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QUARTERLY REPORT

First

QUARTERLY REPORT

ending March 31, 1981

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NASA Contract NAS 5-26425

"Use of MAGSAT anomaly data for crustal structure
and mineral resources in the U.S. Midcontinent"

from

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(881-10094) USE OF MAGSAT ANOMALY DATA FOR
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This work is to involve the combination of MAGSAT magnetic-field data with correlative geophysical and geological data, to better interpret the crustal structure, composition, and resource potential of the U.S. Midcontinent. The project began in December 1980.

Work is proceeding on gathering a data set for the study area. Such data includes ground/airborne magnetics, gravity, gross geology (major structures, geologic provinces, age relations), heat flow, and crustal thickness. The Midcontinent region contains the Midcontinent Geophysical Anomaly (M.G.A.) palaeorift, and the New Madrid seismic zone/rift. Both are of paleotectonic and neotectonic interest.

Research effort at this early stage is being pursued by the following:

Robert Carmichael, Univ. of Iowa -- Prin. Investigator; geophysics, MAGSAT data
Richard Hoppin, Univ. of Iowa -- structural geology, tectonics
Ross Black, Iowa Geol. Survey and graduate student -- computer analysis and modelling of MAGSAT satellite magnetics data; upward/downward continuation, etc.
Raymond Anderson, Iowa Geol. Survey and graduate student -- composite gravity of Iowa and environs, and geologic/structural/geophysical interpretation; modelling of M.G.A.

Our expectation has been to receive and/or develop magnetic anomaly maps derived from the satellite data, and use them for study and interpretation. Some processed MAGSAT data has arrived; namely, two abbreviated sample tapes. As this is being written (March 30th), the morning mail has brought an additional data tape, plus the preliminary MAGSAT anomaly maps from NASA. This is the beginning of the data set with which we will be technically involved.

The attached Figure 1* is a sample data magnetic profile for a track over the U.S. Midcontinent. It shows an anomaly of about 20 gammas, at 35° N. latitude.

Figure 2 gives a map of a part of the midcontinent study area, showing the data tracks available until the present (two tracks from the first sample data tape, the remainder from the second data tape).

* Figs. 1-3 from computer runs and displays by R. Black, 1981
One aspect of evaluating the usefulness of satellite magnetic data for assessing crustal economic potential is determining at what height one can resolve what size crustal anomaly. Satellite at 400-450 km altitude? Satellite at lower altitude? Shuttle at 220 km? High-flying aircraft? The M.G.A. and New Madrid rift zones are major structural trends. Figure 3 shows a perspective display of aeromagnetic data for southwest Iowa; it illustrates one aspect of processing we hope to apply to satellite magnetic data and other correlative information.

An example of computer modelling done here recently, although for a localized feature—and one not likely to be mapped at MAGSAT altitude—and having potential economic interest in the study area, is identified in Figure 4. The figure is a reduced version of the aeromagnetic map of Iowa; the original color version accentuates the anomaly even more. Figure 5** shows the ground magnetic and gravity residual anomalies. These are a substantial 1800 gammas and 46 milligals, respectively. Figure 6 shows a gravity profile and the best-fitting geologic model, and a magnetic profile with the most plausible magnetic source body. Actual areal modelling—as 2-dimensional, so agreement is better than these 1-d profiles would indicate. The body has a diameter of about 37 km, thickness of about 6 km at its center, and has a top at the basement surface which is 640 m. below the ground surface. From a number of geologic considerations for the broader province, the best model is a Precambrian-age mafic (gabbroic) lopolith intruded into a granitic basement. The intrusion cooled over the time the Earth's magnetic field underwent a polarity reversal so that there is a zone of reversed magnetization in the (latest-cooling) upper-central portion of the body. The magnetics were modelled with a remanent magnetization in addition to the usual induced magnetization.

Geologic analogs for such a (differentiated?) lopolith structure would be the Stillwater complex in Montana, Bushveld complex in South Africa, and Muskox intrusion in NW Territories Canada. All these are of economic consequence.

All the evidence for this intrusive in the Iowa region is remote magnetics and gravity; the anomaly feature has not been drilled. Perhaps MAGSAT could help identify geologic provinces having such bodies of potential economic interest, or combined aeromagnetic and satellite data would yield better geologic modelling for such major crustal phenomena.

** Figs. 5-6 are from S. Heathcote, M.S. Thesis, Univ. of Iowa (1979)
Fig. 4

AEROMAGNETIC MAP OF IOWA: COLOR CODED INTENSITIES

By
Isidora Ziets, Francis P. Gilbert, and John H. Kirby, Jr.
1978
Fig. 5
North-south profile showing the interpreted structure and the calculated gravity anomaly.

East-west and north-south profiles for the reversal model.

Fig. 6
Problems
The project has just started, and significant amounts of MAGSAT data have only today (March 30th) been received. To date, there are no problems impeding the progress of the investigation.

Accomplishments and Significant results
Project just beginning.

Publications
Attached is an abstract proposal for the MAGSAT session at the Scientific Assembly of the International Assoc. of Geomagnetism and Aeronomy (August 1981).

Recommendations
Nore to date.
February 10, 1981

Abstract for: 4th Scientific Assembly of Internat. Assoc. of Geomagnetism and Aeronomy
August 3-15, Edinburgh Scotland
To: Dr. N. Fukushima, Geophysics Research Lab,
University of Tokyo, Tokyo 113, Japan
From: Robert S. Carmichael, Department of Geology
University of Iowa, Iowa City, Iowa USA 52242
Session: I-1 (Scientific Results from the MAGSAT Mission), Aug. 4-5
Convenor (and copy of Abstract sent to):
Dr. R. A. Langel, Code 922, Goddard Space Flight Center,
Greenbelt, Maryland USA 20771
Presentation: Oral or Poster
Special request: prefer session indicated (I-1), since speaker may not be at meeting during 2nd week of IAGA

ANALYSIS AND USE OF "MAGSAT" SATELLITE MAGNETIC DATA TO HELP INTERPRET CRUSTAL CHARACTER OF U.S. CENTRAL MIDCONTINENT

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NASA's MAGSAT satellite measured magnetic fields from October 1979 until June 1980. The processed magnetic data yield long-wavelength anomalies that arise from crustal and upper-mantle sources. Interpretation of the anomalies, done in conjunction with correlative data such as gravity and aeromagnetics, heat flow and geothermal gradients, and known nearsurface geology, can lead to better understanding of major deep-seated geologic structures and crustal composition. Such work has application to resource exploration, as well as to geotectonics. As part of the NASA project to investigate and use the MAGSAT data, we are developing analysis techniques to help interpret the structure and character of the lithosphere in central North America. The region includes the "Midcontinent Gravity Anomaly" paleorift zone (1200 km long, 80 km wide, intruding 1.1 billion years ago) and the New Madrid rift/seismic zone, both of which are of paleotectonic and neotectonic interest. Our preliminary analysis of the initial MAGSAT data, combined with correlative geological and geophysical data, shows the utility of the satellite data for regional crustal and basement study. Work in progress supported in large part by NASA contract NASS-26425.