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E82-10318

CR-168897

MAGSAT DATA INVESTIGATION M-004

An investigation of Magsat and complementary data emphasizing Precambrian shields and adjacent areas of West Africa and South America.

Quarterly report<sup>1/</sup> covering activities of the investigation during Federal fiscal year 1981, through 30 September 1981.

David A. Hastings  
Technicolor Graphic Services, Inc.<sup>2/</sup>  
EROS Data Center  
Sioux Falls, SD 57198

<sup>1/</sup> This report is in "letter format." It has not been formally edited for compliance with U.S. Geological Survey standards or nomenclature.

<sup>2/</sup> This work has been performed under U.S. Geological Survey Contract No. 14-08-0001-16439

(E82-10316) AN INVESTIGATION OF MAGSAT AND  
COMPLEMENTARY DATA EMPHASIZING PRECAMBRIAN  
SHIELDS AND ADJACENT AREAS OF WEST AFRICA  
AND SOUTH AMERICA Quarterly Report, period  
ending 30 Sep. 1981 (Technicolor Graphic

N82-24589

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M-004

TYPE II-



## List of Attachments

1. Copy of letter of 20 May 1981 to Magsat Contracting Officer
2. Legend for the Geological Map of the World
3. "Abstract" for internal oral presentation on Magsat at the EROS Data Center, October, 1980
4. Text on Magsat for "U.S. Geological Survey Research, 1981"
5. Abstract for Magsat presentation at EROS Program Office Staff Meeting, April 1981
6. Abstracts for the American Geophysical Union Annual Spring Meeting, May 1981
  - A. Part I as approved by USGS review procedure
  - B. Part II as approved by USGS review procedure
  - C. Combined abstract as edited for publication
7. Abstract for Geological Society of America Annual Meeting, November 1981
8. Magsat total-field anomalies superimposed over the UNESCO International Tectonic Map of Africa included in its (1971) volume "Tectonics of Africa." This is a map prepared only for internal research and contract monitoring. It is not for distribution, because of possible infringement of copyright. Red lines indicate the Magnetic equator and approximately 45° North and South magnetic latitudes.
9. Magsat total-field anomalies superimposed on the U.S. Geological Survey Geologic Map of South America (Misc. Field Studies Map MF-868A). Red lines indicate the approximate locations of the magnetic equator and 45° North and South magnetic latitude.

10. Inventory of expenses, first stage, Magsat Data Investigation M-004.

1) Introduction

As per my letter (see attachment #1) of 20 May 1981 to the Magsat Contracting Officer with a copy sent 10 September 1981 to the Magsat Investigations Officer, and with the lack of response to that letter implying agreement with its contents, this is the first formal quarterly report of Magsat Data Investigation M-004, covering the investigation through 30 September 1981.

This investigation is being carried out under the Statement of Work of this investigation and under the NASA/USGS Magsat Memorandum of Understanding dated 19 November 1979.

Although this is the first formal written quarterly report, an oral progress report was made at the Goddard Space Flight Center on 1 May 1981. In addition, an oral presentation of some preliminary findings of the investigation was made at the Magsat session of the American Geophysical Union's Spring Annual Meeting on 27 May 1981, convened and chaired by the Magsat Project Scientist.

This report follows the format suggested on page 4 of the Statement of Work.

2) Problems

A. The first problem, both chronologically and logistically, was the slowness of NASA's formalization of the work agreement ("contract"). This has affected the scheduling of the Magsat effort vis a vis the schedules of other obligations by the Principal Investigator, and has caused co-investigators to lose interest in participation. The latter problem is minor however, as informal arrangements with other

specialists on (and in) South America are likely to be more fruitful than the originally planned formal arrangements, and will be less costly to NASA than originally proposed for the investigation in early 1979.

- B. Inspection of latitude plots for similar orbital paths for apparently quiet days shows similar characteristics (locations of peaks, troughs and points of inflection) over West Africa, but somewhat dissimilar amplitudes, both in relative value and in absolute value. Such differences would affect models along track by creating uncertainties as to bulk magnetic susceptibilities of hypothesized sources, and to a lesser extent, as to their distribution. Combining data for adjacent tracks appears to be more speculative a task than might be thought at first, owing to the quantitative differences in Magsat measurements over the same crustal features.

The scalar magnetic anomaly maps so far provided by the NASA/GSFC staff are an admirable attempt to overcome this problem. A spatial analysis of anomalies shown on these maps shows remarkable correlations with major features of both the continental and the oceanic crust. These correlations appear to be systematic. Qualitative or semi-quantitative models appear to be possible using existing Magsat anomaly maps and complementary data. I am not so confident yet, however, about the utility of these maps for quantitative models (such as models that estimate bulk crustal magnetization).

One source of assistance in this regard would be added information of vector anomaly maps, as planned by the Project Scientist. In addition to this, a thorough investigation of the latitude plots for West Africa is underway. If a reasonable system can be found to the plots, they will be used to add detail to the anomaly maps (i.e., by interpolating details into the anomaly maps). It is likely that some latitude plots will be modelled individually, as well.

- C. The choice of the Vander Grinten projection is a problem in finding correlative data on geology and mineral deposits. The most pertinent data available in this projection are the National Geographic Society's map of "The Physical World" and NASA Technical Memorandum 79722 "A Geophysical Atlas for Interpretation of Satellite-Derived Data."

The latter is a very useful compendium, though the scale is too small for use in the geological correlation of Magsat anomalies. Plots of these maps on the same scale as the Magsat anomaly maps provided to investigators (the equator is approximately 101.9 cm long in this scale) would be useful. If they cannot be provided by NASA, I will photographically enlarge the figures of the Technical Memorandum to that scale. (See section 3E below.)

The National Geographic Society's map is, however, intended to be more an illustration for the layperson than a research tool for the Earth scientist. There is a french equivalent to this map on the Mercator scale that is at least an easier to use artist's rendition. Ultimately, however, the lack of a good research-quality geological map on one sheet is an obstacle to this investigation. This obstacle is



now being overcome by the production of such a map as part of this investigation. (See section 3E below.)

- D. The delay in delivery of data products (notably the vector Magsat anomaly maps but also the delay in providing the requested gridded data which were contoured to form the scalar anomaly map) has contributed to a delay in the determination of the suitability of the data for quantitative modeling of the data. The lack of supply by NASA of Magsat anomaly maps that can be overlain on UNESCO Geological World Atlas sheets has necessitated the preparation of appropriate map products by this investigator group, as stated in our proposal.

### 3) Accomplishments

- A. An initial description of the Magsat scalar anomaly pattern for Africa (as depicted on the anomaly maps produced by GSFC) has been made. An initial geological correlation and a preliminary qualitative interpretation has been made. This work is subject to uncertainties with the data outlined in section 2B above. This is discussed in section 4 below.
- B. An initial description, geological correlation and preliminary interpretation has been begun for the Magsat scalar anomaly map of South America, subject to uncertainties outlined in section 2B above. This is discussed in section 4 below.
- C. An initial description, geological correlation and preliminary interpretation has been begun for other areas of the Earth, on a somewhat less ambitious scope than for Africa and South America. This is discussed in section 4 below.
- D. An investigation has been made into the potential contribution by

spaceborne (Landsat, Apollo, HCMM) imagery to the interpretation of Magsat data. As expected, the great differences in scale between the resolution of Landsat and Magsat make a direct comparison of the two data sets difficult. However, Landsat data can contribute to the improvements of geological maps which can be prepared on a scale that renders them useful in conjunction with Magsat data. To a lesser degree, reduced-scale mosaics of Landsat images can be used similarly.

Spaceborne imagery is far more useful in indirect analysis/interpretation of Magsat data. The Magsat data can be used to contribute to global and regional models of geotectonics, whereas spaceborne imagery could then be used to study specific aspects of regional tectonics, which can be used in conjunction with smaller-scale geological mapping and geophysical (etc.) data for investigations of the geology and metallogenesis of a specific area.

For example, the South-Central part of the West African shield is dominated by a series of "greenstone belts" alternating with extensive exposures of granitoids. The flanks of these greenstone belts are of great economic significance for their concentrations of gold, manganese and related minerals. Analysis of imagery of a portion of western Upper Volta indicates an area with a spectral response similar to that of the greenstone belts, that has not been previously mapped as a greenstone belt. If surface mapping can confirm the existence of such a greenstone belt the finding could be significant because of the regional associations of the flanks of these belts with mineral deposits. The Magsat data alone show correlations between West Africa and other older Precambrian shields rich in mineral deposits.

E. In order to overcome the lack of a research-quality geological map of the world on one sheet, we have been working on the preparation of such a map. The objective is to prepare a map that is detailed enough not to be trivial to an Earth scientist yet which is small enough in scale to permit coverage on one sheet. The map depicts continental geology and the physiography of the ocean floors (after the Heezen and Tharp maps published by the Geological Society of America and by other organizations).

The legend for this map (see attachment #2) has been designed to facilitate correlations with Magsat anomalies as well as to be consistent with current nomenclature for map legends.

The geological data for the map come from two major sources: the UNESCO Geological World Atlas and the World Atlas of Geology and Mineral Deposits by Duncan R. Derry (published by the Mining Journal, Ltd.). The former is not yet complete, with South America and Australia yet unpublished. But, the detail, scale and legend make this an excellent primary reference. New maps were prepared as compilations of these two major sources plus other regional maps. Map scales were changed photographically. Map projections were changed graphically. Although graphical projection change techniques introduce some errors, this technique was used because of its greater speed and less cost than available alternatives. We consider that the precision of the resultant map is relatively high for the regional applications desired from its use.

The map is being prepared in two projections: the Mercator and the Vander Grinten. The Mercator map has had the continental geology

compiled and colored, and is about to have the physiographic diagram for the oceans added photographically. The Vander Grinten map has had the continental geology compiled, and is about to be colored before having the physiography of the oceans added.

Magsat scalar anomaly map overlays have been prepared for each geological map. The correlations between Magsat anomalies, geology and oceanic physiography are far more striking with such maps than can be seen by any other widely available map. Some of the correlations are very subtle, however, and reinforce the need for confidence in the fine details of the Magsat anomaly map (a confidence in detail that we have been cautioned by the Magsat Project Scientist to be careful in giving). In any case, the correlations are sufficiently striking to overcome a reluctance to use the anomaly map at least qualitatively, with reservations.

The receipt of Magsat vector anomaly maps is awaited, so that overlays can be made for the geology maps. Overlays of tectonics, seismicity, etc., data from NASA Technical Memorandum 79722 are planned, as is the compilation of a map of mineral deposits.

This map, incidentally, was prepared using both USGS funds and funds utilized from the Magsat investigation. The maps are only available for internal research (and for NASA's contract monitoring) in their present state, as public distribution might be construed as copyright infringement (with respect to the representation of the ocean floors).

F. Ancillary information on the geology, tectonics and metallogeny of West Africa are being prepared for publication. I have written a short

article presenting a new Bouguer anomaly map of South-Central West Africa, which is being considered for publication in Geophysics. I have also written an article on the regional tectonics and metallogeny of West Africa for Geoexploration. The latter article is to be included in a special issue of this journal, devoted to correlations of geophysical data, tectonics and metallogenesis in Africa. I am the special editor of this issue. In this capacity, I have also written a paper on the availability of geoscientific data for Africa. Copies of these materials will be submitted to NASA as soon as they reach final editorial stages.

#### 4. Significant Results

Significant results in global analysis of global total-field Magsat anomalies and of analysis of the anomaly pattern for Africa are outlined in attachments 4, 6 and 7<sup>3/</sup>. It should be noted that attachment 4 was written before the complete anomaly map was available, which led to incorrect latitude values being given for observed positive-negative associations. As noted in later abstracts 6 and 7, the anomaly sign changes tend to occur near 45 degrees North and South magnetic latitude.

In South America the Central position of the Brazilian shield tends to form a negative total-field Magsat anomaly, consistent with findings for shields in equatorial Africa. Sedimentary sequences in the Amazon basin and in the Rio de Janeiro-Sao Paulo areas exhibit positive anomalies, also consistent with equatorial Africa. The Andes Mountains only show slight effects, consistent with their North-South orientation.

The Caribbean Sea and Gulf of Mexico regions exhibit negative

anomalies, as would be expected (from the model presented in attachments 6 and 7) for an area North of 45° North latitude (though it should be noted that the Caribbean straddles this latitude and therefore is in a transition zone). The Antilles lie in a positive anomaly, consistent (according to the model) with uplift at their particular latitudes, with a steep gradient to their North and East suggestive of an abrupt end of that uplift. This pattern is interesting in that the Magsat anomaly high continues North of Cuba toward Florida, with the steep gradient following the Northwestward trend of the Bahama Islands. Along the Atlantic continental margin of North America, the continental slope marks a Magsat anomaly gradient in all areas but the Southern portion through the Bahamas. This westward deviation of the gradient through the islands themselves does not appear to be an effect of magnetic latitude<sup>4/</sup> so much as the effect of a possible buried continental margin under the Bahamas. This would be consistent with the hypothesis by R. S. Dietz and J. C. Holden (1970, as reported in *Continents Adrift and Continents Aground*, p. 136, edited by J. Tuzo Wilson, published by W. H. Freeman and Company, San Francisco, 1976) that the Bahamas platform represents an accumulation of sediments followed by coral growth after the continents became separated.

The Magsat anomaly following the Amazon Basin does not trend directly East-West as might be expected, but veers to the North just west of Guyana. This appears to coincide with the western margin of the Guyana shield as currently mapped, and with a relative depression of a northward extension of the Amazon basin through the Roraima territory to the Venezuelan border just west of Guyana. This is an area that has not received much attention from geological mappers, though there is a small area at the eastern edge of this

anomaly that is mapped as having been depressed and covered by a modest thickness of sediments. The mapped sedimentary cover is inadequate to explain the Magsat anomaly, which appears to be due to the overall depression of the area in comparison with the uplifted shields to the east, north and northwest.

The Guyana shield itself is represented by a smaller negative anomaly than expected. The Orinoco River valley in Venezuela is (surprisingly) marked by a negative anomaly. Perhaps it is in the transition zone (near 45° North magnetic latitude) in which remanent magnetization might reverse the net magnetization of the area, or perhaps the anomaly is the cumulative effect of anomalies in the cordillera along Venezuela's coast and the shield to the south, combined with the effect of the Orinoco. This is an important area for future efforts at modeling.

3/ These abstracts are referenced here as attachments 6A+B and 7 and have been passed for publication by the U.S. Geological Survey.

4/ Though this recent finding has not yet been modeled.

## 5. Publications

### A. Publications released through U.S.G.S. review

1. A look at the preliminary Magsat anomaly map, emphasizing Africa:  
I. Are the anomalies significant?
2. A look at the preliminary Magsat anomaly map, emphasizing Africa:  
II. An initial discussion. Note: The two papers listed above were edited into one abstract, presented in the Program of the American Geophysical Union Spring Meeting, Baltimore, May 1981, p. 72.
3. Interpretation of the preliminary total-field Magsat anomaly map. Geological Society of America Abstracts With Programs, Vol. 13, p. 469, 1981.

### B. Publications currently in U.S.G.S. review

1. Global Magsat anomaly signatures, emphasizing West Africa and Eastern South America. Submitted to Geological Survey Research, 1981.

### C. Internal reports, no published abstracts

1. An overview of NASA's Magsat, and of the EROS Data Center's Magsat investigation. Seminar at EROS Data Center, Sioux Falls, SD, 7 October 1980.
2. Magsat-an overview of the program and a first look at the anomaly data. Presented at the EROS Program Office Staff Meeting, 30 April 1981.

Note: Similar oral presentations have been made at the Goddard Space Flight Center on 1 May 1981, for cooperants on West Africa at Hunting Geology and Geophysics Ltd., London, on 5 June 1981,



and at the University of Malaya on 29 June 1981.

6. Recommendations

Recommendations are as follows:

- A. Provision of vector-field Magsat anomaly maps in the near future would be timely. Such provision would assist attempts to quantitatively model the anomaly data.
- B. Provision of the gridded data used to make the total-field anomaly maps (as well as the number of satellite paths used for each grid cell) would assist in the possible modification of anomaly maps, and for the better understanding of anomaly maps, used in modeling. These data were requested from, and offered by, the Magsat Project Scientist on my visit to GSFC on 1 May 1981. I requested these data in writing on September 4, 1981.

I have no other recommendations or requests at this time.

6. Funds expended

An itemization of funds expended through the end of FY 1981 (30 September 1981) is provided as attachment 10.

## 7. Data Utility

The Magsat data appear to have been well described by the Project Scientist, though, naturally, individual investigators must develop their own "feelings" for the data.

My feeling is that the data have great value at somewhat larger than their scale of resolution if two major characteristics of the anomaly maps can be adequately taken into account:

- (1) The algorithm used to tie the data without the existence of tie lines as normally utilized in magnetic surveying, and
- (2) The effect of the inherent errors in the gridded anomaly data on subtle trends in anomaly contours.

The former is important, as it affects the regional shape of anomaly patterns as well as (with the added uncertainty in the choice of the field model to be removed) the effect on the global East-West banding of positive and negative anomalies.

The latter is important, as a close correlation between subtle characteristics of Magsat anomalies and tectonic features can often be made. It is obviously crucial to know when these correlations are justified, and when they are likely to be figments of the system of data collection and processing.

These problems have become a more important aspect of this investigation than originally expected. They are one of the most fascinating parts of this investigation.

Three modifications to the Magsat program that would contribute to greater confidence in the data would be:

1. To have an immediate follow-on mission in FY 1983 or so, to

provide additional data to help supplement the statistical base of the anomaly maps.

2. To have this follow-on mission include a second satellite with a low (i.e.,  $55\frac{1}{4}$ ) orbital inclination to the equator, to provide tie lines so that a major cause of uncertainty in the Magsat data can be investigated. (Or, if two concurrent satellites would be too expensive, a single satellite with a  $60\frac{1}{4}$  orbital inclination to the equator is suggested.)
3. A Magsat mission of some sort should be undertaken at the turn of every decade to monitor changes in the geomagnetic field. In the past, this important function was accomplished to a lower standard by other means. But the vastly better coverage by satellite missions is a valuable contribution to this task.

INVENTORY OF EXPENSES, FIRST STAGE, MAGSAT DATA INVESTIGATION - M004

SALARIES

D. A. Hastings, Principal Investigator

D. Laux, Intern

G. Walvatne, Intern

K. M. Walker, Associate Applications Sci.

Secretarial

Drafting

Employee benefits (12% of direct labor)

Labor subtotal

Overhead (60% of labor)

MATERIALS

1. Custom laboratory interim photographic products

2. Landsat imagery

A. Computer compatible tapes

B. False color composite transparencies

C. False color composite generation

D. Black and white 9" x 9" prints

3. Literature purchases

TRAVEL

Sioux Falls - NASA

Investigators Meeting, December 1980

Investigators Meeting, May 1981

Library research, Reston & Boston

Consultation with colleagues, presenting papers,

Reston & Greenbelt, April 1981

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OTHER

1. EROS Data Center Data Analysis Laboratory

2. Office supplies

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**Subtotal**

**General & Administrative (13.3%)**

\_\_\_\_\_

**Grand Total**

\_\_\_\_\_

**U.S. Geological Survey EROS Data Center  
contribution**

\_\_\_\_\_  
\_\_\_\_\_

**Net to NASA**

Attachment 1

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RE: OAB5-145

May 20, 1981

The Contractor Officer (Code 269)  
NASA Goddard Space Flight Center  
Greenbelt, Maryland 20771

Dear Sir/Madam:

Re: MAGSAT Investigation

Due to the long delay in preparation of the contract for my investigation ("An investigation of MAGSAT and complementary data emphasizing Precambrian shields and adjacent areas of West Africa and South America") from the originally scheduled start-date of the investigation, several conflicts with prior commitments will prevent my submitting a first "quarterly report" by July 10, 1981 as requested by the contract.

Indeed, as the contract was signed only in mid-April 1981, there will not be a full quarter to report on by the end of June.

Do you want to have quarterly reports synchronized (in which case the first report for a complete quarter would be dated September 30, 1981), or would you prefer to receive a report when I can schedule its preparation in the light of the most inflexible of my prior commitments (which might mean August 1 or might mean September 1981)?

Incidentally, I will be out of Sioux Falls between May 22 and about July 16.

Sincerely,

SIGNED

David A. Hastings  
Senior Applications Scientist  
Geophysics/Geology

cc: JNP Chron  
DAH Chron ✓  
AB Reading  
AB Subject

DAHastings/ctm/5/20/81

# LEGEND

UNITS	SEDIMENTARY ROCKS			EXTRUSIVE IGNEOUS ROCKS			INTRUSIVE IGNEOUS ROCKS			METAMORPHIC
	Age	Marine	Continental	Acidic	Intermediate	Basic	Acidic	Intermediate	Basic	
Cenozoic 0-70 m.y.										
Mesozoic 70-225 m.y.										
Paleozoic 225-600 m.y.										
Precambrian A 600-1280 m.y.										
Precambrian B 1280-1640 m.y.										
Precambrian C 1640-2390 m.y.										
Precambrian D 2390-3500 m.y.										

Attachment 2

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Attachment 3

DAN Chron



**Technicolor**  
**GRAPHIC SERVICES, INC.**  
SOUTH DAKOTA OPERATIONS

**INTEROFFICE CORRESPONDENCE**

**TO:** Distribution

**DATE:** September 29, 1980  
**RE:** OAB9-142

**FROM:** Applications Scientist, Geophysics/Geology

**SUBJECT:** Applications Branch Noontime Seminar #25

A brief overview of NASA's MAGSAT, and the research program associated with this satellite will be presented Tuesday, October 7, 1980 at 12:30 p.m. in the AB Classroom. This brief presentation outlines the reasons for creating MAGSAT, gives a brief outline of the system, describes the MAGSAT research program in general, the EDC investigation specifically. All interested parties are invited to attend this talk.

*David A. Hastings*

David A. Hastings  
Applications Scientist,  
Geophysics/Geology

Distribution:

Senior Staff  
AB Staff  
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Lockwood

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Attachment 4 (page 1 of 3)

GLOBAL MAGSAT ANOMALY SIGNATURES,  
EMPHASIZING WEST AFRICA AND EASTERN SOUTH AMERICA\*

David A. Hastings (Technicolor Graphic Services, Inc.) investigated MAGSAT anomaly data for their significance in increasing our understanding of regional crustal structure.

A preliminary MAGSAT scalar (total field)  $2^{\circ} \times 2^{\circ}$  anomaly map was produced at the end of 1980 by NASA's Goddard Space Flight Center (GSFC).

Further refinement of the scalar anomaly map by GSFC is expected in 1981, interpolation of anomaly details into the map by the EROS Data as is the Center. Preparation of global vector anomaly maps by GSFC is expected in 1981.

The Data Center's investigation consisted of (1) the interpretation of ancillary data, the (2) assessment of the suitability of Landsat data for geological investigation in the area of concentration, and (3) a preliminary analysis of the available MAGSAT anomaly map.

- (1) D. A. Hastings (Technicolor Graphic Services Inc.) has been investigating the geological framework of West Africa's mineral deposits since 1972. A synthesis of this work (Hastings, 1980) suggests that a hypothesis of Precambrian rifting and metamorphism with subsequent geomorphologic activity may explain the genesis of central West Africa's mineral deposits through the mid-Mesozoic, as a precursor to the hypothesized formation of the Atlantic Ocean and of petroliferous coastal sedimentary basins in the area (Hastings and Bacon, 1979).
- (2) The West African shield is characterized by a (i) a thick cover of lateritic soil, by (ii) rapid weathering rates and by (iii) vegetative cover by plants possessing generally shallow root systems. Each of these factors is an obstacle to geological remote sensing in the area, as the underlying rock is spatially,

\* This manuscript is still in review for "US Geological Survey Research, 1981."

chemically and biologically divorced from the surface. There is the additional hinderance of severe cloud or haze cover that prevents full coverage of the area by Landsat imagery.

Nevertheless, contrast-enhanced Landsat imagery over parts of Western Upper Volta shows a stronger near-infrared response in some areas that are initially interpreted as healthier vegetation over greenstones than over <sup>neighboring</sup> granitoids or metasediments, ~~in the area~~. The area of stronger infrared response corresponds well with mapped exposures of greenstones, though there is an additional area that the interpretation of Landsat imagery suggests may be underlain by greenstones. If this correlation is confirmed, the finding is significant, as the flanks of greenstone belts are the most important locations for mineral occurrences.

- (3) A preliminary interpretation of the available MAGSAT anomaly map shows the expected preference for east-west orientations over north-south orientations. North of the magnetic equator lower - ~~Precambrian~~ <sup>Precambrian</sup> shields tend to form negative total field MAGSAT anomalies, with sedimentary basins forming positive anomalies. The reverse is true south of the equator. Of particular note is the excellent correspondence of the famous "Bangui anomaly" discovered by the Polar orbiting Geophysical Observatory (POGO) satellites (Regan, Cain and Davis, 1975) with the exposure of lower Precambrian shield <sup>corresponding to</sup> (the central negative anomaly) and the Benue Trough and Congo Basin <sup>corresponding to</sup> (the northerly and southerly flanking negative anomalies, respectively). An as yet unexplained but interesting occurrence on the available anomaly map is that, though the geomagnetic equator crosses Africa at about 11° north latitude the change in polarity of MAGSAT anomalies occurs at 5° to 15° south latitude.

References

- Hastings, D.A., 1980, On the tectonics and metallogenesis of West Africa: a model influenced by new geophysical data (abstract): Proc. 26th International Geological Congress, Paris, p.726.
- Hastings, D.A., and M. Bacon, 1979, Geologic structure and evolution of Keta Basin, West Africa: discussion: Geological Society of America Bulletin v. 90 p. 889-892.
- Regan, R.D., J.C. Cain and W.M. Davis, 1975, A global magnetic anomaly map: Journal of Geophysical Research v. 80 p. 794-802.

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Attachment 5

MAGSAT - An Overview of the Program and a First Look at the Anomaly Data

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David A. Hastings  
Senior Applications Scientist, Geophysics/Geology  
Technicolor Graphic Services  
EROS Data Center  
Sioux Falls, SD 57198

The Magnetic Field Satellite (MAGSAT)\* was the first satellite designed to study the terrestrial magnetic field, and contained the first orbiting vector (component-field) magnetometer in addition to a scalar (total-field) magnetometer. It was also the lowest orbiting satellite to carry a magnetometer for any length of time, providing the greatest spatial resolution of any spaceborne magnetometer to date.

Initial MAGSAT investigations sponsored by NASA address four areas:

1. geomagnetic field modeling,
2. studies of crustal magnetic anomalies,
3. investigations of the inner earth, and to a lesser extent,
4. studies of external current systems.

As data begin to be provided to investigators, this presentation briefly reviews the program and takes a first look at the MAGSAT anomaly data.

\*Launch date 30 October 1979

Reentry date 11 June 1980

Presented at EROS Program Office Staff Meeting  
Reston, Virginia  
30 April 1981

**A LOOK AT THE PRELIMINARY MAGSAT ANOMALY MAP, EMPHASIZING AFRICA:**

**I. ARE THE ANOMALIES SIGNIFICANT?**

---

D. A. Hastings  
Technicolor Graphic Services, Inc.<sup>1/</sup>  
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Sioux Falls, South Dakota 57198

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**ABSTRACT**

The preliminary scalar anomaly map from the magnetic field satellite (Magsat) data closely resembles the map from Polar Orbiting Geophysical Observatory (POGO) data, although the Magsat anomaly map shows considerably greater detail. Highlights over the African Continent include the resolution of the West African Craton into its nucleus, the Taoudenni Basin-Senegal Basin, and the transition from the Reguibat Shield to the Tindouf Basin; the grouping together of the Ahaggar and Tibesti Plateaus as well as the depiction of the partial breaching of this grouping by the Murzuk Basin; the sedimentary basins between the Atlas Mountains and the Ahaggar; the triple "bulls-eyes" apparently caused by the Benue Trough, the Congo Basin, and the band of high-grade Archaean metamorphic shield rocks running from the Central African Republic to Cameroon and Gabon (commonly referred to as the "Bangui anomaly"); the coastal basin of Mozambique; and the Karroo Basin. Offshore features represented on the anomaly map include the Agulhas Plateau southeast of the Karroo Basin, the Indian Ocean ridge system, the near-coastal (east-west trending) segment of the Walvis Ridge, and (to a lesser extent) other tectonic features of the Atlantic Ocean. Indeed, almost all of the major tectonic features of Africa on a scale resolvable by the Magsat satellite appear clearly

OVER →

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<sup>1/</sup>Work performed under U.S. Geological Survey Contract No. 14-08-<sup>0</sup>001-164390.

Attachment 6B (page 1 of 2)

A LOOK AT THE PRELIMINARY MAGSAT ANOMALY MAP, EMPHASIZING AFRICA:

II. AN INITIAL DISCUSSION

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ABSTRACT

In Africa, as elsewhere, the preliminary Magsat anomaly map tends to emphasize east-west trending tectonic features and to subdue north-south trending features. For example, the north-south East African Rift system is not depicted by closed anomalies other than a weak anomaly at the northeastern corner of the Mediterranean Sea which corresponds to the northern end of the system. On the other hand, the east-west Karroo Basin is well depicted by a negative anomaly. This effect is expected, as the greatest net magnetization of crustal bodies occurs along the sides of east-west trending bodies, and at the ends of north-south trending bodies. Another possible contributing factor to the emphasis on east-west trending features might be the lack of east-west tie lines in the north-south orbit of the satellite, coupled with filtering of the data only along-track.

In the northern part of the map for Africa, uplifted Archaean-Proterozoic shields tend to be associated with negative residual Magsat anomalies. Sedimentary basins tend to be associated with positive anomalies. The reverse is generally true south of the equator. Exceptions to these associations are the Reguibat Shield-Tindouf Basin area, which is not fully resolved on the anomaly map, and the horn of Africa where a negative anomaly covers the onshore and offshore

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A FIRST LOOK AT THE MAGSAT ANOMALY MAP,  
EMPHASIZING AFRICA

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The preliminary scalar anomaly map compiled from magnetic field satellite (MAGSAT) data closely resembles the map derived from POGO (Polar Orbiting Geophysical Observatory) data, though with considerably greater detail. In Africa, as elsewhere, the preliminary MAGSAT anomaly map tends to emphasize E-W trending tectonic features such as the Karroo Basin, and subdue N-S features such as the East African Rift System. This is expected, as the greatest net magnetization of crustal bodies occurs along the sides of E-W bodies, but only at the ends of N-S bodies. A second contributing factor might be MAGSAT's N-S orbit, without E-W tie lines, coupled with filtering of the data only along-track. In the northern hemisphere, the main sources of scalar MAGSAT anomalies are older Precambrian shields (generally negative anomalies) and sedimentary basins of various ages (generally positive). The younger Precambrian (Pan African) "mobile belts" tend not to produce marked scalar MAGSAT anomalies. Magnetic anomalies for given types of features change polarity south of about  $10^{\circ}$  S lat. in Africa, whereas the magnetic equator lies at about  $10^{\circ}$  N.

Of particular interest in Africa is the strong correlation between the "Bangui anomaly" and known regional tectonic features. The central negative anomaly correlates well with the E-W Central African Shield. The Chari Basin - Benue Trough and the Congo Basin appear to control the positive anomalies flanking the Bangui anomaly on the N and S, respectively. The consistency of this correlation with other tectonic associations of MAGSAT anomalies in Africa suggests this as an alternative hypothesis to that of Regan and Marsh of the cause of the Bangui anomaly.

The anomaly patterns in Africa and adjacent oceanic areas are broadly representative of global patterns between the mid-latitudes.



AN INTERPRETATION OF THE PRELIMINARY TOTAL-FIELD MAGSAT ANOMALY MAP  
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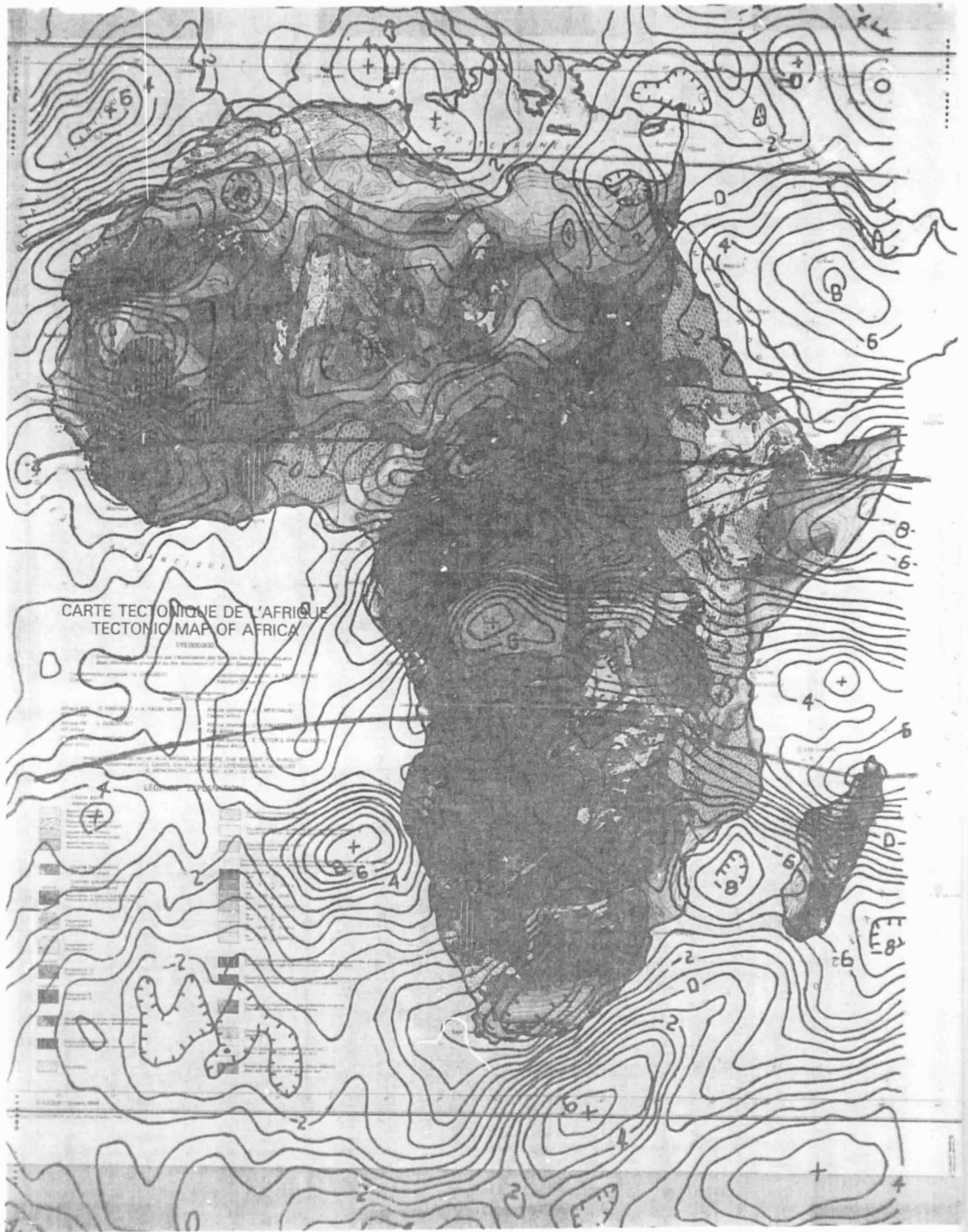
Analysis of the preliminary Magnetic Field Satellite (Magsat) total-field anomaly map reveals an anomaly pattern that correlates with several regional geological features.

Between about  $45^{\circ}$  N. and  $45^{\circ}$  S. magnetic latitude the anomalies associated with large shield areas and mountain blocks tend to be negative, whereas sedimentary basins generally have positive anomalies. Consistent with theoretical models, this correlation reverses for magnetic latitudes greater than about  $45^{\circ}$  N. and  $45^{\circ}$  S. A greater magnetic susceptibility for the uplifted regions (shields, mountain ranges) above the Curie point isotherm and a lesser susceptibility above this isotherm for depressed regions (basins) could cause the anomalies.

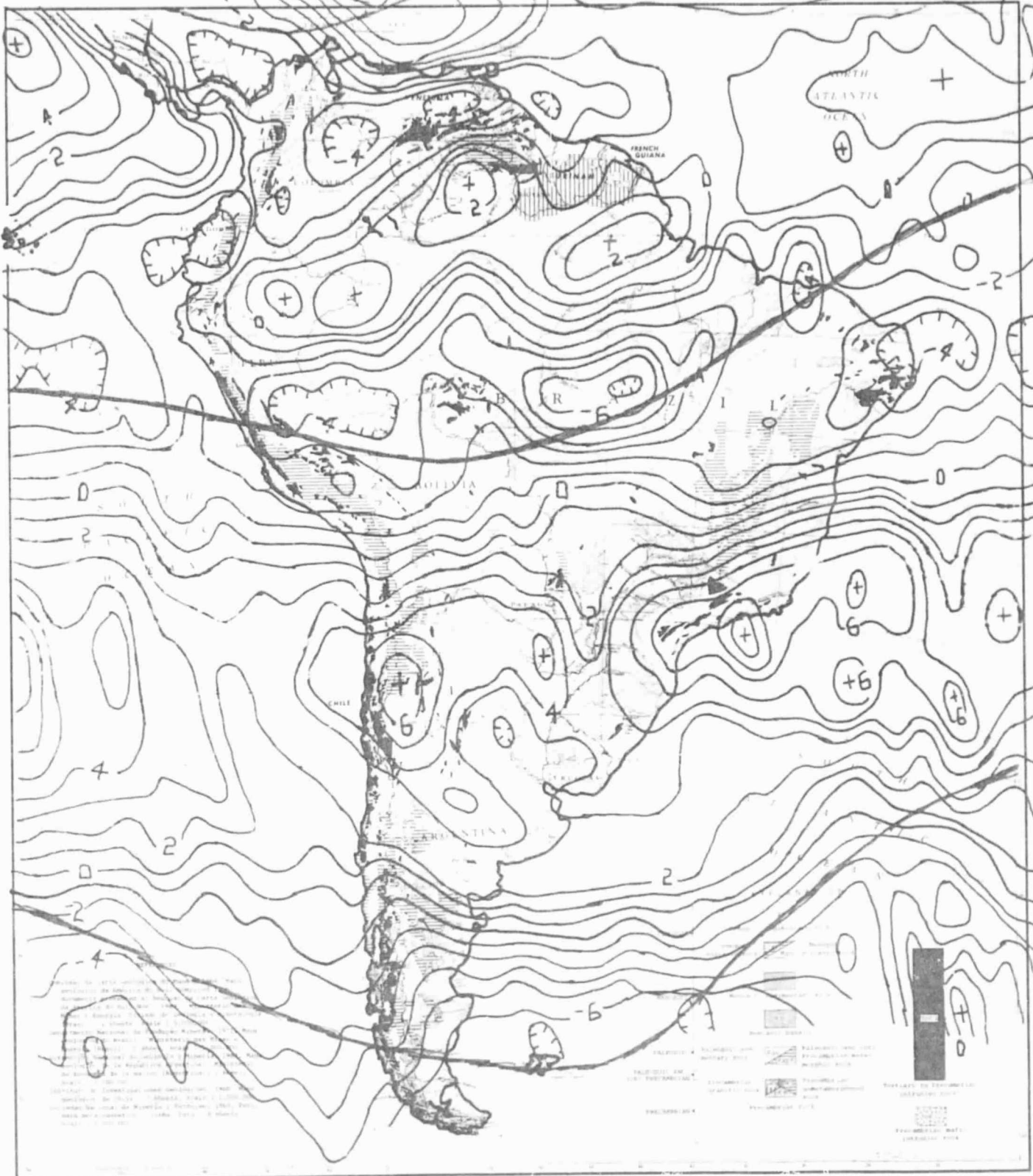
Other correlations occur between the ages of uplifted blocks and their associated anomalies. The oldest Precambrian shields (such as those in Liberia and the Central African Republic) produce the strongest anomalies, whereas younger Precambrian shields (such as that in Nigeria) and younger mountain ranges (the Atlas Mountains, for example) are not strongly correlated with Magsat anomalies. This correlation appears to be consistent (though not uniquely or exclusively so) with a hypothesis of relatively greater uplift and reworking of the older shields and with a relatively higher susceptibility of these areas above the Curie point isotherm. However, some greatly uplifted regions, such as the Himalayas, produce strong anomalies despite their younger ages.

The orientation of crustal blocks affects anomaly strength because (1) the lack of tie lines and the filtering of data used in the Magsat anomaly map reinforces E-W anomalies, and (2) a generally greater surface area is magnetically polarized for E-W trending bodies than is the case for N-S trending bodies. Nevertheless, magnetic effects of N-S trending features such as the Indian Ocean ridge system are subtly evident on the anomaly map.

\*This work was done under USGS contract no. 14-08-0001-06439.



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Map modified from U.S. Department of State  
Geological Map of South America 1949

### GEOLOGIC MAP OF SOUTH AMERICA

Compiled by  
Gus B. Gondrez  
1977

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