N83-24999 505

Technicolor Government Services, Inc.

RE: OAB4-65 April 18, 1983

(E83-1C296) AN INVESTIGATICN CF MAGSAT AND COMPLEMENTARY DATA EMPHASIZING PRECAMBRIAN SHIELDS AND ADJACENT AREAS OF WEST AFRICA AND SOUTH AMERICA Quarterly Report, 1 Jan. - 31 Mar. 1983 (Technicolor Graphics, Inc.) N83-24999 Unclas G3/43 00296

The Contracting Officer
NASA Goddard Space Flight Center
Code 269
Greenbelt, MD 20771

Dear Sir:

Re: MAGSAT Data Investigation M-004

I hereby enclose the quarterly report for this investigation covering the period: January 1 through March 31, 1983.

Sincerely,

David A. Hastings

David A. Hastings
Principal Investigator

Enclosure

cc: Publication Branch
Patent Council
Technical Officer

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[1] covering activities of the investigation during the period January 1 through March 31, 1983.

David A. Hastings

Technicolor Government Services, Inc.[2]

EROS Data Center

Sioux Falls, South Dakota 57198

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

[2] This work has been performed under U.S. Geological Survey Contract No. 14-08-0001-20129.

CONTENTS

1. Introduction

This report on MAGSAT Data Investigation M-004 covers the period January 1 through March 31, 1983.

2. Problems

No new problems were encountered during the period.

There remains, however, the old problem of the east-west banding on MAGSAT anomaly maps. An offshoot of this is the lack of acceptance of quantitative crustal models by specialists on regional geology.

I discussed preliminary computer models of MAGSAT anomalies for northern South America with Allan Gibbs of Cornell University. Dr. Gibbs is co-authoring a book on the Guyana shield. He is uncomfortable with the failure of MAGSAT anomaly maps to describe the most fundamental grouping of types of crust - continental and oceanic crust. He believes that any atempt to make quantitative models of crustal features of north South America is unlikely to be credible until the spillover of east-west trending anomaly bands between continental and oceanic crust can be modeled. Other anomaly patterns disturb him, but these concerns are subsidiary to (and related to) this major (and representative) concern.

Similar discussions with J. Kalliokoski (Michigan Technological University) led to the same comments.

This points to what is likely to be the greatest obstacle to quantitative modeling of MAGSAT anomalies. No matter how prominent the gross correlations between some crustal features and MAGSAT anomaly patterns may be, and no matter how reasonable some quantitative crustal models may appear, these quantitative models have little or no credibility with specialists on regional geology. Such specialists can be made somewhat comfortable with the MAGSAT data collection and processing system's enhancement of east-west trending anomalies

and suppression of north-south trending anomalies. They are comfortable with the gross correlations of large-scale MAGSAT anomalies with regions of relative uplift or depression on the continental crust and to some degree, in oceanic areas. Specialists on the regional tectonics of South America are intrigued by qualitative details such as the correlation between the location of the MAGSAT low nosing from the Brazilian shield northward across the central Amazon, near where the Purus arch is located. However, they expect to see anomalies close off somewhere near the Atlantic continental margin of South America, allowing for some east-west slop. The anomaly bands do not close off at the continental margin. Though extreme values of anomalies do appear to close off, the broad east-west bands continue eastward and westward onto Atlantic and Pacific oceanic crust and beyond.

Using the formula $\lambda = C/2n$ (Harrison and Carle, 1981, Intermediate wavelength magnetic anomalies over ocean basins: Journal of Geophysical Research, v. 86, p. 11,585 - 11,599), where

λ - is the wavelength of the total field represented by any degree of spherical harmonic,

C - is the earth's circumference, and

n - is the particular degree of spherical harmonic.

We see that a cutoff at degree 13 used to produce the MAGSAT anomaly maps should leave the resultant maps devoid of wavelengths longer than about 1,540 km. Cole and Harrison (1982, A problem in representing the core magnetic field of the earth using spherical harmonics: Geophysical Research letters, v. 4, p. 265-268) note that the removal of spherical harmonics up to a certain degree (n) leaves some of the signal of wavelengths longer than C/n. Considering that the power at longer wavelengths is so much greater than power at shorter wavelengths, a small remainder of the long-wavelength field is

likely to dominate the resultant anomaly map.

An inspection of the MAGSAT scalar anomaly map shows that the east-west bands are remarkably evenly spaced, with a wavelength of approximately 20-25 degrees of latitude, or 2,000 - 2,5000 km. Using the Harrison and Carle (1981) formula just cited, this represents about 8th to 10th degree harmonics, considered to be predominantly from sources in the core (although they could conceivably be from distributions of sources in the mantle such as from moving charges related to a core dynamo or mantle convection). Anomaly bands of such long wavelengths and such large magnitudes are not likely to be caused entirely by crustal sources.

The fact remains that there are many reasonable correlations between anomalies (within the bands) and tectonic provinces. Nevertheless, without removal of the longer wavelength, large magnitude bands, quantitative modeling will be deceptive.

3. Accomplishments

During the reporting period quantitative two dimensional models were produced for northern South America that might be considered as working models but for the problem mentioned above. A suggestion of these models is that the presumed Amazon river depression is better developed near Belem and in the upper Amazon basin than in the central Amazon basin. The pattern of the upper Amazon is relatively broad, consistent with a depression created largely by loading of sediments from the Andes. The eastern Amazon has a sharper anomaly, more consistent with that of a trough than is the anomaly pattern for other parts of the Amazon. It also may be somewhat deeper along its northern flank than is depicted by the published Tectonic Map of South America (1978). In the central Amazon the anomaly pattern suggests that the Purus arch (at about 60-62° west longitude) is a major, rather than a minor, uplift that may

partially separate the Amazon basin into eastern and western parts. The Takutu graben is seen as being too small to produce a significant MAGSAT anomaly (a view that is held also by Allan Gibbs of Cornell University [see previous section] and tentatively agreed with by Brian Sucre, geophysicist of the Guyana Geology and Mines Department). However, these models must remain tentative until a better anomaly map can be made with a better separation of the core field from the crustal field.

Although we are not very well equipped to make such separations, (we would have to use a flat-earth model), we may have to make an attempt to do so.

4. Significant Results

No significant results were obtained during the period. (However, see section 2 on problems and section 3 on accomplishments.)

5. Publications

None during the period.

6. Recommendations

Of late, some discussion has revived about the possibility of some of the earth's magnetic field being created in the mantle, below the Curie isotherm. It also appears from observations of the MAGSAT anomaly maps that anomalies caused by sources deeper than the crust remain in the maps. Carle and Harrison (op. cit.) point to this problem and recommend that an anomaly map be produced by removing the total field squared of the first 13 or 14 degrees of the harmonic from the total field squared of the first 23 degrees of harmonic.

The current approach is to remove as little of the field that could have been produced by crustal sources, at the expense of leaving in considerable amounts of field from deeper sources. As the latter are of so much higher magnitude than the former, they hinder the qualitative interpretability of the anomaly maps and veto attempts at quantitative modeling.

If it is not possible to completely remove spherical harmonics of degrees less than 15 fr a the anomaly map, experiments should be conducted to remove as much of this signal as possible, such as by bandpass filtering the anomaly map or by removing higher order harmonics, or both.

Such processing may degrade the crustal "signal" somewhat, but should greatly improve the ratio of crustal "signal" to "noise" form deeper sources. Anomaly maps that are more clearly a product of crustal soruces (even if some crustal signal is sacrificed) would be more credible to many geoscientists, would permit quantitative modeling and would be invaluable for comparisons with the existing anomaly maps.

I shall most likely be able to experiment with bandpass filtering of the gridded anomaly field data, but the experiments will be a bit crude, performed on a plane surface. Nevertheless, if someone does not offer a better approach, this experimenting should be able to reduce the effects of the east-west banding of long wavelength anomalies.

7. Funds Expended January 1 - March 31, 1983

Salaries

D. A. Hastings, Principal Investigator

Secretarial

Employee Benefits (12% of subtotal)

Labor Subtotal

Overhead (60% of labor subtotal)

Travel

Discussions with J. Kalliokoski (Houghton, MI) and

Allan Gibbs (Ithaca, NY)

Other

Data Analysis Laboratory Computer Time

Subtotal

General and Administrative (13.3%)

Total (U.S. Geological Survey Contribution)

8. Data Utility

Without additional processing to remove long wavelength terms, quantitative modeling of the anomaly data could be termed an unintentionally deceptive practice (indeed, it has been called deceptive by people that I have talked with). We have the capability to experiment with filtering the data, and will attempt to perform such filtering. However our capabilities are limited (and are crude), as noted in Section 6, Recommendations.