

REPROCESSING OF NGU EM DATA

BIDJOVAGGEA AREA, FINNMARK

A/C BIDJOVAGGE GRUBER

By

H. D. MacLean
December, 1982

During the course of our association with the Sydvaranger project we reviewed some of the helicopter EM data acquired by the Norwegian Geologic survey with their "Sander" EM type system. It was suspected that the quality of this data could be somewhat enhanced using some of the processing techniques employed by the more modern EM systems, such as Dighem Limited and Aerodat. A sample of the NGU data has now been reprocessed, and based on these preliminary results we are now prepared to recommend that all of the helicopter EM data acquired in the course of this venture be processed. Significant anomalies associated with sulfide mineralization are easier to recognize and detect on the filtered and enhanced data supplied by Dighem Limited, and the enhanced quality of their presentation would appear to justify the cost of the reprocessing.

An example of raw field data as supplied by the NGU accompanies these remarks as Exhibit 1. The data is presented in the same manner as received and reported on by the NGU, with the exception that alternate lines have not been inverted so that they will all read in the same direction; line 124 reads west to east but the other two lines read from east to west. The data is reversed from normal in this case. Electrical conductors are recognized by the downward or negative going spikes in the real and quadrature components. Positive spikes in the quadrature indicate magnetite; positive departures in the inphase (real) are usually attributable to instrument noise. The long wave length drift apparent in the real and quadrature components is caused by a combination of instrument instability (drift) and variations in overburden conductivity. The strong anomalies marked as A1, A2 and A3 are clearly recognizable and if this was the target of interest, there would be need in reprocessing the data.

The problem with the interpretation is that the weaker anomalies of lower amplitude such as B2, C2 and D2 may represent equally as good conductors as are indicated by the anomalies A1, A2 and A3, but because of greater depth of burial, poor coupling angle or excessive aircraft height, the response amplitude is much lower. Though the basic information is available, the eye is inevitably attracted to the 'A' anomalies where the response is much greater. In an area such as this where graphitic shales are common, the high amplitude anomalies such as A1, A2 and A3 are usually associated with graphite horizons and as such have relatively little significance to exploration. The anomalies which are related to sulfide mineralization are frequently displaced perpendicular to strike from these graphitic horizons but their amplitude is low because of short strike length, relatively reduced depth extent, increased depth of burial, and adverse coupling angle even though the conductivity thickness which is the

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most important parameter in the evaluation of EM anomalies may be as high as the 'A' series. The interpreter is faced with the task of ignoring the large amplitude anomalies and recognizing the lesser features which ultimately may be of much greater significance.

This task is made considerably easier by some of the reprocessing which has been performed by Dighem Limited. The raw tapes supplied by the NGU were reformatted by Dighem Limited and gridded. The data was run through some of their noise suppression routines, and the results of this initial processing for three lines are shown in Exhibit 2. The data is inverted on alternate lines so all profiles read from west to east and the sense of the data is reversed so that conductors are indicated by positive departures in the real and quadrature components, which is the normal case. Much of the high frequency noise has been removed even though the low frequency drift is still apparent. Although the data is considerably cleaner there is no real significant increase in the data quality.

Once the low frequency noise is removed by the process of "levelling" a much better quality set of profiles such as those in Exhibit 3 can be produced. In addition to the considerably enhanced inphase and out-of-phase profiles, a resistivity profile has been added. It is this profile which permits the recognition of significant bedrock conductors from the noisy low amplitude responses of the EM components. The resistivity is a function of the ratio of the inphase:out-of-phase response and is, therefore, not dependent upon the amplitude of the real and quadrature components but only on their ratio. The resistivity associated with the 'A' anomaly is low, as would be expected; other significant conductors can be indicated by similar resistivity lows. Generally the minor variations in resistivity are attributable to variable overburden thickness and conductivity. Very sharp resistivity lows can be used to indicate a bedrock conductor when the feature is combined with an anomaly in the real and quadrature components. An example of this is shown in anomaly E2 and F1, on Exhibit 3. Neither of these anomalies was obvious on the raw data yet anomaly E, considering its position to the graphite horizon which causes anomaly A, is possibly one of the more significant conductors since it probably represents a sulfide occurrence. All of the other possible conductors which were indicated by the 'X's' on Exhibit 3 were rejected as non-bedrock conductors due to the wave form and wave length of the resistivity anomaly.

Production of the sets of profiles shown in Exhibit 3 requires a considerable amount of hand labor by a geophysicist. The low frequency roll or non-linear drift has to be removed manually and the filter operators need to be changed continuously in order to remove the high and low frequency noise. The judgement of the geophysicist is required for this purpose since it would be undesirable to remove true anomalies during this filtering process.

Results of the reprocessing are summarized in Exhibits 4 and 5. Exhibit 4 is a resistivity map based on the purely mechanical filtering shown on the profiles of Exhibit 2. Although the resistivity contours permit the correlation and recognition of anomalies such as 'A' and 'G', the noise level is too high to significantly enhance the interpretability of the data. The resistivity map shown on Exhibit 5 compiled from the levelled data represents a marked improvement over the NGU data presentation and would considerably enhance an interpreter's ability to select significant anomalies from the data. Conductors which are correlatable from line to line, such as 'A' and 'G' are immediately recognizable as possible graphite horizons. These anomalies are based on ratios not amplitudes, and anomaly 'G' is almost as strong as 'A' even though the anomaly is scarcely detectable on the raw data profiles. Other anomalies such as those indicated by the 'X's' can be flagged and the ones in a favorable resistivity environment, such as (H, I and J) can be targeted for additional investigation.

Clearly, many anomalies will be identified which have a high probability of being due to noise, rather than to true bedrock conductors. However, anomalies in the area can be field checked quickly and inexpensively, and dealing with the occasional spurious anomaly would be a small inconvenience compared to the benefit of identifying heretofore unrecognized sulfide conductors.

The cost of reprocessing the data in order to produce the products shown in Exhibits 3 and 5 has been quoted by Dighem Limited at \$17 per line kilometer. There are approximately 2,000 line kilometers of data which have been flown by the NGU for the project. Total cost of reprocessing would be approximately \$35,000. It is my recommendation that all of the NGU data within the Gulf joint venture area be reprocessed in accordance with the description contained herein, and in accordance with the recommendations made by Dr. D. Fraser, as set forth in the attached proposal for processing of NGU data dated October 28, 1982. The work should be paid for within the existing budget for airborne EM exploration. The work should be executed forewith subject, of course, to approval by Sydvaranger. Initiation of the project and all negotiations with the contractor should be conducted by Sydvaranger, as they are

operator of this exploration project, but I would, as always, be willing to provide whatever assistance might be required.

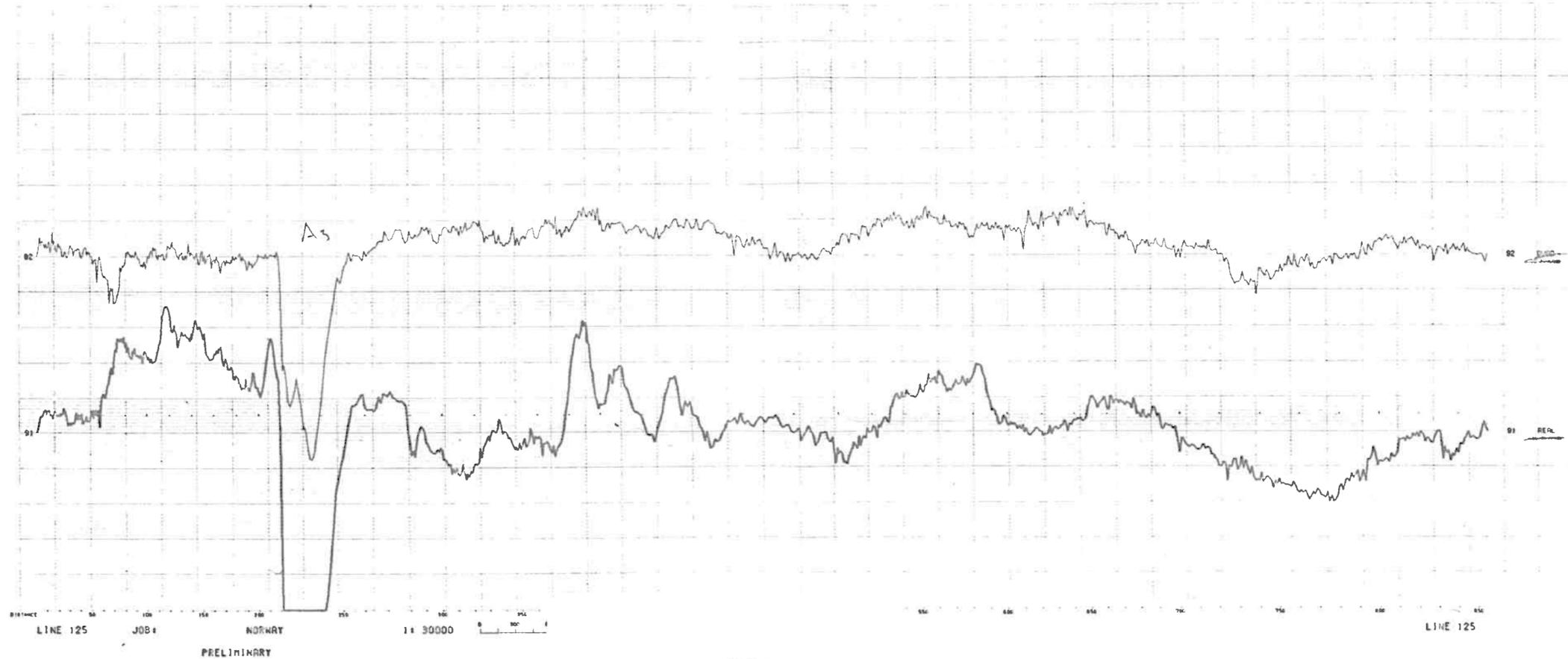
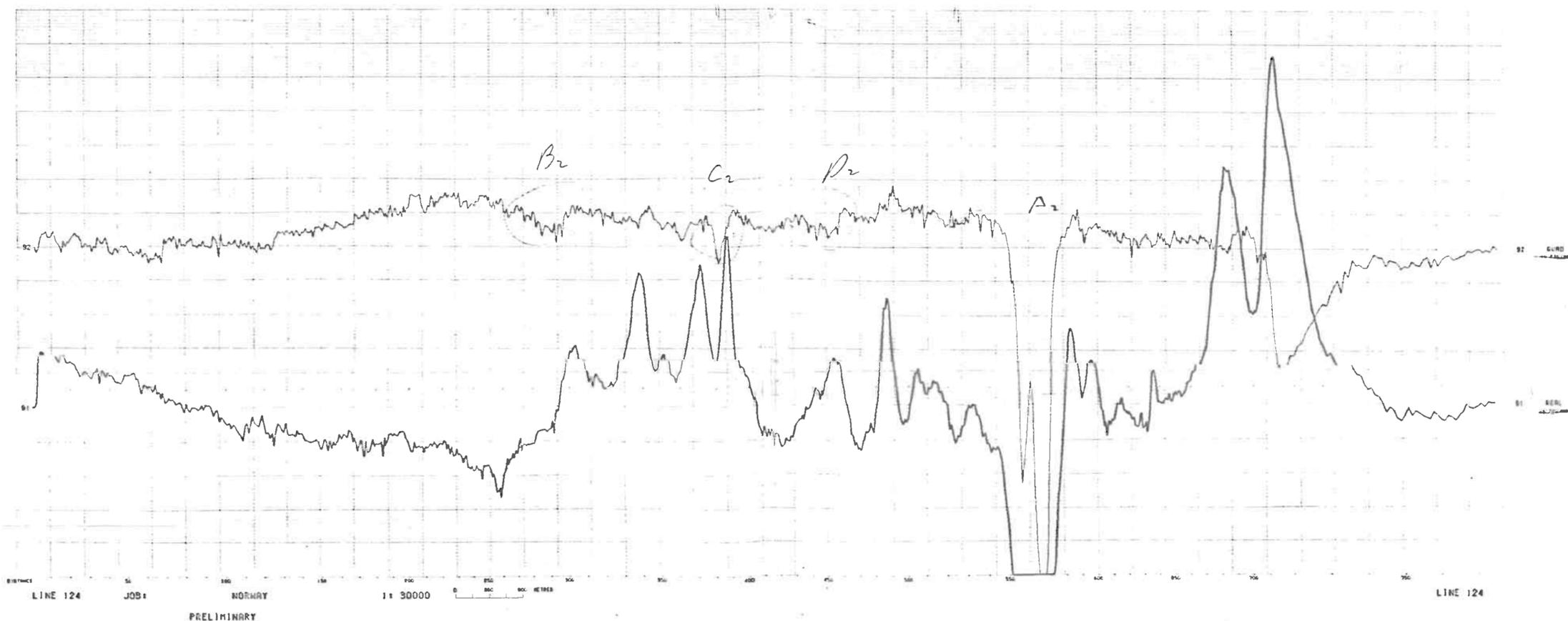
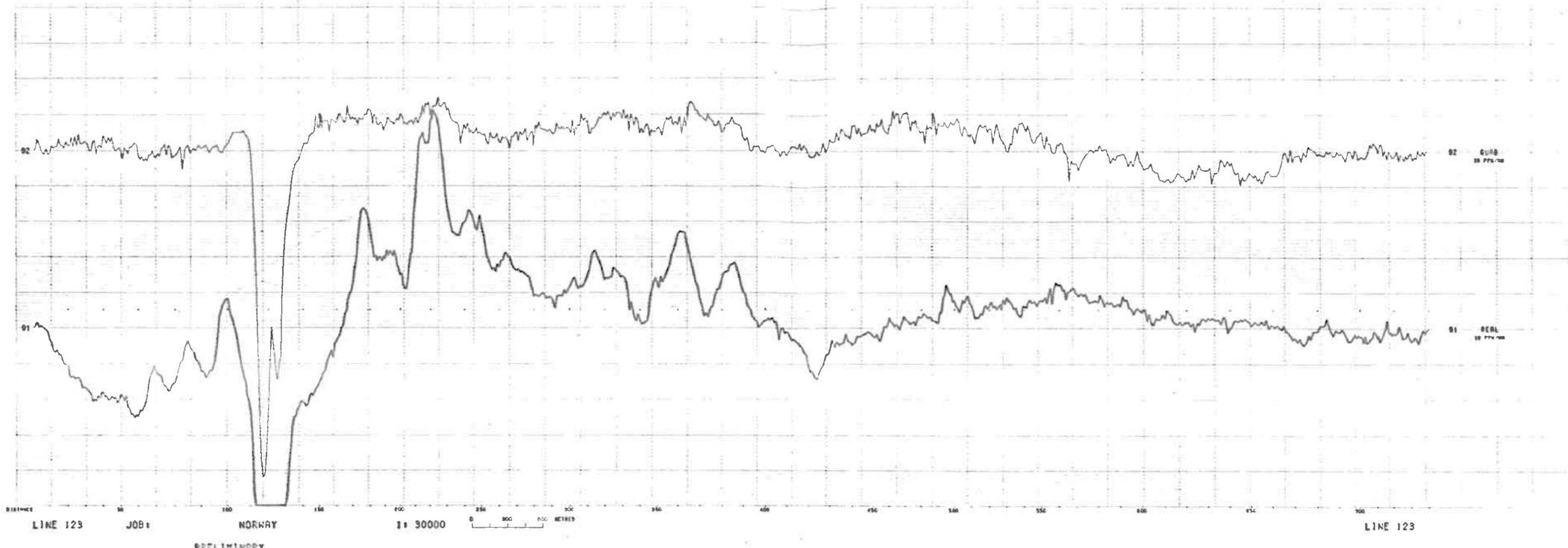
H. David MacLean
H. David MacLean

HDM/wpb

cc: W. S. Cavender
R. Hagen
T. L. Heidrick
G. Reinbold

Attachments and Enclosures

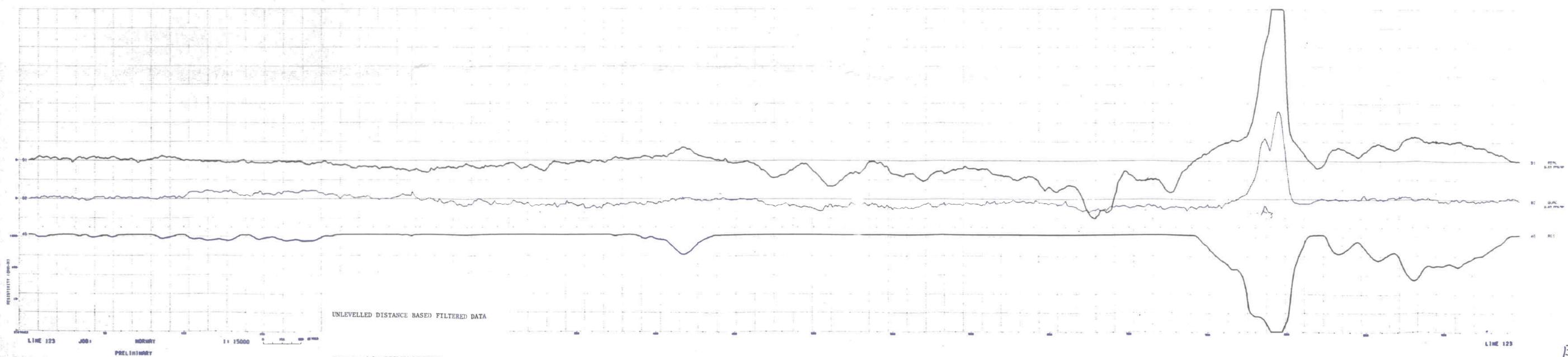
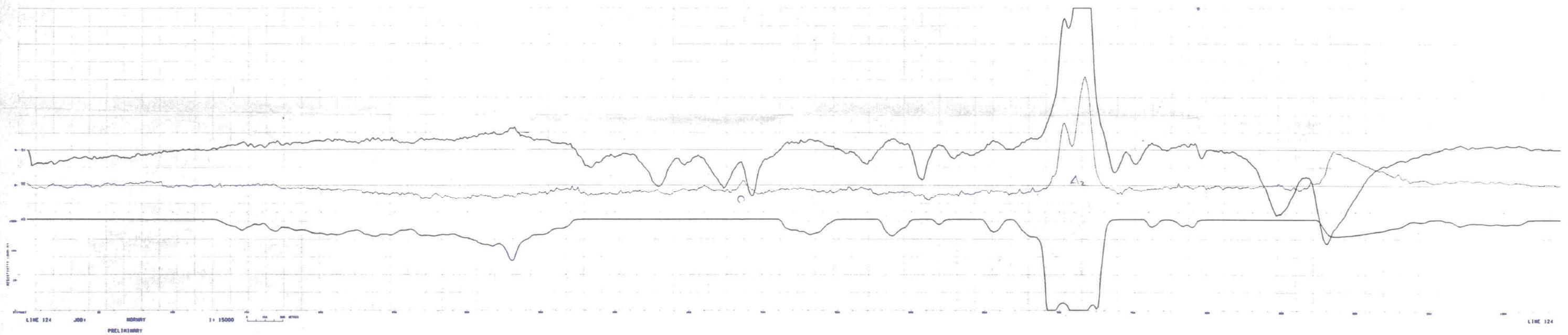
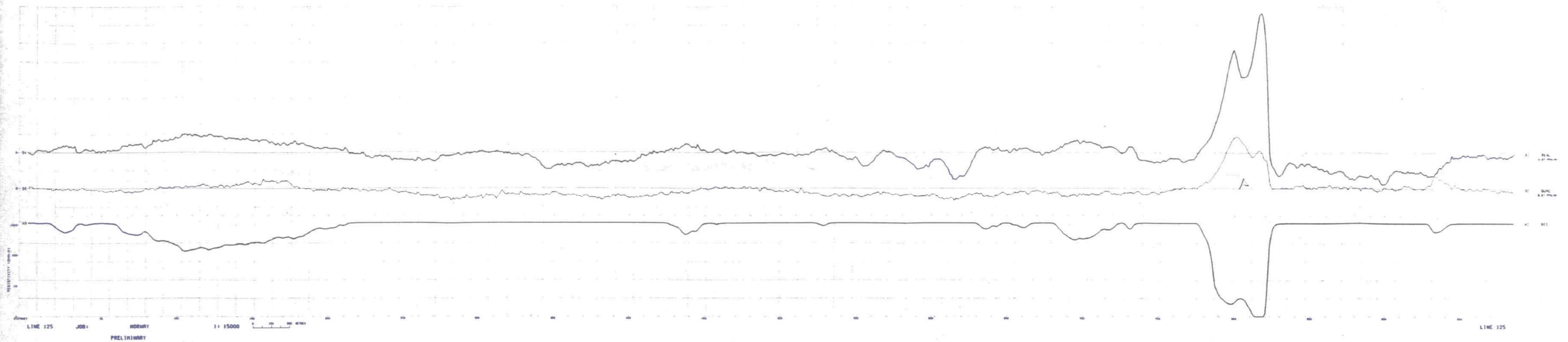
Exhibit 1	NGU EM Data: Raw Profiles
Exhibit 2	NGU EM Data: Filtered Profiles
Exhibit 3	NGU EM Data: Levelled and Filtered Profiles
Exhibit 4	Resistivity Map: Filtered Data
Exhibit 5	Resistivity Map: Levelled and Filtered Data
Appendix 1	Proposal For The Processing Of NGU Data for A/S Sydvaranger Iron Ore Company



TIME BASED RAW DATA

Raw

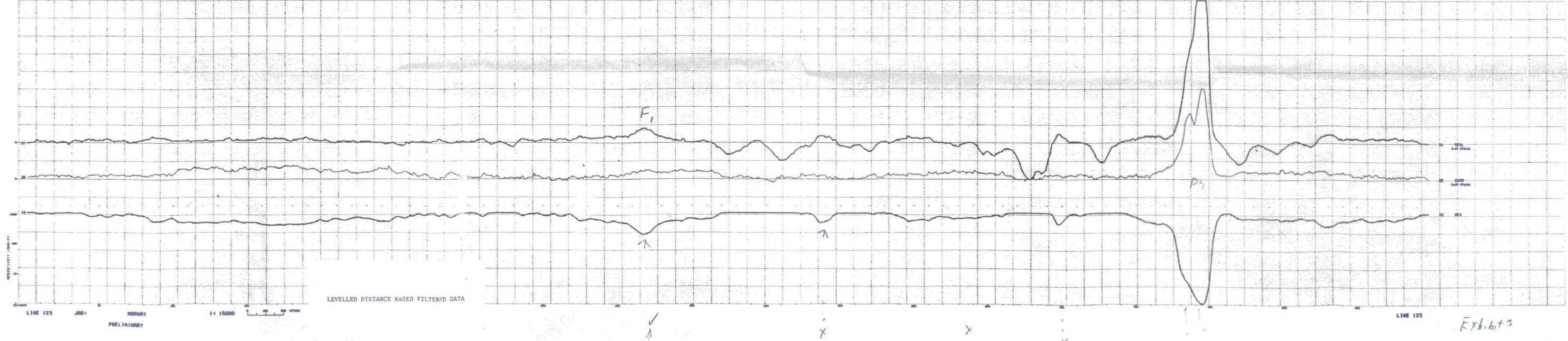
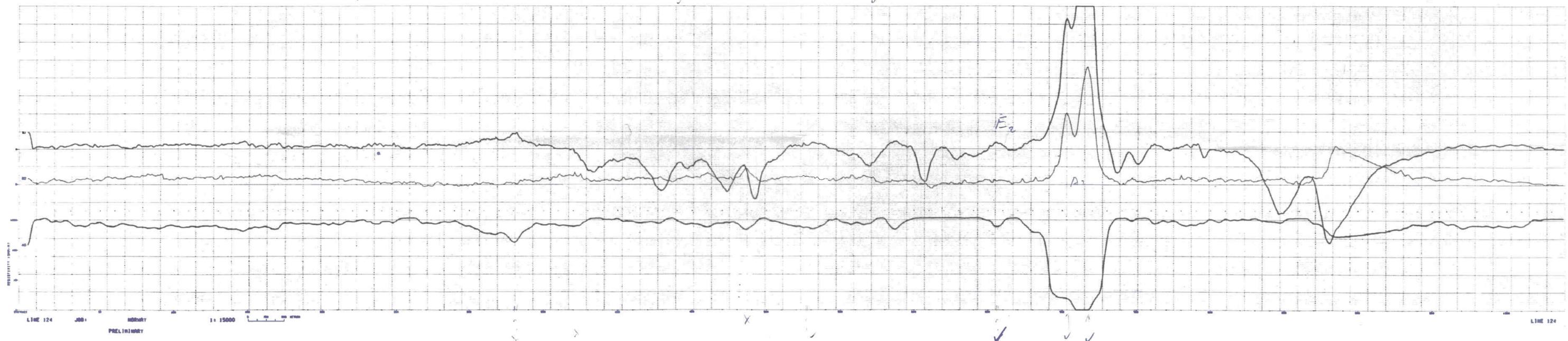
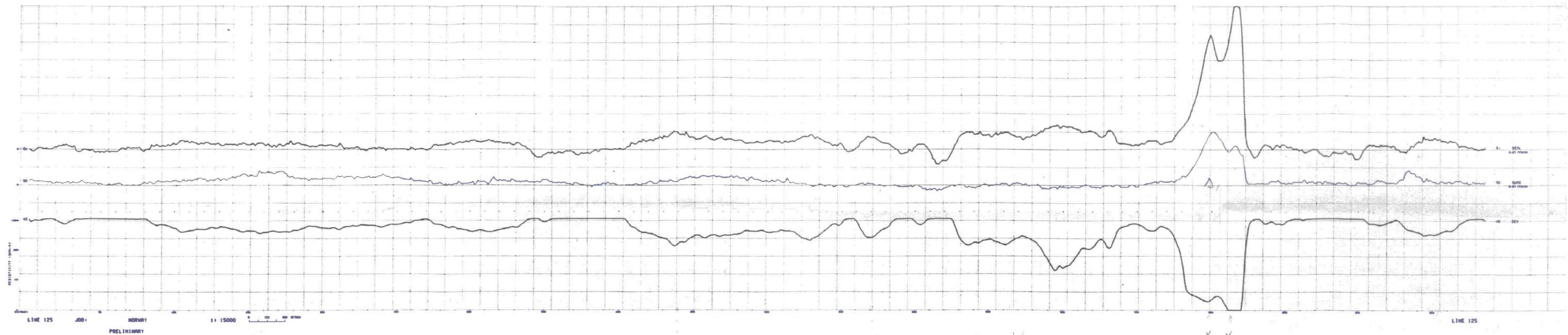
Exhibit 1



UNLEVELLED DISTANCE BASED FILTERED DATA

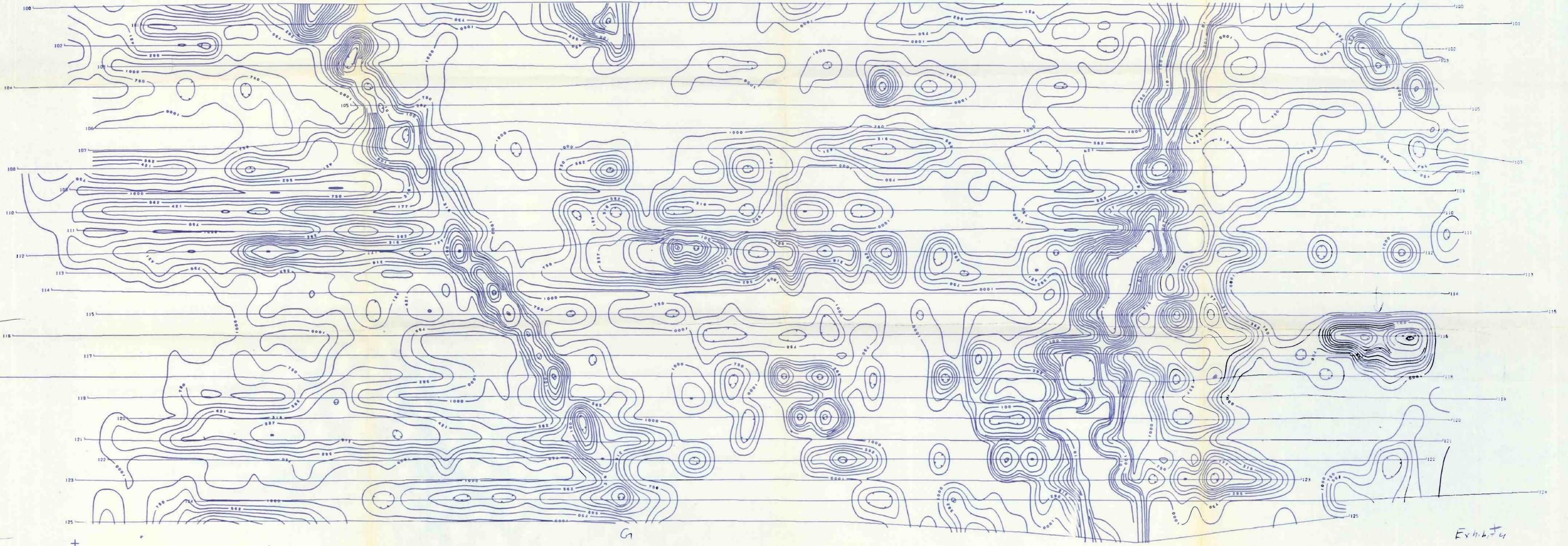
Processed by DIGEM LIMITED

Exhibit 2



RESISTIVITY MAP BASED ON UNLEVELLED DATA

Processed by DIGHEM LIMITED



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RES

Exhibit

RESISTIVITY MAP BASED ON LEVELLED DATA

Processed by DIGHEM LIMITED



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Exhibit 5

APPENDIX 1

PROPOSAL FOR THE PROCESSING
OF NGU DATA

For

A/S SYDVARANGER IRON ORE COMPANY
(Copy to Gulf Mineral Resources Co.)

October 28, 1982

INTRODUCTION

The NGU helicopter-borne EM data contain a high level of noise as well as fairly rapid non-linear drift. The data also contain obvious EM anomalies with responses many times larger than the noise level. Therefore, it can be reasonably assumed that smaller anomalies exist in the data and are masked by noise and/or drift.

The extraction of anomalies which exist within the noise level can often be accomplished by digital filtering. The method works well if there is minimal spectral overlap between anomalies and noise. However, the NGU data contains severe spectral overlap, so special techniques must be employed if digital processing is to be useful. The method described below will yield "anomalies" which can be calibrated crudely in terms of the probability that they reflect bedrock conductors. Thus, for example, anomalies can be graded in the range of 10 to 100, indicating a probability that they are "real" in the range of 10% to 100%.

The categorization of anomalies by probability is unusual. By itself, there is a large chance of judgmental error. This is obvious since a decision might be made to

follow up a 70% anomaly when, by definition, there is a 30% chance that it is noise.

A means of improving the decisions regarding the selection of anomalies for follow-up exploration could be provided by plotting them on suitable geophysical base maps. These base maps would contain geophysical information which is suitable for evaluating the EM anomaly patterns. Such geophysical base maps could be provided by enhanced magnetic contours and by resistivity contours.

THE RECOMMENDED PROCEDURES

The procedures which are recommended for the identification of NGU anomalies are as follows:

- (a) Produce a resistivity contour map; this will require several attempts at manual levelling the EM data.
- (b) Produce an enhanced magnetic contour map.

These two maps will aid in geologic evaluation and mapping. They will also serve as base maps for the appraisal of EM anomalies. Bear in mind that this appraisal is not directed

towards rating conductance. Rather, it is directed towards determining the likelihood of the anomaly being "real", i.e., that it reflects a bedrock conductor.

Continuing with the procedures recommended herein:

- (c) Produce profiles of all raw data. Also produce inphase and quadrature filter function profiles which are designed to display only those spectral components which are characteristic of anomalies.
- (d) Cross-correlate the inphase and quadrature filter functions to produce a cross-correlation profile. An anomaly on this profile will have an amplitude which is crudely proportional to the probability that the anomaly reflects a bedrock conductor.
- (e) Plot the cross-correlation anomalies from (d) above on the base contour maps of (a) and (b) above.
- (f) A total field magnetic map, contoured at 25 nT, could be produced if the 100 nT NGU contour map is considered to be inadequate.

- (g) Additional levelling efforts could be done to produce a magnetite EM map, but its value probably would not warrant the labour cost.
- (h) Interpret the cross-correlation anomalies by studying the maps of (e) above and by referring to the profile data of (c). Anomalies which follow trends on the contour base maps, and which look reasonably permissible on the profiles, would be classed as potential bedrock targets. Those that do not follow trends, and which have the appearance of noise on the profiles, would be discarded. Those that fall between these two classes would be judged on their overall characteristics, geologic association, etc. The interpretation could be done by Sydvaranger personnel.

QUOTATION

The following costs are based on the processing of the data from a 2,000 line-km survey flown by the NGU:

	<u>US\$/km</u>
1. Levelling of EM channels, computation of resistivity, preparation of a resistivity contour map, and plotting of profiles of EM and resistivity	\$10.00 ✓
2. Preparation of an enhanced magnetic contour map	2.00 ✓
3. Computation of inphase and quadrature filter functions and a cross-correlation function, and plot these three profiles	3.00 ✓
4. Plot peaks of the cross-correlation profile as anomalies on the resistivity and enhanced magnetic contour maps. The density of ink for each anomaly will be proportional to its amplitude and, hence, to its probability of being "real" (this requires #3 to be done)	2.00 ✓
5. Produce a total field magnetic contour map	2.00
6. Produce a magnetite EM contour map (this requires #1 to be done)	5.00
7. Interpret the anomalies and recommend follow-up exploration	4.00

A review of the problems inherent in the NGU data suggest that the data processing should include all of items 1 to 4. However, items 5 to 7 are not strictly required. Item 5 is already in existence even though the NGU map is

coarsely contoured. Item 6 is not likely to be cost-effective. Item 7 can be handled by Sydvaranger personnel.

The cost quotations of this proposal assume that geographic coordinates are given on VAX-compatible magnetic tape for each geophysical value.

Respectfully submitted,
DIGHEM LIMITED



D.C. Fraser
President

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