MIDDLE STYX ELECTROMAGNETIC, MAGNETIC, AND RADIOMETRIC AIRBORNE GEOPHYSICAL SURVEY DATA COMPILATION

Burns, L.E., Graham, G.R.C., Emond, A.M., Barefoot, J.D., CGG, and Fugro GeoServices, Inc.

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DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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MIDDLE STYX ELECTROMAGNETIC, MAGNETIC, AND RADIOMETRIC AIRBORNE GEOPHYSICAL SURVEY DATA COMPILATION

Burns, L.E.[1], Graham, G.R.C.[1], Emond, A.M.[1], Barefoot, J.D.[1], CGG, and Fugro GeoServices, Inc.

ABSTRACT

This geophysical survey is located about 150 kilometers northwest of Anchorage, Alaska in the upper South Fork of the Kuskokwim River drainage and south of Rainy Pass in south-central Alaska. The survey is in or near the Yentna, Redoubt, and McGrath mining districts. Frequency domain electromagnetic, magnetic, and radiometric data were collected with the DIGHEMV system from September 12th to November 3rd, 2012 and June 29th to September 27th, 2013. A total of 1154.9 line kilometers were collected covering 406.38 square kilometers. Line spacing was 400 meters (m). Data were collected 30 m above the ground surface from a helicopter towed sensor platform ("bird") on a 30 m long line.

PURPOSE

This airborne geophysical survey is part of a program to acquire data on Alaska's most promising mineral belts and districts. The information acquired is aimed at catalyzing new private sector exploration, discovery, and ultimate development and production. The primary goal of the Middle Styx project is to delineate prospective mineral zones and to support detailed geologic mapping. Prospects of several different types occur in the region surrounding the survey area, including polymetallic veins, epithermal veins, and porphyry copper deposits.

SURVEY OVERVIEW DESCRIPTION

This document provides an overview of the survey and includes text and figures of select primary and derivative products of this survey. A table of digital data packages available for download is provided to assist users in data selection. For reference a catalog of the available maps is presented in reduced resolution. Please consult the metadata, project report, and digital data packages for more information and data.

ACKNOWLEDGMENTS

Funding was provided by the Alaska State Legislature as part of the DGGS Airborne Geophysical/Geological Mineral Inventory (AGGMI) program and the Alaska Strategic and Critical Minerals Assessment Capital Improvement Project (SCMA).

[1] Alaska Division of Geological & Geophysical Surveys, 3354 College Road, Fairbanks, Alaska 99709-3707

AVAILABLE DATA

Data Type	Provider	Description
ascii_data	contractor	ASCII format line data, other ASCII data
databases_geosoft	contractor	Geosoft format database of final line data, other Geosoft format databases
documents	contractor and DGGS	Project and field reports, survey background information, gridded data explanations, other documentation
grids_ermapper	contractor	Geographically registered gridded data, ER Mapper ERS format
grids_geosoft	contractor and DGGS	Geosoft-format grids, these grids can be viewed in ESRI ArcMap using a free plugin from Geosoft or the free viewer available from Geosoft
images_registered	DGGS	GeoTiff format images of all gridded data
kmz	DGGS	keyhole markup language (kml) kmz archive files of project data. Viewable in Google Earth and other compatible programs
maps_pdf_format	contractor	Printable maps in pdf format
maps_prn_format	contractor	Printable maps in HPGL/2 printer file format with extension .prn
profiles_stacked	contractor	Distance-based profiles of the digitally recorded geophysical data are generated and plotted at an appropriate scale. The profiles display electromagnetic anomalies with their respective interpretive symbols. Printable in pdf format
vector_data	contractor and DGGS	Line path, data contours, and survey boundary in ESRI shapefile (SHP) format, ESRI Geodatabase format, and/or AutoCAD dxf format
video_flightpath	contractor	Survey flight path downward facing video

REFERENCES

Akima, H., 1970, A new method of interpolation and smooth curve fitting based on local procedures: Journal of the Association of Computing Machinery, v. 17, n. 4, p. 589–602.

Burns, L.E., Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc., 2013, Middle Styx survey area: Airborne magnetic, electromagnetic, and radiometric data in line (point), grid, vector, and map formats, Lime Hills and Tyonek quadrangles, southcentral Alaska: Alaska Division of Geological & Geophysical Surveys Geophysical Report 2013-2, scale 1:63,360, 1 DVD. http://doi.org/10.14509/25419

CGG, and Fugro GeoServices, Inc., 2015, Farewell and Middle Styx survey areas: Project report, interpretation maps, EM anomalies, stacked multi-channel profiles, and other products of the airborne geophysical surveys, parts of the McGrath, Lime Hills, and Tyonek quadrangles, south-central Alaska: Alaska Division of Geological & Geophysical Surveys Geophysical Report 2014-4, 22 sheets. http://doi.org/10.14509/29349

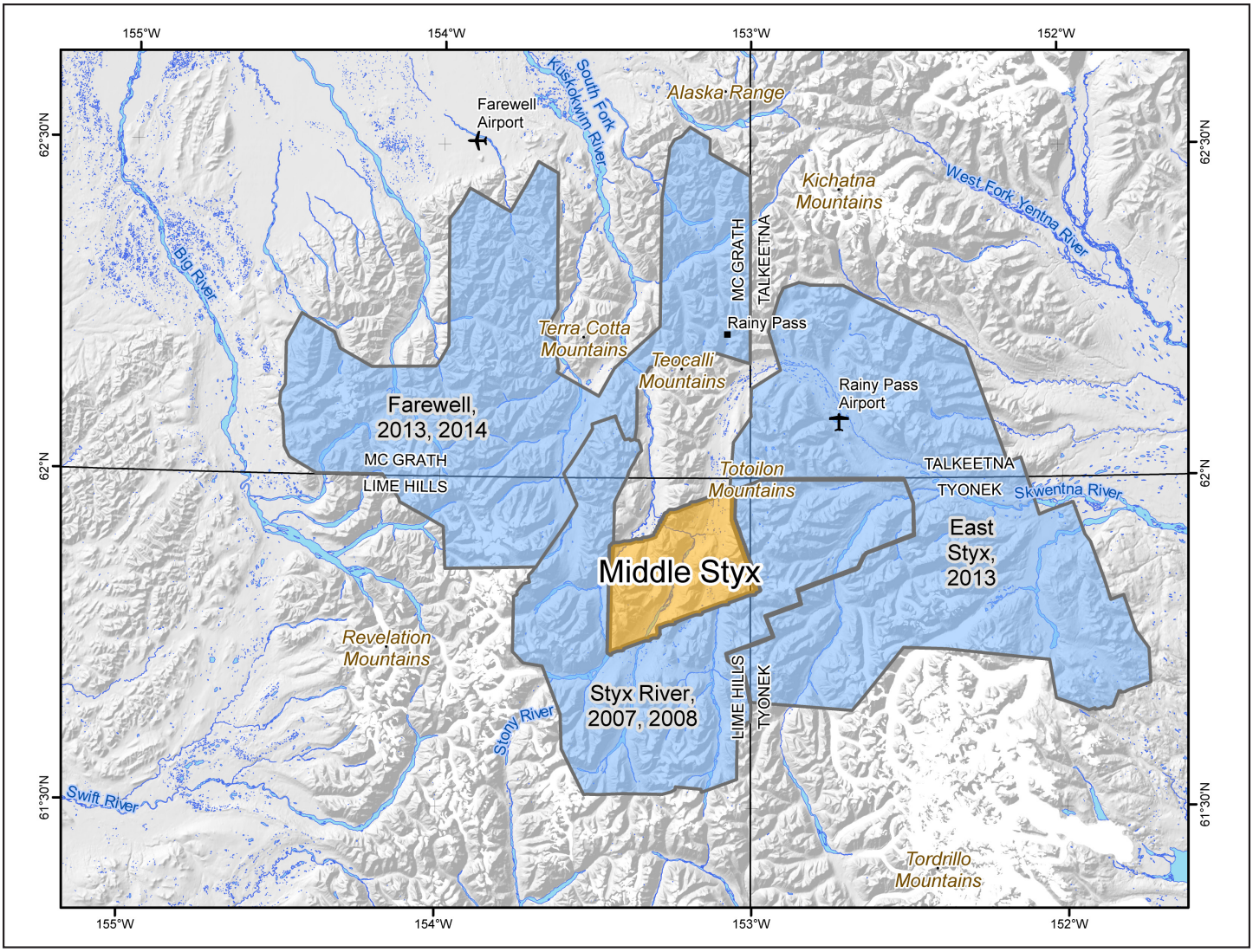

Figure 1. Middle Styx electromagnetic and magnetic airborne geophysical survey location shown in southcentral Alaska (right). Middle Styx survey area shown with adjacent DGGS geophysical surveys, landmarks, relevant 1:250,000-scale quadrangle boundaries, mountain ranges, rivers, glaciers, and elevation hillshade.

Figure 2. Flight path with orthometric image.

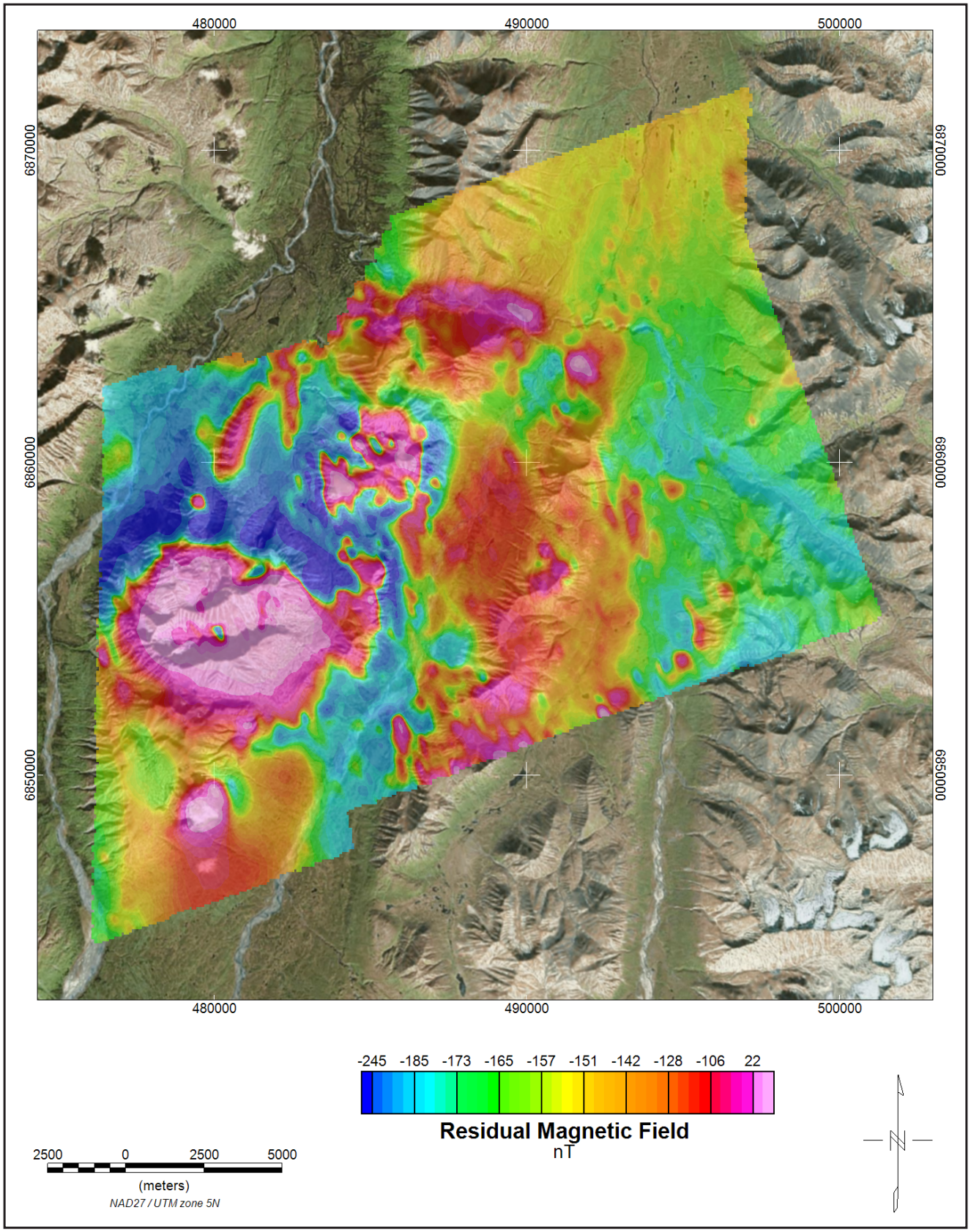

Figure 3. The magnetic total field data were created using digitally recorded data from a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. Data were collected at a sampling interval of 0.1 seconds. The magnetic data were (1) corrected for diurnal variations by subtracting the digitally recorded base station magnetic data, (2) IGRF corrected (IGRF model 2010, updated for date of flight and altimeter variations), (3) leveled to the tie line data, and (4) interpolated onto a regular 80 m grid using a modified Akima (1970) technique.

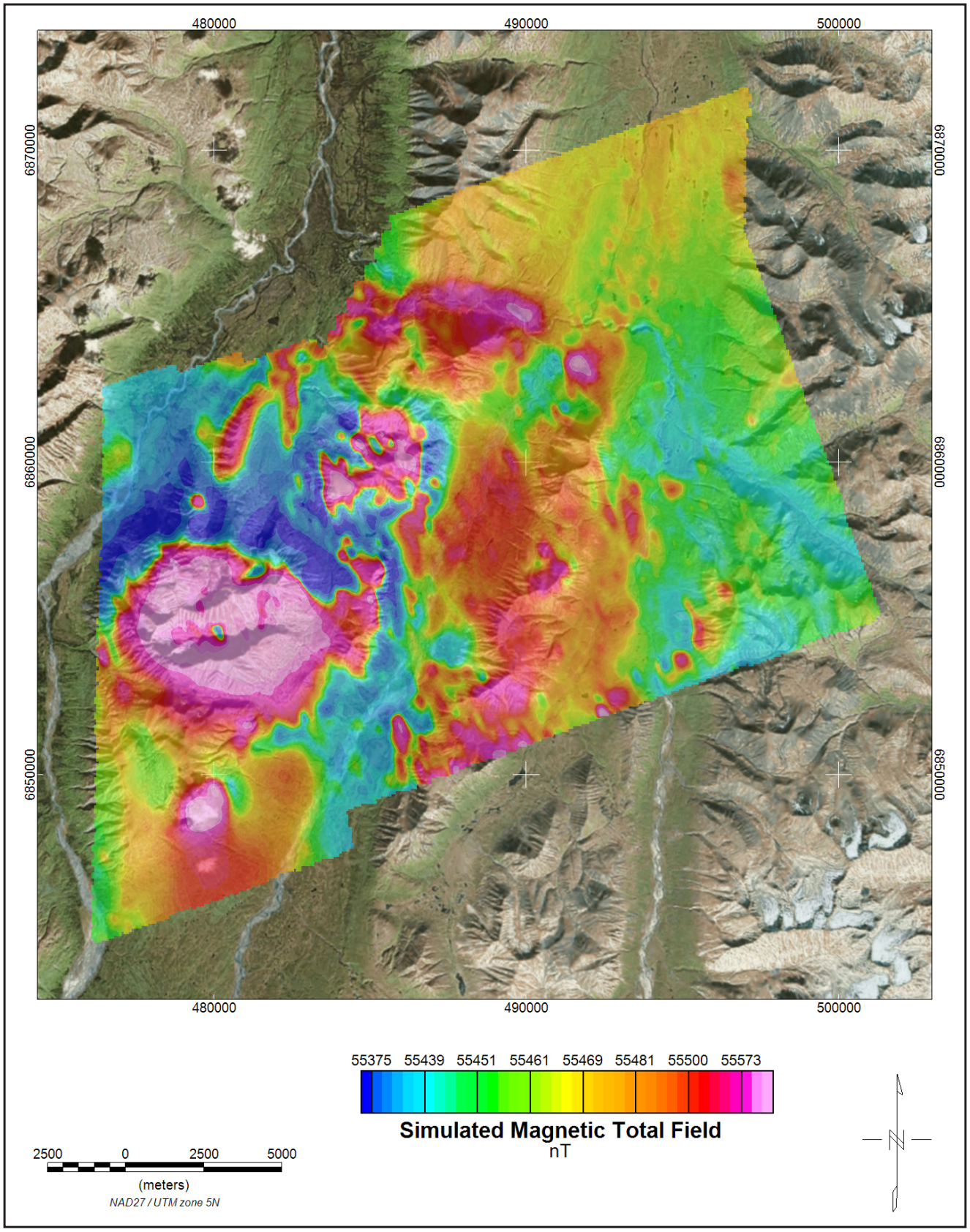

Figure 4. The simulated magnetic total field data were created using digitally recorded data from a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. Data were collected at a sampling interval of 0.1 seconds. The magnetic data were (1) corrected for diurnal variations by subtracting the digitally recorded base station magnetic data, (2) IGRF corrected (IGRF model 2010, updated for date of flight and altimeter variations), (3) leveled to the tie line data, (4) a constant value of approximately 55,000 nT was added to all data, and (5) interpolated onto a regular 80 m grid using a modified Akima (1970) technique.

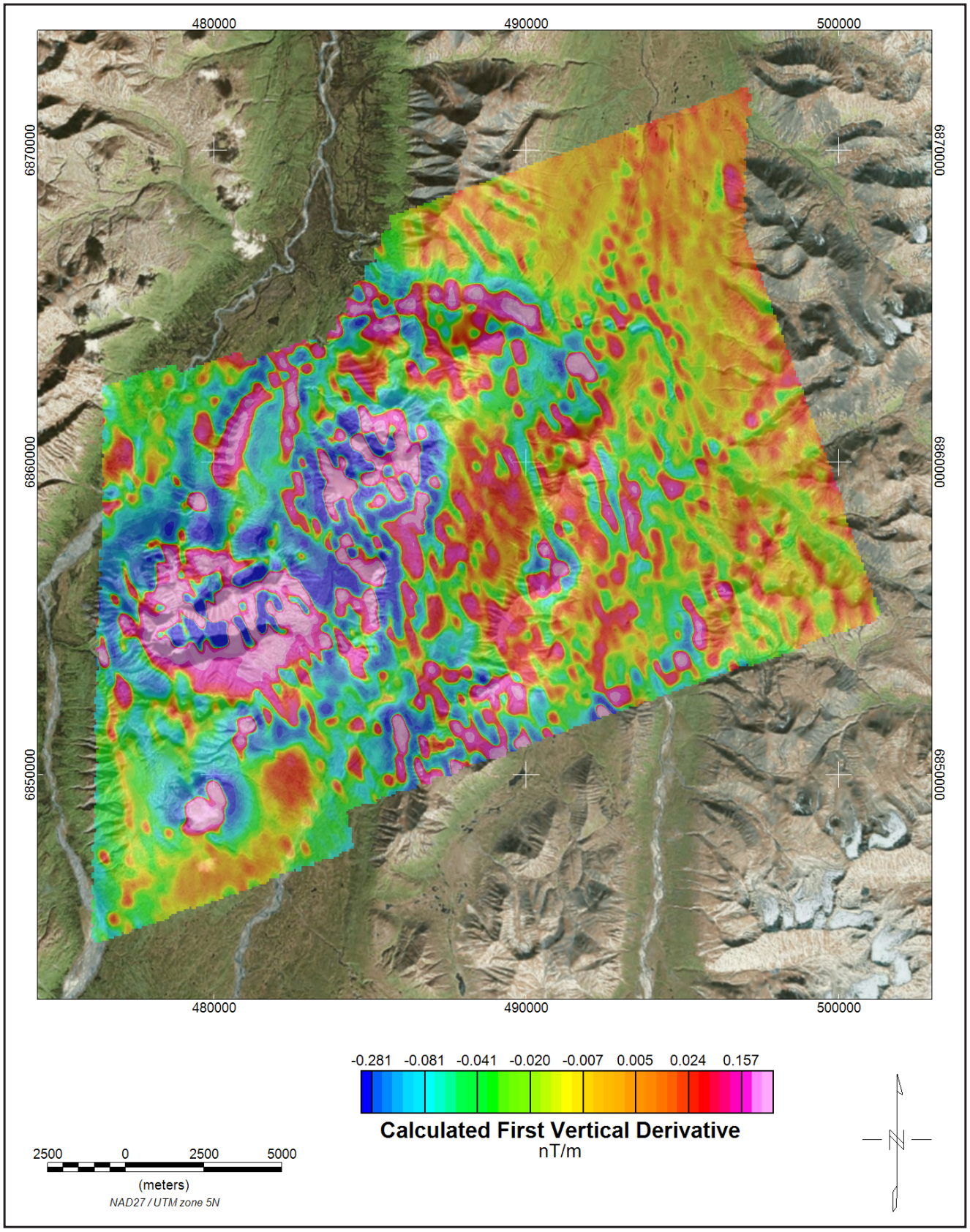

Figure 5. The first vertical derivative grid was calculated from the diurnally-corrected, IGRF-corrected total magnetic field grid using a FFT base frequency domain filtering algorithm. The resulting first vertical derivative grid provides better definition and resolution of near- surface magnetic units and helps to identify weak magnetic features that may not be evident on the total field data.

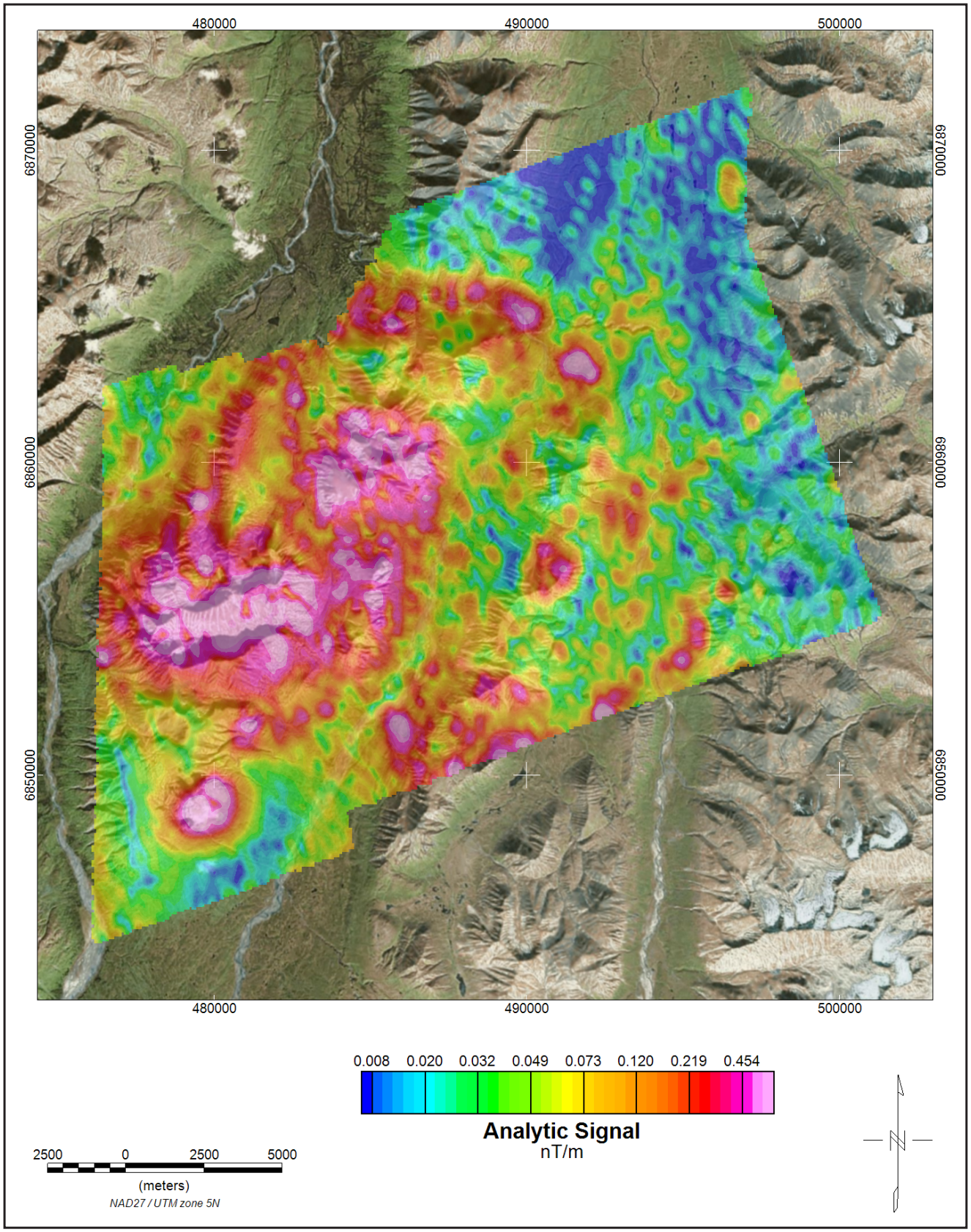

Figure 6. Analytic signal is the total amplitude of all directions of magnetic gradient calculated from the sum of the squares of the three orthogonal gradients. Mapped highs in the calculated analytic signal of magnetic parameter locate the anomalous source body edges and corners (such as contacts, fault/shearzones, etc.). Analytic signal maxima are located directly over faults and contacts, regardless of structural dip, and independent of the direction of the induced and/or remanent magnetizations.

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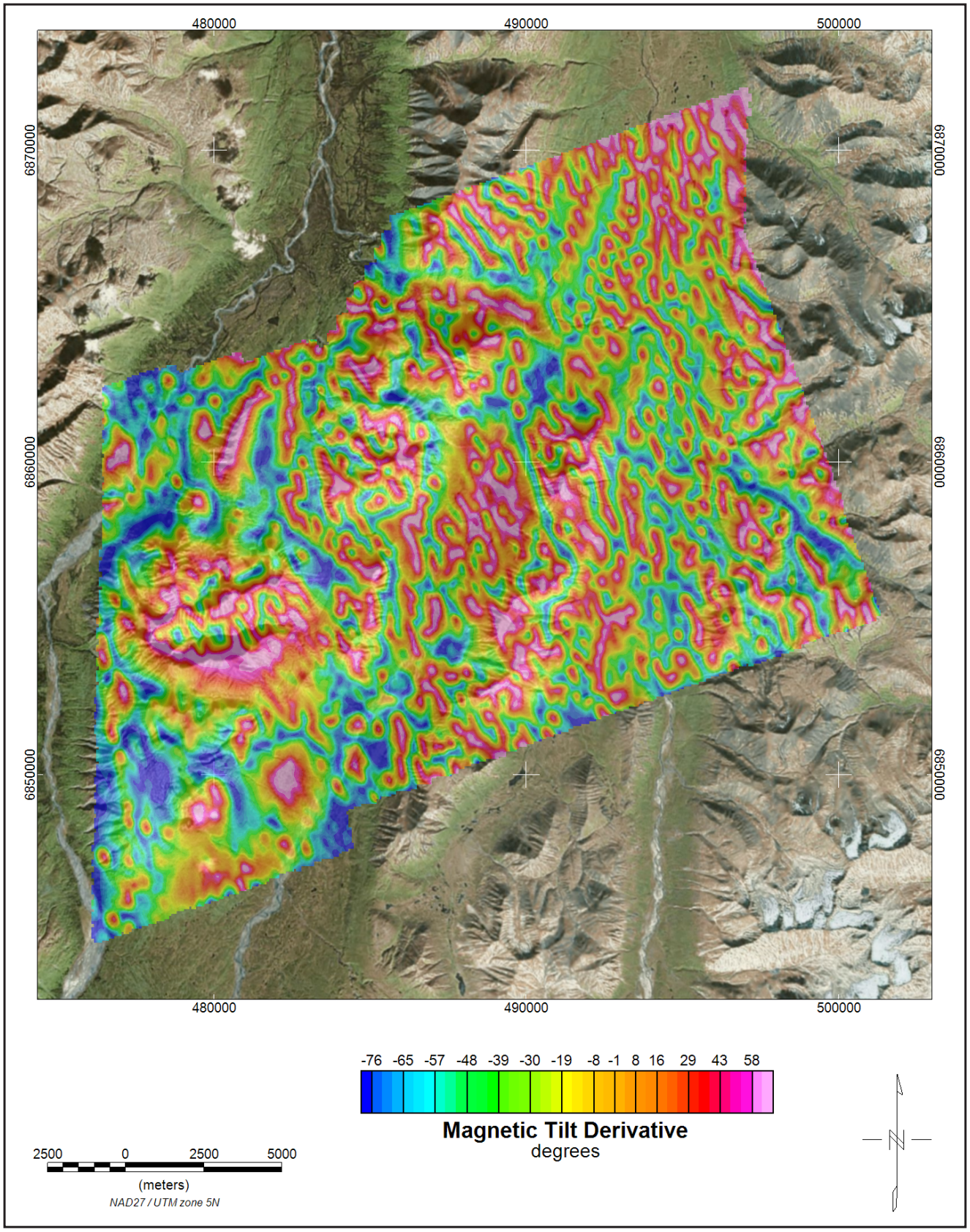

Figure 7. The tilt derivative is the angle between the horizontal gradient and the total gradient, which is useful for identifying the depth and type of source. The tilt angle is positive over the source, crosses through zero at, or near, the edge of a vertical sided source, and is negative outside the source region. It has the added advantage of responding equally well to shallow and deep sources and is able to resolve deeper sources that may be masked by larger responses from shallower sources.

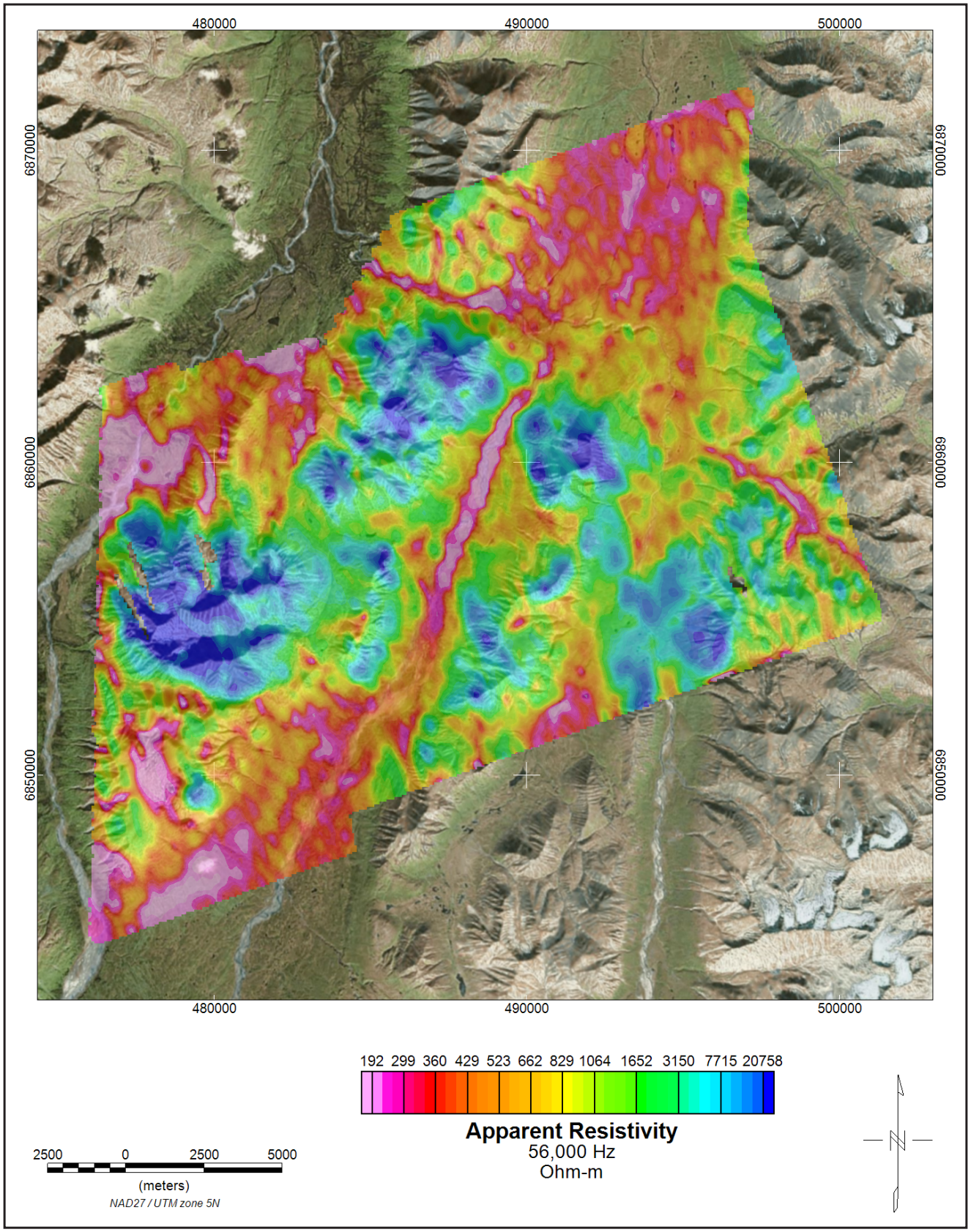

Figure 8. The DIGHEM^{V} EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial coil-pairs operated at 1000 and 5500 Hz while three horizontal coplanar coil-pairs operated at 900, 7,200 and 56,000 Hz. EM data were sampled at 0.1 second intervals. The EM system responds to bedrock conductors, conductive overburden, and cultural sources. Apparent resistivity is generated from the inphase and quadrature component of the coplanar 56,000 Hz using the pseudo-layer half space model. The data were interpolated onto a regular 80 m grid using a modified Akima (1970) technique.

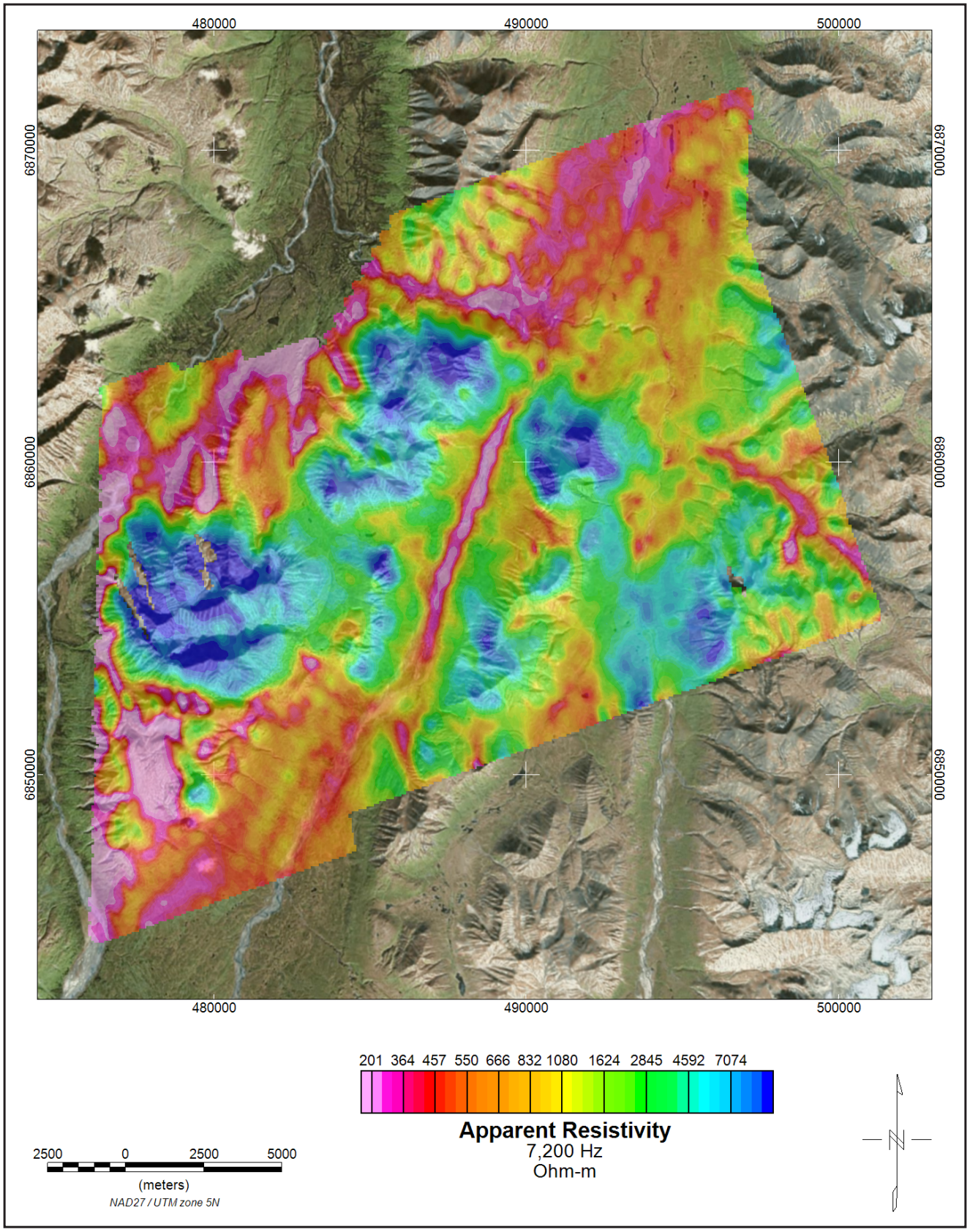

Figure 9. The DIGHEM^{V} EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial coil-pairs operated at 1000 and 5500 Hz while three horizontal coplanar coil-pairs operated at 900, 7,200 and 56,000 Hz. EM data were sampled at 0.1 second intervals. The EM system responds to bedrock conductors, conductive overburden, and cultural sources. Apparent resistivity is generated from the inphase and quadrature component of the coplanar 7,200 Hz using the pseudo-layer half space model. The data were interpolated onto a regular 80 m grid using a modified Akima (1970) technique.

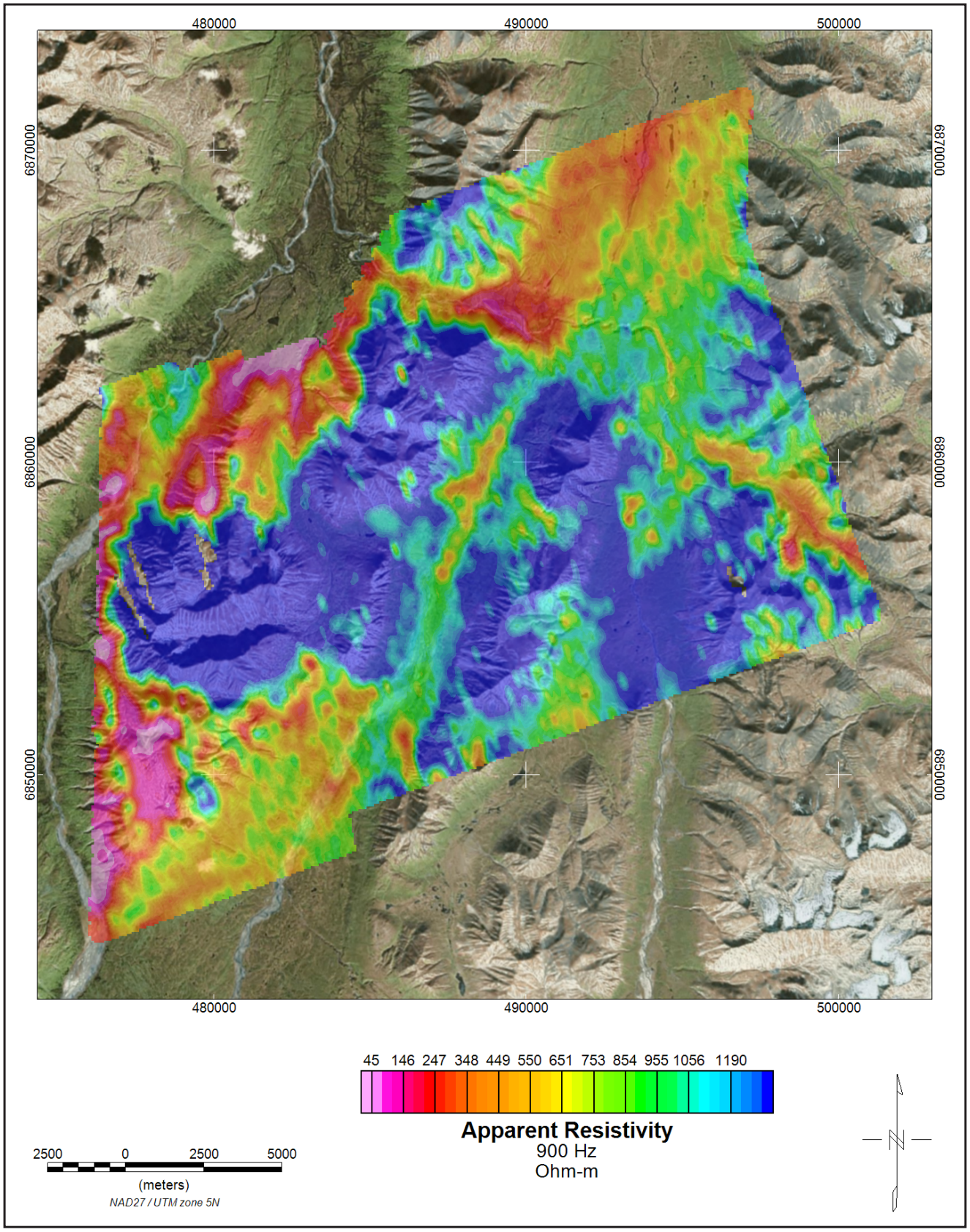

Figure 10. The DIGHEM^{V} EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial coil-pairs operated at 1000 and 5500 Hz while three horizontal coplanar coil-pairs operated at 900, 7,200 and 56,000 Hz. EM data were sampled at 0.1 second intervals. The EM system responds to bedrock conductors, conductive overburden, and cultural sources. Apparent resistivity is generated from the inphase and quadrature component of the coplanar 900 Hz using the pseudo-layer half space model. The data were interpolated onto a regular 80 m grid using a modified Akima (1970) technique.

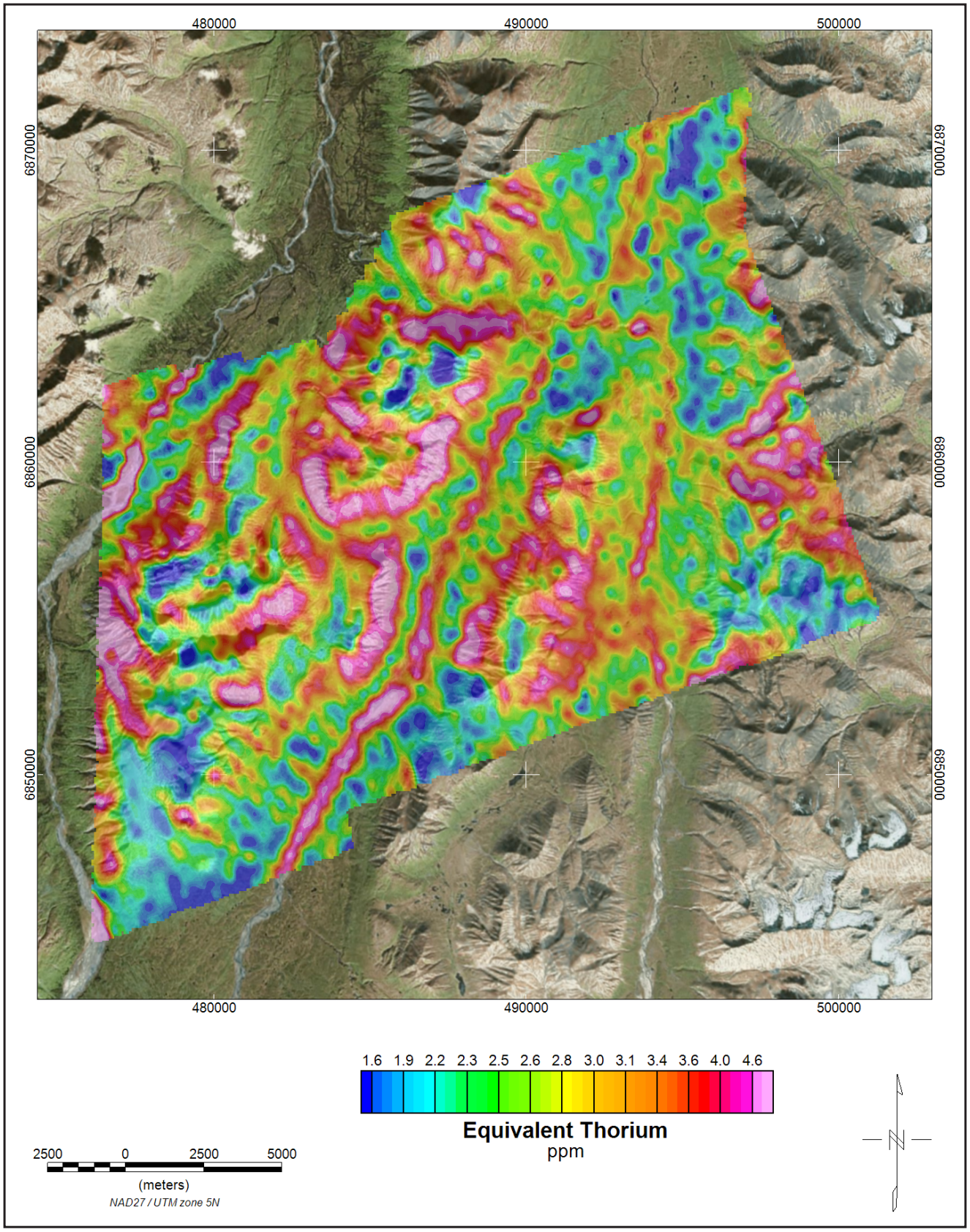

Figure 11. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

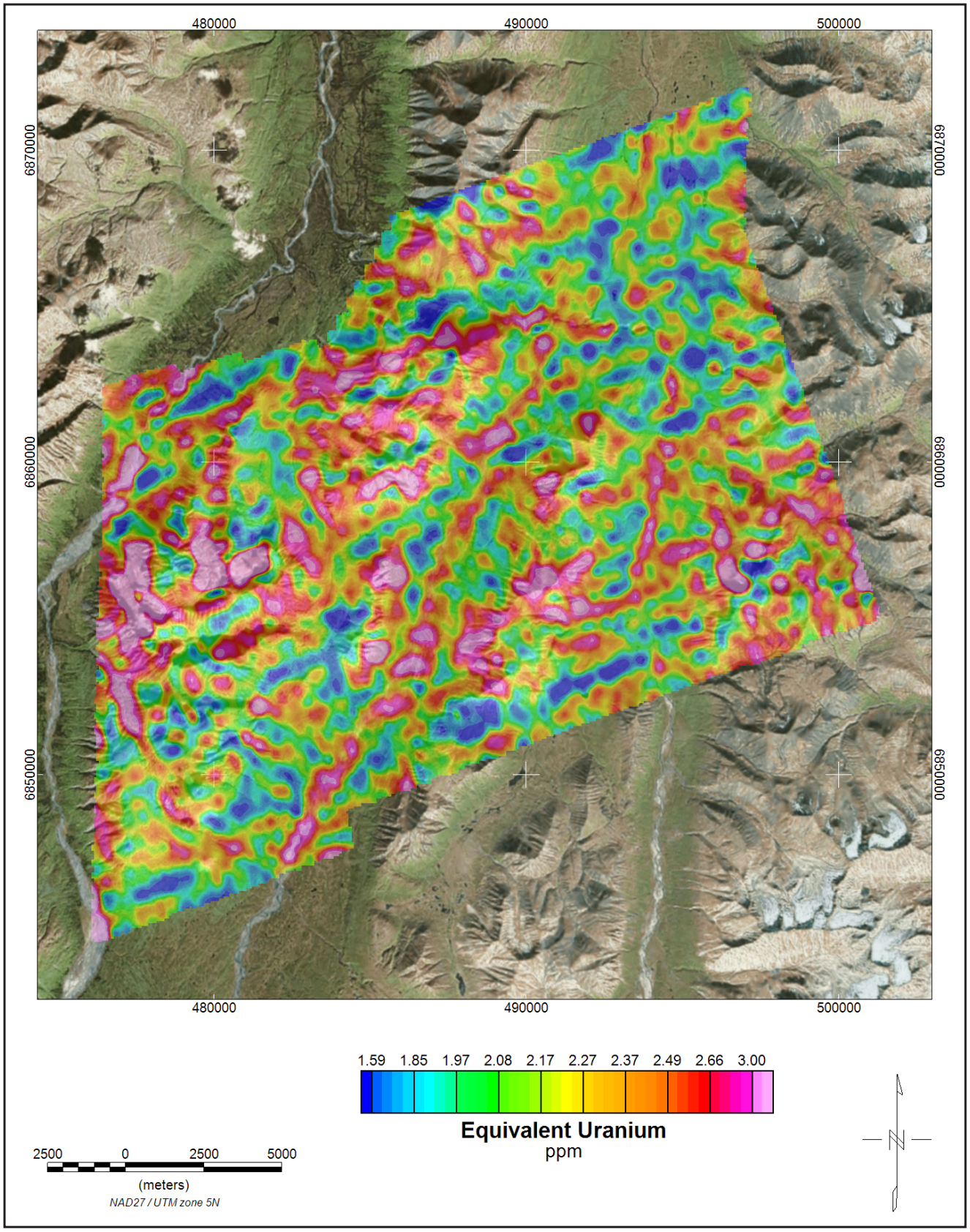

Figure 12. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

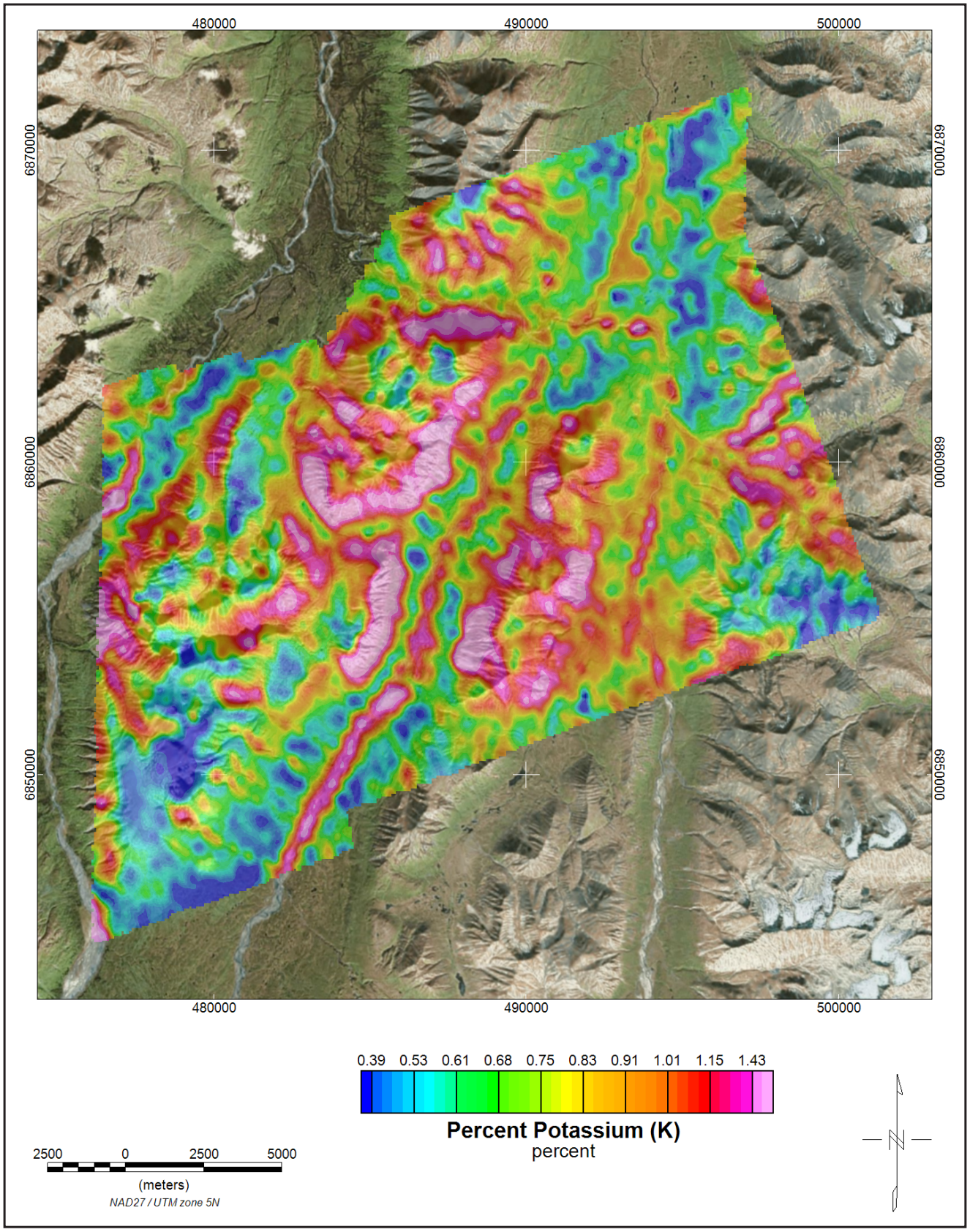

Figure 13. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

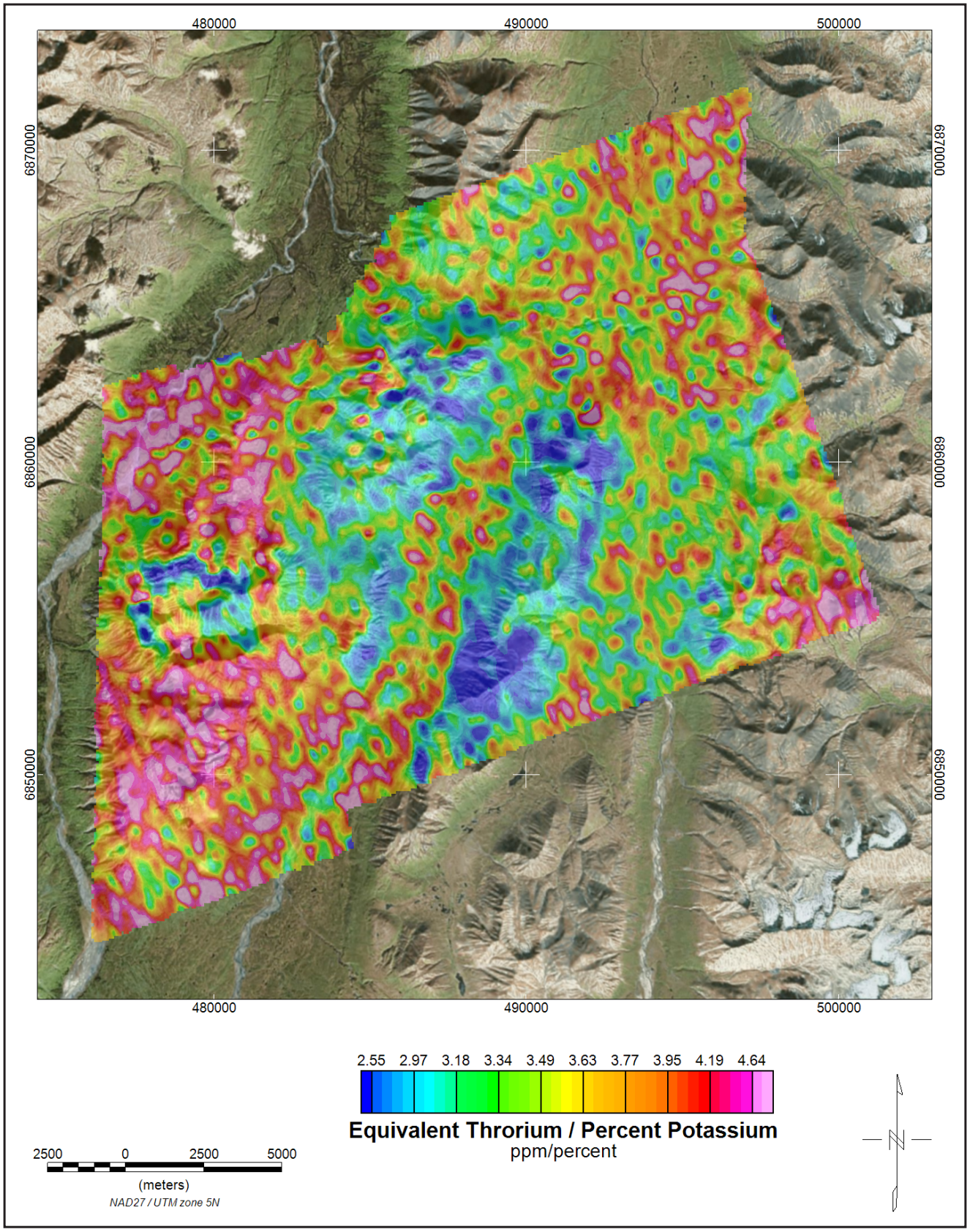

Figure 14. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

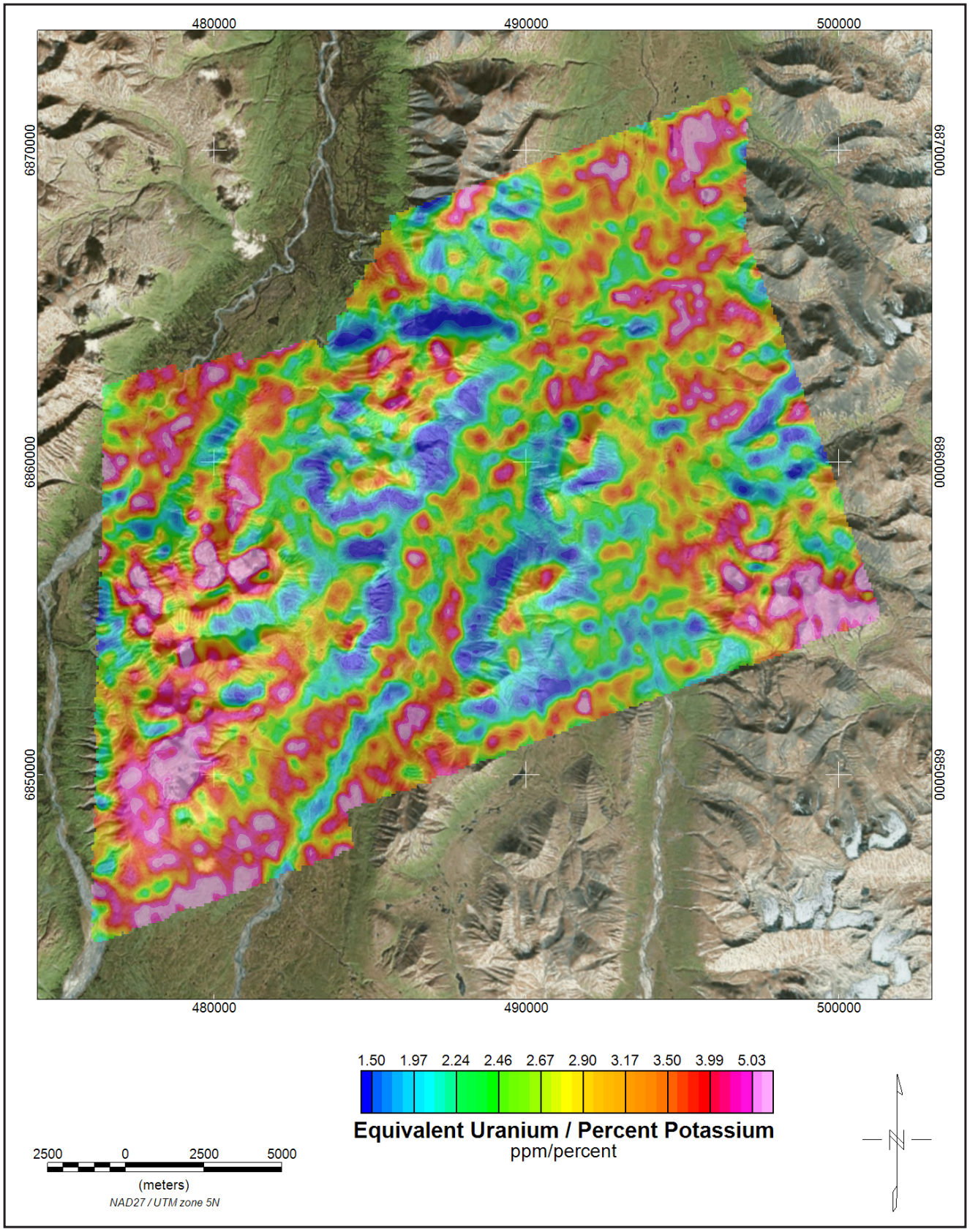

Figure 15. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

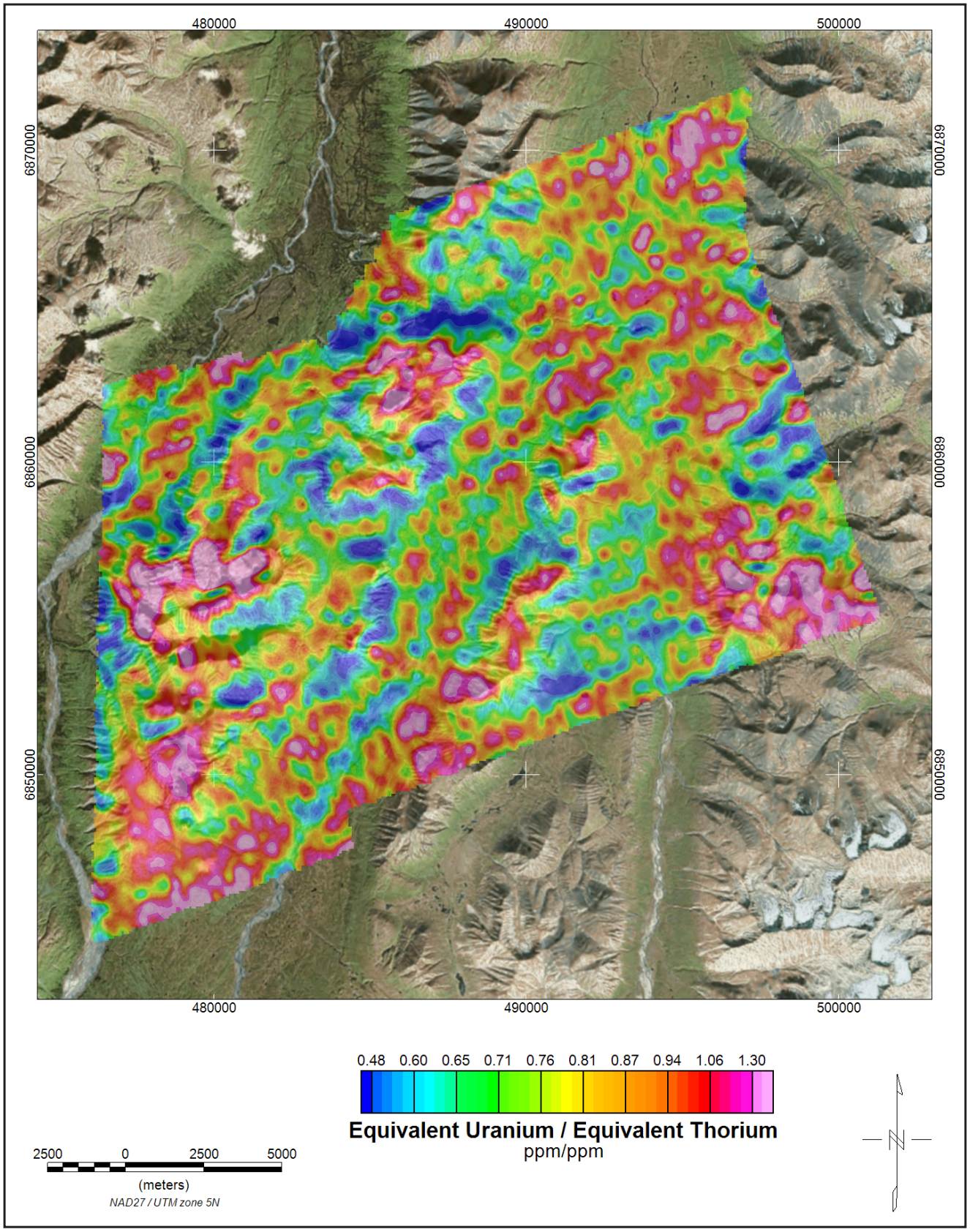

Figure 16. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

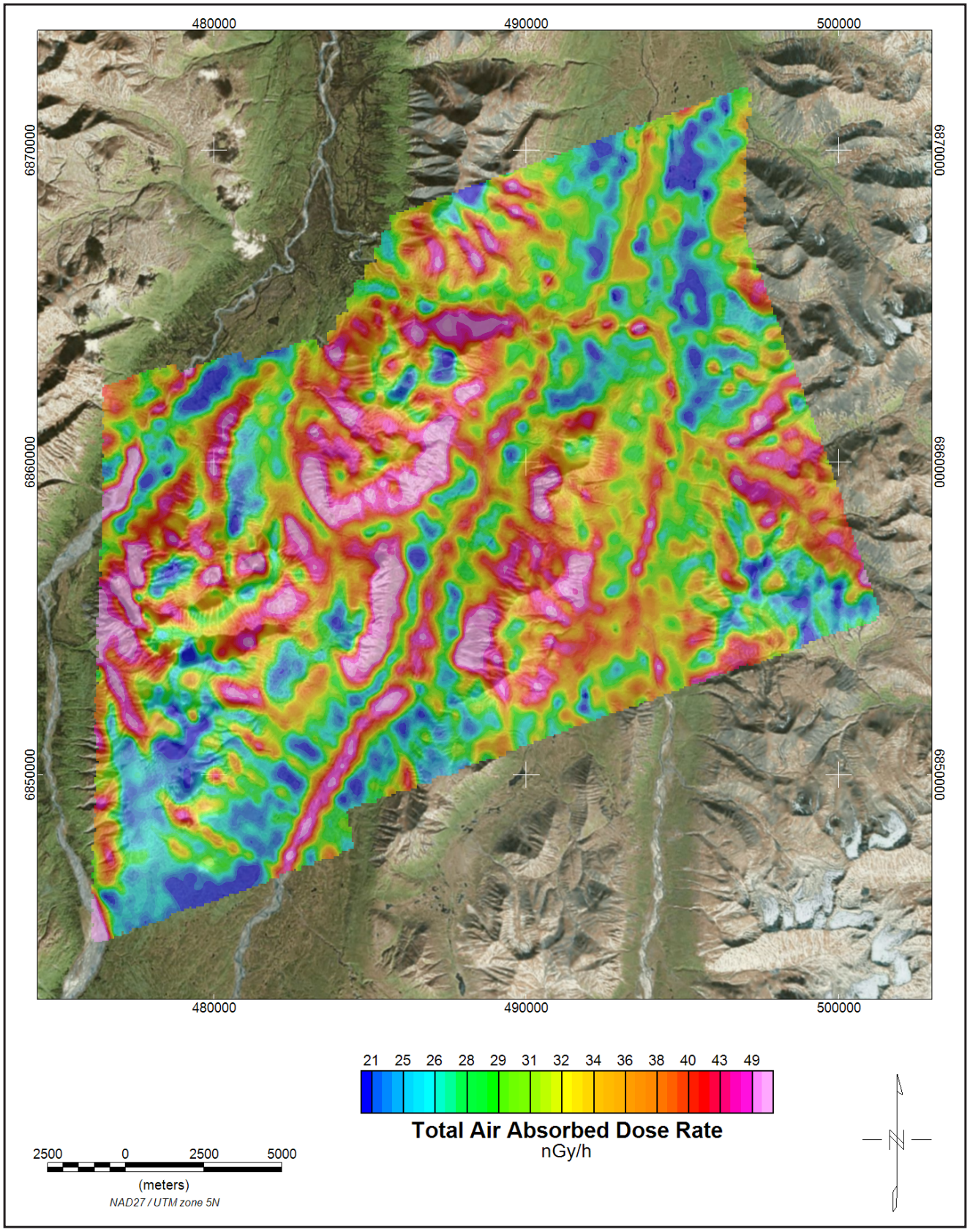

Figure 17. The gamma-ray spectrometry data were recorded at a 1.0 second sample rate into a 256 channel main and radon spectra using a Radiation Solutions RS-500 gamma-ray spectrometer. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 60 m. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique.

Table 1. Copies of the following maps are included at the end of this booklet. The low-resolution, page-size maps included in this booklet are intended to be used as a search tool and are not the final product. Large-scale, full-resolution versions of each map are available to download on this publication's citation page: http://doi.org/10.14509/30188.

Map Title	Description
middlestyx_residualmag_topo_map.pdf	residual magnetic field grid with topographic base map
middlestyx_residualmag_contours_plss_map.pdf	residual magnetic field grid with contours and public land survey system base layer
middlestyx_calculated1vd_topo_map.pdf	calculated first vertical derivative grid with topographic base map
middlestyx_analyticsignal_topo_map.pdf	analytic signal grid with topographic base map
middlestyx_analyticsignal_contours_plss_map.pdf	analytic signal grid with contours and public land survey system base layer
middlestyx_tiltderivative_contours_topo_map.pdf	magnetic tilt derivative grid with contours and topographic base map
middlestyx_residualmag_shaded_tiltderivative_contours_topo_map.pdf	color shaded residual magnetic field grid with magnetic tilt derivative contours and topographic base map
middlestyx_res56khz_topo_map.pdf	56,000 Hz apparent resistivity grid with topographic base map
middlestyx_res56khz_contours_plss_map.pdf	56,000 Hz apparent resistivity grid with contours and public land survey system base layer
middlestyx_res7200hz_topo_map.pdf	7,200 Hz apparent resistivity grid with topographic base map
middlestyx_res7200hz_contours_plss_map.pdf	7,200 Hz apparent resistivity grid with contours and public land survey system base layer
middlestyx_res900hz_topo_map.pdf	900 Hz apparent resistivity grid with topographic base map
middlestyx_res900hz_contours_plss_map.pdf	900 Hz apparent resistivity grid with contours and public land survey system base layer
middlestyx_rad_ratio_th_k_topo_map.pdf	ratio of equivalent thorium to percent potassium grid with topographic base map
middlestyx_rad_ratio_th_k_contours_plss_map.pdf	ratio of equivalent thorium to percent potassium grid with contours and public land survey system base layer
middlestyx_rad_ratio_u_k_topo_map.pdf	ratio of equivalent uranium to percent potassium grid with topographic base map
middlestyx_rad_ratio_u_k_contours_plss_map.pdf	ratio of equivalent uranium to percent potassium grid with contours and public land survey system base layer
middlestyx_rad_ratio_u_th_topo_map.pdf	ratio of equivalent uranium to equivalent thorium grid with topographic base map
middlestyx_rad_ratio_u_th_contours_plss_map.pdf	ratio of equivalent uranium to equivalent thorium grid with contours and public land survey system base layer
middlestyx_rad_pct_k_topo_map.pdf	percent potassium grid with topographic base map
middlestyx_rad_pct_k_contours_plss_map.pdf	percent potassium grid with contours and public land survey system base layer
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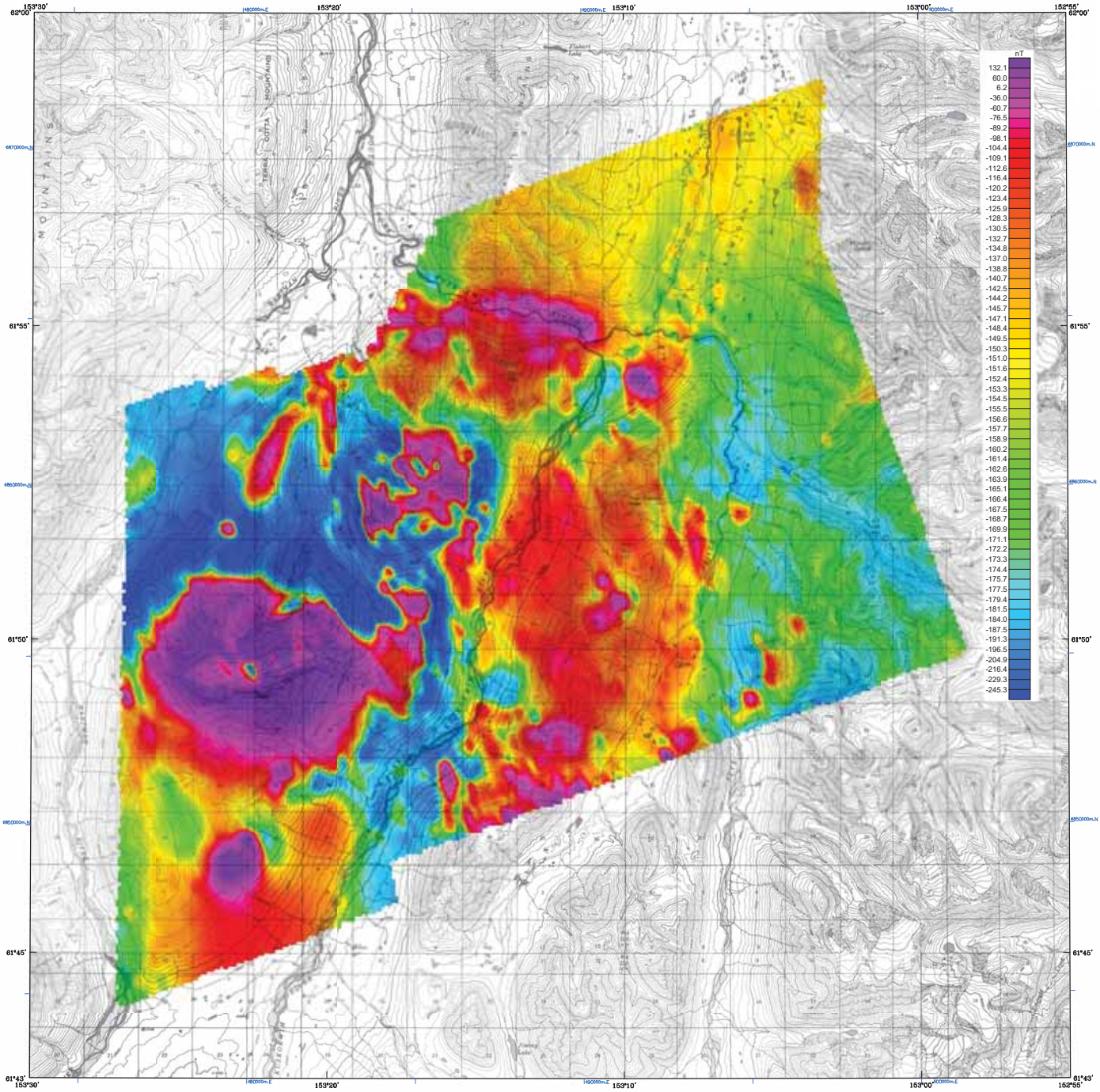


Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-5, 1956; D-5, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

RESIDUAL MAGNETIC FIELD WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

DESCRIPTIVE NOTES

The geophysical data were acquired with a DIGHEM^{V} Electromagnetic (EM) system, Radiation Solutions RS-500 gamma-ray spectrometer and a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. The EM and magnetic sensors were flown at a height of 100 feet. The gamma-ray spectrometer was flown at a height of 200 feet. In addition the survey recorded data from radar and laser altimeters, GPS navigation system, 50/60 Hz monitors and video camera. Flights were performed with an AS-350-B3 Squirrel helicopter at a mean terrain clearance of 200 feet along NE-SW (70°) survey flight lines with a spacing of a quarter of a mile. Tie lines were flown perpendicular to the flight lines at intervals of approximately 3 miles.

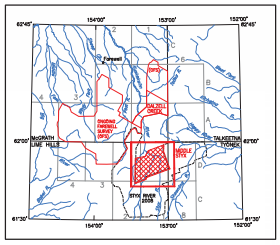
A Novatel OEM4-G2L Global Positioning System was used for navigation. The helicopter position was derived every 0.5 seconds using post-flight differential positioning to a relative accuracy of better than 5m. Flight path positions were projected onto the Clarke 1866 (UTM zone 5) spheroid, 1927 North American datum using a central meridian (CM) of 153°, a north constant of 0 and an east constant of 500,000. Positional accuracy of the presented data is better than 10m with respect to the UTM grid.

RESIDUAL MAGNETIC FIELD

The magnetic total field data were processed using digitally recorded data from a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. Data were collected at a sampling interval of 0.1 seconds. The magnetic data were (1) corrected for diurnal variations by subtraction of the digitally recorded base station magnetic data, (2) IGRF corrected (IGRF model 2010, updated for date of flight and altimeter variations), (3) leveled to the tie line data, and (4) interpolated onto a regular 80 m grid using a modified Akima (1970) technique. All grids were then resampled from the 80 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication.

Akima, H., 1970, A new method of interpolation and smooth curve fitting based on local procedures: Journal of the Association of Computing Machinery, v. 17, no. 4, p. 589-602.

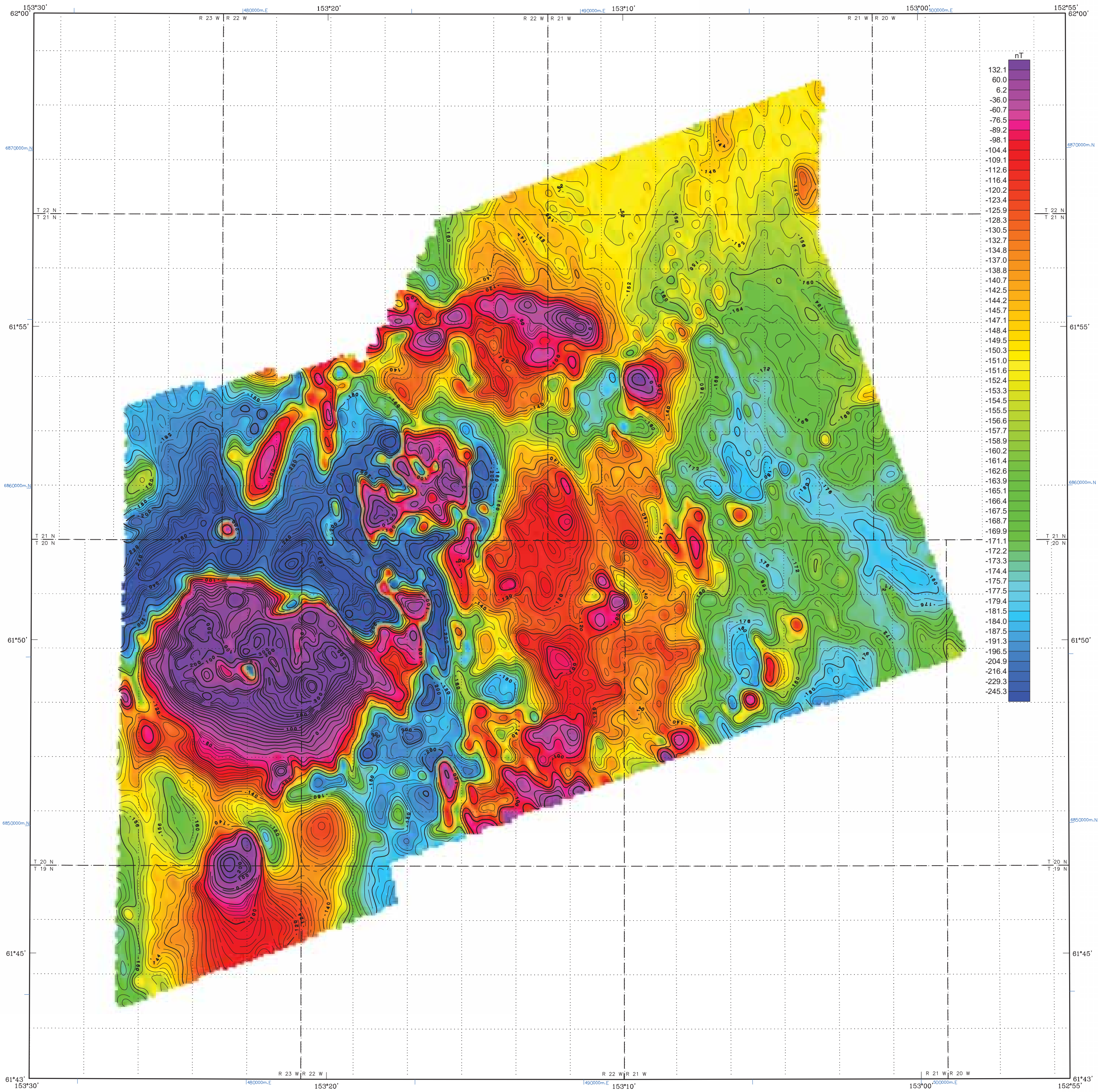
LOCATION INDEX



SURVEY HISTORY

This map has been compiled and drawn under contract between the State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys (DGGS), and Fugro GeoServices, Inc. Airborne geophysical data for the area were acquired and processed by Fugro Airborne Surveys Corp. in 2012 and 2013. Previously flown DGGS surveys adjacent to the current survey are shown in the location map by dashed lines, survey name, and date of publication. The project was funded by the Alaska State Legislature as part of the Alaska Strategic and Critical Minerals Assessment project, which is part of the Alaska Airborne Geophysical and Geological Mineral Inventory Program.

All data and maps produced to date from this survey are available in digital format on DVD for a nominal fee through DGGS, 3354 College Road, Fairbanks, Alaska, 99709-3707, and are downloadable for free from the DGGS website (www.dggs.alaska.gov/pubs). Maps are also available on paper through the DGGS office, and are viewable online at the website in Adobe Acrobat .PDF file format.

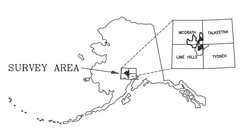


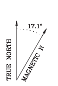
Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1977; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS





APPROXIMATE MEAN DECLINATION, 2010

RESIDUAL MAGNETIC FIELD AND DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

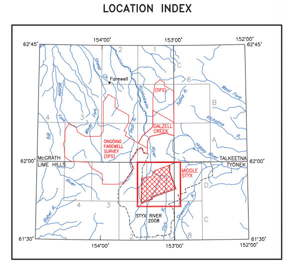
PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by

Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.

2013

LOCATION INDEX



DESCRIPTIVE NOTES

The geophysical data were acquired with a DIGHEM[V] Electromagnetic (EM) system, Radiation Solutions RS–500 gamma–ray spectrometer and a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. The EM and magnetic sensors were flown at a height of 100 feet. The gamma–ray spectrometer was flown at a height of 200 feet. In addition the survey recorded data from radar and laser altimeters, GPS navigation system, 50/60 Hz monitors and video camera. Flights were performed with an AS–350–B3 Squirrel helicopter at a mean terrain clearance of 200 feet along NE–SW (70°) survey flight lines with a spacing of a quarter of a mile. Tie lines were flown perpendicular to the flight lines at intervals of approximately 3 miles.

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Akima, H., 1970, A new method of interpolation and smooth curve fitting based on local procedures: Journal of the Association of Computing Machinery, v. 17, no. 4, p. 589–602.

MAGNETIC CONTOURS

. . . . 100 nT

. . . . 20 nT

. . . . 4 nT

. . . . 2 nT

SURVEY HISTORY

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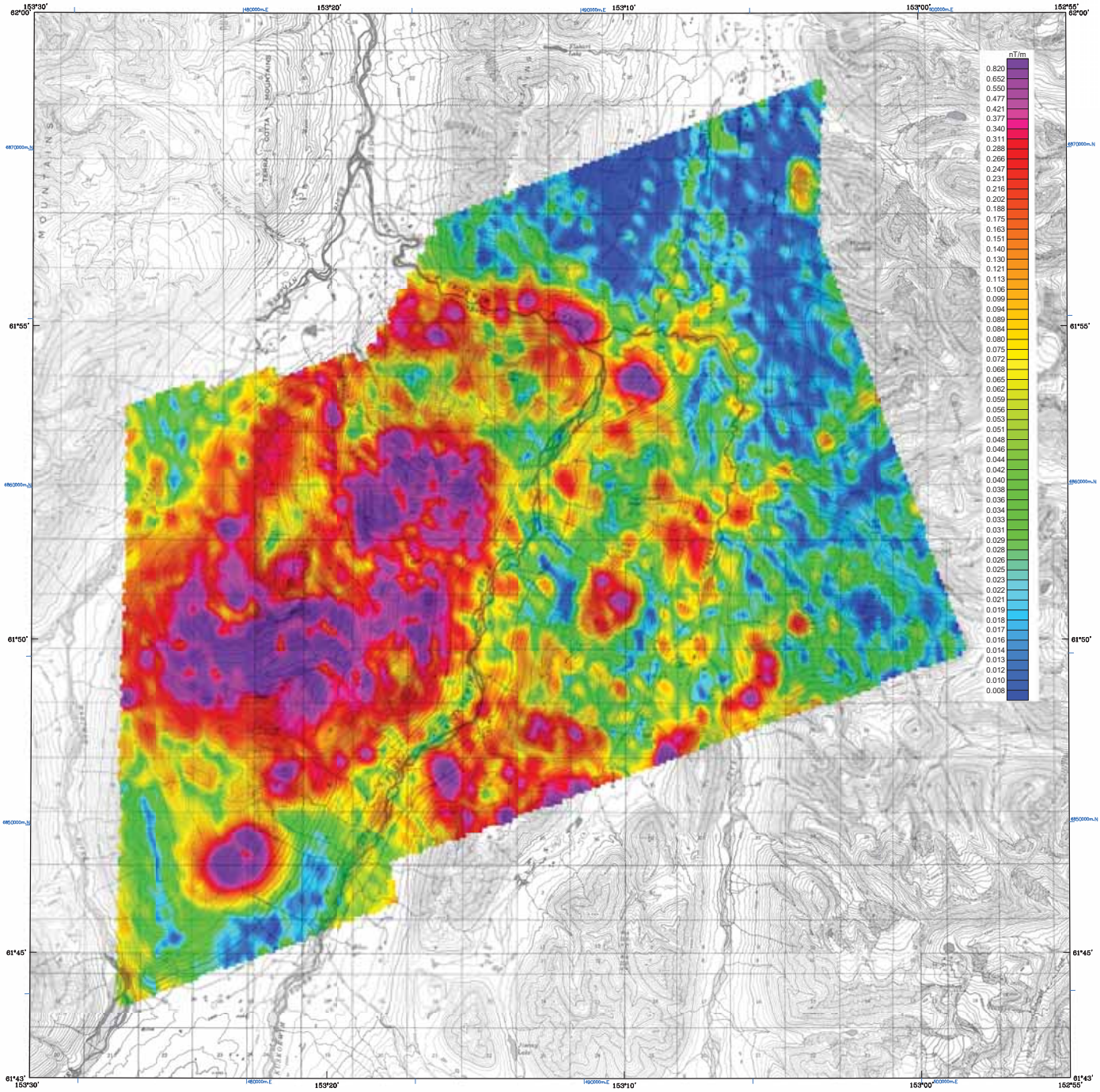

Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-8, 1956; D-8, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

ANALYTIC SIGNAL WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

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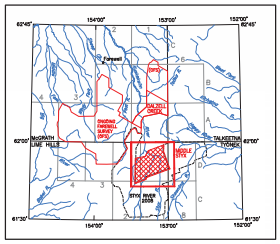

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ANALYTIC SIGNAL

Analytic signal is the total amplitude of all directions of magnetic gradient calculated from the sum of the squares of the three orthogonal gradients. Mapped highs in the calculated analytic signal of magnetic parameter locate the anomalous source body edges and corners (e.g., contacts, fault/shear zones, etc.). Analytic signal maxima are located directly over faults and contacts, regardless of structural dip, and independently of the direction of the induced and/or remanent magnetizations.

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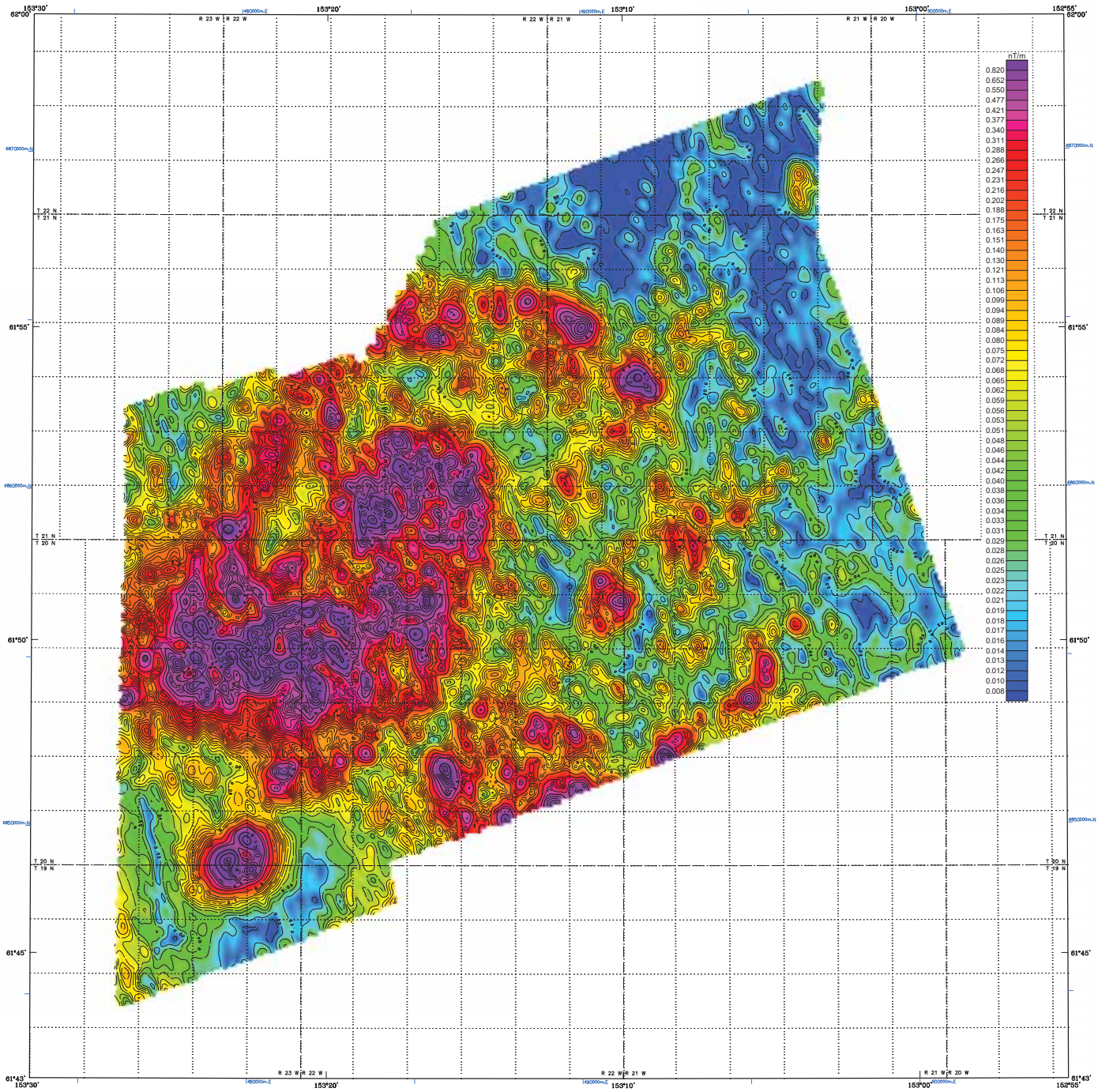

Section outlines from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1975; D-1, 1956; D-2, 1972; Tyonek C-8, 1956; D-8, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

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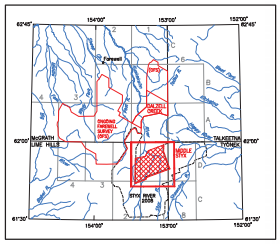
by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

LOCATION INDEX



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ANALYTIC SIGNAL CONTOURS

————————	0.50 nT/metre
————————	0.10 nT/metre
————————	0.02 nT/metre
— — — —	0.01 nT/metre

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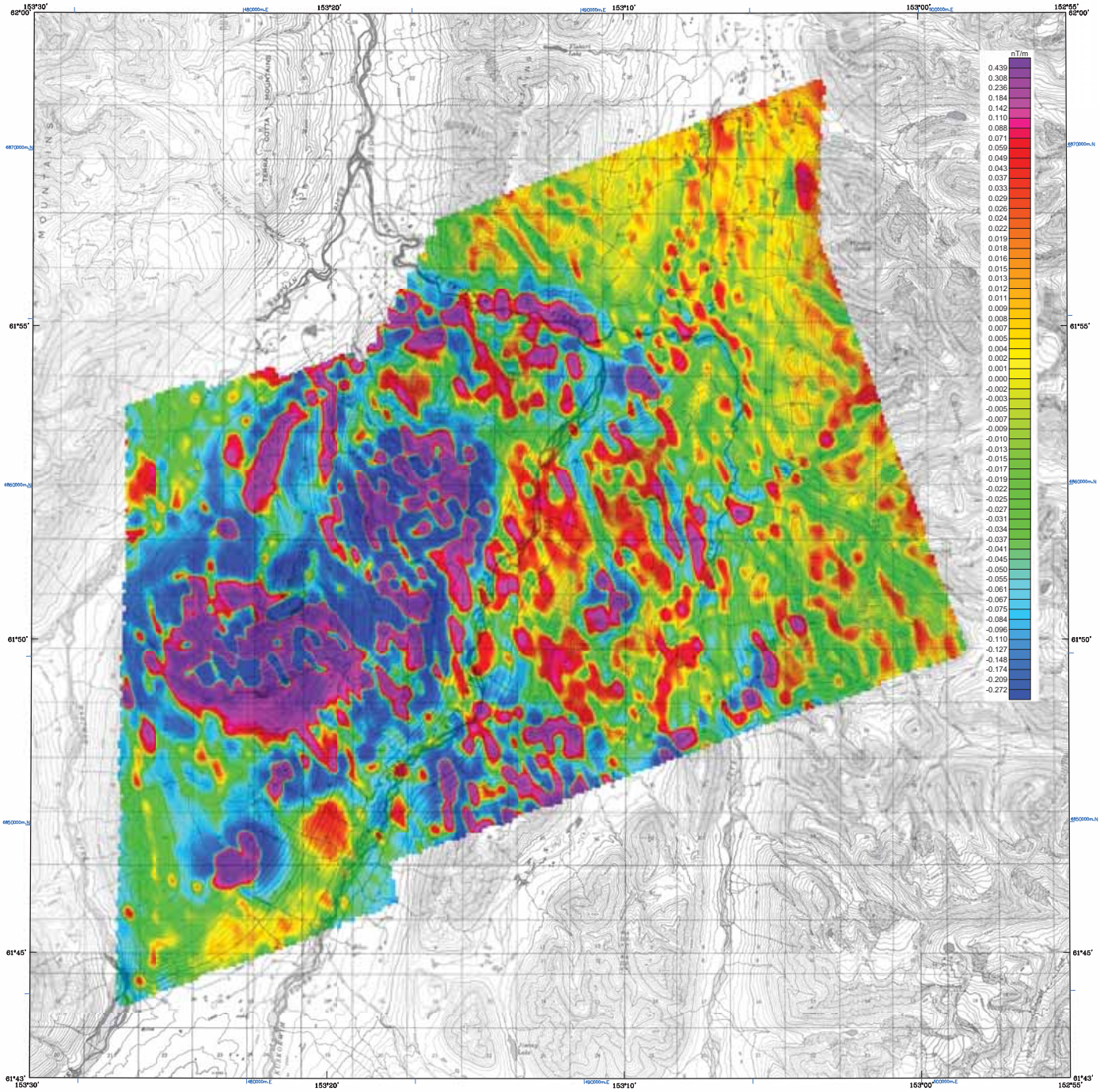

Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-5, 1956; D-5, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

FIRST VERTICAL DERIVATIVE OF THE MAGNETIC FIELD OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.

2013

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COLOR BAR HISTOGRAM

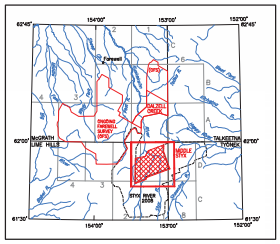
Approximately 98% of the first vertical derivative of the magnetic field for the Middle Styx Survey Area dataset lie within the range displayed on the color bar. Data values actually range from −1.743 nT/m (dark blue) to about 2.541 nT/m (magenta).

FIRST VERTICAL DERIVATIVE OF THE MAGNETIC FIELD

The magnetic total field data were processed using digitally recorded data from a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. Data were collected at a sampling interval of 0.1 seconds. The magnetic data were (1) corrected for diurnal variations by subtraction of the digitally recorded base station magnetic data, (2) IGRF corrected (IGRF model 2010, updated for date of flight and altimeter variations), (3) leveled to the tie line data, and (4) interpolated onto a regular 80 m grid using a modified Akima (1970) technique. All grids were then resampled from the 80 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication. The first vertical derivative grid was calculated from the processed total magnetic field grid using a FFT base frequency domain filtering algorithm. The resulting first vertical derivative grid provides better definition and resolution of near-surface magnetic units and helps to identify weak magnetic features that may not be evident on the total field data.

Akima, H., 1970, A new method of interpolation and smooth curve fitting based on local procedures: Journal of the Association of Computing Machinery, v. 17, no. 4, p. 589-602.

LOCATION INDEX



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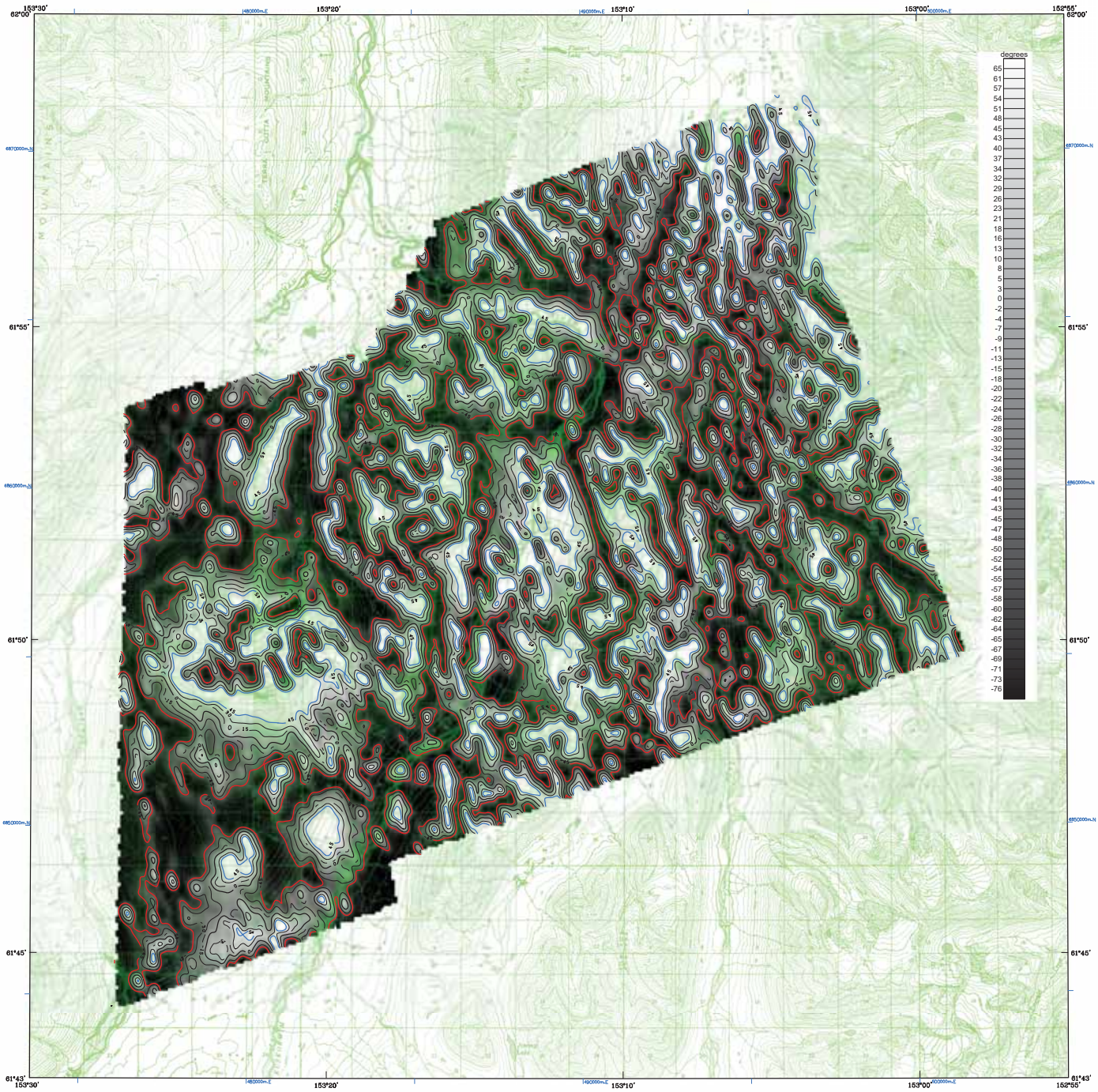


Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-5, 1956; D-5, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

MAGNETIC TILT DERIVATIVE WITH TOPOGRAPHY AND DATA CONTOURS OF THE MIDDLE STYX RIVER SURVEY AREA, SOUTHCENTRAL ALASKA

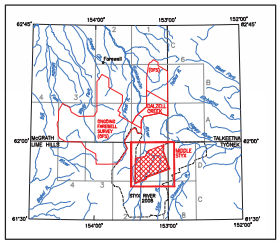
PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by

Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.

2013

LOCATION INDEX



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MAGNETIC TILT DERIVATIVE

The tilt derivative is the angle between the horizontal gradient & the total gradient, which is useful for identifying the depth & type of source. The tilt angle is positive over the source, crosses through zero at, or near, the edge of a vertical sided source, and is negative outside the source region. It has the added advantage of responding equally well to shallow and deep sources and is able to resolve deeper sources that may be masked by larger responses from shallower sources.

MAGNETIC TILT DERIVATIVE CONTOURS

- .....+45 degrees
- .....+30 degrees
- .....+15 degrees
- ..... 0 degrees
- .....-15 degrees
- .....-30 degrees
- .....-45 degrees

SURVEY HISTORY

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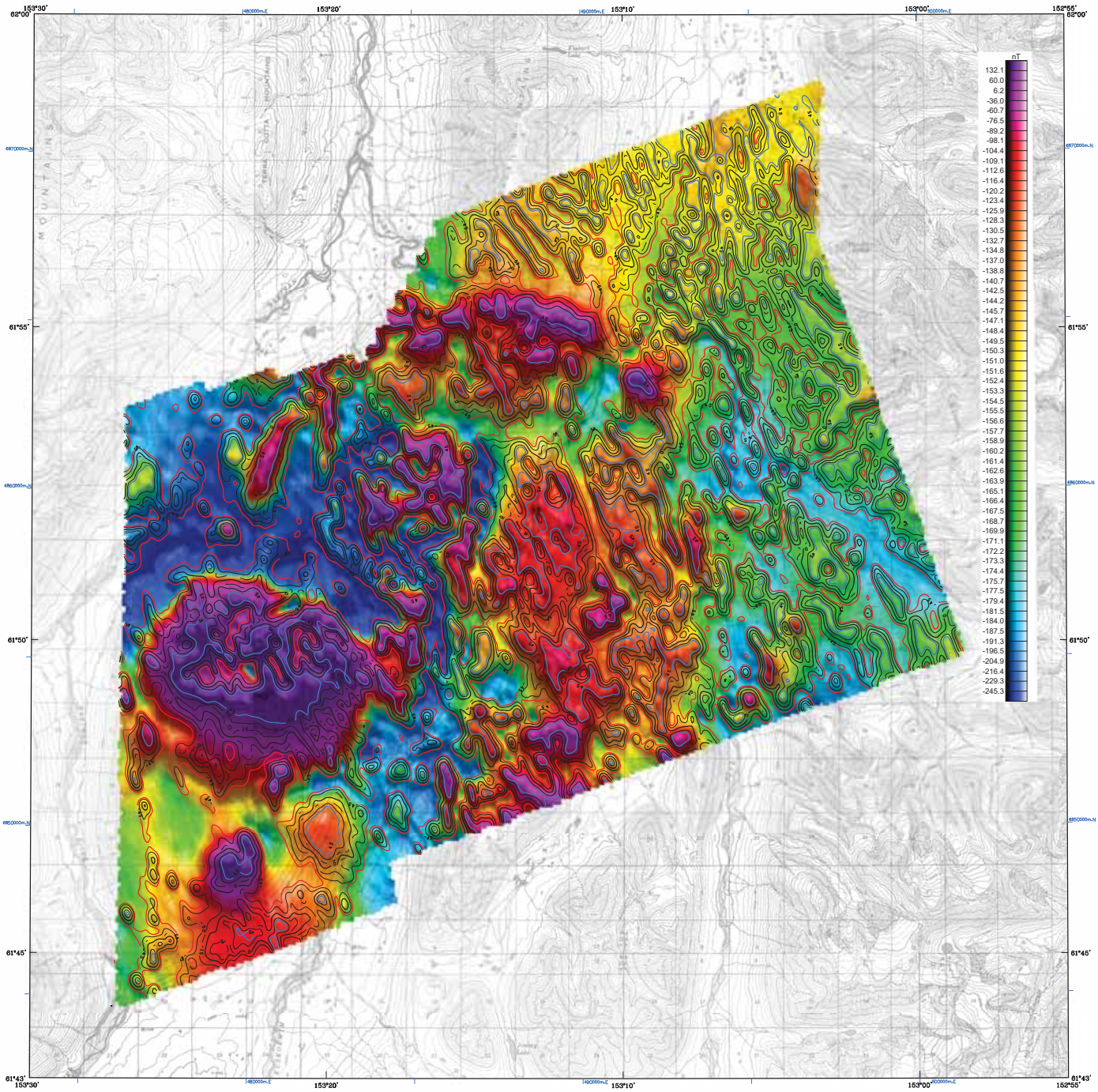

Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1972; Tyonek C-6, 1958; D-6, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

COLOR SHADOW RESIDUAL MAGNETIC FIELD WITH MAGNETIC TILT DERIVATIVE DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

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2013

Sun Azimuth: 0 degrees; Sun Inclination: 45 degrees

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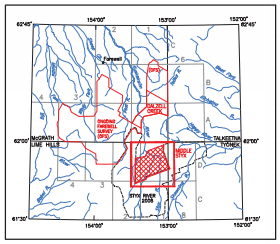
MAGNETIC TILT DERIVATIVE CONTOURS

- +45 degrees
- +30 degrees
- +15 degrees
- 0 degrees
- -15 degrees
- -30 degrees
- -45 degrees

LOCATION INDEX



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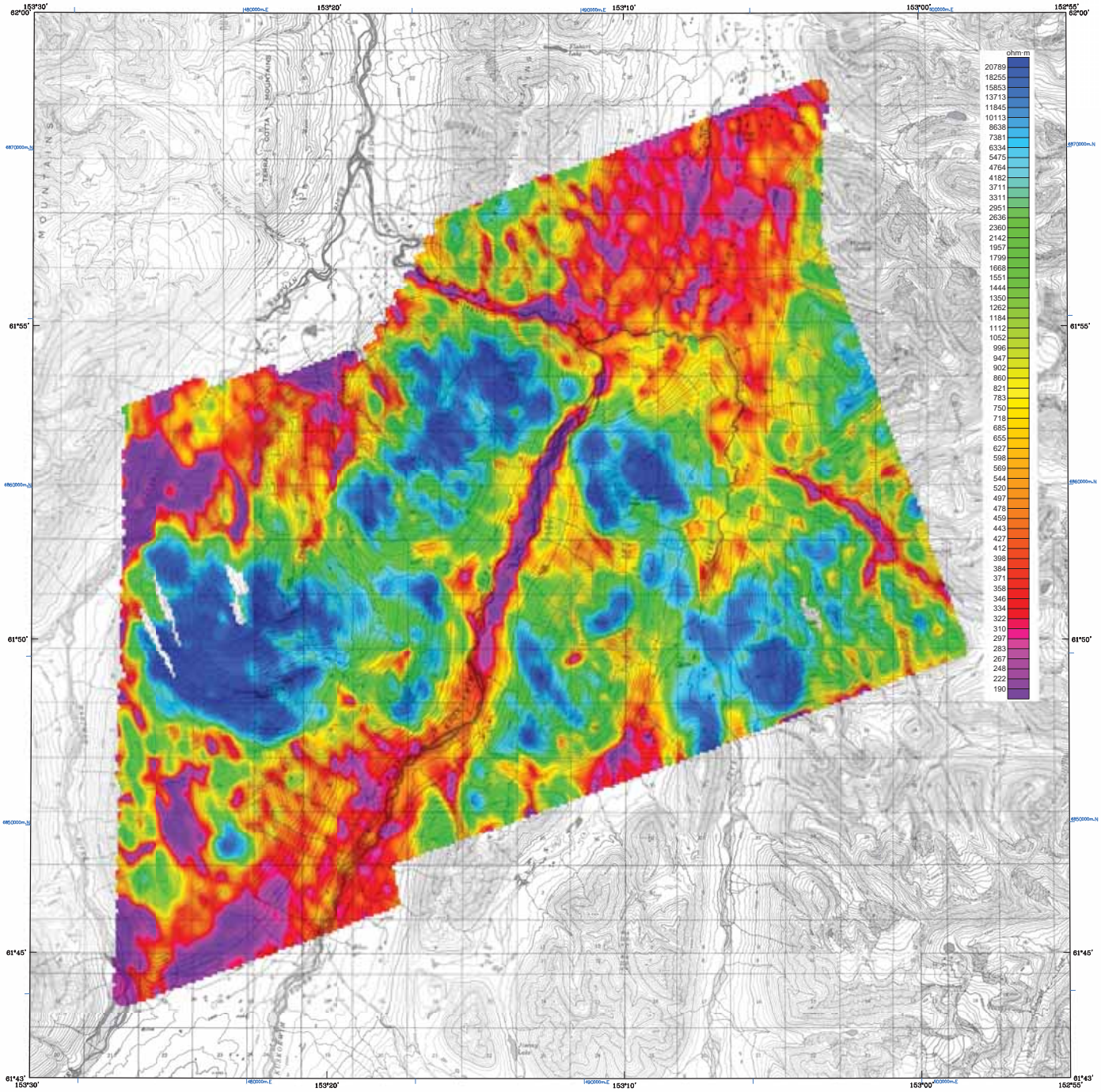

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SCALE 1:63,360

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CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

56,000 Hz COPLANAR APPARENT RESISTIVITY WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

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RESISTIVITY

The DIGHEM^{V} EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial coil-pairs operated at 1000 and 5500 Hz while three horizontal coplanar coil-pairs operated at 900, 7200 and 56,000 Hz. EM data were sampled at 0.1 second intervals. The EM system responds to bedrock conductors, conductive overburden, and cultural sources. Apparent resistivity is generated from the inphase and quadrature component of the coplanar 56,000 Hz using the pseudo-layer half space model. The data were interpolated onto a regular 80 m grid using a modified Akima (1970) technique. All grids were then resampled from the 80 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication.

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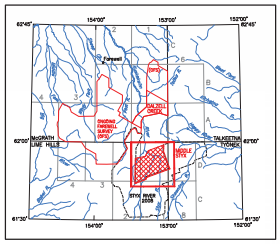
LOCATION INDEX



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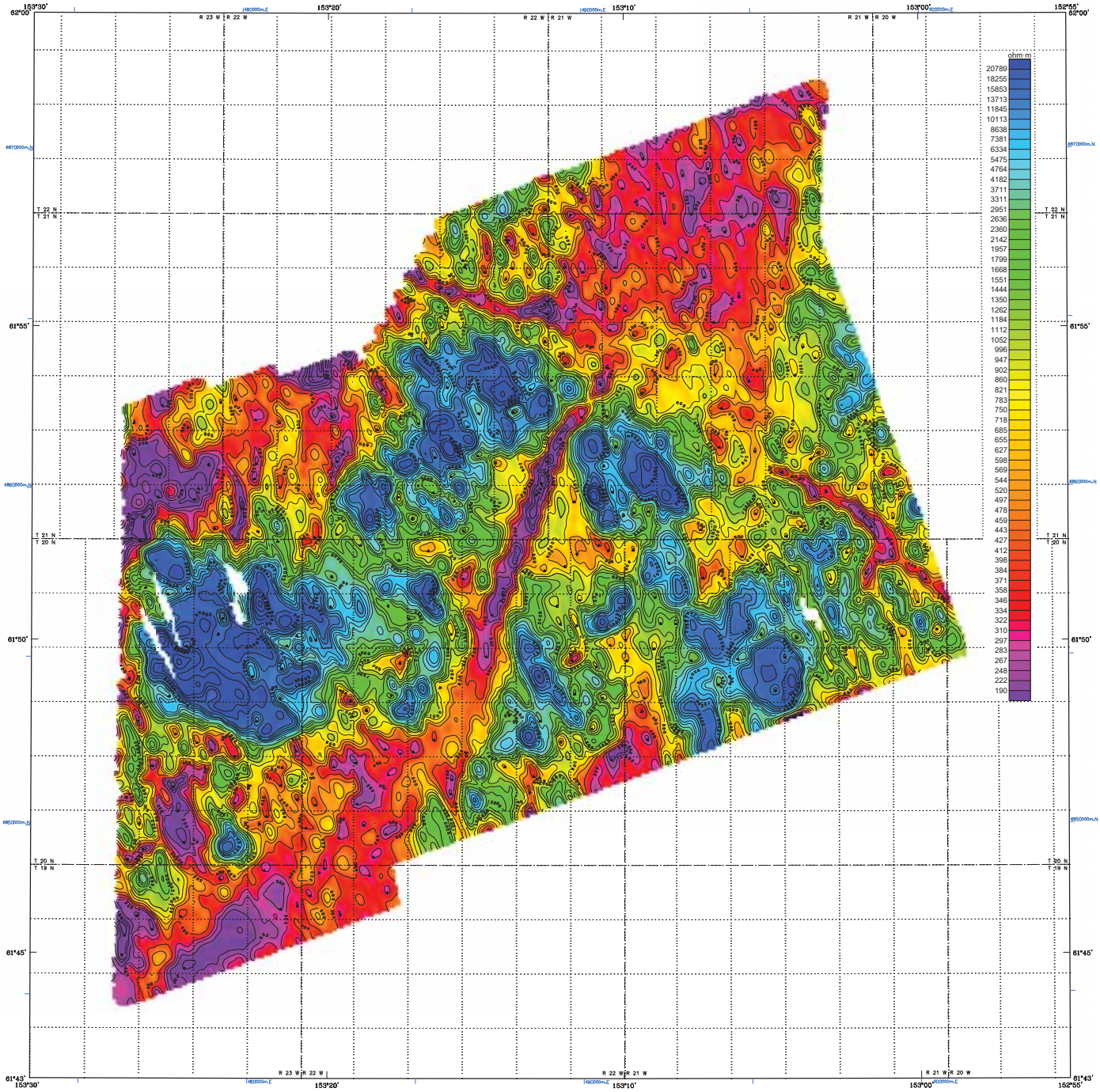

Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1972; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

56,000 Hz COPLANAR APPARENT RESISTIVITY AND DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

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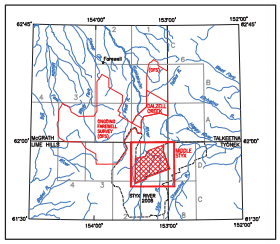

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RESISTIVITY CONTOURS

1000
800
600
500
400
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250
200
150
125
100

Contours in ohm-m at 10 intervals per decade

. . . . . resistivity low

SURVEY HISTORY

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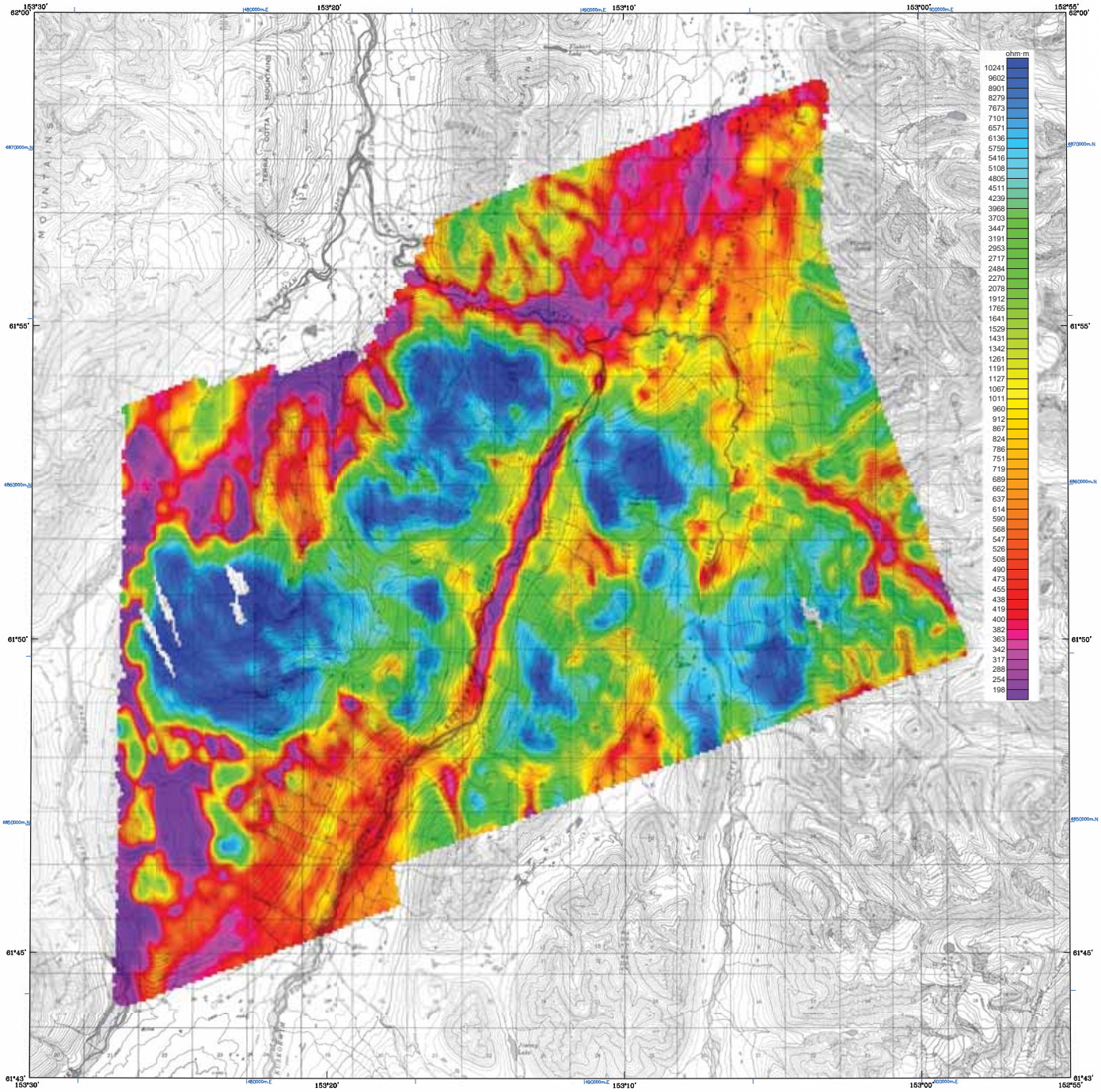

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SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

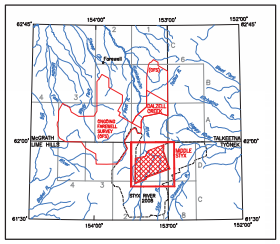
CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

7200 Hz COPLANAR APPARENT RESISTIVITY WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

LOCATION INDEX



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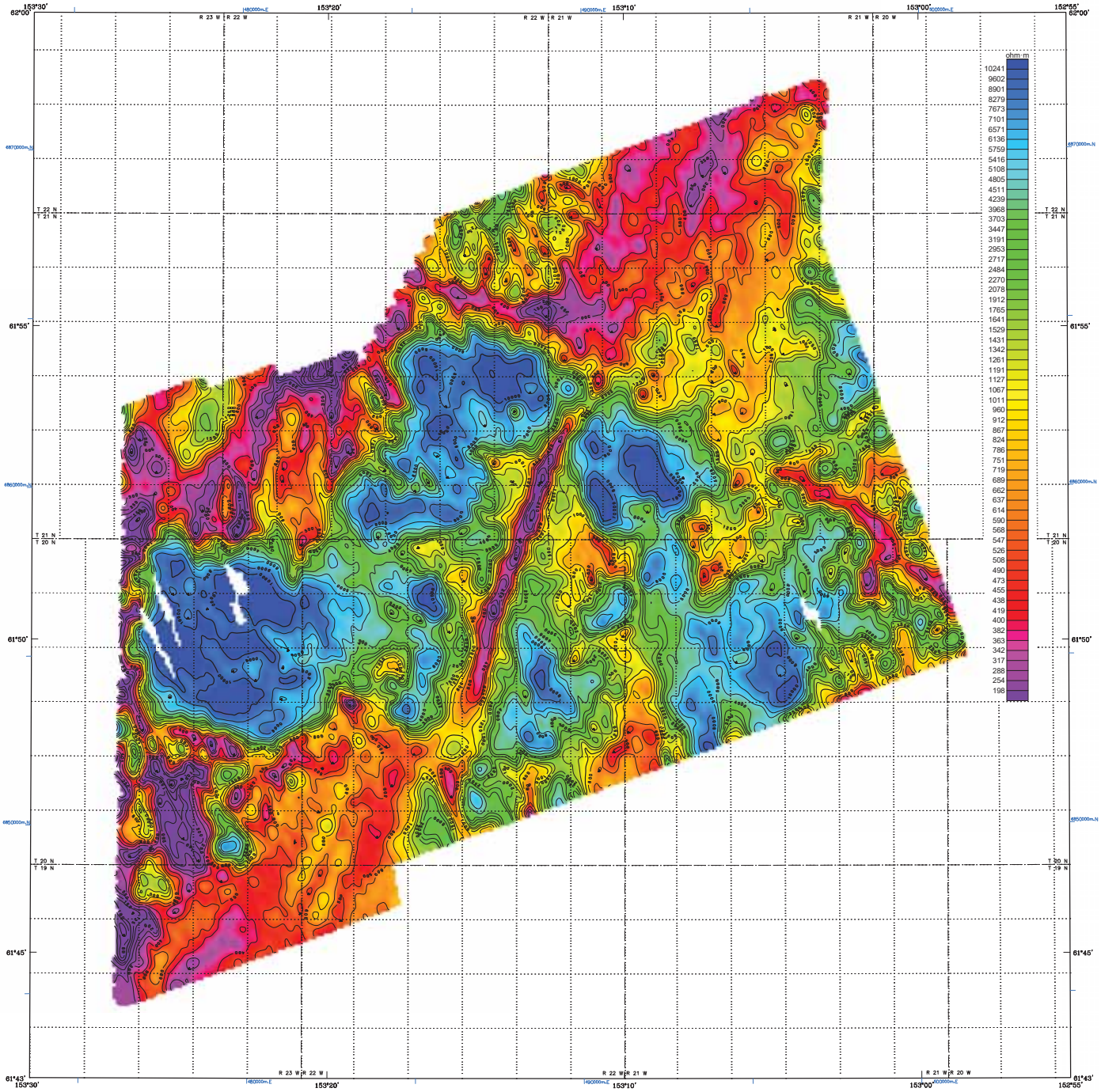

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1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

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2013

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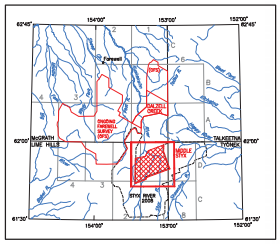

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1000
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Contours in ohm-m at 10 intervals per decade

. . . . . resistivity low

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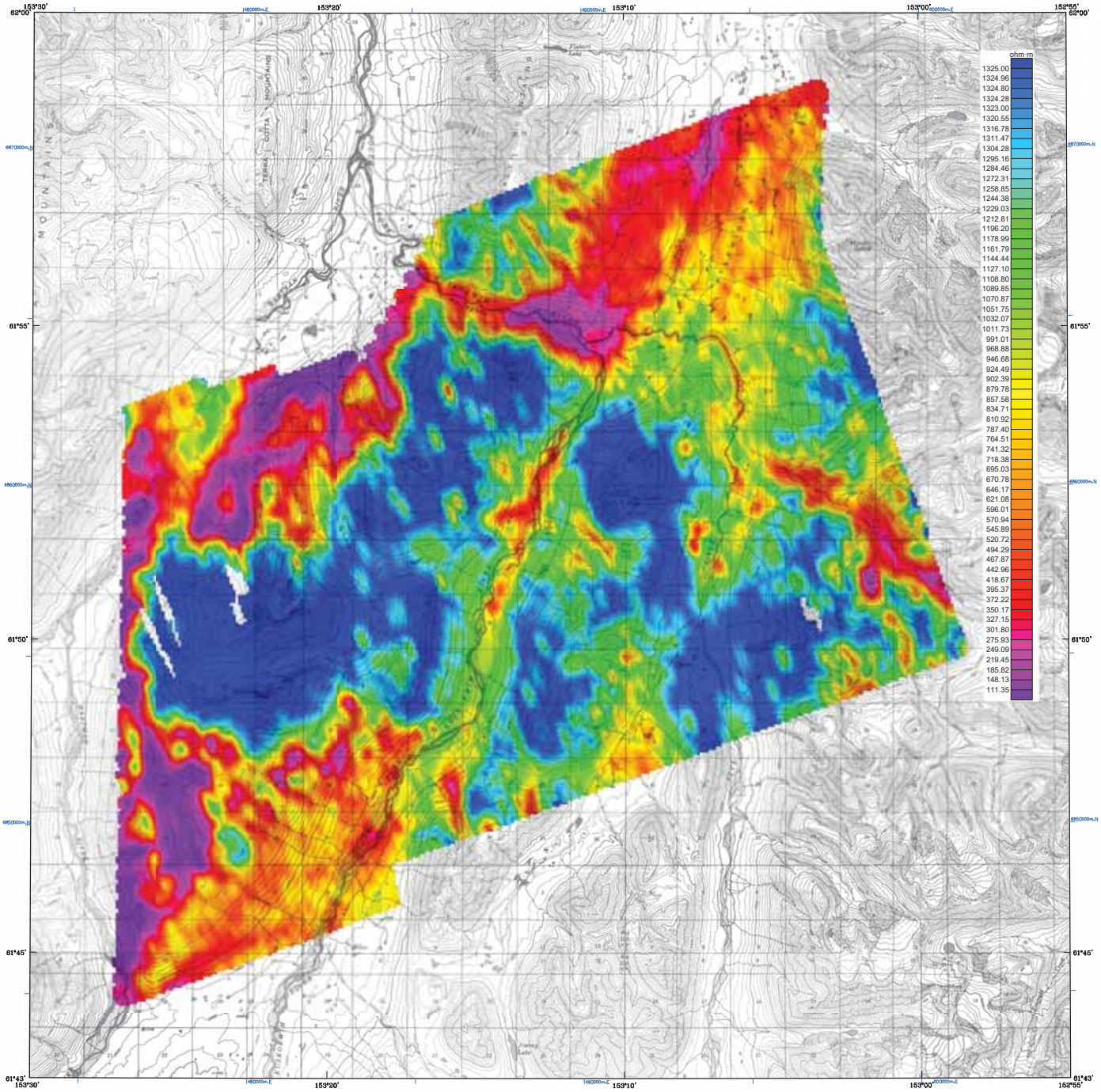

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SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

900 Hz COPLANAR APPARENT RESISTIVITY WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

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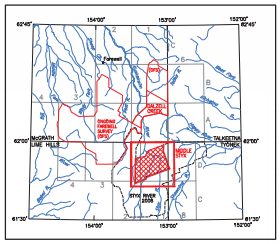

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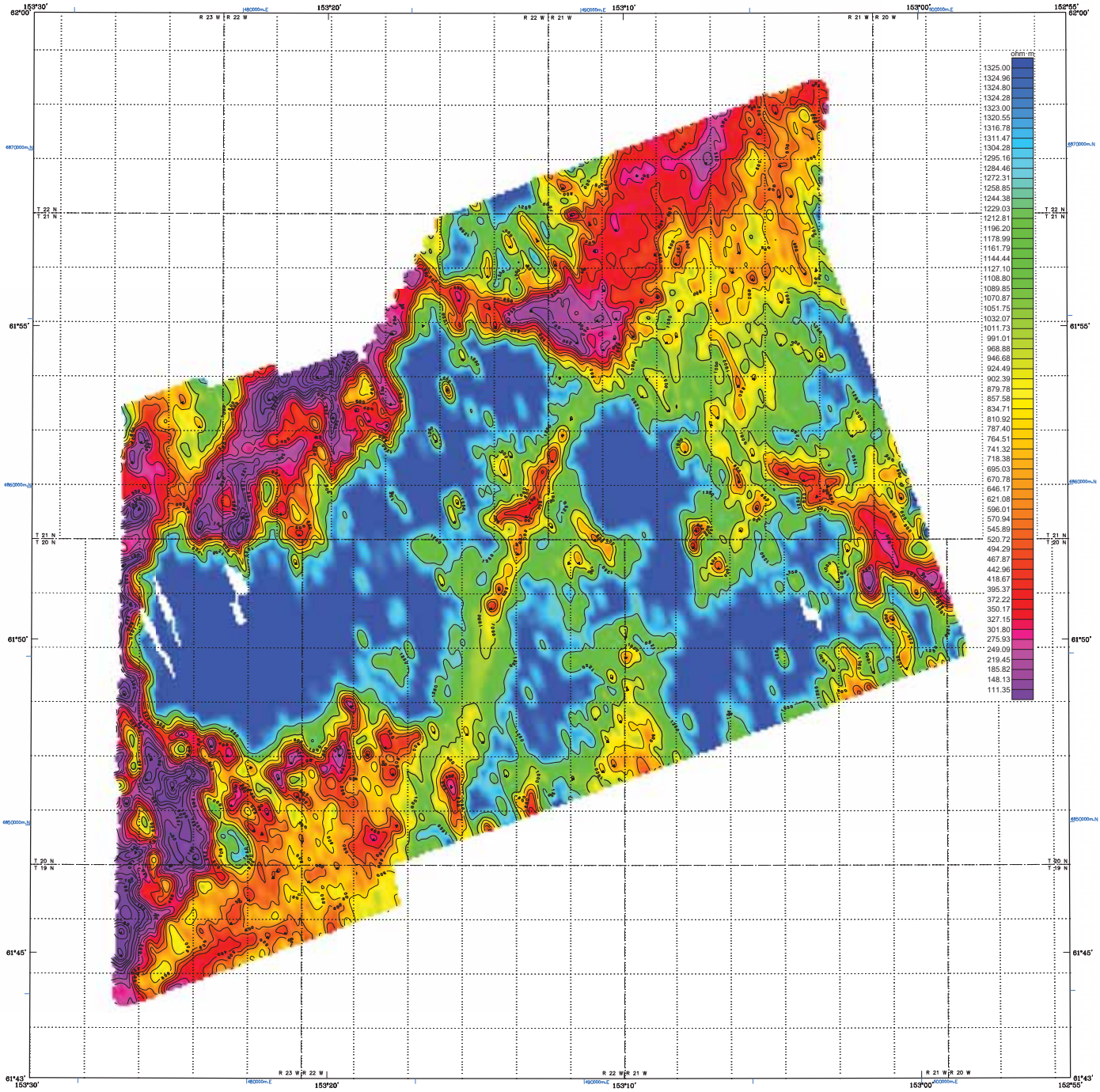

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SCALE 1:63,360

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PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by

Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.

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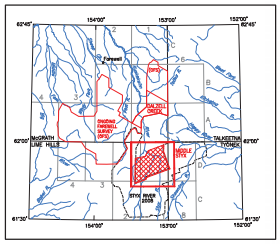

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Contours in ohm-m at 10 intervals per decade

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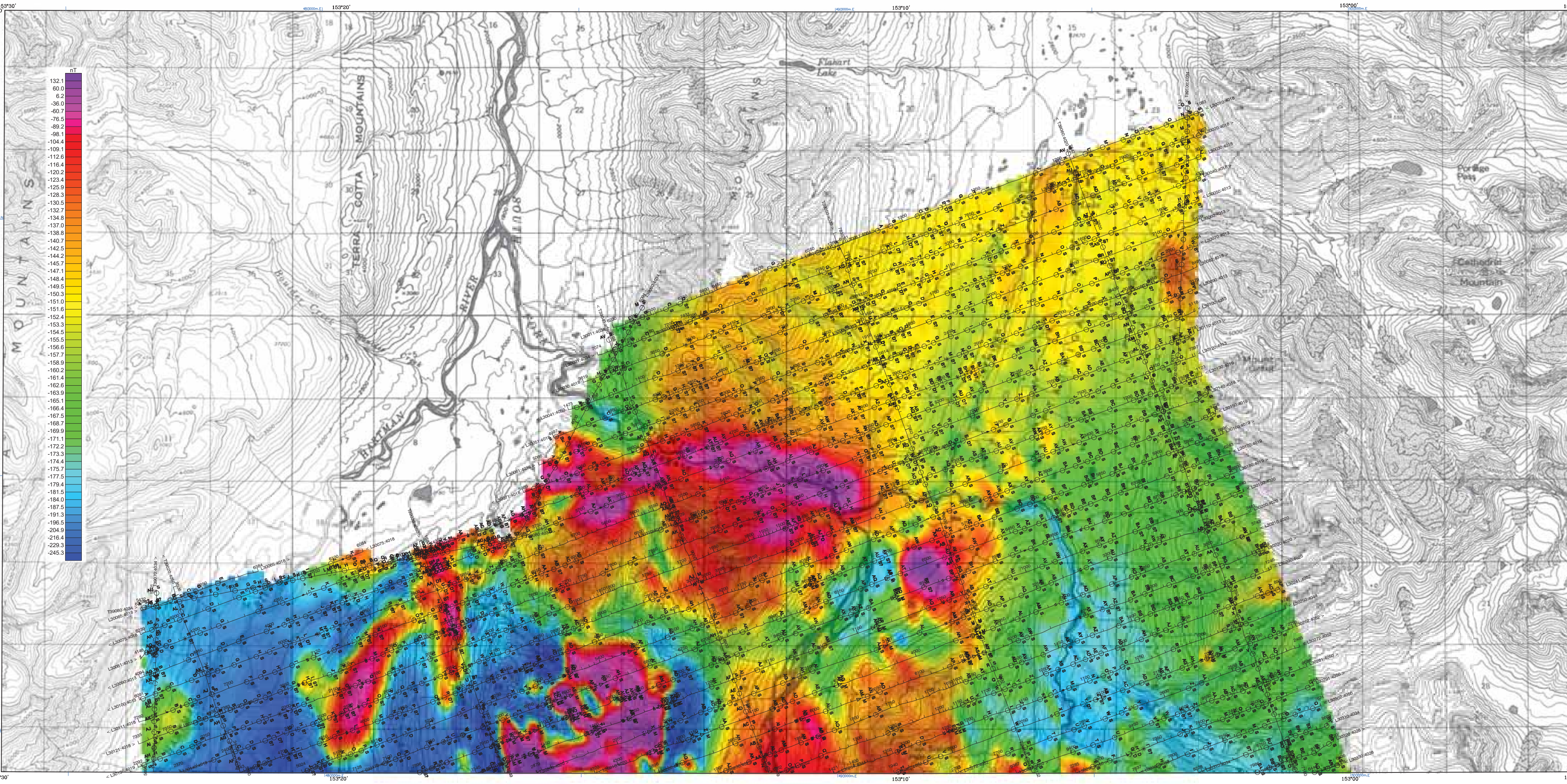
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

GEOPHYSICAL REPORT 2014-4-2i
PARTS of LIME HILLS D-1, D-2 and TYONEK D-8 QUADRANGLES



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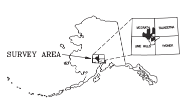
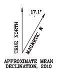




APPROXIMATE MEAN DECLINATION, 2010

SCALE 1:31,680

0.5 0 0.5 1 1.5 2 MILES

0.5 0 0.5 1 1.5 2 2.5 KILOMETERS

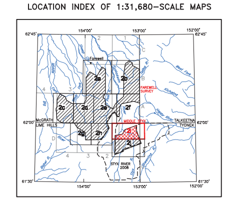
CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

RESIDUAL MAGNETIC FIELD AND DETAILED ELECTROMAGNETIC ANOMALIES WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, WESTERN ALASKA

PARTS of LIME HILLS D-1, D-2 and TYONEK D-8 QUADRANGLES

by
Laurel E. Burns, CGG, and Fugro GeoServices, Inc.
2014

LOCATION INDEX OF 1:31,680-SCALE MAPS



DESCRIPTIVE NOTES

The geophysical data were acquired with a DIGHEM^{V} Electromagnetic (EM) system, Radiation Solutions RS–500 gamma–ray spectrometer and a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. The EM and magnetic sensors were flown at a height of 100 feet. The gamma–ray spectrometer was flown at a height of 200 feet. In addition the survey recorded data from radar and laser altimeters, GPS navigation system, 50/60 Hz monitors and video camera. Flights were performed with an AS–350–B3 Squirrel helicopter at a mean terrain clearance of 200 feet along NE–SW (70°) survey flight lines with a spacing of a quarter of a mile. Tie lines were flown perpendicular to the flight lines at intervals of approximately 3 miles.

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ELECTROMAGNETIC ANOMALIES

Anomaly	Conductance
●	>100 siemens
◕	50–100 siemens
⊖	20–50 siemens
⊕	10–20 siemens
⊕	5–10 siemens
○	1–5 siemens
◌	< 1 siemens
✳	Questionable anomaly
△	EM magnetite response
□	Culture

F B
100
Arcs indicate the conductor has a thickness >10m
Dip direction
Magnetic correlation in nT

Anomaly identifier
C H
Interpretive symbol

Interpretive symbol	Conductor model
B	Bedrock conductor
D	Narrow bedrock conductor ("thin dike")
S	Conductive cover ("horizontal thin sheet")
H	Broad conductive rock unit, deep conductive weathering, thick conductive cover ("half–space")
E	Edge of broad conductor ("edge of half space")
L	Culture, e.g. power line, metal building or fence
M	Magnetite
"?"	Indicates some uncertainty as to the most appropriate EM source model, but does not question the validity of the EM anomaly.

ELECTROMAGNETICS

To determine the location of EM anomalies or their boundaries, the DIGHEM^{V} EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial–coil pairs operated at 1000 and 5500 Hz while three horizontal coplanar–coil pairs operated at 900, 7200, and 56,000 Hz. EM data were sampled at 0.1 second intervals. The EM system responds to bedrock conductors, conductive overburden, and cultural sources. The type of conductor is indicated on the aeromagnetic map by the interpretive symbol attached to each EM anomaly. Determination of the type of conductor is based on EM anomaly shapes of the coaxial– and coplanar–coil responses, together with conductor and magnetic patterns and topography. The power line monitor and the flight track video were examined to locate cultural sources.

RESIDUAL MAGNETIC FIELD

The magnetic total field data were processed using digitally recorded data from a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. Data were collected at a sampling interval of 0.1 seconds. The magnetic data were (1) corrected for diurnal variations by subtraction of the digitally recorded base station magnetic data, (2) IGRF corrected (IGRF model 2010, updated for date of flight and altimeter variations), (3) leveled to the tie line data, and (4) interpolated onto a regular 80 m grid using a modified Akima (1970) technique. All grids were then resampled from the 80 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication.

Akima, H., 1970, A new method of interpolation and smooth curve fitting based on local procedures: Journal of the Association of Computing Machinery, v. 17, no. 4, p. 589–602.

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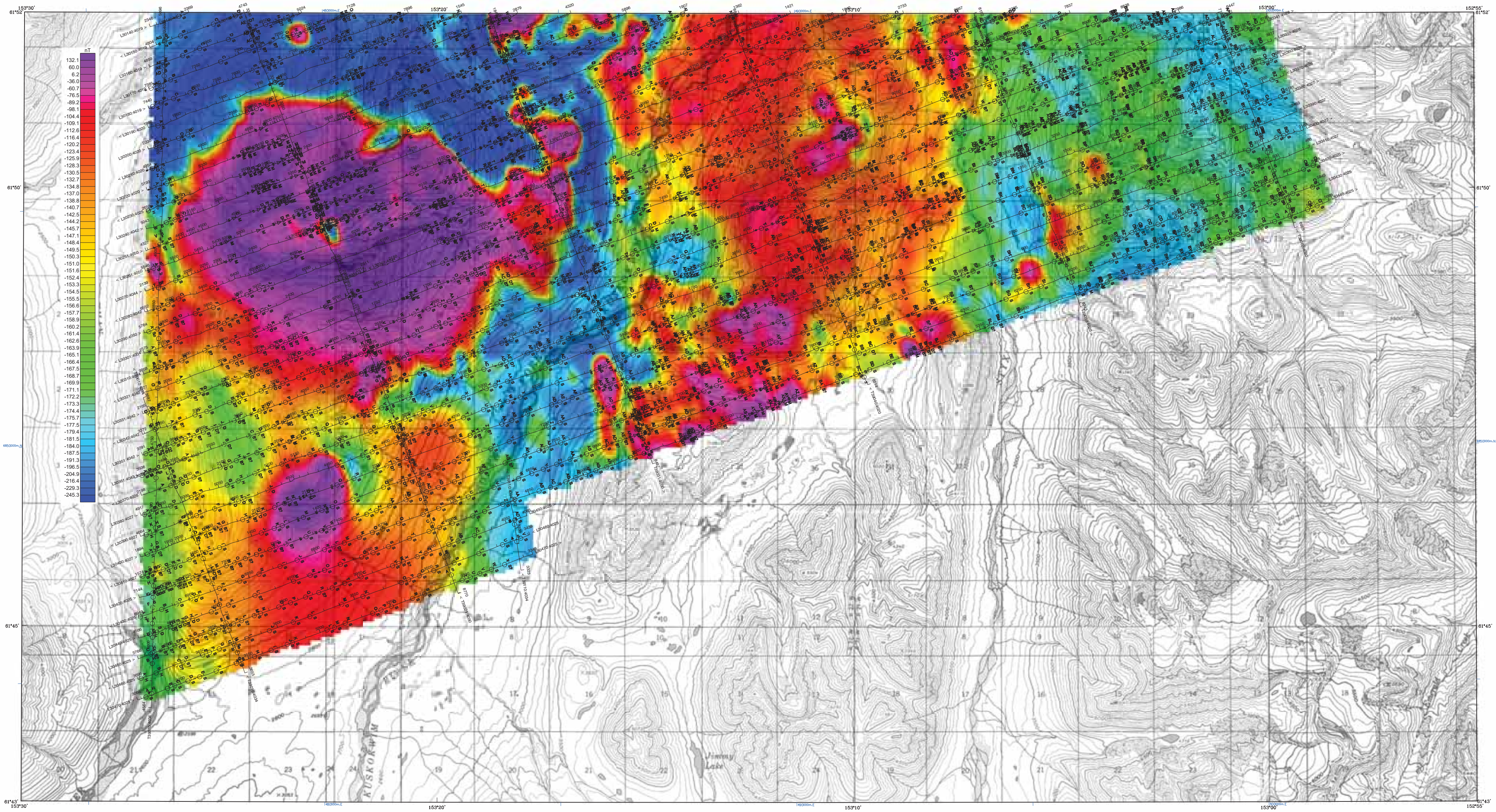


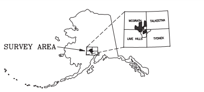
Base from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; McGrath D-2, 1977; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska

SCALE 1:31,680

0.5 0 0.5 1 1.5 2 MILES

0.5 0 0.5 1 1.5 2 2.5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL



APPROXIMATE MEAN DECLINATION, 2010

RESIDUAL MAGNETIC FIELD AND DETAILED ELECTROMAGNETIC ANOMALIES WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, WESTERN ALASKA

PARTS of LIME HILLS C-1, C-2, D-1, D-2, TYONEK C-8 and D-8 QUADRANGLES

by
Laurel E. Burns, CGG, and Fugro GeoServices, Inc.
2014

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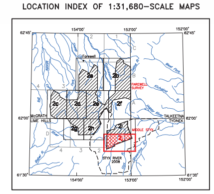

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Arcs indicate the conductor has a thickness >10m
Dip direction
Magnetic correlation in nT

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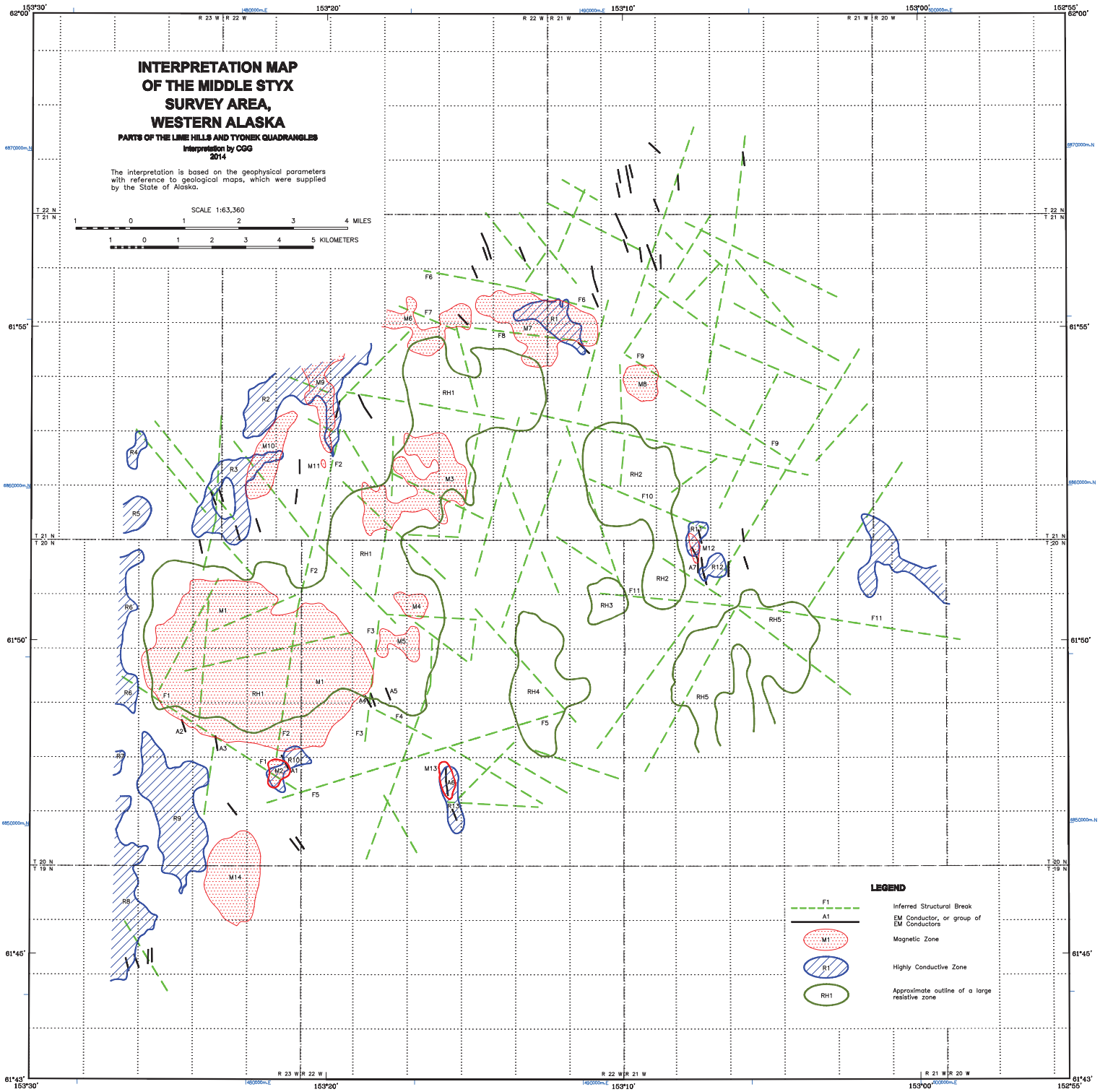
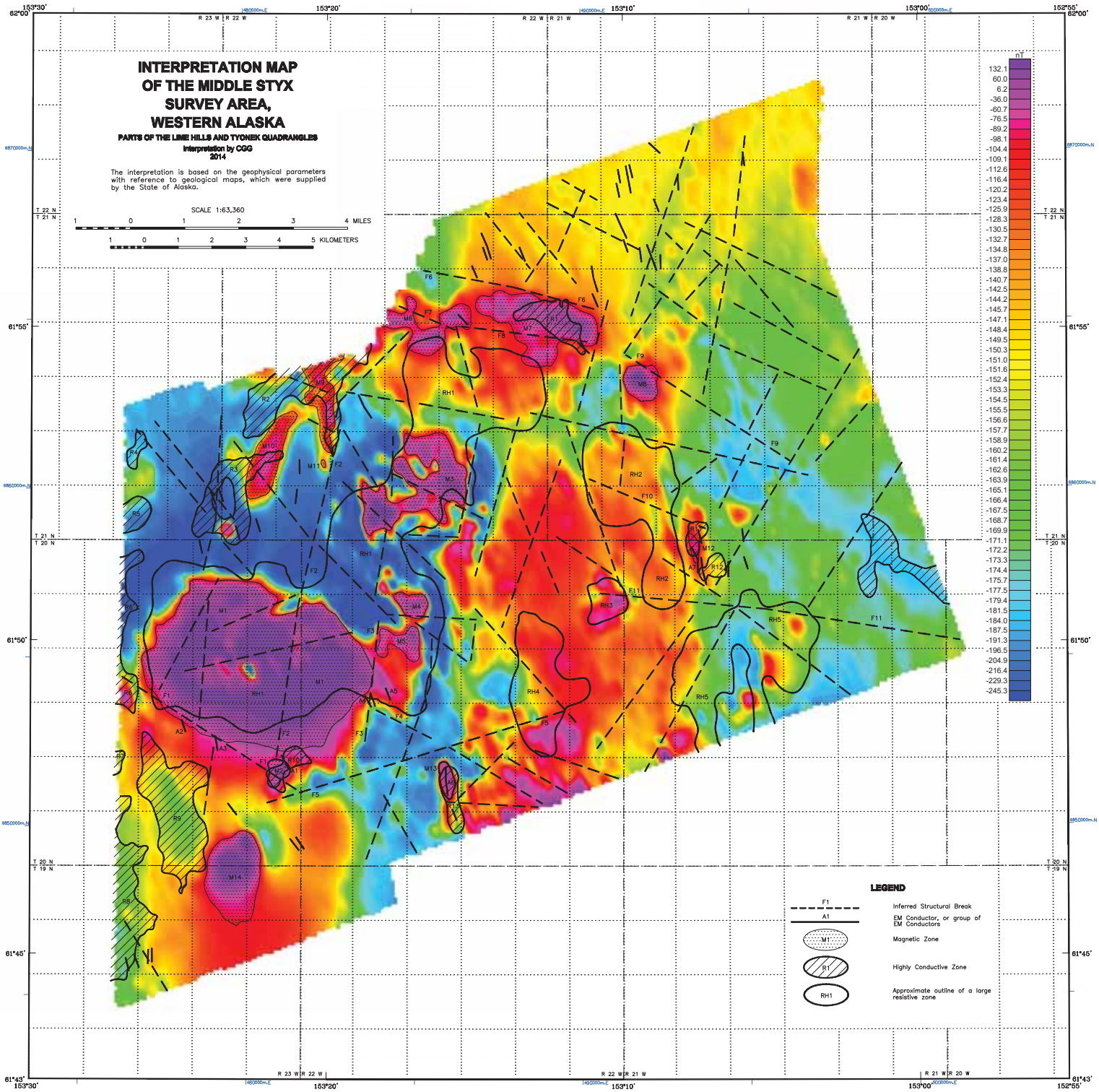

INTERPRETATION MAP
OF THE MIDDLE STYX
SURVEY AREA,
WESTERN ALASKA
PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES
Interpretation by CGG
2014
The interpretation is based on the geophysical parameters with reference to geological maps, which were supplied by the State of Alaska.
SCALE 1:63,360
1 0 1 2 3 4 MILES
1 0 1 2 3 4 5 KILOMETERS
LEGEND
F1 Inferred Structural Break
A1 EM Conductor, or group of EM Conductors
M1 Magnetic Zone
R1 Highly Conductive Zone
RH1 Approximate outline of a large resistive zone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4 MILES
5 KILOMETERS
nT
LEGEND
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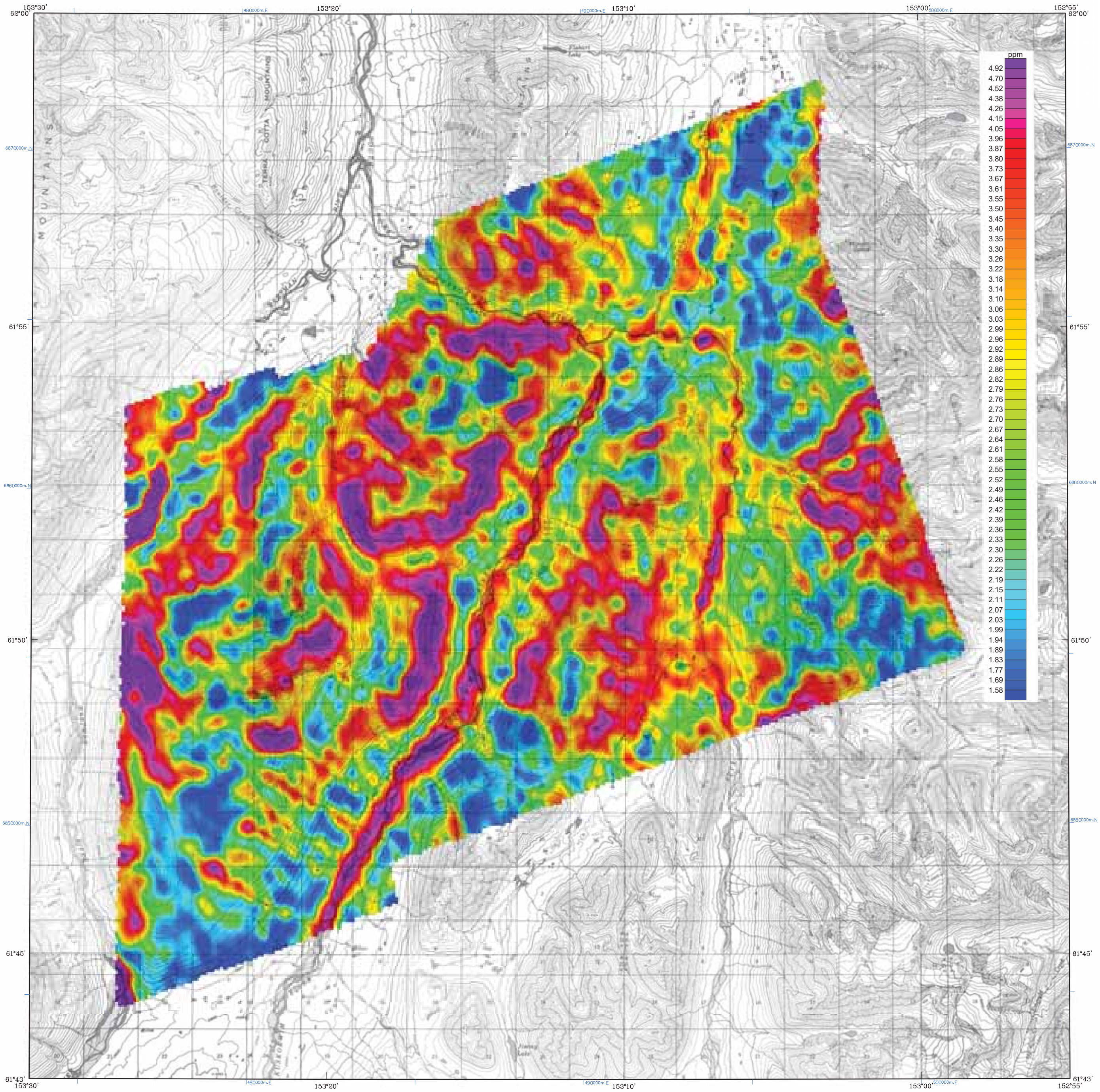
Approximate outline of a large resistive zone



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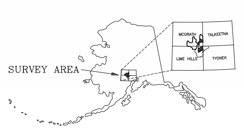
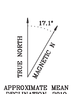


SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL



APPROXIMATE MEAN DECLINATION, 2010

THORIUM (eTH) WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

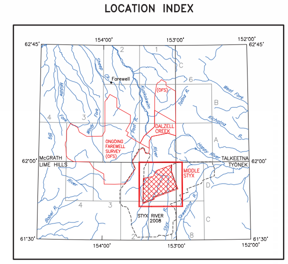
PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by

Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.

2013

LOCATION INDEX



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The gamma–ray spectrometry data were recorded at a 1.0 second sample rate using a Radiation Solutions RS–500 gamma–ray spectrometer. It was configured with 16.8L (1024 cubic inches) of main (downward) NaI crystal detector, and 4.2L (256 cubic inches) of upward looking (radon) detector. After application of Noise Adjusted Singular Value Decomposition to the spectra, counts from the main detector were recorded in five windows corresponding to thorium (2410–2810 keV), uranium (1660–1860 keV), potassium (1370–1570 keV), total radioactivity (400–2815 keV) and cosmic radiation (3000–>6000 keV). Counts from the radon detector were recorded in the radon window (1660–1860 keV). The radon detection system was calibrated following methods outlined in IAEA Report 323. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 200 feet. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique. All grids were then resampled from the 100 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication.

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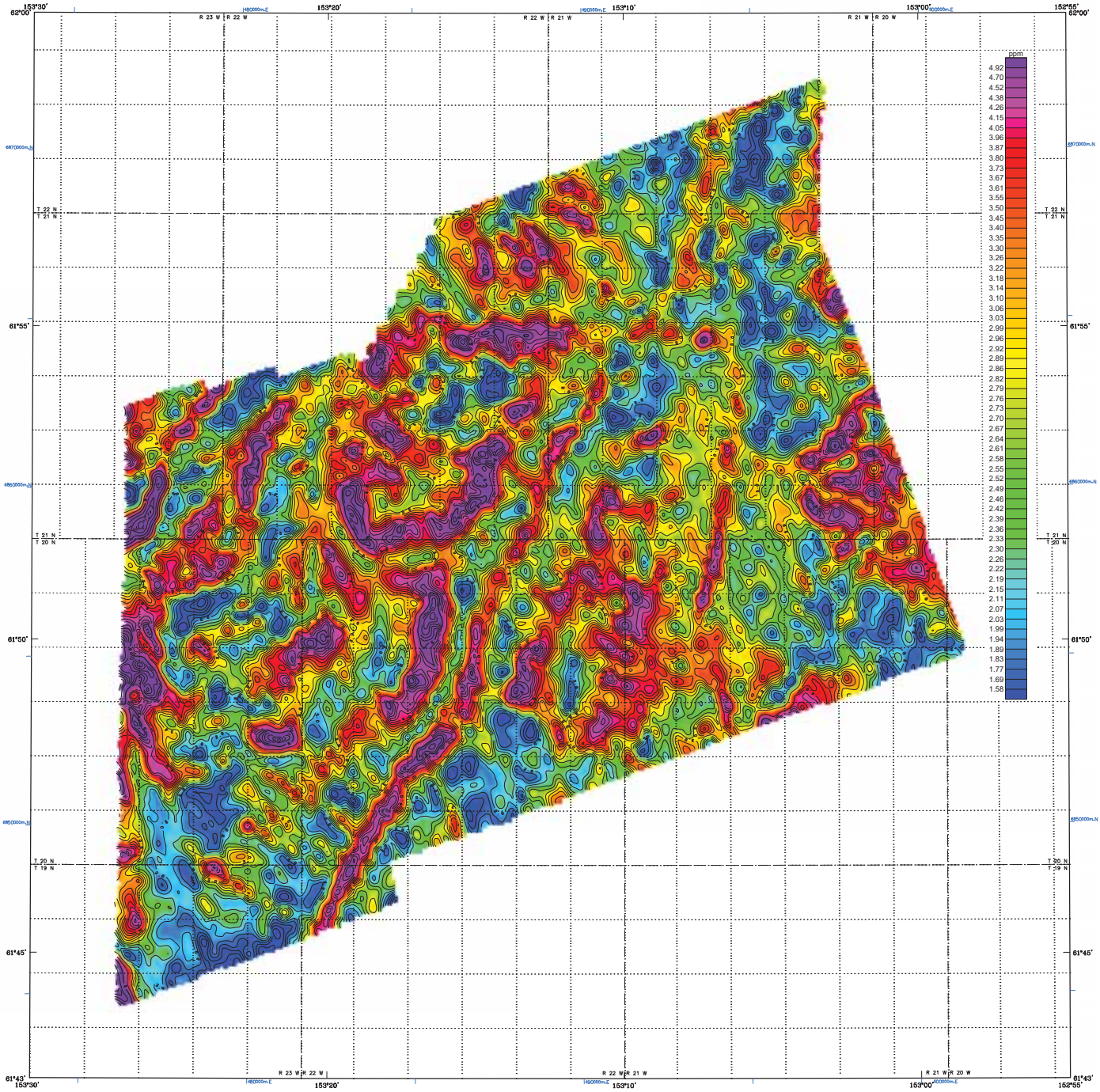

Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1972; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

THORIUM (eTH) AND DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

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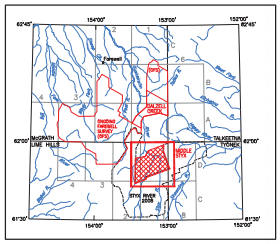
CONTOUR INTERVAL

_____ . . . . . 5.0 ppm

_____ . . . . . 1.0 ppm

_____ . . . . . 0.2 ppm

LOCATION INDEX



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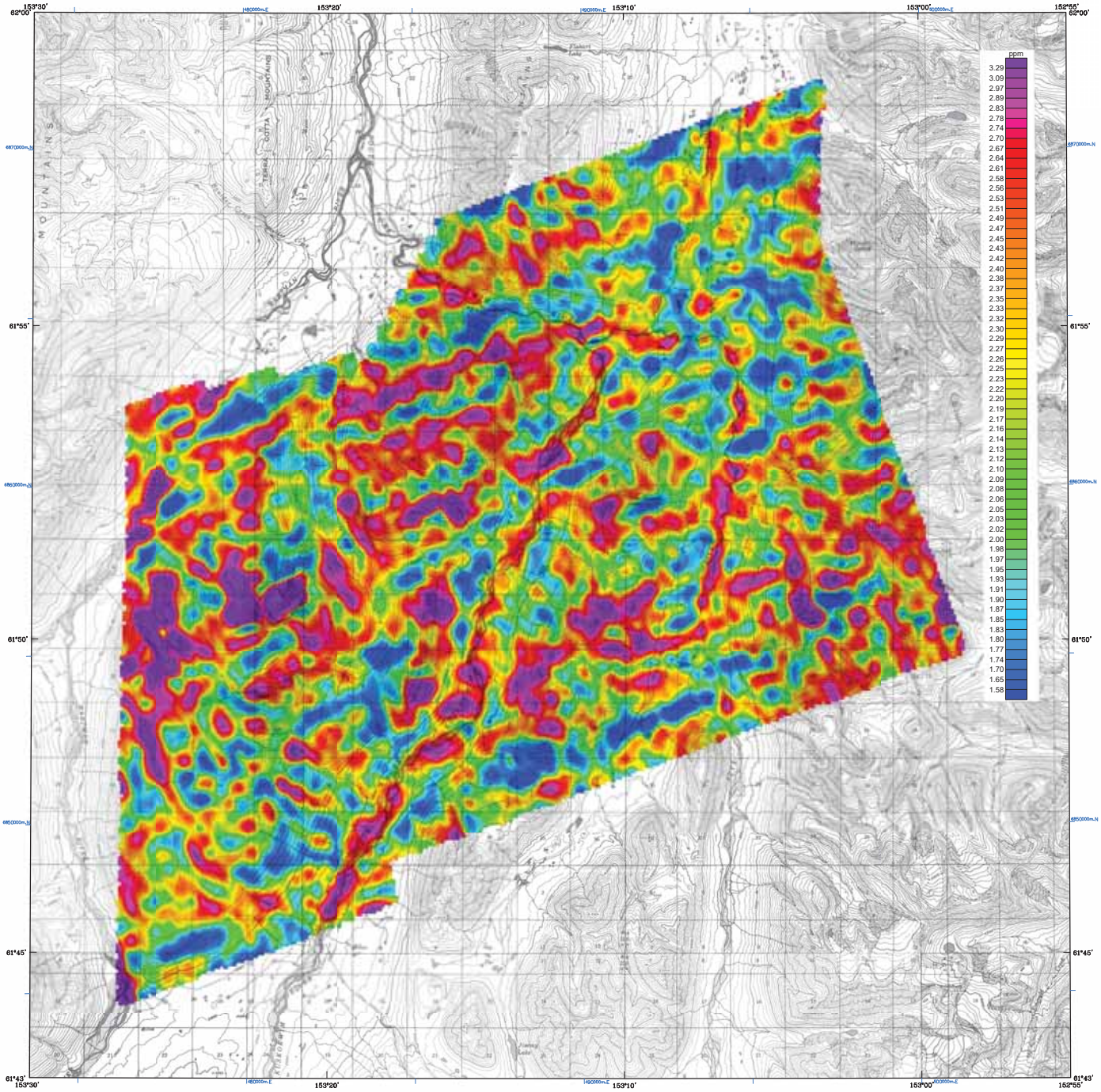

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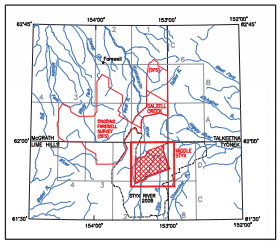

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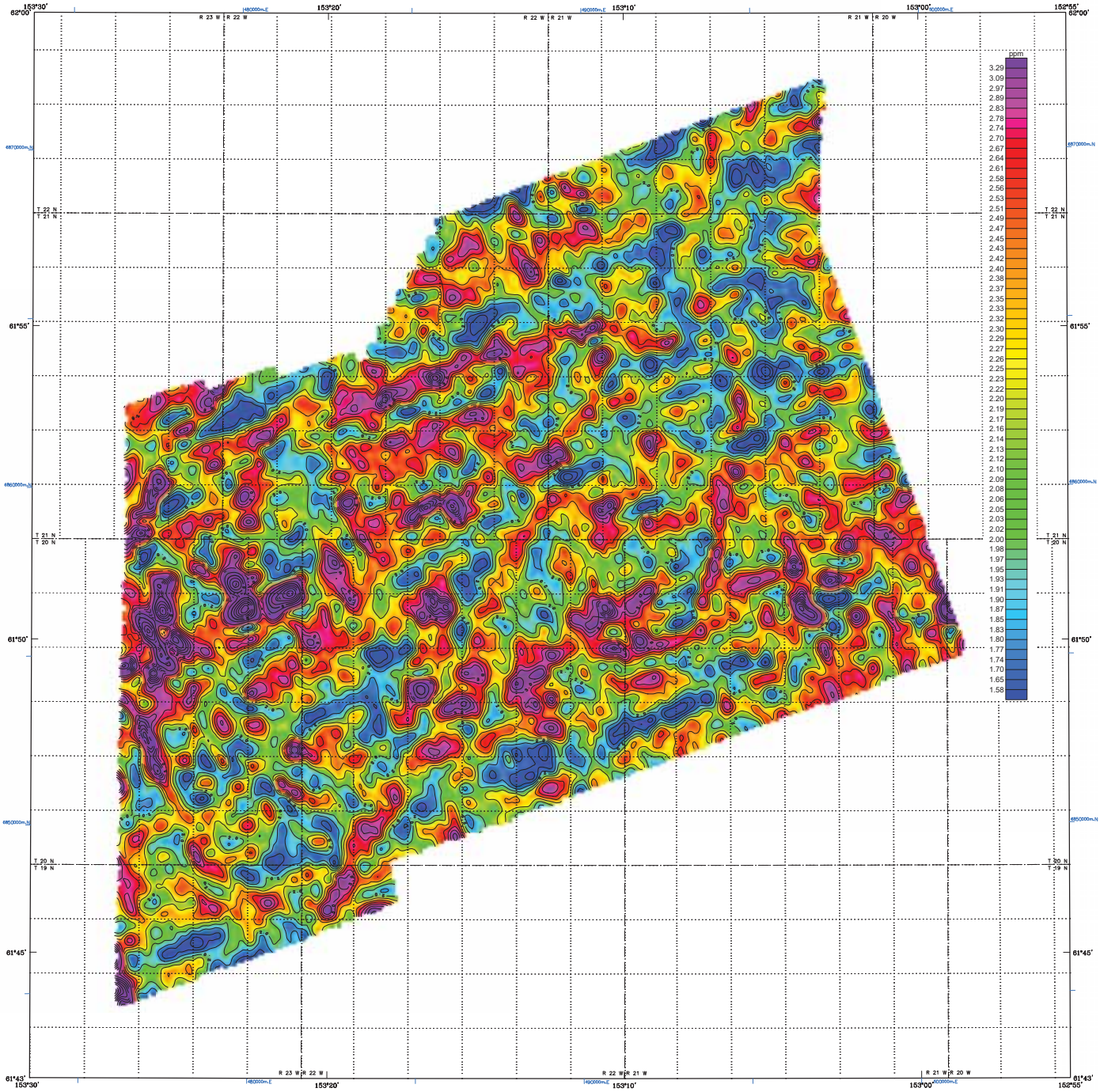

Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1972; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

URANIUM (eU) AND DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

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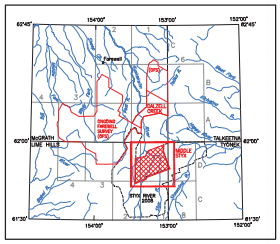

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CONTOUR INTERVAL

_____ . . . . . 5.0 ppm

_____ . . . . . 1.0 ppm

_____ . . . . . 0.2 ppm

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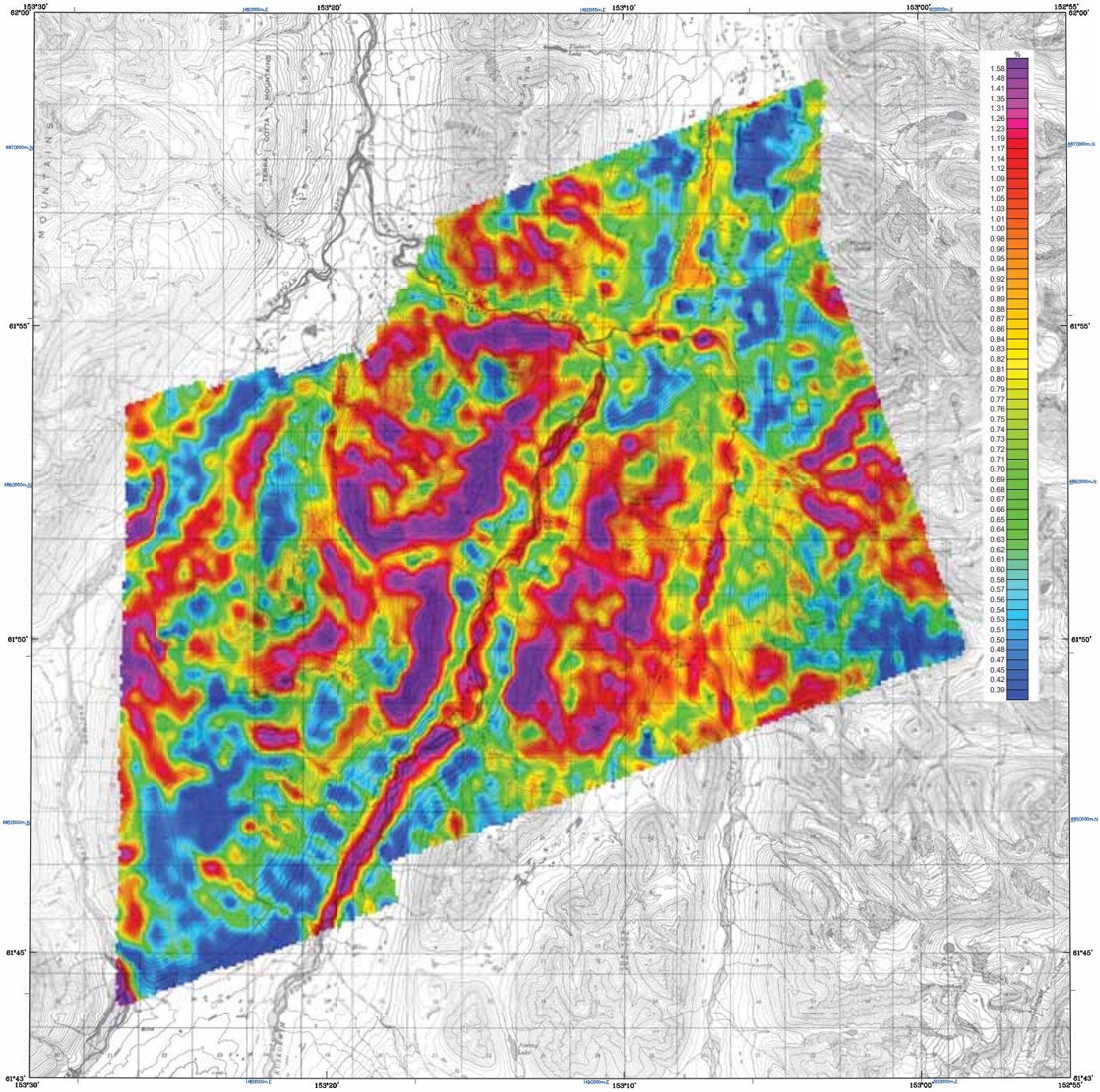

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SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

POTASSIUM (K%) WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

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by
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2013

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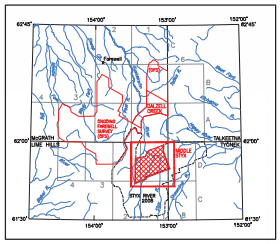

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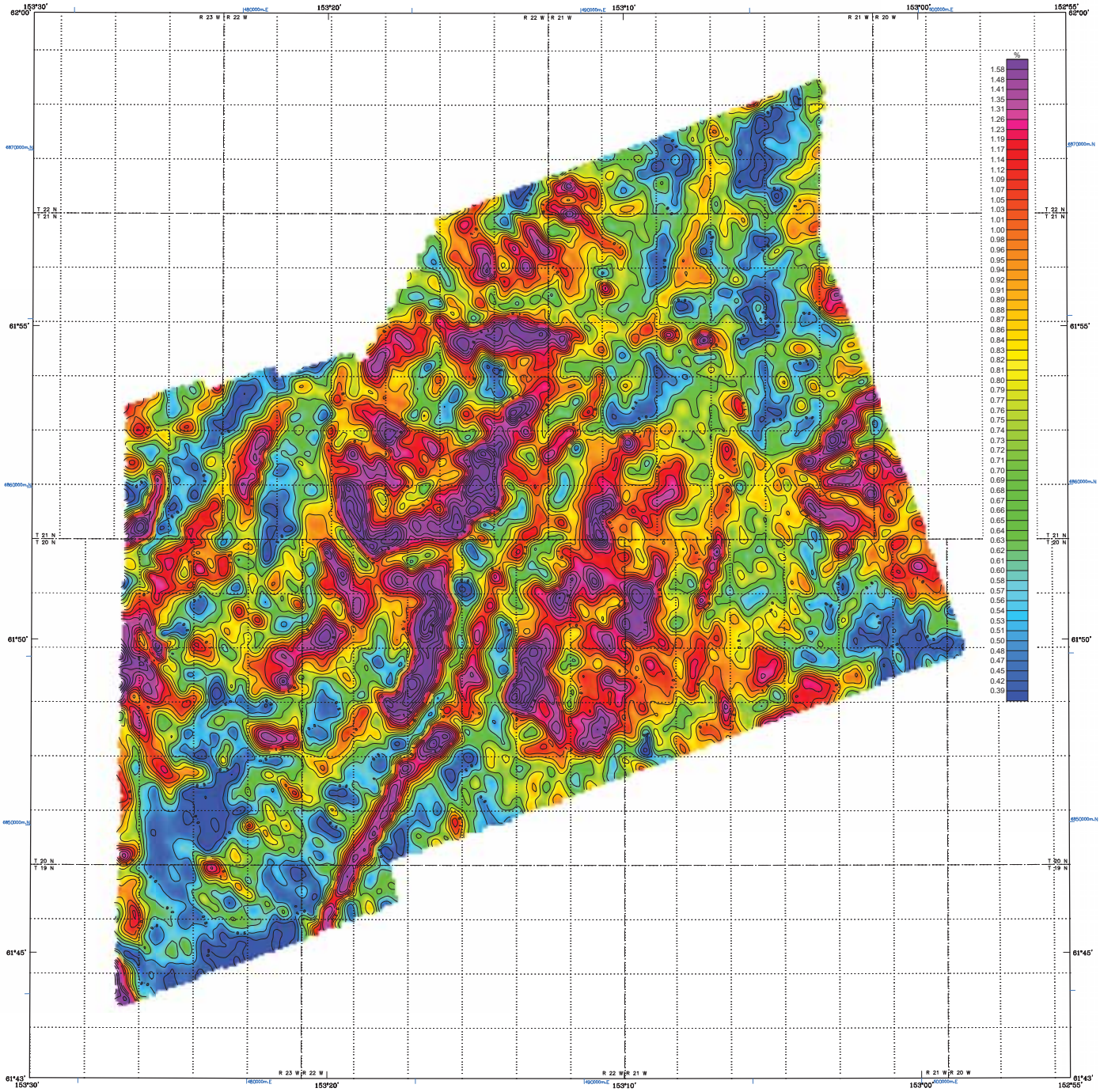

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1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

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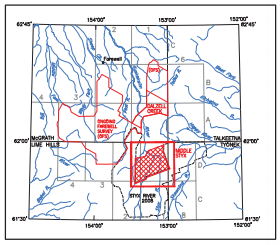
CONTOUR INTERVAL

.....	2.50 %
.....	0.50 %
.....	0.10 %

LOCATION INDEX



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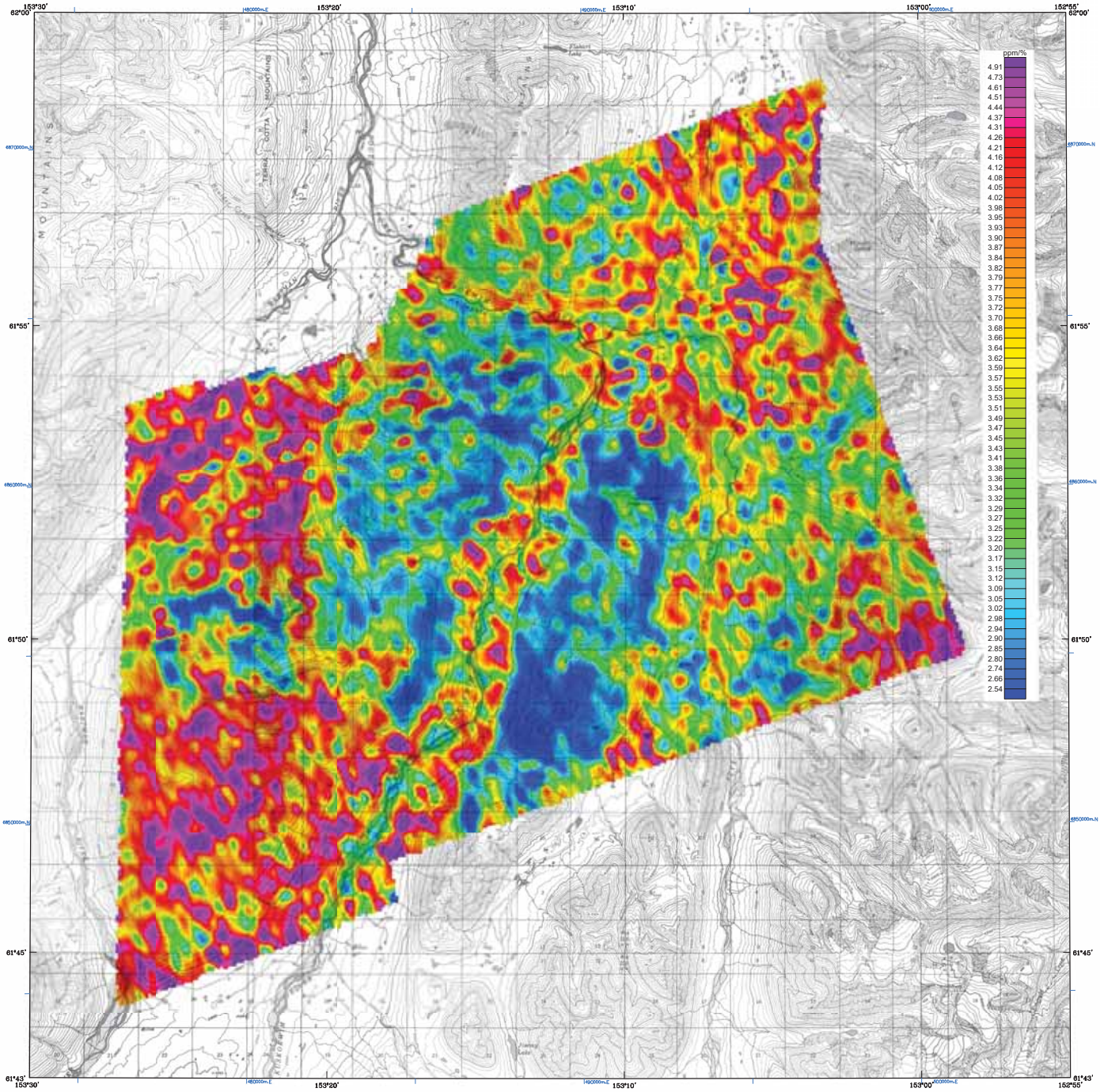

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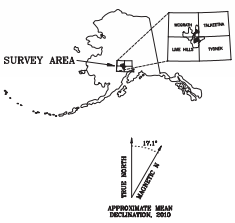
1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL



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A blank region indicates an area where the summed concentrations fall below thresholds required for a meaningful calculation of the ratio.

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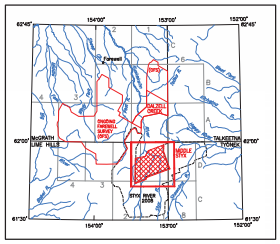

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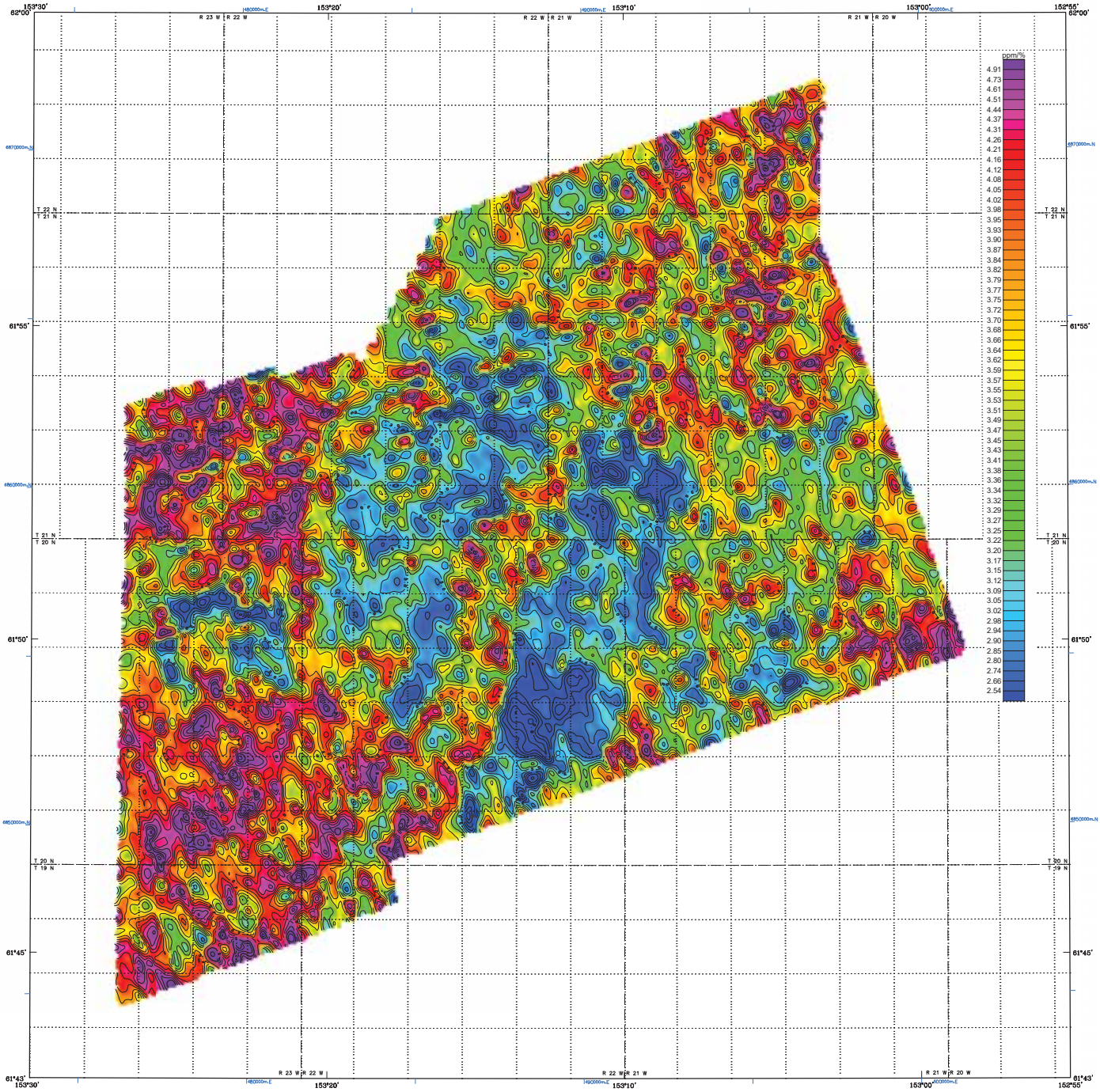

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APPROXIMATE MEAN DECLINATION, 2010

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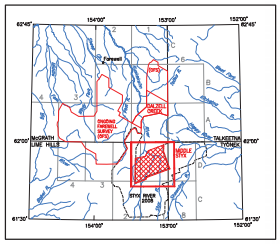

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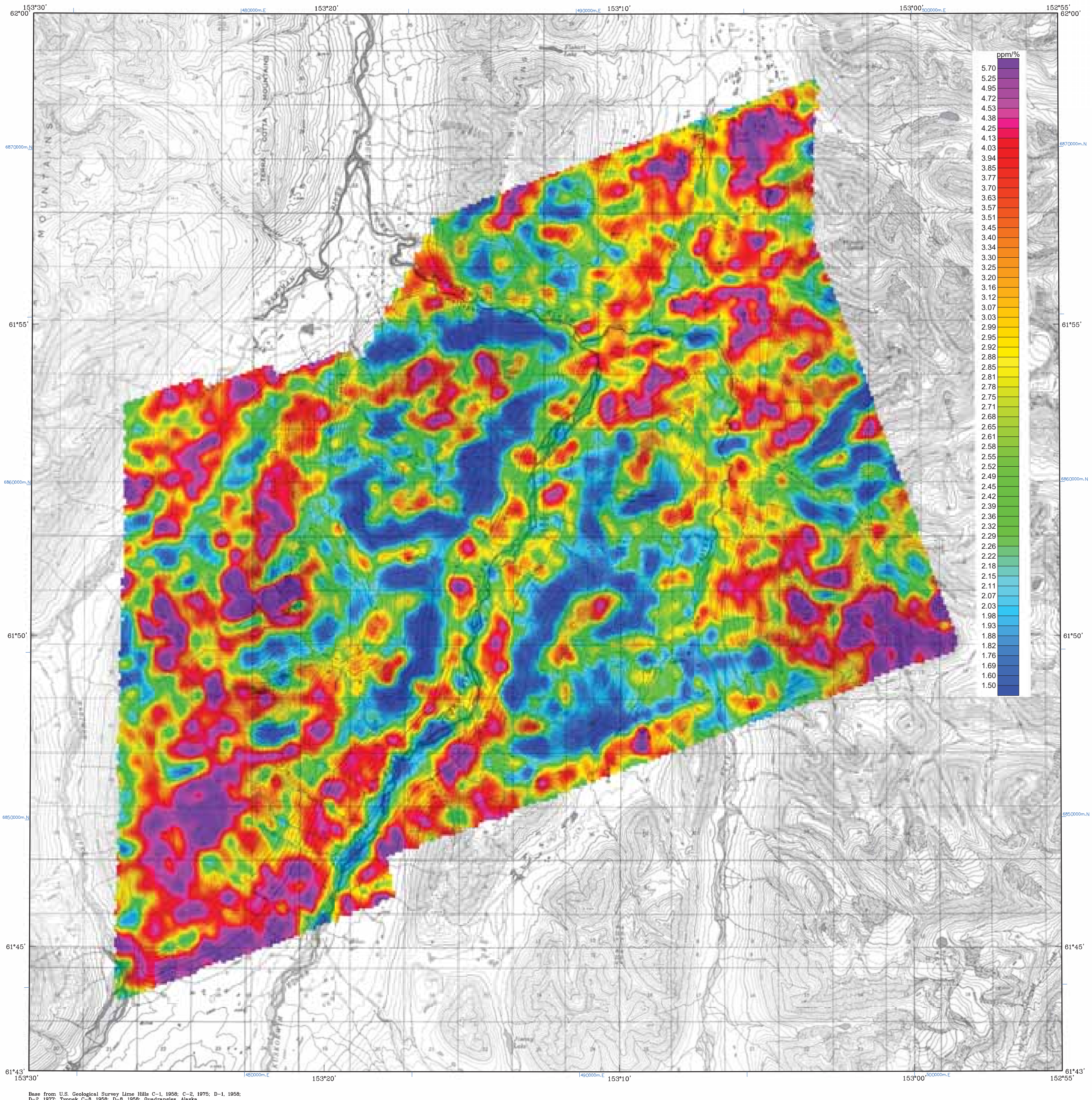

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1 0 1 2 3 4 MILES

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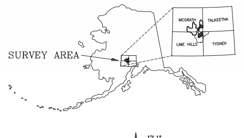
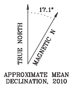
DATUM MEAN SEA LEVEL





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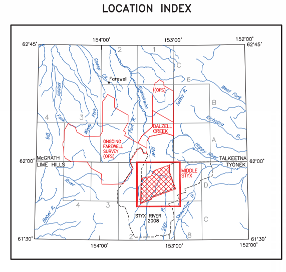

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International Atomic Energy Agency, 1991, Airborne Gamma Ray Spectrometer Surveying. Technical Report 323, International Atomic Energy Agency, Vienna.

URANIUM / POTASSIUM (eU/K)

Measured radioelement concentrations for uranium and potassium will vary sympathetically with variations in soil thickness and moisture content. The ratio parameter isolates areas of enrichment of one radioelement relative to another.
A blank region indicates an area where the summed concentrations fall below thresholds required for a meaningful calculation of the ratio.

SURVEY HISTORY

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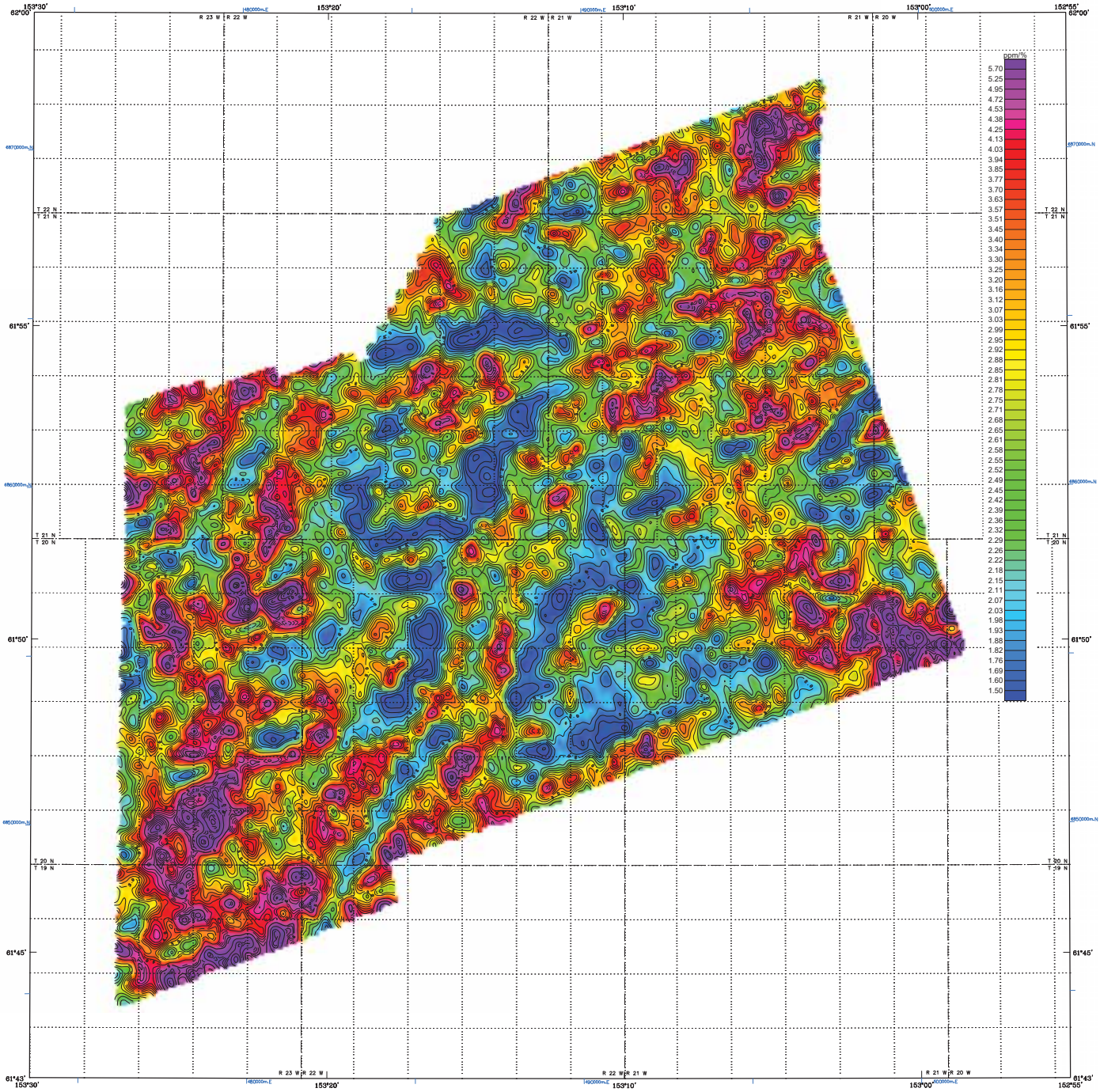


Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1972; Tyonek C-6, 1958; D-6, 1958; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

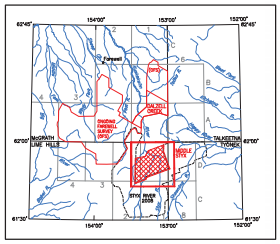
APPROXIMATE MEAN DECLINATION, 2010

URANIUM / POTASSIUM (eU/K) AND DATA CONTOURS OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

LOCATION INDEX



DESCRIPTIVE NOTES

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CONTOUR INTERVAL

_____	. . . . . 5.0 ppm/%
_____	. . . . . 1.0 ppm/%
_____	. . . . . 0.2 ppm/%

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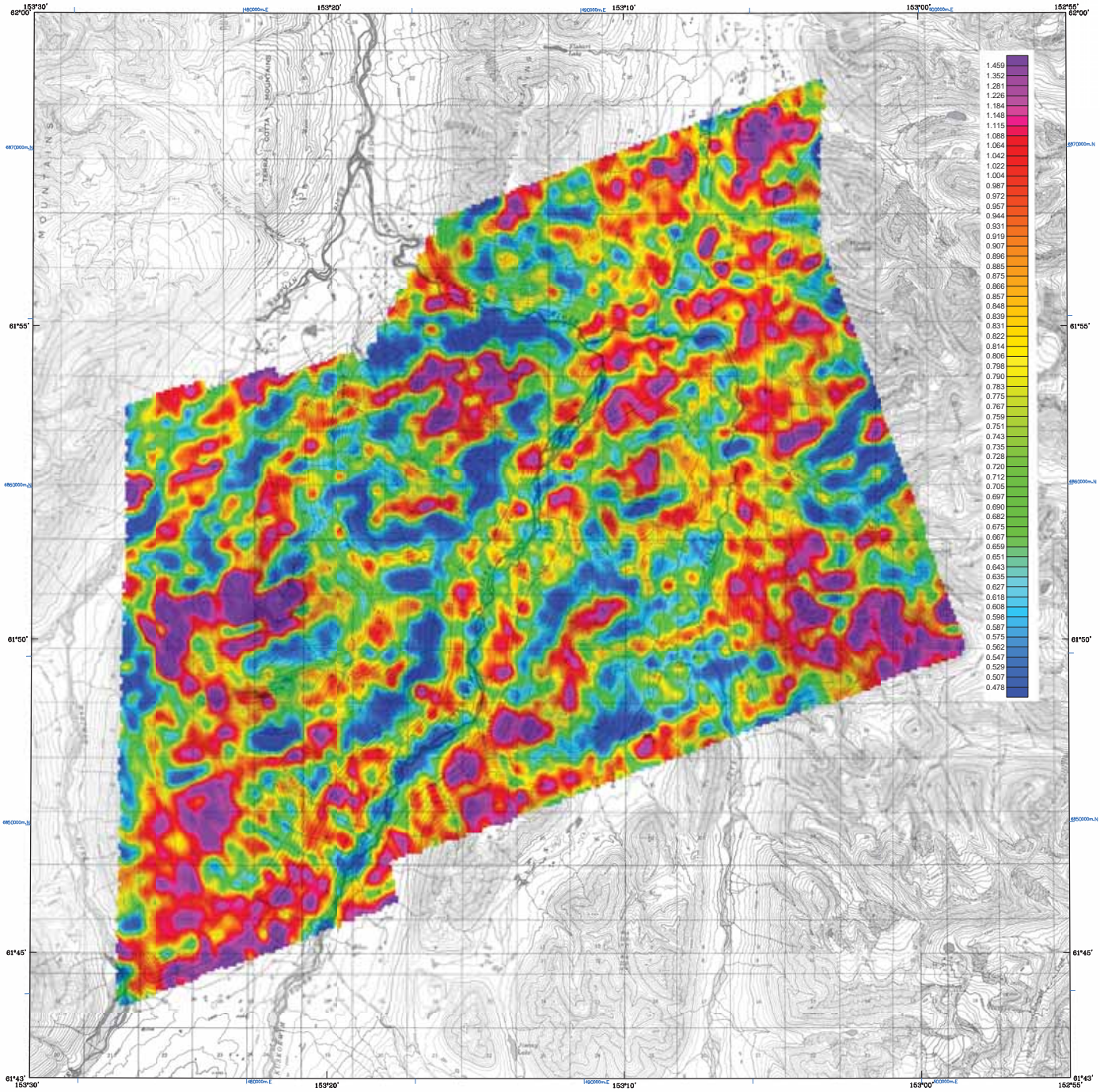

Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-5, 1956; D-5, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL

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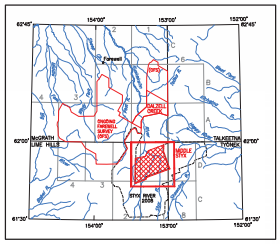

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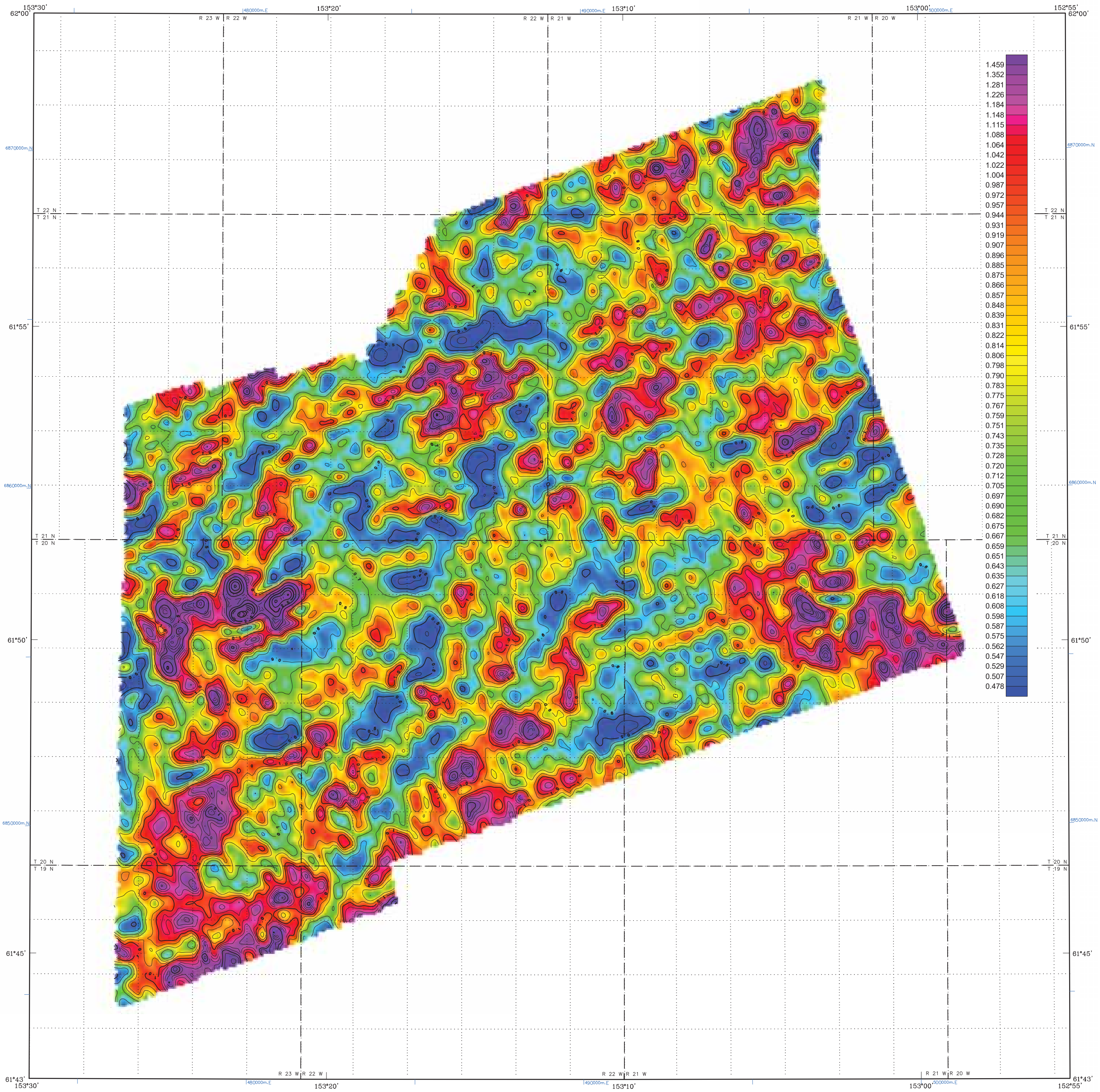
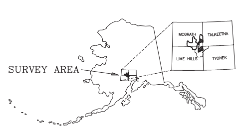
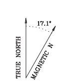


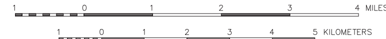
Section outlines from U.S. Geological Survey Lime Hills C-1, 1958; C-2, 1975; D-1, 1958; D-2, 1977; Tyonek C-8, 1958; D-8, 1958; Quadrangles, Alaska



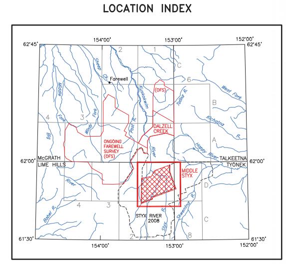


APPROXIMATE MEAN DECLINATION, 2010

SCALE 1:63,360



LOCATION INDEX



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PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

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The geophysical data were acquired with a DIGHEM V Electromagnetic (EM) system, Radiation Solutions RS–500 gamma–ray spectrometer and a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. The EM and magnetic sensors were flown at a height of 100 feet. The gamma–ray spectrometer was flown at a height of 200 feet. In addition the survey recorded data from radar and laser altimeters, GPS navigation system, 50/60 Hz monitors and video camera. Flights were performed with an AS–350–B3 Squirrel helicopter at a mean terrain clearance of 200 feet along NE–SW (70°) survey flight lines with a spacing of a quarter of a mile. Tie lines were flown perpendicular to the flight lines at intervals of approximately 3 miles.

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CONTOUR INTERVAL

______	2.50
______	0.50
______	0.10

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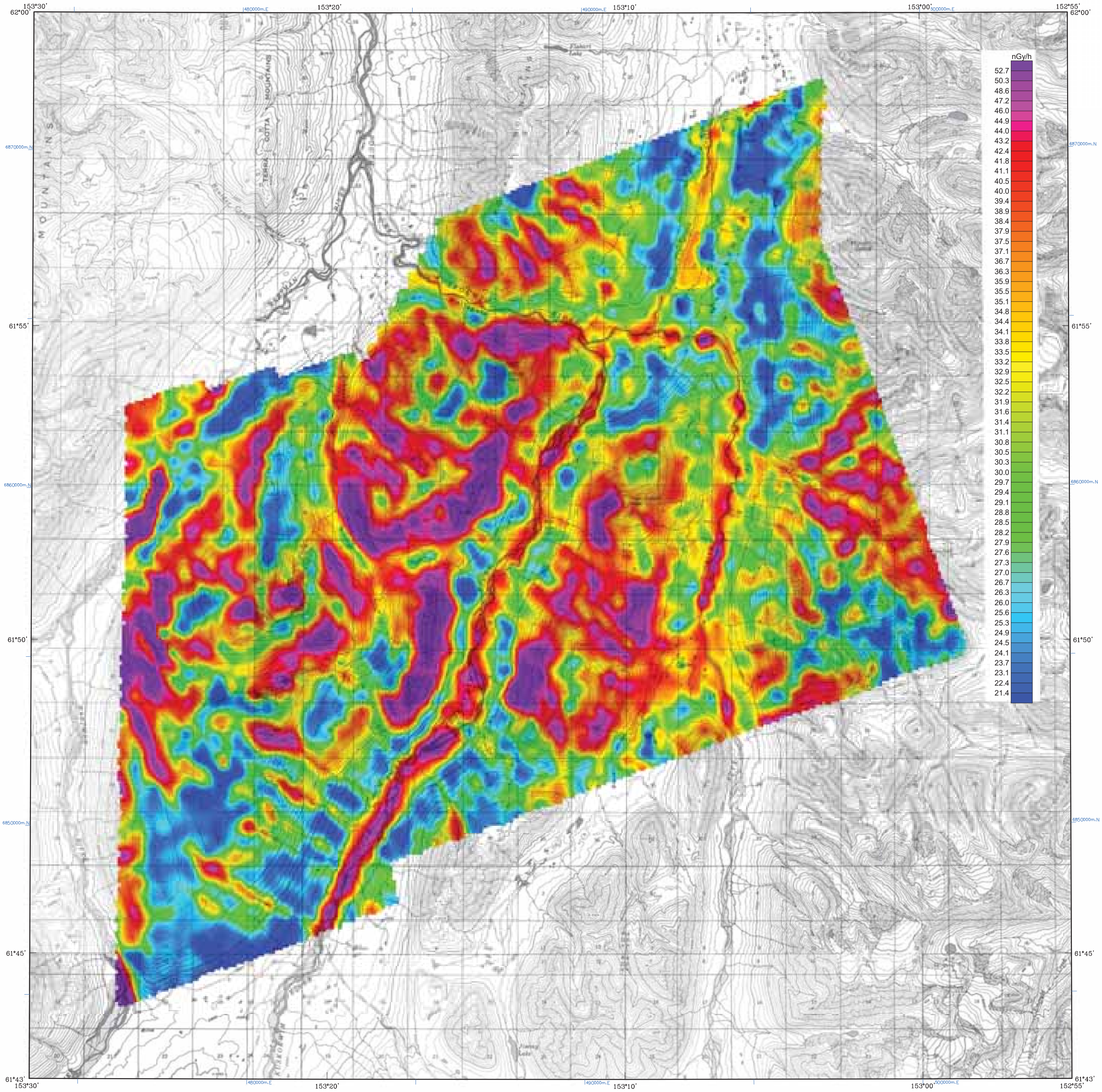

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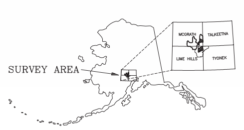
SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM MEAN SEA LEVEL



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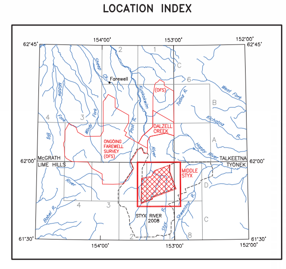

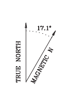

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Raw counts have been converted to radioelement concentrations, and combined to produce natural air−absorbed dose rate, so that the results are independent of crystal volume and planned survey height. This facilitates comparisons to other surveys and ground data. Measurements are nanograys per hour (nGy/h).

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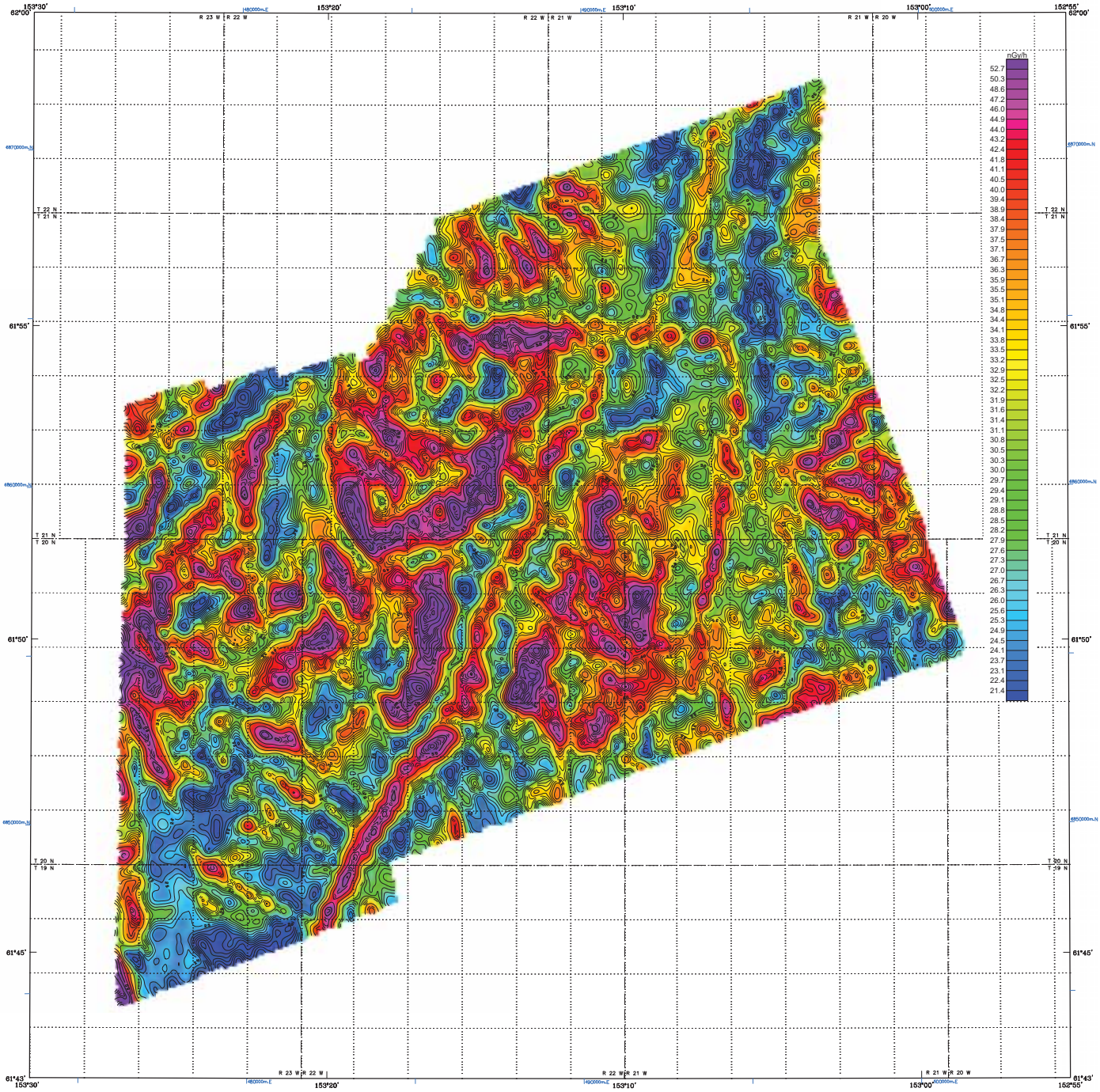

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SCALE 1:63,360

1 0 1 2 3 4 MILES

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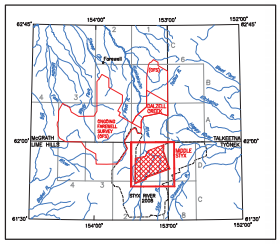

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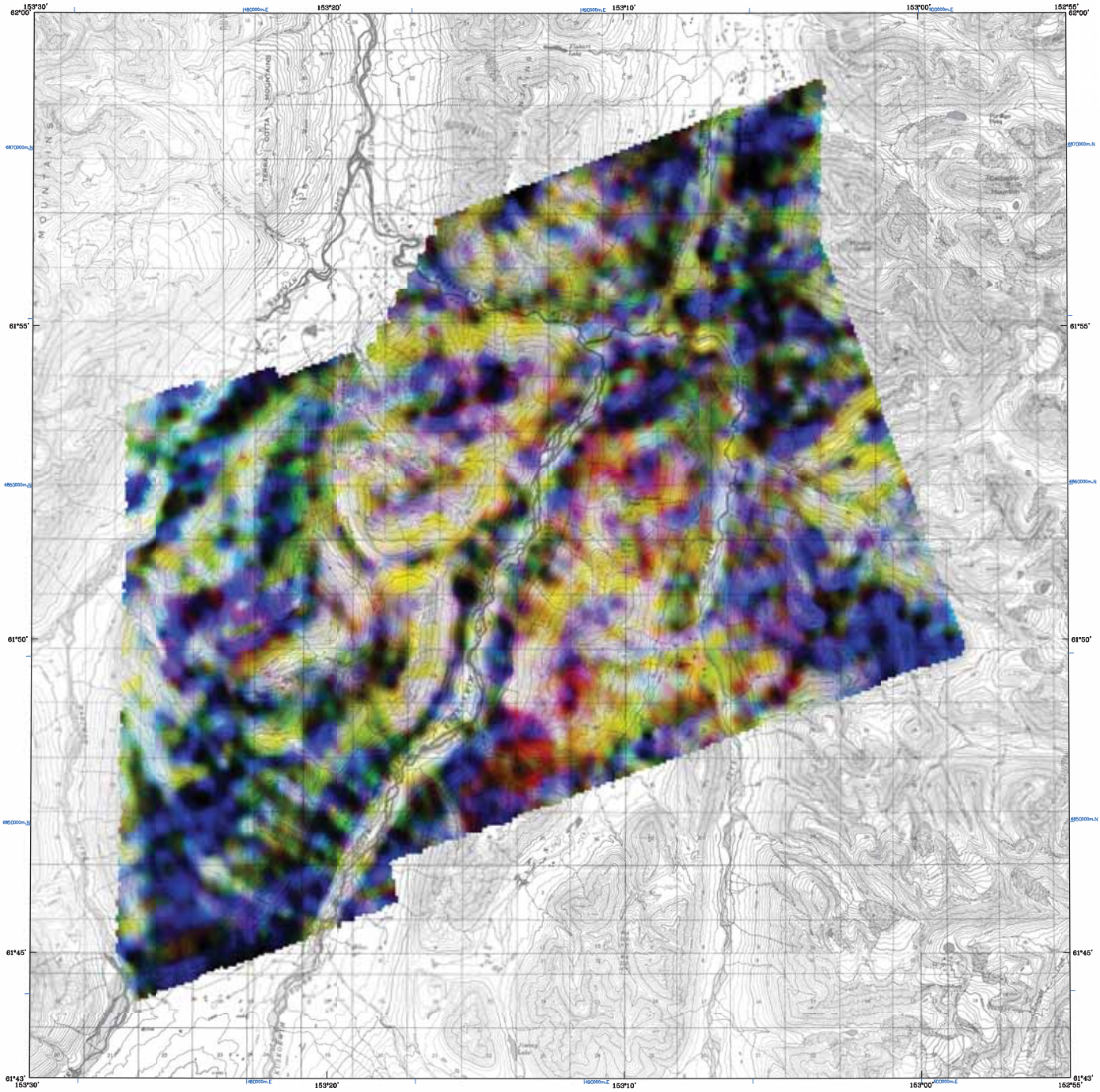
CONTOUR INTERVAL

.....	50 nGy/h
.....	5 nGy/h
.....	1 nGy/h

SURVEY HISTORY

This map has been compiled and drawn under contract between the State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys (DGGS), and Fugro GeoServices, Inc. Airborne geophysical data for the area were acquired and processed by Fugro Airborne Surveys Corp. in 2012 and 2013. Previously flown DGGS surveys adjacent to the current survey are shown in the location map by dashed lines, survey name, and date of publication. The project was funded by the Alaska State Legislature as part of the Alaska Strategic and Critical Minerals Assessment project, which is part of the Alaska Airborne Geophysical and Geological Mineral Inventory Program.

All data and maps produced to date from this survey are available in digital format on DVD for a nominal fee through DGGS, 3354 College Road, Fairbanks, Alaska, 99709-3707, and are downloadable for free from the DGGS website (www.dggs.alaska.gov/pubs). Maps are also available on paper through the DGGS office, and are viewable online at the website in Adobe Acrobat .PDF file format.



Base from U.S. Geological Survey Lime Hills C-1, 1956; C-2, 1976; D-1, 1956; D-2, 1977; Tyonek C-5, 1956; D-5, 1956; Quadrangles, Alaska

SCALE 1:63,360

1 0 1 2 3 4 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 500 FEET
DATUM MEAN SEA LEVEL

RADIOELEMENT - TERNARY WITH TOPOGRAPHY OF THE MIDDLE STYX SURVEY AREA, SOUTHCENTRAL ALASKA

PARTS OF THE LIME HILLS AND TYONEK QUADRANGLES

by
Laurel E. Burns, Fugro Airborne Surveys Corp., and Fugro GeoServices, Inc.
2013

DESCRIPTIVE NOTES

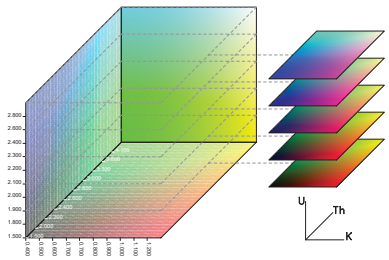
The geophysical data were acquired with a DIGHEM^{V} Electromagnetic (EM) system, Radiation Solutions RS-500 gamma-ray spectrometer and a Fugro D1344 magnetometer with a Scintrex CS3 cesium sensor. The EM and magnetic sensors were flown at a height of 100 feet. The gamma-ray spectrometer was flown at a height of 200 feet. In addition the survey recorded data from radar and laser altimeters, GPS navigation system, 50/60 Hz monitors and video camera. Flights were performed with an AS-350-B3 Squirrel helicopter at a mean terrain clearance of 200 feet along NE-SW (70°) survey flight lines with a spacing of a quarter of a mile. Tie lines were flown perpendicular to the flight lines at intervals of approximately 3 miles.

A Novatel OEM4-G2L Global Positioning System was used for navigation. The helicopter position was derived every 0.5 seconds using post-flight differential positioning to a relative accuracy of better than 5m. Flight path positions were projected onto the Clarke 1866 (UTM zone 5) spheroid, 1927 North American datum using a central meridian (CM) of 153°, a north constant of 0 and an east constant of 500,000. Positional accuracy of the presented data is better than 10m with respect to the UTM grid.

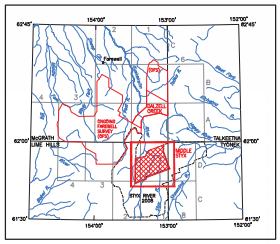
RADIOMETRICS

The gamma-ray spectrometry data were recorded at a 1.0 second sample rate using a Radiation Solutions RS-500 gamma-ray spectrometer. It was configured with 16.8L (1024 cubic inches) of main (downward) NaI crystal detector, and 4.2L (256 cubic inches) of upward looking (radon) detector. After application of Noise Adjusted Singular Value Decomposition to the spectra, counts from the main detector were recorded in five windows corresponding to thorium (2410-2810 keV), uranium (1660-1860 keV), potassium (1370-1570 keV), total radioactivity (400-2815 keV) and cosmic radiation (3000->6000 keV). Counts from the radon detector were recorded in the radon window (1660-1860 keV). The radon detection system was calibrated following methods outlined in IAEA Report 323. After removal of the background, the data were corrected for spectral interferences, changes in temperature, pressure, and departures from the planned survey elevation of 200 feet. The data were then converted to standard concentration units which were interpolated to a 100 m grid using a minimum curvature technique. All grids were then resampled from the 100 m cell size down to a 25 m cell size to produce the maps and final grids contained in this publication.

International Atomic Energy Agency. 1991. Airborne Gamma Ray Spectrometer Surveying. Technical Report 323. International Atomic Energy Agency. Vienna.



LOCATION INDEX



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