MAGNETOTELLURIC DATA ALONG THE TANGLE LAKES PROFILE, ALASKA

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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INTRODUCTION

The 89 km long Tangle Lakes profile (Figure 1) of 14 magnetotelluric (MT) stations extends southward from 4 km south of the confluence of Augustana Creek and the Delta River. The northernmost station, TLM13, is located on the southside of the Denali Fault in the rugged Clearwater Mountains of south central Alaska. The profile crosses the Ampitheater Mountains northwest of the Tangle Lakes area and terminates in the flatlands on the southside of the Alphabet Hills.

Various rock assemblages and structural features are crossed by this profile. MT data obtained in this study in conjunction with magnetic and gravity data should help provide the following information:

1. An estimate of the thickness of the Nikolai basalts in the Amphitheater Syncline.
2. Whether or not the Fish Lake and Tangle ultramafic complexes join at depth or are at different stratigraphic horizons beneath the Amphitheater Mountains Syncline.
3. A determination if there is a deep rooted magmatic feeder or a sequence of sedimentary material beneath the Amphitheater Syncline.
4. The dip and orientation of the Rainy and Broxson Gulch thrust systems.
5. Identification of other structures along the profile.

Geologic constraints are minimal for the section of the profile south of the Denali Highway. A better understanding of the deep structure should be gained from subsequent modeling of the MT data. The MT survey permits interpretation of structures and lithologic packages to greater depths than is produced by surface mapping alone. With the addition of deep, 3-dimensional MT data, the potential field geophysics (aeromagnetic and gravity data) of



Figure 1. Index map showing the location of fourteen magnetotelluric (MT) stations acquired in August of 2001 along the 89 km Tangle Lakes profile in south central Alaska. The map scale is 1:500,000 with north at the top of the figure. Base maps used for this figure are the Mt. Hayes and Gulkana, Alaska 1:250,000 U.S. Geological Survey topographical maps.

the region surrounding the profile can also be modelled in greater detail than would be possible from surface geologic observations alone. The purpose of this report is to release the MT sounding data. No interpretation of the data is included.

MAGNETOTELLURIC METHOD

The magnetotelluric (MT) method is a passive surface geophysical technique that uses the earth's natural electromagnetic fields to investigate the electrical resistivity structure of the earth's subsurface. The resistivity of geologic units is largely dependent upon their fluid content, porosity, degree of fracturing, temperature, and conductive mineral content (Keller, 1989). Saline fluids within the pore spaces and fracture openings can reduce resistivities in a resistive rock matrix. Also, resistivity can be lowered by the presence of conductive clay minerals, carbon, and metallic mineralization. It is common for altered volcanic rocks to contain authigenic minerals that have resistivities ten times lower than those of the surrounding rocks (Nelson and Anderson, 1992). Higher temperatures cause increased ionic mobility and mineral activation energy, which reduces rock resistivities significantly. Unaltered or unfractured igneous rocks are normally very resistive (typically 1,000 ohm-m or greater). Faults will show low resistivity (less than 100 ohm-m) when they are comprised of rocks fractured enough to have hosted fluid transport and consequential mineralogical alteration (Eberhart-Phillips and others, 1995). Carbonate rocks are moderately to highly resistive (hundreds to thousands of ohm-m) dependent upon their fluid content, porosity, fracturing, and impurities. Marine shales, mudstones, and clay-rich alluvium are normally very conductive (a few ohm-m to tens of ohm-m). Unaltered metamorphic rocks (non-graphitic) are moderately to highly resistive (hundreds to thousands of ohm-m). Tables of electrical

resistivity for a variety of rocks, minerals and geological environments may be found in Keller (1987) and Palacky (1987). Generally, as temperature, degree of fracturing, and fluid content rises on any given rock, the electrical resistivity of that rock decreases.

The MT method can be used to probe the Earth's crust from depths of tens of meters to depths of tens of kilometers (Vozoff, 1991). Natural variations of the Earth's magnetic and electric field are measured and recorded at each MT station. The primary frequency bands used by the MT method are 10,000 Hz to 1 Hz originating from worldwide lightning activity and 1 Hz to 0.0001 Hz originating from geomagnetic micropulsations from within the earth or from solar magnetic disturbances. The natural electric and magnetic fields propagate vertically in the earth because the very large resistivity contrast between the air and the earth causes a vertical refraction of both fields transmitted into the earth (Vozoff, 1972). Generally, the lower frequency fields will penetrate deeper into the earth's crust than the higher frequency fields.

The natural electric and magnetic fields are recorded in two orthogonal, horizontal directions. The vertical magnetic field ("tipper")is also recorded. The resulting time-series signals are used to derive the tensor apparent resistivities and phases. First, the signals are converted to complex cross-spectra using FFT (fast-Fourier-transform) techniques. Then, least-squares, cross-spectral analysis (Bendat and Piersol, 1971) is used to solve for a tensor transfer function that relates the observed electric fields to the magnetic fields under the assumption that the Earth consists of a two-input, two-output, linear system with the magnetic fields as input and the electric fields as output. Prior to conversion to apparent resistivity and phase, the tensor

is normally rotated into principal directions that correspond to the direction of maximum and minimum apparent resistivity. For a two-dimensional (2-D) Earth, the MT fields can be decoupled into transverse electric (TE) and transverse magnetic (TM) modes. Generally, 2-D modeling is done to fit both modes. When the geology satisfies the 2-D assumption, the MT data for the TE mode represents the electric field parallel to geologic strike. The data for the TM mode represents the electric field perpendicular to geologic strike. The MT method is well-suited for studying complicated geological environments because the electric and magnetic relations are sensitive to vertical and horizontal variations in resistivity. The method is capable of establishing whether the electromagnetic fields are responding to subsurface terranes of effectively 1-, 2-, or 3-dimensions. An introduction to the MT method and references for a more advanced understanding are contained in Dobrin and Savit (1988) and Vozoff (1991).

MAGNETOTELLURIC SURVEY

Fourteen MT soundings were acquired along the Tangle Lakes Profile in August of 2001 (Figure 1). The profile is north-south, however, the southern six stations are offset 18 km to the west of the northern seven stations, thus forming two distinct segments. One station was placed midway between the two north-south segments. Spacing between soundings varied from 5 to 8 km on the northern segment, from 8 to 16 km on the southern segment, and from 8 to 11 km on the east-west segment. All but three of the stations were acquired with helecopter support. The profile orientation is approximately perpendicular to the known geologic strike. All data were collected with a portable EMI MT-1 system (EMI, 1996). Horizontal electric fields were sensed using copper-sulfate electrodes placed in an L-shaped, three-electrode array with dipole lengths of 30 m. The orthogonal, horizontal magnetic fields in the direction of the electric-field

measurement array were sensed using permalloy-cored induction coils. Frequencies sampled ranged from 70 to 0.004 Hz using single station recordings of both orthogonal horizontal components of the electric and magnetic fields, along with the vertical magnetic field.

The following table shows fourteen magnetotelluric (MT) station locations as recorded using a global positioning system during field acquisition. Coordinates are referenced to the 1866 Clarke spheroid and North American 1927 Alaska datum. Longitude and latitude format below is degrees-minutes-seconds.

TABLE 1

Locations of Tangle Lakes Magnetotelluric Stations

Station	Longitude	Latitude	elevation (m)
TLM01	W146-00-22	N63-07-07	1360
TLM02	W146-02-13	N63-03-02	891
TLM03	W146-00-23	N63-11-03	1248
TLM04	W146-20-11	N63-05-12	1214
TLM05	W146-11-02	N63-04-17	1126
TLM06	W145-57-06	N63-14-14	1089
TLM07	W146-19-36	N62-36-32	952
TLM08	W146-16-04	N62-41-32	854
TLM09	W145-52-29	N63-18-04	1247
TLM10	W145-51-13	N63-20-21	1202
TLM11	W146-19-24	N62-49-26	970
TLM12	W146-21-29	N62-45-22	1225
TLM13	W145-48-14	N63-24-05	1032
TLM14	W146-19-12	N62-58-04	944

MAGNETOTELLURIC DATA

The recorded time-series data were transformed to the frequency domain and processed to determine a two-dimensional apparent resistivity and phase tensor at each site. The impedance tensor was then rotated to maximum and minimum directions to decouple the TE and TM modes. Remote reference sensors are often used in an MT survey to help reduce bias in the impedance determinations due to instrument or environmental noise (Gamble and others, 1979a; Clarke and others, 1983). Remote sensors were not used at any of the stations in this survey because of limited helicopter time. Although remote reference techniques were not used in our survey, we did sort cross-power files to select optimal signal-to-noise data sets.

The effects of near-surface resistivity anomalies cause "static shifts" (Sternberg and others, 1988) in the data. Static shifts affect most of this data set and range from 0.1 to 1.0 of a log decade. Stations TLM01, TLM02, TLM05, TLM06, TLM07, TLM09, TLM10, TLM12, and TLM13 had static shifts larger than one-third of a log decade. The remainder of the stations had very minor static shifts. The larger static shifts should be accounted for in any subsequent modeling of the data. Cultural features can effect the response of the MT system. Fences, pipelines, communication lines, railways and other man-made conductors can contaminate the responses. TLM02, TLM04, and TLM05 were located within a few hundred meters of the Denali Highway. Data were not acquired if moving vehicles were in the area. Data acquisiton at stations TLM01 and TLM03 was difficult due to electrical interference (possibly radio or microwave transmissions) from military exercises being conducted in the area.

The figures in the Appendix represent the field-processed MT data for each station after the time series data were converted to the frequency domain and the tensor-transfer function was rotated into principal directions as described above in the "Magnetotelluric Method" section.

For each station, nine separate graph plots are given:

1. Apparent Resistivity for the rotated maximum (x symbol) and minimum (o symbol) modes.
2. Impedance Phase for the rotated maximum (x symbol) and minimum (o symbol) modes.
3. Rotation Angle for the impedance tensor (maximum apparent resistivity direction).
4. Impedance Skew for the impedance tensor.
5. Multiple Coherency for the rotated maximum (x symbol) and minimum (o symbol) modes of the electric field.
6. Impedance Polar Plots (at 12 selected frequencies).
7. Tipper Magnitude for the vertical magnetic field.
8. Tipper Strike for the vertical magnetic field.
9. HzHx (x symbol) and HzHy (o symbol) Coherency.

Each of the graphs are plotted with frequency being the horizontal axis. The Apparent Resistivity, Impedance Phase, and Multiple Coherency plots use x and o symbols to distinguish the two tensor modes. During the next phase of the interpretation process, those modes will be identified as being either TE or TM prior to modeling. The x and o symbols on the HzHx and HzHy Coherency plot represent HzHx and HzHy coherency, respectively. Error bars are probable errors within one standard deviation of the sample variance (Gamble and others, 1979b).

Apparent resistivity is the magnitude of the ratio of the electric field strength over the magnetic field strength for a given frequency. The impedance phase is proportional to the slope of the apparent resistivity curve on a log-log plot, but from a baseline at -45 degrees (Vozoff, 1991). A measure of the dimensionality for MT data is provided by the impedance skew of the impedance tensor (Vozoff, 1972). If the effective measured resistivity response to the geology beneath a MT station is truly 1-D or 2-D, then the skew will be zero. Both instrument and environmental sources of noise contribute to non-zero skew values, but are typically small (about 0.1) for relatively low noise level recordings. Higher skews (above 0.2) are an indication of either the resistivity response to 3-D geology or higher levels of noise. Man-made electrical noise, such as power lines, power generators, moving vehicles and trains can have a negative effect on MT data quality. All of these local disturbances produce an incoherent noise mainly affecting higher frequencies, usually above 1 Hz. Other man-made electrical noise, such as direct current electric trains and active cathodic protection of pipelines produce coherent electromagnetic signals mainly affecting frequencies below 1 Hz.

The Tangle Lakes profile is located in a remote area of south-central Alaska. Power lines, power generators, pipelines, railroads, steam-driven trains, moving vehicles, and mining operations, were not a noise factor in most of this survey. Station TLM02 was located within a half kilometer of the Tangle Lakes Lodge (mile 22 on the Denali Highway). No electrical interference originating from that facility was visible in the data. Stations TLM02, TLM04, and TLM05 were located within 0.2 km of the Denali Highway. Recordings were not made when noise from moving vehicles affected the magnetic signals. Local lightning, wind, and rainstorms can also degrade data quality, but these

were avoided by not recording during active thunderstorm periods. Wind noise was minimized by burying the magnetic induction coils and by keeping the E-field lines lying flat on the ground as much as possible.

Predicted values of the electric field can be computed from the measured values of the magnetic field (Vozoff, 1991). The coherence of the predicted electric field with the measured electric field is a measure of the signal-to-noise ratio provided in the multiple coherency plot. Values are normalized between 0 and 1, where values at 0.5 signify signal levels equal to noise levels. For this data set, coherencies were at an acceptable level below 0.1Hz except for station TLM03. Coherencies in the "dead band" (0.1 to 5 Hz) were low for all stations and will severily reduce the quality of future 2-dimensional models. Data at frequencies above 5 Hz had high coherencies at nearly all stations. Station TLM09 had good coherencies only below 0.1 Hz and the two highest frequencies. Data quality at TLM09 and TLM12 was poor due to high winds. The lower frequency ionospheric signals are related to sunspot activity whose levels typically follow an 11 year cycle. The sunspot activity was near the highest level of the cycle during this survey.

The figures in the Appendix represent the field-processed MT data at each station, which includes some data scatter and poor signal-to-noise ratios. Our only effort at removing noisy data points was to visually inspect and select the best signal-to-noise field data to combine into the final data plots.

The impedance polar plots provide a measure of the MT data dimensionality (Reddy and others, 1977). For 1-D resistivity structures, the principal impedance polar diagram (dashed line) is a circle. For 2-D or 3-D resistivity structures, the

principal impedance polar diagram (dashed line) elongates either parallel or perpendicular to strike direction. Over a resistor, the principal impedance polar diagram elongates perpendicular to strike direction. Over a conductor, the principal impedance polar diagram elongates parallel to strike direction. Also, for 2-D resistivity structures, the additional impedance polar diagram (solid line) attains the shape of a symmetric clover leaf. For 3-D resistivity structures, the additional impedance polar diagram (solid line) elongates in one direction and its amplitude is comparable to that of the principal impedance polar diagram (dashed line). Sites along the Tangle Lakes profile whose polar plots indicated 3-D character in the lower frequencies were MT stations TLM06, TLM08, TLM11, TLM12 and TLM13. Data for MT stations TLM01 and TLM03 are very noisy, however, and appear to be 3-D also.

The tipper can be calculated when the vertical component of the magnetic field is measured. The tipper magnitude is a measure of the tipping of the magnetic field out of the horizontal plane (Vozoff, 1991). The magnitude is zero for the 1-D case and typically increases to values between 0.1 to 0.5, but rarely as great as 1, as it responds to 2-D and 3-D vertical and sub-vertical buried structures. The tipper strike is typically used to help resolve the 90-degree ambiguity in the impedance rotation angle. The vertical component of the magnetic field was measured at all MT stations. The tipper magnitude of these stations was typically 0.3 to 0.5 over the lower frequencies indicating vertical structure at depth. The HzHx and HzHy coherency is a measure of the signal-to-noise ratio of the vertical magnetic field with respect to each of the orthogonal horizontal magnetic field directions. Values are normalized between 0 and 1, where values at 0.5 signify signal levels equal to noise levels. These three-component magnetic field coherencies provide a check on the

signal-to-noise ratio of the measured values in the tipper magnitude and tipper strike plots.

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APPENDIX

MAGNETOTELLURIC DATA PLOTS

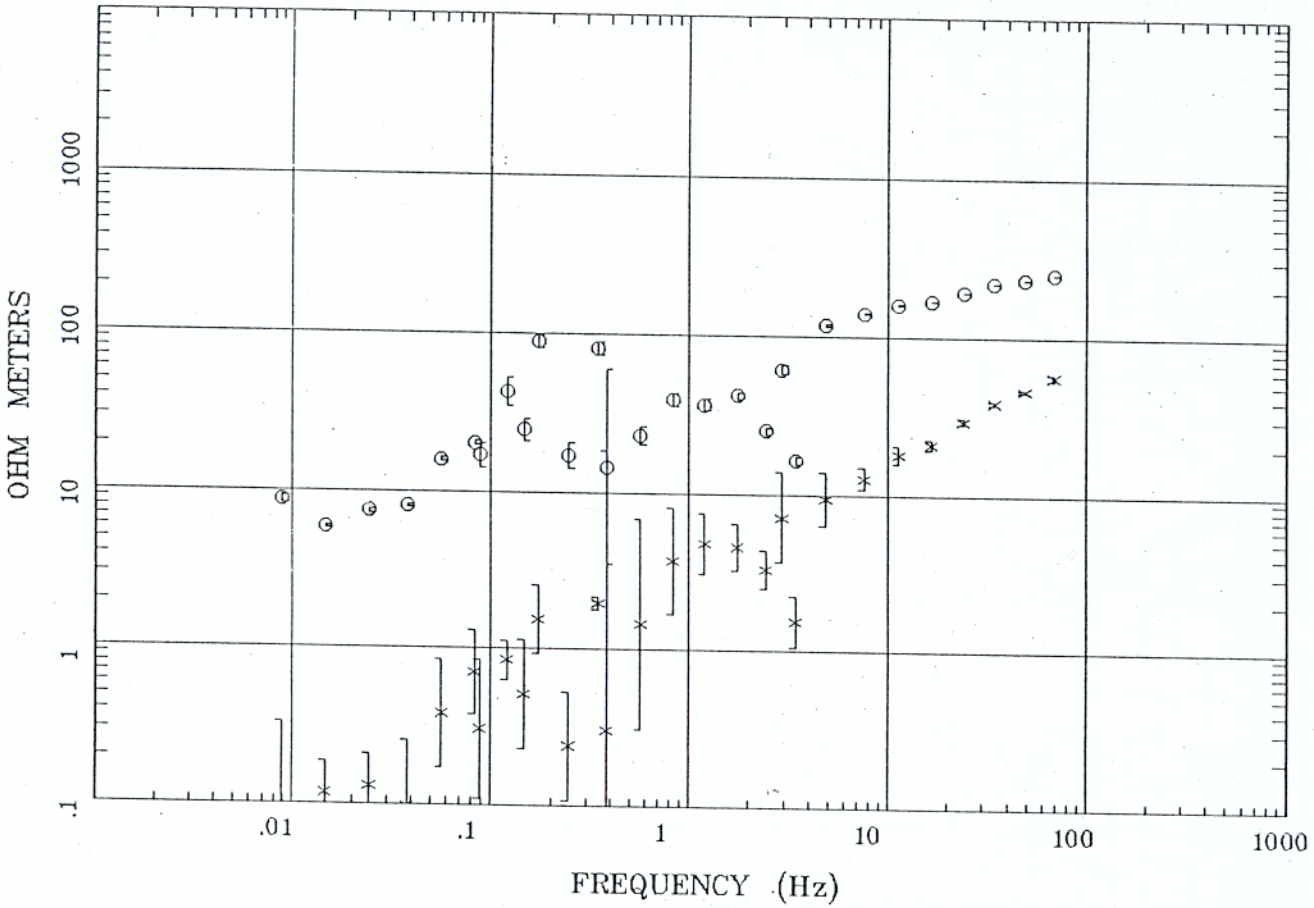
For each station, there are nine separate graph plots:

1. Apparent Resistivity for the rotated maximum (x symbol) and minimum (o symbol) modes,
2. Impedance Phase for the rotated maximum (x symbol) and minimum (o symbol) modes,
3. Rotation Angle for the impedance tensor (maximum apparent resistivity direction),
4. Impedance Skew for the impedance tensor,
4. Multiple Coherency for the rotated maximum (x symbol) and minimum (o symbol) modes of the electric field,
6. Impedance Polar Plots (at 12 selected frequencies),
7. Tipper Magnitude for the vertical magnetic field,
8. Tipper Strike for the vertical magnetic field, and
9. HzHx (x symbol) and HzHy (o symbol) Coherency.

Refer to the "Magnetotelluric Data" section in this report for an explanation of these plots.

APPARENT RESISTIVITY

Tangle Lakes, Alaska



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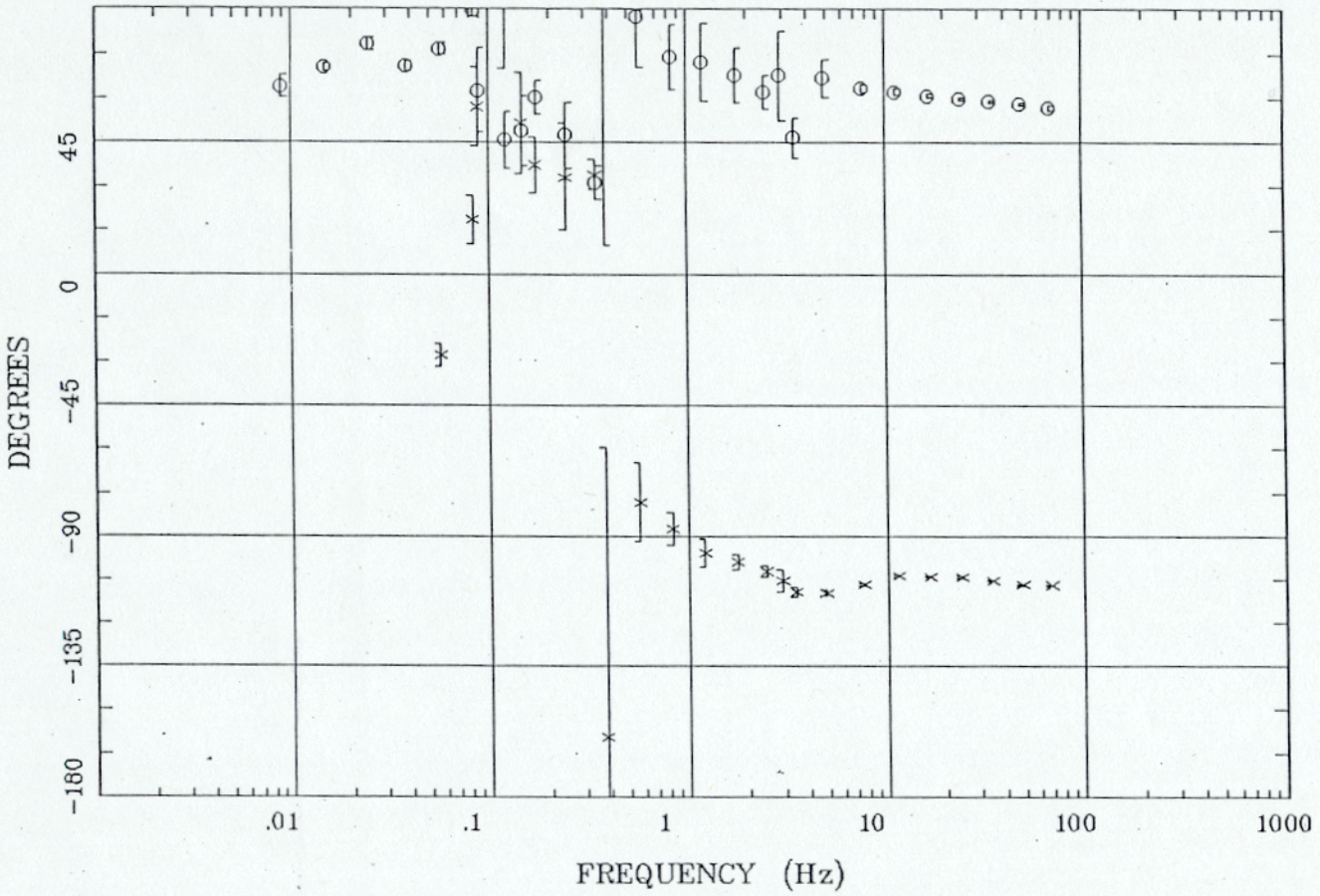
81

IMPEDANCE PHASE

Tangle Lakes, Alaska



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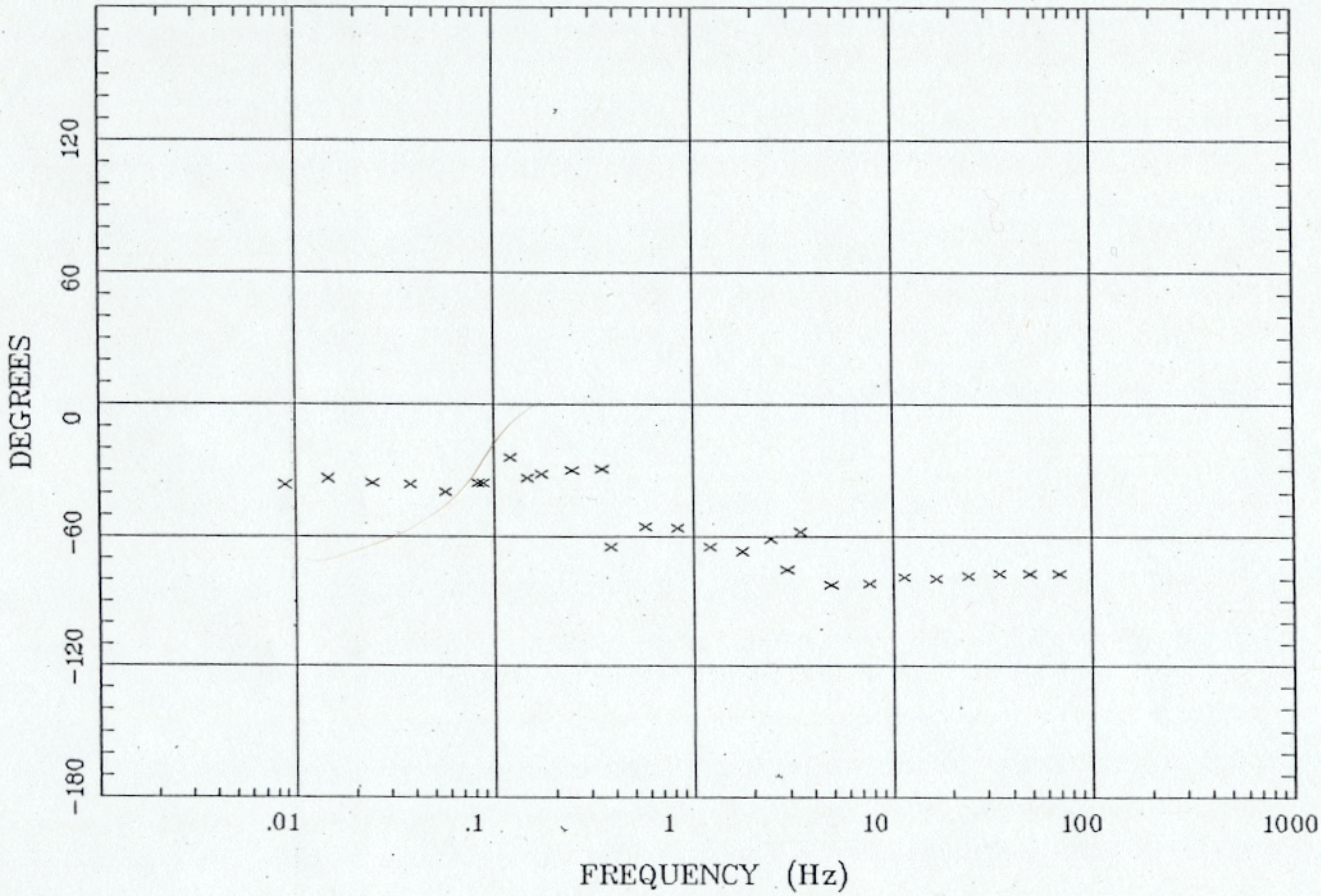

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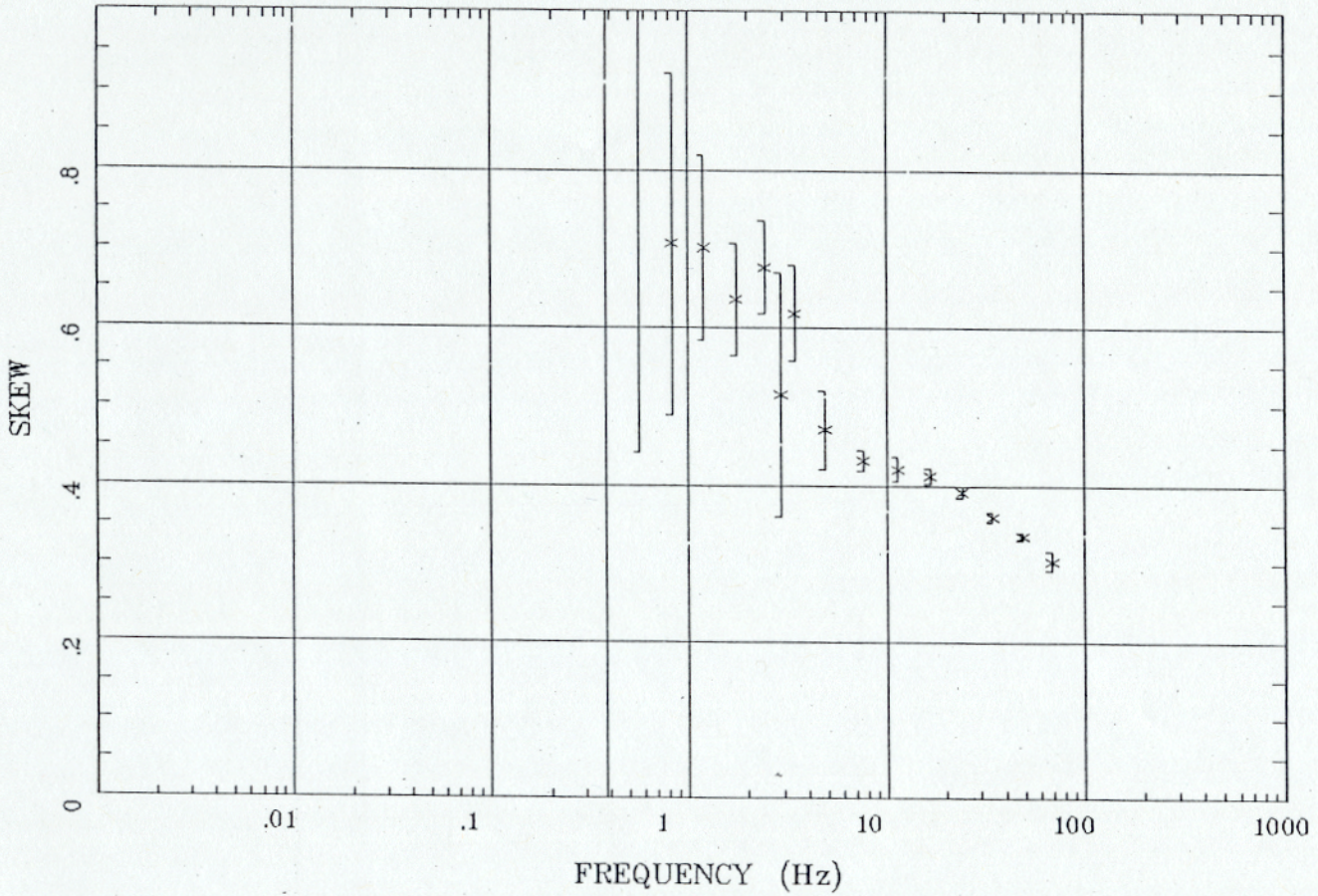

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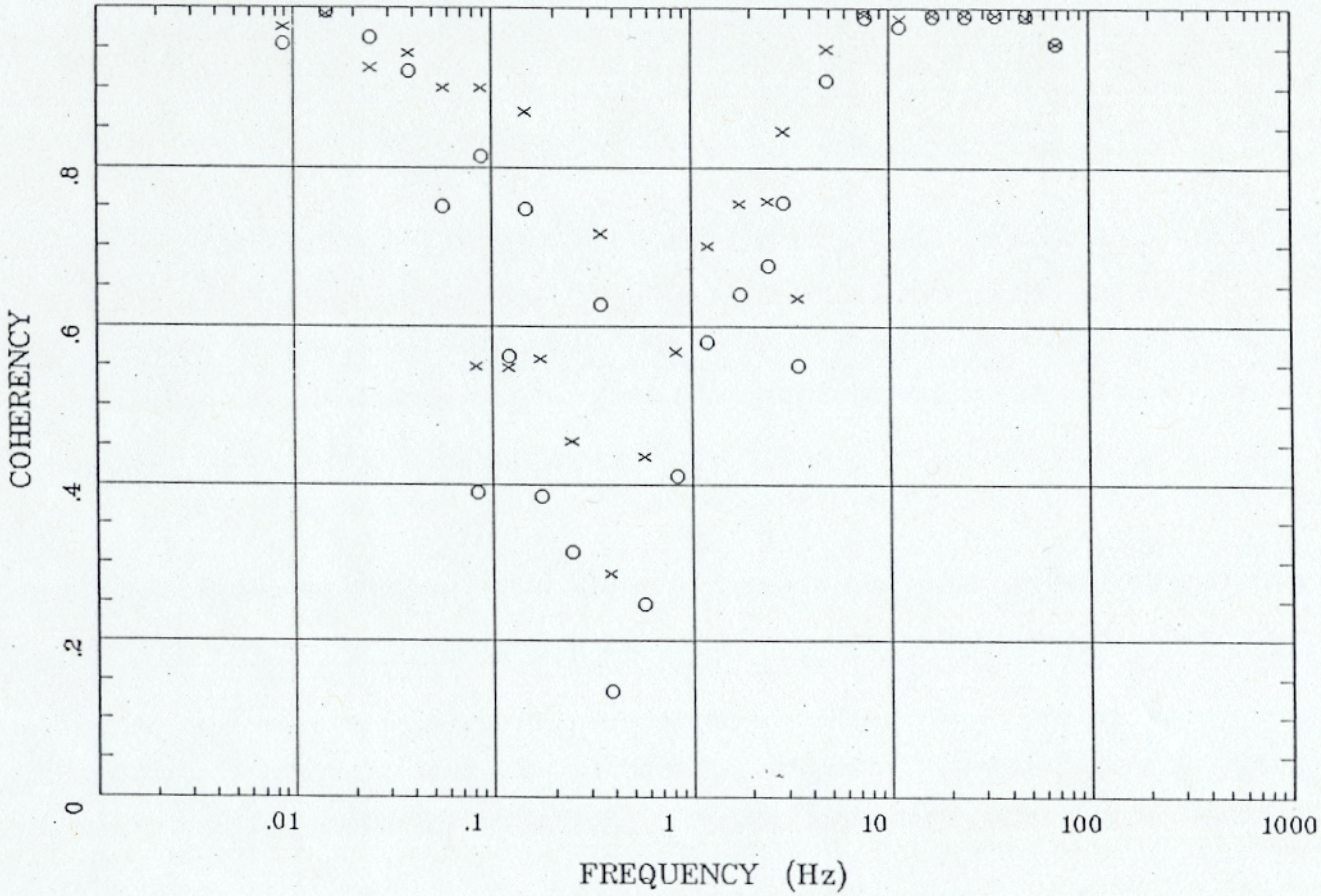

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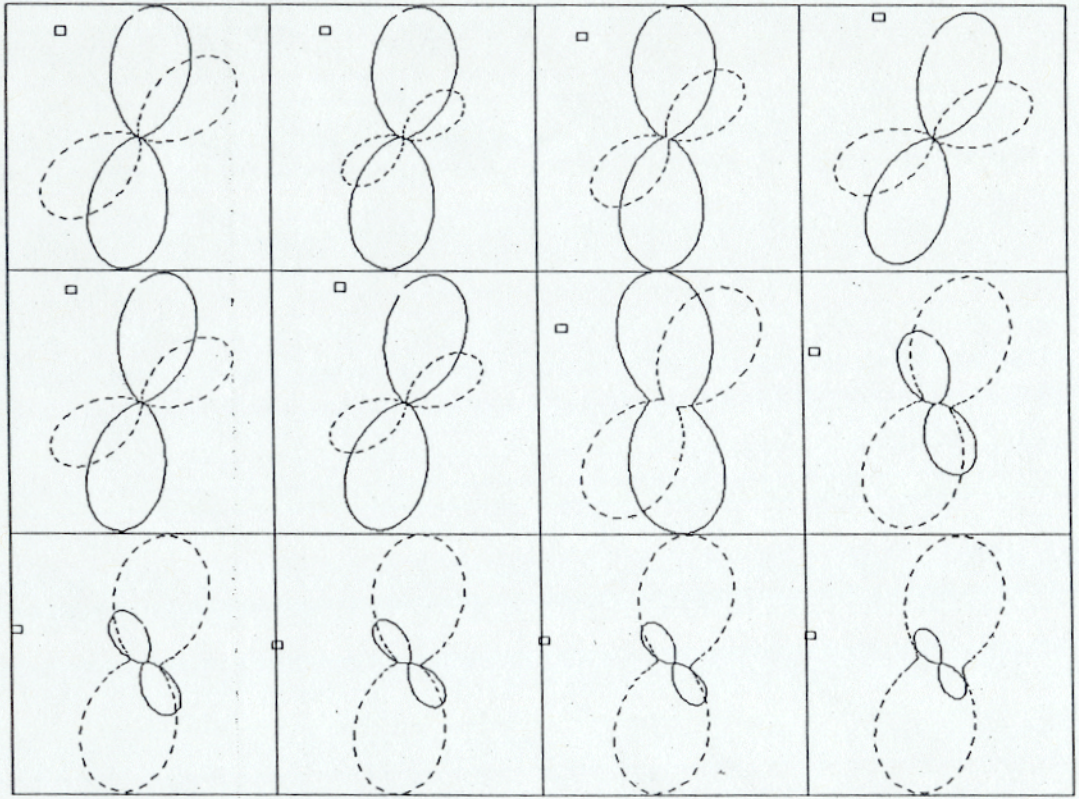
POLAR PLOTS Tangle Lakes, Alaska



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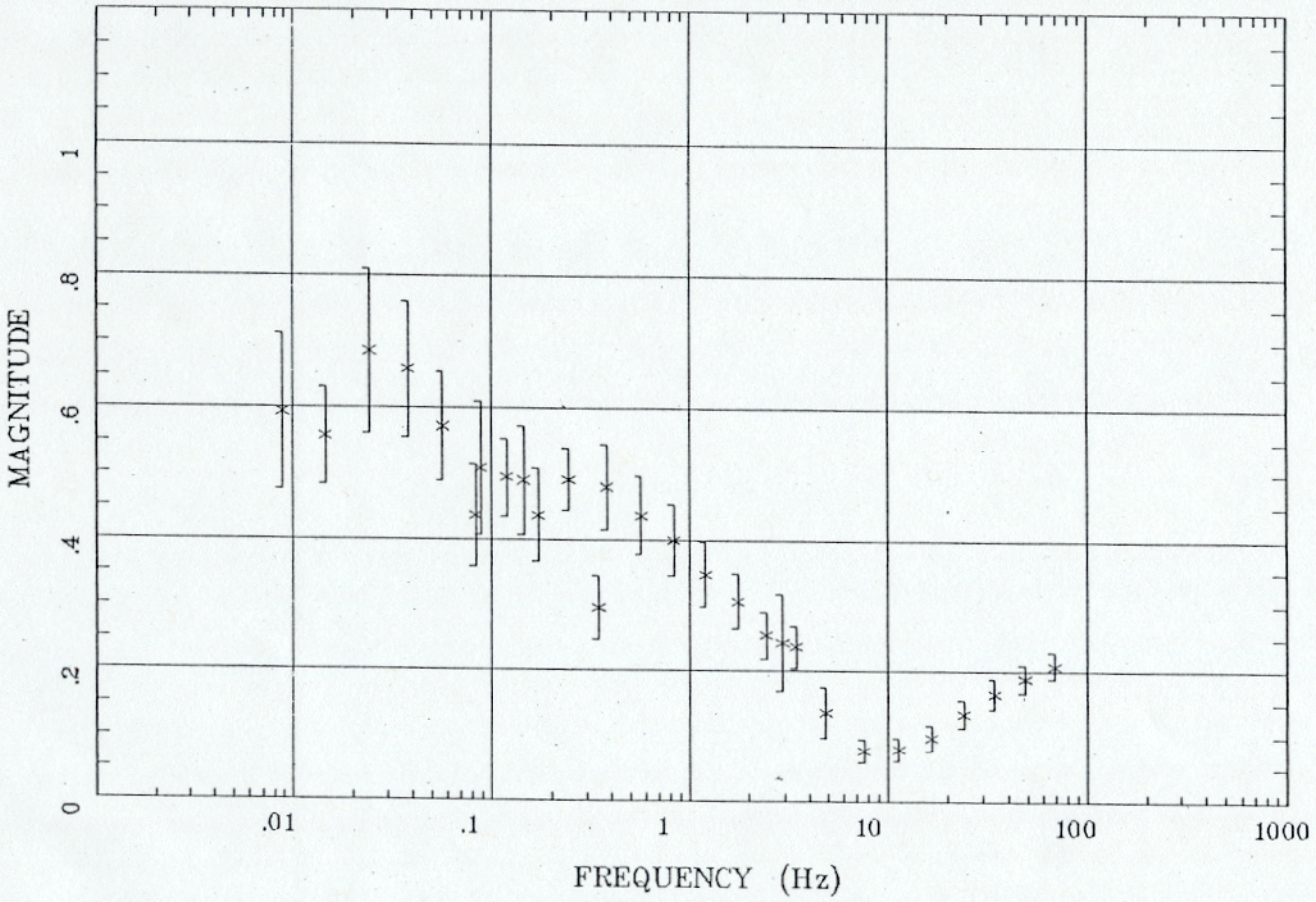
TIPPER MAGNITUDE

Tangle Lakes, Alaska



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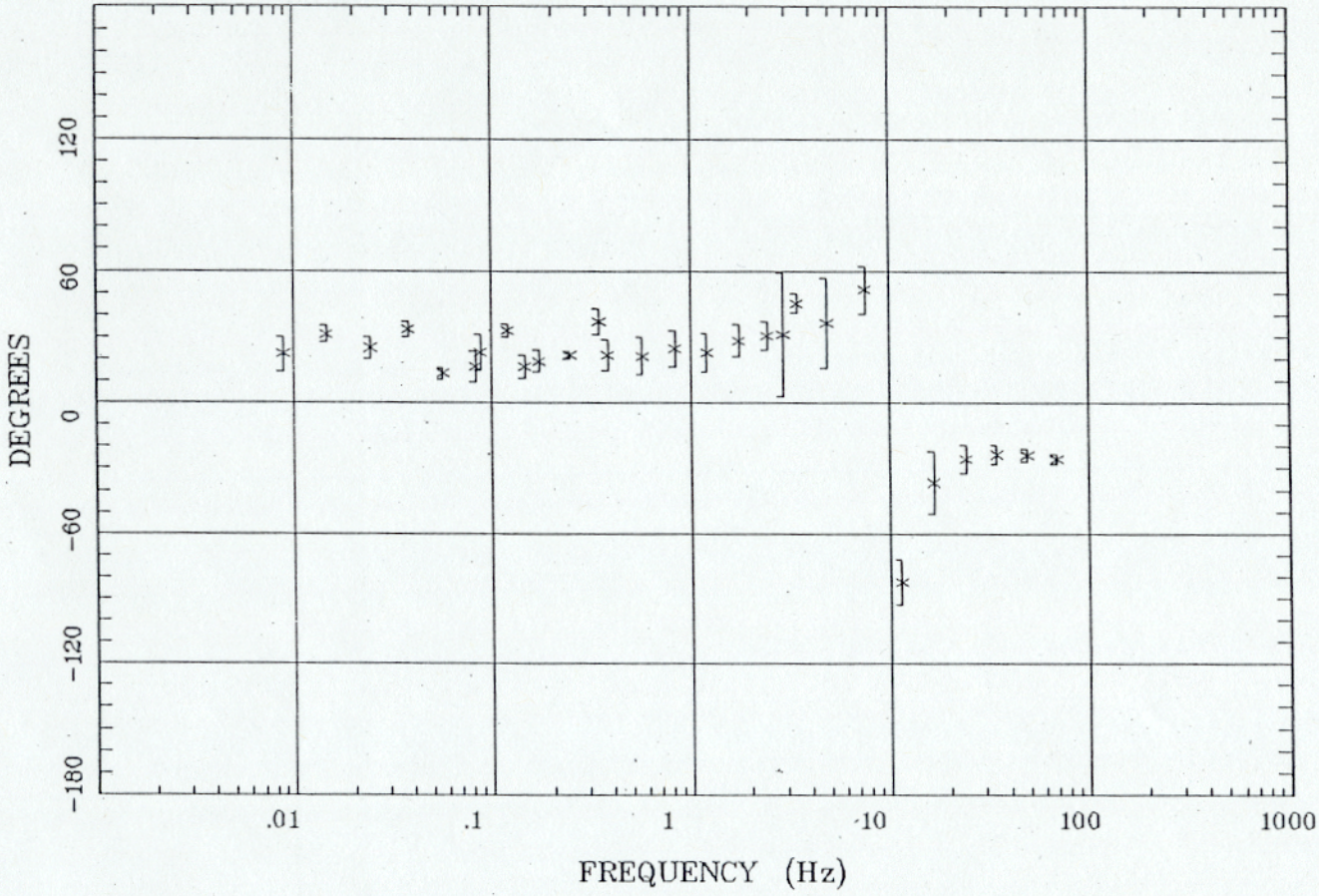

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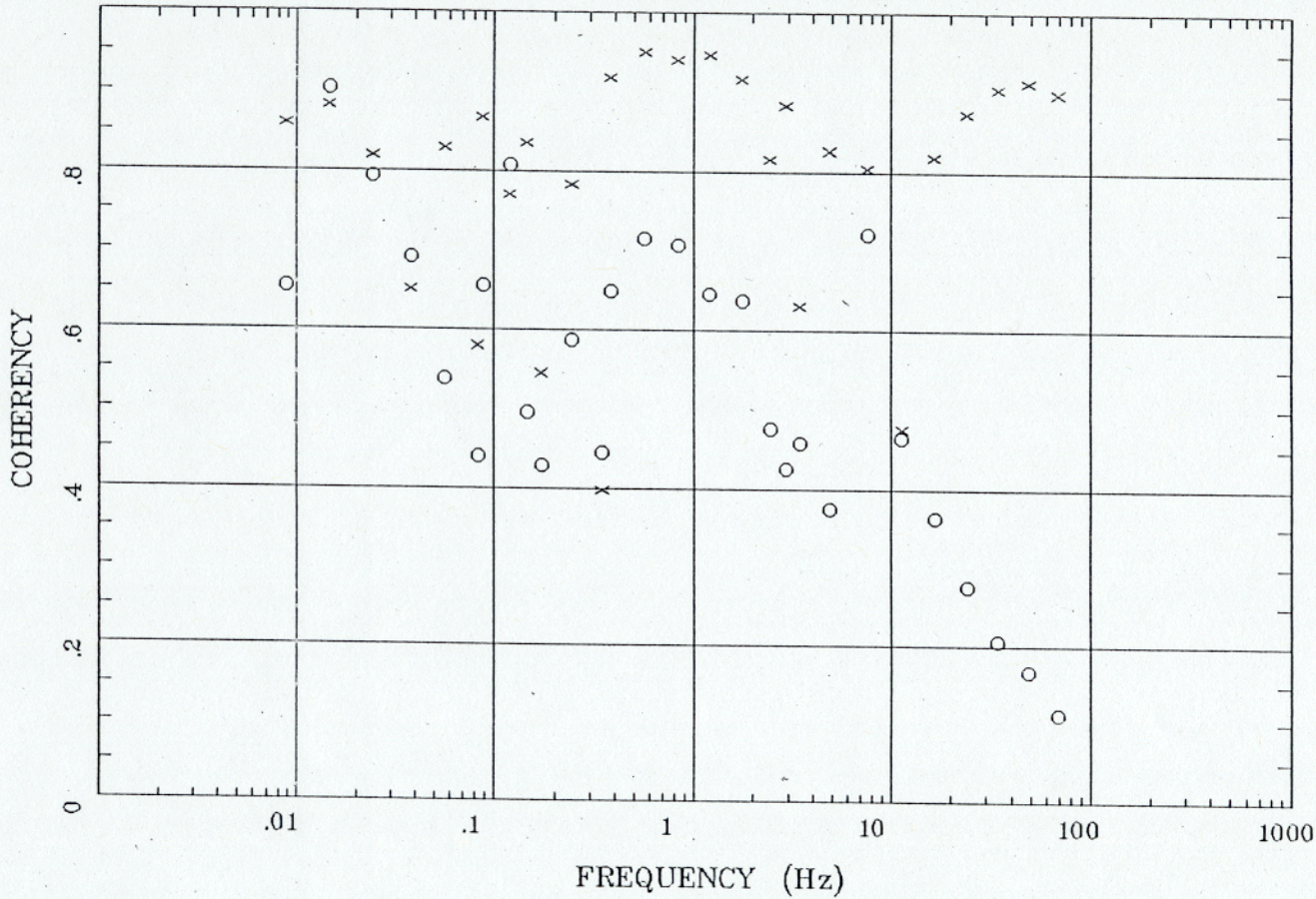
HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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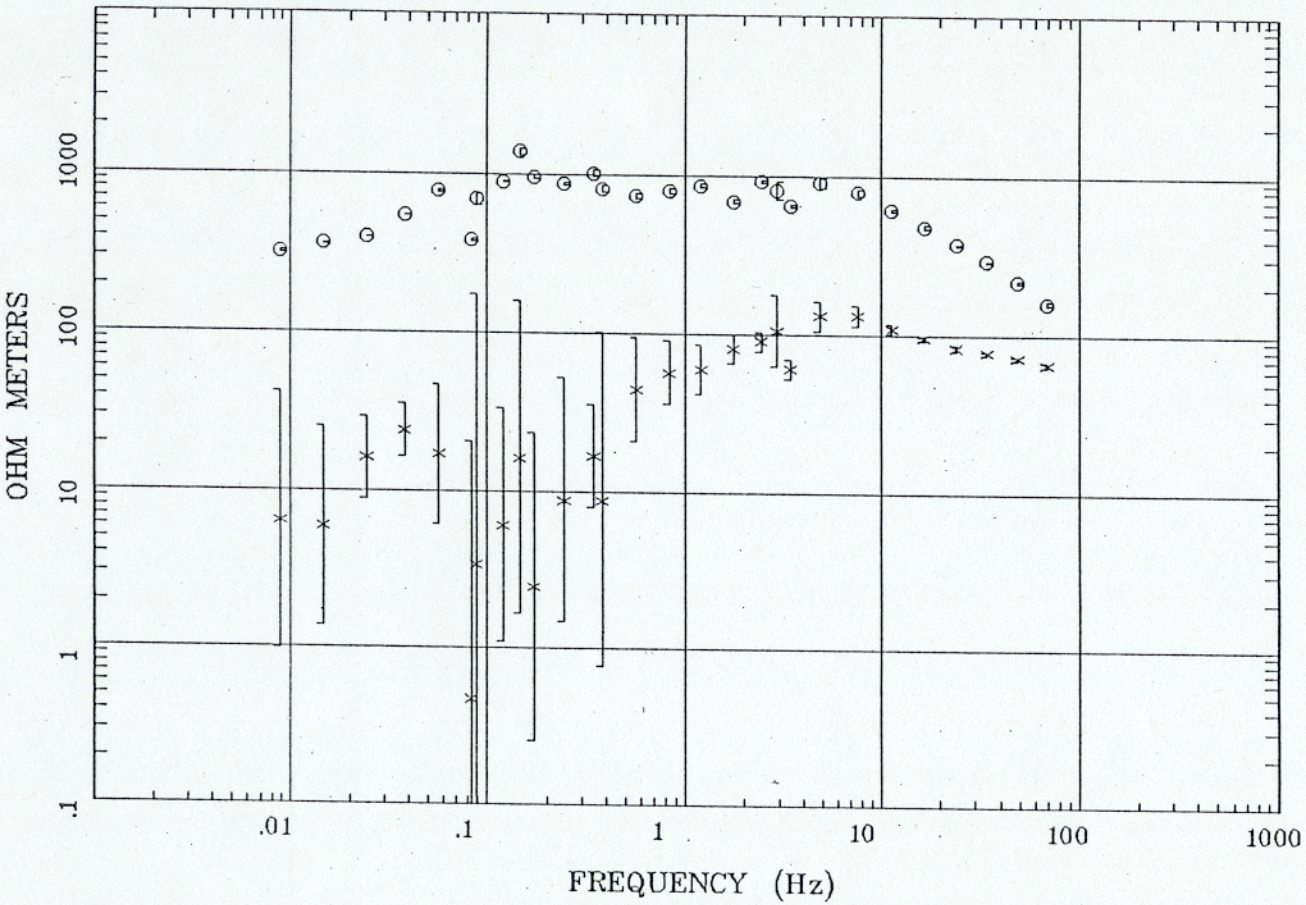
APPARENT RESISTIVITY

Tangle Lakes, Alaska



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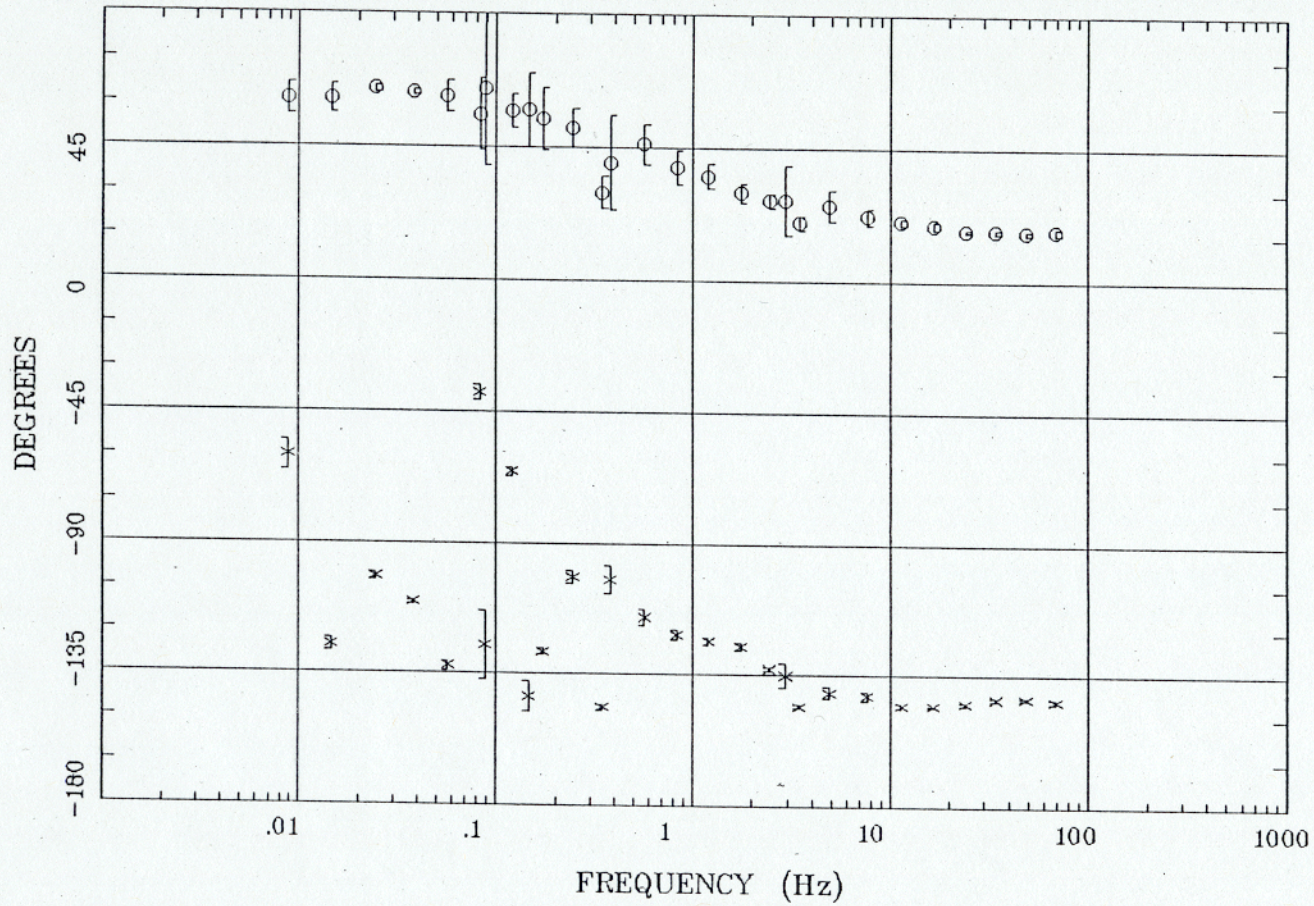
IMPEDANCE PHASE

Tangle Lakes, Alaska



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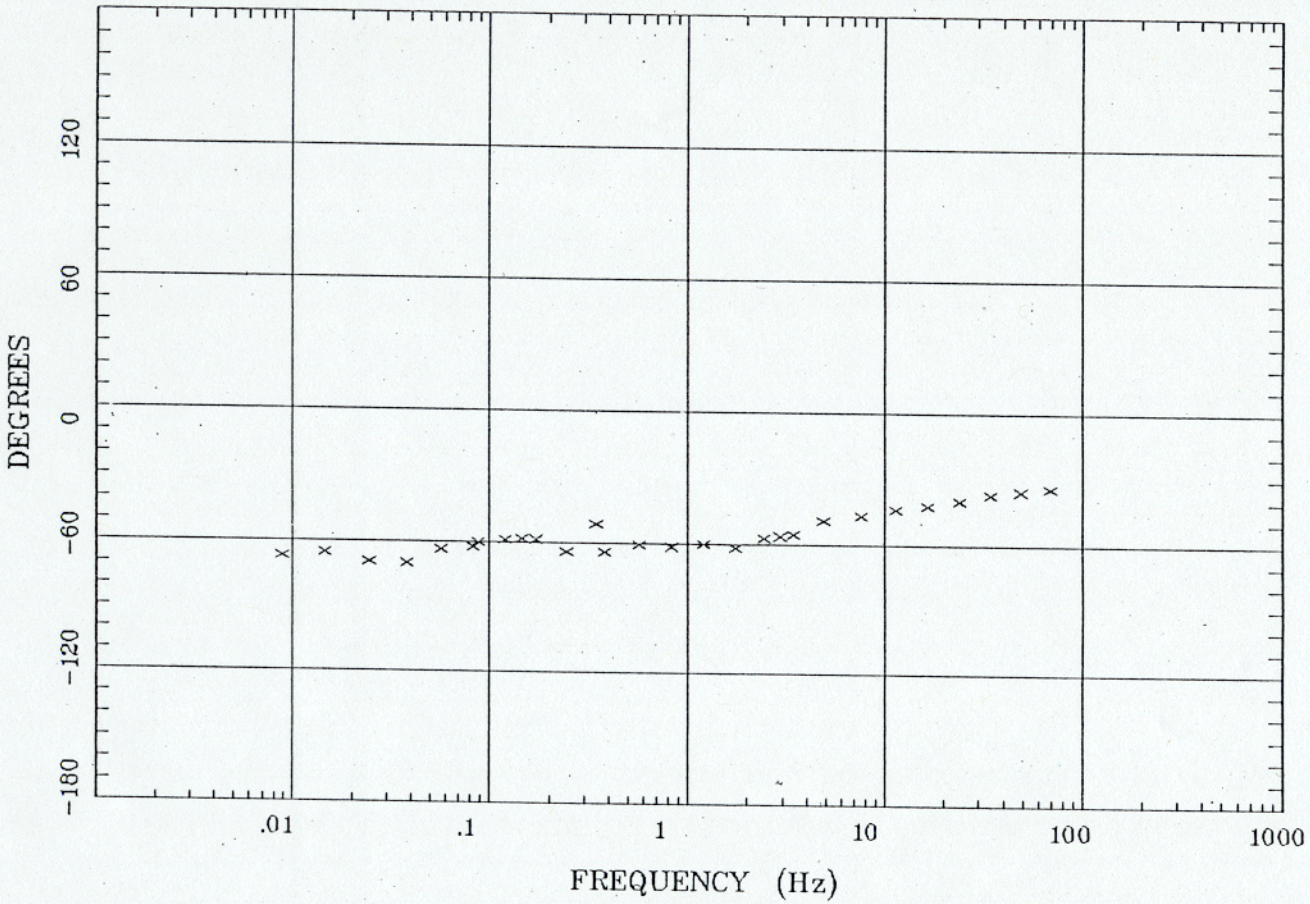
ROTATION ANGLE

Tangle Lakes, Alaska

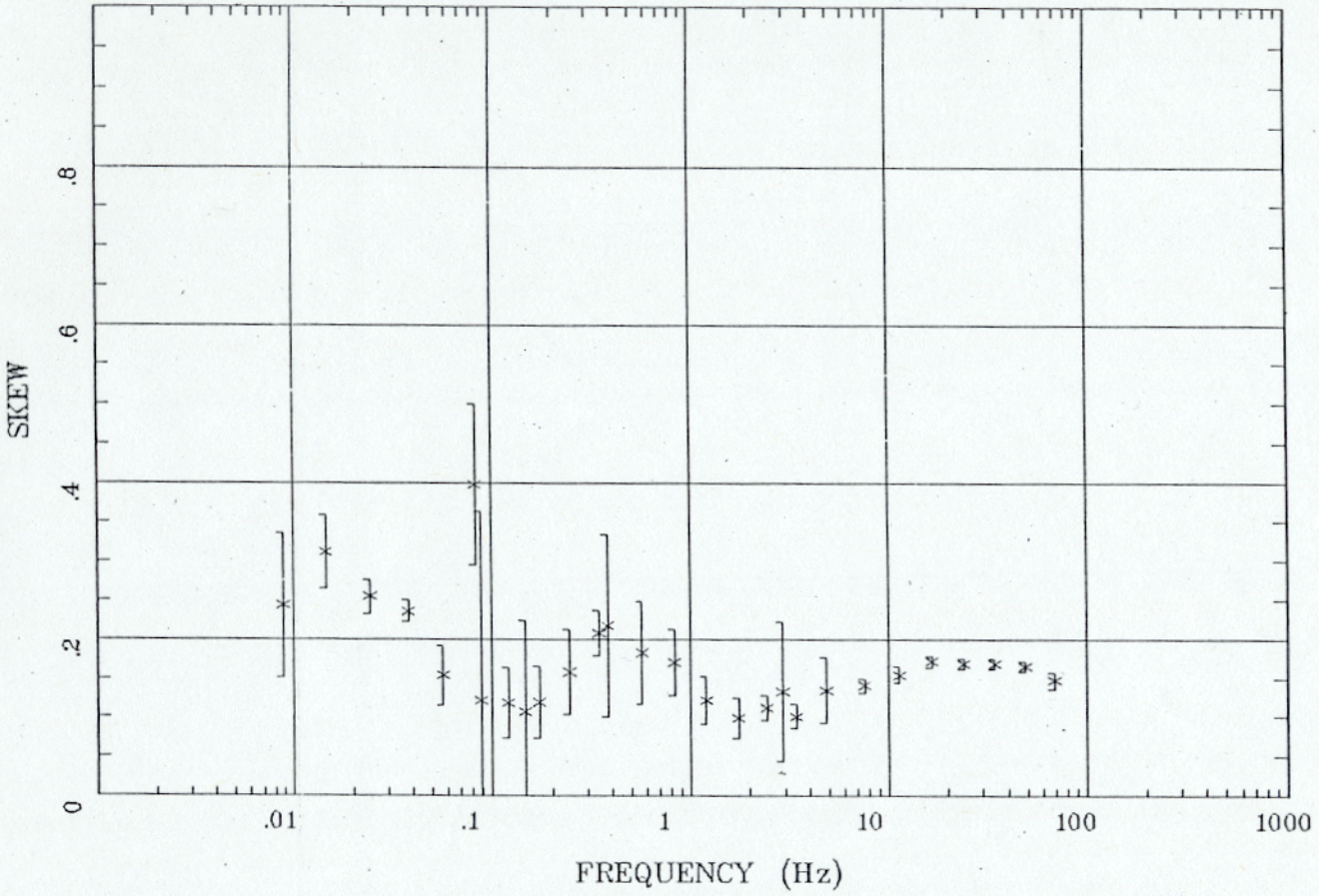


Client:
Remote: none
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska



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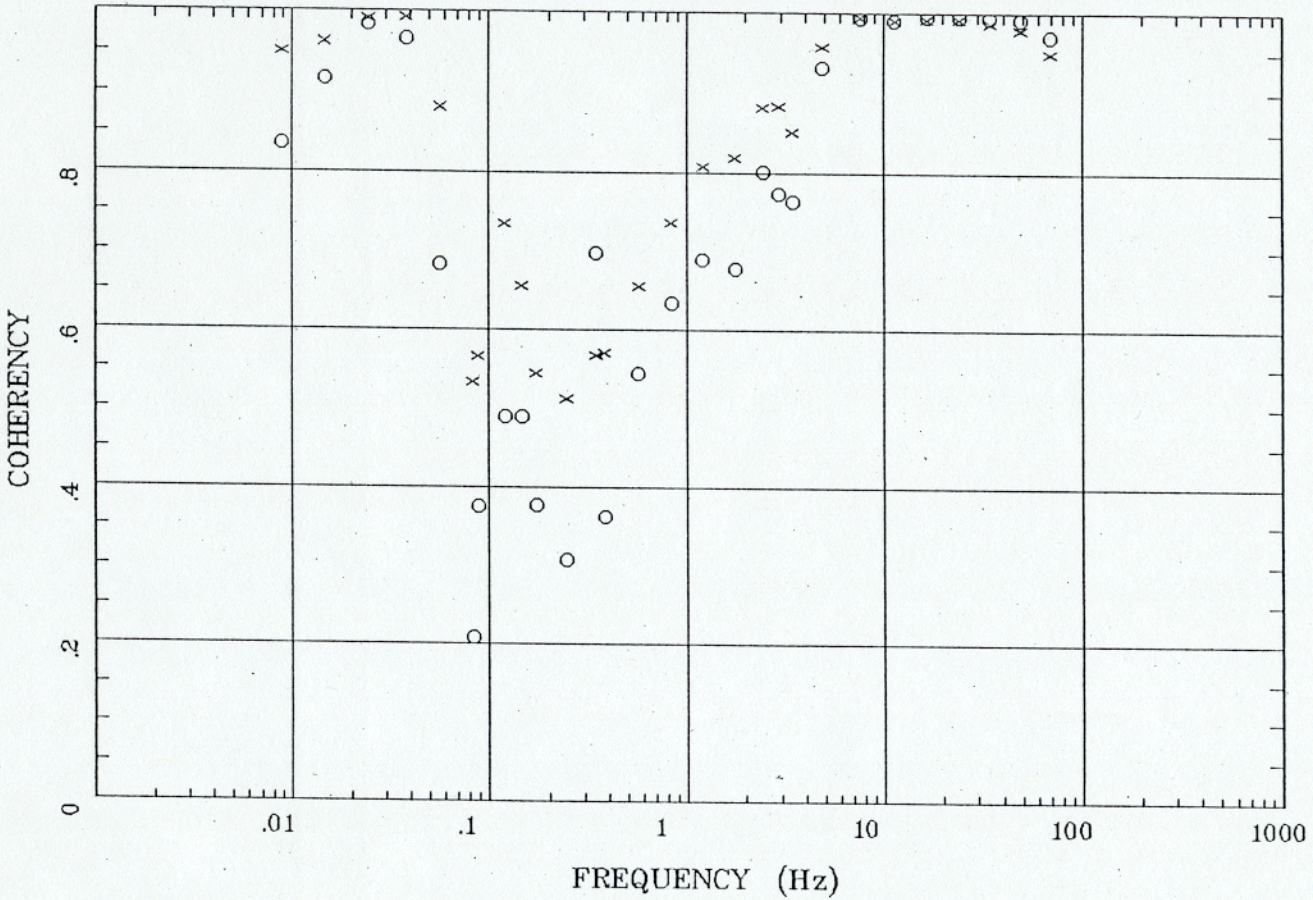
Remote: none
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI - ElectroMagnetic Instruments >

E MULT Coh.

Tangle Lakes, Alaska

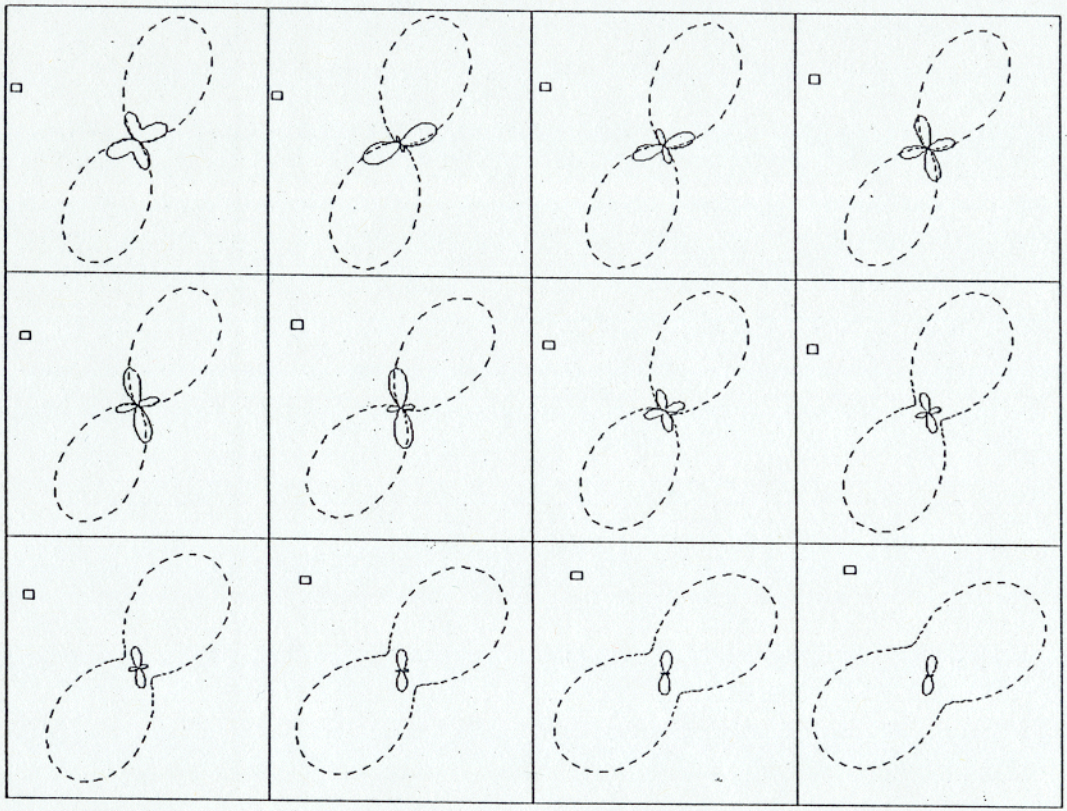


Client:
Remote: none
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska

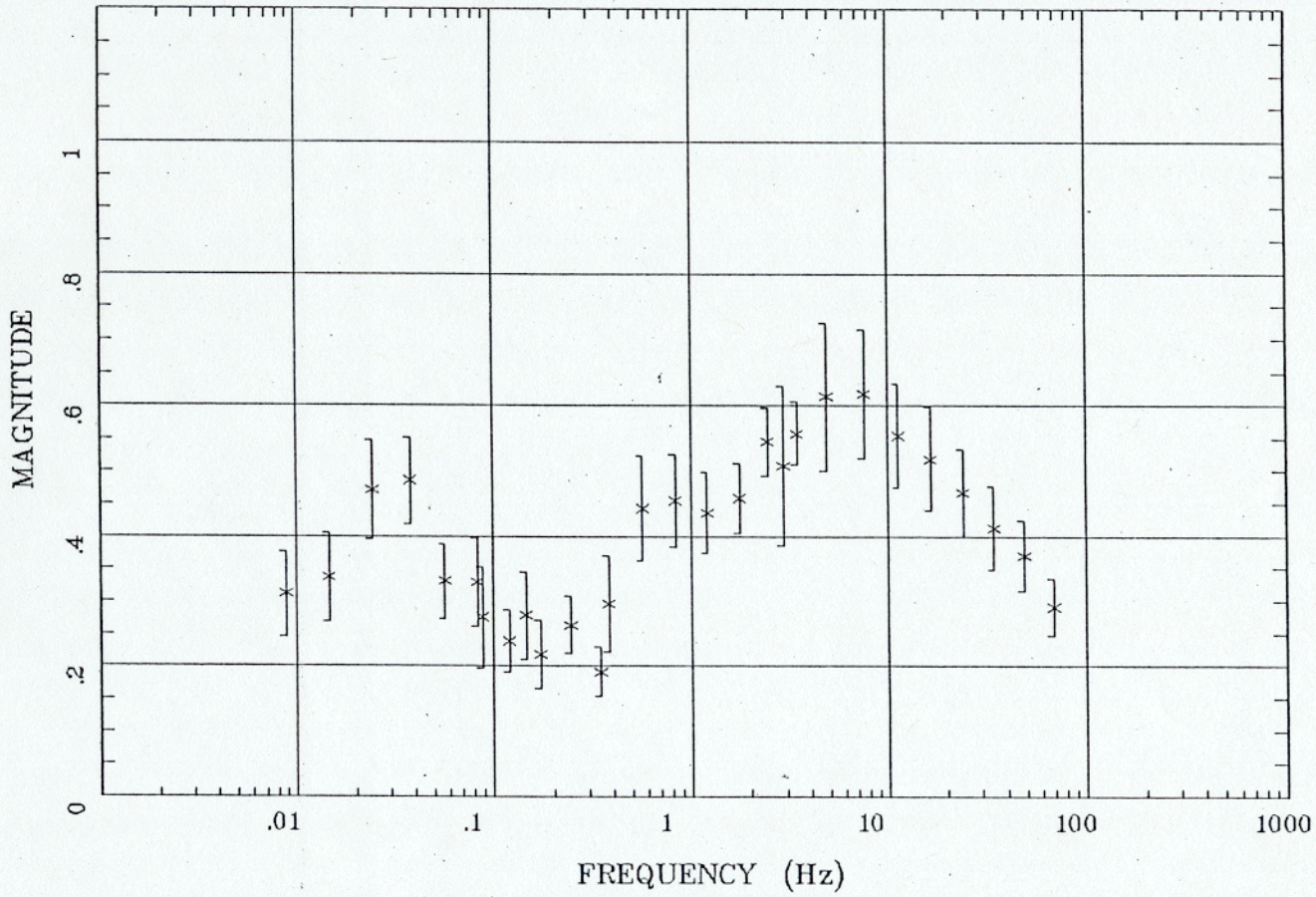


.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE Tangle Lakes, Alaska

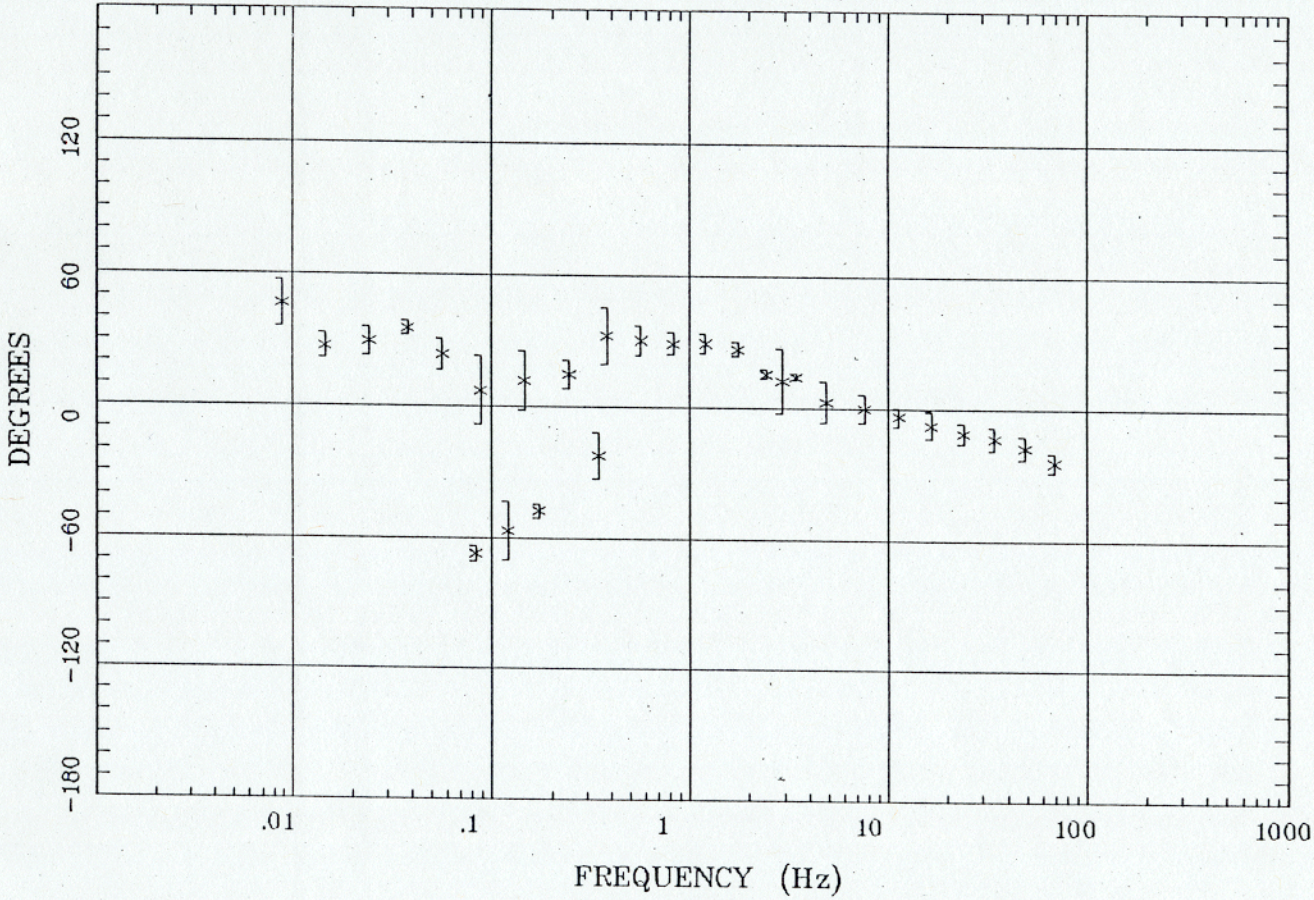


Client:
Remote: none
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



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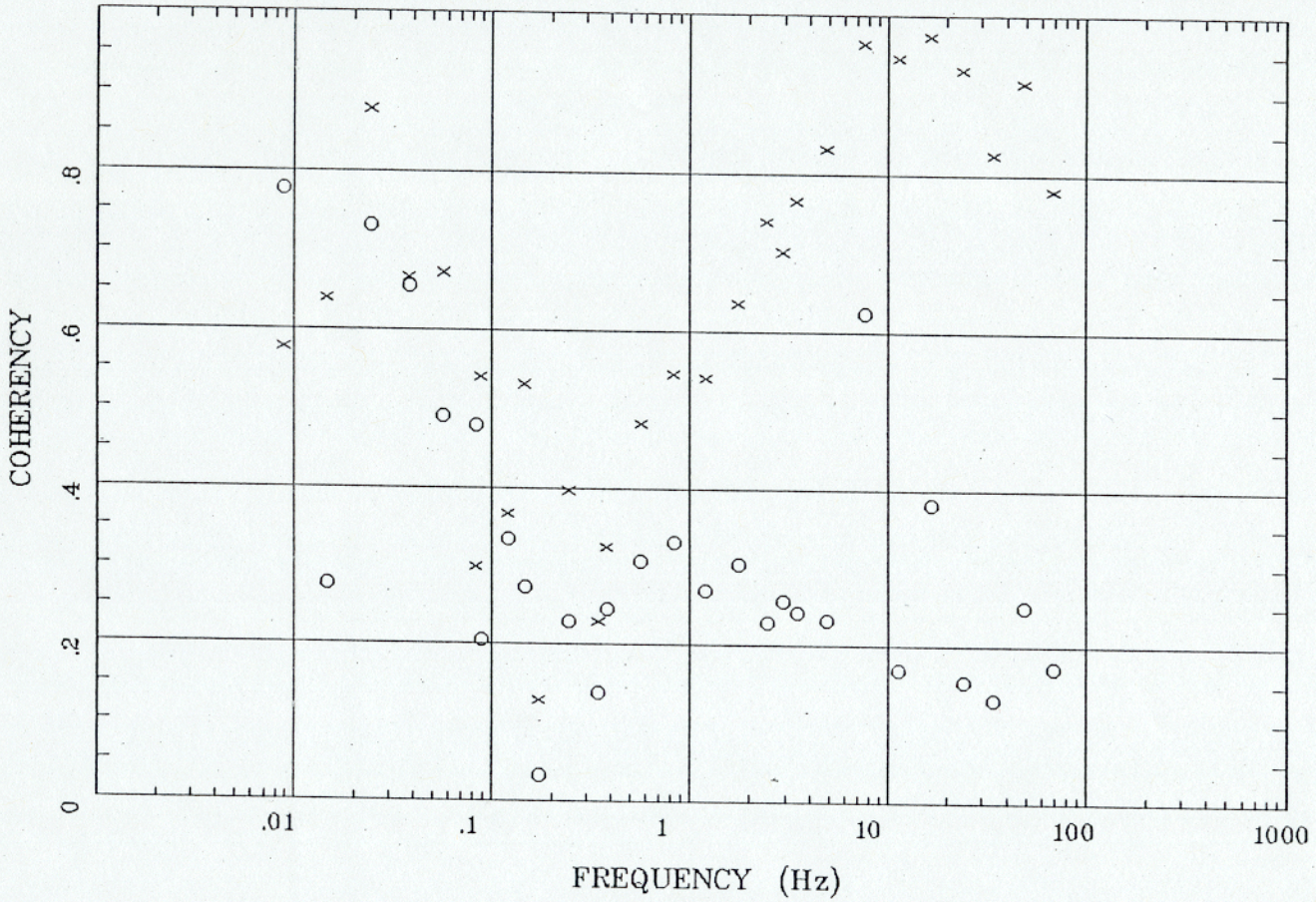
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:40 Oct 19, 2001
< EMI - ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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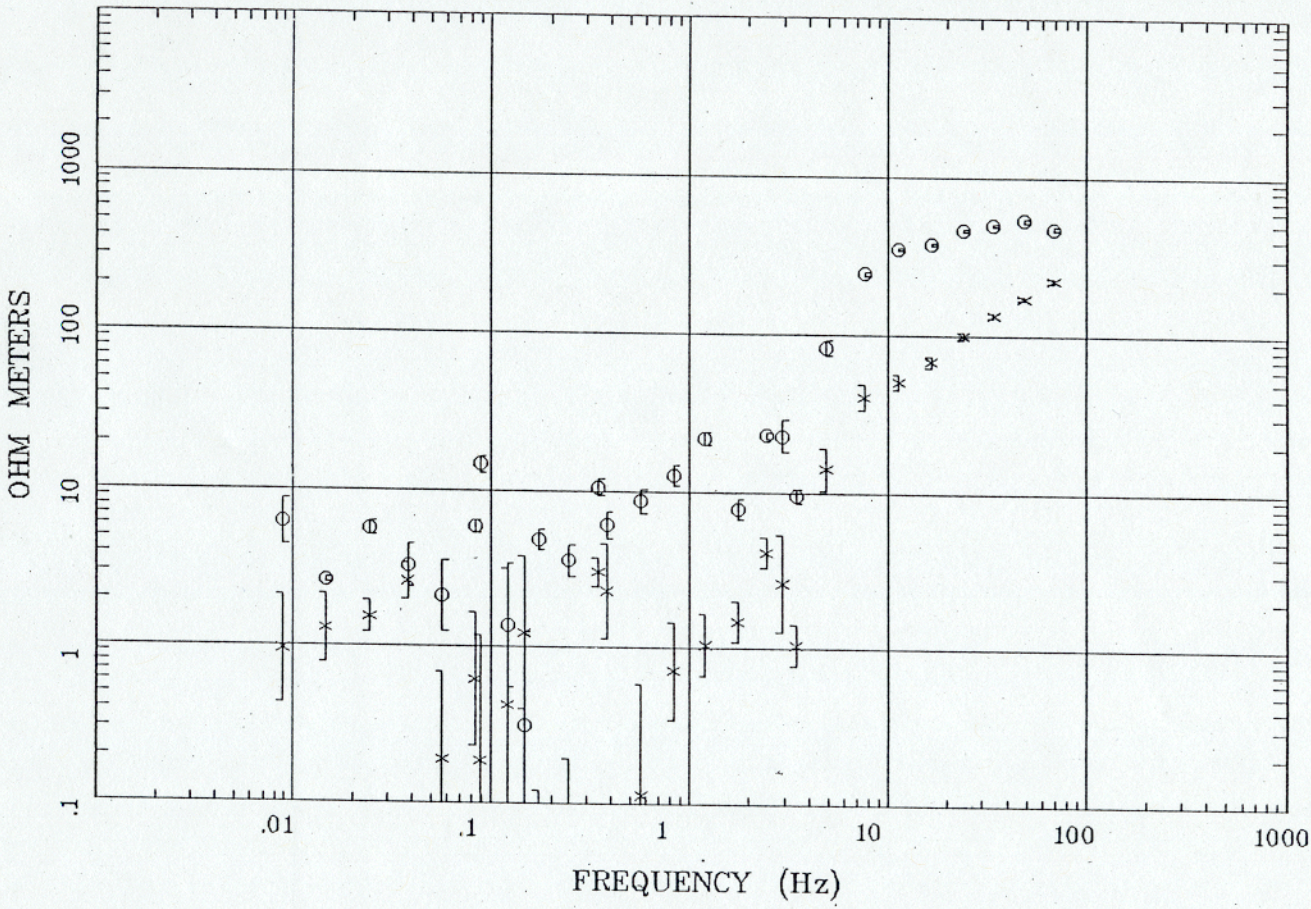
Acquired: 13:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm02all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 12:41 Oct 19, 2001
< EMI - ElectroMagnetic Instruments >

APPARENT RESISTIVITY

Tangle Lakes, Alaska

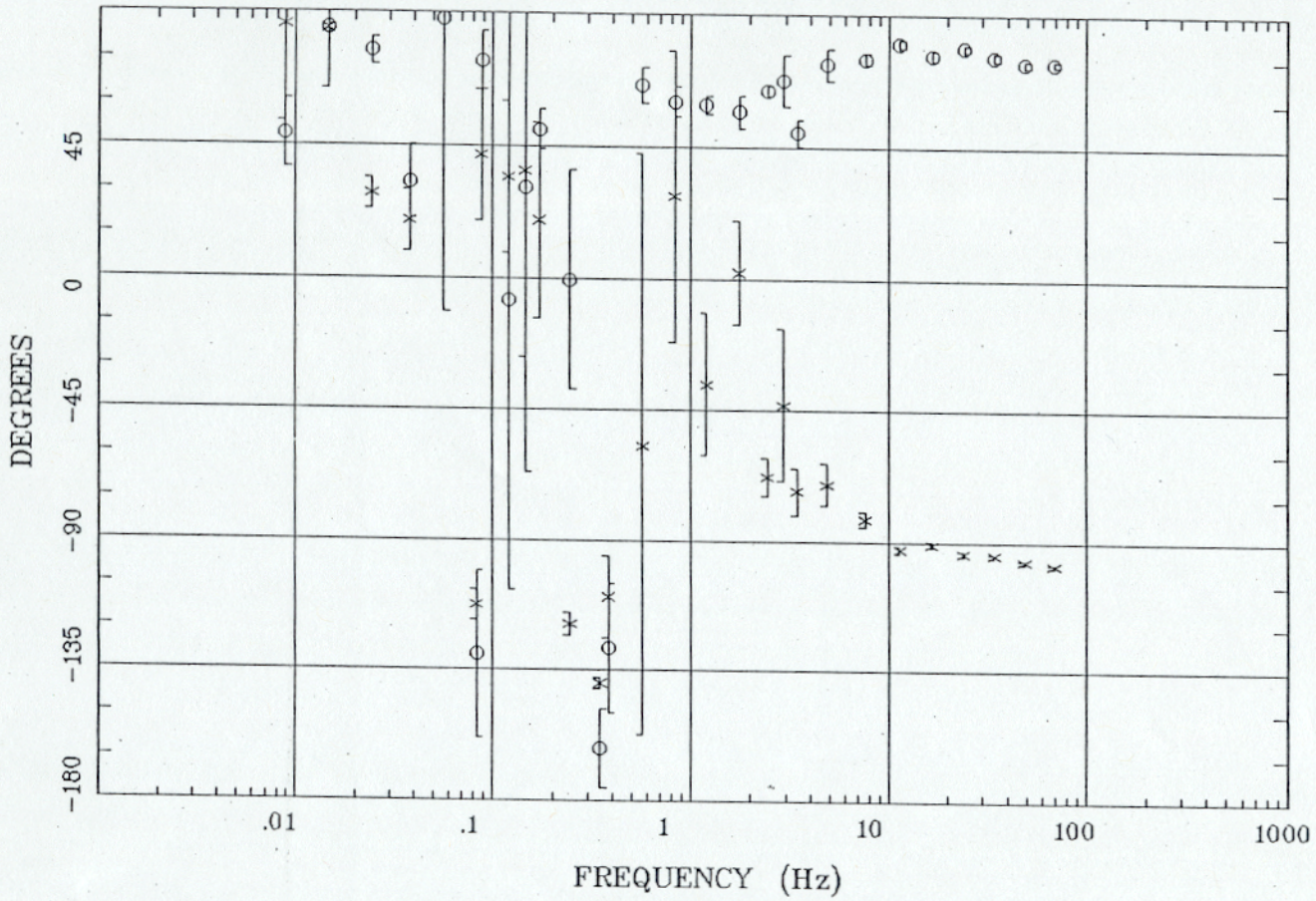


Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

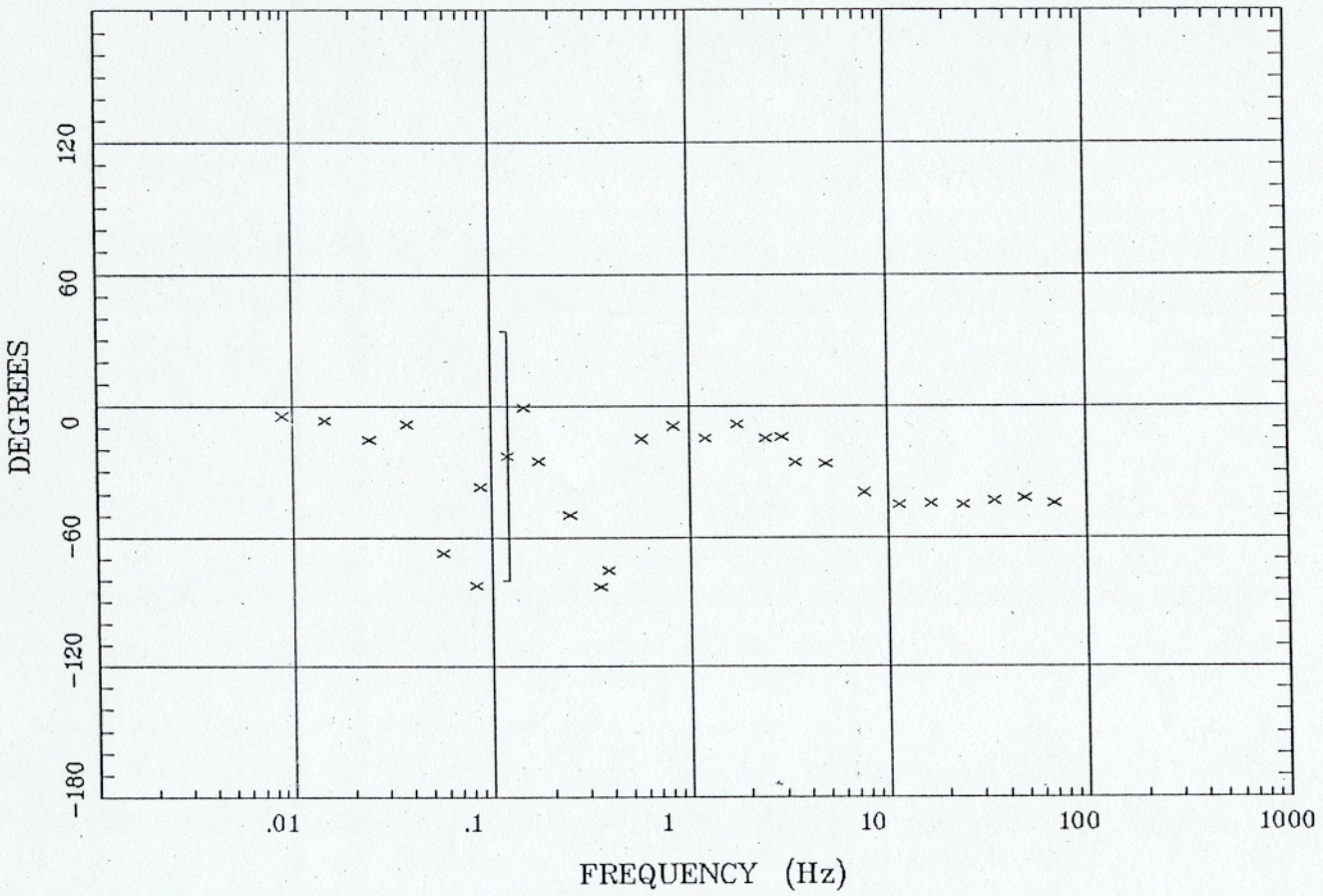
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE Tangle Lakes, Alaska

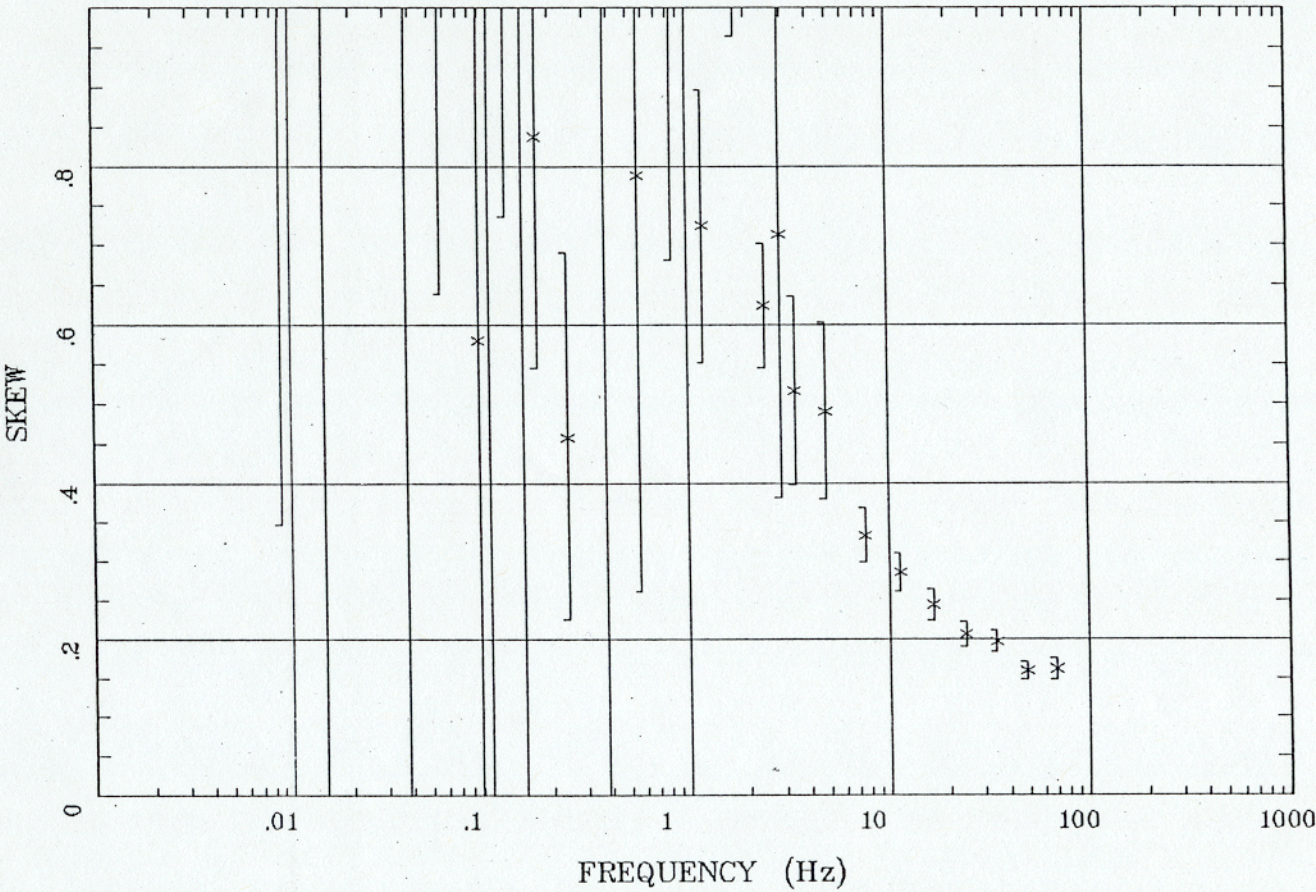


Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

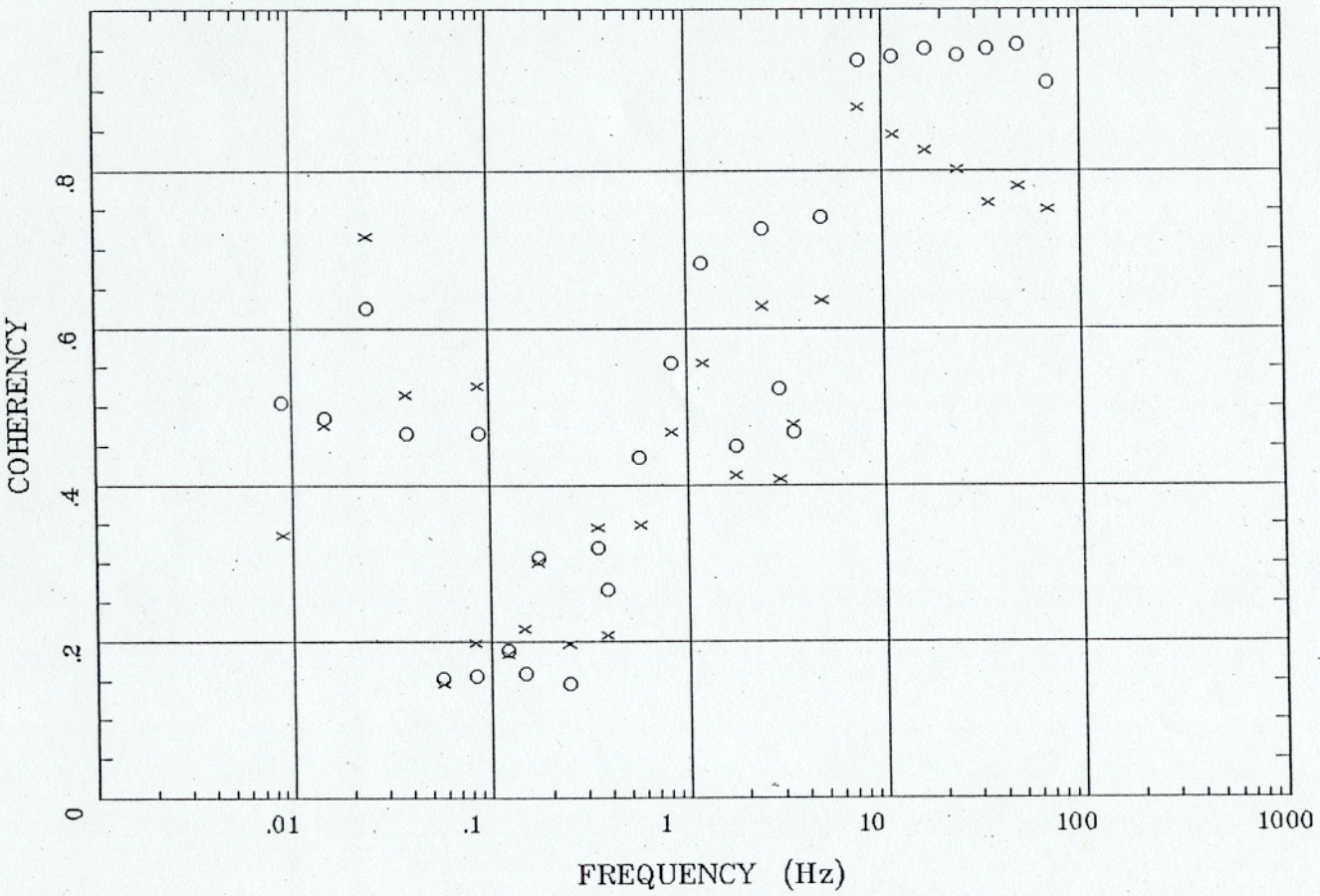
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska

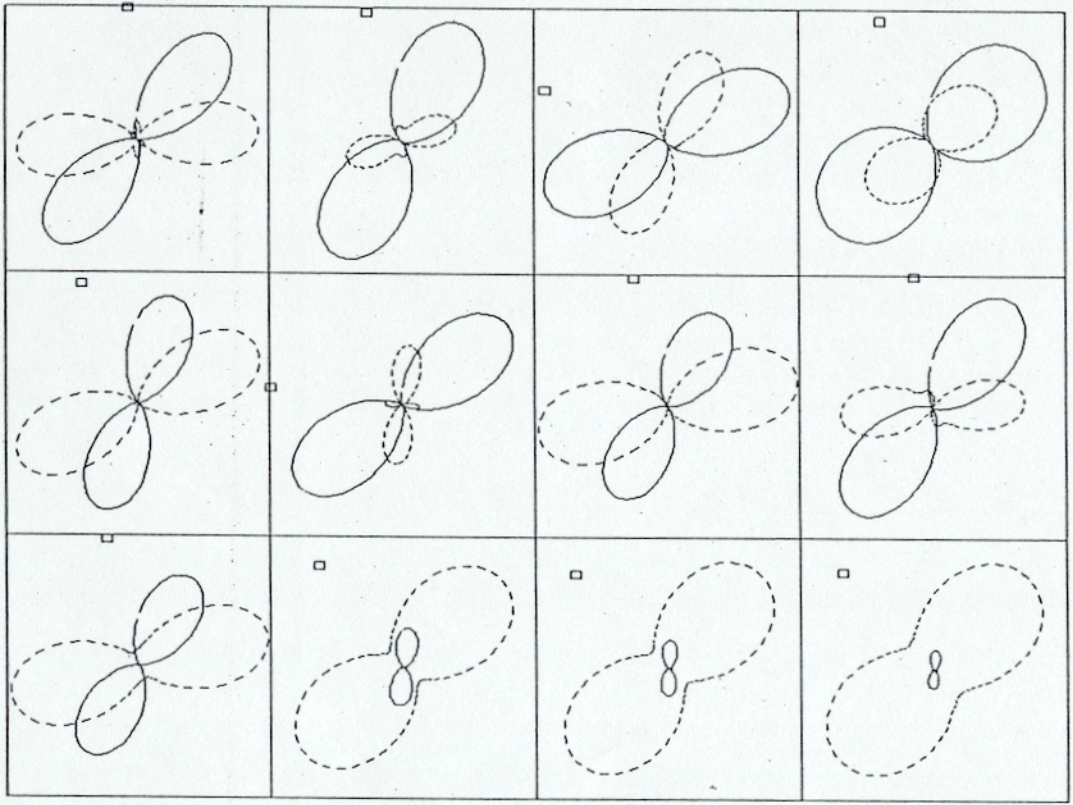


Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska



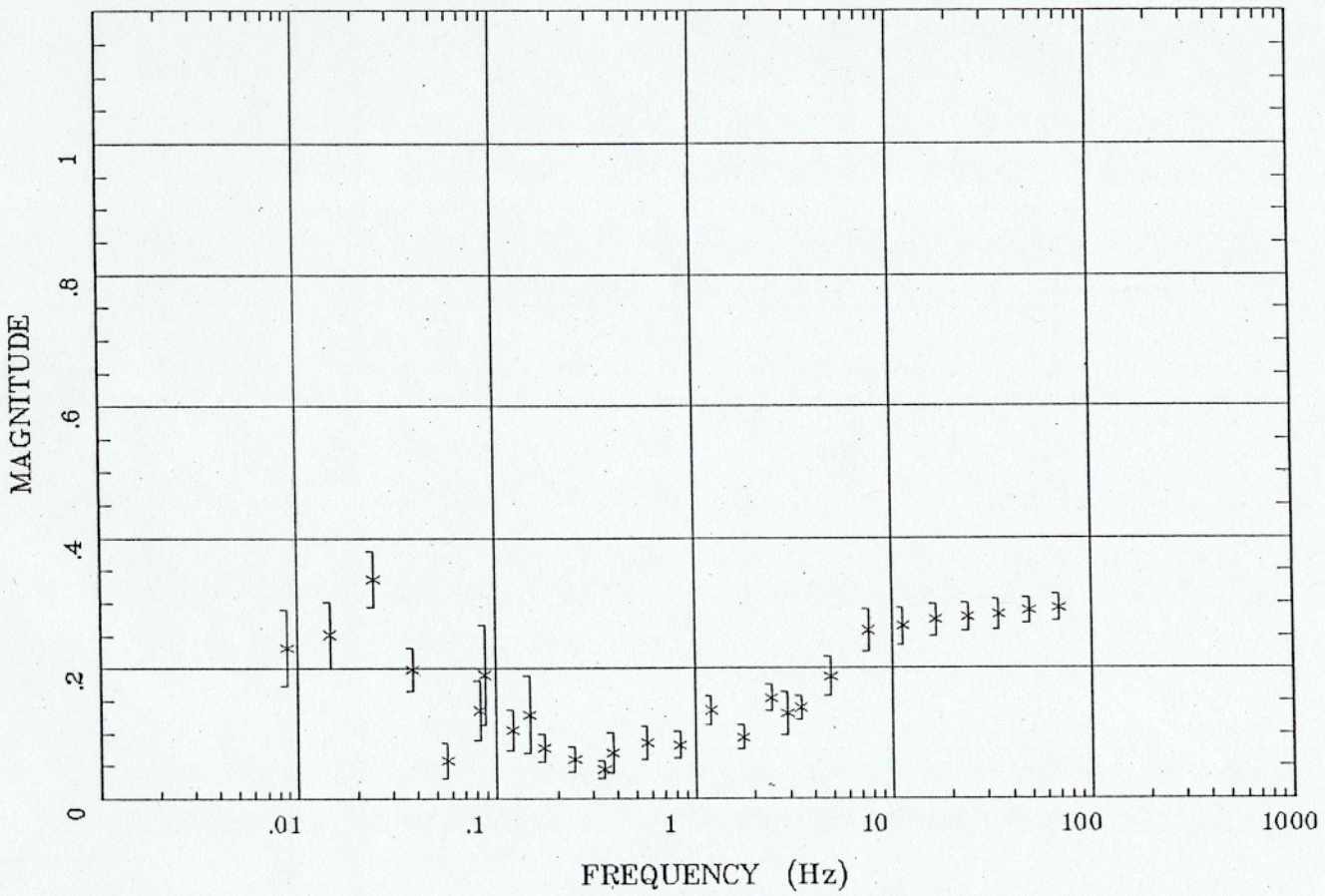
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska

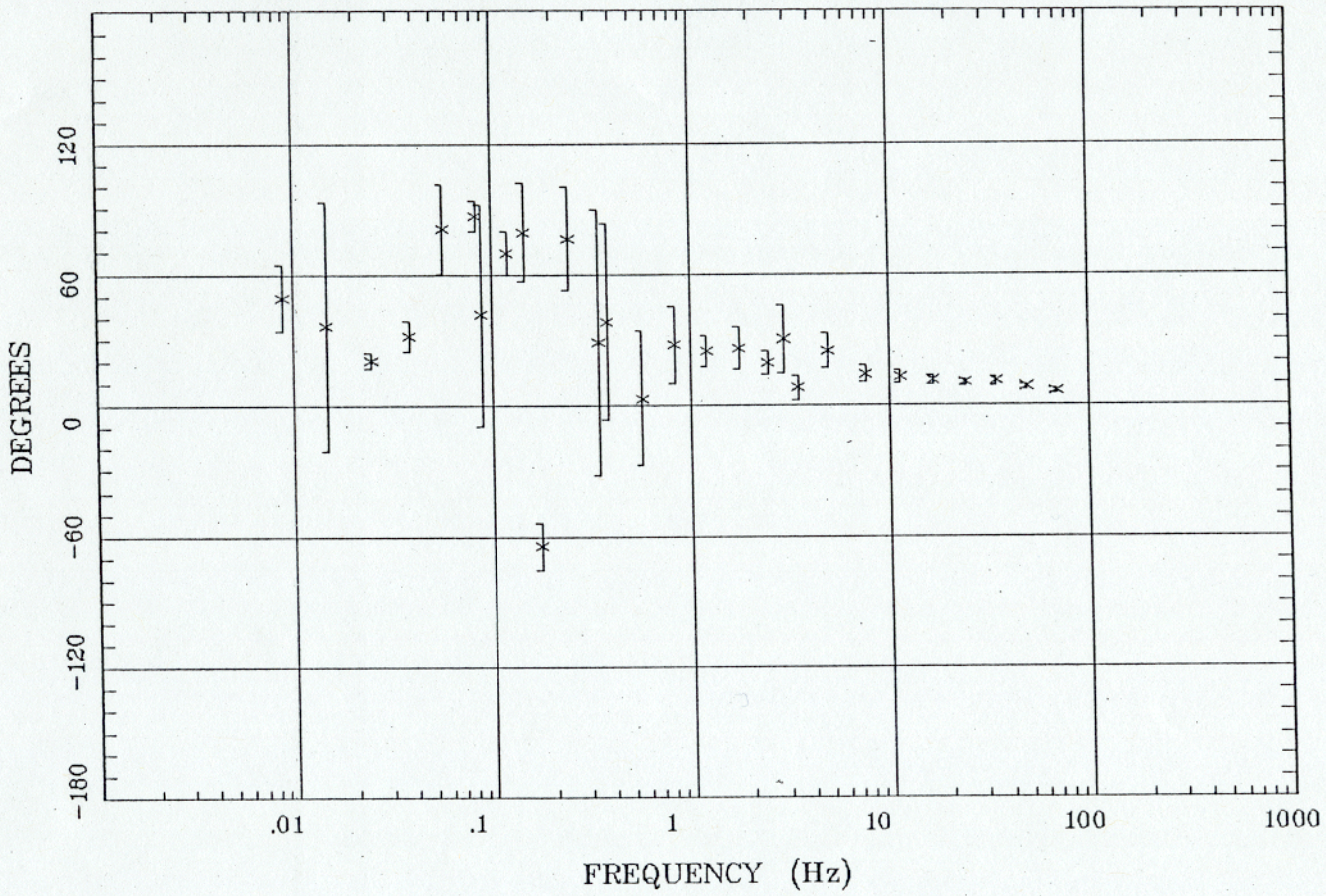


Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



Client:
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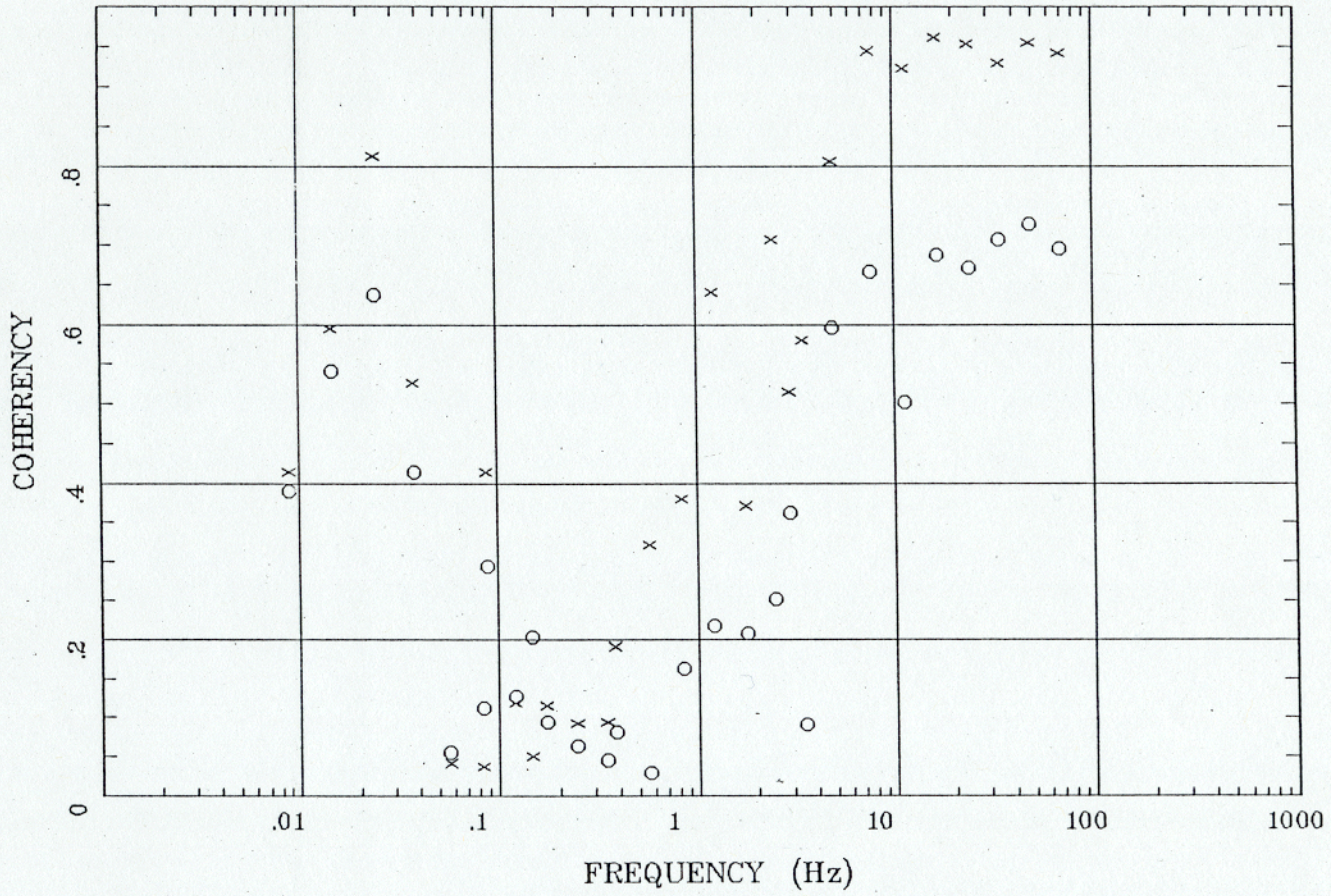
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

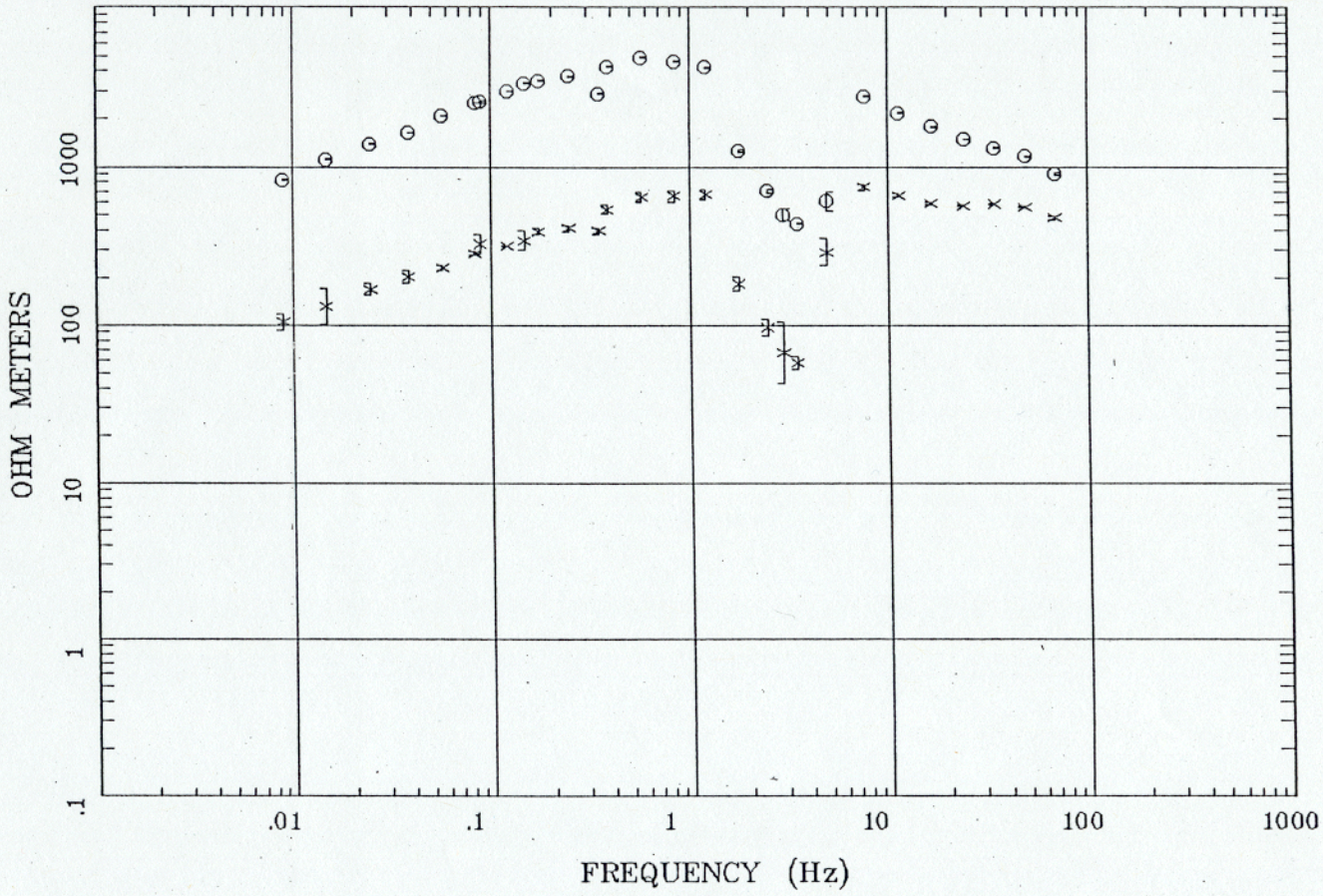
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 19:1 Aug 16, 2001
Survey Co:USGS

Rotation:
Filename: tlm03all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 15:59 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY Tangle Lakes, Alaska

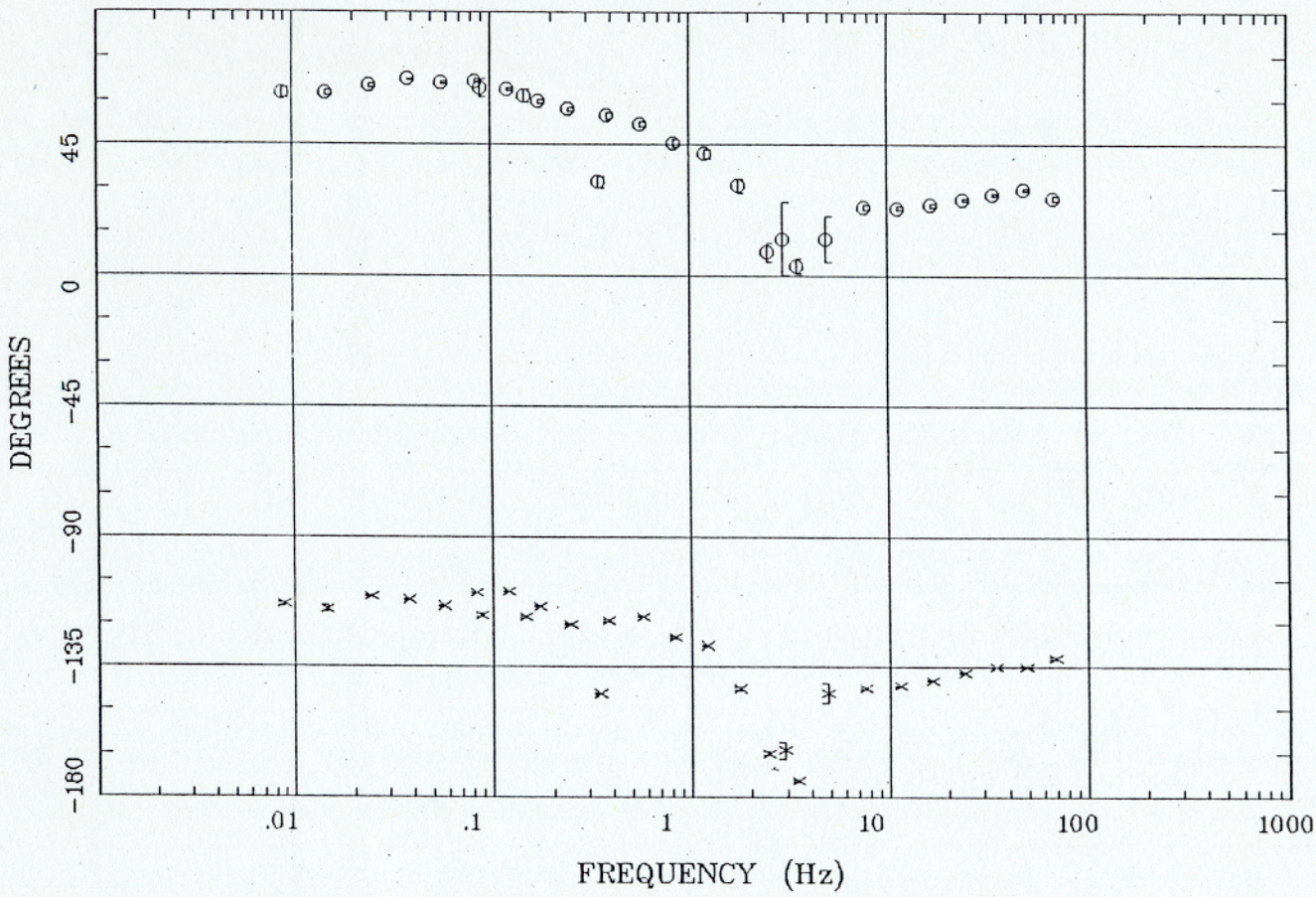


Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:00 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska

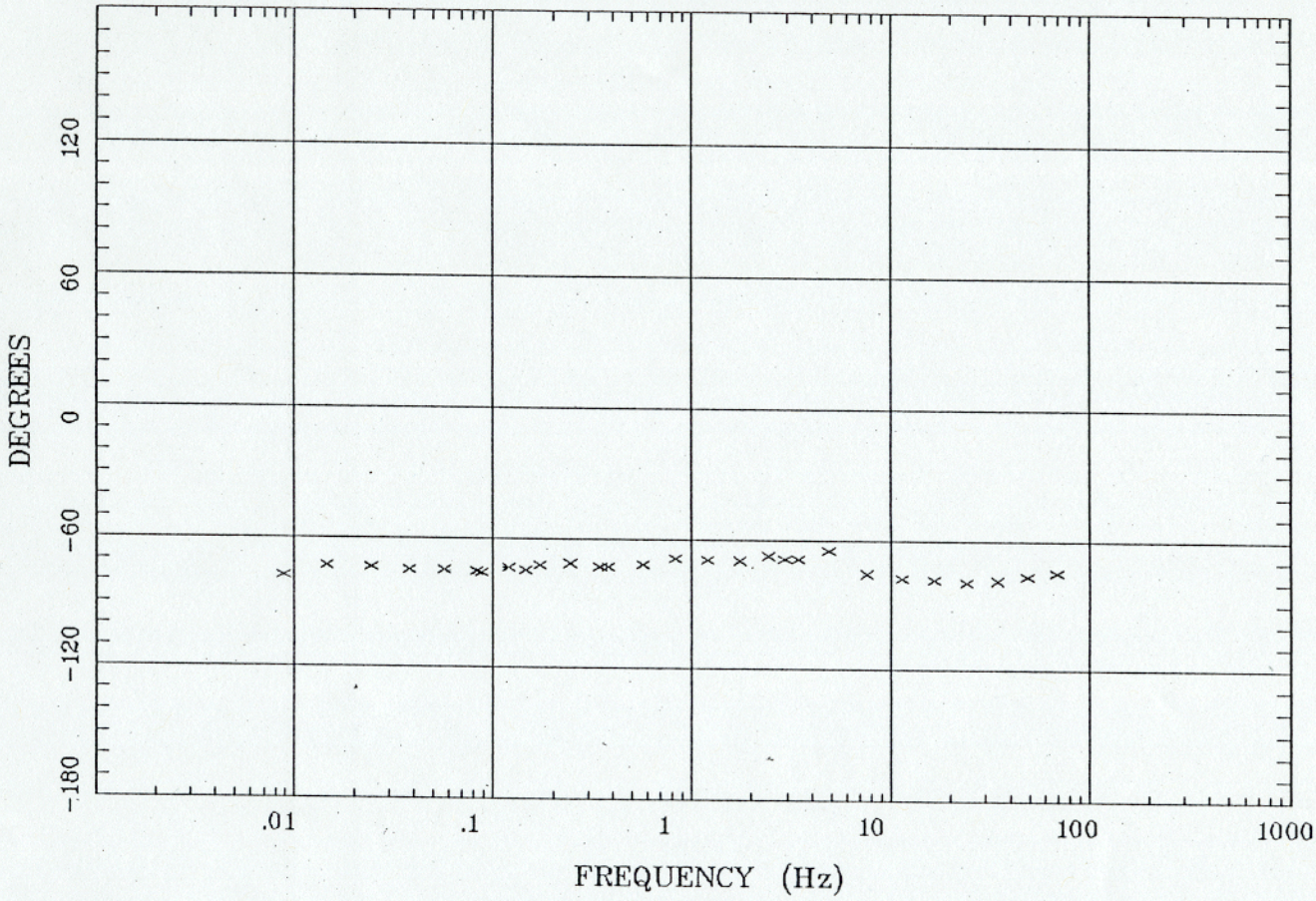


Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska

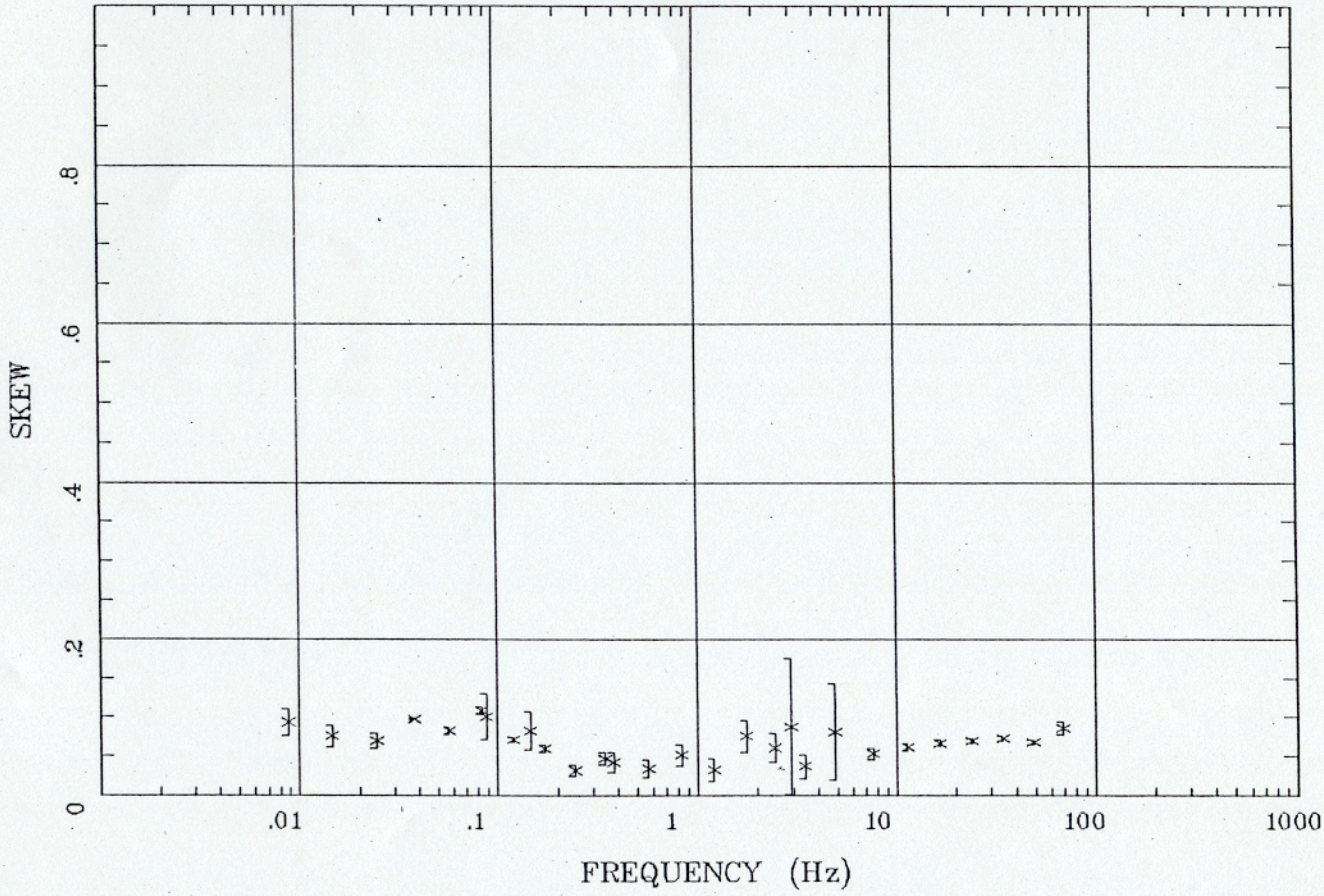


Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE SKEW

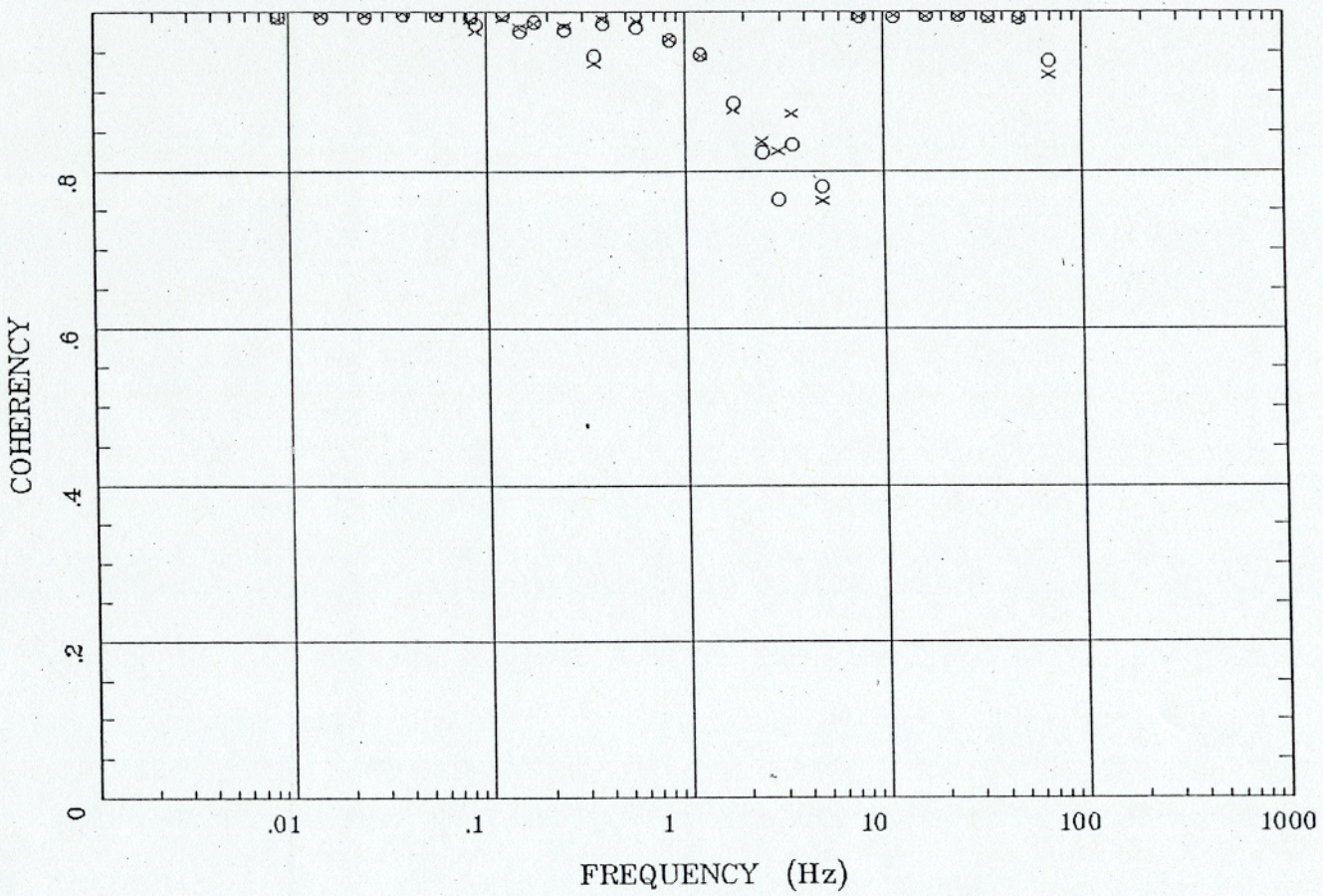
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

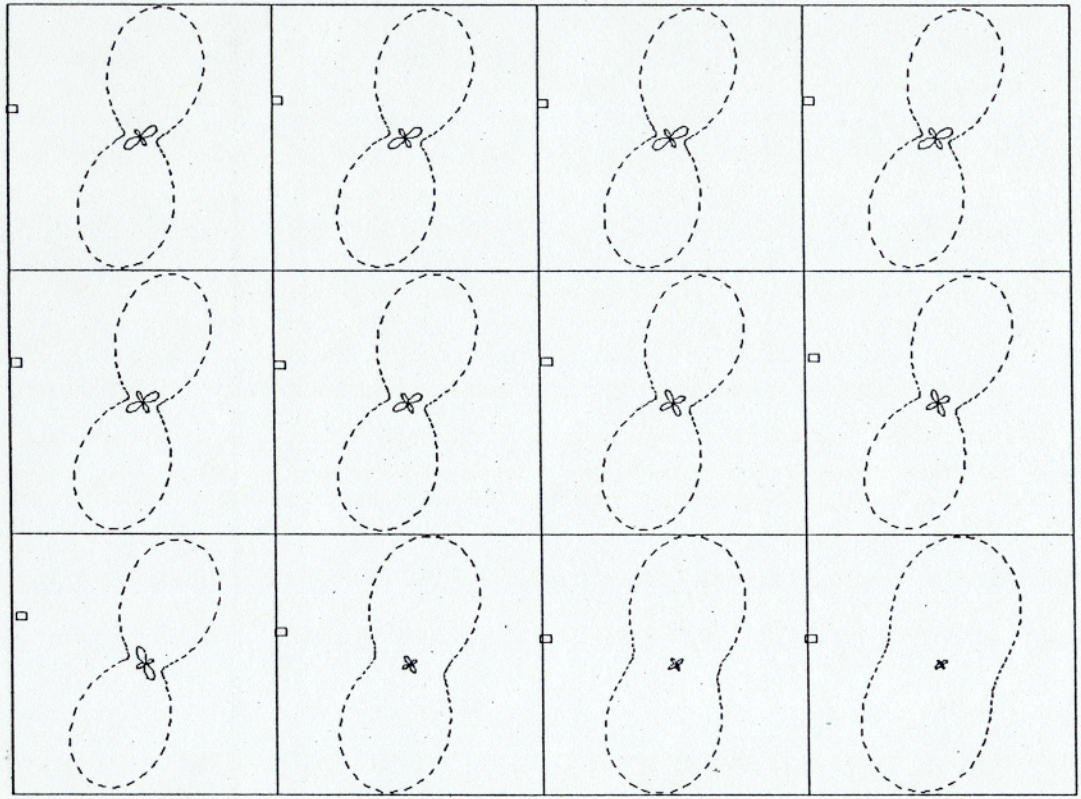
E MULT Coh. Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS Tangle Lakes, Alaska



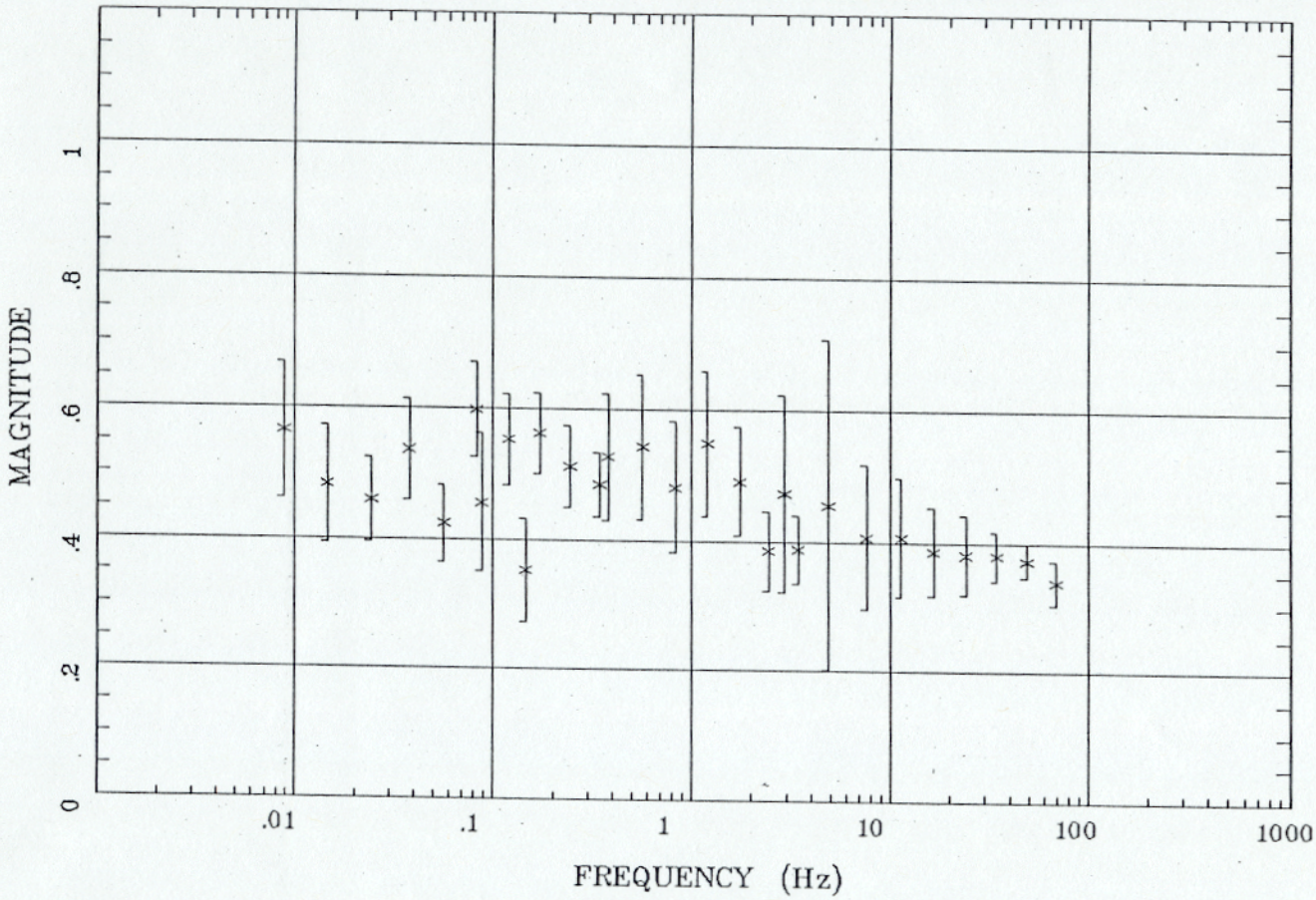
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska

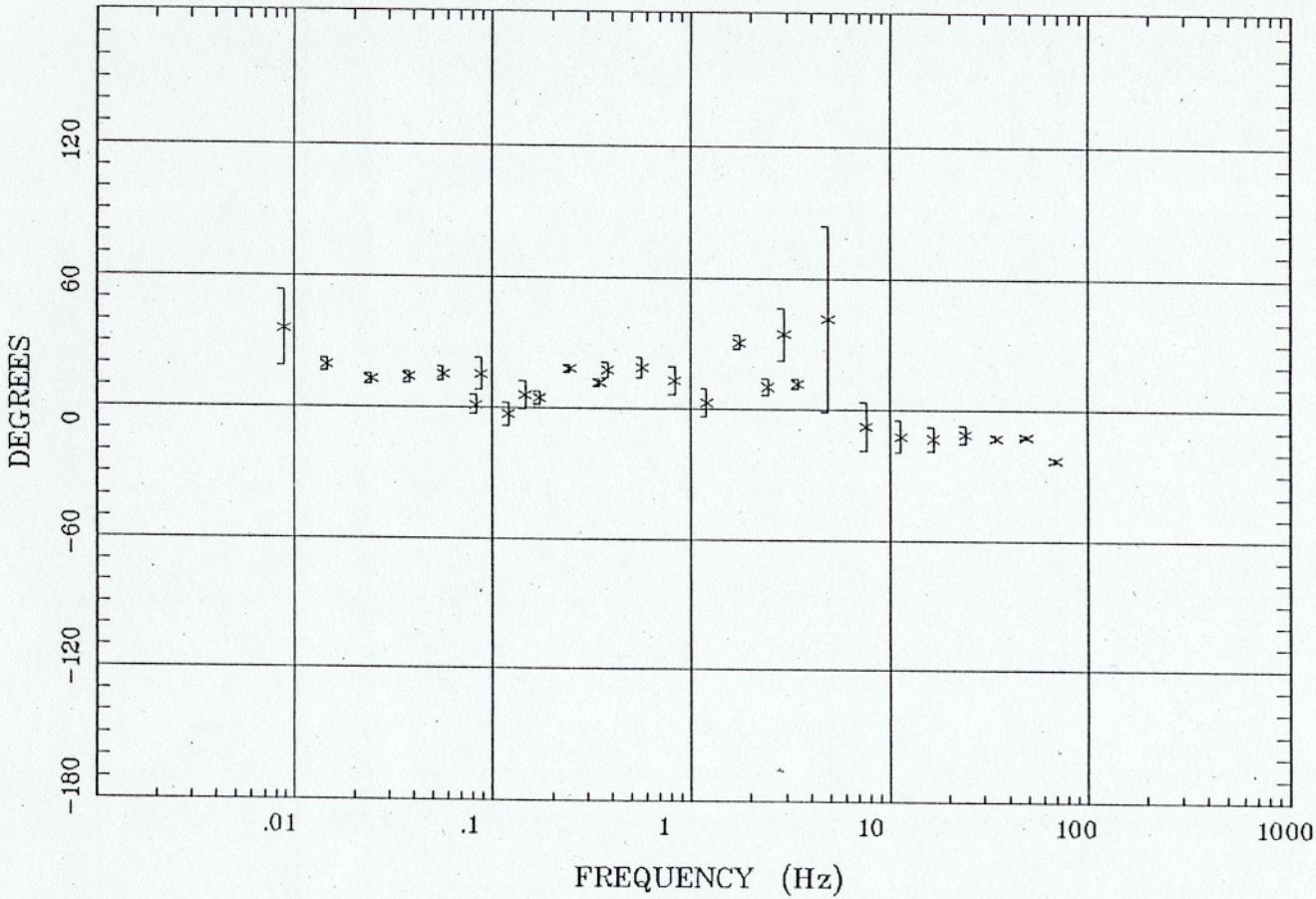


Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

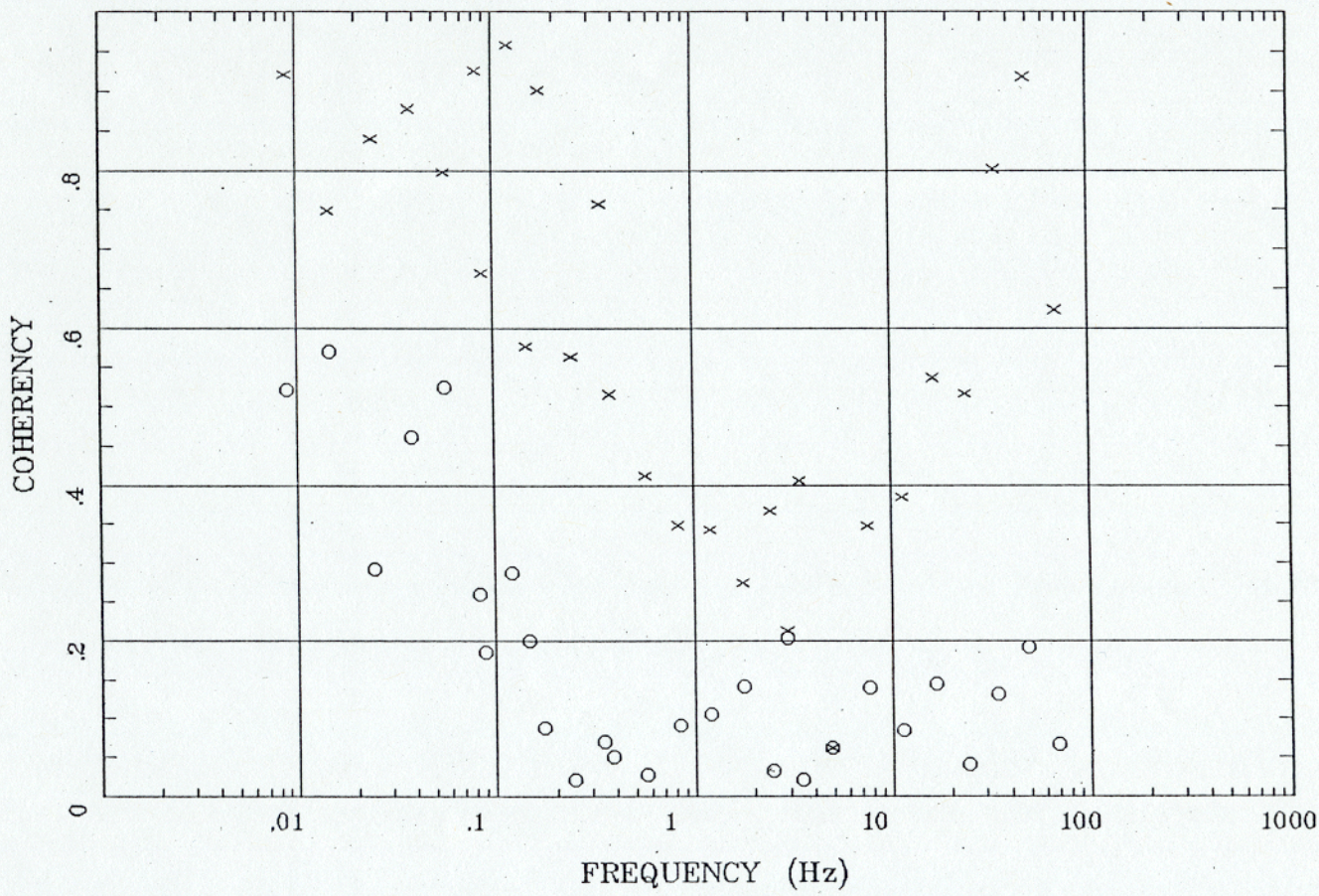
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o Tangle Lakes, Alaska

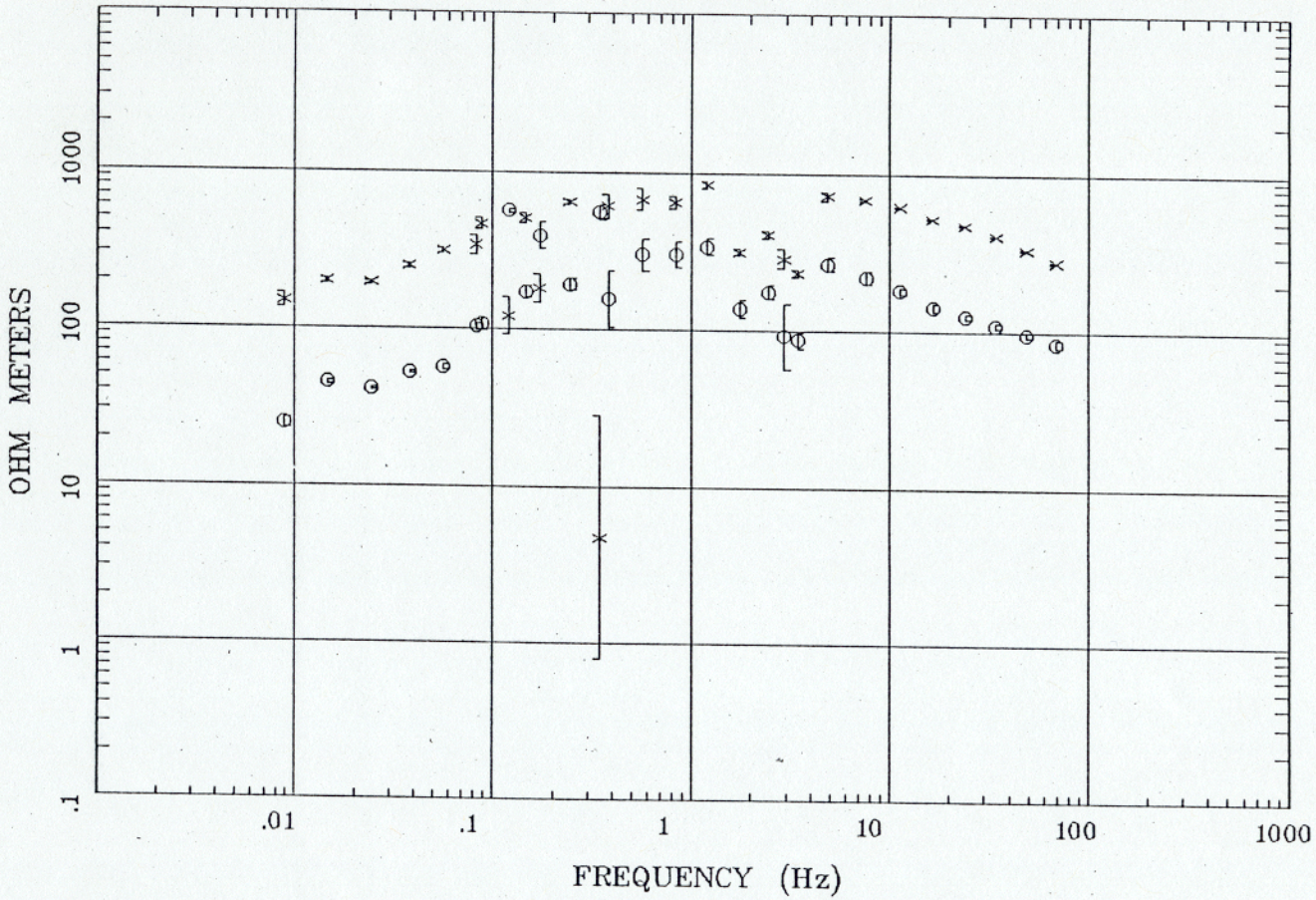


Client:
Remote: none
Acquired: 14:4 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm04all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:01 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY

Tangle Lakes, Alaska

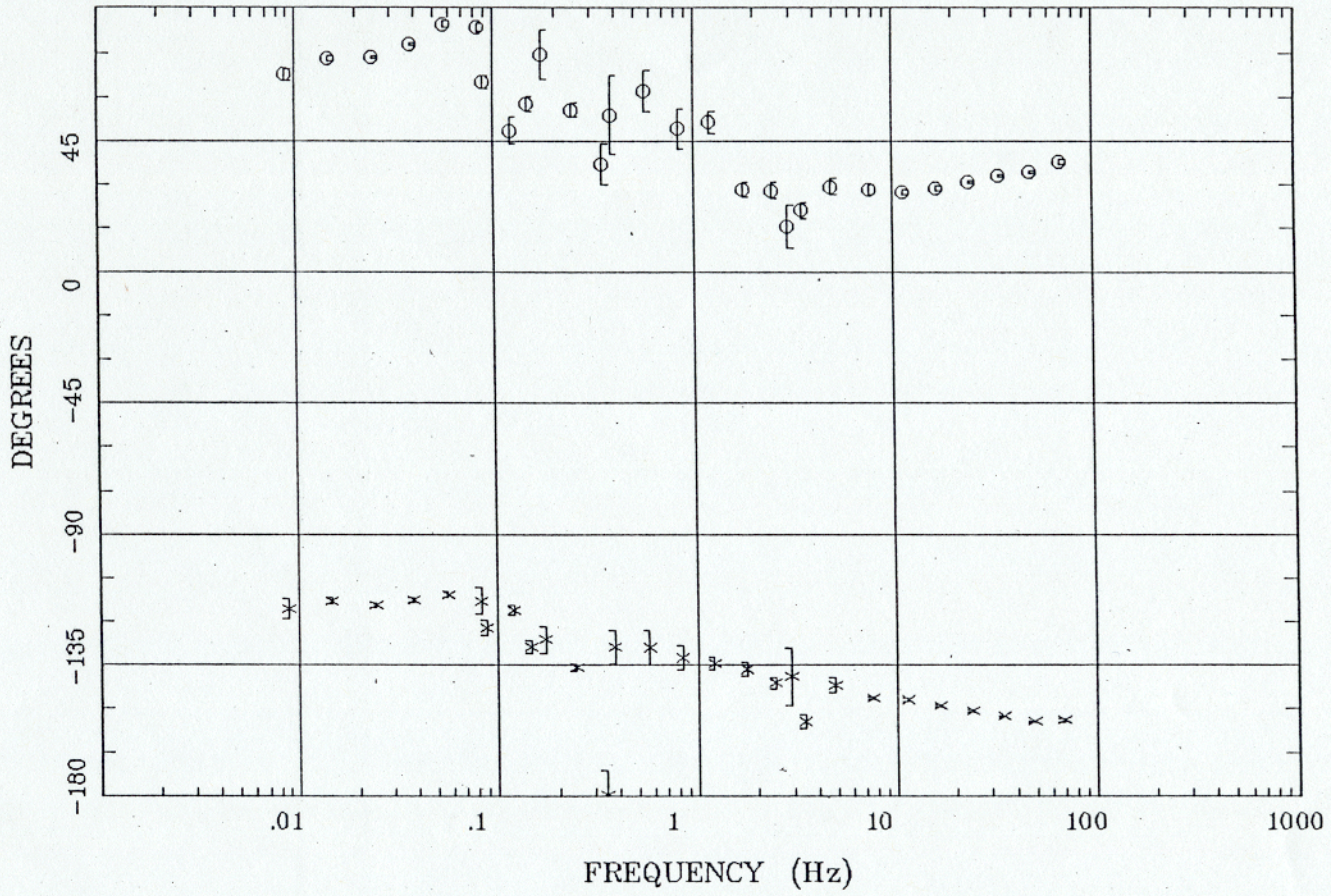


Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

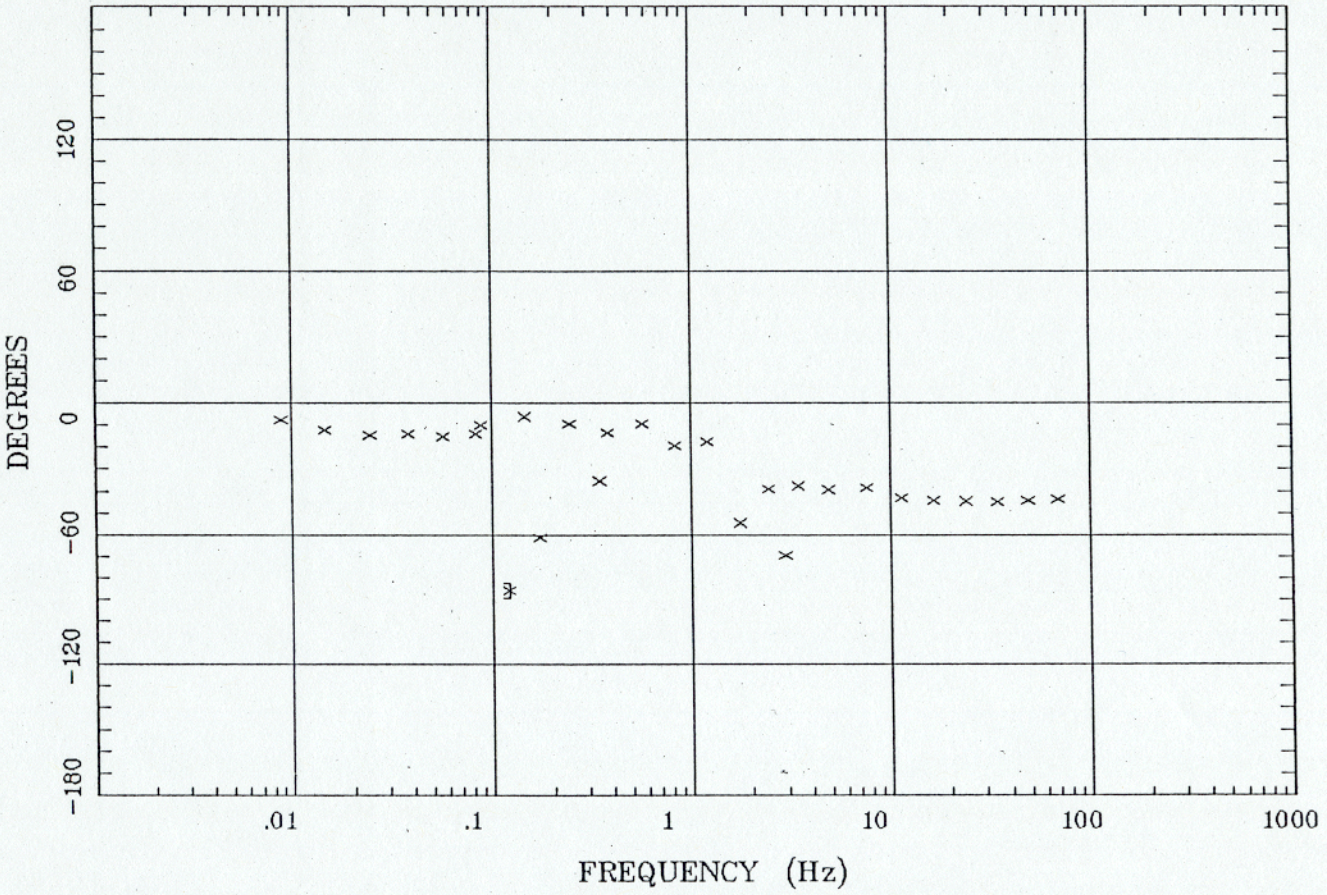
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE Tangle Lakes, Alaska

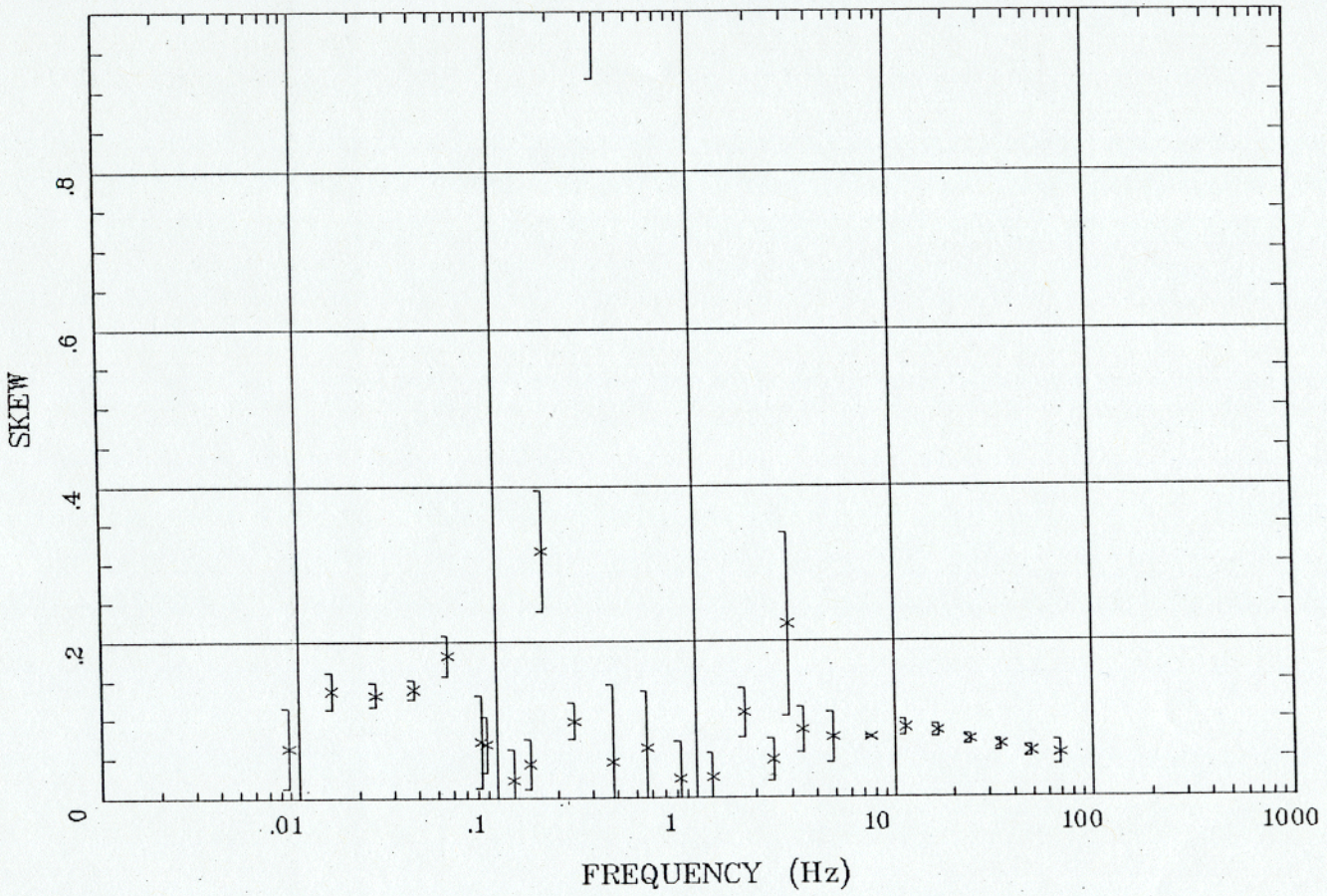


Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

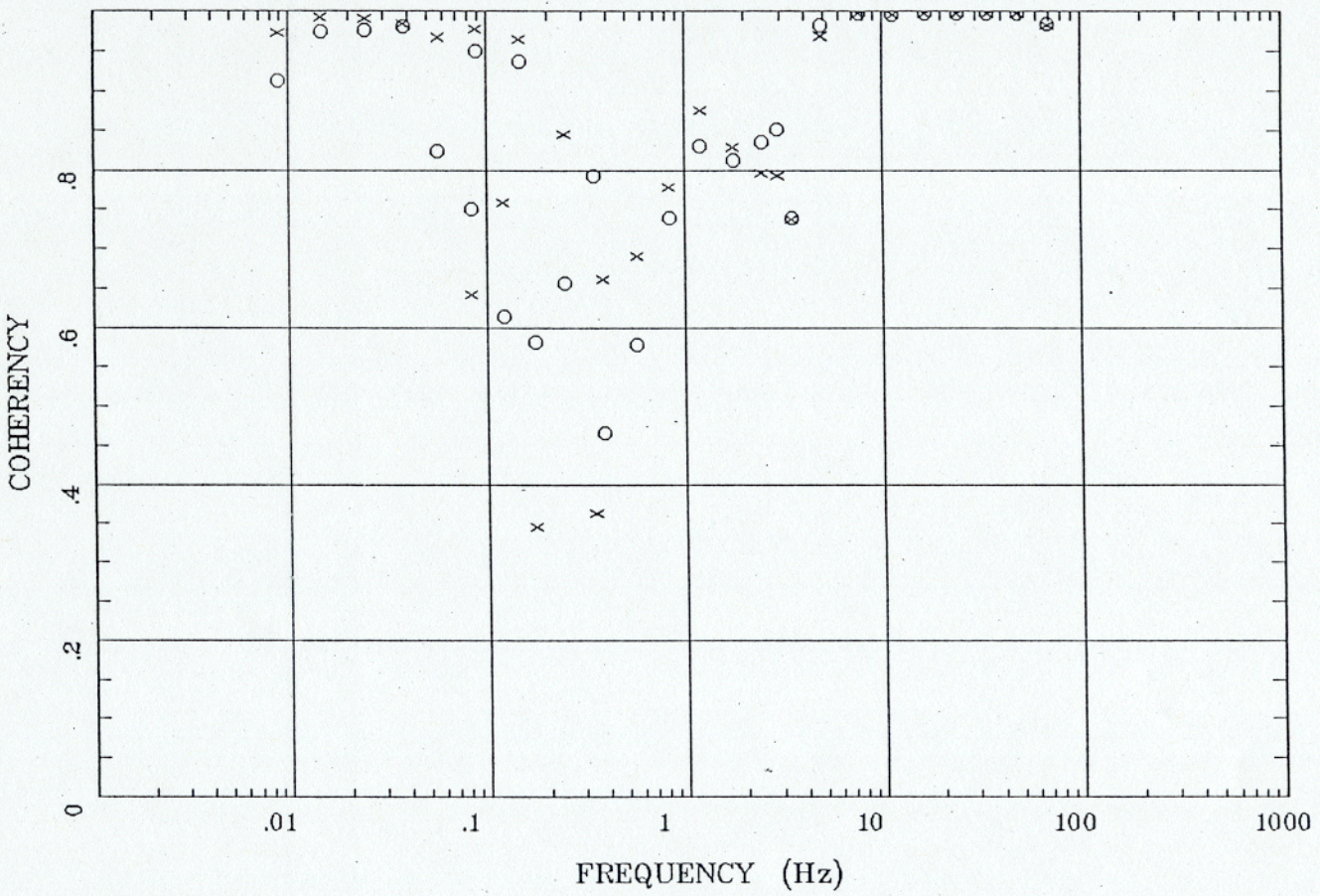
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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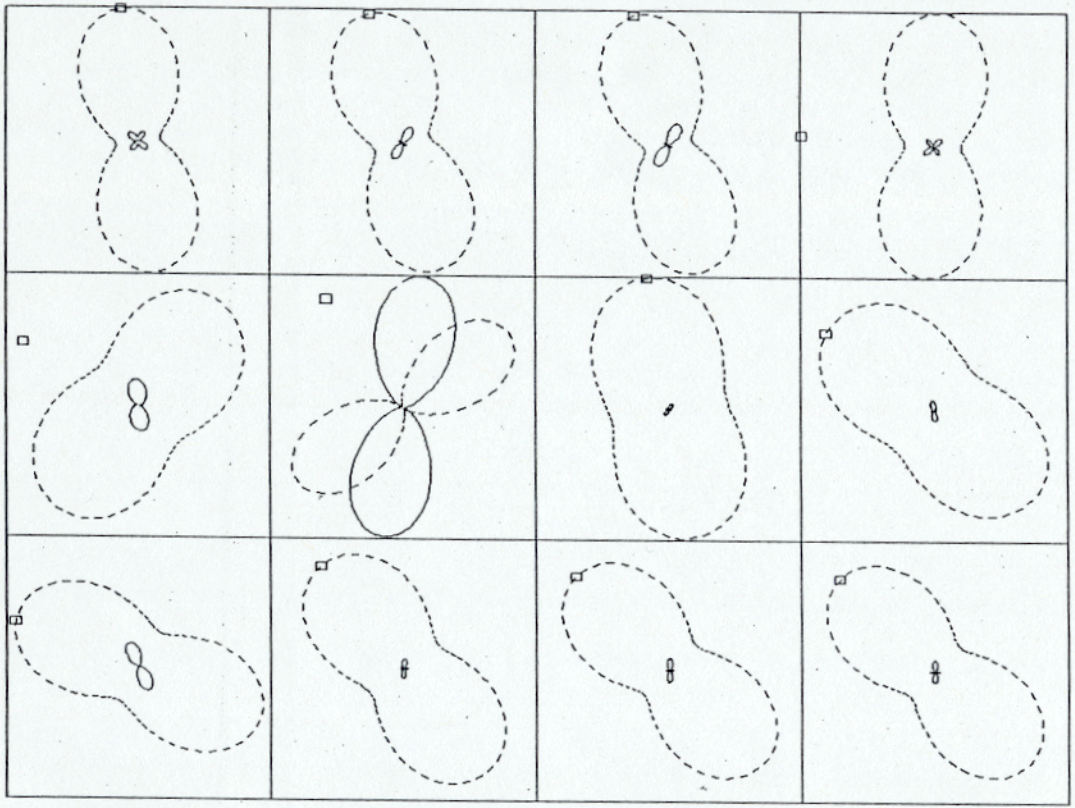
POLAR PLOTS

Tangle Lakes, Alaska



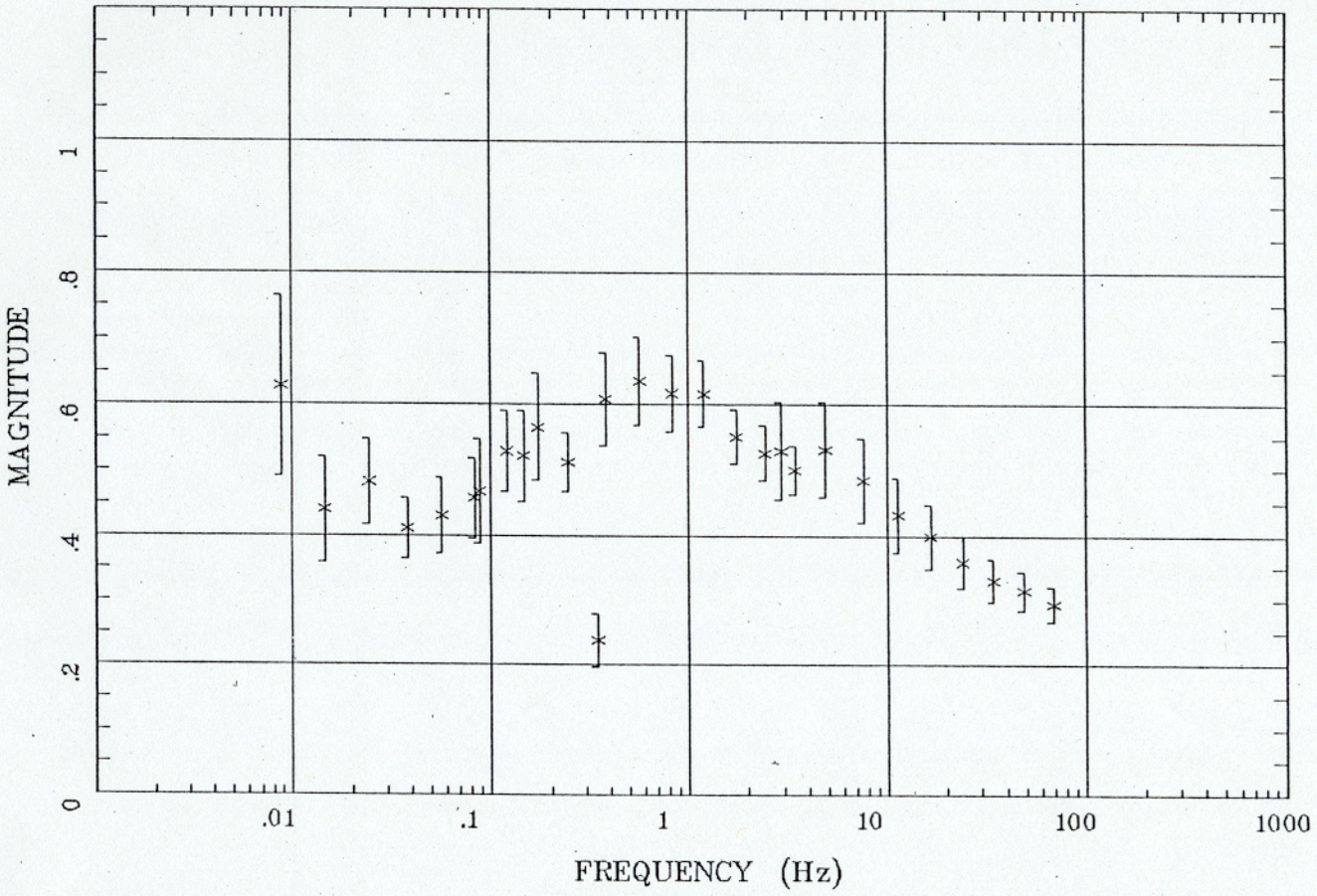
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:02 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska

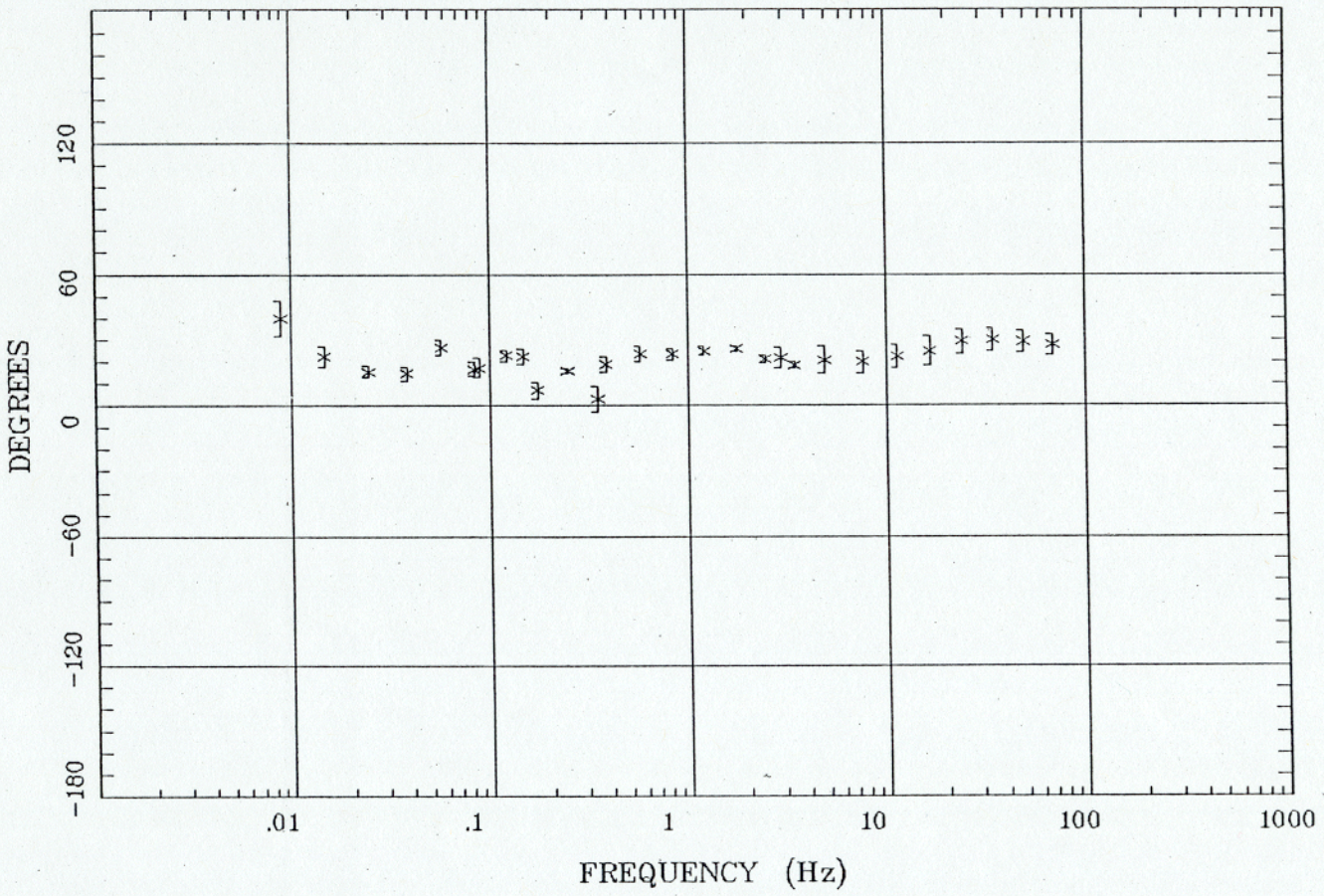


Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:03 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

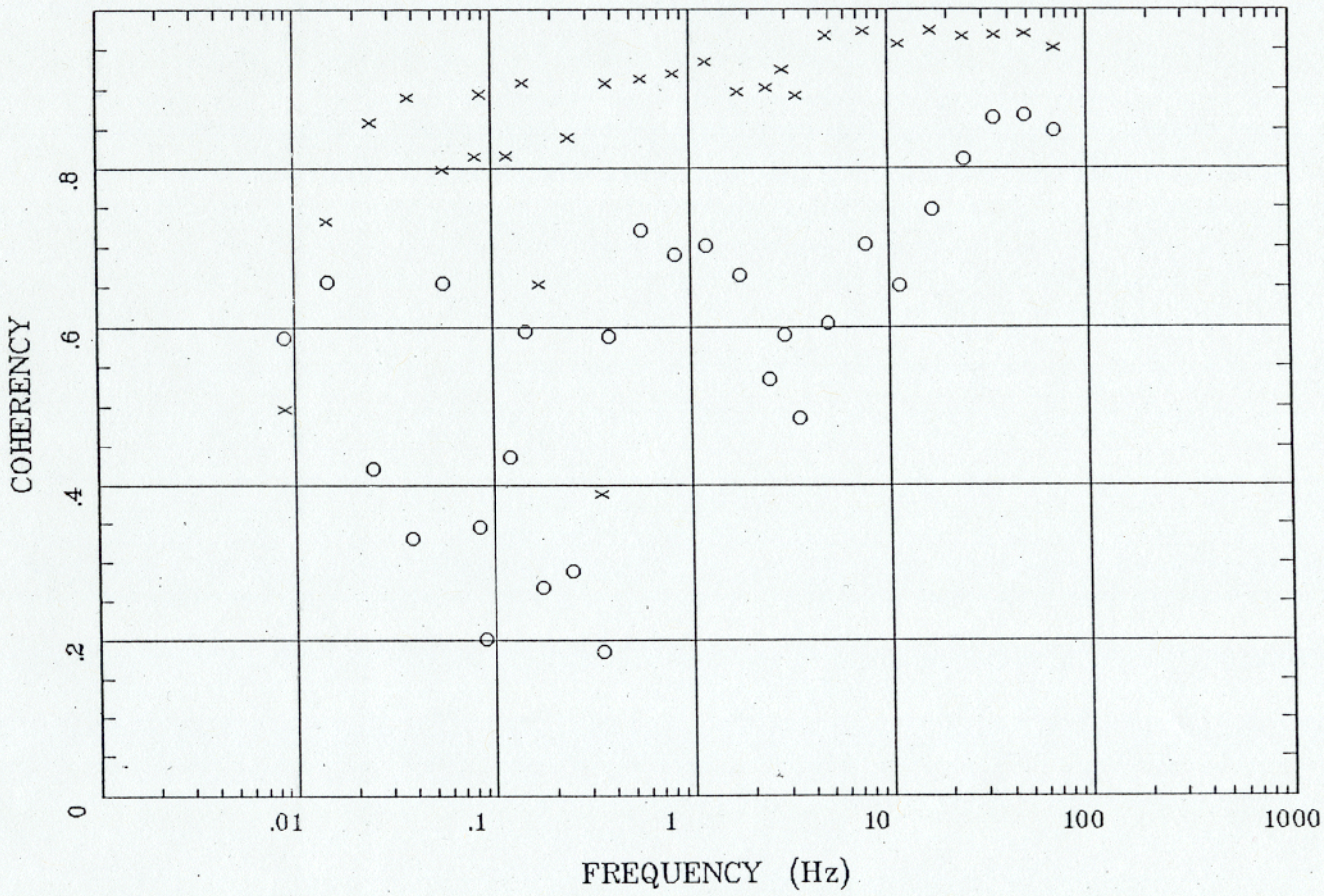
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:03 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o Tangle Lakes, Alaska

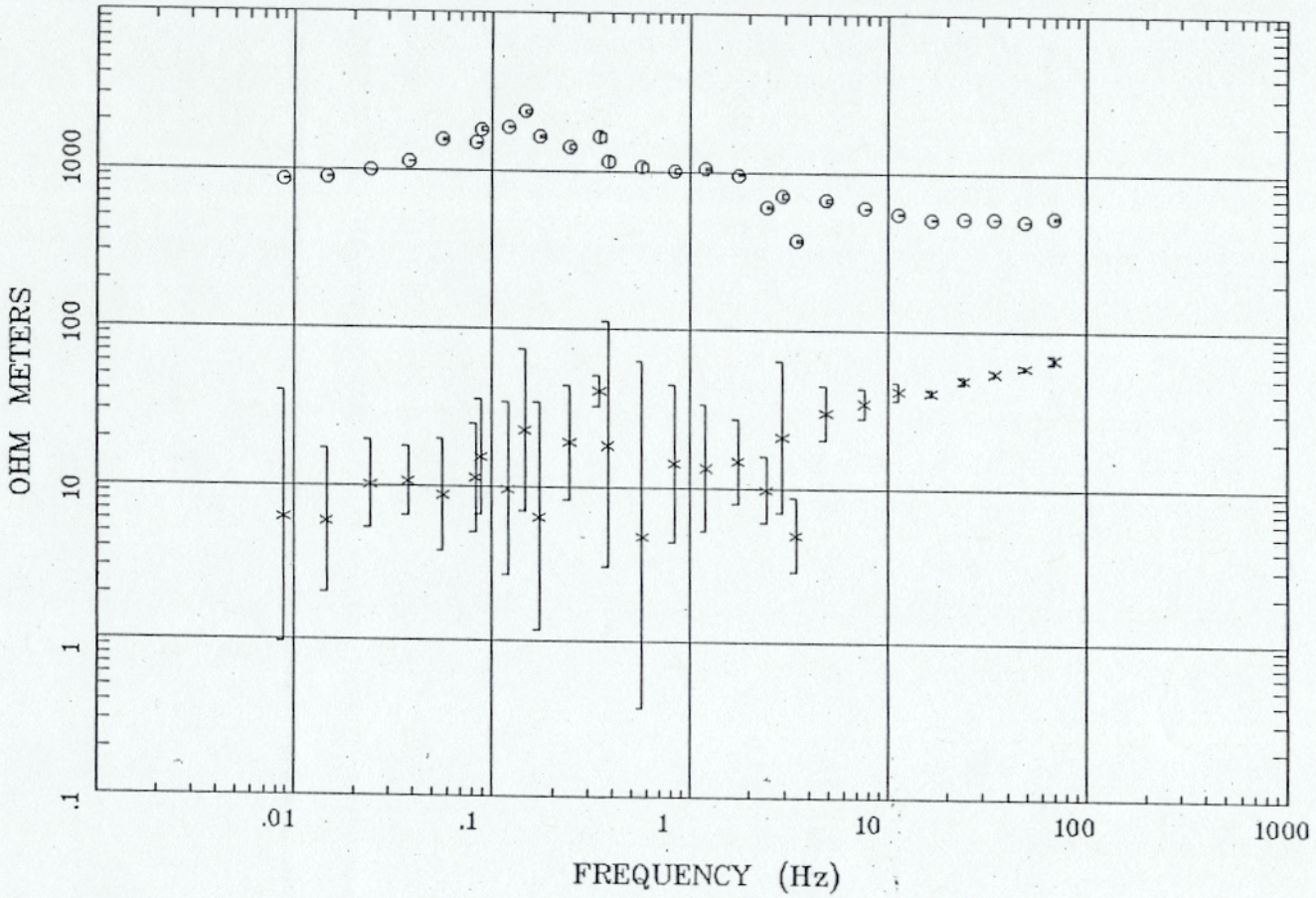


Client:
Remote: none
Acquired: 17:2 Aug 17, 2001
Survey Co:USGS

Rotation:
Filename: tlm05all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:03 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY

Tangle Lakes, Alaska



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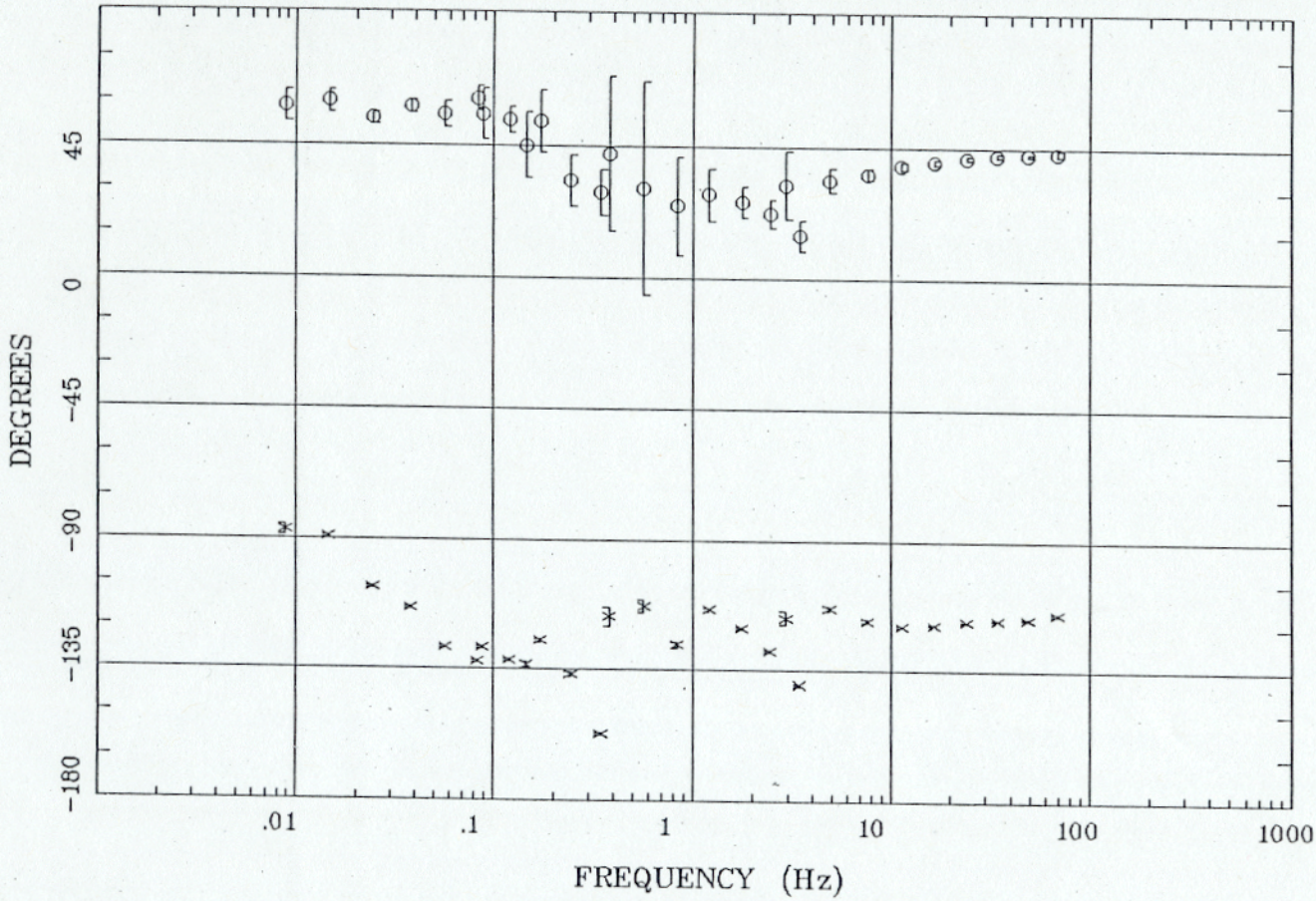
Acquired: 12:2 Aug 18, 2001
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



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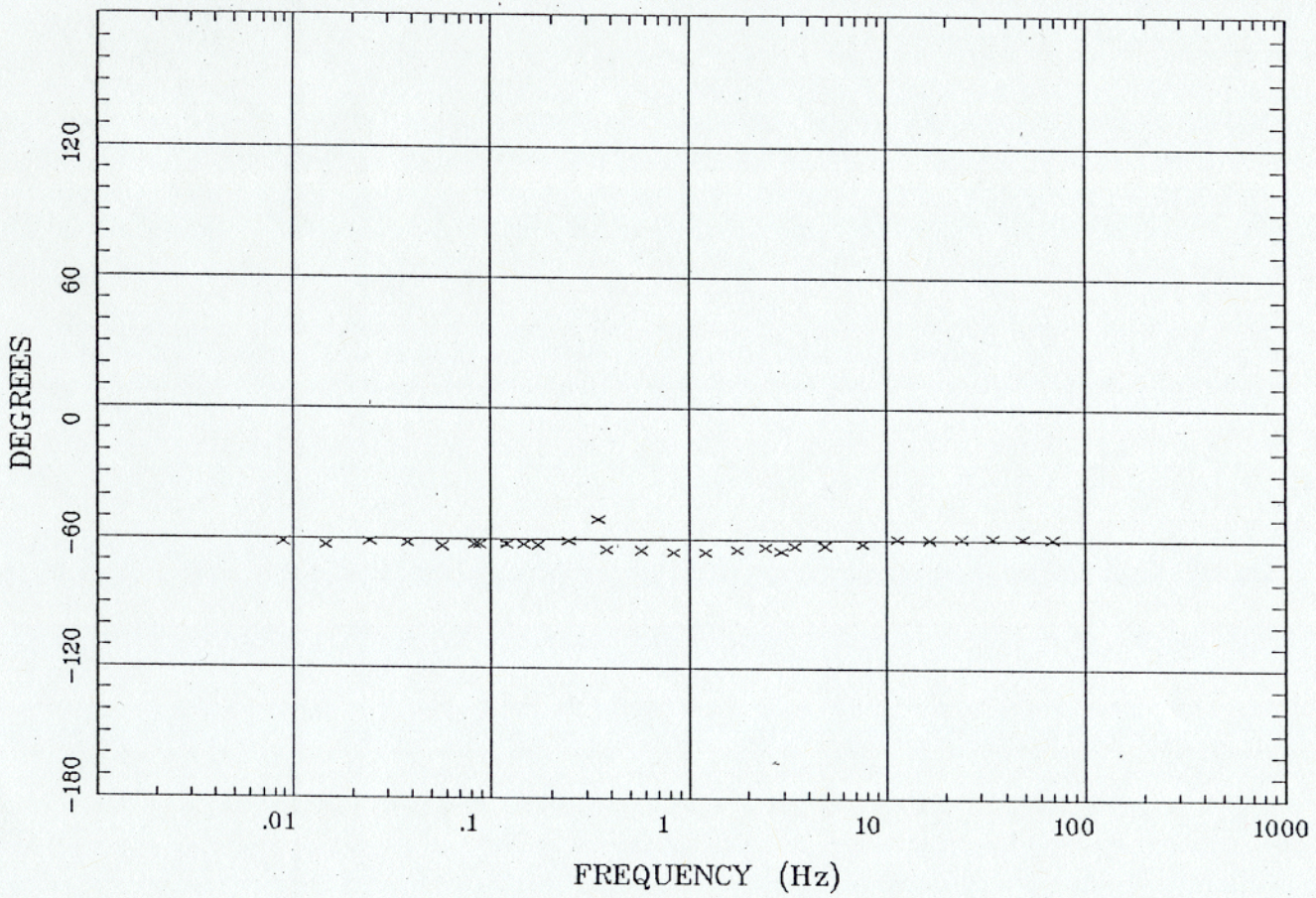
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska



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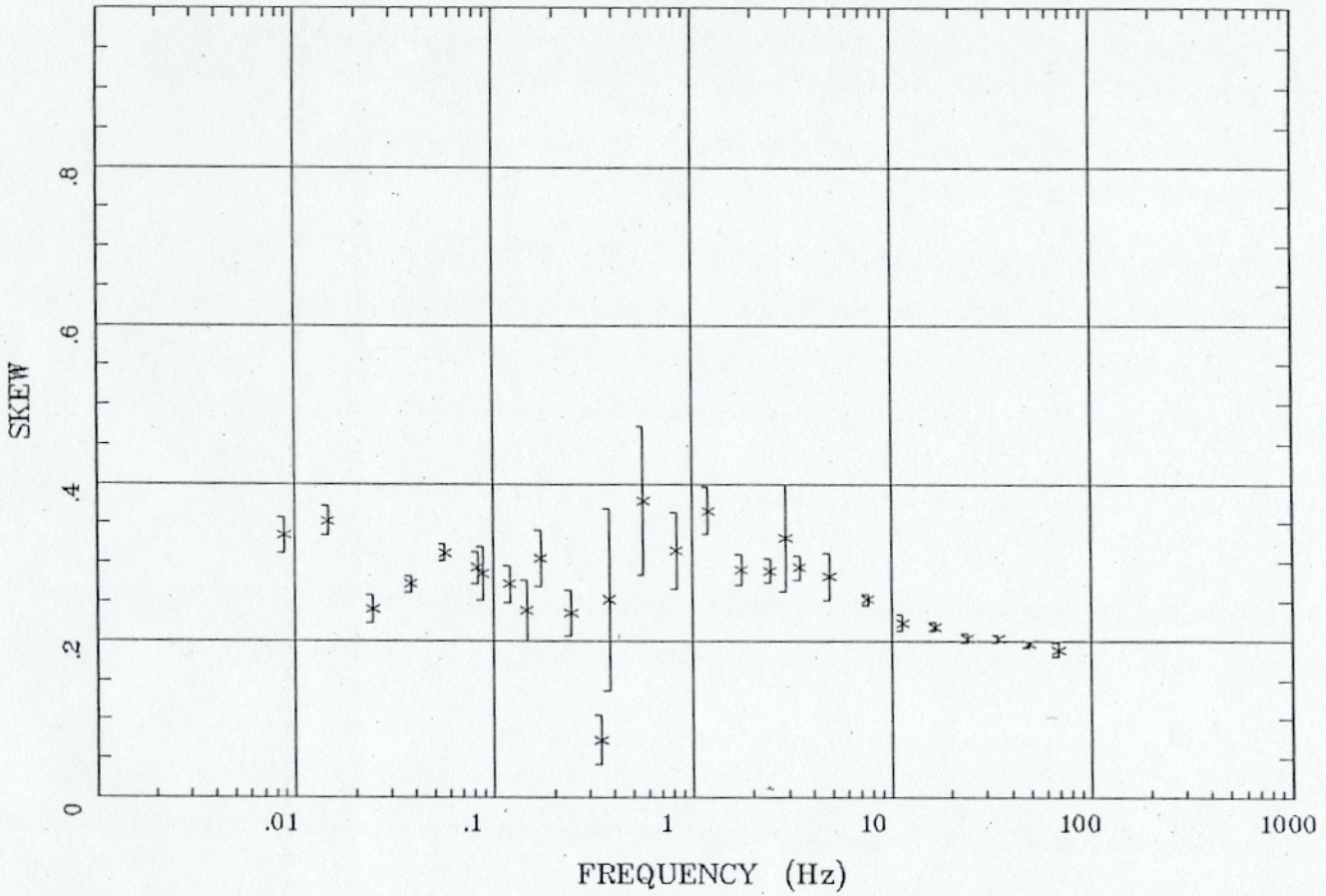
Remote: none
Acquired: 12:2 Aug 18, 2001
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska



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Rotation:
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Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

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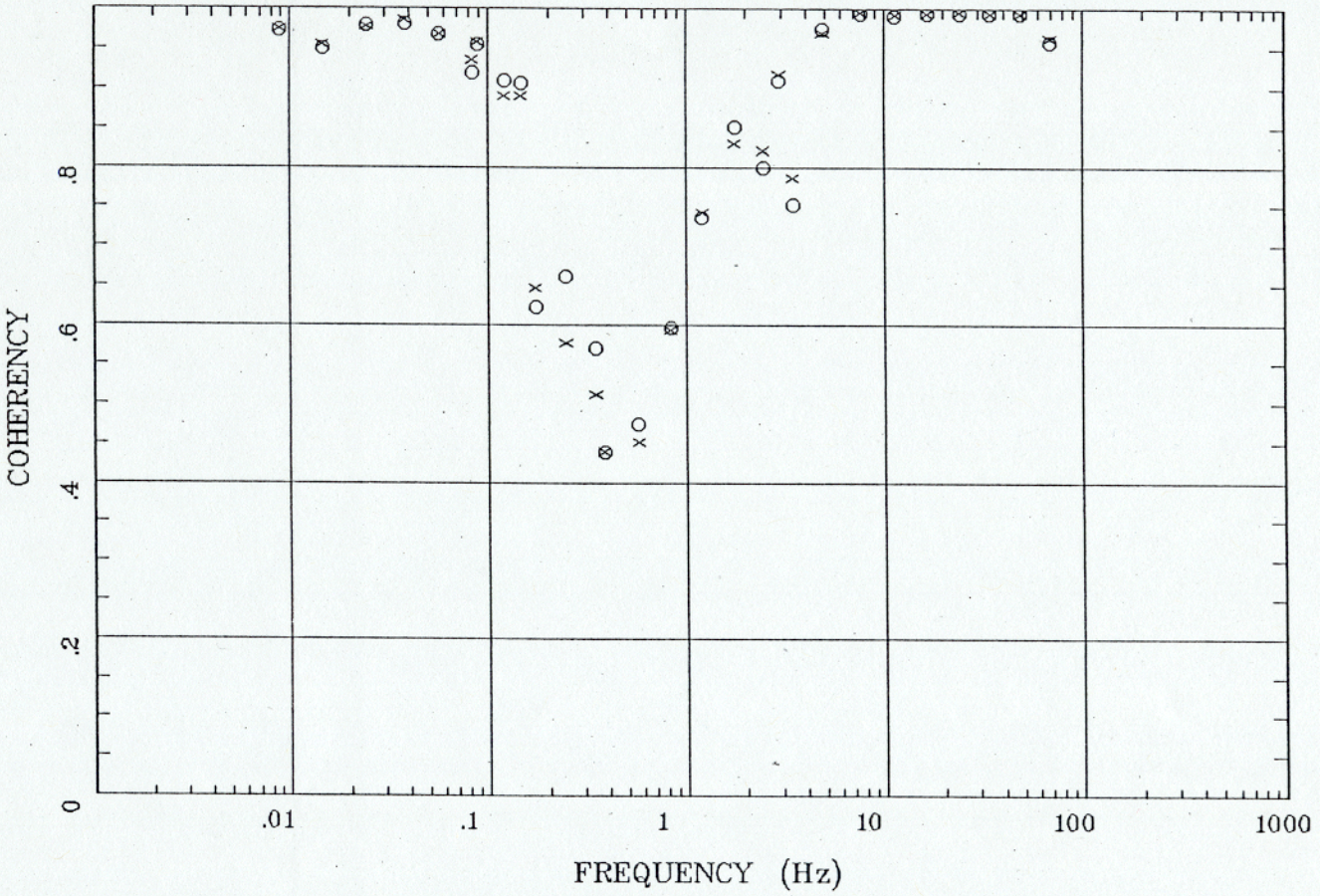
E MULT Coh. Tangle Lakes, Alaska



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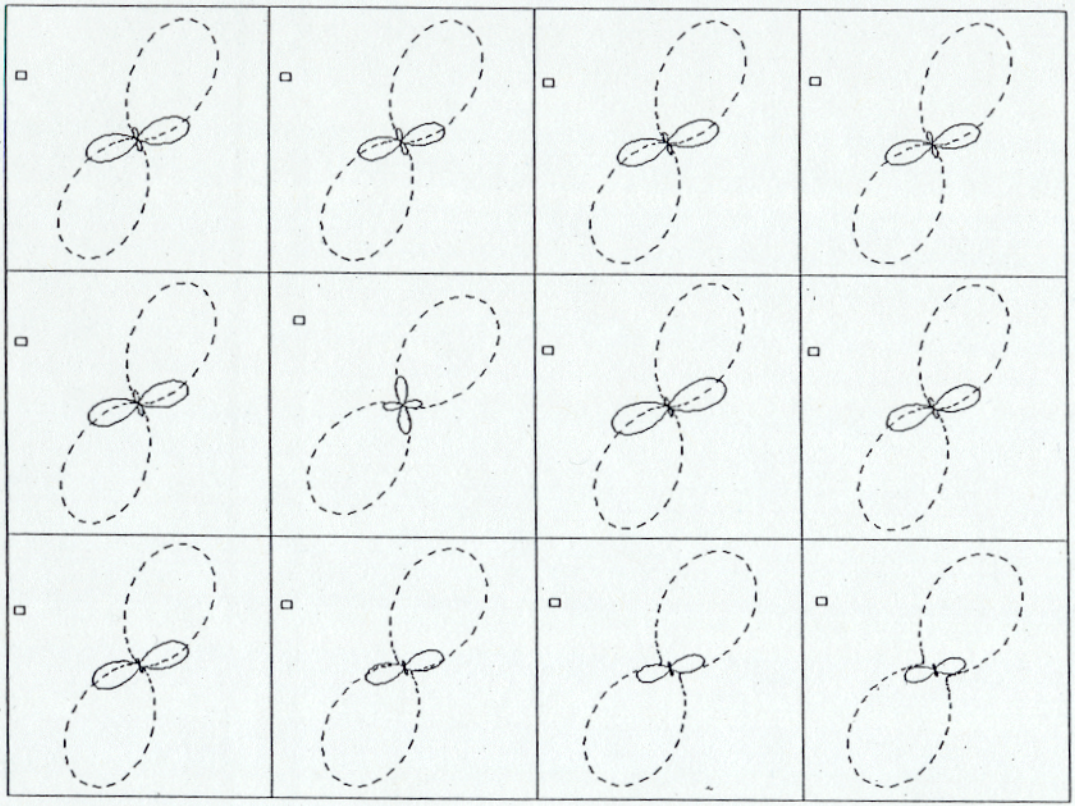
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS Tangle Lakes, Alaska



.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 12:2 Aug 18, 2001
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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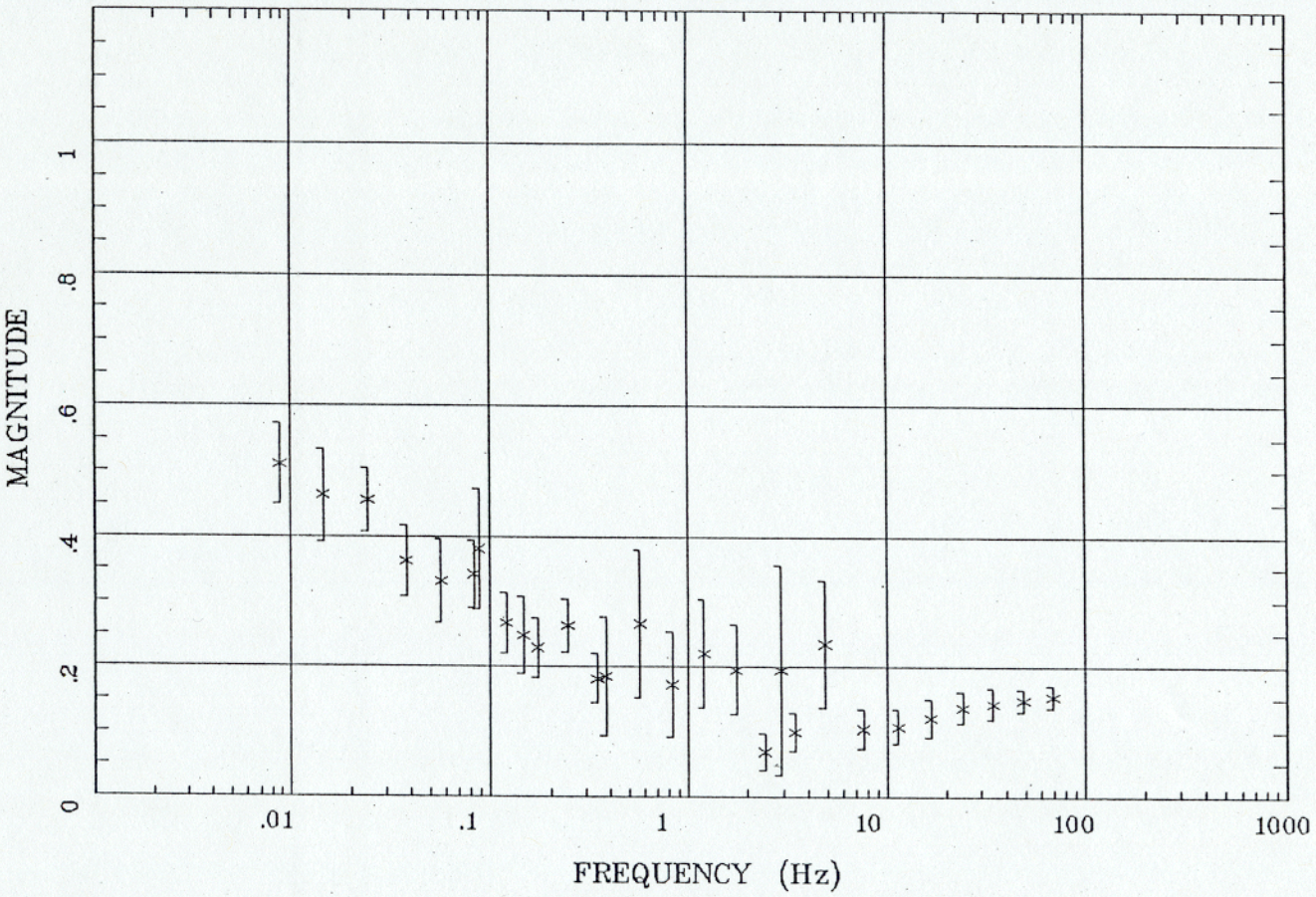
TIPPER MAGNITUDE

Tangle Lakes, Alaska



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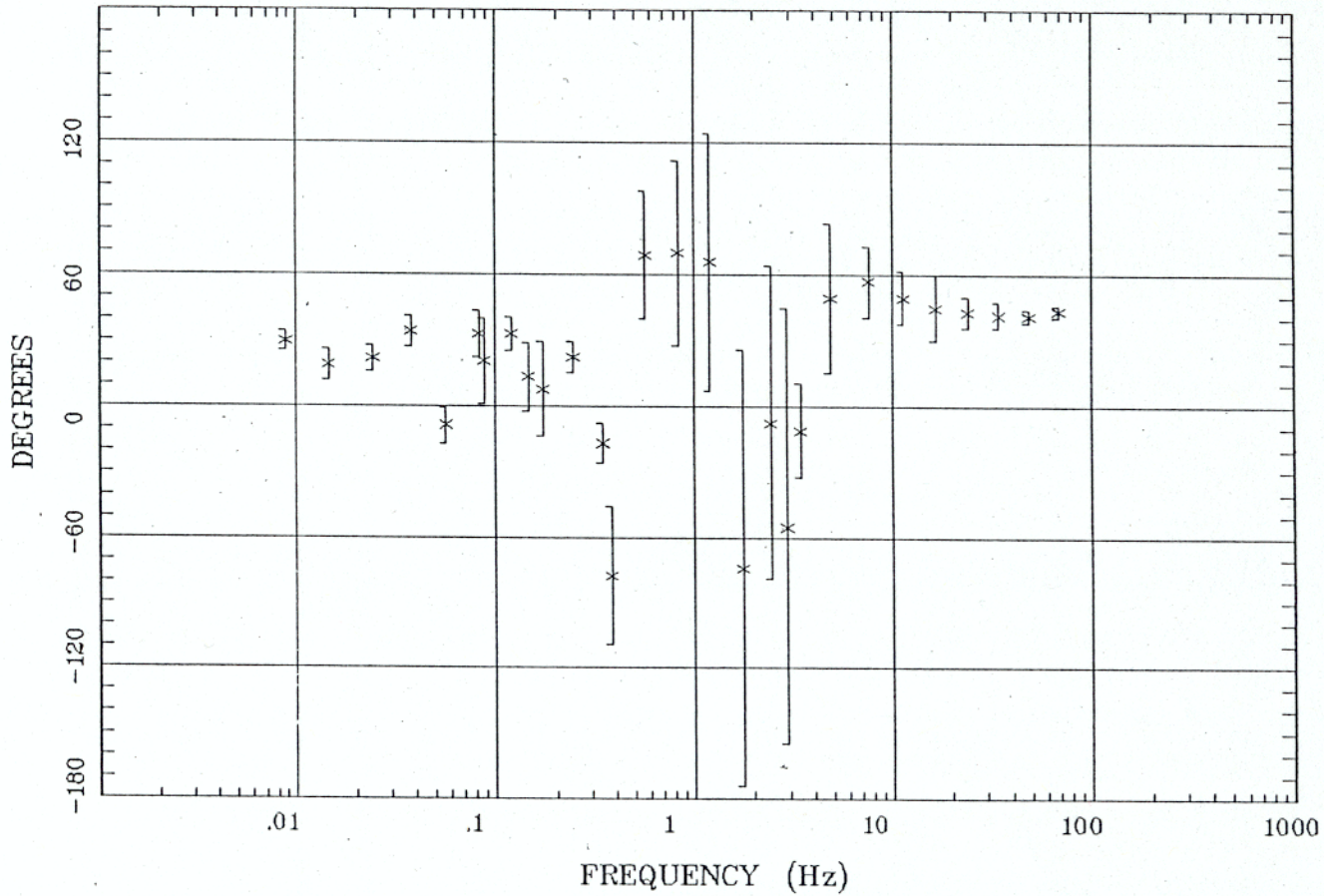
Acquired: 12:2 Aug 18, 2001
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



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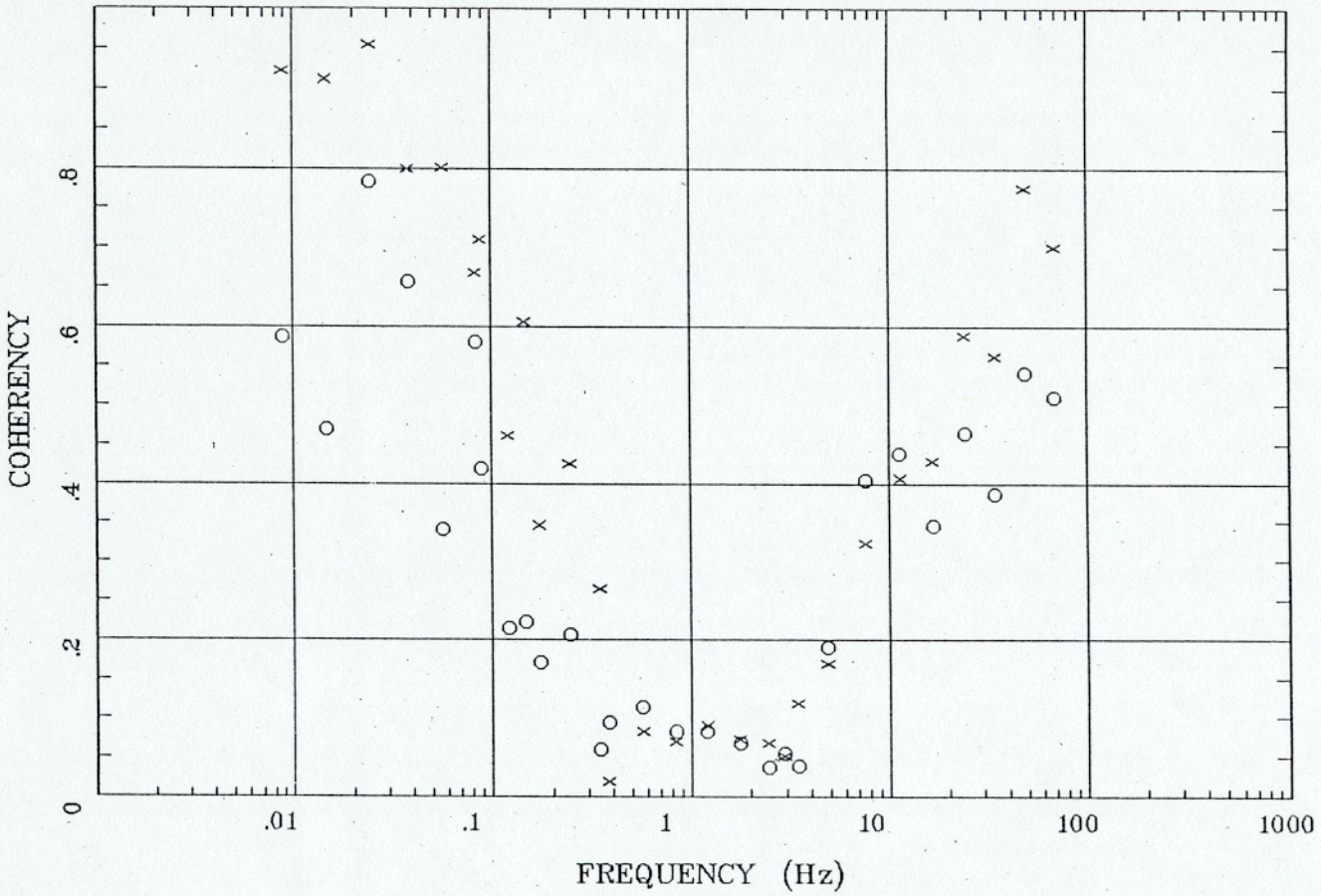
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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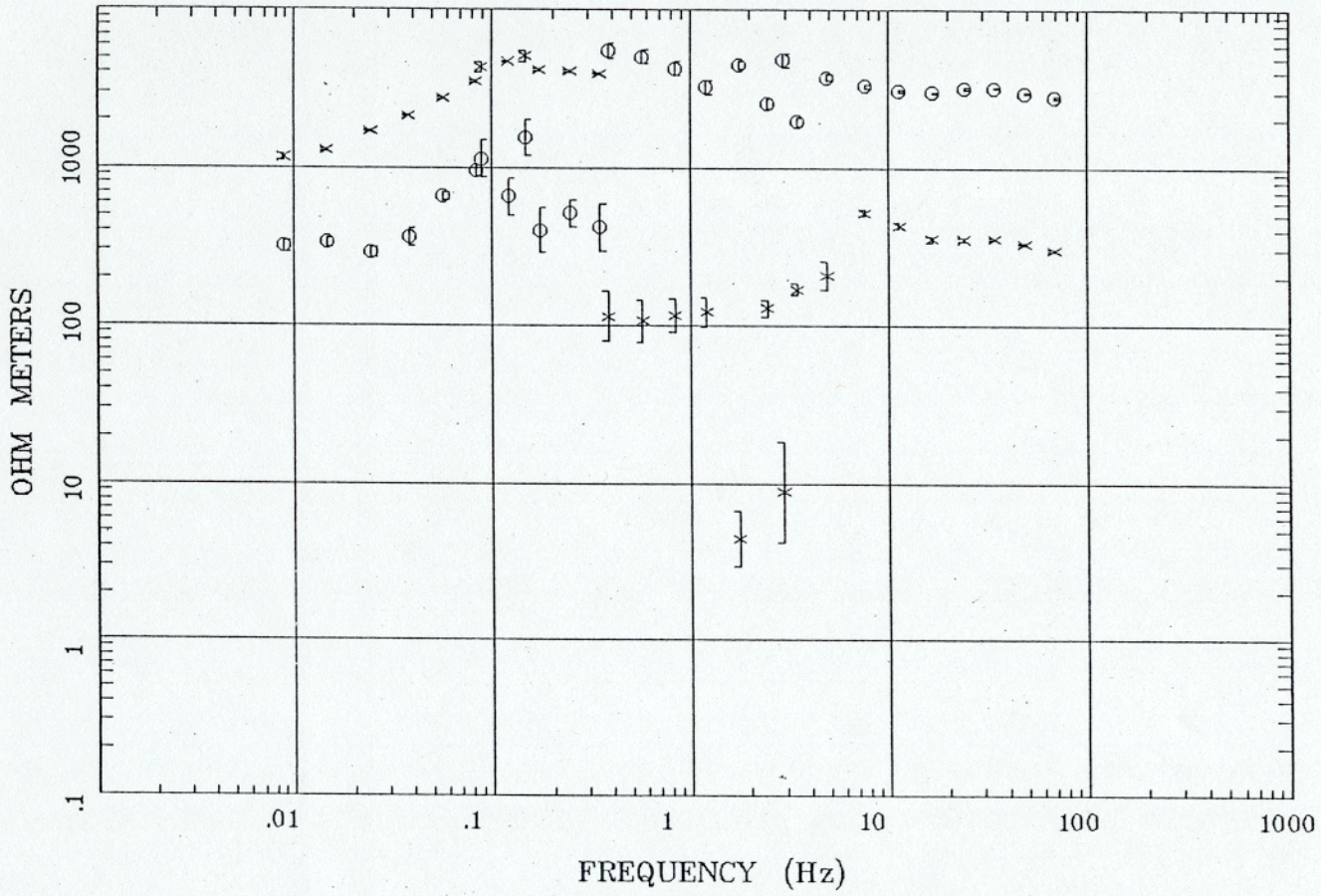
Acquired: 12:2 Aug 18, 2001
Survey Co:USGS

Rotation:
Filename: tlm06all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:05 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY Tangle Lakes, Alaska

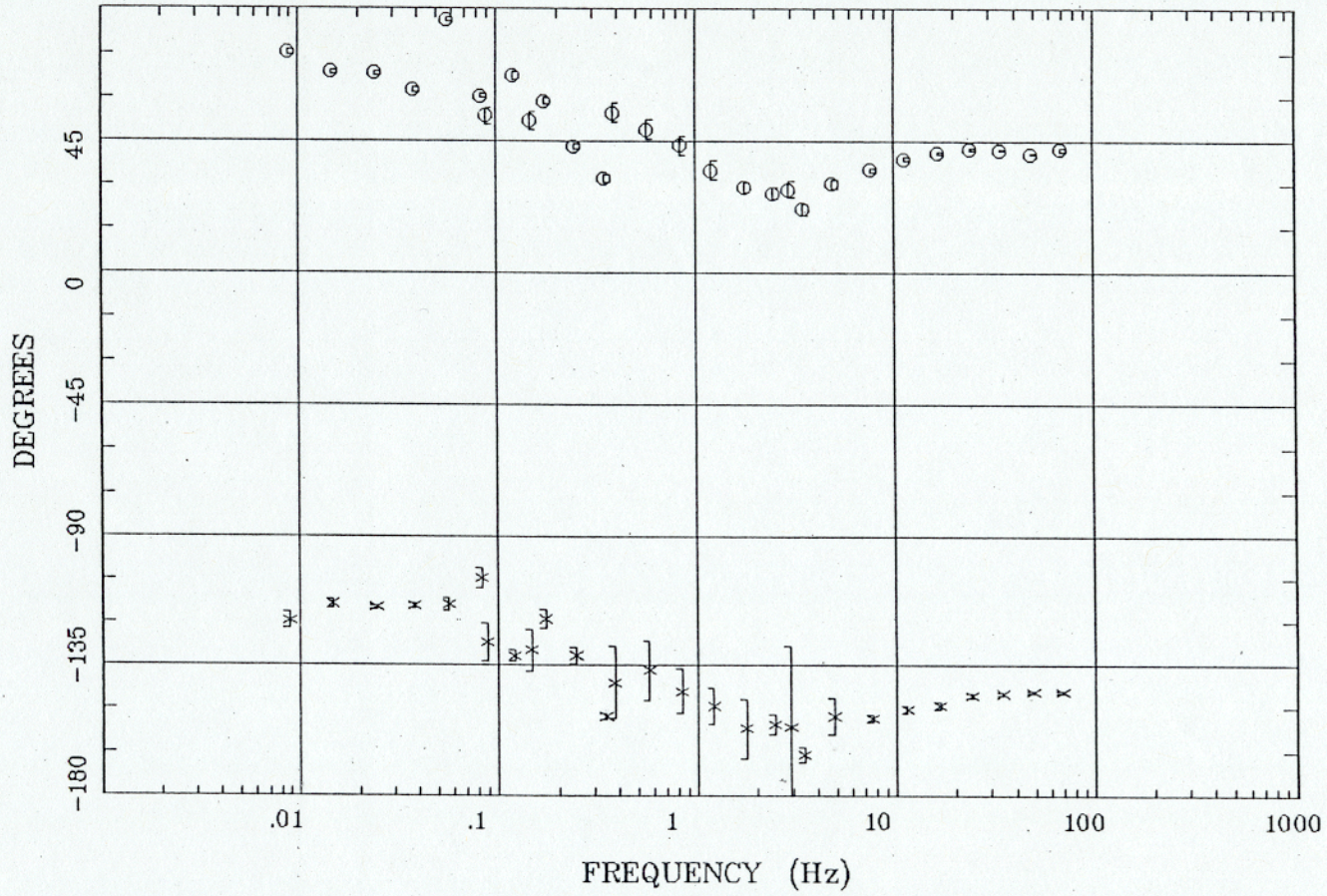


Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska

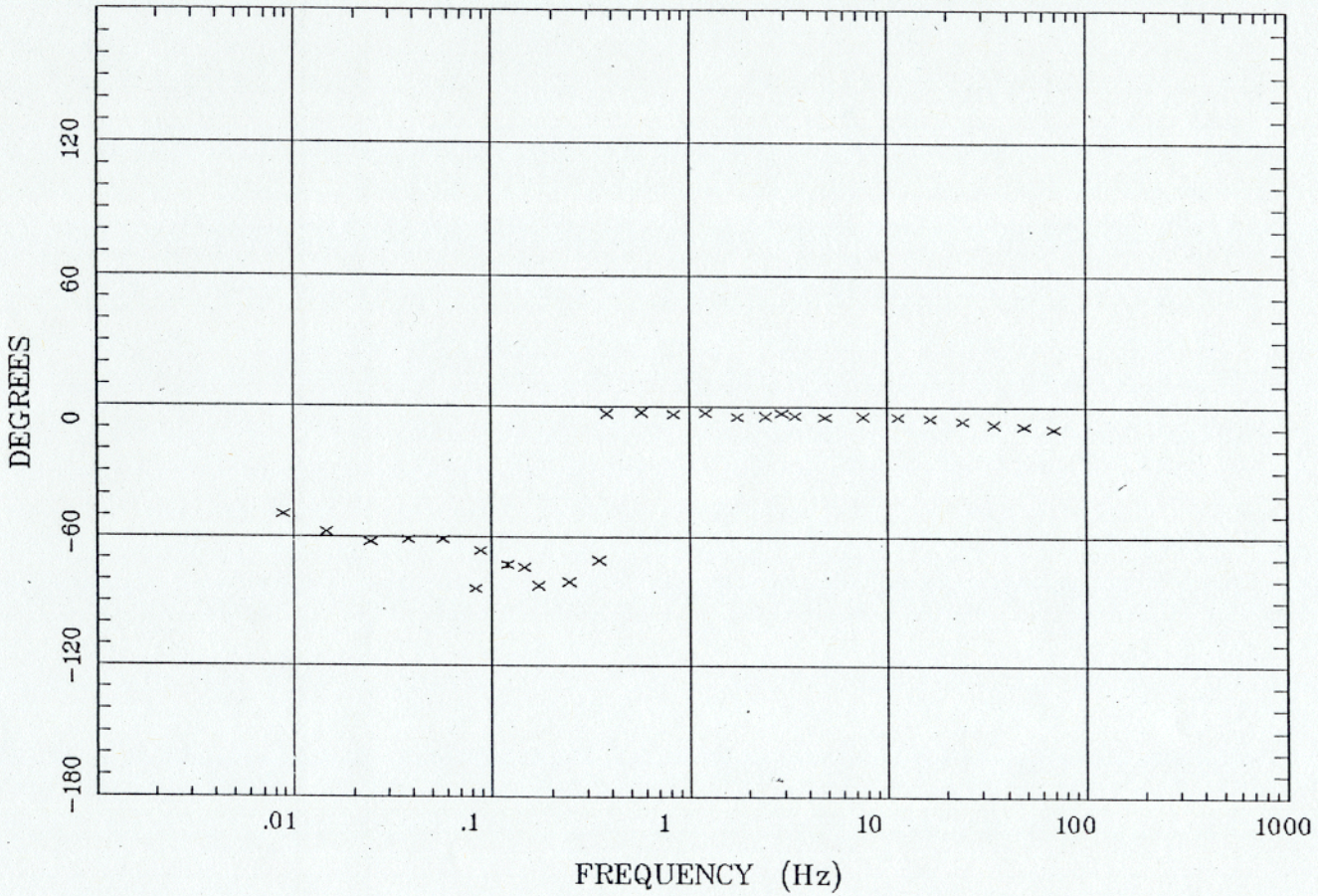


Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska



Client:
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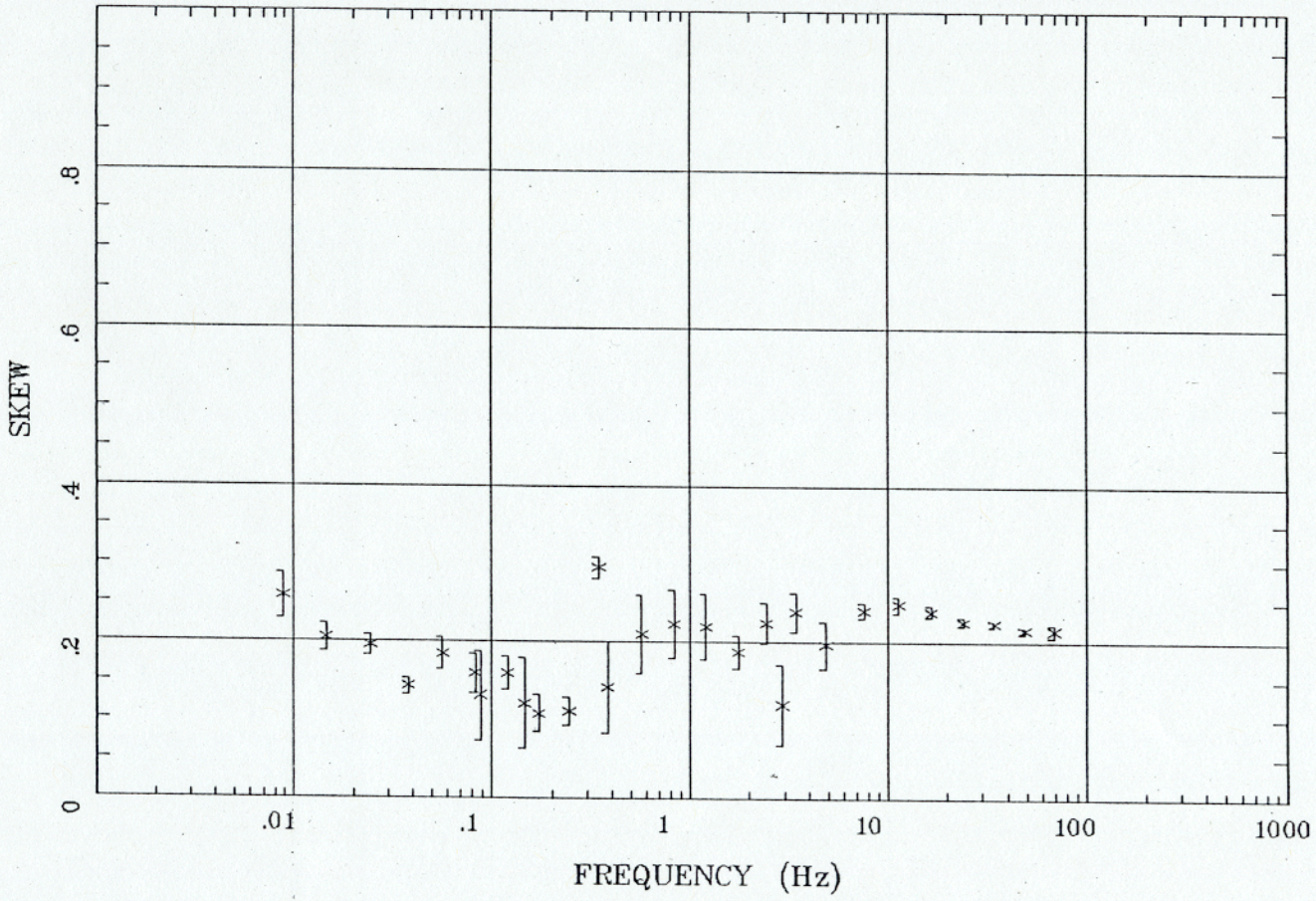
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska



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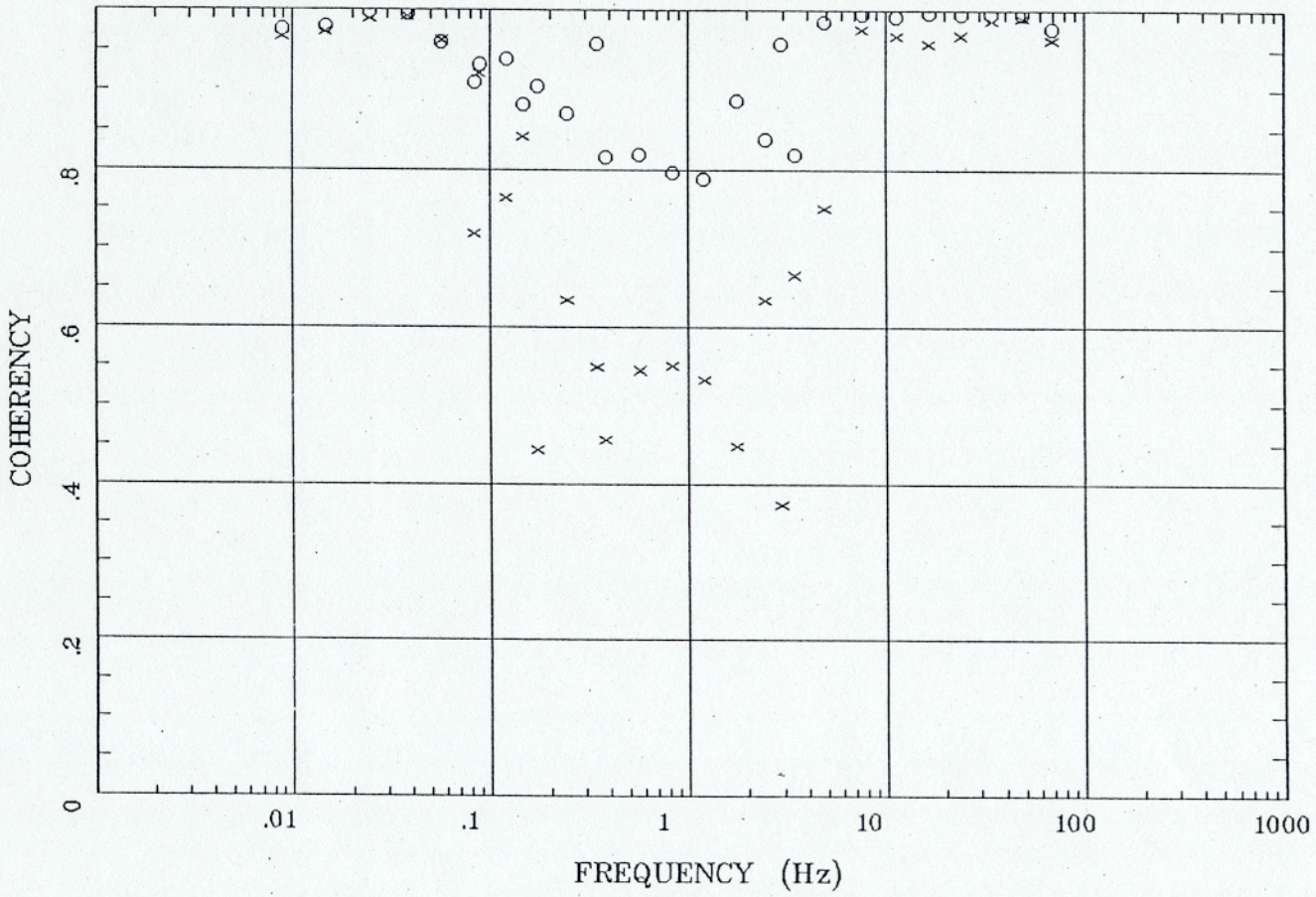
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh.

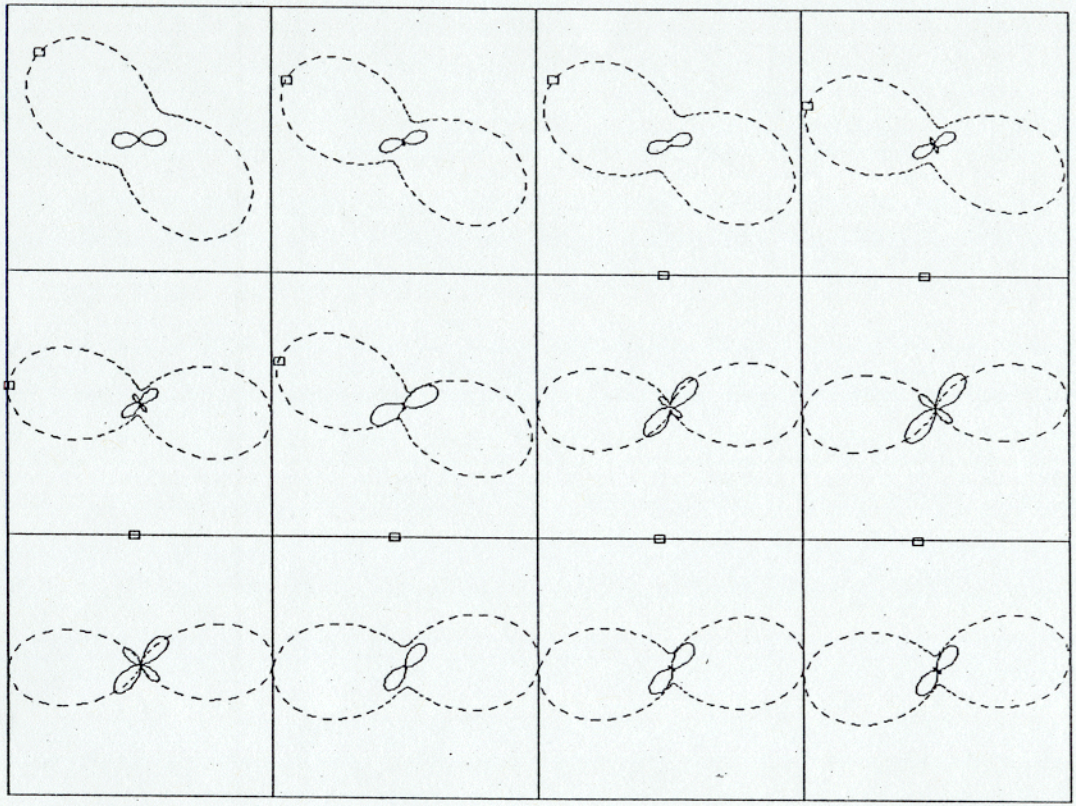
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS Tangle Lakes, Alaska



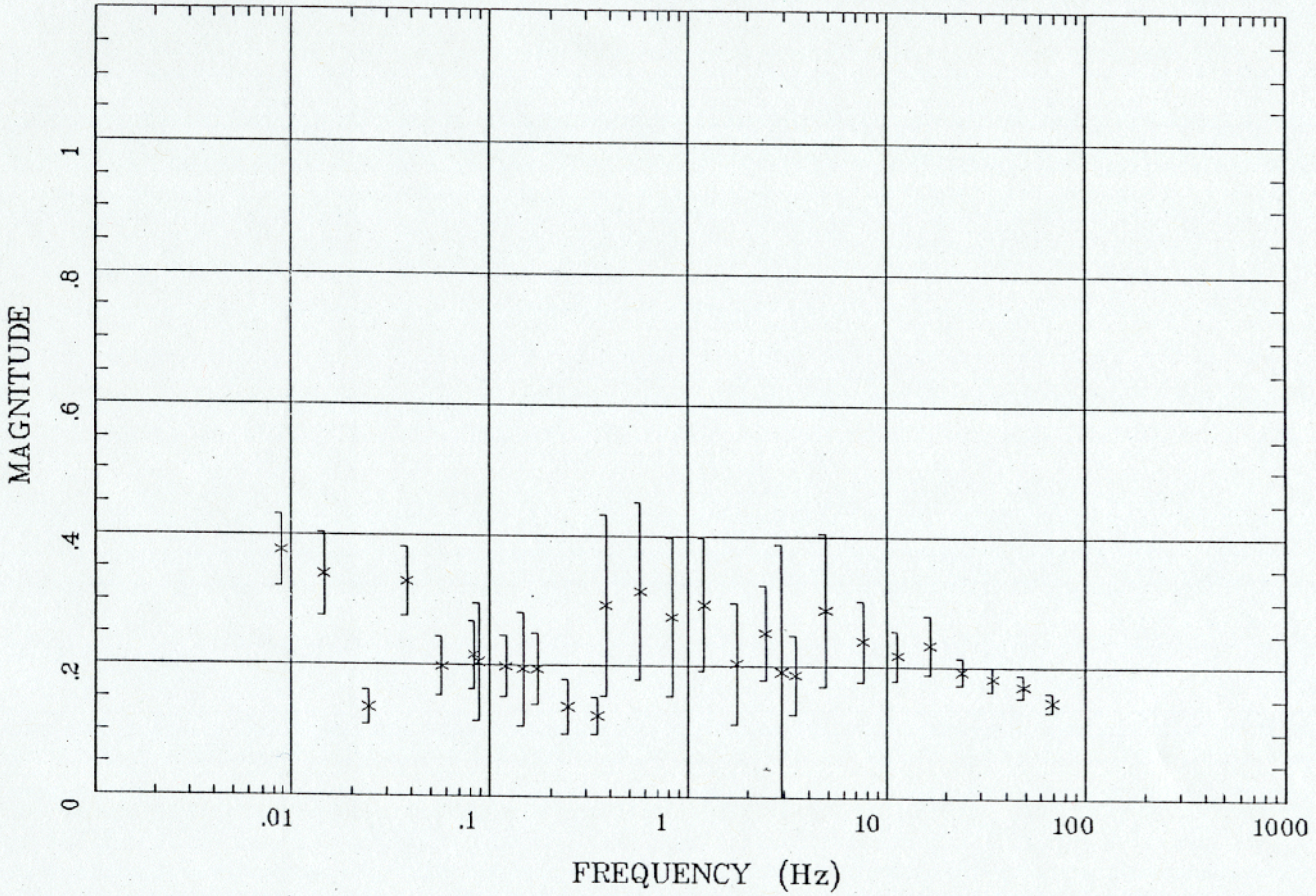
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska

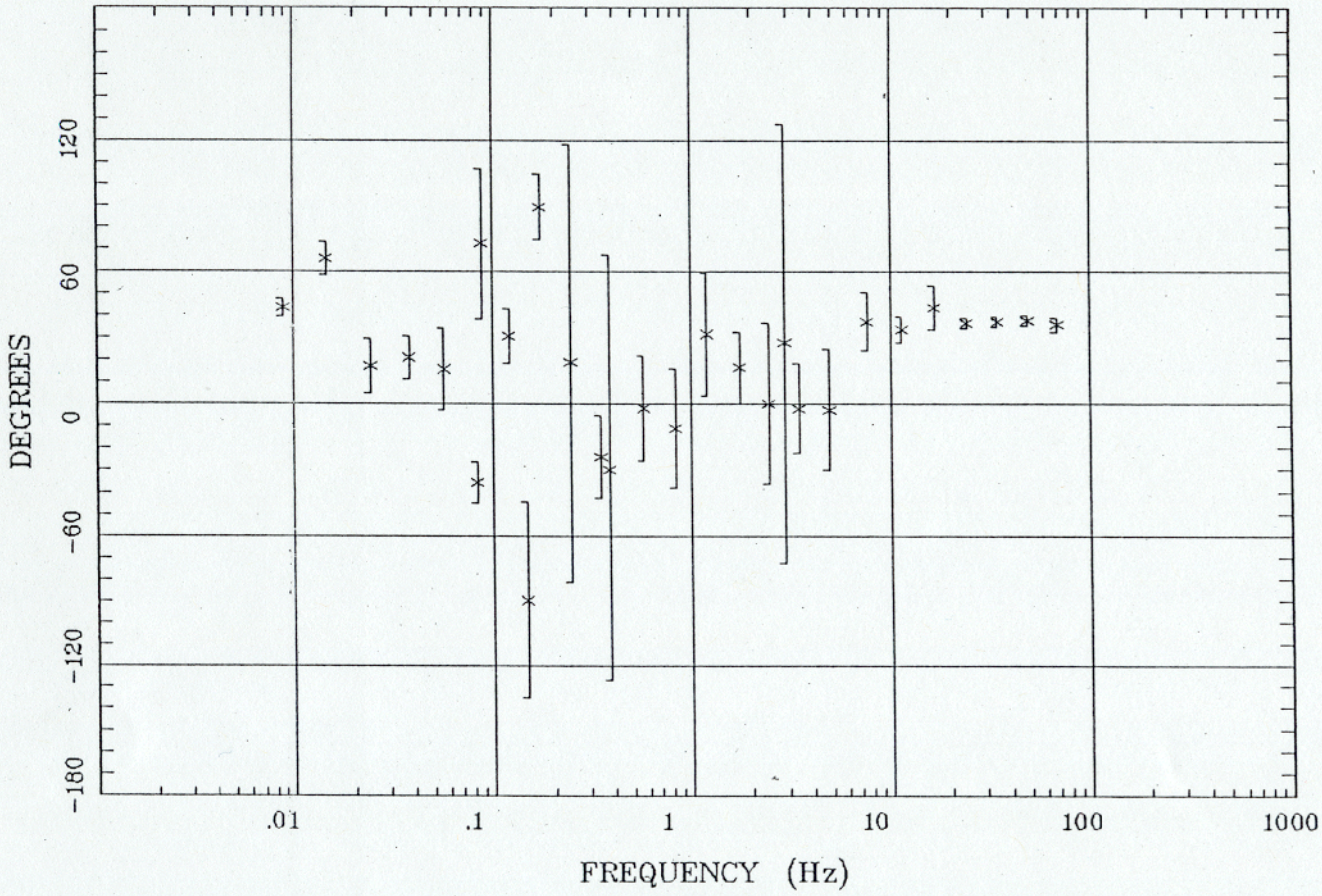


Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:06 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



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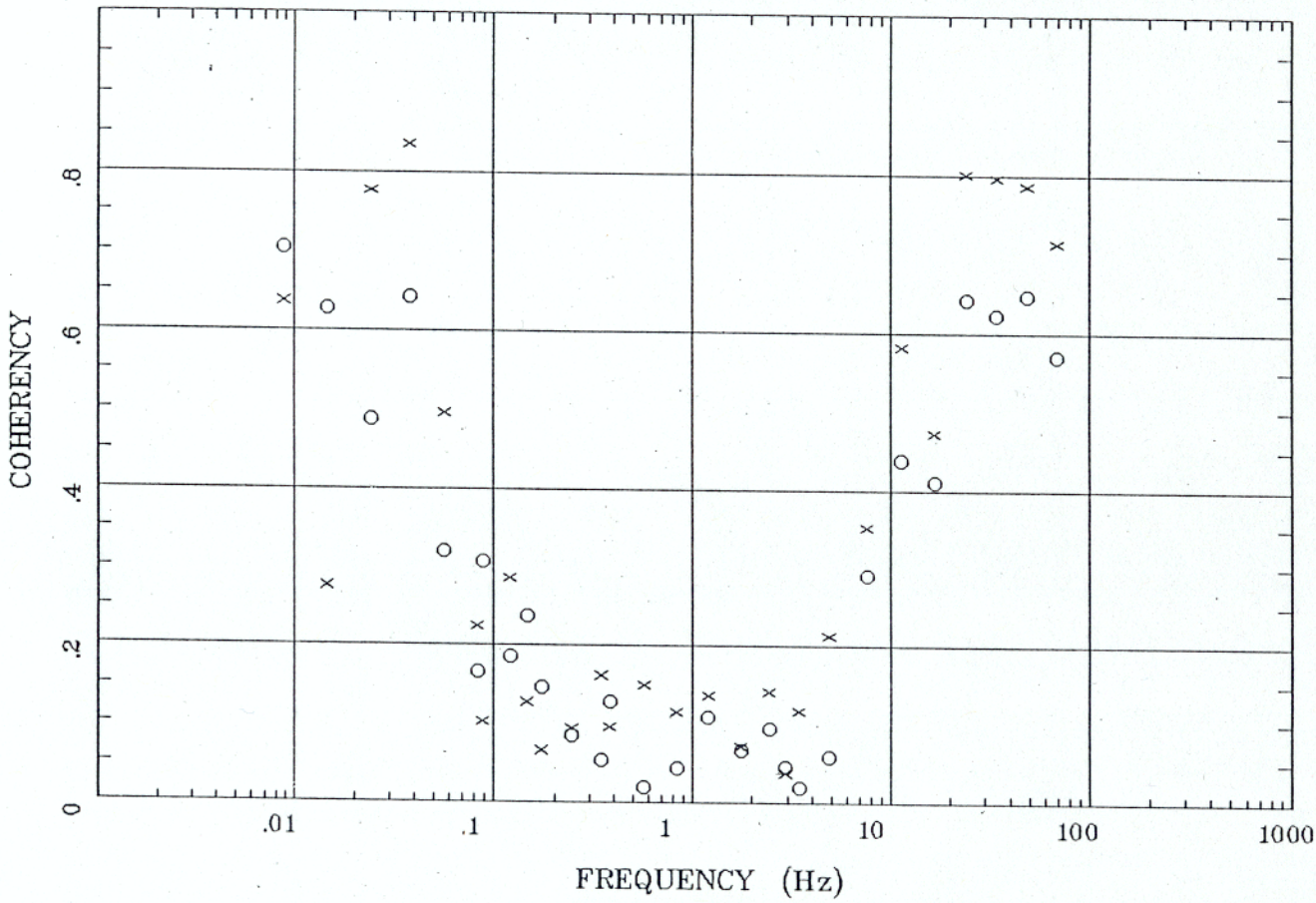
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:07 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

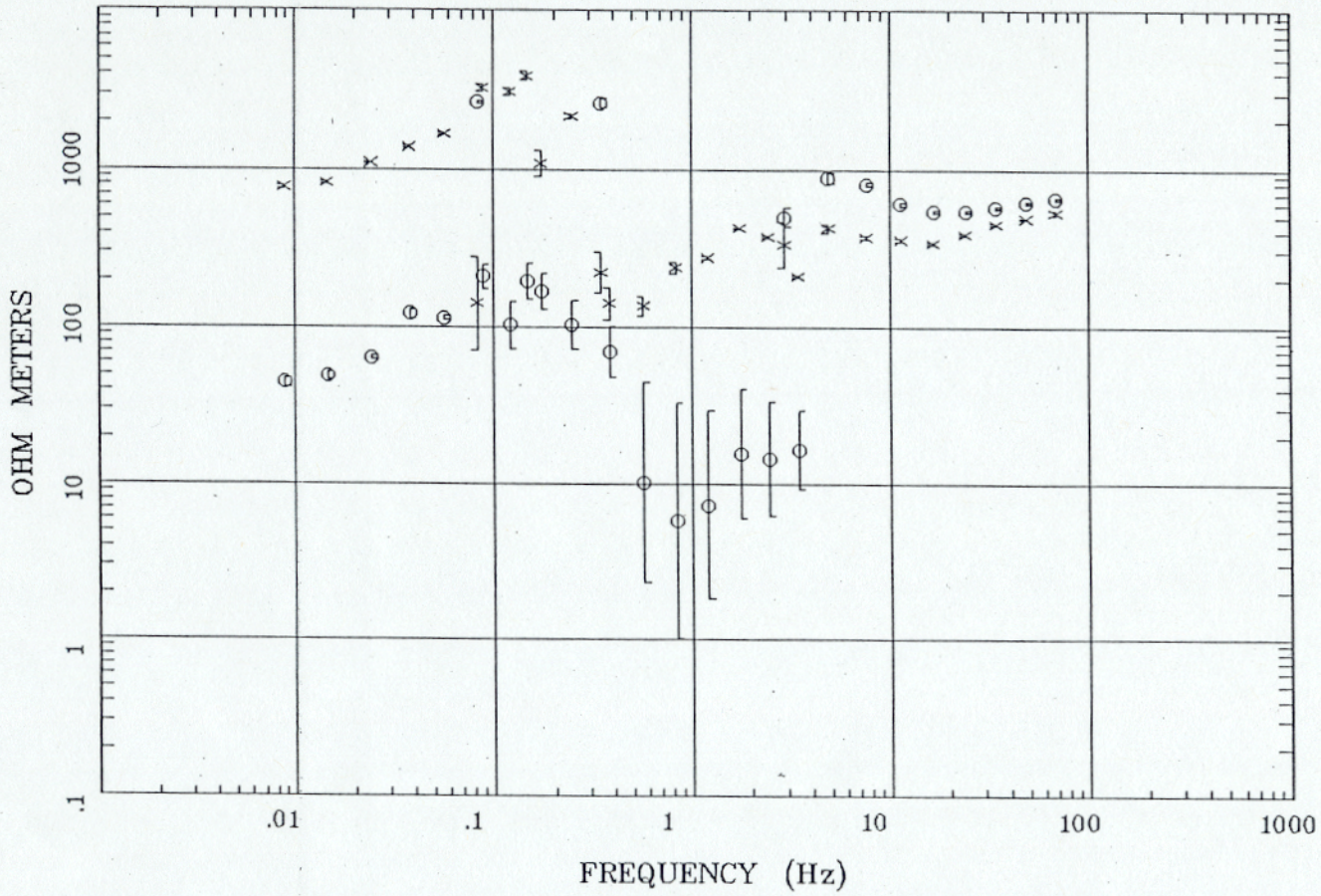
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 13:2 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm07all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:07 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY Tangle Lakes, Alaska

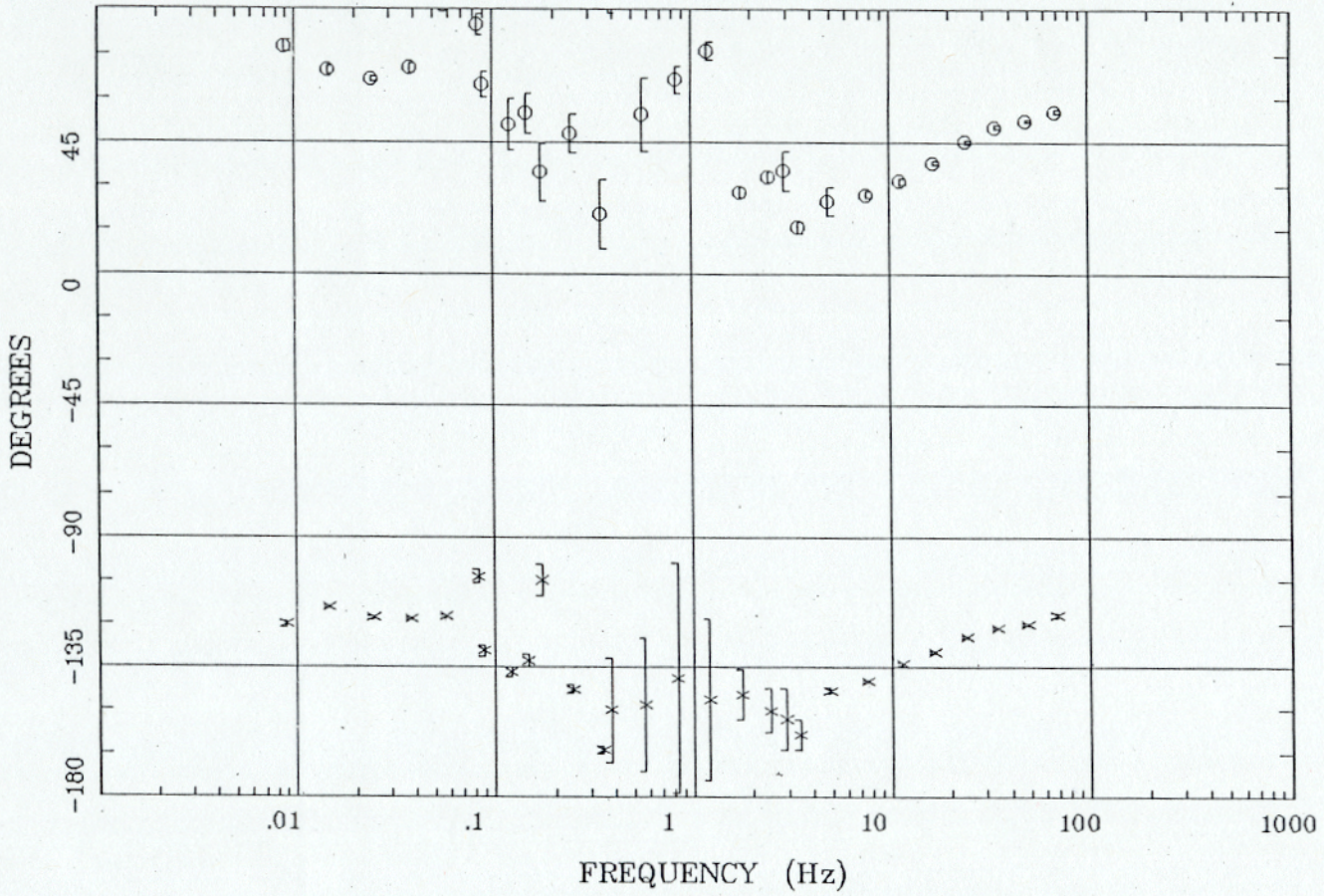


Client:
Remote: none
Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:07 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



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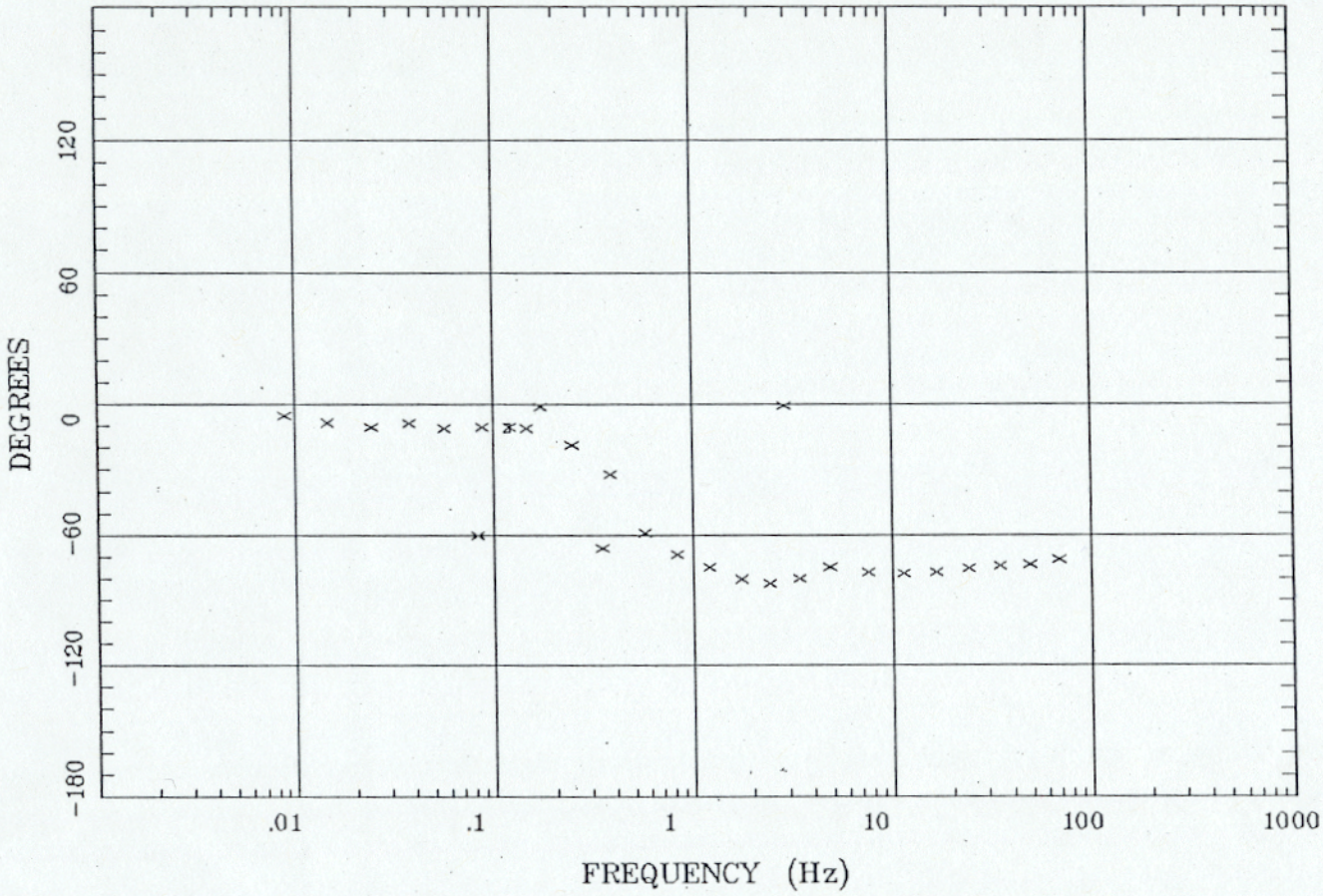
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska



Client:
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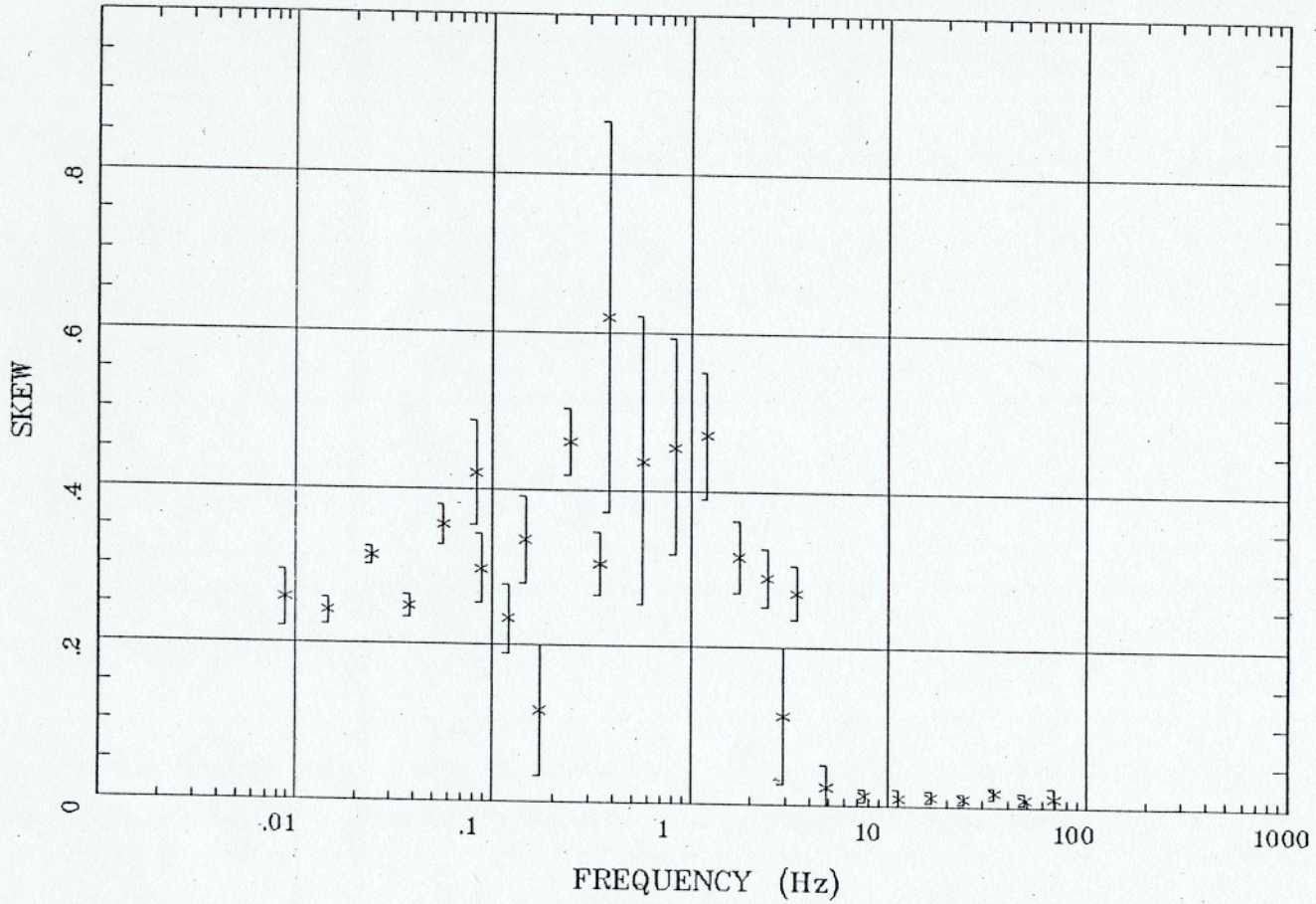
Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska



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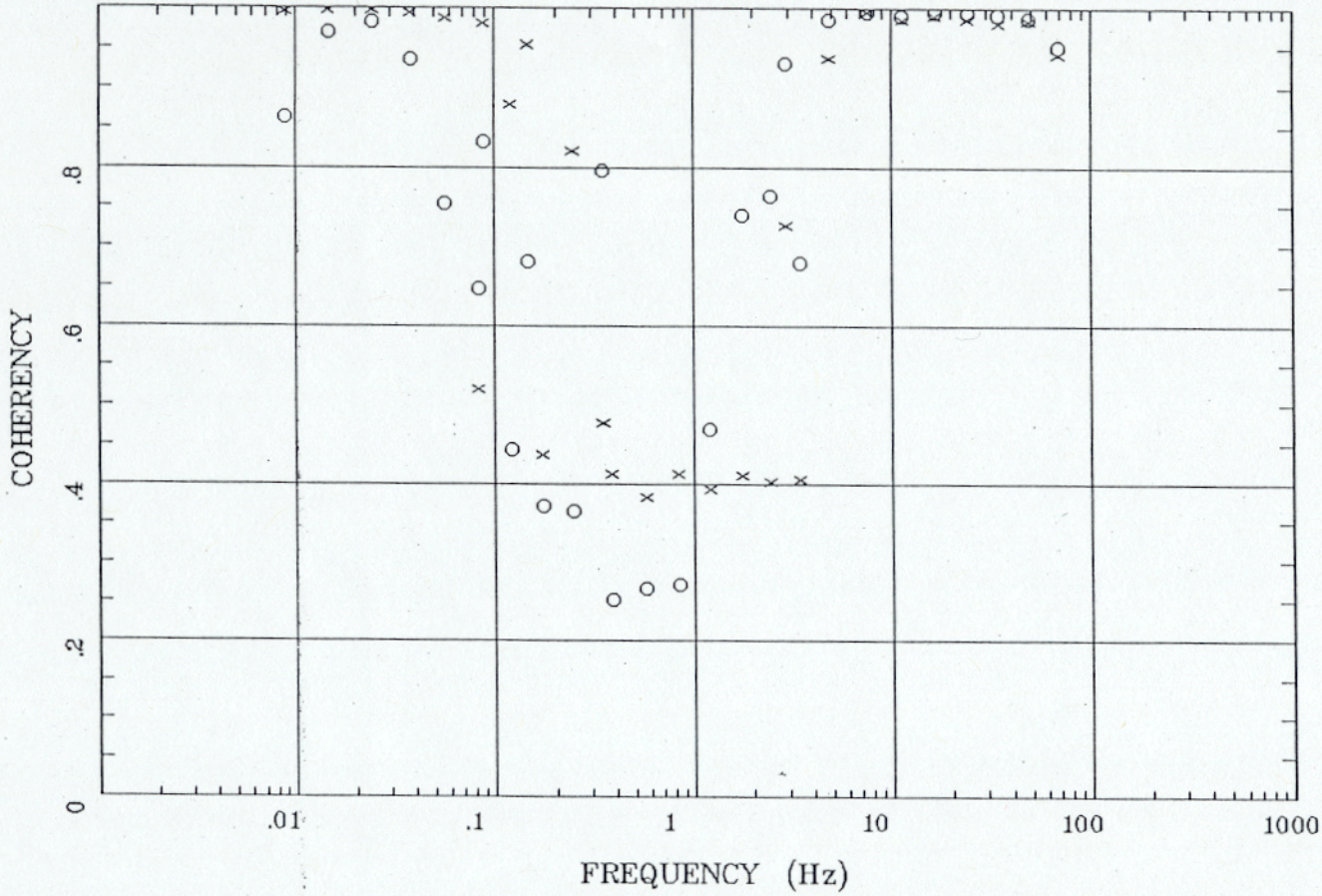
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska



Client:
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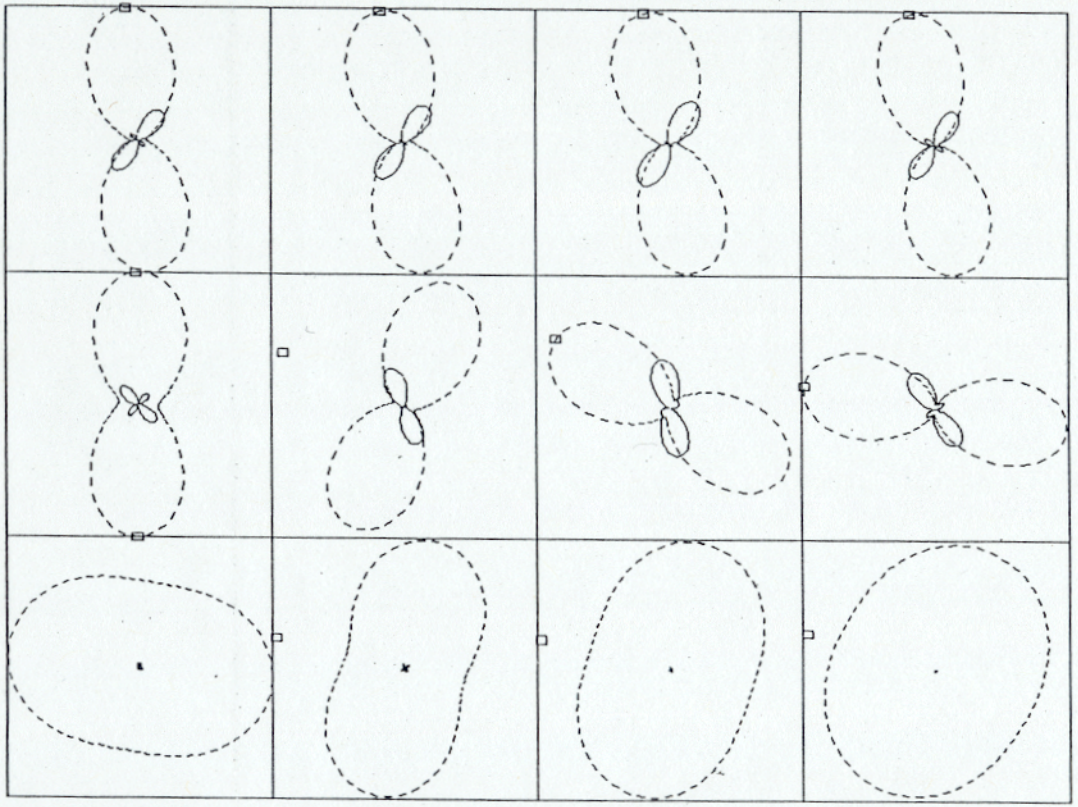
Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska



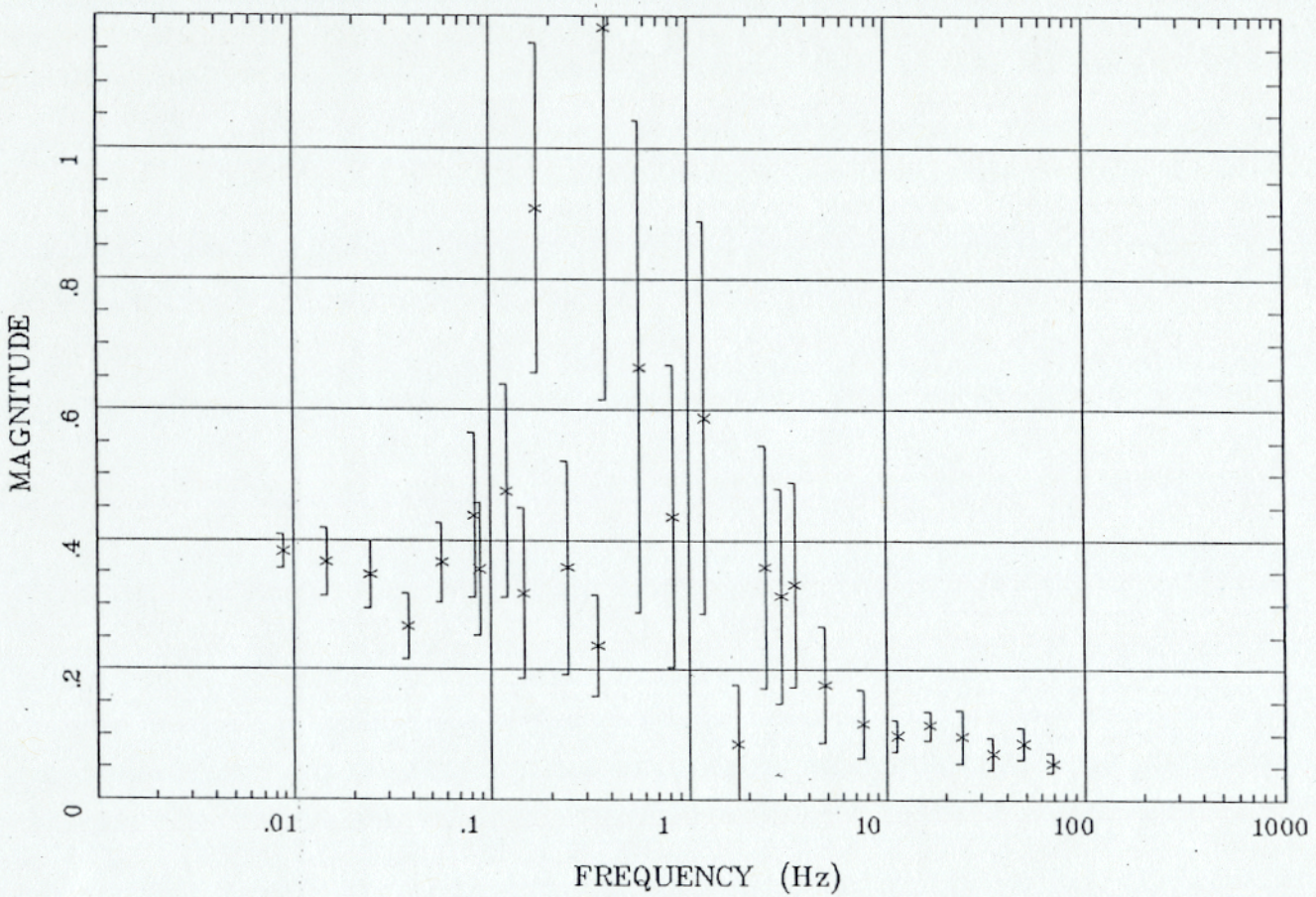
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska



Client:
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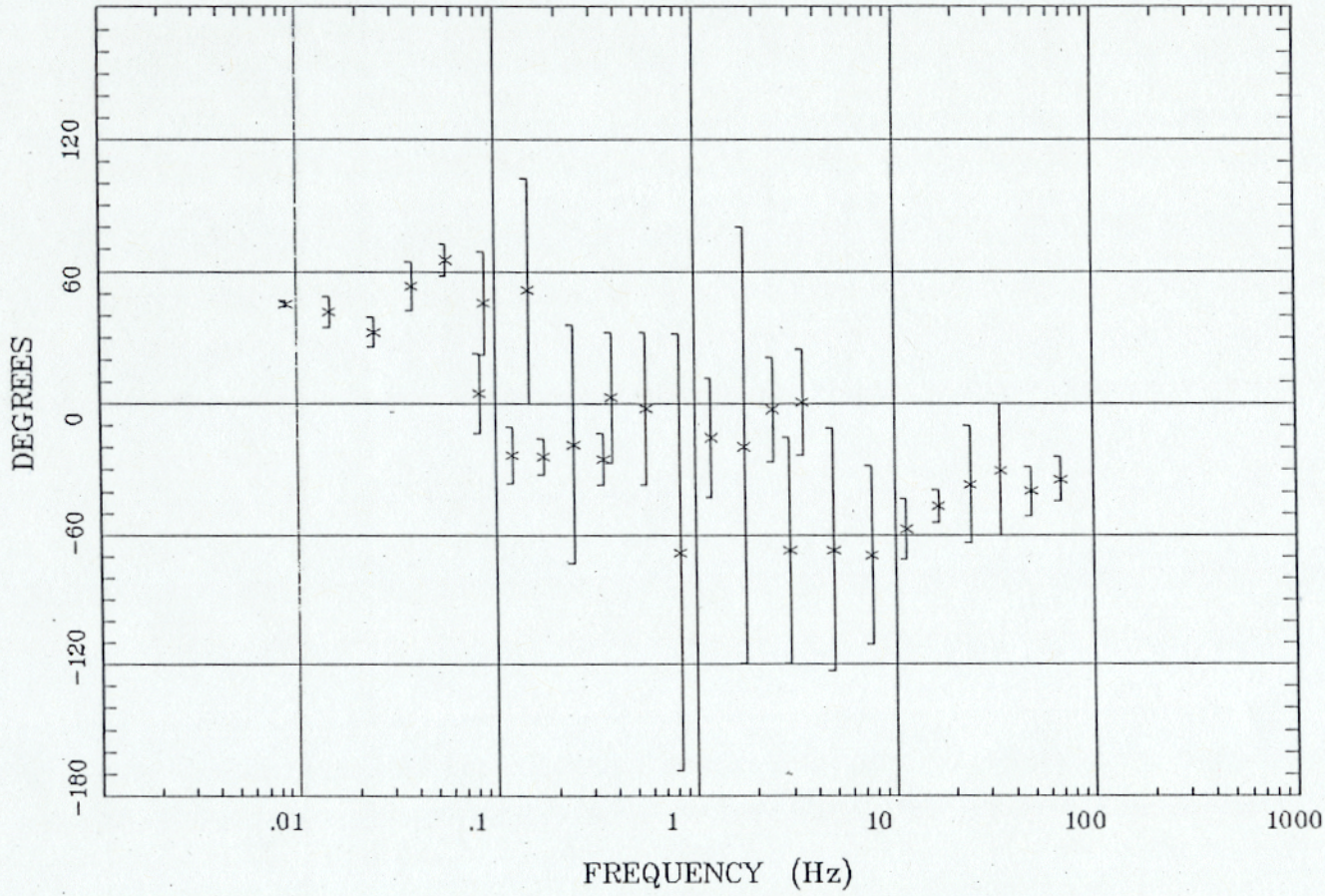
Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



Client:
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Acquired: 17:3 Aug 19, 2001
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

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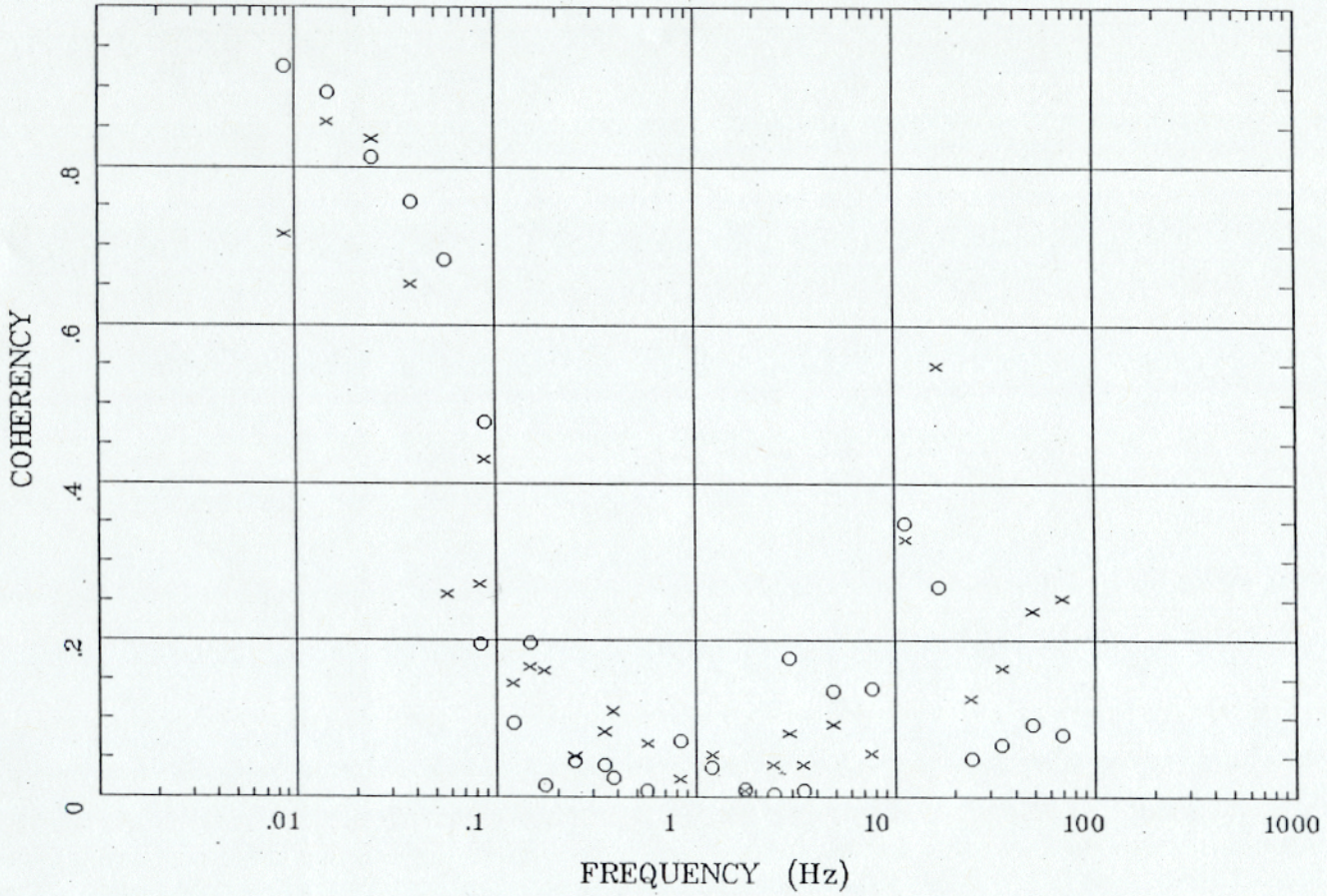
HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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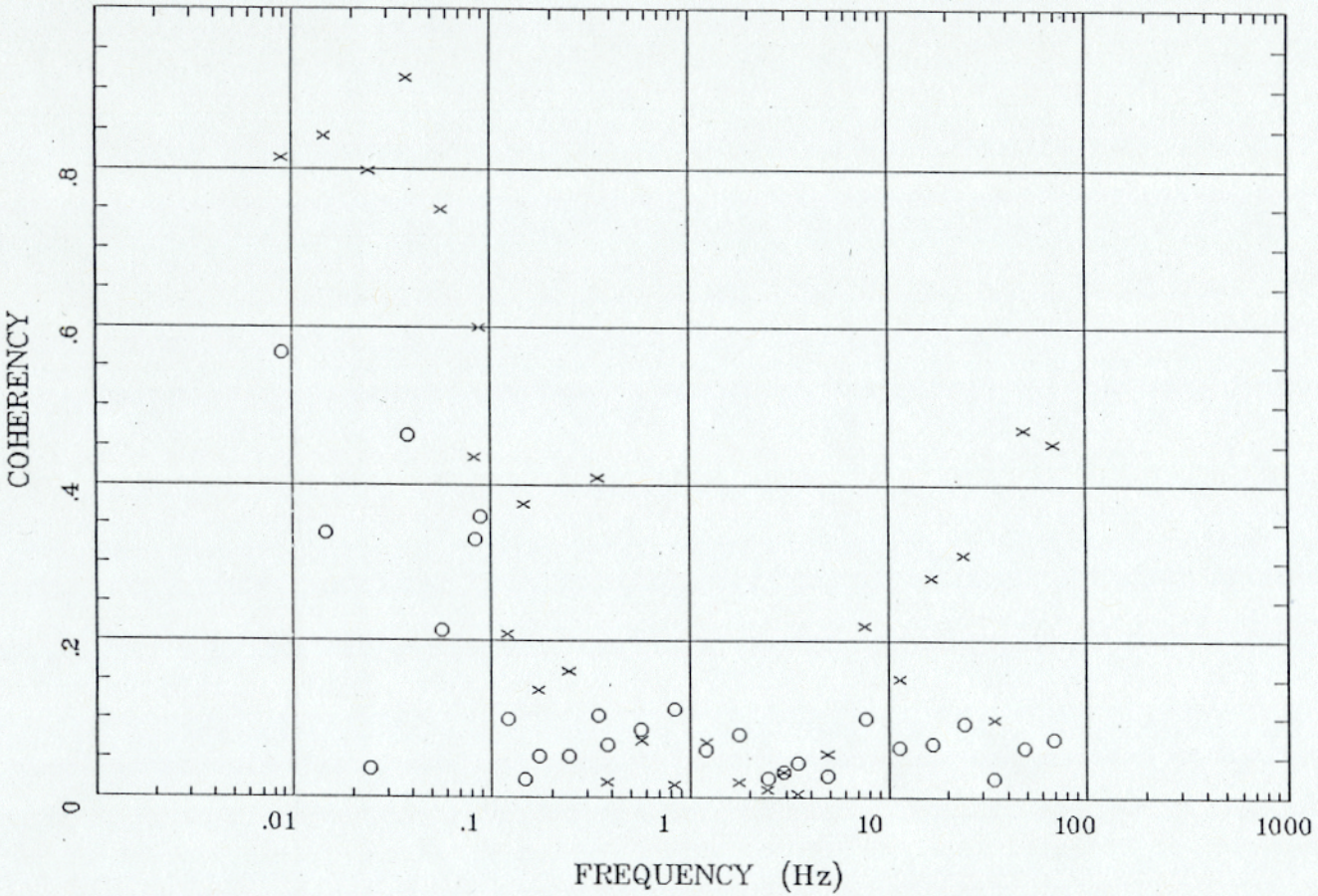
Survey Co:USGS

Rotation:
Filename: tlm08all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:08 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

89

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



Client:
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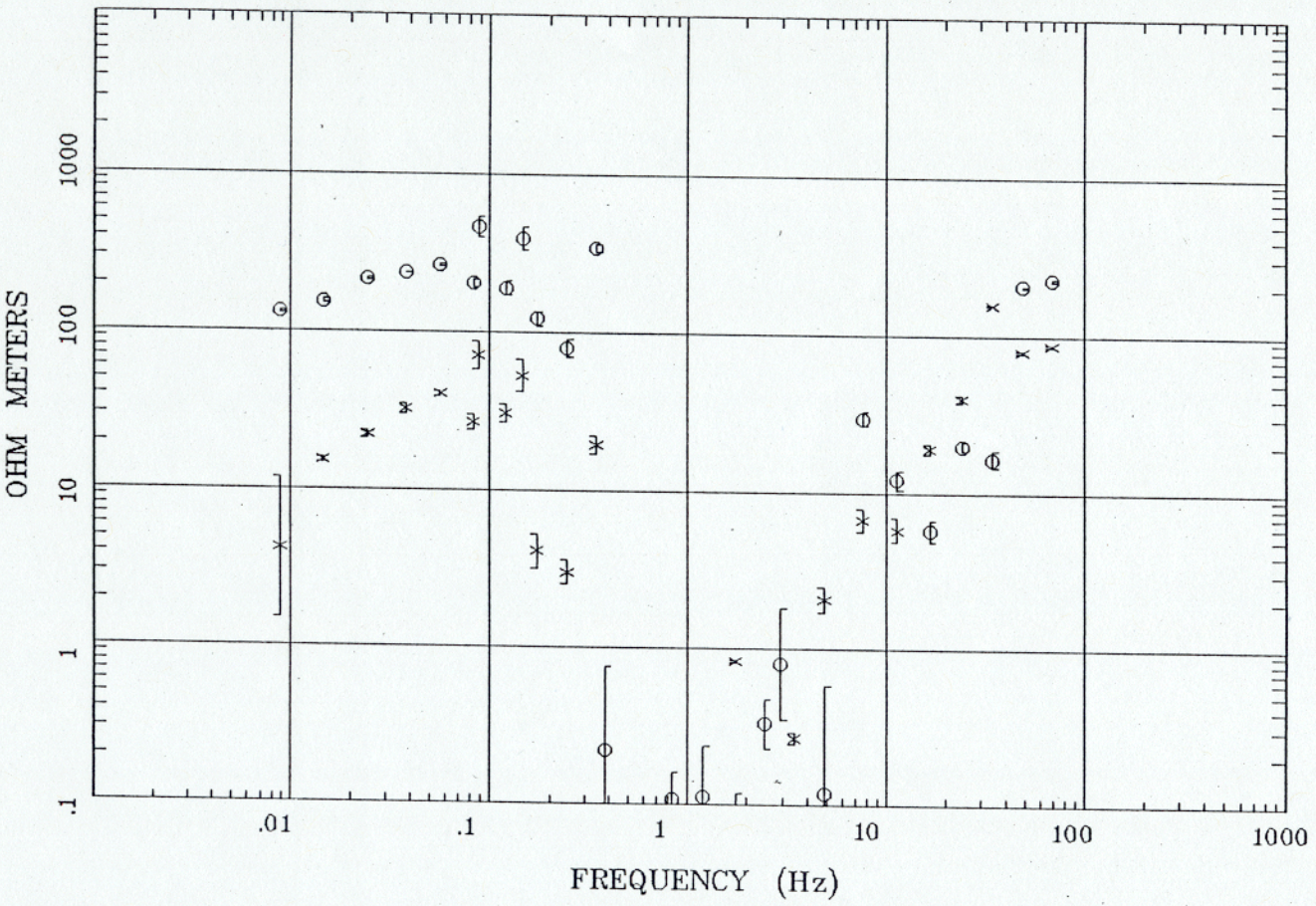
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

APPARENT RESISTIVITY

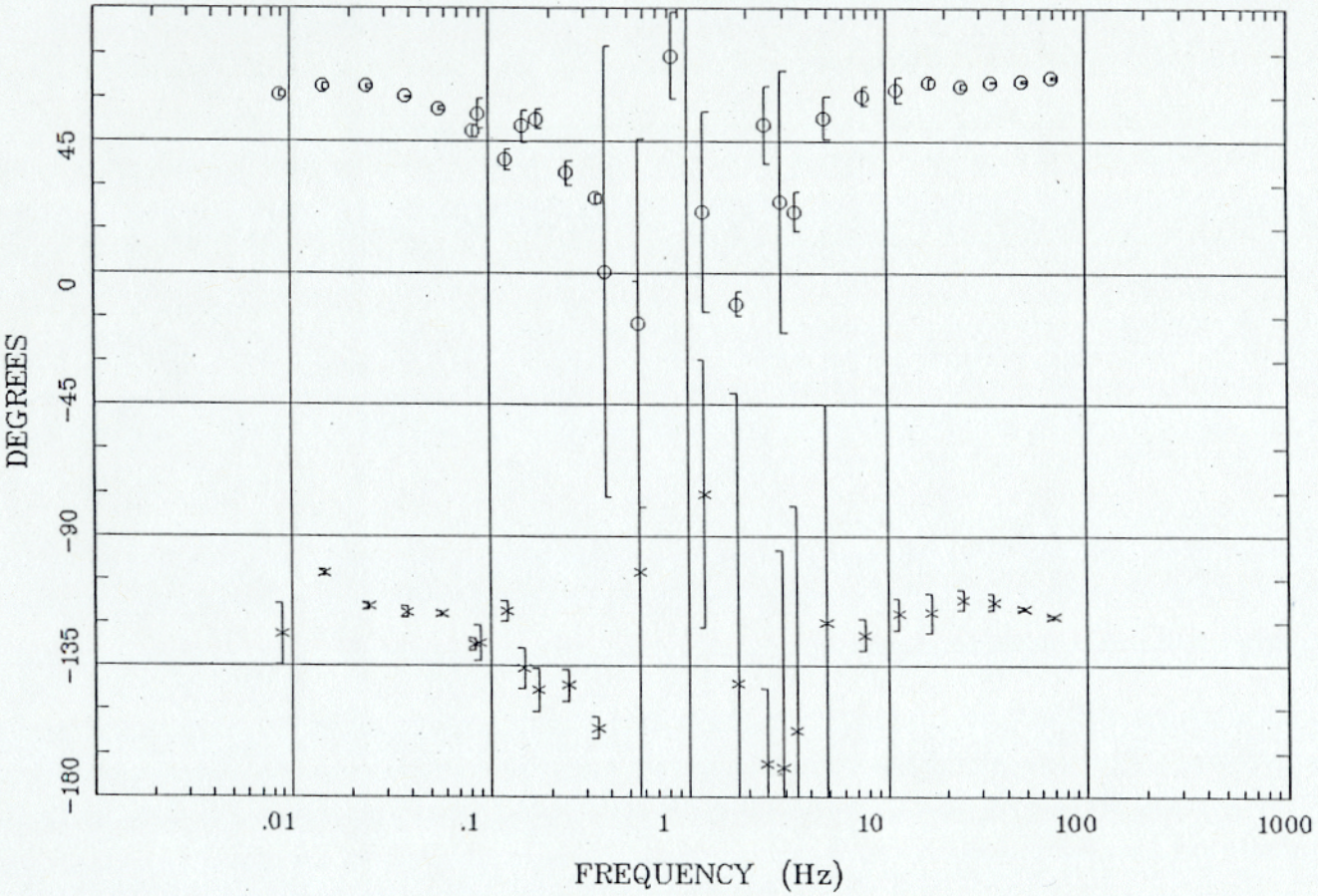
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

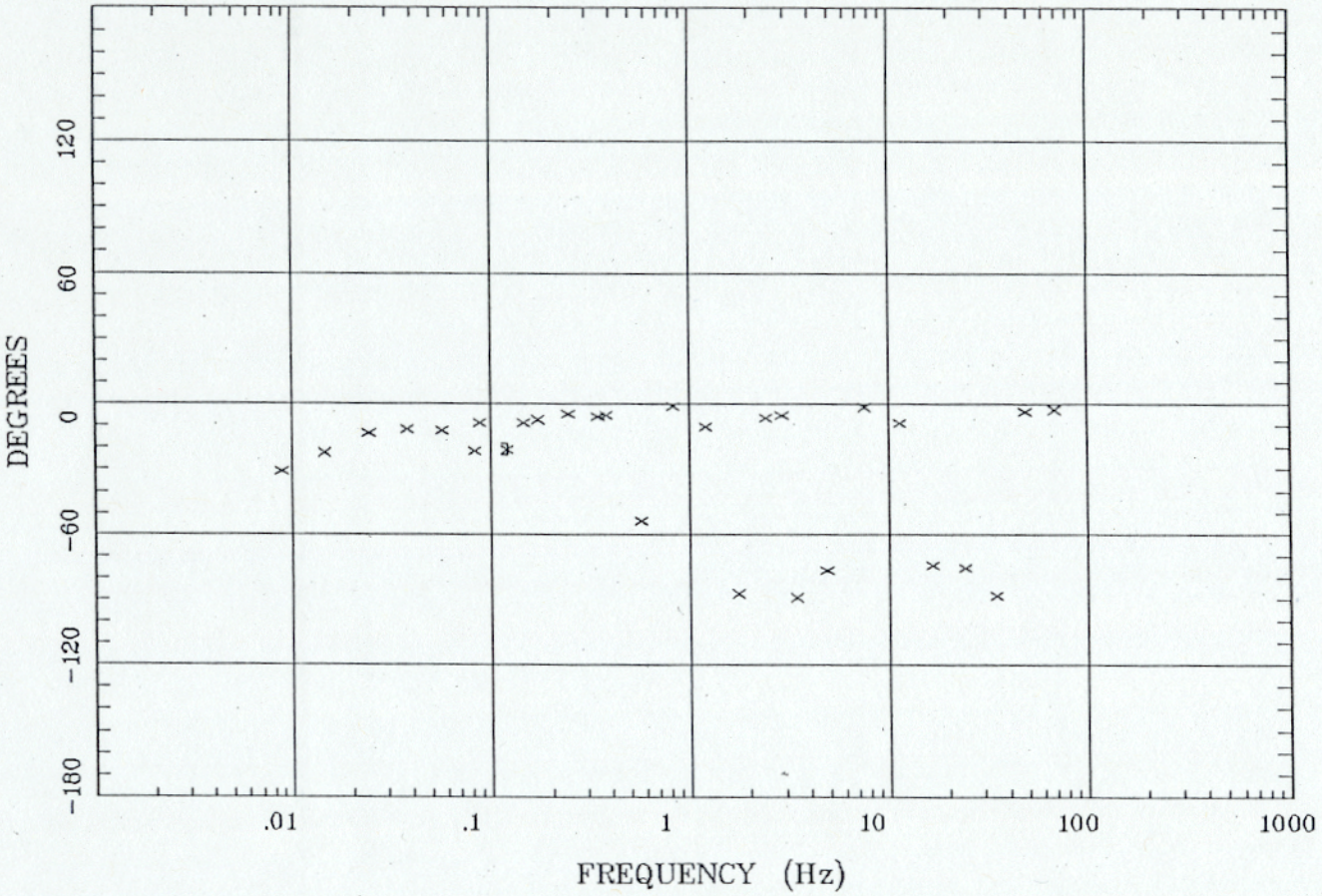
IMPEDANCE PHASE Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

ROTATION ANGLE Tangle Lakes, Alaska

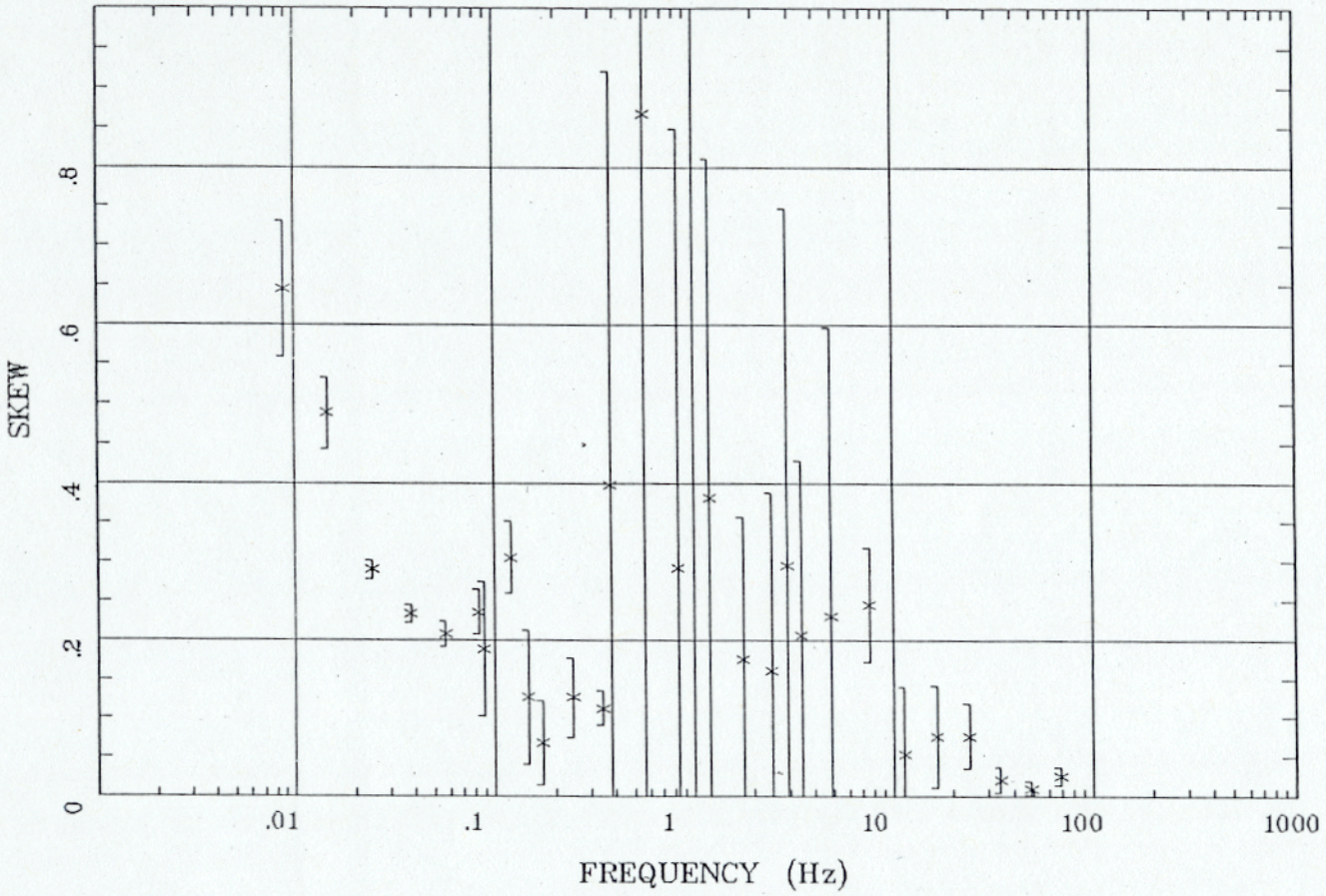


Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

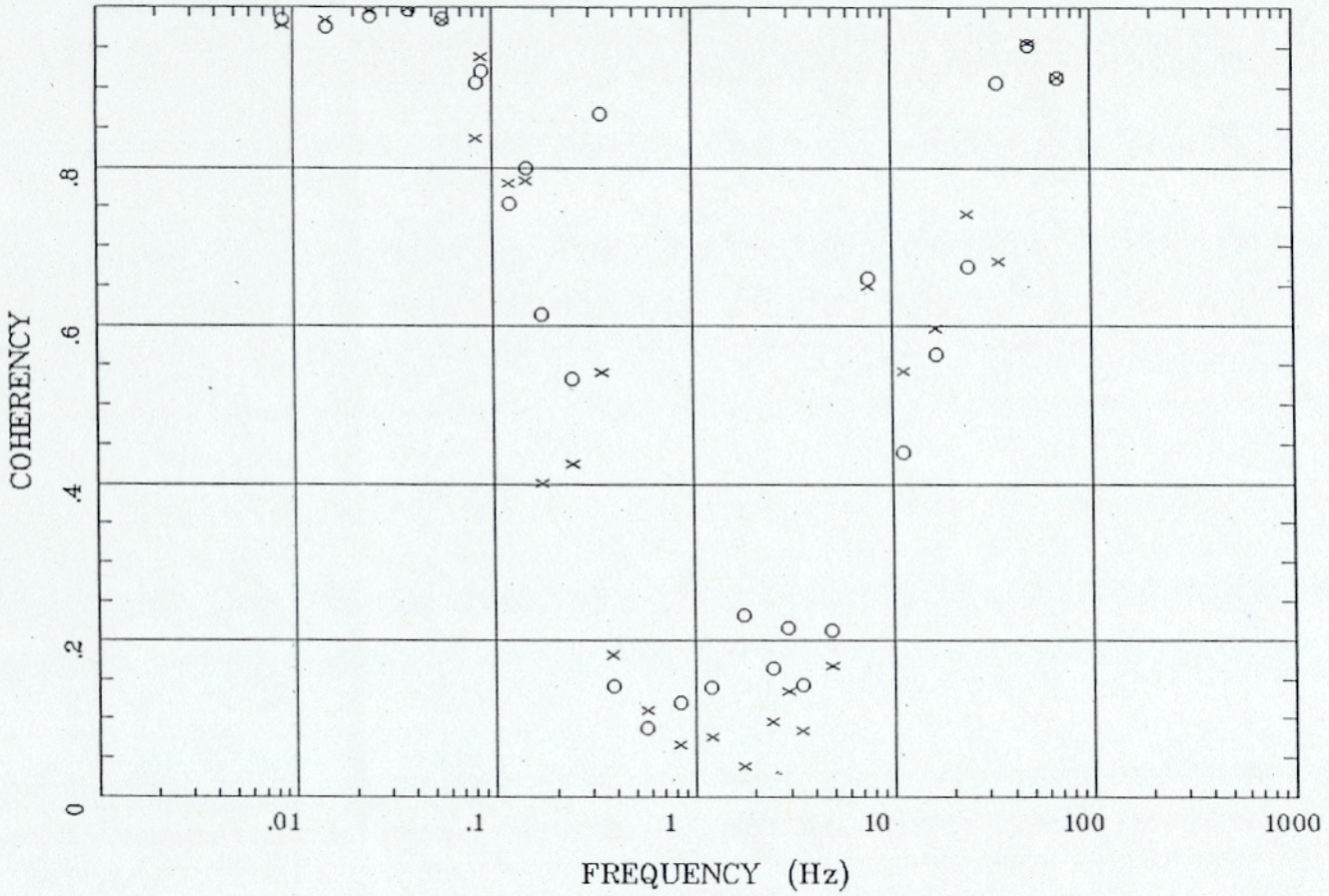
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska

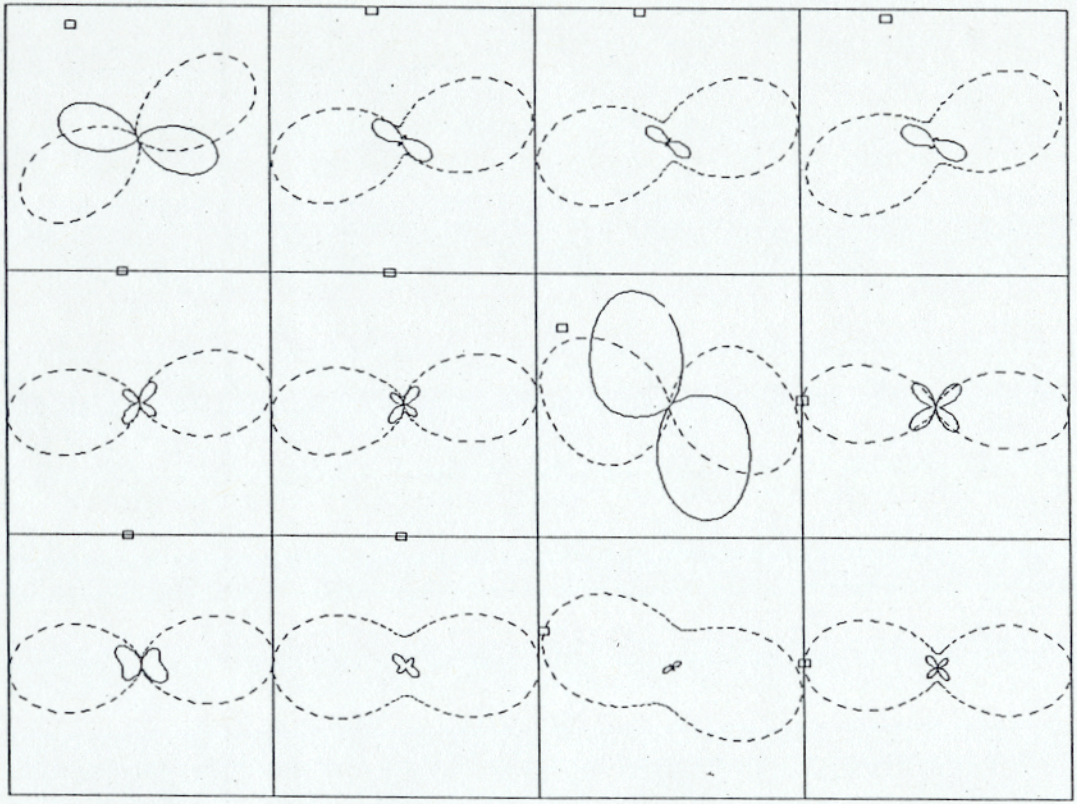


Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska



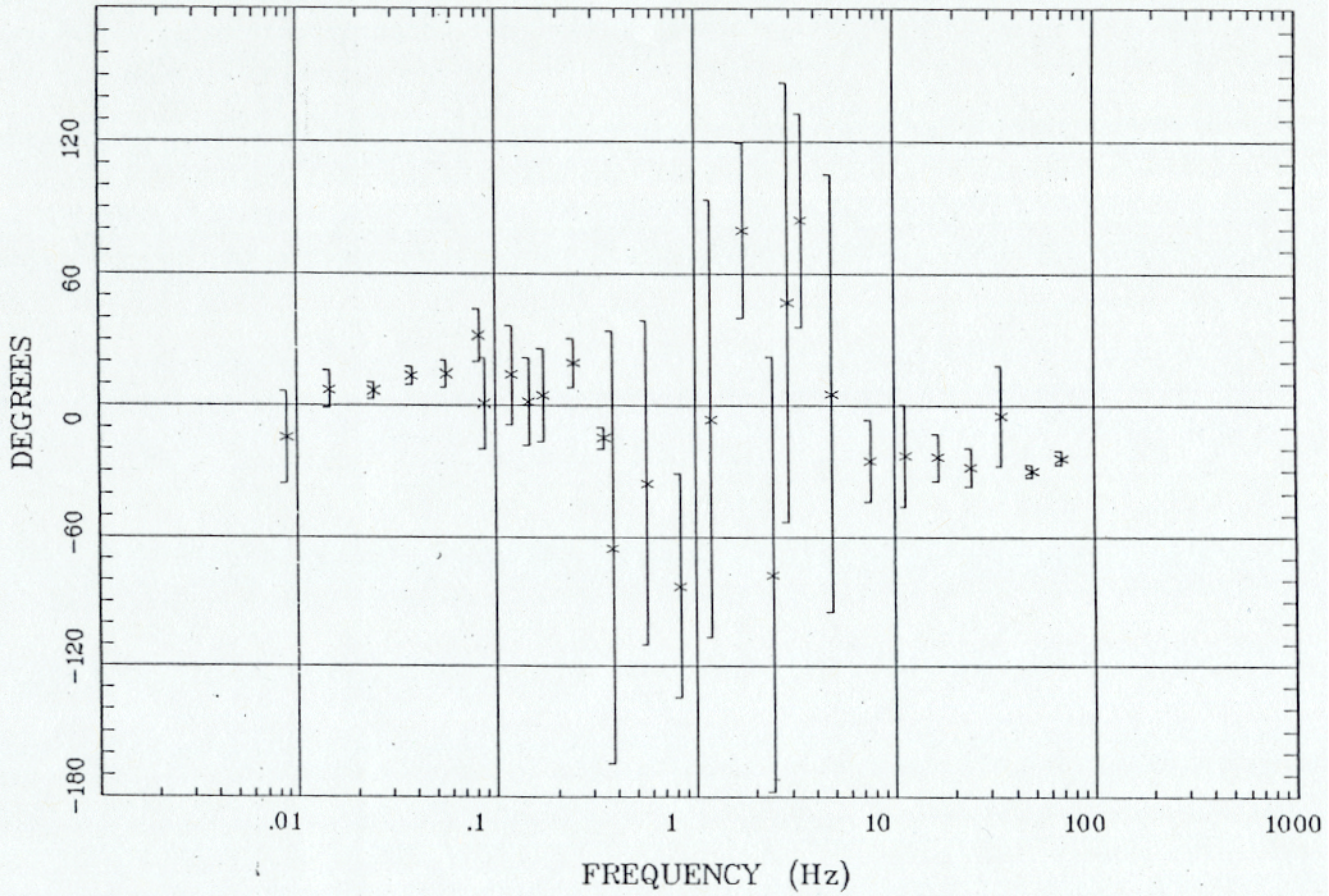
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska

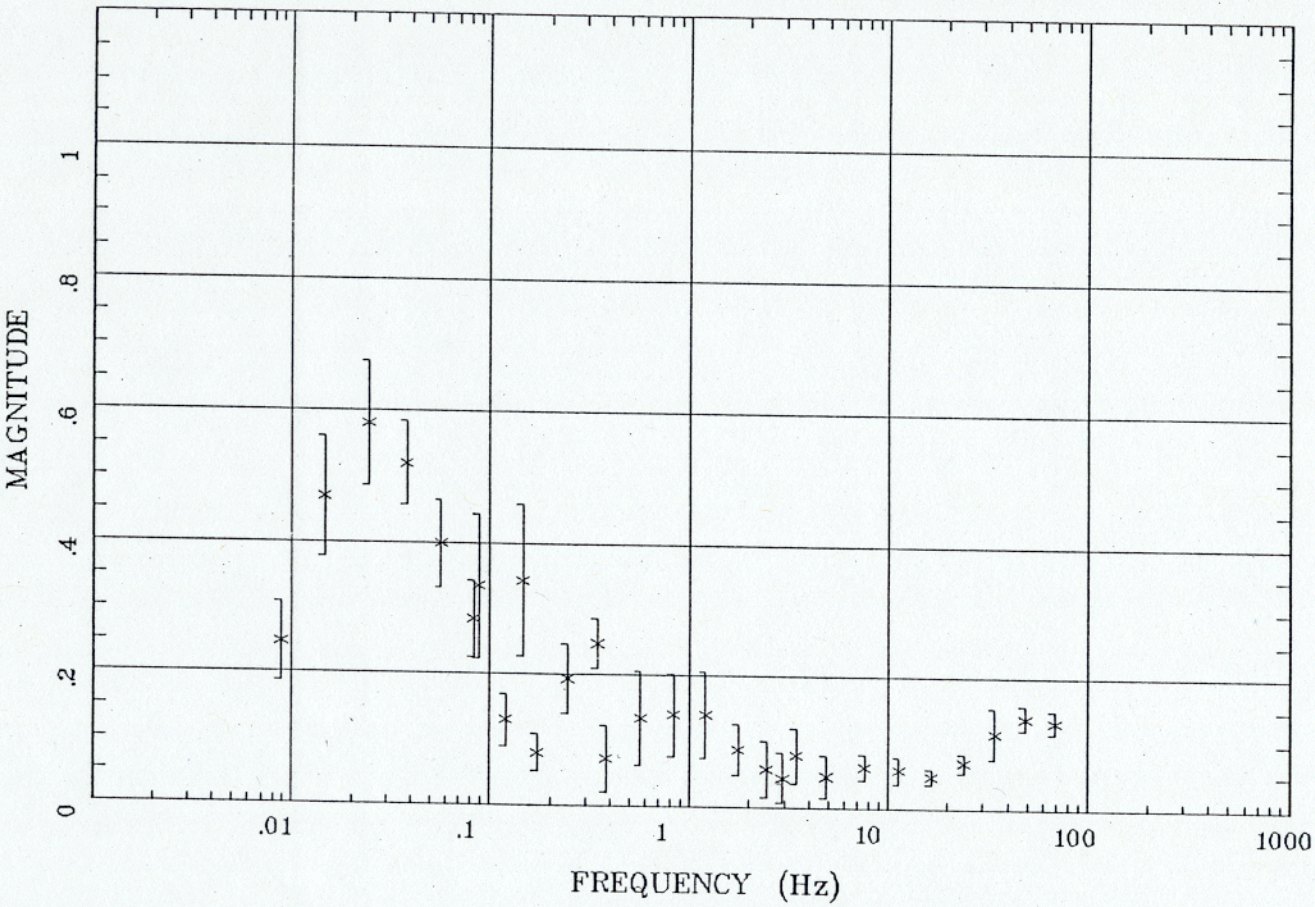


Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

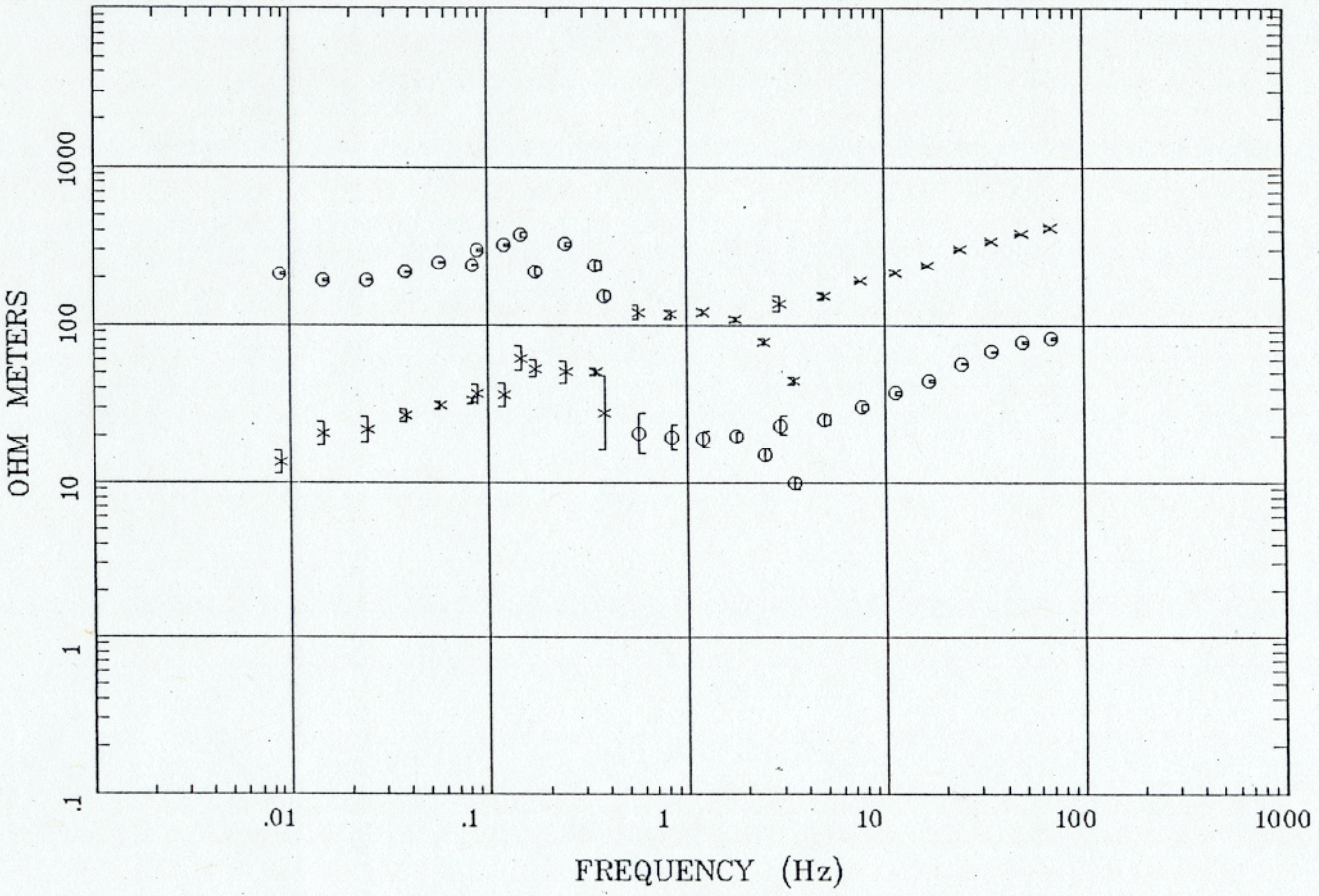
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 12:3 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm09all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:10 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY Tangle Lakes, Alaska



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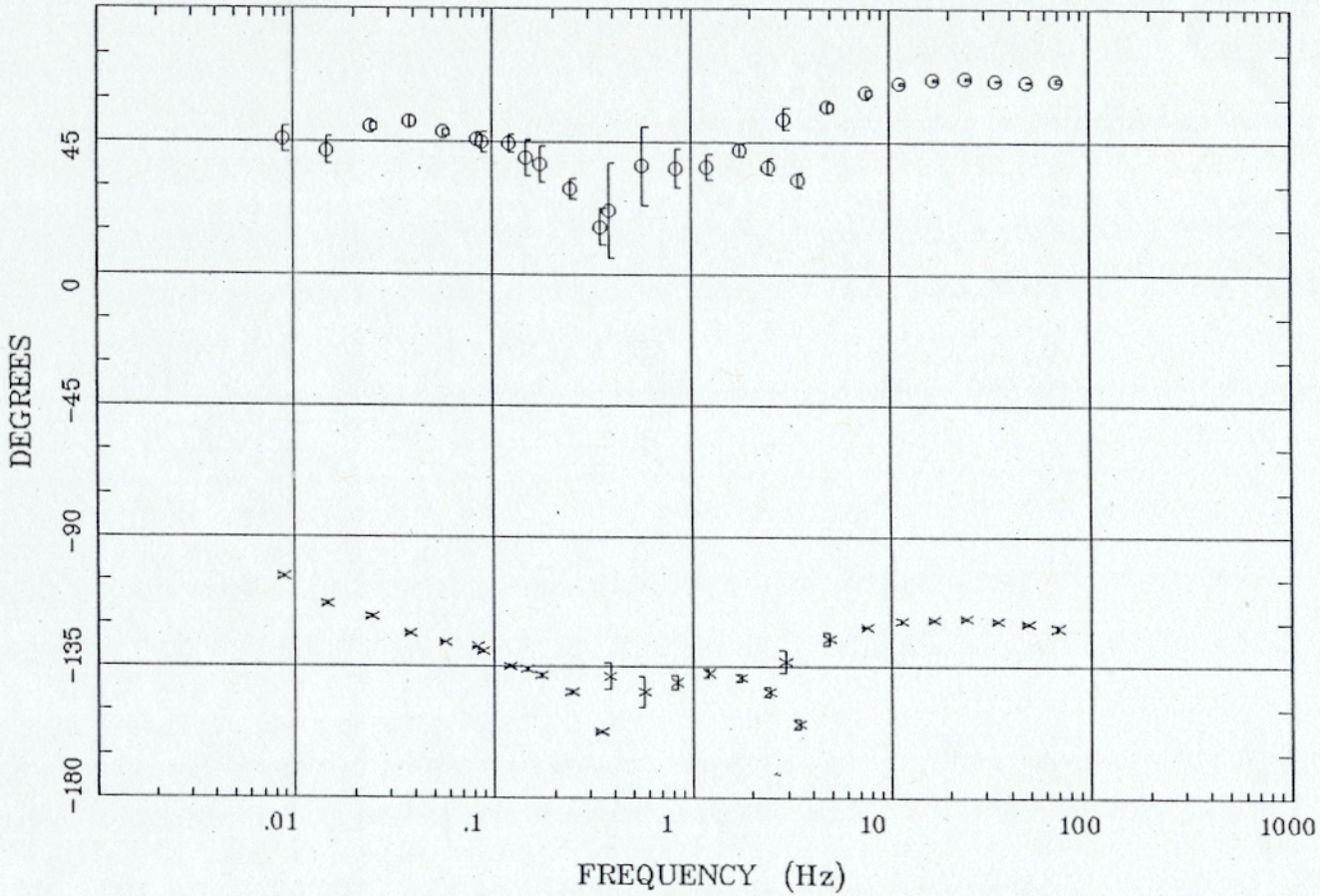
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:11 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



Client:
Remote: none
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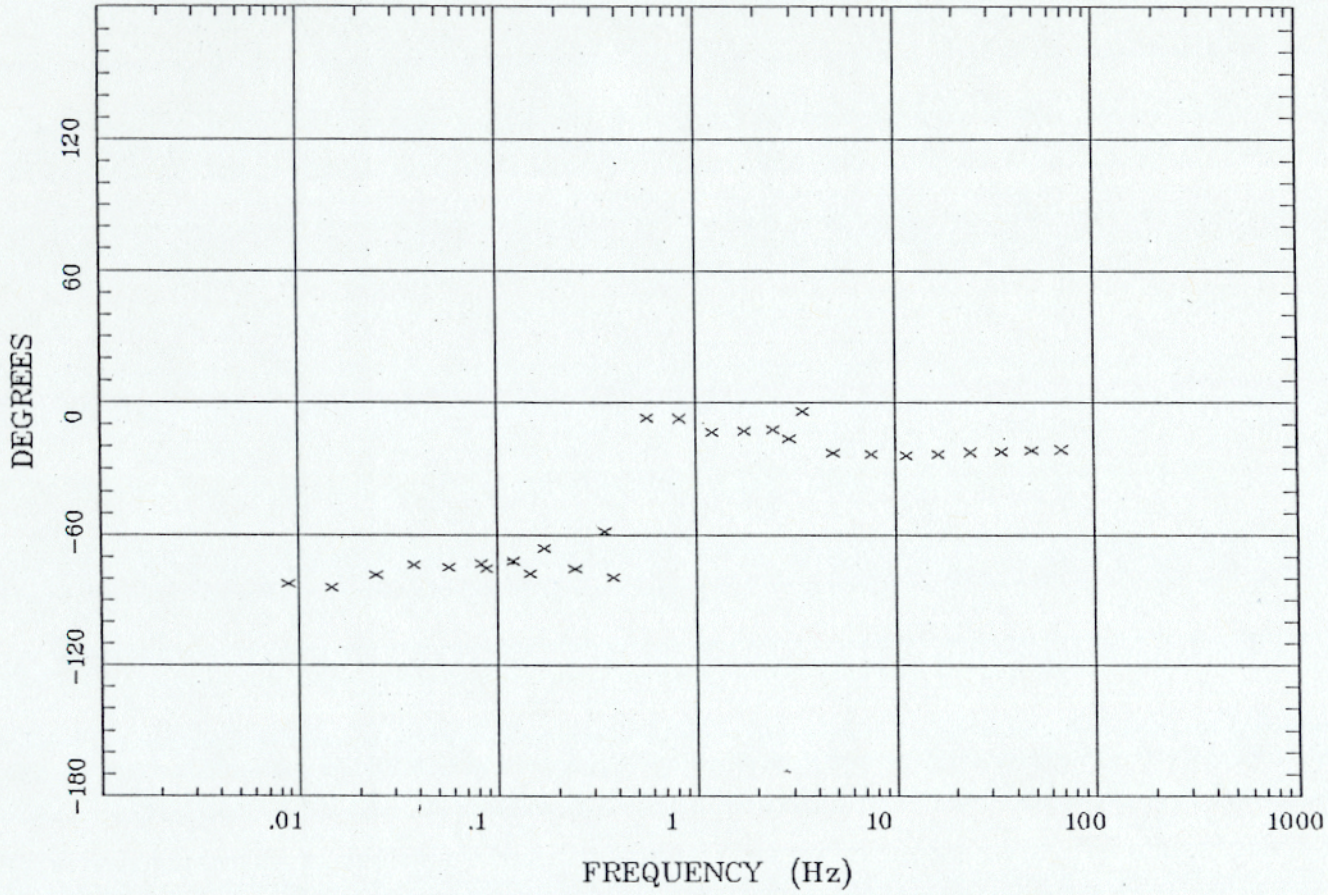
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:11 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska

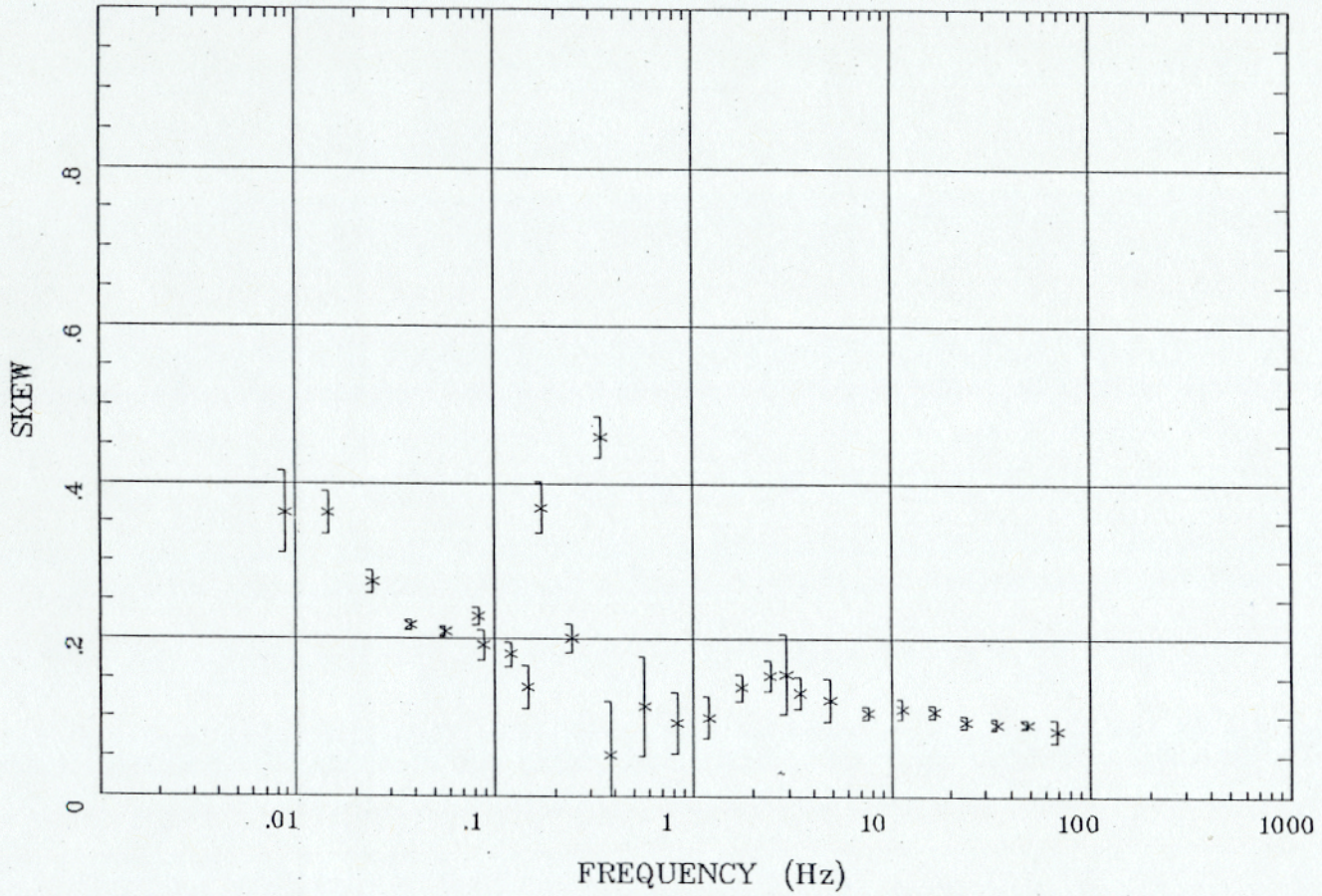


Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:11 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska

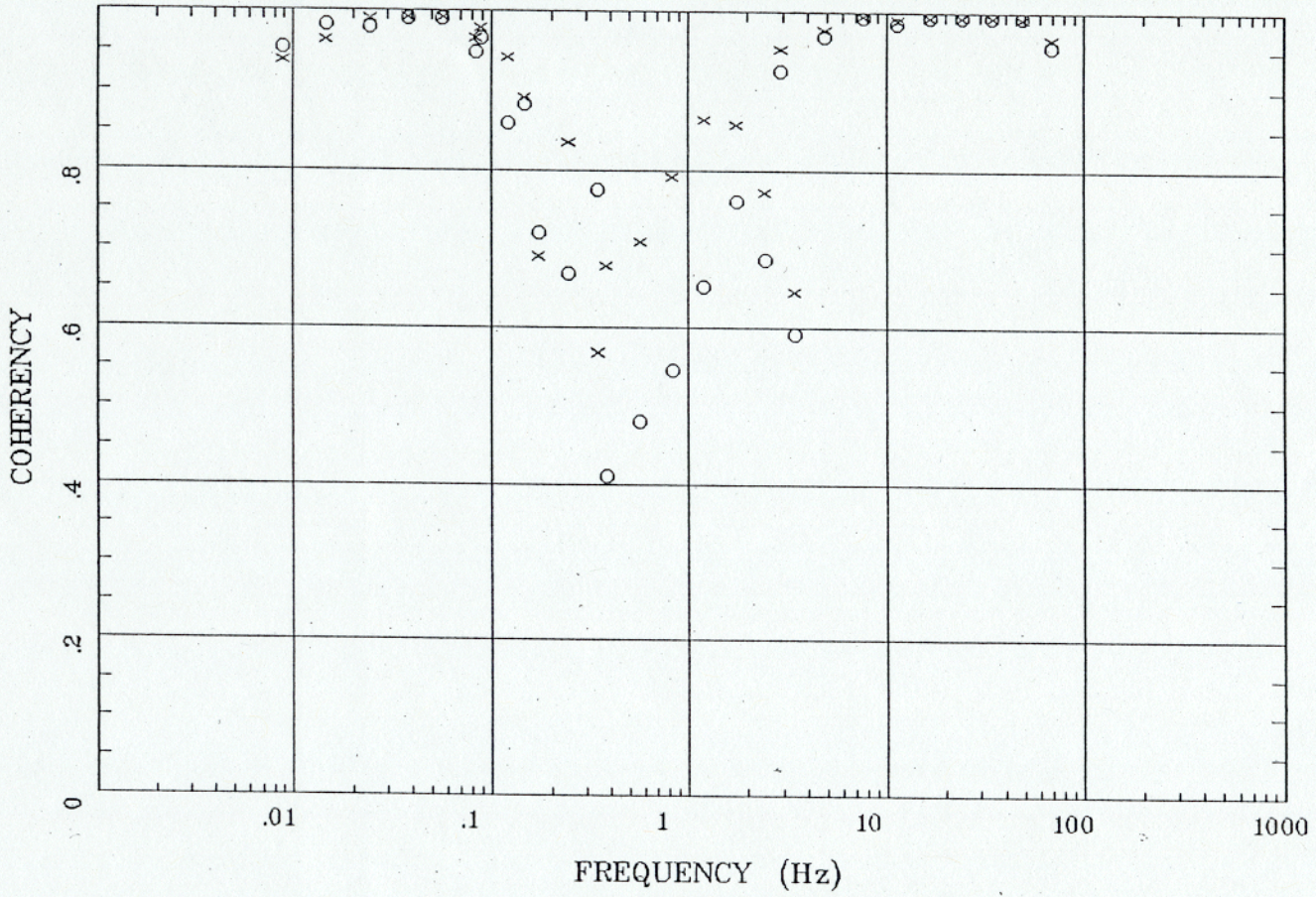


Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh.

Tangle Lakes, Alaska



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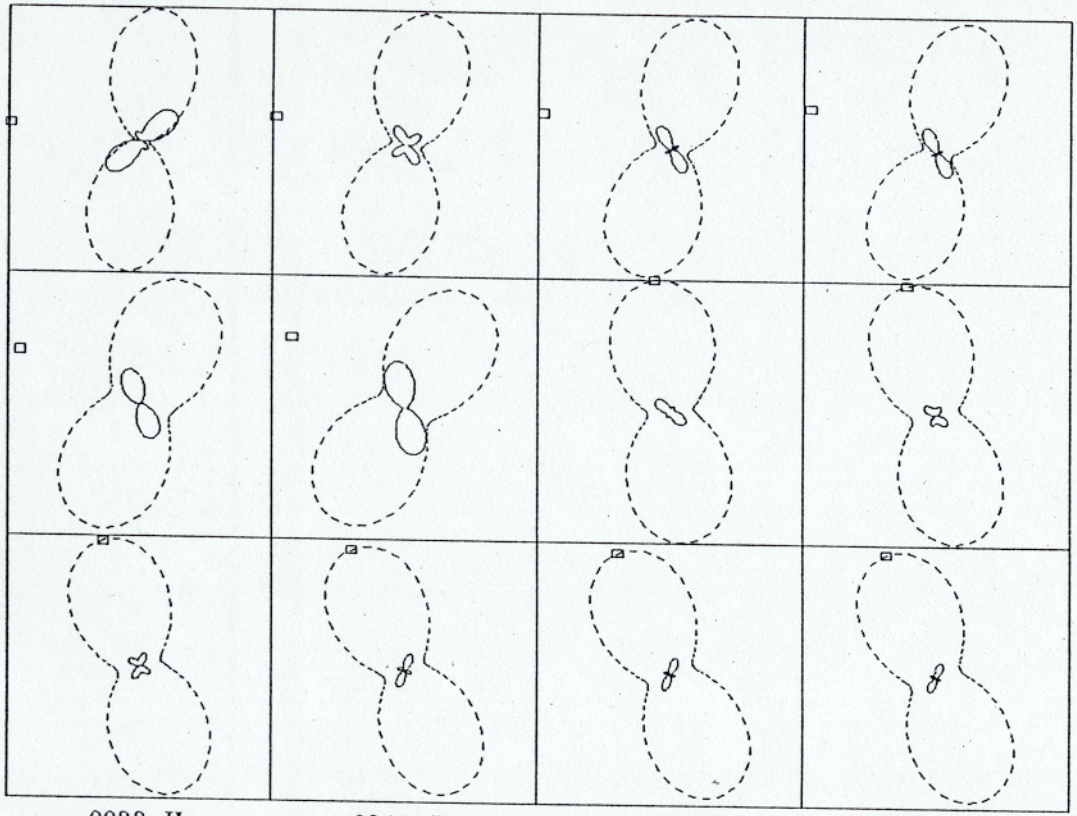
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska



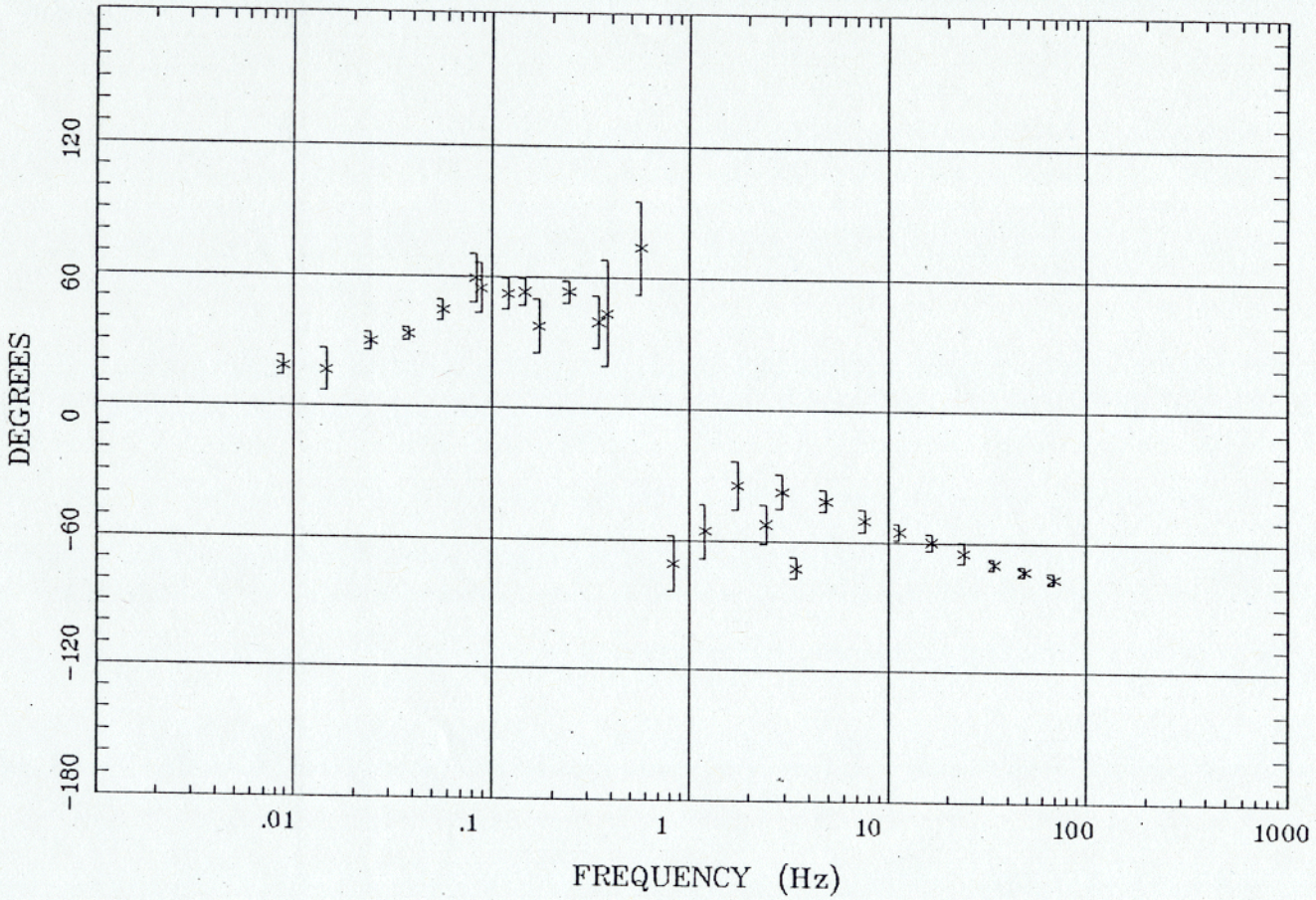
.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska

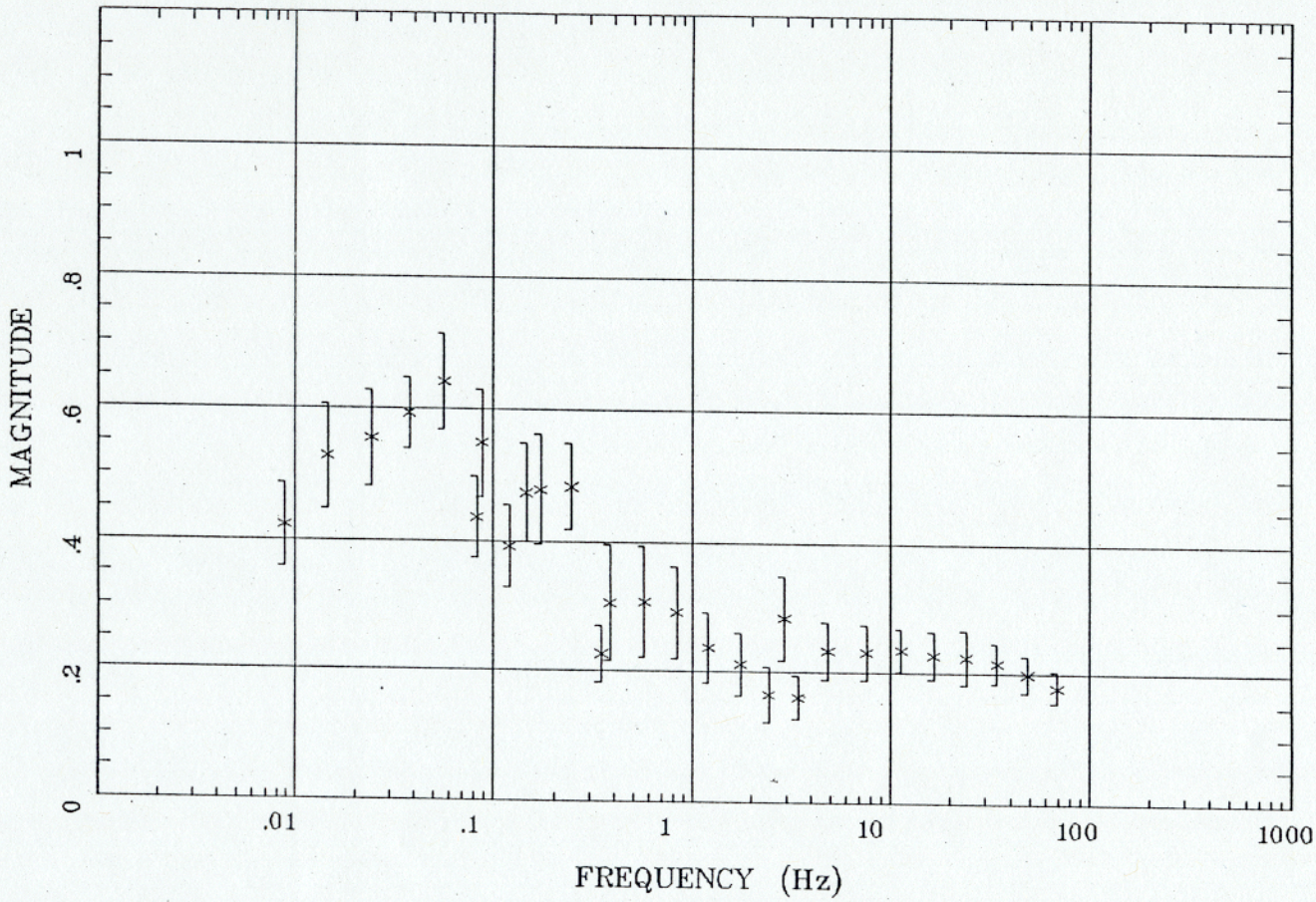


Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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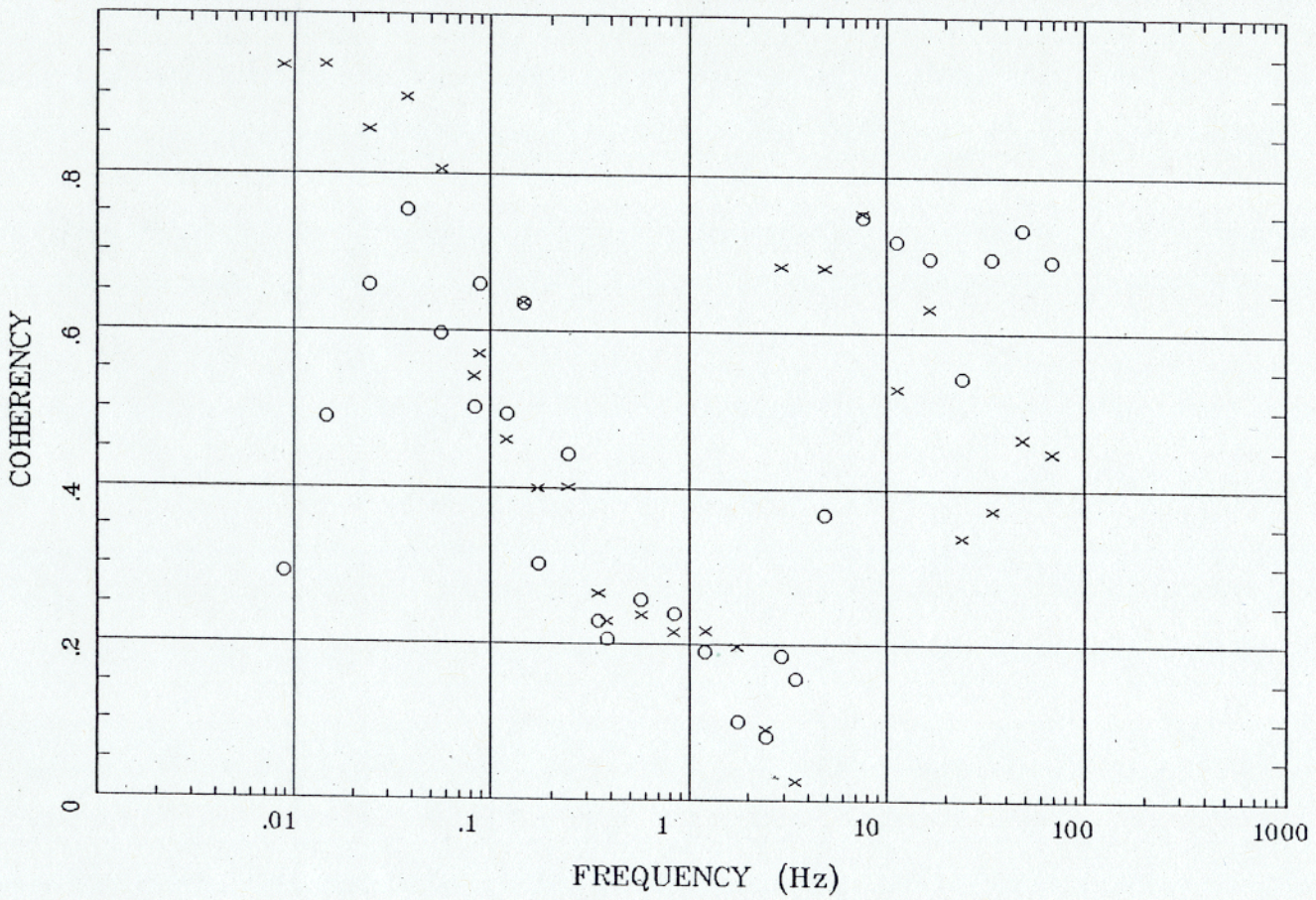
HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 16:4 Aug 20, 2001
Survey Co:USGS

Rotation:
Filename: tlm10all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:12 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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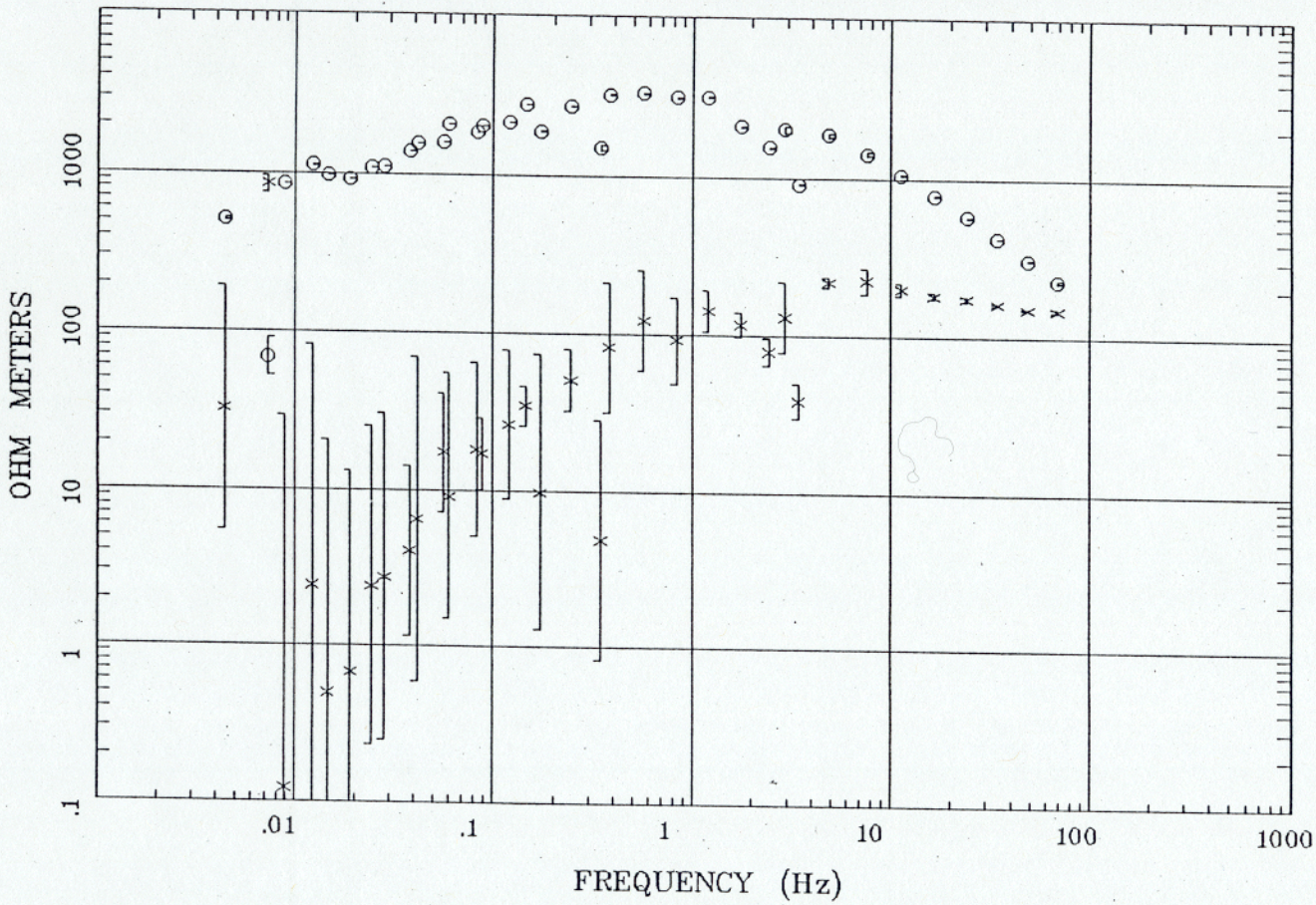
APPARENT RESISTIVITY

Tangle Lakes, Alaska

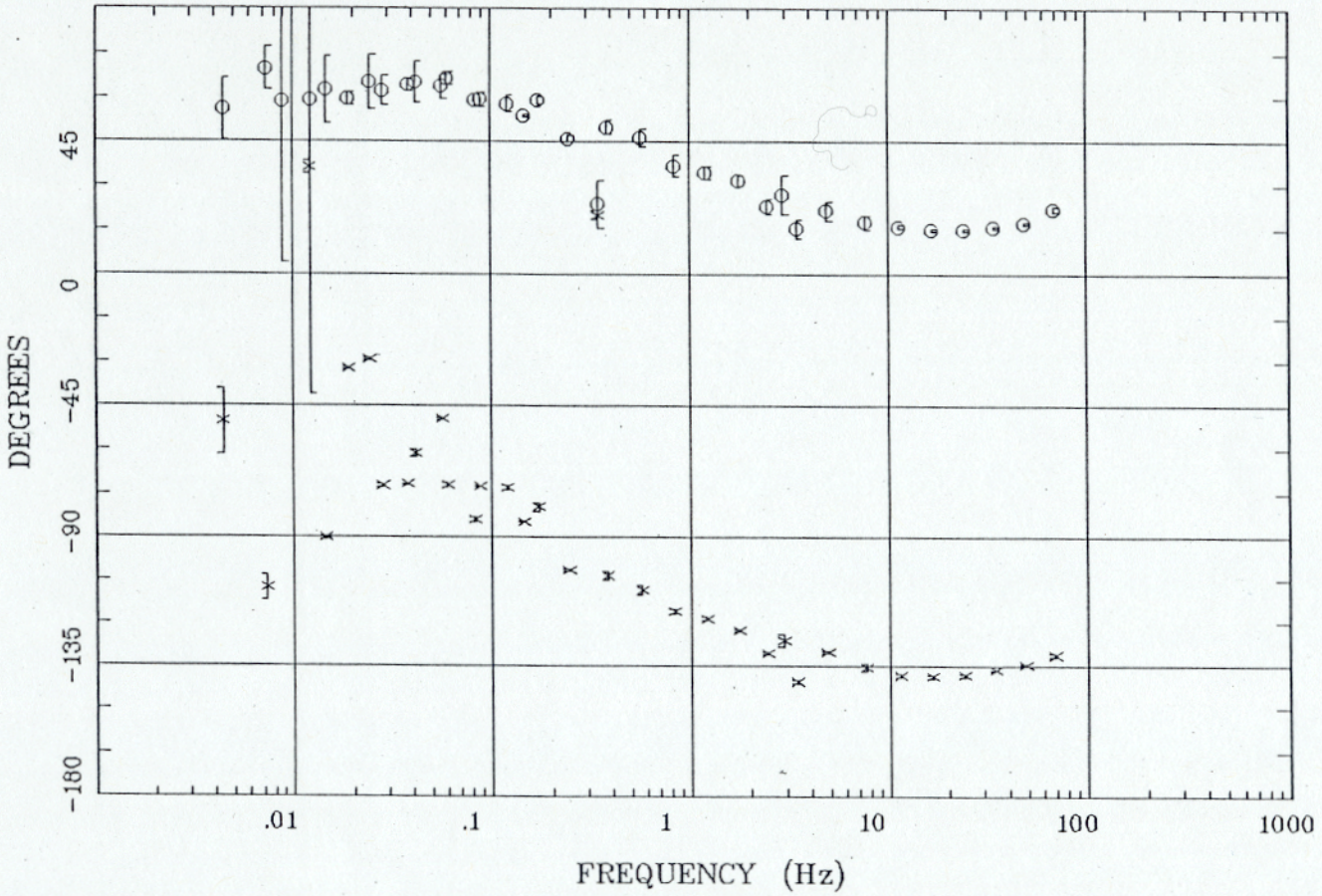


Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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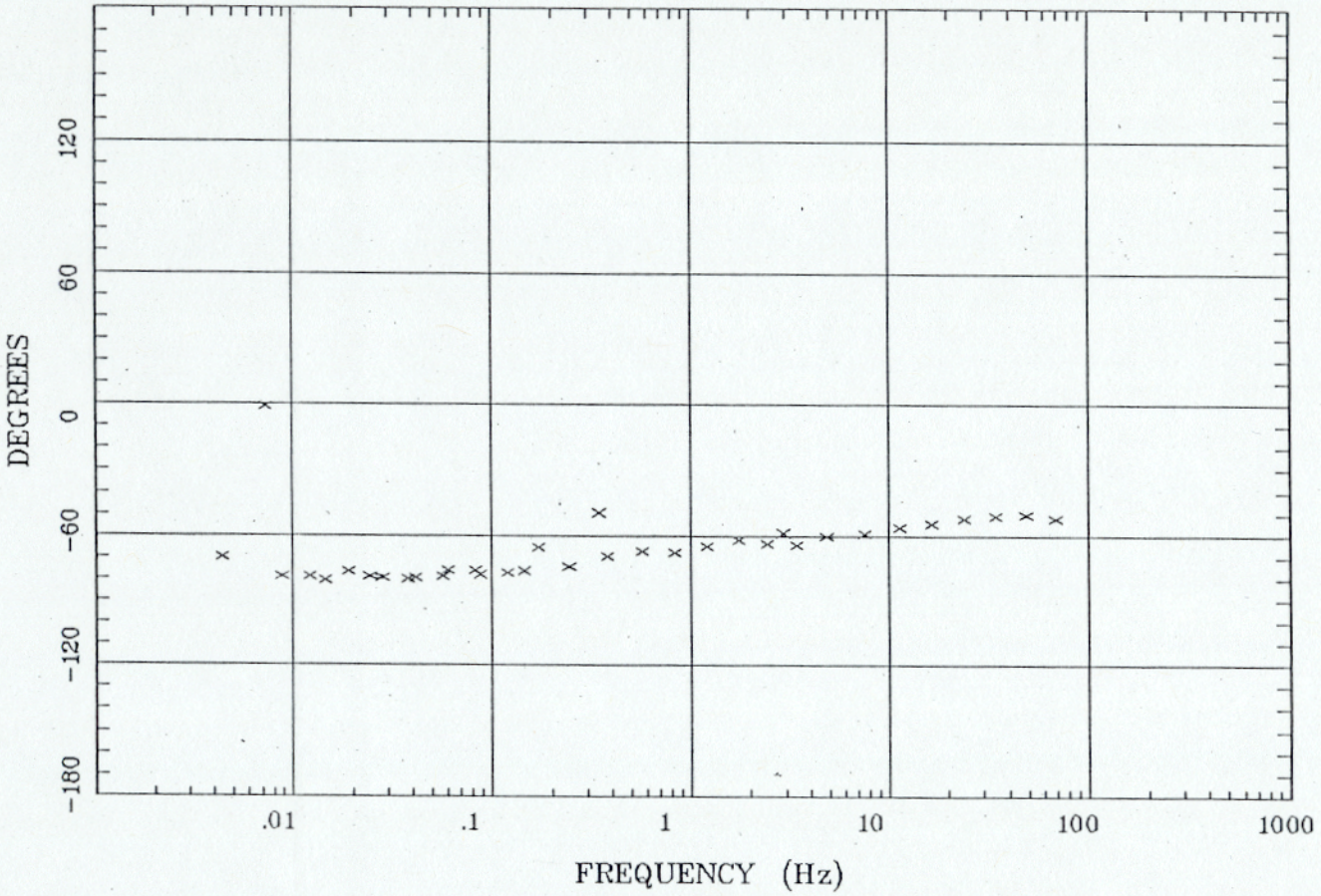
ROTATION ANGLE

Tangle Lakes, Alaska

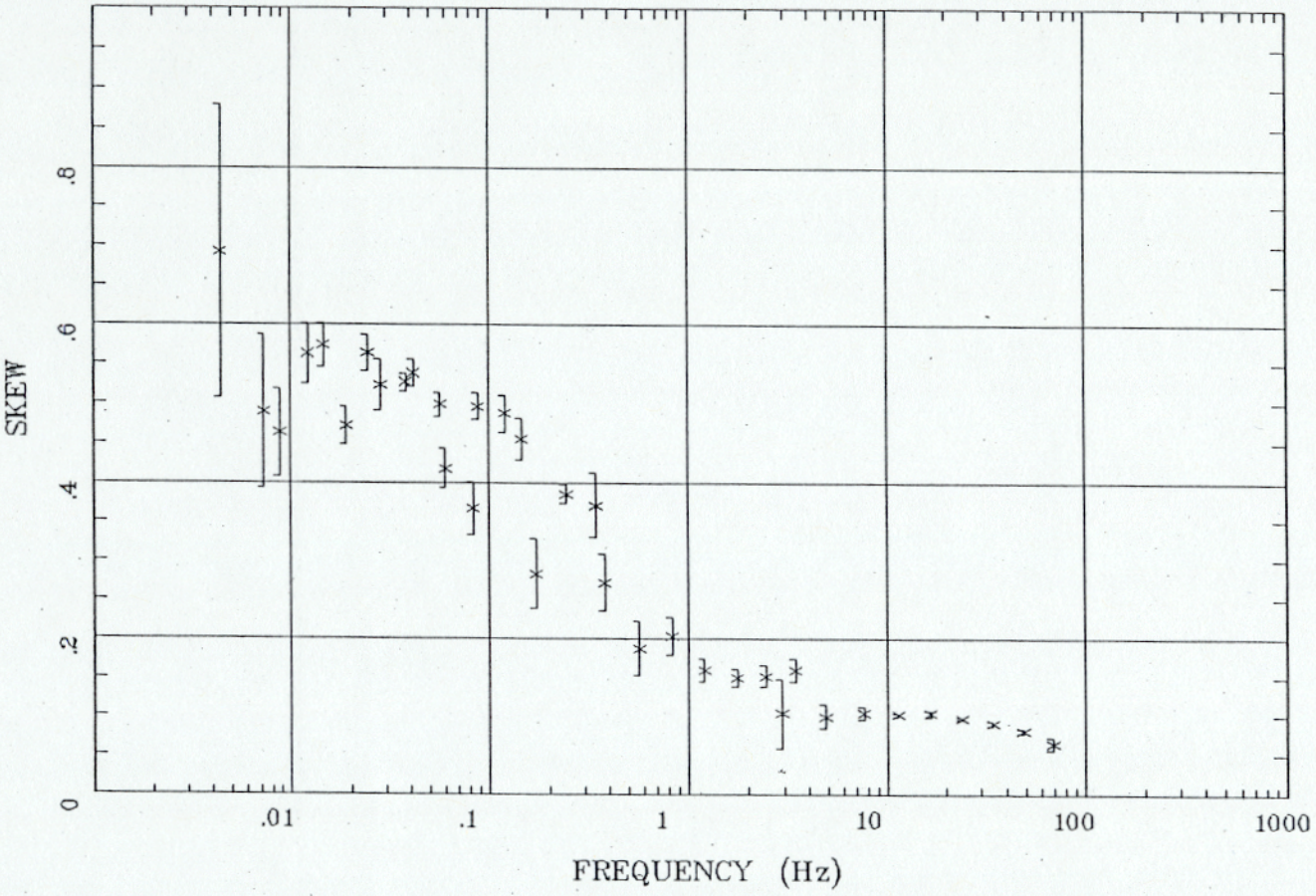


Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE SKEW

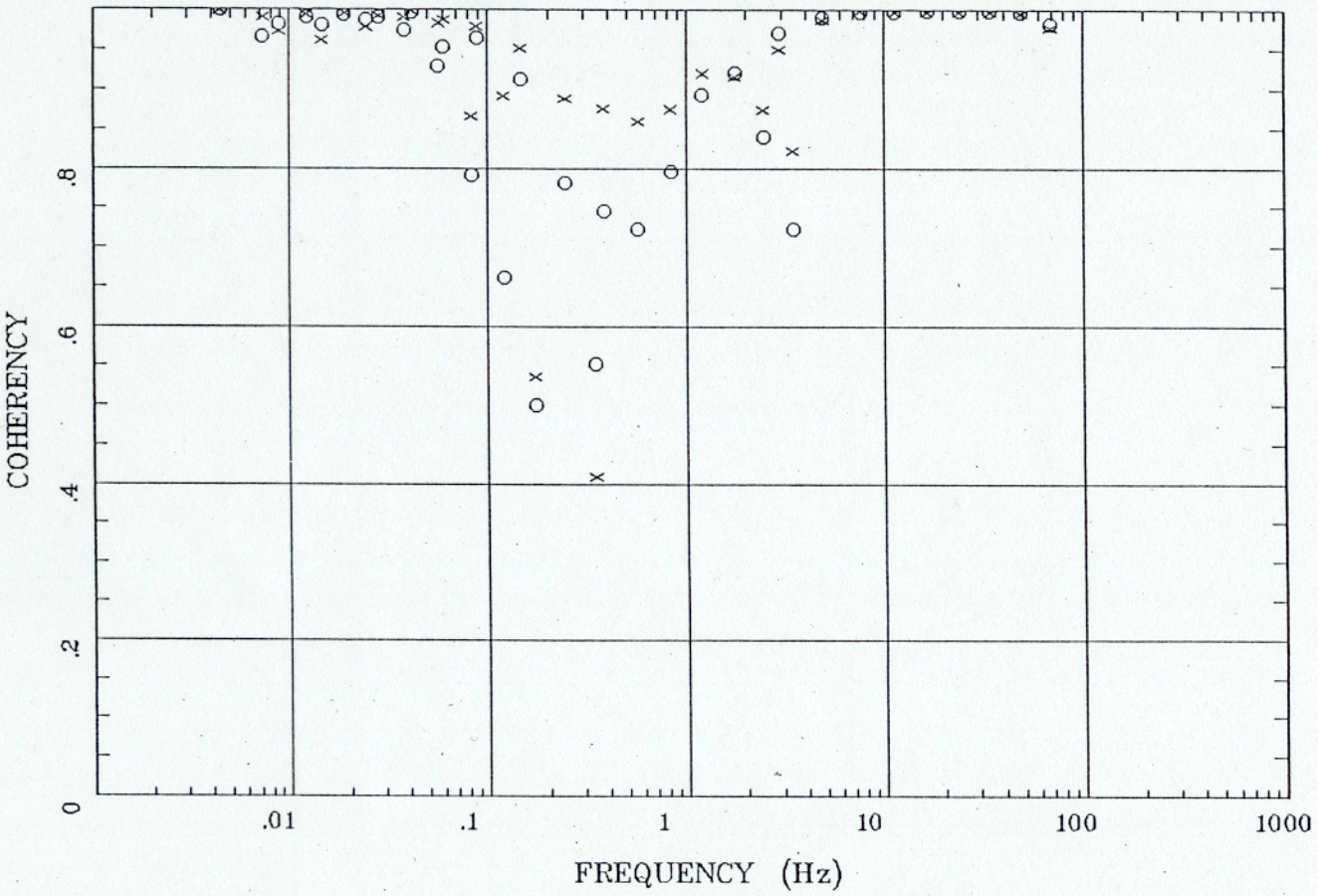
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska

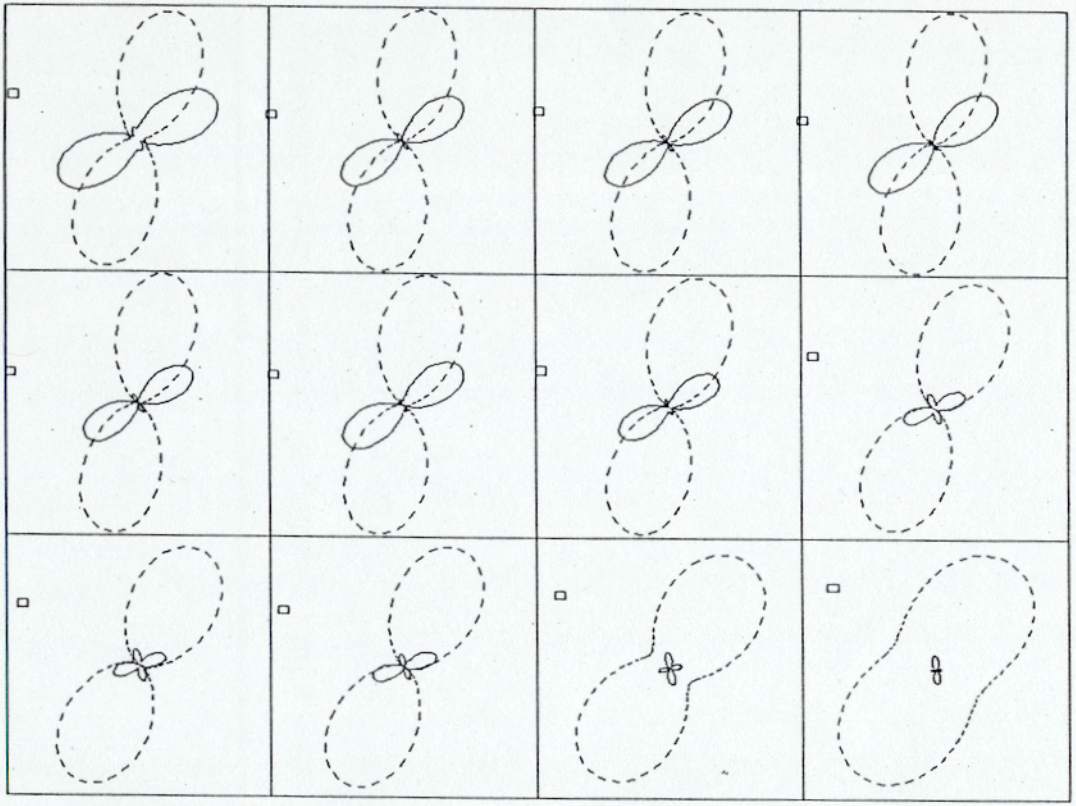


Client:.
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska



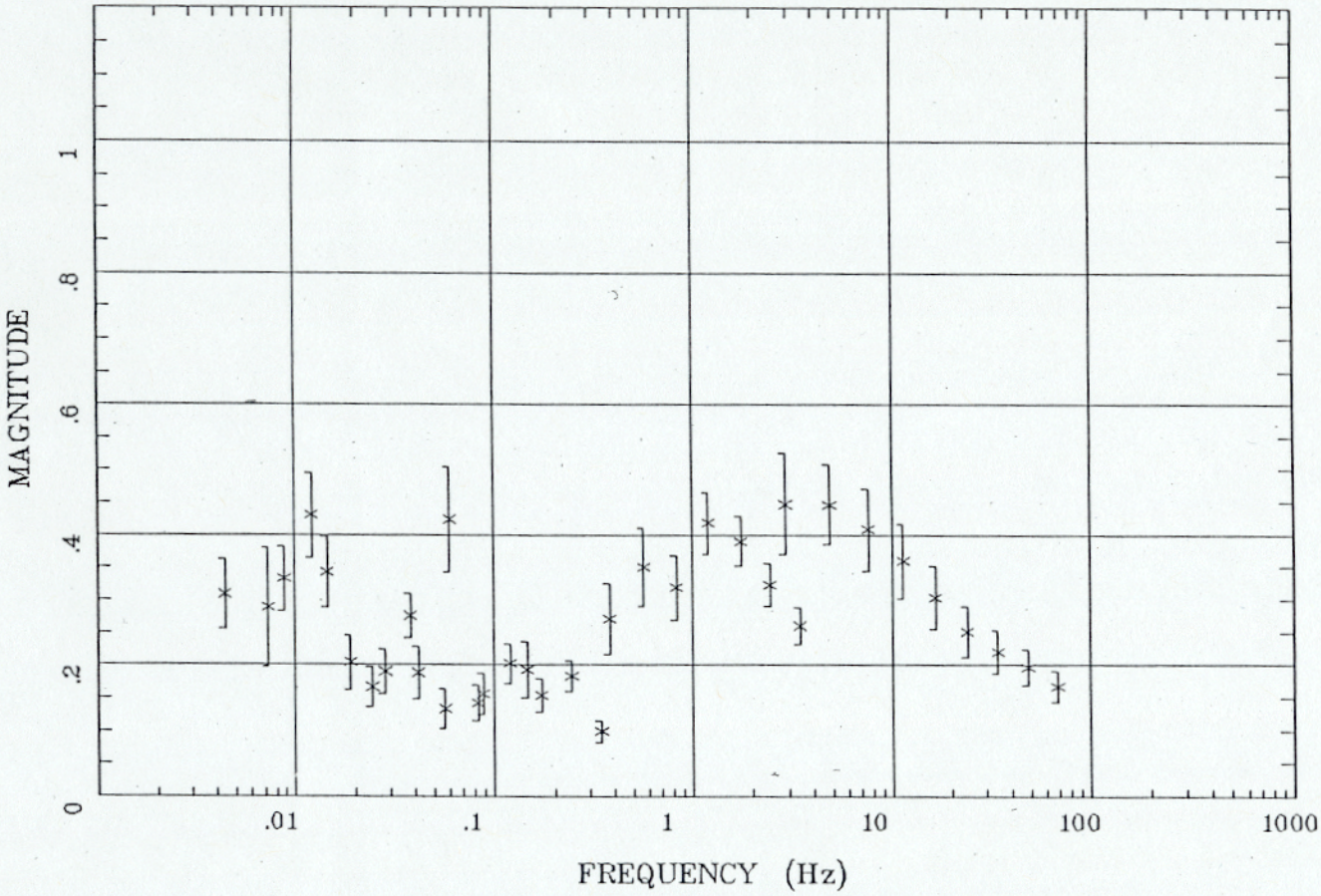
.0044 Hz	.0088 Hz	.0190 Hz	.0381 Hz
.0601 Hz	.120 Hz	.244 Hz	.566 Hz
1.758 Hz	3.447 Hz	11.328 Hz	34.375 Hz

Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE

Tangle Lakes, Alaska

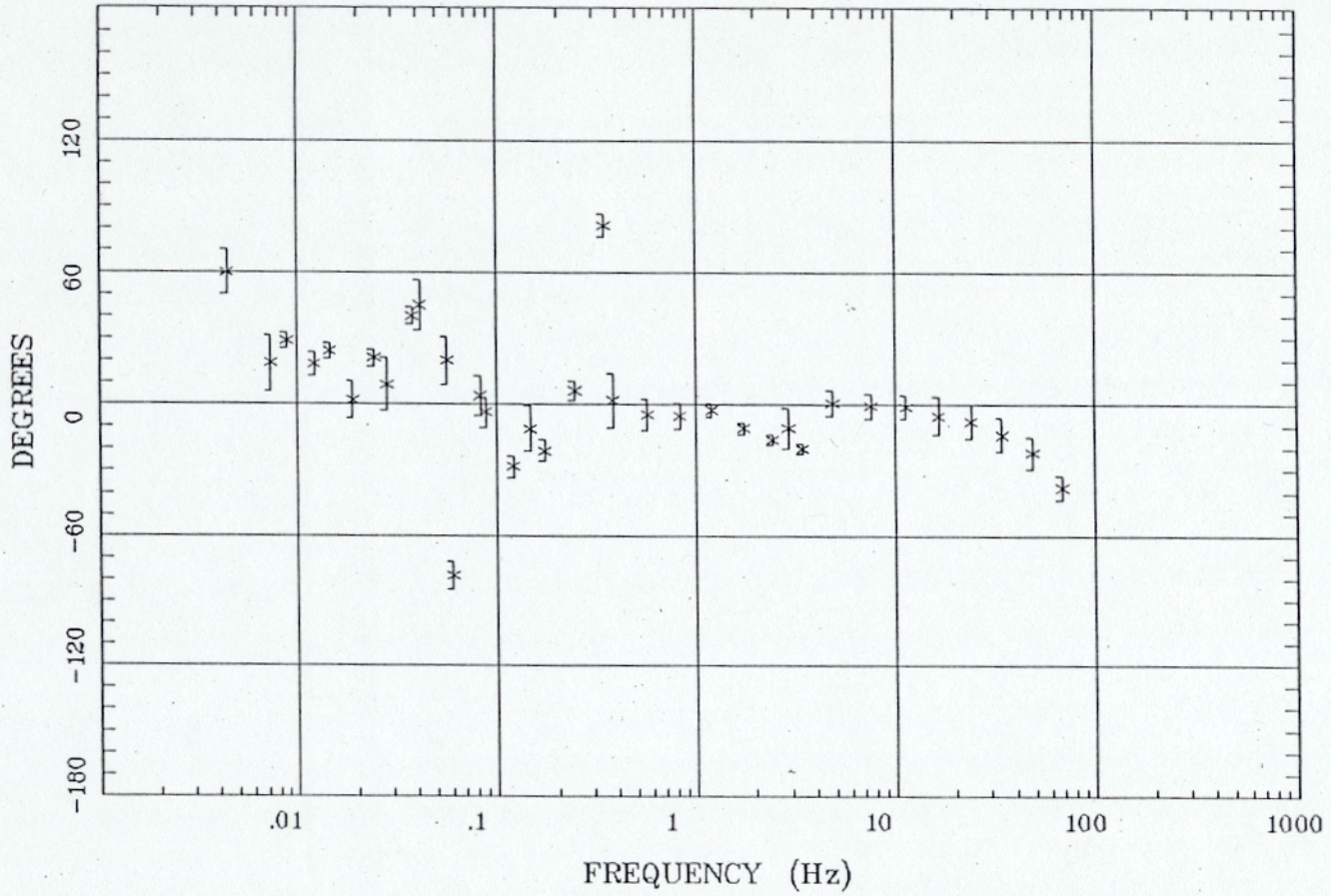


Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska

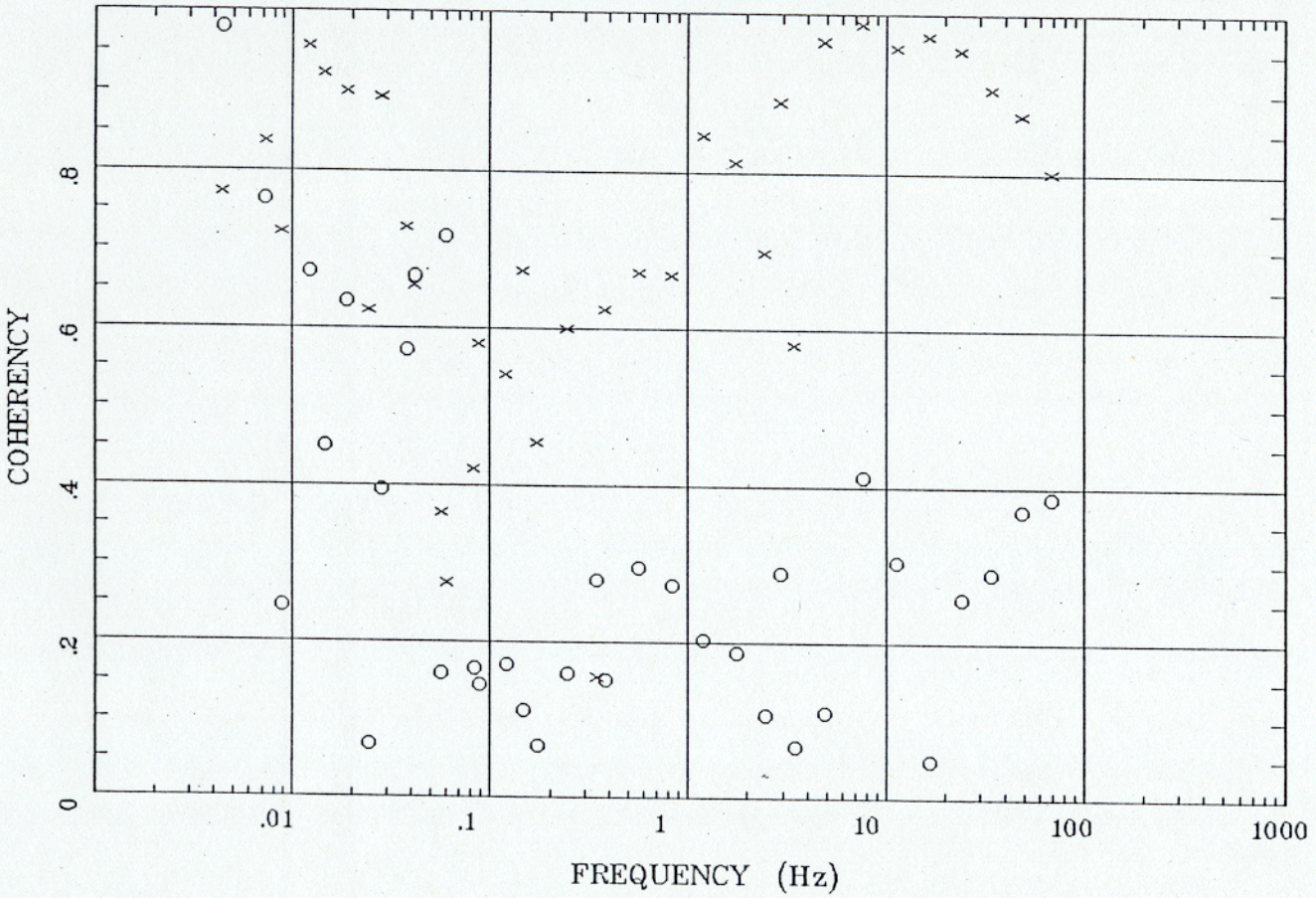


Client:
Remote: none
Acquired: 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: , 13:1 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm11all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:13 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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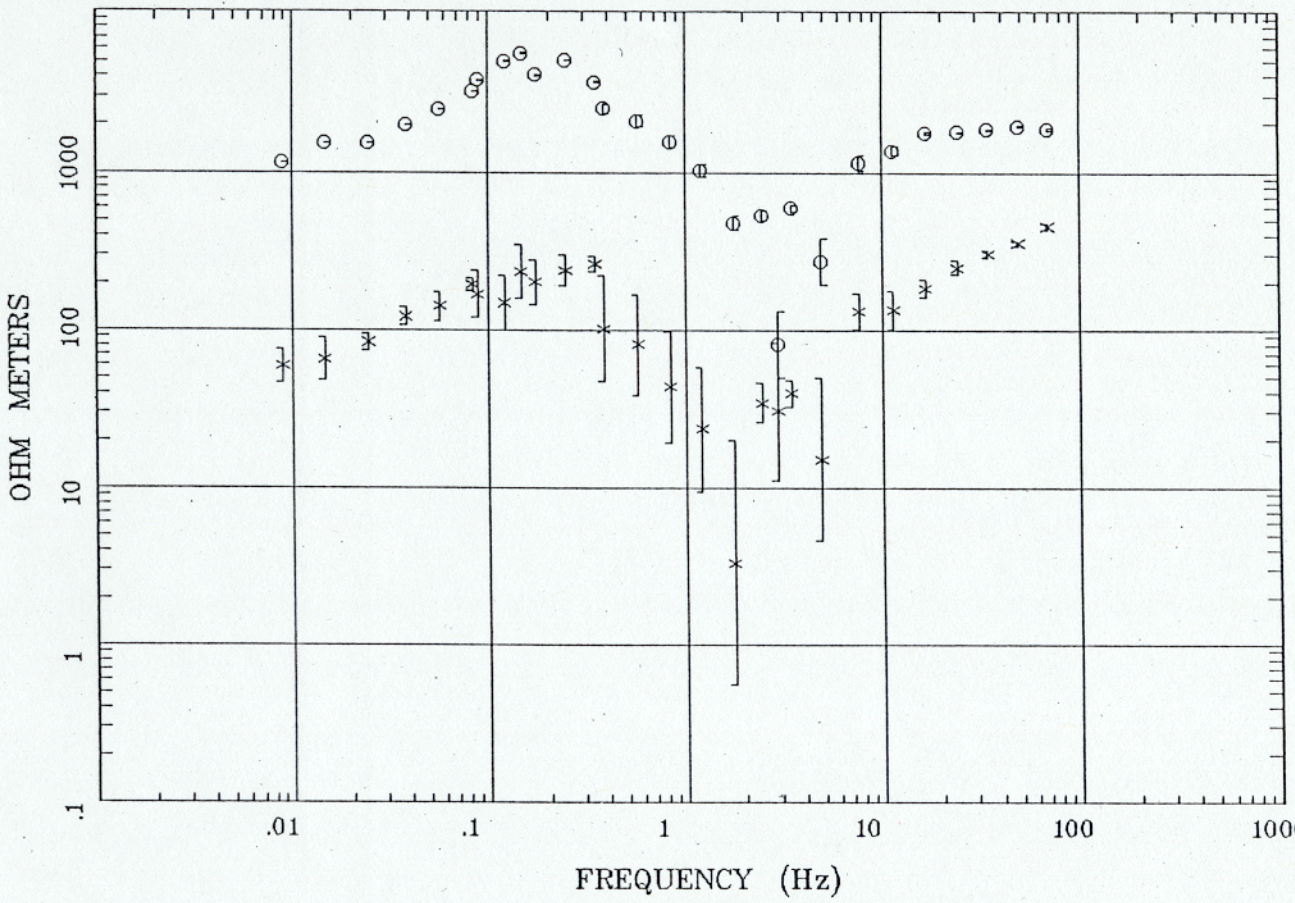
APPARENT RESISTIVITY Tangle Lakes, Alaska

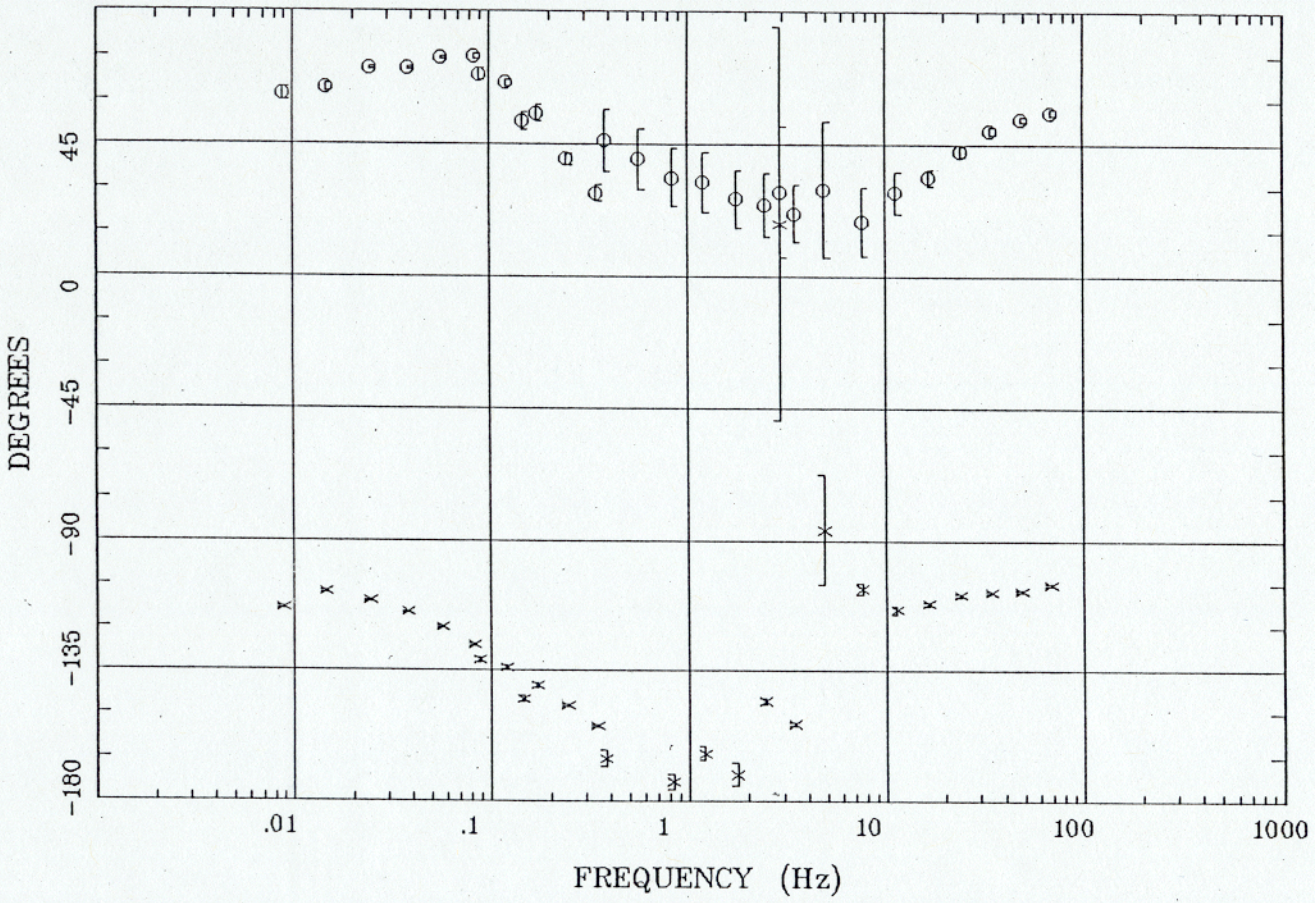


Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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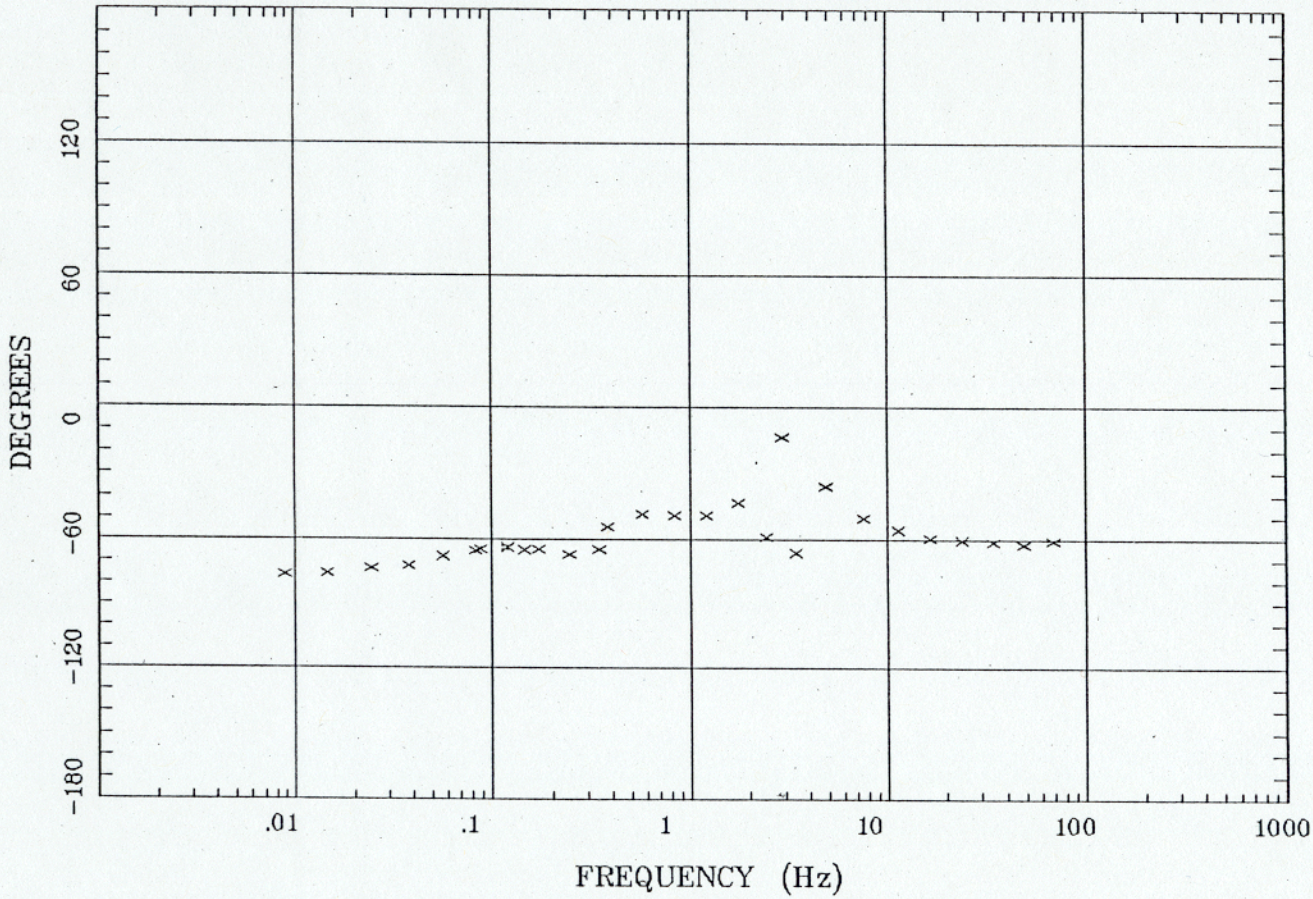
ROTATION ANGLE

Tangle Lakes, Alaska

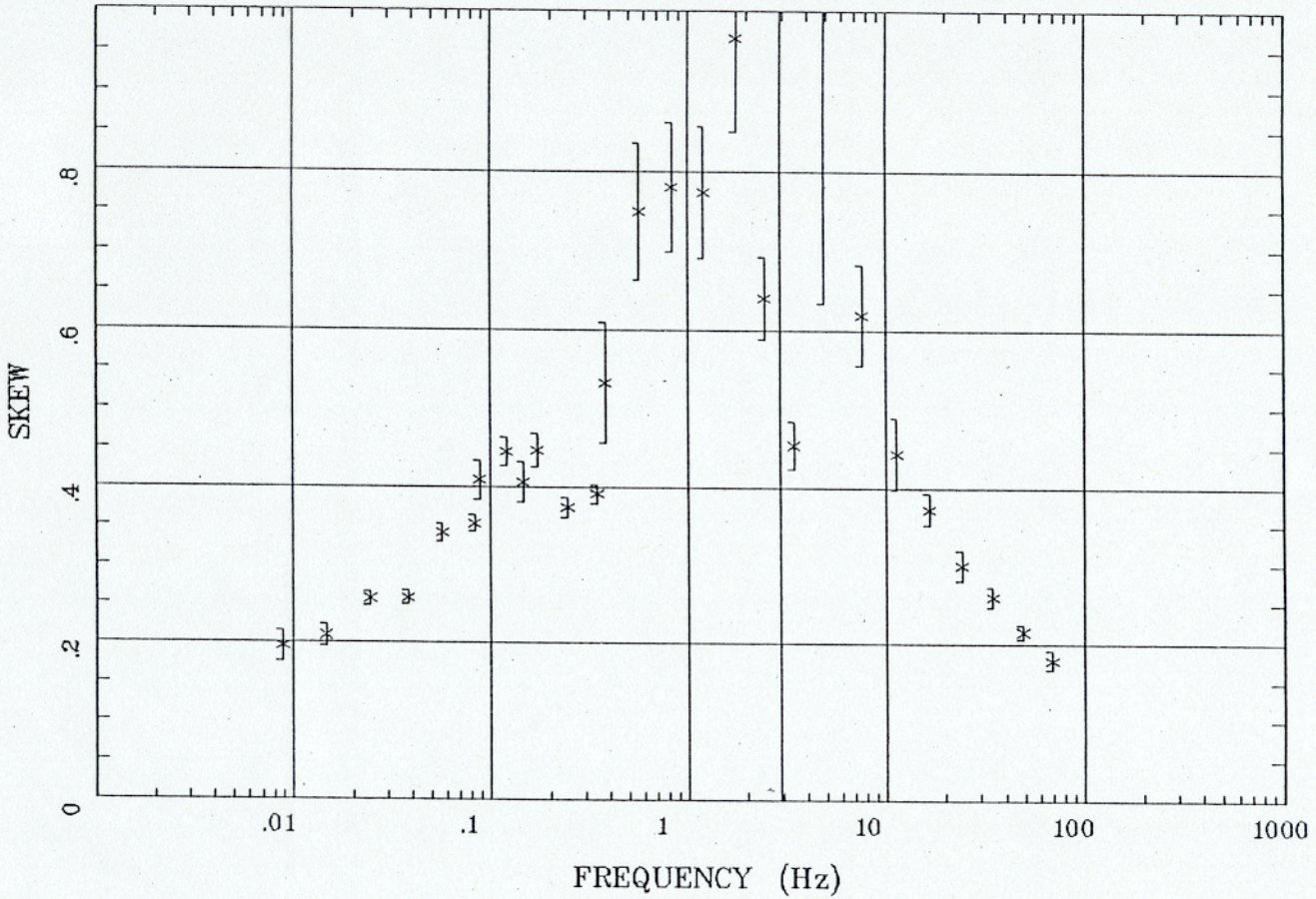


Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE SKEW

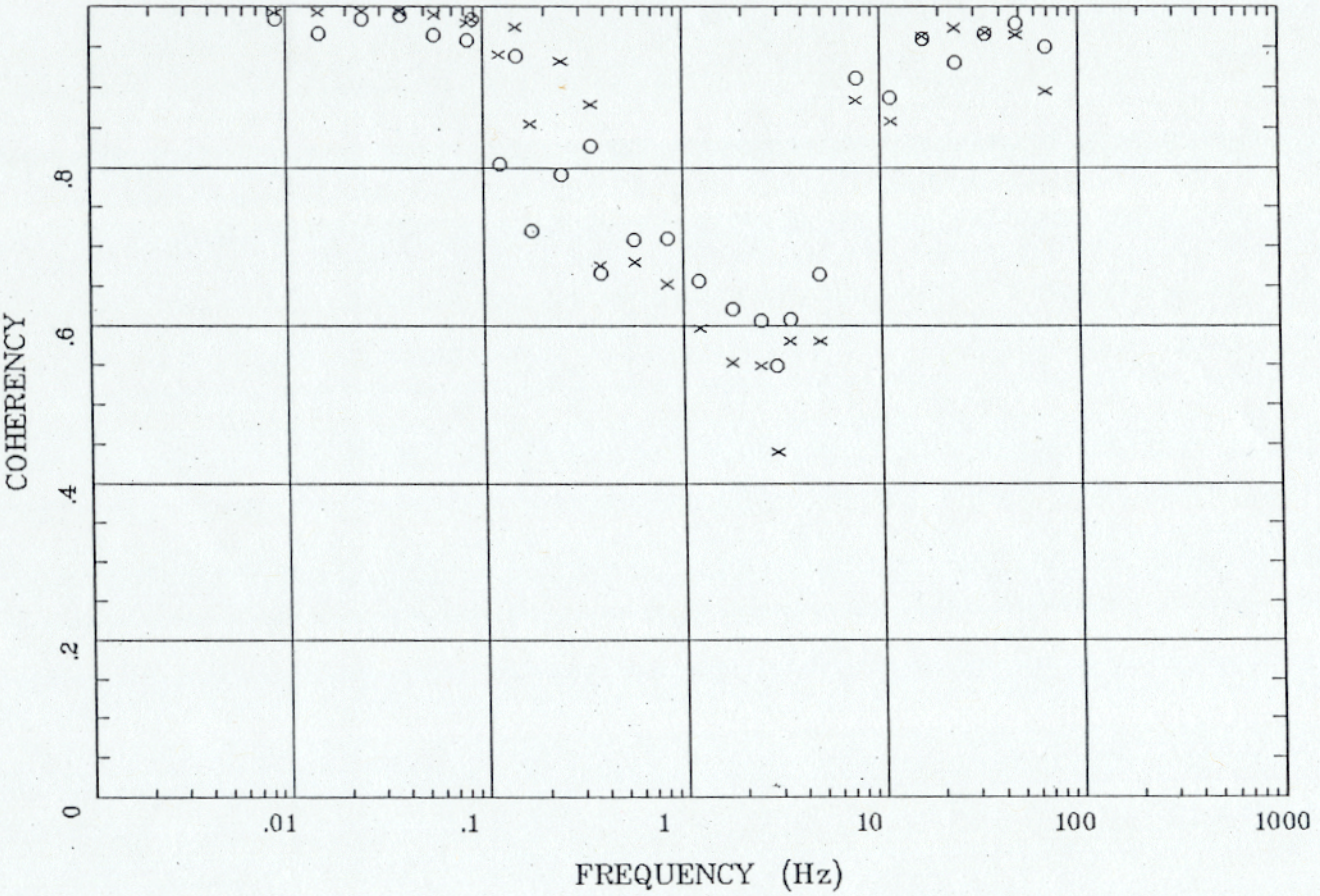
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

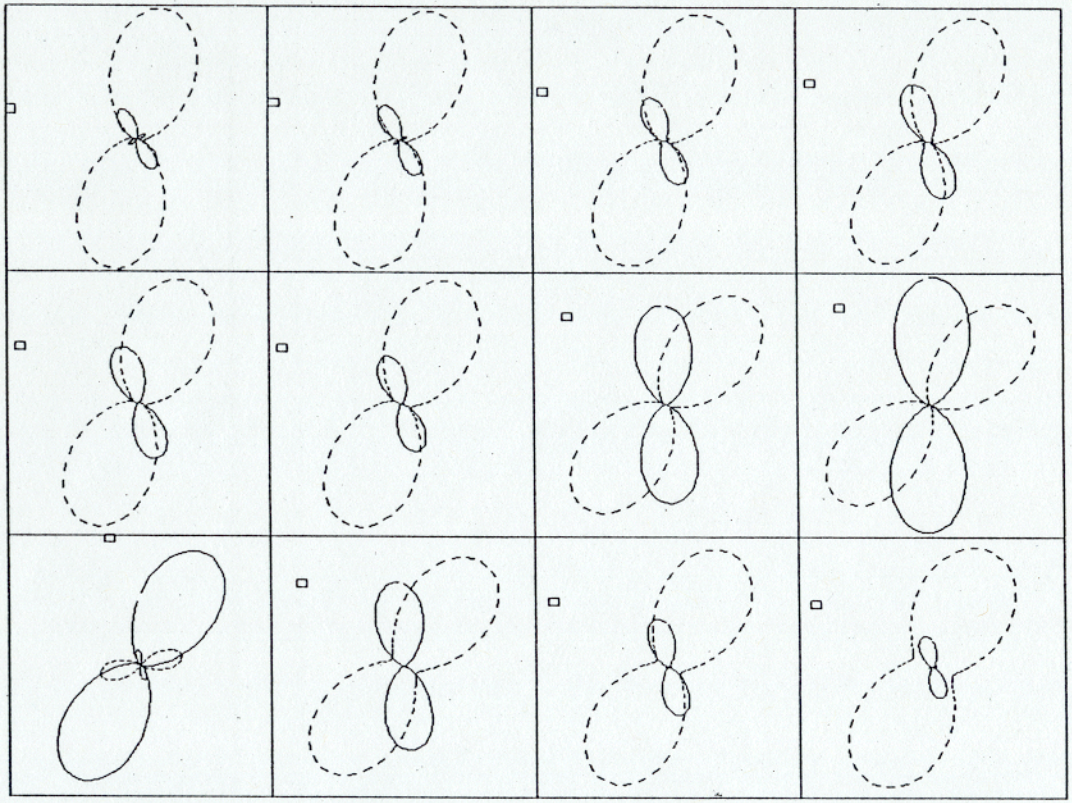
E MULT Coh. Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS Tangle Lakes, Alaska



.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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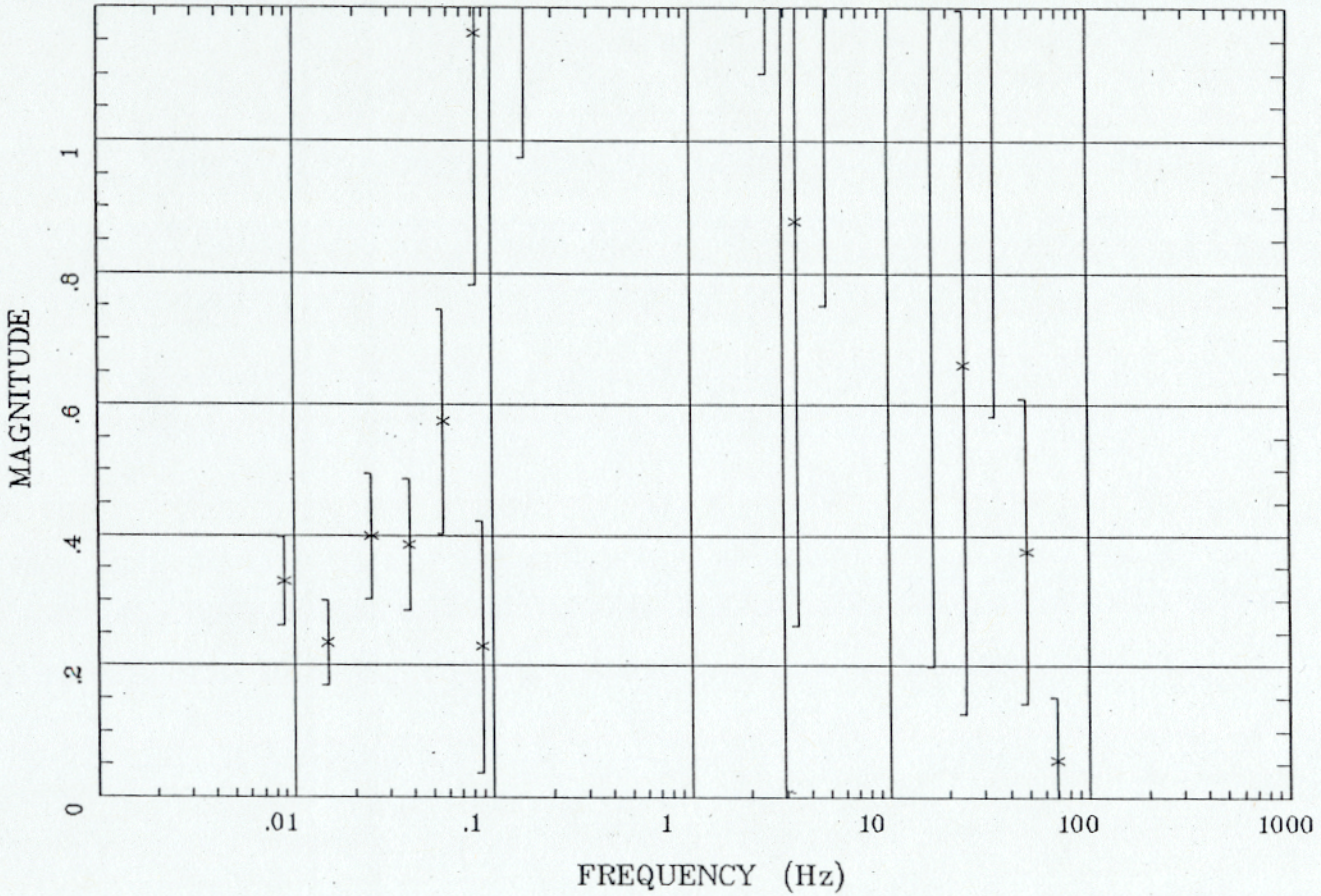
TIPPER MAGNITUDE

Tangle Lakes, Alaska

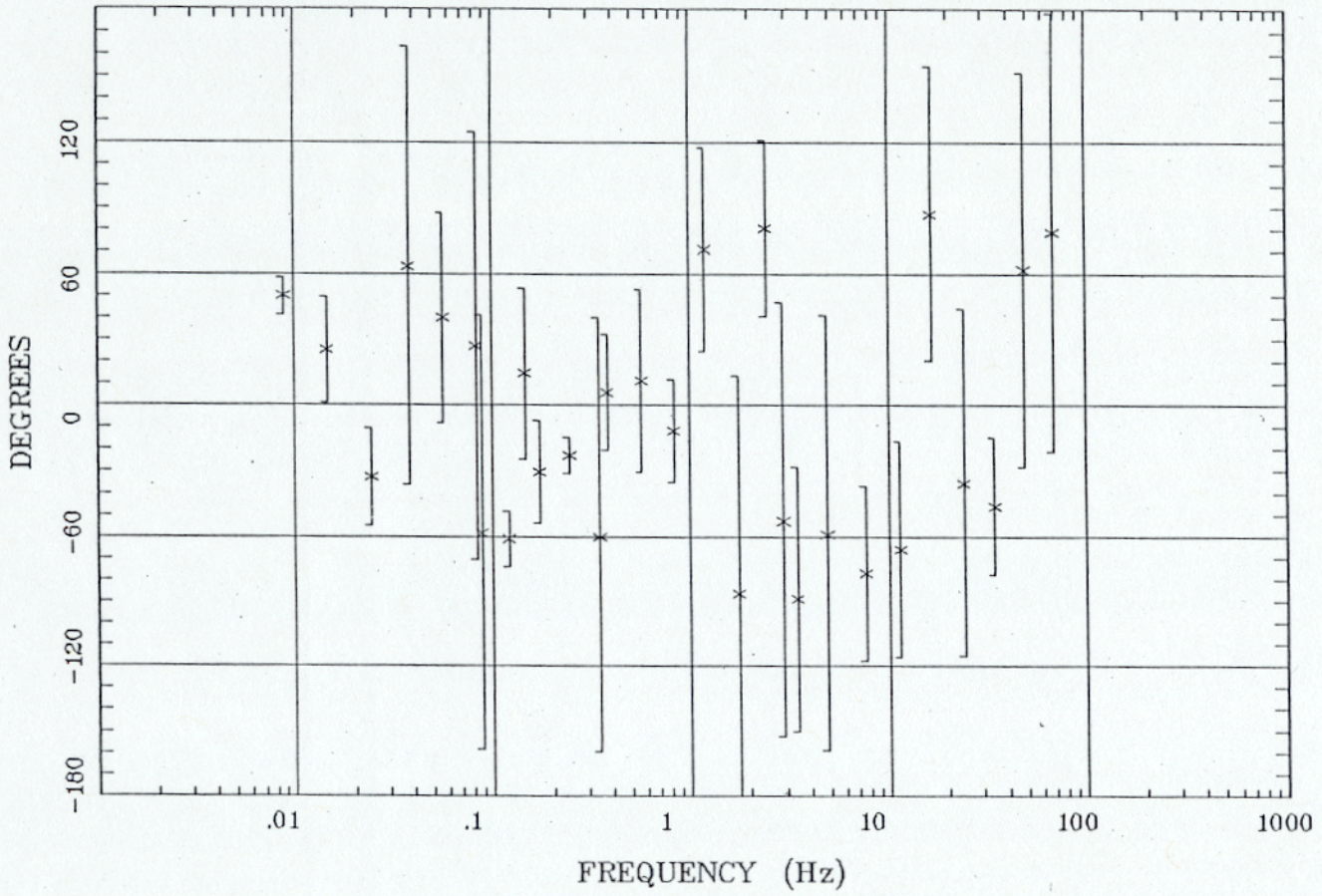


Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



Client:
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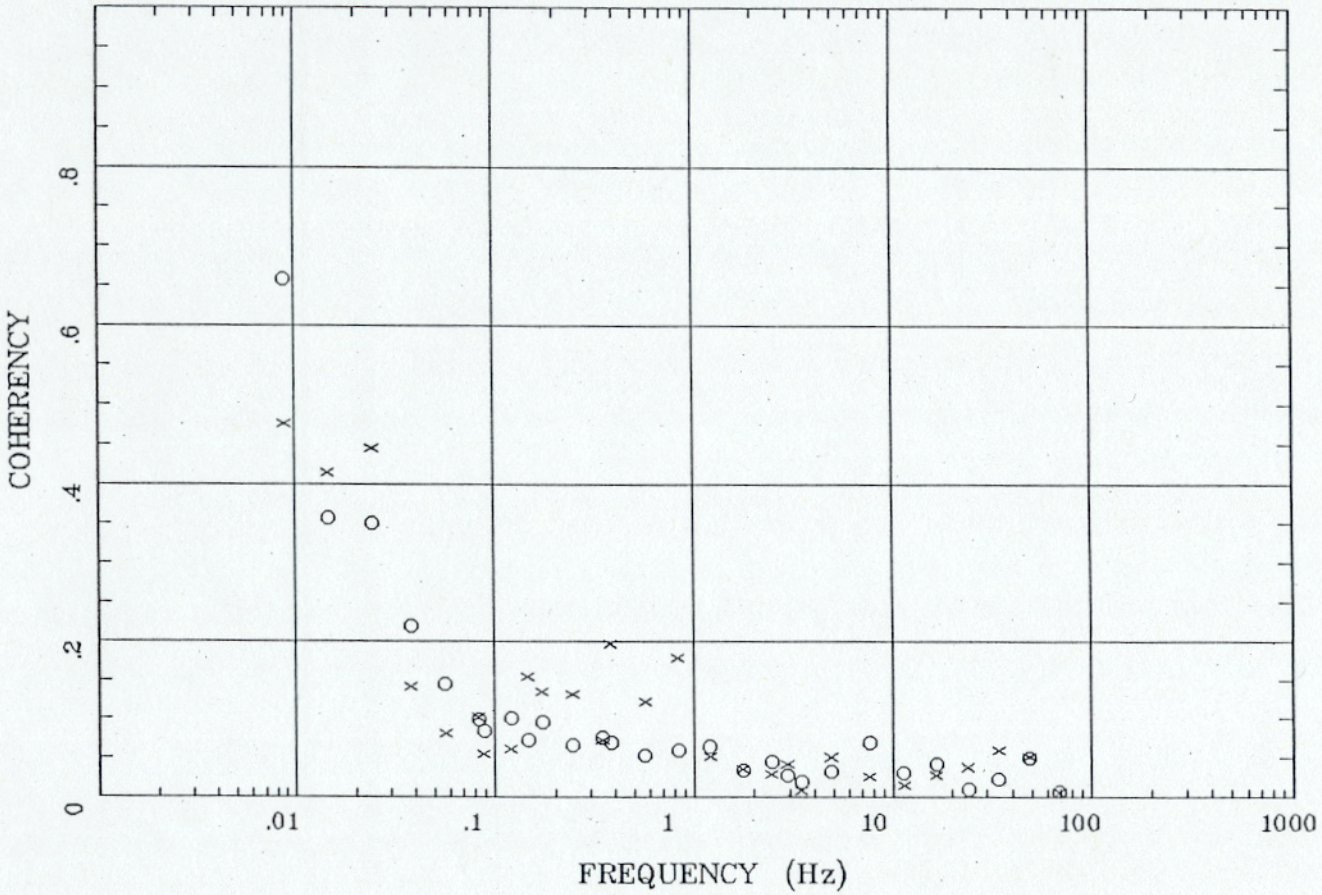
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

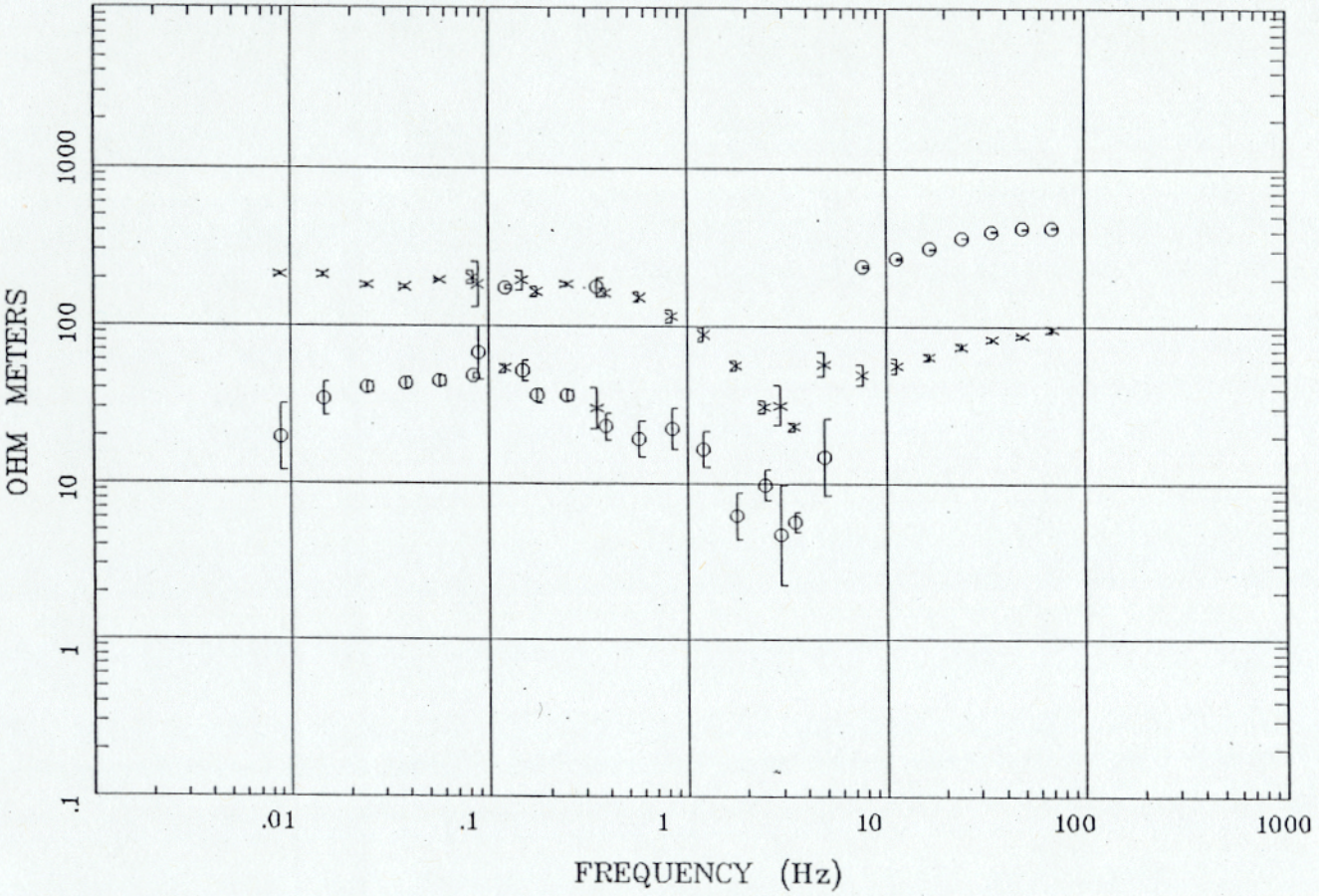
Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 17:4 Aug 21, 2001
Survey Co:USGS

Rotation:
Filename: tlm12all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:17 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

APPARENT RESISTIVITY Tangle Lakes, Alaska

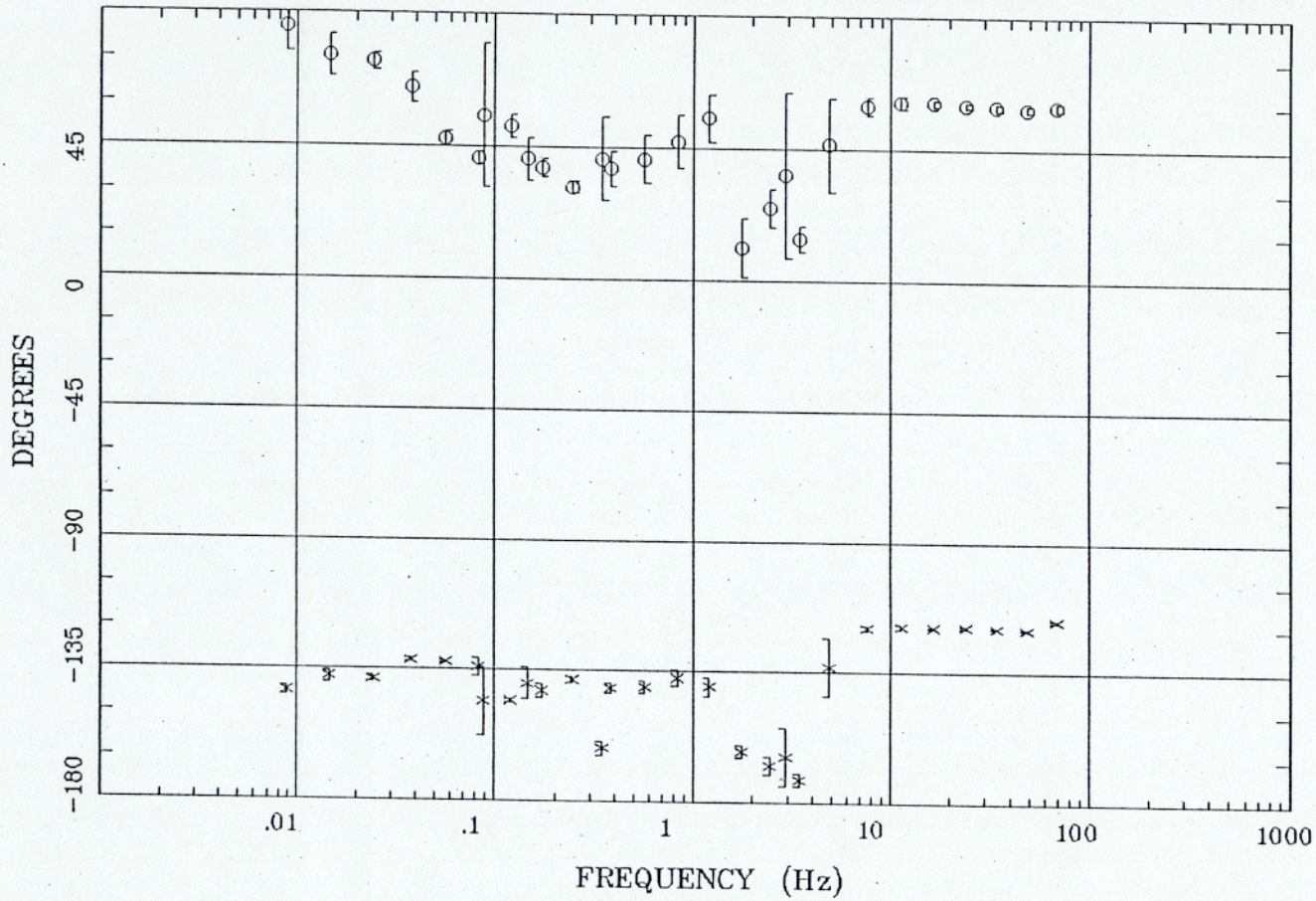


Client:
Remote: none
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:18 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

IMPEDANCE PHASE

Tangle Lakes, Alaska



Client:
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Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:18 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

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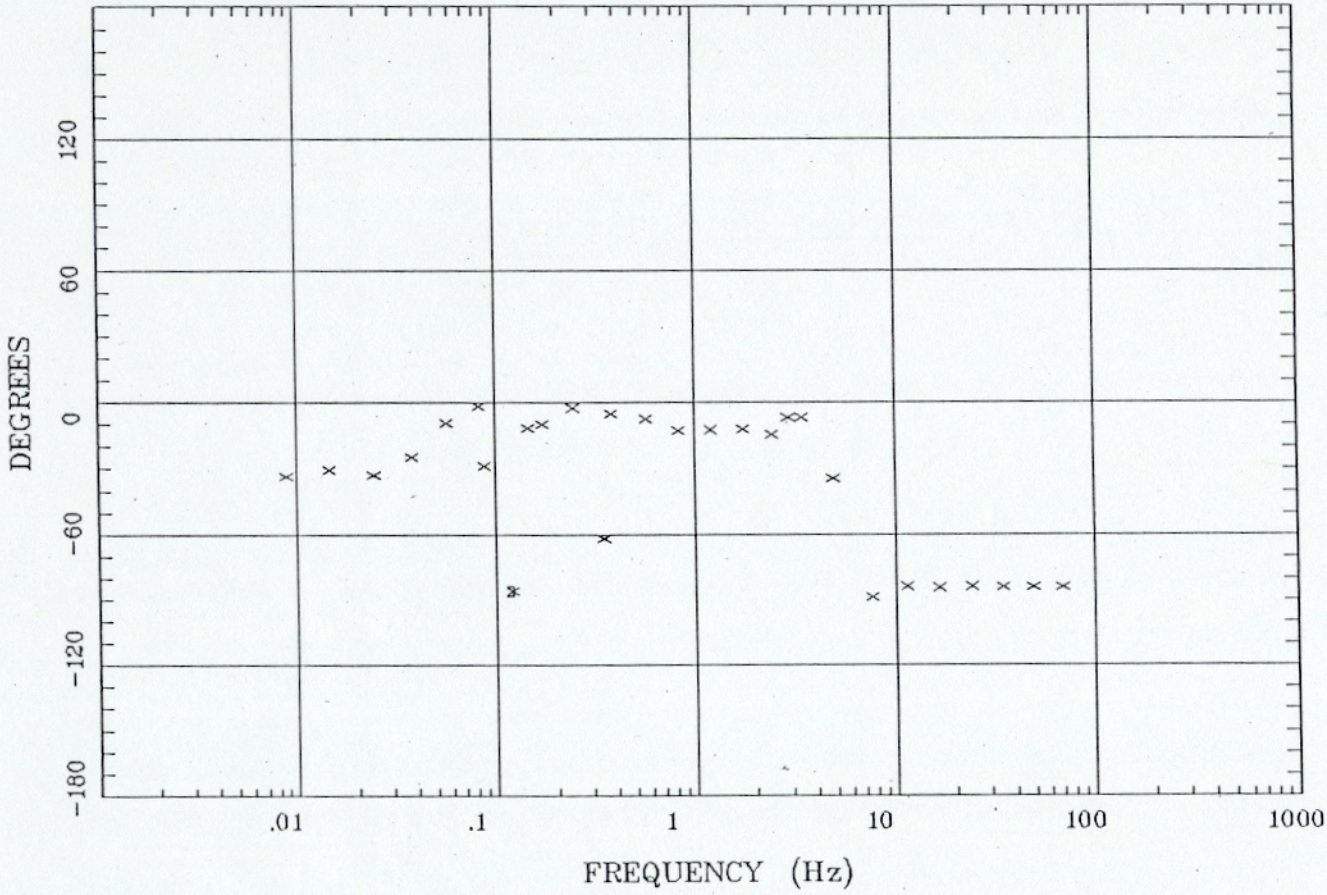
ROTATION ANGLE

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:18 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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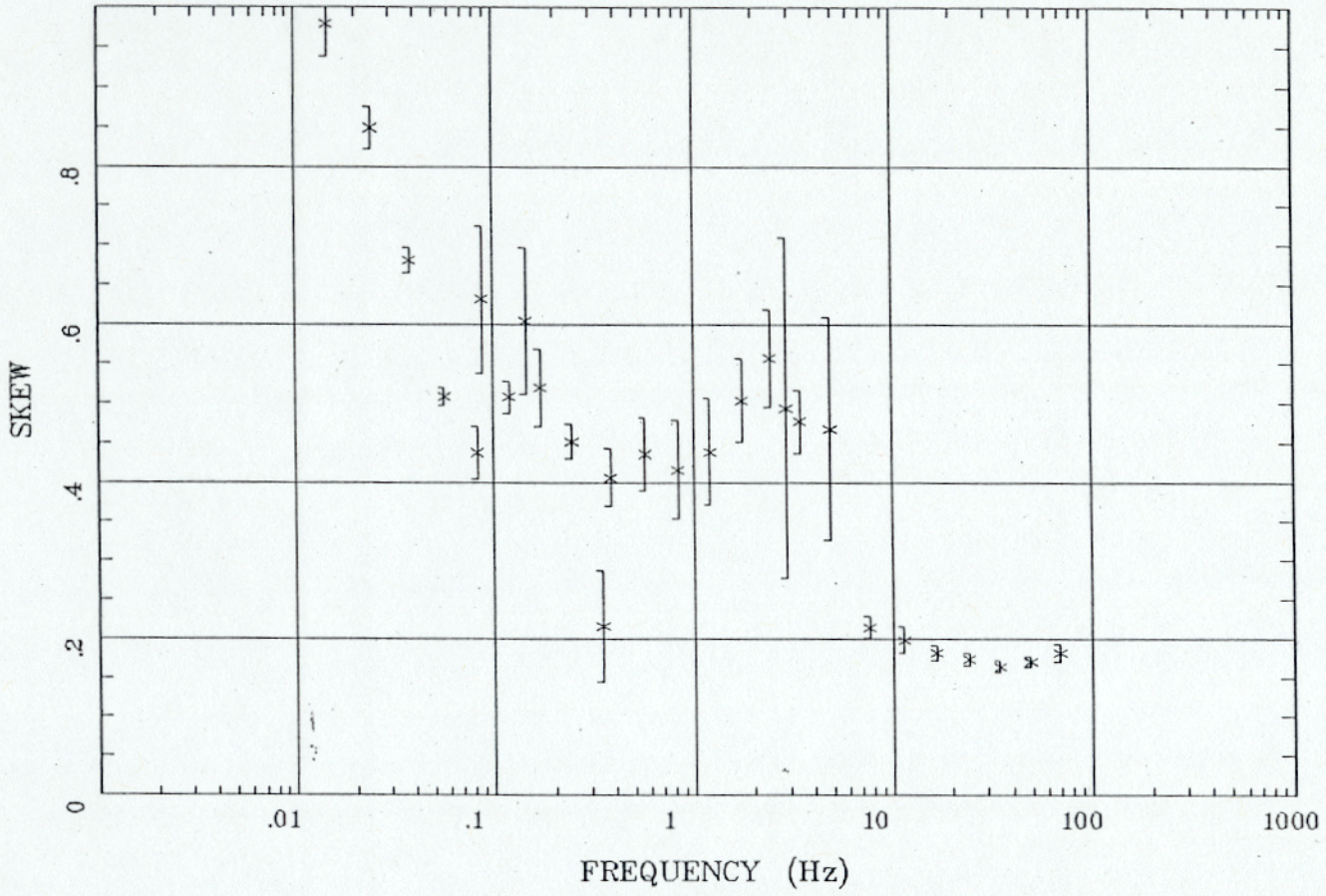
IMPEDANCE SKEW

Tangle Lakes, Alaska



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Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
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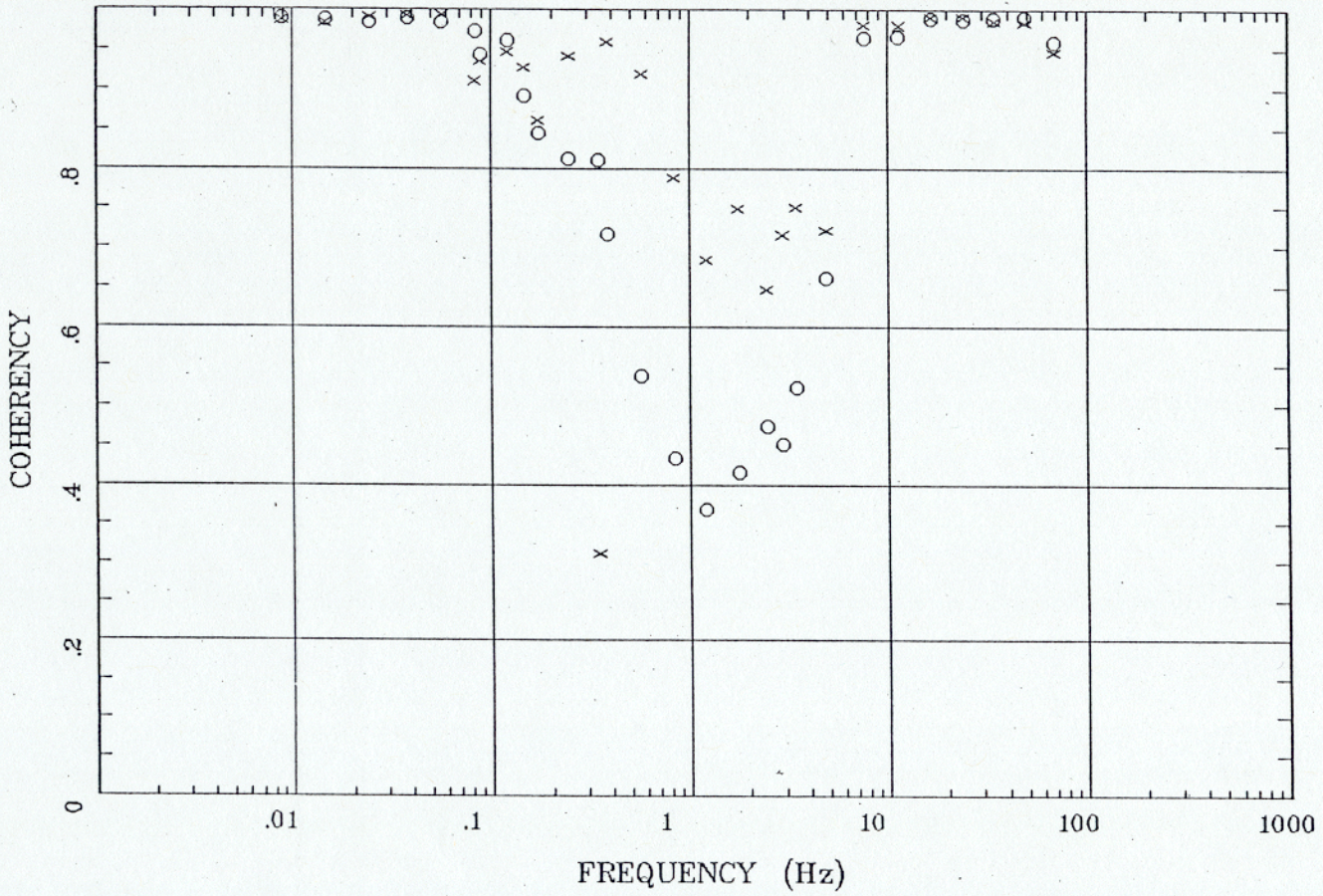
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:18 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska



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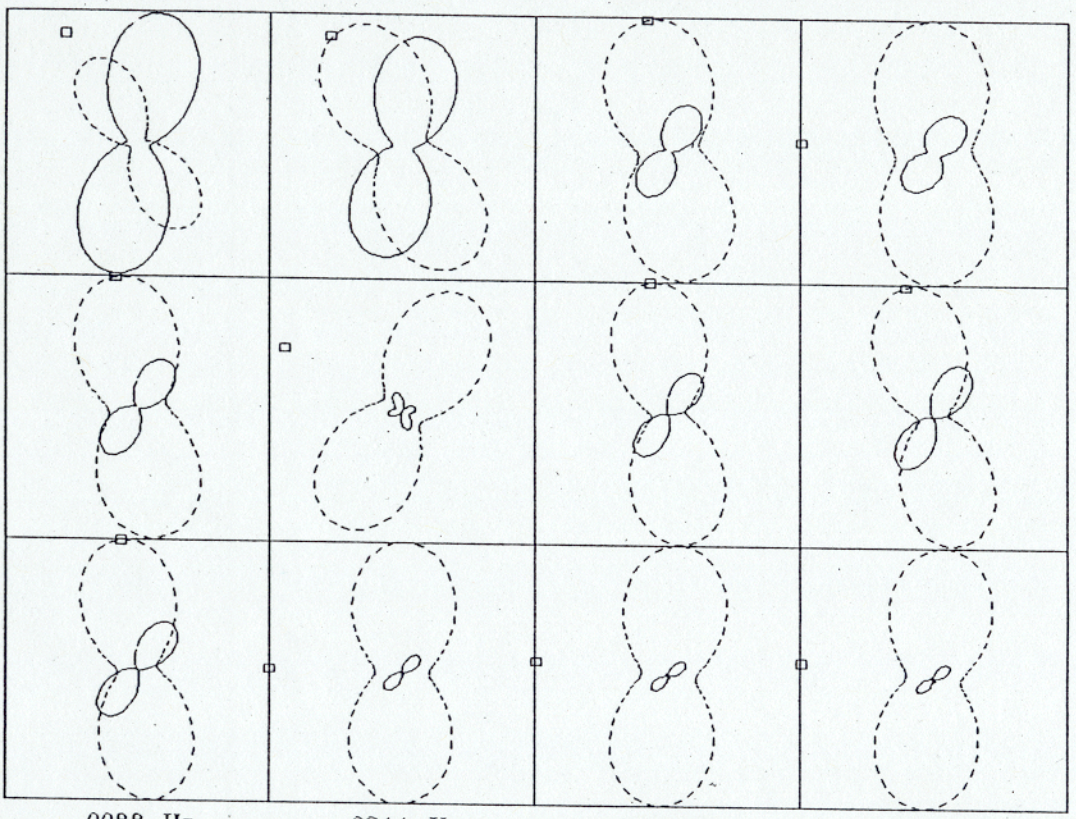
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:18 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

POLAR PLOTS

Tangle Lakes, Alaska

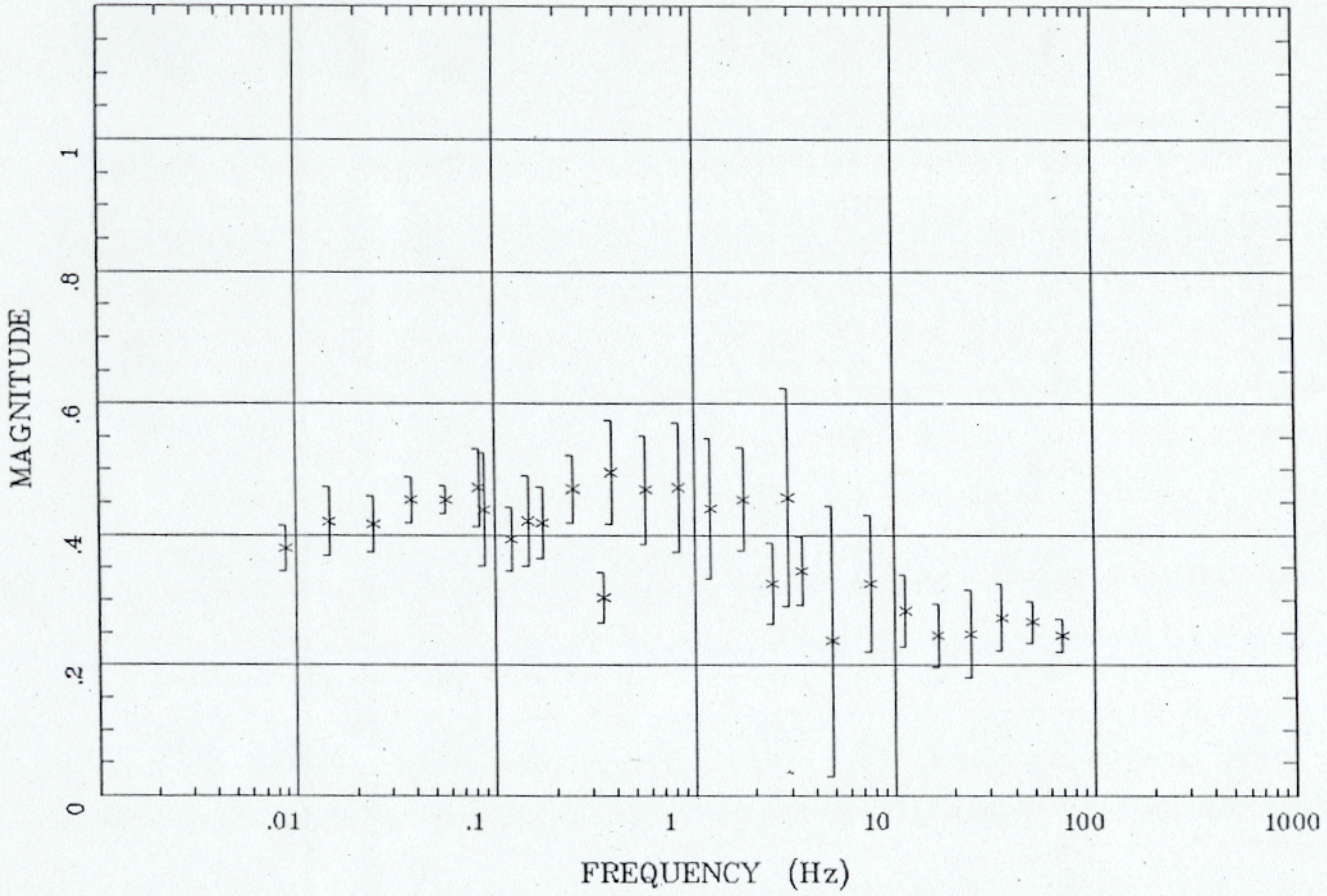


.0088 Hz	.0244 Hz	.0566 Hz	.120 Hz
.172 Hz	.345 Hz	.566 Hz	1.758 Hz
2.930 Hz	7.617 Hz	16.602 Hz	34.375 Hz

Client:
Remote: none
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:19 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER MAGNITUDE Tangle Lakes, Alaska



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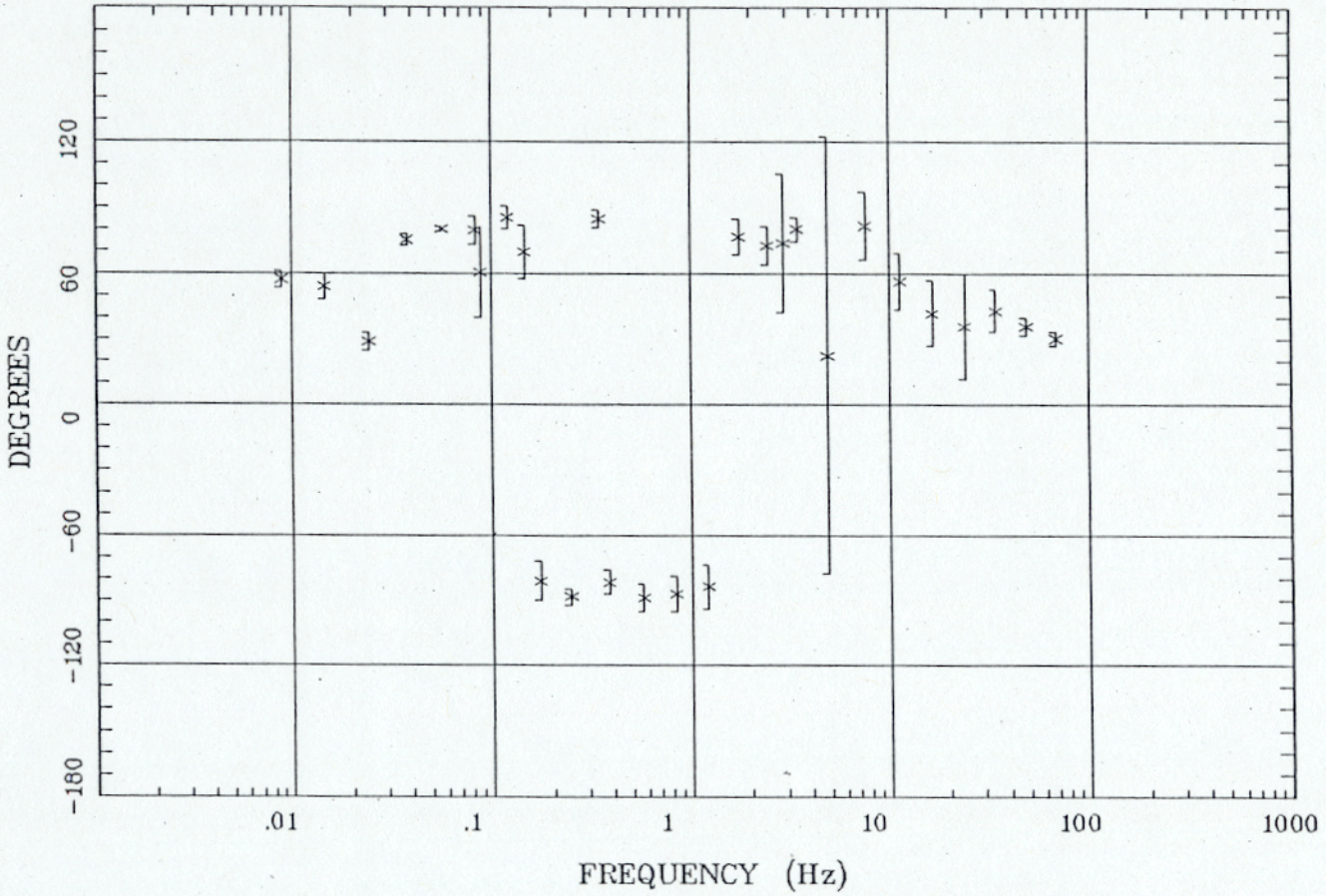
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:19 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



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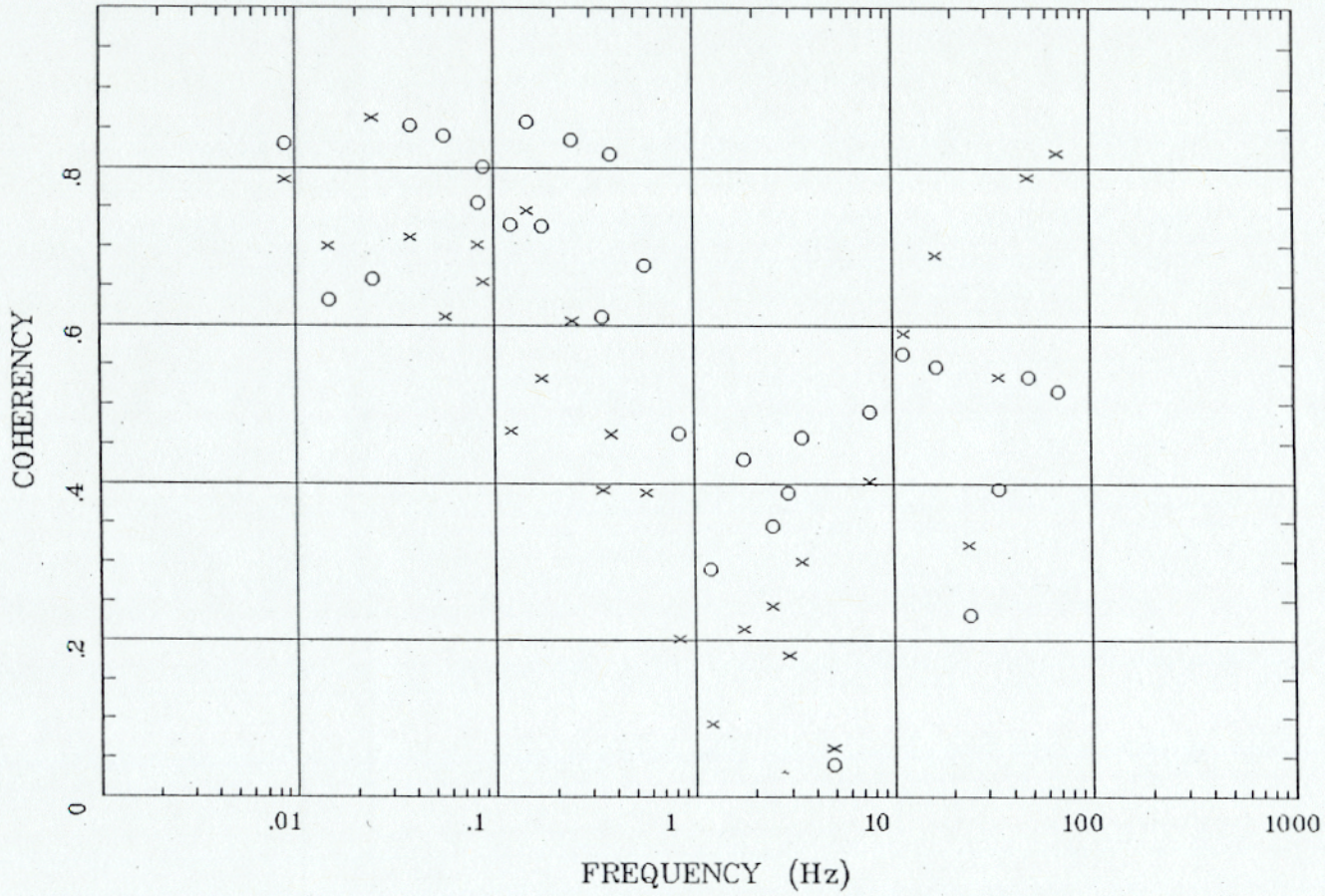
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:19 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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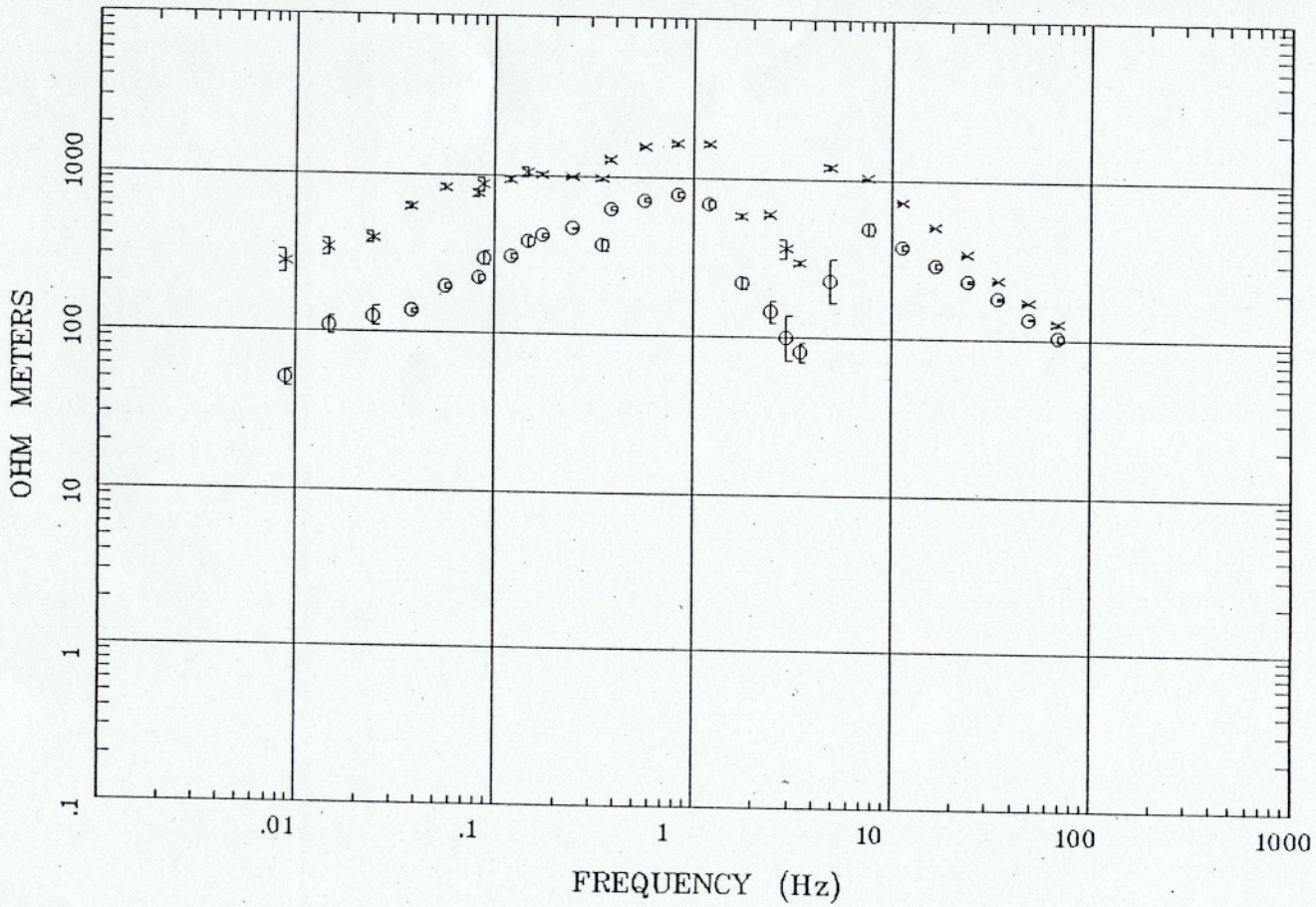
Acquired: 13:2 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm13all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:19 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

APPARENT RESISTIVITY

Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 16:5 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

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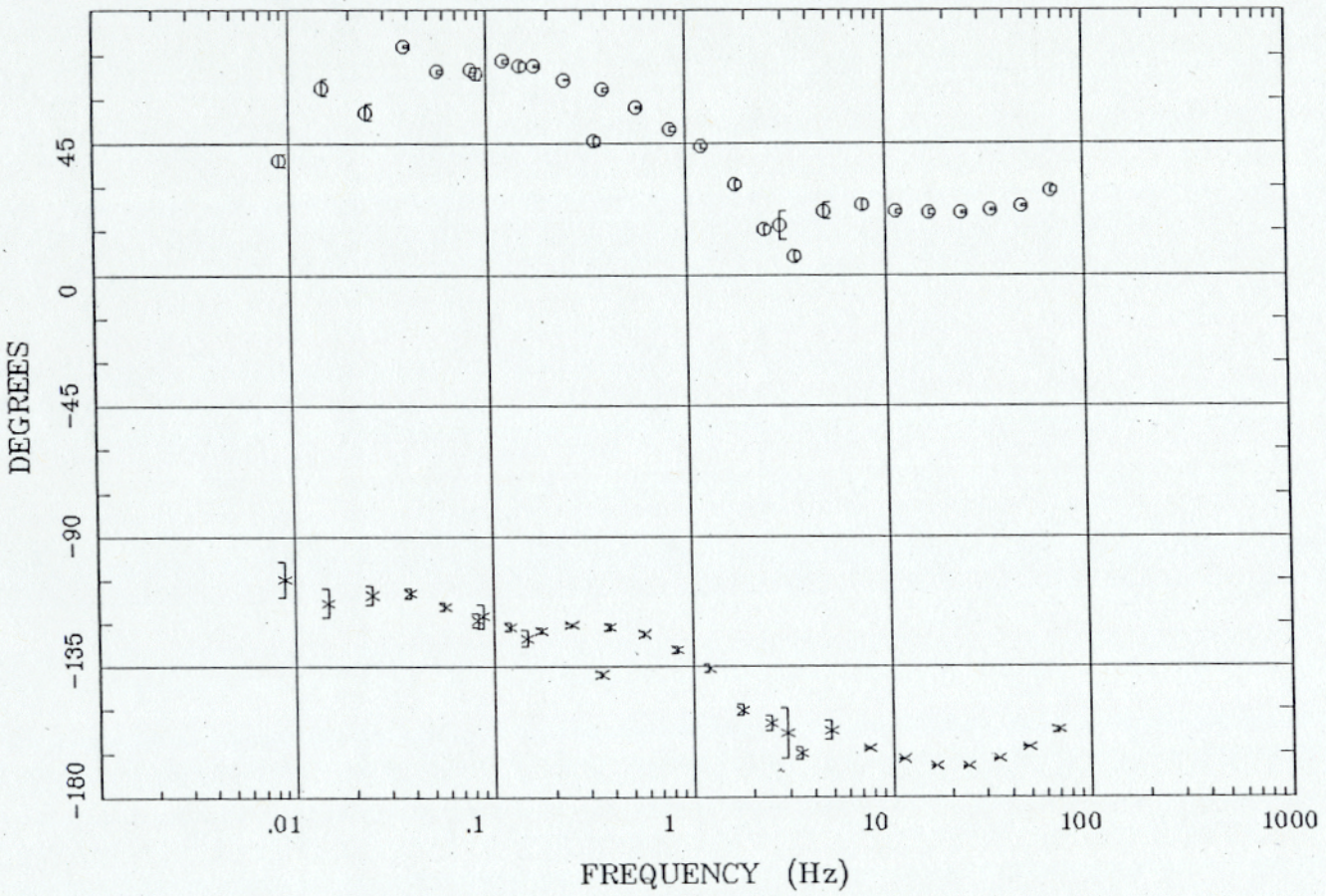
IMPEDANCE PHASE Tangle Lakes, Alaska



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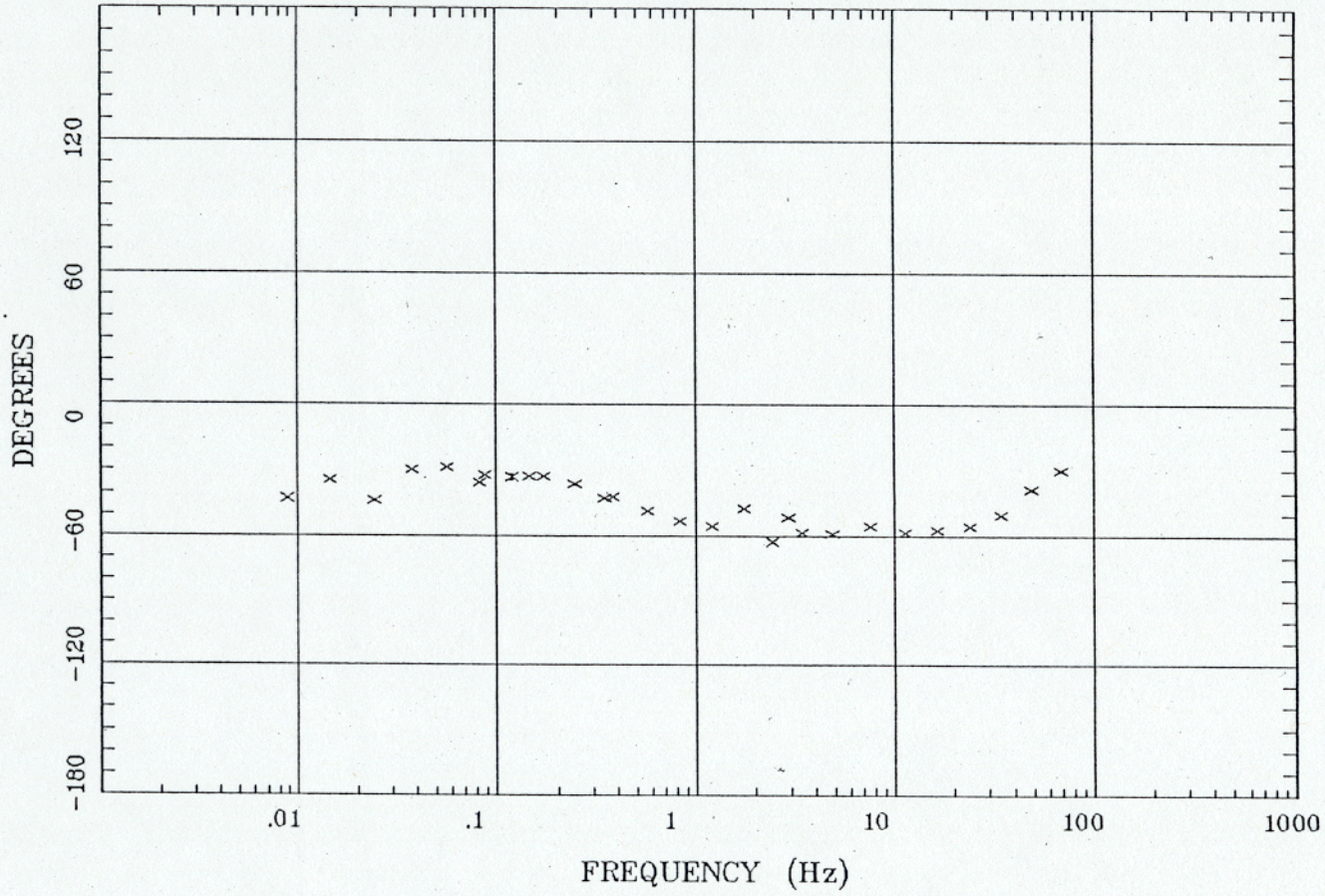
Remote: none
Acquired: 16:5 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

ROTATION ANGLE

Tangle Lakes, Alaska

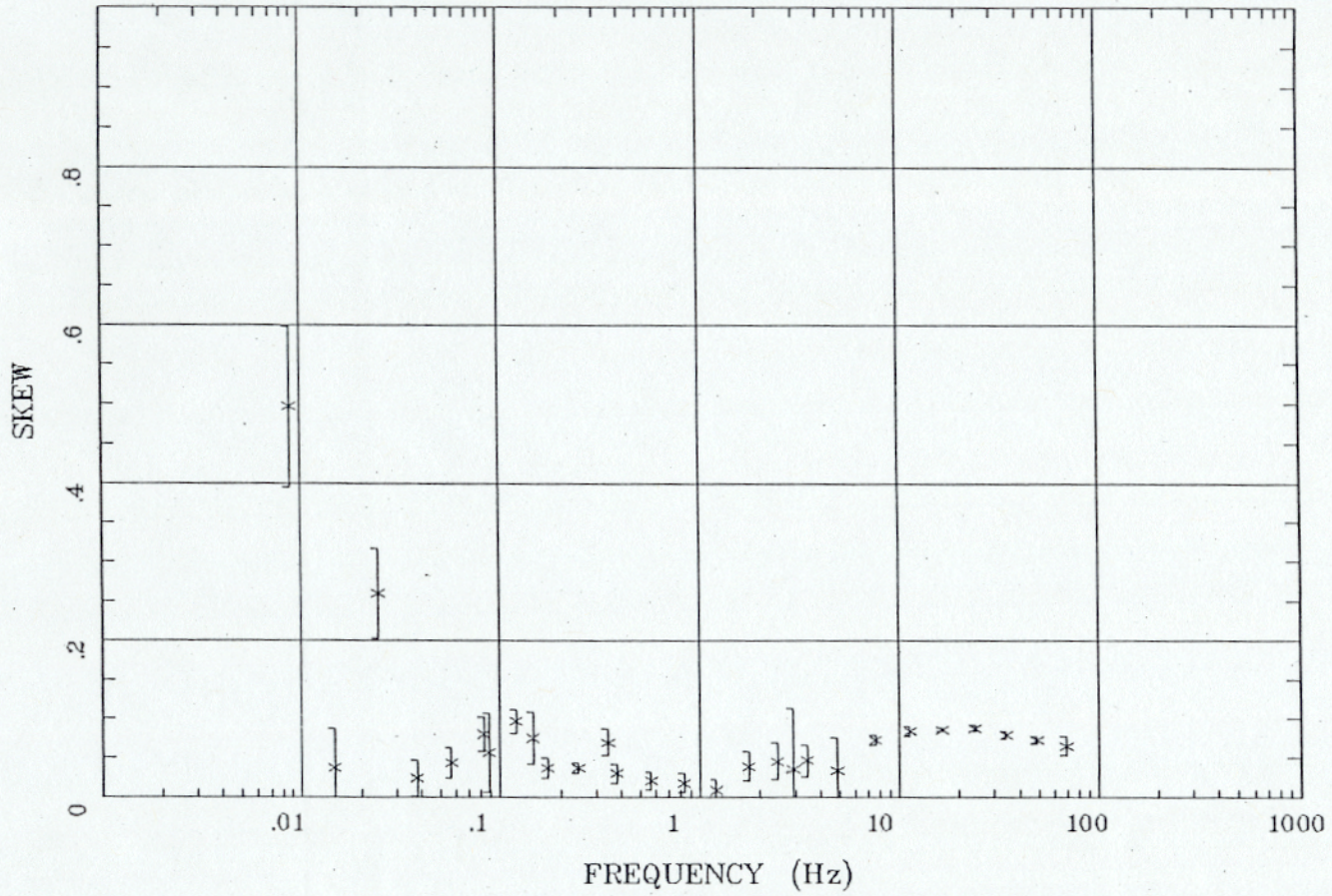


Client:
Remote: none
Acquired: 16:5 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI - ElectroMagnetic Instruments >

IMPEDANCE SKEW

Tangle Lakes, Alaska



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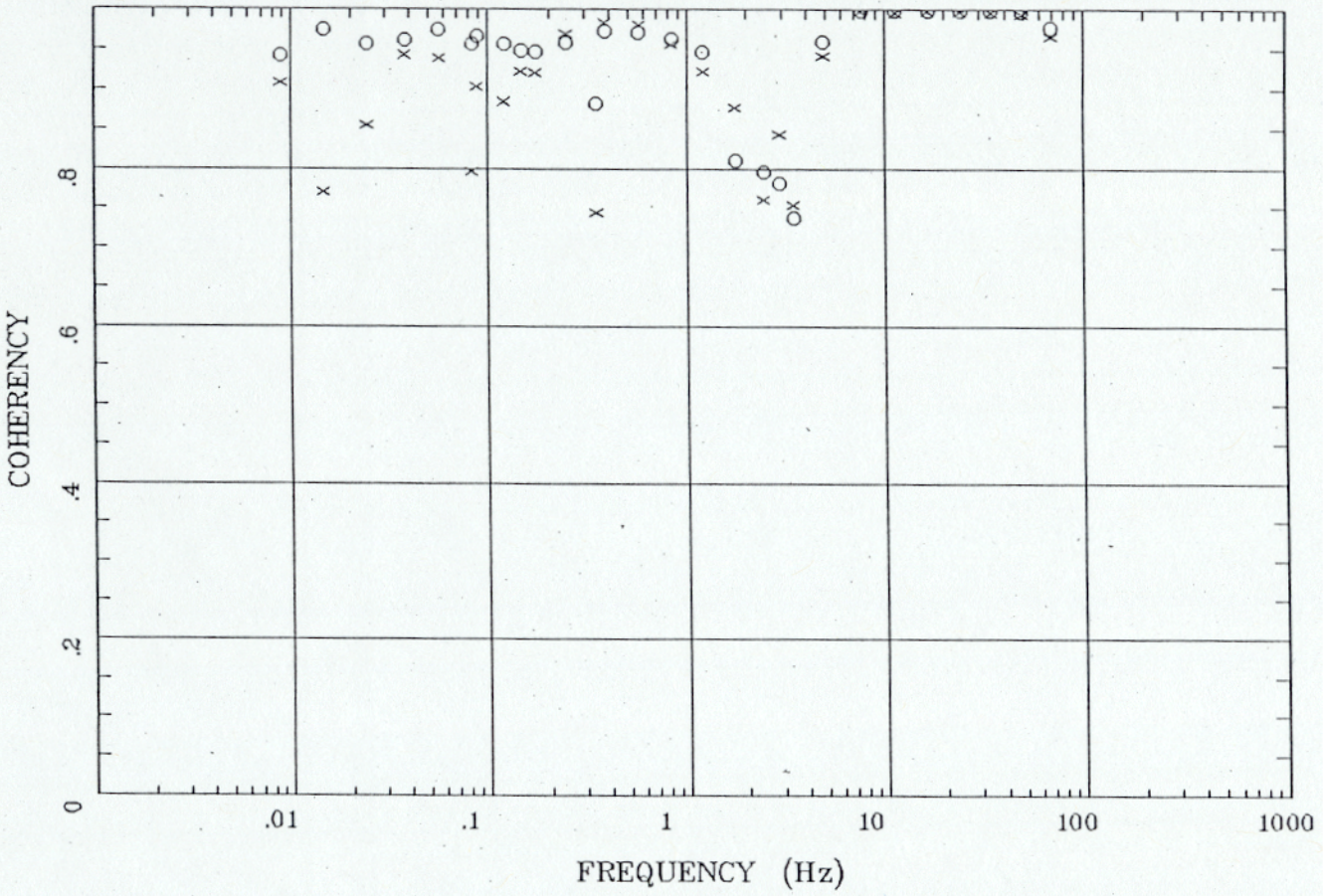
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

E MULT Coh. Tangle Lakes, Alaska



Client:
Remote: none
Acquired: 16:5 Aug 22, 2001
Survey Co:USGS

Rotation:
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
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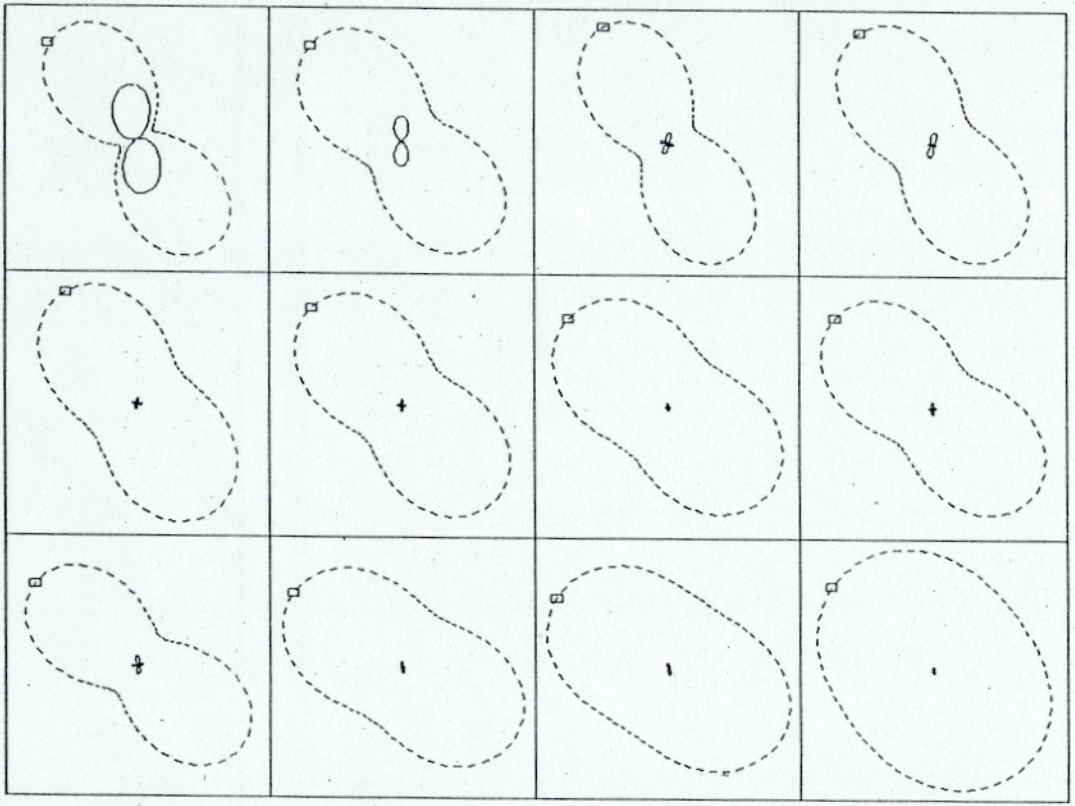
POLAR PLOTS

Tangle Lakes, Alaska



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Plotted: 16:20 Oct 18, 2001
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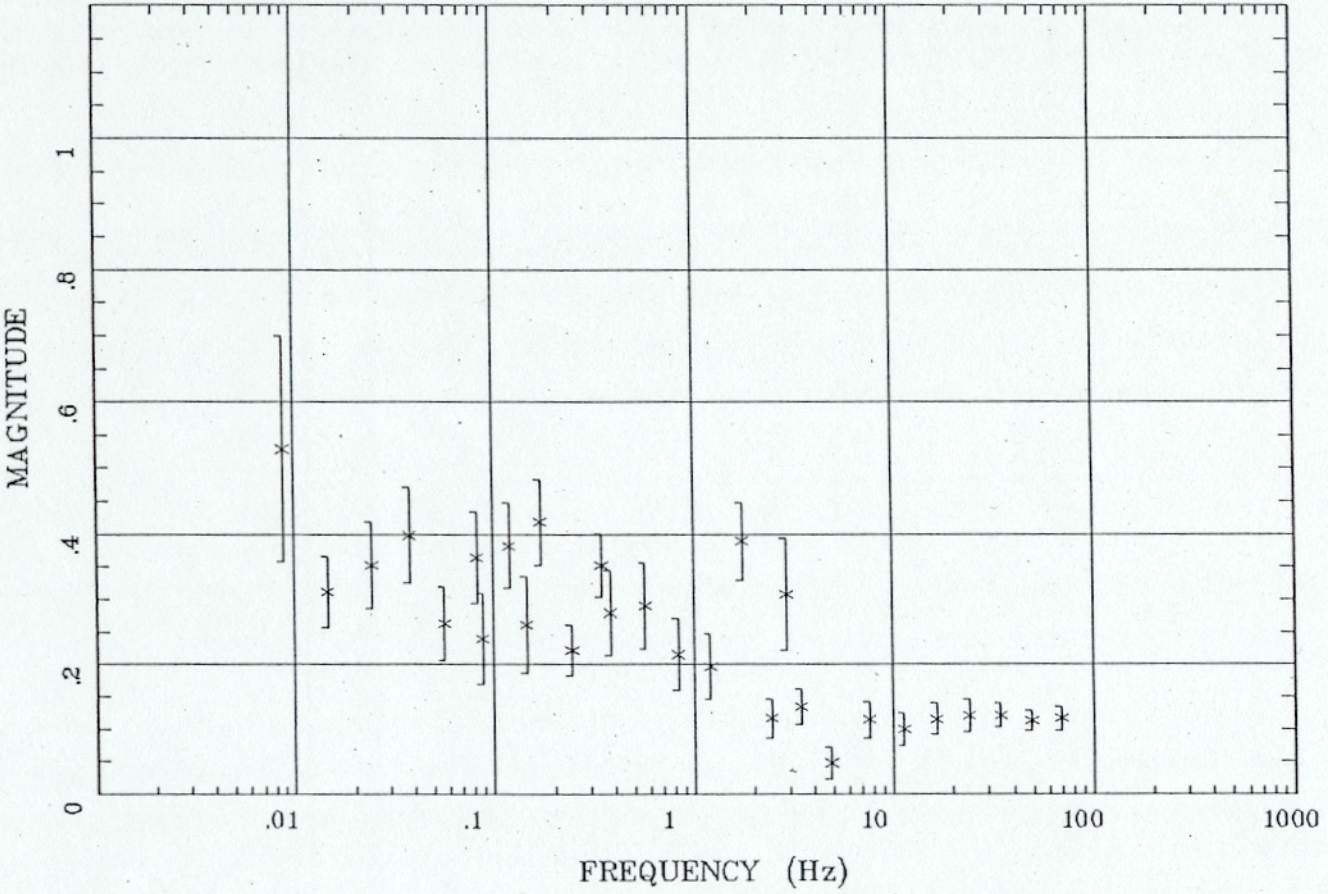
TIPPER MAGNITUDE

Tangle Lakes, Alaska



Client:
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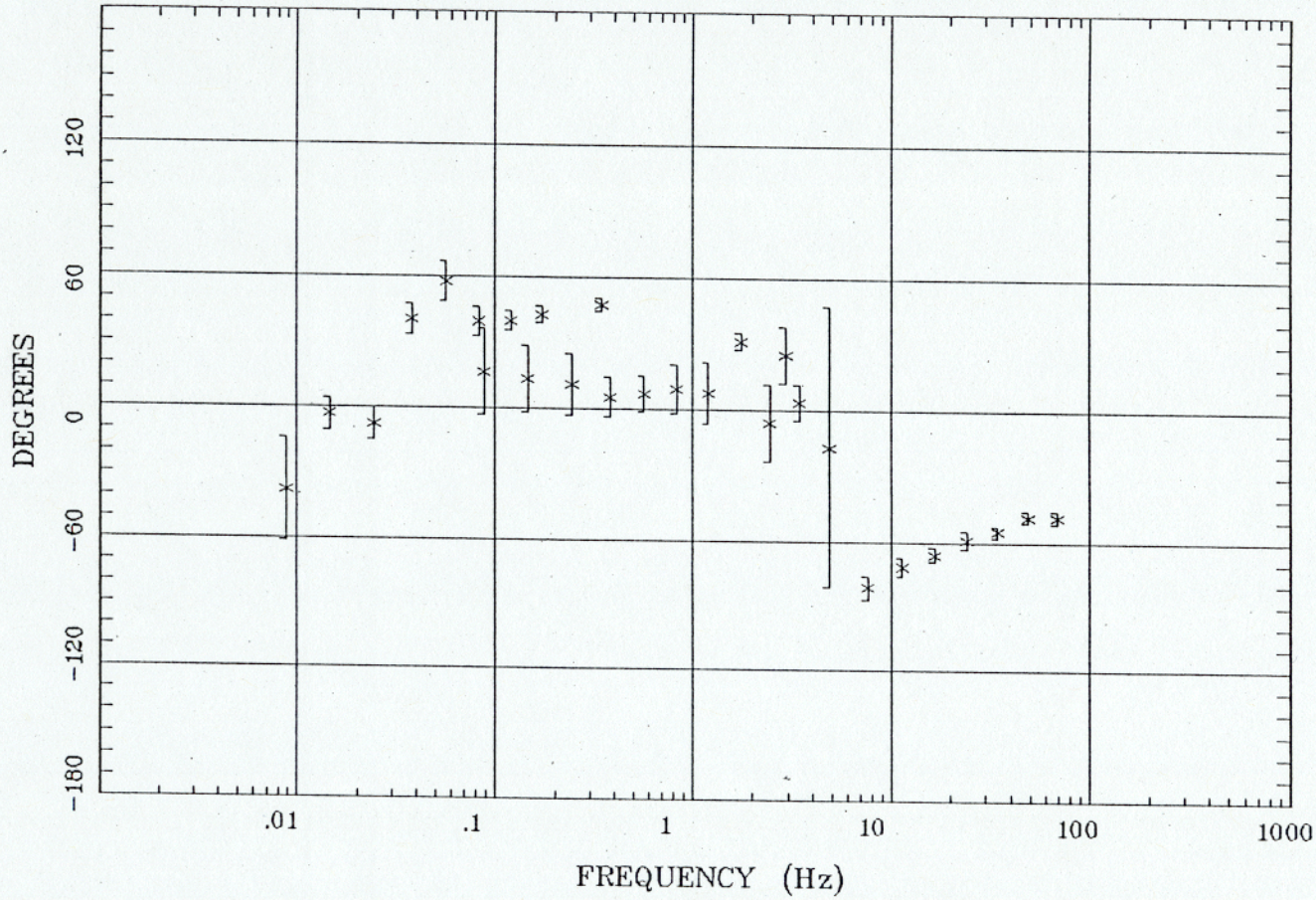
Rotation:
Filename: tlm14all.avg
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

TIPPER STRIKE

Tangle Lakes, Alaska



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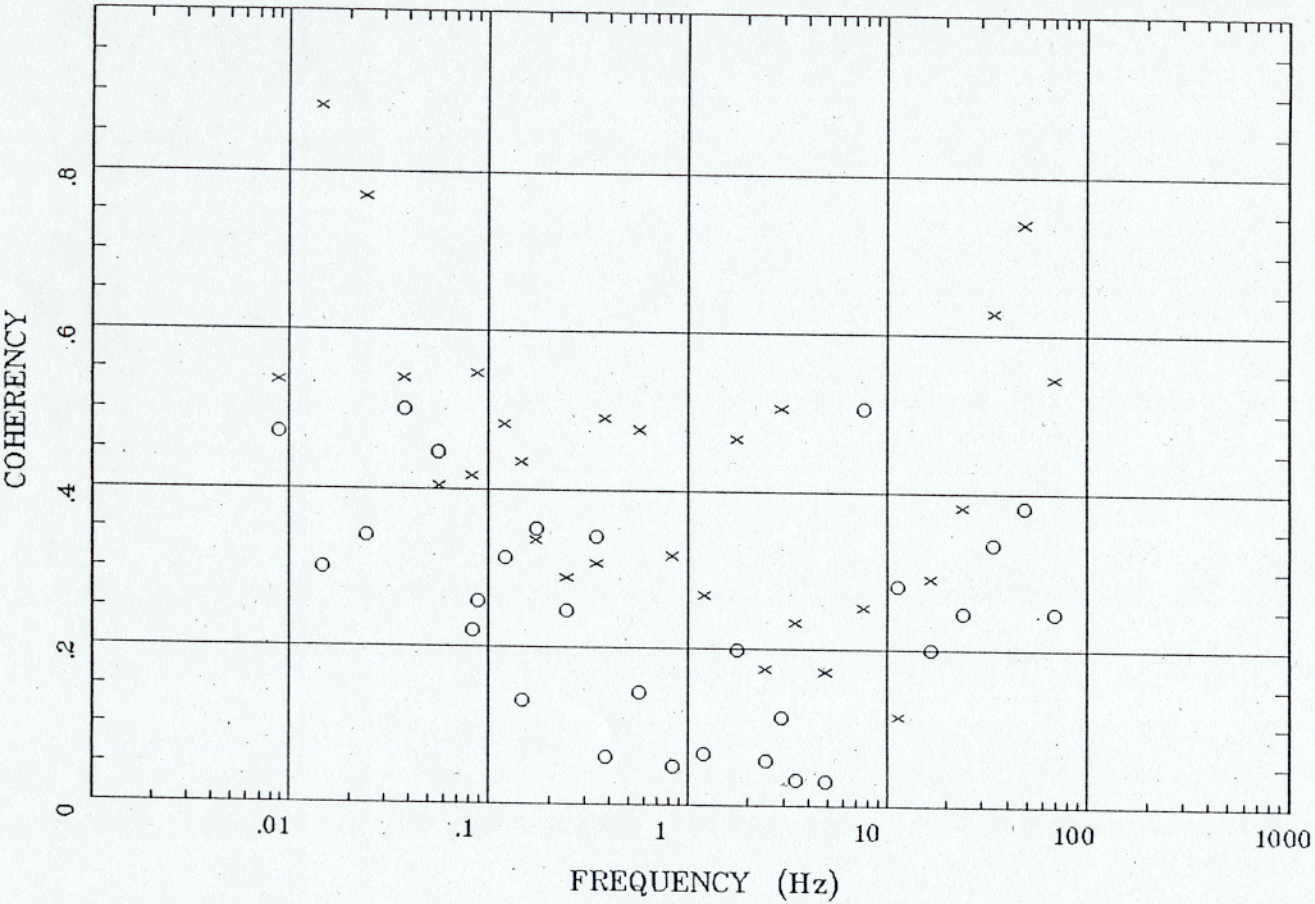
Channels: Ch1 Ch2 Ch3 Ch4 Ch5 Ch3 Ch4
Plotted: 16:20 Oct 18, 2001
< EMI – ElectroMagnetic Instruments >

HzHx.x Coh HzHy.o

Tangle Lakes, Alaska



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