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Geological Survey

Telluric Traverse and Self Potential Data Release in the Vicinity of the Pinson Mine, Humboldt County, Nevada

by

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Introduction

During May 1985, five telluric traverses were made on the east side of the Osgood mountains in the vicinity of the Preble, Pinson and Getchell disseminated gold deposits. This work is part of a group of integrated studies performed under the Development of Assessment Techniques (DAT) program of the USGS, directed at developing a more complete understanding of disseminated precious metal deposits. These traverses supplement telluric work alone in June 1984 (Hoover and others 1984) designed to define the geoelectric structure on the east flank of the Osgood Mountains and to look for possible electrical signatures associated with these disseminated gold deposits. This report presents the telluric and supplemental self potential data without interpretations, to effect timely release of the data.

The Telluric Traverse Method

The telluric traverse (TT) method employs natural earth currents (telluric currents) at various frequencies to measure, indirectly, changes in earth resistivity along a traverse. It was used as early as 1921 by C. Schlumberger (Leonardon, 1928), but until recently has been little used in the United States. Beyer (1977) discusses the method in some detail and presents a series of model results computed for two-dimensional structures. He concludes that the method is well suited for rapid reconnaissance of regions several hundred square-kilometers in area, when searching for targets such as hydrothermal systems. The method should be applicable as well to fossil hydrothermal systems, some of which are associated with mineral deposits, because rock alteration will remain long after the hydrothermal convection cells have ceased.

In applying the technique a receiving array of three electrodes are used, spaced equidistant and in line. This array is, in effect, two colinear dipoles sharing a common electrode. The potential difference across each dipole is then proportional to the component of the telluric field in the direction of the array. This configuration permits the measurement of the ratio of the telluric field at each dipole array location in the direction of the dipole line. The traverse data is extended by moving the three-electrode array forward one dipole length so that the forward electrode becomes the center electrode for the next ratio measurement. This process is repeated for as long as desired.

Telluric measurements are made in a narrow frequency band typically using micropulsations near 30 second periods (0.033 Hz), but may be made over a wide range of frequencies. Because lower frequency electromagnetic signals penetrate to greater depths than higher frequencies, one can, to some extent, select a maximum depth of exploration. The maximum depth, however, is a function of earth resistivity as well as frequency. A useful criterion for the maximum depth of exploration in a half-space is given by (Bostick, 1977)

$$1) \qquad D = 355\sqrt{p/f} \text{ meters}$$

where D is the depth in meters

p is the half-space resistivity in ohm-meters

f is the frequency in Hz.

The USGS has recently designed a multi-frequency telluric receiver operating from 25 Hz to .016 Hz. This receiver was used for data acquisition. Frequencies of 25, and 7.5 Hz were measured on all lines in the survey. From preliminary unpublished audio-magnetotelluric (AMT) measurements in the area, the Preble Formation has a resistivity generally in the range of 100 ohm-meters at these frequencies. From equation 1, the maximum depth of exploration would be in the range of 700 to 1300 meters in this environment.

The natural signal sources used in the 4.5 Hz to 25 Hz frequency range arise from world-wide lightning storms. These signals are very impulsive, but occur essentially continuously throughout the day. In this frequency band there are few problems with the effective use of natural electromagnetic signals.

On all traverses 125 meter dipoles were used, one fifth or less of the maximum exploration depth. Short spacial wavelength anomalies seen on the traverse data imply shallow structures, or structures whose top is shallow, exactly analogous to other potential field data. The close correlation seen between the curves at each frequency (fig. 3, 4, 5, 6, and 7) is typical of telluric data measured over a small frequency span and results from the measurements averaging the earth resistivity from the surface to the maximum depth of exploration. For electromagnetic fields in a non-layered earth the electric field at a point varies with the direction of measurement as does the resistivity. They are tensor quantities. The horizontal electric field variations rather than the magnetic field, in general, reflect the variations in earth resistivity. For two-dimensional structures it can be shown (Beyer, 1977) that the electric field ratio measured normal to strike (the transverse magnetic TM mode) is proportional to the square root of the resistivity variation. Because of this, telluric traverses are typically run normal to the expected regional structural trends in a survey area. The traverses also are kept in a straight line because of the tensor nature of the electric field.

Telluric traverse data is presented as curves of relative telluric voltage. A value of unity is arbitrarily assigned to one dipole on the traverse and, for each frequency, the value of all other dipoles are computed relative to it. Without other information there is no way to reference, in an absolute sense, a curve at one frequency to that of another frequency. The curves presented in this report for each line have been nested with an arbitrary shift between the initial values. The relative voltage is plotted on a logarithmic scale.

The Self Potential Method

The self potential method measures the natural direct current potential occurring on, or within, the earth arising from naturally occurring sources. This is an old and well established technique. For those not familiar with the method, Corwin and Hoover (1979) provide a recent summary. Source mechanisms, however, continue to present problems. A recent discussion is given by Corry (1985).

Because non-polarizing electrodes are used when making telluric traverse measurements, the self potential is easily measured as a supplement to the telluric data. At each telluric station the self potential between the center electrode and the forward or rear electrode was measured. As the systems moved forward this provided two independent measurements of each dipole, except for each end dipole. This "leap frog" method of self potential measurement is not particularly desirable because cumulative errors may occur. This can be seen in the present data. However the ease of data acquisition, the redundancy provided by two measurements, and the ability to identify, large self potential anomalies makes such data useful.

In this survey lead-lead chloride electrodes were used and measurements were made with a 10 megohm input impedance voltmeter. Zero reference for each profile was the first electrode of the profile.

Electrical Data

Figures 1 and 2 show traverse locations for all lines run, including those ran in June 1984 (Hoover and others 1984). Figures 3, 4, 5, 6, and 7 show the telluric and self potential data for lines Getchell 3 and 4, Pinson 1, Christison 1, and Preble 3 respectively.

Acknowledgements

We wish to thank the personnel of the Pinson Mining Company and FRM Minerals, Inc., for permission to conduct this research on their property, and for the many courtesies extended us during the field operations.

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Appendix I

Tabulated telluric and self potential data follows for lines Getchell 3 and 4, Pinson 1, Christison 1, and Preble 3. The tables show the voltage ratio measured at each station between adjacent dipoles and the standard deviation referenced to a starting dipole value of 1 unit. The self potential data is given in millivolts referenced to the starting electrode.

Telluric Traverse and Self Potential Data
Getchell, Line 3

Station No.	Ratio/Std. Deviation		Relative Voltage		Self Potential (millivolts)	
	25Hz	7.5Hz	25Hz	7.5Hz		
4W						20
			0.45	0.56		
3W	0.75/.03	0.87/.04			12	16
			0.33	0.48		
2W	0.93/.06	1.09/.09			15	17
			0.36	0.44		
1W	2.78/.07	2.25/.20			0	0
			1.	1.		
0	1.66/.08	1.77/.05			4	1
			0.60	0.56		
1E	1.25/.02	1.32/.05			22	17
			0.75	0.75		
2E	1.41/.02	1.52/.03			27	19
			0.53	0.49		
3E	0.92/.02	0.99/.03			31	22
			0.49	0.49		
4E	0.82/.01	0.85/.03			33	30
			0.60	0.57		
5E	1.29/.02	1.44/.06			39	28
			0.77	0.82		
6E	1.24/.04	1.25/.05			43	27
			0.62	0.66		

Telluric Traverse and Self Potential Data
Getchell, Line 3

Station No.	Ratio/Std. Deviation		Relative Voltage		Self Potential	
	25Hz	7.5Hz	25Hz	7.5Hz	(millivolts)	
7E	1.93/.03	1.83/.05			18	-1
			1.20	1.20		
8E	1.34/.03	1.35/.03			29	6
			0.90	0.89		
9E	1.50/.03	1.51/.02			42	15
			1.35	1.35		
10E	1.45/.03	1.48/.03			53	20
			0.93	0.91		
11E	0.81/.01	0.87/.01			55	20
			0.75	0.79		
12E	1.03/.02	1.07/.03			62	20
			0.73	0.74		
13E	2.60/.08	2.53/.15			97	50
			1.90	1.87		
14E	1.61/.14	1.40/.14			91	40
			1.18	1.34		
15E					99	

Telluric Traverse and Self Potential Data
Getchell, Line 4 (Riley Mine)

Station No.	Ratio/Std. Deviation		Relative Voltage		Self Potential (millivolts)	
	25Hz	7.5Hz	25Hz	7.5Hz		
0					+33	
			1.	1.		
1	0.37/.01	0.38/.01			0	0
			0.37	0.38		
2	0.86/.01	0.90/.02			-5	-1
			0.32	0.34		
3	0.16/.01	0.19/.03			-16	-12
			0.05	0.07		
4	0.62/.09	0.45/.05			-23	-9
			0.08	0.14		
5	1.31/.20	1.52/.33			-53	-35
			0.11	0.22		
6	1.20/.13	1.13/.09			-98	-82
			0.09	0.19		
7	1.21/.16	1.46/.22			-124	-114
			0.11	0.28		
8	0.71/.04	0.66/.04			-84	-83
			0.15	0.43		
9	1.02/.02	1.12/.03			6	-13
			0.16	0.48		
10	0.96/.09	1.12/.02			36	14
			0.16	0.43		

Telluric Traverse and Self Potential Data
Getchell, Line 4 (Riley Mine)

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
11	0.89/.03	0.93/.07			67	29
			0.15	0.40		
12	0.93/.06	0.86/.10			84	22
			0.16	0.46		
13	0.88/.10	0.83/.01			97	10
			0.14	0.39		
14	1.09/.04	1.09/.09			103	40
			0.13	0.35		
15	1.23/.04	1.40/.11			96	41
			0.16	0.49		
16	0.97/.02	0.98/.09			92	45
			0.16	0.50		
17	1.07/.05	1.23/.08			79	42
			0.17	0.62		
18	0.94/.01	0.91/.07			76	46
			0.18	0.68		
19	1.13/.02	1.17/.10			74	51
			0.21	0.80		
20	0.98/.01	1.05/.14			71	49
			0.21	0.76		
21	1.01/.01	1.01/.07			62	40
			0.21	0.77		

Telluric Traverse and Self Potential Data
Pinson, Line 1
125m dipoles

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
0						+78
			0.88	1.14		
1	0.88/.02	1.14/.17			0	0
			1.0	1.0		
2	1.23/.08	1.26/.15			-128	-127
			1.23	1.26		
3	0.57/.01	0.68/.05			-304	-302
			0.70	0.86		
4	0.76/.08	0.71/.12			-389	-388
			0.93	1.21		
5	0.64/.15	0.64/.17			-391	-392
			0.59	0.77		
6	1.18/.33	1.23/.25			-556	-551
			0.50	0.63		
7	0.66/.10	0.64/.12			-540	-531
			0.33	0.40		
8	0.68/.07	0.82/.07			-330	-315
			0.49	0.49		
9	0.93/.10	1.12/.07			-253	-238
			0.45	0.55		
10	0.79/.07	0.80/.11			30	46
			0.57	0.69		

Telluric Traverse and Self Potential Data
Pinson, Line 1
125m dipoles

Station No.	Ratio/Std. Deviation		Relative Voltage		Self Potential	
	25Hz	7.5Hz	25Hz	7.5Hz	(millivolts)	
11	0.85/.11	0.92/.04			93	114
			0.48	0.63		
12	1.10/.02	1.27/.15			98	124
			0.44	0.50		
13	1.63/.24	1.92/.29			93	129
			0.72	0.95		
14	0.95/.04	0.97/.06			73	118
			0.76	0.98		
15	3.56/.20	3.10/.24			37	88
			2.70	3.05		
16	1.50/.10	1.25/.11			-60	-2
			1.80	2.44		
17	0.96/.03	0.97/.05			-106	-42
			1.72	2.37		
18	2.20/.03	1.98/.26			-148	-98
			0.78	1.20		
19	0.37/.04	0.46/.11			-158	-118
			0.29	0.55		
20	1.00/.02	1.06/.14			-81	-39
			0.29	0.52		
21	1.51/.23	1.49/.21			-36	7
			0.44	0.77		

Telluric Traverse and Self Potential Data
Pinson, Line 1
125m dipoles

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
22	0.86/.12	0.73/.10			-10	40
			0.51	1.06		
23	1.26/.04	1.31/.09			12	63
			0.65	1.39		
24	0.83/.04	0.87/.07			29	83
			0.77	1.59		
25	0.96/.00	0.96/.05			35	97
			0.74	1.53		
26						118

Telluric Traverse and Self Potential Data
Christison, Line 1

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
1					11	
			0.87	0.90		
2	0.87/.01	0.90/.03			0	0
			1.	1.		
3	1.12/.01	1.17/.04			-9	-11
			1.12	1.17		
4	0.91/.01	0.97/.03			-24	-18
			1.23	1.21		
5	0.79/.01	0.82/.02			-55	-41
			0.97	0.99		
6	1.49/.02	1.45/.04			-59	-46
			0.65	0.68		
7	1.06/.02	1.16/.04			-22	-7
			0.69	0.79		
8	0.44/.00	0.47/.01			-7	12
			1.56	1.68		
9	0.96/.01	0.99/.02			5	20
			1.50	1.67		
10	2.43/.03	2.45/.2			0	29
			0.62	0.68		
11	1.07/.04	1.02/.12			5	20
			0.66	0.69		

Telluric Traverse and Self Potential Data
Christison, Line 1

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
12	0.97/.06	1.03/.05			2	21
			0.68	0.67		
13	0.94/.04	1.01/.12			7	-21
			0.64	0.68		
14	1.02/.05	1.13/.09			-4	31
			0.57	0.60		
15	1.18/.13	1.06/.04			-12	29
			0.68	0.64		
16	0.93/.07	0.94/.15			-1	46
			0.73	0.68		
17	0.96/.03	0.94/.05			-1	55
			0.70	0.64		
18	1.06/.07	1.06/.06			0	60
			0.66	0.60		
						64

Telluric Traverse and Self Potential Data
Preble, Line 3
125m Dipoles

Station No.	Ratio/Std. Deviation 25Hz	Ratio/Std. Deviation 7.5Hz	Relative Voltage 25Hz	Relative Voltage 7.5Hz	Self Potential (millivolts)	
0						-6
			1.	1.		
1	0.89/.01	0.95/.01			0	0
			1.12	1.05		
2	1.06/.03	1.12/.07			-1	2
			1.19	1.18		
3	0.86/.07	0.76/.14			10	7
			1.38	1.55		
4	0.98/.06	1.01/.08			14	2
			1.36	1.57		
5	1.01/.04	1.09/.06			18	2
			1.34	1.44		
6	0.95/.02	1.11/.12			3	-17
			1.28	1.60		
7	0.93/.05	0.86/.06			14	-14
			1.37	1.86		
8	1.15/.09	1.20/.21			25	-14
			1.58	2.23		
9	0.88/.17	0.83/.04			25	-18
			1.79	2.68		
10	1.10/.03	1.33/.20			12	-36
			1.97	3.57		

Telluric Traverse and Self Potential Data
Preble, Line 3
125m Dipoles

Station No.	Ratio/Std. Deviation 25Hz	7.5Hz	Relative Voltage 25Hz	7.5Hz	Self Potential (millivolts)	
11	0.81/.08	0.79/.06			17	-38
			2.44	4.52		
12	1.04/.09	0.98/.13			25	-35
			2.53	4.43		
13	1.19/.08	1.16/.16			2	-61
			2.13	3.82		
14	1.07/.07	1.19/.07			4	-63
			2.28	4.54		
15	0.72/.06	0.80/.06			14	-59
			3.16	5.67		
16	0.95/.12	0.89/.06			22	-56
			3.01	5.0		
17	0.94/.02	1.02/.10			31	-49
			3.20	4.9		
18	1.01/.08	1.06/.11			33	-49
			3.23	5.2		
19	0.66/.04	0.70/.05			23	-61
			4.89	7.5		
20	1.24/.12	1.39/.16			33	-55
			6.07	10.4		
21	1.43/.11	1.58/.07			15	-17
			4.24	6.6		

Telluric Traverse and Self Potential Data
Preble, Line 3
125m Dipoles

Station No.	Ratio/Std. Deviation		Relative Voltage		Self Potential	
	25Hz	7.5Hz	25Hz	7.5Hz	(millivolts)	
22	2.15/.15	2.06/.36			15	-80
			9.12	13.6		
23	0.67/.09	0.60/.08			8	-87
			13.6	22.6		
24	1.25/.03	1.26/.03			9	-87
			17.0	28.5		
25	1.27/.03	1.36/.03			19	-84
			13.4	21.0		
26	0.91/.04	0.93/.03			3	-105
			12.2	19.5		
27						-100

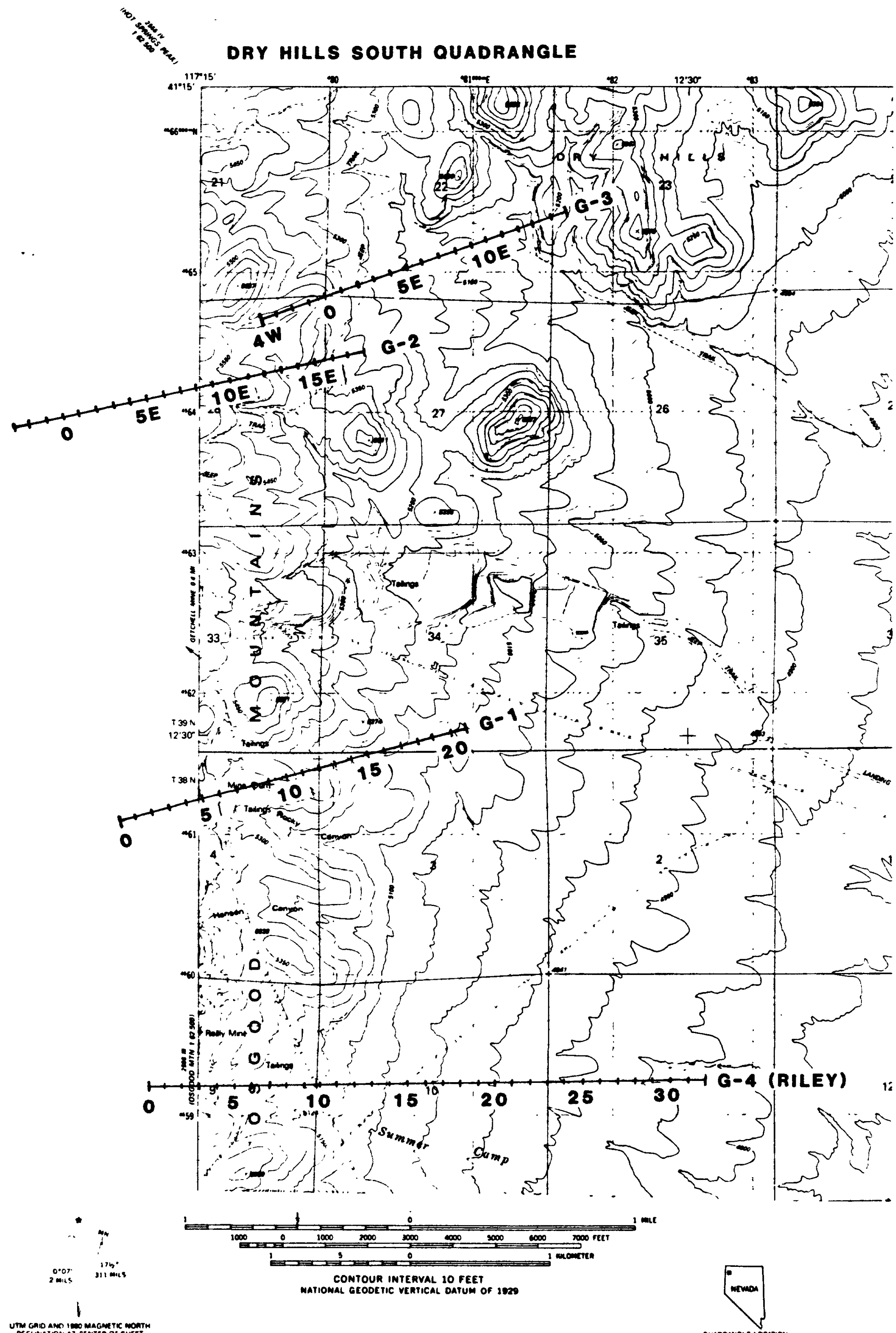

Figure 1. Telluric traverse location map for lines Getchell 1, 2, 3 and 4 (Riley Mine), Getchell mine area, Humbolt County, Nevada. Map base is the Dry Hills South 7-1/2 minute quadrangle. Dipole length is 125 meters.

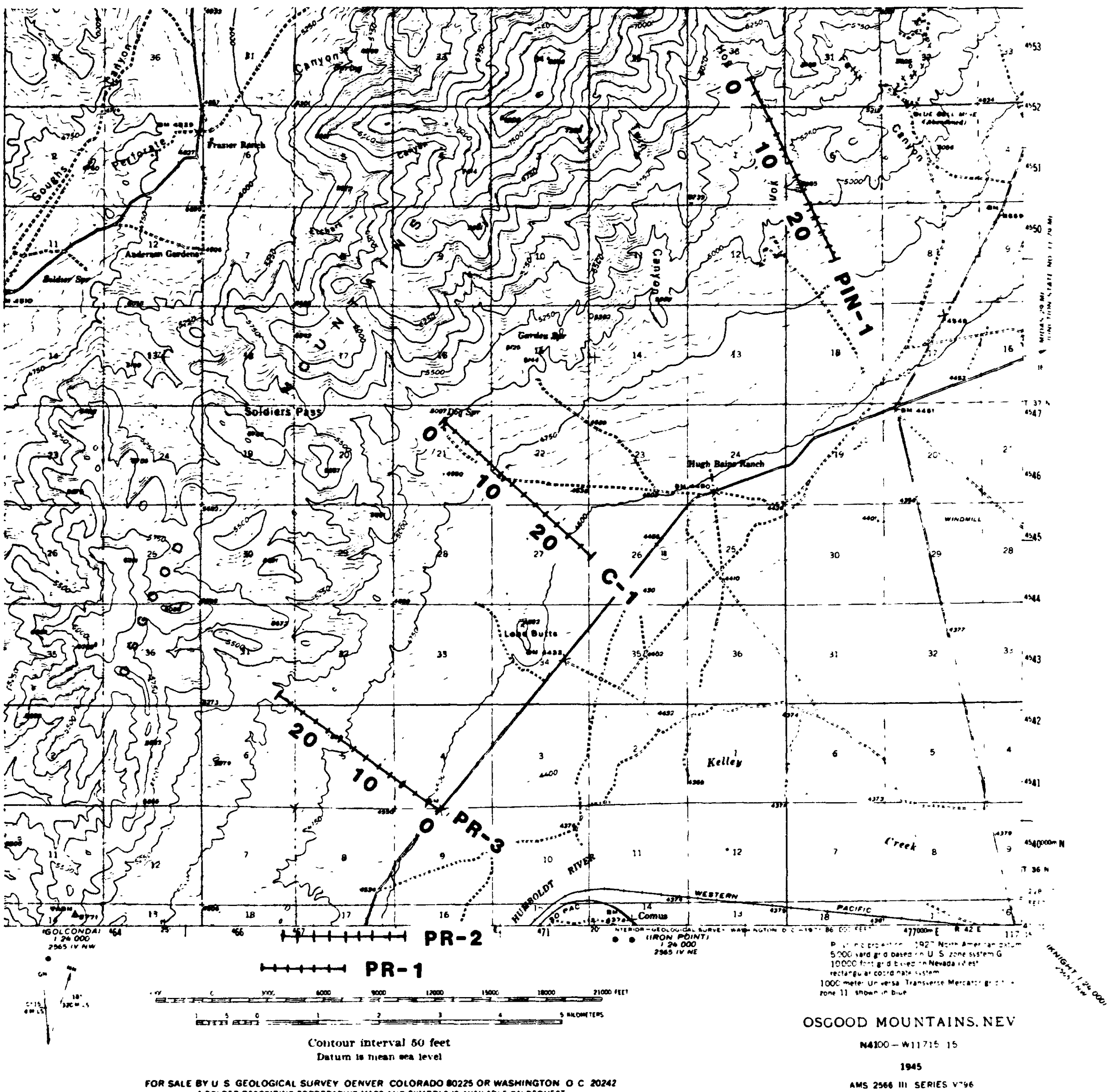

Figure 2. Telluric traverse location map for lines Pinson 1, Christison 1 and Preble 1, 2 and 3, Pinson and Preble mine areas, Humbolt County, Nevada. Map base is the Osgood Mountains, Nevada 15 minutes to quadrangle. Dipole length is 125 meters and every other electrode location is shown.

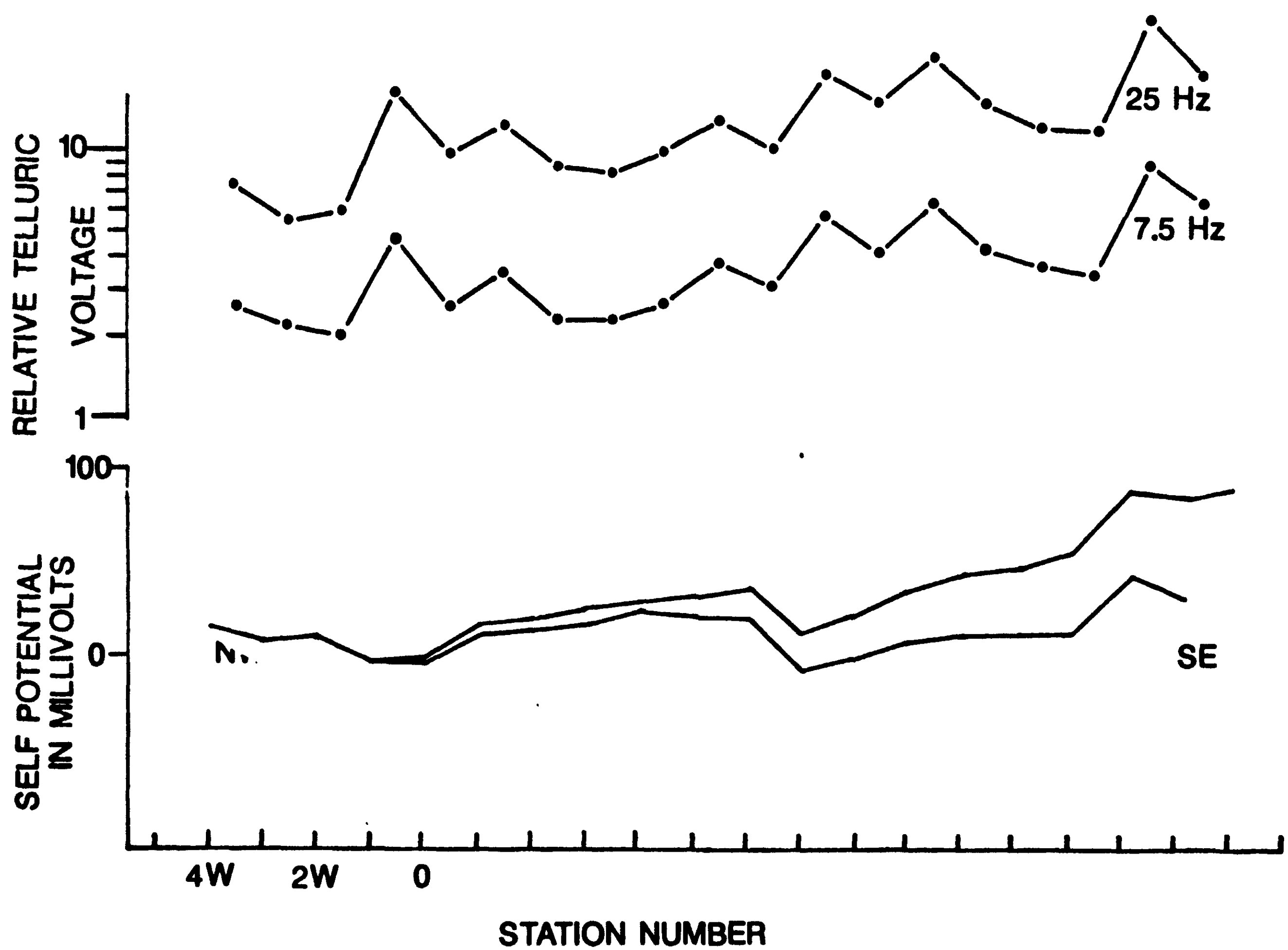

Figure 3. Telluric traverse and self potential data for line Getchell 3, Humbolt County, Nevada. Station interval is 125 meters.

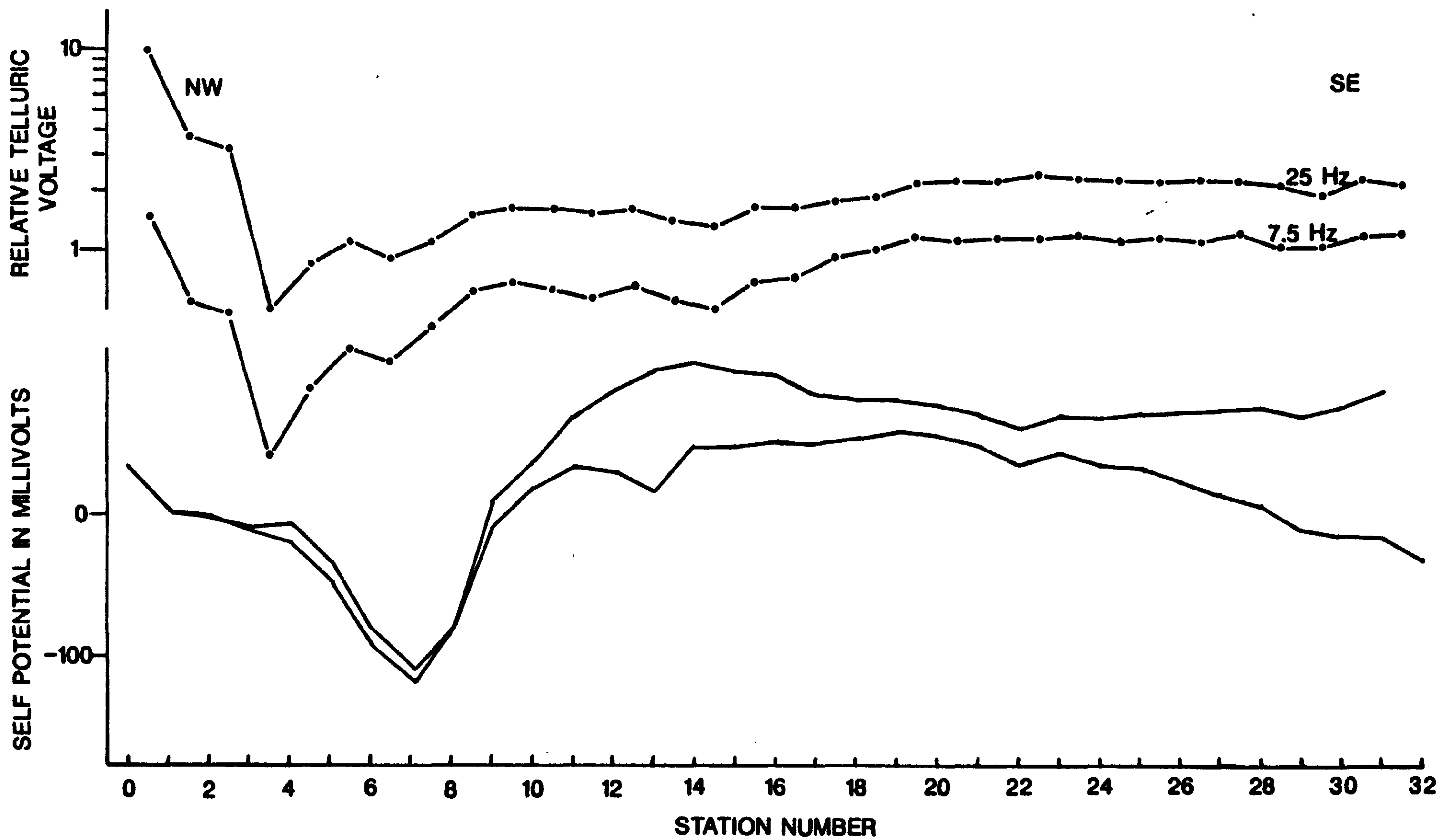

Figure 4. Telluric traverse and self potential data for line Getchell 4, Humbolt County, Nevada. Station interval is 125 meters.

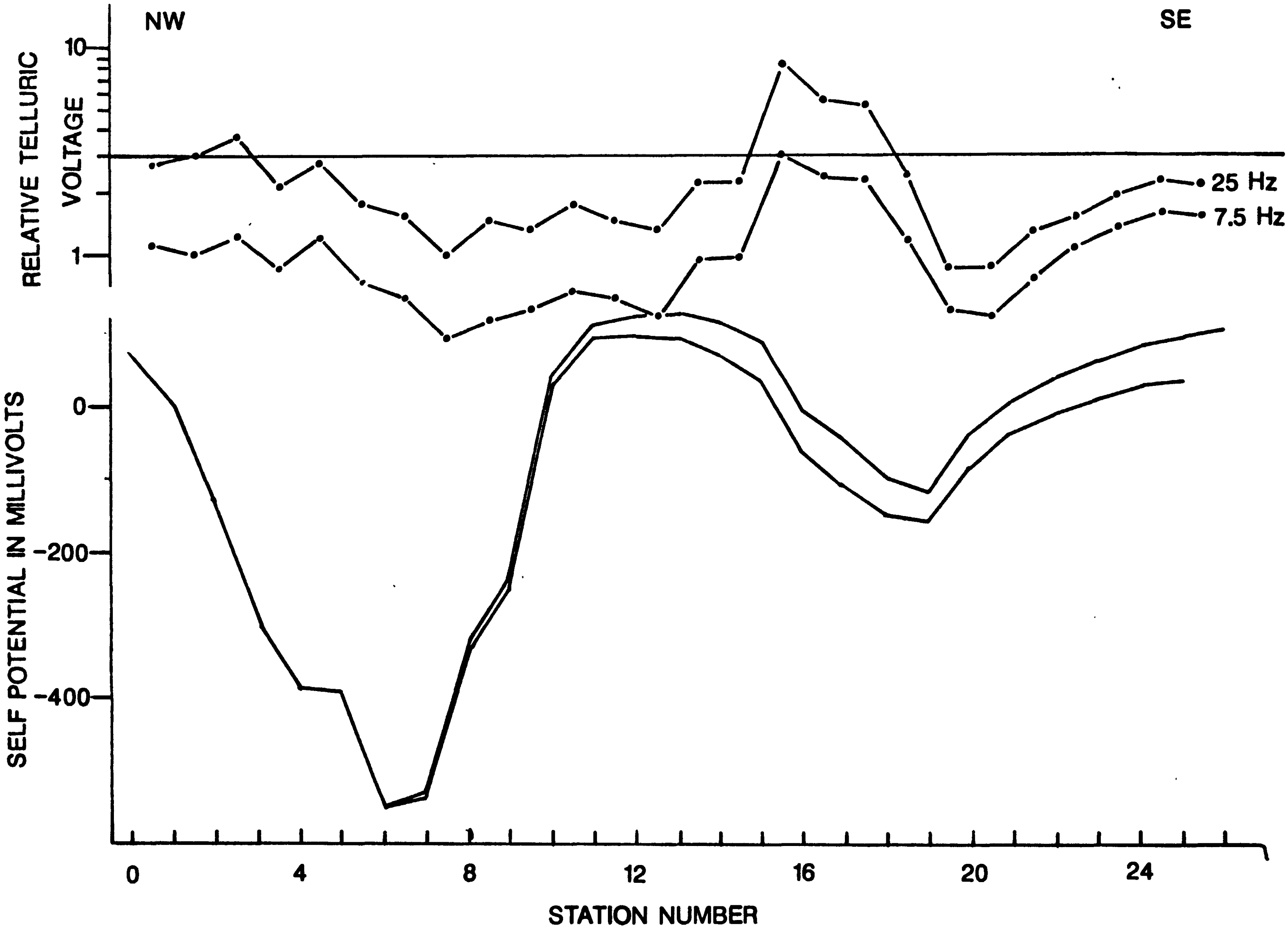

Figure 5. Telluric traverse and self potential data for line Pinson 1, Humbolt County, Nevada. Station interval is 125 meters.

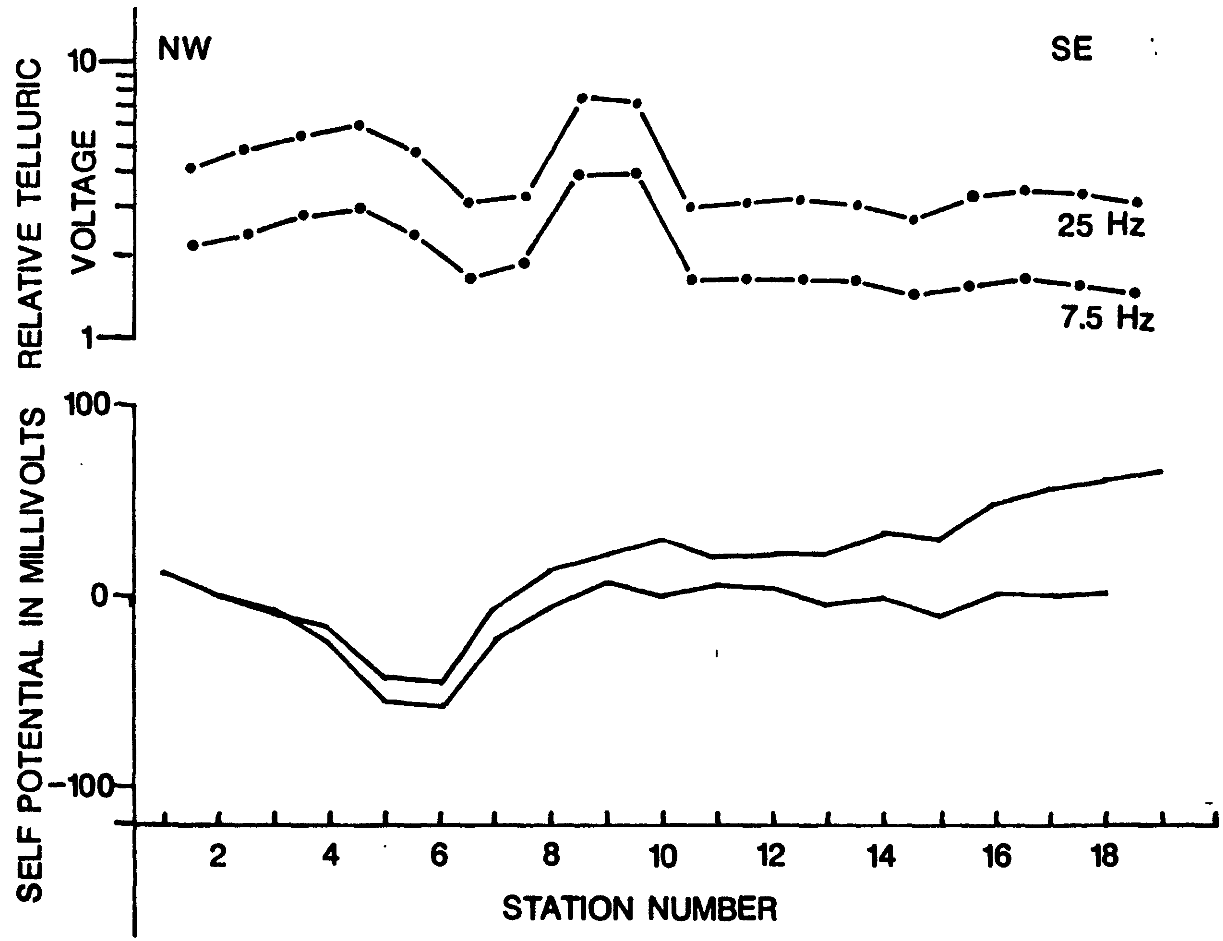

Figure 6. Telluric traverse and self potential data for line Christison 1, Humbolt County, Nevada. Station interval is 125 meters.

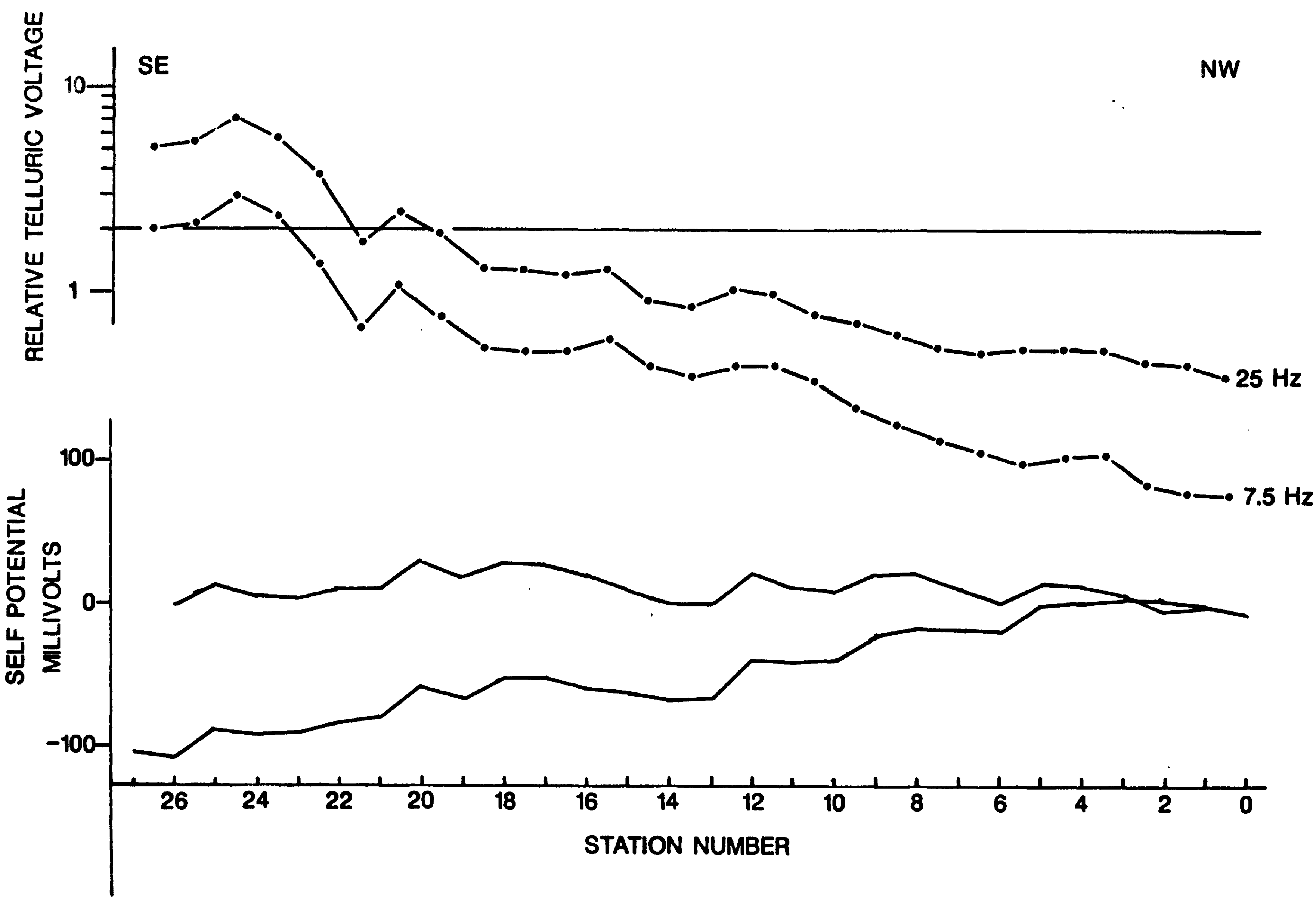

Figure 7. Telluric traverse and self potential data for line Preble 3, Humbolt County, Nevada. Station interval is 125 meters.