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Some results from Project AEM Greenland 1995

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ISBN-87-7871-007-3

Abstract

The recent surge in diamond exploration activity around the world has not bypassed Greenland, a country with known kimberlites and reported microdiamonds.

The main focus of Project AEM Greenland 1995 was the search for nickel bearing, massive sulphide deposits within the norite belt of the Archaean craton of West Greenland (Stemp, 1996). A secondary objective was to evaluate the potential application of this airborne data in the direct search for kimberlite pipes. This specific application is the subject of this report.

Contents

7 figures included

1. Introduction

The principle objective of Project AEM Greenland 1994-98 is to locate massive sulphide deposits which may host economic base metal and/or precious metal mineralization (Stemp & Thorning, 1995). The detailed, low altitude, airborne survey data have many other applications, including the search for kimberlite pipes.

Part of the funding for Project AEM 1995 and justification for 200 metre flight line spacing over a portion of the Maniitsoq-Nuuk survey area, was to test the use of the airborne data for kimberlite prospecting. This short report briefly describes the geological potential of the area, guidelines for the use of the airborne survey data and also provides some specific examples of kimberlite pipe targets. This report should be used in conjunction with Report 1996/11 which fully describes the Maniitsoq- Nuuk airborne survey (Stemp, 1996).

Since this kimberlite study was initiated , there has been a tremendous resurgence in diamond exploration in Southwest Greenland, including participation by some of the major companies active in the diamond play in the Northwest Territories of Canada. As of June 1996, exclusive mineral exploration licences have been issued for virtually all of the ice-free area on the west coast from South Greenland north to the Disko Bay region (MINEX 1996). Thus, this study is now dwarfed by the large private exploration programmes presently underway.

The reason for this recent activity can be best summarized by the following two press release quotes:

a) **Quadrant Resources Pty Ltd - 25 January 1996**
"In 1995 Quadrant carried out diamond prospecting in West Greenland. The diamond indicator minerals found in the stream sediment samples have compositions which confirm that they are derived from the diamond stability field. The areas identified are "new" and it would appear likely that the minerals have been derived from large intrusive bodies of kimberlite and/or lamproite."

b) **Platinova A/S - 8 July 1996**
"Platinova has been awarded several large concession areas covering the Archean Geological Province of West Greenland. Kimberlite dykes with prospective mineral chemistry are known to occur in this area. Recent work suggests that kimberlite pipes may be present concealed by small lakes following glacial erosion, as is the case in the Northwest Territories of Canada."

2. Diamond (kimberlite) Exploration Stages

The basic steps in diamond exploration can be summarized as follows (Jennings, 1995):

(a) locate a potentially favourable geological province
(b) stream sediment/soil sampling for diamond indicator minerals
(c) photogeological studies for circular structures, including lakes
(d) detailed, low level, airborne geophysical surveys for kimberlite pipe targets
(e) if pipes are located, determine if they are diamondiferous
(f) if diamondiferous, determine if they are economic

The use and order of application of these steps can vary widely depending on factors such as the geological environment and exploration funds available. This report relates to steps (c) and (d).

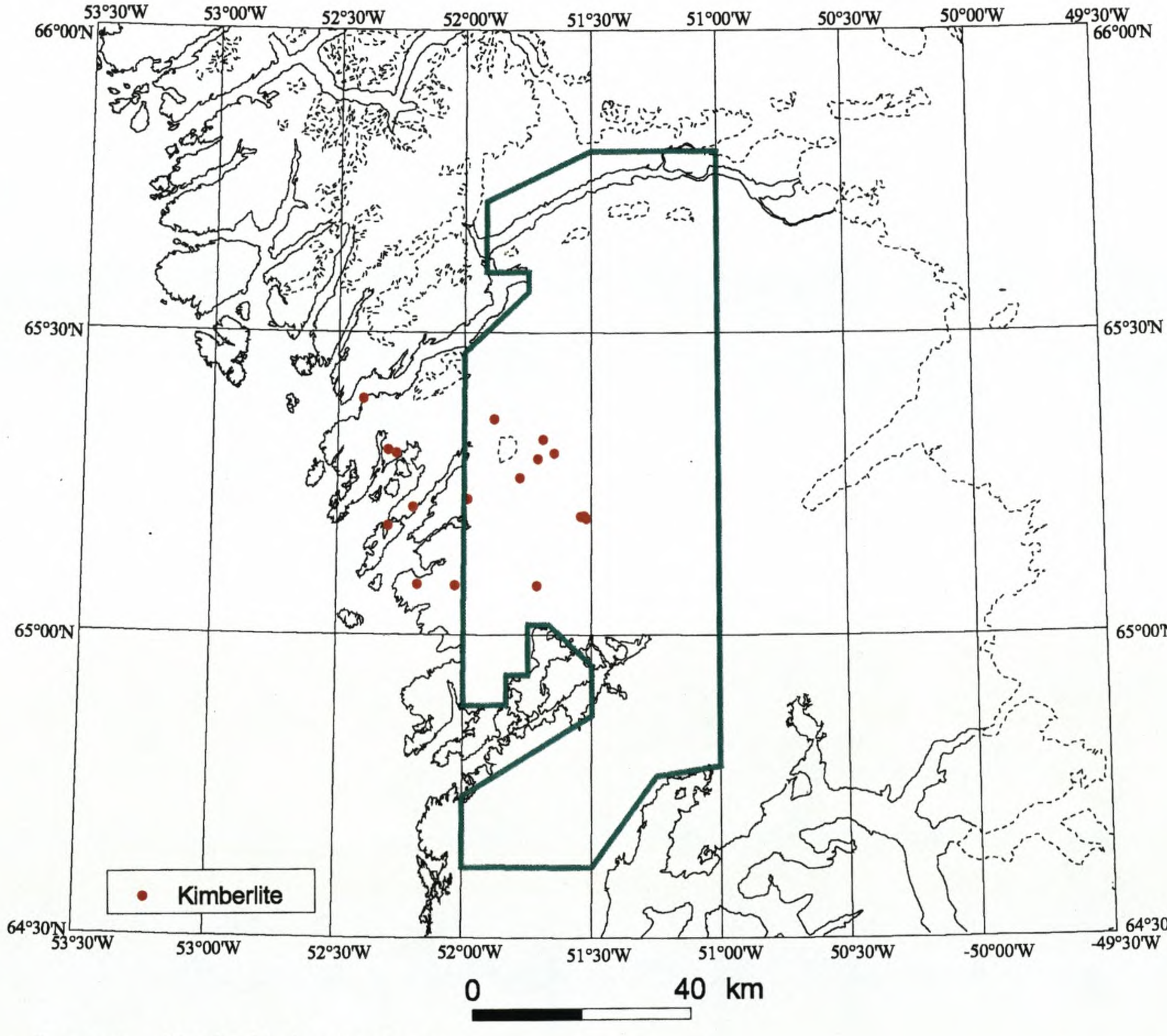

Figure 1. Kimberlite location map

3. Geological Potential

The diamond potential of the Archean craton of West Greenland has been established for many years. Kimberlite dykes and float have been reported from many localities (Larsen, 1991) and a few microdiamonds have been found. More recent pressure-temperature studies together with the discovery of diamond indicator minerals have enhanced this potential. On the negative side, no kimberlite pipe has yet been discovered.

Figure 1 shows the location of the Maniitsoq-Nuuk survey area plotted on one of Larsen's (1991) kimberlite location maps. Note that there are a few reported kimberlite occurrences within the survey area.

Figure 2 shows the 1:50 000 map sheet layout. All of the examples used in this report are from map sheet 6 (shaded) situated immediately east of the mapped norite belt as well as some reported kimberlites. Re-examination of these kimberlites would be a logical first step in any detailed exploration of this immediate area.

The author believes that any kimberlites in the area would use the same deep mantle "plumbing" system that established the norite belt. He also believes that this system consists of major NNE trending faults with numerous younger cross cutting fracture zones oriented approximately N60E.

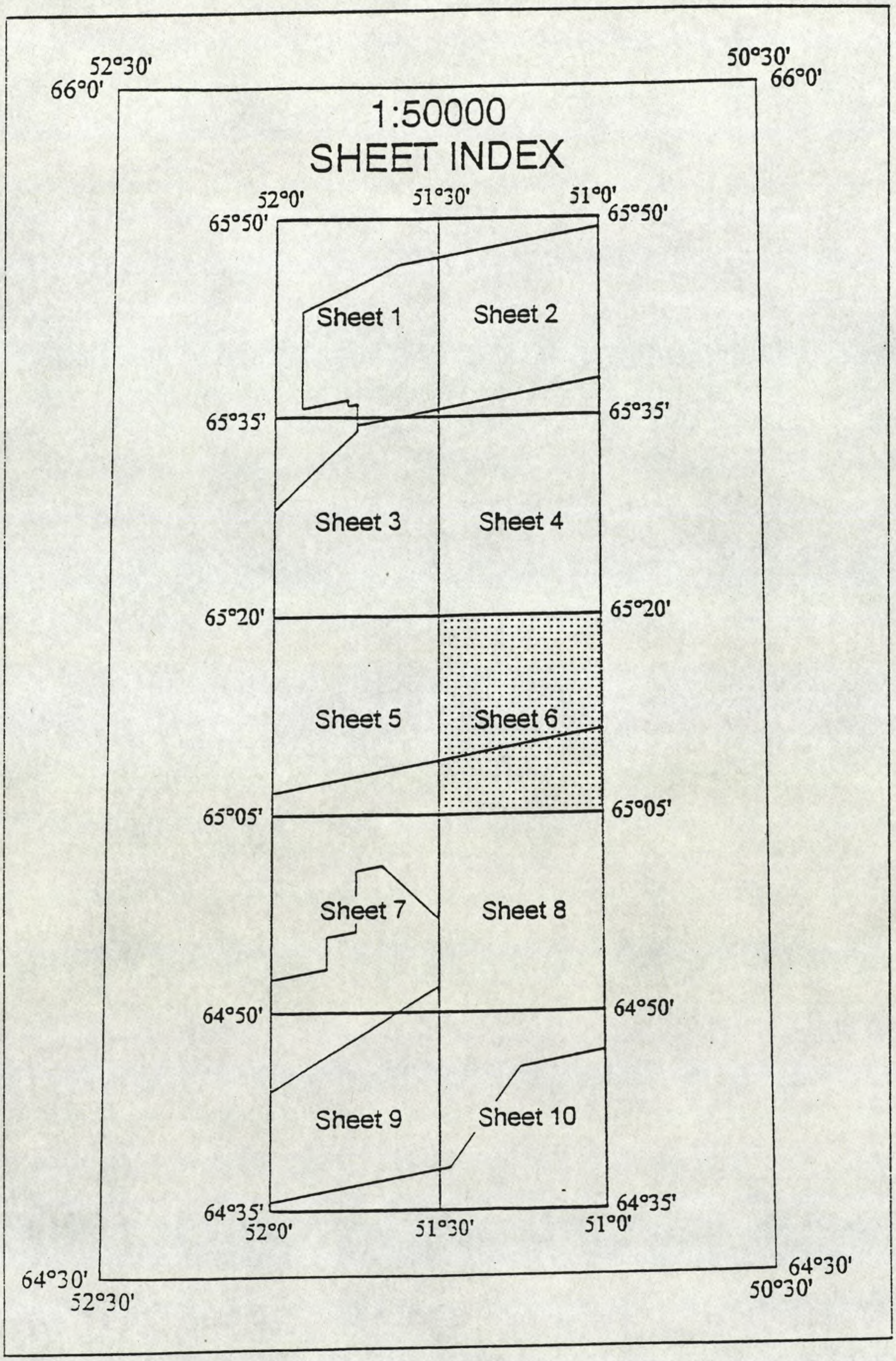

Figure 2. 1:50 000 map sheet layout

4. Data Available From The Survey

There are four types of data sets available from the survey that may prove useful in locating kimberlite pipes.

- **Landsat TM base maps**

In order to provide an accurate topographic base for the geophysical data, Landsat images were produced. At a scale of 50 000 these images are extremely useful in identifying circular structures, round lakes etc. that could represent kimberlite pipes.

- **Colour Video**

It is generally standard practice on airborne geophysical surveys to record the flight path below the aircraft on a colour video camera. This is mainly intended for flight path recovery but with the advent of good global GPS coverage, this use has been greatly diminished. However in Greenland the video has many geological applications because of large areas of bedrock exposure.

For kimberlite prospecting, it can be used directly on its own to search for circular anomalies or it can be used to check targets already selected from the Landsat or geophysical data sets. It can also be used to check vegetation cover and to determine in a simplified fashion whether a lake is shallow or deep. These last two factors sometimes play a role in kimberlite exploration.

- **Magnetic Data**

This includes profile data, contour maps and derived products such as first vertical derivative maps. It is the most useful geophysical tool and has two important applications (Macnae, 1995):

- mapping regional structures that may have a direct bearing on the distribution/location of kimberlite pipes, and

- direct detection of the classic " bull's eye" magnetic signatures of the pipes (Keating, 1994)

Kimberlite pipes are small targets for airborne detection (a few hundred metres in diameter) and therefore surveys have to be designed with close line spacing (preferably 200 metres maximum) and low sensor altitudes. The pipes are almost always magnetic, but often less than 100 nT to an airborne system. Remnant magnetization is the key element, and thus negative or positive anomalies are possible, depending on location and geologic age.

The ability of magnetics to resolve the pipe signatures is highly dependent on the magnetic properties of the host lithology.

- **EM data**

Electromagnetic data is normally less effective in kimberlite pipe exploration as often the pipes are non- conductive. However, in certain geographic regions, the EM can be very effective, especially when used in conjunction with magnetic data (Smith *et al*, 1996). This is the case in northern Canada where round lakes or parts of lakes generally provide the surface expression of the pipes. There is a lot of controversy as to the source of the weak conductivity anomalies over these pipes *e.g.* lake bottom sediments, clay minerals formed by weathering, porosity of the pipes, lake water or some combination.

As with magnetics, the ability to easily resolve the "bull's eye" conductivity patterns is highly dependent on the electrical properties of the host lithology and any overburden that is present.

5. Data Integration Maps

As an experiment for this study, some additional compilation was carried out to produce a set of data integration maps at a scale of 1:50 000. This was an attempt to combine a number of geophysical signatures onto a single map and possibly highlight potential kimberlite prospects *i.e.* create a set of "kimberlite key-maps". It should be stressed that this is not new data but an attempt to find a quick evaluation technique when faced with large amounts of data. If the data integration map draws attention to a particular feature, then the more detailed individual data maps referred to in section 4 should be examined closely to best define the possible source of the feature.

For this particular study, the EM information is represented by the amplitude of the Z-coil channel 20 (cyan), the amplitude of the total energy envelope of channel 1 (yellow) and the amplitude of the decay constant (magenta). The magnetic information is represented by the calculated vertical gradient, with the negative values contoured in red and the positive values contoured in black. To avoid clutter, the mid-range values (-200 to + 200 nT/km) were not contoured. Figure 7 is an example of this presentation.

Other combinations of geophysical parameters and colours could , of course, be tried.

6. Discussion of Results

Since there is no known kimberlite pipe in Greenland to use as a benchmark, the interpretation of all of the parameters must use the circular shape and limited diameter as the main selection criteria. For example:

- will pipes form lake filled topographic lows such as in the Northwest Territories or small hills such as the mapped norites in the region?

- will the pipes be magnetic and/or conductive?

- will magnetic anomalies be positive or negative?

Even with a standard model, the physical characteristics of kimberlites usually vary within specific kimberlite provinces.

Another key item in an interpretation is the coincidence of responses, such as a round lake coincident with a magnetic anomaly of the same size. This is the reason for experimenting with the data integration maps.

Sample targets from the map sheet 6 region are illustrated in 5 figures:

Figure 3. This is a typical Landsat scene at a scale of 1:50 000 which can be used to search for round lakes or structures. The circular depression which is highlighted in the south central part of the scene is verified on the video. It is situated just south of an east-west fault zone and also associated with a positive magnetic anomaly of about 200nT.

Figure 4. This displays multi-parameter profiles from the airborne geophysical survey.

Example A shows high amplitude, negative magnetic anomalies related to mapped norites

Example B shows low amplitude, negative magnetic anomalies of unknown origin

- these local anomalies (usually appearing on 1 or 2 flight lines only) are quite common in this study area east of the mapped norites and reported kimberlites
- are they small, unmapped norites or other intrusives?
- magnetometer scale: 1 cm = 100 nT

Figure 5. Residual intensity magnetic map at scale of 1: 20 000
This colour contour map highlights some "bull's eye" magnetic anomalies of varying magnitude and polarity. It also demonstrates that the ease of selecting these targets is highly dependent on their magnetic susceptibility together with the susceptibility of the host lithologies.

Figure 6. EM presentation: Total energy envelope of channel 1 (scale 1:50 000)
This GEOTEM presentation combines the amplitude response from both the X and Z receiver coils in an attempt to emphasize localized conductivity changes. These EM targets are best used in combination with other parameters.

Figure 7. Data integration map targets as discussed in section 5. Note that there are still some EM levelling problems visible on the channel 20 (cyan) plot.

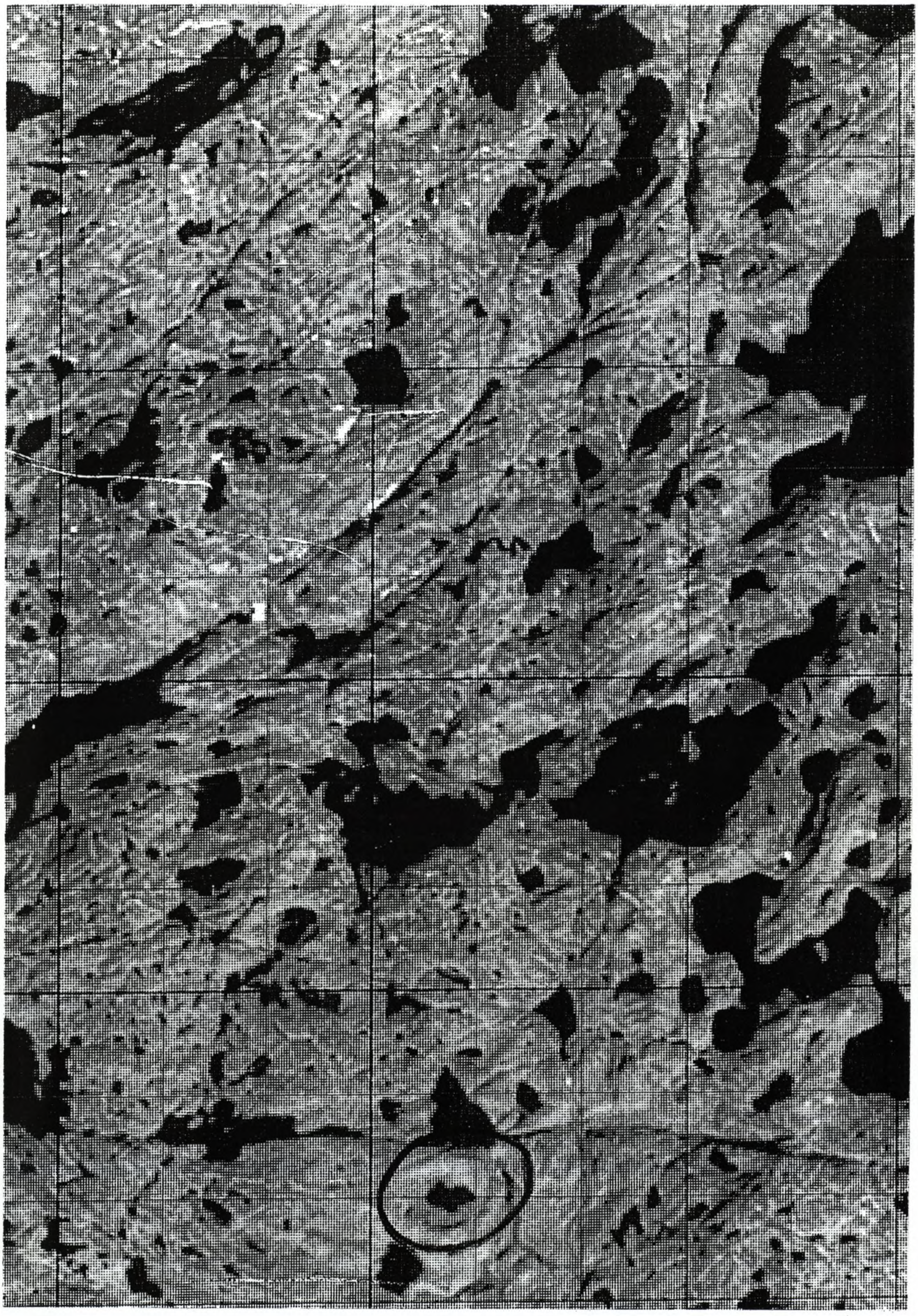

Figure 3. LANDSAT TM scene

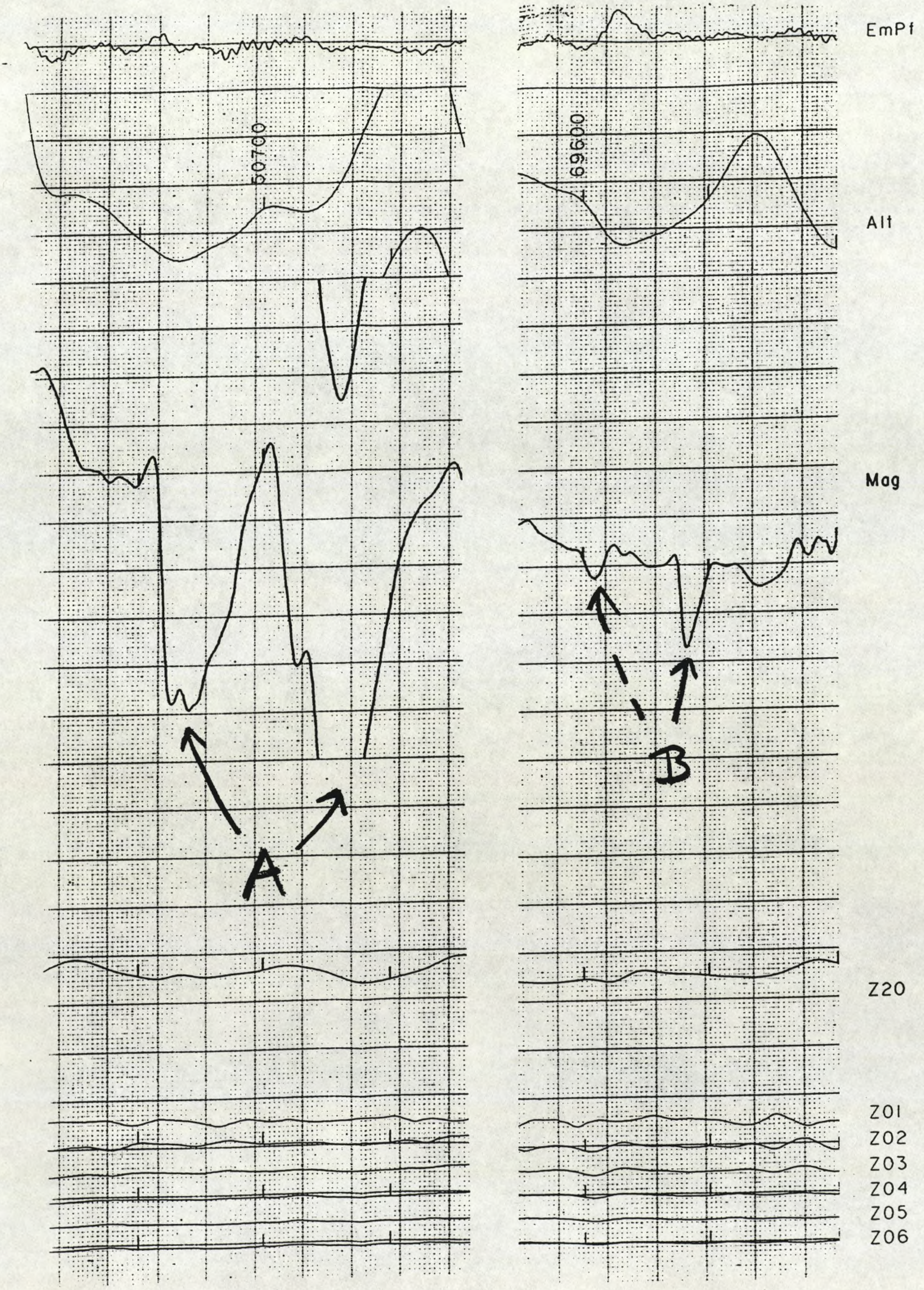

Figure 4. Negative magnetic anomalies

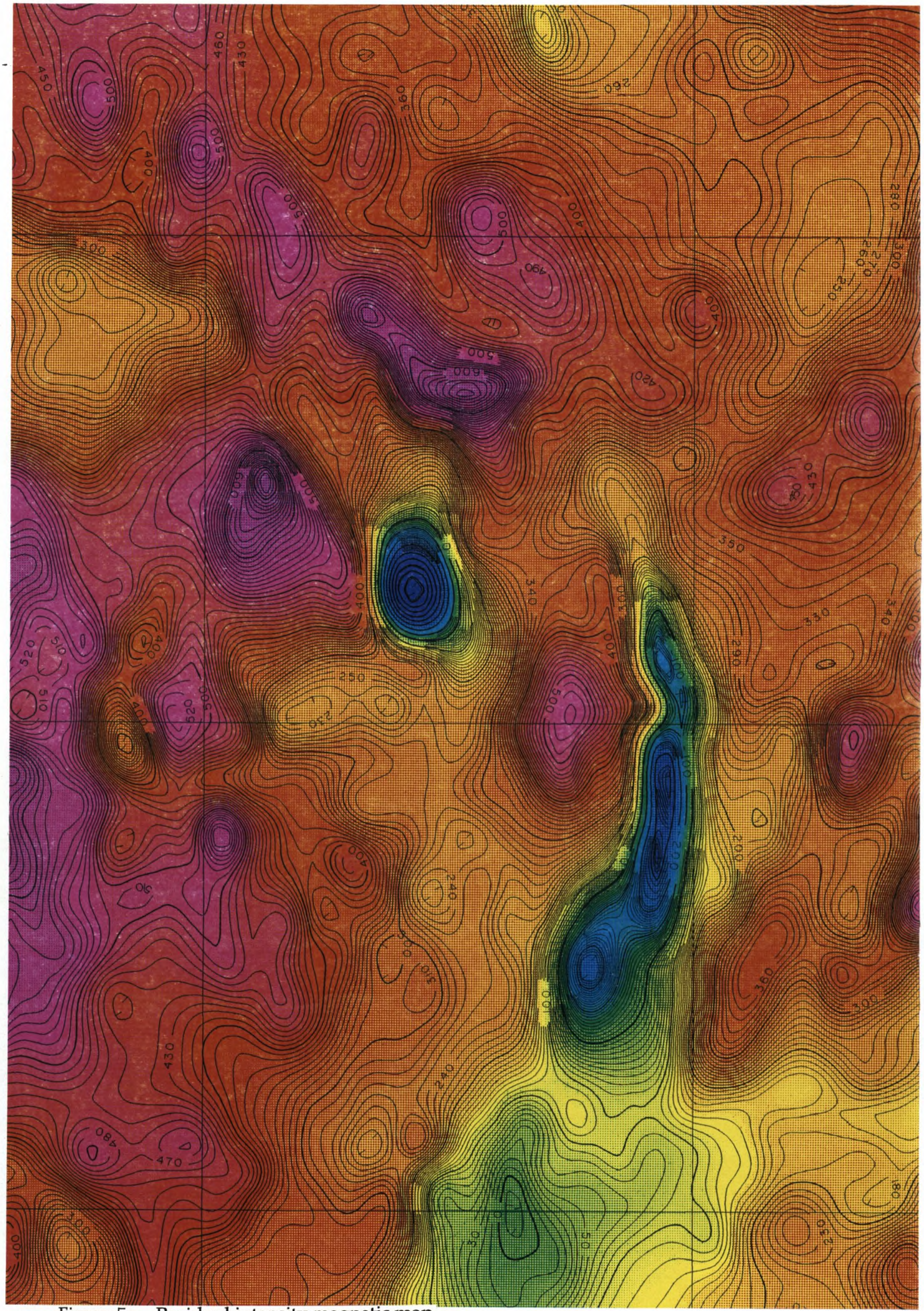

Figure 5. Residual intensity magnetic map

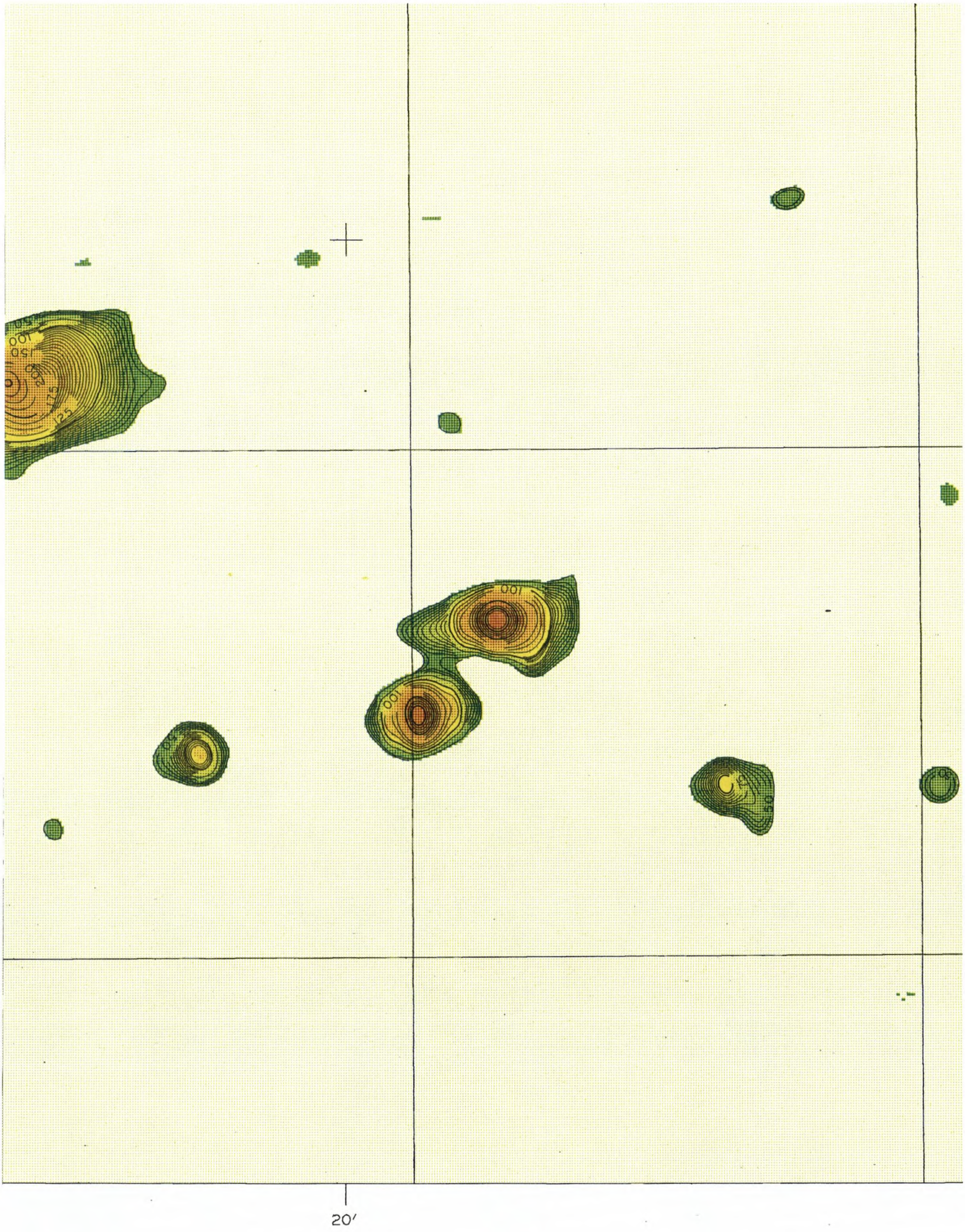

Figure 6. GEOTEM total energy envelope of channel 1

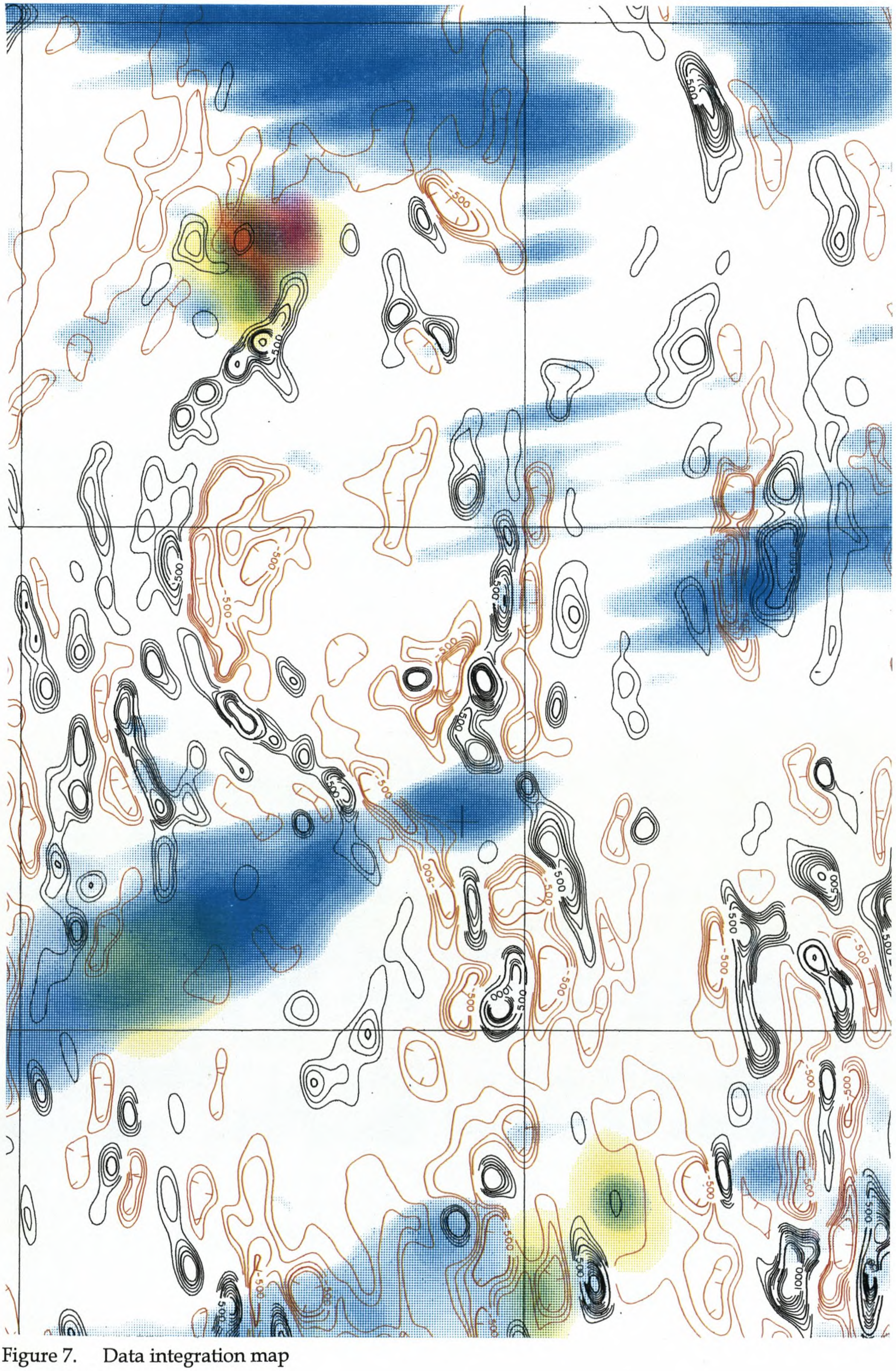

Figure 7. Data integration map

7. Conclusions

The exploration guidelines presented in this report can be applied to any low level, airborne geophysical data set including Project AEM 1994 in Inglefield Land (Stemp & Thorning, 1995) and Project AEM 1996 in the Grønnedal area (results not yet released). This latter survey has some resolution advantages since it was flown by helicopter, and it also includes radiometric measurements which may provide additional diagnostic information.

The present guidelines when applied to the Maniitsoq-Nuuk survey area are "too open" and actually provide too many potential anomalies. New information and/or ground truthing is required to narrow the focus of the anomaly selection process.

It should be stressed that this report is not an attempt at interpretation of the Maniitsoq-Nuuk survey data, but rather a guide on "how to" with selected examples.

8. Acknowledgements

Project AEM Greenland 1994-1998 is financed by the Greenland Home Rule Government. An additional financial contribution was provided by Cominco Ltd. for the Maniitsoq-Nuuk project. Local logistical support and office facilities provided by the Minerals Office staff in Nuuk are acknowledged. Final thanks go to the Geoterrex staff for meeting all obligations of the contract in a dedicated, professional and timely manner and especially to Jean Lemieux for his specific discussions relating to the "data integration map set".

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