DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/12

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Results from Project AEM Greenland 1996

Robert W. Stemp

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Contents

44 figures are included

Abstract

This report provides a general overview, together with a specific selection of geophysical anomalies recommended for ground follow-up, of the results from Project AEM Greeenland 1996 - a multiple sensor, helicopter borne geophysical survey conducted in the Grønnedal region of South-West Greenland as the third survey of Project AEM Greenland 1994-1998. This was the most comprehensive (four geophysical techniques simultaneously measuring 19 separate parameters), detailed, low level airborne survey ever carried out in Greenland. During this initial phase of compilation, ten (10) separate map products were created together with multi-channel profile plots for each flight line, all at a scale of 1:20 000.

Five separate blocks were surveyed, primarily covering Ketilidian (early Proterozoic) and Tartoq (Archean) supracrustal belts. Individual discussions of each survey block, with respect to economic mineral prospects, are presented in the appendices.

This report is specifically intended for mineral explorationists but the data can also be used by other earth scientists for a variety of applications. Detailed geological mapping can be greatly enhanced by these multi-sensor data.

Mineral exploration prospects for direct ground follow-up that companies and geoscientists familiar with the use of these geophysical results may be seeking, could include some of the following:

- massive sulphide zones related to specific EM anomalies
- uranium concentrations mapped by the radiometric survey
- "magnetite" mapping by both EM and magnetic surveys for indirect detection of associated minerals
- alteration zones mapped by the radiometric survey (potassium channel)
- kimberlite pipe detection, i.e. circular structures on magnetic, radiometric or EM maps (Stemp, 1996b).

Introduction

Phase three of Project AEM Greenland 1994-1998 was formally concluded on 1 March 1997 with the public release of all data and reports. A helicopter-borne, multi-frequency electromagnetic system was used for the first time together with simultaneous magnetic, radiometric and VLF-EM measurements. The project is financed by the Government of Greenland and managed by GEUS under the direction of project leader L. Thorning and geophysicist R. W. Stemp.

The survey blocks are situated near the southern Archean boundary of West Greenland and were initially selected to cover both Proterozoic and Archean supracrustal belts with a potential for economic base metal or precious metal mineralization. Another initial requirement was for the survey blocks to be free of existing mineral licences. The result of this selection process was three-fold:

- more heavily prospected supracrustal belts to the south and west were not surveyed
- new mineral exploration licences were issued covering the survey blocks in anticipation of the geophysical data to be released
- the Sermiligarssuk North area was extended to the north to cover older? greenstone rocks of more limited areal extent.

Field operations for Project AEM Greenland 1996 were based in Grønnedal, a Danish naval base, over the period from the 30 May to the 22 October, 1996. The survey was carried out by Aerodat Inc., a Canadian contractor, and supervised by GEUS personnel. An ASTAR (AS-350B2) helicopter owned and operated by Greenlandair A/S served as the platform for the geophysical system. Total financing of the project was provided by the Government of Greenland.

A total of 8,756 line kilometres of geophysical data was acquired over five separate survey blocks (Figure 1), namely:

Survey Block	Flight Line Direction	Line Kilometres
1) Sermiligaarsuk North	150	3,540
2) Midternæs	150	2,950
3) Grænseland	90	1,515
4) Sioralik South	90	463
5) Arsuk Ø	0	288

The survey was flown at a mean helicopter terrain clearance of 60 metres with flight lines spaced at 200 metre intervals and control lines at 2000 metre intervals.

This report is divided into two main sections. The main body of the report provides a comprehensive overview of all aspects of the survey and examines the results of the various geophysical parameters in a comparable way with respect to the geological setting of the five survey blocks. The second section of the report, i.e. Appendices A-E, discusses each survey block separately with respect to anomalous geophysical prospects for future ground follow-up.

Additional information on survey specifications and data compilation procedures is available in a report by Aerodat (1997) which is provided with each data purchase.

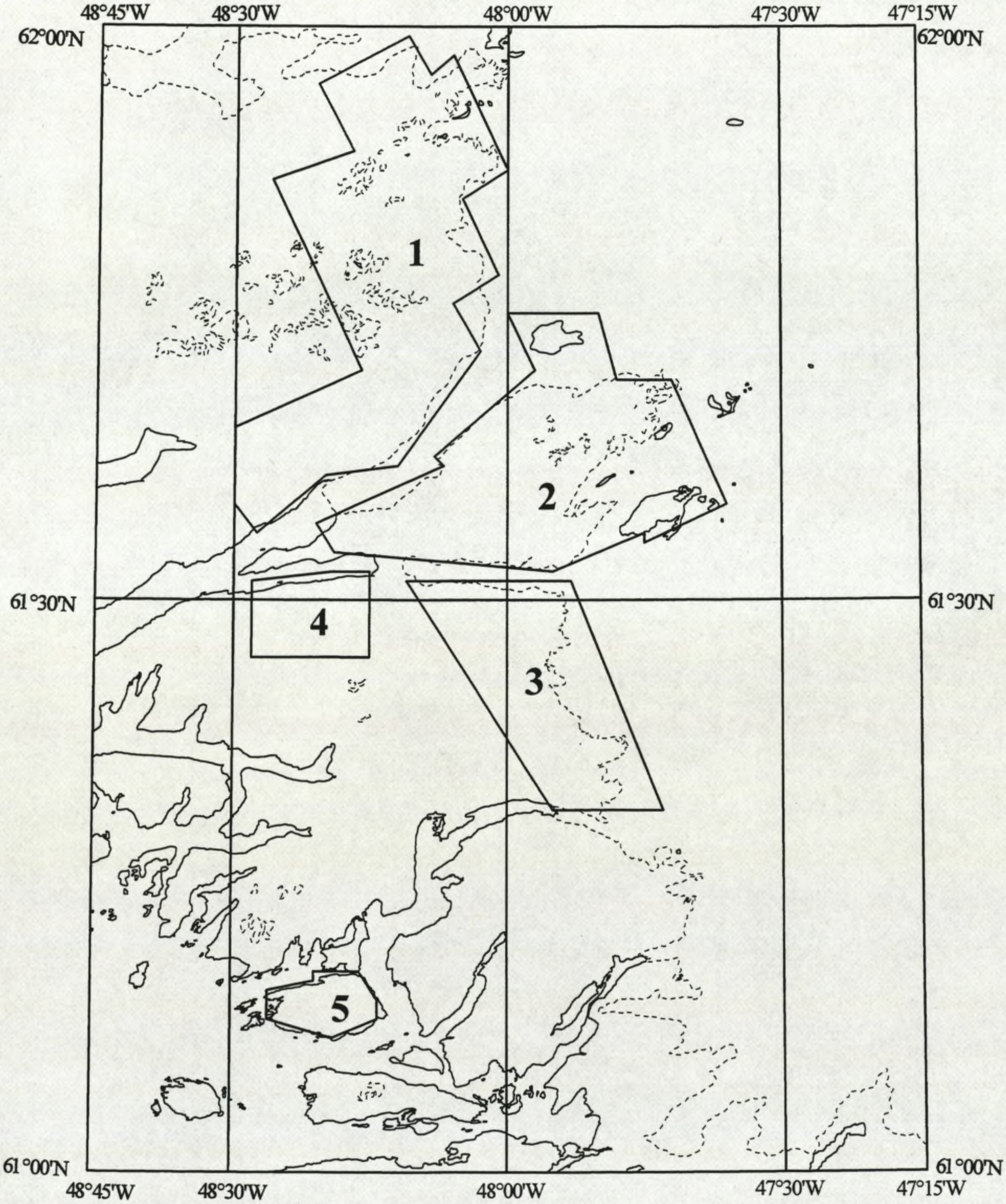

Figure 1. *Location map. (1) Sermiligaarsuk North, (2) Midternæs, (3) Grænseland, (4) Sioralik South, and (5) Arsuk Ø*

Outline of geology

The survey areas are situated in the southernmost part of the Archean craton of southern West Greenland. To the south the craton is flanked by a Paleoproterozoic orogen, the Ketilidian orogen. The Archean section is tectonically disturbed by the orogen and display an increasing degree of Proterozoic deformation towards the boundary, which is situated at Kobberminebugt.

The 1:500 000 scale geological map (Allaart, 1975) and map description (Kalsbeek *et al.*, 1990) give a good introduction to the geology. More detailed descriptions are found in Higgins (1990) for the area north of latitude 61°30'N and by Berthelsen & Henriksen (1975) for the area south of 61°30'N. Thorning *et al.* (1994) and Ady & Tukiainen (1995) present maps of existing regional geological, geophysical and geochemical data.

A geological sketch map (modified from Higgins, 1970) serves as a simple reference for readers of this report.

The Archean is dominated by 2.7 to 2.9 Ga old gneisses, but contains the older Tartoq Group supracrustals consisting of mafic to ultramafic metavolcanic units with subordinate felsic metavolcanic or metasedimentary rocks. The Tartoq supracrustals are intruded by a granitoid dated at *c.* 2.944 Ga. The Archean basement is uncorformably overlain by Ketilidian supracrustal rocks and is intruded by Ketilidian dolerite dykes and granites. The supracrustal rocks comprise a lower unit of shales and greyvackes with subordinate quartzite, conglomerate and carbonate rocks and an upper unit of predominantly basic lavas intruded by basic sills and sheets. The supracrustal rocks are almost unmetamorphosed at Midternæs, while the metamorphic grade increases to amphibolite facies in southern Grænseland and Arsuk Ø. In Mesoproterozoic times (Gardar period, 1.3 to 1.1 Ga) the boundary region between the Archean and Ketilidian terrains was subjected to rifting and intrusions of numerous dykes of basaltic to trachytic compositions as well as of felsic alkaline complexes including carbonatites.

Specific economic geology references will be made throughout the report during discussions on interesting geophysical anomalies.

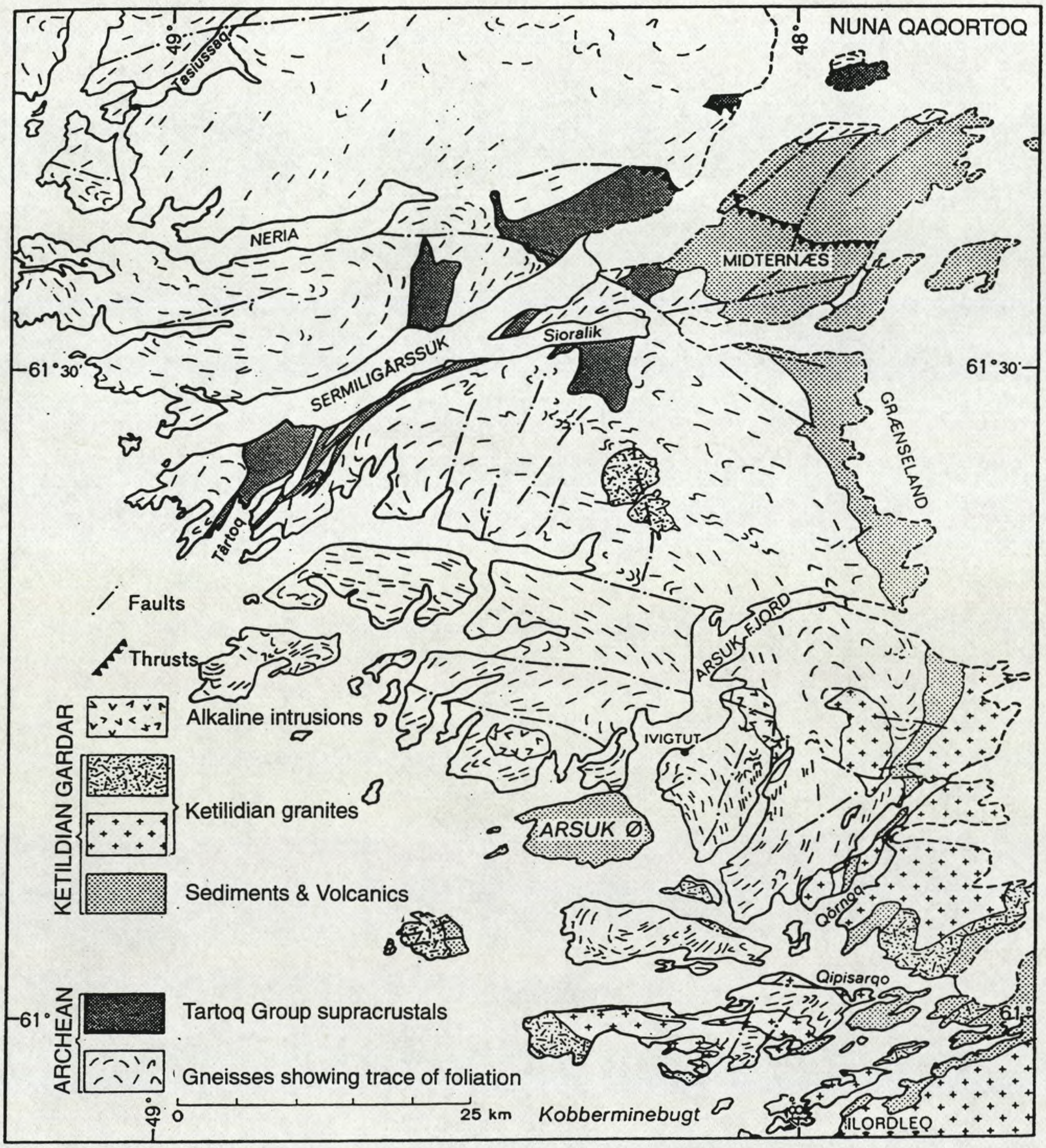

Figure 2. *Geological sketch-map of the area between Kobberminebugt and Neria*

Instrumentation

Aerodat's multi-sensor, helicopter geophysical survey system is depicted in Figure 3. The multi-frequency HEM system is housed in the lower bird at a mean survey terrain clearance of 30 metres. The upper bird is flown at 45 metres terrain clearance and houses both the magnetometer and VLF-EM sensors. All other equipment is mounted on the helicopter platform, including a gamma ray spectrometer, a video camera, the GPS navigation system, radar and barometric altimeters plus analog and digital recorders.

For this contract survey, the HEM system and the magnetometer were considered the primary geophysical instruments, whereas radiometric and VLF-EM data were recorded on a "best effort" basis without interfering with the primary survey production. For example, some radiometric data was collected with snow on the ground and VLF signals were often noisy/weak for one of the channels. Despite these limitations, very useful radiometric and VLF-EM data was collected in all five survey blocks.

Electromagnetic system

An Aerodat five (5) frequency inphase/quadrature measuring system was used with two sets of vertical coaxial coil pairs and three sets of horizontal coplanar coil pairs providing 10 simultaneous EM parameter measurements every 0.1 seconds.

1) 860 Hz - horizontal coplanar
2) 920 Hz - vertical coaxial
3) 4200 Hz - horizontal coplanar
4) 4600 Hz - vertical coaxial
5) 33000 Hz - horizontal coplanar

Magnetometer

High sensitivity, cesium vapour sensors manufactured by Scintrex were employed both in the air and as a ground base station. The airborne sampling rate was 0.1 second and the ground sampling rate 1.0 seconds.

Gamma ray spectrometer

A 256-channel gamma ray spectrometer (Exploranium GR820) utilizing a sodium iodide detector crystal volume of 16.8 litres carried out the radiometric measurements. The system also employed an upward looking atmospheric detector of 4.2 litres. Corrected count rates were presented for the four traditional channels i.e. total count, potassium, uranium and thorium at 1.0 second intervals.

VLF-EM

A 2-channel Herz Totem 2A VLF-EM receiver provided total field and quadrature measurements from the line and ortho stations. Transmitting stations used included Cutler, Maine (24.0 kHz), Bordeaux, France (15.1 kHz) and Rugby, England (16.0 kHz).

Readers are again referred to Aerodat (1997) for a more comprehensive description of the instrumentation package.

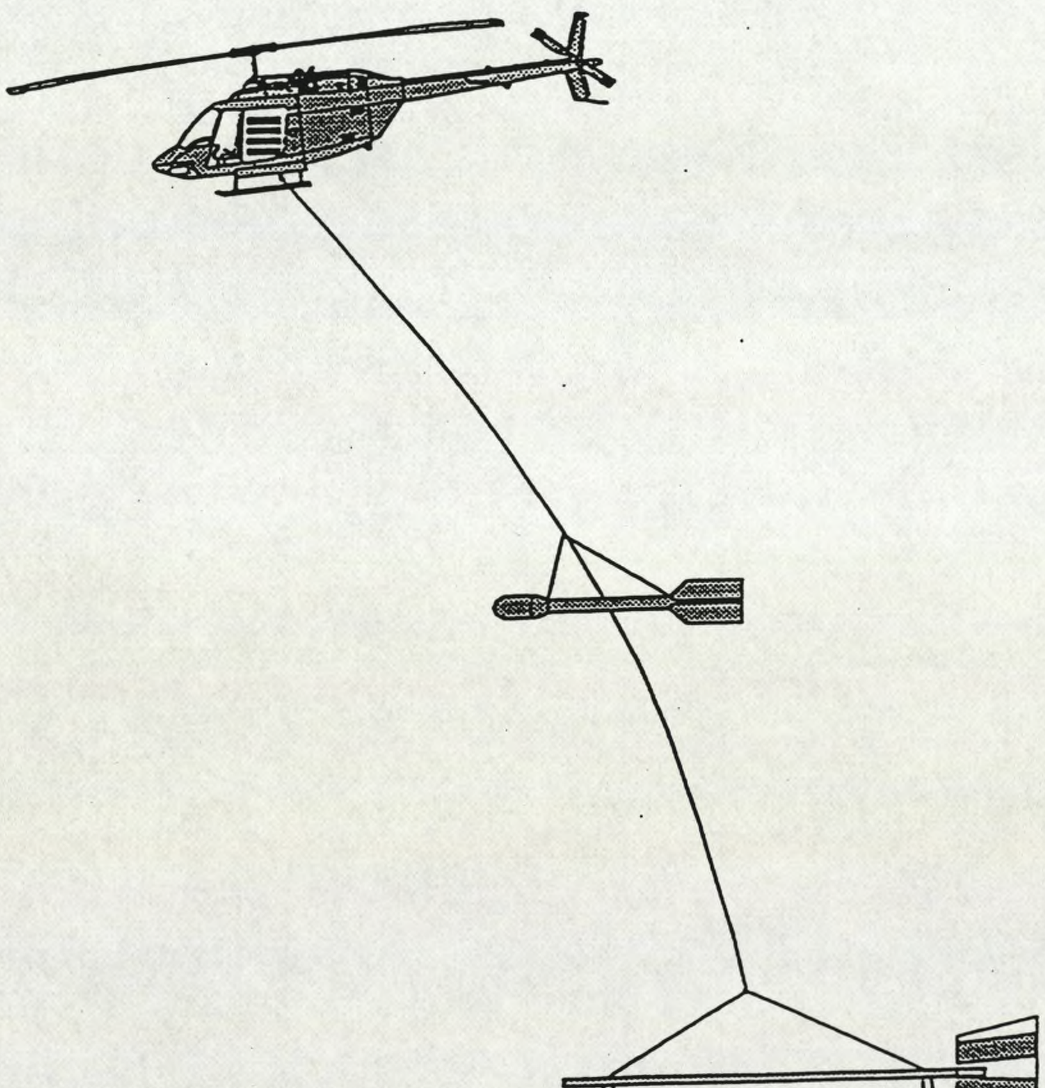

Figure 3. *Aerodat's integrated helicopter survey system. The large EM sensor and the VLF EM sensor are at the end of the cable. The smaller magnetic sensor is placed halfway up the cable.*

Presentation of results

Final products delivered to GEUS in accordance with the contract are listed below. These products are available for viewing at the GEUS office in Copenhagen as well as the Government of Greenland Minerals Office in Nuuk. These data are also available for purchase.

- Digital line and grid archives on CD-ROM (Geosoft format)
  - one CD-ROM per survey block

- 1:20 000 paper prints(black line & colour) of the listed parameters
  - base maps with flight lines and EM anomalies
  - total magnetic intensity contours
  - calculated magnetic vertical gradient contours
  - EM profile maps (inphase and quadrature) for the 4600 Hz coaxial data
  - calculated apparent resistivity contours based on the 4200 Hz coplanar data
  - VLF-EM total field contours from one transmitter station
  - corrected total count radiometric contours
  - corrected potassium count radiometric contours
  - corrected uranium count radiometric contours
  - corrected thorium count radiometric contours

  A total of 17 map sheets are produced for each listed parameter based on the following survey block distribution:

1) Sermiligaarsuk North	6 sheets
2) Midternæs	5 sheets
3) Grænseland	4 sheets
4) Sioralik South	1 sheet
5) Arsuk Ø	1 sheet

  NOTE: Although some of the 1:20 000 map sheets overlap, only data from one survey block is presented on a single map sheet i.e. separate sheet layouts for each survey block

- 1: 100 000 composites(colour) of the listed parameters
  - total magnetic intensity contours
  - calculated magnetic vertical gradient contours
  - calculated apparent resistivity contours based on the 4200 Hz coplanar data
  - VLF-EM total field contours from one transmitter station
  - corrected total count radiometric contours
  - corrected potassium count radiometric contours
  - corrected uranium count radiometric contours
  - corrected thorium count radiometric contours

  One map, covering all five survey blocks, is produced for each listed parameter.

- A4 format (colour)

  Page-size print sets were produced for each survey block for use in technical reports and Greenland promotional publications. Each set contains eight prints, based on the same parameters listed previously for the composite maps.

  In order to maximize the information presented on these single sheets and due to the size variation of the survey blocks, presentation scales are variable, namely:

1) Sermiligaarsuk North	1:250 000
2) Midternæs	1:250 000
3) Grænseland	1:200 000
4) Sioralik South	1:100 000
5) Arsuk Ø	1:100 000

- Multi-channel stacked profiles

  - one plot per flight line showing all measured/calculated parameters
  - 1:20 000 scale

Electromagnetic results

Since the principle objective of Project AEM Greenland 1994-1998 (Stemp & Thorning, 1995a, b) is to locate massive sulphide deposits of potential economic interest, the electromagnetic system is the prime geophysical tool.

The rough terrain associated with the 1996 survey blocks dictated the use of a helicopter in order to maintain the required survey elevation. HEM surveys provide higher resolution and more quantitative information for modelling specific anomalies than wider geometry, fixed-wing systems (e.g. GEOTEM) but are inferior with respect to depth of penetration. The lack of overburden in Greenland somewhat compensates for the penetration factor, except when exploring under the margins of the Inland Ice. HEM surveys also require a closer line spacing which is a cost disadvantage, but a plus for kimberlite pipe exploration (Stemp, 1996b).

The electromagnetic data is presented in four ways: as selected anomaly plots, as computed apparent resistivity maps, as profiles plotted along flight lines and as stacked profiles for each flight line. The resistivity map at 1:100 000 provides an excellent view of the EM results over all survey blocks. It is an inescapable fact that the Precambrian terrain is very resistive and thus bedrock conductors are readily highlighted as lower resistivity features. This was also noted in both the 1994 and 1995 surveys (Stemp, 1996a; Stemp & Thorning, 1995a, b). The ease of interpreting EM data in these parts of Greenland is in direct contrast to difficulties in many regions of Australia with very conductive overburden.

The main problem in Greenland, other than topography, is salt water and surveys are designed to minimize salt water areas. Arsuk Ø (Island) presented a special challenge in 1996 and as a result all survey lines started and ended over the sea. Thus, the resistivity map outlines the shape of the island!

Fresh water lakes show little conductivity but if a higher frequency (33,000 Hz) was used for the apparent resistivity calculation, more effects would be observed. The most obvious exception is the lake (Overløbssø) anomaly on the west side of Grænseland but it raises other questions because of an associated? intrusive magnetic anomaly.

On a regional basis, the apparent resistivity compilation shows a very distinct pattern. Most of the bedrock conductors are found in the mapped Ketilidian supracrustals of Midternæs, Grænseland and Arsuk Ø. In the latter block, they are less easily recognized because of proximity to conductive salt water along the northern coast of the island. For the most part, these long formational conductors are probably related to graphitic horizons which have been reported in the geological references.

However, they vary considerably in conductivity, magnetic association and strike patterns which may indicate areas of sulphide mineralization as well. In the Midternæs area, in particular, the resistivity results outline some very complex patterns. Note the highly conductive elliptical- shaped pattern that is mapped on sheet 1 (1:20 000). Some of these features are structural, but others are simply due to differential erosion which exposes or lessens the cover thickness to the conductive layer, which is gently dipping. Quantitative interpretation of the EM data from Midternæs will be the subject of an ongoing Ph.D. study by Lene Hjelm Poulsen. This is a co-operative program between GEUS and Århus University. The formational conductors in Grænseland generally have a northerly strike, whereas the dominant magnetic trend is northeast. The reason for this is that the EM conductors are in the Ketilidian and the magnetic pattern is strongly influenced by the older underlying rocks.

A lesser number of bedrock conductors were identified by the helicopter survey in mapped Tartoq supracrustal rocks in Sioralik South, as well as parts of Sermiligaarsuk North and Midternæs blocks. Graphite is not known to occur in this lithologic unit, so massive sulphide mineralization should be expected. In fact most of the high priority, massive sulphide, ground follow-up targets referred to in Appendices A-E are associated with Tartoq supracrustals. Base metals are normally the prime target of electromagnetic surveys, but in the Tartoq areas, the potential for associated gold mineralization is also excellent based on geological investigations carried out to date (Evans & King, 1993; Erfurt, 1990 and Erfurt & Lind, 1990).

The EM survey also identified some localized conductors within older greenstone belts in the most northerly part of the survey area i.e. Sermiligaarsuk North. Massive sulphide mineralization should be expected as the source of these conductors. This region has experienced little prospecting activity to date.

Magnetic permeability features, often referred to as magnetite anomalies, are also mapped by frequency domain EM systems. This produces a negative inphase anomaly which is opposite in sign to the conductive response and is thus a very diagnostic event. It is also possible to get combined permeability and conductivity effects. Although these can normally be recognized, inphase/quadrature ratios are distorted which affects conductivity calculations. Magnetite anomalies are plotted on the EM maps with a special symbol (see legends) and will be referred to in the Appendices.

Magnetic results

The aeromagnetic data is presented as contours of the total magnetic intensity as well as the calculated vertical gradient. These two parameters are also presented in profile form as part of the multi-channel, detailed profiles of each flight line.

Although the results are presented at 1:20 000 scale for individual survey blocks, it is interesting to look at the composite results to get a more regional picture. Even at the composite scale of 1:100 000 the amount of geological information is impressive. Since these survey blocks lie within the regional aeromagnetic coverage i.e. Projects Aeromag 1995 and 1996 (Thorning & Stemp, 1997), it is interesting to see how much extra information is mapped by the low level surveys. A comparison from the Midternæs block is shown in Figure 4. This comparison should not be viewed in a negative way since the programs have entirely different goals, and Project AEM Greenland and Project Aeromag have both been extremely successful.

Regionally, total magnetic intensity increases from the southeast to the northwest with the Archean crystalline rocks generally being more magnetic than the youngest supracrustals. The survey results show a total variation of approximately 5000 nT. The most dominant trend direction is north-easterly, corresponding to the old gneisses and the majority of the dykes. However, many other important structural trends have been mapped by the magnetometer. The vertical gradient presentation enhances both structural and near surface features.

The Ketilidian supracrustals are believed to have a generally low magnetic intensity but a first look at the compiled maps does not give this impression. There are three main reasons for this, namely:

1) In many areas the Ketilidian section is quite thin and the observed magnetic patterns are from the older, underlying lithology e.g. northern and western Midternæs.

2) Numerous dykes of higher magnetic susceptibility cut through Ketilidian supracrustals in all three pertinent blocks.

NOTE: It would be an interesting exercise to use the magnetic data to locate pre-Ketilidian age dykes and trace them under these younger rocks.

3) There are mineralized zones within the Ketilidian that are magnetic e.g. some northerly striking magnetic highs in the Grænseland block.

By contrast, the Tartoq supracrustals covered by this survey generally exhibit high magnetic signatures which probably reflects the predominance of basic to ultrabasic rock types. Another important observation is that most of the ultrabasic intrusives mapped by the aeromagnetic survey are associated with Tartoq areas. These are the highest amplitude magnetic units identified by the airborne survey. For example, the ultrabasics in the Sioralik South block were previously mapped, whereas the magnetic survey identified a feature interpreted as a new intrusive under the glacier in the Midternæs block just south of Nuna qaqortoq.

There may be one exception to the lack of ultrabasic intrusions in the Ketilidian as a high intensity magnetic unit was mapped in the central part of Arsuk Ø.

Specific ground follow-up targets related to magnetic anomalies will be discussed in the Appendices section of this report.

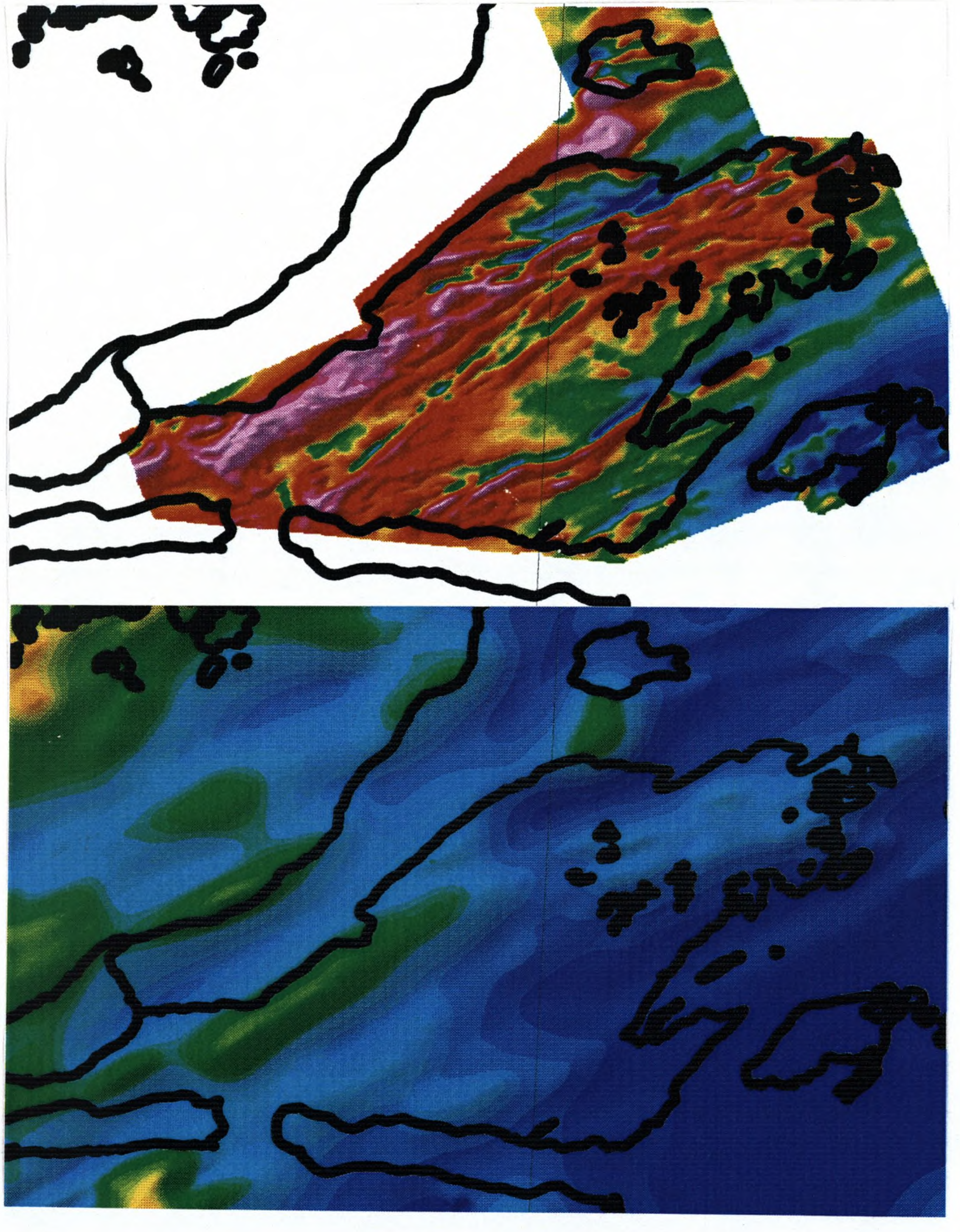

Figure 4. *Comparison of the detailed aeromagnetic anomaly map from Midternæs produced in Project AEM Greenland 1996 (top) and the regional aeromagnetic map from Project AEROMAG 1996*

Radiometric results

After corrections for background, altitude and Compton scatter the gamma ray spectrometer count rates are presented as contours of total radiation, potassium, uranium and thorium i.e. four separate map products. These parameters are also presented on the multichannel profiles of each flight line.

The combination of crystal volume, survey altitude, velocity and sampling rate provided reliable statistical information. However, the survey started in late May with snow cover at high elevations and was completed in October with new snow cover in certain areas. The video can be used to determine if snow was present, but it does not seem to have caused any major problems judging by the excellent range and variety of features mapped. Survey blocks 3, 4 and 5 which were flown in the spring, are affected the most by snow moisture. Unlike electromagnetic and magnetic techniques, the gamma ray spectrometer is essentially a surface mapper and thus no information is obtained over ice and water covered areas. However, the high percentage of outcropping bedrock in Greenland is advantageous for this mapping technique.

Supracrustal rocks normally exhibit lower background radioactivity than most crystalline intrusive and metamorphic varieties. Mapped exposures of the Tartoq greenstone dominated supracrustals in the southern part of Sermiligaarsuk South block are clearly outlined on the radiometric maps by their lower radioactivity. This excellent correlation with the 1:100 000 geological mapping is not as apparent in the smaller Tartoq exposures of Midternæs and Sioralik South.

There is at least one horizon within the Ketilidian that is highly radioactive. It is a basal or near basal layer that is also highly conductive or closely layered with a conductive unit. Unfortunately, the radioactivity is derived from potassium and thorium, as opposed to uranium mineralization. It is a very distinct geophysical marker horizon and thus could be used for stratigraphic correlation between the Ketilidian blocks. It may also be useful in the detailed analysis of EM anomalies for ground follow-up. An example of this feature that can be easily identified is along the northern coast of Arsuk Ø. It is also very common in Midternæs.

A localized, high intensity thorium anomaly was also identified on the north central coast of Arsuk Ø. This interested the author during preliminary interpretation in the field because of the relatively close proximity to the cryolite deposit at Ivigtut and the intrusive nature of the anomaly. Subsequent personal communication with GEUS geologists, e.g. T. Tukiainen, indicates a carbonatite plug as the source.

The radiometric survey also mapped a large anomalous area immediately north of the Tartoq supracrustals in Sermiligaarsuk North that was not identified during geological mapping. This area will have to be re-examined to determine the lithology/reason for elevated uranium values, also because elevated U, Th and K concentrations have been recorded in stream sediments from this area and attributed to intrusive granite exposures (Steenfelt 1994, Steenfelt *et al.,* 1994). Possibly there is some relationship to the radioactive granite mapped on Nuna qaqortoq to the east.

Other anomalous features in this survey block will have to be examined in more detail. Some of these may relate to pegmatites, mapped in the block, which are usually very radioactive.

VLF-EM results

A 2-channel VLF-EM receiver was included in the geophysical instrumentation package as a low priority option since it is a very inexpensive “add on” to an airborne survey. During each survey flight VLF transmitter stations were monitored to select the best line and ortho signal. Preliminary compilation of the data was then used to to select either the line or ortho channel results in each survey block for final presentation.

NOTE: The designation “line” is for a direction to a transmitter station approximately normal to the flight line direction. The direction to the ortho station would, ideally, be orthogonal to the line station. In practice, ideal situations are rare due to the limited number of VLF stations available.

Final data is presented as contours of the total field for the selected channel in each survey block. However on the multi-channel profiles, total field and quadrature data is presented for both the line and ortho channels i.e. 4 individual traces.

Users of the 1:100 000 VLF-EM composite map should be cautious about comparing results between survey blocks because of the mixture of flight line directions and transmitter stations.

This was the first attempt at using the VLF technique on Project AEM Greenland and the results certainly indicate that it was worthwhile. By its nature, data quality can vary between and even during flights, with some stoppages inevitable. The resistive lithology and lack of conductive overburden is a positive application factor in the survey region, but rugged topography can produce terrain anomalies in the data. The method has the capability of mapping major geological structures as well as localized bedrock conductors, but can be inconsistent with all of the variables involved.

In the Sermiligaarsuk North block some important easterly trending features (faults?) are highlighted by the VLF data. These are not always readily apparent on the vertical gradient maps which seem to be influenced to a greater extent by the dykes. These two data sets complement each other and should be used together in structural interpretations.

From a bedrock conductor standpoint, the northerly trending formational conductors in Grænseland are clearly outlined on the VLF maps. However, the VLF pattern in neighbouring Midternæs is much more difficult to relate to the apparent resistivity presentation.

The more localized bedrock conductors can usually be identified (but not always) on the VLF profiles. For example, the strong conductors in Sioralik South are mapped crosscutting other northeast trending geological structures. The greatest task in interpreting VLF-EM data is in conductor discrimination i.e. source identification. From this survey, it would be difficult to prepare a list of priority massive sulphide prospects without the conventional EM data.

Another interesting observation is the lack of a "salt water" effect on the VLF profiles as compared to the conventional EM data.

VLF ground instruments may prove to be very useful (and inexpensive) to initially locate airborne EM conductors of interest on the ground in this part of Greenland.

Conclusions

The comprehensive airborne geophysical data sets acquired by Project AEM Greenland 1996 will, in the short term, focus mineral exploration on a number of specific anomalies within the survey blocks with hopes for a " discovery". In the longer term, the data sets will create a better understanding of the detailed lithology and structure of these supracrustal belts.

The multi-frequency EM survey has mapped a large number of bedrock conductors, particularly within the Ketilidian rocks of Midternæs and Grænseland. These are the most difficult areas to interpret and follow-up on the ground because of the presence of graphitic horizons. Local massive sulphide lenses can occur within either resistive (easy to identify) or conductive (much harder to discriminate) host rocks and during initial exploration stages in an area, are equally important prospects.

Previous exploration has recognized the Tartoq as a Cu-Au province and therefore all bedrock EM anomalies should be carefully investigated. These massive sulphide targets occur in Sermiligaarsuk North, Sioralik South and western and northern parts of Midternæs.

Bedrock conductors mapped in the northern section of Sermiligaarsuk North block are also highly regarded by the writer.

Possible pipe-type geophysical signatures are present in all five survey blocks which will be of particular interest to companies currently exploring for diamonds in West Greenland. The data set is ideal for this application.

The potentially new uranium province revealed by the gamma ray spectrometer survey in Sermiligaarsuk North should also be noted.

Acknowledgements

Project AEM Greenland 1996 was financed by the Government of Greenland. Successful completion of the project was dependent on the special skills and dedication of staff from Aerodat Inc. and Greenlandair A/S. The valuable assistance provided by the Minerals Office in Nuuk and the Danish naval staff in Grønnedal is also acknowledged.

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Appendices

This section of the report is divided into five appendices, one for each survey block, to accommodate readers with special interests, mineral licences etc. in select areas.

Each appendix contains the following two types of information:

1) An initial list of geophysical anomalies recommended for ground follow-up investigations. To use this information properly the reader needs access to the digital data and/or compiled map sets at a scale of 1:20 000.

2) A complete set of page-size colour maps as described earlier in this report (Presentation of results).

Appendix A - Sermiligaarsuk North (1)

This area was originally intended to only cover the Tartoq supracrustals in the south but was later extended northwards to cover other geological events and thus became the largest survey block. On a per area basis it contains the fewest number of bedrock EM anomalies, primarily since no long formational conductors are present. It is an easy area for ground follow-up since virtually all plotted anomalies (salt water excluded) represent massive sulphide mineralization.

Surveying of the block commenced on 11 August 1996, but an HEM bird loss the following day (12 August) resulted in a lengthy delay. Surveying finally restarted on 5 October with a 3-frequency HEM bird and the survey was completed on 22 October 1996. Thus flights 75-77 were flown using the 5-frequency system and flights 78-103 with the 3-frequency system.

Six (6) map sheets at scale 1:20 000 cover the survey block. Anomalous gold values have been reported from many locations within the Tartoq rocks in the south.

Geophysical Anomalies Recommended for Initial Ground Follow-up:

Map sheet 1:

1) *the conductive system on the west side of sheet 1 between traverses 10110 and 10191*
   - *this system is not well mapped since it tends to parallel the flight lines*
   - *ground check anomalies 10110A, 10150B and 10160F initially*
   - *also note the high intensity magnetic feature which is associated with this conductive zone*

2) *weak EM anomalies 10230A,B andC*
   - *a separate parallel conductor?*

3) *magnetite anomaly 10320A*

4) *magnetite anomaly 10470A*
   - *this is also a weak conductor*

5) *source of U and Th anomalies in extreme northwest corner of sheet*

Map sheet 2:

- *nil*

Map sheet 3:

6) EM anomaly 10920D

7) EM anomaly 11000B

8) high U values centered on traverse 10870 - time fiducial 14:37:50

Map sheet 4:

9) magnetite anomaly 11210B

10) weak EM anomaly centered on traverse 11420 - time fiducial 16:33:08

11) U hot spots in south-west corner of sheet

NOTE: There is also an indication of a north-west linear feature on the uranium contour map that may be associated with a major fault zone. This could be significant.

Map sheet 5:

12) EM anomalies 11340G&H on the boundary between map sheets 5 and 6

- an excellent prospect with associated negative remanent magnetization (50nT)

13) U anomalies to the north and west of prospect #12

Map sheet 6:

14) weak EM anomaly 11340E

- it coincides with a major VLF-EM anomaly (structure) striking northeasterly

15) EM anomaly 11390A

- related to prospect #12 on map sheet5

16) EM anomalies 11490F&G

17) magnetite anomaly 11671D

18) EM anomaly 11600C

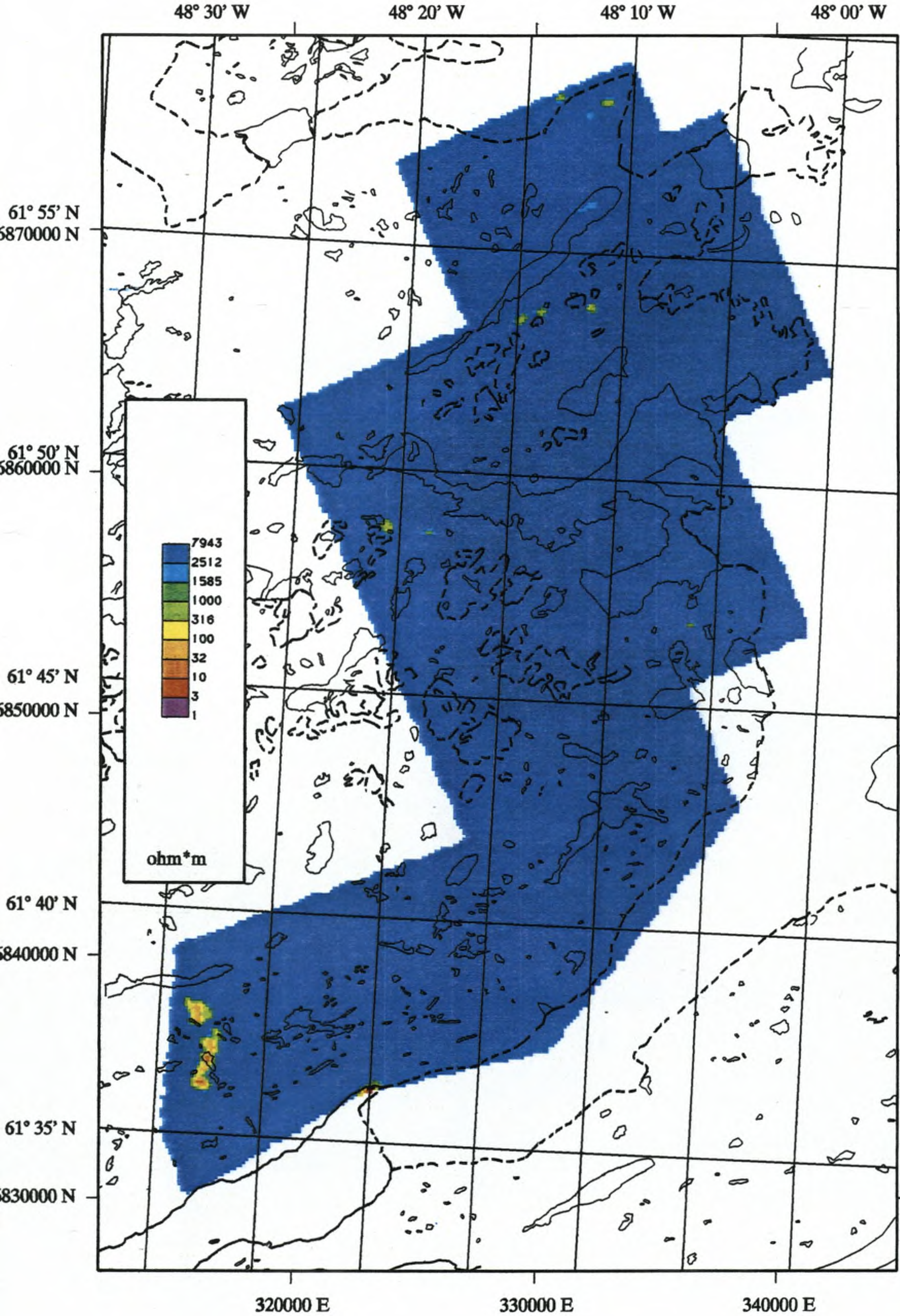
- at edge of ice cap

19) EM anomalies 11690B&C

20) numerous U anomalies on uranium count map

PROJECT AEM GREENLAND 1996

SOUTH-WEST GREENLAND



GEUS

SERMILIGAARSUK NORTH

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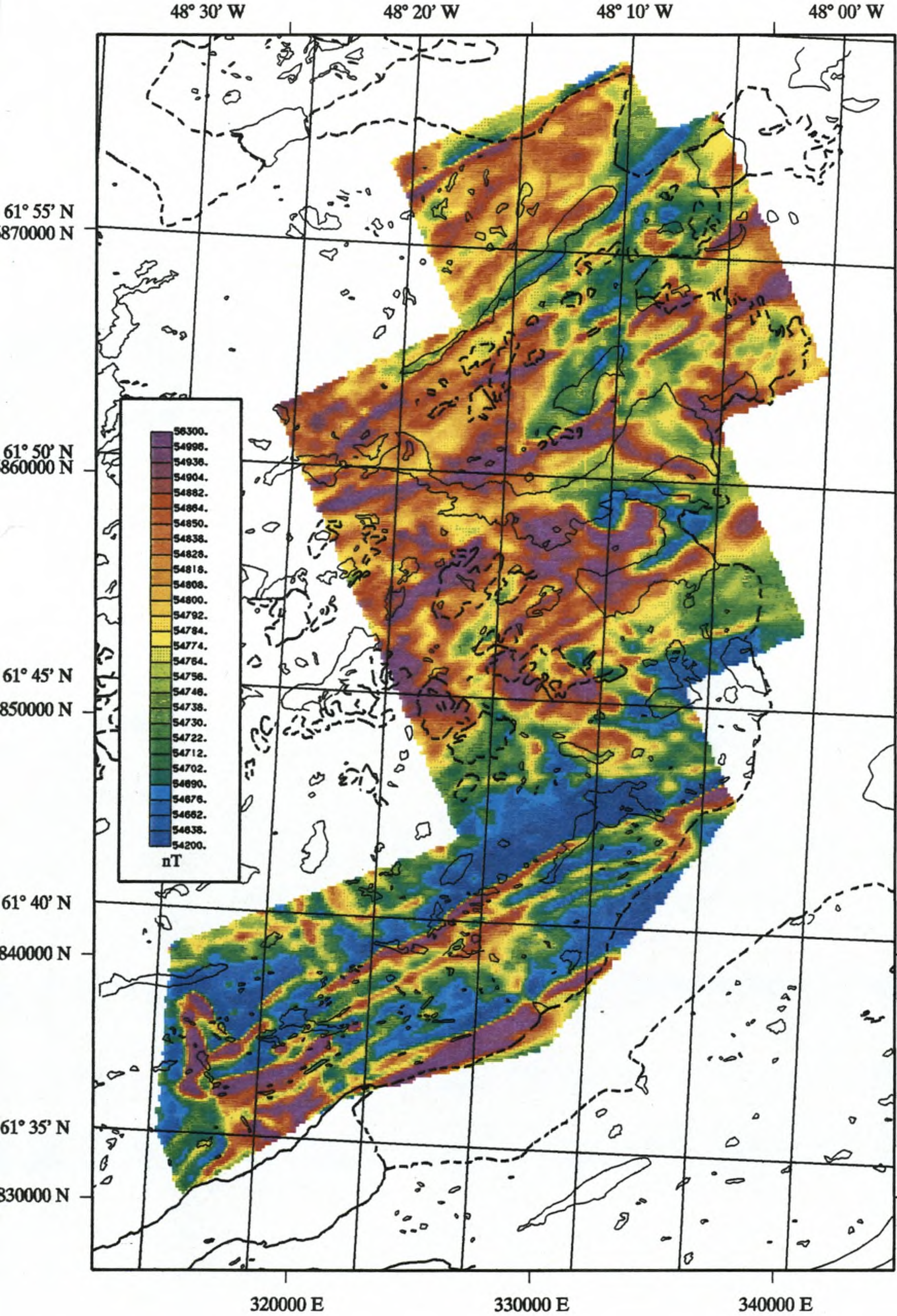

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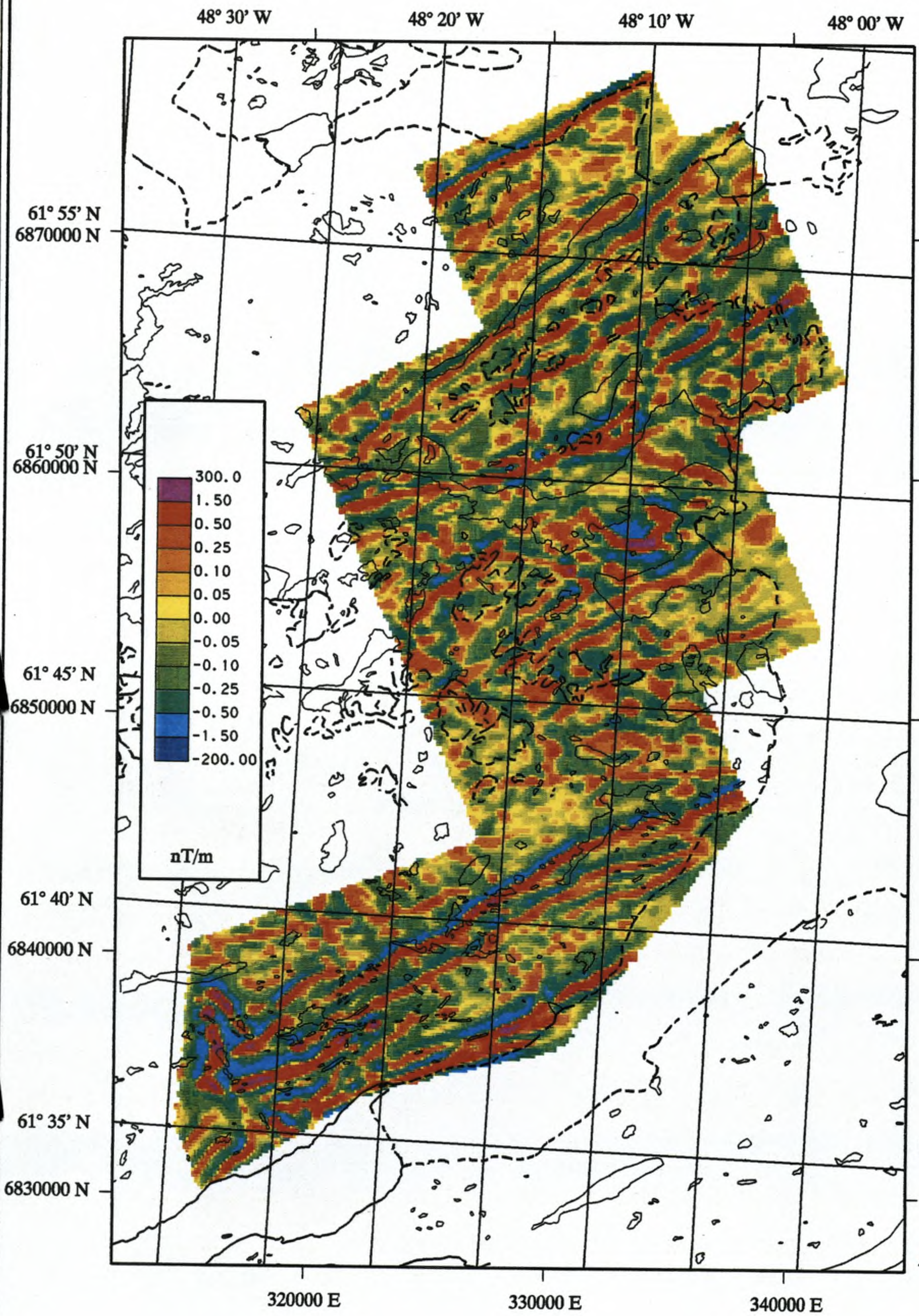

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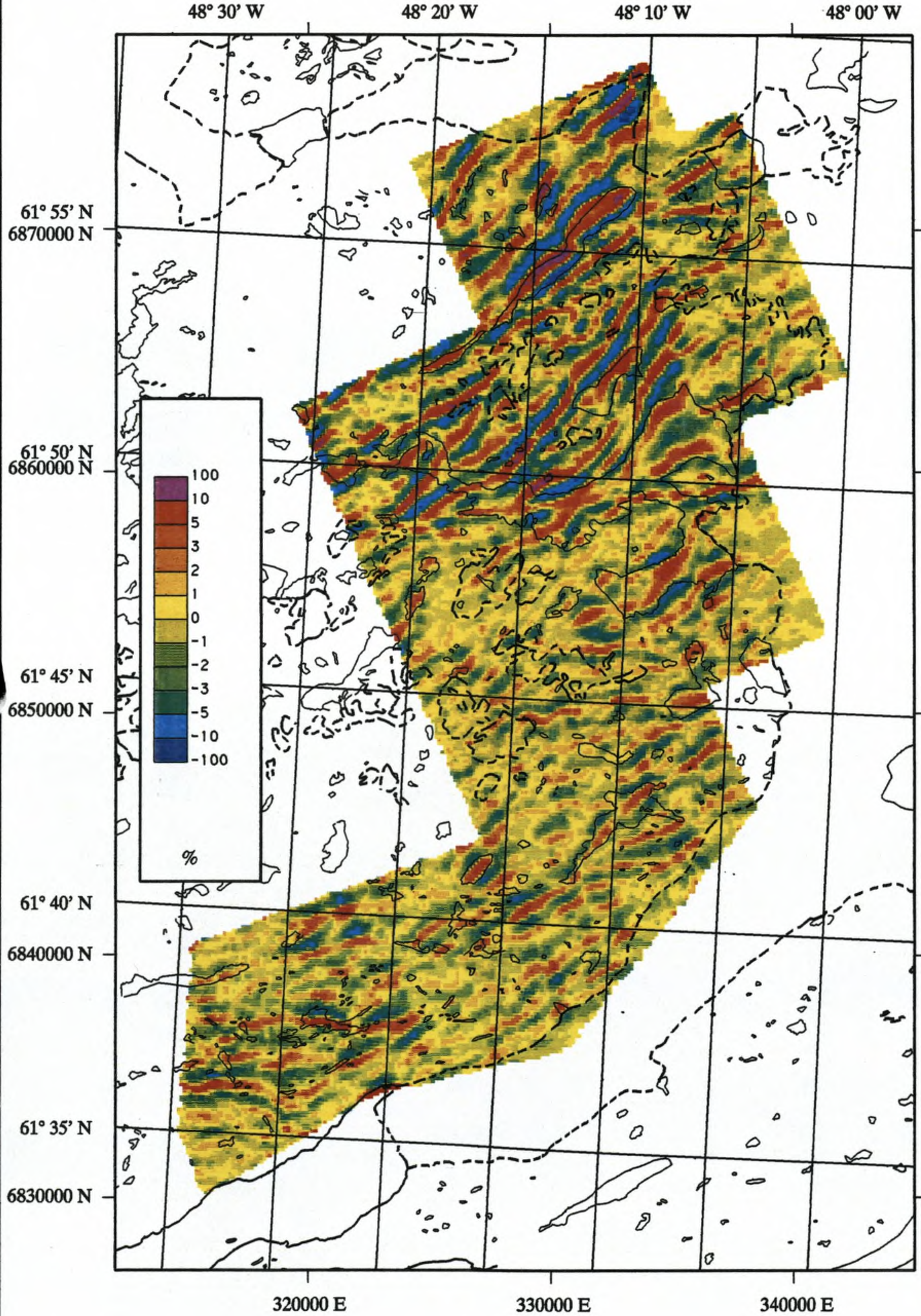

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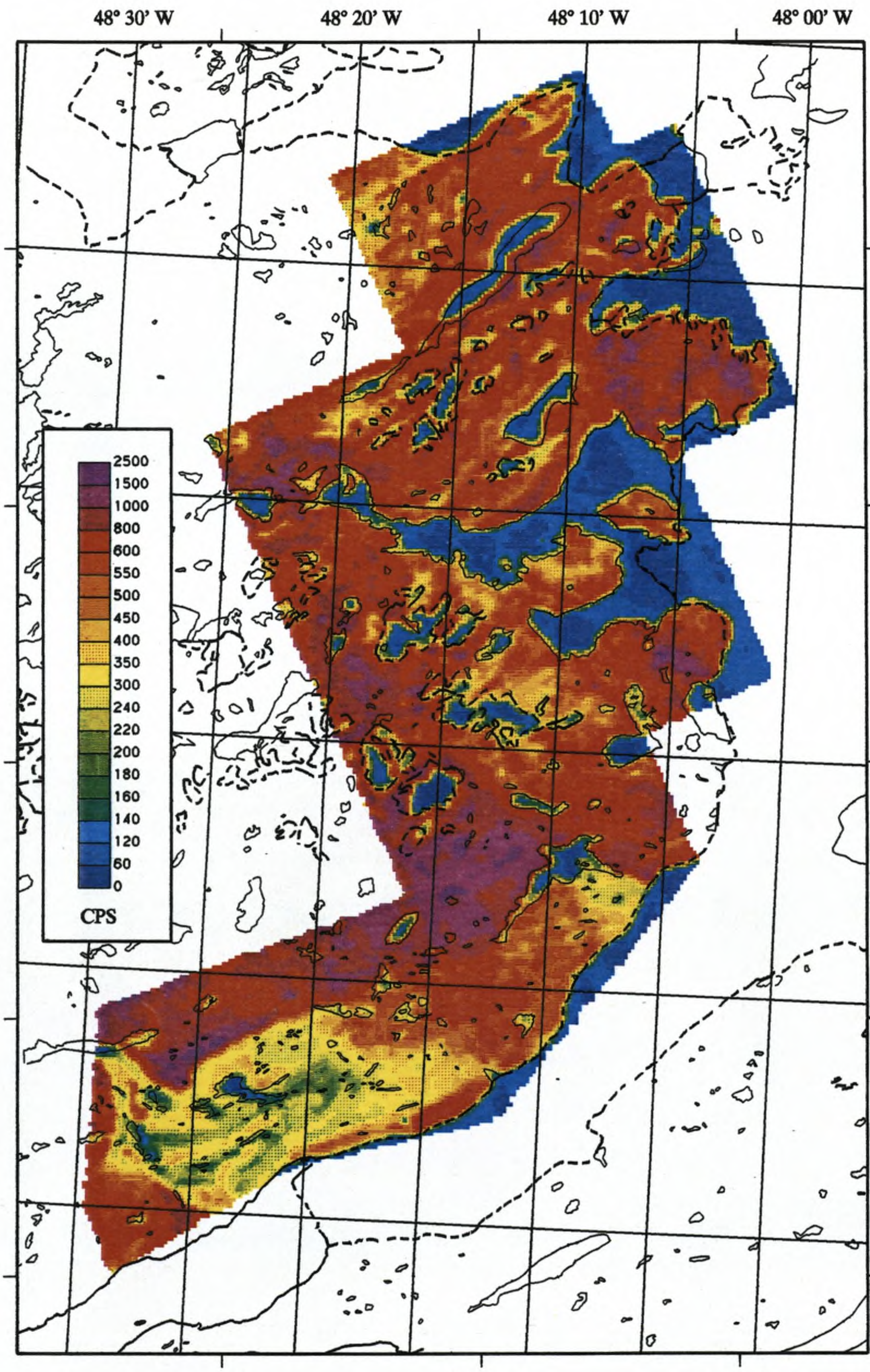

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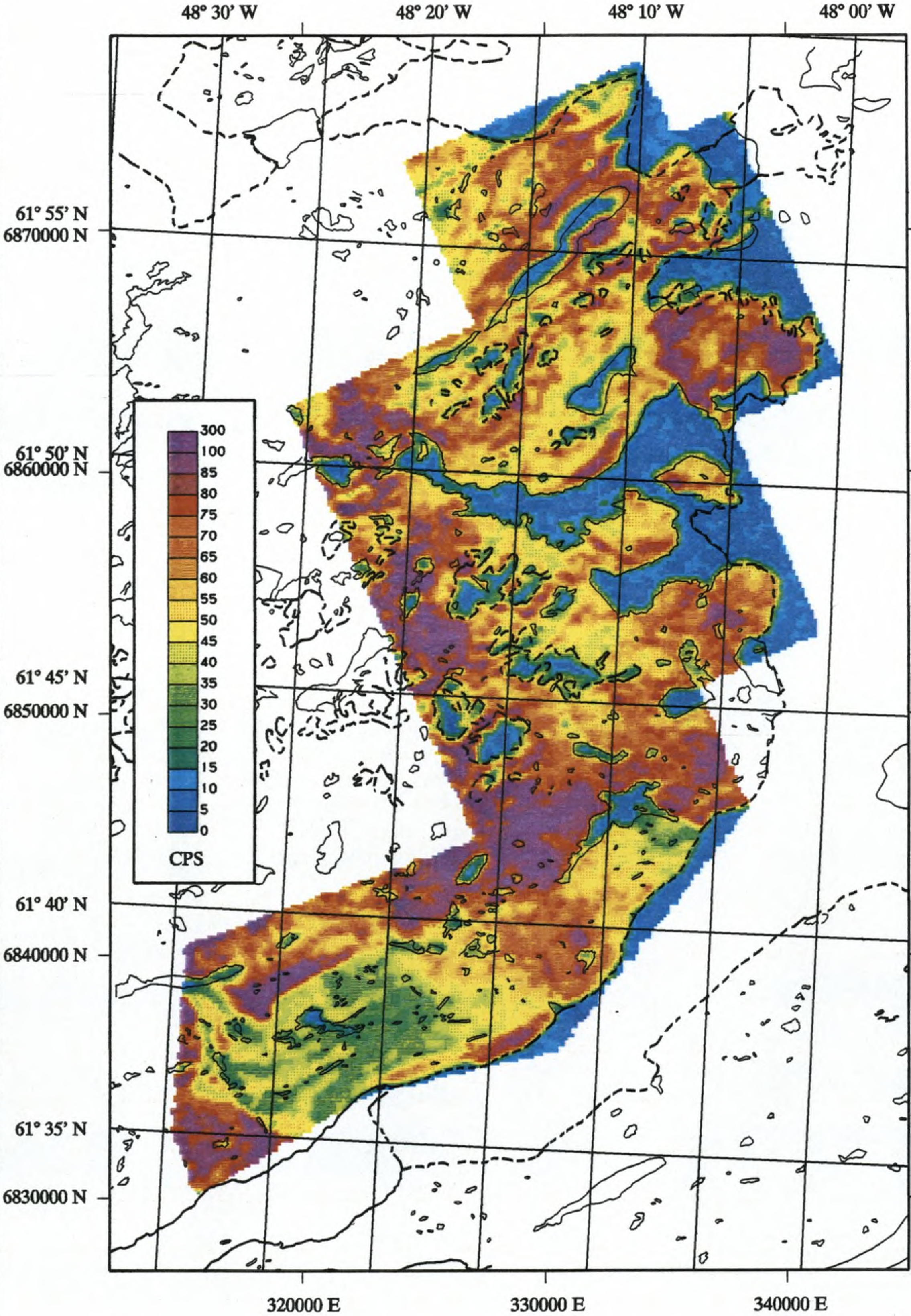

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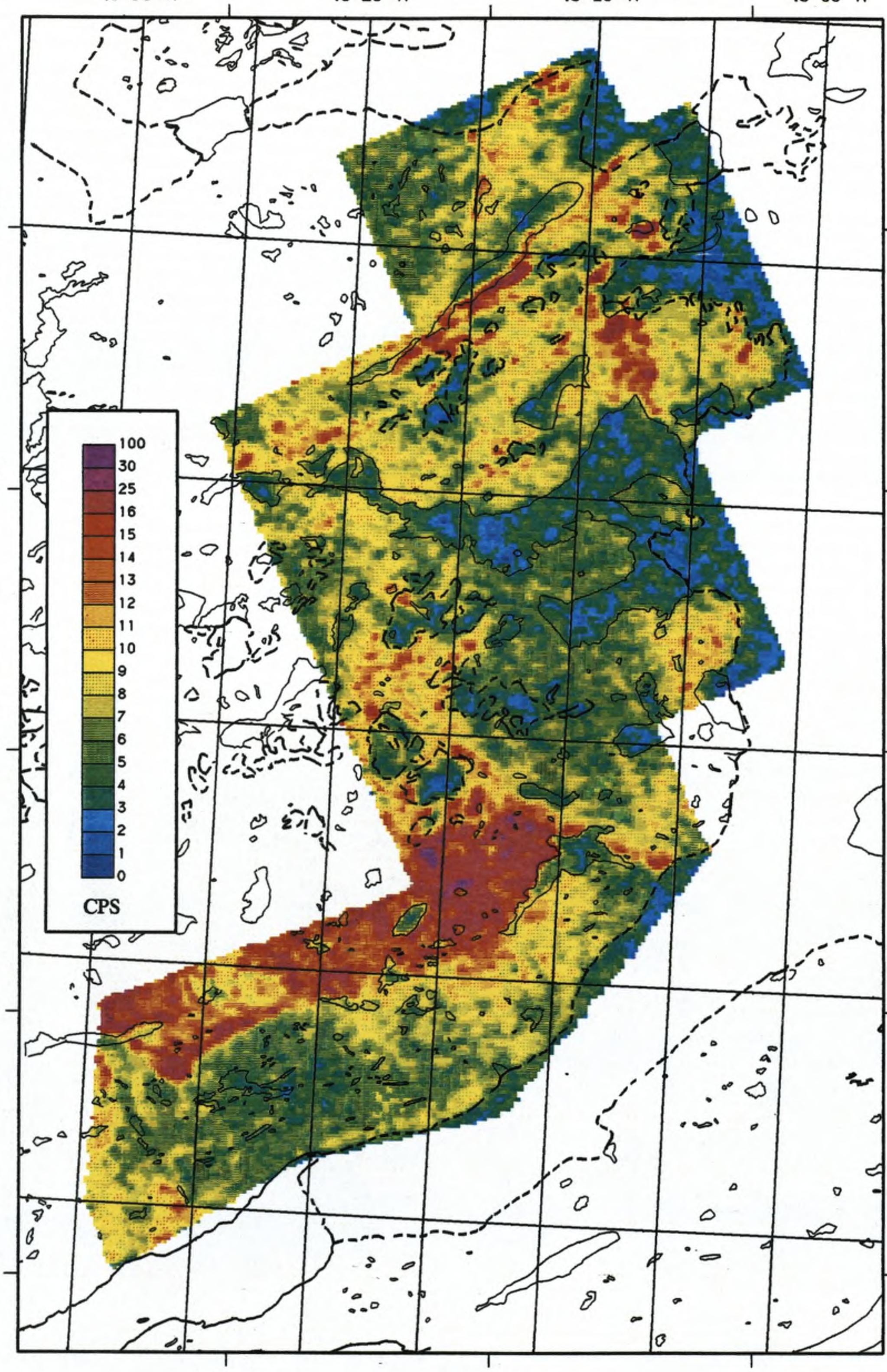

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RADIOMETRICS URANIUM

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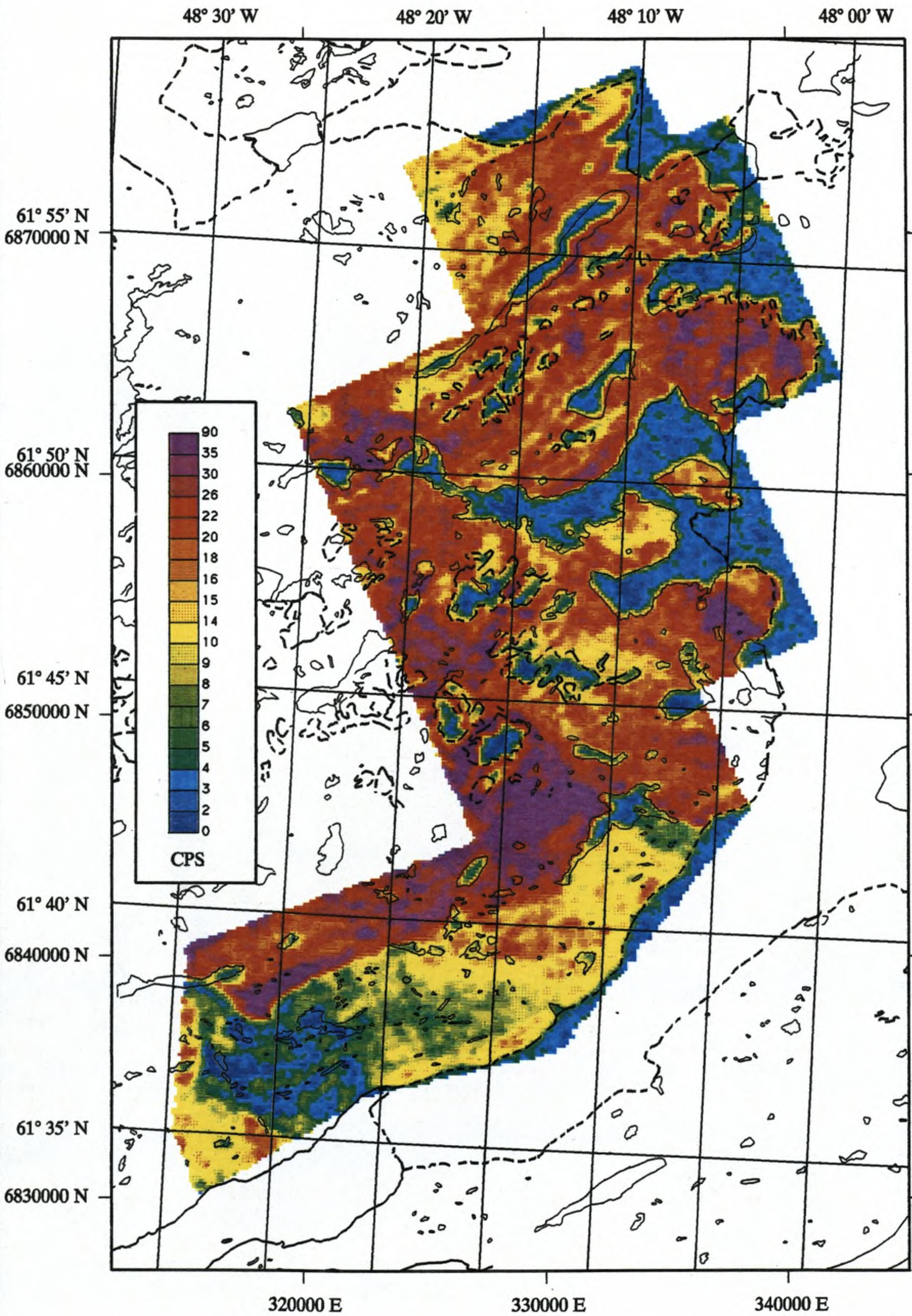

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RADIOMETRICS THORIUM

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<u>Appendix B</u> - Midternæs (2)

This survey block covers the largest area of supracrustal rocks, primarily Ketilidian, but Tartoq units are exposed in the extreme west as well as in the north on Nuna Qaqortoq. Exploration work in the early 70's by Renzy Mines Ltd. and in the early 80's by Greenex A/S and GGU focussed mainly on the western Tartoq area and the adjacent Perledal valley area to the east. Small showings of gold and base metals, as well as kimberlite dykes have been reported within the survey block. The promising airborne geophysical results are enhanced by some of these showings and a major ground follow-up program is certainly warranted.

Airborne geophysical coverage of this block took place between 6 June and 11 August, 1996, in a progressive manner from west to east. Five(5) map sheets at a scale of 1:20 000 cover the survey block.

Geophysical Anomalies Recommended for Initial Ground Follow-up:

Map sheet 1:

1) EM conductors wihin the Tartoq supracrustals between traverses 21550 and 21700
-special attention to EM anomaly 21600B, an excellent massive sulphide prospect

2) magnetite anomaly 21610B
- possible association with other mineralization

3) magnetite anomaly 21480B
- close to mapped kimberlite dyke

Plus some selected targets within the Ketilidian to attempt to establish the presence of sulphides within major graphitic horizons. In this regard, much more interpretative time is required.

4) EM anomaly 21300Y

5) EM anomaly 21300U

6) EM anomaly 21440M

7) EM anomaly 21390O

8) EM anomaly 21380J

9) EM anomaly 21350S

10) EM anomaly 21320Q

11) EM anomaly 21280M

Map sheet 2:

12) EM anomaly 21261A

13) EM anomaly 21240K

14) EM anomaly 21180C

15) EM anomaly 21170AE

16) EM anomaly 21170M

17) EM anomaly 21153J

18) EM anomaly 21050A

19) EM anomaly 21040W

20) EM anomaly 21000P

21) EM anomaly 20970X

22) EM anomaly 20950D

23) EM anomaly 20921J

24) EM anomaly 20910R

25) EM anomaly 20910F

26) EM anomaly 20900AE

27) EM anomaly 20890AA
Plus more isolated EM targets

28) EM anomaly 20770B

29) EM anomaly 20680J

30) EM anomaly 20500G

31) EM anomaly 20500E

32) EM anomaly 20730B

33) radiometric anomaly(strong Th with some U) on traverse 20970 - time fiducial 14:34:36

Map sheet 3:

34) EM anomaly 20541C - iron formation reported in this vicinity

Map sheet 4:

35) EM anomaly 20810AA

36) EM anomaly on traverse 20610 - time fiducial 15:20:38

37) EM anomaly 20460A
plus EM anomalies on Nuna qaqortoq

38) EM anomaly 20520A

39) EM anomaly 20430B

40) mafic intrusions i.e. high intensity magnetic features situated on, and south of, Nuna qaqortoq

41) elevated U and Th values on Nuna qaqortoq
- an association with the mapped granite

Map sheet 5:

42) EM anomaly 20110A

43) EM anomaly 20220B

44) anomalous U at north end of traverse 20170

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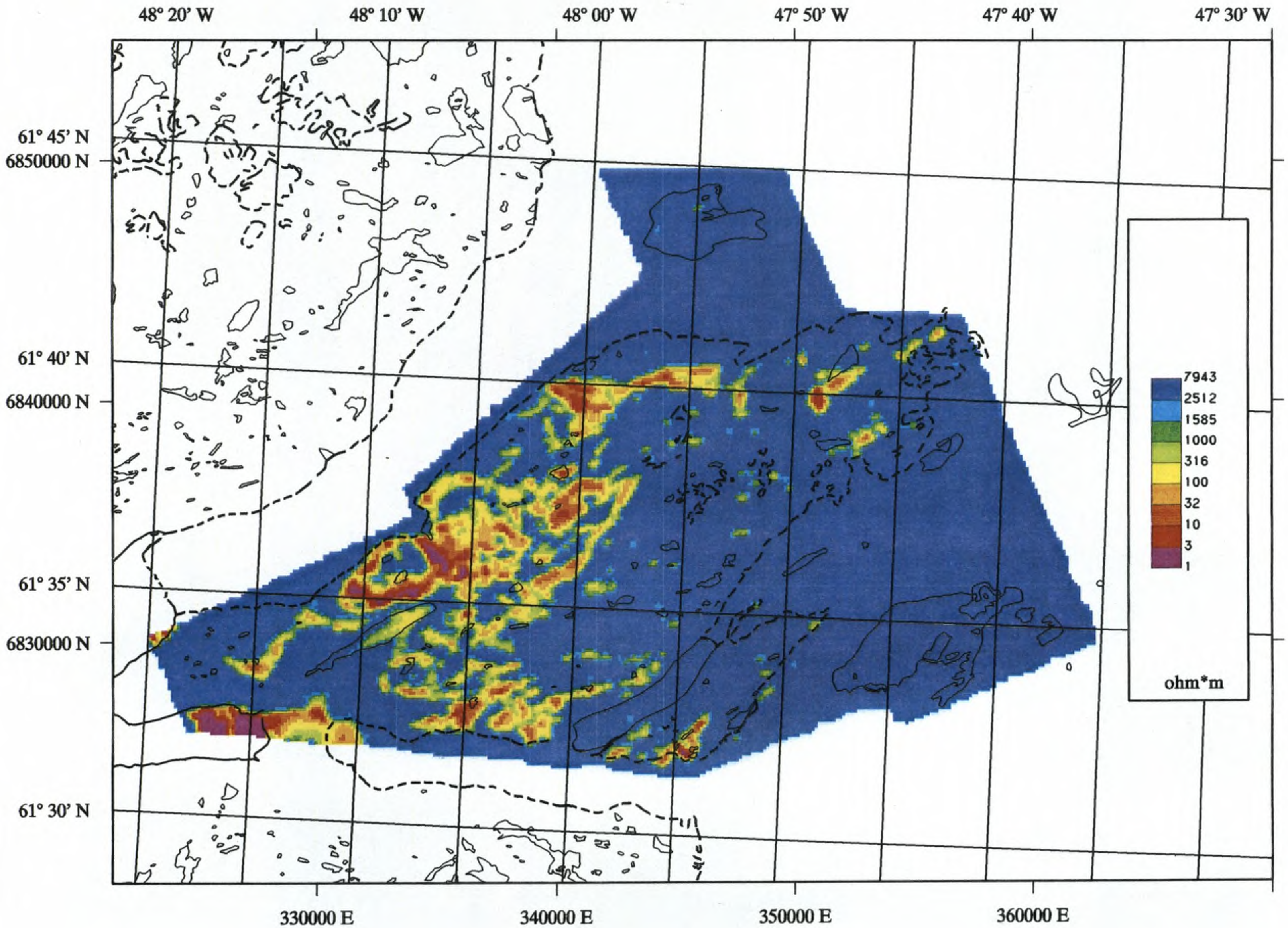
SOUTH-WEST GREENLAND



MIDTERNÆS

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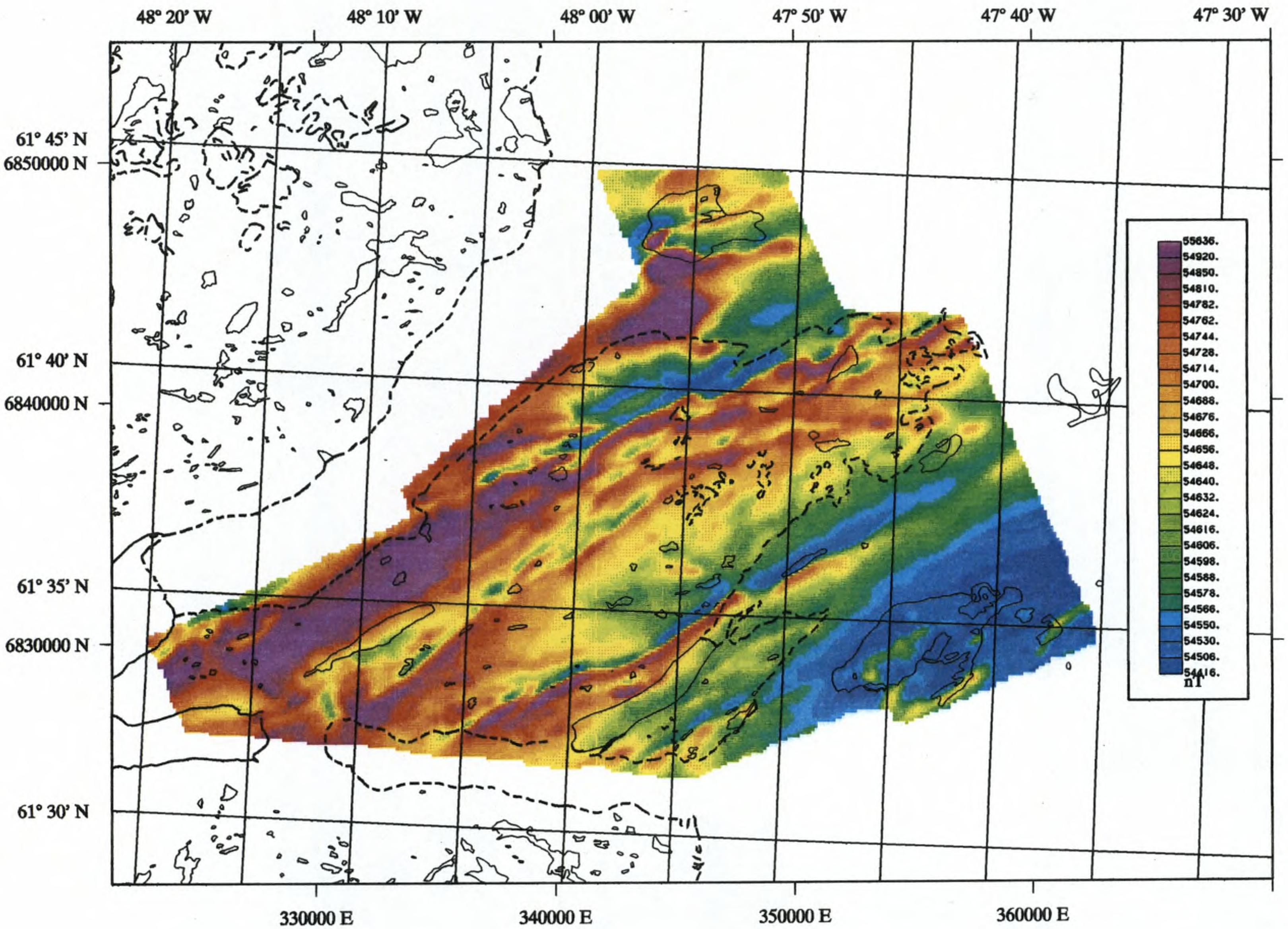

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MIDTERNÆS

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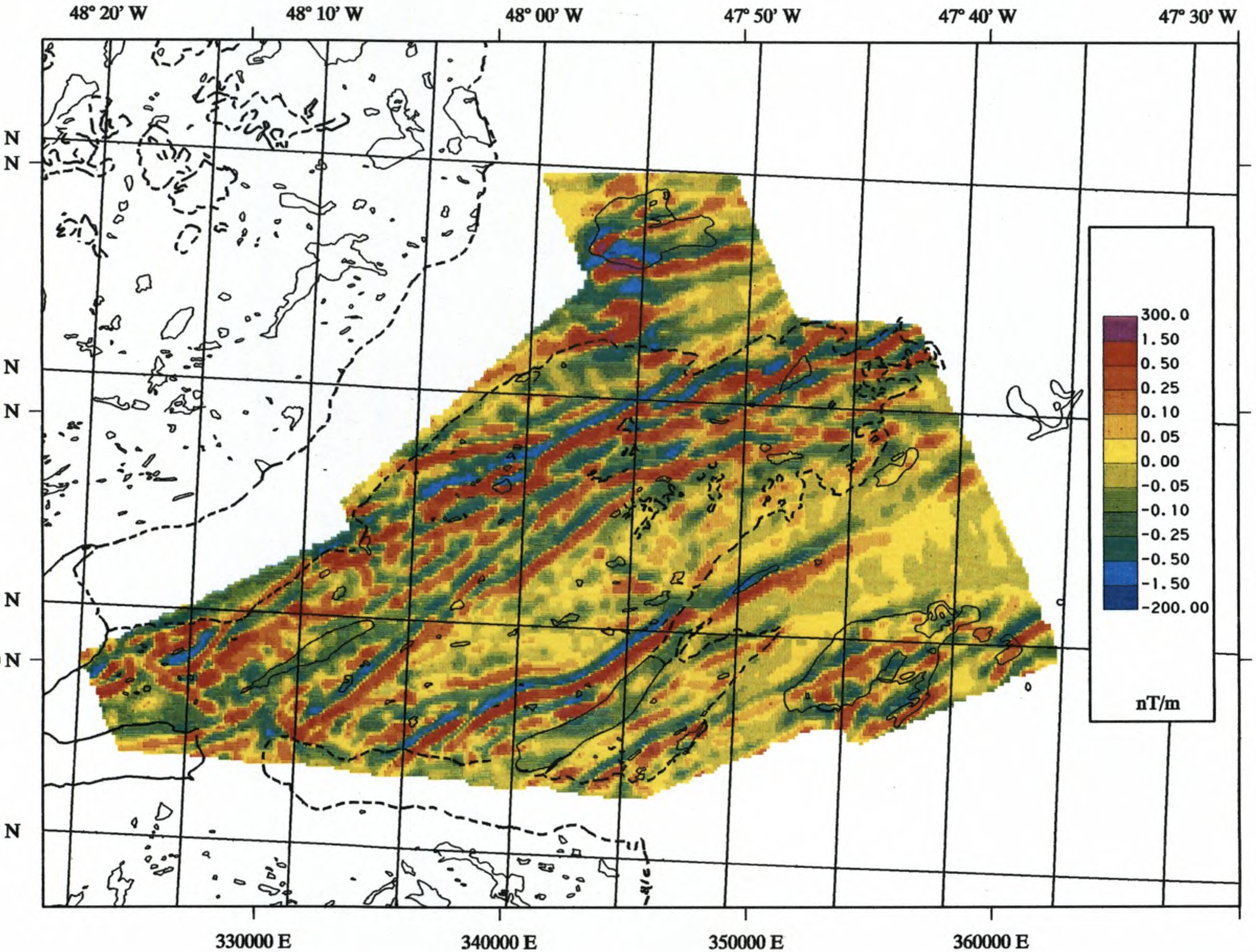

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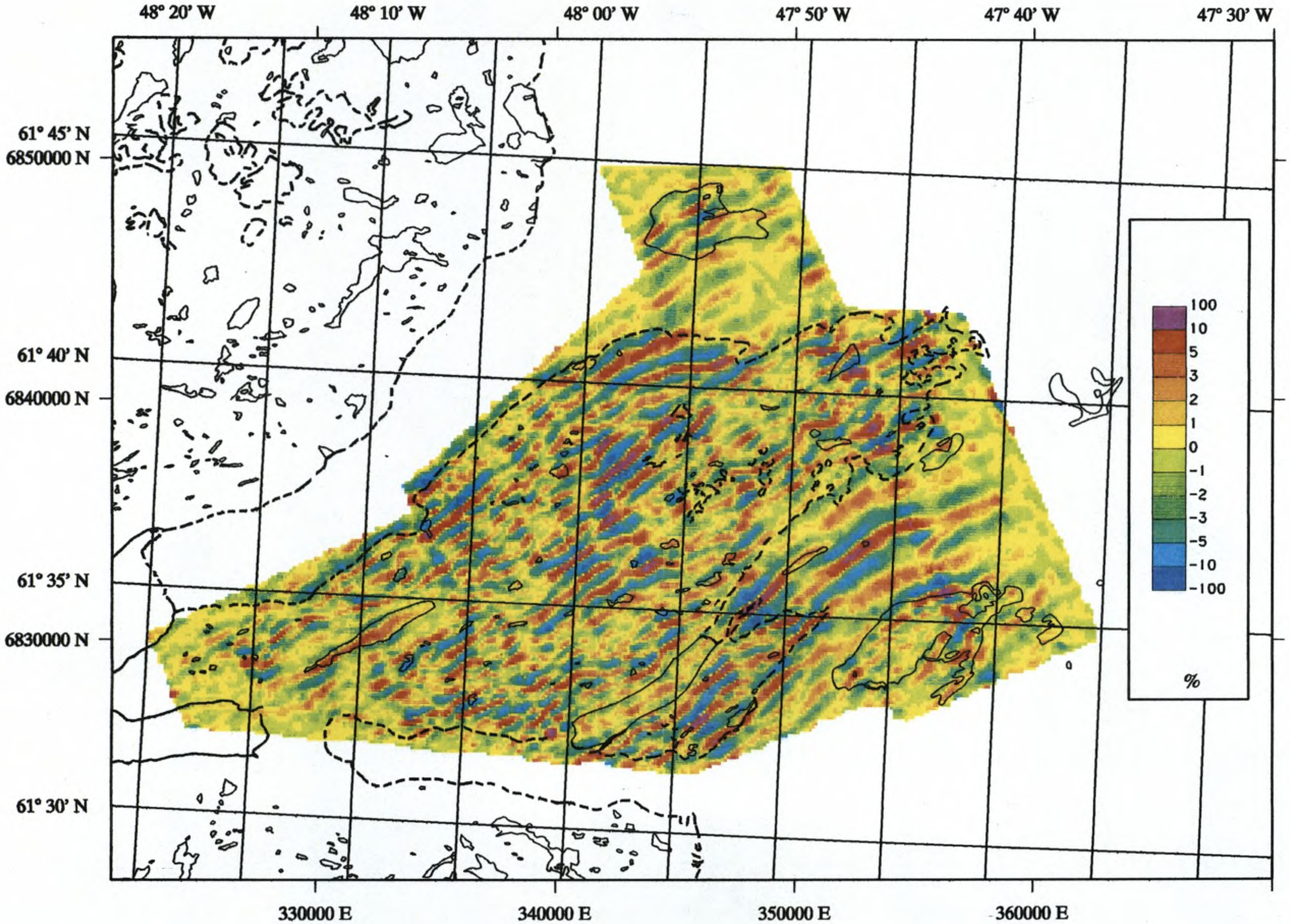

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V.L.F.- EM

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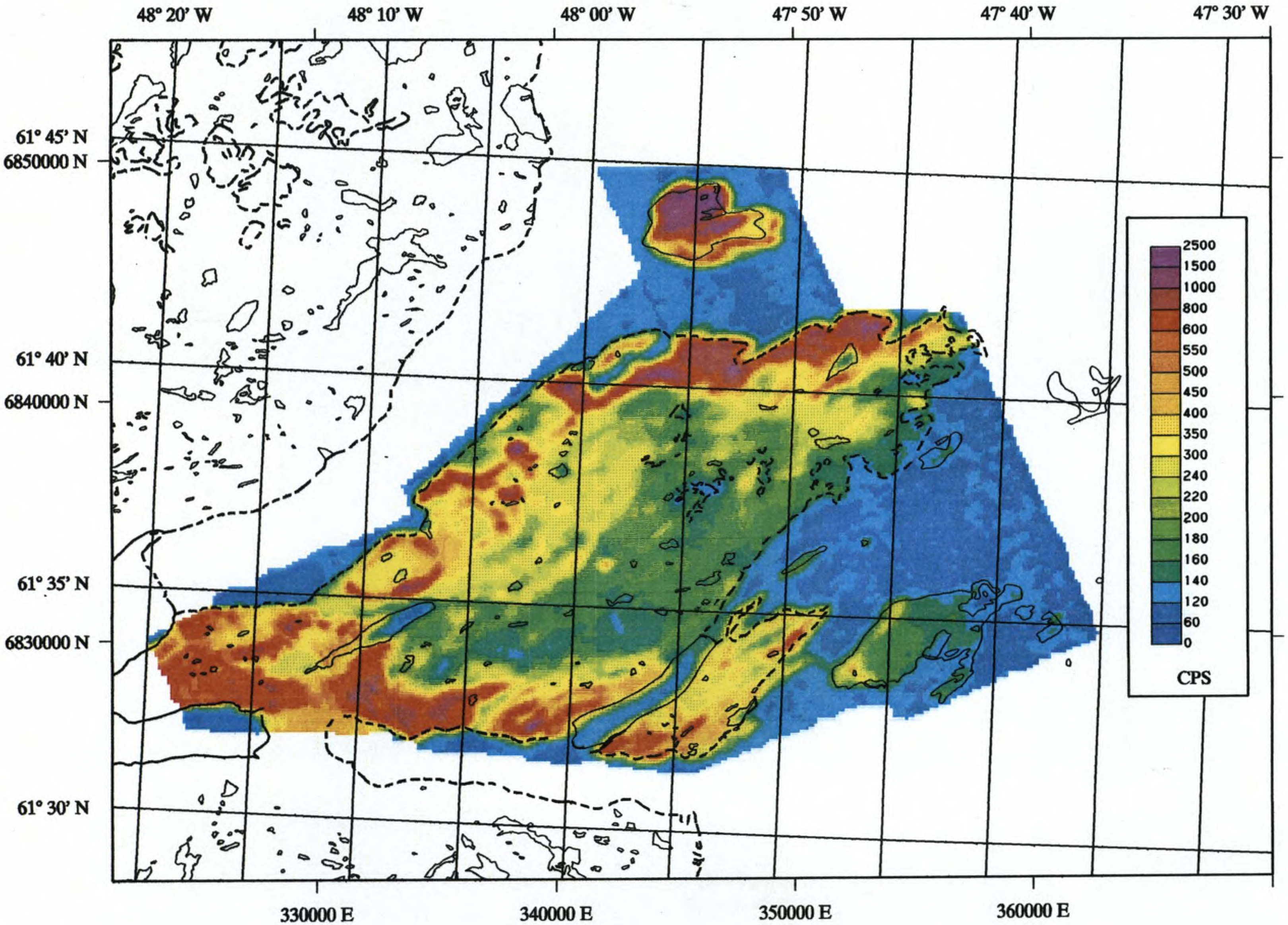

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MIDTERNÆS

TOTAL COUNT RADIOMETRICS

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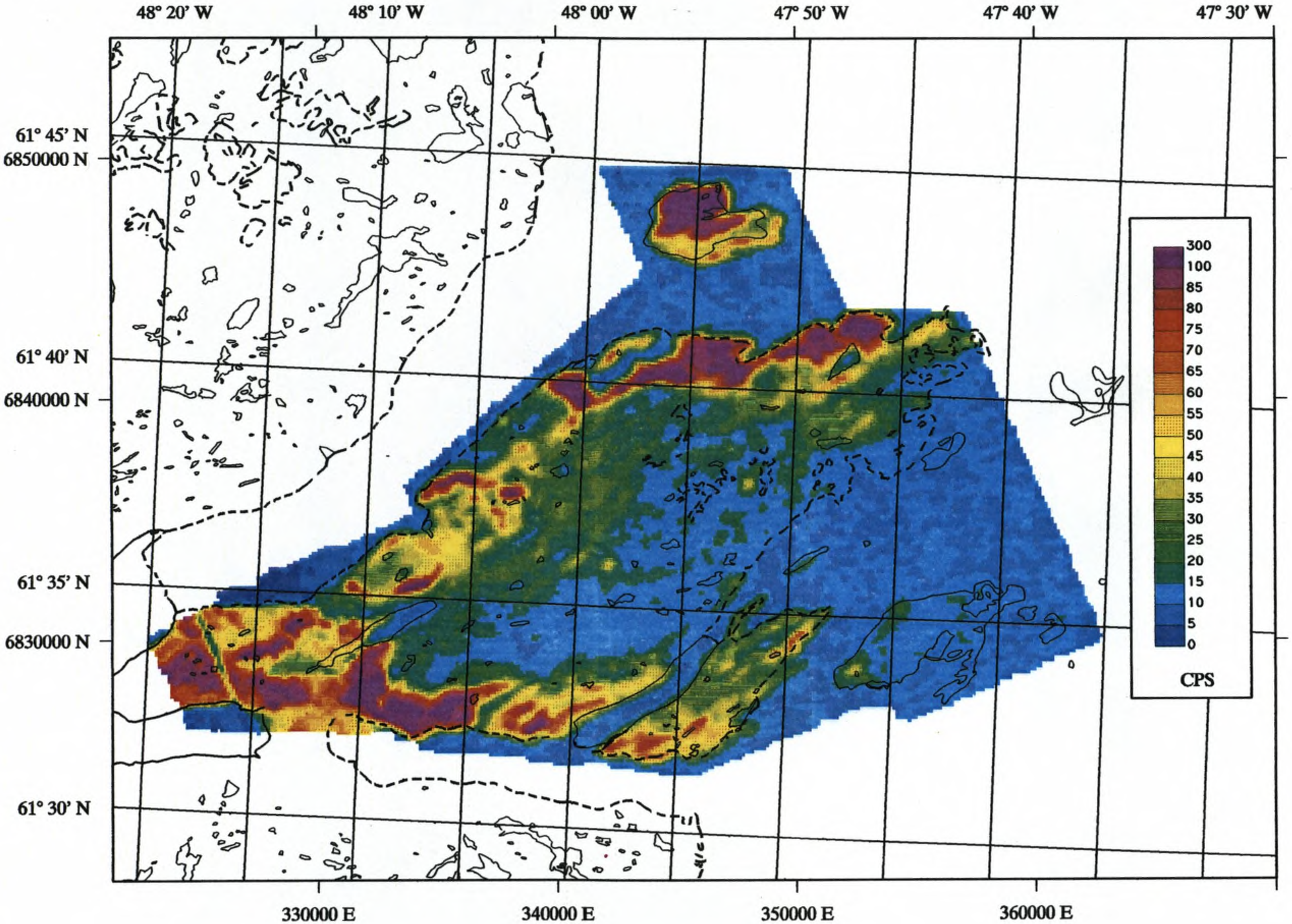
SOUTH-WEST GREENLAND



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POTASSIUM RADIOMETRICS

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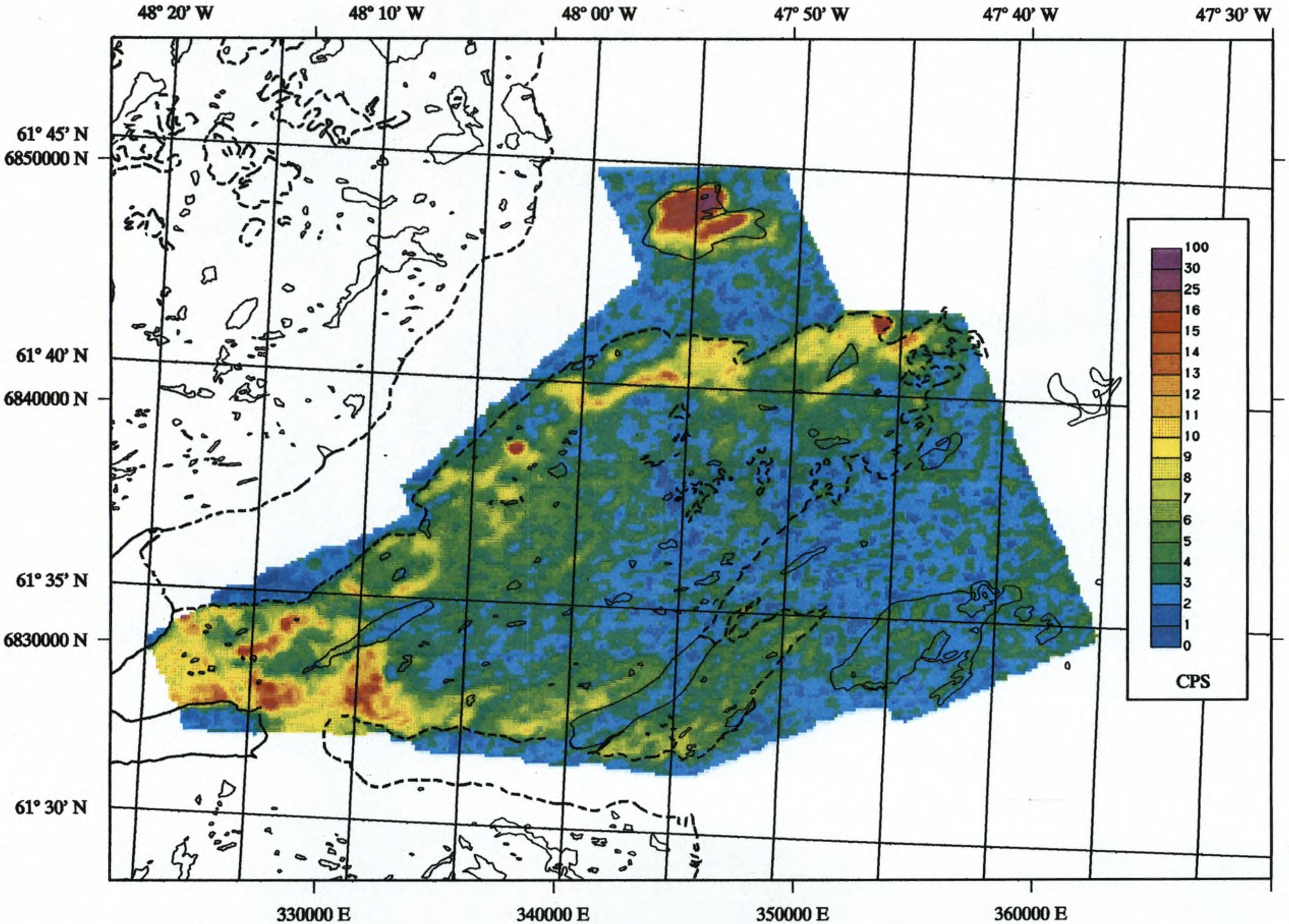

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URANIUM RADIOMETRICS

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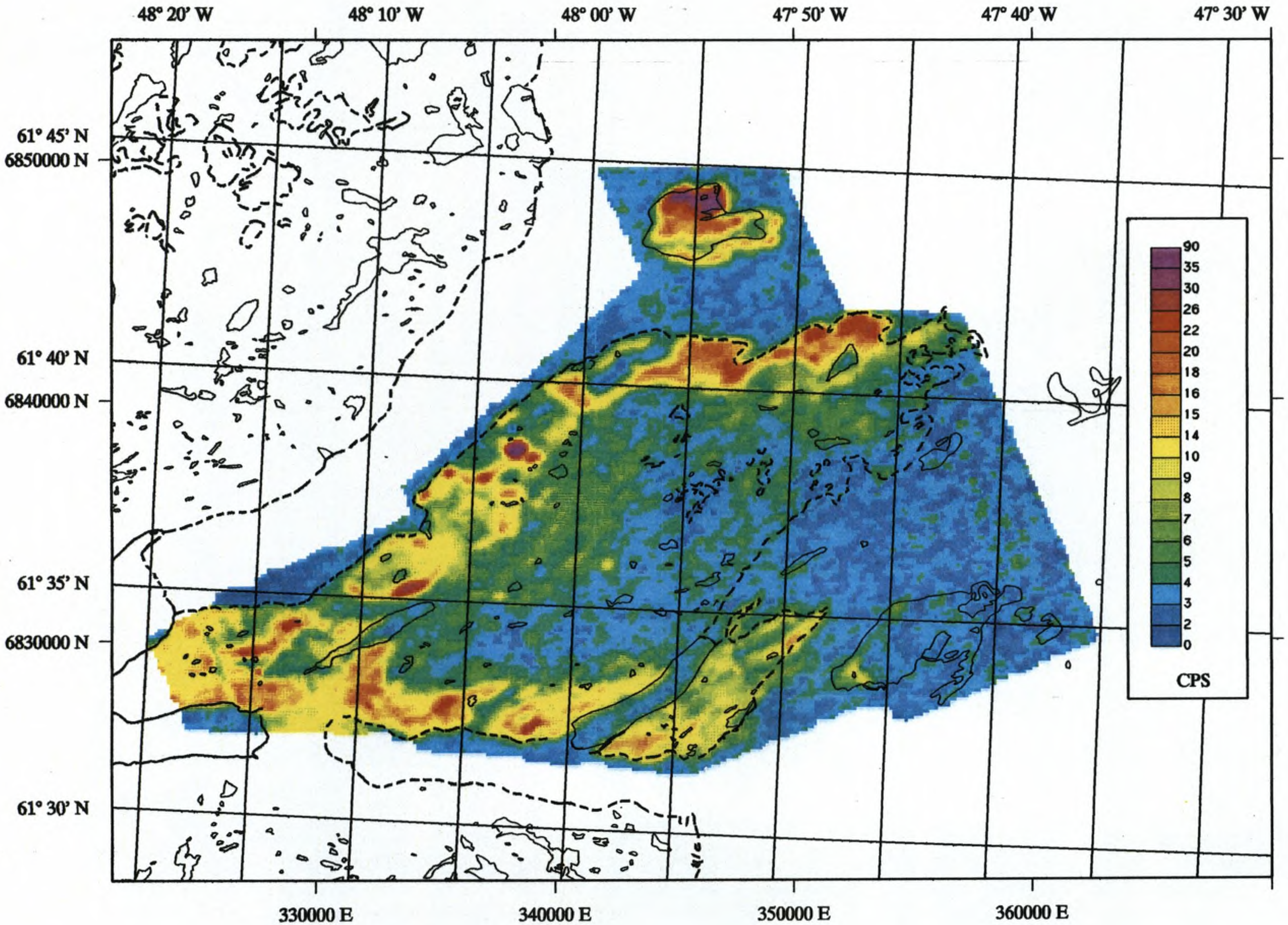
SOUTH-WEST GREENLAND



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THORIUM RADIOMETRICS

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Appendix C - Grænseland (3)

This survey block was designed to cover a large exposure of Ketilidian supracrustals which extend under the ice cap to the east and overlie Archean gneisses to the west. Block boundaries were liberal resulting in quite extensive overlap with the gneisses and the ice cap. Four map sheets at a scale of 1:20 000 cover the area. Fifteen survey flights over the period 30 May-22 June were required to cover this block.

Exploration work in the area has been minimal and no significant mineral showings have been reported to date. Activities have mainly focussed on a magnetite-bearing, basal conglomerate in the Vallen lake region. The geophysical results, however, are very encouraging and a large number of bedrock conductors have been mapped. Graphitic sediments undoubtably account for much of this conductivity but a number of possible massive sulphide zones are also indicated.

Geophysical Anomalies Recommended for Initial Ground Follow-up:

Map sheet 1:

1) *Uranium anomaly on traverse 30230 - time fiducial 16:53:20*
   - in the original field data but not plotted/compiled since it lies beyond the western survey boundary

2) *Circular magnetic anomaly in weakly conducting lake(Overløbssø) centered on traverse 30480 - time fiducial 18:46:50*
   - kimberlite pipe prospect
   - there are also some uranium indications near the south shore of the lake near the intersection of line 30420 and tie line 83010

3) *EM anomaly 30551C*
   - increased conductivity and magnetics within a longer formational conductor
   - situated east of a magnetic marker horizon which is believed to be the basal conglomerate

Map sheet 2:

4) *Local magnetic feature centered on anomaly 30050A*
   - this is representative of a number of possible pipe-type features located on map sheet 2 although some lie under the ice cap

5) *Vicinity of EM anomaly 30140A*
   - this is a weak feature but tie line 83040 shows some very sharp EM anomalies which indicate a northeast strike to the conductors. This anomalous direction with respect to other bedrock conductors on the map sheet should warrant ground checking

6) *EM anomaly 30110C*

- a high amplitude EM anomaly

- although part of a formational conductive system it sits in an interesting structural environment immediately south of a northeast trending, linear magnetic low

- the local magnetic feature centering on EM anomaly 30130C should also be examined

7) EM anomaly 30260H

- a representative bedrock conductor that is also magnetic

- magnetic sulphides or graphite plus magnetite?

8) EM anomaly 30350K

- a strong bedrock conductor

9) EM anomaly 30400A

- a strong conductor with coincident magnetics

10) high frequency conductor i.e.low conductivity feature situated just east of EM anomaly 30420F

- a different type of target that seems to have a bedrock origin

- it is important to sample a wide variety of anomalies, not just the strong conductors

Map sheet 3:

11) EM anomaly on traverse 30820, time fiducial13:13:17

- a very high amplitude and high conductivity anomaly

- should be an easy location to check type of mineralization

12) magnetite anomaly 30880E

- a local feature east of the basal conglomerate

13) negative magnetic anomaly on traverse 31000, time fiducial 21:37:46 together with EM anomalies on east side

14) uranium anomaly centered on traverse 30741, time fiducial 13:45:18

Map sheet 4:

15) circular magnetic feature on traverse 30840, time fiducial 13:34:58

16) north-south striking EM conductor with a coincident magnetic anomaly centering on EM anomaly 31040N

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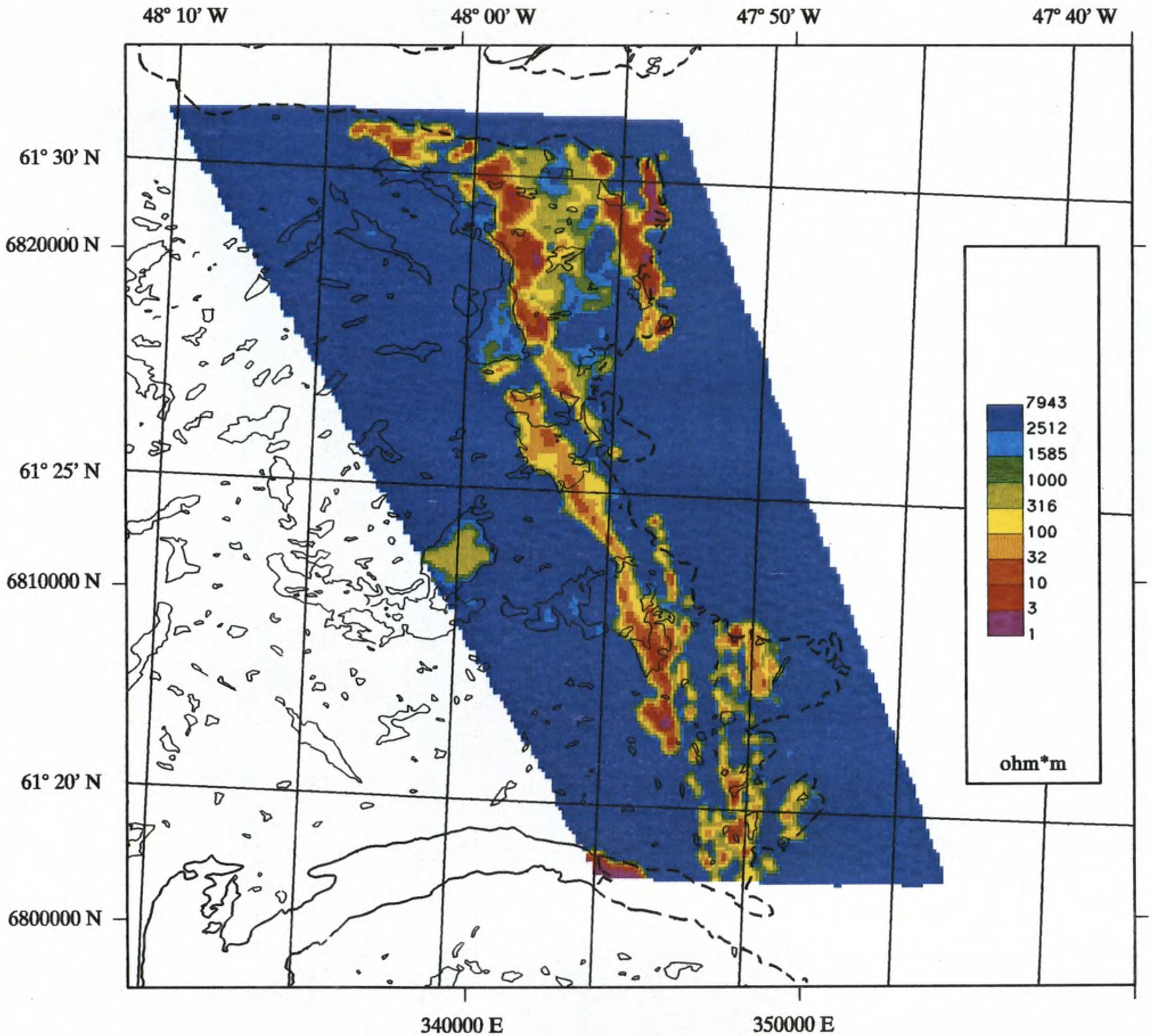
SOUTH-WEST GREENLAND



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GRÆNSELAND

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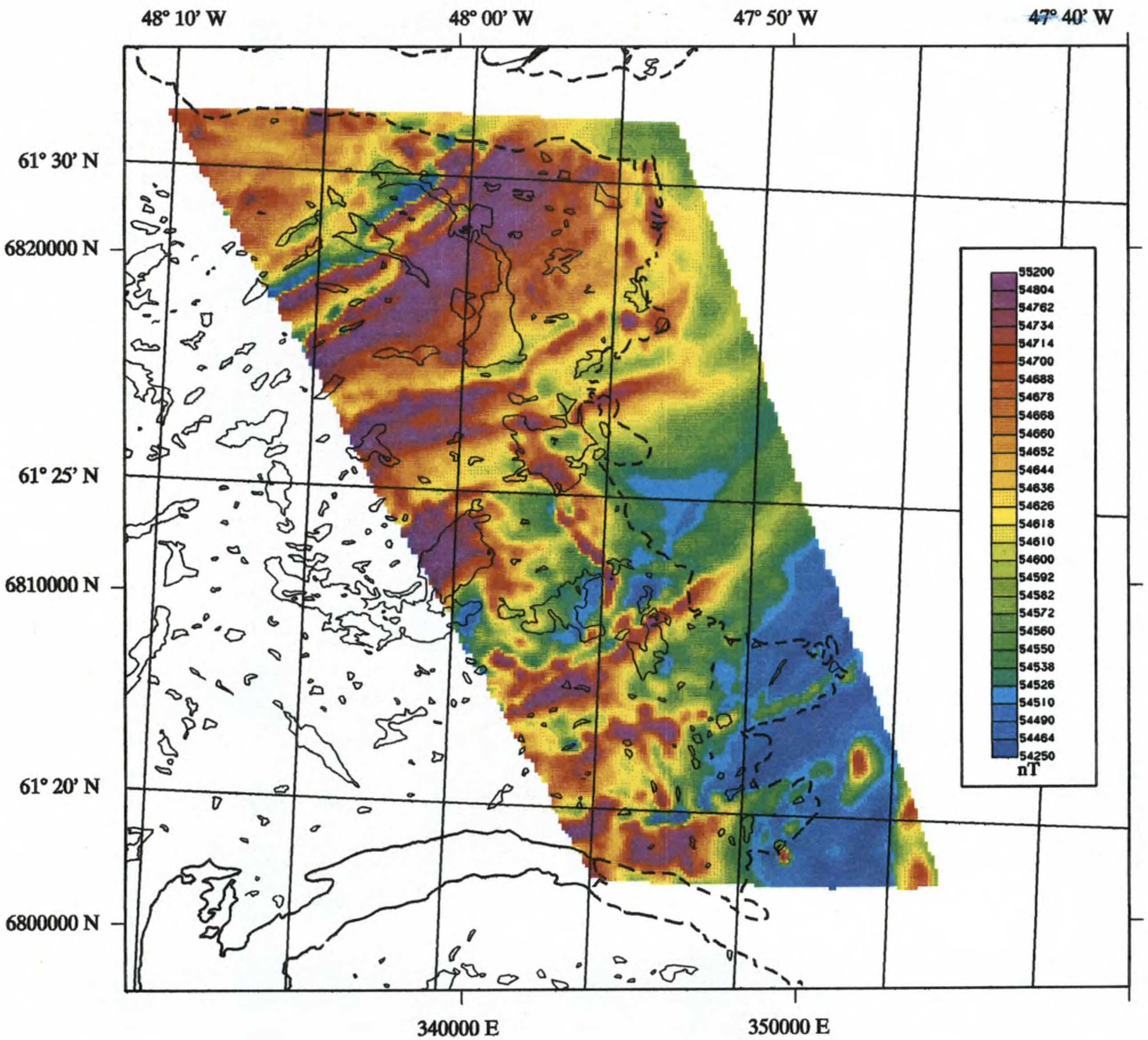

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GRÆNSELAND

TOTAL MAGNETIC INTENSITY

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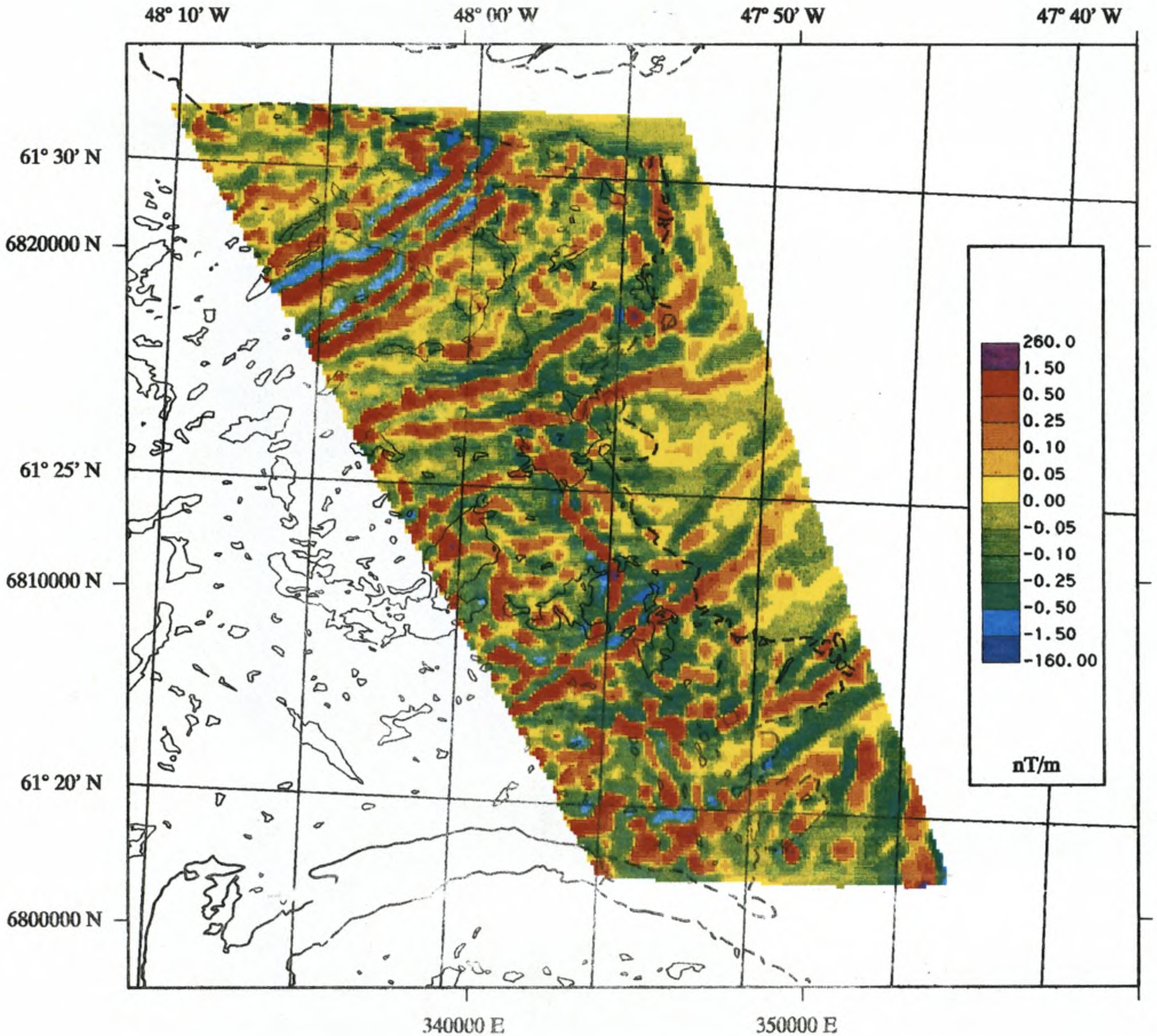
SOUTH-WEST GREENLAND



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GRÆNSELAND

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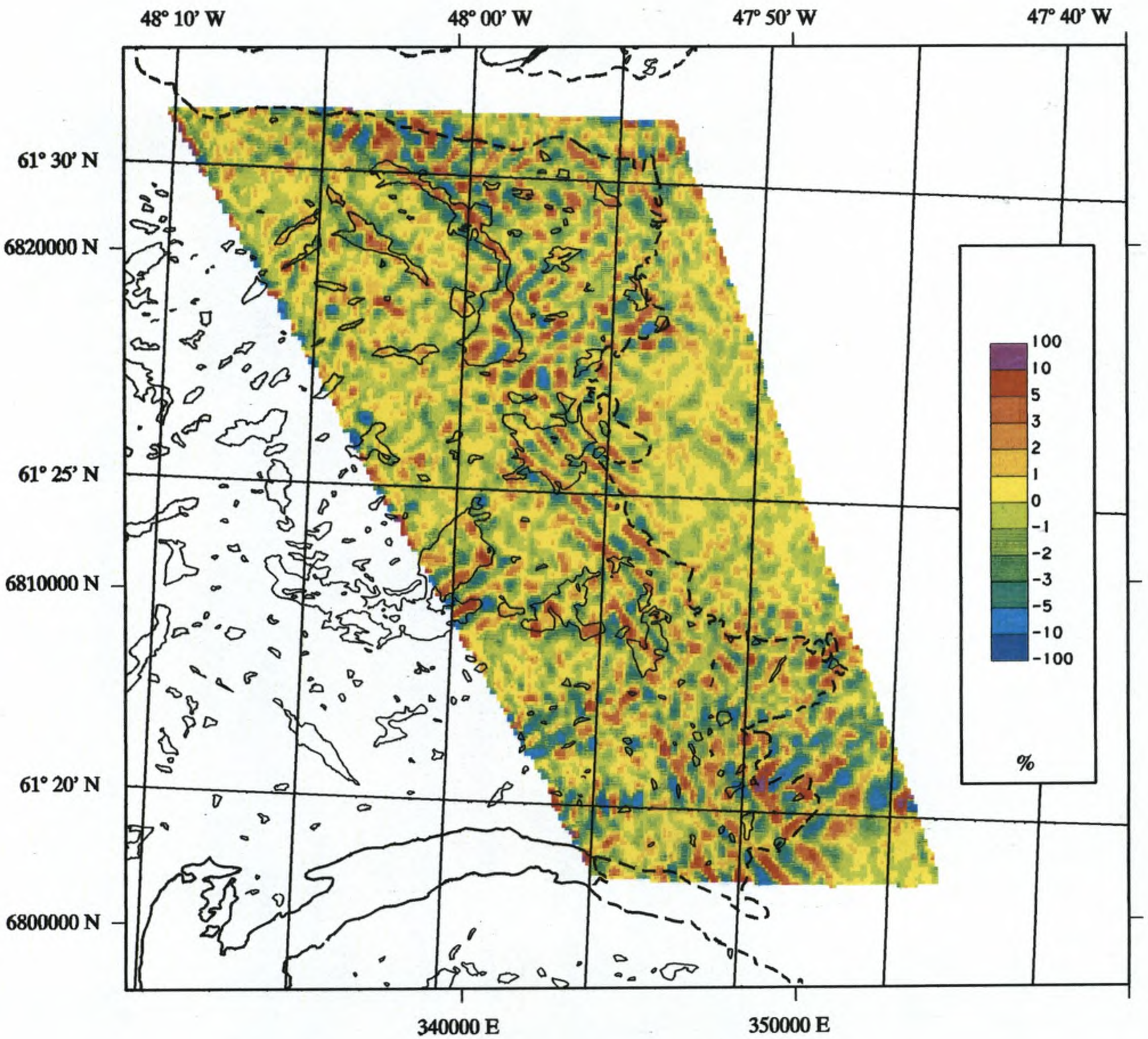

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GRÆNSELAND

V.L.F.- EM

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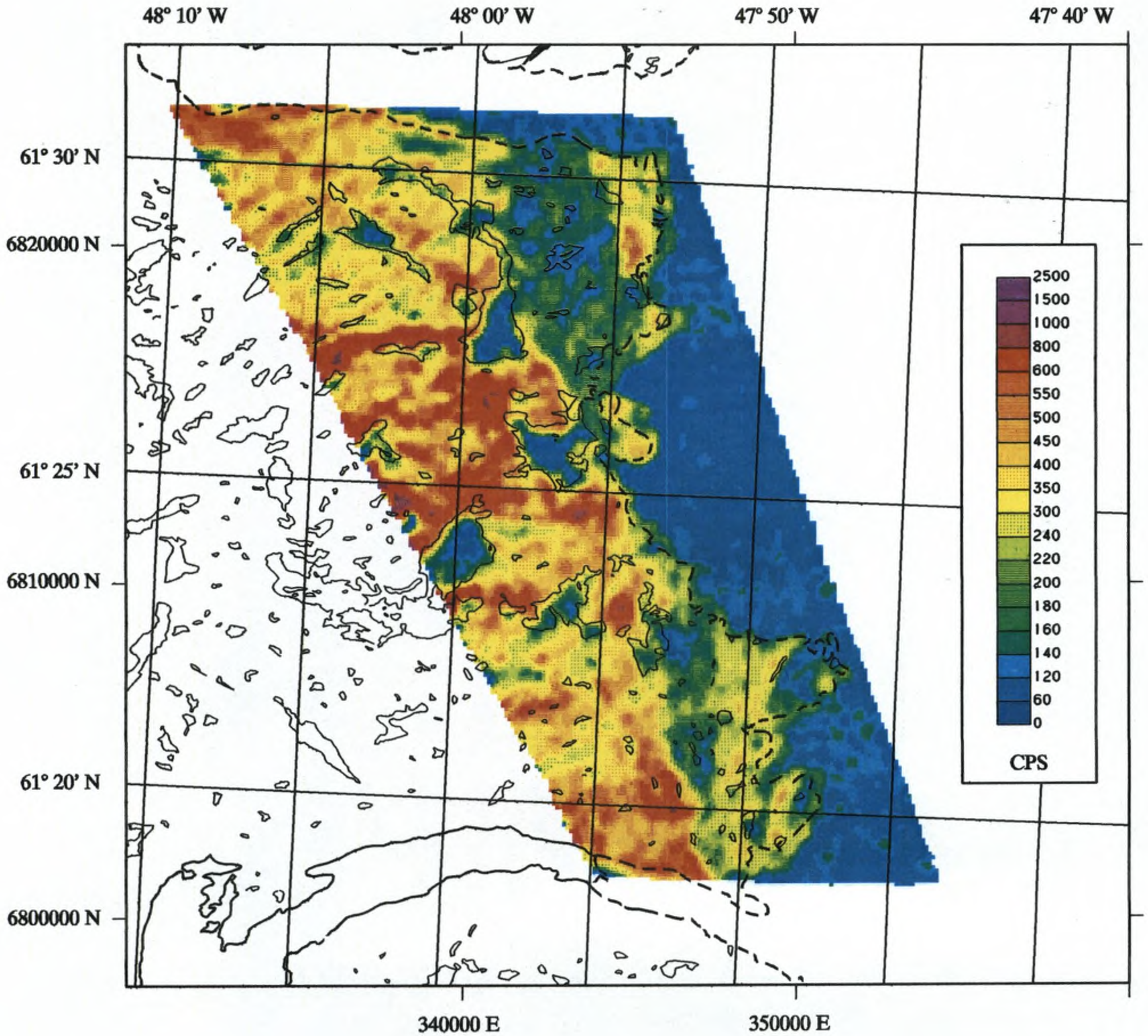
SOUTH-WEST GREENLAND



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GRÆNSELAND

TOTAL COUNT RADIOMETRICS

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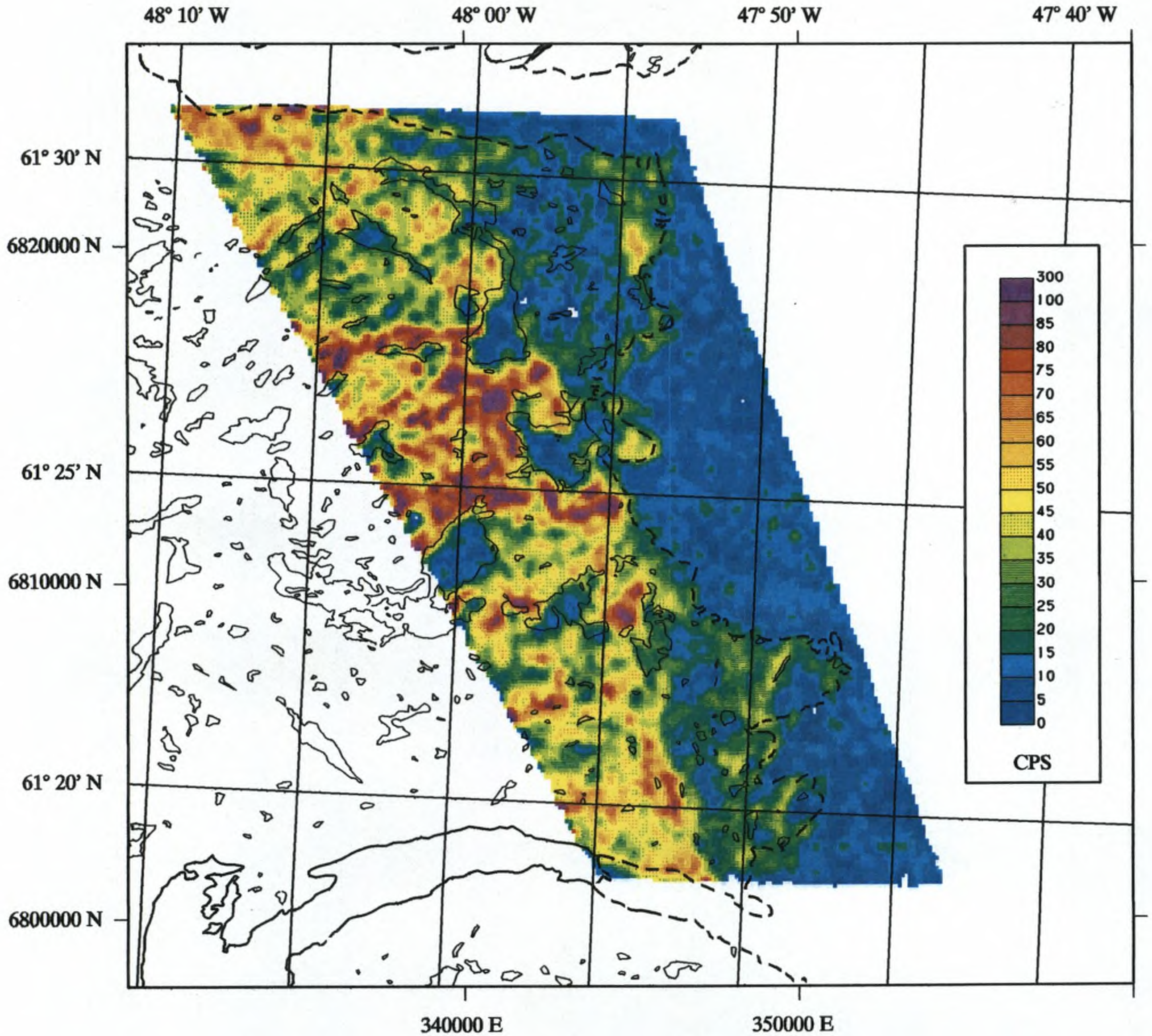

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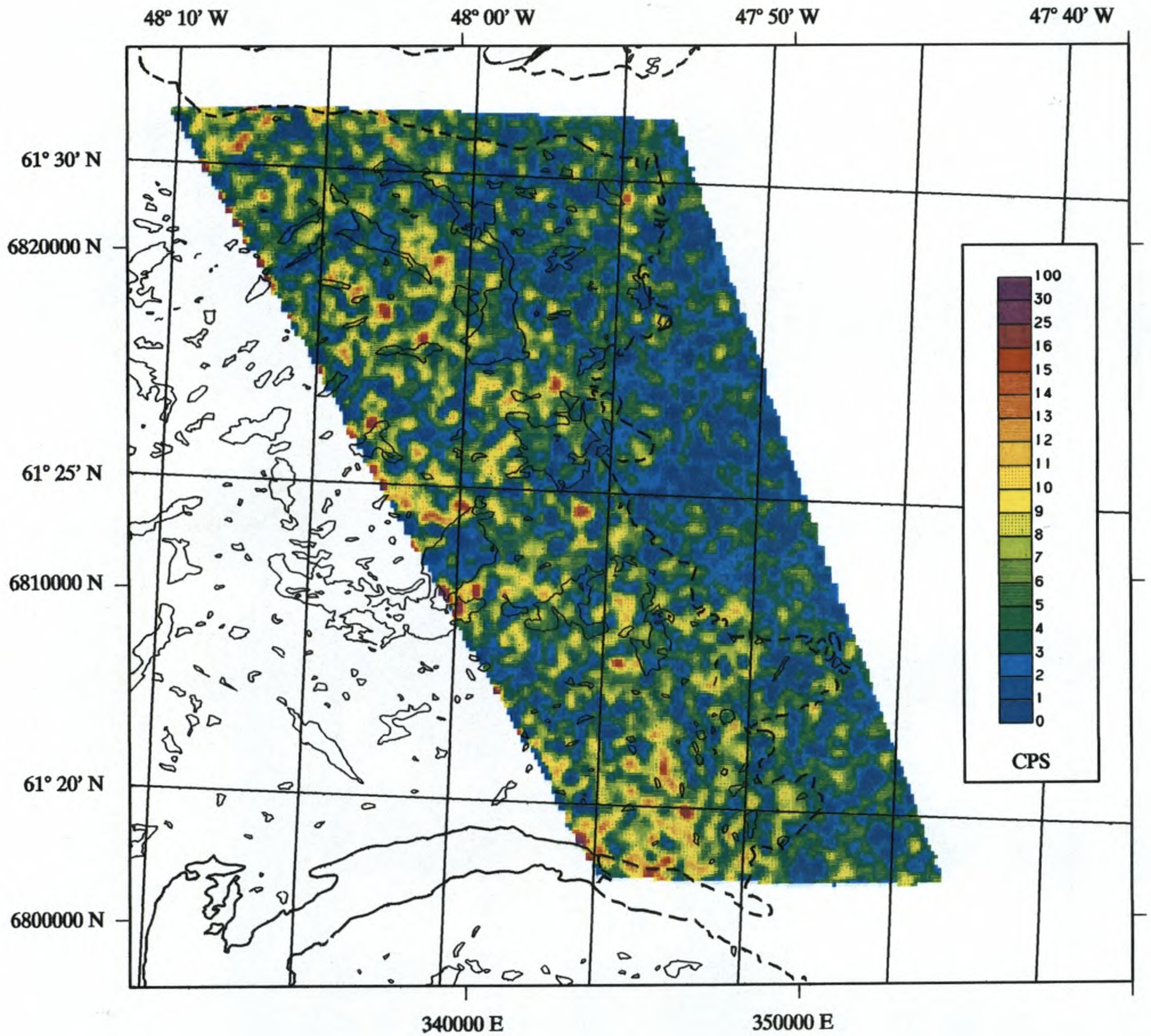

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URANIUM RADIOMETRICS

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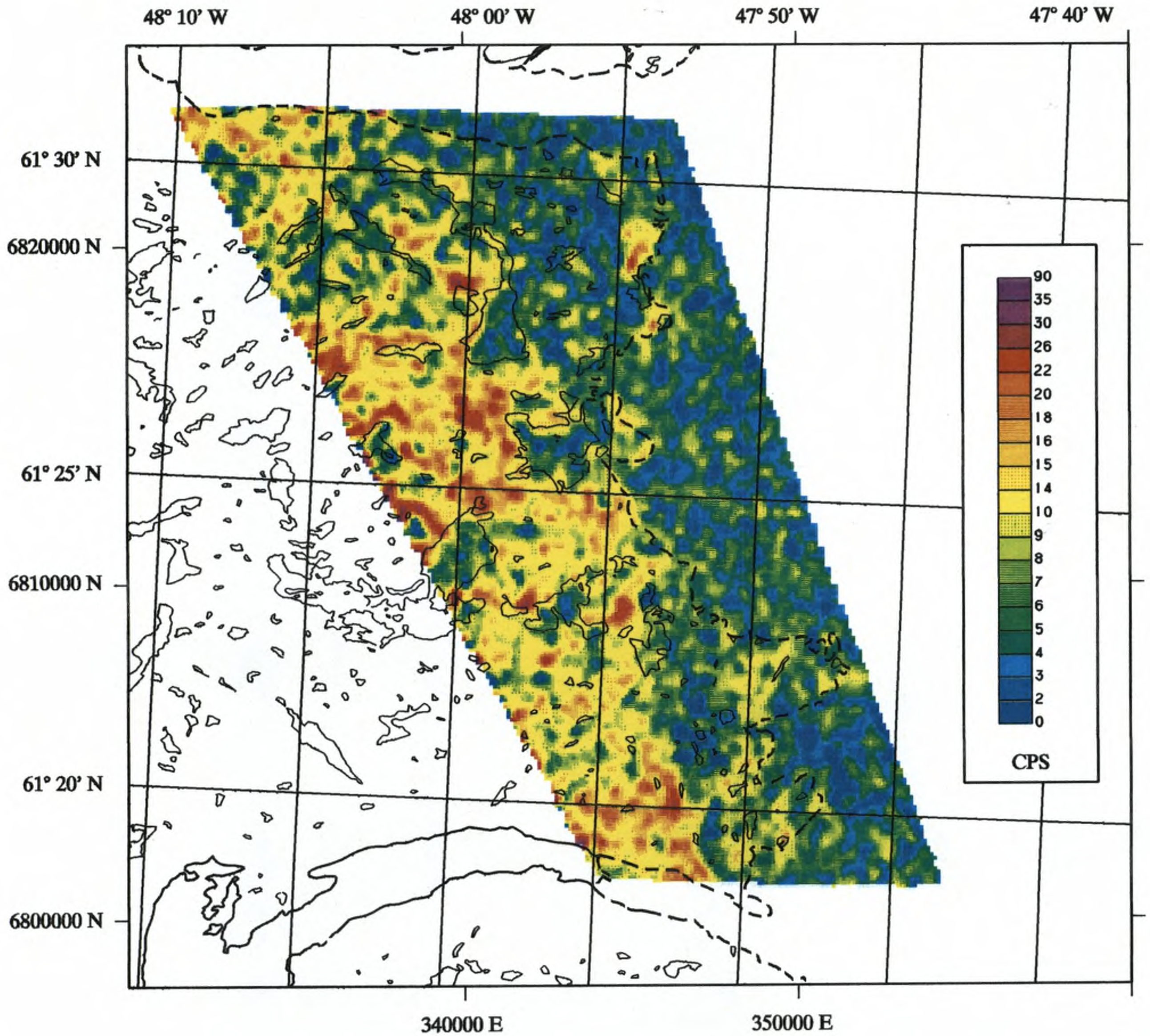

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<u>Appendix D -</u> Sioralik South (4)

This survey block was designed to cover a rather limited area of Tartoq supracrustals and surrounding gneisses which has received little prospecting activity to date. Survey flights 22-26 were carried out over the area between 8-10 June 1996.

The geophysical results were extremely encouraging and a number of massive sulphide targets were detected by the electromagnetic survey providing a potential for economic base metal and/or associated gold mineralization. This area warrants very detailed ground followup. Most of the massive sulphide anomalies are associated with a horseshoe-shaped formation mapped as a rust horizon. Correlation of EM anomalies from line to line is quite erratic in terms of conductivity- thickness, length, multiplicity and magnetic association. The formation is highly magnetic and should probably be classed as an iron formation.

The magnetic results confirm the presence of small ultramafic intrusives shown on the 1:100 000 scale geological maps. In this regard, the highest intensity magnetic feature was mapped on traverse 40170 and is partly under the lake in the area.

Geophysical Anomalies Recommended for Initial Ground Follow-up

1) EM anomaly 40230D
- thick sulphide section indicated at or near surface
- chalcopyrite float located nearby(Sample #786 - Renzy Mines Ltd.)

2) EM anomaly 40260C
- area of highest conductivity
- multiple or broad

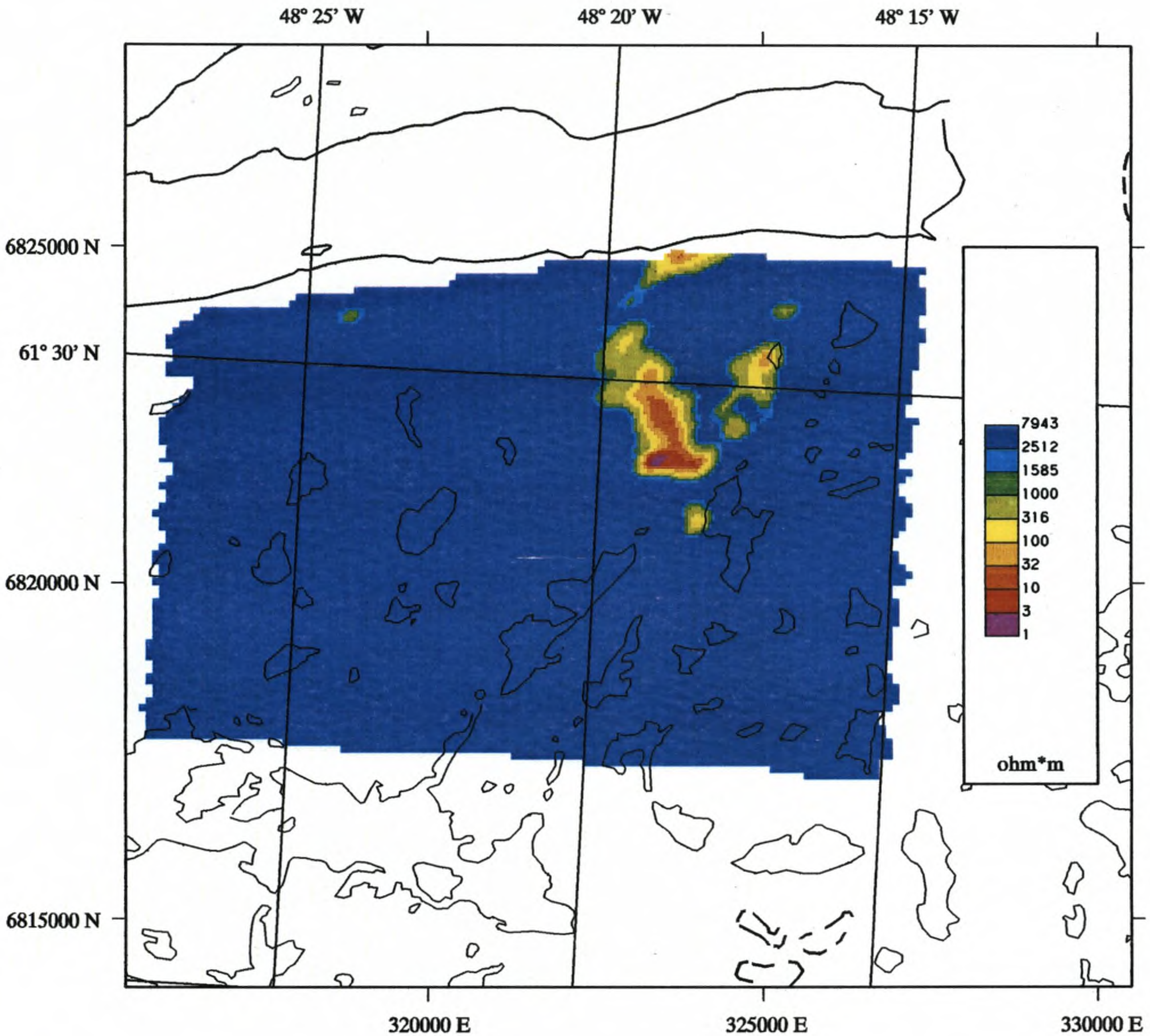
3) EM anomaly 40280H
- highest amplitude
- at or near surface

The above three anomalies all lie within the western flank of the horseshoe structure.

4) EM anomaly 40240G
- localized, narrow sulphide target
- at or near contact with ultramafic plug

PROJECT AEM GREENLAND 1996

SOUTH-WEST GREENLAND



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SIORALIK SOUTH

APPARENT RESISTIVITY

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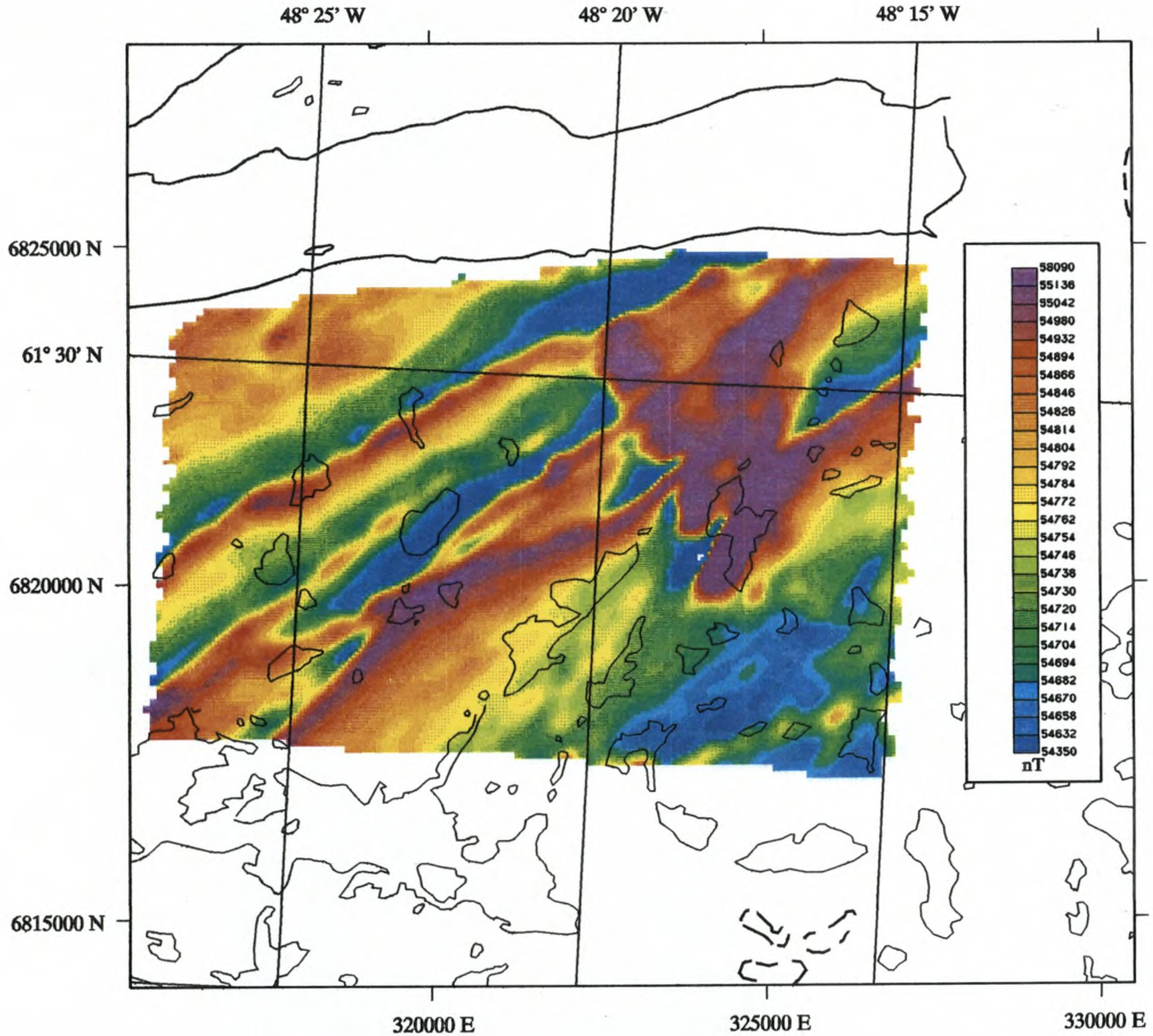

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SIORALIK SOUTH

TOTAL MAGNETIC INTENSITY

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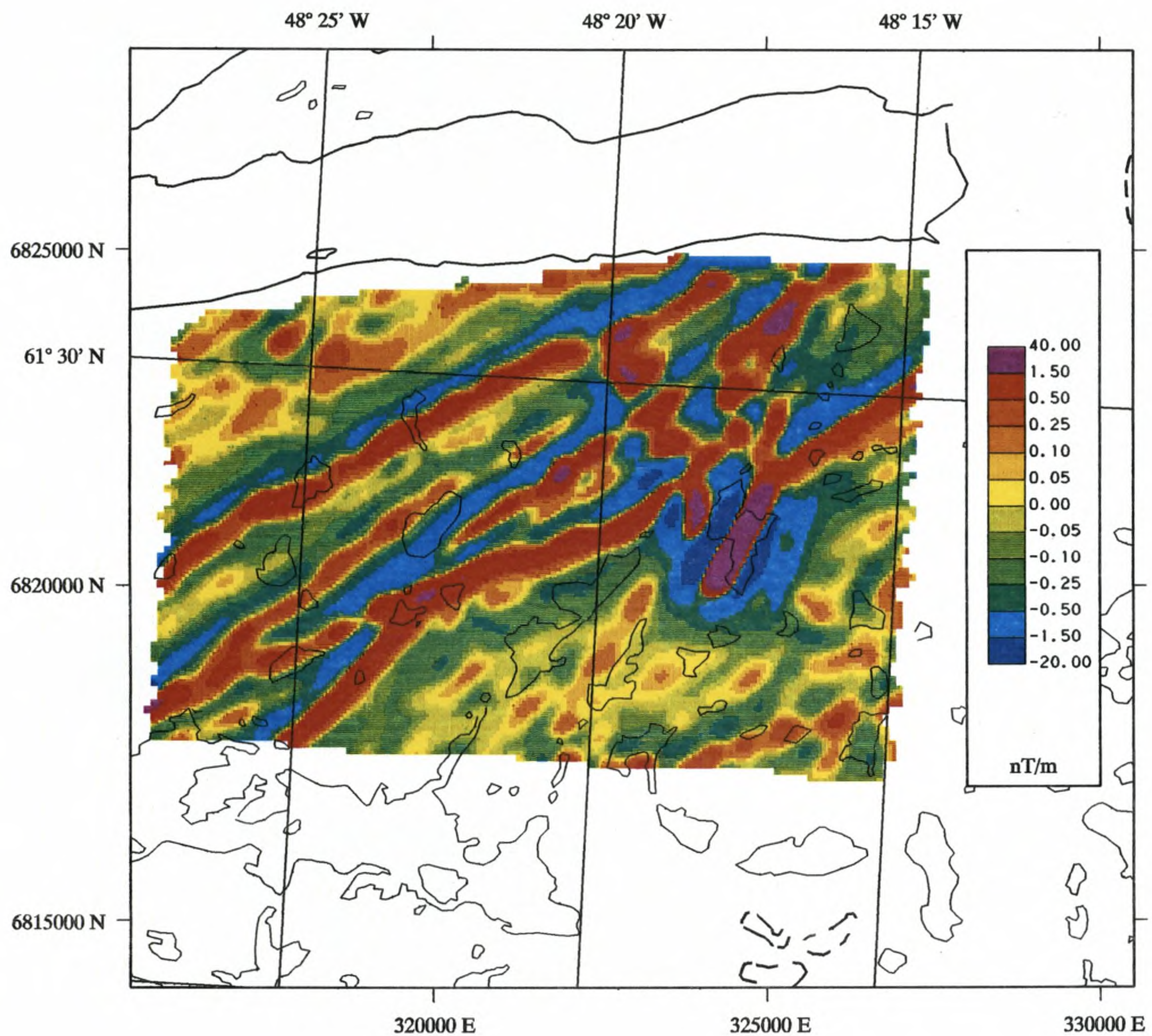

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SIORALIK SOUTH

VERTICAL MAGNETIC GRADIENT

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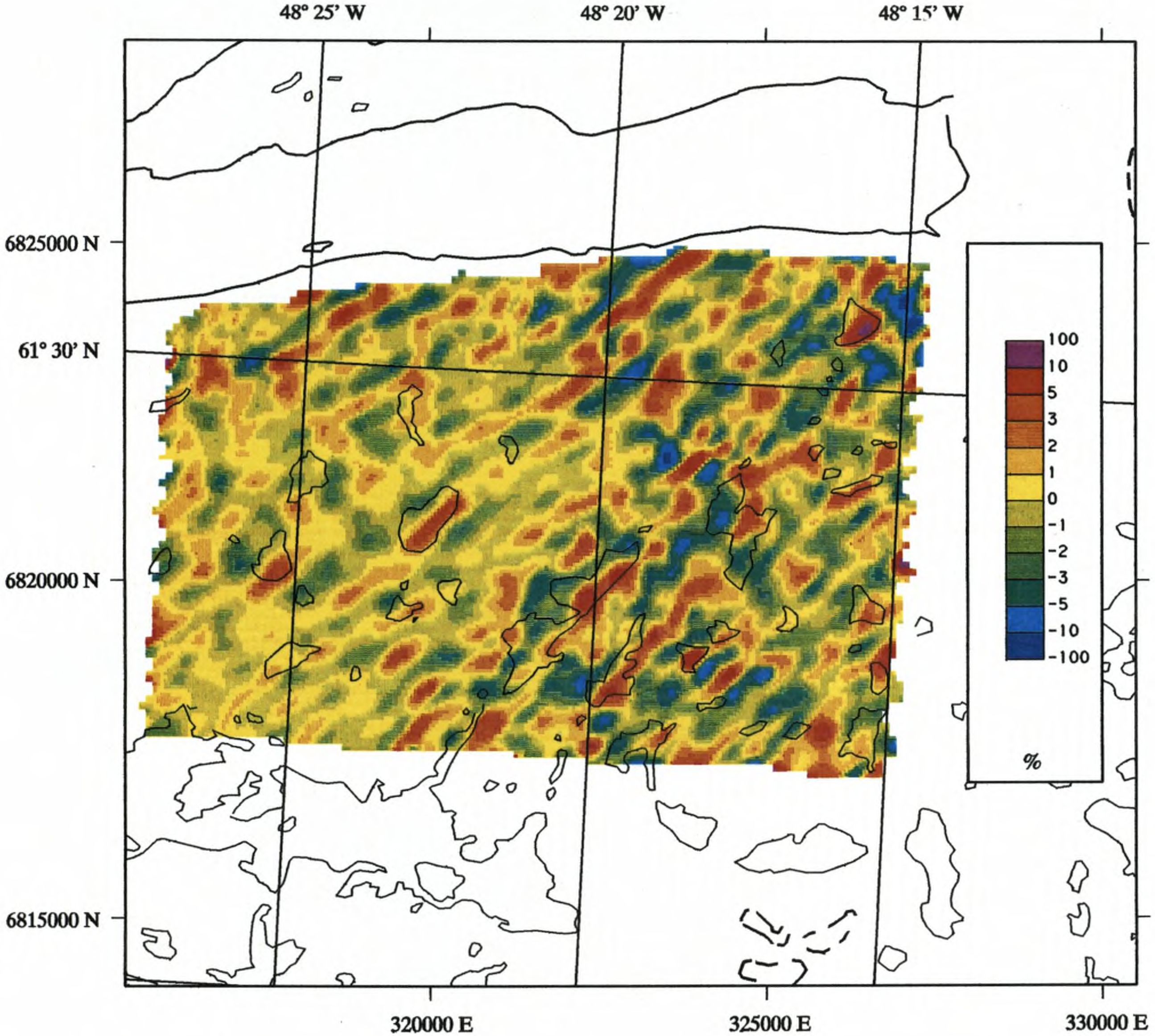

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V.L.F.- EM

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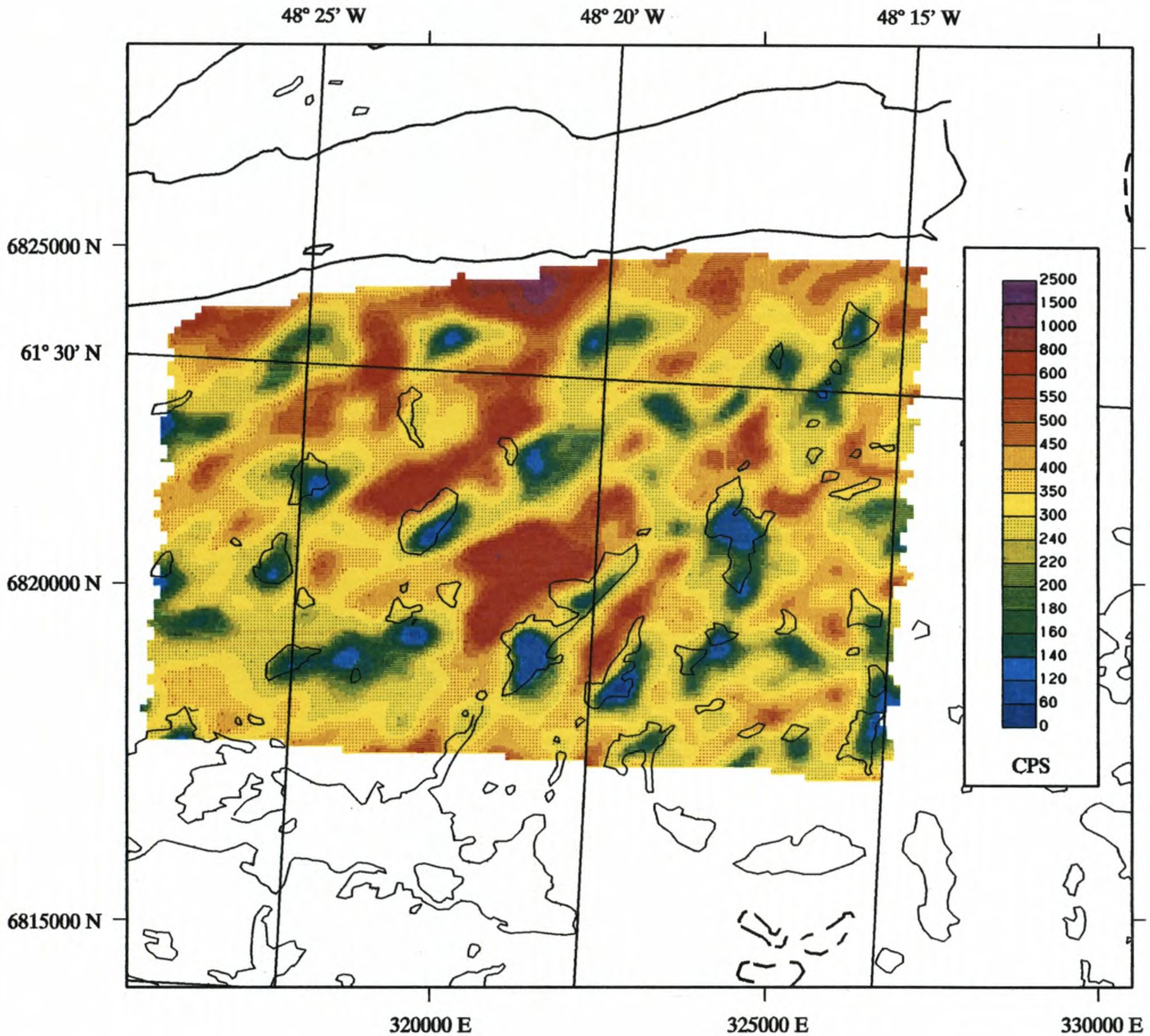

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SIORALIK SOUTH

TOTAL COUNT RADIOMETRICS

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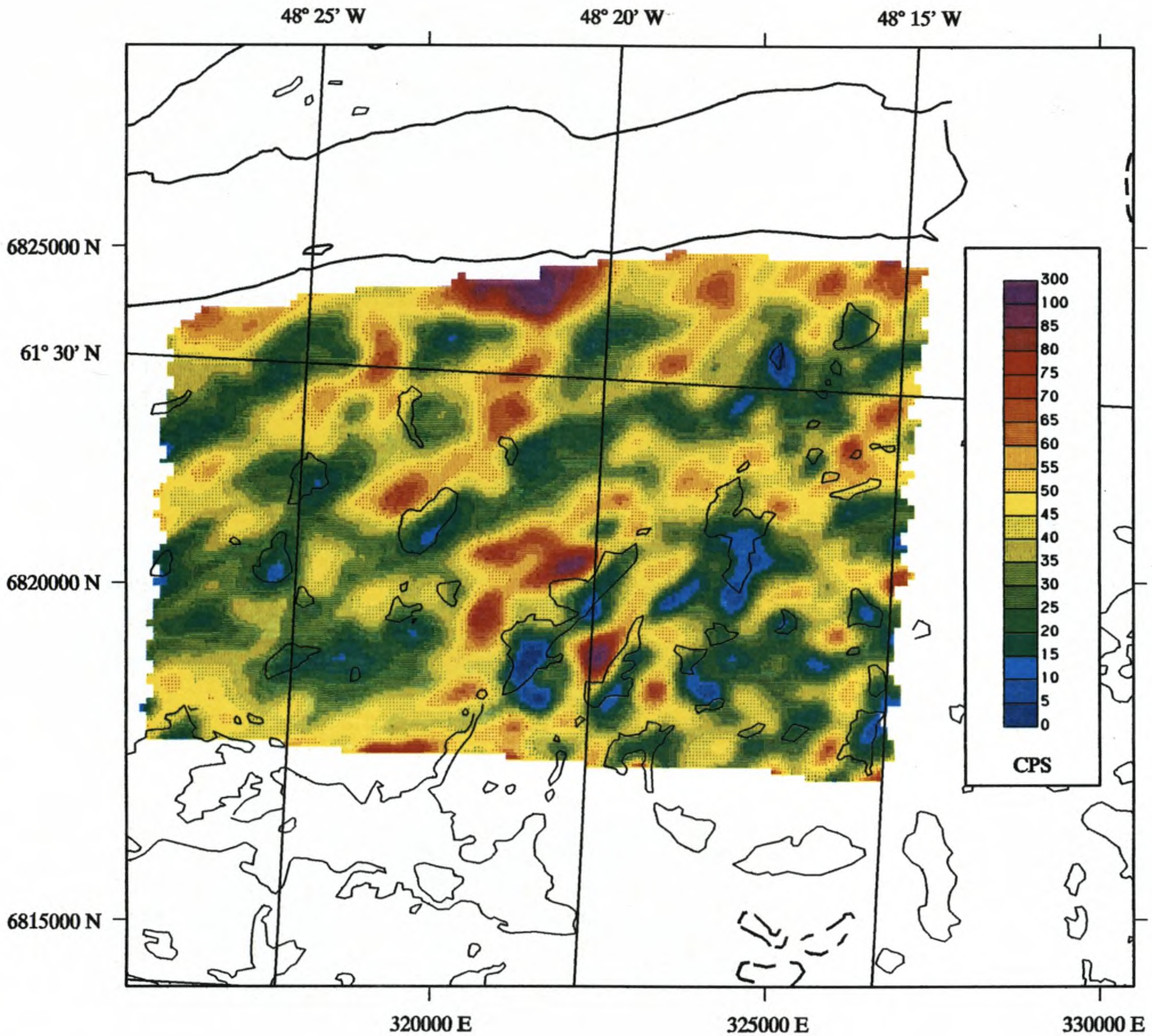

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SIORALIK SOUTH

POTASSIUM RADIOMETRICS

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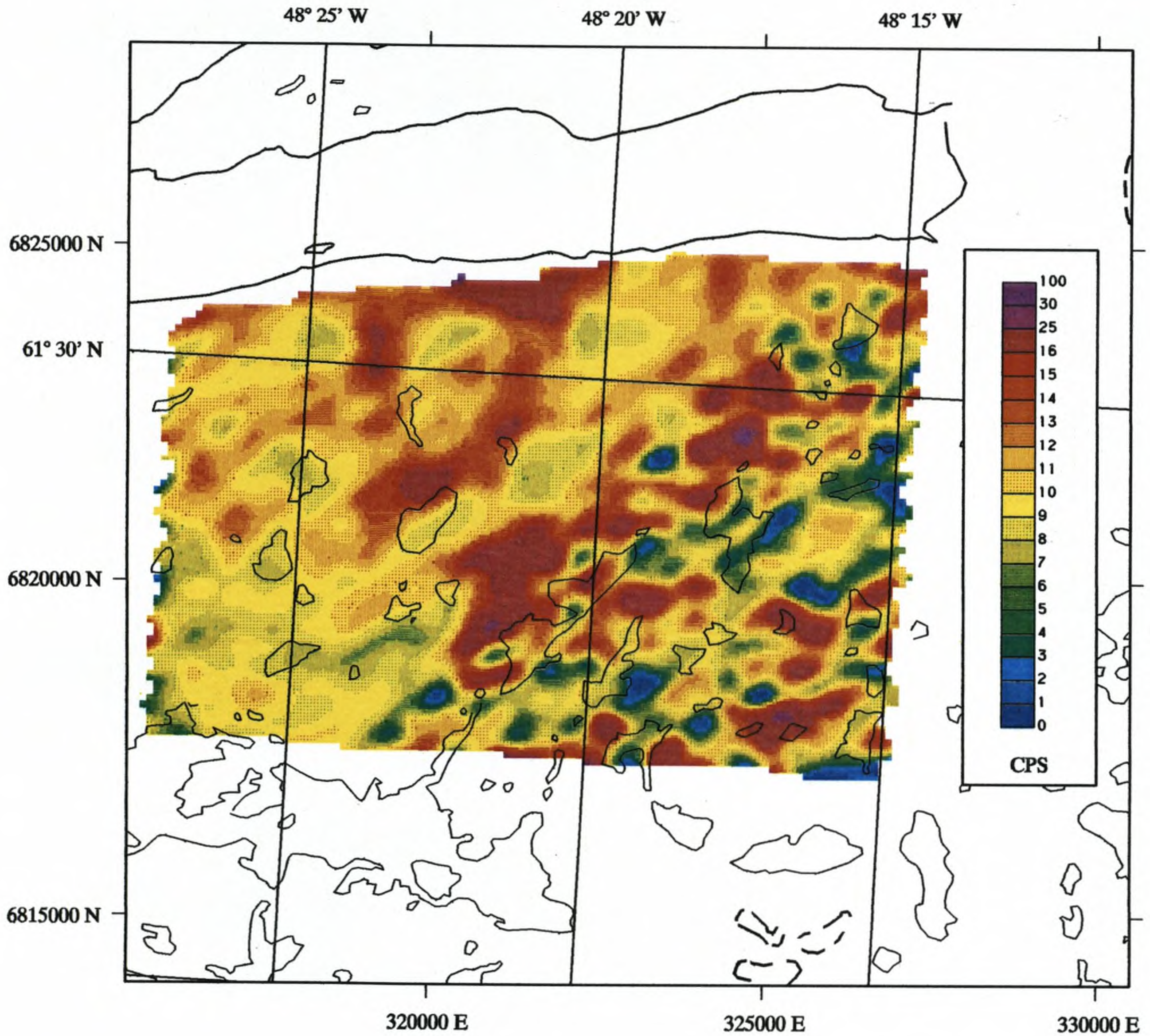

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SIORALIK SOUTH

URANIUM RADIOMETRICS

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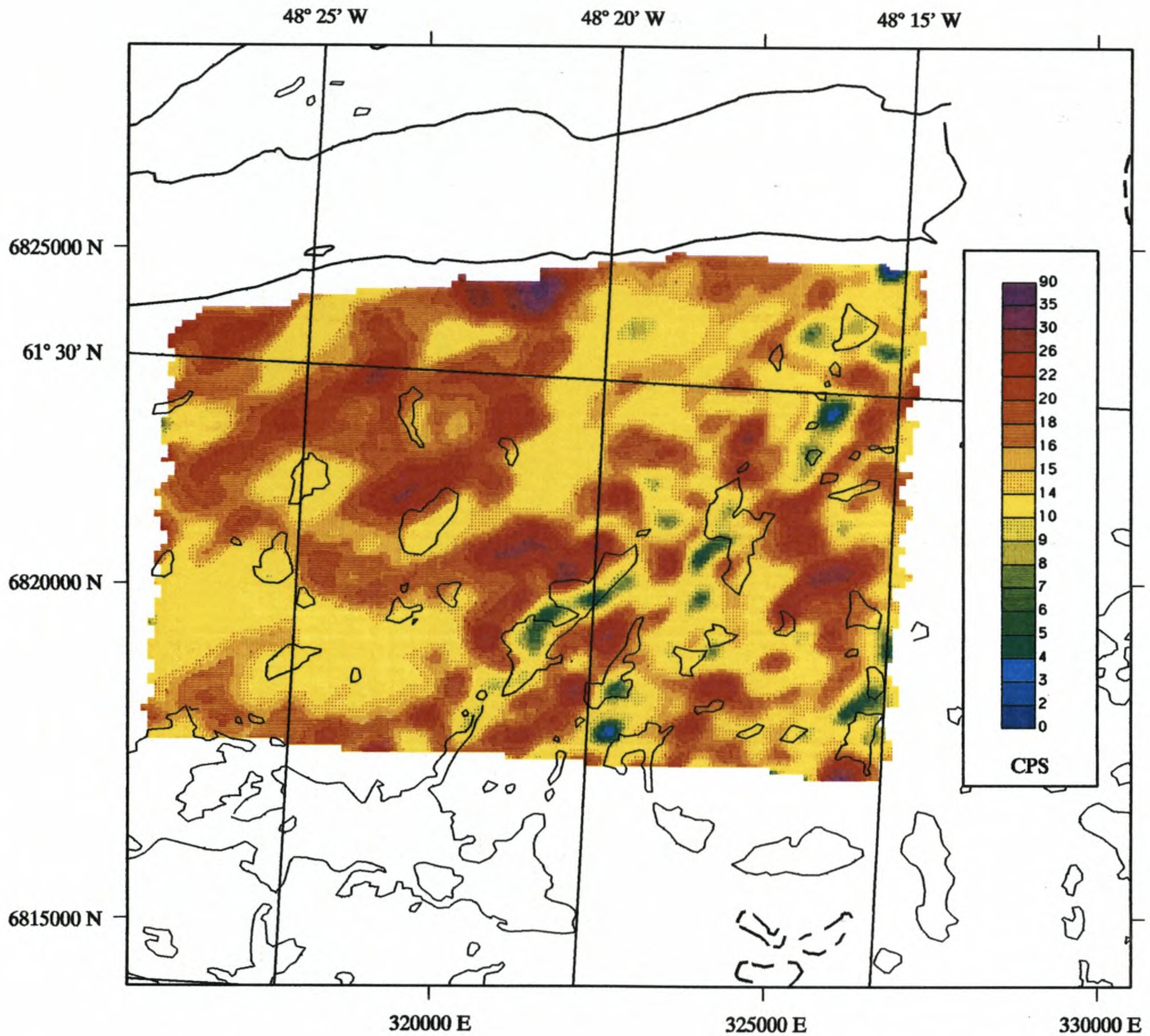
SOUTH-WEST GREENLAND



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SIORALIK SOUTH

THORIUM RADIOMETRICS

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<u>Appendix E</u> - Arsuk Ø (5)

This is the smallest of the survey blocks and required only one day (11 June 1996) and four helicopter flights (number 27-30) to complete. The steep south face of the island was a problem for the helicopter, and some of the flight lines could only be surveyed in a southerly direction.

The most common geophysical feature to the other Ketilidian areas surveyed is the highly conductive/radioactive formation mapped along the northern and eastern coasts. The most uncommon feature is the abundance of basic rock units outlined by the magnetic survey together with the magnetite anomalies detected by the electromagnetic survey. Some young (Mesozoic) NNW striking dykes were also mapped on the eastern side of the island

A reported gold occurrence (Thematic Map Series 94/1) in the upper metavolcanic part of the sequence should be re-evaluated in conjunction with the ground follow-up of geophysical targets.

Geophysical Anomalies Recommended for Initial Ground Followup:

1) *EM anomaly on traverse 50200 - time fiducial 13:35:30 together with magnetite anomaly 50210A*
   - local sulphide mineralization in close proximity to magnetite

2) *Magnetite anomaly 50282D*
   - highest intensity magnetic anomaly detected by the 1996 survey (5000nT)

3) *Thorium hotspot near north end of traverse 50230 at intersection with tie line 85010*
   - see earlier reference under Radiometric results

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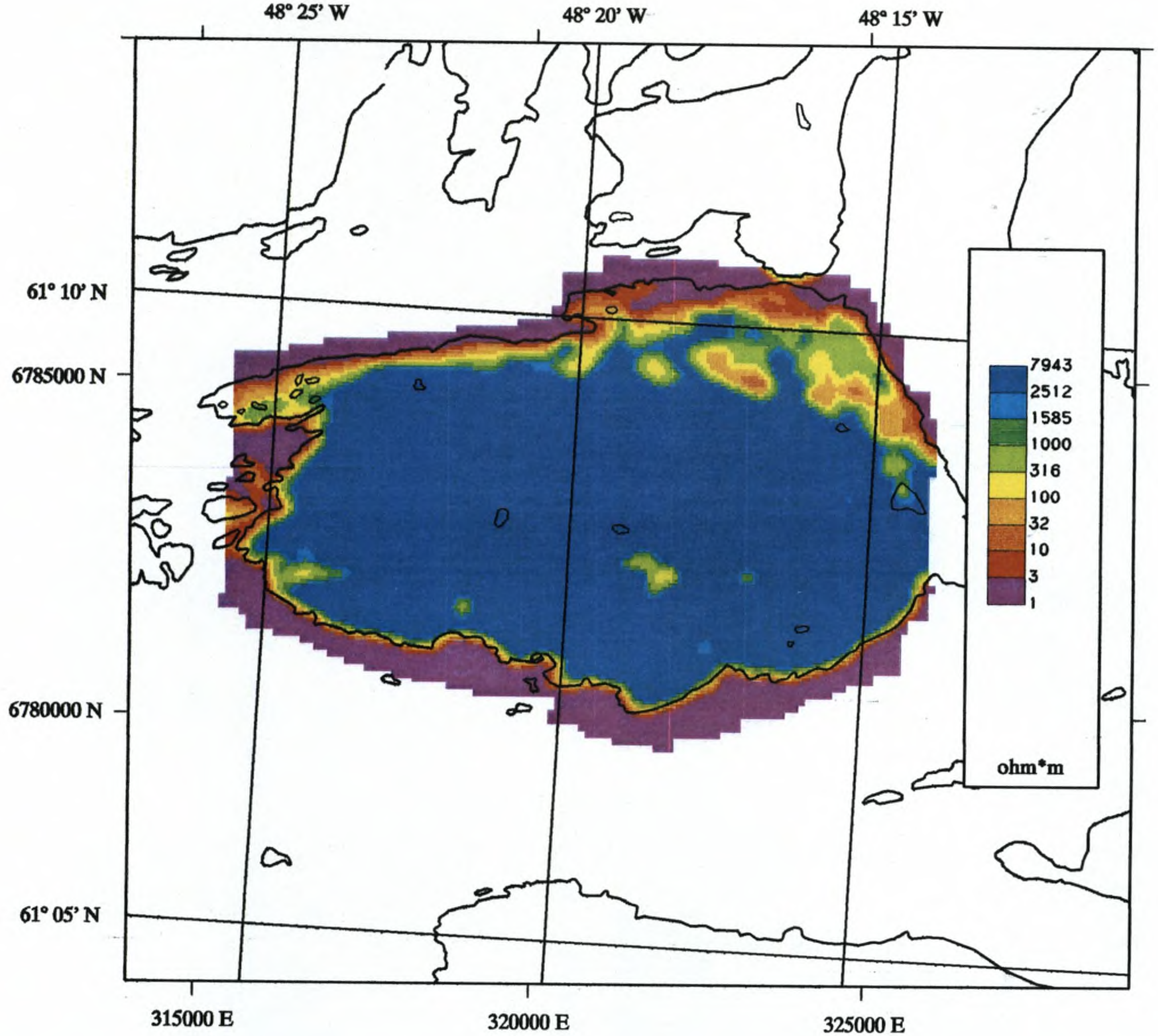
SOUTH-WEST GREENLAND



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ARSUK Ø

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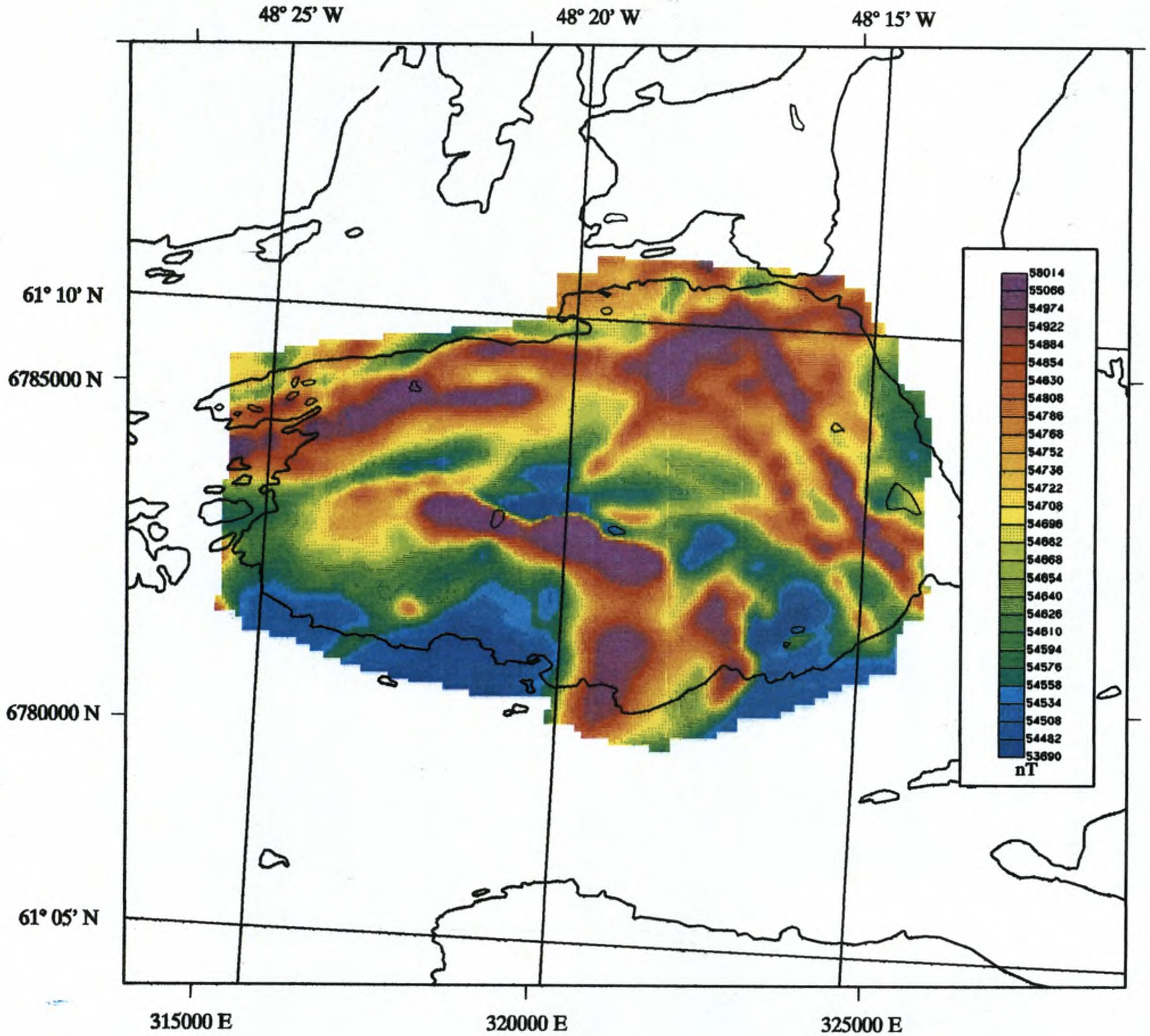

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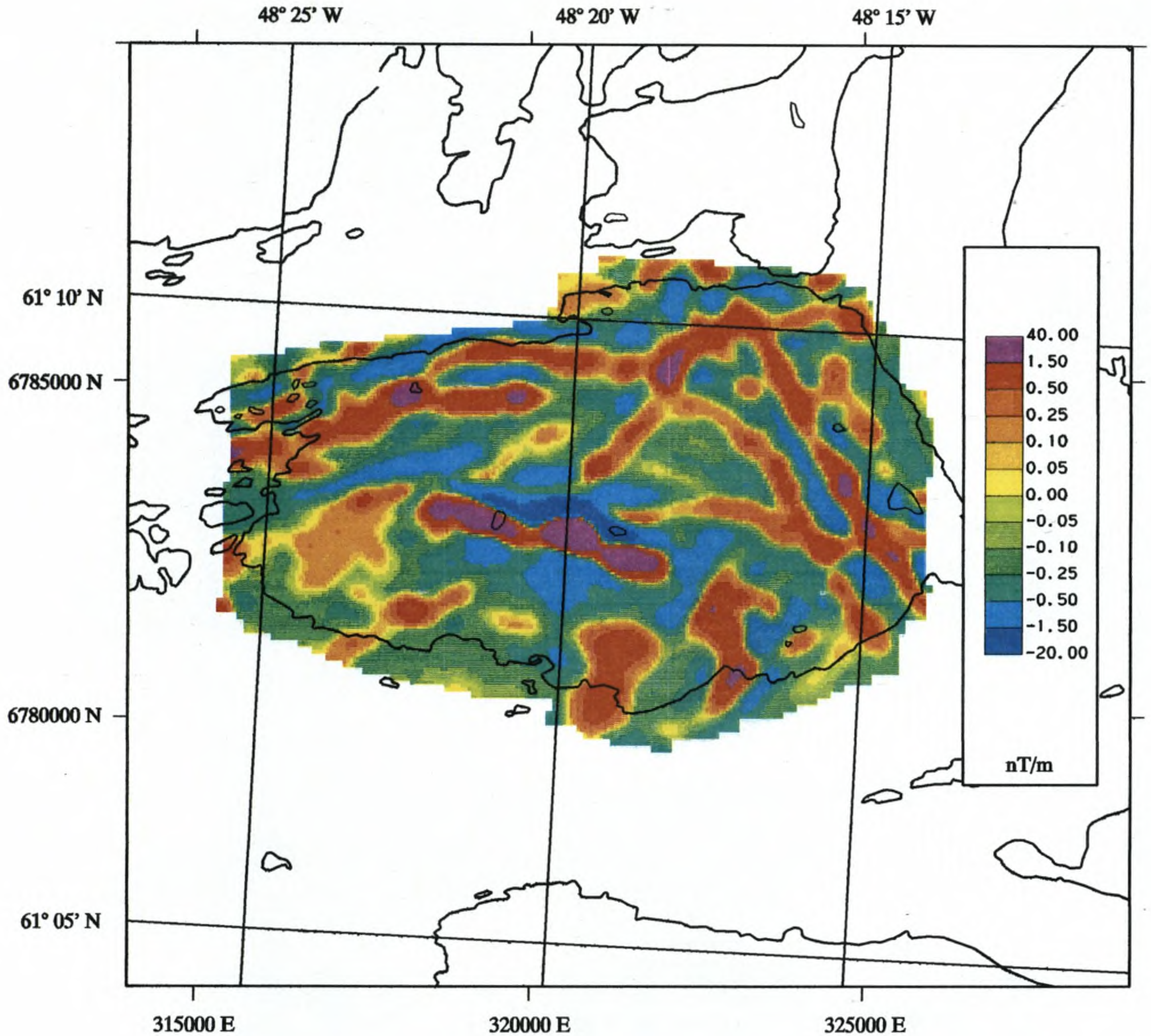

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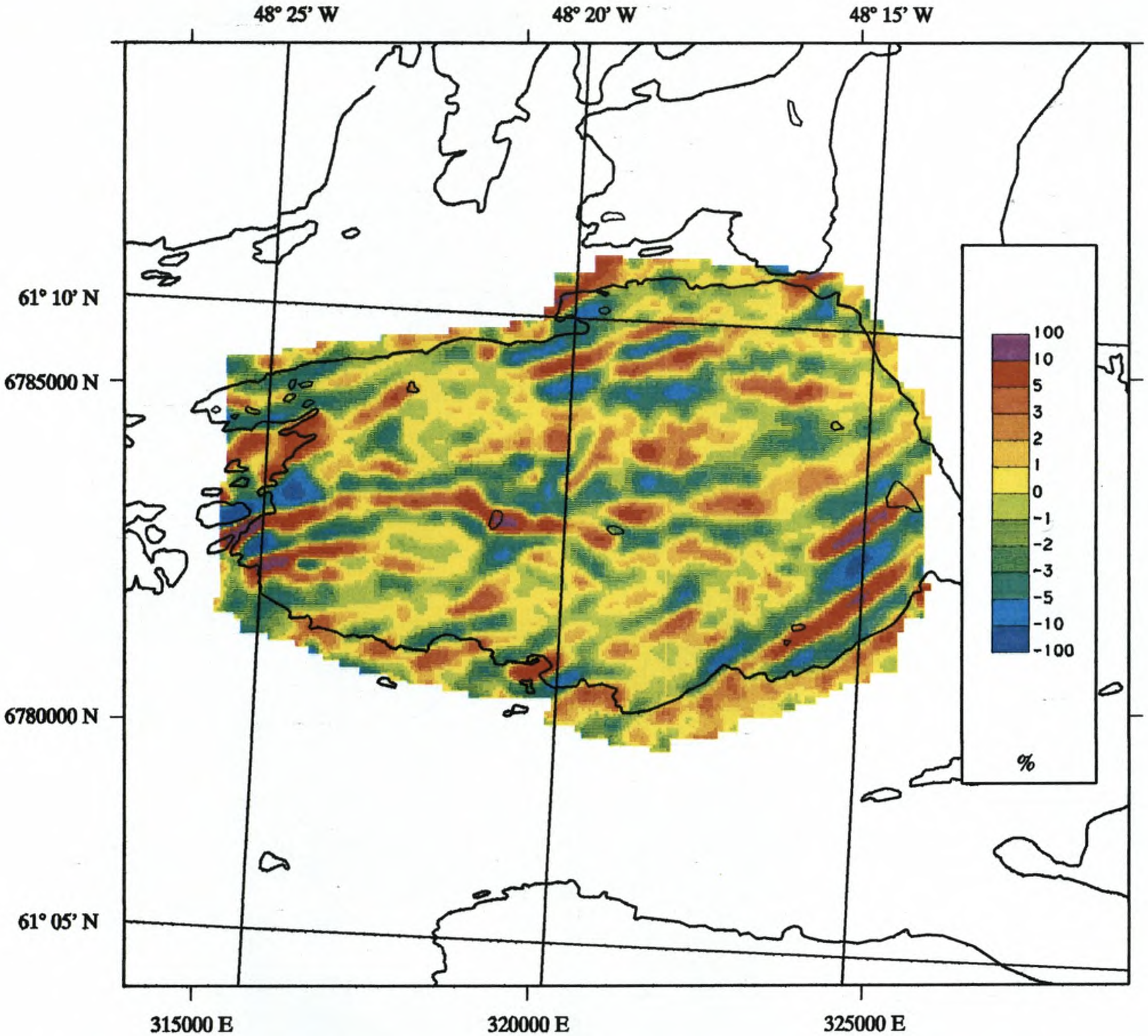

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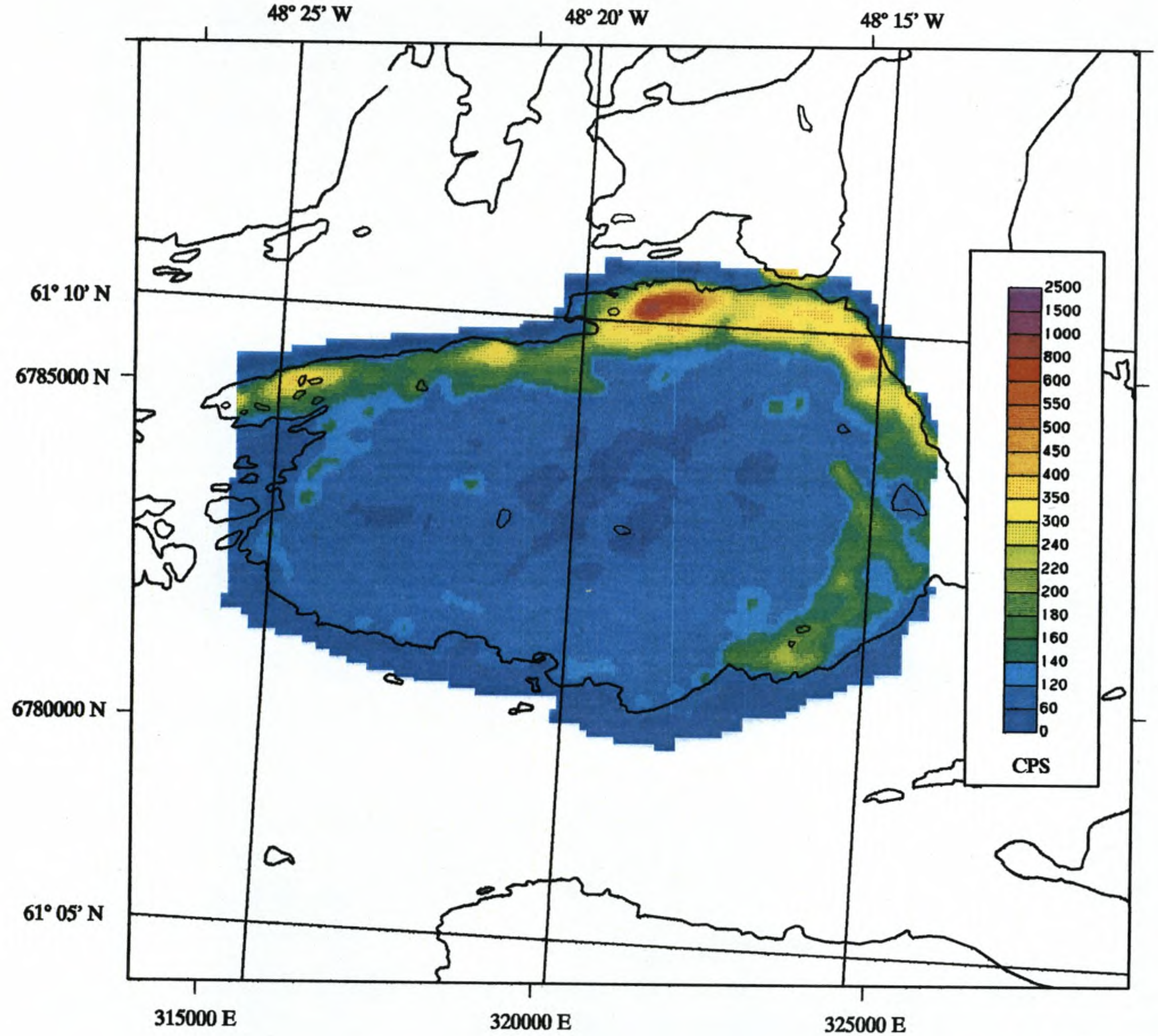

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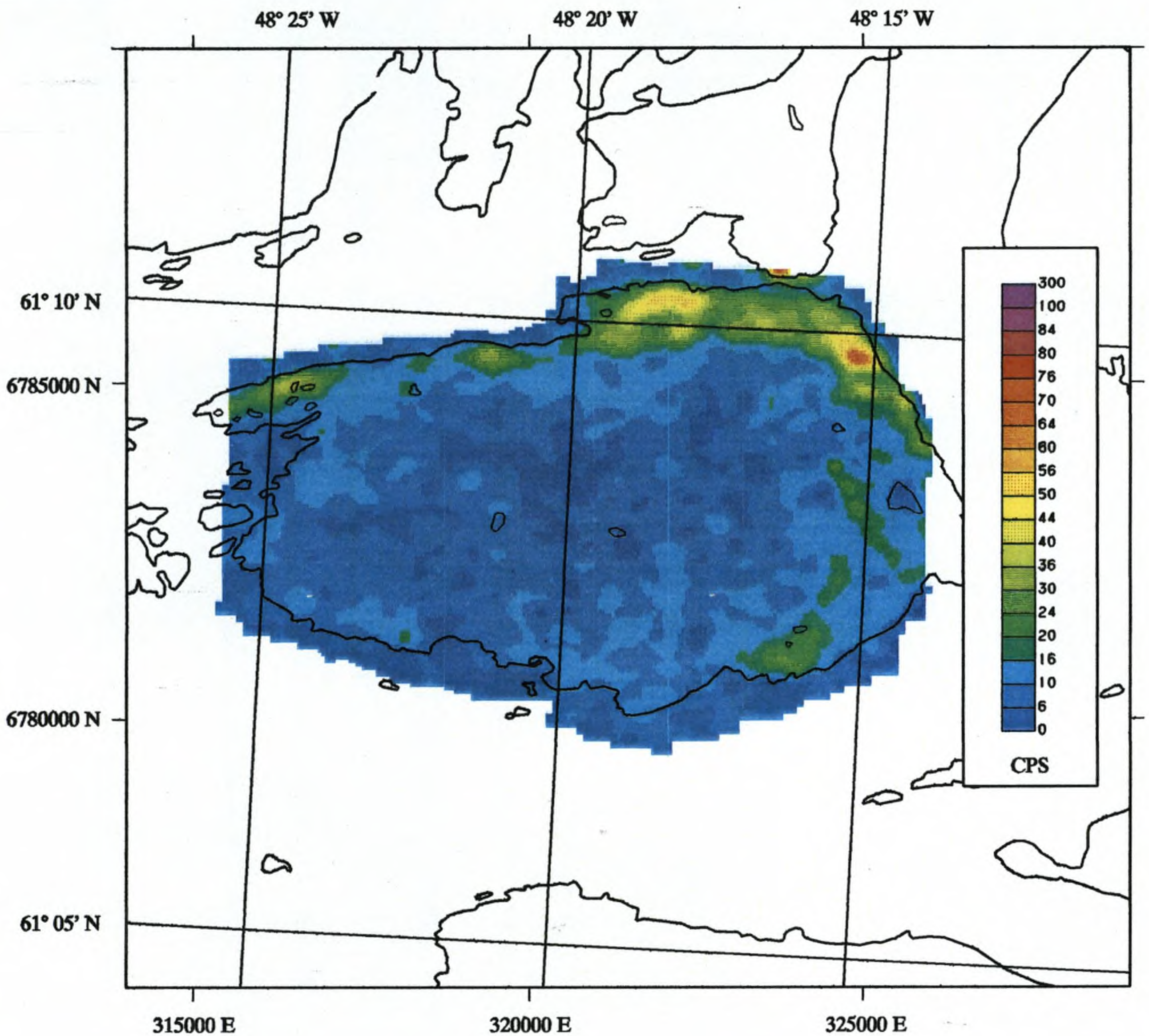

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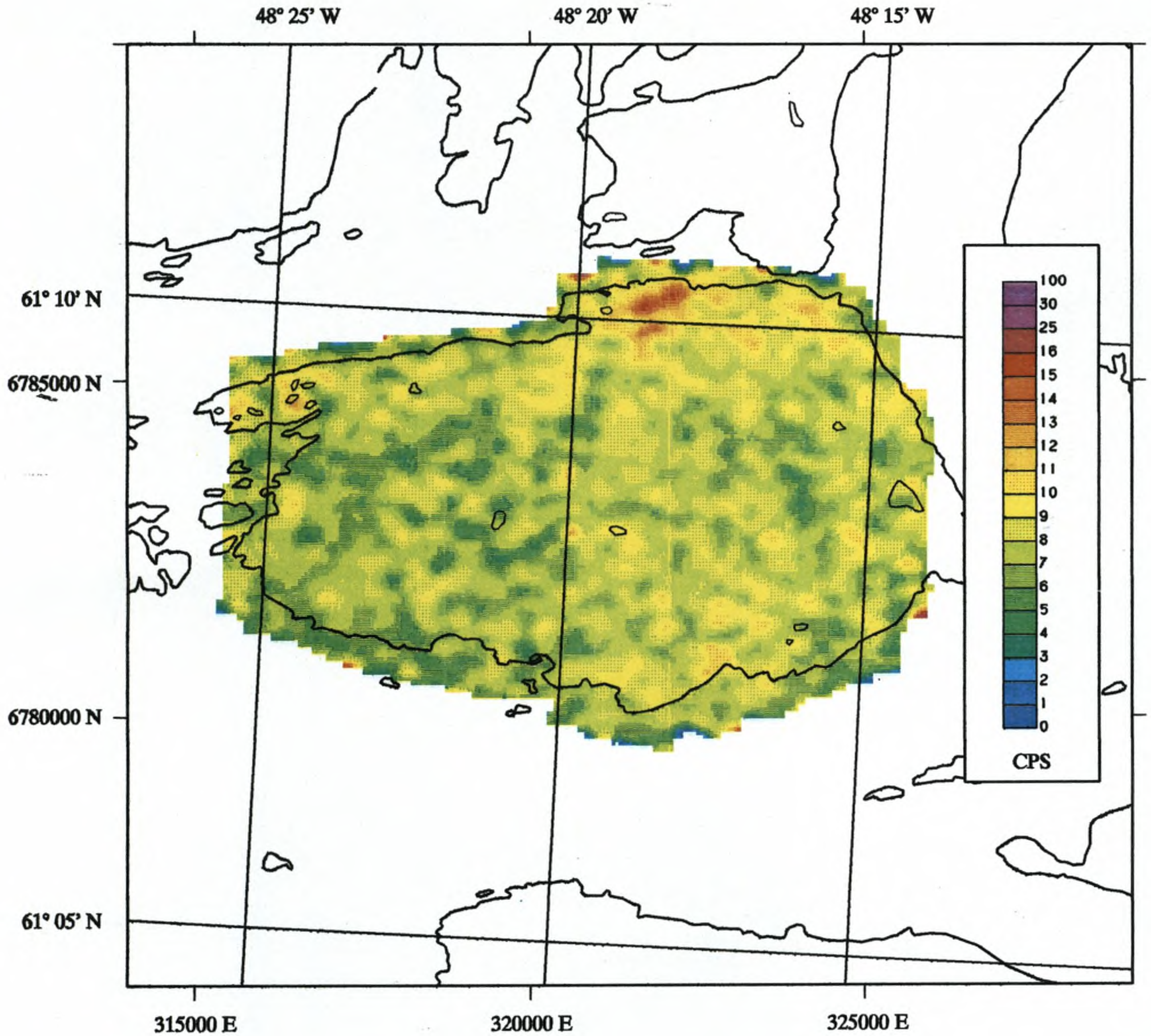

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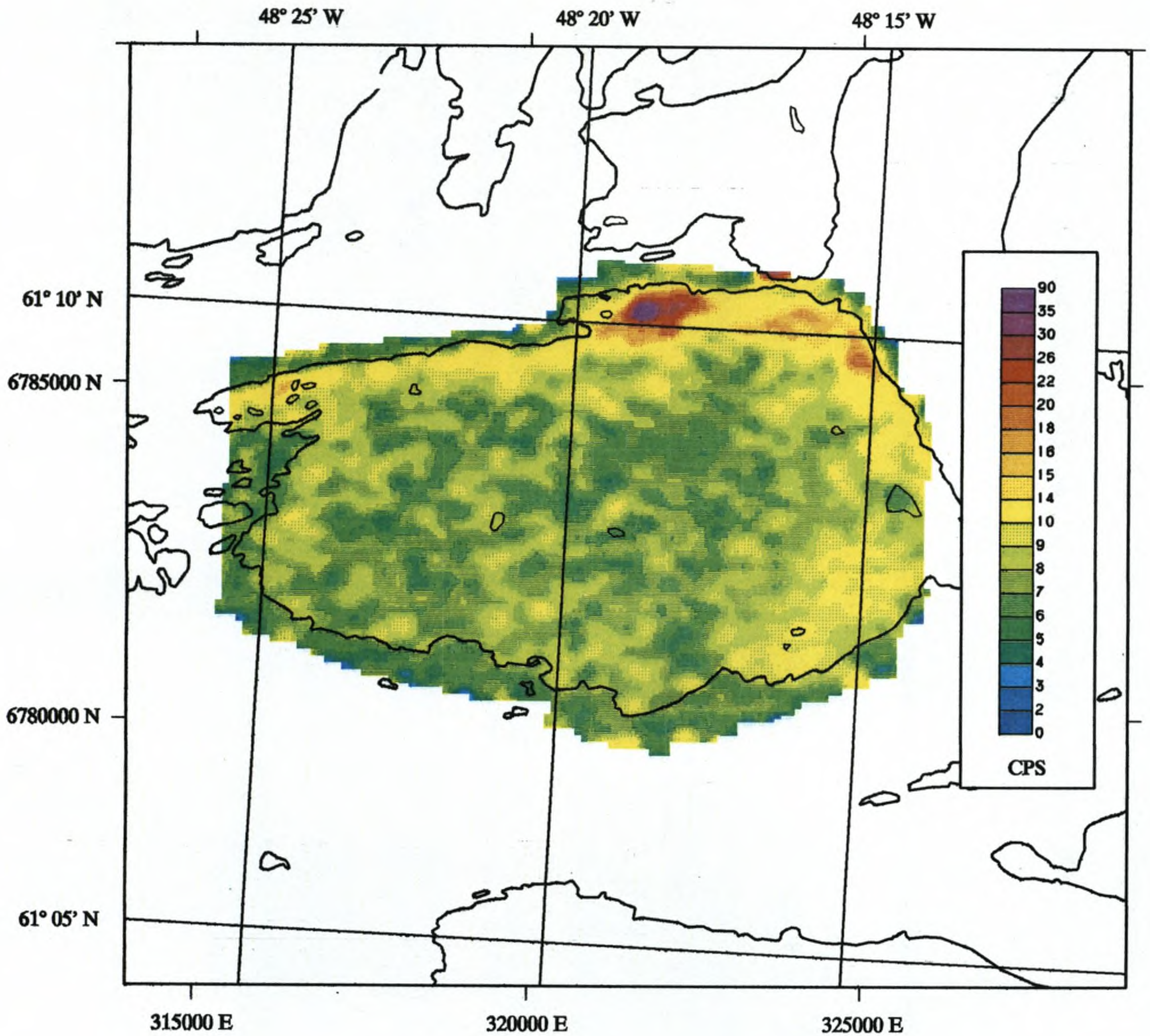

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