U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Magnetotelluric data on and near the Goshute Indian Reservation, Utah and Nevada: location map and data report

by

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Open-File Report 94-296

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1994

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Introduction

Data from sixty-nine magnetotelluric (MT) soundings were acquired between 1988 and 1991 on or near the Goshute Indian Reservation (fig. 1 and table 1). The Reservation is located approximately 60 miles south of Wendover, Nevada and straddles the Utah-Nevada border. These data were obtained by the U.S. Geological Survey as part of a 3-year multidisciplinary precious metal assessment of the Reservation. Magnetotelluric data can be used to map subsurface geologic features (such as faults and lithologic variations) that have contrasting electrical properties. Specifically, these soundings were made to determine the thickness of overburden (unconsolidated rock overlying bedrock) in Antelope Valley and Spring Creek Flat, to locate the range-front fault at the western base of the Ibapah pluton, and to estimate the thickness of the Ibapah pluton (fig. 1). This report presents the uninterpreted field data (see Appendix) from MT stations numbered 1-6 and 31-69. MT data were collected at stations 7-30 (locations not shown on fig. 1 or in Table 1) with a prototype portable MT system. Those data cannot be processed and are not included with this report.

No other magnetotelluric data are known to exist in the vicinity of the Goshute Indian Reservation. However, an audio-magnetotelluric (AMT) study was carried out by Senterfit and McCafferty (1994) in the Deep Creek Range which is located on the eastern border of the Reservation. The AMT method uses the same basic principles as MT, however signals are recorded at higher frequencies (4.5 to 27,000 Hz). The AMT method has shallower penetration, but greater resolution when compared to the MT method.

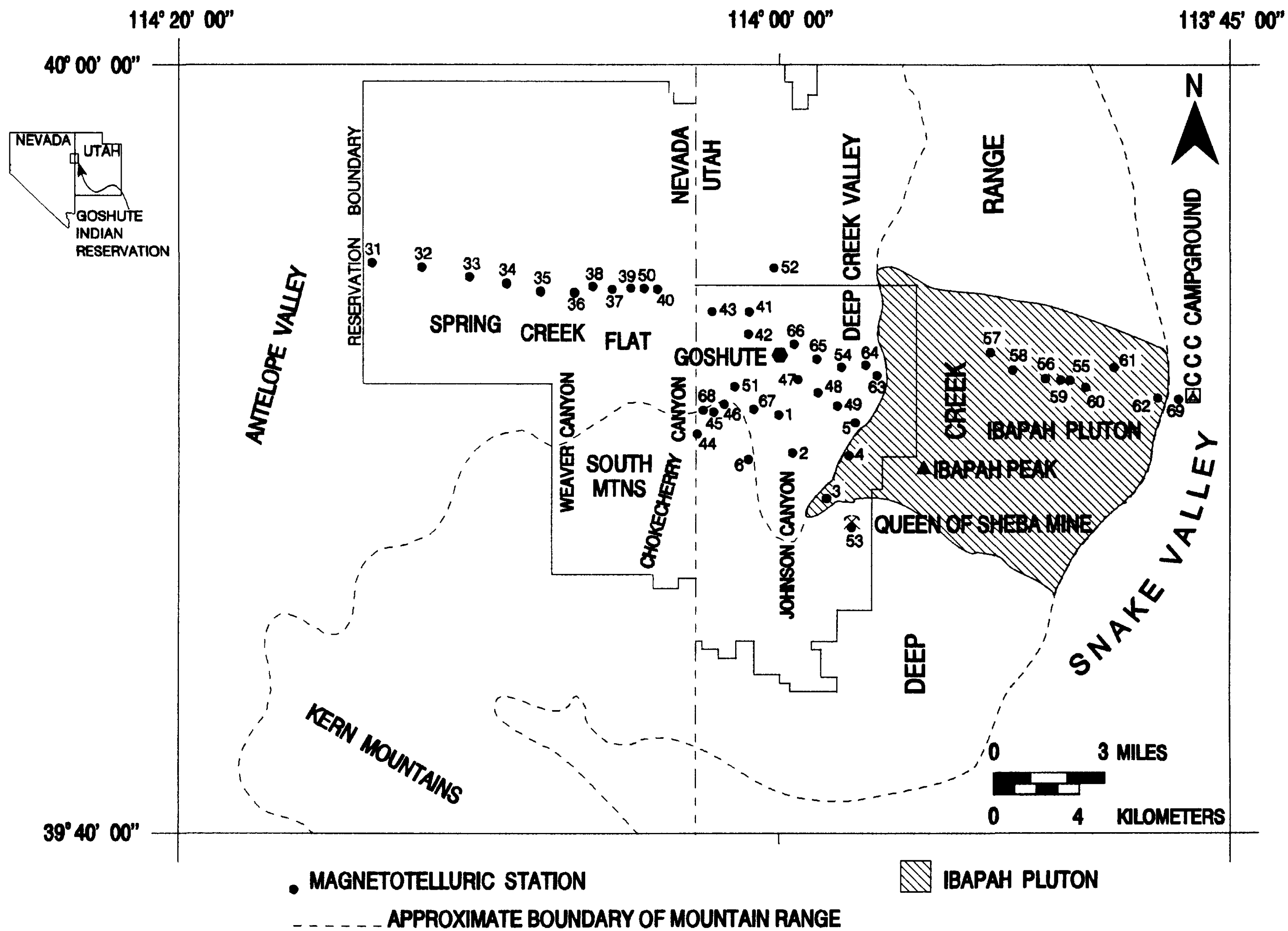

Figure 1. Location of magnetotelluric soundings.

TABLE 1.--MAGNETOTELLURIC SOUNDING LOCATIONS			
SOUNDING	LATITUDE (N)	LONGITUDE (W)	ELEVATION (m)
1	113° 59' 57"	39° 51' 05"	1980
2	113° 59' 30"	39° 50' 06"	2090
3	113° 58' 21"	39° 48' 55"	2335
4	113° 57' 35"	39° 50' 01"	2360
5	113° 57' 25"	39° 50' 51"	2225
6	114° 00' 54"	39° 49' 54"	2010
31	114° 13' 30"	39° 54' 50"	1740
32	114° 11' 44"	39° 54' 44"	1760
33	114° 10' 06"	39° 54' 31"	1810
34	114° 08' 53"	39° 54' 19"	1780
35	114° 07' 50"	39° 54' 09"	1780
36	114° 06' 50"	39° 54' 05"	1790
37	114° 05' 21"	39° 54' 09"	1790
38	114° 05' 51"	39° 54' 11"	1785
39	114° 04' 46"	39° 54' 15"	1800
40	114° 03' 55"	39° 54' 09"	1790
41	114° 00' 56"	39° 53' 44"	1835
42	114° 00' 59"	39° 53' 06"	1860
43	114° 02' 10"	39° 53' 43"	1830
44	114° 02' 34"	39° 50' 32"	2030
45	114° 02' 02"	39° 51' 06"	1965
46	114° 01' 44"	39° 51' 20"	1915
47	113° 49' 18"	39° 51' 59"	1950
48	113° 58' 38"	39° 51' 38"	2035
49	113° 58' 00"	39° 51' 17"	2120
50	114° 04' 20"	39° 54' 14"	1800
51	114° 01' 20"	39° 51' 48"	1910
52	114° 00' 25"	39° 54' 52"	1790
53	113° 57' 32"	39° 58' 14"	2805
54	113° 57' 53"	39° 52' 15"	2050
55	113° 50' 19"	39° 51' 57"	2305
56	113° 51' 09"	39° 51' 58"	2270
57	113° 53' 01"	39° 52' 36"	2595
58	113° 52' 10"	39° 52' 11"	2415
59	113° 50' 32"	39° 52' 00"	2280
60	113° 49' 49"	39° 51' 45"	2240
61	113° 48' 53"	39° 52' 16"	1920
62	113° 47' 29"	39° 51' 32"	1530
63	113° 56' 44"	39° 52' 06"	2200
64	113° 57' 05"	39° 52' 21"	2140
65	113° 58' 42"	39° 52' 30"	1950
66	113° 59' 28"	39° 52' 49"	1880
67	114° 00' 46"	39° 51' 17"	1940
68	114° 02' 21"	39° 51' 10"	1935
69	113° 46' 44"	39° 51' 28"	1485

The Magnetotelluric Method

The magnetotelluric method measures time variations (micropulsations) of naturally occurring magnetic and electric fields of the earth. The data are used to compute apparent resistivity and phase over a range of frequencies that define the electromagnetic response of the Earth (Vozoff, 1963, 1972, 1991). The measured fields range in frequency from .001-250 Hz. The low-frequency energy (.001 to 1.0 Hz) results from a complex interaction of electrically charged solar wind particles with the earth's magnetic field and other electrically charged particles trapped within the earth's ionosphere. The higher frequency energy (1.0 to 250 Hz) results mainly from the propagation of electromagnetic energy from global thunderstorms. The thunderstorm energy reflects between the conductive earth and the conductive ionosphere within the resistive atmosphere. This waveguide effect allows the energy to travel large distances from its source. Because of the high resistivity contrast between the earth and the atmosphere and the large distance from the source regions, the electromagnetic fields are assumed to strike the earth as plane waves of variable frequency. Most of the energy from the electromagnetic field is reflected, although a small portion of the energy penetrates the earth's surface and induces telluric currents (similar to eddy currents in transformers) in the underlying conductive rocks. The depth of penetration of the energy is inversely proportional to the frequency of the energy and the conductivity of the subsurface material through which it passes. High-frequency energy (1 Hz or more) generally penetrates the earth to depths less than 5 km while low-frequency energy (less than 1 Hz) can penetrate to depths greater than 20 km.

Data presented in this report were acquired using one of two truck-mounted systems designed and built by the U.S. Geological Survey in Denver, Colorado. The MT system and data acquisition programs, which have since been modified, are similar to that described by Stanley and Frederick (1979). Induction coils (3.8 cm in diameter and 152 cm long) are used to detect the naturally occurring fluctuations in the earth's magnetic field. A pair of lead strip electrodes (4 cm by 20 cm) plated with lead chloride or porous pot electrodes containing copper and copper sulfate solution are used to detect voltage fluctuations which are related to electric field variations.

Figure 2 shows a typical MT station setup, one coil (Hx) of the pair is placed horizontally on the ground pointing north, the other coil (Hy) points east. The electrode pairs are laid out at any azimuth but as close to orthogonal as possible. The electrodes are placed an equal distance (from 37.5 to 150 meters depending on signal strength) from a common center electrode located near the coils. The electrode with an E-line azimuth closest to north-south is called the Ex electrode while the second electrode is the Ey electrode. The actual azimuths of the electrode pairs are entered into the computer which automatically rotates the directions to north and east respectively for data calculation. Coils and E-lines are weighted with rocks or buried in shallow trenches to minimize signal noise due to wind. The electrodes are placed in shallow holes, covered over with dirt, and moistened with either salt water or fresh water depending on the type of electrode used.

Magnetic and electrical signals are pre-amplified and then transmitted through a multiconductor shielded cable to the data acquisition system mounted in the field vehicle. Reference data can be recorded simultaneously with a second set of coils and/or electrodes to

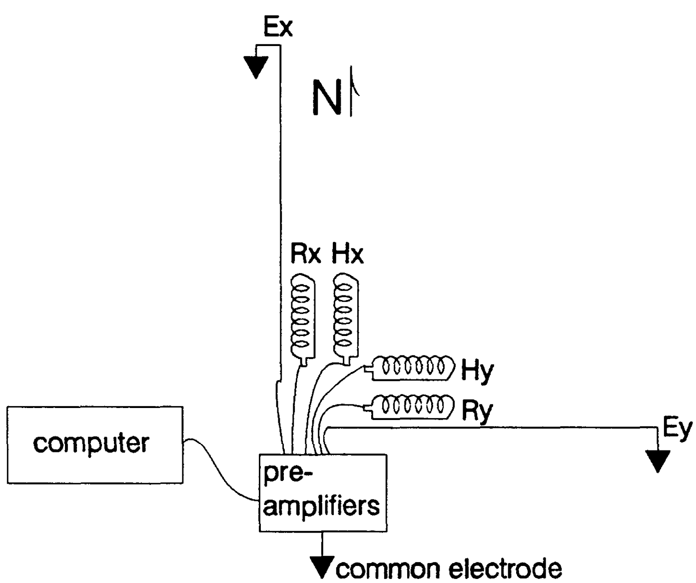

Figure 2. Schematic layout of magnetic (Hx, Rx, Hy, and Ry) and electric (Ex, Ey, and common) field sensors for magnetotelluric measurements.

help reduce uncorrelated noise in the analysis (Clark and others, 1983). For the Goshute survey reference coils (Rx and Ry) placed 1 m from the primary coils were used for stations 1-6 and 31-52.

Observations are made in three overlapping frequency bands: 2.44 to 238 Hz (high), .05 to 3.42 Hz (mid), and .002 to .17 Hz (low). For each frequency band, several timeseries consisting of 1024 samples of each field component (channel) are collected. The sample rate is 1,000 samples per second for the high band, 16 for the mid band, and .8 for the low band. The magnetic and electrical fluctuations for all channels are displayed on the computer monitor as timeseries (figs. 3-5). Timeseries exhibiting obvious noise are rejected by the operator. When a series is accepted, the Fourier coefficients are calculated using the Fast Fourier Transform (FFT), averaged across a frequency band, combined into cross-spectra, and the cross-spectra are stacked (averaged) with previously acquired cross-spectra coefficients. After a pre-determined number of timeseries are processed for a given frequency band, the computer calculates the MT results including tensor apparent resistivities, phases, and related quality and dimensional parameters for each frequency (Vozoff, 1972, 1991; Clarke and others, 1983). These MT tensor quantities are plotted against frequency for inspection by the operator. The procedure is continued until satisfactory data are acquired. The final plots merge the results from the three acquired frequency bands. Plots presented in this report are identical to the final results seen in the field. Further office processing (not done for this report) may sort out poorer data and thus improve the results.

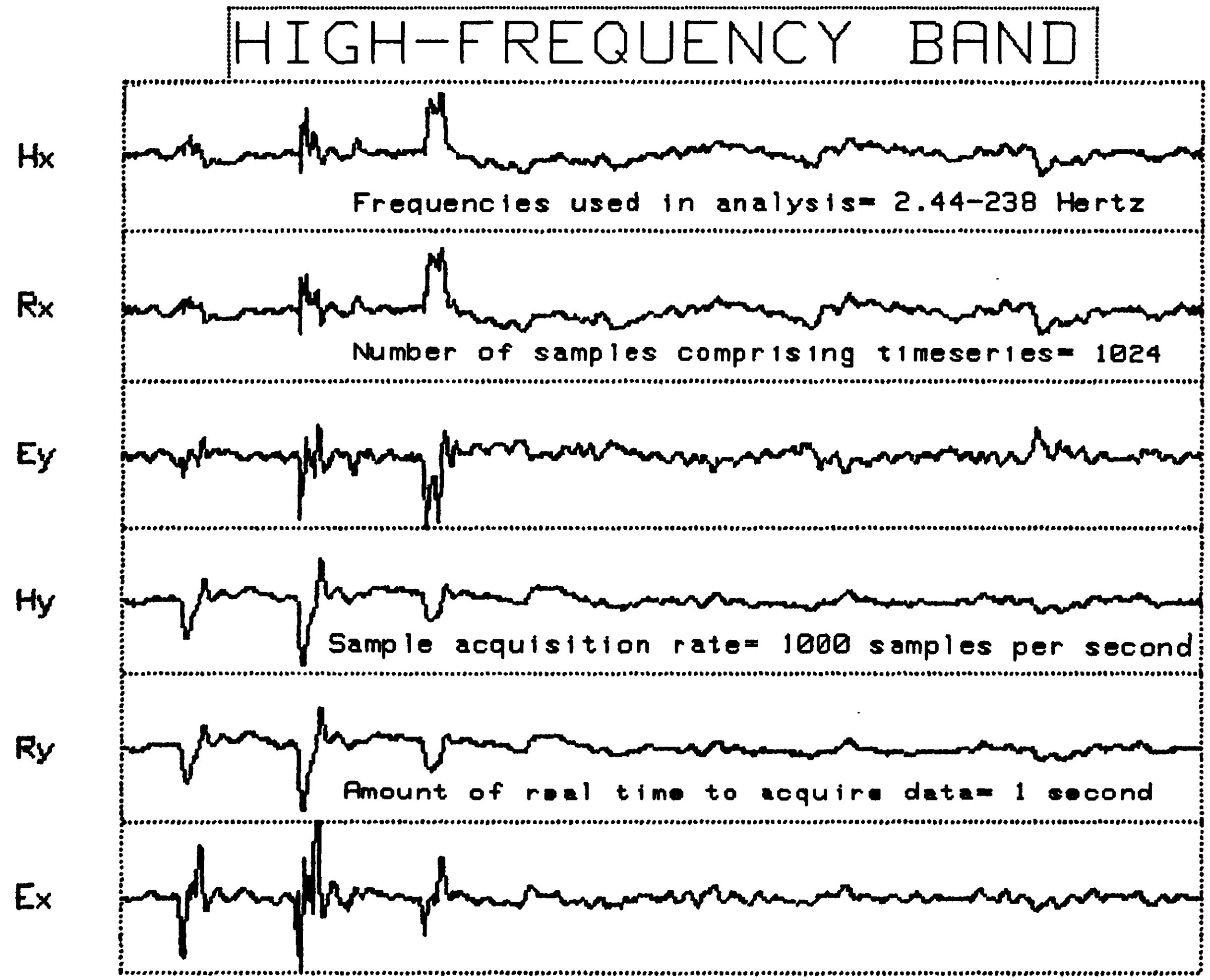

Figure 3. Example of high-band timeseries.

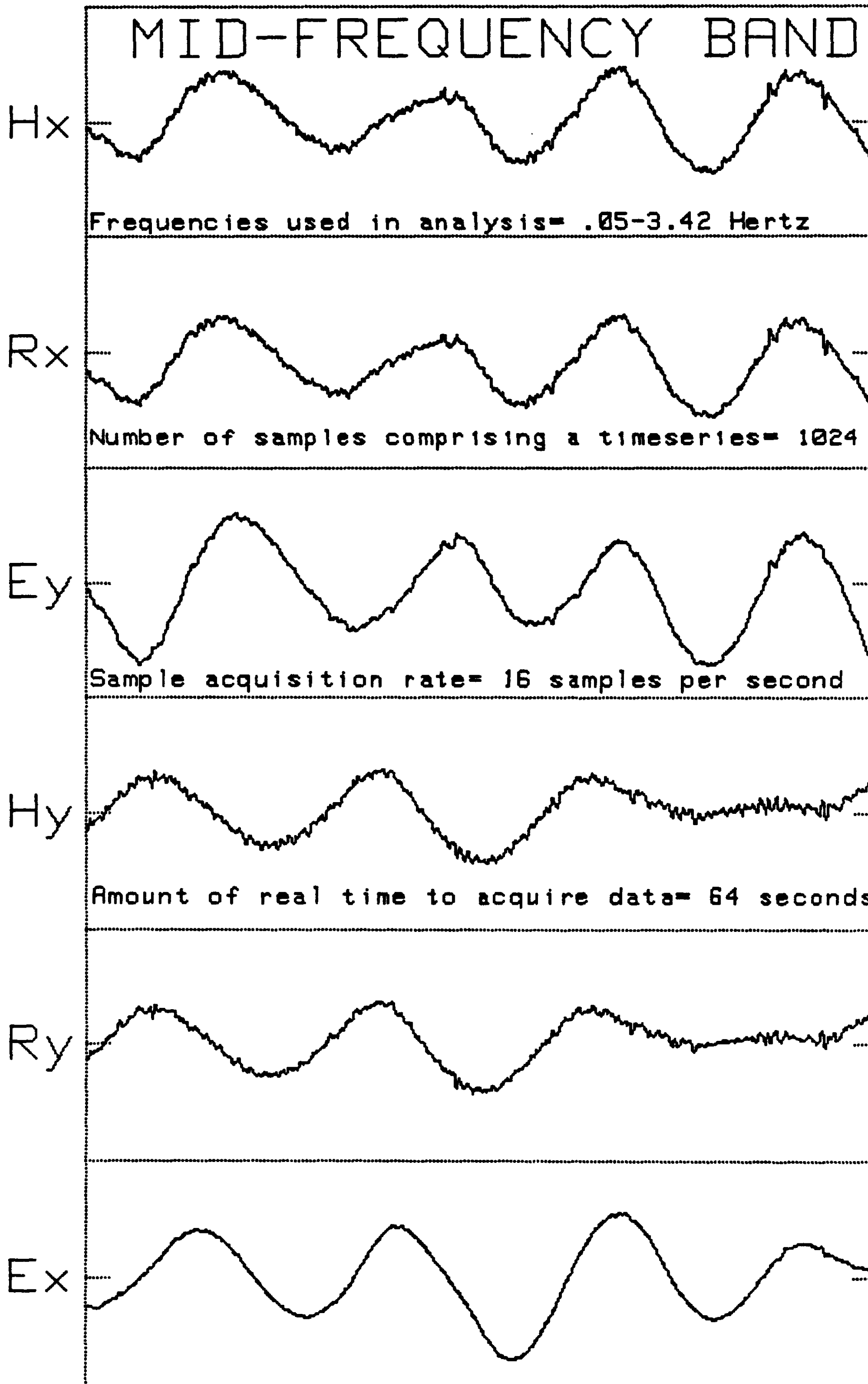

Figure 4. Example of mid-band timeseries.

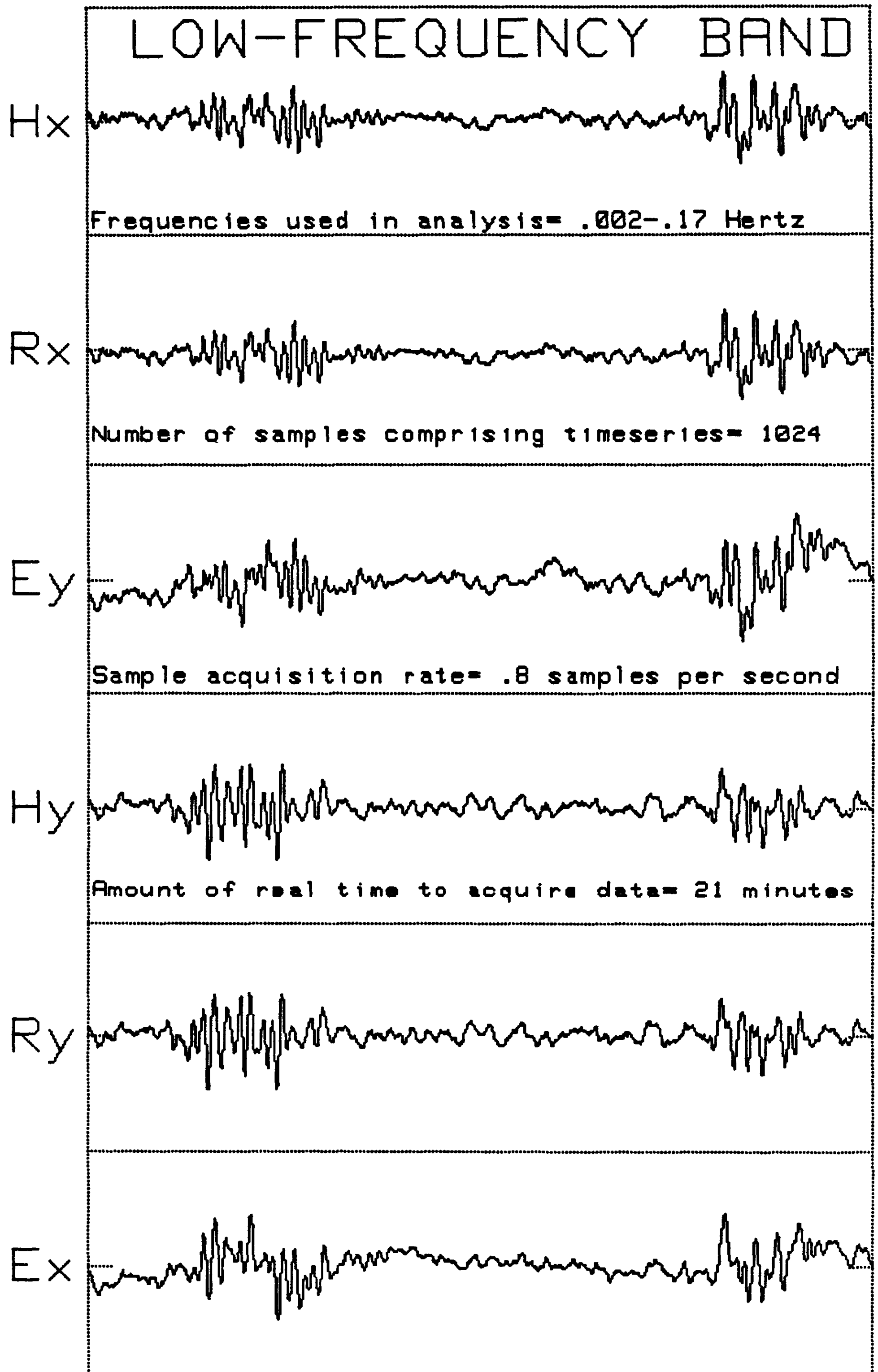

Figure 5. Example of low-band timeseries.

The MT data calculated for each station of the Goshute study are presented as four plots and are included as an appendix to this report. The plots show values of apparent resistivity, impedance phase, principal direction of the impedance tensor, and impedance skew.

Magnetotelluric Quantities

MT quantities are all directly computed from the impedance tensor, Zij, which is defined by the equation:

$$Ei = Zij \bullet Bj; \; i,j = x,y,$$

where Ei is the electric field (volt/m), Bj is the magnetic field (Tesla), and Zij has the units of volt/m/T, which is usually converted to the more common units of mV/km/nT. The chief MT quantities, apparent resistivity, impedance phase, principle direction of the impedance tensor, and impedance skew are computed according to equations given by Vozoff (1972, 1991) and (Clarke and others, 1983).

Apparent resistivity (ohm-meters) and impedance phase (degrees) are the primary quantities used to interpret the resistivity structure of the earth, specifically the apparent resistivity and phase for the principal values of Zxy and Zyx (rotated into the coordinate system of the principle direction of the impedance). Apparent resistivity and phase are computed quantities, as compared to the true resistivity of the earth which is sought. Impedance values of Zxx and Zyy are used mainly for 3-dimensional analysis. It is instructive to note that in the case of a homogeneous or one-dimensional earth (resistivity varying only with depth) that Zxy and Zyx are equal but opposite in sign, and the corresponding apparent resistivities are equal. In the more common 2- and 3-dimensional cases, Zxy and Zyx diverge. Only in the 3-D case do Zxx and Zyy appear non-zero. In real (noisy) data, small variations from the above generalization are expected.

Resistivity is a physical property expressing the difficulty with which electrical current can be made to flow through a material. The resistivity of different rock types can vary over a wide range. For example, a granite may have a measured resistivity of 1,000 ohm-meters (ohm-m) while a shale may have a resistivity of only 10 ohm-m. The shale is much more conductive (less resistive to current flow) than the granite. When apparent resistivity is calculated from measured field values, as it is with the MT method, the resulting value is a bulk or averaged resistivity value of possibly several rock types at a given frequency (which is a function of depth).

In a uniform earth, the resistivity will equal the apparent resistivity at every frequency measured and the electric field (E) will lead the magnetic field (H) in phase by 45 degrees at all frequencies (Vozoff, 1972). Phase is the time lag which occurs between the primary inducing magnetic field and the resulting secondary electric field. The amount of lag is dependent upon the impedance (resistivity) structure of the earth. In a non-uniform earth, the phase will vary from the 45 degree lead value. The phase curve responds to conductivity changes at depth at a higher frequency than does the apparent resistivity. This is useful (in estimating the basement structure) in cases where the resistivity curves have not yet reached their asymptotic values.

In formal interpretation, the MT data across the observed frequency range (sounding curves) are compared to theoretical responses computed for various resistivity distributions until a satisfactory fit is found. The resistivity distribution that forms the best fitting theoretical response is assumed to be a reasonable approximation to the resistivity of the earth in the vicinity of the measurement. Automated data inversions are often used as well in formal interpretation (for example, Bostick, 1977; Smith, 1988; Smith and Booker, 1988). Vozoff (1985, 1991) presents much of the theory with examples, and numerous references on the problem of interpretation.

The principal direction of the impedance (or rotation) and the skew are the chief dimensional parameters. These parameters provide information on the 2- or 3-dimensional distribution of earth resistivity. For a one-dimensional earth both of these parameters are near zero, but more commonly there is a strike (2-D case) or an effective strike (3-D case), and often the electrical strike is frequency dependent, indicating that the dimensionality of the earth's resistivity is changing laterally, or with depth.

Data presented in this report are rotated into the coordinate system of the principal axis of the impedance for each frequency. Thus Zxy is parallel to the (apparent) electrical strike (the effective TE mode) and Zyx is perpendicular to strike (the effective TM mode). When the earth is 2-D, skew remains small (below 0.3; zero in noise-free data). Skew is the primary indicator of 3-dimensional resistivity structure. Both the skew and the rotation are used in interpretation to evaluate the complexity of the electrical structure of the earth.

The following appendix includes data collected on and near the Goshute Indian Reservation. The X's and O's which form the observed apparent resistivity and phase curves represent the Zxy and Zyx data respectively. The error bars that appear on most plots represent uncertainty or "scatter" in the data.

References

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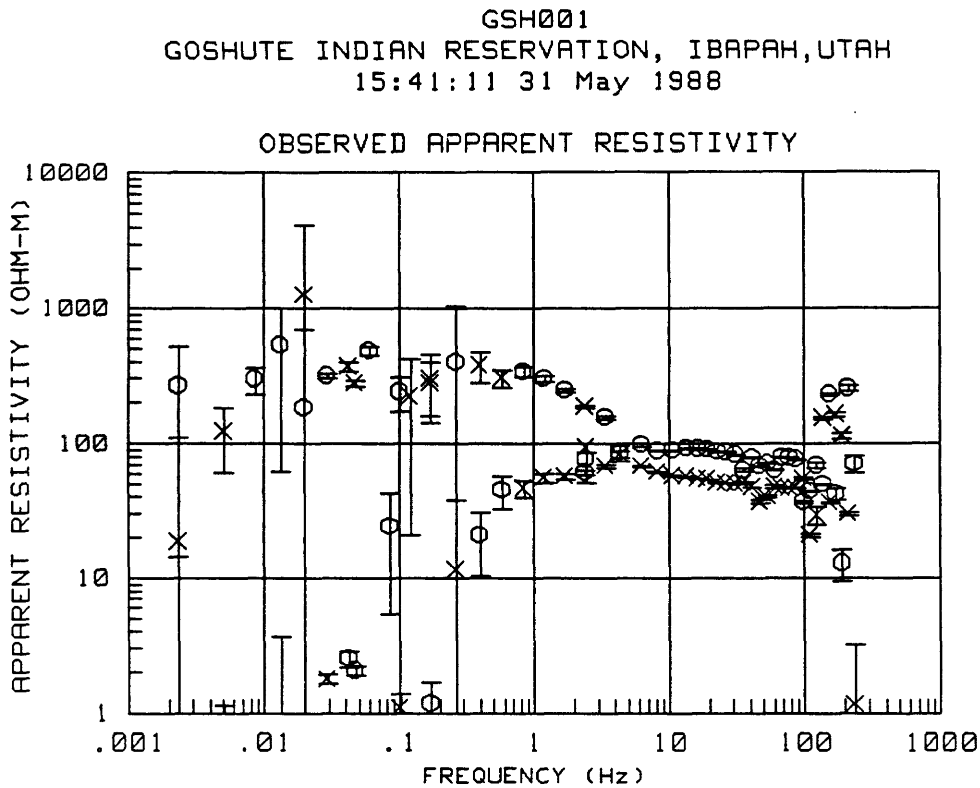
APPENDIX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APPARENT RESISTIVITY (OHM-M)
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10
1
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1000
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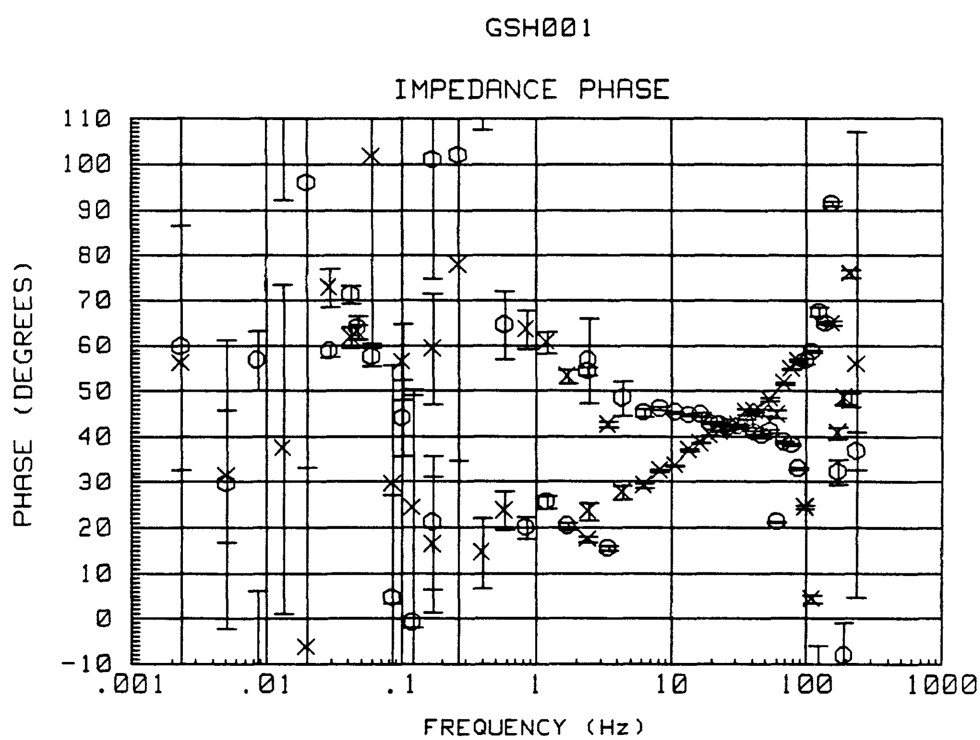
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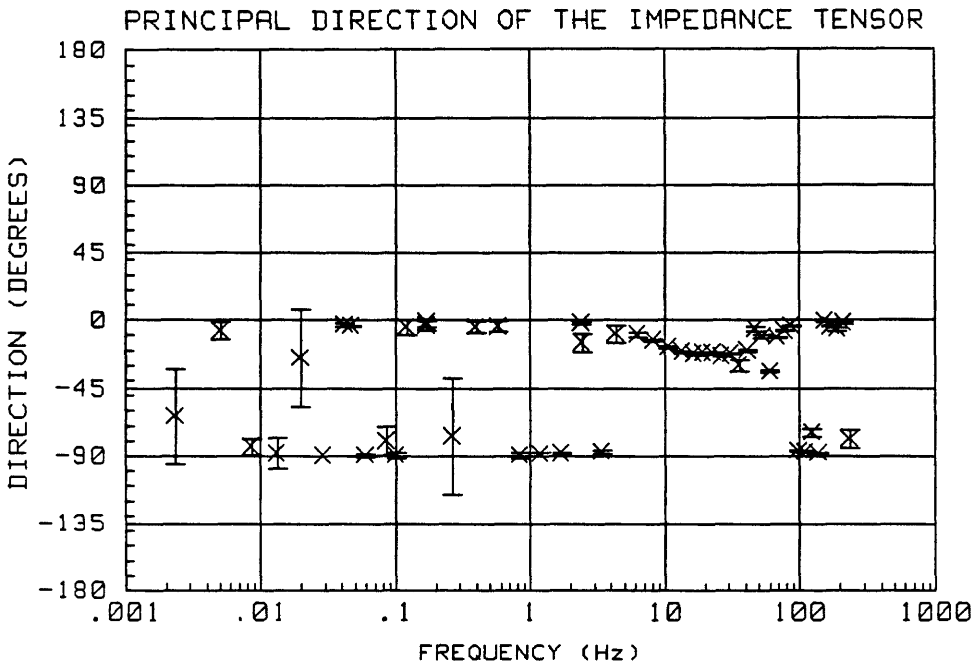
1
10
100
1000
FREQUENCY (Hz)

GSH001



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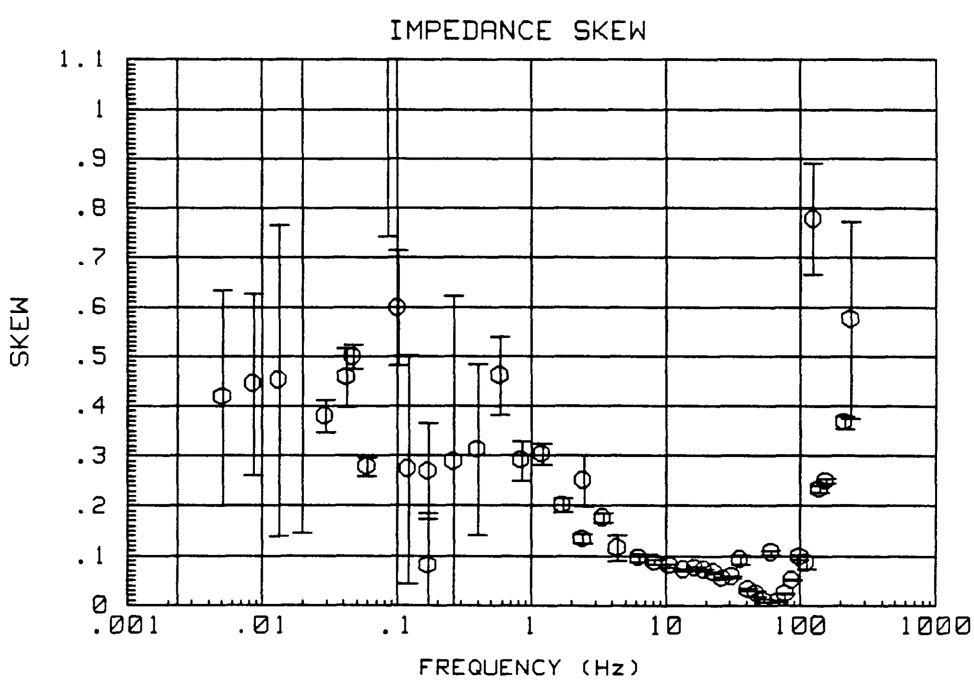

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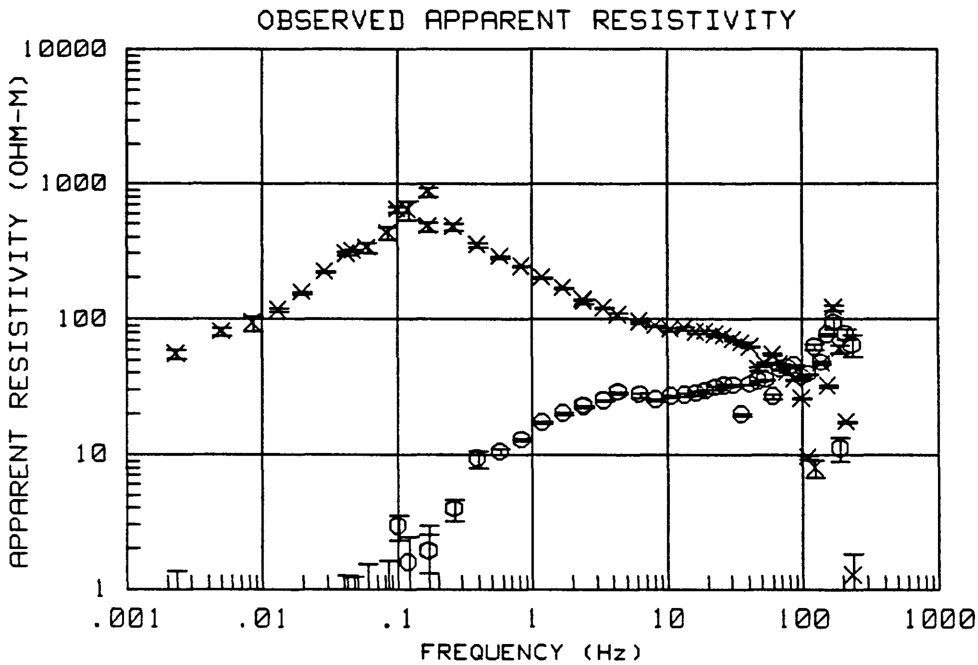

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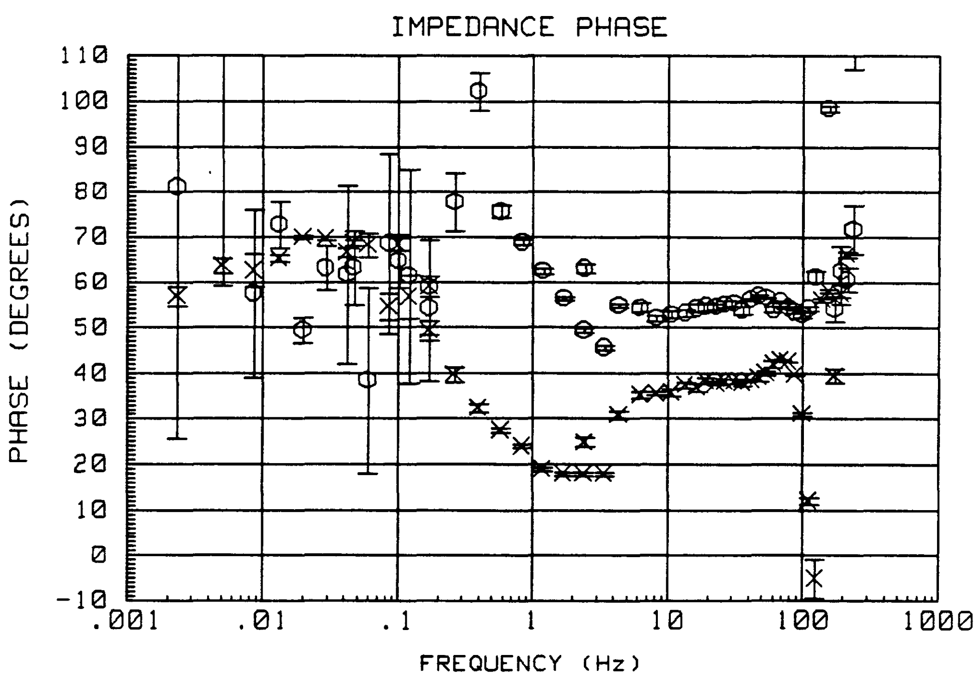

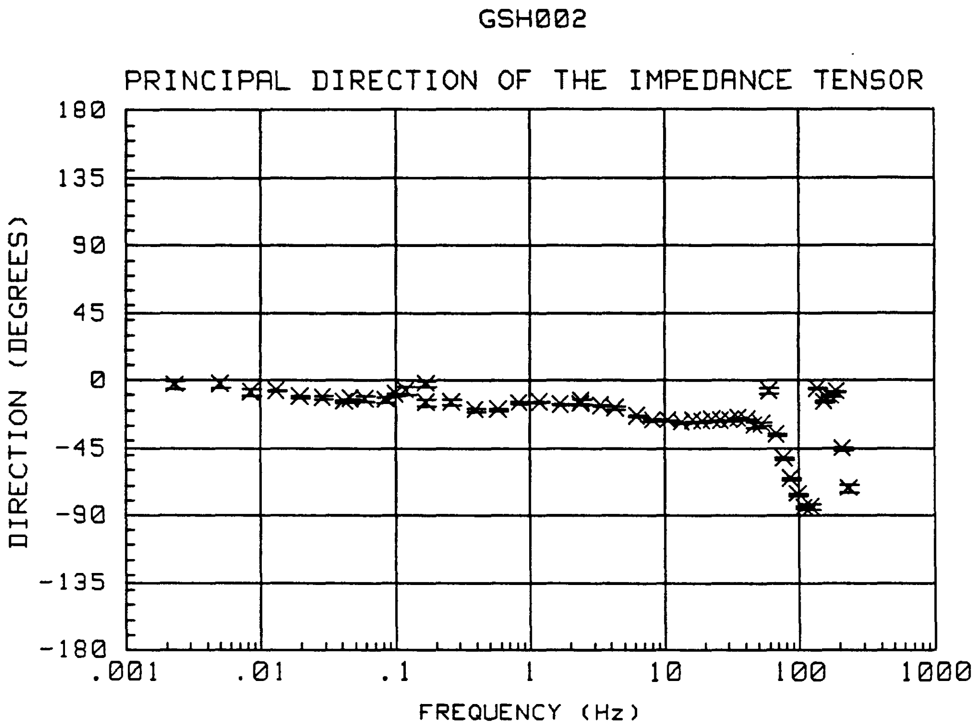
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1
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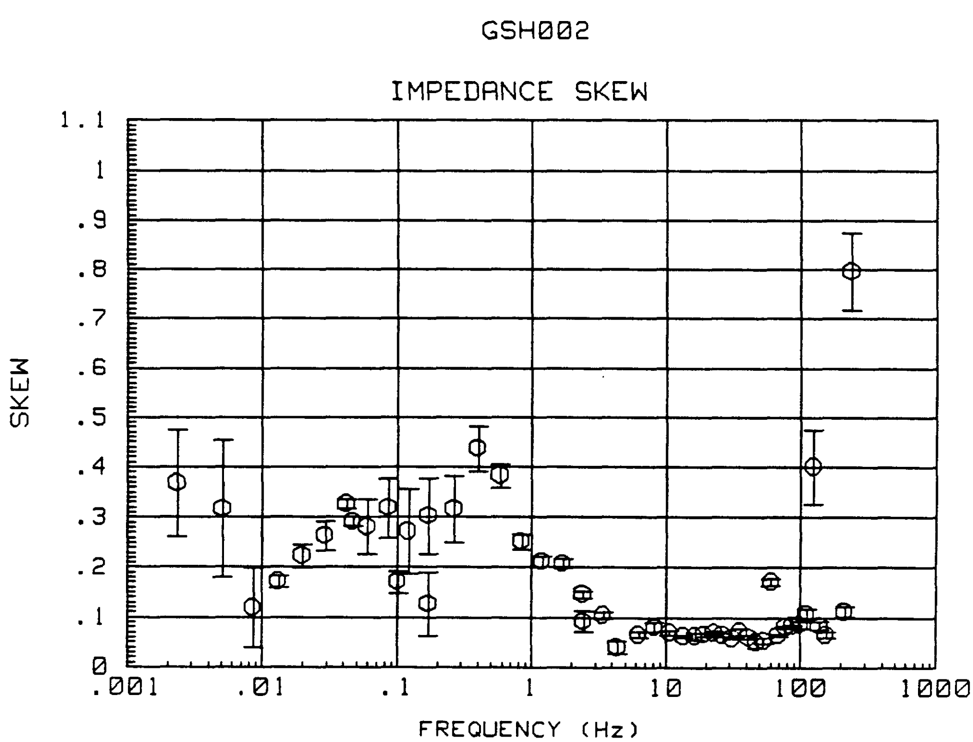
100
1000
FREQUENCY (Hz)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IMPEDANCE SKEW
SKEW
1.1
1
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.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

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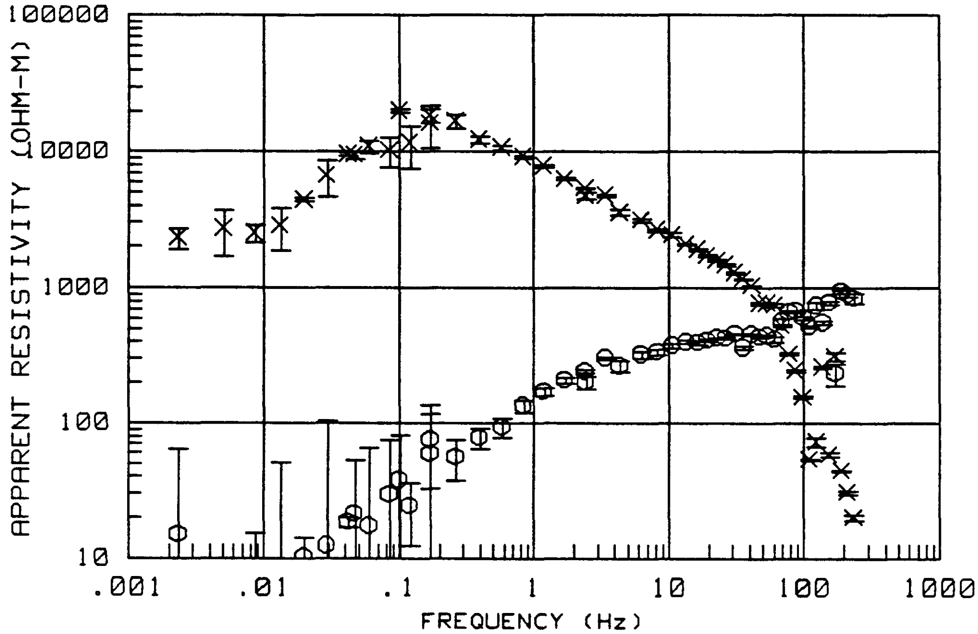

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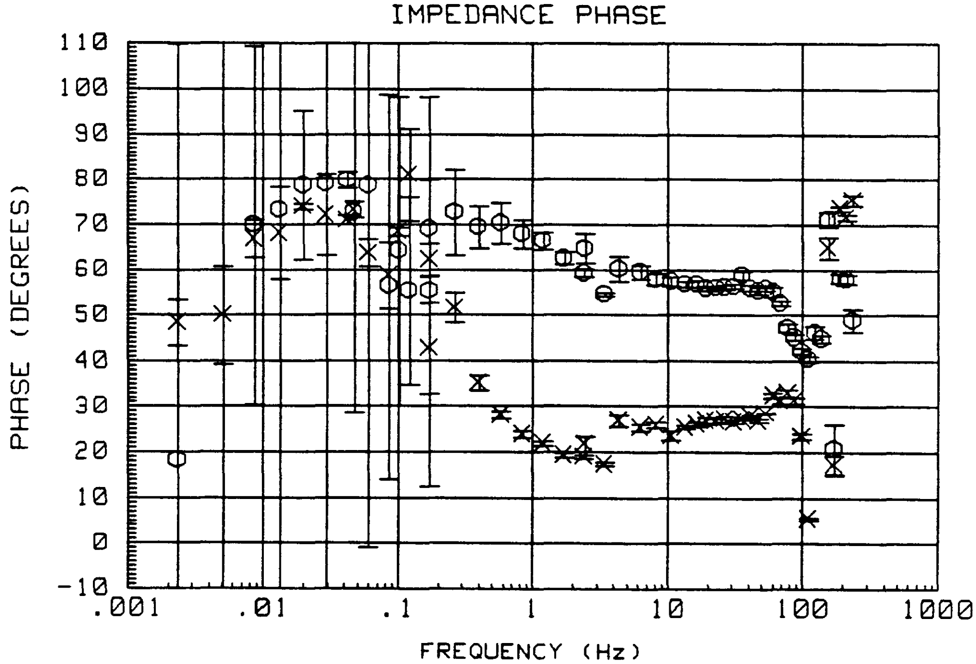

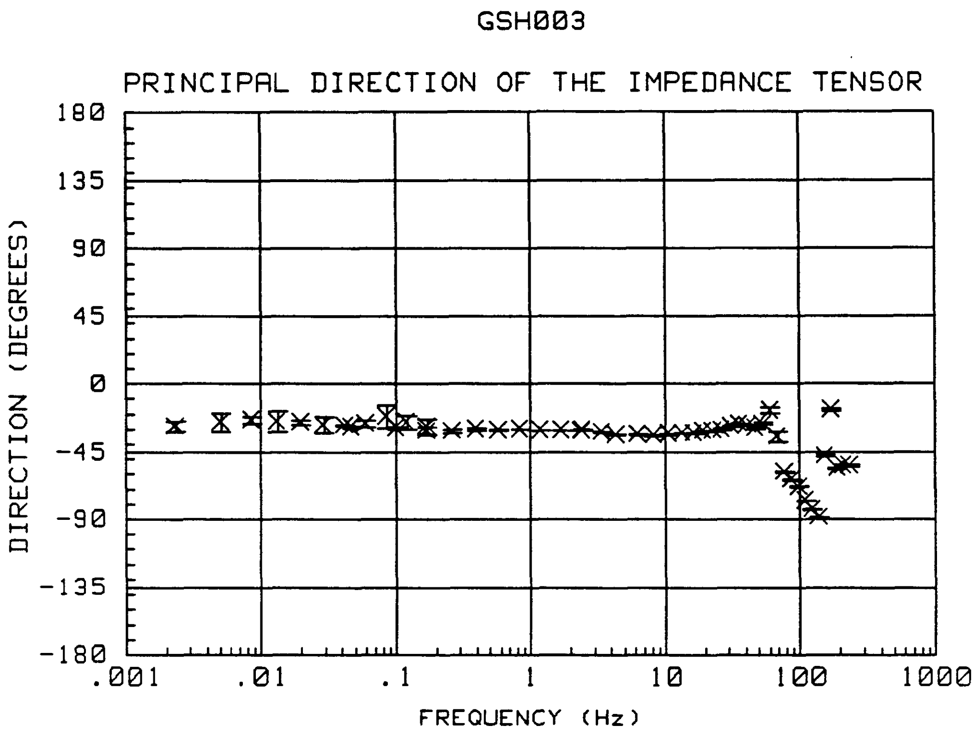
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PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
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-90
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.01
.1
1
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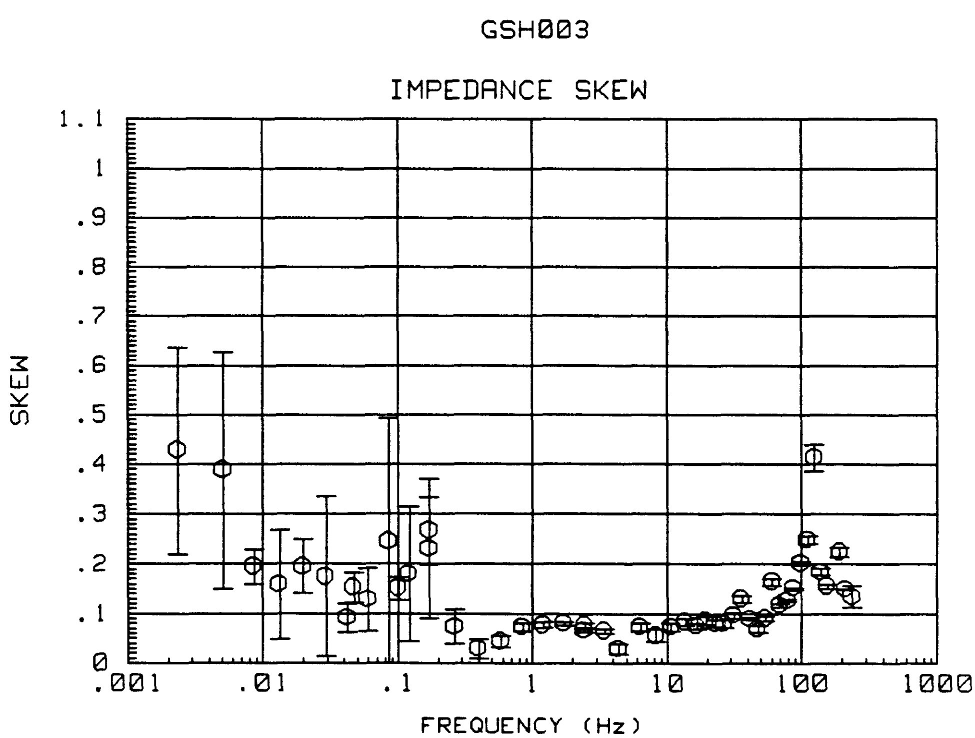
100
1000
FREQUENCY (Hz)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IMPEDANCE SKEW
SKEW
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.7
.6
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.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

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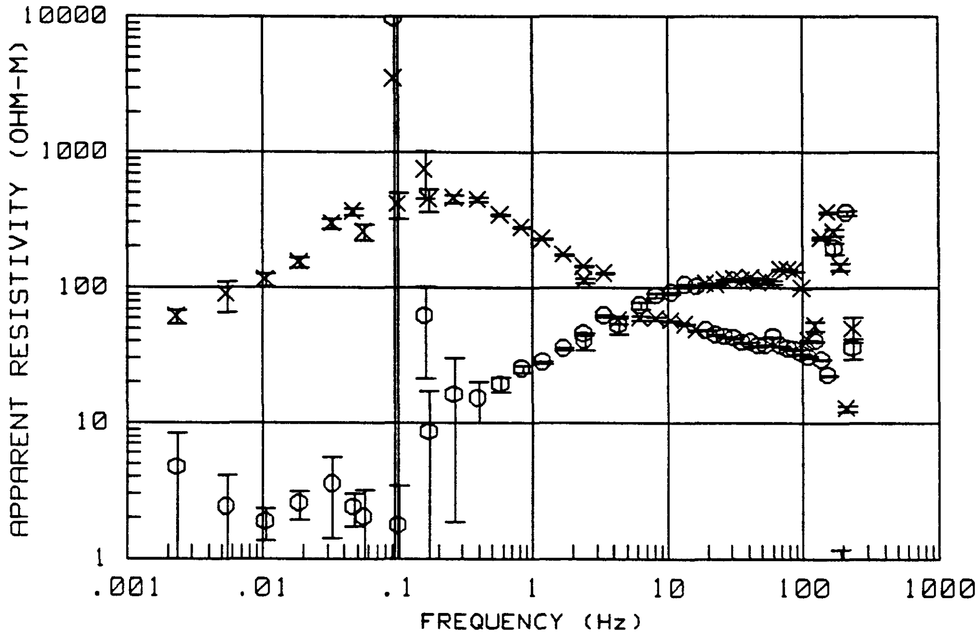

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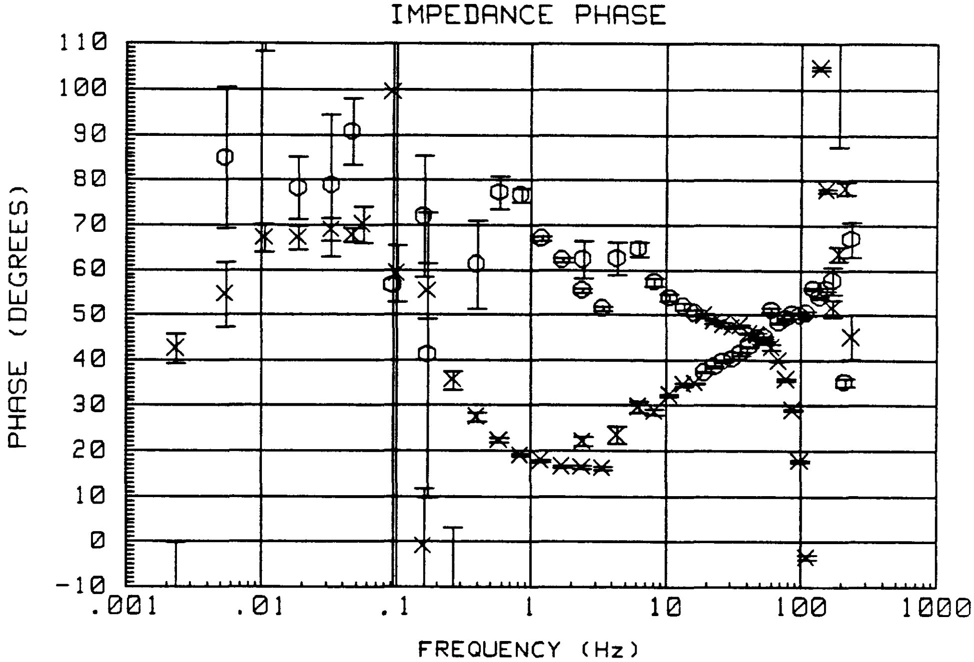

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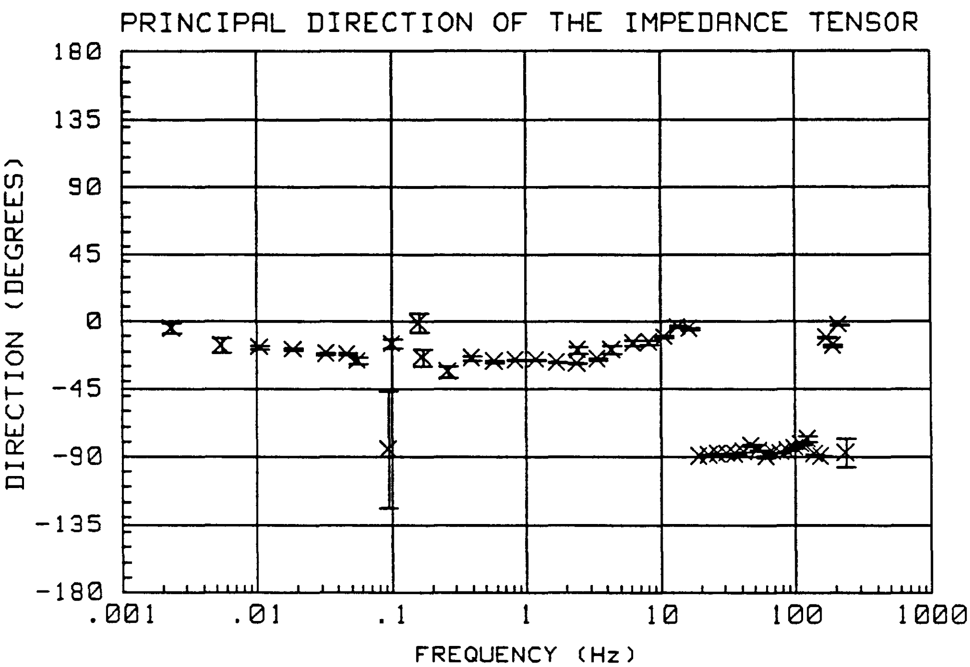

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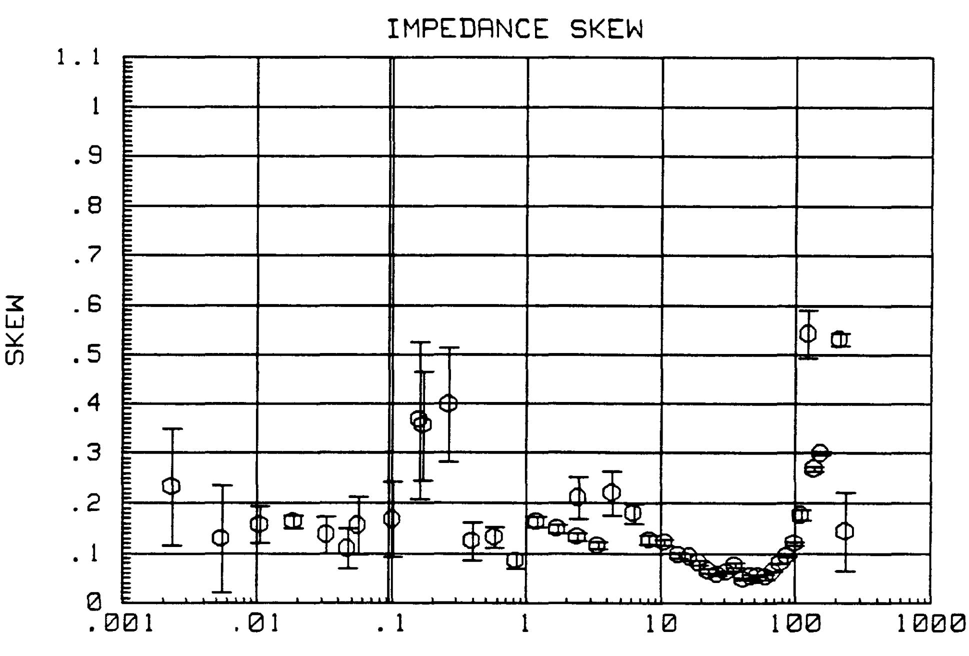

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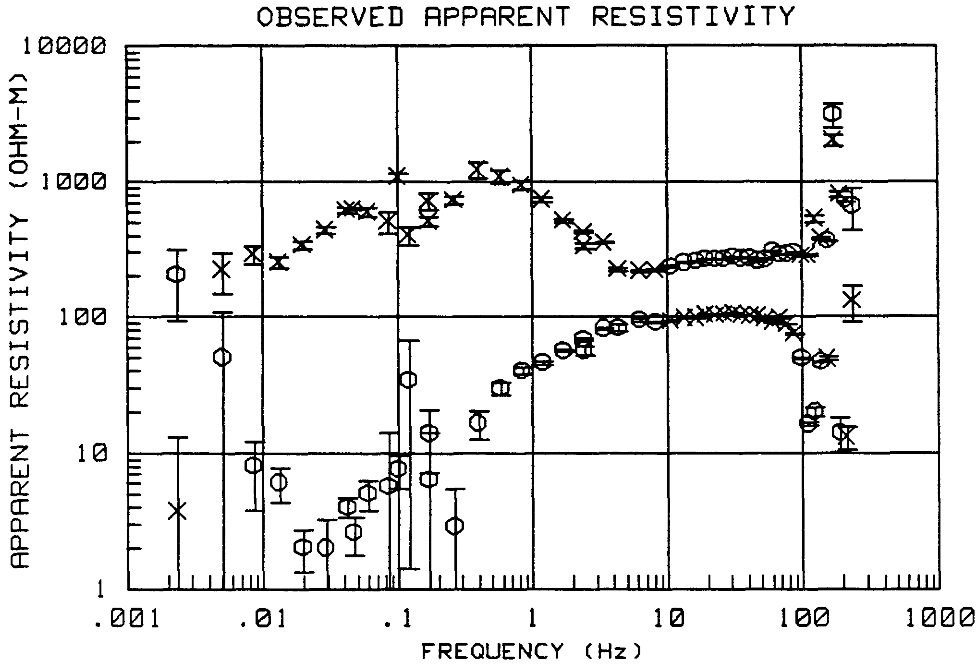

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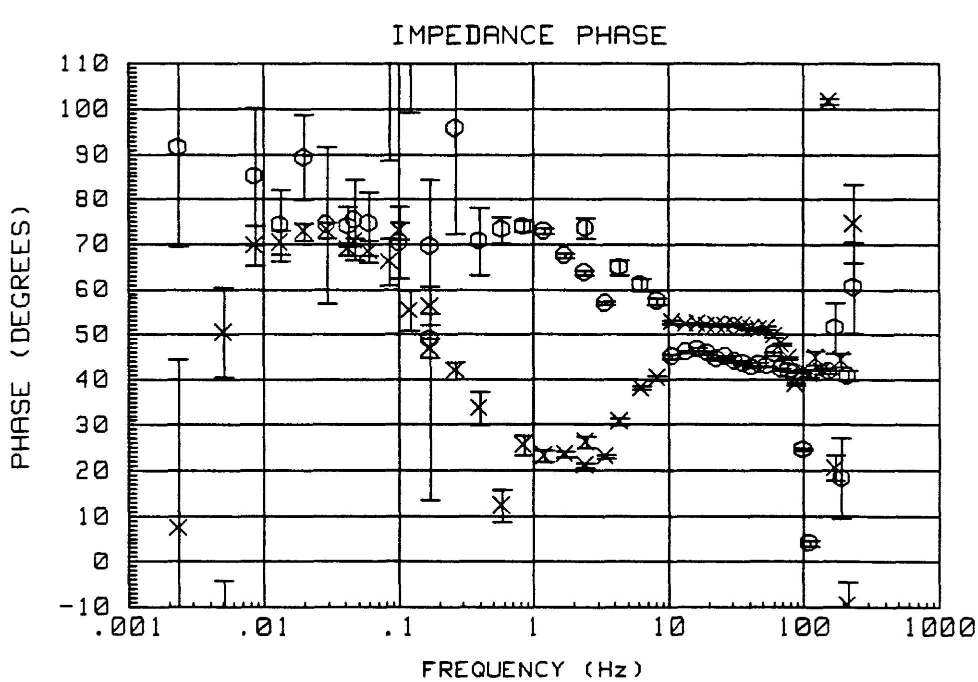

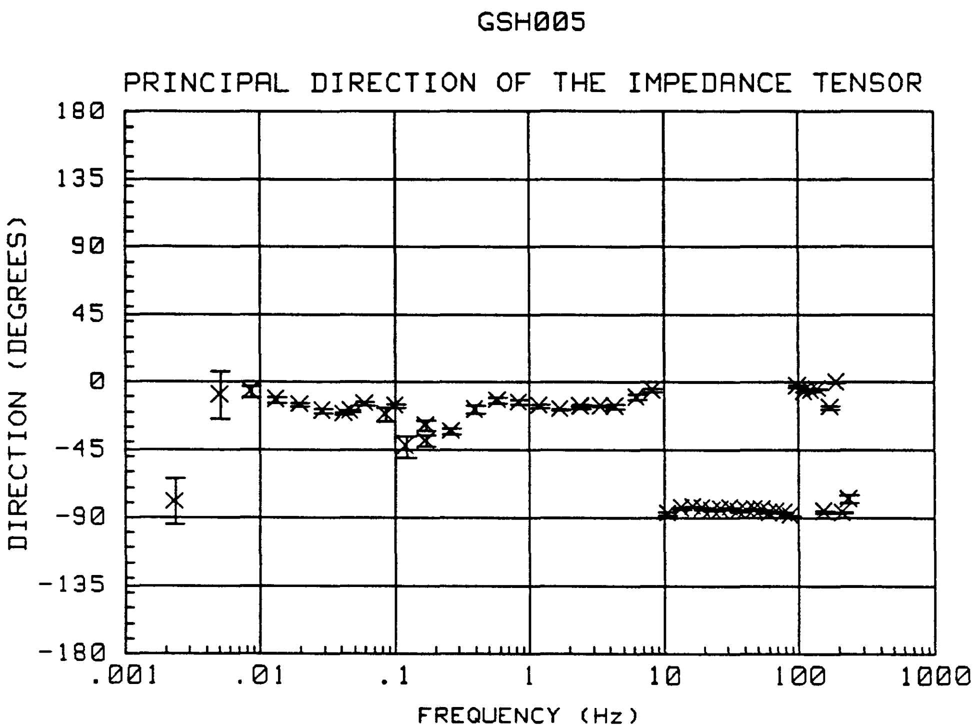
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DIRECTION (DEGREES)
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-45
-90
-135
-180
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.01
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1
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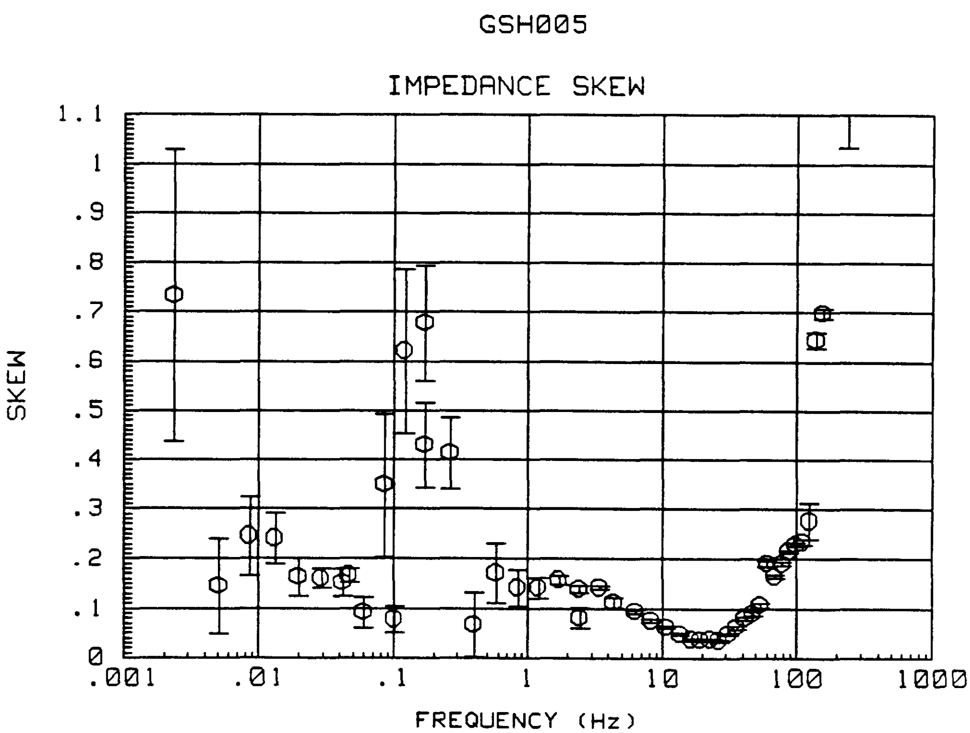
100
1000
FREQUENCY (Hz)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SKEW
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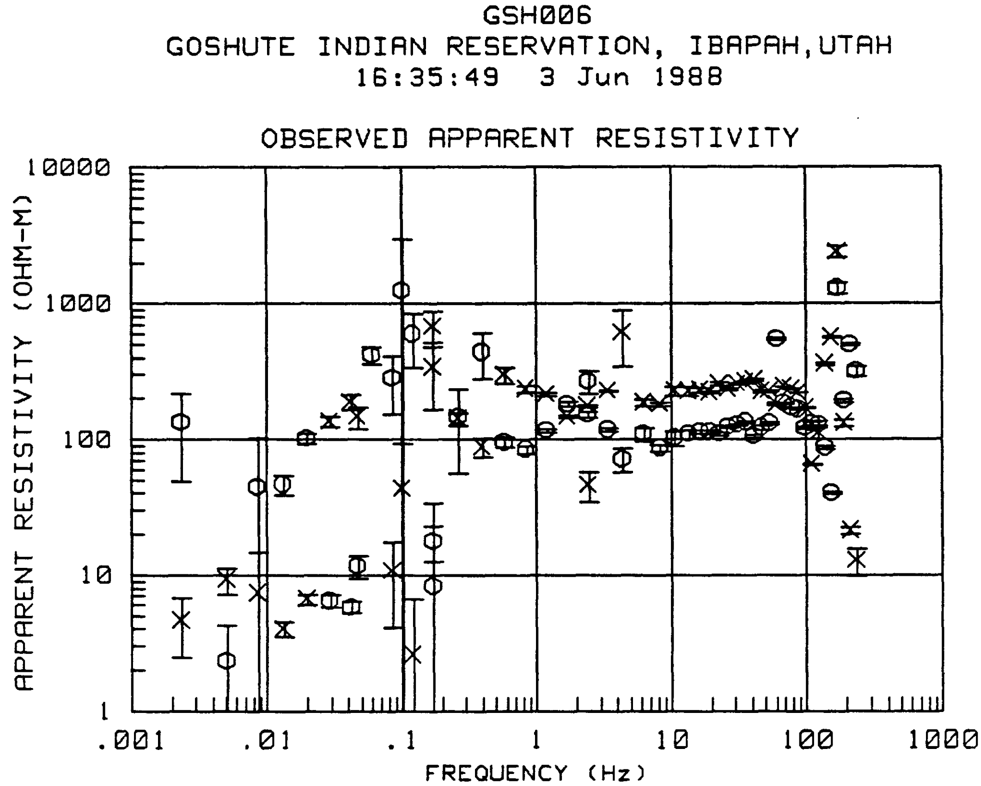
1000
FREQUENCY (Hz)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10
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.001
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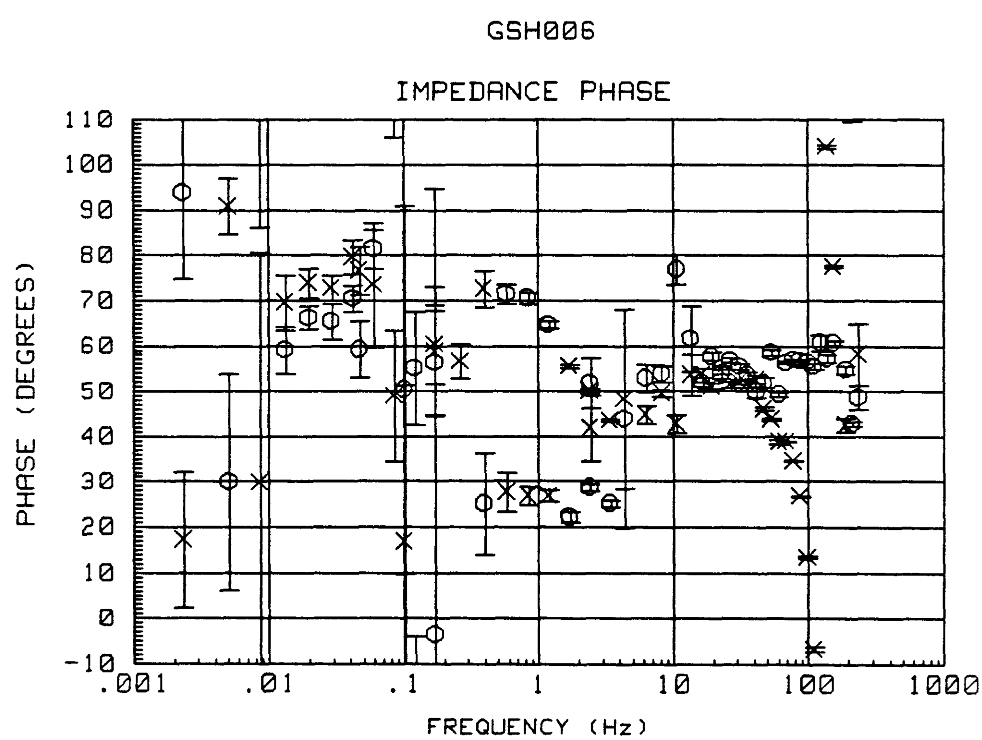
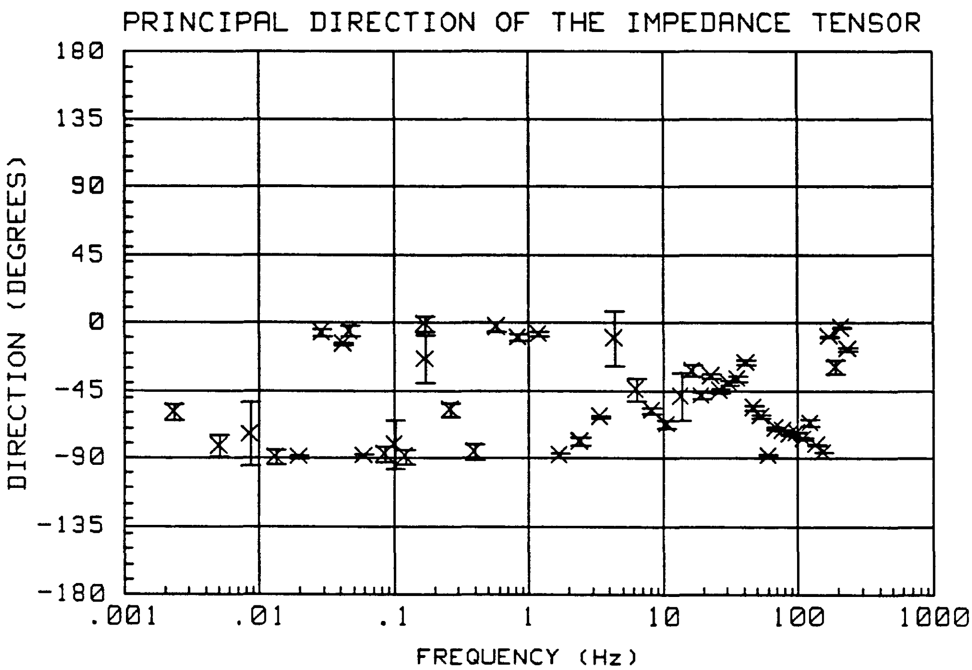
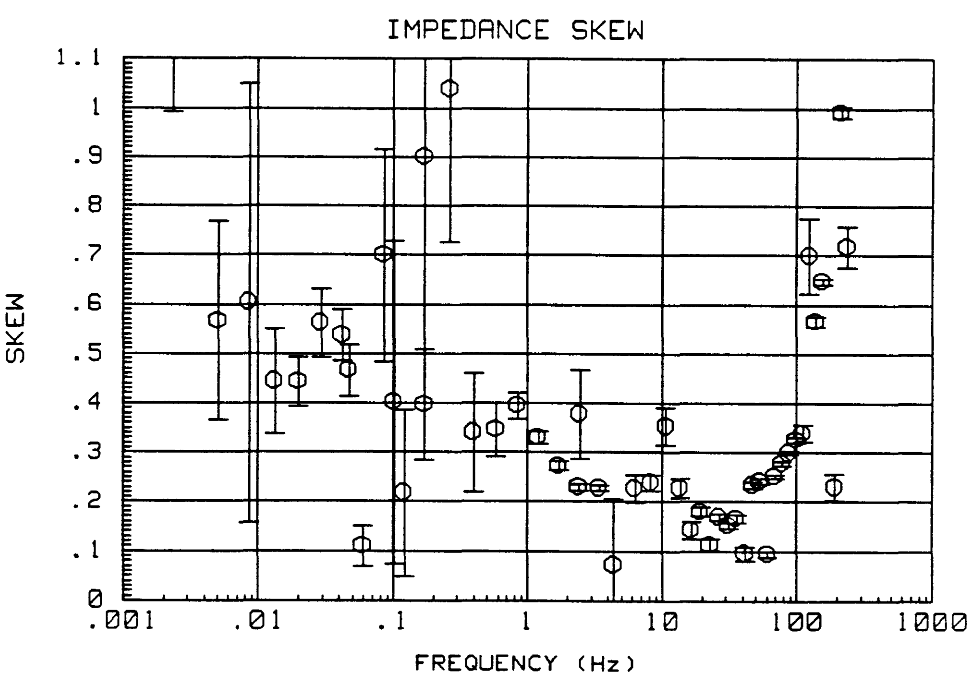
1
10
100
1000
FREQUENCY (Hz)


GSH006
IMPEDANCE PHASE
PHASE (DEGREES)
110
100
90
80
70
60
50
40
30
20
10
0
-10
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

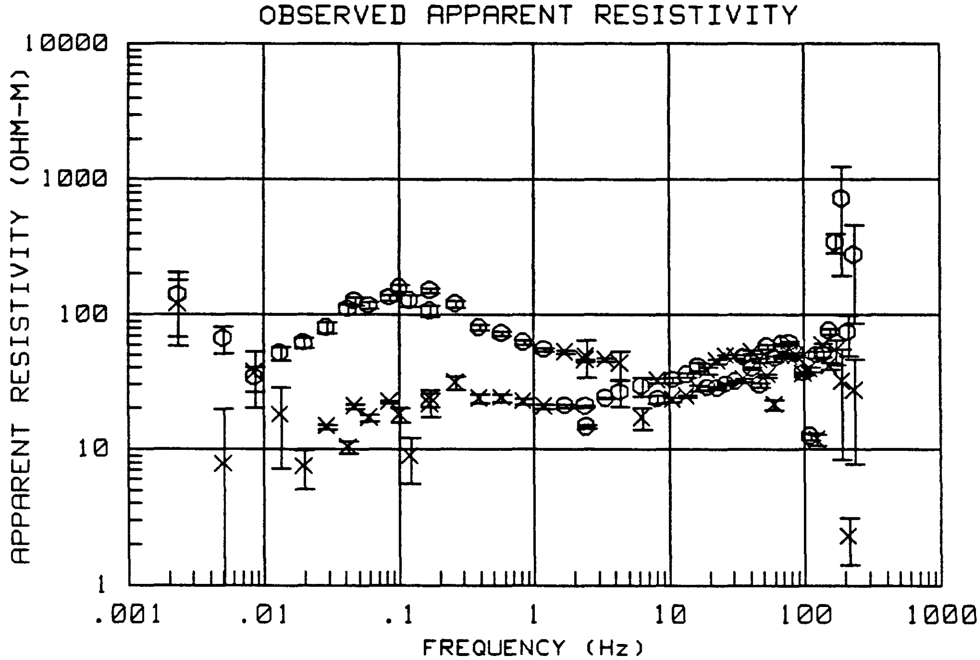
GSH006



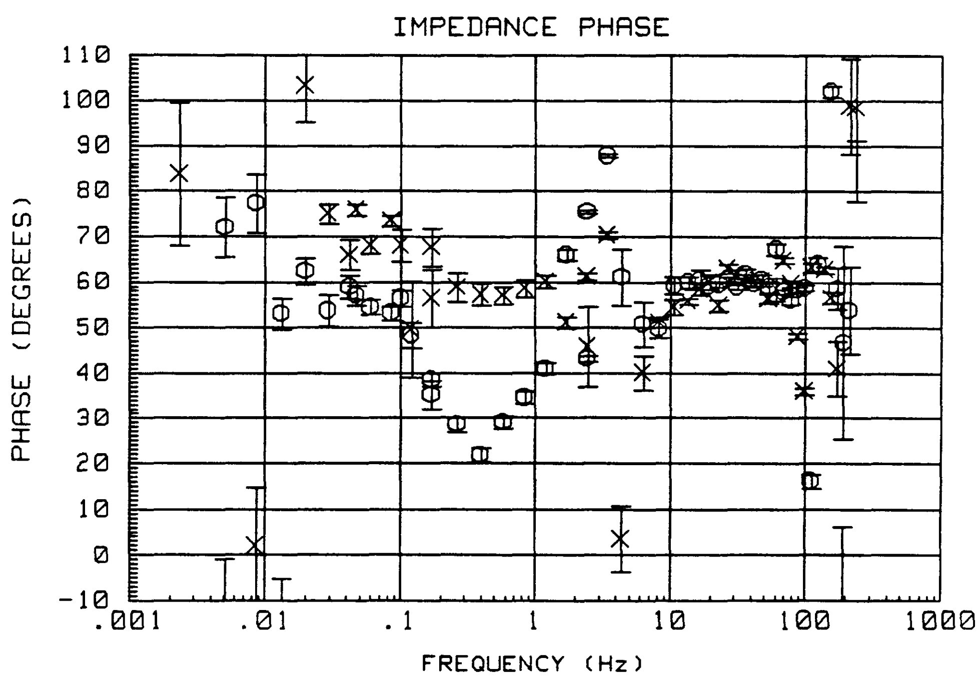
GSH006

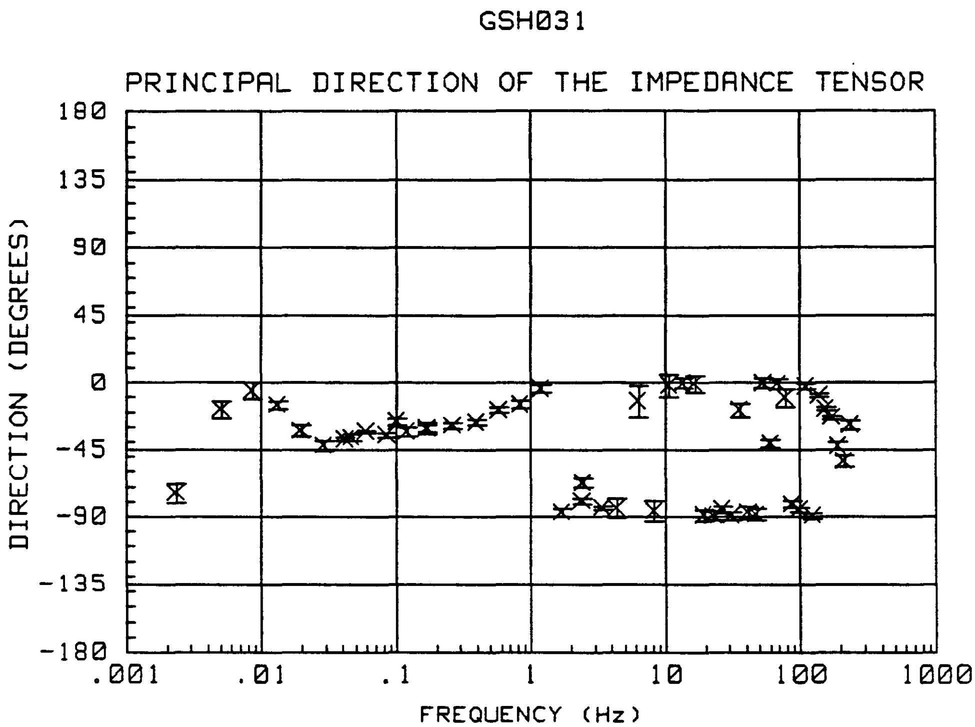


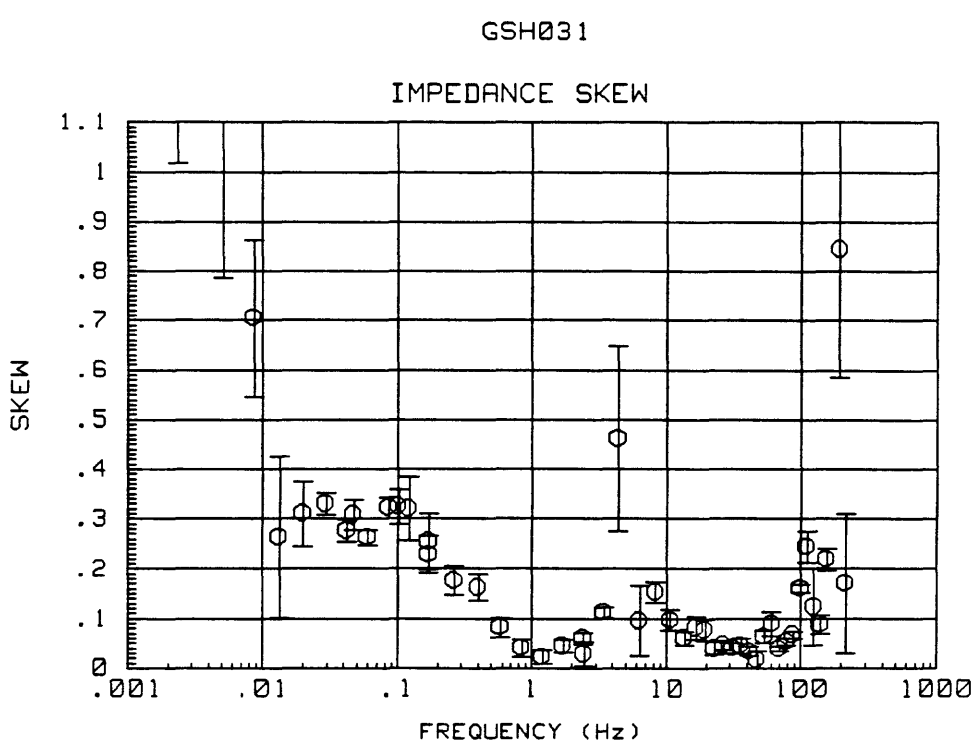
GSH031
GOSHUTE INDIAN RESERVATION, IBAPAH, UTAH
14:46:24 22 May 1991



GSH031

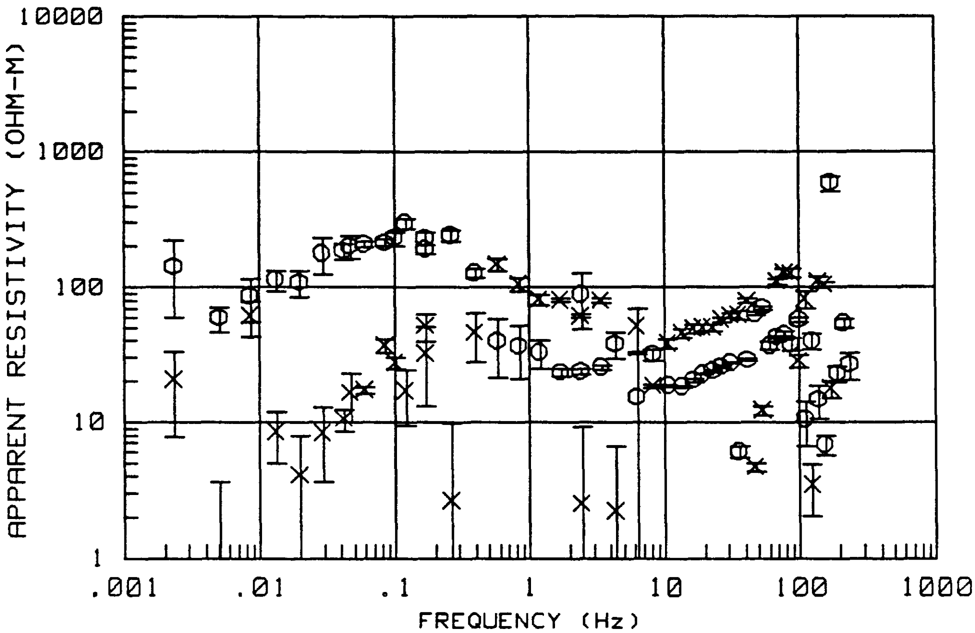



GSH031
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH031
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

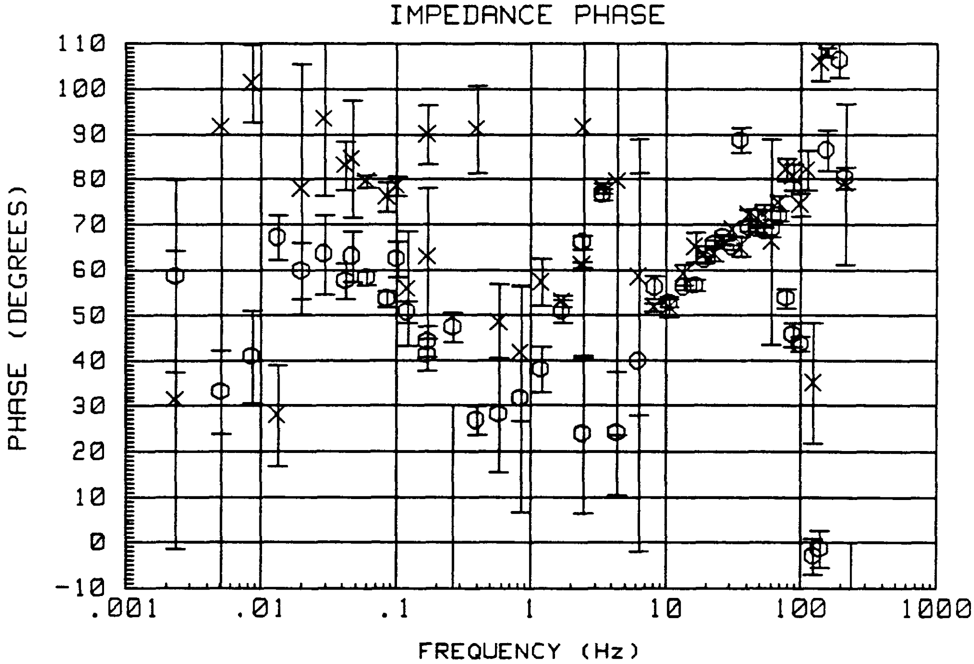
GSH032
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
11:03:49 23 May 1991

OBSERVED APPARENT RESISTIVITY

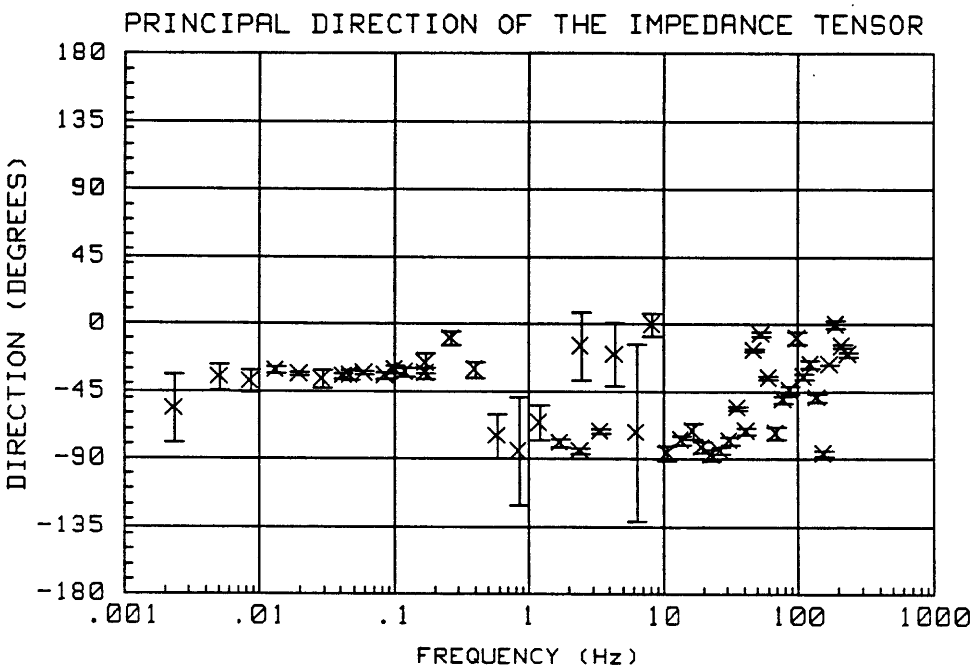


GSH032

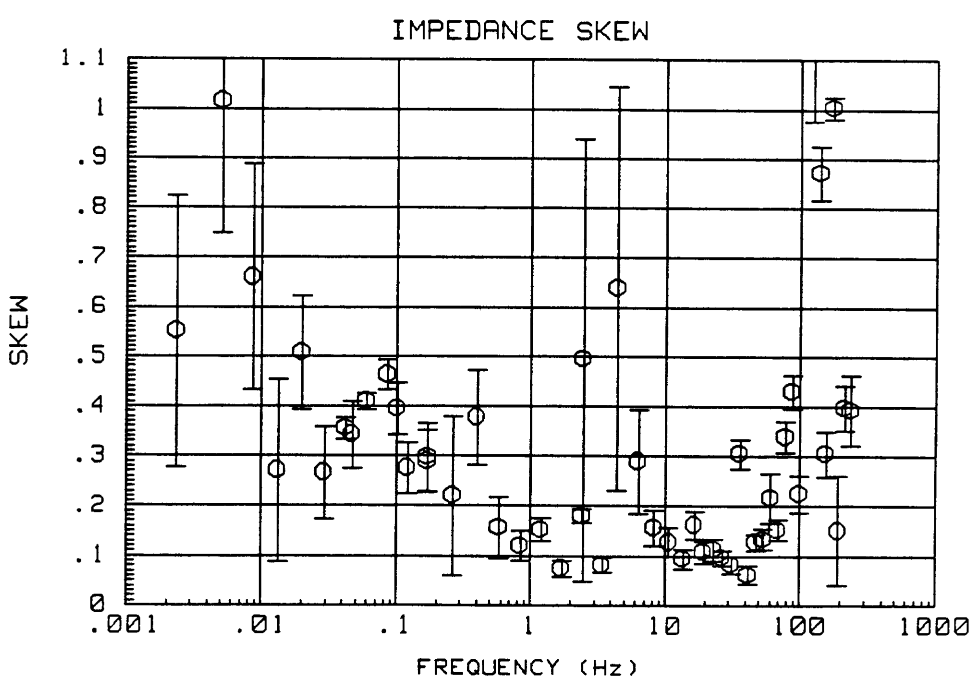
IMPEDANCE PHASE



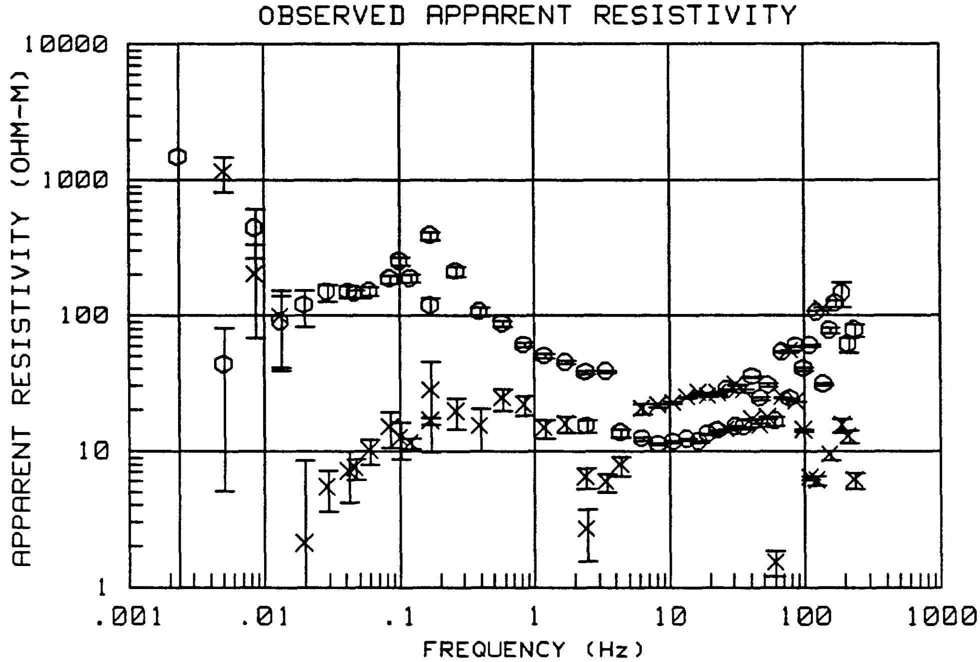
GSH032



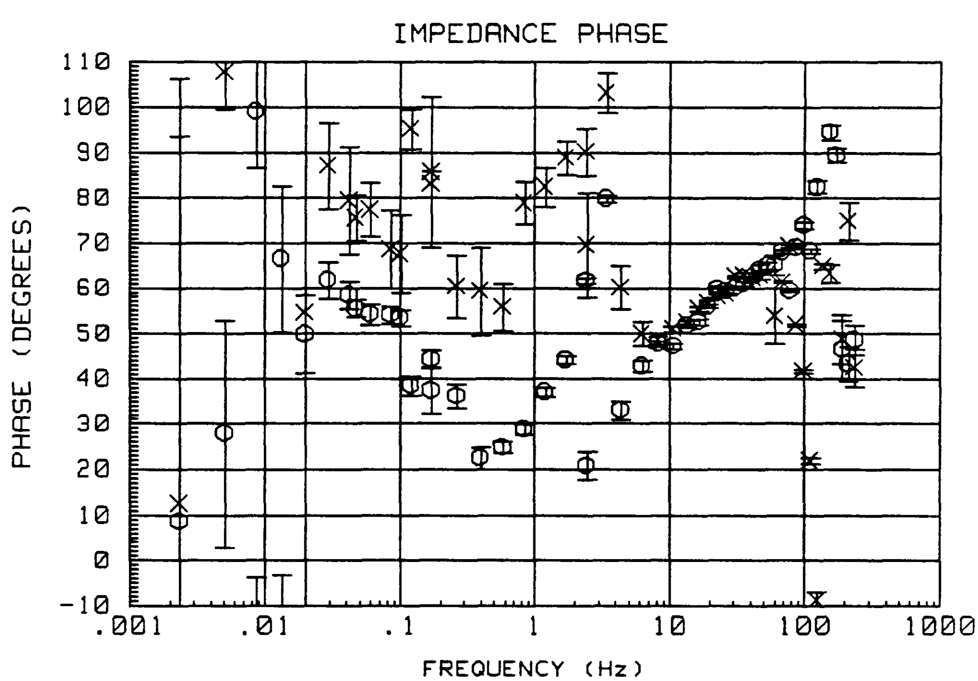
GSH032

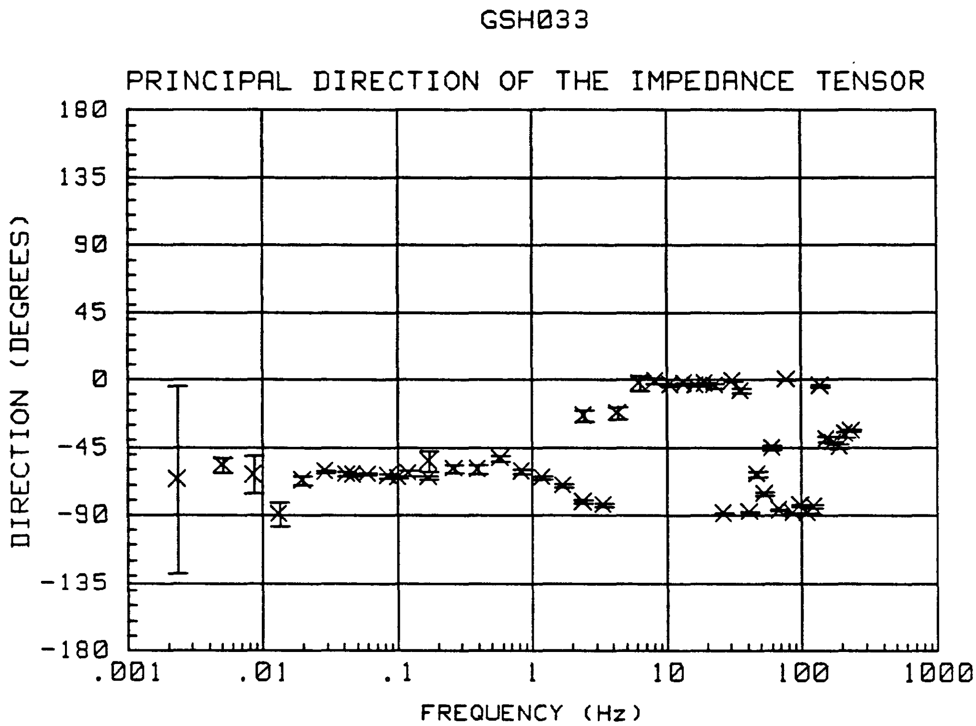


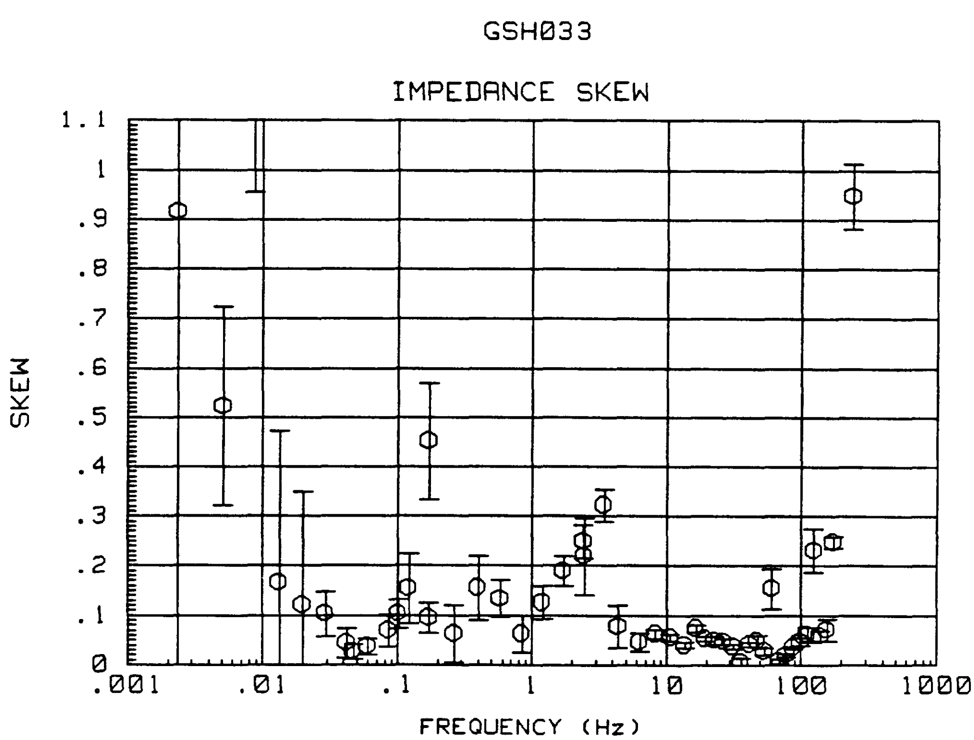
GSH033
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
13:11:17 23 May 1991



GSH033

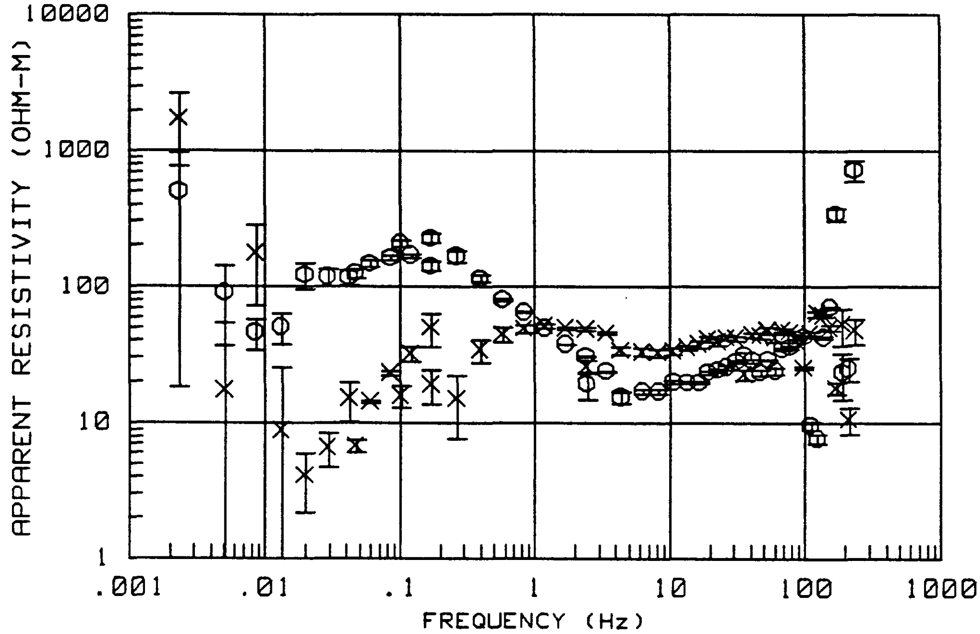



GSH033
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
DIRECTION (DEGREES)
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH033
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SKEW
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

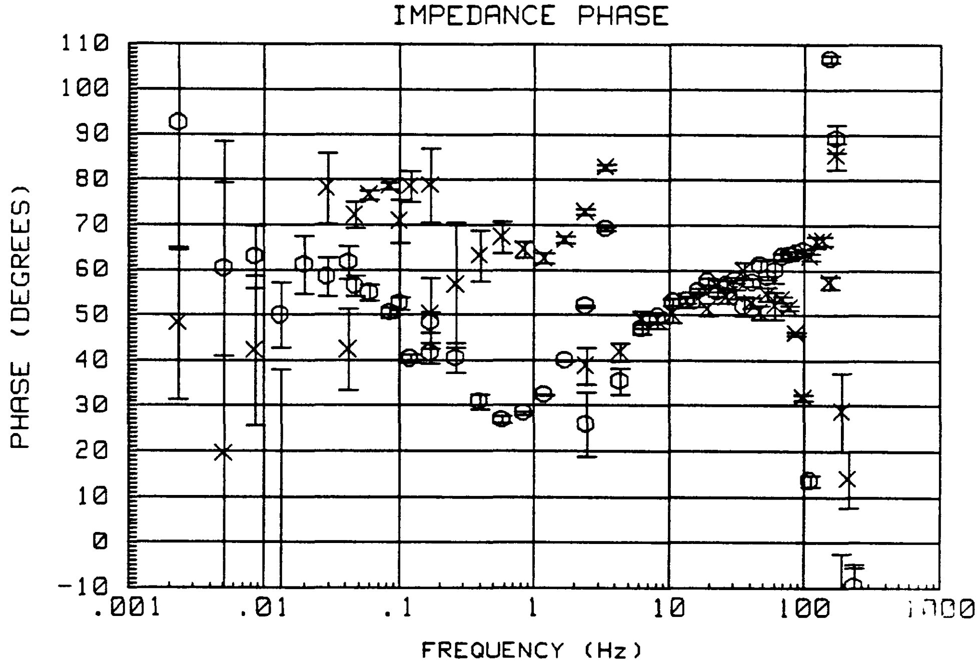
GSH034
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
16:36:25 23 May 1991

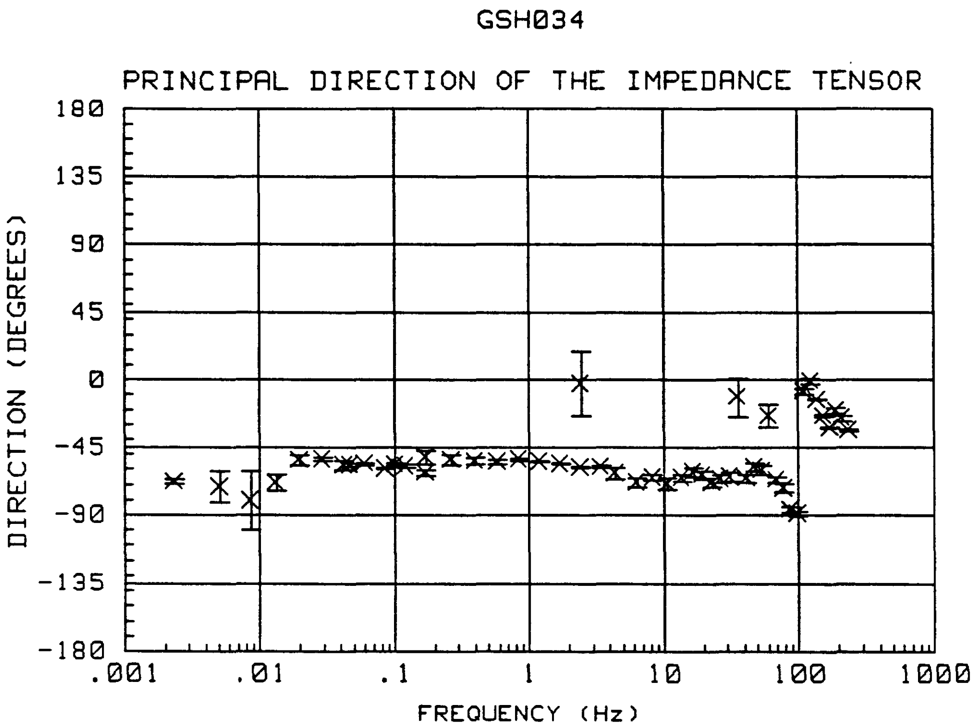
OBSERVED APPARENT RESISTIVITY

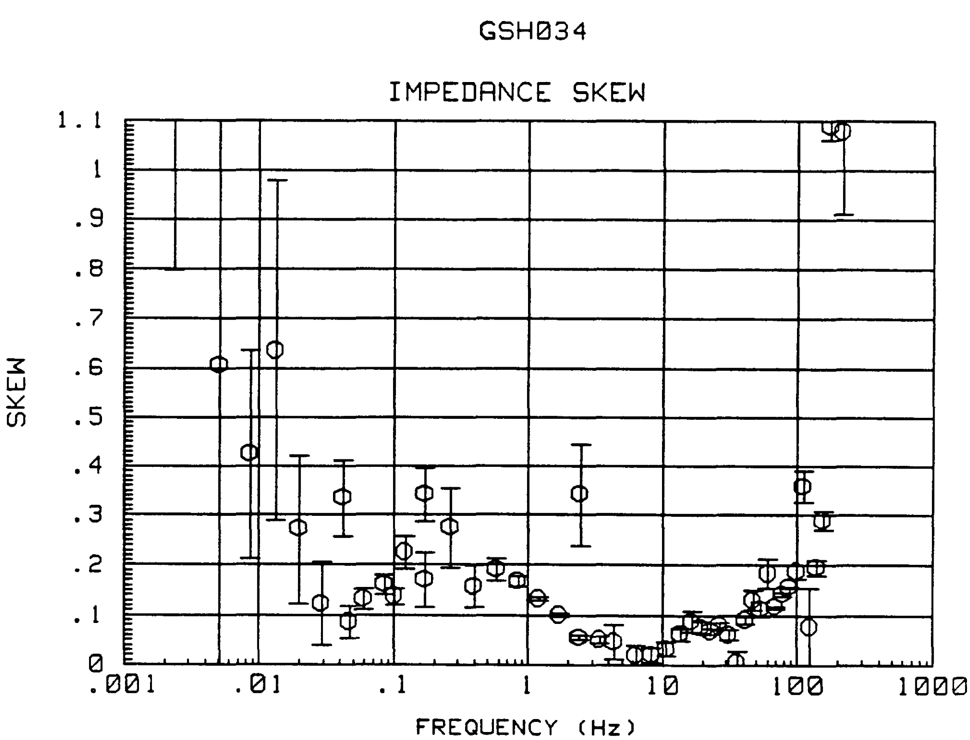


GSH034

IMPEDANCE PHASE



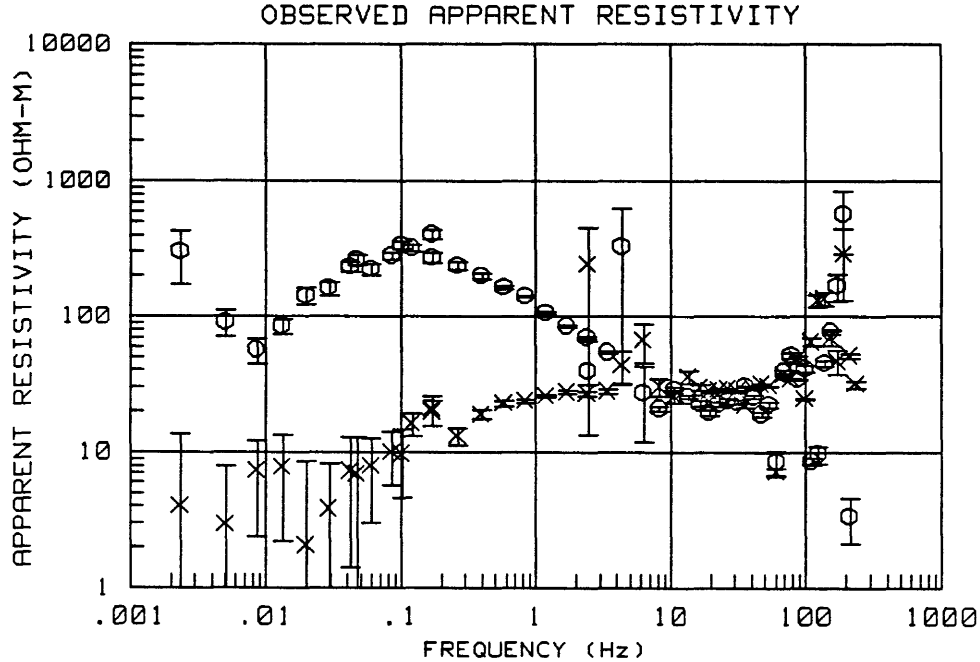

GSH034
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH034
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

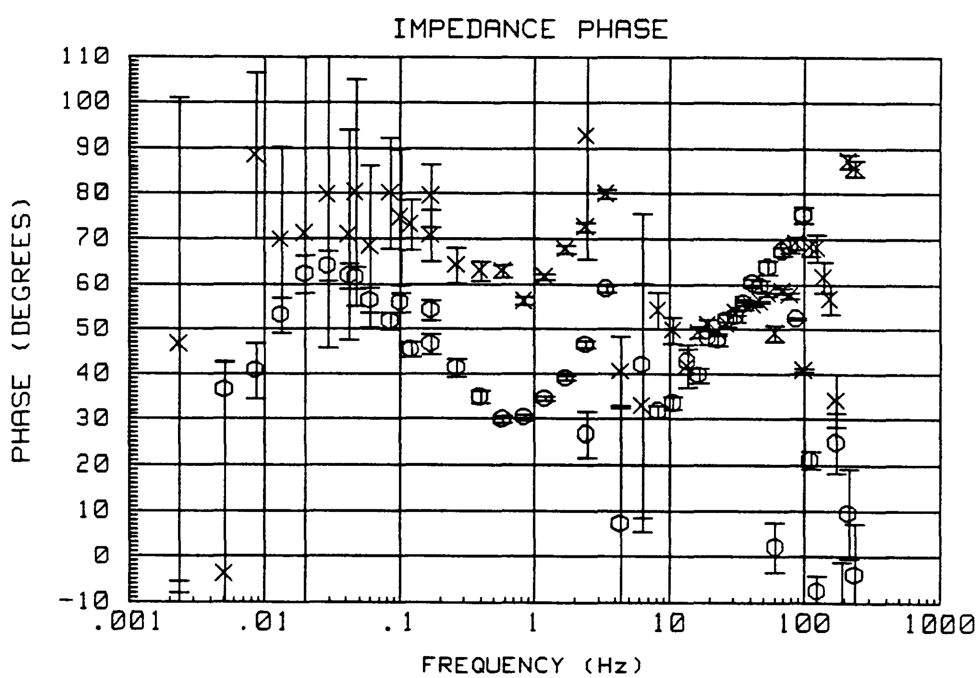
GSH035

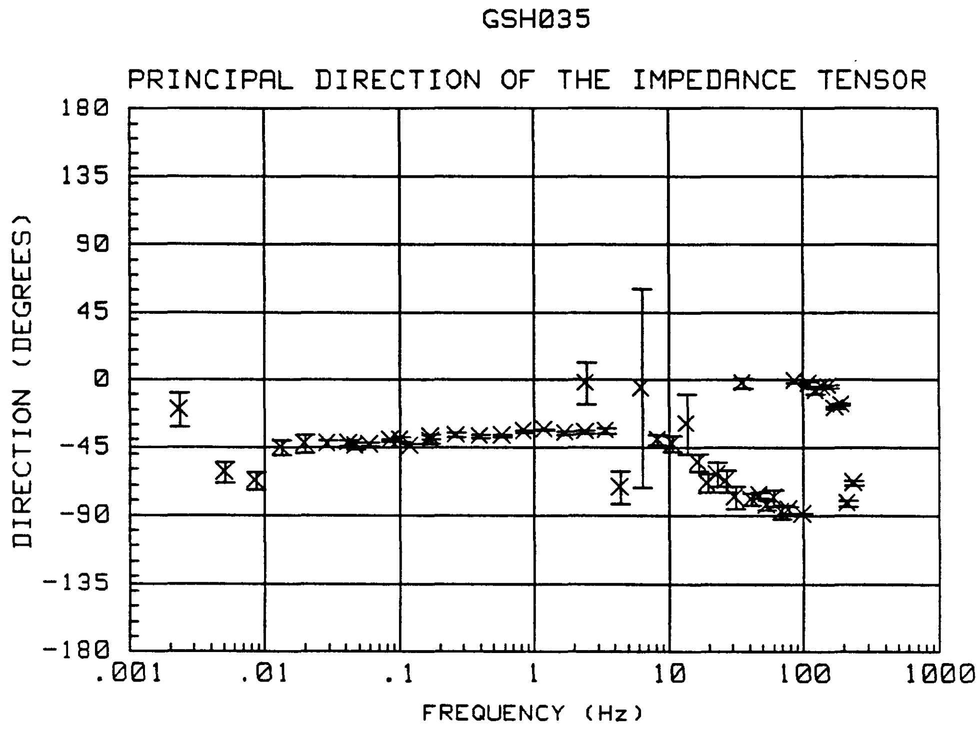
GOSHUTE INDIAN RESERVATION, IBAPAH, UTAH

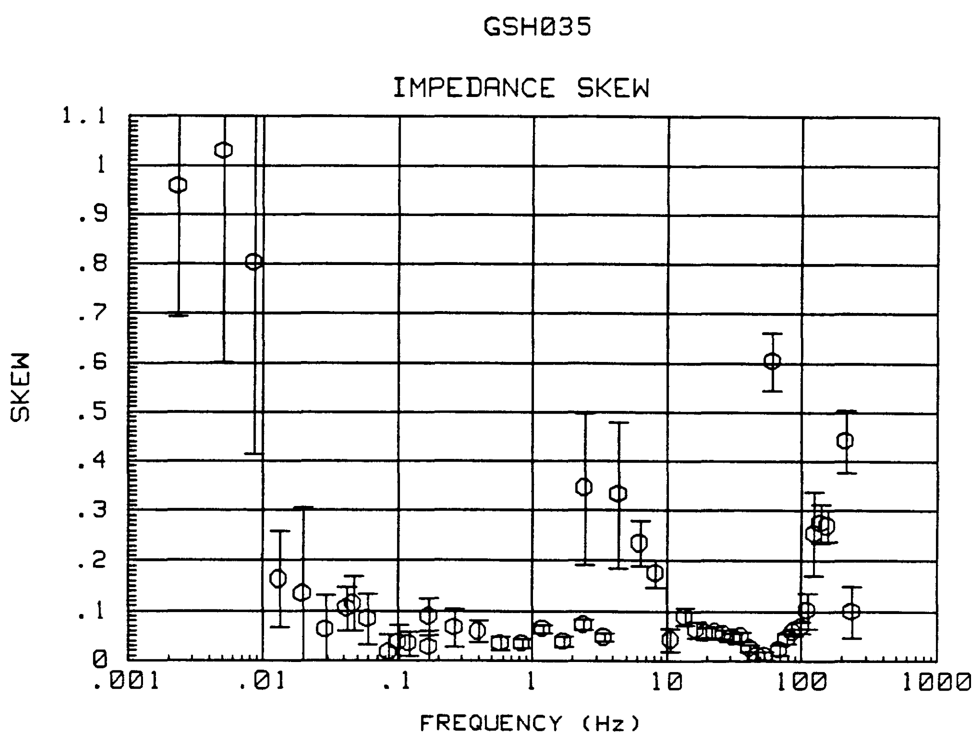
10:25:56 24 May 1991



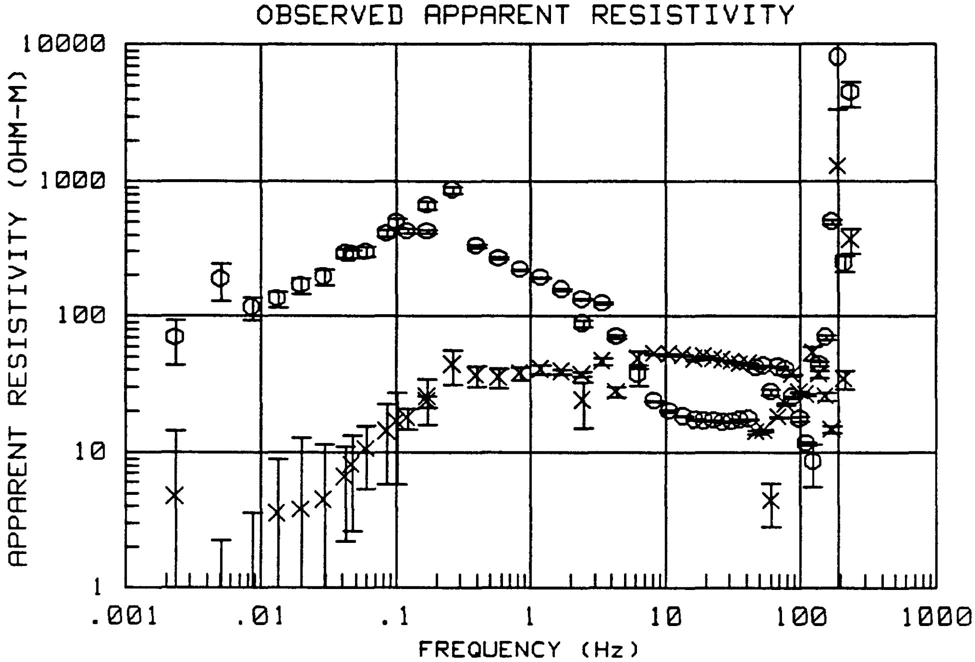
GSH035



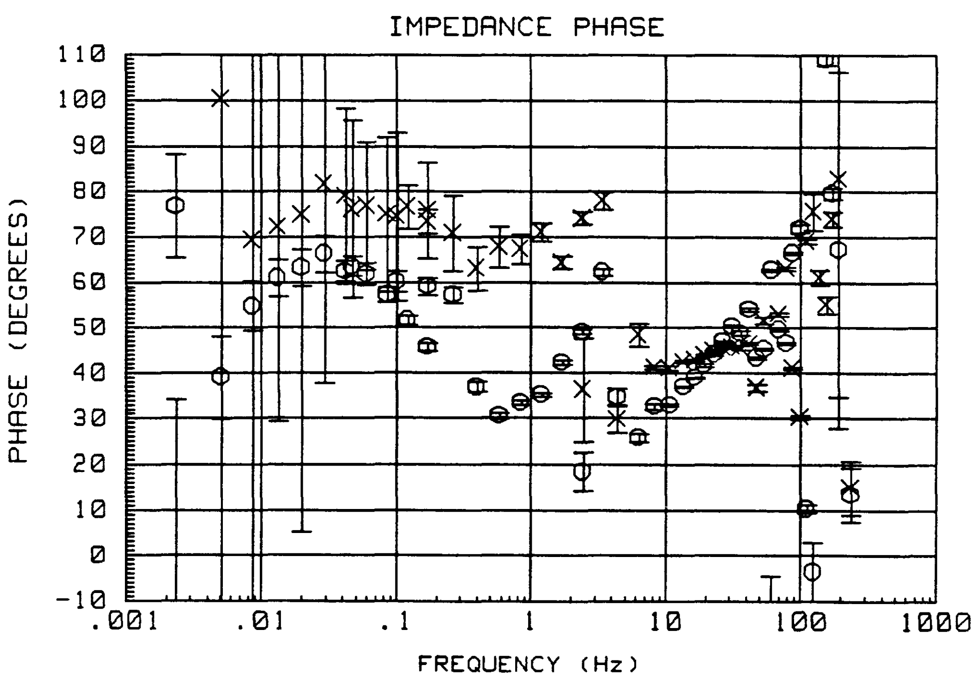

GSH035
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
DIRECTION (DEGREES)
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

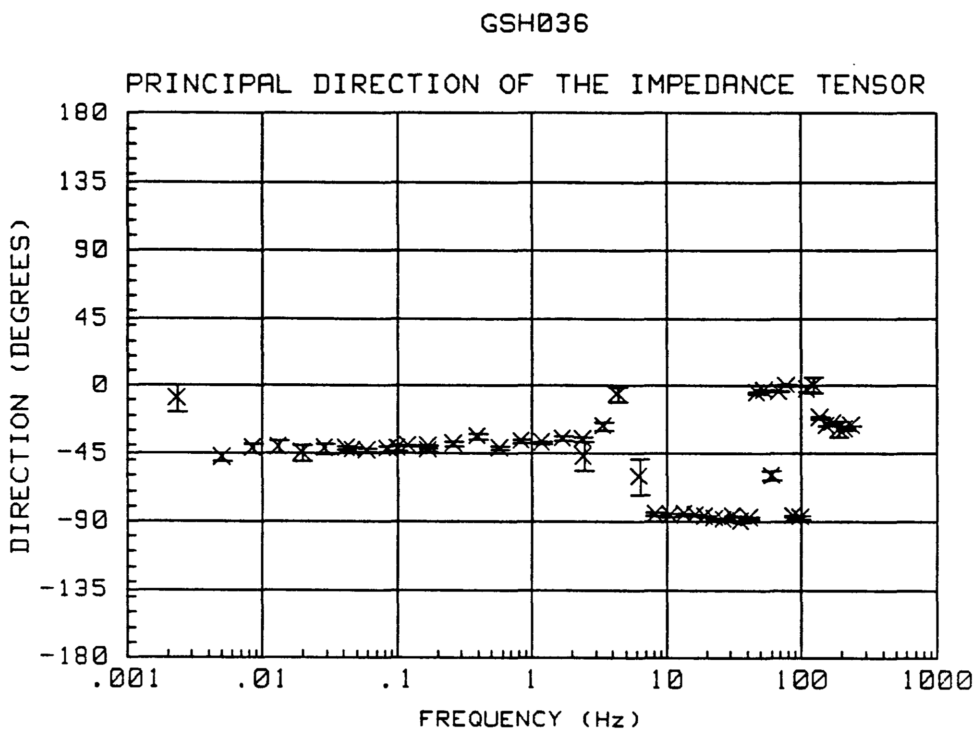

GSH035
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SKEW
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

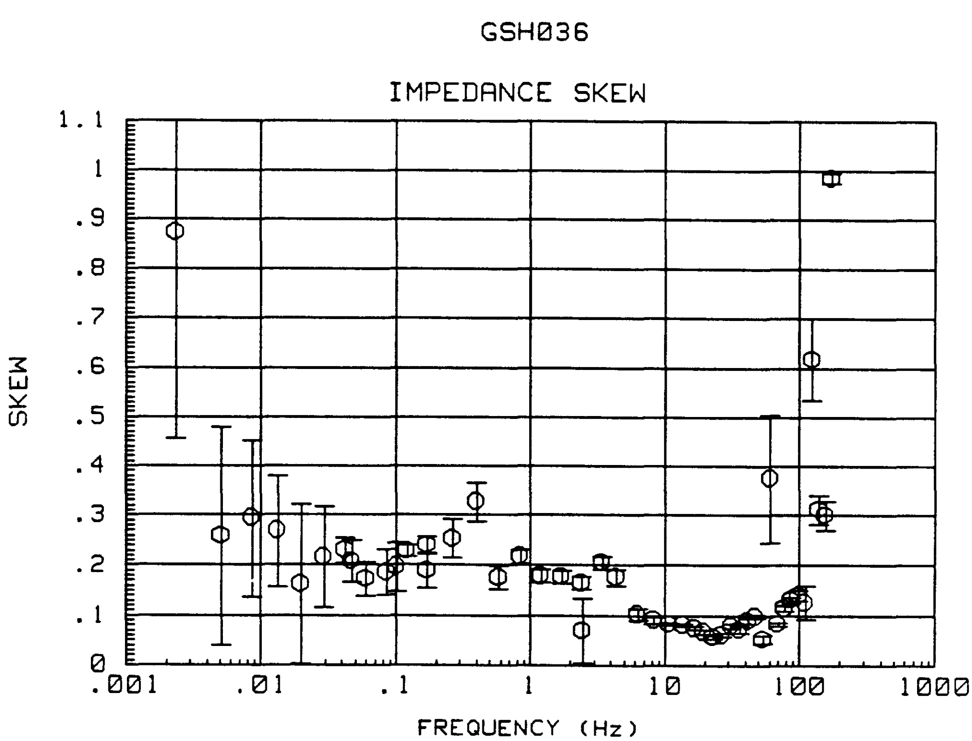
GSH036
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
13:20:12 24 May 1991



GSH036

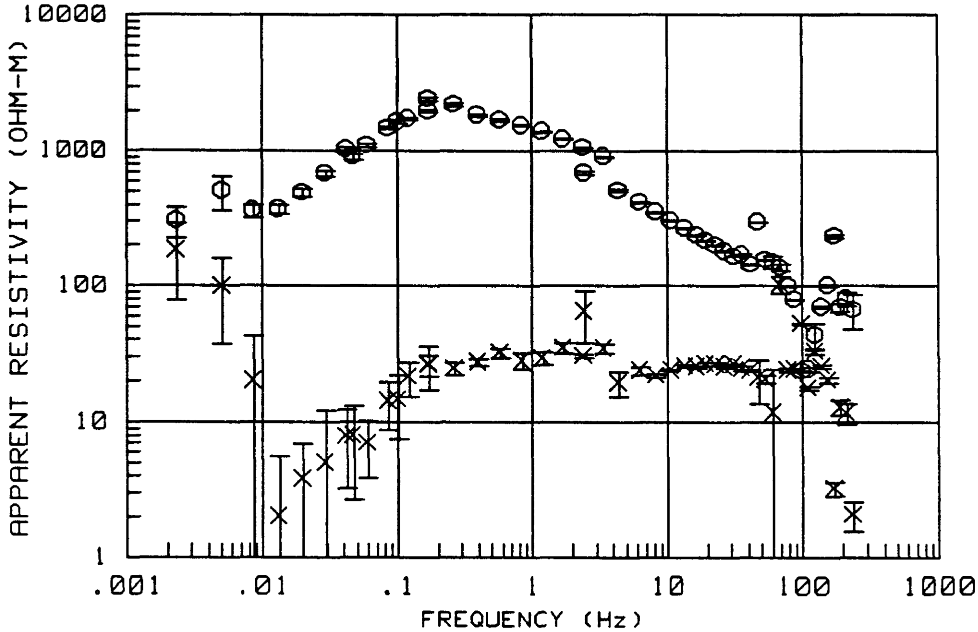



GSH036
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH036
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

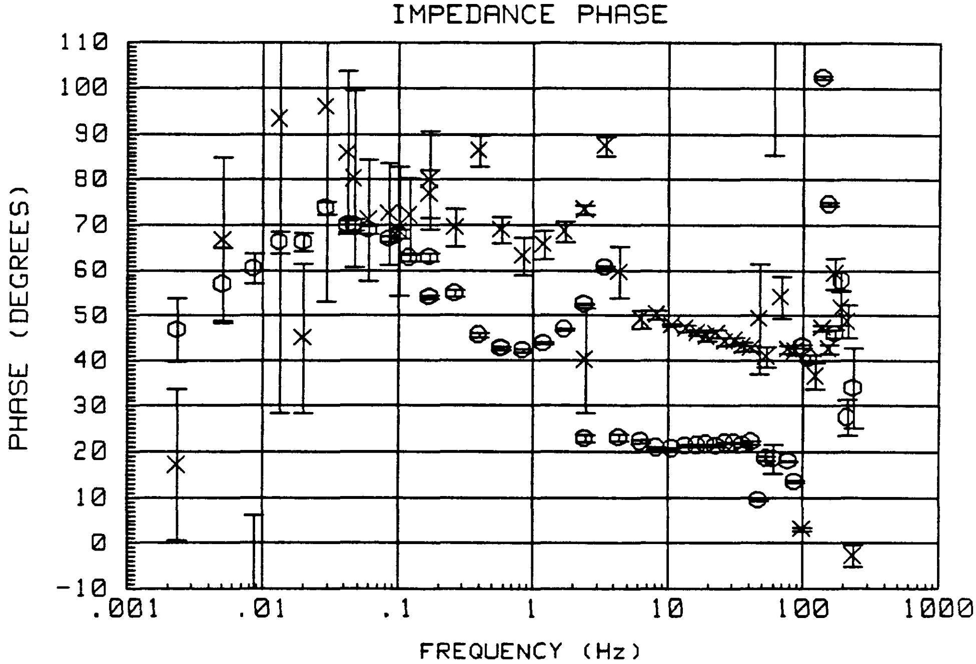
GSH037
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
16:37:33 24 May 1991

OBSERVED APPARENT RESISTIVITY



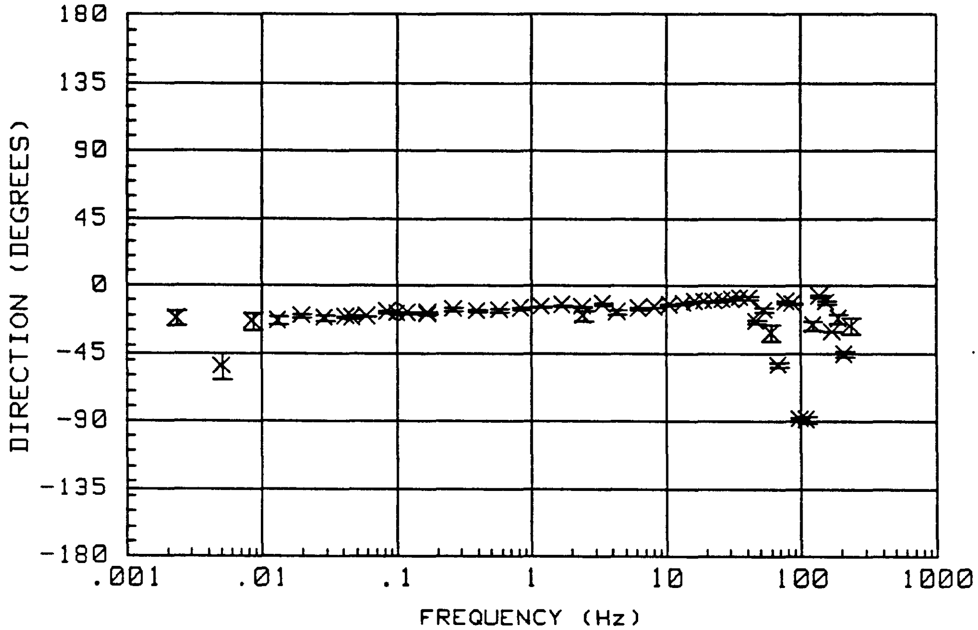
GSH037

IMPEDANCE PHASE



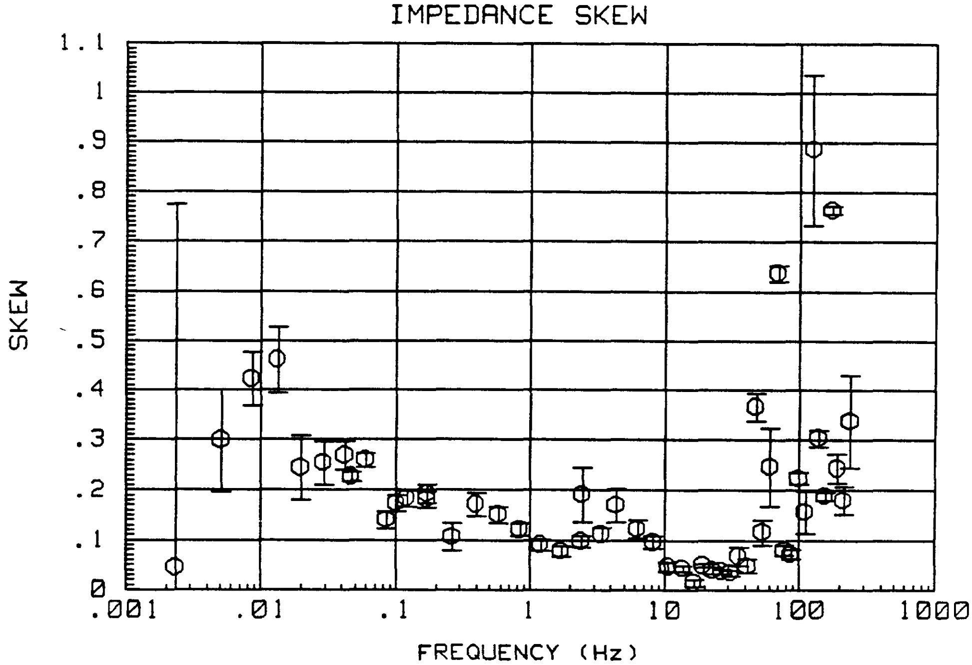
GSH037

PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR

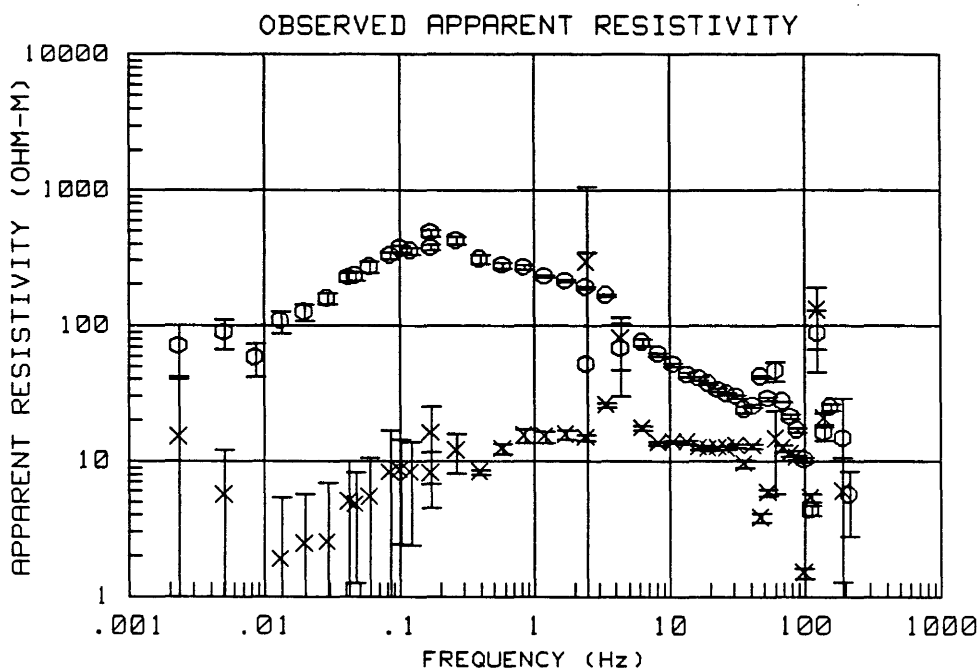


GSH037

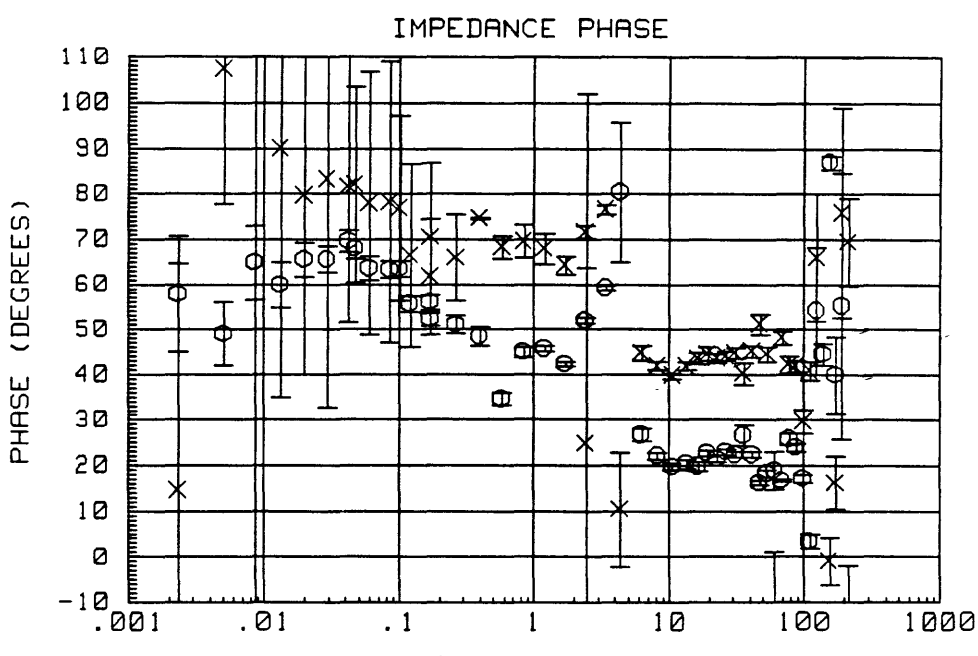
IMPEDANCE SKEW

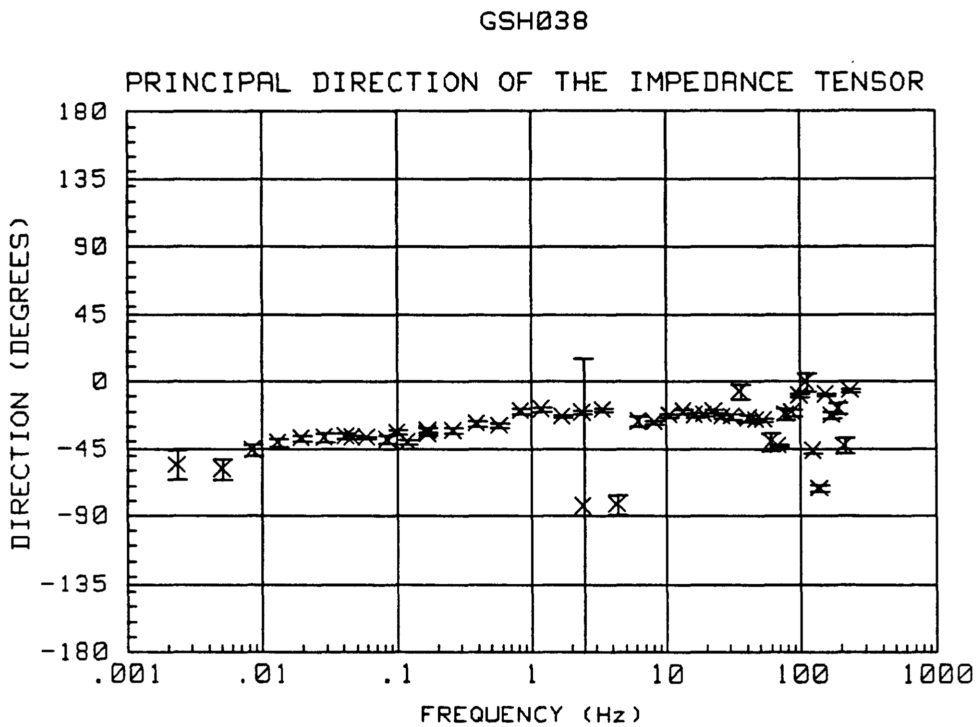


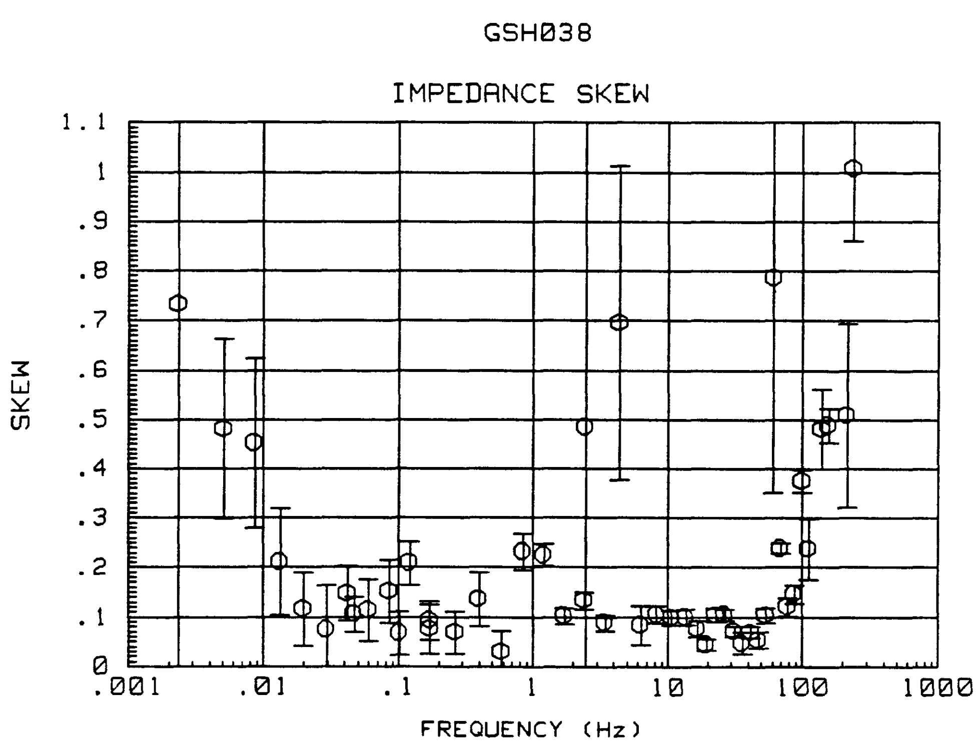
GSH038
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
10:18:25 25 May 1991



GSH038

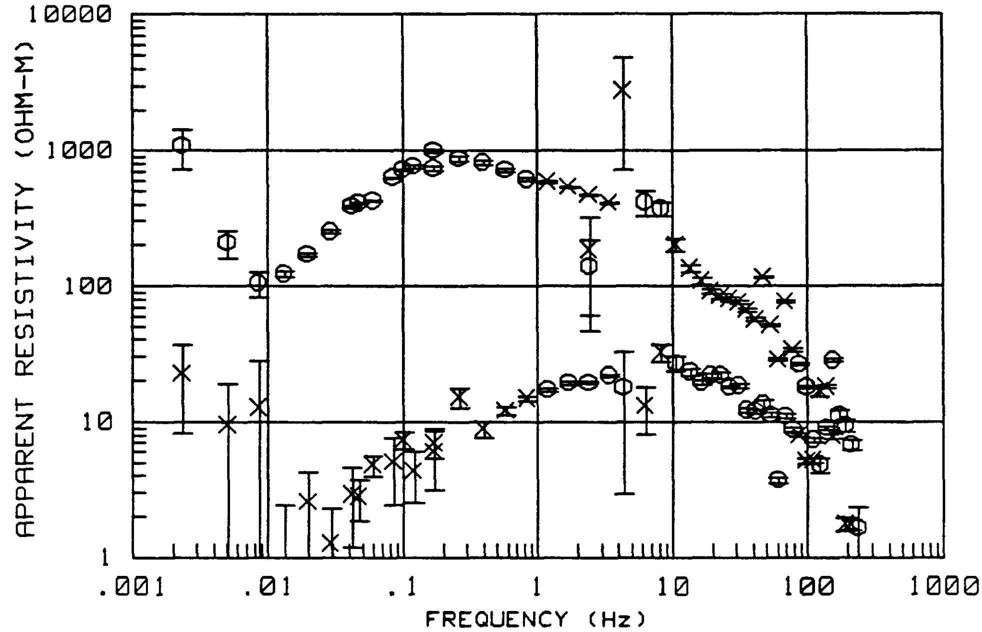



GSH038
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH038
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

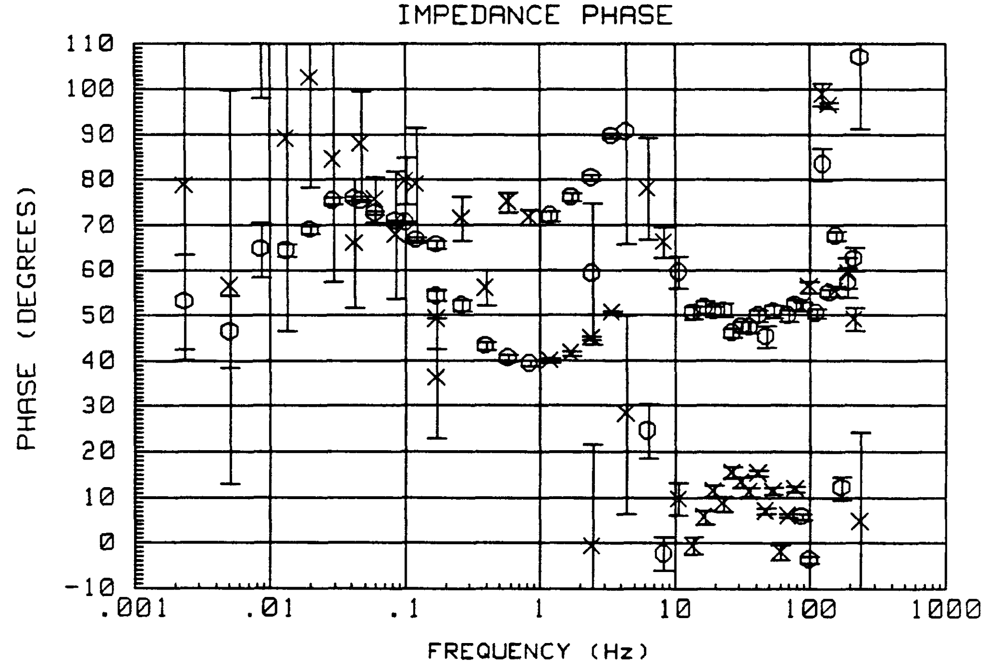
GSH039
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
15:00:23 25 May 1991

OBSERVED APPARENT RESISTIVITY



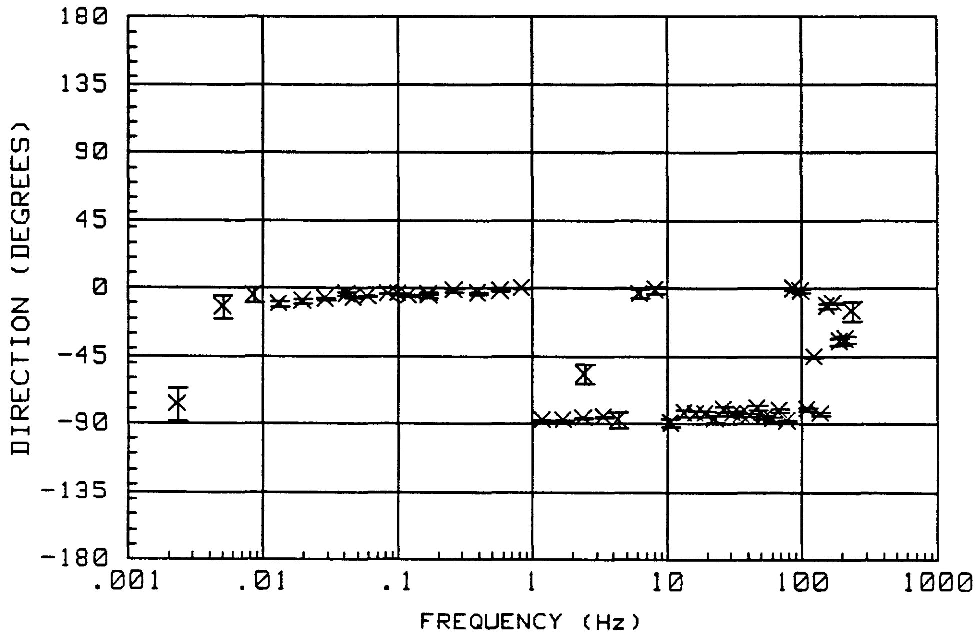
GSH039

IMPEDANCE PHASE



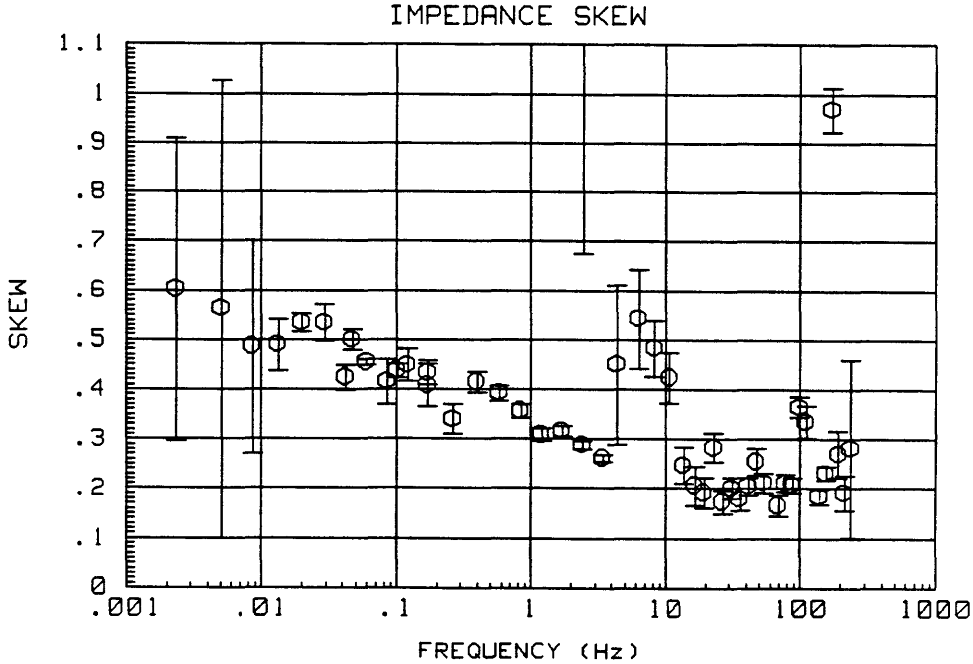
GSH039

PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR



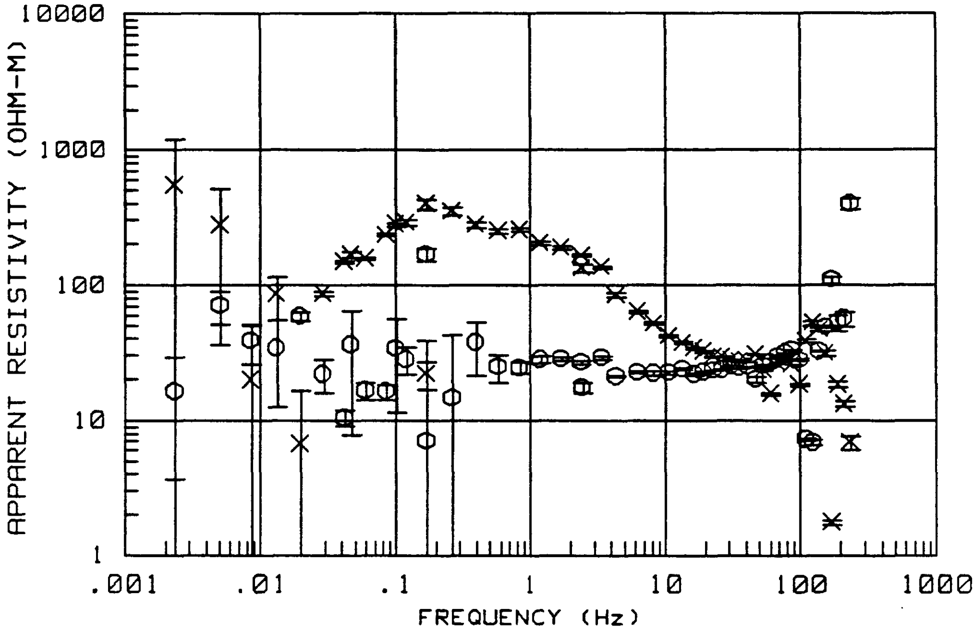
GSH039

IMPEDANCE SKEW



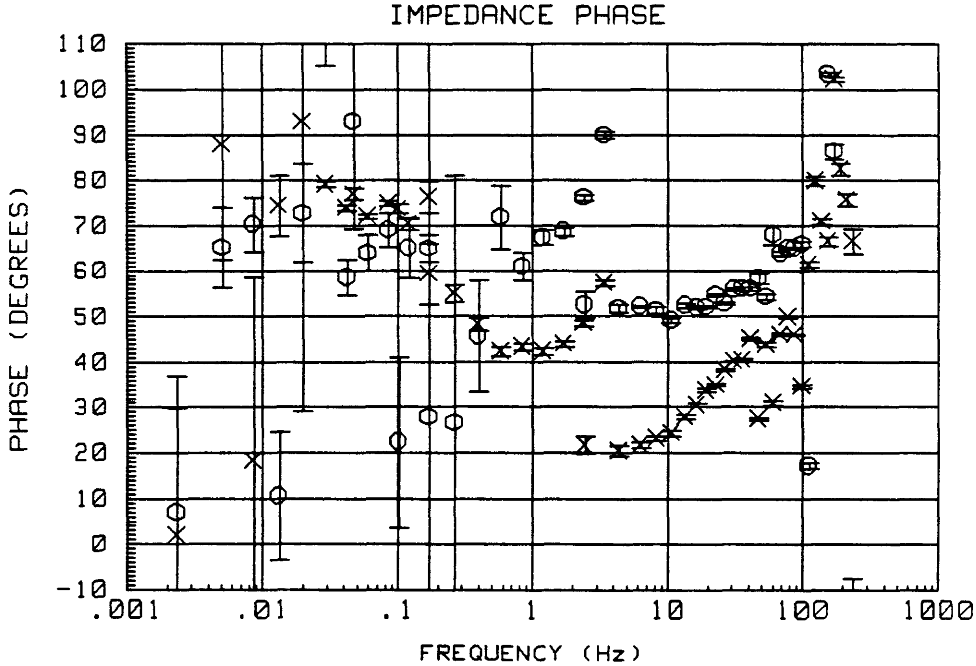
GSH040
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
17:44:04 25 May 1991

OBSERVED APPARENT RESISTIVITY

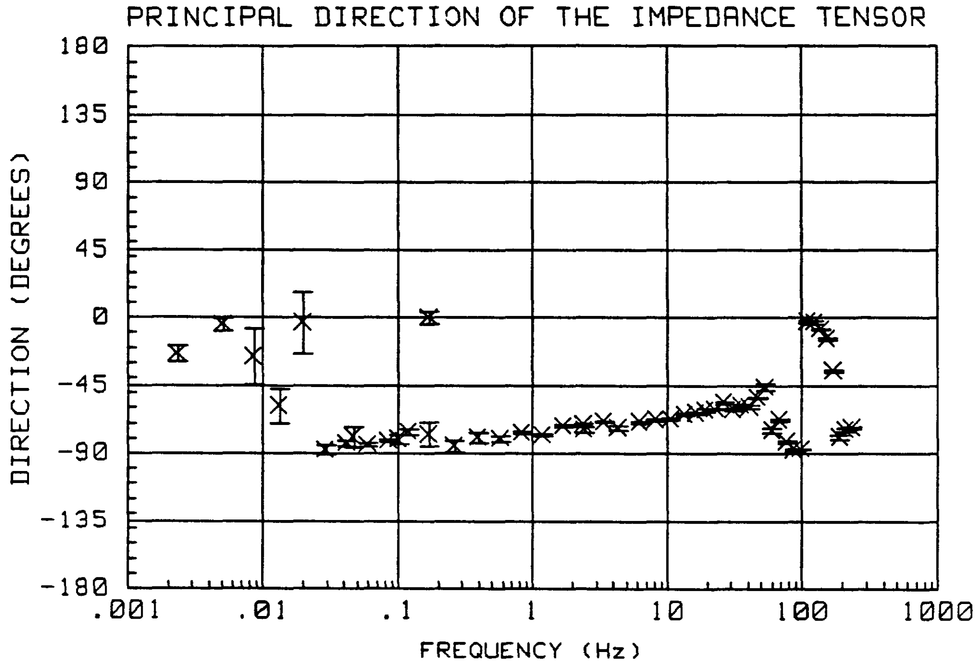


GSH040

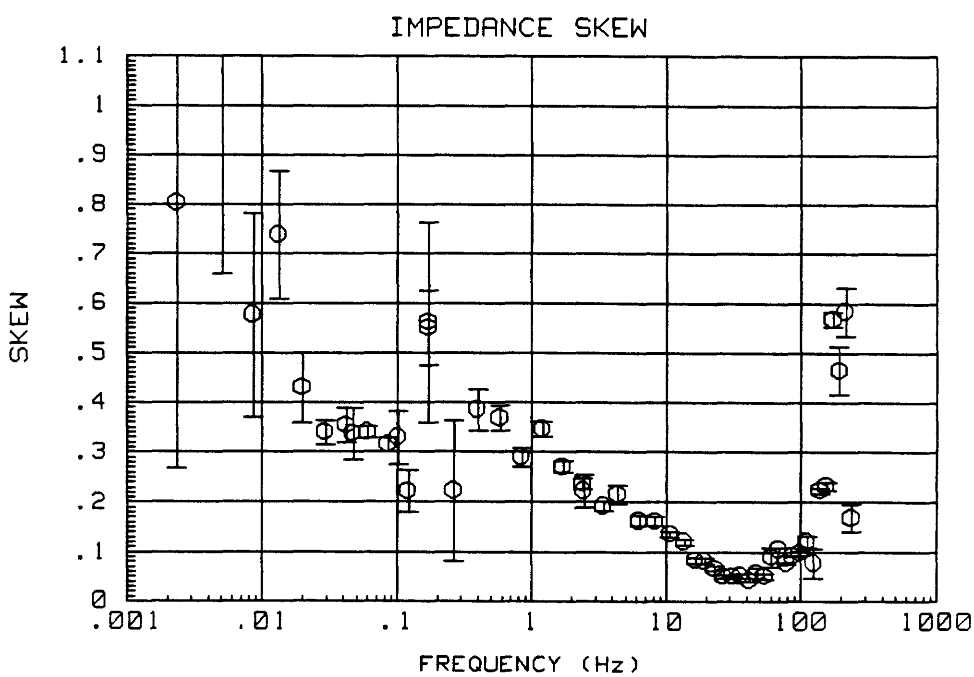
IMPEDANCE PHASE

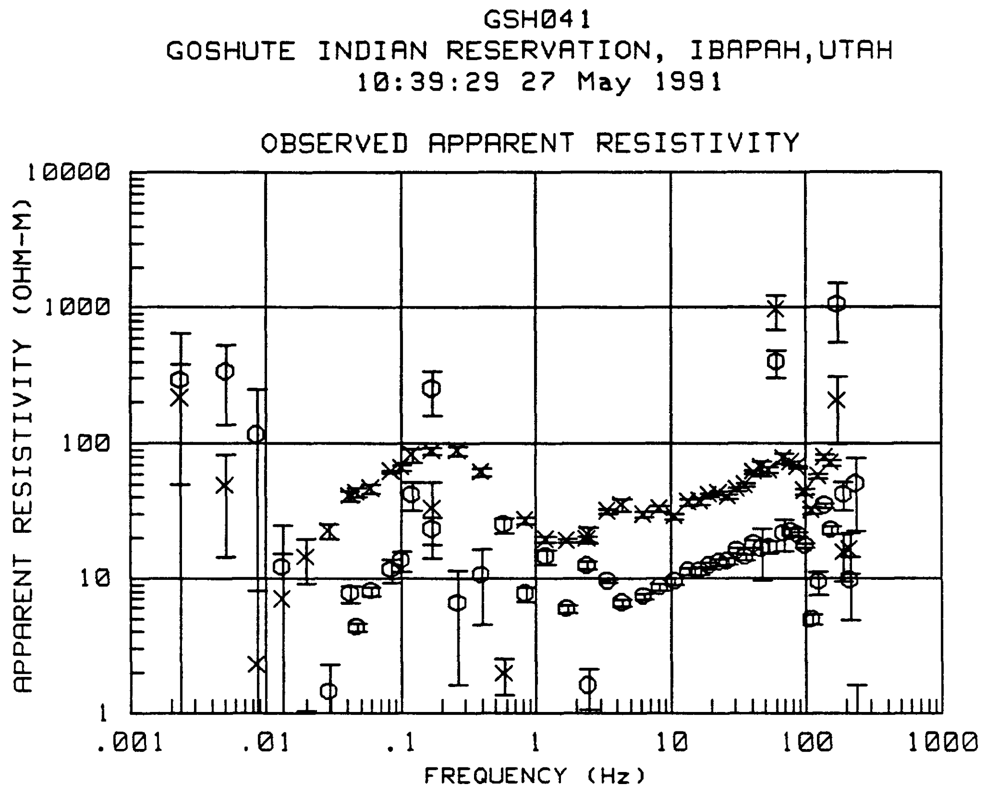


GSH040

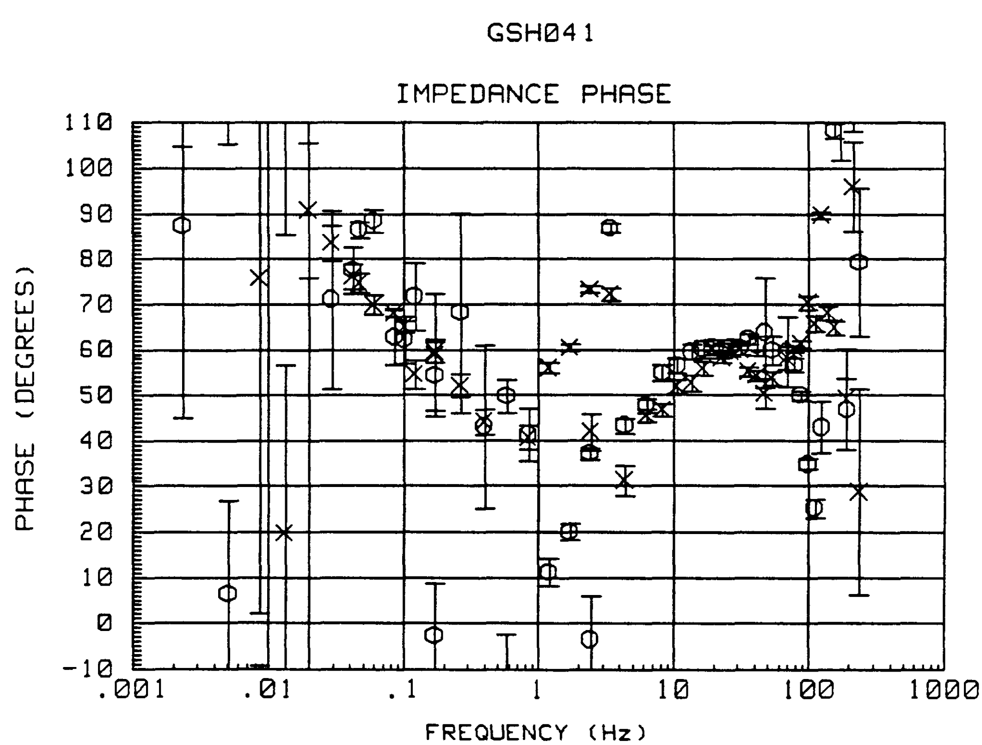


GSH040

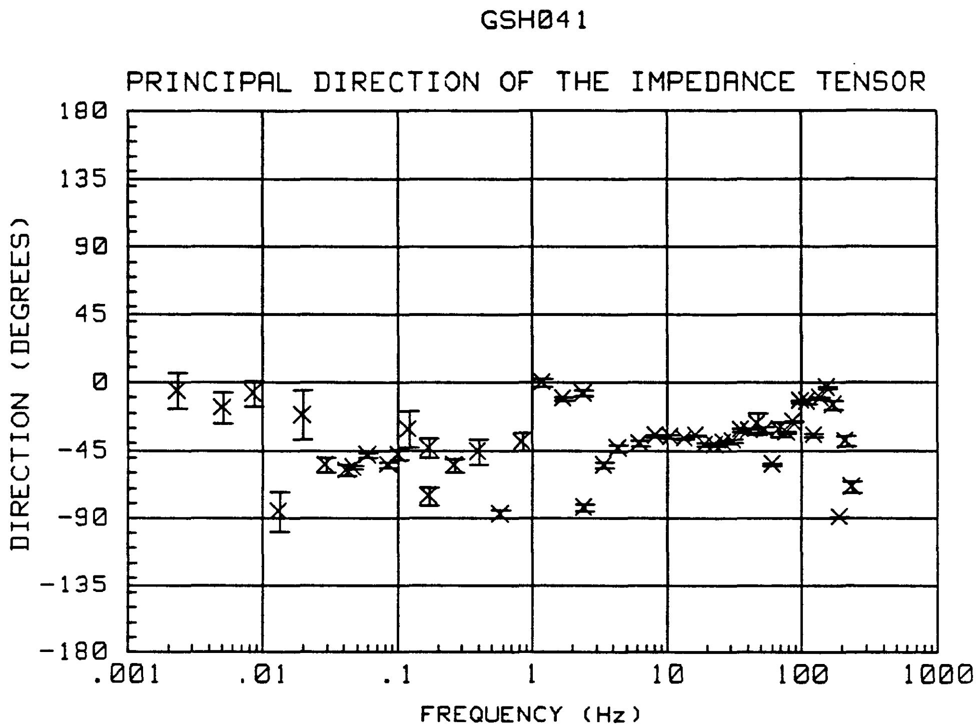


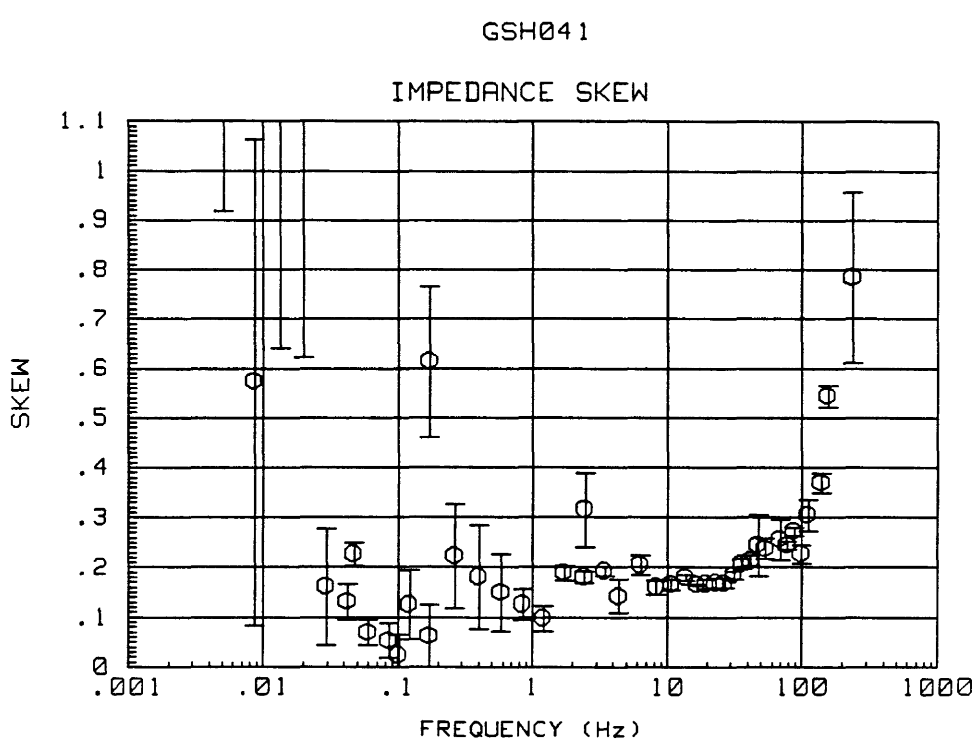


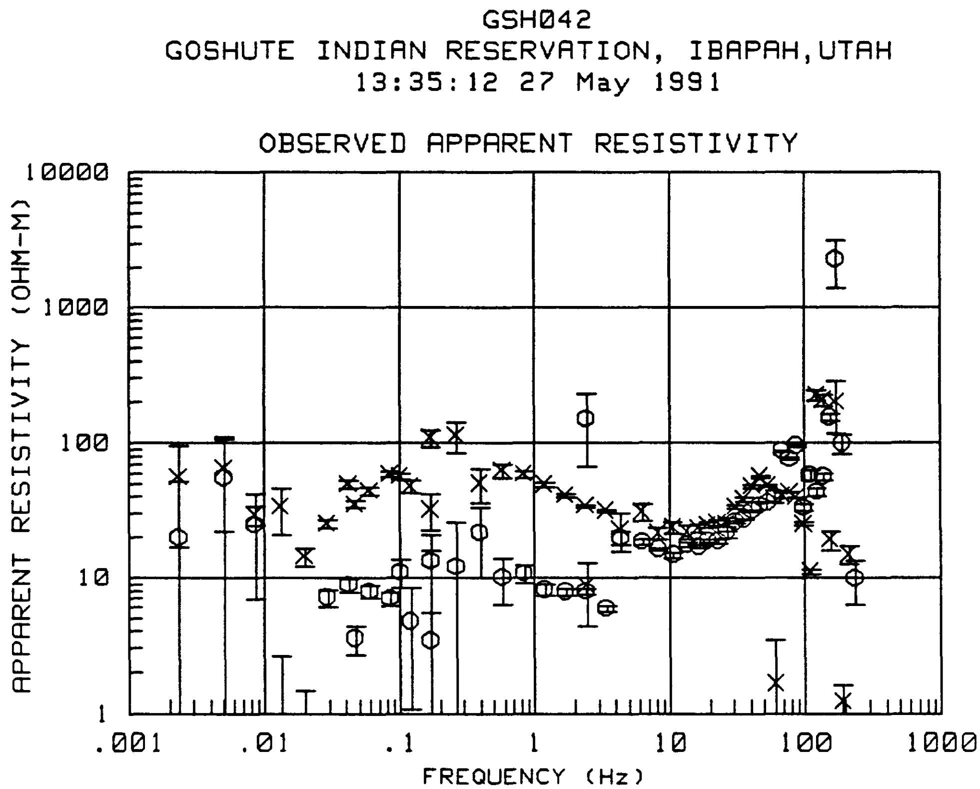
GSH041
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
10:39:29 27 May 1991
OBSERVED APPARENT RESISTIVITY
APPARENT RESISTIVITY (OHM-M)
10000
1000
100
10
1
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

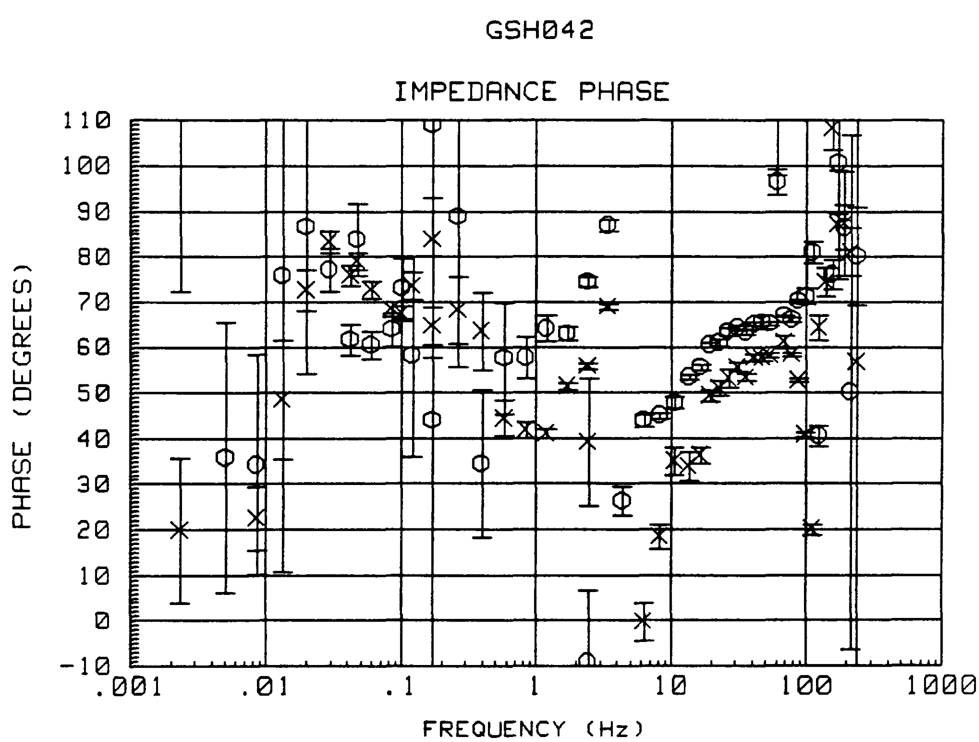


GSH041
IMPEDANCE PHASE
PHASE (DEGREES)
110
100
90
80
70
60
50
40
30
20
10
0
-10
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH041
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

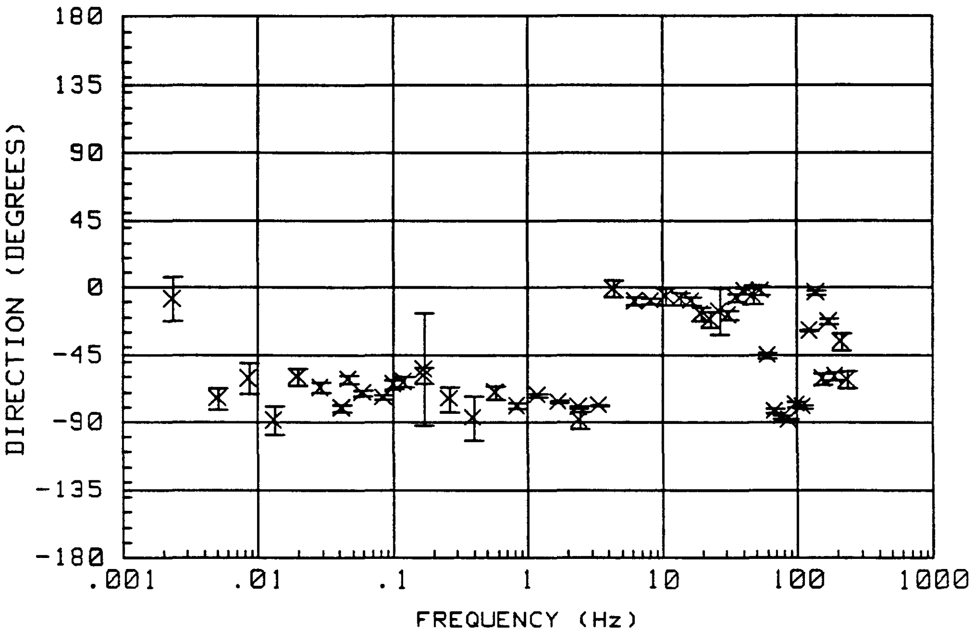

GSH041
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH042
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
13:35:12 27 May 1991
OBSERVED APPARENT RESISTIVITY
APPARENT RESISTIVITY (OHM-M)
10000
1000
100
10
1
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH042
IMPEDANCE PHASE
PHASE (DEGREES)
110
100
90
80
70
60
50
40
30
20
10
0
-10
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

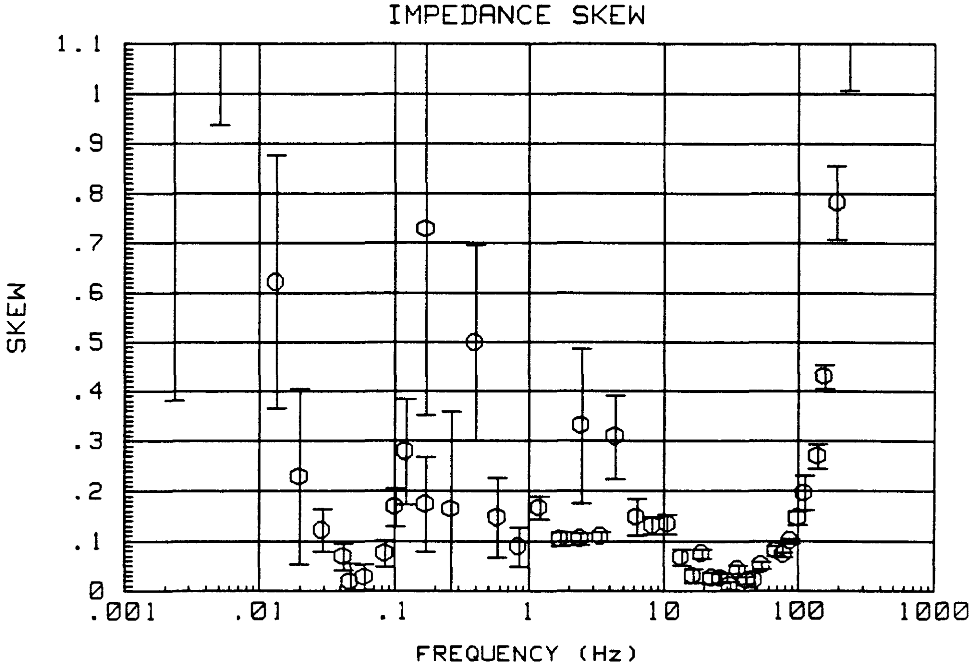
GSH042

PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR

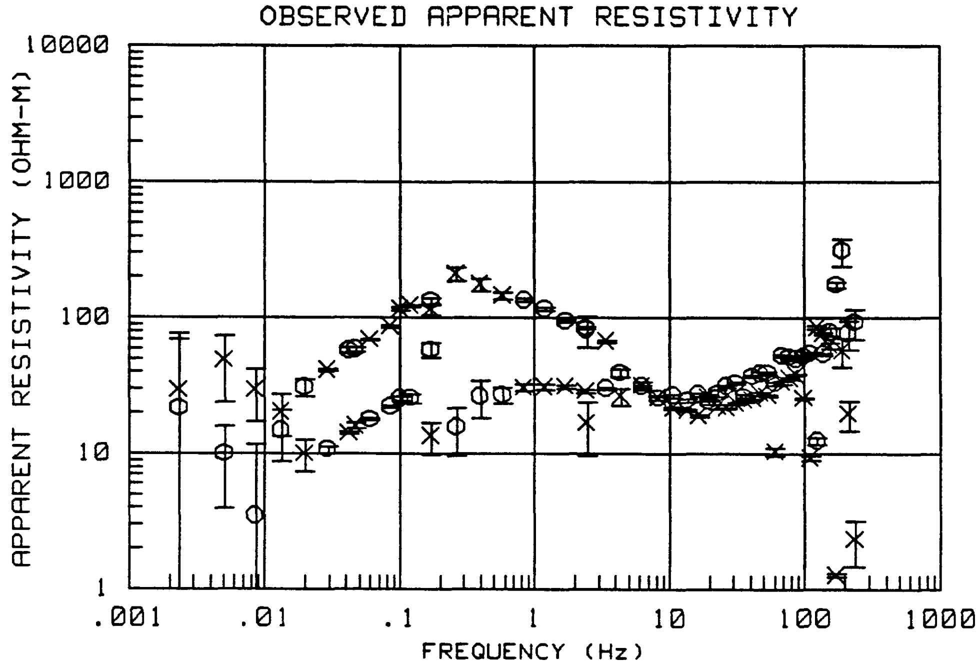


GSH042

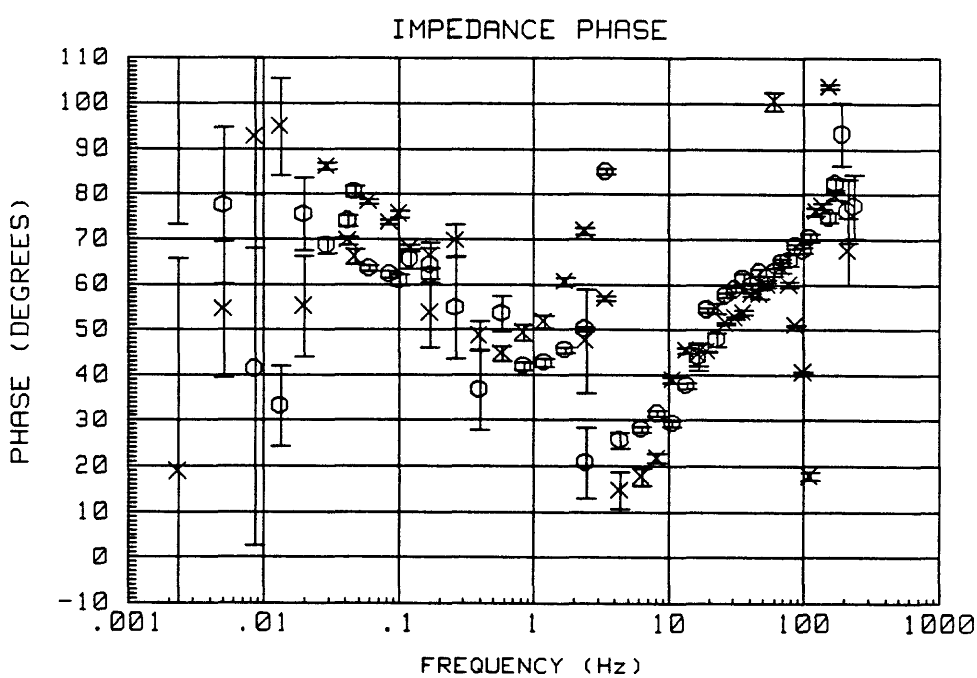
IMPEDANCE SKEW

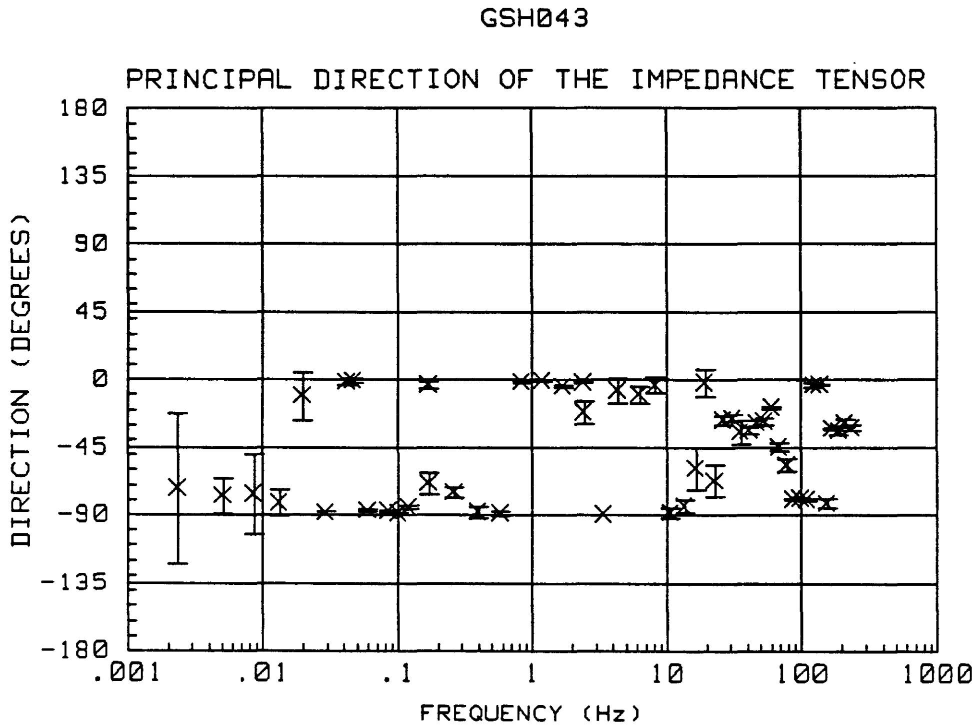


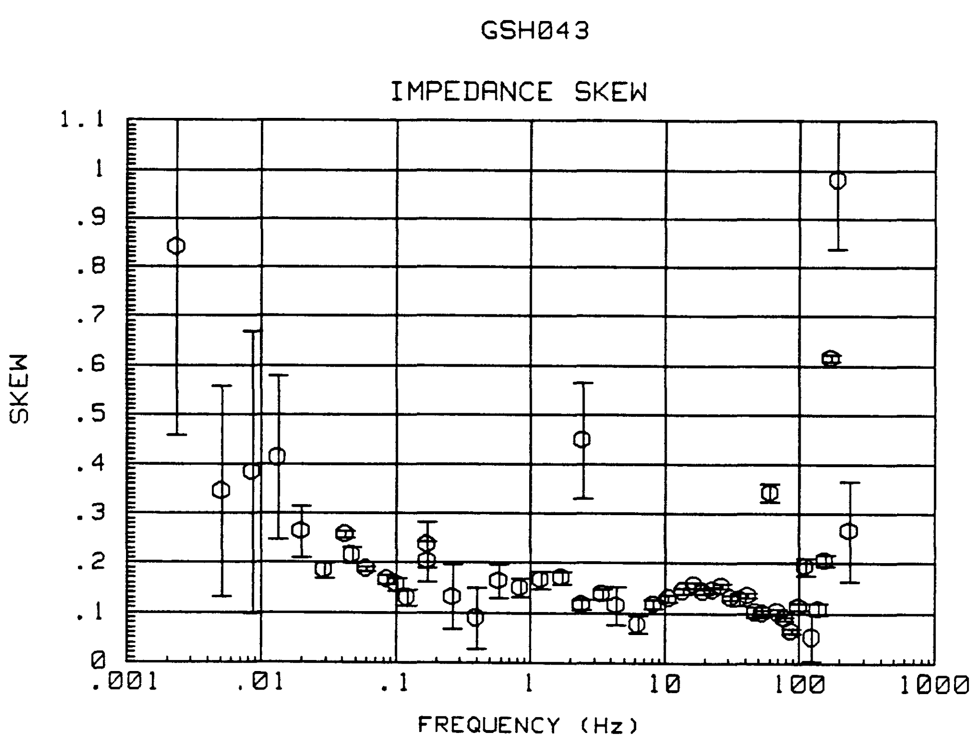
GSH043
GOSHUTE INDIAN RESERVATION, IBAPAH, UTAH
16:22:51 27 May 1991



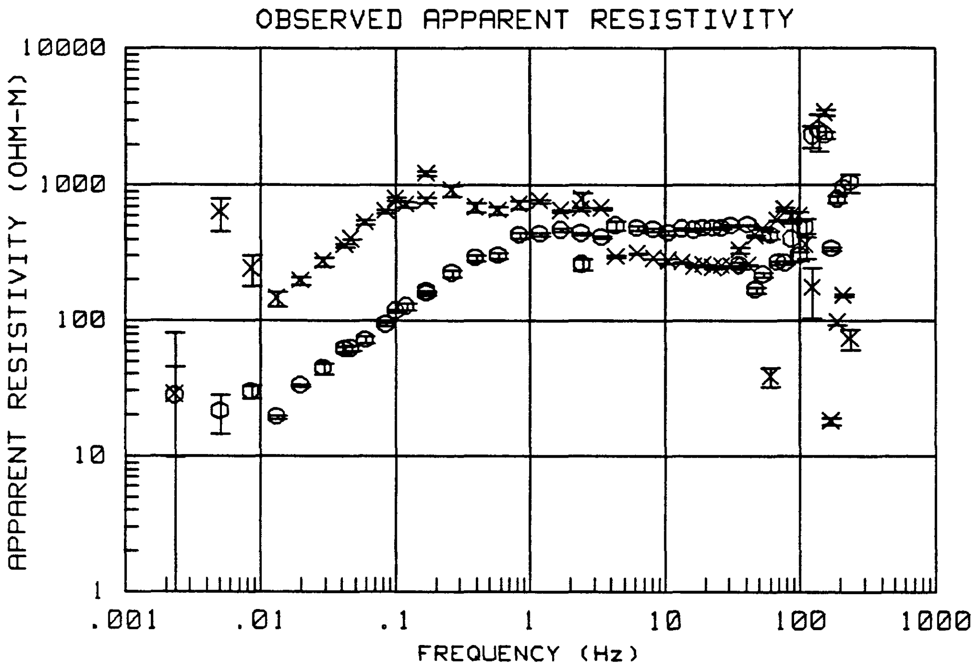
GSH043



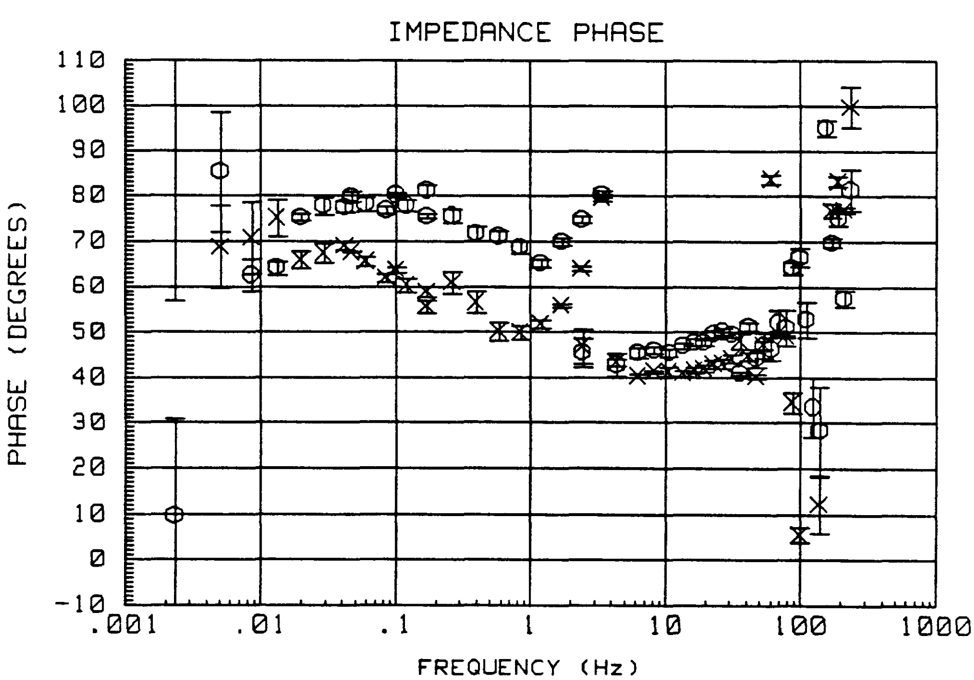

GSH043
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
DIRECTION (DEGREES)
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

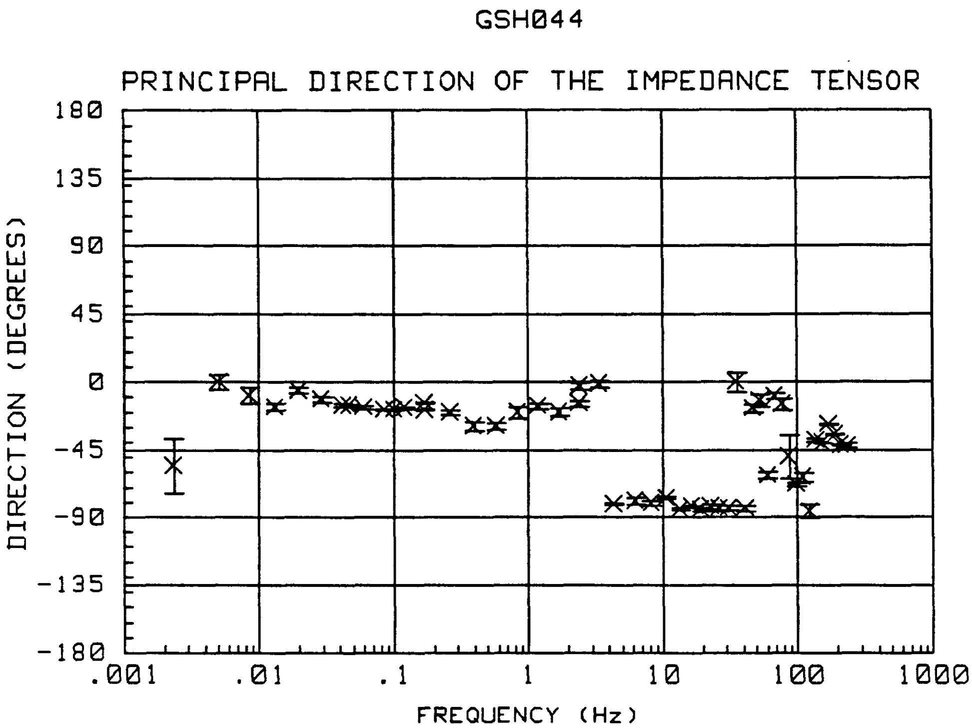

GSH043
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SKEW
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

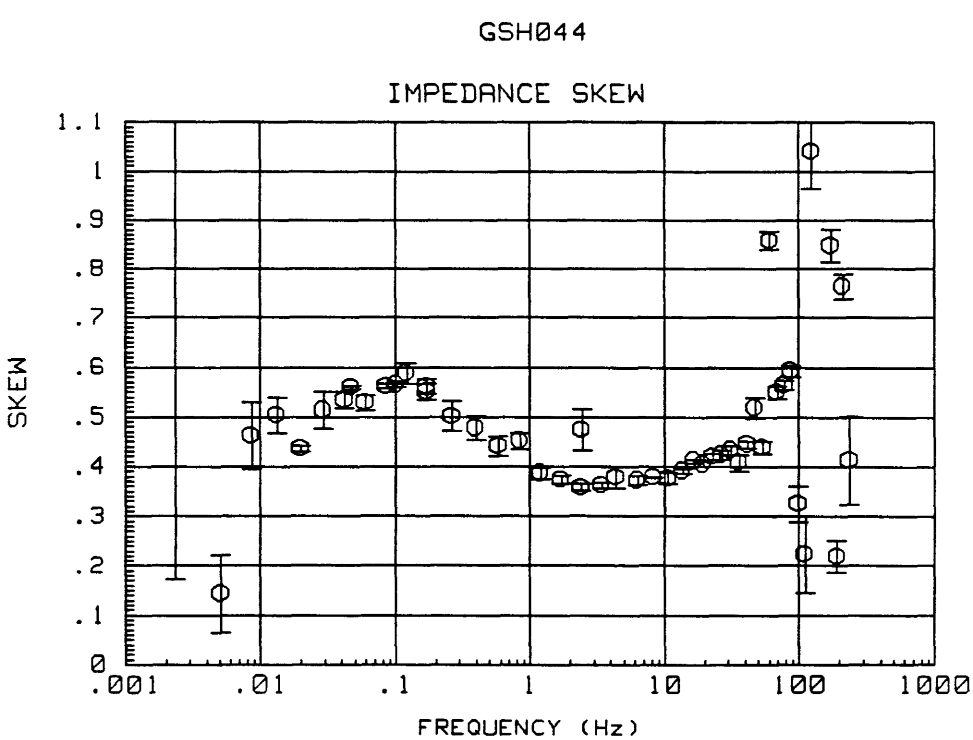
GSH044
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
13:48:18 28 May 1991



GSH044

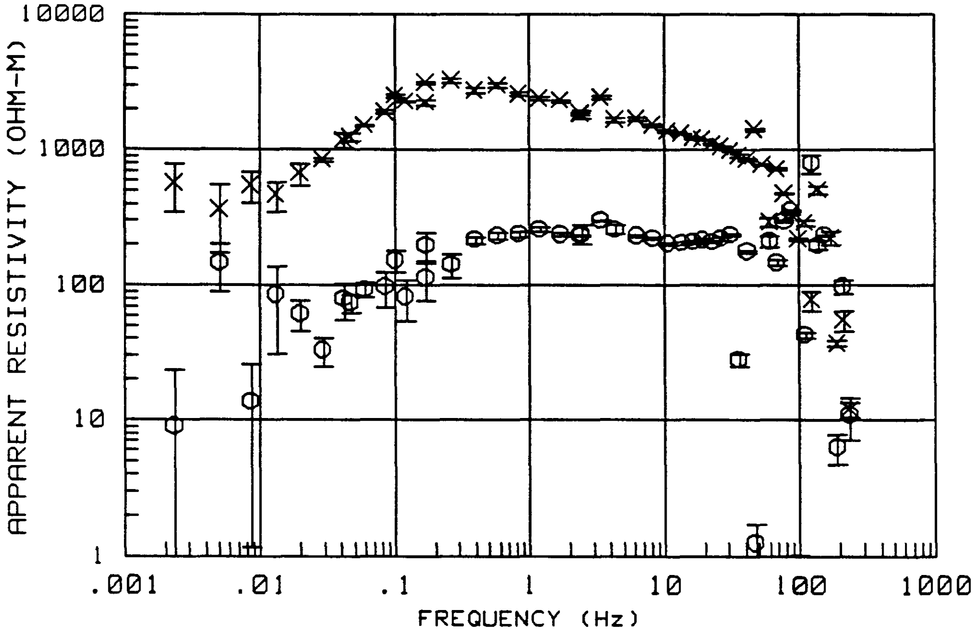



GSH044
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
DIRECTION (DEGREES)
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH044
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SKEW
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

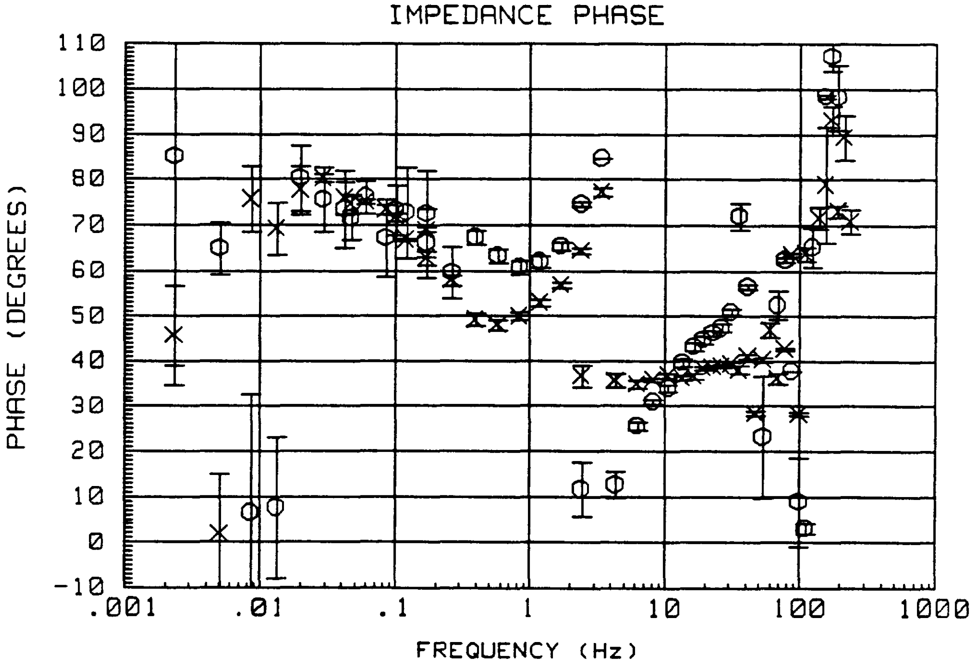
GSH045
GOSHUTE INDIAN RESERVATION, IBAPAH, UTAH
11:00:04 28 May 1991

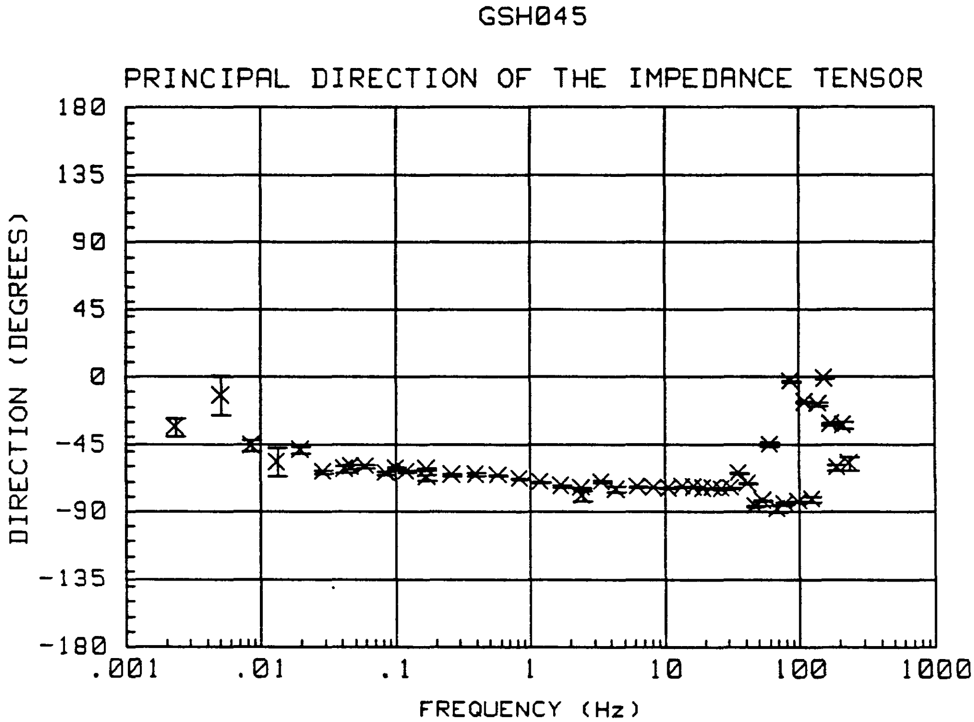
OBSERVED APPARENT RESISTIVITY

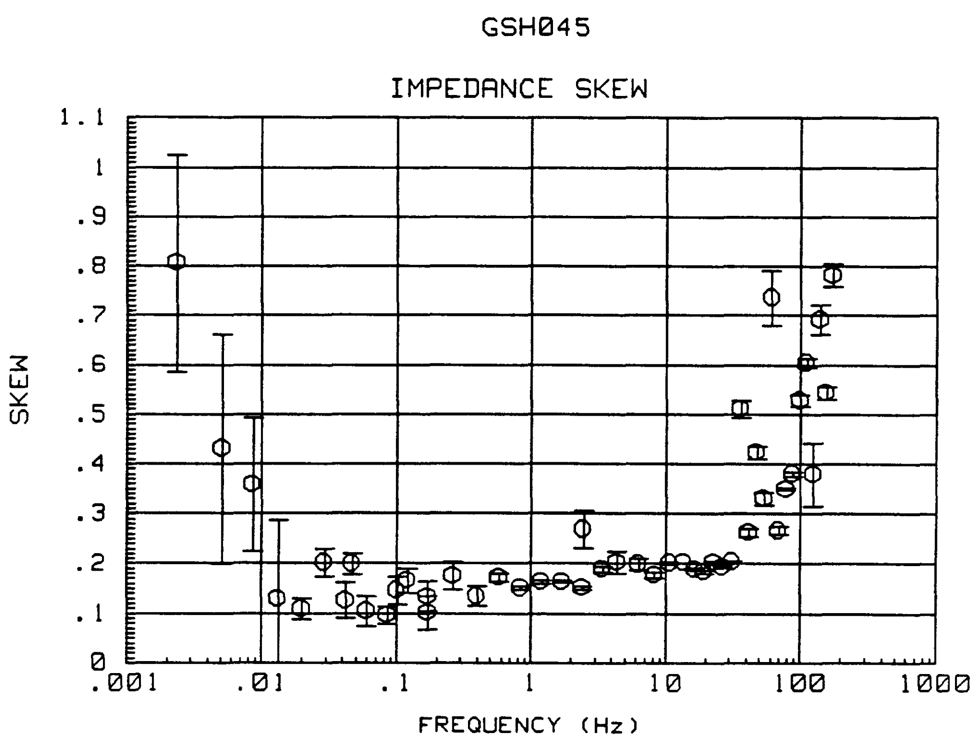


GSH045

IMPEDANCE PHASE



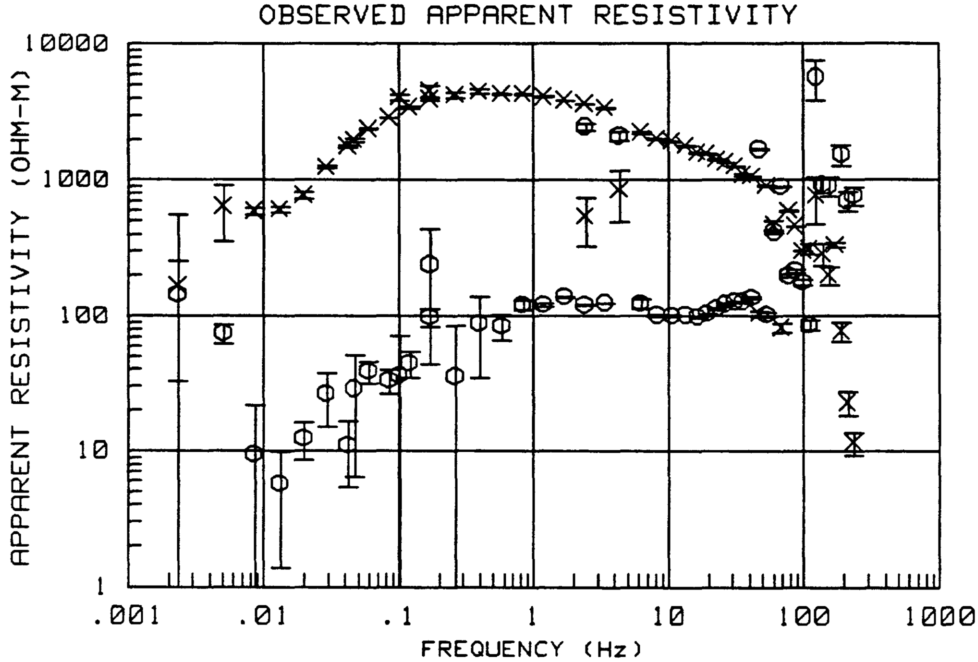

GSH045
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH045
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

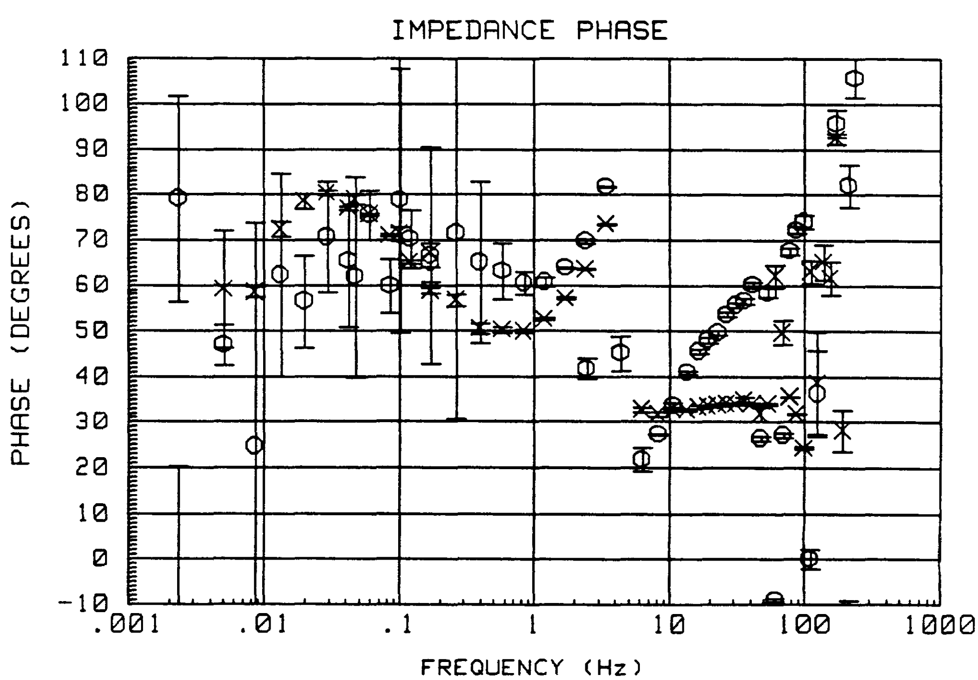
GSH046

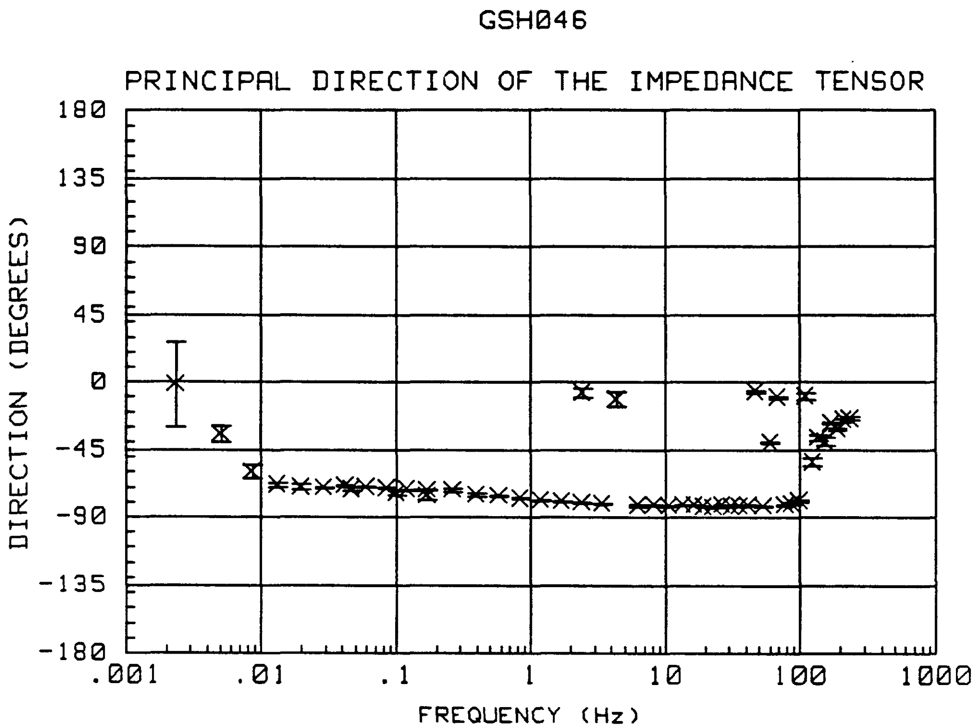
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH

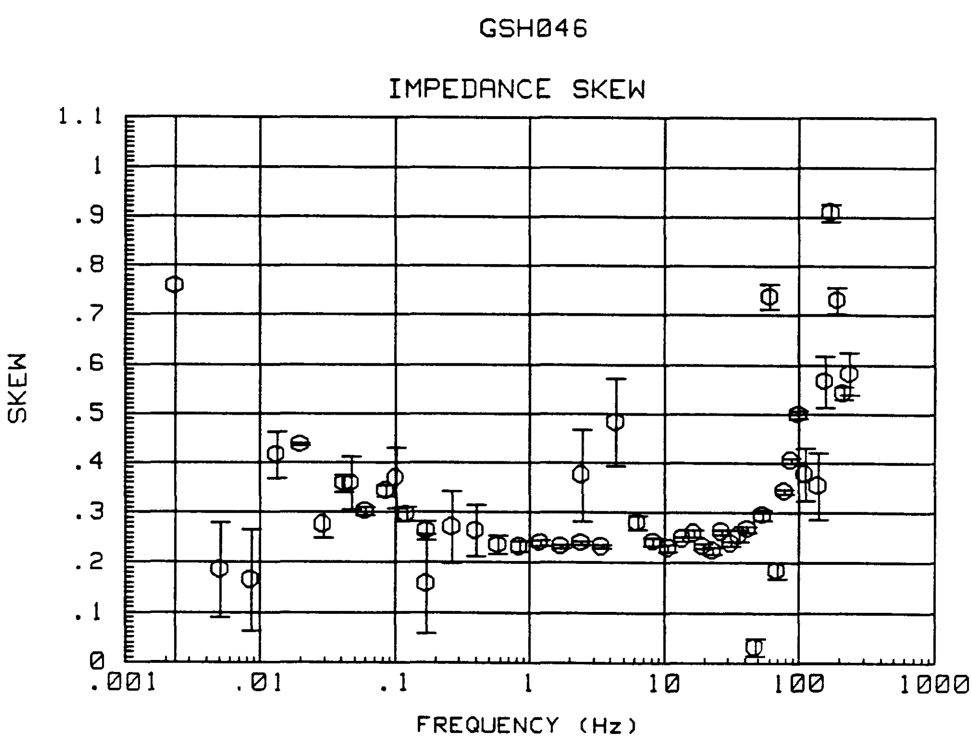
16:58:23 28 May 1991



GSH046

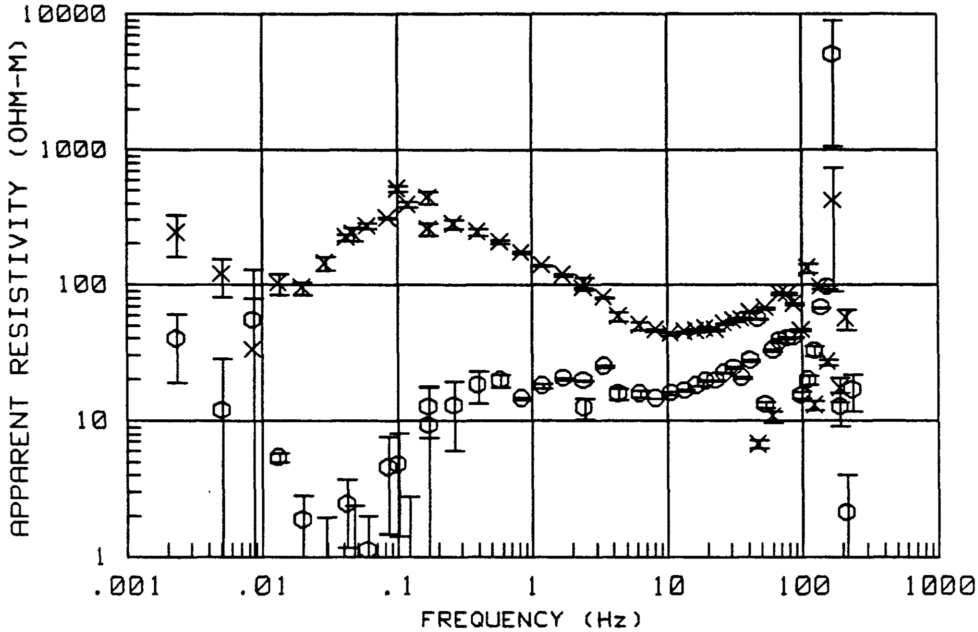



GSH046
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH046
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

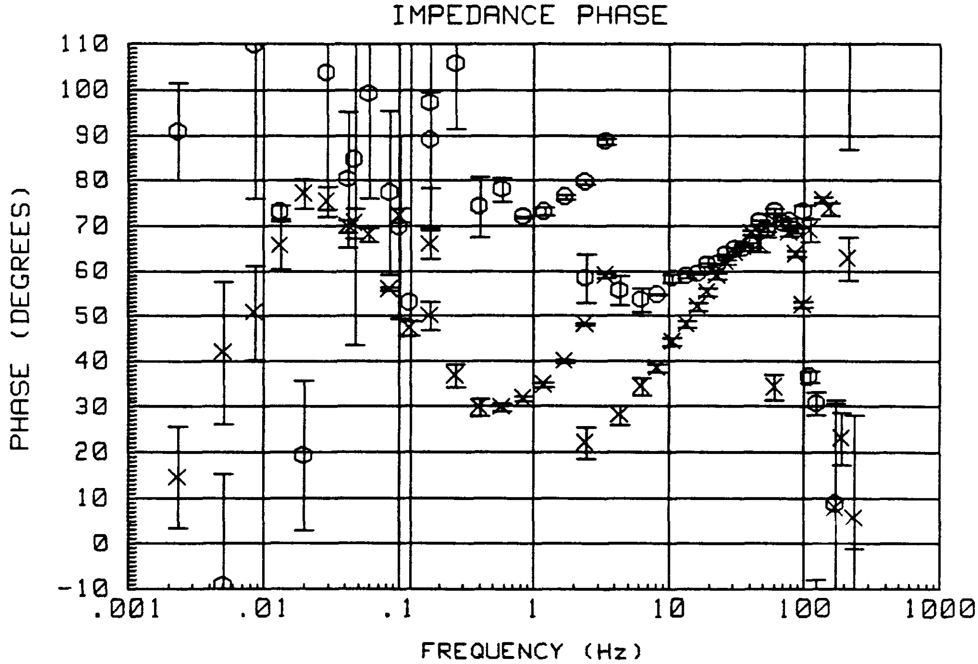
GSH047
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
10:30:24 29 May 1991

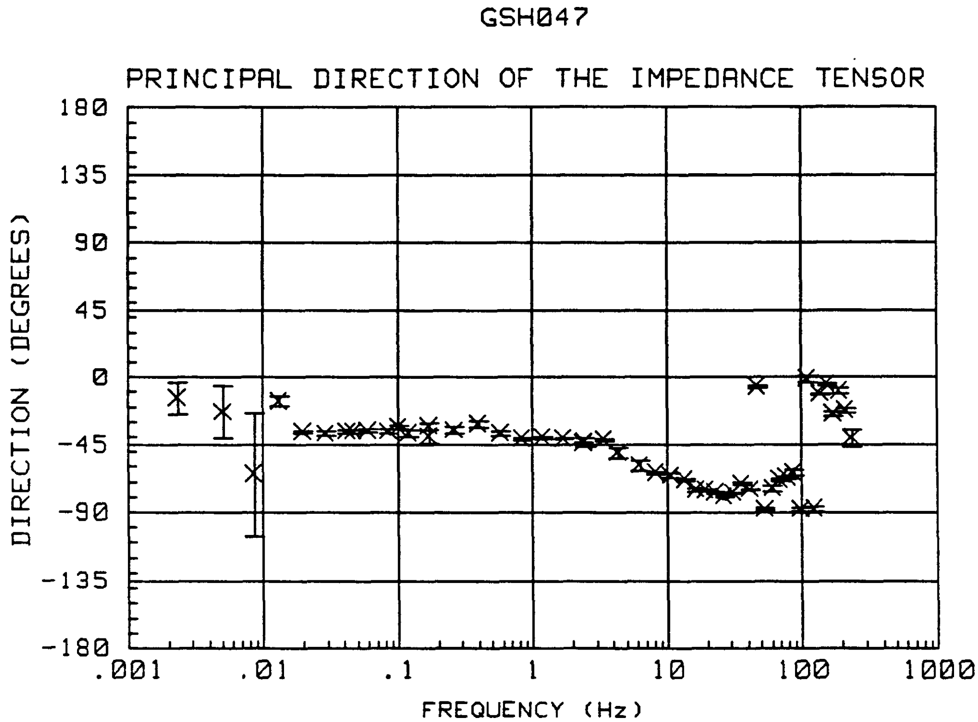
OBSERVED APPARENT RESISTIVITY



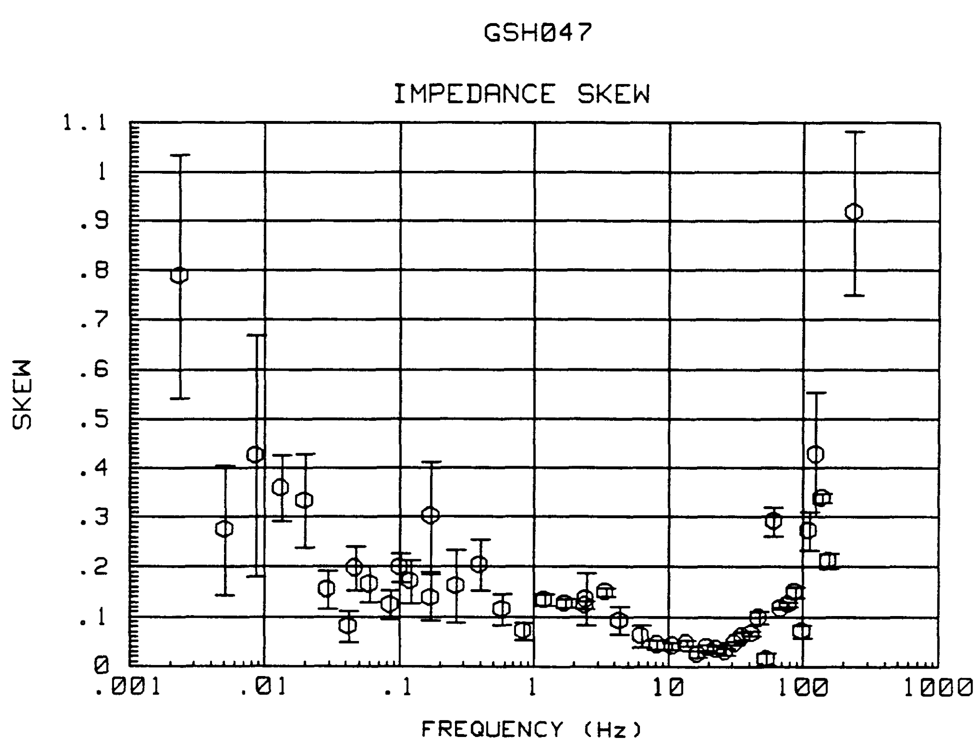
GSH047

IMPEDANCE PHASE





GSH047
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)



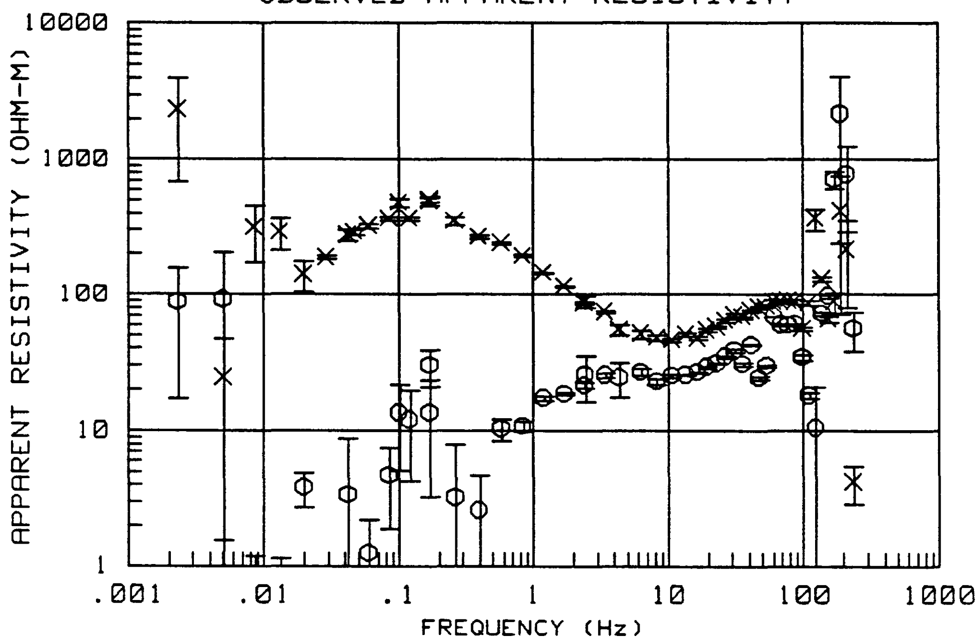
GSH047
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

GSH048

GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH

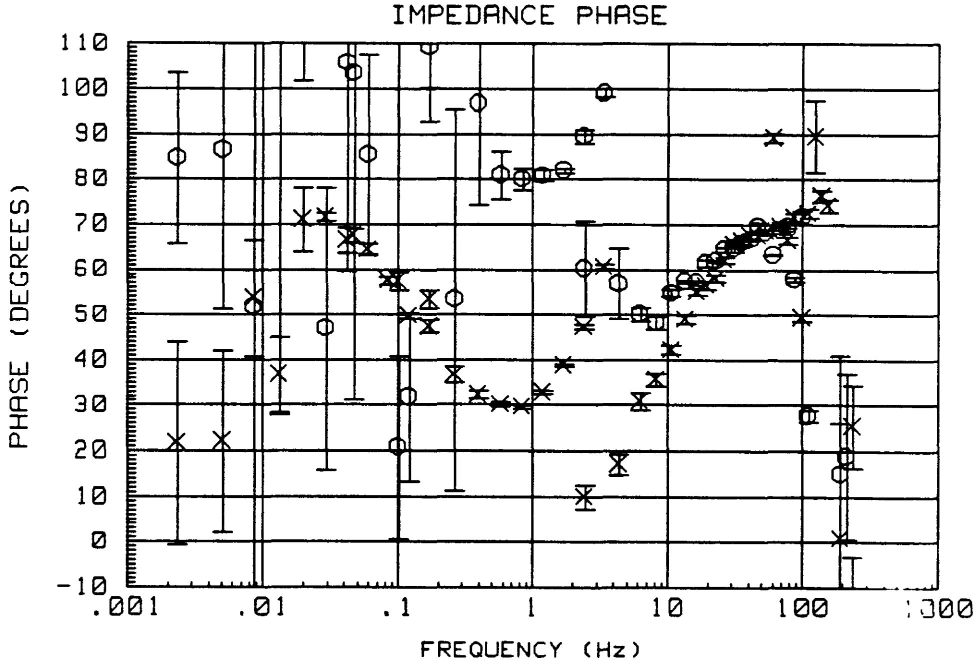
13:08:47 29 May 1991

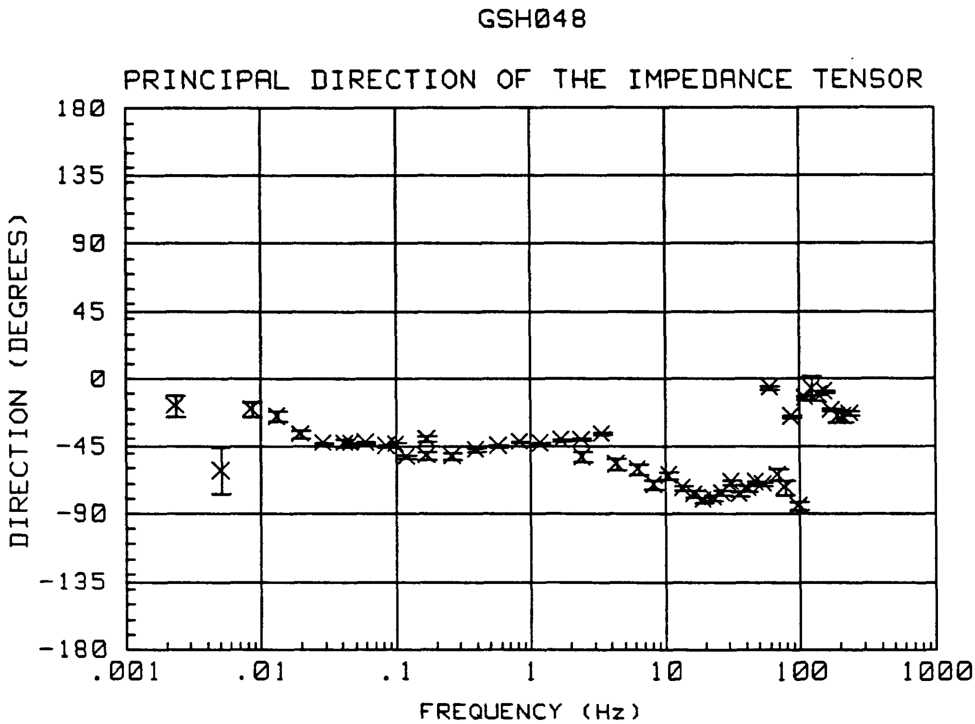
OBSERVED APPARENT RESISTIVITY

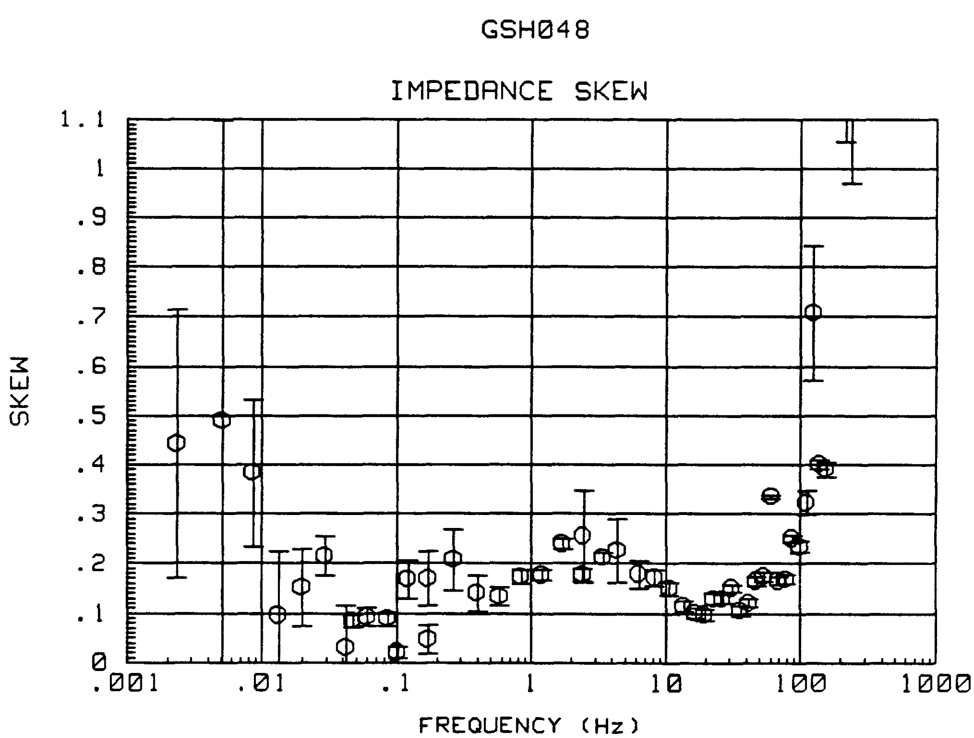


GSH048

IMPEDANCE PHASE

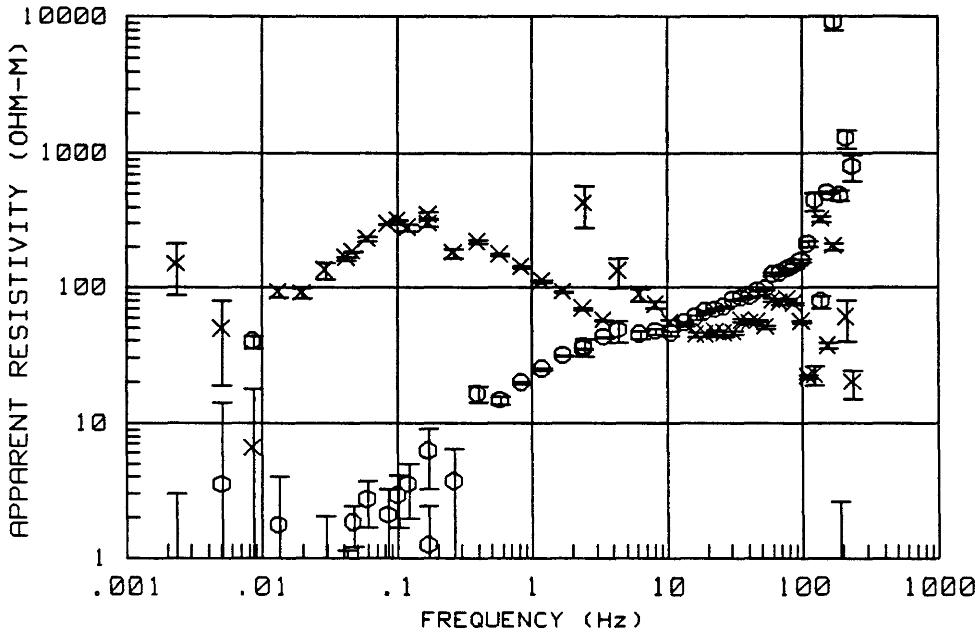



GSH048
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
DIRECTION (DEGREES)
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH048
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SKEW
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

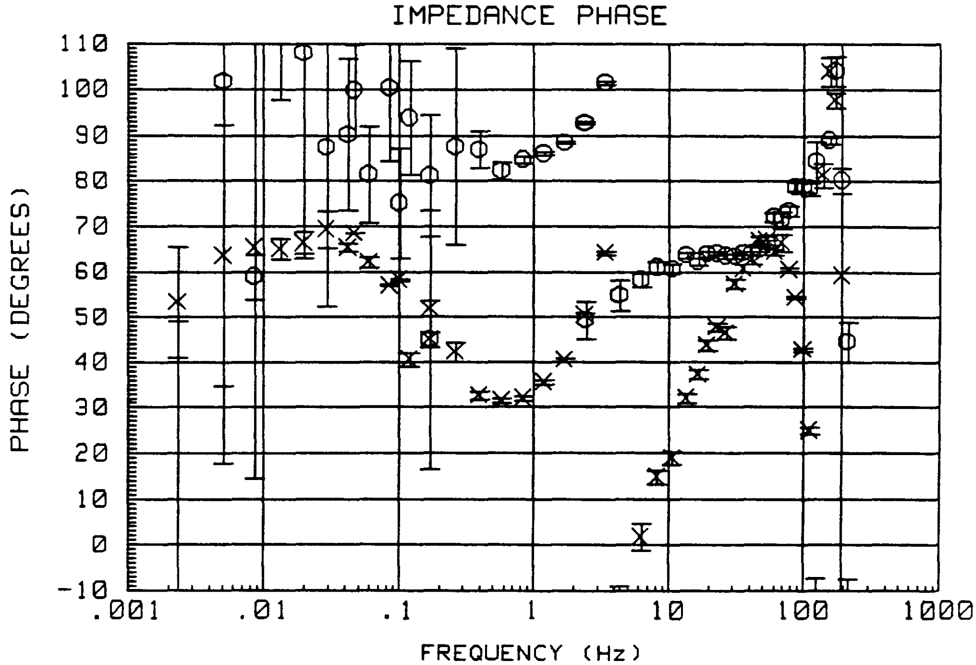
GSH049
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
16:12:50 29 May 1991

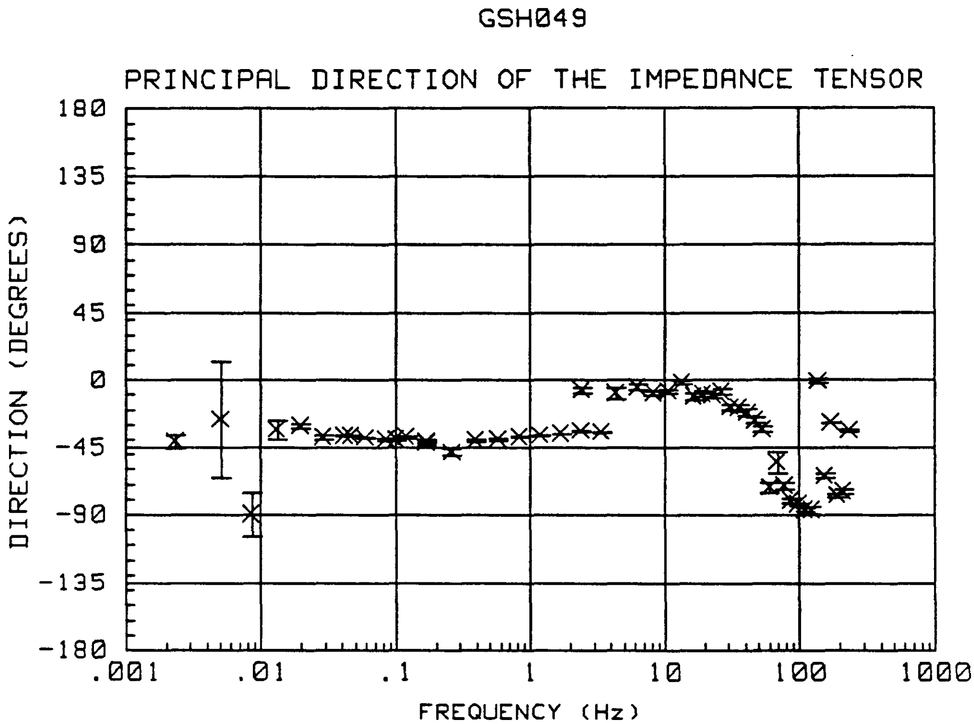
OBSERVED APPARENT RESISTIVITY

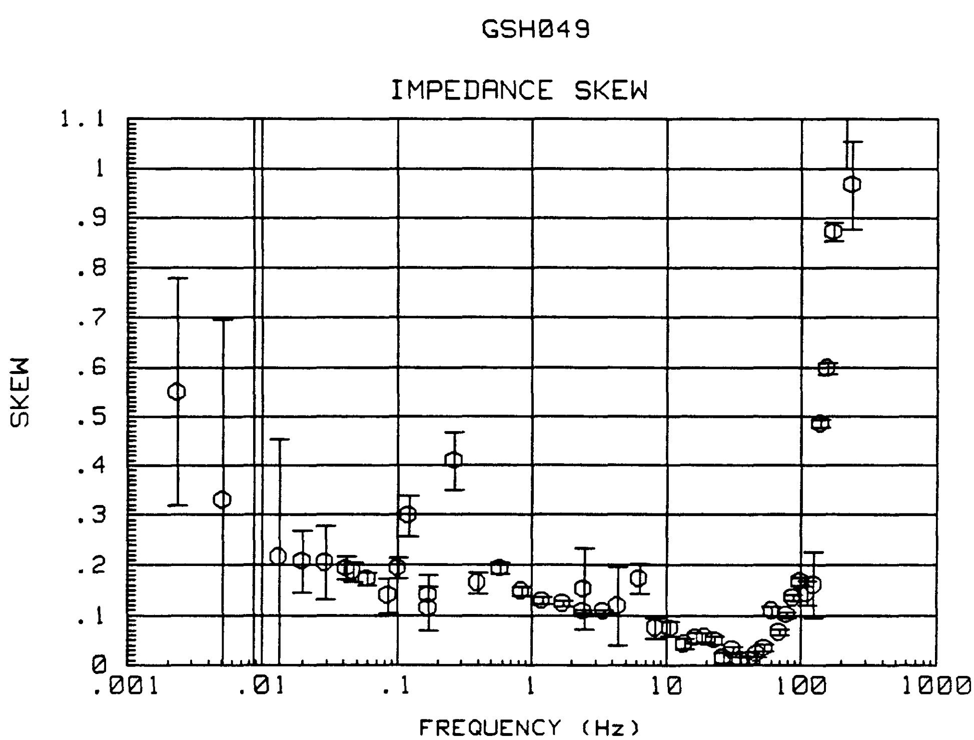


GSH049

IMPEDANCE PHASE

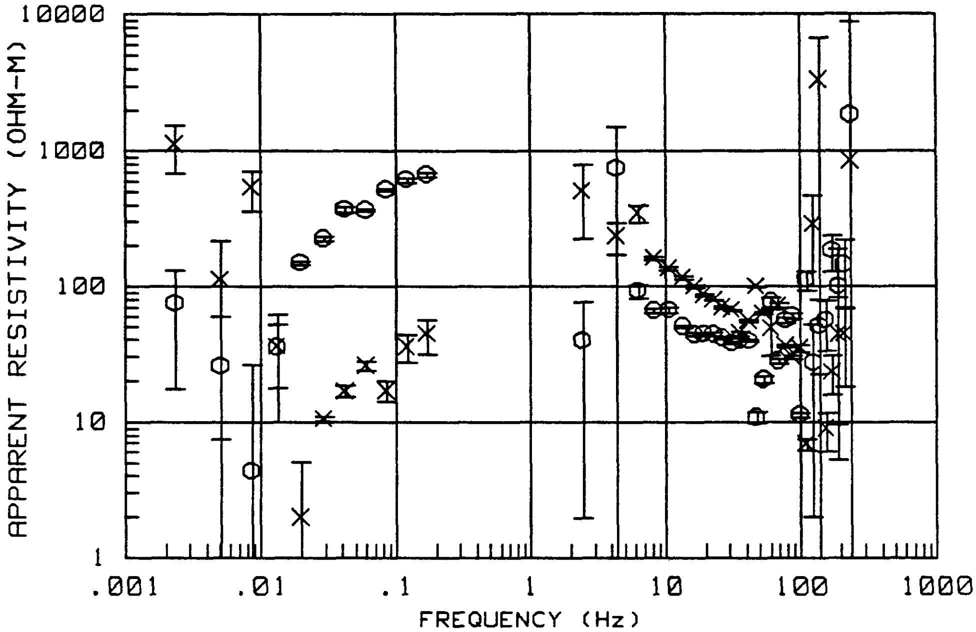



GSH049
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)


GSH049
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

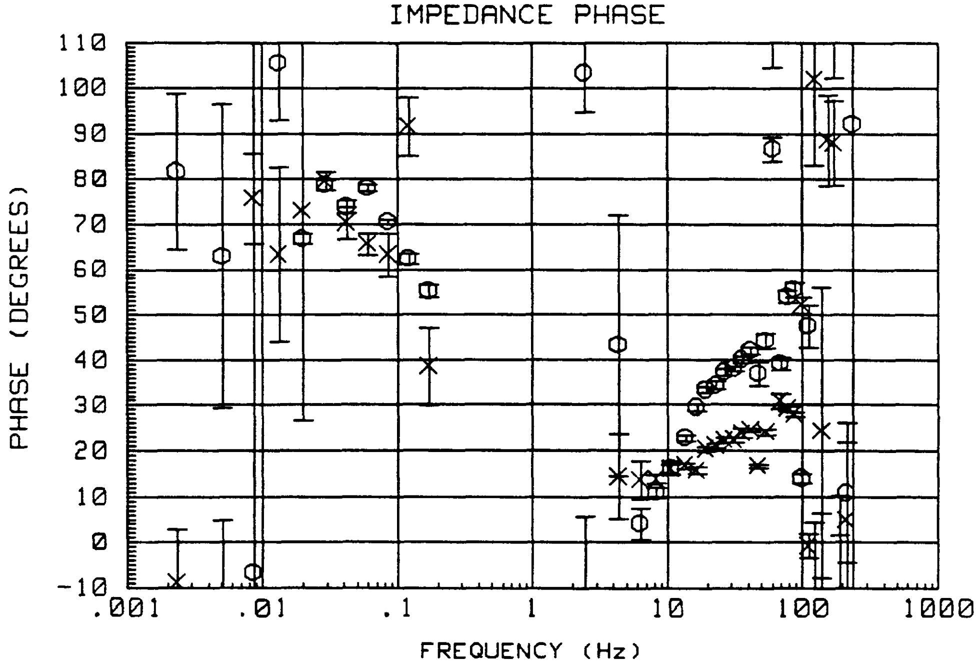
GSH050
GOSHUTE INDIAN RESERVATION, IBAPAH, UTAH
15:27:37 30 May 1991

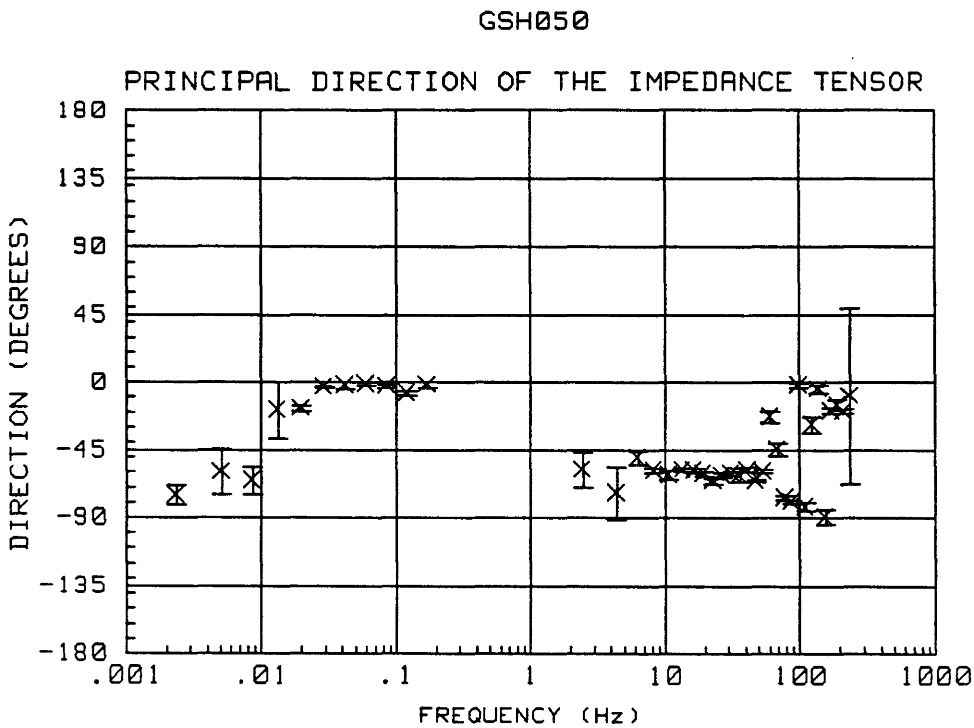
OBSERVED APPARENT RESISTIVITY

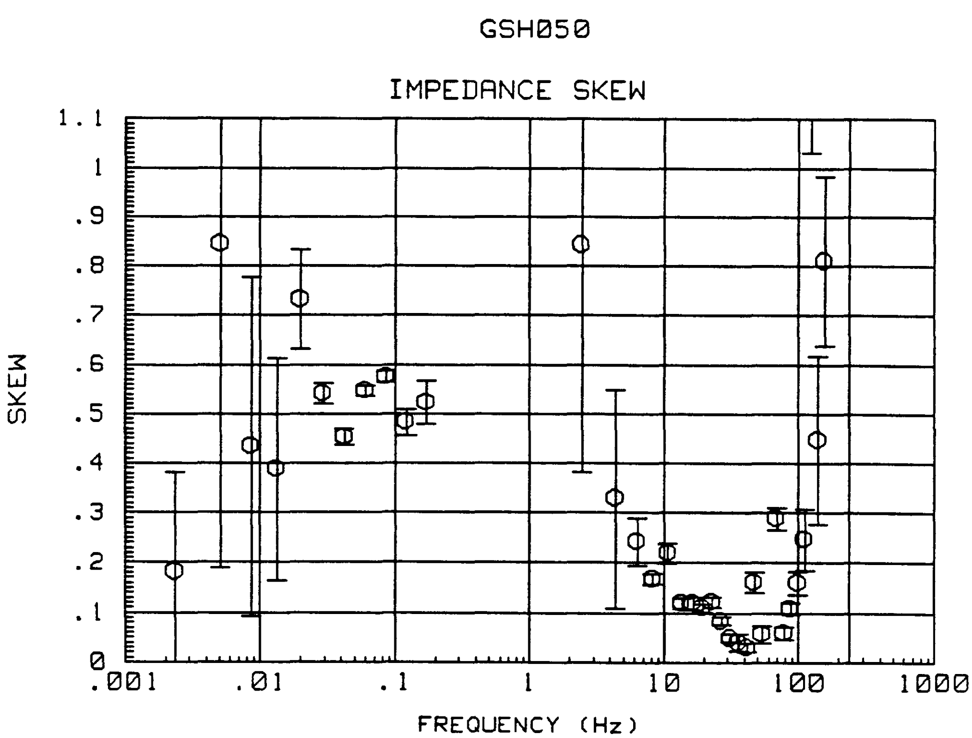


GSH050

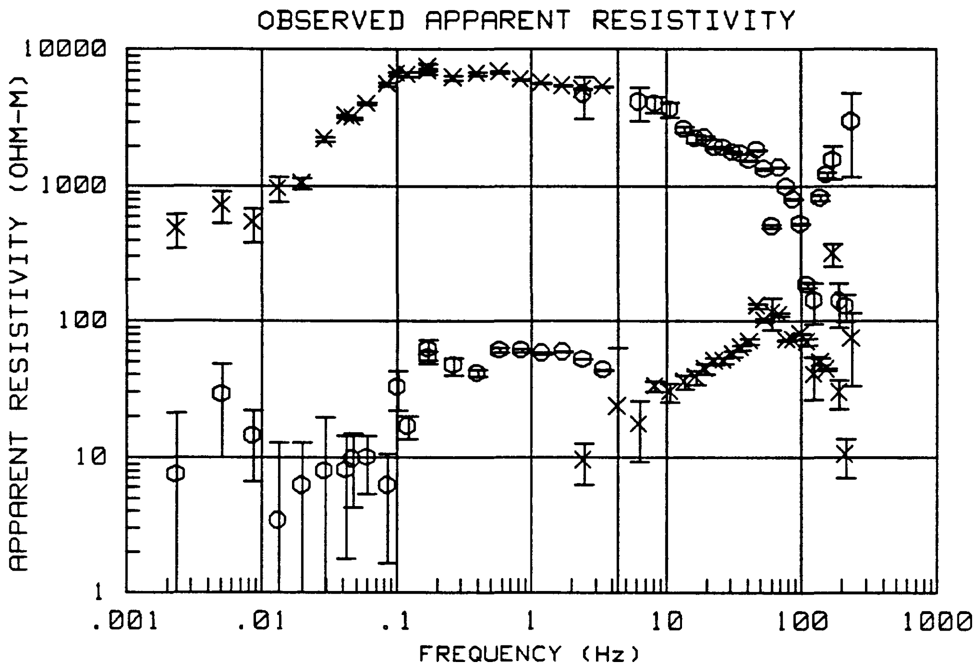
IMPEDANCE PHASE



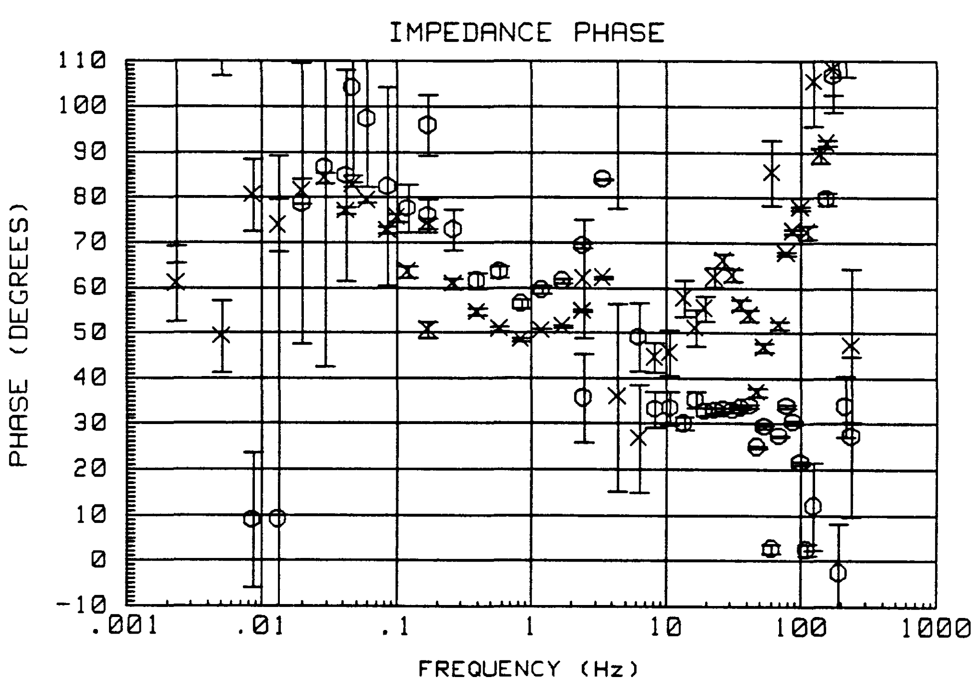

GSH050
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
DIRECTION (DEGREES)
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

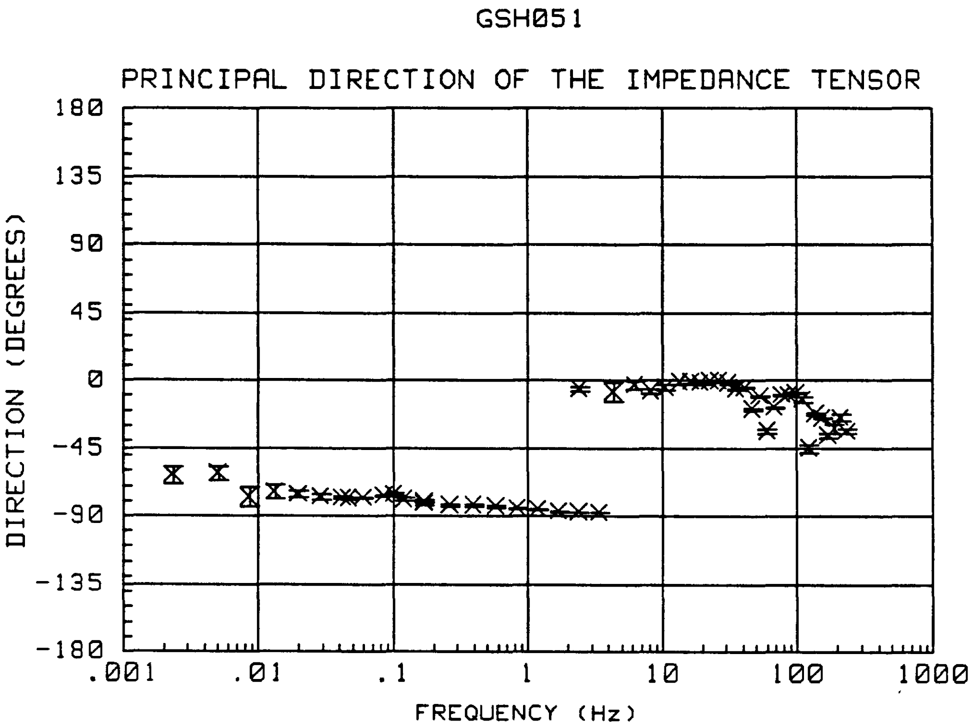

GSH050
IMPEDANCE SKEW
SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)

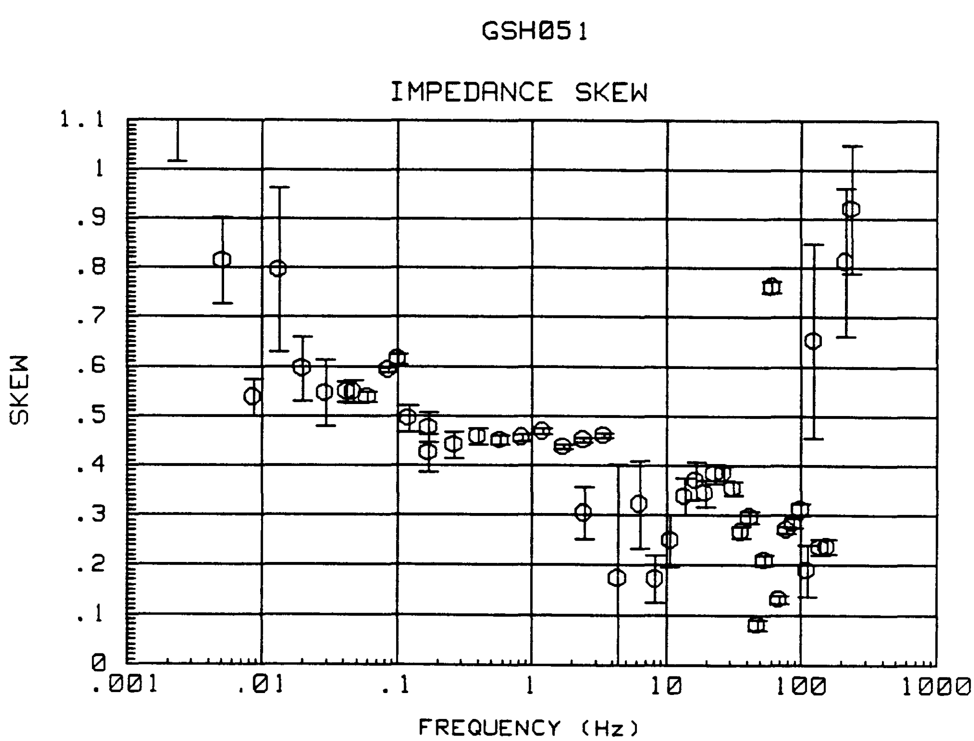
GSH051
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
16:15:33 30 May 1991



GSH051

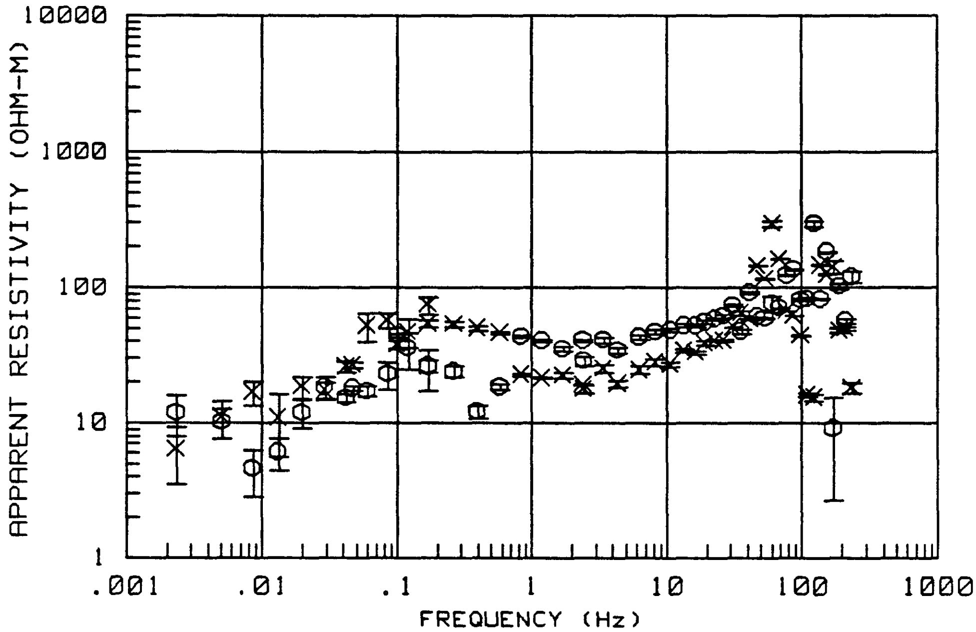



GSH051
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR
180
135
90
45
0
-45
-90
-135
-180
.001
.01
.1
1
10
100
1000
DIRECTION (DEGREES)
FREQUENCY (Hz)


GSH051
IMPEDANCE SKEW
1.1
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.001
.01
.1
1
10
100
1000
SKEW
FREQUENCY (Hz)

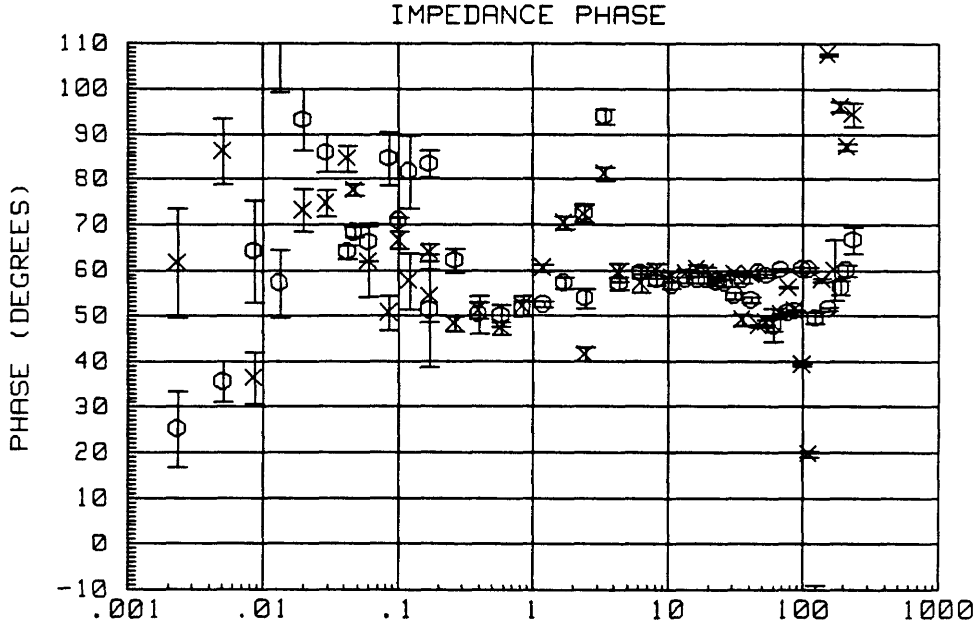
GSHØ52
GOSHUTE INDIAN RESERVATION, IBAPAH,UTAH
11:33:45 1 Jun 1991

OBSERVED APPARENT RESISTIVITY



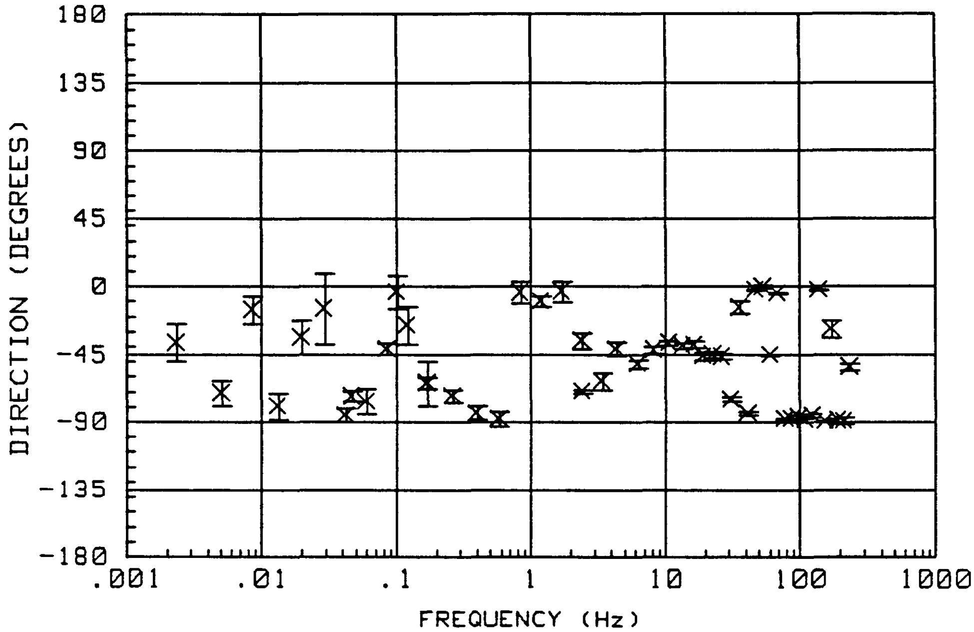
GSHØ52

IMPEDANCE PHASE



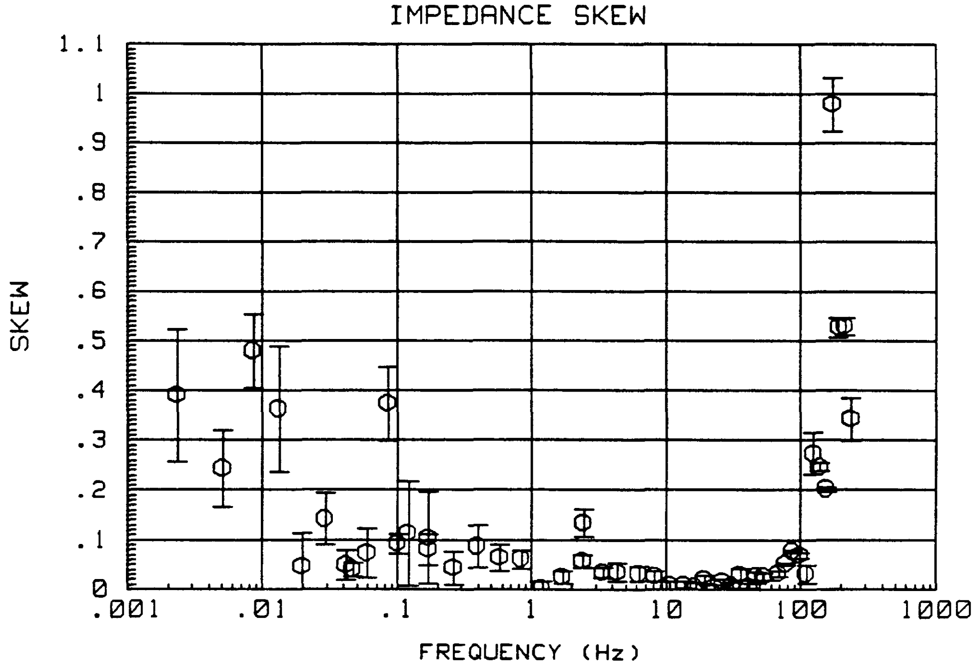
GSH052

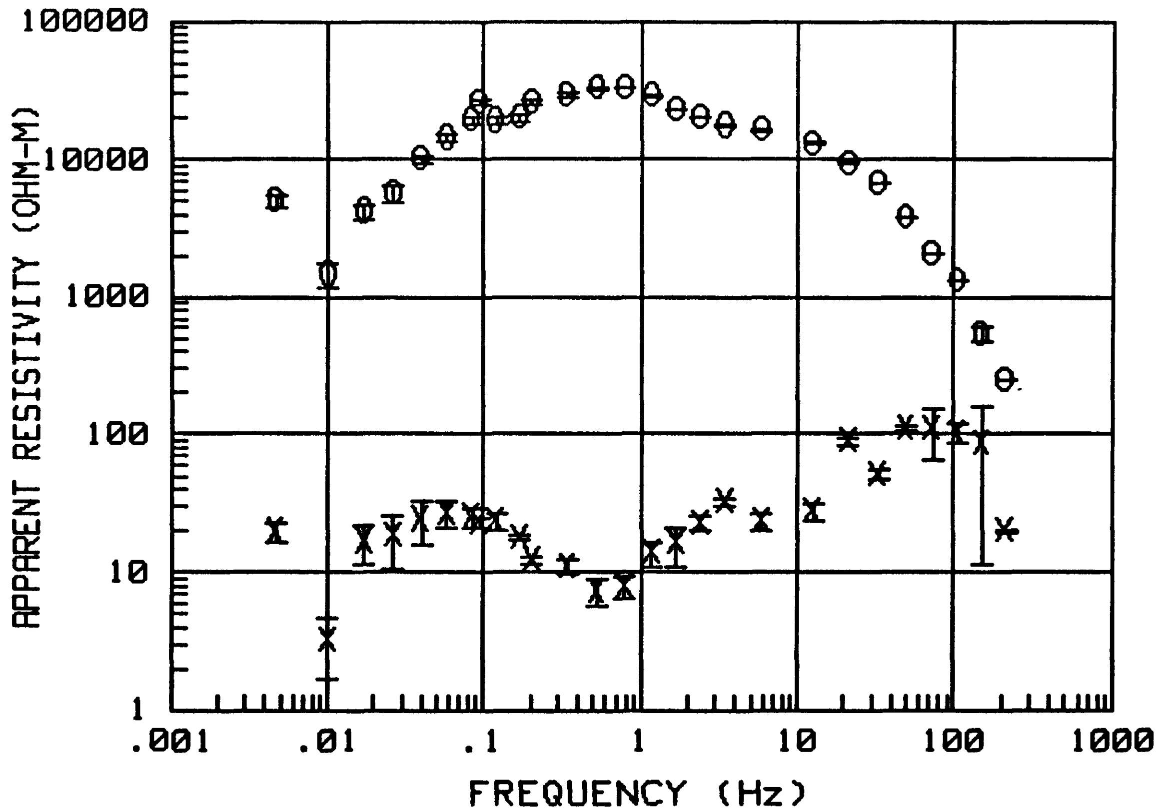
PRINCIPAL DIRECTION OF THE IMPEDANCE TENSOR



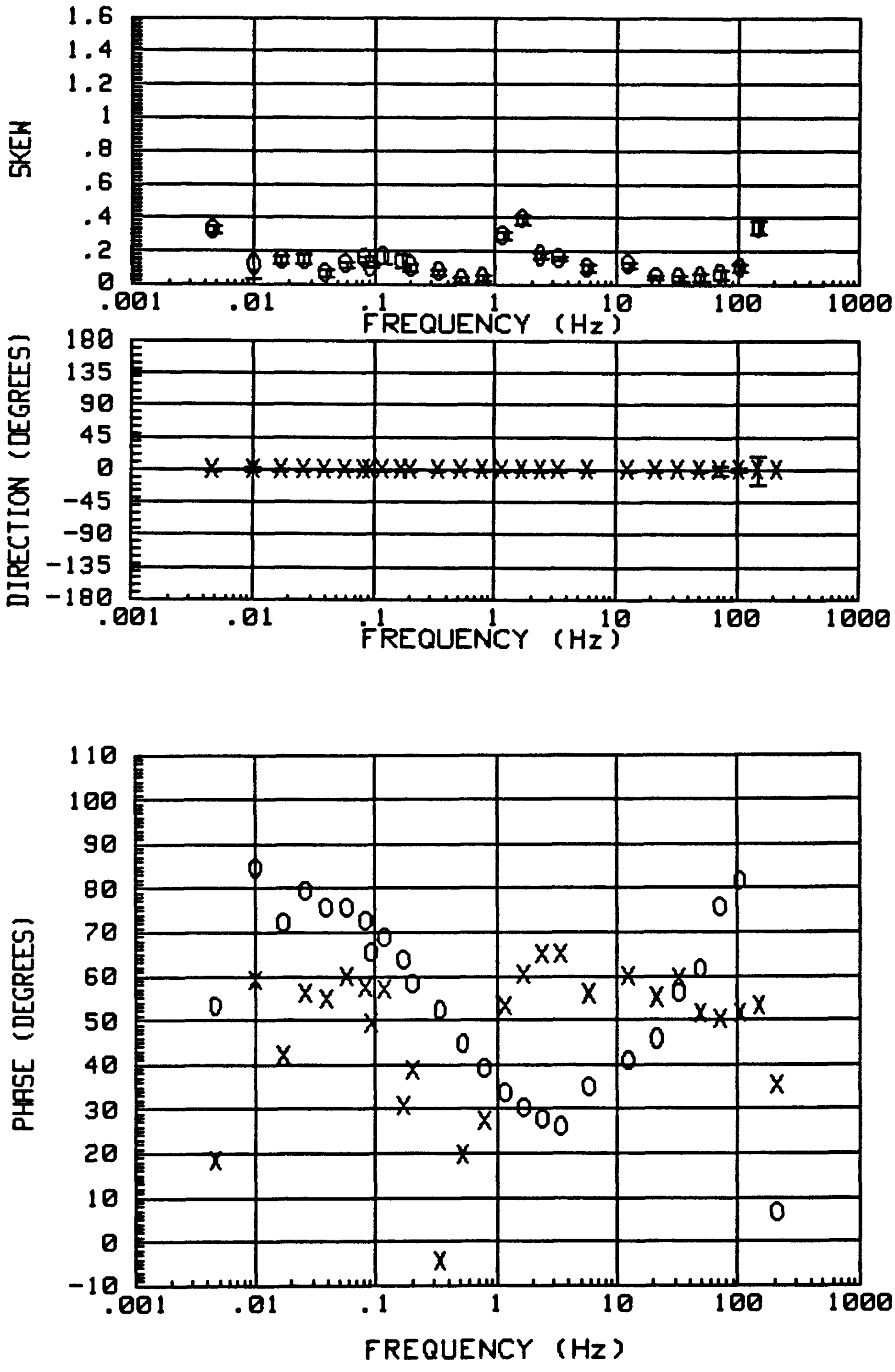
GSH052

IMPEDANCE SKEW

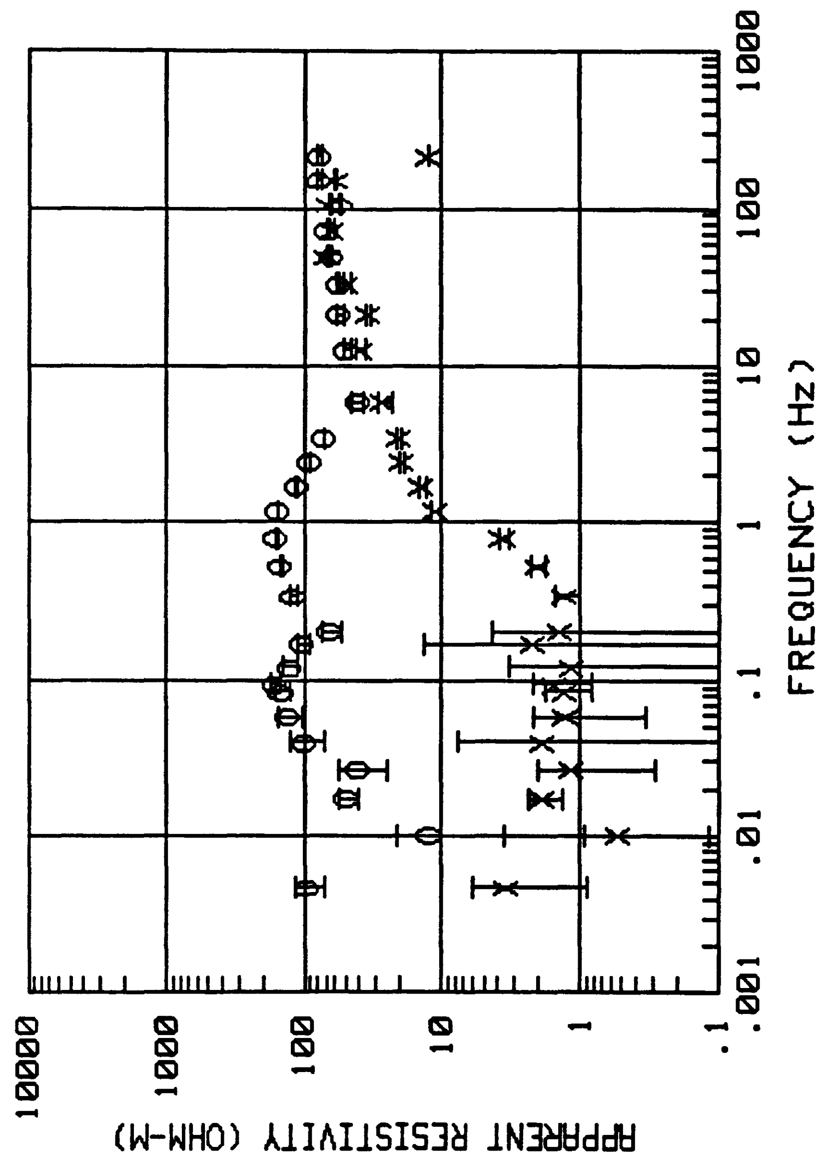




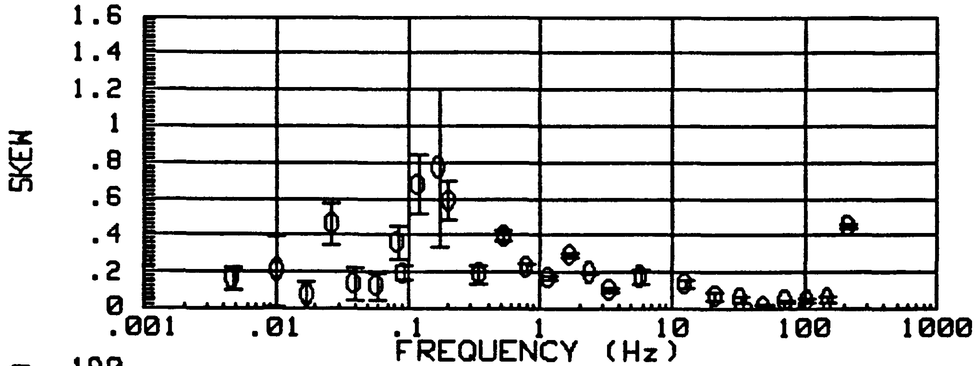
Station Name= GSH053
Fixed Rotation Angle= -1 Degrees
06:13:47 15 Aug 1991

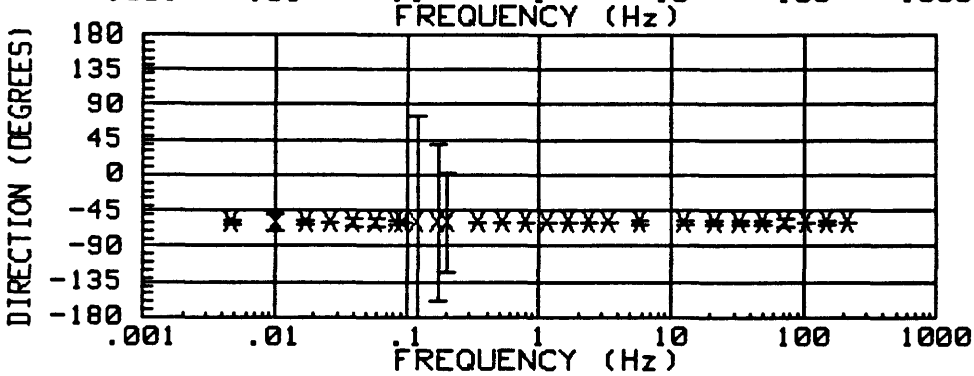


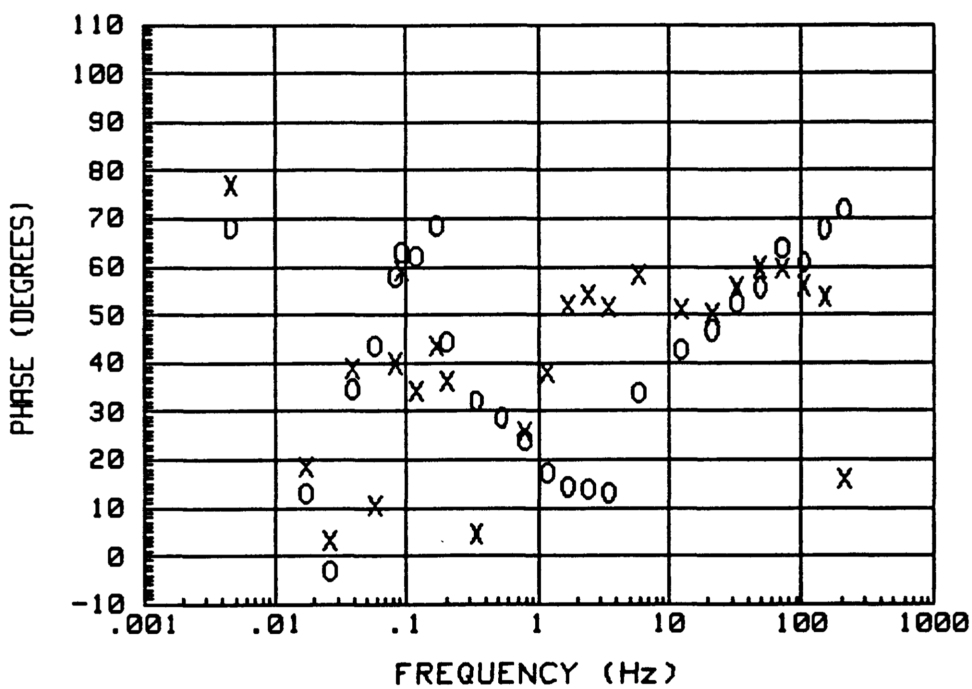
Station Name= GSH053
Fixed Rotation Angle= -1 Degrees
06:13:47 15 Aug 1991



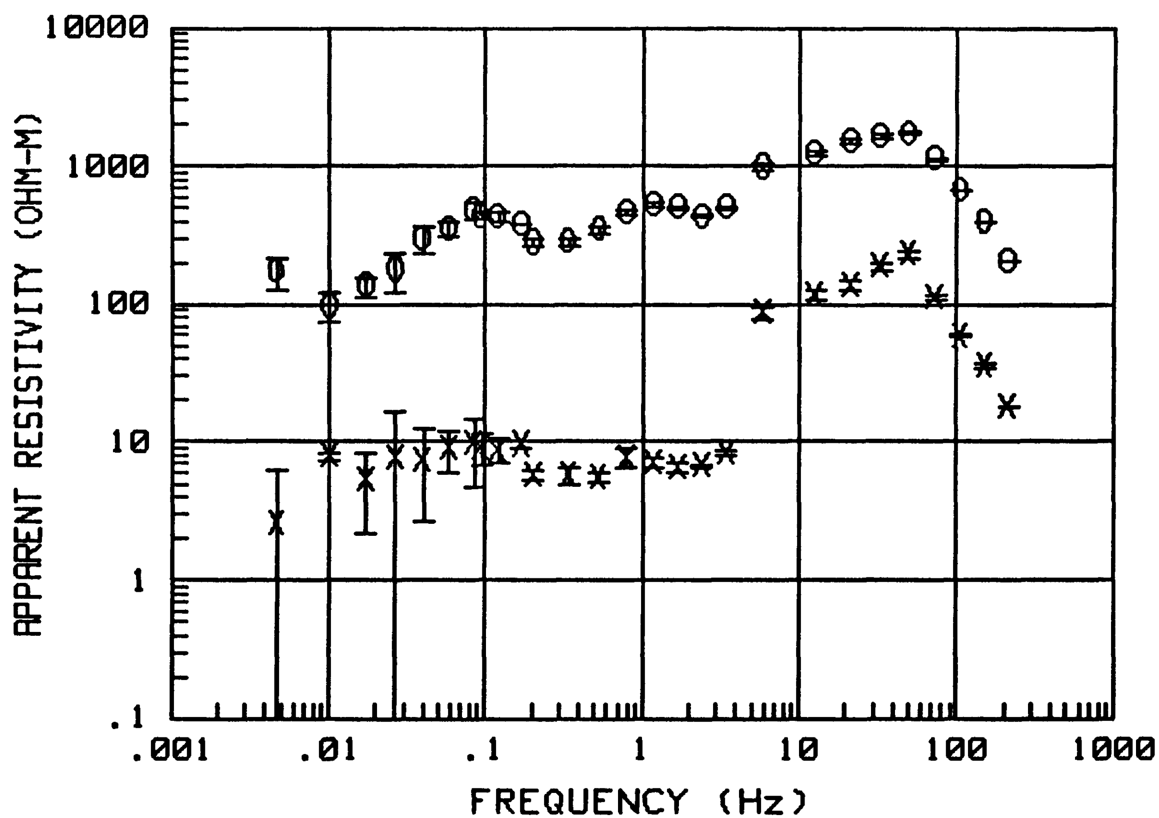
Station Name= GSH054
Fixed Rotation Angle= -60 Degrees
09:28:15 15 Aug 1991



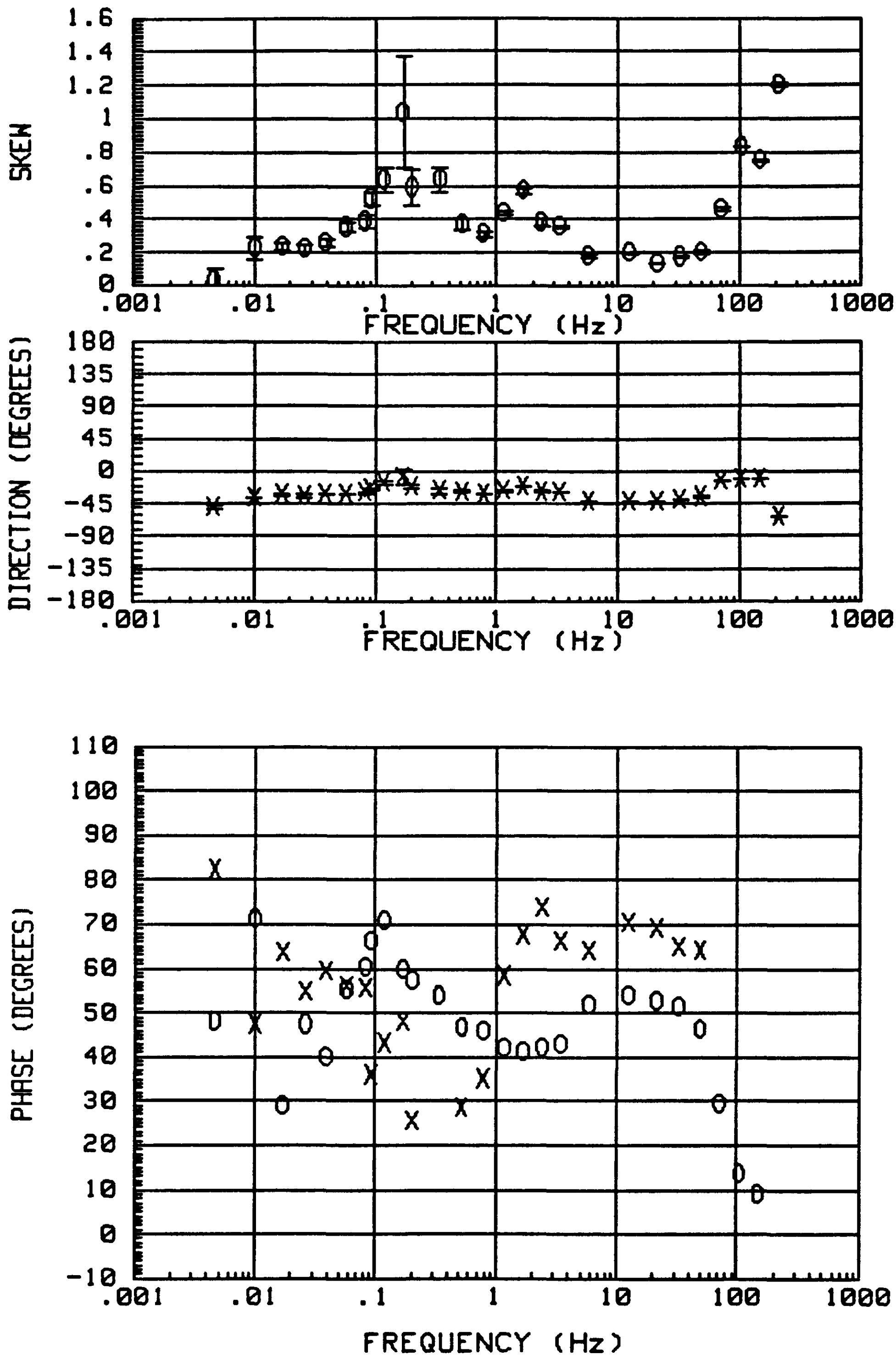




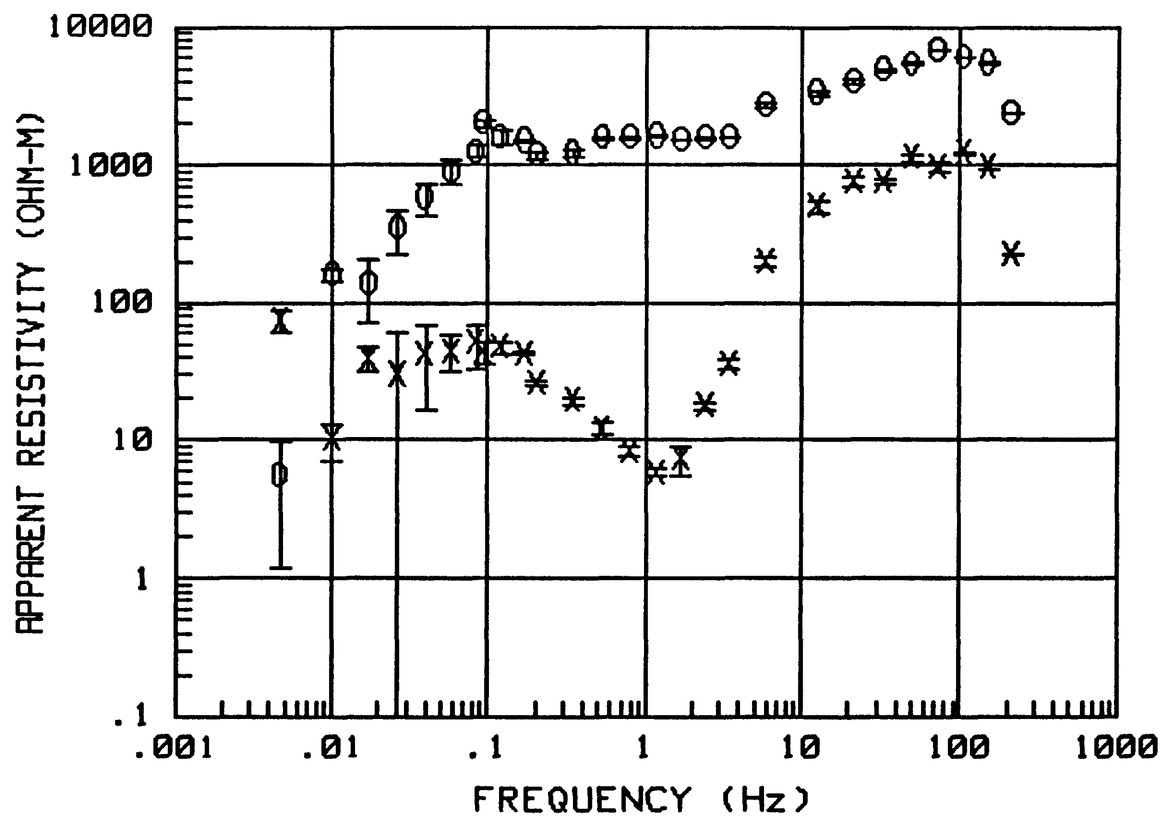
Station Name= GSH054
Fixed Rotation Angle= -60 Degrees
09:28:15 15 Aug 1991



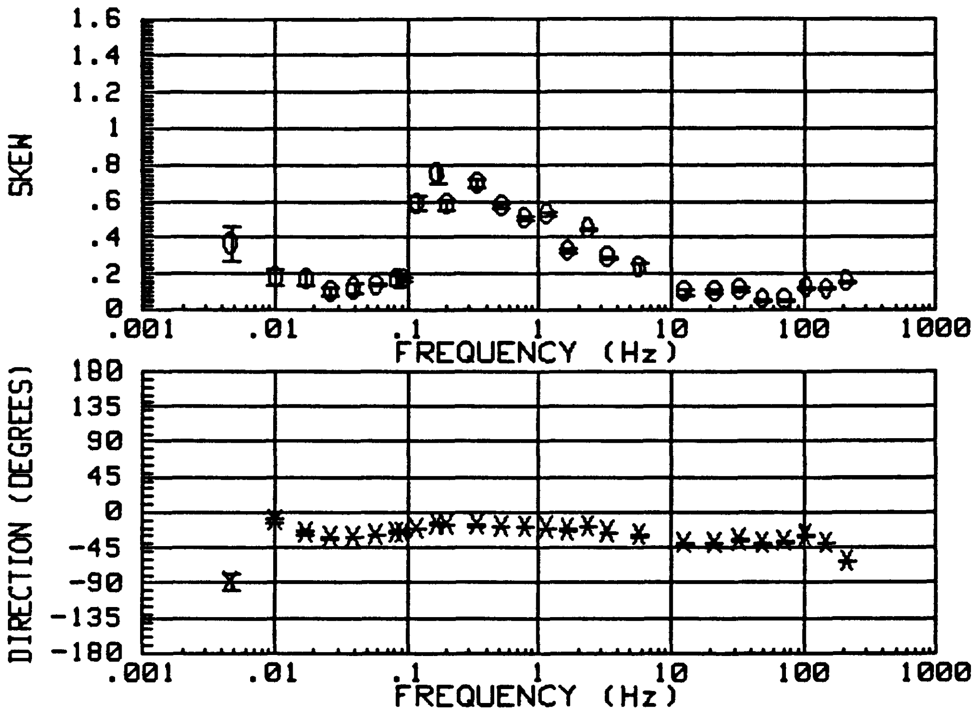
Station Name= GSH055
Free Rotation
12:35:36 15 Aug 1991

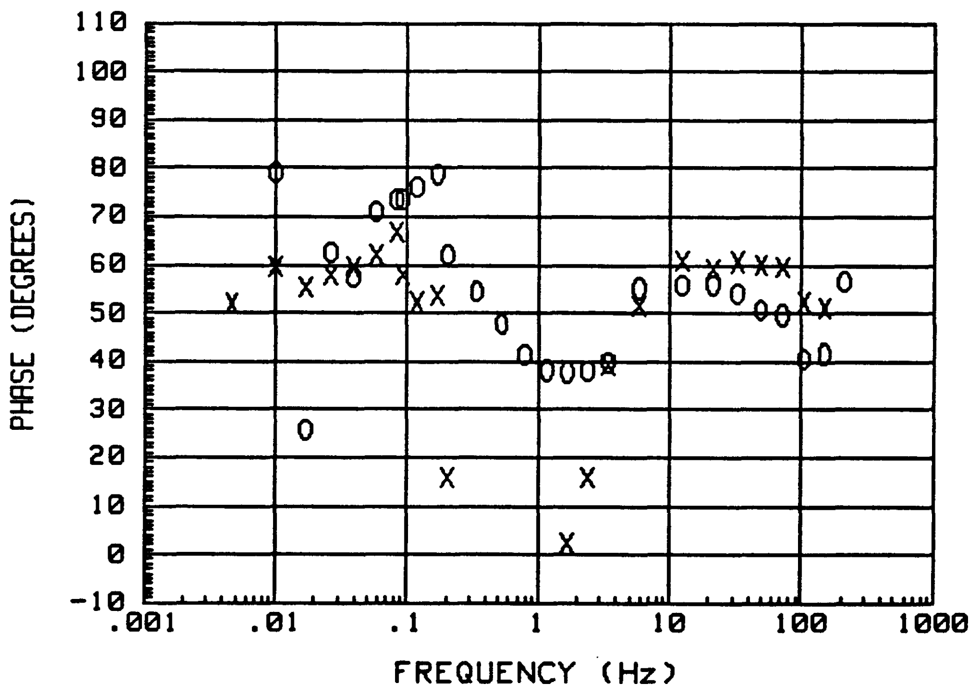


Station Name= GSH055
Free Rotation
12:35:36 15 Aug 1991

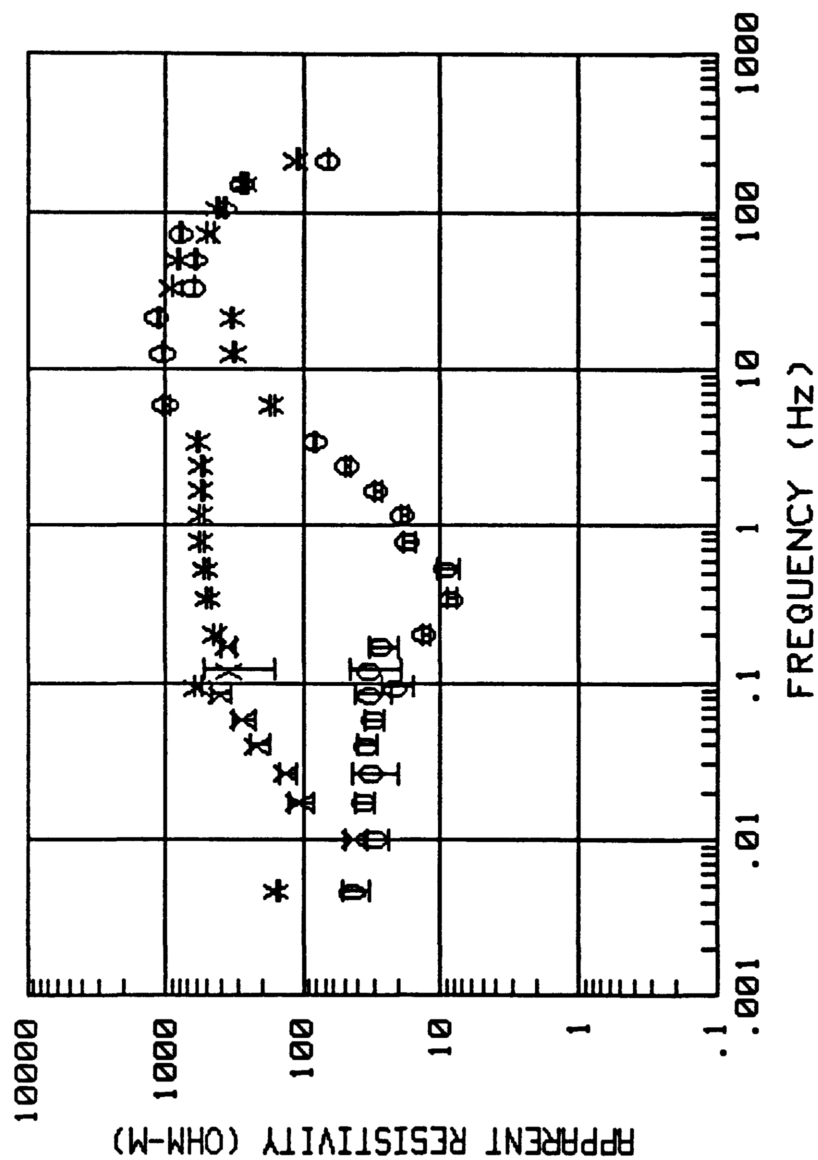


Station Name= GSH056
Free Rotation
15:19:54 15 Aug 1991

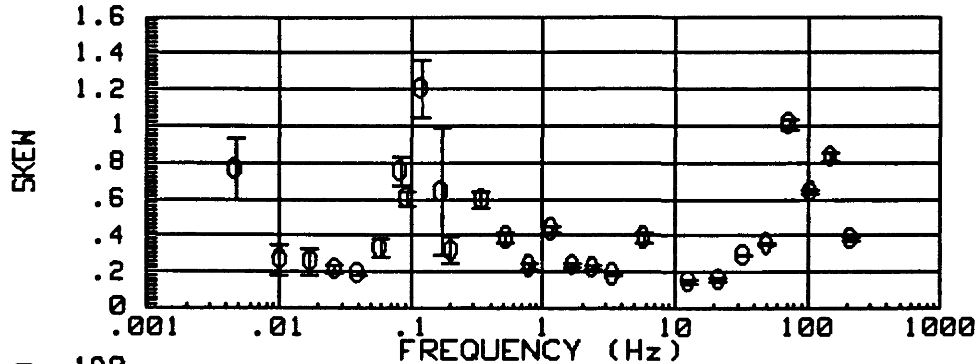


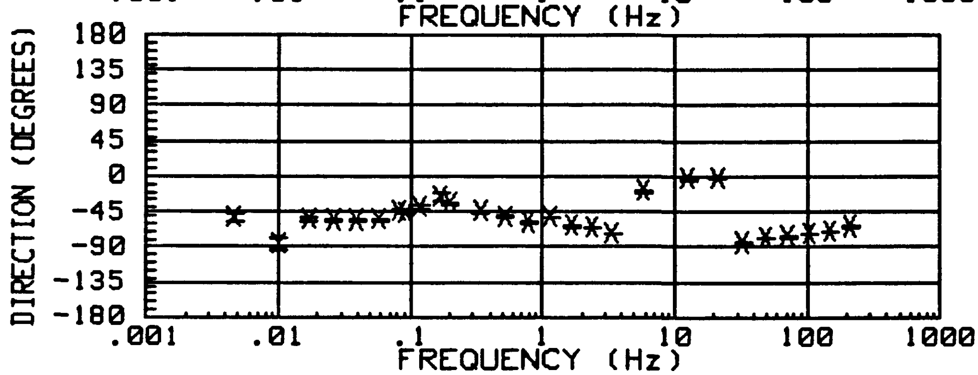


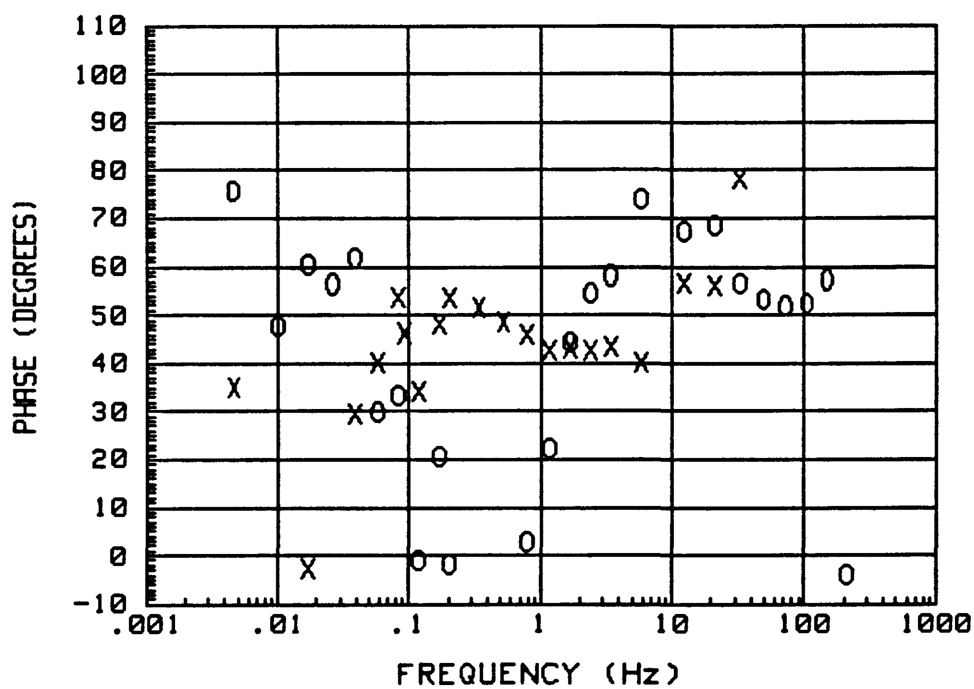
Station Name= GSH056
Free Rotation
15:19:54 15 Aug 1991



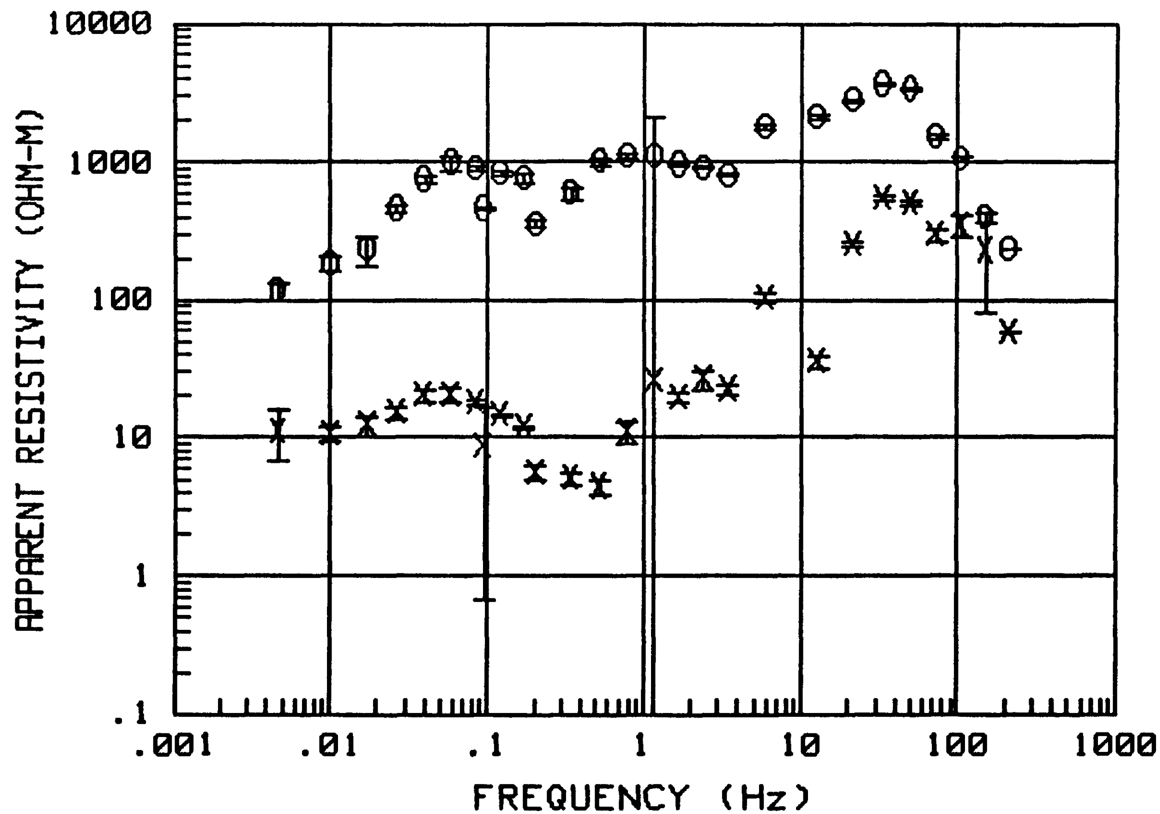
Station Name= GSH057
Free Rotation
18:22:35 15 Aug 1991



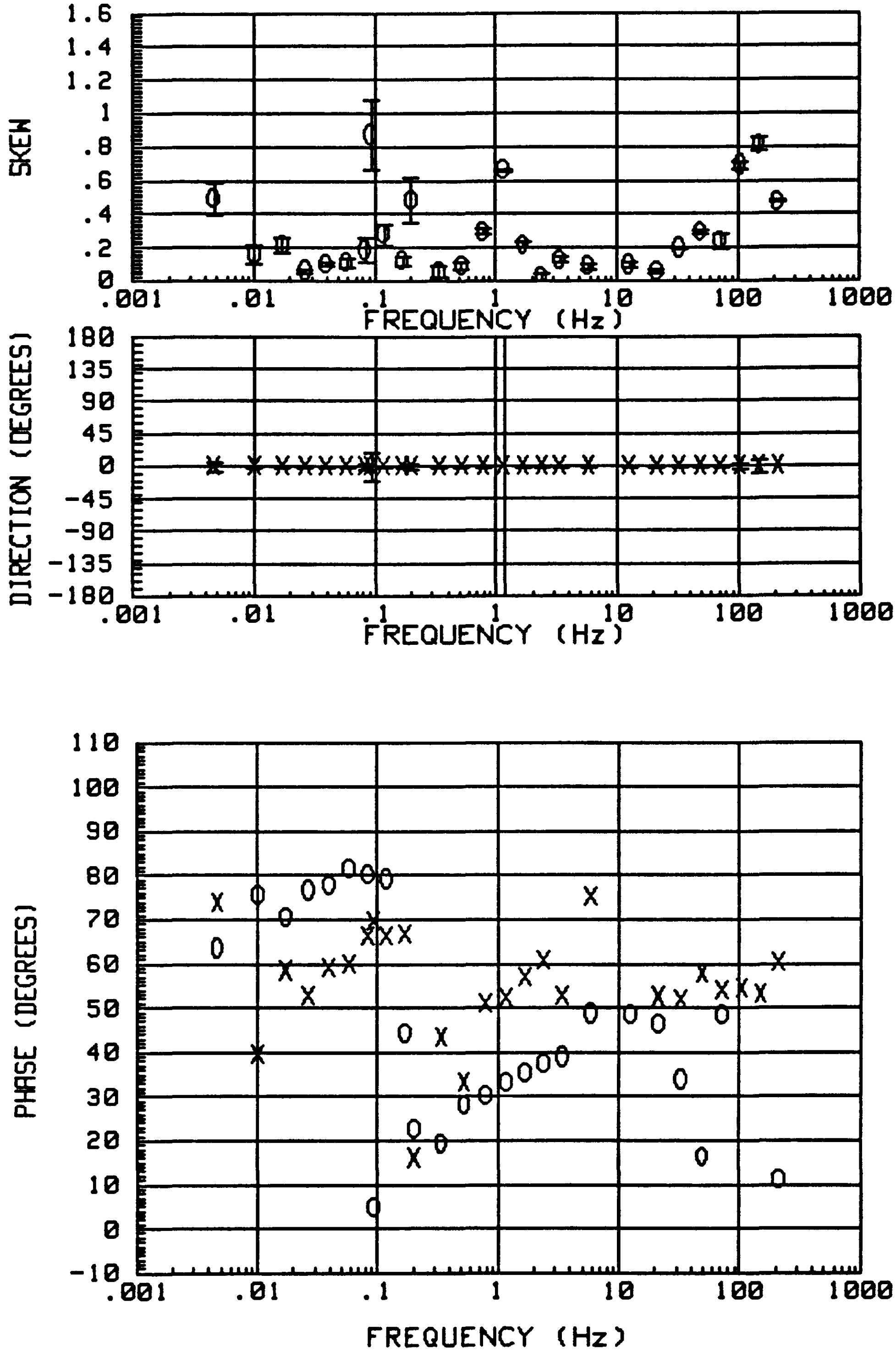




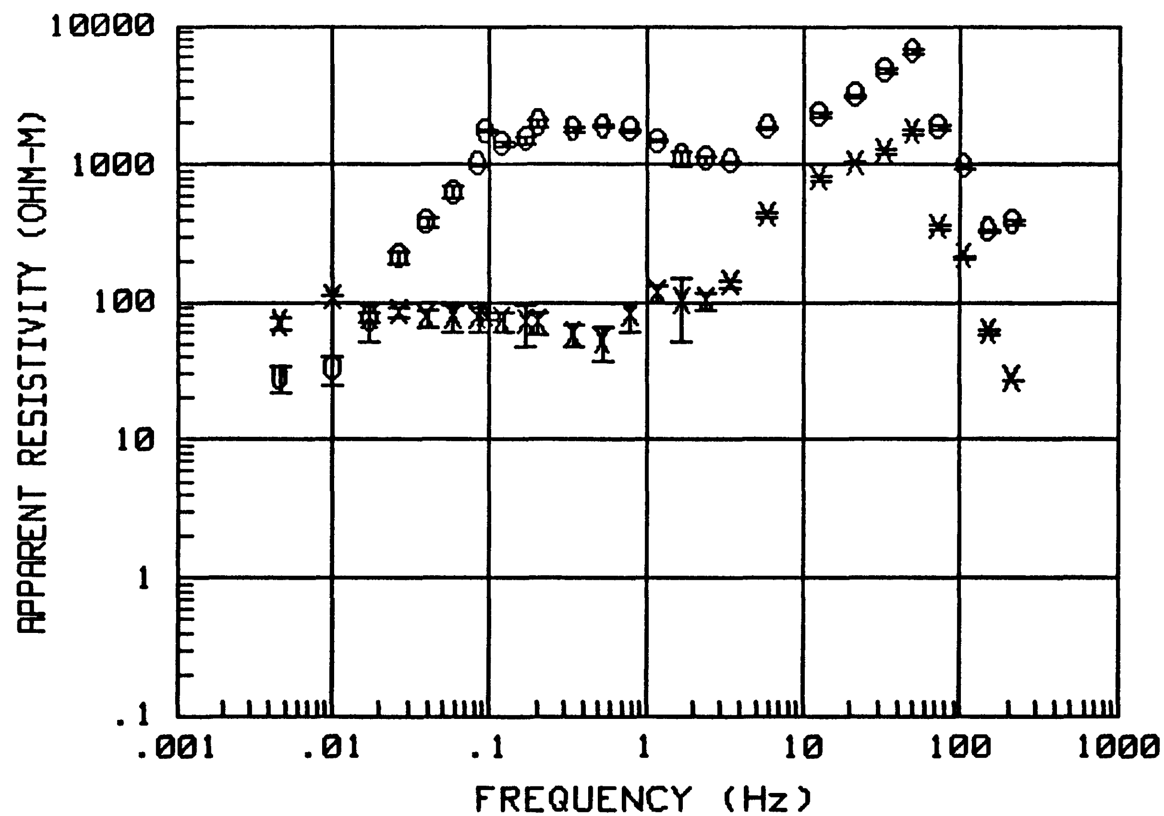
Station Name= GSH057
Free Rotation
18:22:35 15 Aug 1991



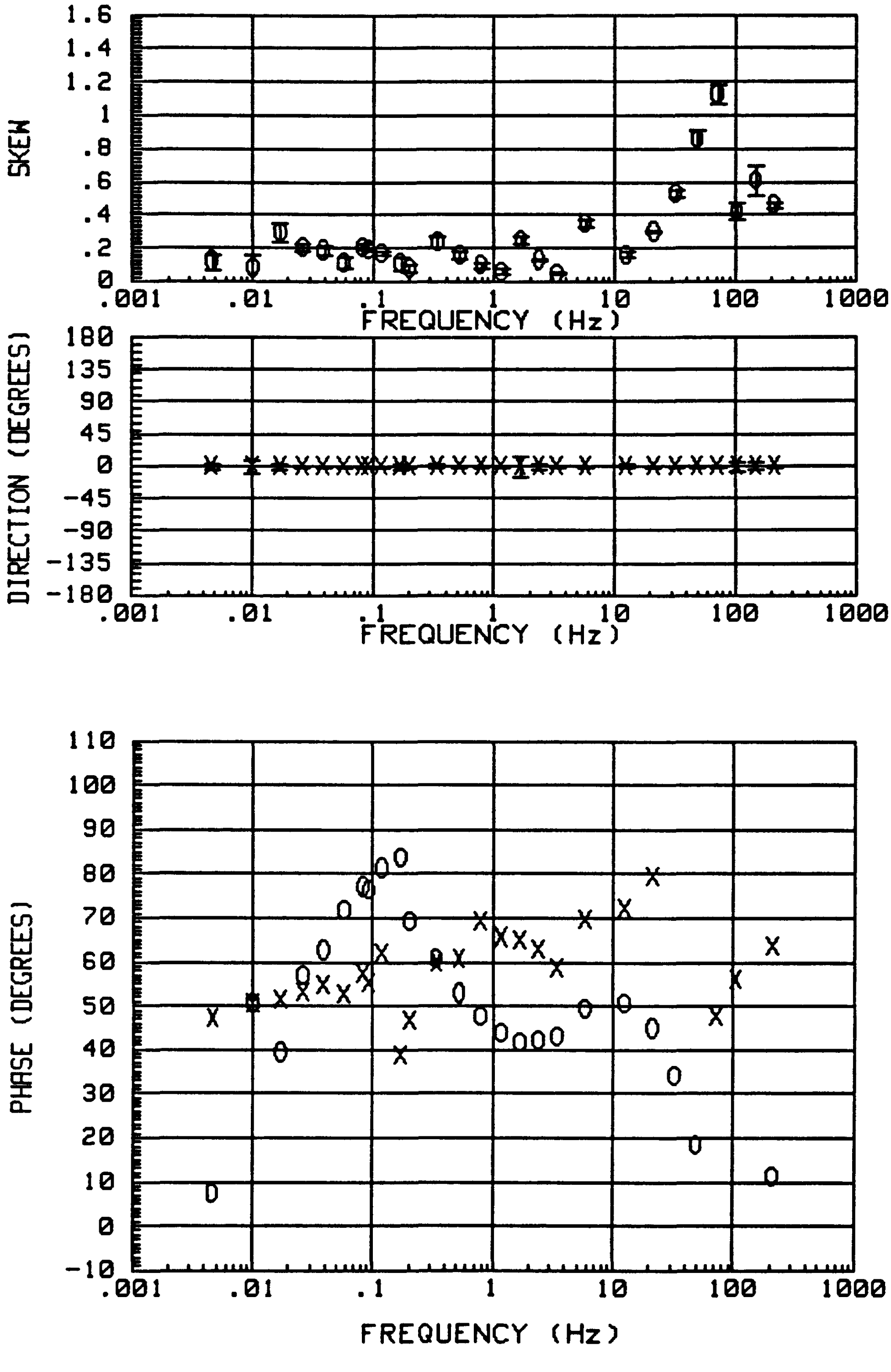
Station Name= GSH058
Fixed Rotation Angle= -1 Degrees
20:59:30 15 Aug 1991



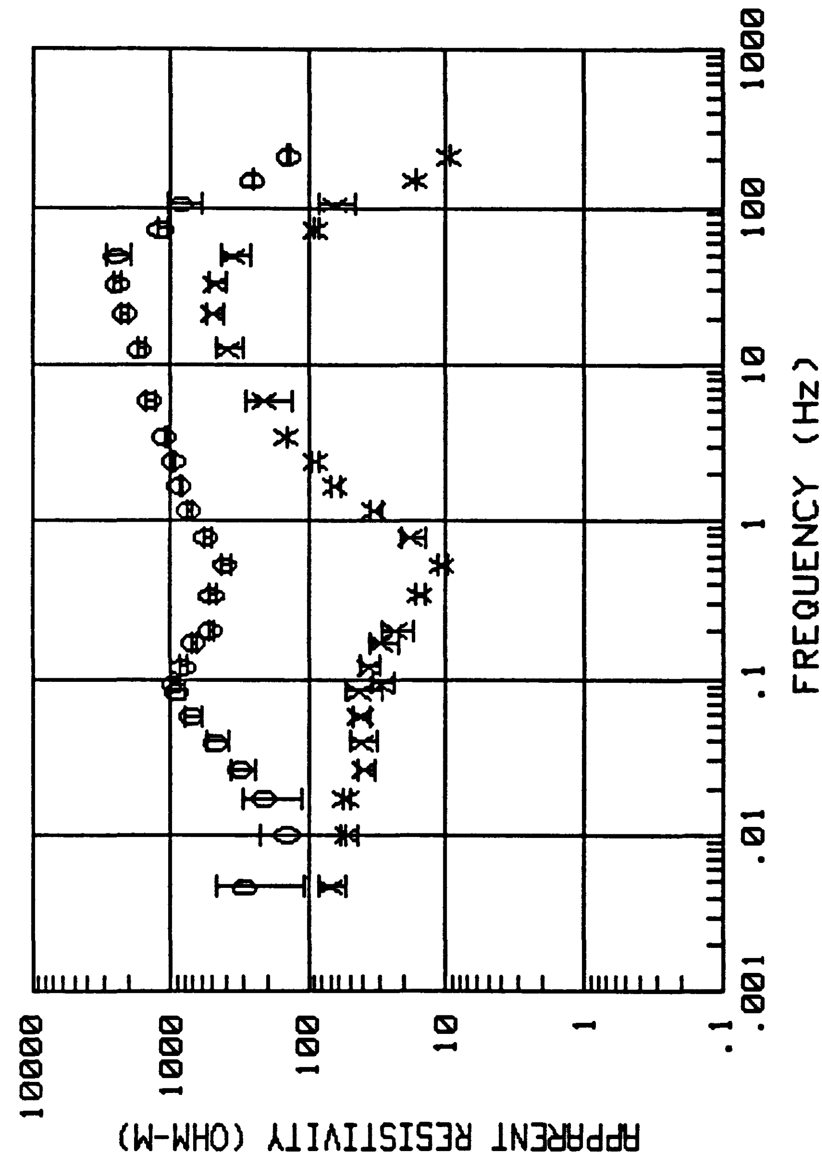
Station Name= GSH058
Fixed Rotation Angle= -1 Degrees
20:59:30 15 Aug 1991



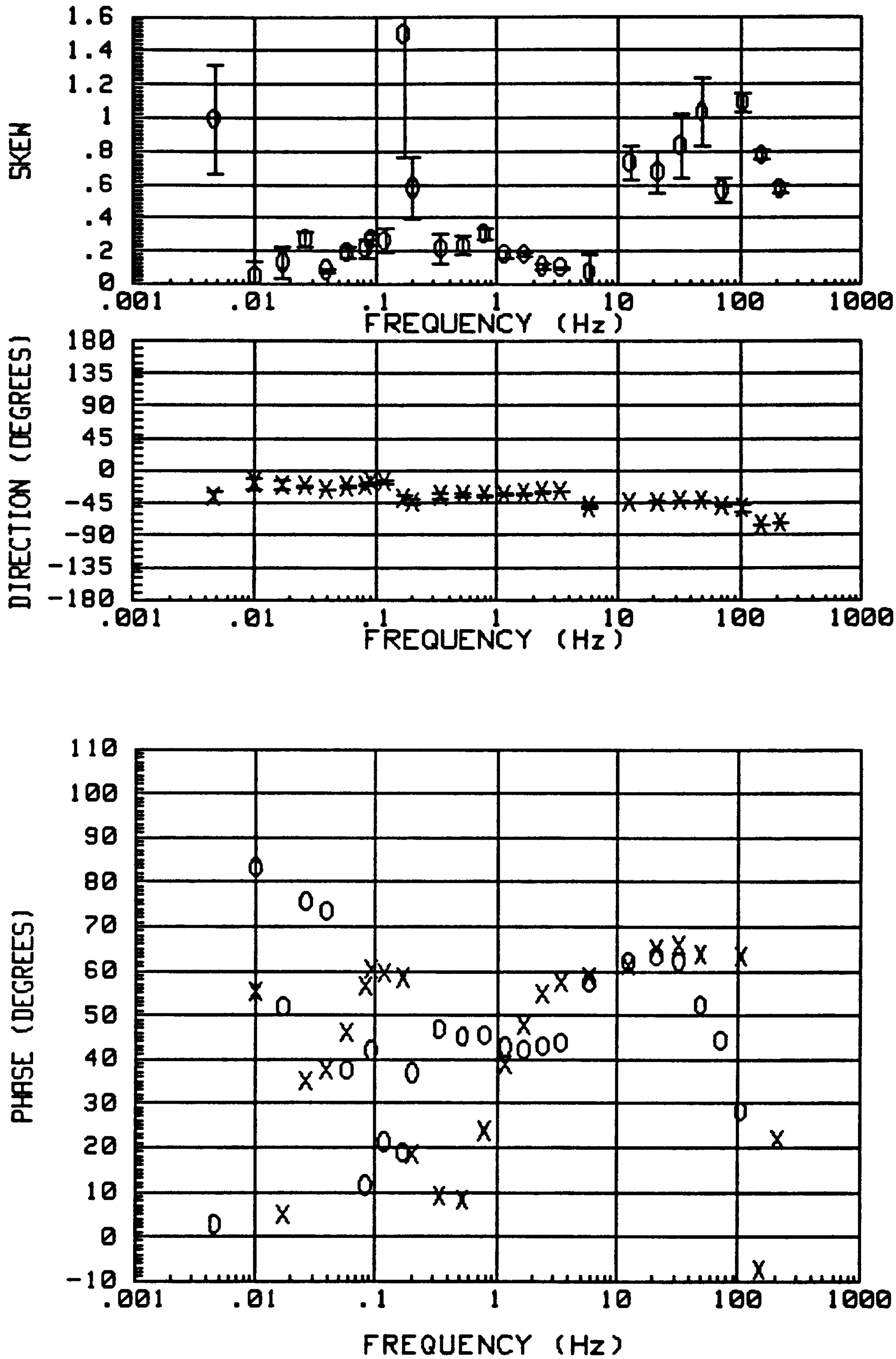
Station Name= GSH059
Fixed Rotation Angle= -1 Degrees
00:12:50 16 Aug 1991



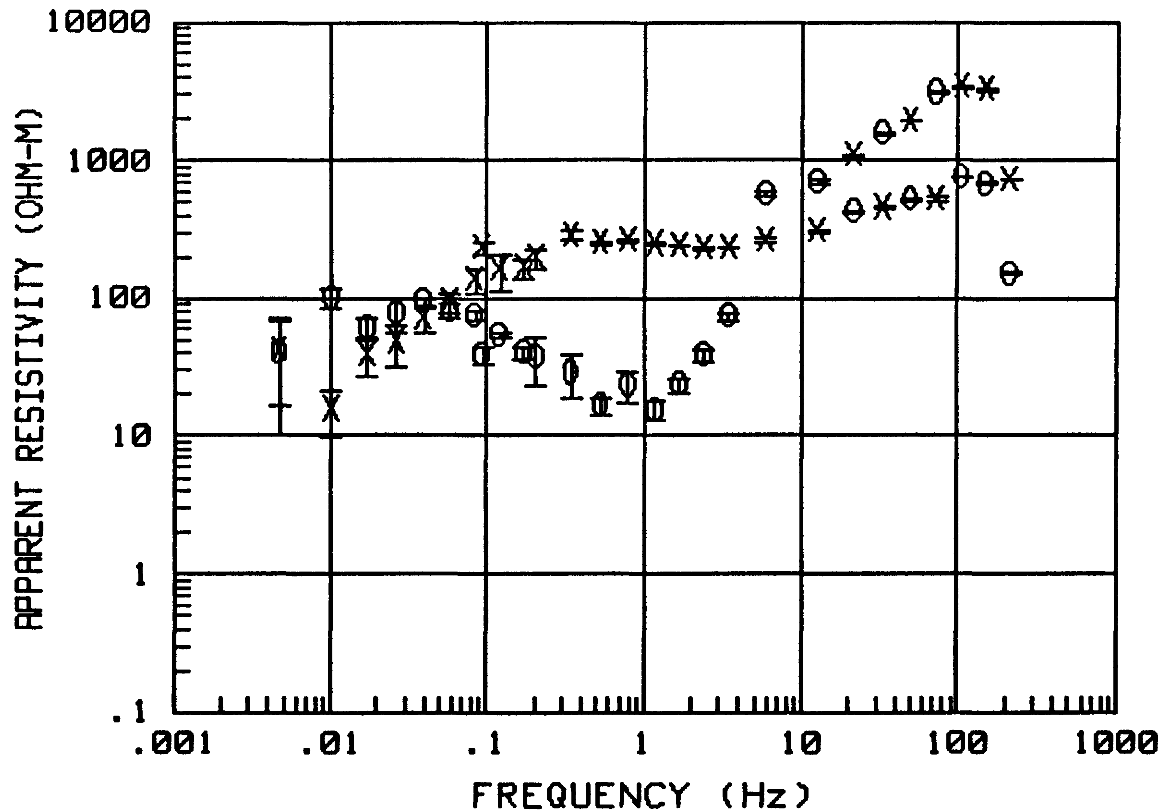
Station Name= GSH059
Fixed Rotation Angle= -1 Degrees
00:12:50 16 Aug 1991



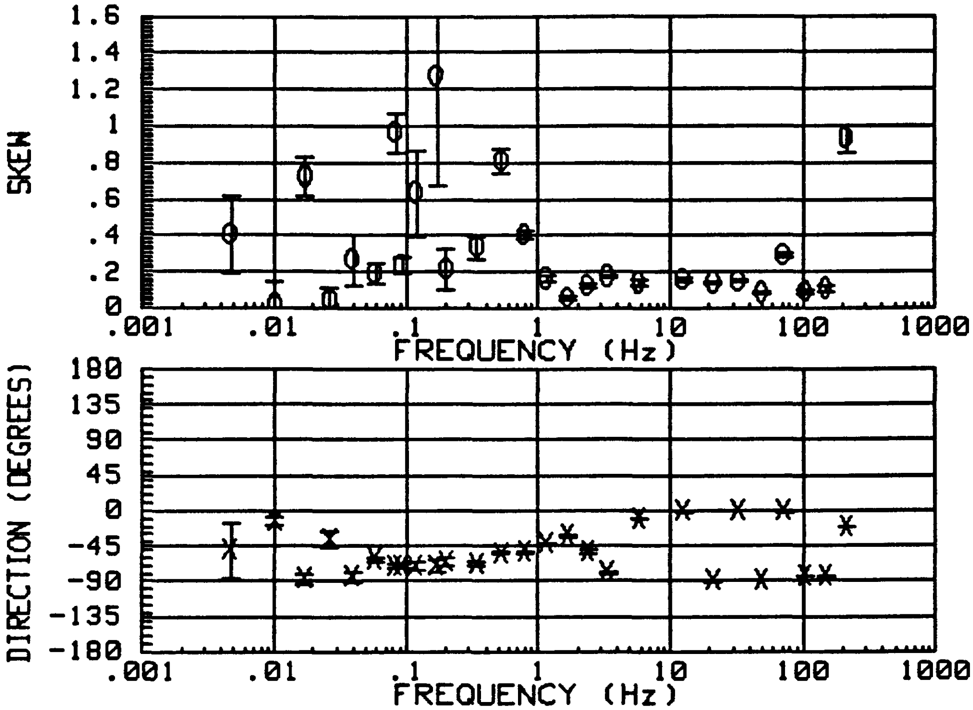
Station Name= GSH060
Free Rotation
02:56:30 16 Aug 1991

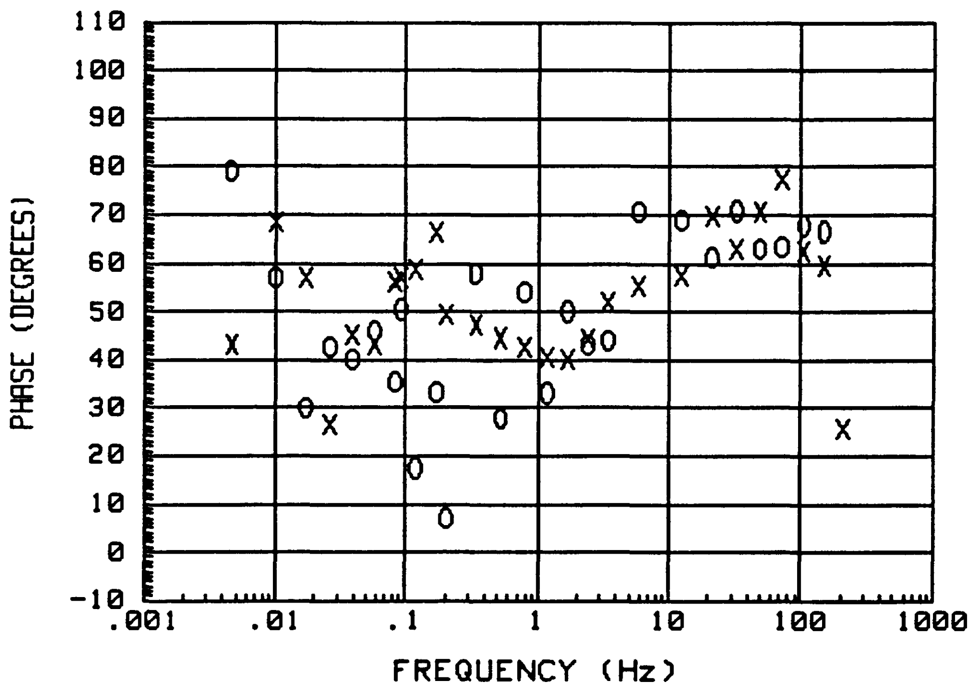


Station Name= GSH060
Free Rotation
02:56:30 16 Aug 1991



Station Name= GSH061
Free Rotation
08:20:57 16 Aug 1991





Station Name= GSH061
Free Rotation
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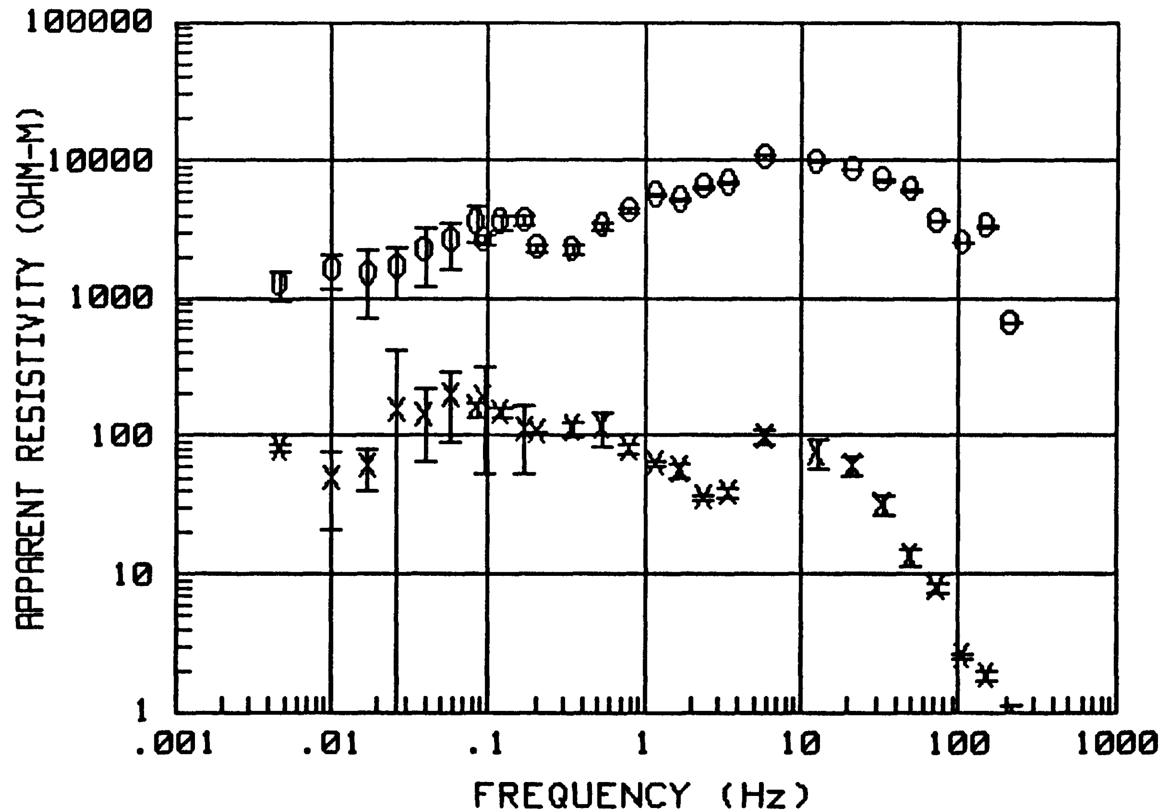
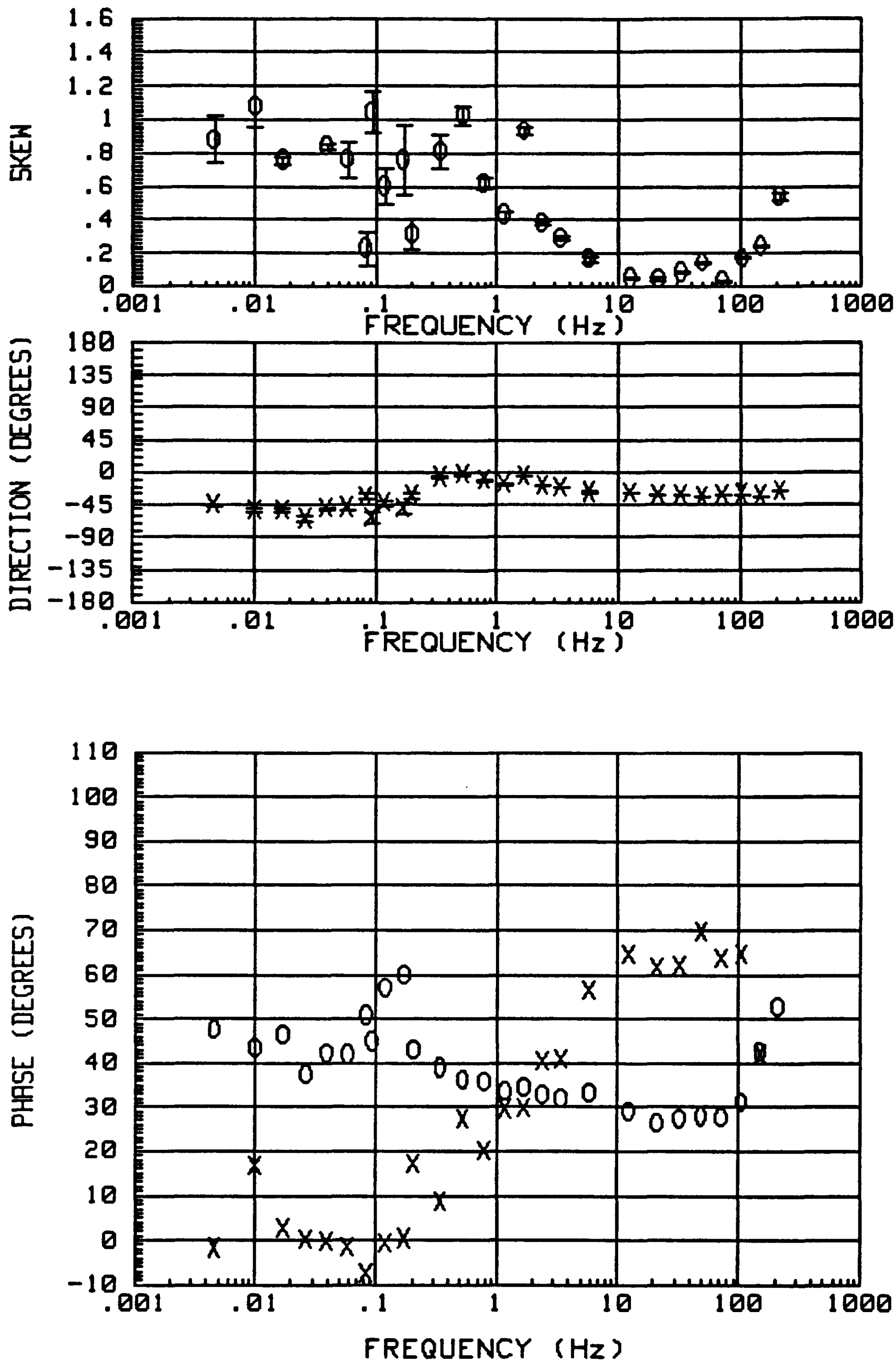
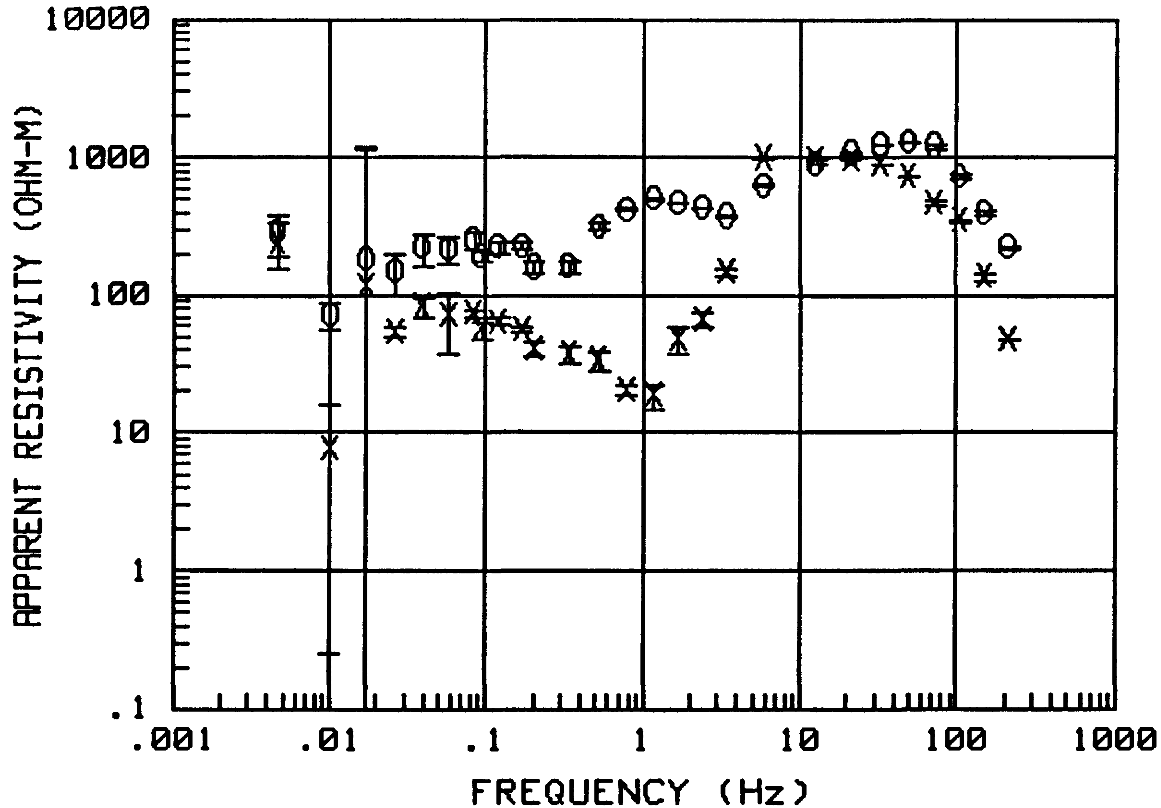


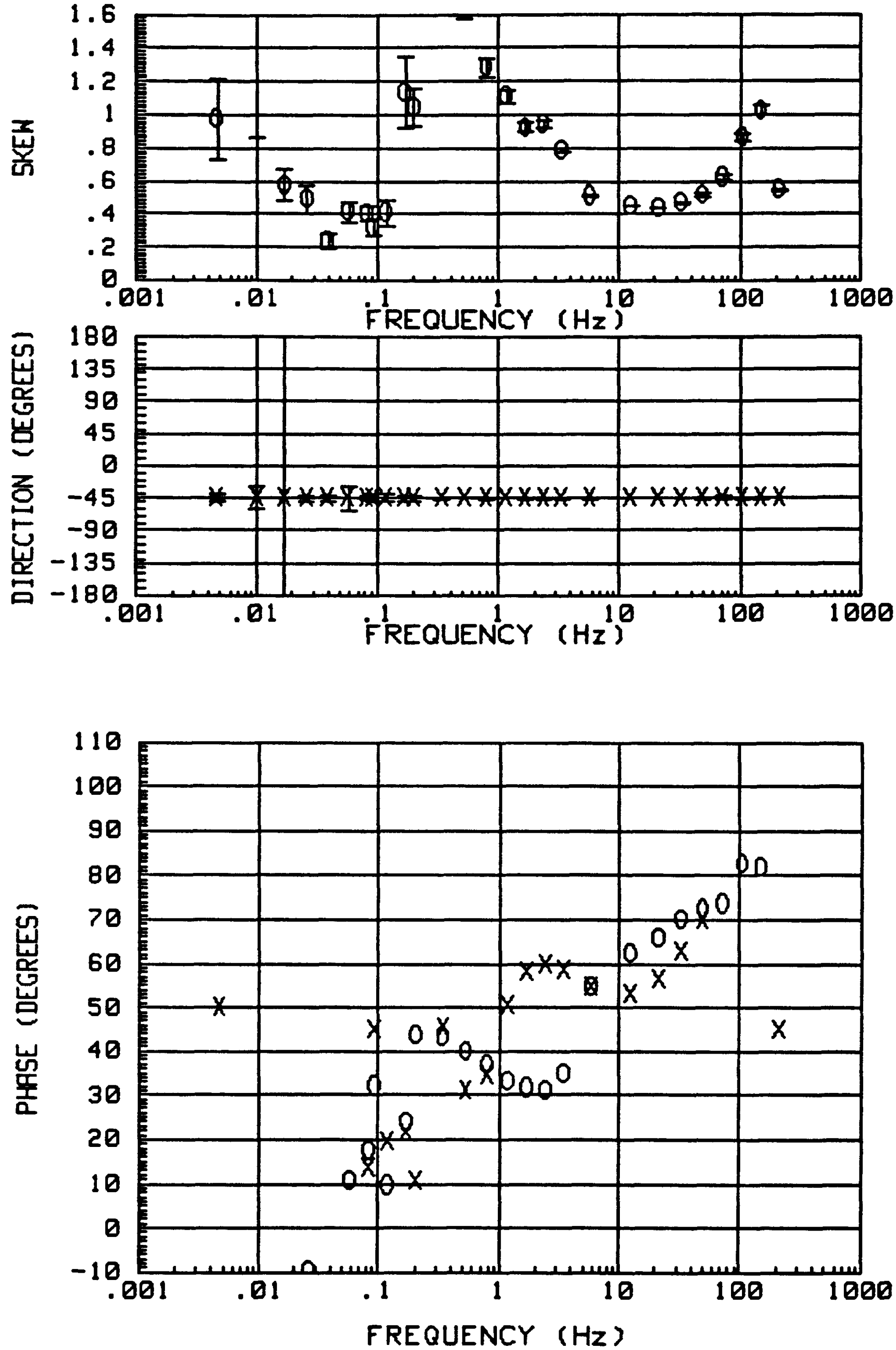
Station Name= GSH062
Free Rotation
09:57:45 16 Aug 1991



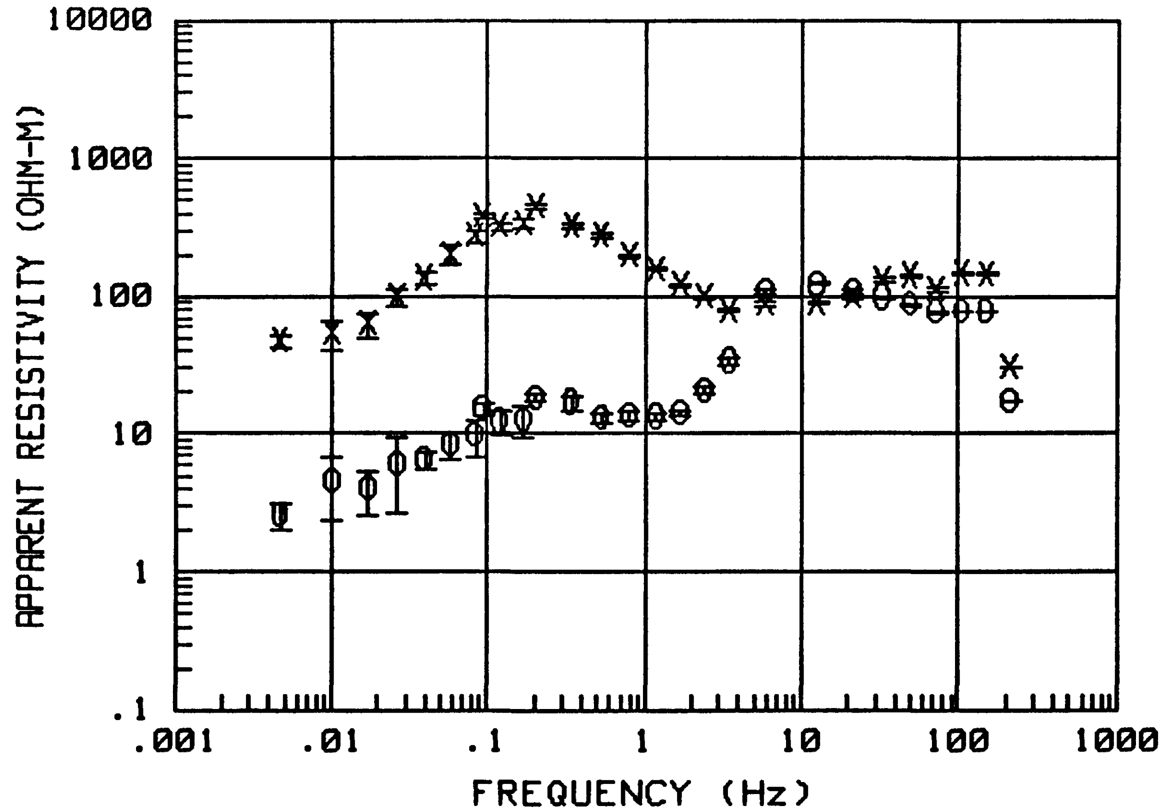
Station Name= GSH062
Free Rotation
09:57:45 16 Aug 1991



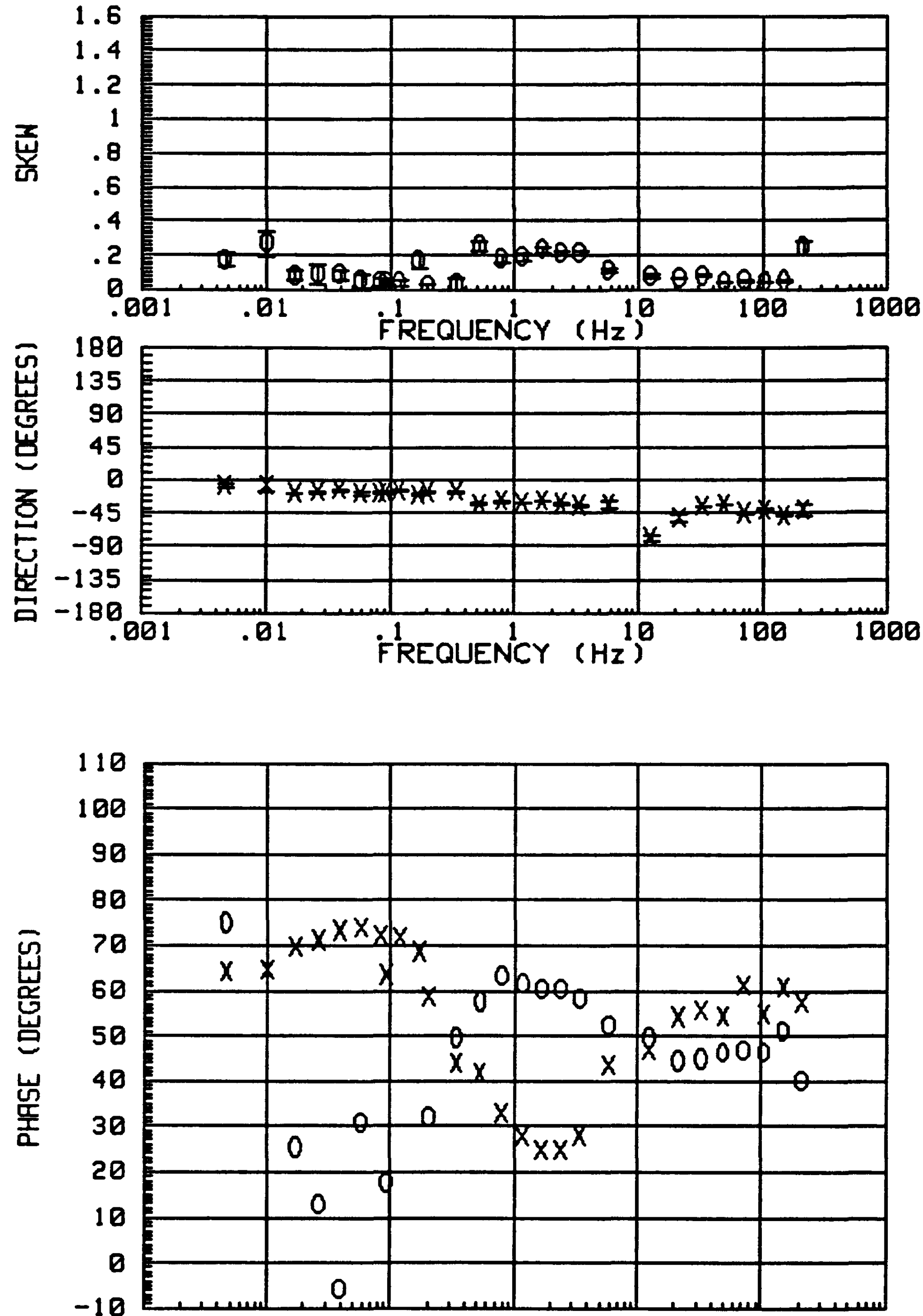
Station Name= GSH063
Fixed Rotation Angle= -45 Degrees
13:16:12 16 Aug 1991



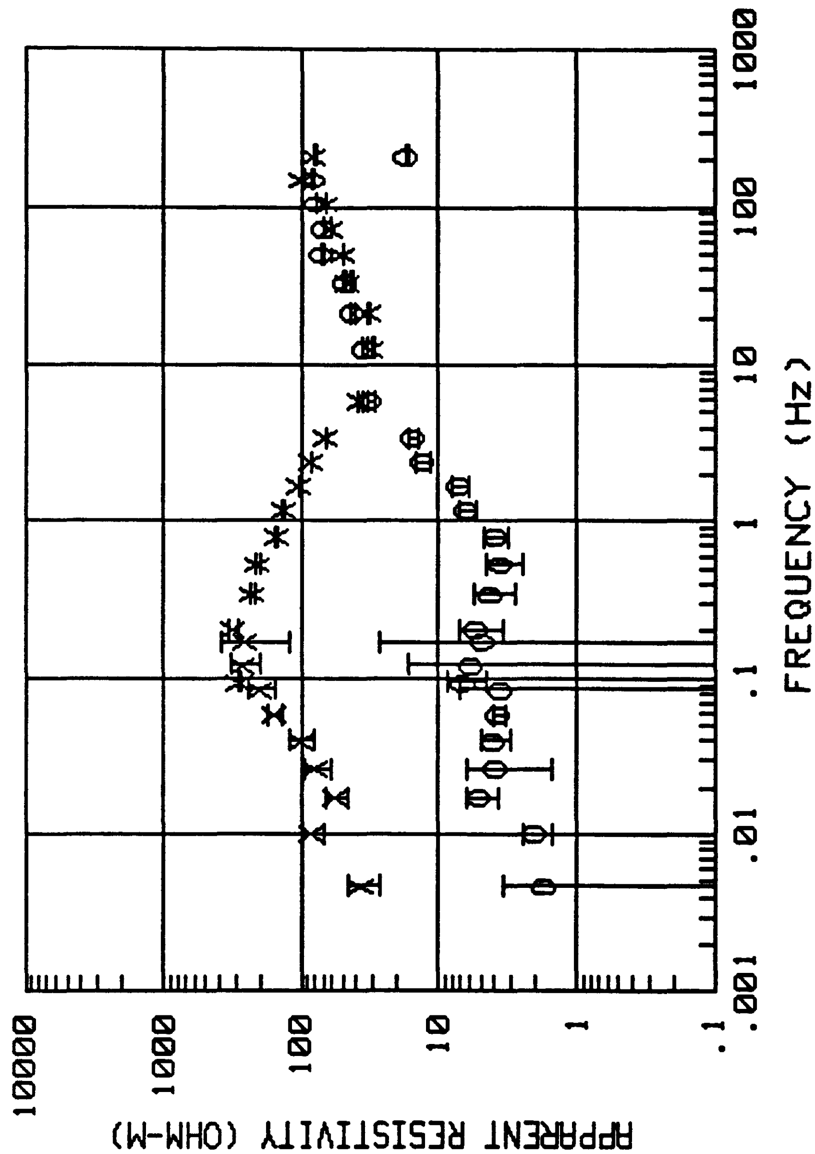
Station Name= GSH063
Fixed Rotation Angle= -45 Degrees
13:16:12 16 Aug 1991



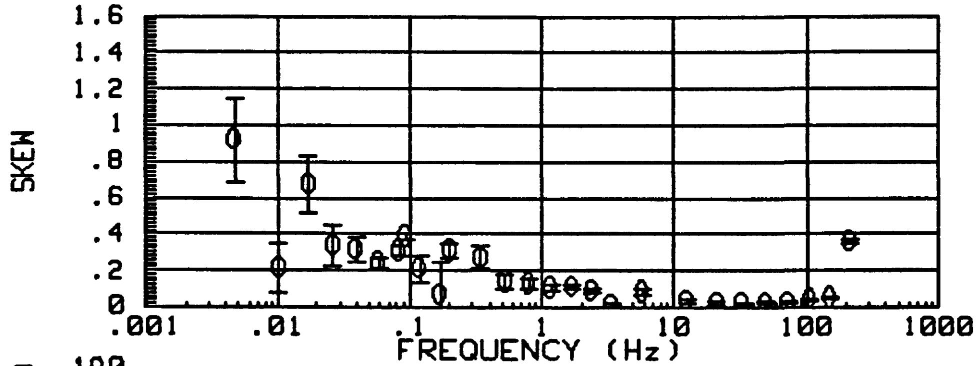
Station Name= GSH064
Free Rotation
13:49:01 17 Aug 1991

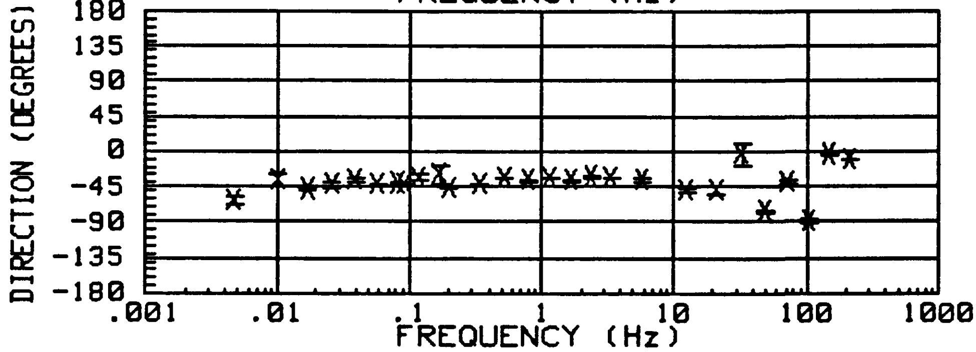


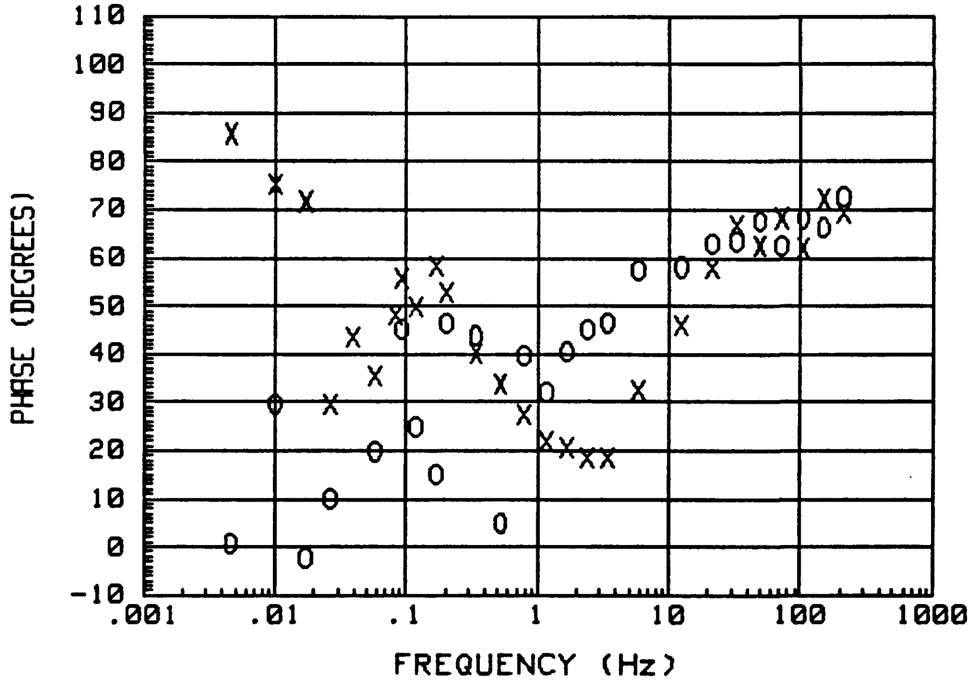
Station Name= GSH064
Free Rotation
13:49:01 17 Aug 1991



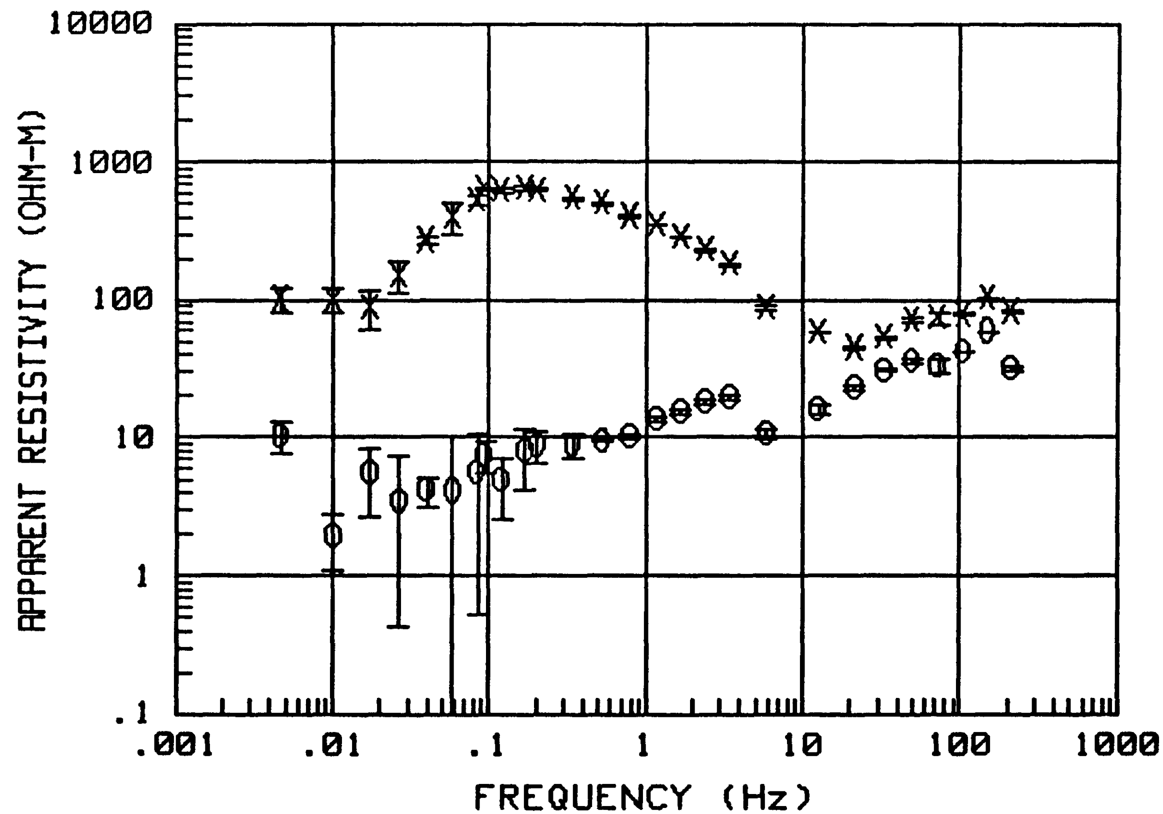
Station Name= GSH065
Free Rotation
09:15:49 17 Aug 1991



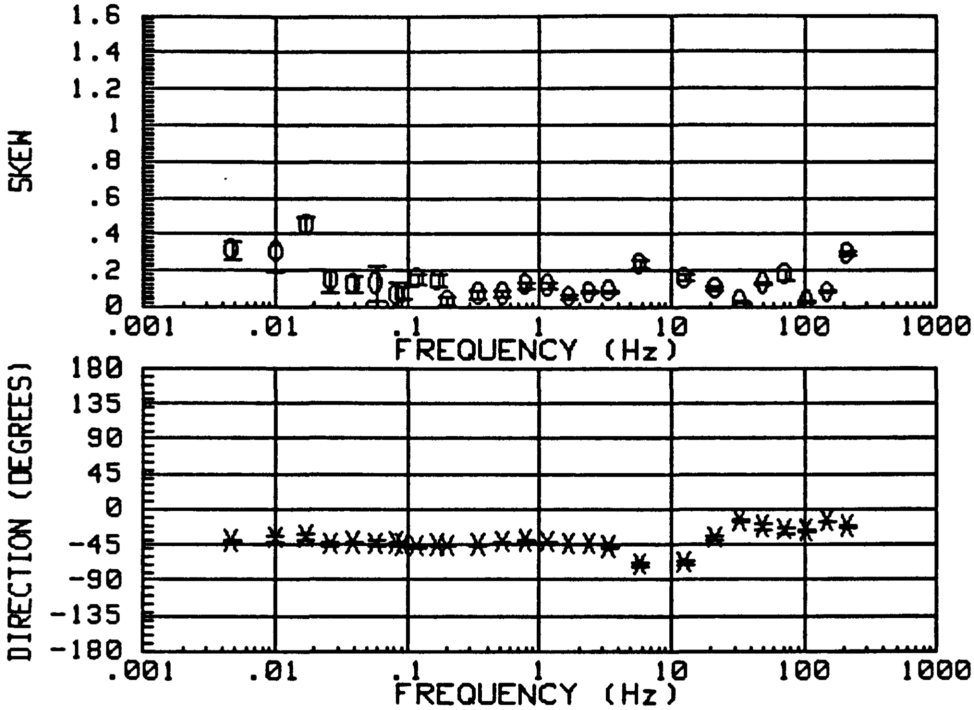


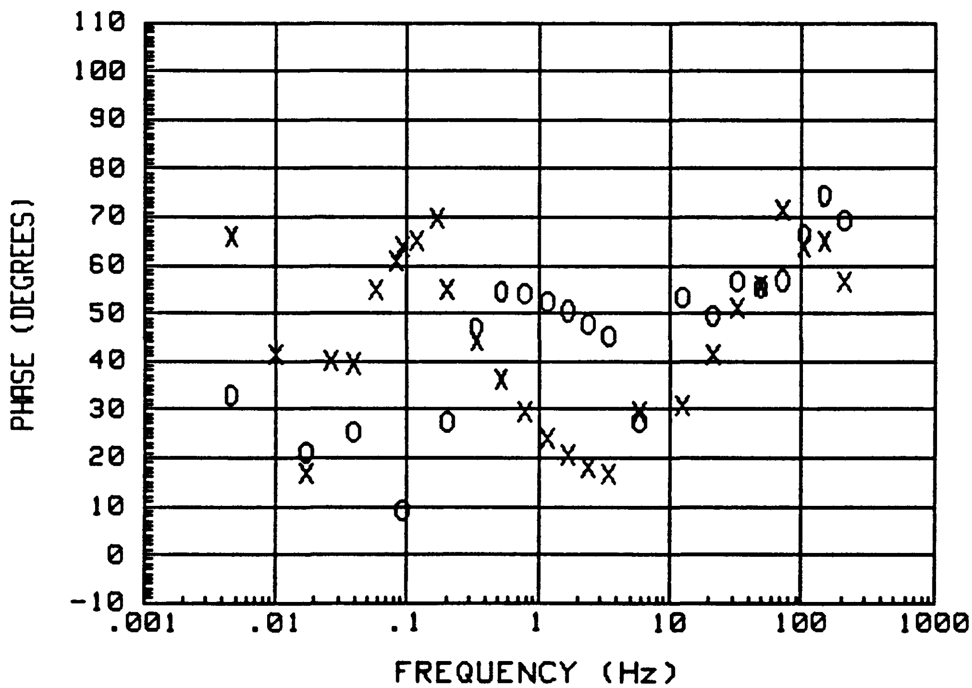


Station Name= GSH065
Free Rotation
09:15:49 17 Aug 1991

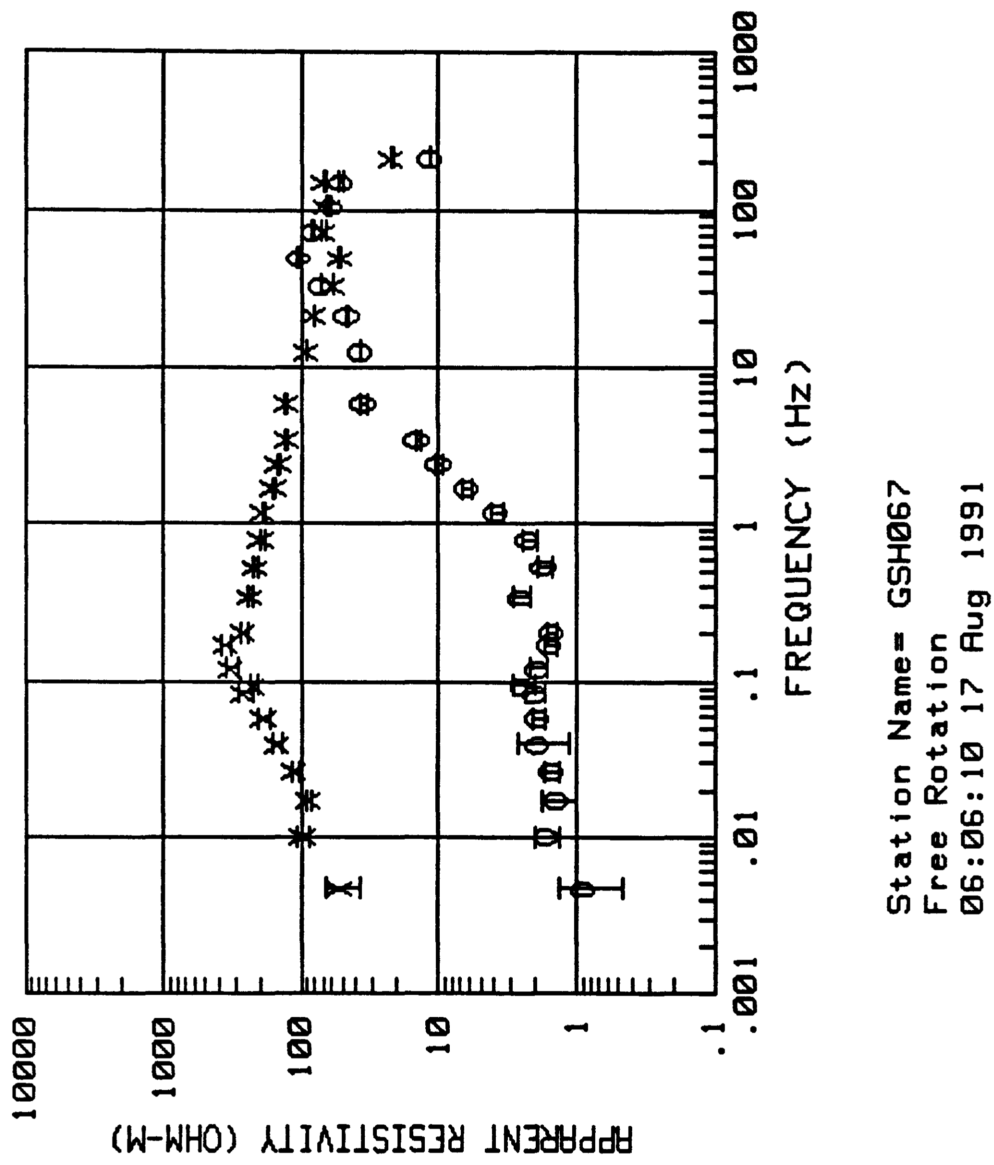


Station Name= GSH066
Free Rotation
10:51:42 17 Aug 1991

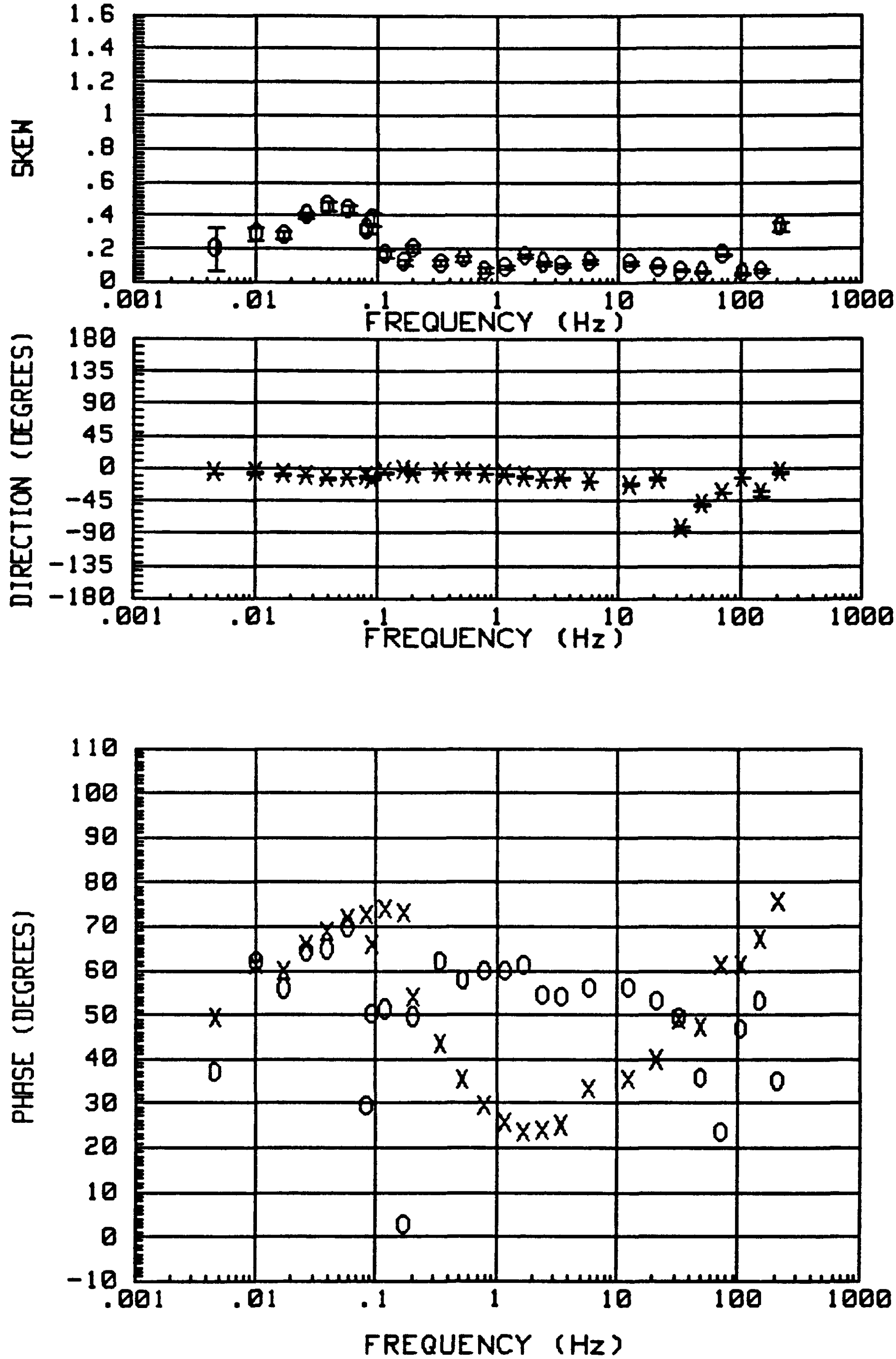




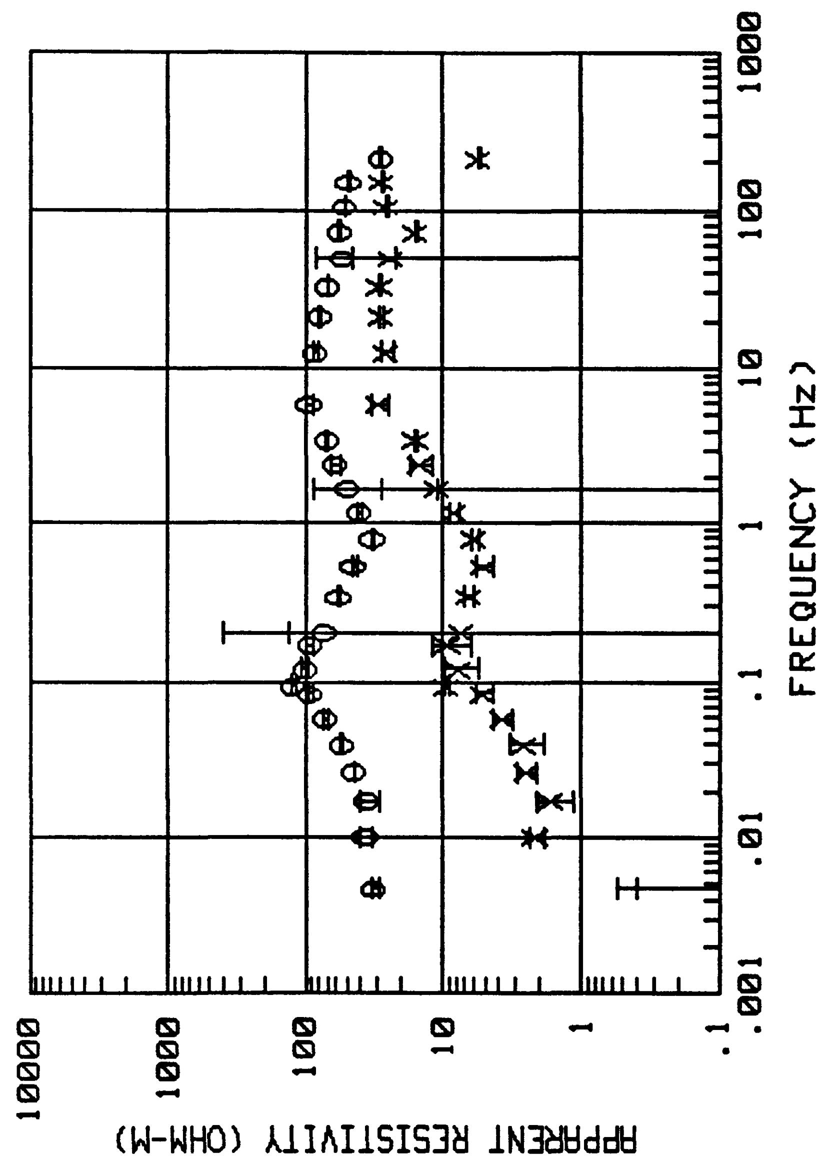
Station Name= GSH066
Free Rotation
10:51:42 17 Aug 1991



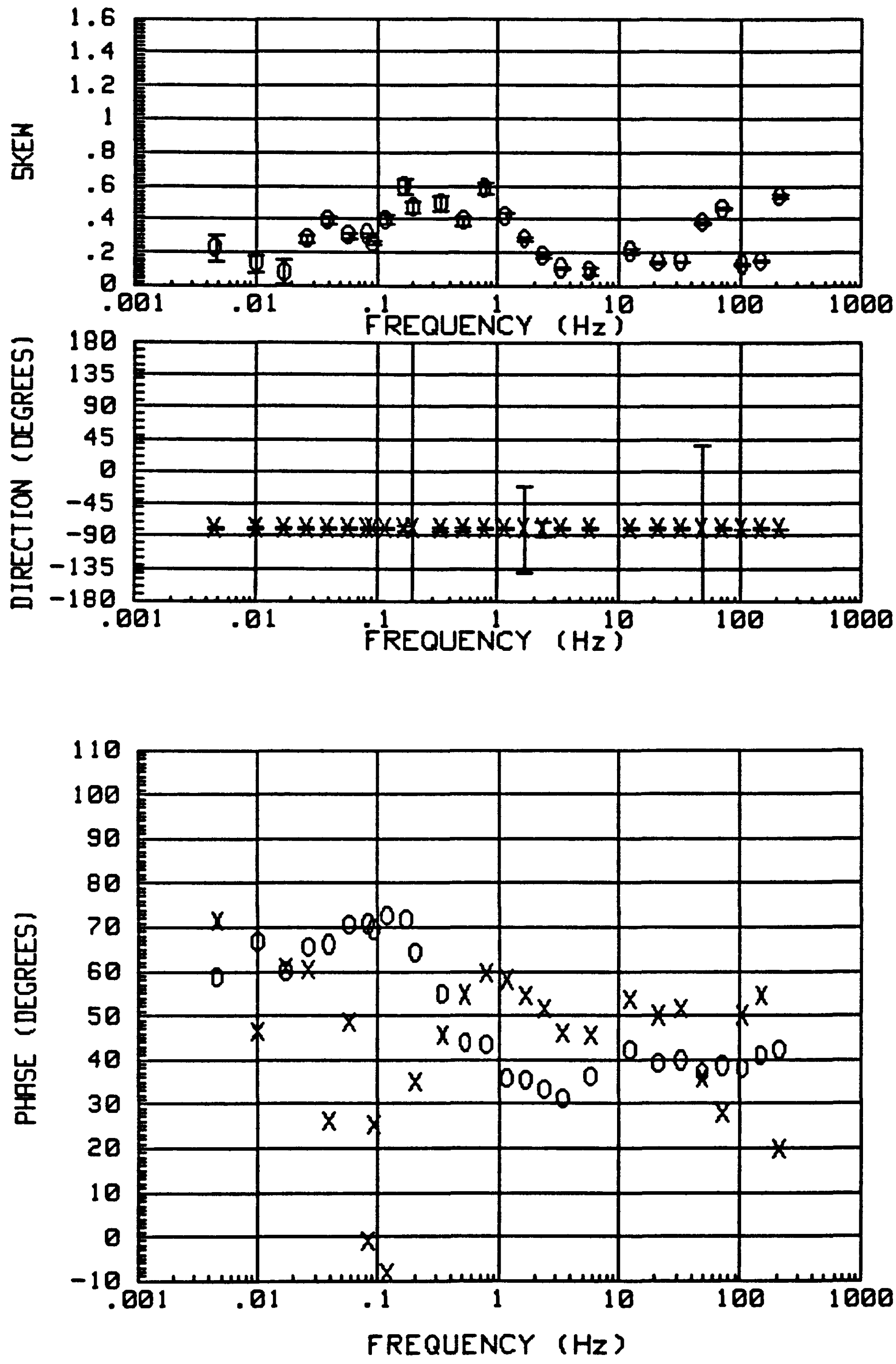
APPARENT RESISTIVITY (OHM-M)
10000
1000
100
10
1
.1
.001
.01
.1
1
10
100
1000
FREQUENCY (Hz)
Station Name= GSH067
Free Rotation
06:06:10 17 Aug 1991



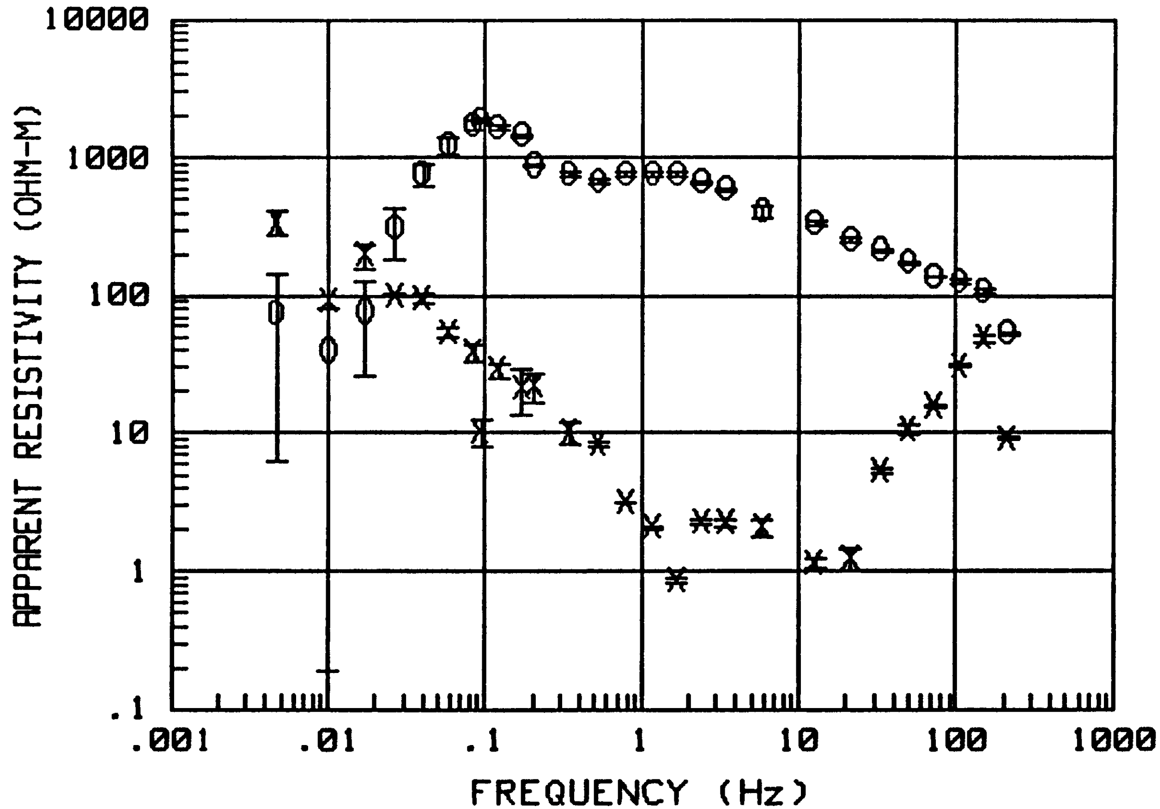
Station Name= GSH067
Free Rotation
06:06:10 17 Aug 1991



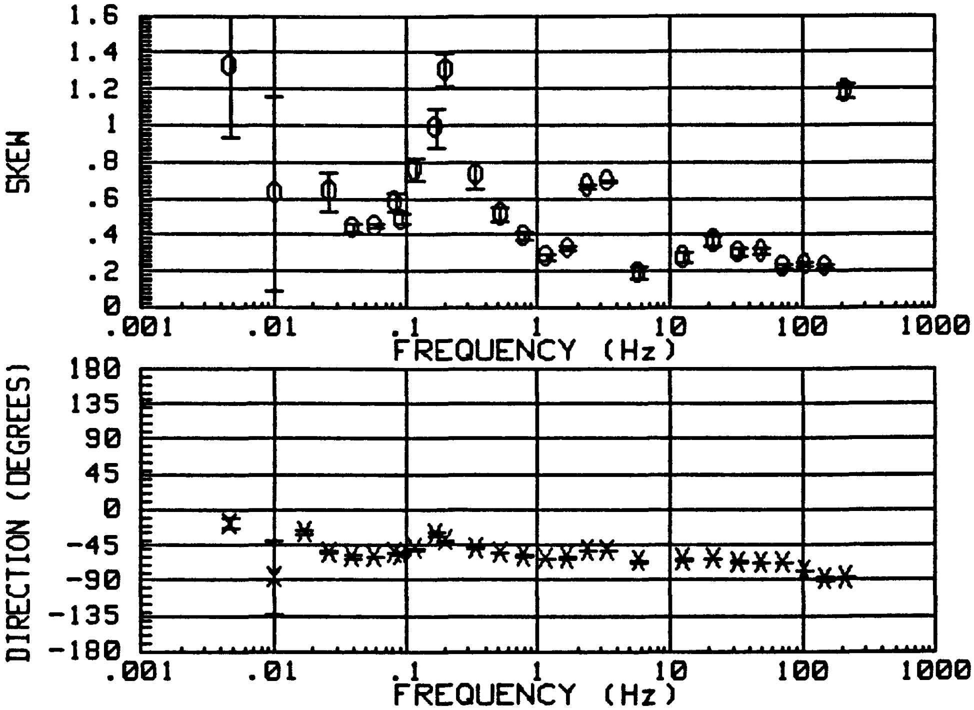
Station Name= GSH068
Fixed Rotation Angle= -80 Degrees
07:03:43 17 Aug 1991

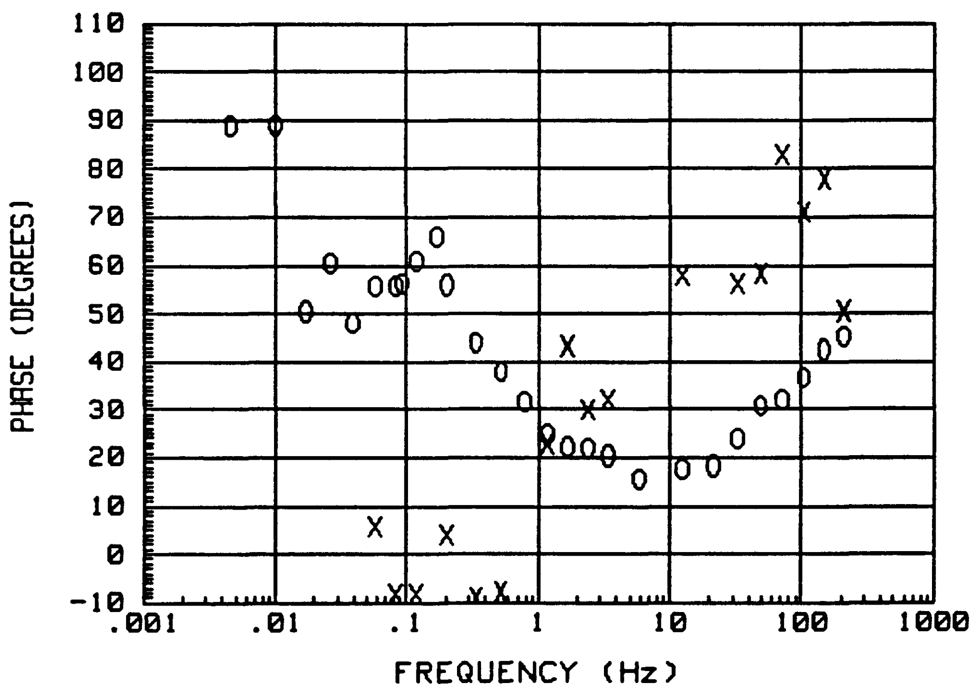


Station Name= GSH068
Fixed Rotation Angle= -80 Degrees
07:03:43 17 Aug 1991



Station Name= GSH069
Free Rotation
15:29:02 17 Aug 1991





Station Name= GSH069
Free Rotation
15:29:02 17 Aug 1991