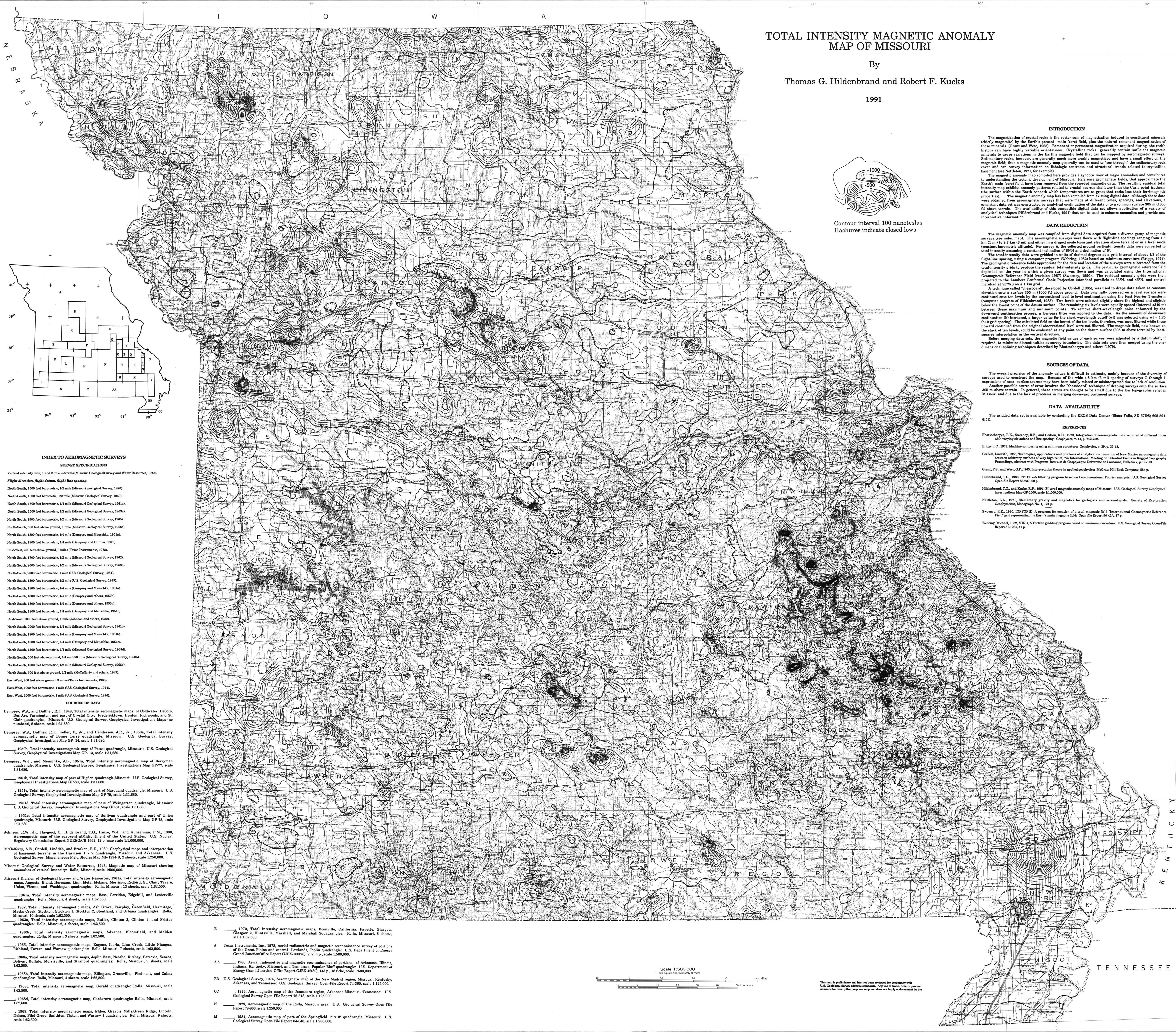
TOTAL INTENSITY MAGNETIC ANOMALY MAP OF MISSOURI

By

Thomas G. Hildenbrand and Robert F. Kucks

1991



Contour interval 100 nanoteslas
Hachures indicate closed lows

INTRODUCTION

The magnetization of crustal rocks is the vector sum of magnetization induced in constituent minerals (chiefly magnetite) by the Earth's present main (core) field, plus the natural remanent magnetization of those minerals (Grant and West, 1965). Remanent or permanent magnetization acquired during the rock's history can have highly variable orientations. Crystalline rocks generally contain sufficient magnetic minerals to cause variations in the Earth's magnetic field that can be mapped by aeromagnetic surveys. Sedimentary rocks, however, are generally much more weakly magnetized and have a small effect on the magnetic field; thus a magnetic anomaly map generally can be used to "see through" the sedimentary-rock cover and can convey information on lithologic contrasts and structural trends related to crystalline basement (see Nettleton, 1971, for example).

The magnetic anomaly map compiled here provides a synoptic view of major anomalies and contributes to understanding the tectonic development of Missouri. Reference geomagnetic fields, that approximate the Earth's main (core) field, have been removed from the recorded magnetic data. The resulting residual total intensity map exhibits anomaly patterns related to crustal sources shallower than the Curie point isotherm (the surface within the Earth beneath which temperatures are so great that rocks lose their ferrimagnetic properties). The magnetic anomaly map has been compiled from existing digital data. Although these data were obtained from aeromagnetic surveys that were made at different times, spacings, and elevations, a consistent data set was constructed by analytical continuation of the data onto a common surface 305 m (1000 ft) above terrain. The availability of this compatible digital data set allows application of a variety of analytical techniques (Hildenbrand and Kucks, 1991) that can be used to enhance anomalies and provide new interpretive information.

DATA REDUCTION

The magnetic anomaly map was compiled from digital data acquired from a diverse group of magnetic surveys (see index map). The aeromagnetic surveys were flown with flight-line spacings ranging from 1.6 km (1 mi) to 9.7 km (6 mi) and either in a draped mode (constant elevation above terrain) or in a level mode (constant barometric altitude). For survey A, the collected ground vertical-intensity data were converted to total intensity assuming a constant inclination of 69°N and declination of 0°.

The total-intensity data were gridded in units of decimal degrees at a grid interval of about 1/3 of the flight-line spacing, using a computer program (Webring, 1982) based on minimum curvature (Briggs, 1974). The geomagnetic reference fields appropriate for the date and location of the surveys were subtracted from the total-intensity grids to produce the residual total-intensity grids. The particular geomagnetic reference field depended on the year in which a given survey was flown and was calculated using the International Geomagnetic Reference Field (revision 1987) (Sweeney, 1990). The residual anomaly grids were then projected to the Lambert Conformal Conic Projection (standard parallels at 33°N. and 45°N. and central meridian at 93°W.) on a 1 km grid.

A technique called "chessboard", developed by Cordell (1985), was used to drape data taken at constant elevation onto a surface 305 m (1000 ft) above ground. Data originally observed on a level surface were continued onto ten levels by the conventional level-to-level continuation using the Fast Fourier Transform (computer program of Hildenbrand, 1983). Two levels were selected slightly above the highest and slightly below the lowest point of the datum surface. The remaining six levels were equally spaced (interval <340 m) between these maximum and minimum points. To remove short-wavelength noise enhanced by the downward continuation process, a low-pass filter was applied to the data. As the amount of downward continuation (h) increased, a larger value for the short wavelength cutoff (wl) was selected using wl = 1.25 (h+2 grid spacing). The calculated field on the lowest of the ten levels, therefore, was most filtered while those upward continued from the original observational level were not filtered. The magnetic field, now known on the stack of ten levels, could be evaluated at any point on the datum surface (305 m above terrain) by least-squares interpolation in the vertical direction.

Before merging data sets, the magnetic field values of each survey were adjusted by a datum shift, if required, to minimize discontinuities at survey boundaries. The data sets were then merged using the one-dimensional splining techniques described by Bhattacharyya and others (1979).

SOURCES OF DATA

The overall precision of the anomaly values is difficult to estimate, mainly because of the diversity of surveys used to construct the map. Because of the wide 4.8 km (3 mi) spacing of surveys C through I, expressions of near- surface sources may have been totally missed or misinterpreted due to lack of resolution.

Another possible source of error involves the "chessboard" technique of draping surveys onto the surface 305 m above terrain. In general, these errors are thought to be small due to the low topographic relief in Missouri and due to the lack of problems in merging downward continued surveys.

DATA AVAILABILITY

The gridded data set is available by contacting the EROS Data Center (Sioux Falls, SD 57198; 605-594-6151).

REFERENCES

Bhattacharyya, B.K., Sweeney, R.E., and Godson, R.H., 1979, Integration of aeromagnetic data acquired at different times with varying elevations and line spacing: Geophysics, v. 44, p. 742-752.

Briggs, I.C., 1974, Machine contouring using minimum curvature: Geophysics, v. 39, p. 39-48.

Cordell, Lindrith, 1985, Techniques, applications and problems of analytical continuation of New Mexico aeromagnetic data between arbitrary surfaces of very high relief, *in International Meeting on Potential Fields in Rugged Topography Proceedings, Abstract with Program: Institute de Geophysique Universite de Lausanne, Bulletin 7, p. 96-101.

Grant, F.S., and West, G.F., 1965, Interpretation theory in applied geophysics: McGraw-Hill Book Company, 584 p.

Hildenbrand, T.G., 1983, FFTFIL--A filtering program based on two-dimensional Fourier analysis: U.S. Geological Survey Open-file Report 83-237, 60 p.

Hildenbrand, T.G., and Kucks, R.P., 1991, Filtered magnetic anomaly maps of Missouri: U.S. Geological Survey Geophysical investigations Map GP-1000, scale 1:1,000,000.

Nettleton, L.L., 1971, Elementary gravity and magnetics for geologists and seismologists: Society of Exploration Geophysicists, Monograph No. 1, 121 p.

Sweeney, R.E., 1990, IGRFGRID--A program for creation of a total magnetic field "International Geomagnetic Reference Field" grid representing the Earth's main magnetic field: Open-file Report 90-45A, 37 p.

Webring, Michael, 1982, MINC, A Fortran gridding program based on minimum curvature: U.S. Geological Survey Open-File Report 81-1224, 41 p.

INDEX TO AEROMAGNETIC SURVEYS

SURVEY SPECIFICATIONS

A Vertical intensity data, 1 and 2 mile intervals (Missouri GeologicalSurvey and Water Resources, 1943).

Flight direction, flight datum, flight-line spacing.

B North-South, 1500 feet barometric, 1/2 mile (Missouri geological Survey, 1970).

C North-South, 1500 feet barometic, 1/2 mile (Missouri Geological Survey, 1969).

D North-South, 1500 feet barometric, 1/4 mile (Missouri Geological Survey, 1961a).

E North-South, 1500 feet barometric, 1/2 mile (Missouri Geological Survey, 1963a).

F North-South, 1500 feet barometric, 1/2 mile (Missouri Geological Survey, 1965).

G North-South, 500 feet above ground, 1 mile (Missouri Geological Survey, 1968c)

H North-South, 1800 feet barometric, 1/4 mile (Dempsey and Meuschke, 1951a).

I North-South, 1800 feet barometric, 1/4 mile (Dempsey and Duffner, 1949).

J East-West, 400 feet above ground, 3 miles (Texas Instruments, 1978).

K North-South, 1700 feet barometric, 1/2 mile (Missouri Geological Survey, 1962).

L North-South, 2000 feet barometric, 1/2 mile (Missouri Geological Survey, 1968a).

M North-South, 2000 feet barometric, 1 mile (U.S. Geological Survey, 1984).

N North-South, 1800 feet barometric, 1/2 mile (U.S. Geological Survey, 1979).

O North-South, 1800 feet barometric, 1/4 mile (Dempsey and Meuschke, 1951a).

P North-South, 1800 feet barometric, 1/4 mile (Dempsey and others, 1950b).

Q North-South, 1800 feet barometric, 1/4 mile (Dempsey and others, 1950a).

R North-South, 1800 feet barometric, 1/4 mile (Dempsey and Meuschke, 1951d).

S East-West, 1000 feet above ground, 1 mile (Johnson and others, 1980).

T North-South, 2000 feet barometric, 1/4 mile (Missouri Geological Survey, 1961b).

U North-South, 1800 feet barometric, 1/4 mile (Dempsey and Meuschke, 1951b).

V North-South, 1800 feet barometric, 1/4 mile (Dempsey and Meuschke, 1951c).

W North-South, 1500 feet barometric, 1/4 mile (Missouri Geological Survey, 1968d).

X North-South, 500 feet above ground, 1/4 and 5/8 mile (Missouri Geological Survey, 1968b).

Y North-South, 1000 feet barometric, 1/2 mile (Missouri Geological Survey, 1968b).

Z North-South, 500 feet above ground, 1/2 mile (McCafferty and others, 1989).

AA East-West, 400 feet above ground, 3 miles (Texas Instruments, 1980).

BB East-West, 1000 feet barometric, 1 mile (U.S. Geological Survey, 1974).

CC East-West, 1000 feet barometric, 1 mile (U.S. Geological Survey, 1976).

SOURCES OF DATA

I Dempsey, W.J., and Duffner, R.T., 1949, Total intensity aeromagnetic maps of Coldwater, DeSoto, Des Arc, Farmington, and part of Crystal City, Fredericktown, Ironton, Richwoods, and St. Clair quadrangles, Missouri: U.S. Geological Survey, Geophysical Investigations Maps (no numbers), 8 sheets, scale 1:31,680.

Q Dempsey, W.J., Duffner, R.T., Keller, F., Jr., and Henderson, J.R., Jr., 1950a, Total intensity aeromagnetic map of Bonne Terre quadrangle, Missouri: U.S. Geological Survey, Geophysical Investigations Map GP- 14, scale 1:31,680.

P ______, 1950b, Total intensity aeromagnetic map of Potosi quadrangle, Missouri: U.S. Geological Survey, Geophysical Investigations Map GP- 13, scale 1:31,680.

O Dempsey, W.J., and Meuschke, J.L., 1951a, Total intensity aeromagnetic map of Berryman quadrangle, Missouri: U.S. Geological Survey, Geophysicsl Investigations Map GP-77, scale 1:31,680.

U ______, 1951b, Total intensity map of part of Higdon quadrangle,Missouri: U.S. Geological Survey, Geophysical Investigations Map GP-80, scale 1:31.680.

V ______, 1951c, Total intensity aeromagnetic map of part of Marquand quadrangle, Missouri: U.S. Geological Survey, Geophysical Investigations Map GP-79, scale 1:31,680.

R ______, 1951d, Total intensity aeromagnetic map of part of Weingarten quadrangle, Missouri: U.S. Geological Survey, Geophysical Investigations Map GP-81, scale 1:31,680.

H ______, 1951e, Total intensity aeromagnetic map of Sullivan quadrangle and part of Union quadrangle, Missouri: U.S. Geological Survey, Geophysical Investigations Map GP-78, scale 1:31,680.

S Johnson, R.W., Jr., Haygood, C., Hildenbrand, T.G., Hinze, W.J., and Kunselman, P.M., 1980, Aeromagnetic map of the east-centralMidcontinent of the United States: U.S. Nuclear Regulatory Commission Report NUREG/CR-1662, 12 p. map scale 1:1,000,000.

Z McCafferty, A.E., Cordell, Lindrith, and Bracken, R.E., 1989, Geophysical maps and interpretation of basement terrane in the Harrison 1 x 2 quadrangle, Missouri and Arkansas: U.S. Geological Survey Miscellaneous Field Studies Map MF-1994-B, 2 sheets, scale 1:250,000.

A Missouri Geological Survey and Water Resources, 1943, Magnetic map of Missouri showing anomalies of vertical intensity: Rolla, Missouri,scale 1:500,000.

D Missouri Division of Geological Survey and Water Resources, 1961a, Total intensity aeromagnetic maps, Augusta, Bland, Hermann, Linn, Meta, Mokane, Morrison, Redbird, St. Clair, Tavern, Union, Vienna, and Washington quadrangles: Rolla, Missouri, 13 sheets, scale 1:62,500.

T ______, 1961a, Total intensity aeromagnetic maps, Boss, Corridon, Edgehill, and Lesterville quadrangles: Rolla, Missouri, 4 sheets, scale 1:62,500.

K ______, 1962, Total intensity aeromagnetic maps, Ash Grove, Fairplay, Greenfield, Hermitage, Macks Creek, Stockton, Stockton 1, Stockton 2, Stoutland, and Urbana quadrangles: Rolla, Missouri, 10 sheets, scale 1:62,500.

E ______, 1963a, Total intensity aeromagnetic maps, Butler, Clinton 3, Clinton 4, and Fristoe quadrangles: Rolla, Missouri, 4 sheets, scale 1:62,500.

Y ______, 1963c, Total intensity aeromagnetic maps, Advance, Bloomfield, and Malden quadrangles: Rolla, Missouri, 3 sheets, scale 1:62,500.

F ______, 1965, Total intensity aeromagnetic maps, Eugene, Iberia, Linn Creek, Little Niangua, Richland, Tavern, and Warsaw quadrangles: Rolla, Missouri, 7 sheets, scale 1:62,500.

L ______, 1968a, Total intensity aeromagnetic maps, Joplin East, Neosho, Ritchey, Sarcoxie, Seneca, Bolivar, Buffalo, Morrisville, and Strafford quadrangles: Rolla, Missouri, 9 sheets, scale 1:62,500.

X ______, 1968b, Total intensity aeromagnetic maps, Ellington, Greenville, Piedmont, and Zalma quadrangles: Rolla, Missouri, 4 sheets, scale 1:62,500.

G ______, 1968c, Total intensity aeromagnetic map, Gerald quadrangle: Rolla, Missouri, scale 1:62,500.

W ______, 1968d, Total intensity aeromagnetic map, Cardareva quadrangle: Rolla, Missouri, scale 1:62,500.

C ______, 1969, Total intensity aeromagnetic maps, Eldon, Gravois Mills,Green Ridge, Lincoln, Nelson, Pilot Grove, Smithton, Tipton, and Warsaw 1 quadrangles: Rolla, Missouri, 9 sheets, scale 1:62,500.

B ______, 1970, Total intensity aeromagnetic maps, Boonville, California, Fayette, Glasgow, Glasgow 2, Huntsville, Marshall, and Marshall 2quadrangles: Rolla, Missouri, 8 sheets, scale 1:62,500.

J Texas Instruments, Inc., 1978, Aerial radiometric and magnetic reconnaissance survey of portions of the Great Plains and central Lowlands, Joplin quadrangle: U.S. Department of Energy Grand JunctionOffice Report GJBX-100(78), v. 2, n.p., scale 1:500,000.

AA ______, 1980, Aerial radiometric and magnetic reconnaissance of portions of Arkansas, Illinois, Indiana, Kentucky, Missouri, and Tennessee, Popular Bluff quadrangle: U.S. Department of Energy Grand Junction Office Report GJBX-42(80), 143 p., 18 fiche, scale 1:500,000.

BB U.S. Geological Survey, 1974, Aeromagnetic map of the New Madrid region, Missouri, Kentucky, Arkansas, and Tennessee: U.S. Geological Survey Open-File Report 74-360, scale 1:125,000.

CC ______, 1976, Aeromagnetic map of the Jonesboro region, Arkansas-Missouri- Tennessee: U.S. Geological Survey Open-File Report 76-318, scale 1:125,000.

N ______, 1979, Aeromagnetic map of the Rolla, Missouri area: U.S. Geological Survey Open-File Report 79-966, scale 1:250,000.

M ______, 1984, Aeromagnetic map of part of the Springfield 1° x 2° quadrangle, Missouri: U.S. Geological Survey Open-File Report 84-648, scale 1:250,000.

Scale 1:500,000
1 inch equals approximately 8 miles

10 0 10 20 30 40 Miles
10 0 10 20 30 40 50 Kilometers

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the