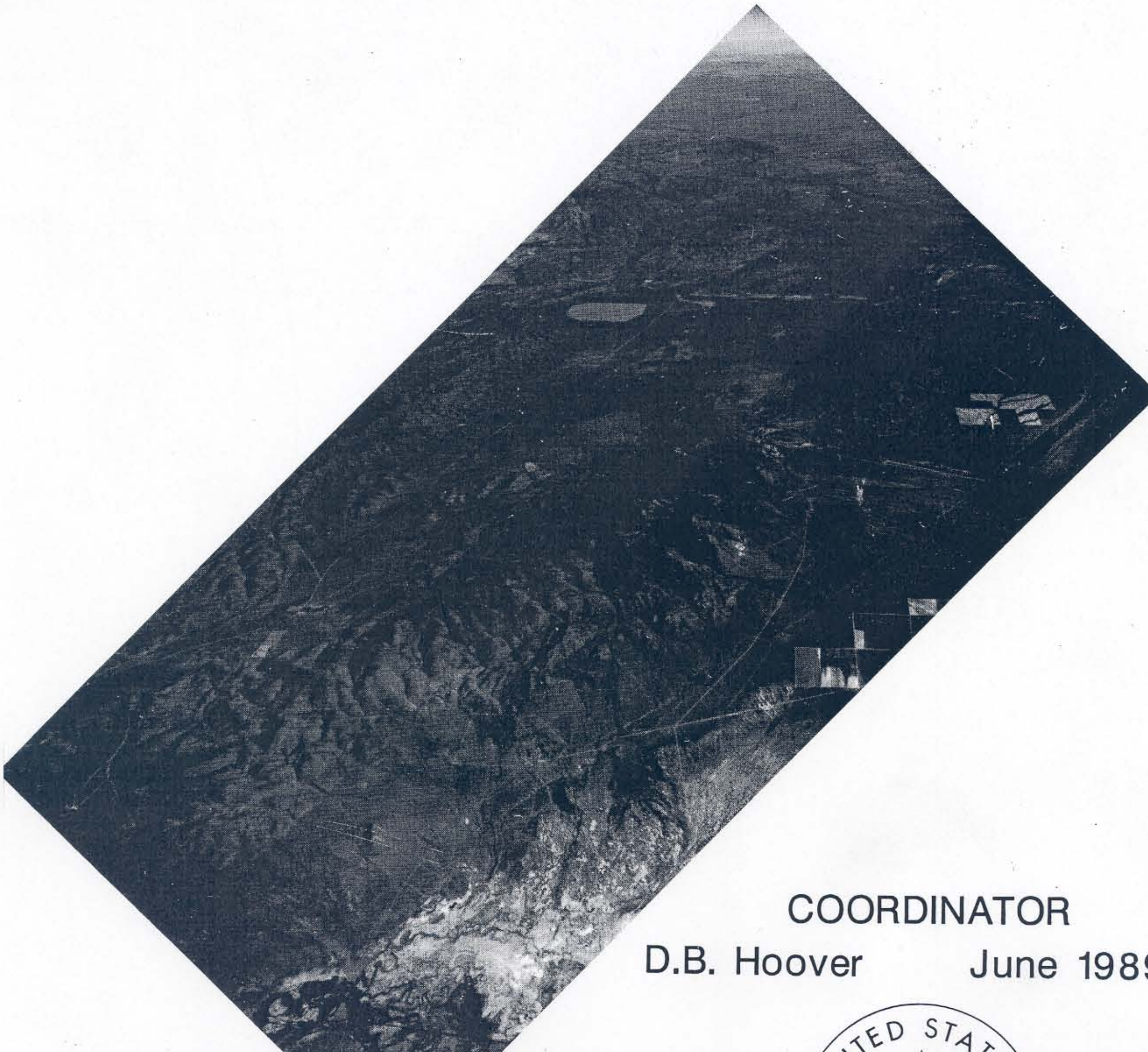
GETCHELL TREND NEVADA AIRBORNE GEOPHYSICS MAP FOLIO



COORDINATOR

D.B. Hoover June 1989

UNITED STATES GEOLOGICAL SURVEY

Prepared By

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* SEE FLAT FILES FOR WHOLE REPORT

United States Department of the Interior

GEOLOGICAL SURVEY
BOX 25046 M.S. 964
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

Technical Announcement
Geologic Division
August, 1989

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COLOR GEOPHYSICAL MAPS FOR THE GETCHELL TREND, NEVADA NOW AVAILABLE

The U.S. Geological Survey has compiled a folio of 25 colored geophysical maps and overlays at a scale of 1:100,000 for the Getchell Trend Airborne Demonstration Project. The Getchell Trend Airborne Demonstation Project is a multi-disciplinary effort to evaluate a variety of geophysical techniques for assessing mineral potential beneath cover.

The colored geophysical maps are derived from digital data available through the National Geophysical Data Center, U.S. Department of Commerce, World Data Center for Solid Earth Geophysics in Boulder, Colorado. The Getchell Folio is intended for previewing of the available digital data by potential users. For convenience to the users overlays of cultural features, topography, and geology as well as some derivative geophysical maps are included in the folio. Copies of the folio will be available for viewing at the following facilities.

U.S. Geological Survey
Earth Science Information Centers (ESIC):

Menlo Park-ESIC
Rm. 3128, Bldg. 3 (MS 532)
345 Middlefield Rd.
Menlo Park, CA 94025
(415)329-4390/FTS 459-4390

Salt Lake City-ESIC
8105 Federal Bldg.
125 S. State St.
Salt Lake City, UT 84138
(801)524-5652/FTS 588-5652

Lakewood-ESIC
MS 504, Bldg. 25, Room 1813
Box 25046, Federal Center
Denver, CO 80225
(303)236-5829/FTS 776-5829

Spokane-ESIC
678 U.S. Courthouse
W. 920 Riverside Ave.
Spokane, WA 99201
(509)456-2524/FTS 439-2524

Washington, D.C-ESIC
Dept. of the Interior Bldg.
18th & C Sts., NW, Rm. 2650
Washington, D.C. 20240
(202)343-8073/FTS(202)343-8073

and at:

see Room 311 files

Nevada Bureau of Mines and Geology
Mackay School of Mines, Attn: B. Weimer
University of Nevada-Reno
Reno, Nevada 89557
(702)784-6691

U.S. Geological Survey
Branch of Geophysics, Attn: Dennis Krohn
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U.S. Geological Survey, MS-964
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Box 25046, Federal Center
Denver, CO 80225
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U.S. Geological Survey, Attn: Karen Bolm
Minerals Information Office
845 N. Park Ave., No. 100
Tucson, AZ 85719
(602)882-4795 Ext. 21

United States Department of the Interior

GEOLOGICAL SURVEY
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DENVER FEDERAL CENTER
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TAKE PRIDE IN AMERICA

IN REPLY REFER TO: Mail Stop 964

August 4, 1989

B. Weimer
Nevada Bureau of Mines and Geology
Mackay School of Mines
University of Nevada-Reno
Reno, Nevada 89557

Dear Ms. Weimer:

Attached is a folio of color geophysical maps and transparent overlays compiled at a scale of 1:100,000 showing results from the Getchell Trend Airborne Demonstration Project of the Branch of Geophysics. The Getchell Trend is located in northcentral Nevada, and contains a number of important bulk-mineable gold deposits. There has been a great deal of industry interest in this data set, because of the quality, and variety of methods employed. Because of the high industry interest the digital data was released last February. This map folio is intended to provide the public with hard copy derived from the digital data so that they can examine the data set to determine if they wish to obtain some or all of the digital data.

This folio is not an edited or reviewed USGS product, and will not be listed in New Publications. The 33 pages of text attached to the folio explains the flight and instrument parameters for each of the airborne methods used, and a brief explanation of the geophysical technique employed. The purpose of the folio is to make examples of the data available to the public as quickly as possible.

Also attached to this letter is a Technical Announcement that will be mailed the week of August 8 to the public. As you can see, there are only nine centers where the folio will be available for viewing. We believe this will be sufficient, and expect that Denver and Reno will see the most action.

If there are any questions please feel free to call me.

Sincerely,

D B Hoover

D. B. Hoover
Branch of Geophysics

cc: W. Hassibe
W. Bagby

Getchell Trend Nevada Airborne Geophysics Map Folio*

Prepared by

V. J. S. Grauch, D. B. Hoover, M. D. Krohn, H. A. Pierce, and J. A. Pitkin

Coordinator

D. B. Hoover

July 1989

*This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. All brand names are for descriptive purposes only and do not imply endorsement by the U.S. Geological Survey.

Getchell Trend Nevada Airborne Geophysics Map Folio

Introduction

The U.S. Geological Survey conducted an integrated airborne geophysical survey along the Getchell Trend of gold deposits in Humboldt County, NV. Magnetic, gamma-ray, electromagnetic, and 64 channel visible and near IR remote sensing data were acquired by fixed wing and helicopter airborne systems during the summer and fall of 1988. These data were acquired as a one-time demonstration project. The purpose of the program is to demonstrate the advantages of using a multidisciplinary set of state-of-the-art airborne data for resource assessment or exploration of covered mineral deposits. The Getchell Trend was selected because of the presence of a variety of known mineral deposits including five active bulk mineable gold deposits, and one covered deposit (Rabbit Creek) which had been defined but had not yet been put in production. The Rabbit Creek deposit provided a unique opportunity for testing and evaluating airborne techniques over covered terrain.

Preliminary results of the airborne demonstration program were presented at the 5th Annual V. E. McKelvey Forum on Mineral and Energy Resources, January 24-26, 1989, (USGS Circular 1035) and at the Workshop on Mineral Industry and Government Cooperative Studies on concealed Mineral Deposits within the Basin and Range, January 27, 1989. Release of the digital data presented in this folio was made through the U.S. Department of Commerce's National Geophysical Data Center, and announced February 17, 1989. Further information on the digital data may be obtained from Mr. R. Buhmann, Tape Librarian, NCG, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Mountain Administrative Support Center 325 Broadway, Boulder, CO 80303-3328, Telephone (303) 497-6128. Because some potential users do not have easy access to computer facilities for processing the large volume of digital data, this folio of maps was prepared for placement in some U.S. Geological Survey map distribution centers. This also gives potential users of the digital data a chance to examine the data sets for appropriateness to their needs.

The following is a listing of the maps, images, and overlays comprising this folio:*

TOPOGRAPHIC, CULTURAL, AND GEOLOGIC DATA

1. Transparent overlay of the topography showing airborne survey areas flown specifically for this project.
2. Transparent overlay showing major gold mine locations, major roads and topography.
3. Transparent overlay of the geology showing locations of mines and prospects.
4. Color shaded relief topographic map derived from Defense Mapping Agency 1 degree x 2 degree sheet digital data.

REMOTE SENSING DATA

5. Thermal-Infrared Multispectral Scanner (TIMS) image.
6. Composite image derived from two Geophysical Environmental Research 64-channel scanner flightlines. Not geometrically rectified, approximately 1:100,000 scale.

RADIOELEMENT DATA

7. Transparent overlay showing flight line locations of gamma-ray survey.
8. Gamma-ray color contour map of the uranium distribution in ppm.
9. Gamma-ray color contour map of the potassium distribution in ppm.

*All maps are presented at a scale of 1:100,000 unless otherwise noted.

10. Gamma-ray color contour map of the thorium distribution in percent.

11. Gamma-ray color composite map of uranium, potassium and thorium.

12. Gamma-ray color composite map of uranium, U/Th and U/K.

13. Gamma-ray color composite map of potassium, K/U and K/Th.

14. Gamma-ray color composite map of thorium, Th/U and Th/K.

AEROMAGNETIC DATA

15. Transparent overlay showing flight-line locations of the USGS in-house aeromagnetic survey.

16. Transparent overlay map showing magnetization boundaries derived from the in-house USGS aeromagnetic data.

17. Color shaded relief aeromagnetic map of data acquired by USGS in-house system.

18. Transparent overlay showing flight-line locations of the contract airborne electromagnetic and magnetic surveys.

19. Transparent overlay map showing magnetization boundaries derived from the contract aeromagnetic data.

20. Color shaded relief aeromagnetic map of data acquired under contract to DIGHEM.

21. Color shaded-relief aeromagnetic map of data digitized from a 1973 Continental Oil survey.

AIRBORNE ELECTROMAGNETIC DATA

22. Color shaded-relief map of 56,000 Hz airborne data.

23. Color shaded-relief map of 7,200 Hz airborne data.

24. Color shaded-relief map of 900 Hz airborne resistivity data.

25. Color shaded-relief map of airborne very low frequency (VLF) total field electromagnetic data.

For those users not completely familiar with all the types of data presented in this folio, a brief introduction and discussion of each data set follows. The maps and images presented are preliminary and have not been edited for compliance with USGS standards.

Acknowledgements

USGS studies along the Getchell Trend, both ground and airborne, have been done in cooperation with FirstMiss Gold Inc., Santa Fe Mining, Pinson Mining, and Battle Mountain Exploration who provided access to their lands. The ability to obtain complementary ground data was an important factor in determining where the airborne surveys would be flown. In particular we wish to thank Mr. Richard Nanna of First Miss Gold, Mr. Roy Owen of Santa Fe Minerals, Mr. Edward Kretchmer of Pinson Mining, and Mr. Kurt Payne of Battle Mountain Exploration for all the help given and for many hours of lively discussion.

The Airborne Geophysical Demonstration Project was funded from a special grant provided by the USGS Chief Geologist, Dr. Benjamin Morgan III who we thank for his very generous support.

TOPOGRAPHIC, CULTURAL AND GEOLOGIC DATA

Introduction

Three transparent overlays and one color shaded-relief map of topographic, cultural and geologic data are provided in this section as aids for the user of the newly acquired geophysical data. No new information is contained in these maps, all data having been obtained from previously published sources. The transparent overlays are intended for use with all of the new geophysical data sets to aid in the location of geophysical features with respect to topography, culture or geology.

Topographic Map Description

The color shaded-relief topographic map is a presentation that shades the topographic data as though it were obliquely illuminated from the east, and uses a color scale to show elevation differences. The digital data base used to produce the map was obtained from the Defense Mapping Agency and based on 1^{o} by 2^{o} topographic quadrangles. The data were projected into UTM coordinates (base latitude 0^{o}; central meridian 117^{o}w) and interpolated onto grids having equally spaced intervals of 0.08 km (262 ft). Besides the digital geophysical data these digital topographic data are also available from the National Geophysical Data Center.

Topographic Overlay Showing Airborne Geophysical Survey Areas

The topographic base for this overlay was made by compiling a mosaic of the U.S. Geological Survey Osgood Mtns, Hot Springs Peak, Edna Mountain, and Paradise Valley 15 minute quadrangles and the Dry Hills North, Dry Hills South, Red House Flat East, Knight, Valmy, Ellison, Hot Pot, Elevenmile Well, The Knolls, Kenny Creek, Gumboot Lake, Golconda Butte, Pole Creek, and Adelaide 7-1/2 minute quadrangles at a scale of 1:100,000. On this map the outlines of the various areas flown for the Airborne Geophysical Demonstration project are shown.

Topographic Overlay Showing Major Roads and Gold Mine Locations

The topographic base used for this overlay is the same as that used to show the Airborne Geophysical Survey Areas. On this base are highlighted the major roads in the survey area and the major bulk mineable gold deposits, Preble, Pinson, Mag, Getchell, Rabbit Creek and Chimney. Besides providing convenient reference positions, this overlay may be used in conjunction with the geophysical maps to identify the geophysical expressions of each deposit or locations of particular features seen in any of the geophysical data sets.

Geologic Overlay Showing Locations of Mines and Prospects

The geologic overlay was compiled from maps published by Hotz and Willden (1964) and Willden (1964). We have added to this base geologic map the locations of known mines and deposits in the area of the geophysical surveys. Deposits of gold are indicated by circular-, tungsten by square-, silver by diamond-, barite by triangular- and manganese by star-shaped symbols. The major gold deposits are also named on the overlay. Faulting is shown adapted from Hotz and Willden (1964) and Willden (1964) with four of the important faults identified by name; the Getchell, Village, Granite Creek thrust and one informally named the Hotz and Willden fault. Expressions of these faults can be seen in some of the geophysical data sets and will be referred to in the geophysical discussion. Explanation of the various symbols used on the geologic overlay are given in appendix 1.

This overlay is intended to be used with the various geophysical data sets to identify correlations with geology and identify the geophysical expressions associated with the various identified mineral deposits.

References

Hotz, P. E., and Willden, R., 1964, Geology and mineral deposits of the Osgood mountains quadrangle, Humboldt County, Nevada: U.S. Geological Survey Professional Paper 431, 128 p.

Willden, Ronald, 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines and Geology Bulletin 59, 154 p.

REMOTE SENSING DATA

Introduction to Remote Sensing Images

Three remote sensing data sets were analyzed in this folio; satellite Landsat Thematic Mapper (TM) data, airborne thermal data from the Thermal-Infrared Multispectral Scanner (TIMS), and data from the 64-channel Geophysical Environmental Research (GER) visible/near-infrared scanner (GER). The satellite and the thermal data sets were acquired prior to the airborne demonstration program; the multi-channel visible/near-IR was acquired in August 1988 specifically for the Getchell Trend studies. Copies of the Landsat TM images are not included in the folio, but can be examined at the National Center in Reston, VA.

Remote sensing is a pivotal element in multi-disciplinary efforts, because it integrates aspects of geophysics, geochemistry, and geology. For the attempt to locate concealed deposits beneath the cover rocks of the Basin and Range Province, remote sensing studies must extrapolate geomorphic and mineralogic features of the surface to the near subsurface. The alluvial basins can be divided into regions based on morphology of the bottom boundary, like the oceans, rather than features on the surface. The shallow region between the exposed ranges and the deep parts of the central basin, tentatively called a suballuvial bench, is the focus of the Getchell Trend studies. Here many of the rock properties from the exposed bedrock can be extrapolated into the shallow subsurface.

Remote sensing can contribute to locating concealed deposits in two principal ways. Structural trends in the exposed bedrock can be extended into the basins from analysis of linear features by photogeologic methods. Mineralogic features related to changes in alluvial, colluvial and other parts of the regolith can be identified by their unique spectral absorption features. Remote sensing techniques utilize differential reflection, absorption, and emission of electromagnetic radiation in minerals caused by specific molecular bonds to give diagnostic spectral absorption features. The wavelength ranges of radiation used to produce these images are visible, 0.4 - 0.7 micrometers; near-infrared, 0.7 - 2.5 micrometers; and thermal-infrared, 2.5 - 50 micrometers. Visible and near-IR wavelength images are based on reflected solar radiation; thermal-IR images are based on emitted radiation from solar heating. A basic description of remote sensing techniques can be found in Sabins (1978). The spectral and spatial features obtained by remote sensing can be used to correlate specific surface expressions to potential field anomalies observed in the other geophysical data sets.

Reference

Sabins, F. F., Jr., 1978, Remote sensing - principles and interpretation: San Francisco, W. H. Freeman, 476 p.

Data Description: Landsat Thematic Mapper (TM) Image

The Landsat Thematic Mapper data provides a regional context for the other airborne data sets. The Landsat Scene ID 50137-17550 was acquired on 16 July 84 and is available to members of the Federally-Owned Landsat Data (FOLD), a government-industry cooperative to share pre-proprietary Landsat data. TM data includes 7 broad spectral channels, 3 visible, 3 near-infrared, and one thermal-infrared. Spatial resolution of the TM data is 25 meters (81 feet) for the visible and near-IR and 100 meters (325 feet) for the thermal channel. Several false color composite and color-ratio composite images were made.

Preliminary Image Description: Landsat Thematic Mapper Image

The Landsat image is used to provide a common structural context for the Osgood Mountains with the younger volcanic rocks to the east. Structural trends from Basin and Range extension are present in the exposed volcanic rocks and can be interpreted to extend underneath the regolith cover. N-S to NNW-trending normal faults, down to the west (Stewart and Carlson, 1978), are expressed as steep linear canyons readily seen on Landsat images. Several of the drainages east of the Getchell mine in the center of basin show analogous looking linear features and some abrupt offsets implying structural control. Roughly orthogonal to that is a series of E-W to ENE trending features that have been mapped as a set of horsts and grabens (Wallace, 1988., Wallace et al 1988). Several ENE trending features that have been mapped in the alluvial basin west of the Midas area toward the Osgoods in a compilation of younger alluvial scarps can be observed on the TM images (J. Dohrenwend, 1988, pers. comm.).

References

Stewart, J. H., and Carlson, J. E., 1978, Geologic Map of Nevada, Scale 1:500,000.

Wallace, A. R., 1988, Geologic Map of the Little Humboldt River Wilderness Study area, Elko, Co., Nevada, U.S. Geological Survey MF 2053.

Wallace, A. R., Turner, R. L., Grauch, V.J.S., Plesha, J. L., Krohn, M. D., Duval, J. S., and Gabbey, P. N., 1988, Mineral resources of the Little Humboldt River Wilderness Area, Elko County, Nevada: U.S. Geological Survey Bull. 1132-B, pp. 81-821.

Data Description: Thermal Infrared Multi-Spectral Scanner (TIMS)

Data from the 6-channel Thermal Infrared Scanner was acquired in 1983 from the Lear Jet platform of NASA's National Space Technology Laboratory (NSTL) (now the Stennis Space Center) Bay St. Louis, MS. The daytime thermal imagery was acquired between 8 and 12 micrometers to detect variations in Si-O molecular bonds related to silicate mineralogy. Since thermal emissions comprise over 95% of the signal, an enhancement technique known as a decorrelation stretch, or inverted principal component, is used to remove the high degree of interband correlation (Krohn and others, 1981). In the TIMS image red areas are highly siliceous rocks and correspond to quartzites, silicified veins, a few larger areas of jasperoids, and some areas of dune sand. Blue areas are rocks with a mixed felsic and mafic content, such as the granodiorite of the Osgood Mountain intrusive. Green areas are rocks without Si-O spectral features and can include carbonates and certain types of mafic volcanic rocks such as basalts.

Preliminary Image Description: Thermal Infrared Multispectral Scanner (TIMS)

Lithologic and structural studies made using the TIMS image are briefly described. The central dumbell shaped intrusion of the Osgood Mountain pluton can be seen as a blue area west and south of the Getchell mine with a red area of Osgood Mountains Quartzite to the south. Effects of contact metamorphism are seen as light blue areas near the Getchell mine. The Preble Formation, host for many of the disseminated gold deposits is seen as yellow areas generally in the south. In part of the image jasperoids are visible as small individual picture elements (pixels), but the scale of the image is too coarse to clearly show them.

With the acquisition of the additional airborne geophysical data sets correlations could be made with structural features analyzed from the TIMS image. Previous work had shown that structural features mapped on ground-based electromagnetic lines could be coupled with a graben-like pair of linear features mapped east of the Getchell mine. Several other strong trends correspond in positions both to trends in the aeromagnetic and gamma-ray data. A fault mapped by Hotz and Willden (1964), east of the Pinson mine, that is shown as separating recent from Pleistocene alluvium can be seen as a color tone line or feature on the TIMS data. A continuation of the Getchell fault (Hotz and Willden, 1964) north of the Getchell mine is also observed on the TIMS image and several of the other geophysical data sets. In the northern part of the TIMS image several of the E-W to WNW linear drainages correspond to features in the other geophysics data sets. In the southern part of the image, additional NNE trending features are observed, particularly in the area between the Pinson and Preble mines. These linear features reveal distinctive trends between the northern and southern parts of the image suggesting that ENE trends observed in the Landsat image from the Midas trough may also be separating the Osgood Mountains into distinctive structural domains.

References

Krohn, M. D., Milton, N. M., Segal, D. B., and England, A. W., 1981, Discrimination of a chestnut-oak forest unit for geologic mapping by means of a principal component enhancement of Landsat multispectral scanner data: Geophysical Research Letters, v. 8, p. 151-154.

Hotz, P. E., and Willden, R., 1964, Geology and mineral deposits of the Osgood mountains quadrangle, Humboldt County, Nevada: U.S. Geological Survey Professional Paper 431, 128 p.

Data Description: GER 64-Channel Scanner data

Two lines of multi-channel airborne remote sensing data were acquired from the Geophysical Environmental Research (GER) scanner operated by Dr. William Collins, New York, NY. The scanner data are part of a new type of acquisition termed imaging spectrometer data. The spectral resolution of the detectors is fine enough so that the data can be presented across channels as a spectrum or along channels as an image. Of the 64 channels, 24 are in the wavelength range of the visible and near-IR between 0.5 and 1.0 micrometers at a spectral resolution of 15 nannometers; 8 channels are between 1.0 and 2.0 micrometers with a resolution of 200 nannometers; and 32 channels between 2.0 and 2.5 micrometers at a resolution of 10 nannometers. The data are collected with a theoretical dynamic range of 16 bits, a range of 0 - 65,000, as compared to most previous 8-bit scanners. In practice, most data falls within a range of 1-10,000. Over 2000 scanlines were collected along each line with 512 pixels per line. This encompasses over 264 million bytes of data per flight line. The northern flight line includes the Getchell and Pinson mines, but is located west of the Chimney and Rabbit Creek mines. The southern line includes the Preble mine, a barite mine at the mouth of Hogshead canyon, and the Pinson mine. The flight lines are shown as 3-band composites, portrayed to look like a color-infrared image, using one infrared and two visible range channels.

Preliminary Image Description

Because of the massive amounts of data, only cursory evaluation of the GER data sets has been initiated. A version of the Spectral Analysis Manager program (SPAM), initially written by the Jet Propulsion Laboratory, was converted to run on Sun* 3 and Sun* 4 computers with the window software, SunView.*

The output from SPAM shows a combined spectral and spatial display of the data. The area near the Getchell mine was initially chosen because of the large exposures in the mine dumps. The mineral illite was searched for in the following way. A spectrum was derived from each pixel of the image and compared to a library spectrum for illite in the same wavelength range. The colored area on the image corresponds to where the mineral was identified and correlates to many of the dump areas.

*All brand names are for descriptive purposes only and do not imply endorsement by the U.S. Geological Survey.

RADIOELEMENT DATA

Introduction to Gamma-ray Radioelement Maps

Gamma-ray measurements detect the radiation emitted by radioisotopes in the near-surface (approximately 0 to 50 cm; 0 to 18 inches) rock and soil, which result from decay of the natural radioelements uranium-238, thorium-232, and potassium-40. The near-surface distribution of the natural radioelements is controlled by geologic processes, which enables the use of radioelement measurements in geologic mapping and mineral exploration. Killeen (1979) discusses the applications of gamma-ray spectrometry in mineral exploration.

In the Getchell area, mineralizing processes could have affected the distribution of one or more radioelements in manners anomalous for specific rock types or host rocks. Ground gamma-ray measurements done by D.B. Hoover and H. A. Pierce on a limited scale in the area of the Getchell mine during 1986 indicated the possibility of such anomalous occurrences. An aerial gamma-ray survey of the Getchell area was undertaken to map the distribution of radioelements and to determine the areal extent of gamma-ray (radioelement) anomalies.

Data Description: Radioelement Distribution Maps

The USGS contracted with TerraSense, Inc., of Sunnyvale, California for a helicopter gamma-ray spectrometer survey of the Getchell area. The survey was flow in October 1988 on 432-m (1/4 mi) spaced flight lines oriented northwest-southeast at a nominal 122-m (400 feet) above ground level. The spectrometer system used 33 liters (2048 cubic inches) of sodium iodide crystals to detect near surface terrestrial gamma-rays and a 8 liter (512 cubic inches) detector to monitor radon in air. The gamma-ray data were corrected for background radioactivity, spectral backscatter, radon in air, were altitude normalized, and were converted to concentration units of parts per million for uranium (U) and thorium (Th) and percent for potassium (K). Equilibrium in the uranium and thorium decay series was assumed. The data were projected into UTM coordinates (base latitude 0^{o}; central meridian $117^{o}W$) and interpolated onto grids having equally spaced intervals of 0.08 km (262 feet).

Preliminary Map Description

Color contour and color composite maps were prepared from the fully corrected radioelement data. The three radioelement contour maps are color coded for colder (blue) to warmer (red) colors to correspond to lower to higher concentrations of the respective radioelement. The four color composite maps (CCMs) show the three radioelements or one radioelement and two ratios composited as one map, using a technique described by Duval (1983). The elements CCM shows the combined distribution of the three radioelements, and the respective radioelement and its ratios CCMs highlight the distribution of the primary radioelement relative to the other two. Color coding for the CCMs is described on each map. The color contour maps show the quantitative distribution of the near surface radioelements and the color composite maps show the qualitative distibution between the radioelements.

General radioelement features that may be significant for mineralization can be seen in the radioelement maps. One such prominent feature is a southwest trending linear zone, particularly evident in the uranium contour map, that starts 3.2 km (2 miles) west of the Pinson mine and runs to the southwest for 21 km (13 miles). The northeasternmost 8 km (5 miles) of this radioelement linear correlates with the surface outcrop of the Granite Creek thrust (Hotz and Willden, 1964). Where mapped, the thrust juxtaposes less radioactive Osgood Mountain quartzites on the northwest on Preble Formation shale, slate, and limestone to the southeast. Linear zones of relative high K, U, and especially Th occur in Preble Formation rocks adjacent to the

Granite Creek thrust, perhaps reflecting hydrothermal alteration. Several areas of higher K and to a lesser extent of Th occur in Osgood Mountains Quartzite near the thrust, indicating mineralogic variants in the quartzite or possibly alteration. Outcrops of Preble Formation rocks 4 and 7 km (2.5 and 4.3 mi) south-southwest of the Preble mine are associated with distinct relative highs in K and Th and to a lesser extent of U, and could also reflect the occurence of hydrothermal alteration. Broad highs of K, U, and Th occur in Quaternary pediment gravels southeast of the Pinson mine where extensions of the Getchell fault and a northeast-striking unnamed fault mapped by Hotz and Willden (1964) are thought to intersect. Unconsolidated sediments west of the unnamed fault are relatively thin, based on other geophysical data, and the pattern of somewhat elevated radioelement concentrations could reflect alteration at depth where the faults intersect. Local relative U highs occur at the Getchell mine, including the south pit, the tailings pile, and the heap leach pad. These features indicate that at least some Getchell gold ore is associated with slightly elevated concentations of U, which is consistent with ground gamma-ray data obtained from the south pit (D.B. Hoover and H. A. Pierce, oral commun., 1986).

The CCMs expand the utility of the radioelement data by showing areal and relatively localized features not apparent in contour maps. Areal features on the elements CCM include areas where a primary color dominates indicate the primacy of that radioelement. The large area of reds on the southern part of the study area indicates the dominance of U, areas of blue through the study area indiates the dominance of Th, and mapped granodiorite west and southwest of the Getchell mine area correlates well with K-dominant areas of the elements CCM. Relatively localized features include the anomalous areas in Preble Formation rocks adjacent to the Granite Creek thrust, which the various

CCM's show to be primarily of K and Th composition rather than U. Across the fault in the Osgood Mountains Quartzite, the anomalies are also primarily K and Th, with slight U expression. The anomalies in Preble Formation rocks 4 and 7 km (2.5 and 4.3 mi) south-southwest of the Preble mine include a U component as shown by the elements CCM, but are mostly K and Th features. The area of postulated intersecting faults southeast of the Pinson mine has a Th component in addition to U and K, as indicated by the mottled white area on the elements CCM. In the area of the Getchell mine and to the south, bright reds on the elements CCM and whites on the U CCM show areas where U dominates relative to K and Th. West of the Getchell fault, and west and northwest of the Getchell mine, white areas on the K CCM indicate areas of dominant K which includes areas of known and potential hydrothermal alteration.

References

Duval, J. S., 1983, Composite color images of aerial gamma-ray spectrometric data: Geophysics, v. 48, no. 6, p. 722-735.

Hotz, P. E., and Willden, R., 1964, Geology and mineral deposits of the Osgood mountains quadrange, Humboldt County, Nevada: U.S. Geological Survey Professional Paper 431, 128 p.

Killeen, P. G., 1979, Gamma ray spectrometric methods in uranium exploration - application and interpretation, in Hood, P.J., (ed.), Geophysics and geochemistry in the search for metallic ores: Geological Survey of Canada, Economic Geology Report 31, p. 163-229.

AEROMAGNETIC DATA

Introduction to Aeromagnetic Maps

Aeromagnetic measurements represent variations in the strength and direction of the Earth's magnetic field that are produced by rocks containing a significant amount of magnetic minerals (commonly magnetite). The shape and magnitude of an anomaly produced by one body of rock is complexly related to the body's shape and magnetization (see Sharma, 1986). Magnetization is determined by the amount and distribution of magnetic minerals and the magnetic properties of those minerals, which are influenced by a number of factors, including the history of the rock (McElhinny, 1973; Sharma, 1986). The location of the anomaly over the rock body in the magnetic latitude present in northern Nevada is offset southward and is accompanied by a weak low on the northern side, called a polarity low (Sharma, 1986). Anomalies on aeromagnetic maps, when viewed as patterns, generally express structural, topographic, and lithologic variations. Anomalies due to crystalline rocks commonly dominate aeromagnetic maps because these rocks ordinarily are more magnetic than other rock types.

The depth to which magnetic rocks can be detected below the surface is primarily a function of the magnetization strength and size of the rock bodies and the resolution of the aerial survey. Large, strongly magnetic sources can be detected by most surveys at great depths, but smaller, weaker sources may not be detected except at near-surface depths by high-resolution surveys. However, even when both deep and shallow sources are detected, discrimination of magnetic sources can be very difficult because the signals of all the sources may interfere with each other. In some cases, the anomalies of shallow, strongly magnetic sources (such as certain basalts) may completely overwhelm the signature of other anomalies on the aeromagnetic map.

The special resolution of an aeromagnetic survey is determined primarily by flight-line spacing and height above ground. The narrower the flight-line spacing and the shorter the distance flown above the ground, the greater is the resolution. Out of the three survey data sets presented in this folio, the contract data have the best resolution, the in-house data have intermediate resolution, and the digitized Continental Oil Company data have the lowest resolution.

Introduction to Magnetization Boundaries (Overlays)

Magnetization boundaries are boundaries between rocks of contrasting magnetic properties and commonly occur at faults and other geologic contacts. The overlays display these boundaries by the alignments of the small x's and were computed from the digital aeromagnetic data (see Cordell and Grauch, 1985; Blakely and Simpson, 1986). The sizes of the x's are related to the depth and magnitude of magnetization contrast across the boundaries. Maps of computed magnetization boundaries help delineate buried faults and lithologic patterns and more precisely locate magnetic sources than do anomalies, which are offset due to polarity effects (see the first section above; Sharma, 1986).

IN-HOUSE AEROMAGNETIC DATA

Data Description

The colored map presents aeromagnetic data acquired over the Getchell Trend in October 1988 using the USGS Branch of Geophysics in-house system. The survey was flown with a proton magnetometer onboard a fixed-wing aircraft along lines that smoothly drape over topography generally 137 m (450 feet) above ground. The flight lines for the western half of the survey were directed northeast-southwest and spaced about 200 m (1/8 mile) apart; the lines for the eastern half were directed northwest-southeast and spaced 400 m

(1/4 mile) apart. The data were projected into UTM coordinates (base latitude 0^o; central meridian 117^oW) and interpolated onto grids having equally spaced intervals of 0.08 km (262 feet) and 0.16 km (525 feet) for the western and eastern halves, respectively. Diurnal variations and the standard International Geomagnetic Reference Field model were removed from the grids. The western grid was regridded and its magnetic values shifted by a small amount in order to better match the eastern grid, then the two grids were merged into one larger grid.

Preliminary Map Description

The color shaded-relief map shown here is a presentation that shades the aeromagnetic data as though it were topography obliquely illuminated by the sun, and uses a color scale to show different values. The most prominent anomaly in the center of the map, which is only partially defined by the data, is attributed to the Cretaceous granodiorite pluton in the Osgood Mountains, along whose eastern edge the Getchell, Mag, and Pinson deposits are located. The busy, high-amplitude anomaly pattern along the southern half of the western survey area is probably caused by exposed volcanic rocks. Broader and lower amplitude anomalies in the less busy areas probably indicate igneous rocks at depth. The linear, northwest-southeast trending anomalies in the southwest part of the survey area may indicate faulting which disrupts the generally northerly lithologic and topographic patterns.

Preliminary Overlay Description

A fairly straight, approximately north-south striking, continuous magnetization boundary in the northeastern part of the survey area probably represents a previously unmapped fault. The inferred northwest-southeast faulting in the southwest part of the survey area (mentioned above), is delineated by several northwesterly trending magnetization boundaries. The isolated magnetic body of rock in the northern part of the area, which is almost completely encircled by a magnetization boundary, demonstrates anomaly offset due to polarity effects.

CONTRACT AEROMAGNETIC DATA

Data Description

The colored map presents aeromagnetic data acquired over the Getchell Trend area by DIGHEM, Inc. in October 1988. The survey was flown by helicopter with a cesium-vapor magnetometer nominally 45 m (148 feet) above ground. The flight lines were directed northwest-southeast and spaced 400 m (1/4 mile) apart except over the vicinity of known gold deposits where they were spaced 200 m (1/8 mile) apart (see the flight line map elsewhere in this folio). Three extra long flights across the area (the arm-like colored areas) are for magnetic modeling purposes. The data were projected into UTM coordinates (base latitude 0^{o}; central meridian 117^{o}W) and interpolated onto a grid having equally spaced intervals of 0.08 km (262 feet). Diurnal variations and the standard International Geomagnetic Field model were removed from the grid. Fig. 19

Preliminary Map Description

The color shaded-relief map is a presentation that shades the aeromagnetic data as though it were topography obliquely illuminated by the sun, and uses a color scale to show different values. The most prominent anomaly near the center of the map is attributed to the Cretaceous granodiorite pluton in the Osgood Mountains, along whose eastern edge the Getchell and Pinson deposits are located. The busy, high-amplitude anomaly pattern along the southwestern edge of the area is probably caused by exposed volcanic rocks. Buried volcanic rocks are suggested where this anomaly pattern is repeated, although more subdued, in the southeastern part of the area. Less busy anomaly patterns, whose individual anomalies are slightly broader, connect the two areas of busy anomaly patterns and occur near the south-central edge of the area. These patterns are located near exposed intrusive rocks and may express intrusions at depth.

Preliminary Overlay Description

A somewhat straight, continuous magnetization boundary in the northeastern part of the survey area probably represents a previously unmapped fault. Fairly continuous magnetization boundaries encircle the granodiorite along its contact with surrounding rock. The discontinuous boundaries parallel to this contact on the east may be due to faulted or irregular sides of the granodiorite at depth. The sets of parallel, north-trending magnetization boundaries that can be traced almost 25 km along the southeastern edge of the area probably delineate subsurface fault blocks that have been downdropped to the east.

DIGITIZED AEROMAGNETIC DATA

Data Description

The colored map presents aeromagnetic data from a survey flown west of the Getchell Trend area in 1973 by the minerals department of Continental Oil Company. The survey was flown at a nominal 152 m (500 feet) altitude above ground level with flight lines directed east-west and spaced 805 m (1/2 mile) apart. Because digital data from this survey no longer exist, 1:24,000 contour maps were digitized, projected into UTM coordinates (base latitude 0^{o}; central meridian 117^{o}W), and interpolated onto a grid having equally spaced intervals of 0.25 km (820 feet). Presumably, only an arbitrary datum was removed from the contoured data (which means the data are uncorrected for the Earth's magnetic field), but records of the data reduction procedure are not available. The contour maps are on file at the Nevada Bureau of Mines and Geology in Reno, Nevada.

Preliminary Map Description

The color shaded-relief map shown here is a presentation that shades the aeromagnetic data as though it were topography obliquely illuminated by the sun, and uses a color scale to show different values. The fuzzy appearance of the map is due to the low resolution of the data at this map scale. The gradual, broad change from low values (blue colors) in the south to higher values in the north (yellows and greens) could probably be removed by correcting for the effects of the Earth's magnetic field. The most prominent anomaly in the east-central part of the map is attributed to the Cretaceous granodiorite pluton in the Osgood Mountains, along whose eastern edge the Getchell and Pinson deposits are located. Another prominent high in the southwest corner of the area is also associated with granodiorite. The NNE-trending broad high in the north-central part of the area is mostly located over mapped basin fill. The high most likely represents shallowly buried basalt because many of the highs at the northern and southern ends of the trend are associated with exposed basalt.

Fig. 20

The area between $40^{o}55'$ and $41^{o}05'$ corresponds in location to the southern part of the contract aeromagnetic map which displays data from a higher resolution survey. The clarity of the anomaly patterns on the contract aeromagnetic map contrasts sharply with the out-of-focus, subdued display of the same patterns on this map. This comparison stresses the importance of low-flying, closely spaced aeromagnetic surveys.

References

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AIRBORNE ELECTROMAGNETIC DATA

Introduction to Airborne Resistivity Mapping

There are numerous airborne electromagnetic (AEM) systems that have been developed since operation of the first system in 1950. Most of these AEM systems measure the mutual impedance between two coils flown close enough to the earth's surface that coupling to the earth occurs (Ward, 1967). The response of a coil pair to earth structures will vary depending on many factors, such as relative orientation of each coil, the coil pair orientation relative to the earth's surface and flight direction, the frequency or frequencies used, and whether time or frequency domain techniques are employed. The proliferation of different systems has tended to cause confusion to the uninitiated because of the differing responses to earth conductivity structures. Most early systems were used in the search for massive sulfides where it was sufficient to identify discrete high conductivity bodies within the earth. During the 1970's the use of AEM techniques were further extended to production of resistivity maps based on a homogeneous half-space model, or a simple layered-earth model (Fraser, 1978; Palacky, G.J., 1986).

Resistivity (or conductivity) is a fundamental earth property such as density or magnetic susceptibility, hence maps of this property may be used to help determine the lithologic and structural nature of the earth in a manner analogous to the use of gravity and magnetic maps. However, in contrast, however, to gravity and magnetic techniques the exploration depth of electrical methods can be controlled so that resistivity maps for varying depths of exploration may be prepared. Ground electrical techniques have virtually no limit to the maximum depth of exploration, whereas, AEM methods are generally limited to the upper 100 meters.

Very low frequency (VLF, 3 kHz to 30 kHz) AEM systems are often operated as supplementary systems to other airborne surveys because of the low cost (Herz 1986). VLF systems differ from most other AEM systems by using distant VLF radio transmitters for a source of electromagnetic energy. Modern instruments employ a triaxial coil sensor and measure all three components of the transmitted radio frequency field. Commonly the total magnetic field is calculated and presented as maps.

Earth resistivity (or conductivity) is primarily a function of the interconnected porosity of the rock, the amount and quality of contained water, and degree of saturation (Keller and Frischknecht, 1966). Electronically conductive minerals such as metallic sulfides which have very low resistivities generally contribute little to bulk resistivities of earth materials unless present in large quantitities. Thus, earth resistivity is normally determined by ionic conduction through the pore spaces of rocks. As an example, intrusive rocks have low porosity in contrast to most sediments and they normally have much higher resistivities than sediments. Or, a sandstone aquifer, if saturated with fresh water, might have intermediate values of resistivity, but if salt water is present would have very low values. The presence of clay minerals also will lower resistivities significantly because of their surface electrical properties.

Data Description

Four AEM maps are presented in this folio: a total field VLF map obtained with a Herz Industries Totem-2A VLF receiver (Herz, 1986) and three resistivity maps derived from the DIGHEM IV system (Fraser, 1986) using algorithms described by Fraser (1978). The VLF total field map was prepared using transmitters at Cutler, Maine (24 kHz), and Annapolis, Maryland (21.4 kHz). The horizontal coplaner coil pairs used in the DIGHEM IV system were operated at 56,000 Hz, 7200 Hz and 900 Hz. The AEM data were acquired over the Getchell Trend in October, 1988. The survey was flown by helicopter with the sensor at a nominal 30 m (100 feet) above ground. Flight lines were oriented northwest-southeast and spaced 400 m (1/4 mile) apart except in the vicinity of known gold deposits where the spacing was 200 m (1/8 mile) apart (see the flight line map elsewhere in this folio). The AEM data were projected into UTM coordinates (base latitude 0^{o}; central meridian 117^{o}W) and interpolated onto a grid having equally spaced intervals of 0.06 km (197 feet).

Preliminary Map Descriptions

The color shaded-relief maps represent the AEM data as though it were topography obliquely illuminated by sunlight from the east. A color scale is used to show resistivity values on a logarithmic scale going from low values in blue to high values in red.

The 900 Hz resistivity map, because it represents the deepest measurements obtained in the AEM survey, best reflects contrasts in resistivity within bedrock units and between bedrock and thick unconsolidated cover. Exploration depth is not constant but varies with frequency, resistivity, and the variation of resistivity with depth. It is on the order of 90 m at 900 Hz.

The 900 Hz resistivity map is the most useful for definition of both exposed and covered lithologies, and can be used to illustrate some geologic features that may be inferred from the data. The prominent dumbell-shaped area of high resistivity (shown in red) near the center of the survey area and west of the Getchell mine, corresponds to the Cretaceous granodiorite pluton in the Osgood Mountains. Extending southwest from the granodiorite a band of high resistivity rock correlates with Paleozoic quartzite (Hotz and Willden, 1964). The Getchell fault zone occurs on the eastern margin of the granodiorite where it is associated with a narrow low resistivity trough in the airborne data. The Mag and Getchell deposits are located on the low resistivity trough. The Preble deposit also is expressed as a small region of low resistivity aligned on a north trending low resistivity zone that may be an expression of faulting. Within the southern part of the survey area, mapped resistive units correlate with exposed basalts and Paleozoic sediments. Areas covered with Quaternary deposits display resistivities less than 100 ohm-m (yellow, green, and blue colors). Along the southeast edge of the survey area, a narrow north-trending zone of about 30 ohm-m superimposed on a flat 10 ohm-m surface may represent a buried basalt cliff. This correlates with a similar feature seen in the magnetic data.

The higher frequency maps show resistivity variation measured at shallower depths: on the order of 30 m for the 7200 Hz map, and 10 m for the 56,000 Hz and VLF maps. The maps show the same general features as the 900 Hz map, but the range of observed resistivity values are reduced.

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APPENDIX 1

Explanation of Rock Units for Geology Overlay

Qal - Quaternary alluvium

Qoa - Quaternary older alluvium

Qg - Quaternary gravel

Qtb - Quaternary to Tertiary basalt

Tr - Tertiary (Miocene) rhyolite flows and tuffs

Ts - Tertiary sedimentary rocks

Tba - Tertiary (Miocene) basalt and basaltic andesite

Kg - Cretatceous granodiorite (about 90 Ma)

JTu - Jurassic and Triassic meta-sedimentary rocks, undivided

PPu - Permian and Pennsylvanian Antler Peak limestone, Highway limestone, Battle Formation, Edna Mountain formation, undivided. In the Osgood Mountains, includes the Etchart limestone and the Adam Peak formation.

Pp - Pennsylvanian Pumpernickel Formation

PPh - Pennsylvanian and Permian Havallah Group. Includes the Farrel Canyon formation in the Osgood Mountains and rocks similar to the Havallah and Pumpernickel formations in the Hot Springs range.

Msv - Mississippian siliceous sediments and volcanic rocks. In the Osgood Mountains, includes the Goughs Canyon formation.

Oc - Ordovician Comus Formation

Ov - Ordovician Valmy Formation

Osr - Ordovician Sonoma Range Formation

Eh - Cambrian Harmony Formation, including small exposures of Cambrian Paradise Valley chert on the west side of the Hot Springs Range.

Ep - Cambrian Preble Formation

Eom - Cambrian Osgood Mountains Quartzite

Rock units primarily follow Willden (1964). Additional geologic names provided by Hotz and Willden (1964). Age date for Kg from Silberman and others (1974).

Contact ———

Fault ▬▬▬ ▬ ▬ ▬ • • • •

Dashed where approximately located, dotted where concealed.

Thrust fault ▲▲▲

Saw teeth on side of upper plate.

Mineral deposits:

Gold ●

Names indicate operational mines or known deposits

Tungsten ▣

Silver ◊

Barite △

Manganese ★

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GETCHELL TREND NEVADA
AIRBORNE GEOPHYSICS
MAP FOLIO

COORDINATOR
D.B. Hoover June 1989

Prepared By
V.J.S. GRAUCH, D.B. HOOVER,
M.D. KROHN, H.A. PIERCE, and J.A. PITKIN

GETCHELL TREND, NEVADA

3 SECOND TERRAIN DATA

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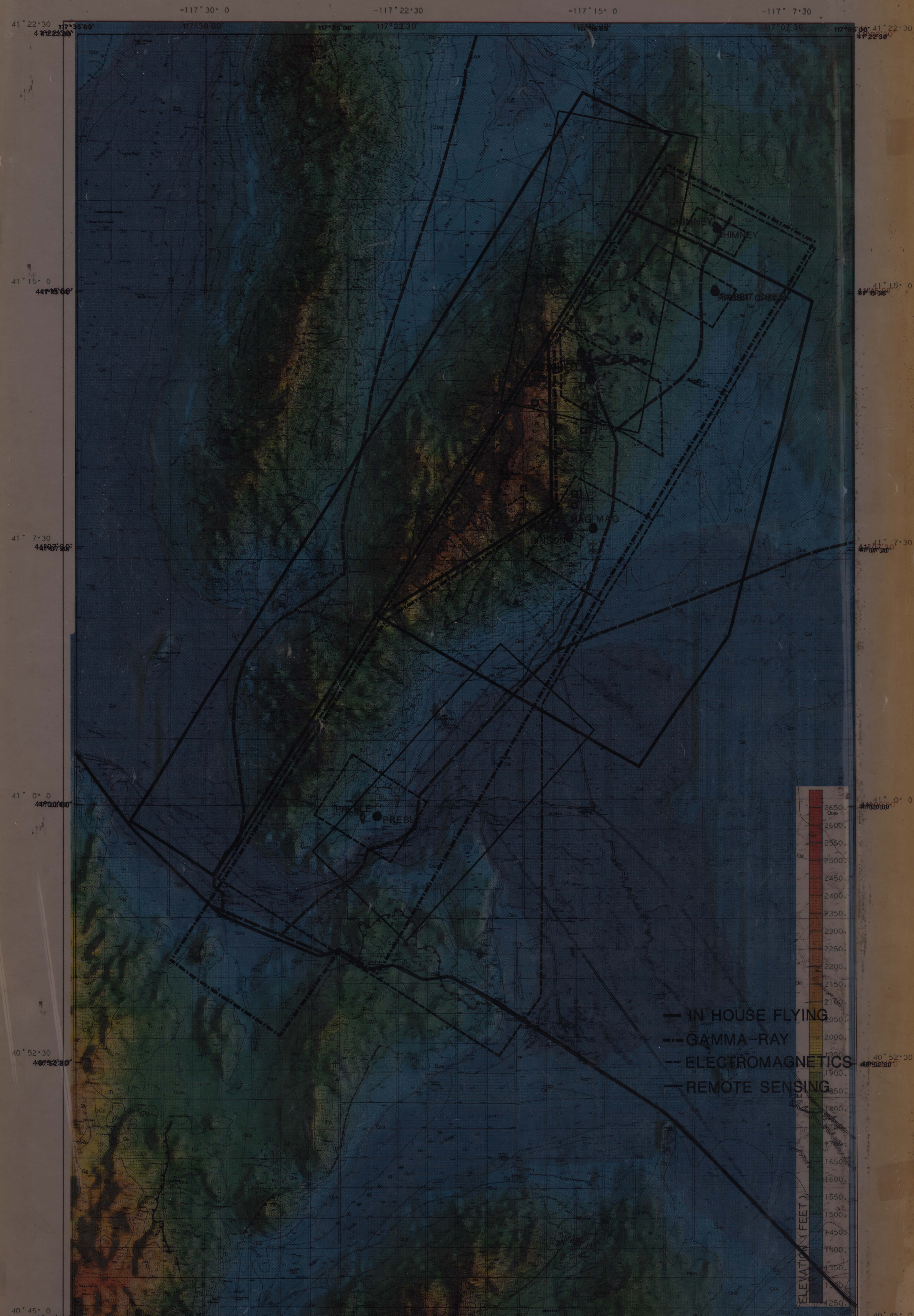

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36800106a

GETCHELL TREND, NEVADA

3 SECOND TERRAIN DATA

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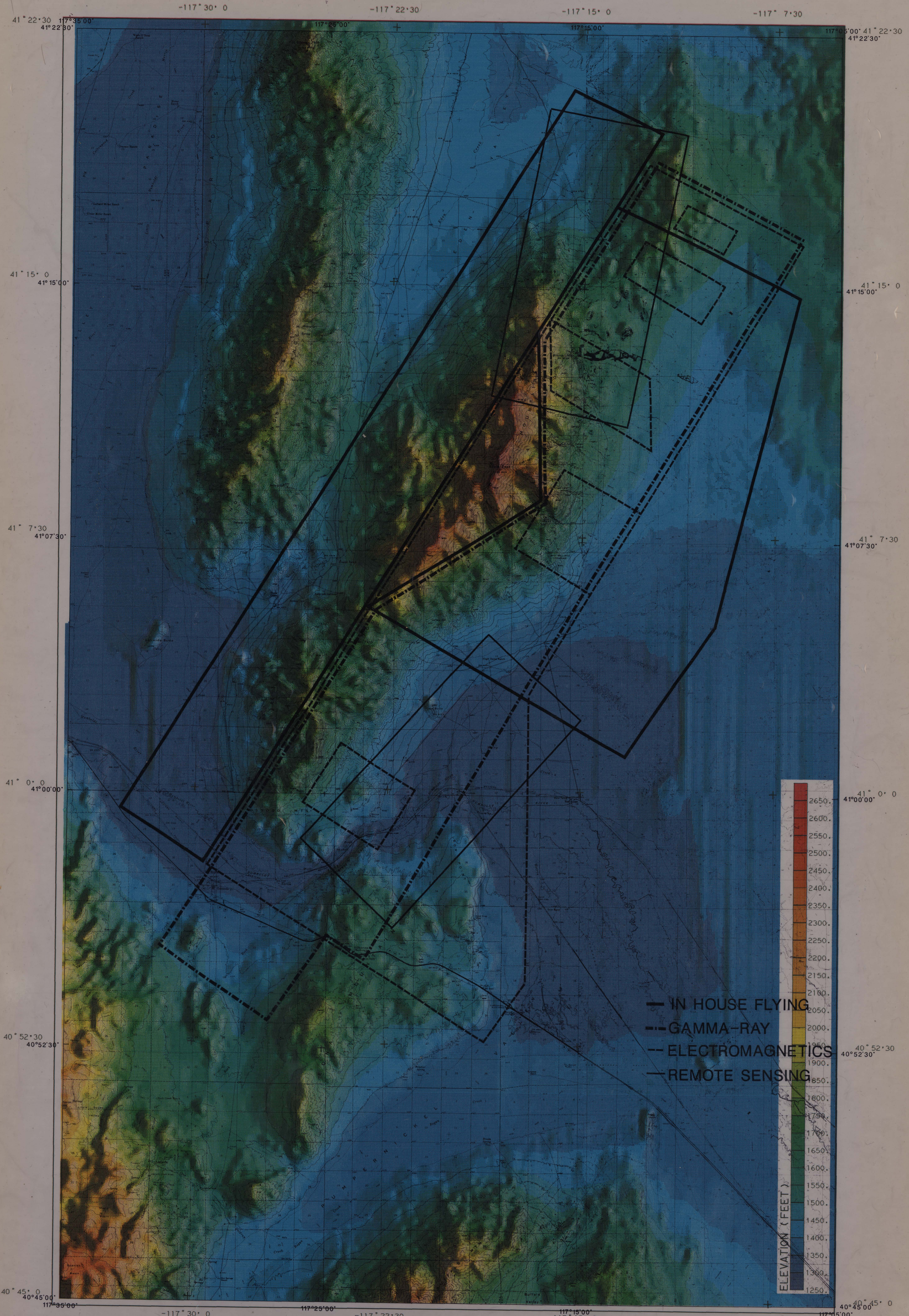


36800106b

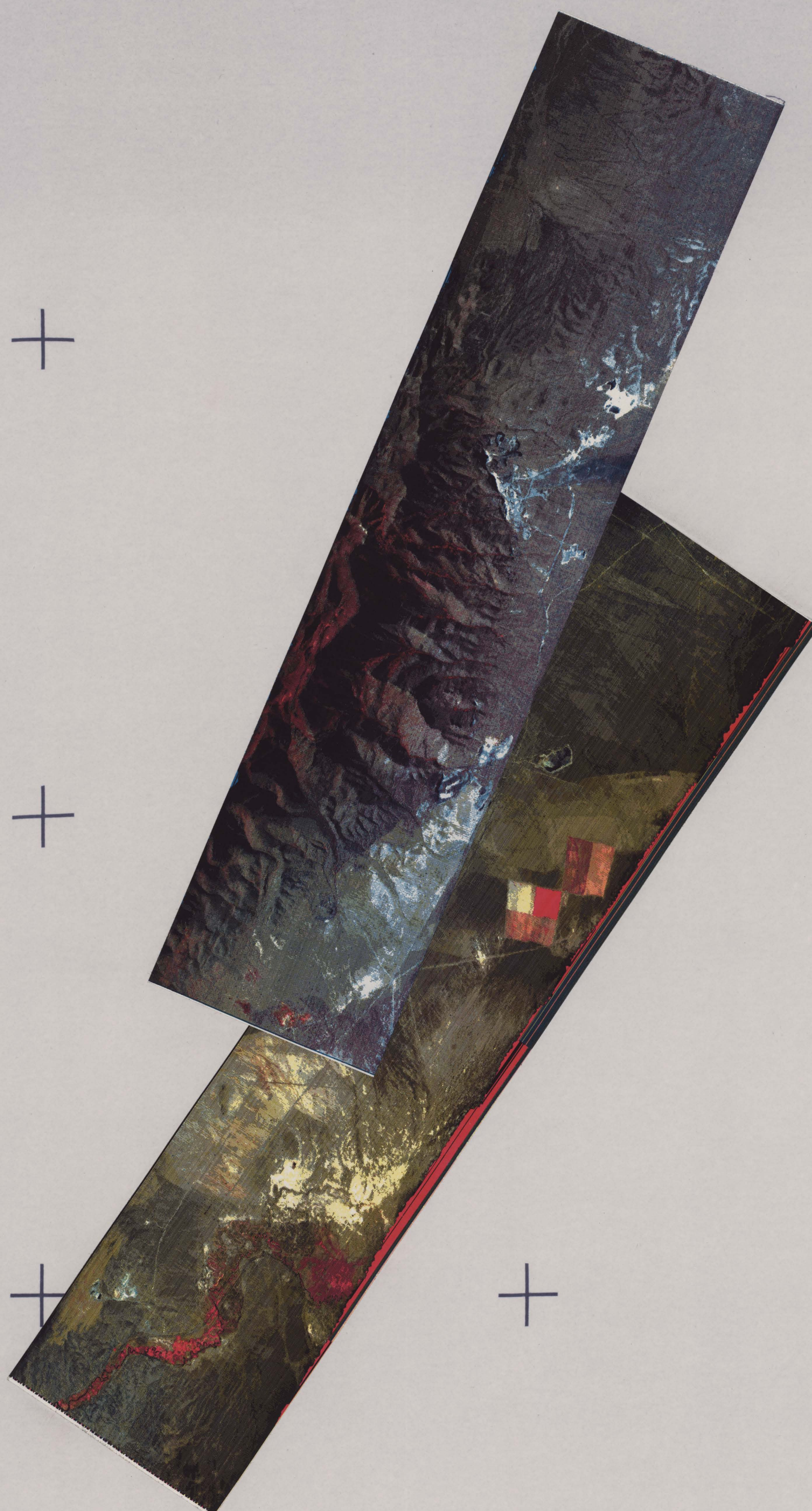

117°22.5'
117°15'
117°7.5'
117°00'
41°22.5'
41°15'
41°7.5'
41°00'
40°52.5
Chimney
Rabbit Cr.
TIMS flight
80
N
0 1 2 3
Kilometers
0 1 2 3
Miles

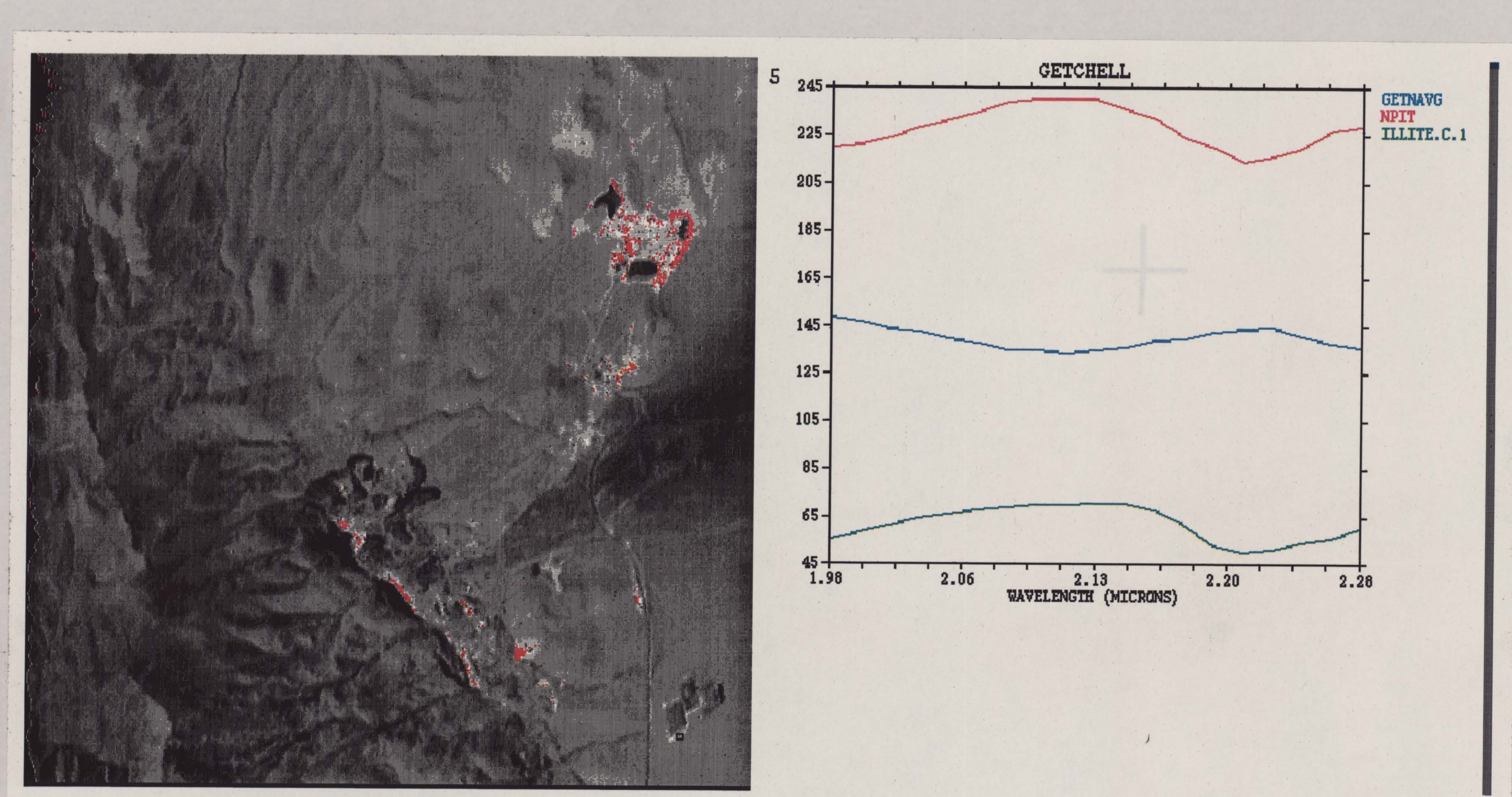
5

Getchell Trend, Nevada

117° 35'30" 117° 05'00"

41° 22'30" 41° 22'30"





40° 45'00" 40° 45'00"

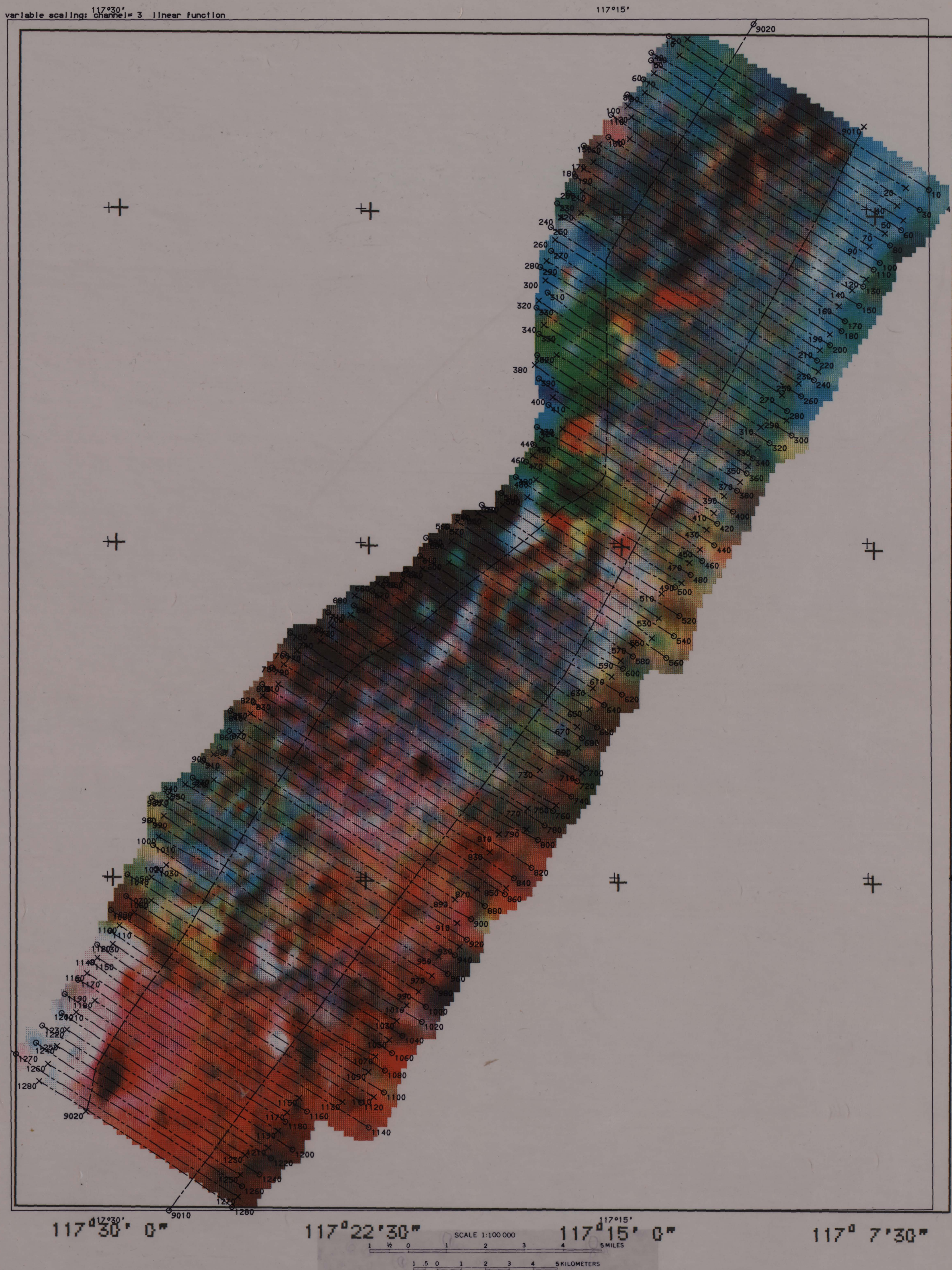
117° 35'30" 117° 05'00"

SCALE 1:100 000

Geophysical Environmental Research (GER) imaging spectrometer data shown as 3-band composits. The two images are approximately at a scale of 1:100,000 but have not been projected into UTM coordinates. Coordinates are approximate only.

36800106g

6

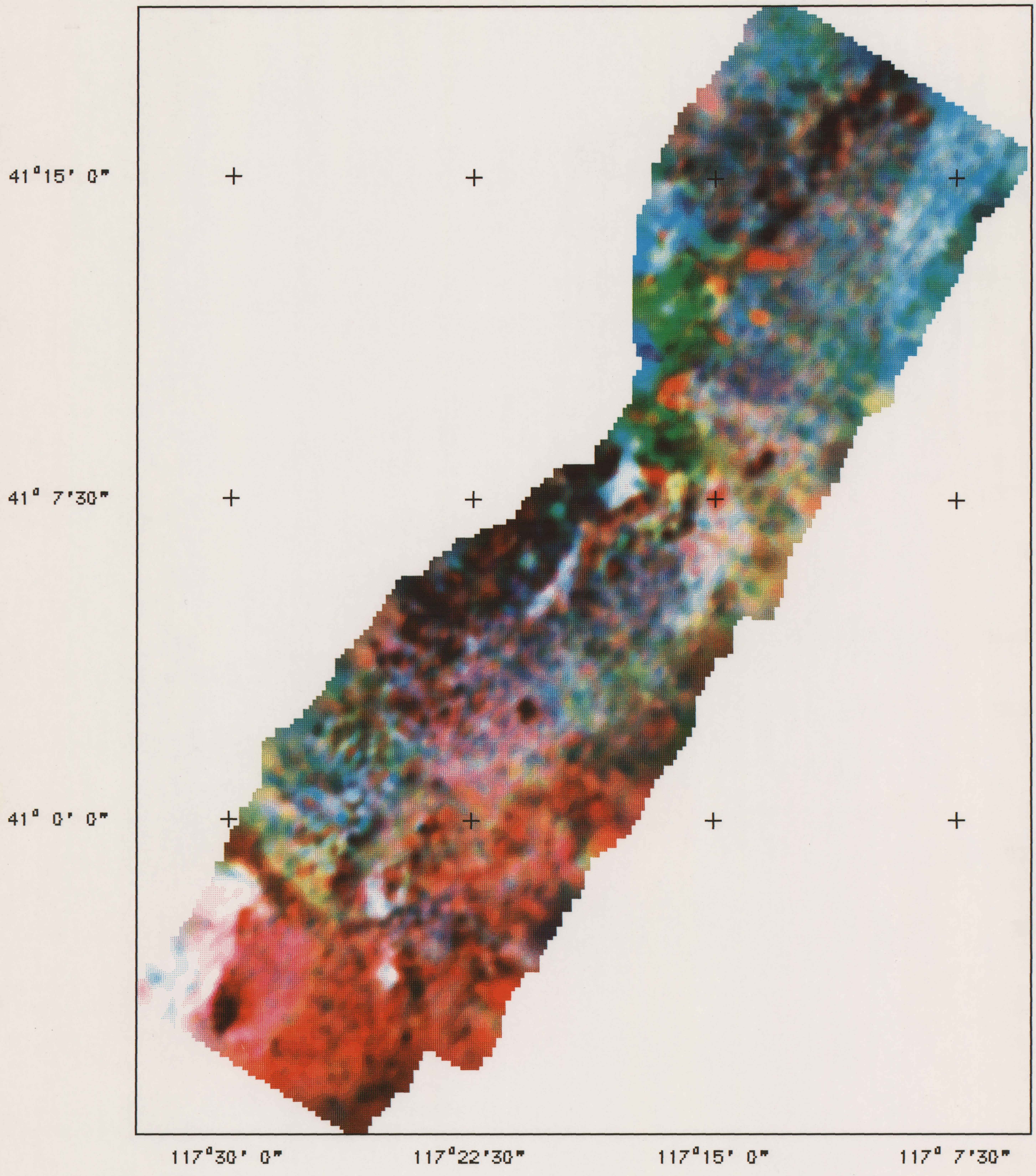


Getchell elements color composite map, scale 1:100,000
U=red, K=green, Th=blue, combined highs=light, combined lows=dark

GAMMA-RAY FLIGHT LINE LOCATIONS

36800106h

78



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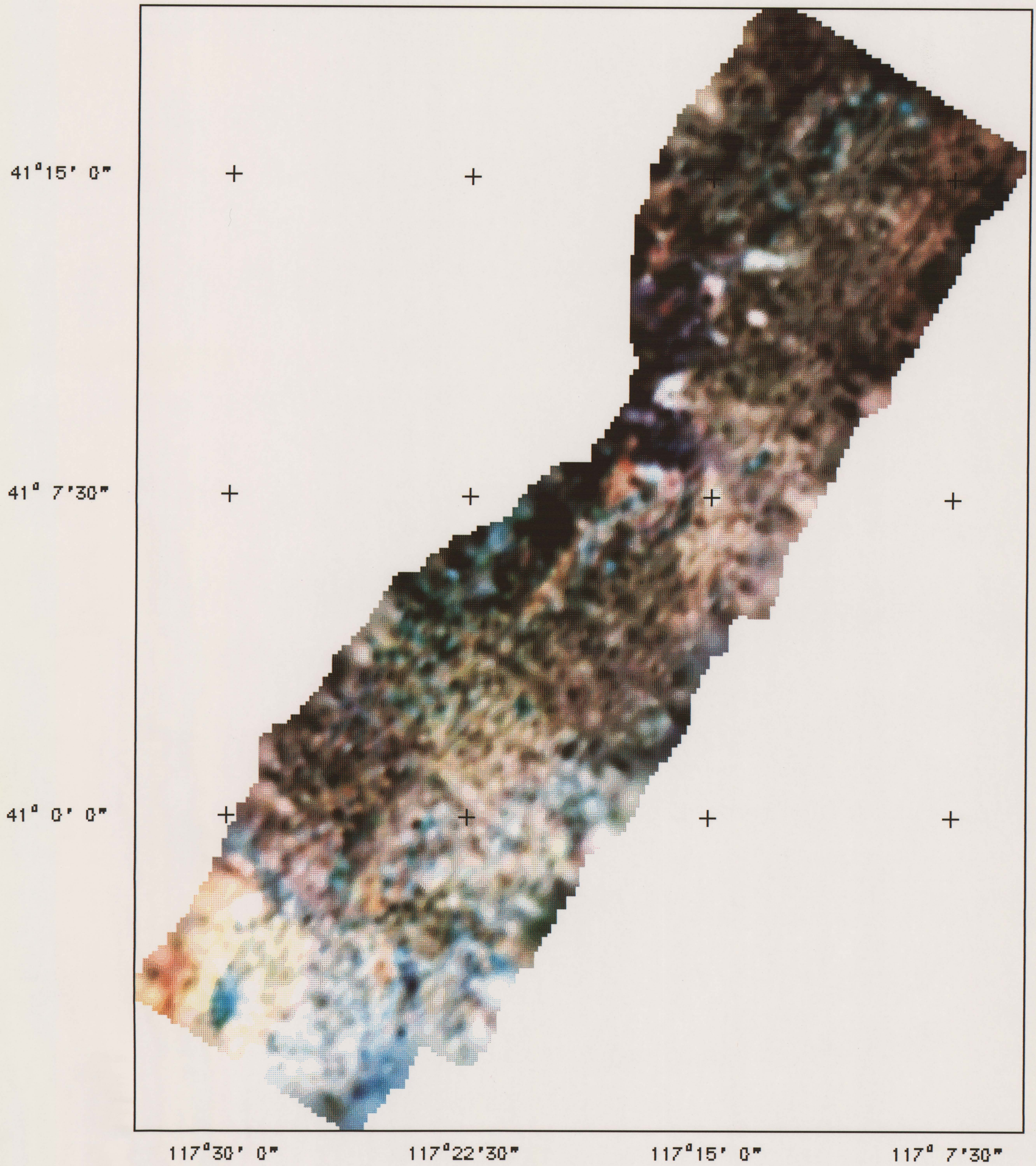
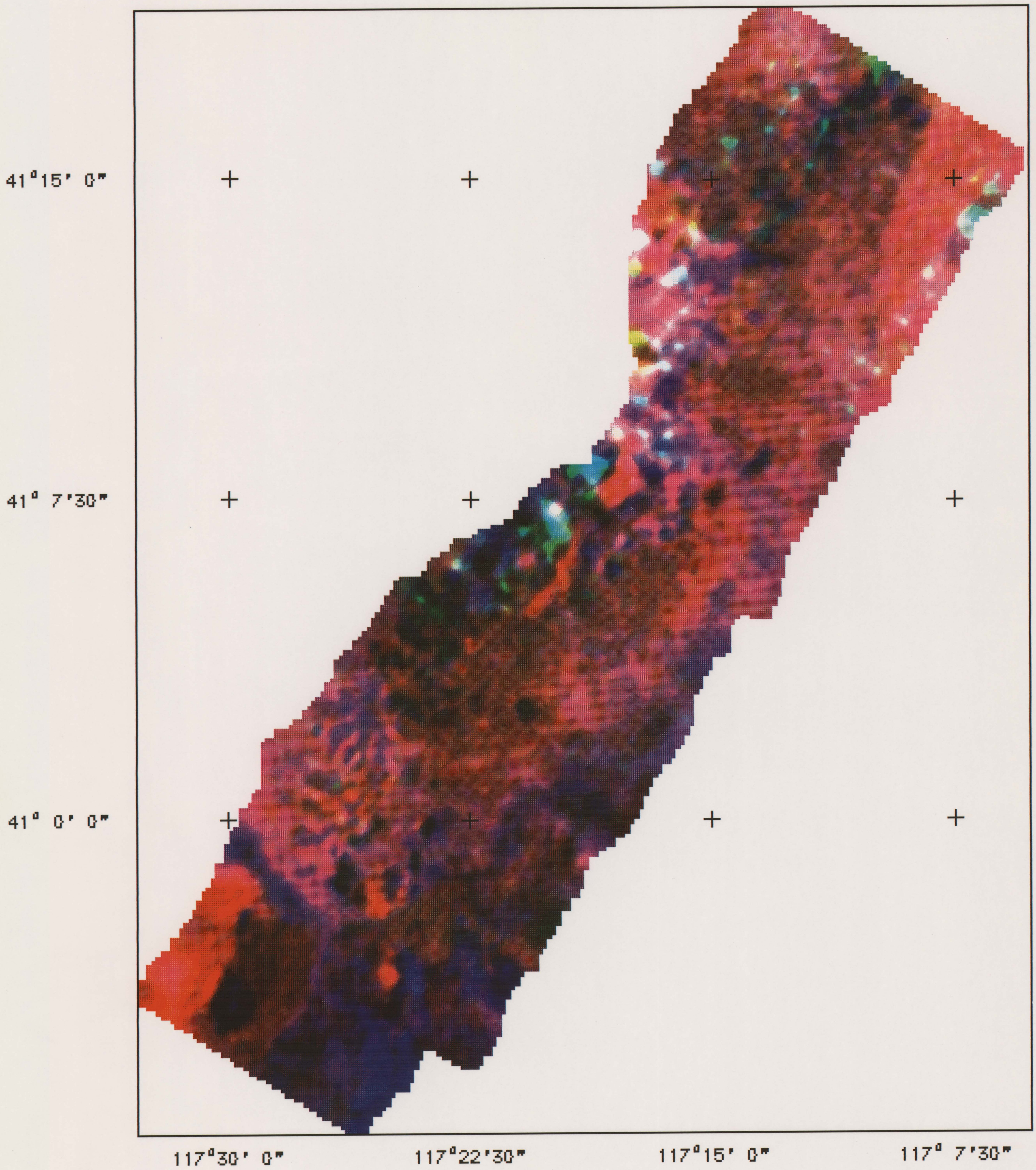
U=red, K=green, Th=blue, combined highs=light, combined lows=dark



Getchell uranium color composite map, scale 1:100,000
U=red, U:K=green, U:Th=blue, combined highs=light, combined lows=dark



Getchell potassium color composite map, scale 1:100,000
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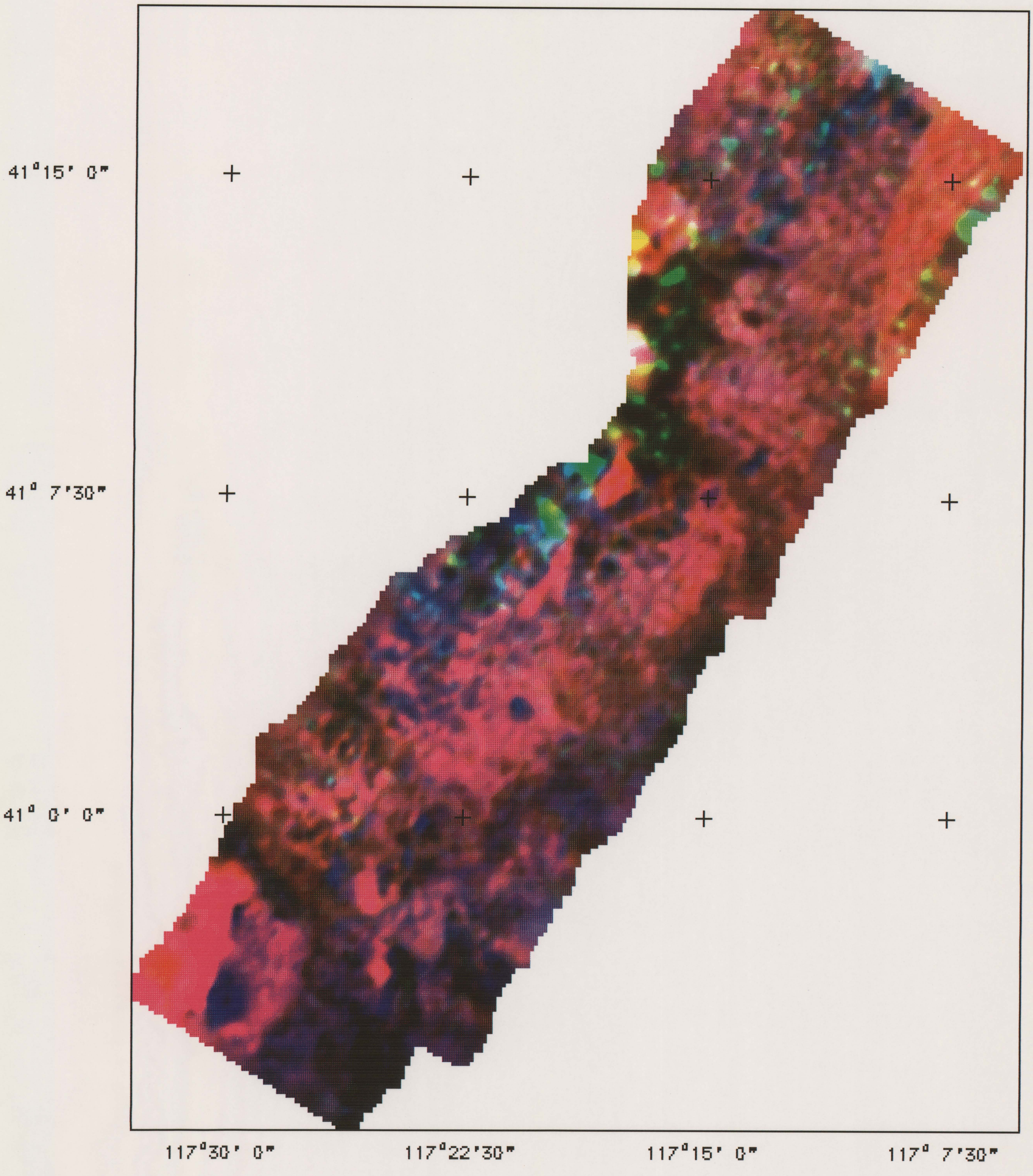
36800106k



Getchell thorium color composite map, scale 1:100,000
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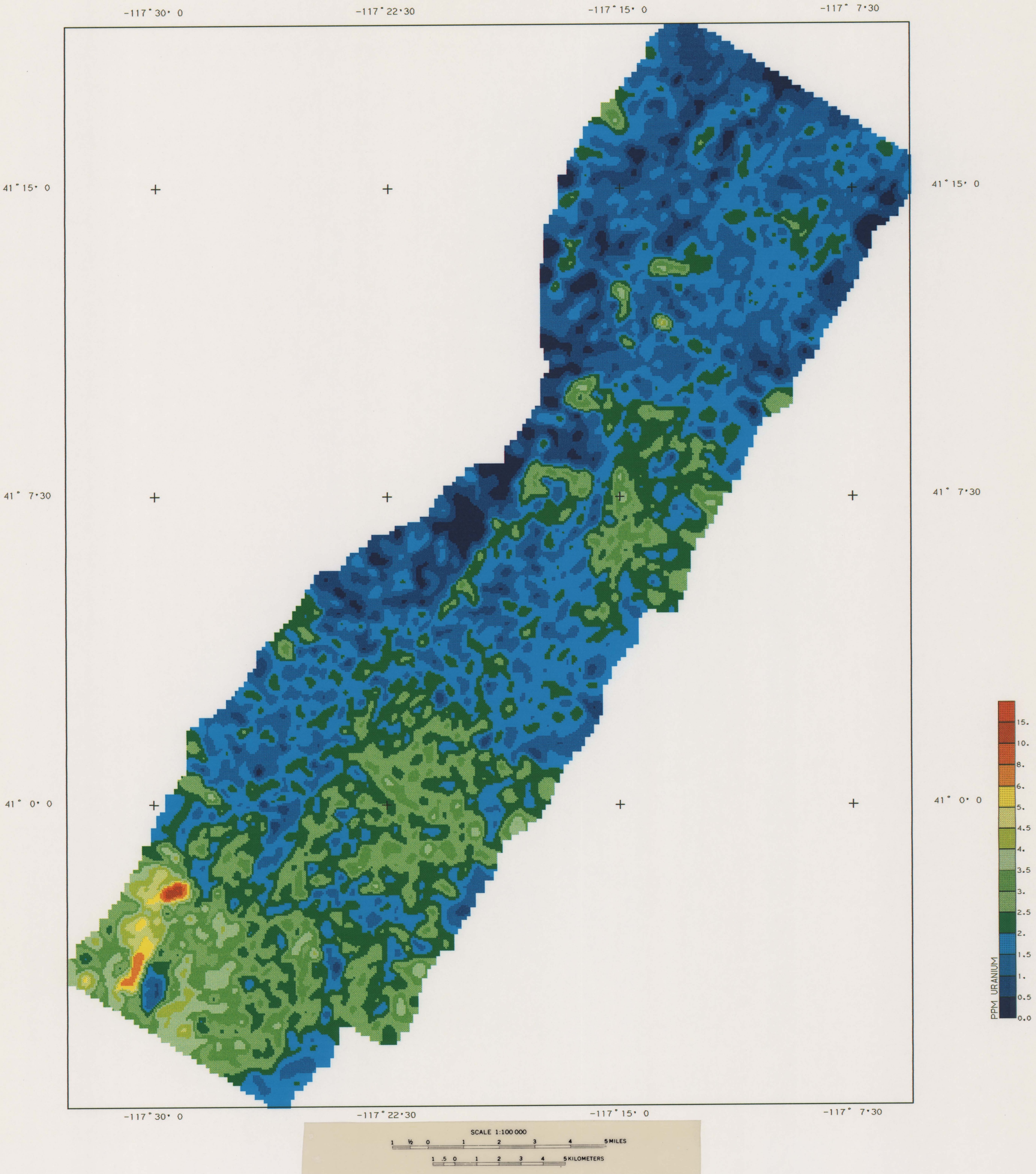
URANIUM MAP, GETCHELL AREA, NEVADA
SCALE 1:100,000



36800106m

POTASSIUM MAP, GETCHELL AREA, NEVADA
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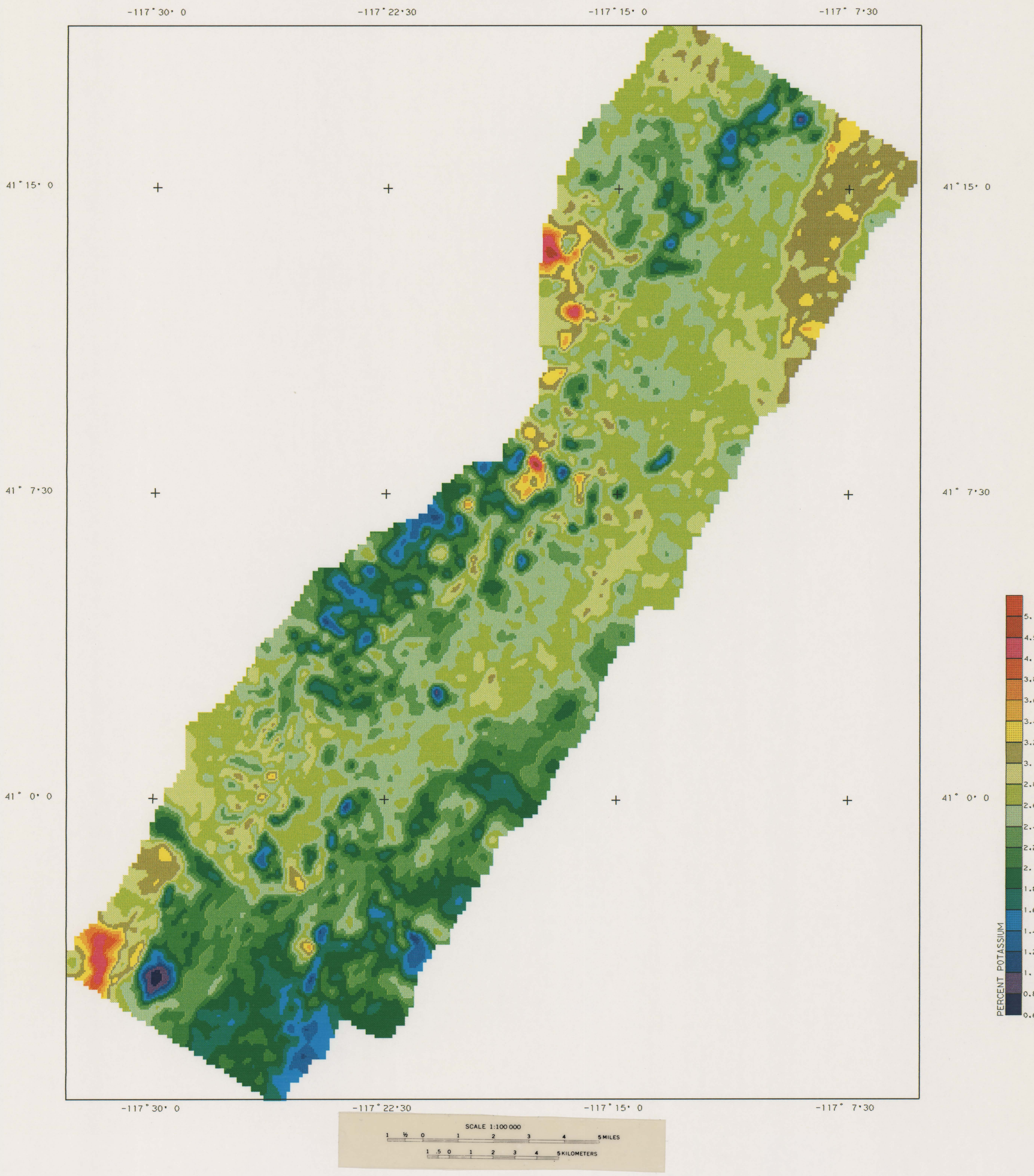
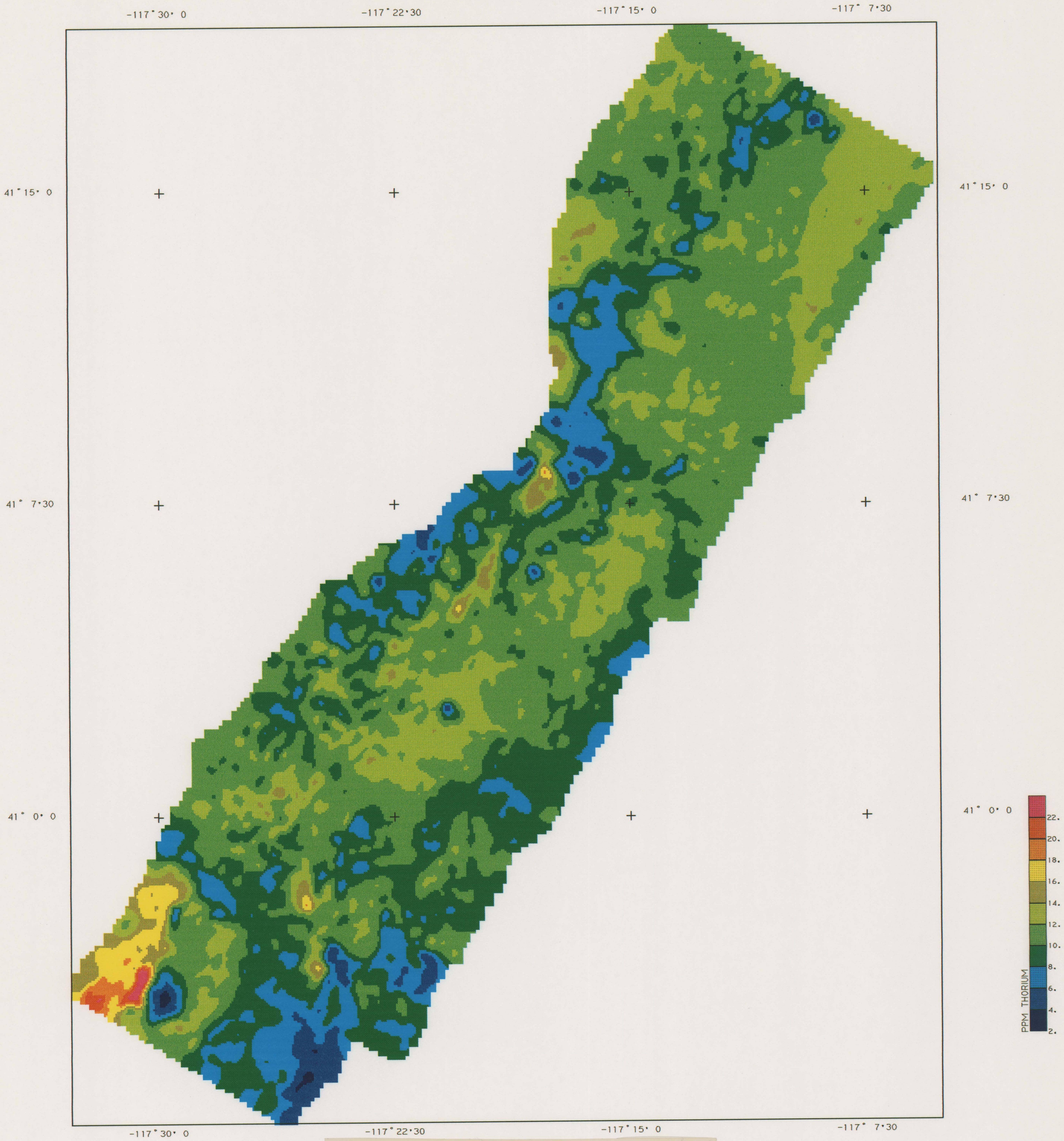
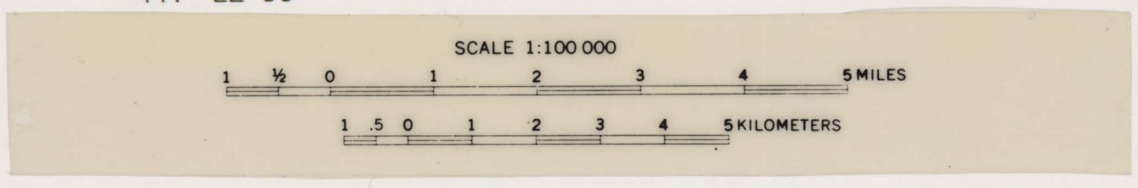


THORIUM MAP, GETCHELL AREA, NEVADA
SCALE 1:100,000





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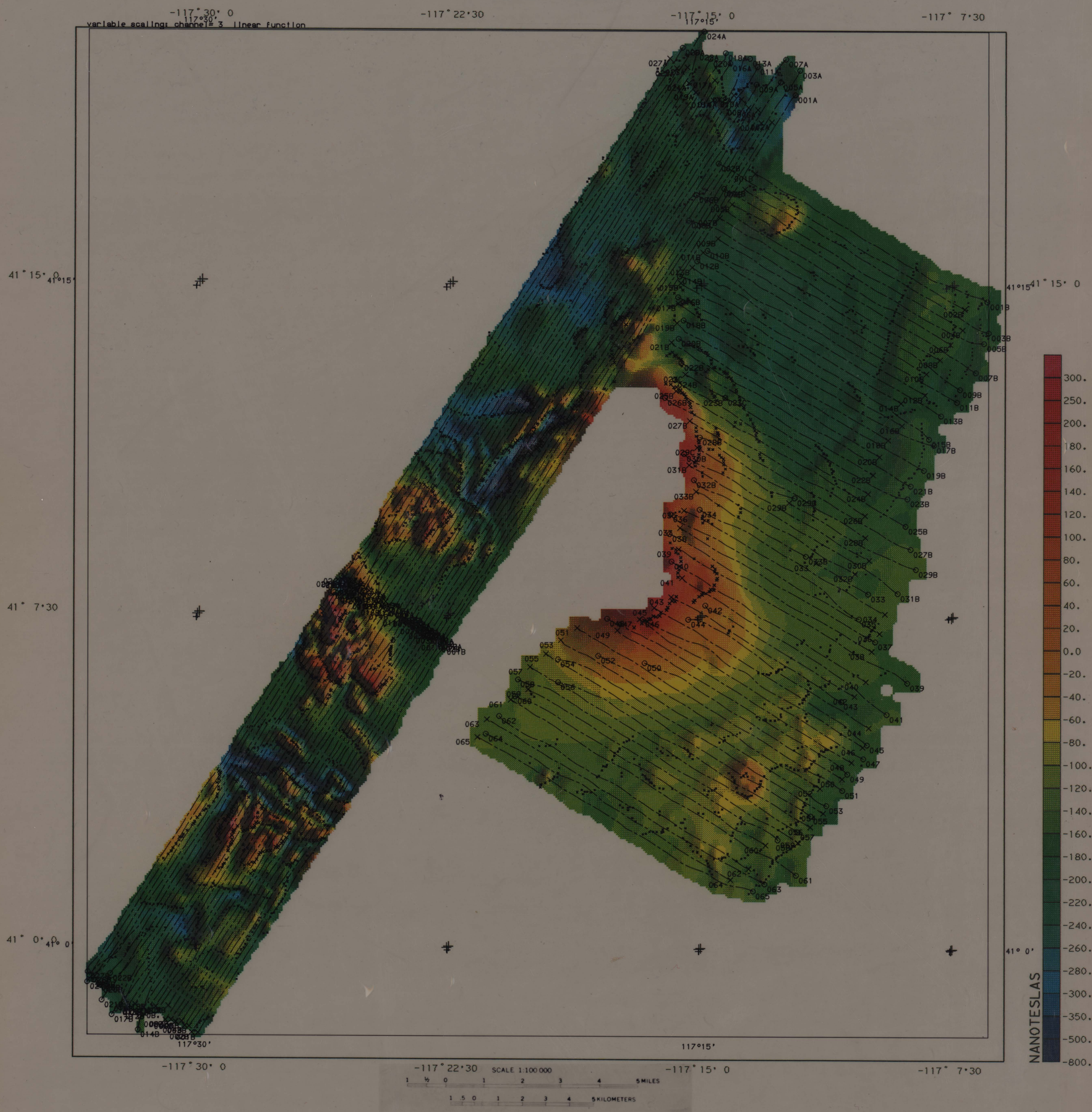
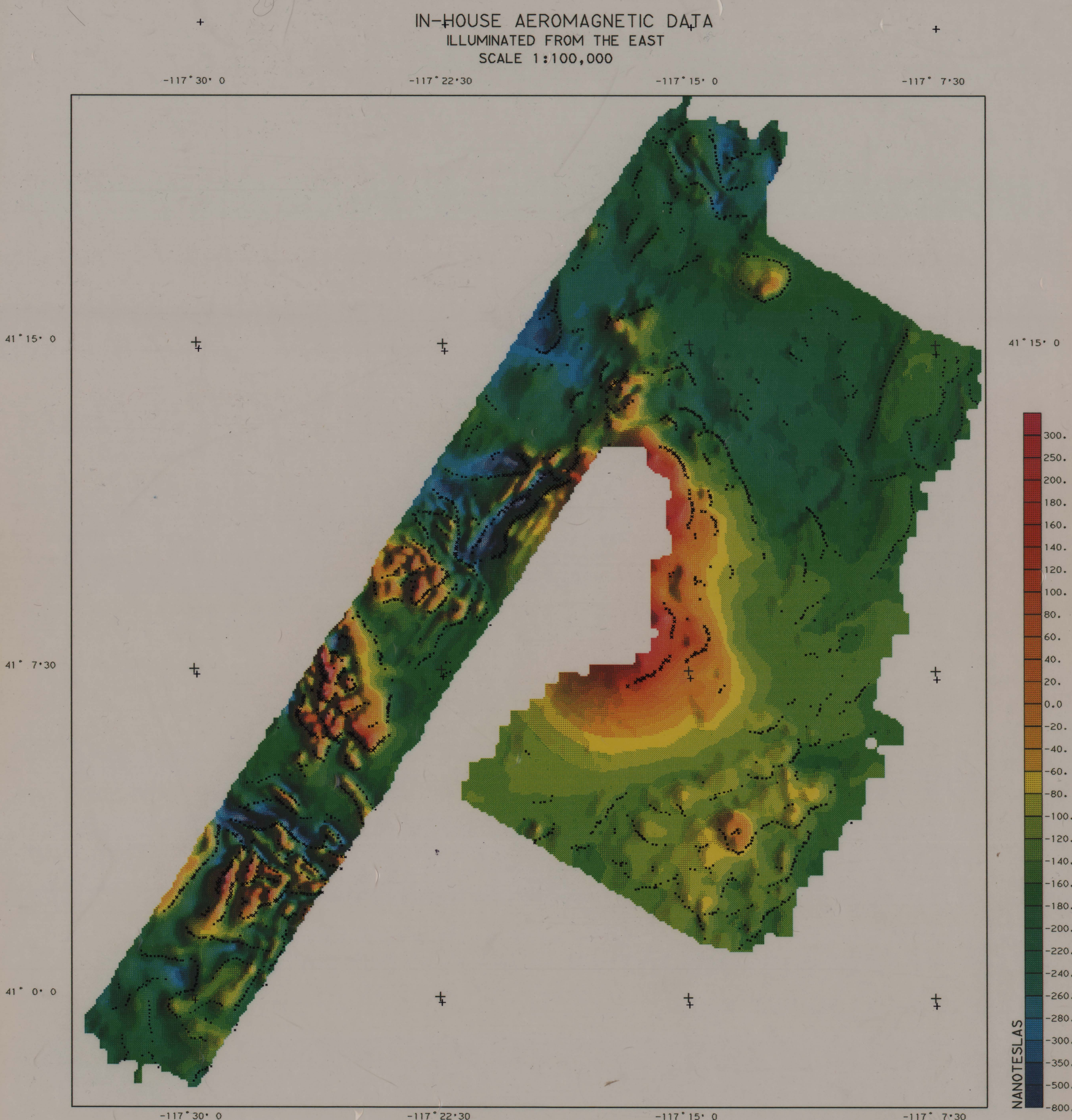


MAGNETIZATION BOUNDARIES

GETCHELL, U.S.G.S. AEROMAG FLIGHT LINE LOCATIONS



MAGNETIZATION BOUNDARIES

IN-HOUSE AEROMAGNETIC DATA
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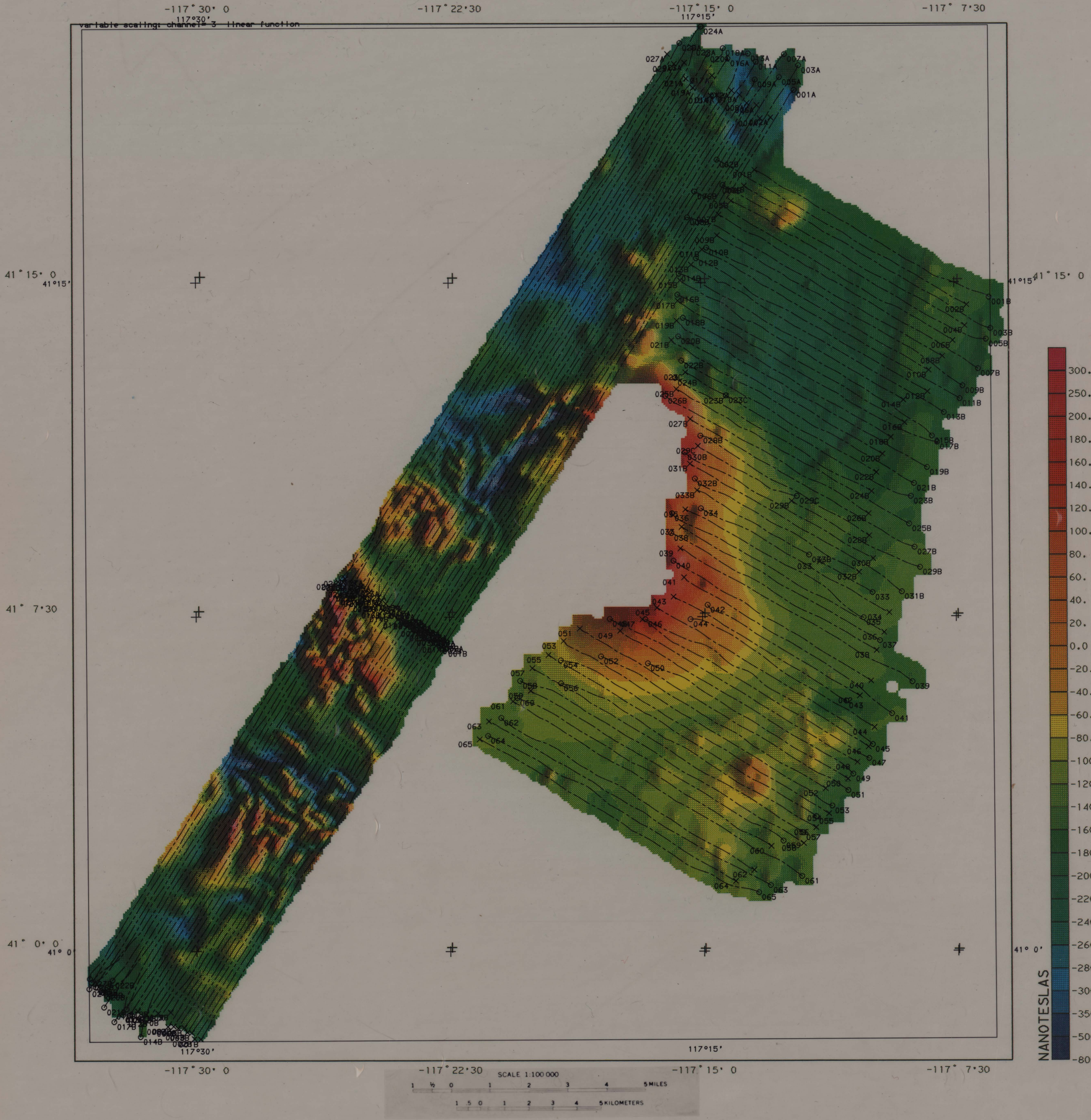
SCALE 1:100,000



GETCHELL, U.S.G.S. AEROMAG FLIGHT LINE LOCATIONS

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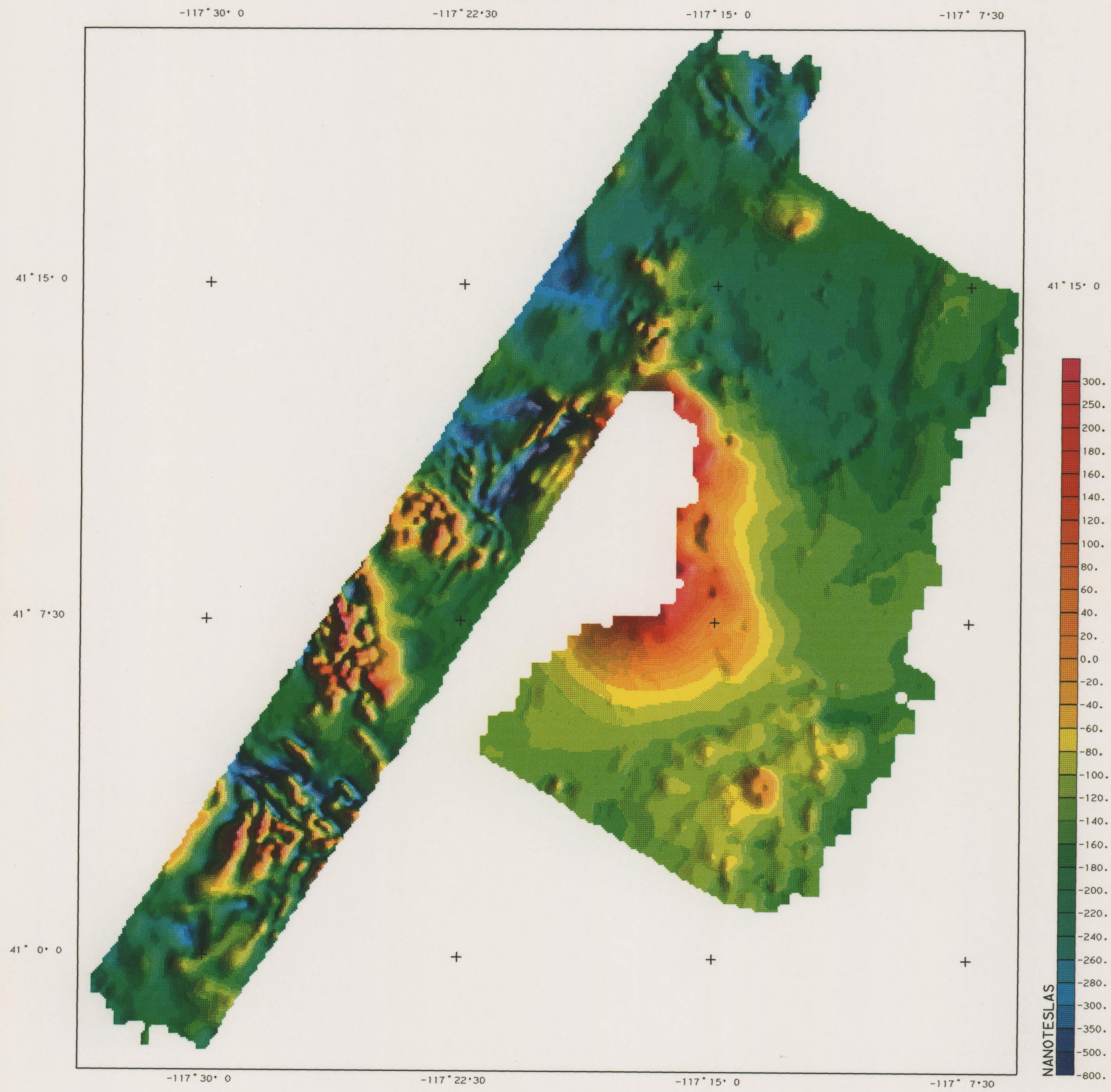

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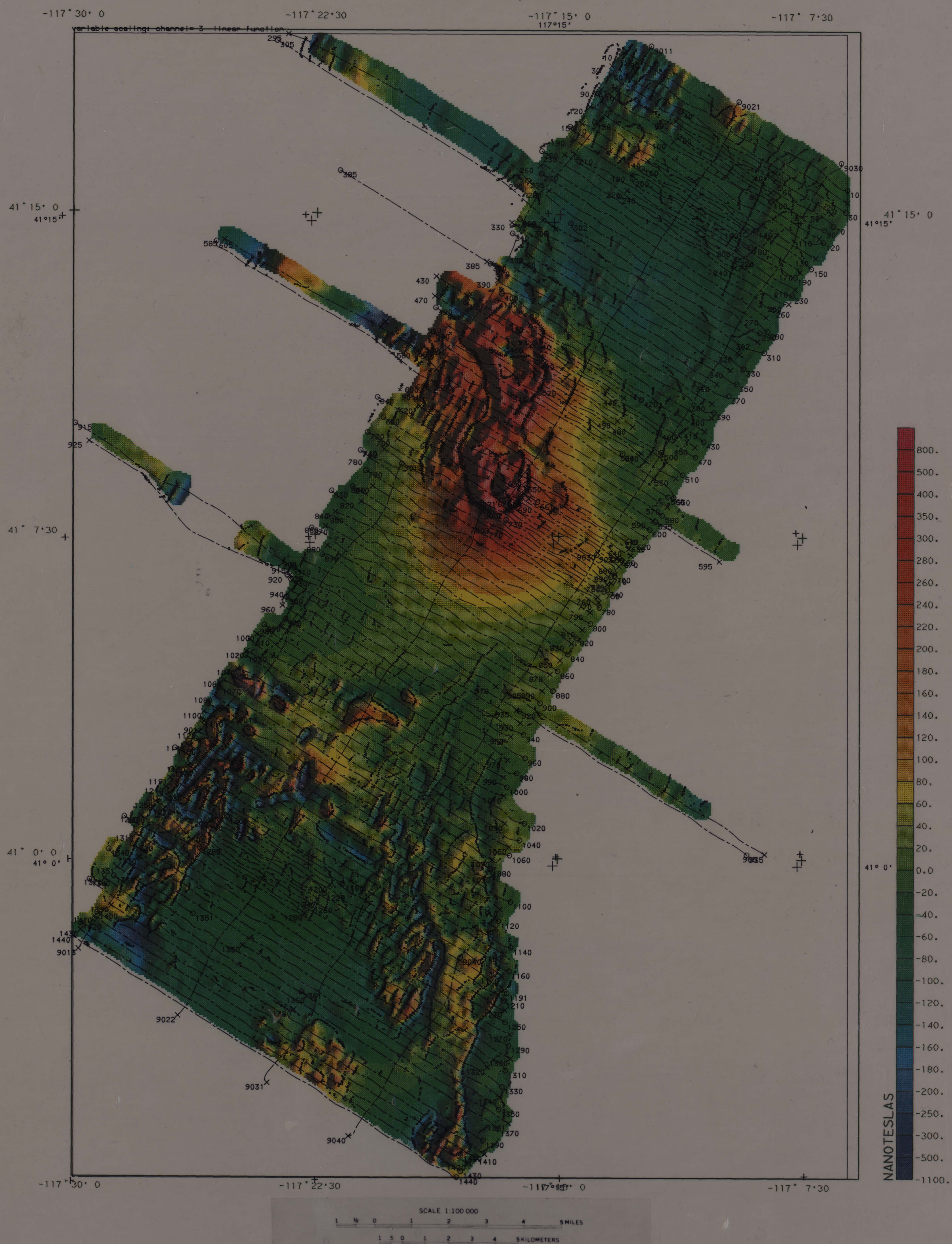


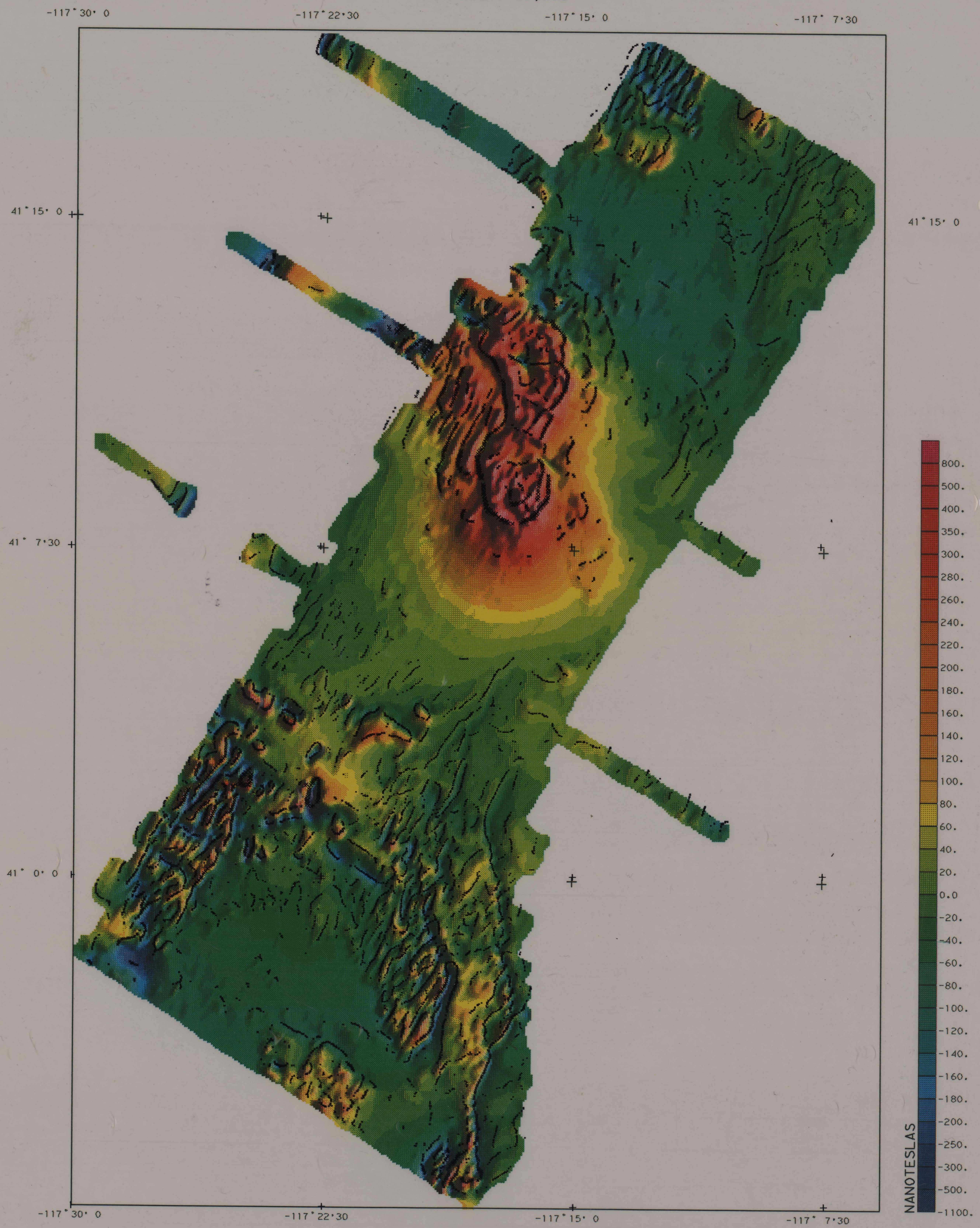
MAGNETIZATION BOUNDARIES

DIGHEM FLIGHT LINE LOCATIONS

18

19

CONTRACT AEROMAGNETIC DATA
ILLUMINATED FROM THE EAST
SCALE 1:100,000



MAGNETIZATION BOUNDARIES

CONTRACT AERONAGNETIC DATA

ILLUMINATED FROM THE EAST

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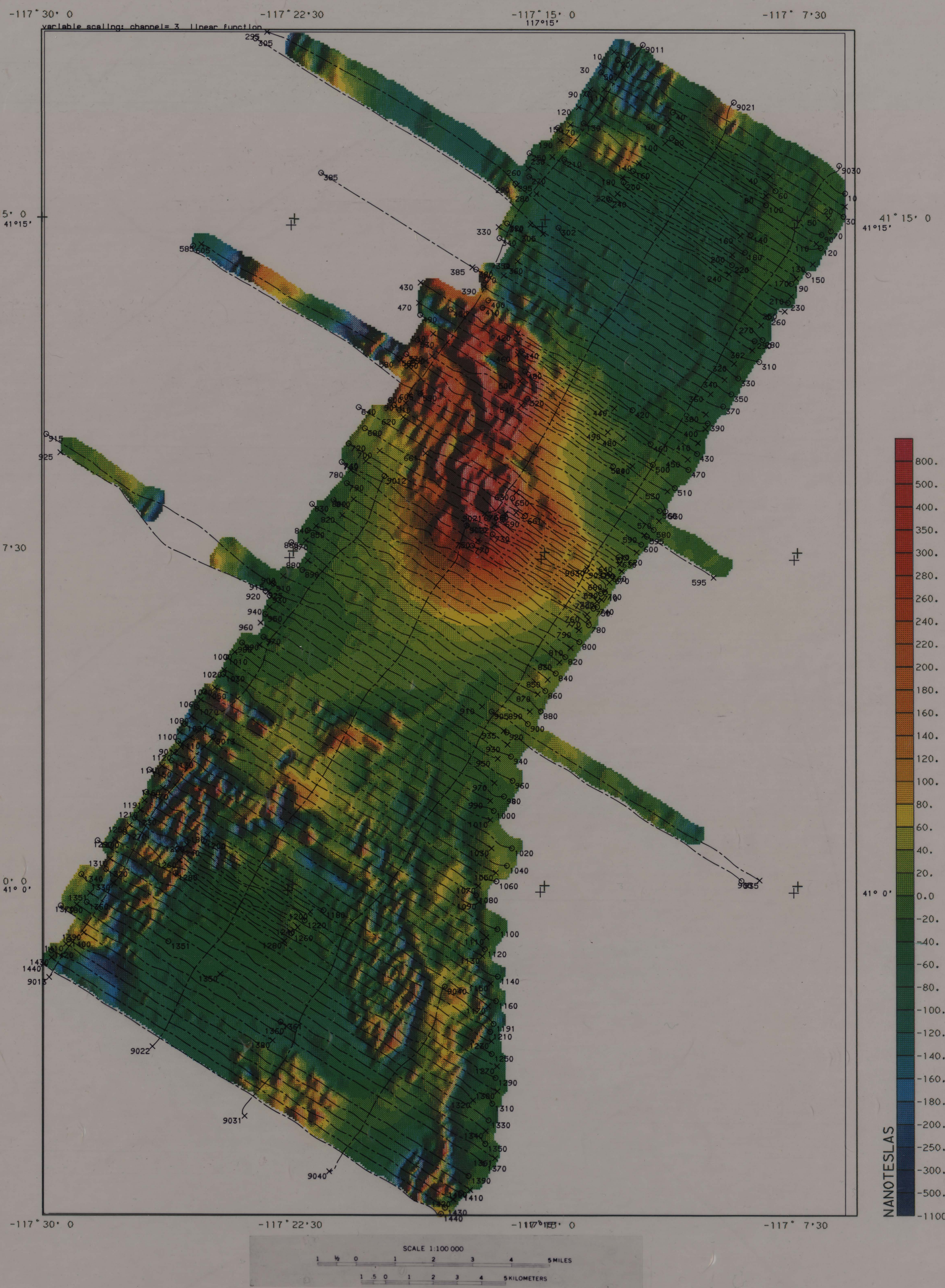

DIGHEM FLIGHT LINE LOCATIONS

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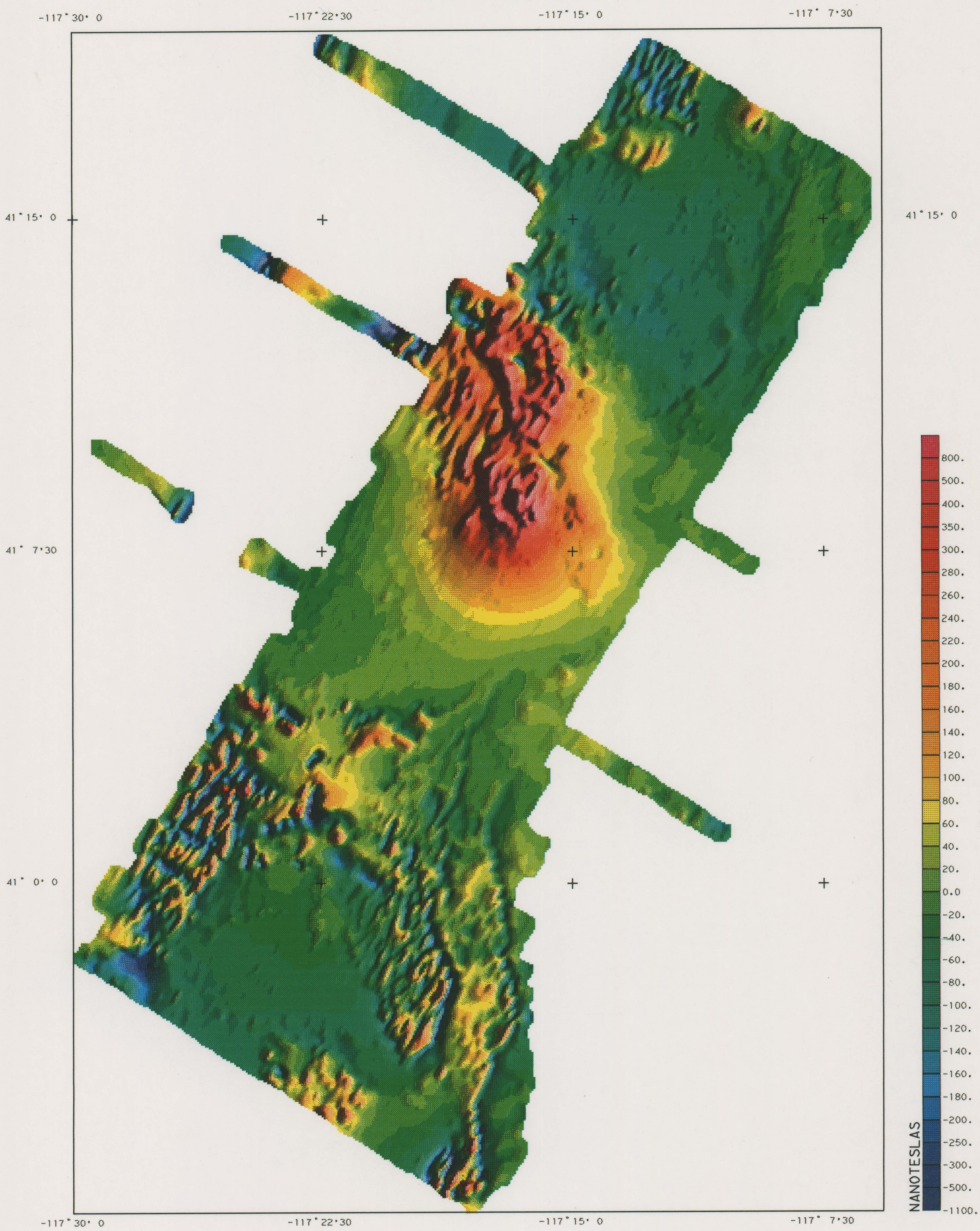

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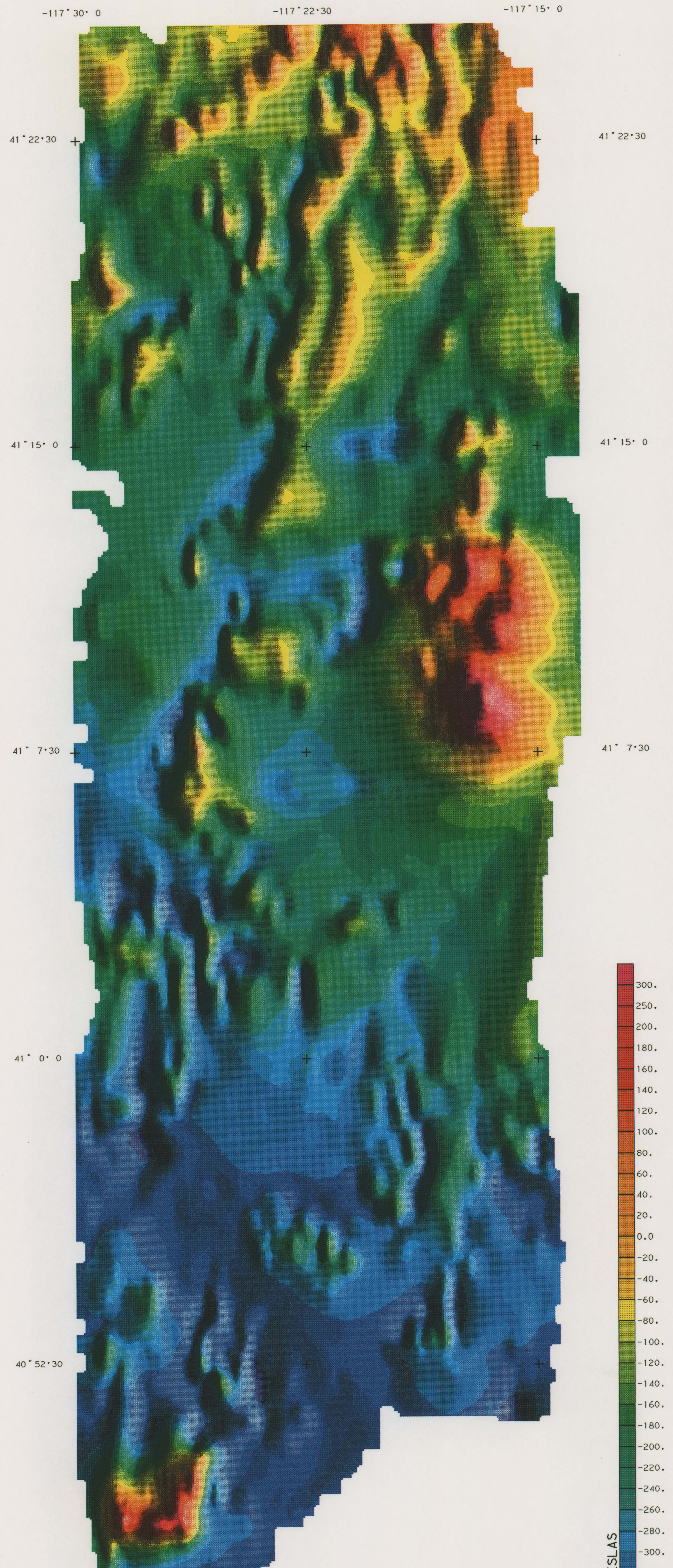
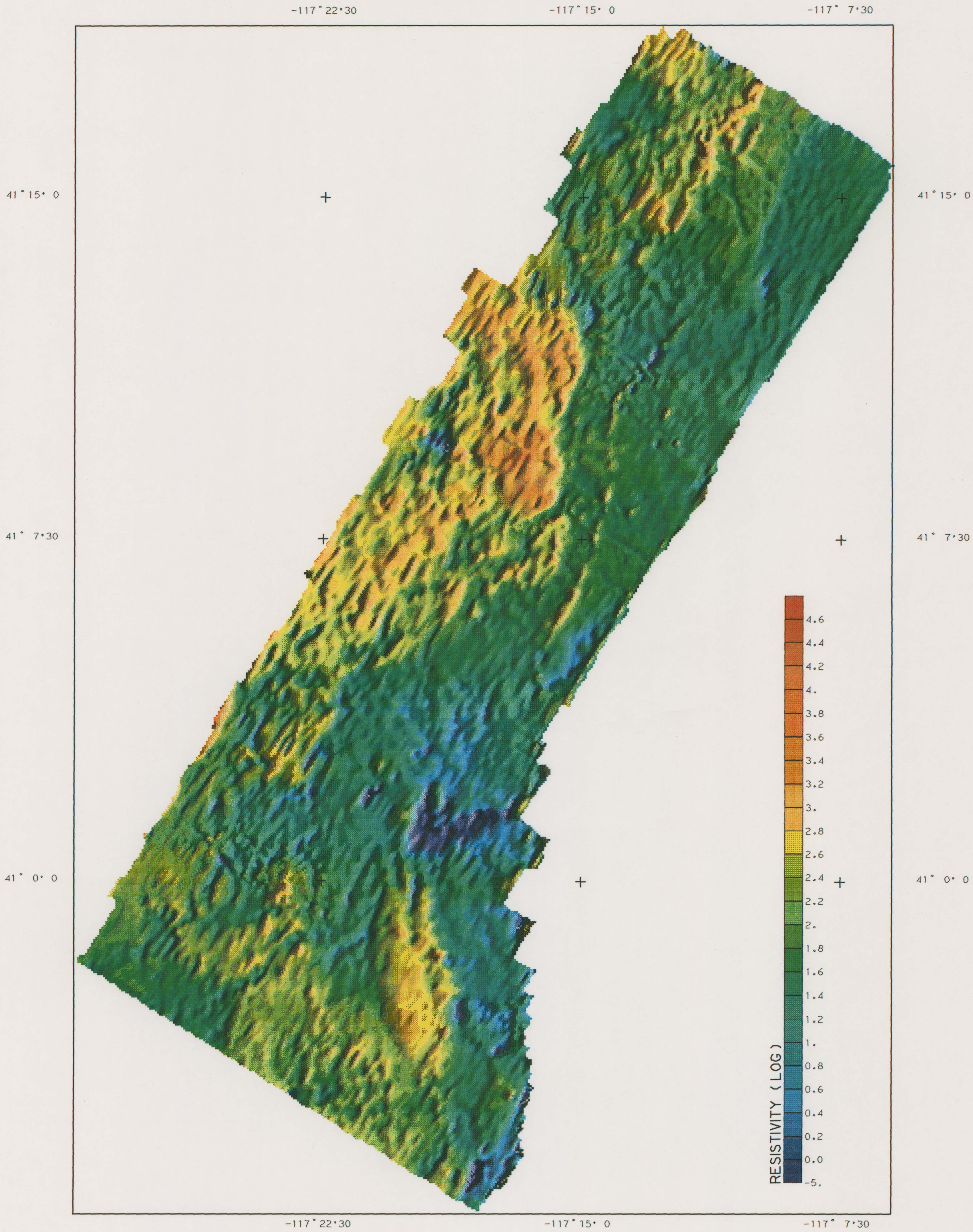
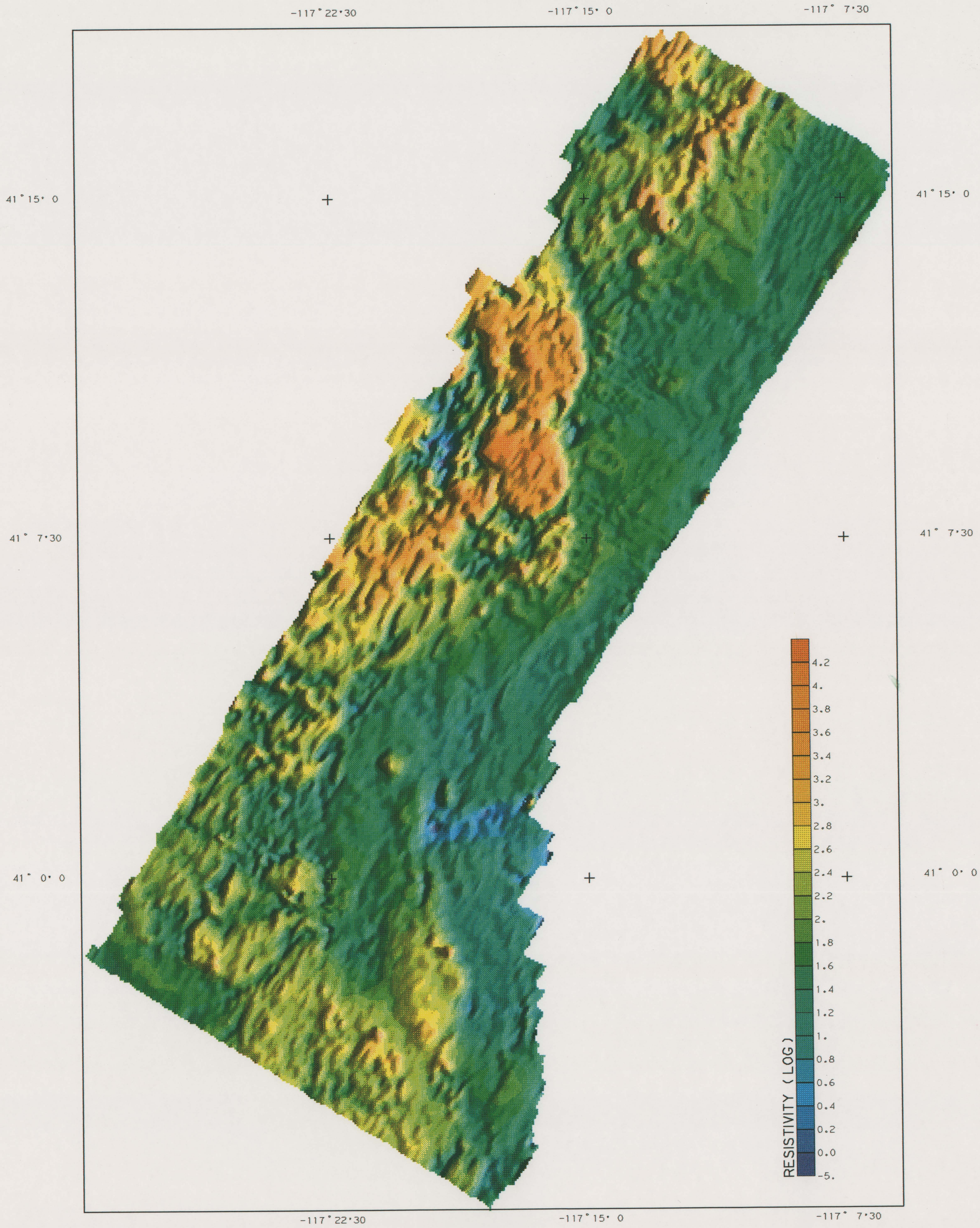


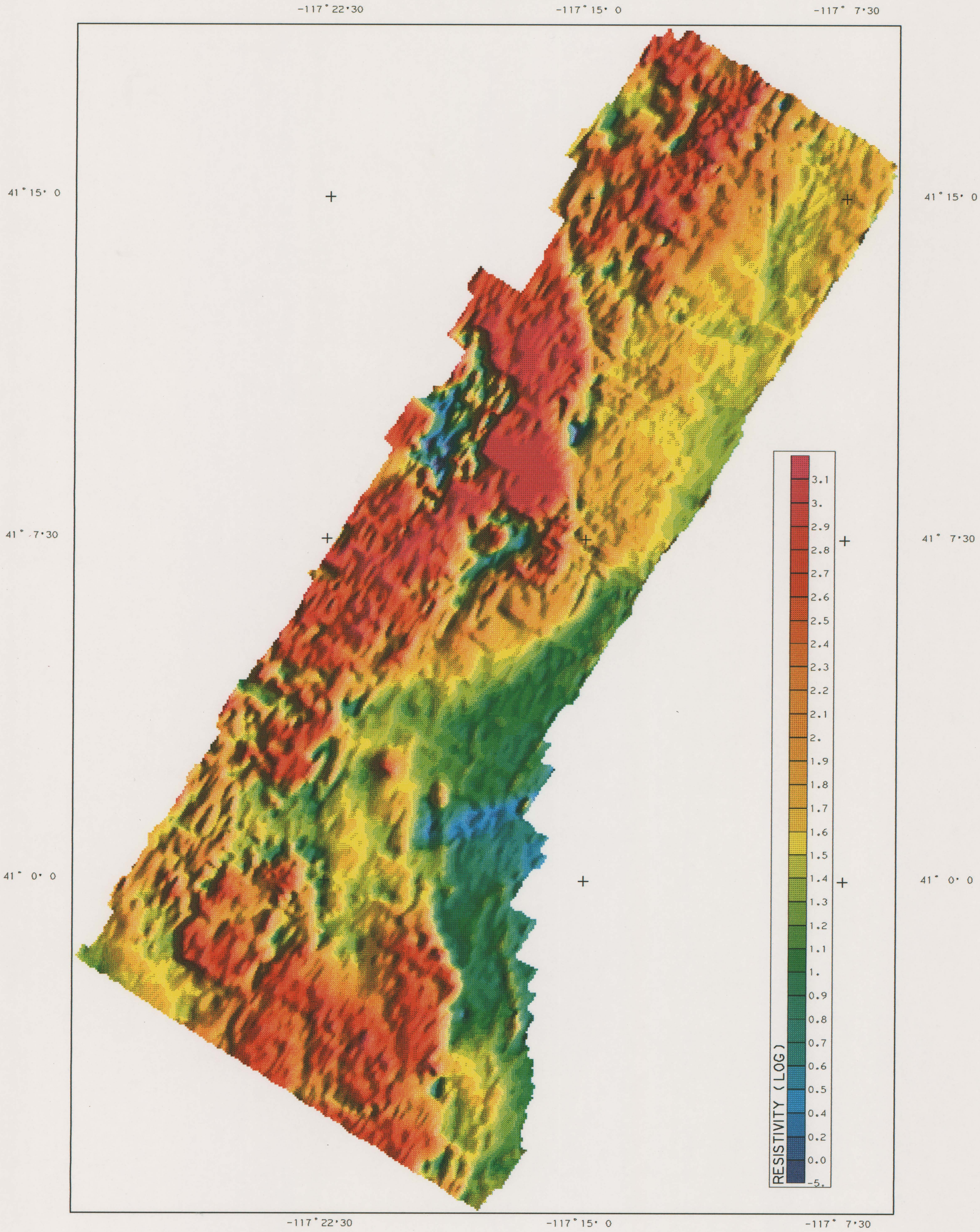
GETCHELL TREND, NEVADA
56,000 HZ ELECTROMAGNETICS
1:100,000 - ILLUMINATED FROM THE EAST



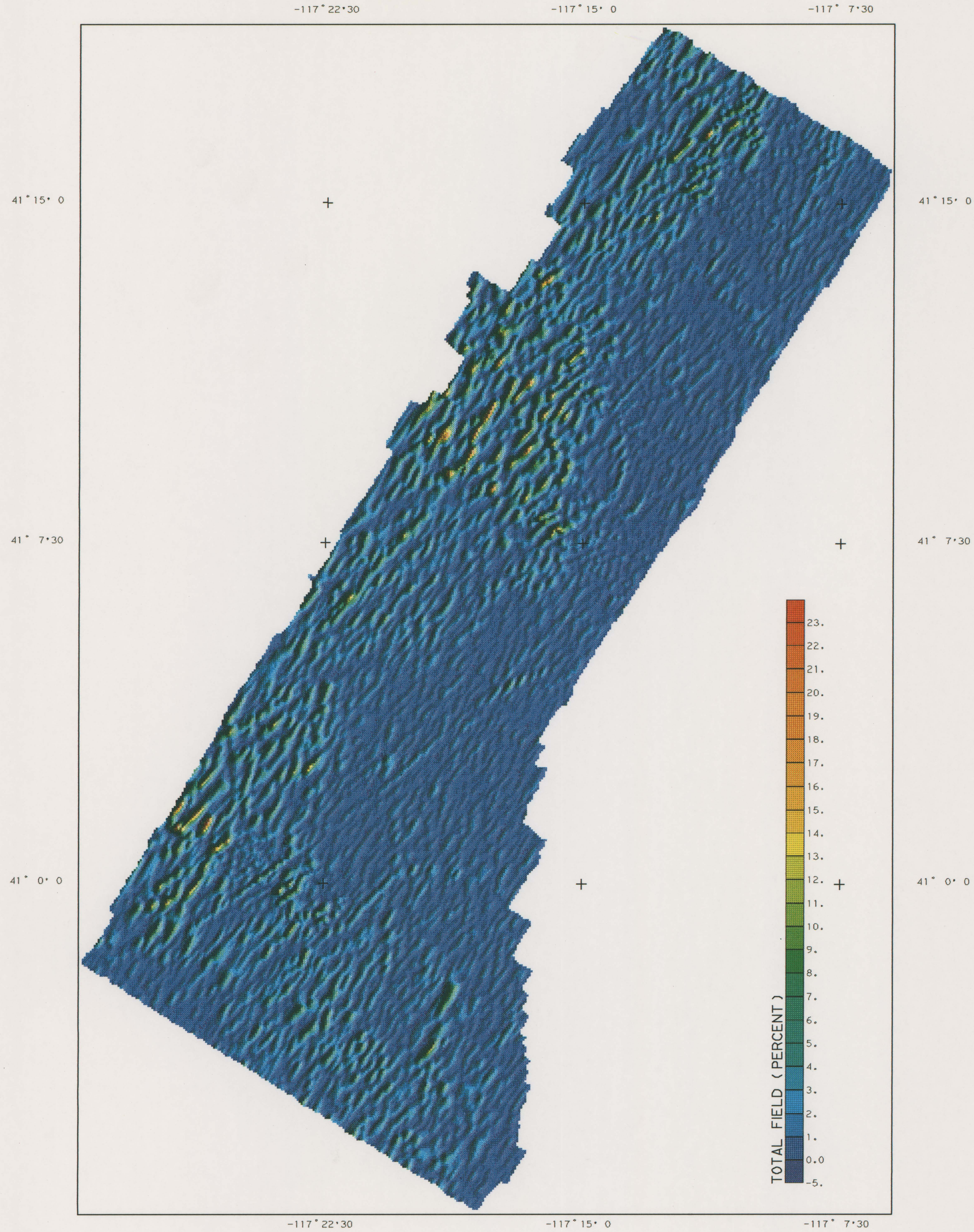
GETCHELL TREND, NEVADA
7200 HZ ELECTROMAGNETICS
1:100,000 - ILLUMINATED FROM THE EAST



GETCHELL TREND, NEVADA
900 HZ ELECTROMAGNETICS
1:100,000 - ILLUMINATED FROM THE EAST



GETCHELL TREND, NEVADA
VERY LOW FREQUENCY DATA (VLF)
1:100,000 - ILLUMINATED FROM THE EAST



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