cannot be located with the limited data available.

Operationally the technique is somewhat slow. This situation was exacerbated by the long transmitter wire used. A more practical scheme would be to use a shorter "U" shaped transmitter wire about 400 m on a side. A still better method might be to use a long straight wire and to make measurements off one end of the wire. This geometry would reduce the anomalous magnetic fields produced by variations of the transmitter wire from its assumed straight line between surveyed points.

References

Edwards, R. N., 1974, The magnetometric resistivity method and its application to the mapping of a fault: Canadian Journal of Earth Science, v. 11, 1136-1156.

Edwards, R. N., and Howell, E. C., 1976, A field test of the magnetometric resistivity (MMR) method: Geophysics, v. 41, 1170-1183.

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Gomez-Trevino, E., and Edwards, R. N., 1979, Magnetotelluric resistivity (MMR) anomalies of two-dimensional structures: Geophysics, v. 44, 947-958.

Lipman, P. W., and McKay, E. J., 1965, Geologic map of the Topopah Spring SW Quadrangle, Nye County, Nevada: U.S. Geological Survey Geological Quadrangle Map GQ-439.

Appendix

This section contains basic information on the instrumentation gains, wire geometry, and the observed and reduced data. The Gain File contains information about the shunt resistor used to measure the transmitter current, and the gain and phase shift of the magnetometer and the receiver amplifier and filter. The Wire File gives the coordinates of the transmitter wire nodes. The highest numbered node is a current sink, and node 1 is a current source. The Data File contains an entry for each observation point. There is a column for each field component, the first row contains the x, y, and z coordinates of the observation point. The next three lines are the receiver real and quadrature voltages, and gain setting respectively. The actual gain and phase shift are found by looking under the corresponding gain entry in the Gain File. The next two lines are the transmitter real and quadrature voltages measured across the shunt resistor. The normalized primary, measured, and secondary magnetic fields are shown on the next three pairs of lines. The first line of each entry is the amplitude, and the second line is the phase. The amplitudes may be negative to keep the phases between $+90^{o}$ and -90^{o}. The last line gives the percentage MMR anomaly.

NEVADA TEST SITE

GAIN FILE

RSHUNT= .18 Ω

MAGNETOMETER GAIN

CHAN	MAG(nT/V)	PHS(DEG)
X	70.4	-2.0
Y	67.4	-3.0
Z	75.8	-4.0

AMPLIFIER-FILTER GAIN

N	GAIN	MAG	PHS(DEG)
1	10.0	-7.1	-1.1
2	30.0	-21.4	-1.1
3	100.0	-70.7	-1.3
4	300.0	-216.0	-1.5
5	1000.0	-707.0	-1.1
6	3000.0	-2110.0	-1.3
7	10000.0	-7000.0	-1.3

NEVADA TEST SITE 1 & 2

WIRE FILE

N	X(M)	Y(M)	Z(M)
1	-1407.6	0.0	-42.9
2	-570.7	-1042.3	-10.8
3	-341.3	-1336.0	-6.0
4	811.3	-470.6	-29.4
5	1407.6	0.0	-22.8

NEVADA TEST SITE 1

STATION 1	X	Y	Z
COORD (m)	681.3	-311.9	-31.2
Rx:R-Ro	-.361	.492	-.553
Q-Qo	.024	-.025	.050
GAIN	300	100	30
Tx:R-Ro	.327	.327	.326
Q-Qo	-.001	.001	0.000
Bp/I:MAG (nT/A)	.041	-.152	1.029
PHS (DEG)	.2	-.2	0.0
Bm/I:MAG (nT/A)	.065	-.259	1.086
PHS (DEG)	-.3	1.4	1.4
Bs/I:MAG (nT/A)	.024	-.107	.057
PHS (DEG)	-1.1	3.6	-1.3
%MMR	-12.9	57.5	-30.6

STATION 2	X	Y	Z
COORD (m)	574.4	-178.4	-36.1
Rx:R-Ro	-.344	.459	-.305
Q-Qo	.018	-.020	.024
GAIN	1000	100	30
Tx:R-Ro	.327	.327	.327
Q-Qo	-.001	0.000	0.000
Bp/I:MAG (nT/A)	.016	-.154	.571
PHS (DEG)	.2	0.0	0.0
Bm/I:MAG (nT/A)	.019	-.241	.597
PHS (DEG)	.1	1.8	1.8
Bs/I:MAG (nT/A)	.002	-.087	.026
PHS (DEG)	-.4	5.0	13.7
%MMR	-1.5	51.4	-15.6

STATION 3	X	Y	Z
COORD (m)	476.8	-55.1	-41.3
Rx:R-Ro	.250	.449	-.703
Q-Qo	-.004	-.024	.059
GAIN	1000	100	100
Tx:R-Ro	.327	.327	.327
Q-Qo	.001	0.000	0.000
Bp/I:MAG (nT/A)	.002	-.151	.406
PHS (DEG)	-.2	0.0	0.0
Bm/I:MAG (nT/A)	-.014	-.236	.416
PHS (DEG)	2.2	1.2	1.2
Bs/I:MAG (nT/A)	-.015	-.085	.011
PHS (DEG)	1.9	3.5	19.4
%MMR	9.7	53.7	-6.9

STATION 4	X	Y	Z
COORD (m)	360.4	89.7	-48.1
Rx:R-Ro	.412	.430	-.505
Q-Qo	-.012	-.019	.025
GAIN	1000	100	100
Tx:R-Ro	.332	.331	.331
Q-Qo	0.000	.001	.001
Bp/I:MAG (nT/A)	-.008	-.144	.303
PHS (DEG)	0.0	-.2	-.2
Bm/I:MAG (nT/A)	-.022	-.223	.295
PHS (DEG)	1.4	1.8	1.8
Bs/I:MAG (nT/A)	-.015	-.080	-.016
PHS (DEG)	2.2	5.3	-56.9
%MMR	9.7	53.7	10.9

NEVADA TEST SITE 1

STATION 5		X	Y	Z
COORD	(m)	263.2	209.4	-51.4
Rx:R-Ro		.412	.400	-.388
Q-Qo		-.019	-.022	.031
GAIN		1000	100	100
Tx:R-Ro		.332	.332	.331
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.010	-.137	.251
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.022	-.207	.227
PHS	(DEG)	.5	1.2	1.2
Bs/I:MAG	(nT/A)	-.012	-.070	-.024
PHS	(DEG)	.8	3.4	-6.8
%MMR		8.7	48.9	17.1

STATION 6		X	Y	Z
COORD	(m)	161.1	336.7	-55.1
Rx:R-Ro		.144	.345	-.303
Q-Qo		-.110	-.016	.034
GAIN		1000	100	100
Tx:R-Ro		.339	.339	.339
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.008	-.130	.212
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.010	-.175	.174
PHS	(DEG)	-34.3	1.6	1.6
Bs/I:MAG	(nT/A)	.005	-.045	-.039
PHS	(DEG)	85.1	6.4	4.9
%MMR		-3.9	32.1	27.8

STATION 7		X	Y	Z
COORD	(m)	53.8	472.9	-57.7
Rx:R-Ro		0.000	.876	-.737
Q-Qo		.025	-.058	.079
GAIN		1000	300	300
Tx:R-Ro		.362	.353	.353
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.004	-.123	.181
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	.001	-.140	.133
PHS	(DEG)	-86.9	.7	.7
Bs/I:MAG	(nT/A)	.004	-.017	-.049
PHS	(DEG)	-17.5	6.0	1.7
%MMR		-3.0	12.1	35.4

STATION 8		X	Y	Z
COORD	(m)	-47.9	597.5	-60.8
Rx:R-Ro		-.078	.775	-.651
Q-Qo		.018	-.038	.061
GAIN		1000	300	300
Tx:R-Ro		.349	.343	.343
Q-Qo		-.002	-.002	-.002
Bp/I:MAG	(nT/A)	.002	-.116	.158
PHS	(DEG)	.3	.3	.3
Bm/I:MAG	(nT/A)	.004	-.127	.120
PHS	(DEG)	-9.9	1.7	1.7
Bs/I:MAG	(nT/A)	.002	-.011	-.038
PHS	(DEG)	-21.6	16.2	.9
%MMR		-1.4	8.1	27.8

NEVADA TEST SITE 1

STATION 9	X	Y	Z
COORD (m)	-158.1	736.8	-66.6
Rx:R-Ro	-.275	.697	-.591
Q-Qo	.027	-.044	.055
GAIN	1000	300	300
Tx:R-Ro	.340	.339	.339
Q-Qo	0.000	.001	.001
Bp/I:MAG (nT/A)	.010	-.108	.137
PHS (DEG)	0.0	-.2	-.2
Bm/I:MAG (nT/A)	.015	-.116	.111
PHS (DEG)	-2.5	.9	.9
Bs/I:MAG (nT/A)	.005	-.008	-.027
PHS (DEG)	-7.7	15.3	-1.6
%MMR	-3.4	5.8	19.2

STATION 10	X	Y	Z
COORD (m)	-255.6	858.2	-72.9
Rx:R-Ro	-.377	.612	-.520
Q-Qo	.060	-.066	.065
GAIN	1000	300	300
Tx:R-Ro	.338	.338	.339
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.017	-.100	.121
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.020	-.102	.098
PHS (DEG)	-5.9	-1.7	-1.7
Bs/I:MAG (nT/A)	.004	-.004	-.023
PHS (DEG)	-30.9	-51.6	6.8
%MMR	-2.9	2.7	16.7

STATION 11	X	Y	Z
COORD (m)	-361.0	991.2	-75.7
Rx:R-Ro	-.525	.558	-.458
Q-Qo	.067	-.008	.057
GAIN	1000	300	300
Tx:R-Ro	.339	.339	.339
Q-Qo	.001	.001	.001
Bp/I:MAG (nT/A)	.023	-.090	.105
PHS (DEG)	-.2	-.2	-.2
Bm/I:MAG (nT/A)	.028	-.092	.086
PHS (DEG)	-4.2	3.7	3.7
Bs/I:MAG (nT/A)	.005	-.006	-.019
PHS (DEG)	-22.7	73.8	6.2
%MMR	-3.5	4.4	13.3

STATION 12	X	Y	Z
COORD (m)	-464.3	1120.3	-78.8
Rx:R-Ro	-.650	.509	-.395
Q-Qo	.068	-.011	.056
GAIN	1000	300	300
Tx:R-Ro	.339	.339	.340
Q-Qo	.002	.002	.001
Bp/I:MAG (nT/A)	.028	-.081	.092
PHS (DEG)	-.3	-.3	-.2
Bm/I:MAG (nT/A)	.035	-.084	.074
PHS (DEG)	-2.9	3.3	3.3
Bs/I:MAG (nT/A)	.006	-.006	-.018
PHS (DEG)	-14.3	57.0	9.9
%MMR	-4.2	4.1	11.7

NEVADA TEST SITE 2

STATION 1		X	Y	Z
COORD	(m)	-547.8	-851.8	-18.5
Rx:R-Ro		.303	.307	-.275
Q-Qo		.007	-.014	.021
GAIN		300	100	10
Tx:R-Ro		.290	.290	.290
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.021	-.041	1.663
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.061	-.182	1.835
PHS	(DEG)	4.8	1.7	1.7
Bs/I:MAG	(nT/A)	-.040	-.141	.174
PHS	(DEG)	7.4	2.2	7.7
%MMR		25.2	88.4	-108.9

STATION 2		X	Y	Z
COORD	(m)	-609.1	-669.1	-26.4
Rx:R-Ro		.353	.295	-.468
Q-Qo		-.005	-.009	.044
GAIN		300	100	30
Tx:R-Ro		.290	.290	.288
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.031	-.072	1.126
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.071	-.175	1.041
PHS	(DEG)	2.7	2.6	2.6
Bs/I:MAG	(nT/A)	-.041	-.103	-.086
PHS	(DEG)	4.7	4.4	3.3
%MMR		24.3	61.5	51.4

STATION 3		X	Y	Z
COORD	(m)	-504.3	-506.1	-34.0
Rx:R-Ro		.925	.355	-.340
Q-Qo		-.007	-.006	.024
GAIN		1000	100	30
Tx:R-Ro		.293	.293	.293
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.028	-.109	.649
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.057	-.208	.742
PHS	(DEG)	2.7	3.3	3.3
Bs/I:MAG	(nT/A)	-.029	-.100	.093
PHS	(DEG)	5.3	7.0	8.5
%MMR		18.4	64.1	-59.8

STATION 4		X	Y	Z
COORD	(m)	-479.7	-328.6	-41.4
Rx:R-Ro		.726	.417	-.833
Q-Qo		.016	-.009	.071
GAIN		1000	100	100
Tx:R-Ro		.292	.292	.291
Q-Qo		0.000	0.000	0.000
Bp/I:MAG	(nT/A)	-.021	-.129	.488
PHS	(DEG)	0.0	0.0	0.0
Bm/I:MAG	(nT/A)	-.045	-.245	.554
PHS	(DEG)	4.4	3.1	3.1
Bs/I:MAG	(nT/A)	-.024	-.117	.066
PHS	(DEG)	8.3	6.5	3.6
%MMR		15.3	75.9	-43.1

NEVADA TEST SITE 2

STATION 5	X	Y	Z
COORD (m)	-460.7	-170.1	-46.4
Rx:R-Ro	.325	.461	-.661
Q-Qo	.034	-.020	.054
GAIN	1000	100	100
Tx:R-Ro	.305	.305	.305
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	-.011	-.141	.392
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	-.019	-.260	.420
PHS (DEG)	9.1	1.8	1.8
Bs/I:MAG (nT/A)	-.008	-.118	.028
PHS (DEG)	21.7	4.0	9.6
%MMR	5.4	77.8	-18.1

STATION 6	X	Y	Z
COORD (m)	-440.5	-2.7	-51.2
Rx:R-Ro	-.071	.465	-.493
Q-Qo	.047	-.023	.045
GAIN	1000	100	100
Tx:R-Ro	.313	.313	.313
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.001	-.147	.316
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.005	-.255	.305
PHS (DEG)	-30.4	1.5	1.5
Bs/I:MAG (nT/A)	.004	-.109	-.011
PHS (DEG)	-36.9	3.5	-2.2
%MMR	-2.7	72.0	7.5

STATION 7	X	Y	Z
COORD (m)	-422.5	155.0	-56.3
Rx:R-Ro	-.413	.420	-.344
Q-Qo	.063	-.020	.033
GAIN	1000	100	100
Tx:R-Ro	.313	.313	.314
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.012	-.145	.261
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.024	-.231	.212
PHS (DEG)	-5.6	1.6	1.6
Bs/I:MAG (nT/A)	.012	-.086	-.048
PHS (DEG)	-10.7	4.2	.8
%MMR	-8.3	57.5	32.4

STATION 8	X	Y	Z
COORD (m)	-400.1	326.1	-60.3
Rx:R-Ro	-.537	.325	-.798
Q-Qo	.060	-.017	.082
GAIN	1000	100	300
Tx:R-Ro	.319	.319	.318
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.020	-.137	.213
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.030	-.175	.159
PHS (DEG)	-3.3	1.3	1.3
Bs/I:MAG (nT/A)	.011	-.038	-.054
PHS (DEG)	-9.1	6.0	1.1
%MMR	-7.4	26.0	36.2

NEVADA TEST SITE 2

STATION 9	X	Y	Z
COORD (m)	-353.9	468.7	-64.6
Rx:R-Ro	-.508	.281	-.674
Q-Qo	.066	-.012	.073
GAIN	1000	100	300
Tx:R-Ro	.320	.320	.320
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.021	-.127	.181
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.029	-.151	.134
PHS (DEG)	-4.3	1.9	1.9
Bs/I:MAG (nT/A)	.008	-.025	-.047
PHS (DEG)	-15.7	11.5	1.9
%MMR	-5.5	16.9	32.4

STATION 10	X	Y	Z
COORD (m)	-356.7	664.4	-69.5
Rx:R-Ro	-.540	.231	-.570
Q-Qo	.066	-.011	.070
GAIN	1000	100	300
Tx:R-Ro	.320	.320	.320
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.024	-.113	.147
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.030	-.124	.113
PHS (DEG)	-3.9	1.6	1.6
Bs/I:MAG (nT/A)	.007	-.011	-.033
PHS (DEG)	-17.8	17.7	5.1
%MMR	-4.6	7.7	22.9

STATION 11	X	Y	Z
COORD (m)	-389.0	821.2	-72.7
Rx:R-Ro	-.565	.616	-.489
Q-Qo	.065	-.027	.059
GAIN	1000	300	300
Tx:R-Ro	.322	.322	.322
Q-Qo	-.001	-.001	0.000
Bp/I:MAG (nT/A)	.027	-.102	.124
PHS (DEG)	.2	.2	0.0
Bm/I:MAG (nT/A)	.032	-.108	.097
PHS (DEG)	-3.5	2.0	2.0
Bs/I:MAG (nT/A)	.005	-.007	-.028
PHS (DEG)	-21.7	31.7	4.8
%MMR	-3.7	4.4	18.8

STATION 12	X	Y	Z
COORD (m)	-438.5	968.7	-75.8
Rx:R-Ro	-.535	.537	-.433
Q-Qo	.061	-.017	.049
GAIN	1000	300	300
Tx:R-Ro	.320	.320	.320
Q-Qo	0.000	0.000	0.000
Bp/I:MAG (nT/A)	.029	-.091	.106
PHS (DEG)	0.0	0.0	0.0
Bm/I:MAG (nT/A)	.030	-.094	.086
PHS (DEG)	-3.4	2.7	2.7
Bs/I:MAG (nT/A)	.002	-.005	-.021
PHS (DEG)	-57.8	54.8	4.0
%MMR	-1.4	3.6	13.6

NEVADA TEST SITE 2

STATION 13		X	Y	Z
COORD	(m)	-491.0	1131.5	-79.0
Rx:R-Ro		-.556	.463	-.375
Q-Qo		.017	-.002	.050
GAIN		1000	300	300
Tx:R-Ro		.299	.330	.330
Q-Qo		-.003	.001	.001
Bp/I:MAG	(nT/A)	.030	-.080	.090
PHS	(DEG)	.6	-.2	-.2
Bm/I:MAG	(nT/A)	.033	-.079	.072
PHS	(DEG)	1.4	4.3	4.3
Bs/I:MAG	(nT/A)	.003	.006	-.018
PHS	(DEG)	8.0	-80.5	7.6
%MMR		-2.3	-4.0	11.6

STATION 14		X	Y	Z
COORD	(m)	-591.8	1268.1	-82.4
Rx:R-Ro		-.626	.436	-.320
Q-Qo		.042	-.015	.055
GAIN		1000	300	300
Tx:R-Ro		.330	.330	.331
Q-Qo		.001	-.001	0.000
Bp/I:MAG	(nT/A)	.033	-.069	.078
PHS	(DEG)	-.2	.2	0.0
Bm/I:MAG	(nT/A)	.034	-.074	.062
PHS	(DEG)	-.7	2.5	2.5
Bs/I:MAG	(nT/A)	.001	-.006	-.017
PHS	(DEG)	-15.7	32.8	16.0
%MMR		-.8	3.4	10.1

STATION 15		X	Y	Z
COORD	(m)	-680.9	1379.8	-85.4
Rx:R-Ro		-.600	.385	-.932
Q-Qo		.075	-.004	.161
GAIN		1000	300	1000
Tx:R-Ro		.330	.330	.330
Q-Qo		.001	.001	.001
Bp/I:MAG	(nT/A)	.034	-.061	.069
PHS	(DEG)	-.2	-.2	-.2
Bm/I:MAG	(nT/A)	.033	-.066	.055
PHS	(DEG)	-4.0	3.9	3.9
Bs/I:MAG	(nT/A)	-.003	-.006	-.014
PHS	(DEG)	52.6	49.1	17.5
%MMR		1.6	3.5	8.1