Division of Geological & Geophysical Surveys

GEOPHYSICAL REPORT 2000-24

PORTFOLIO OF AEROMAGNETIC, RESISTIVITY, AND RADIOMETRIC MAPS OF THE SALCHA RIVER - POGO MINING AREA, CENTRAL ALASKA

by

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PORTFOLIO OF AEROMAGNETIC, RESISTIVITY, AND RADIOMETRIC MAPS OF THE SALCHA RIVER – POGO MINING AREA, CENTRAL ALASKA

In the summer of 1999, the Alaska Division of Geologic and Geophysical Surveys acquired airborne geophysical data over 1032 square miles in the Big Delta Quadrangle (figure 1). The data were acquired and processed under contract by Stevens Exploration Management, Corp. and their subcontractor, Geoterrex-Dighem. Aeromagnetic, electromagnetic, and radiometric data were collected in fall of 1999 and were released in February 2000 in the forms of maps and digital files.

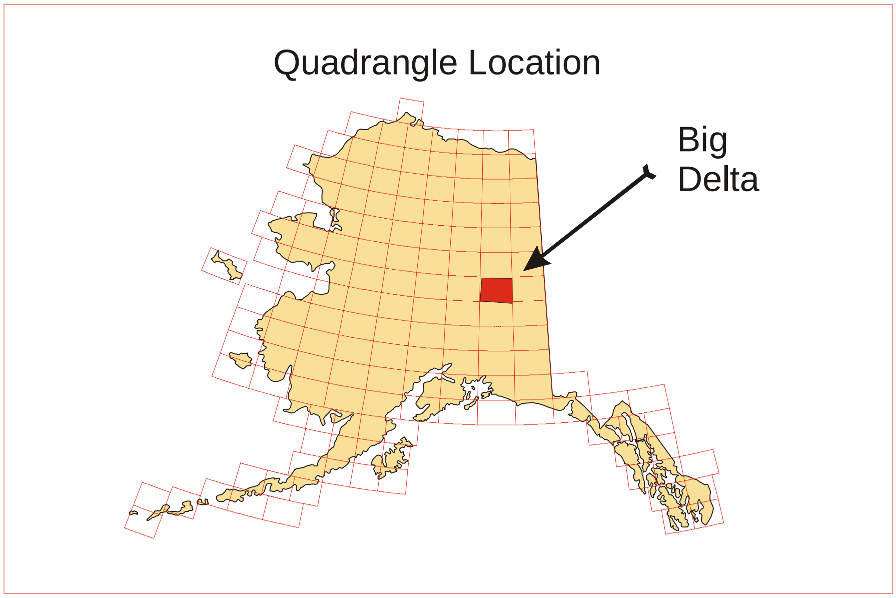

Figure 1. Location of Salcha River - Pogo survey area.

This Geophysical Report (GPR) contains generalized information on data acquisition, data interpretation, publications, and data formats available for the Salcha River - Pogo survey area. Page-size color maps of most of the data and a few additional maps deemed to be of interest are also included. The contractor's report, GPR 98-23, gives a more detailed interpretation of the data and a more complete description of the processing.

The acetate topography included with this portfolio should be used only for generalized locations. For accurate locations, the large scale geophysical maps or the computer files should be used. The area surveyed includes parts of the Big Delta B-2, B-3, B-4, C-2, C-3, C-4, D-2, D-3, and D-4 quadrangles.

Clients can request maps from this geophysical survey from the Alaska Division of Geological & Geophysical Surveys. Ordering information and available maps are listed at the end of this portfolio. Some of the products are available at DNR's Public Information Center in Anchorage. Most of the maps in this portfolio are available from DGGS. Custom plots of variations of the data can be made at any scale at the DGGS office for a reasonable fee.

Maps are available of the aeromagnetic, the 7200 Hz coplanar resistivity data, and various radiometric data. Grids of the 900 and 56,000 Hz coplanar resistivity data are included on the CD-ROM (GPR 2000-15) and the zip disc..

Most of the maps for the Salcha River - Pogo survey were produced at 1:63,360 scale (1 inch = 1 mile, fig. 2). The two sheets needed to cover the area are included in each 1:63,360-scale publication. Aeromagnetic maps with electromagnetic (EM) anomalies are released at both the 1:63,360 and the 1:31,680 scale (1 inch = ½ mile; fig. 3).

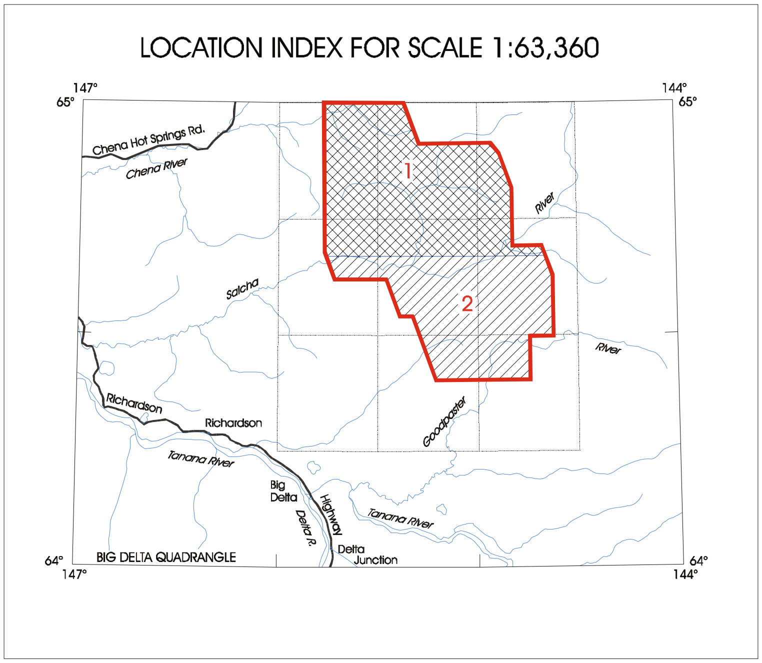

Figure 2. Index map for aeromagnetic and resistivity maps that are available at 1:63,360 (1 inch = 1 mile) scale.

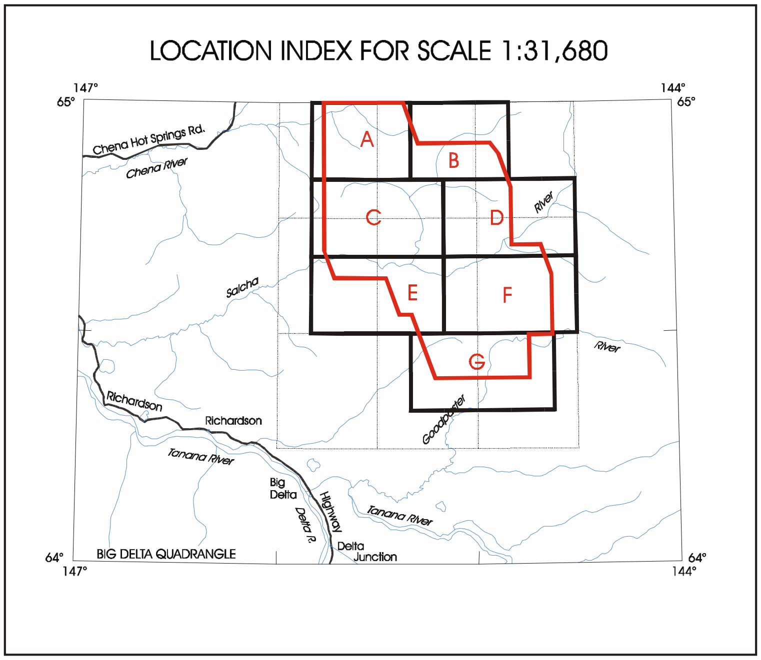

Figure 3. Index map for aeromagnetic maps available at 1:31,680 (1 inch = ½ mile) scale. Only aeromagnetic maps with detailed EM anomalies are available at this scale.

Survey history, instrumentation, & data processing

The following indented section describing the instrumentation and processing is modified from the maps produced by Burns and others (2000).

> The airborne geophysical data for the Salcha River - Pogo area were compiled and processed under contract between the State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys, and Stevens Exploration Management Corporation. Airborne geophysical data were acquired by Geoterrex-Dighem, a division of CGG Canada Ltd., in 1999.
>
> A GPS navigation system was used for location. The data were acquired with a DIGHEM^V Electromagnetic (EM) system, Scintrex cesium magnetometer, and N wZPLOEnium FE-810 fMM-Ey apwxreomwrwe. The equipment was installed in AS350B-2 Squirrel helicopters. In addition, the survey recorded data from a radar altimeter, 50/60 Hz monitors, and a video camera.
>
> Flights were performed at a mean terrain clearance of 200 feet along survey flight lines with a spacing of a quarter of a mile. The EM and magnetic sensors were flown at a height of 100 ft. The gamma-ray spectrometer was flown at a height of 200 feet. Flight direction was NW-SE (340°). Tie lines were flown perpendicular to the flight lines at intervals of approximately three miles.
>
> ### Total Field Magnetics:
> The magnetic total field contours were produced using digitally recorded data from a Scintrex cesium magnetometer, with 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) leveled to the tie line data, and (3) interpolated onto a regular 100 m grid using a modified Akima (1970) technique. The regional variation (or IGRF gradient, 1995 updated to September 1999) was removed from the leveled magnetic data.
>
> ### Resistivity:
> The Dighem^V EM system measured inphase and quadrature components at five frequencies. Two vertical coaxial coil-pairs operated at 900 and 5000 Hz while three horizontal coplanar coil-pairs operated at 900, 7200, and 56,000 Hz. EM data were sampled at 0.1 second intervals. For the 900 and 7200 Hz resistivity maps, the resistivity is generated from the inphase and quadrature component of the coplanar 900 and 7200 Hz respectively using the pseudo-layer half space model. The data were interpolated onto a regular 25 m grid using a modified Akima (1970) technique.
>
> ### Radiometrics:
> The gamma-ray spectrometry data were recorded at 1.0 second sample rate into 256 channel main and radon spectra using an Exploranium GR820 gamma-ray spectrometer. The volume of NaI in the two detectors comprising the system were; main detector, 16.7L; radon detector 4.2L. 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 where were interpolated to a 100 m grid using a modified Akima (1970) technique.

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.

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

Generalized information about aeromagnetic, electromagnetic, and radiometric data

Magnetic data

The magnetometer is a passive instrument that measures the earth's magnetic field in nanoTeslas (nT). Rocks with high magnetic susceptibilities (measured in SI units) locally attenuate or dampen these magnetic signals producing the relative highs and lows. Iron-rich magnetic minerals such as magnetite, ilmenite, and pyrrhotite have the highest magnetic susceptibility. These minerals commonly occur in mafic volcanic rocks (such as basalt), mafic and ultramafic plutonic rocks (such as serpentinite, clinopyroxenite, and gabbro), some skarns, and in some other geologic units. Rocks with low to no iron tend to produce little variation in the magnetic signal. These include silicic volcanic rocks (rhyolites), silicic plutonic rocks (granites), and most sedimentary rocks (for example, limestone, sandstone, and shale). Some iron rich minerals – such as pyrite – are not magnetic and do not produce a magnetic signal.

Different types of ore deposits have different magnetic signatures. A bedrock gold deposit associated with the top of a granitic pluton would likely be an aeromagnetic low whereas a magnetite-bearing gold skarn would be an aeromagnetic high. A gold deposit hosted by a low-angle (thrust) fault has a different signature than one hosted by a high-angle fault.

Figure 4a shows the aeromagnetic data for the survey area. The high values (in nT) are purple and orange and indicate appreciably magnetic rocks. The low values are the blues and greens. A gradual change in color indicates a gradual change in the magnetic field strength. This can be caused by either a gradual change in magnetic susceptibility of rocks near the surface, the gradual burial of a rock unit of relatively constant magnetic susceptibility, or the introduction of a new unit at depth. Conversely, an abrupt change in color indicates an abrupt change in the magnetic susceptibility. This is caused by juxtaposing two rock units with very different magnetic susceptibilities such as is the case with faults, volcanic dikes, or some mineralized zones. Faults can be inferred on aeromagnetic maps from linear or curvilinear features composed of discontinuous aeromagnetic highs or lows.

Figures 4b and 4c show the aeromagnetic data presented respectively as a traditional "color shadow" maps where a simulated light source is shown on the three-dimensional data. The higher values appear bright like mountaintops struck by sunlight. The light source can be rotated in a complete circle with 0° (north) clockwise to 180° (south) and back to 360° (north). Shadow maps can enhance structures, such as faults, intrusions, and the trend of stratigraphic layers. A different type of shadow map containing three sources of illumination is shown in Figure 4d. Here red illumination is shown from the west, blue from the northeast, and green from the southeast combine to highlight different trends on the same diagram.

Resistivity data

The electromagnetic (EM) system is an active instrument that measures the resistivity of the rocks below it by sending out electromagnetic signals at different frequencies and recording the signals that are returned from the earth. The high values (measured in ohm-m) are indicative of resistive (low conductivity) rocks, such as quartzite. Low resistivity (high conductivity) values are present for bedrock conductors (water-saturated clays, graphite, concentrations of certain sulfides, some alteration halos), conductive overburden (water-saturated zones), and cultural sources (e.g. powerlines). The main conductive minerals are graphite, most sulfides, (but not sphalerite), and water-saturated clays. Rocks hydrothermally altered to clay minerals also are conductive. Some faults will show up very well on the resistivity maps, because they either offer a conduit for ground water or they separate rocks with markedly different resistivities.

The EM instrument (bird) contains 5 or more transmitting coils in front and 5 matching (paired) receiver coils in the rear. Three of these pairs are coplanar – the axes of the coils are perpendicular to the long axis of the bird. Two of these pairs are coaxial – the axes of the coils are parallel to the long axis of the bird. These two major geometric configurations, coplanar and coaxial, record different information about the conductivity of the rocks below. Coplanar coils emphasize horizontal and flat lying conductive units. Coaxial coils emphasize vertical to near vertical conductive units.

The 7200 Hz coplanar resistivity map is shown in Figure 5. The resistivity maps are produced from the EM coplanar coil pairs, and emphasize horizontal or near horizontal units and structures. Since ground penetration correlates inversely with frequency, the 56,000 Hz reflects very near surface rocks and the 900 Hz adds the influence of deeper rocks in general. The 7200 Hz in general reflects rocks between the two extremes. However, the depth of penetration is variable depending on the resistivity of the rocks the signal is passing through.

EM anomalies are shown with both the 1:63,360 and 1:31,680 scale magnetic maps. EM anomalies are derived from the coaxial coil pairs, which emphasize vertically- or near-vertically-dipping “discrete” bedrock conductors. These EM anomalies are shown as circular symbols along flight lines with the aeromagnetic contours. On the 1:63,360 scale maps, anomalies are subdivided into those with 1) a signal strength greater than 50 siemens, 2) a signal strength less than 50 siemens, and 3) weak conductivity associated with an EM magnetite response. Questionable (or possible) anomalies are also noted.

More detailed interpretations for the electromagnetic anomalies are shown on the 1:31,680 scale aeromagnetic maps. In these maps, the EM anomaly is shown as a symbol that denotes more information about signal strength and the anomaly source than on the 1:63,360 maps. Instead of two signal strengths (greater than or less than 50 siemens) shown on the 1:63,360 maps, signal strength on the 1:31,680 maps is broken into seven subdivisions (e.g. 5-10 siemens, 1-5 siemens, etc). In addition, potential sources shown for each symbol include 1) bedrock conductors, 2) narrow bedrock conductors (“thin dike”), 3) conductive covers (“horizontal thin sheet”), 4) combination including broad conductive rock units, deep conductive weathering, and thick conductive cover, 5) edge of broad conductor, and 6) culture. This information is also available on the CD-ROM. The project report, GPR 2000-23, gives a more detailed discussion of these EM anomalies.

Radiometric data

Airborne spectrometry can measure gamma rays emitted at the earth’s surface from the radioisotopes of K, Th, and U. The intensity and abundance of the gamma rays can yield information about the composition of the soil, bedrock, or cover of a region. The values can be used to trace alteration, bedrock variation, and to map overburden.

The gamma-ray detection system consists of a detector and a spectrometer. Scintillation detectors meausure the fluorescence on the detector caused by excitation of the gamma-rays and are normally used for airborne surveys. Four sodium iodide crystals with a light reflective coating are commonly used in one detector. Two detectors are commonly mounted in the aircraft.

Water strongly absorbs gamma rays; thus even a thin film of water prevents gamma rays from reaching the spectrometer. Airborne detection of gamma radiation is therefore heavily dependent on rainfall, soil moisture, overburden, and vegetation. The gamma rays that are measured by airborne methods are those emitted within a foot or two of the earth’s surface. For the total air absorbed dose map (GPRs 14 and 20) raw counts have been converted to radioelement concentrations and total counts to total air-absorbed dose rates. This form of the data is the one to be used to compare the Salcha River – Pogo surveys to other airborne surveys and ground data. The calculated results are independent of crystal volume and survey heights.

In an area of complete exposure, gamma ray intensity variations reflect different rock compositions and thus can be used to identify subtle differences in rock or alteration types. In practice gamma ray intensity variations reflect both the degree of surficial cover and rock type variations. Because absolute values are strongly affected by surface cover, in areas of variable cover ratios of different gamma rays can be more useful than simple intensities alone in pinpointing rock types.

Page-size maps of the radiometric data included with this portfolio include potassium (K%), thorium (equivalent Th in ppm), uranium (equivalent U in ppm), Th/K, U/Th, and radioelement ternary diagrams (figures 6-11 respectively). On the ratio maps (figs. 9 and 10), a blank region indicates an area where the summed concentrations fall below thresholds required for a meaningful calculation of the ratio. K is shown in color draped over the magnetics shown as height in figure 12.

Geoterrex-Dighem's project report for this survey (GPR 2000-23) contains further information on data acquisition or processing for this particular survey. Both the Canadian Geological Survey and the Australian Geological Survey have produced many gamma-ray surveys. Both these agencies have websites, articles, and books discussing the interpretation of airborne gamma-radiation surveys.

DGGS PUBLICATIONS PRODUCED FOR THE SALCHA RIVER - POGO AREA SURVEY

Bold font is used below to highlight the differences between the maps.

AEROMAGNETIC MAPS

GPR 2000-1. Total field **magnetics** of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360**. **Topography included**. **Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-2. Total field **magnetics and electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Magnetic contours and section lines included**. **Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-3. Color shadow magnetic map of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Section lines included.**

GPR 2000-4. Total field **magnetics and electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Mylar. Magnetic contours and section lines included**.

GPR 2000-5. Total field **magnetics and electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Blueline. Magnetic contours and section lines included**.

GPR 2000-6A. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta D-3 and D-4 quadrangles**). **Blueline. Magnetic contours and section lines included.**

GPR 2000-6B. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta D-2 and D-3 quadrangles**). **Blueline**. **Magnetic contours and section lines included.**

GPR 2000-6C. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta C-3, C-4, D-3, and D-4 quadrangles**). **Blueline. Magnetic contours and section lines included.**

GPR 2000-6D. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta C-2, C-3, D-2, and D-3 quadrangles**). **Blueline**. **Magnetic contours and section lines included.**

GPR 2000-6E. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta C-3 and C-4 quadrangles). Blueline**. **Magnetic contours and section lines included.**

GPR 2000-6F. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680** (**parts of Big Delta C-2 and C-3 quadrangles). Blueline. Magnetic contours and section lines included.**

GPR 2000-6G. Total field **magnetics and detailed electromagnetic anomalies** of Salcha River - Pogo mining area, central Alaska, 1 sheet, **scale 1:31,680 (parts of Big Delta B-2 and B-3 quadrangles). Blueline. Magnetic contours and section lines included.**

RESISTIVITY MAPS

GPR 2000-7. 7200 Hz coplanar resistivity of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Topography included. Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-8. 7200 Hz coplanar resistivity of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Resistivity contours and section lines included**. **Full-color plot** from electronic file, 600 dpi. Made on request.

GPR 2000-9. 7200 Hz coplanar resistivity of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Blueline. Resistivity contours and section lines included**.

RADIOMETRIC MAPS

GPR 2000-10. Radioelement—ternary of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Topography included. Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-11. Thorium/Potassium (eTh/K) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Topography included. Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-12. Thorium/Potassium (eTh/K) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Full-color plot** from electronic file, 600 dpi. Made on request.

GPR 2000-13. Thorium/Potassium (eTh/K) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Blueline**.

GPR 2000-14. Total air absorbed dose rate of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Full-color** plot from electronic file, 600 dpi. Made on request.

GPR 2000-15. To be announced.

GPR 2000-17. Potassium (K%) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Blueline.**

GPR 2000-18. Uranium (eU) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Blueline.**

GPR 2000-19. Thorium (eTh) of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Blueline.**

GPR 2000-20. Total air absorbed dose rate of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Data contours and section lines included**. **Blueline.**

DIGITAL FILES, PROJECT REPORT, PORTFOLIO, AND FLIGHT LINES

GPR 2000-16. Flight lines of Salcha River - Pogo mining area, central Alaska, 2 sheets, **scale 1:63,360. Blueline. Photographic topography** included.

GPR 2000-21. CD-ROM containing **profile data, gridded data, and section lines** of **geophysical survey data** for Salcha River - Pogo area, parts of the Big Delta, Dixon Entrance, and Salcha River - Pogo quadrangles, central Alaska.

GPR 2000-22. Zip disk containing **gridded files in Geosoft format and section lines** of **geophysical survey data** for Salcha River - Pogo area, parts of the Big Delta quadrangle, central Alaska.

GPR 2000-23. Project report of the **airborne geophysical survey** for the **Salcha River** - **Pogo area**, central Alaska.

GPR 2000-24. Portfolio of aeromagnetic and resistivity maps of Salcha River - Pogo mining area, central Alaska. Includes **color and shadow maps**. Maps fit **8½" x 11" sheets**.

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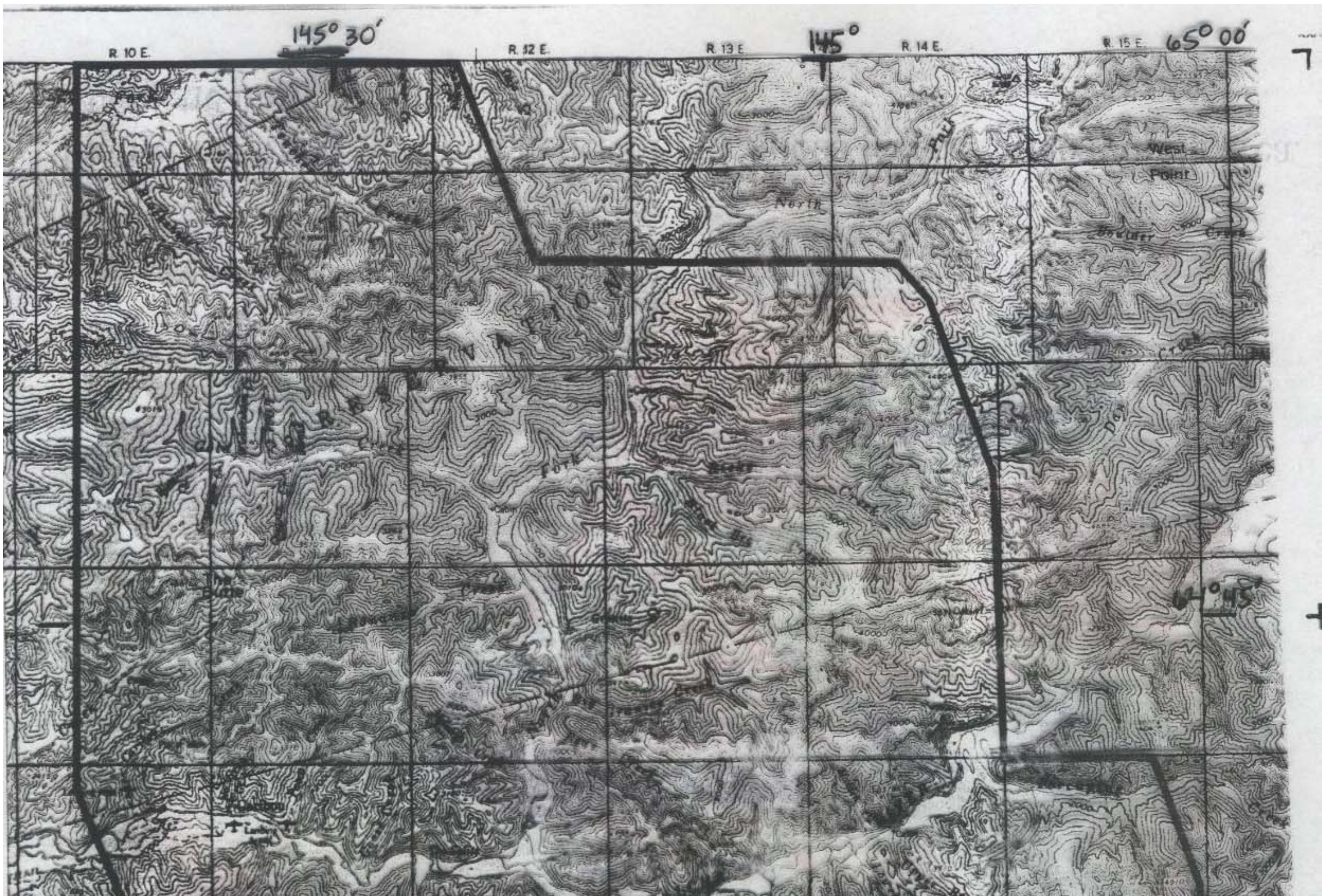

Approximate location of the survey area in the Big Delta Quadrangle.

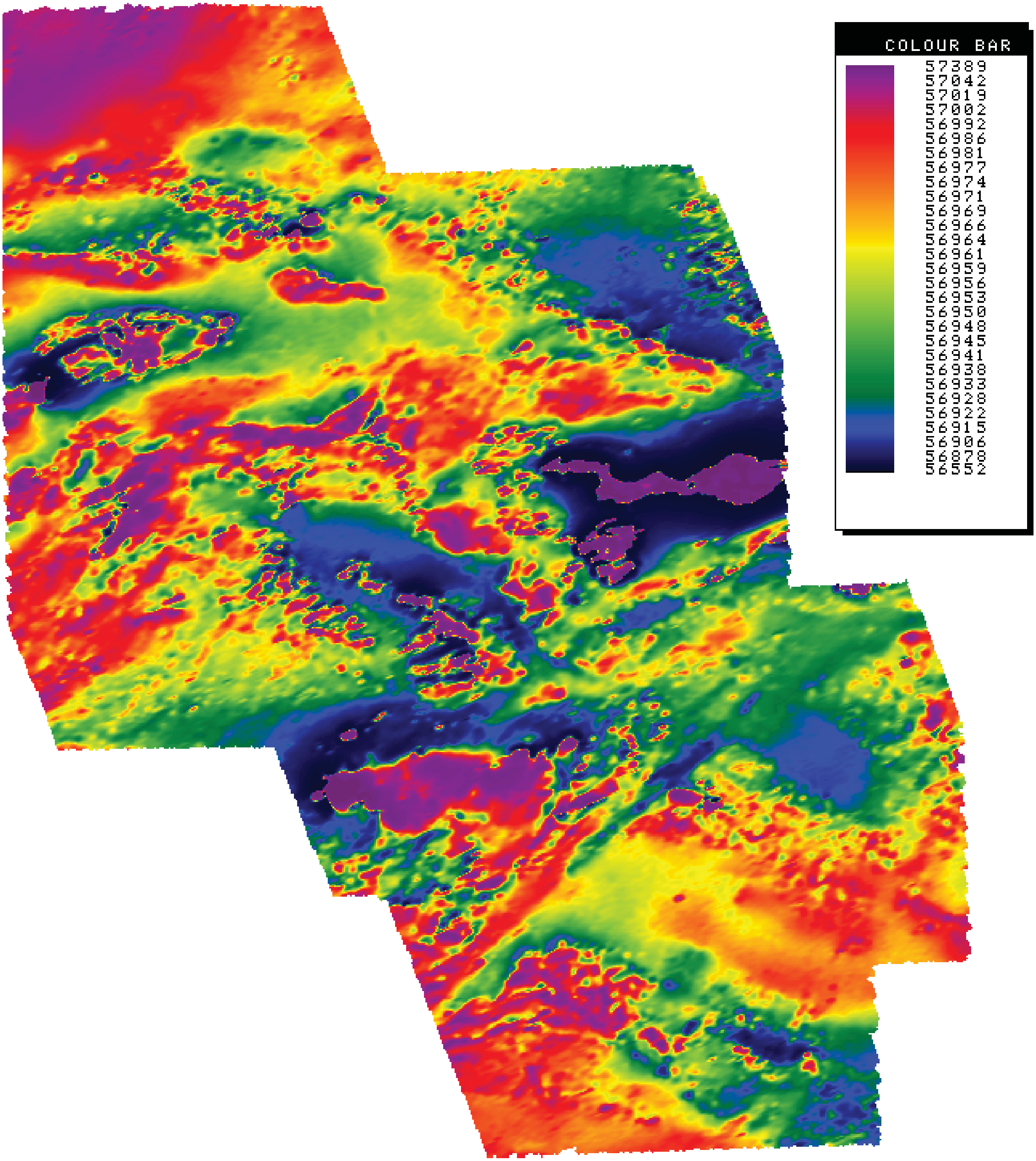

Figure 4a. Total field magnetics of the Salcha River - Pogo mining area. Magnetic units are in nT.

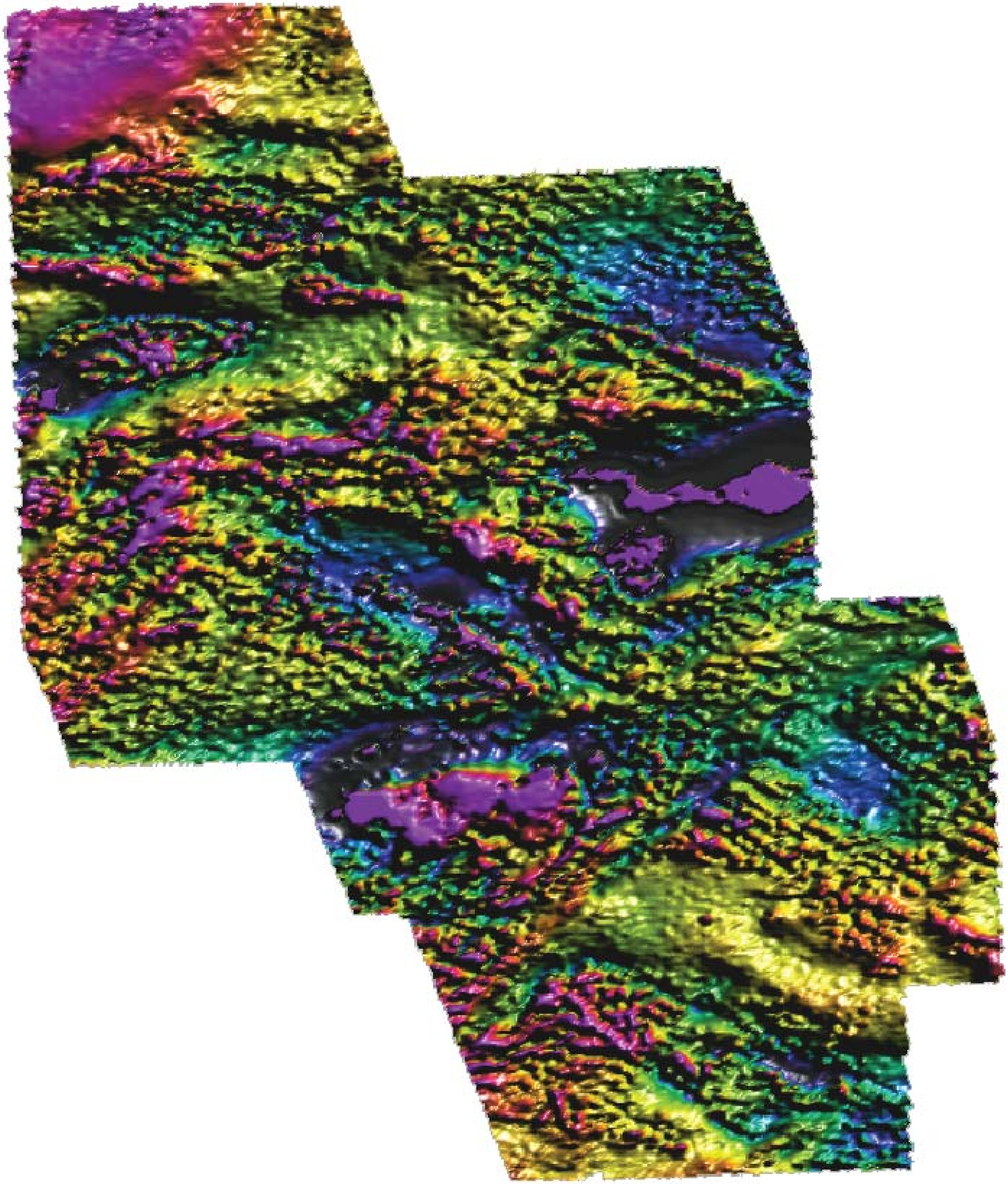

Figure 4b. Color shadow map of the total field magnetics of the Salcha River - Pogo mining area. Illumination is from the northeast. Magnetic units are in nT.

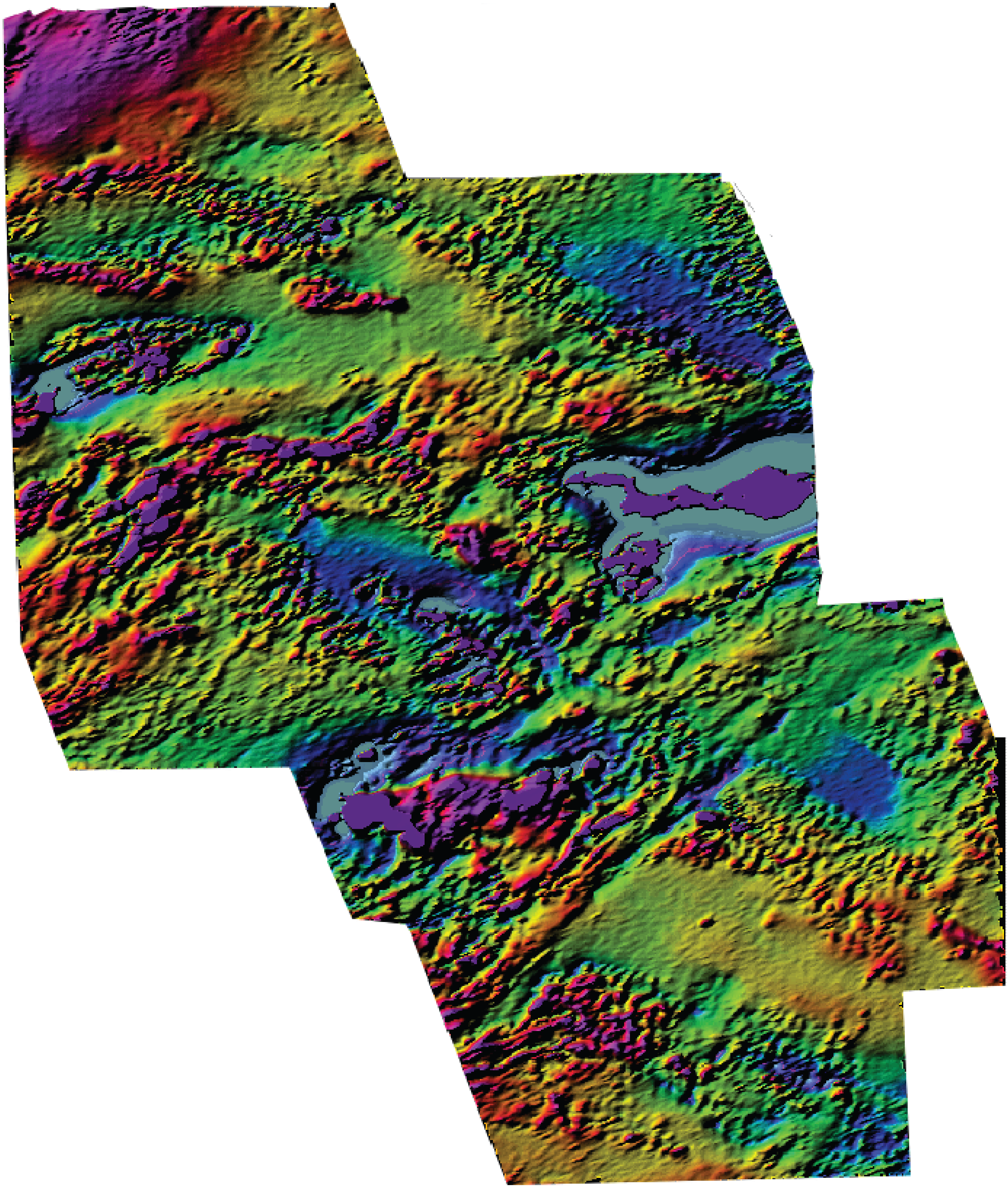

Figure 4c. Color shadow map of the total field magnetics of the Salcha River - Pogo mining area. Illumination is from the northwest. Magnetic units are in nT.

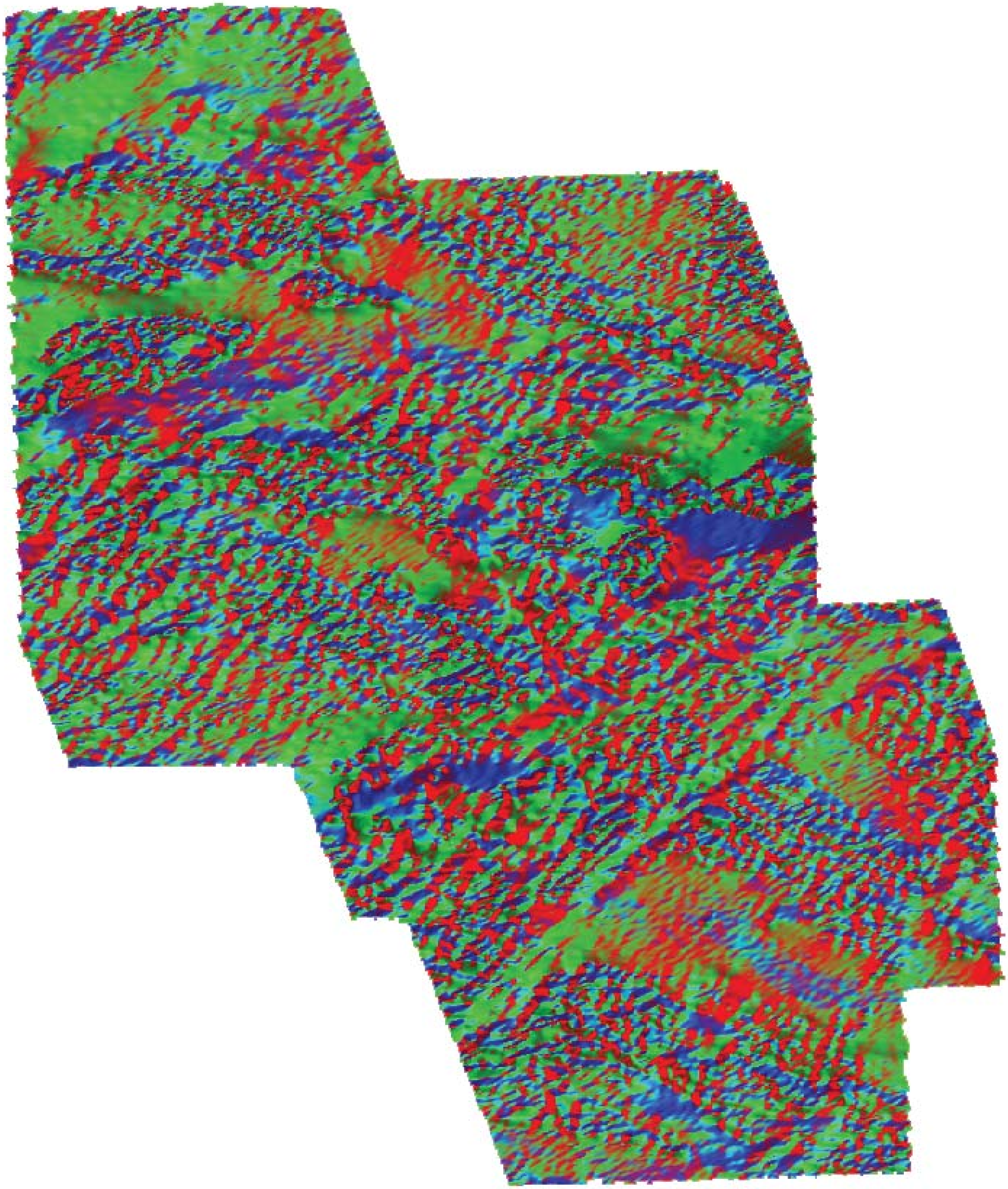

Figure 4d. Directional color shading of the total field magnetics, with red illumination from the west, blue illumination from the northeast, and green illumination from the southeast, for the Salcha River - Pogo mining area.

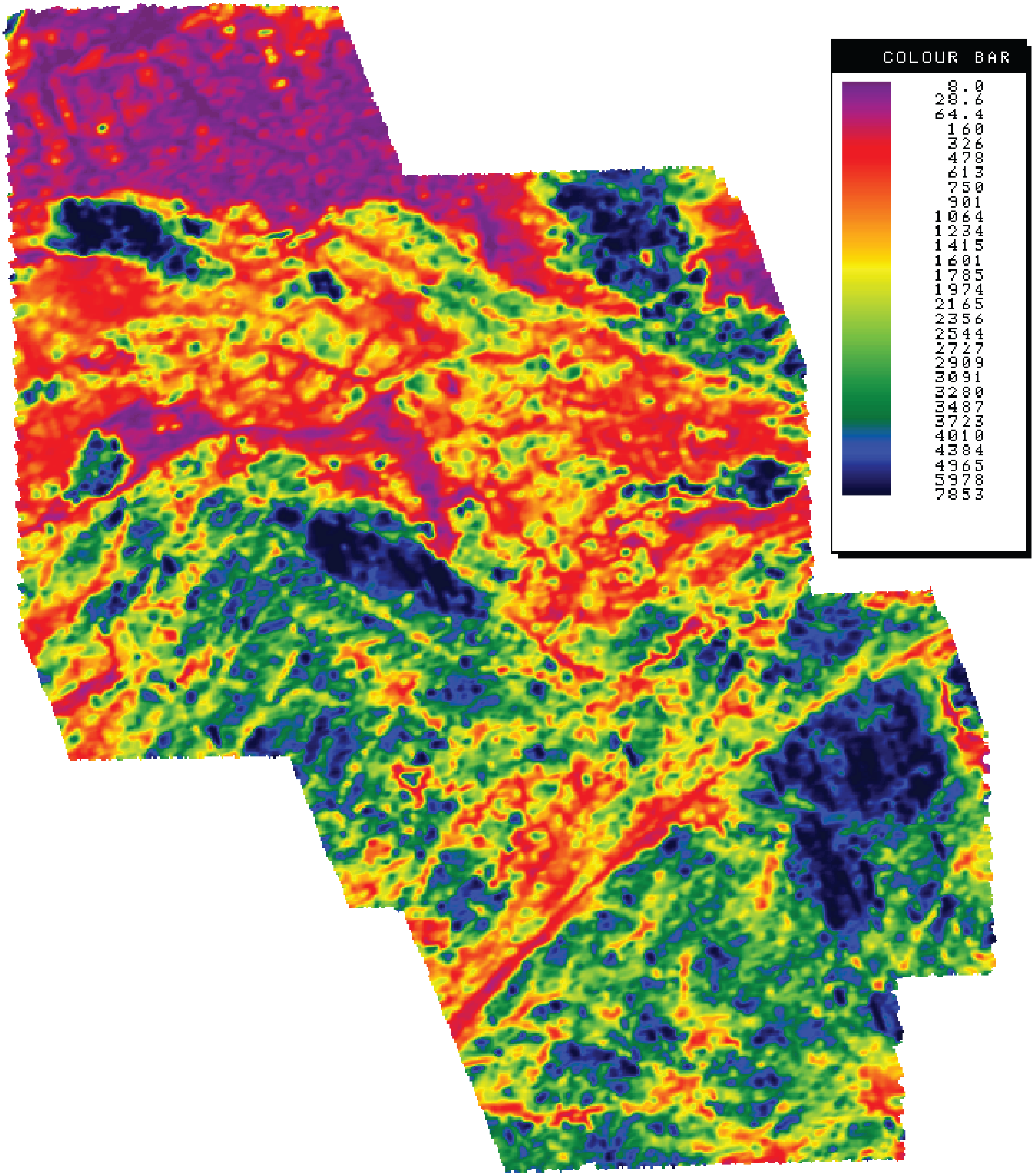

Figure 5. 7200 Hz coplanar resistivity of the Salcha River - Pogo mining area. Resistivity units in ohm-m. Conductive units have low numbers and are shown in purple and orange on this map.

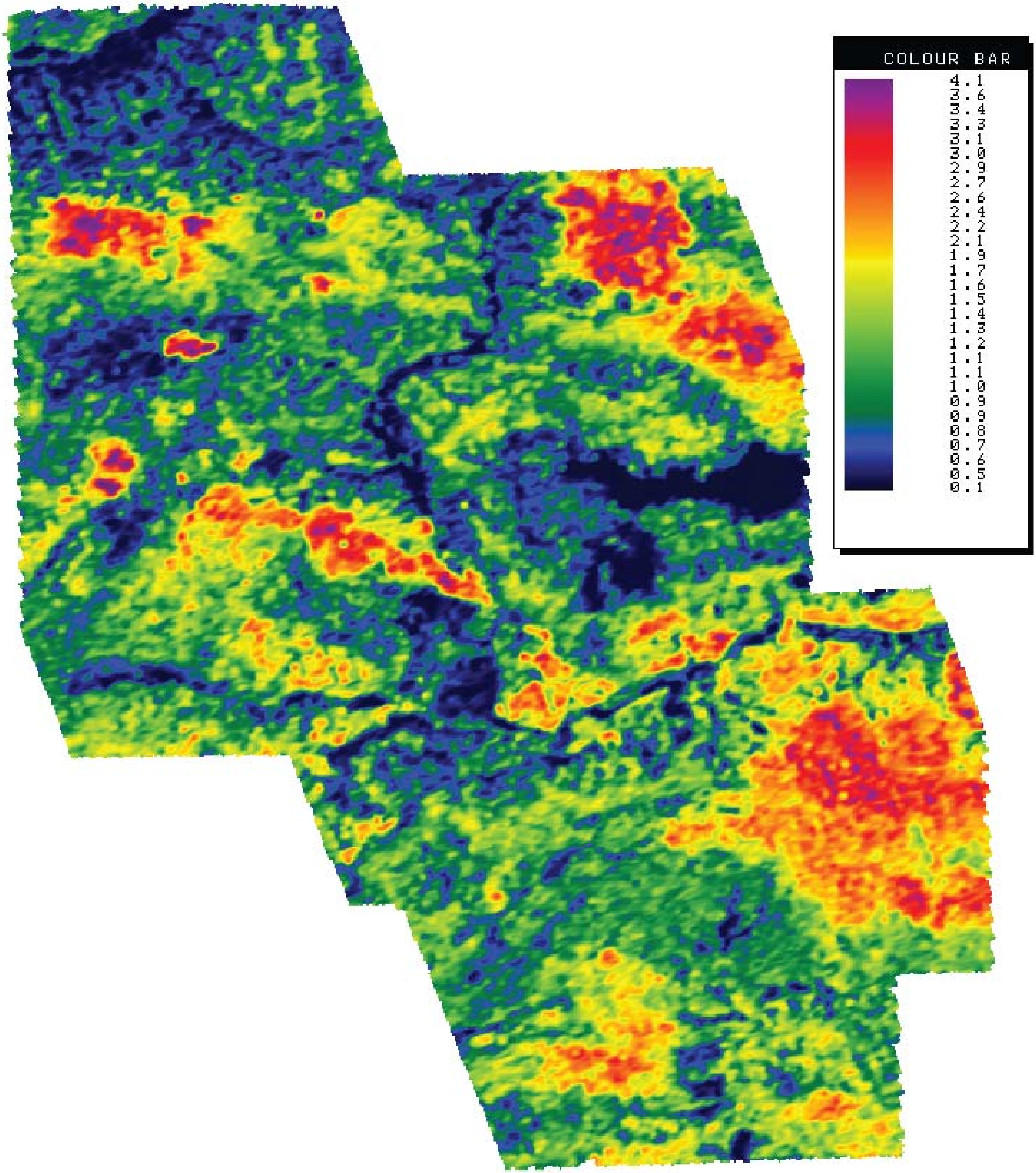

Figure 6. Potassium (K%) of the Salcha River - Pogo mining area shown with Gaussian color scheme.

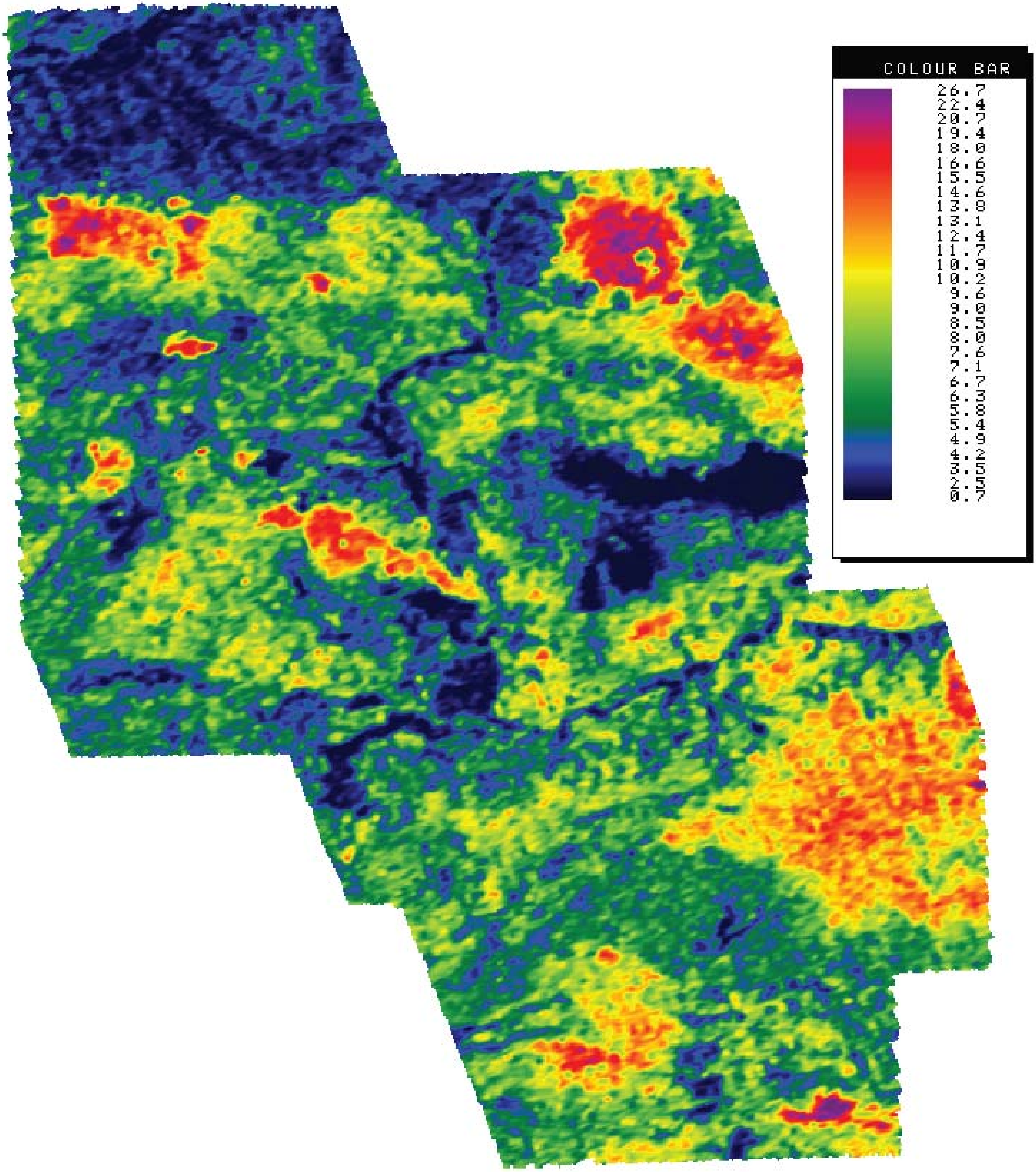

Figure 7. Equivalent thorium of the Salcha River - Pogo mining area shown with Gaussian color scale. Units in ppm.

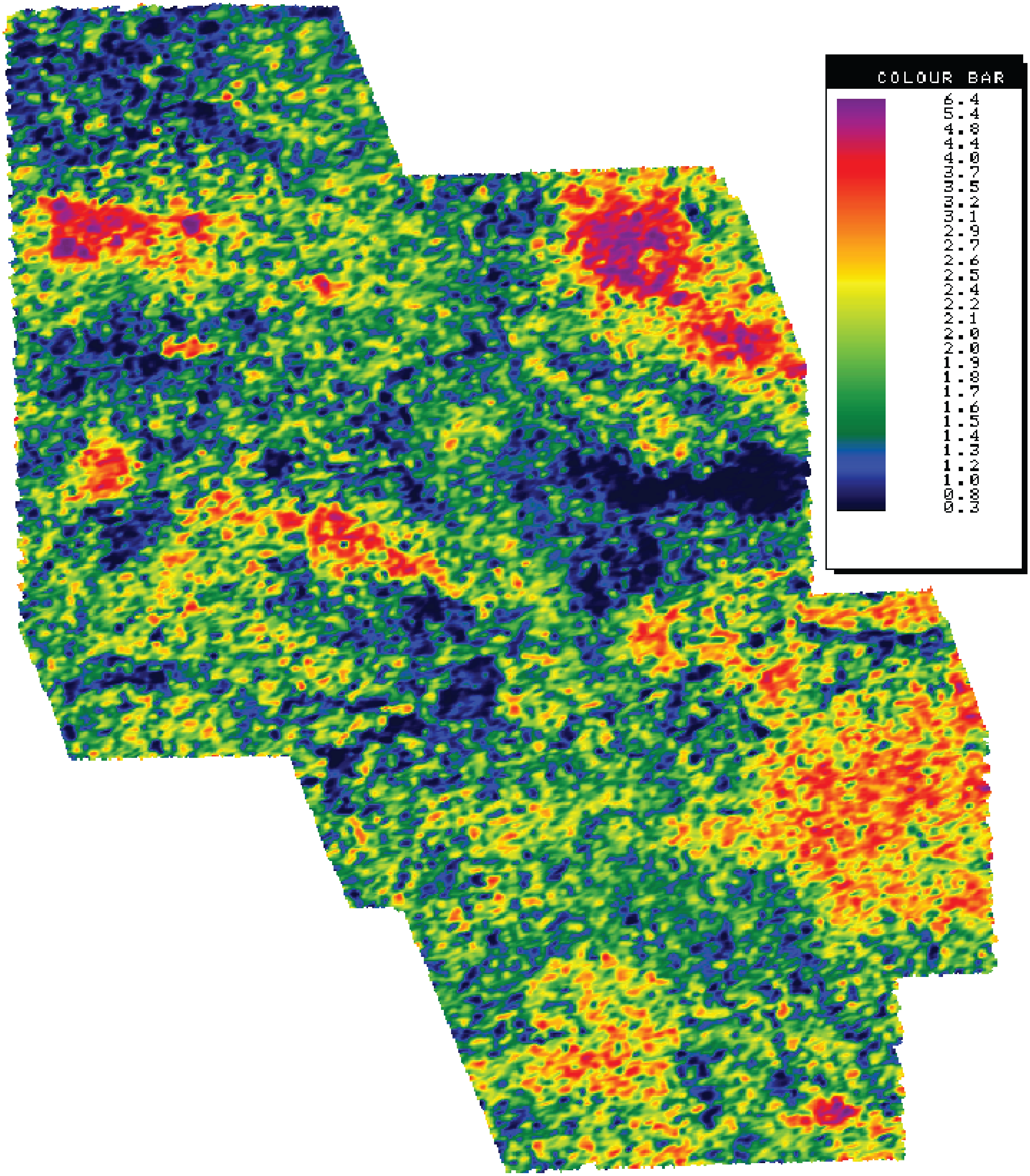

Figure 8. Equivalent uranium of the Salcha River - Pogo mining area shown with Gaussian color scale. Units in ppm.

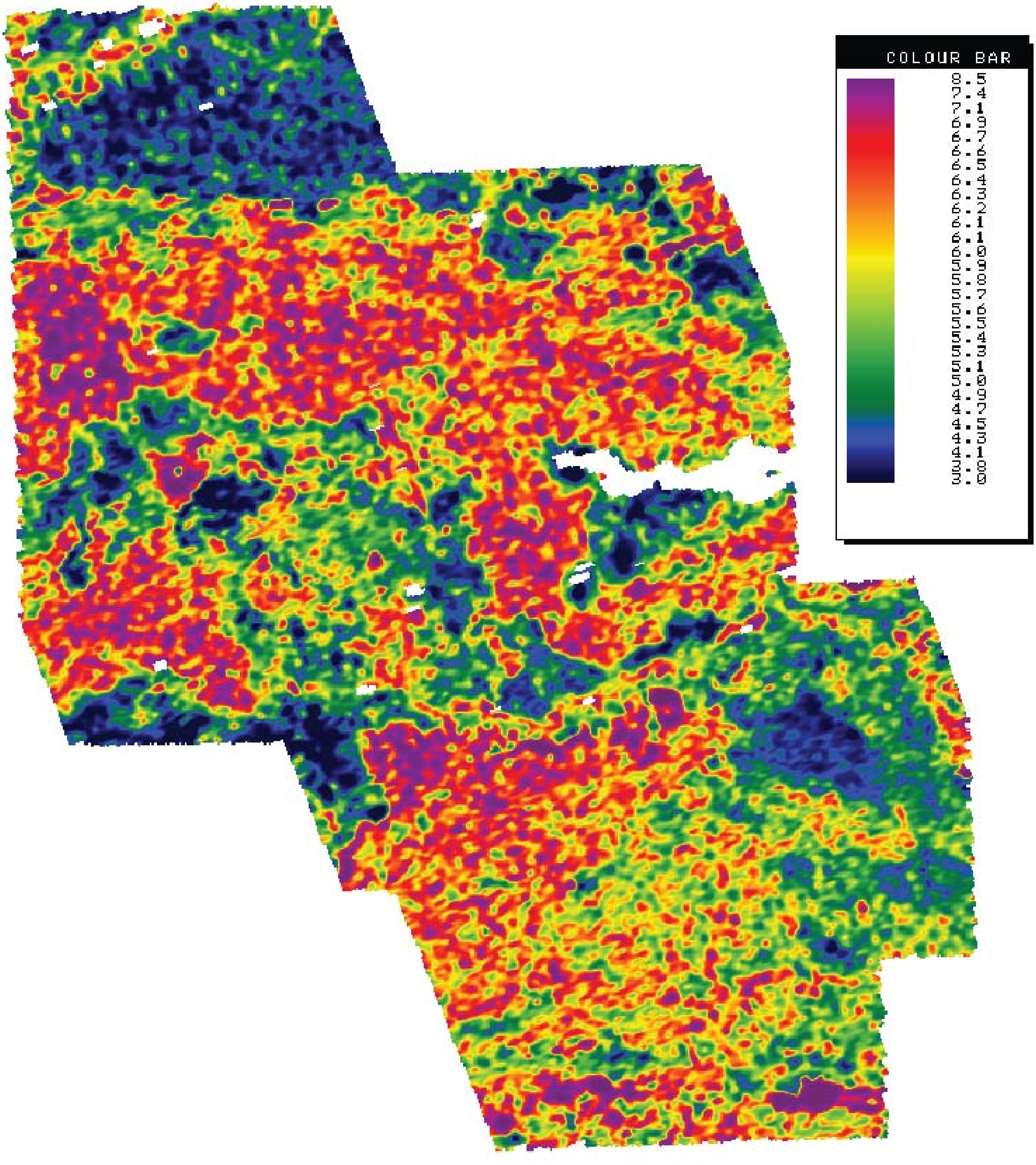

Figure 9. Th/K(eTh/K) of the Salcha River - Pogo mining area shown with equal area color scale. Units on color bar should be multiplied by 10e-4 to get the proper ratio. White areas are discussed in text.

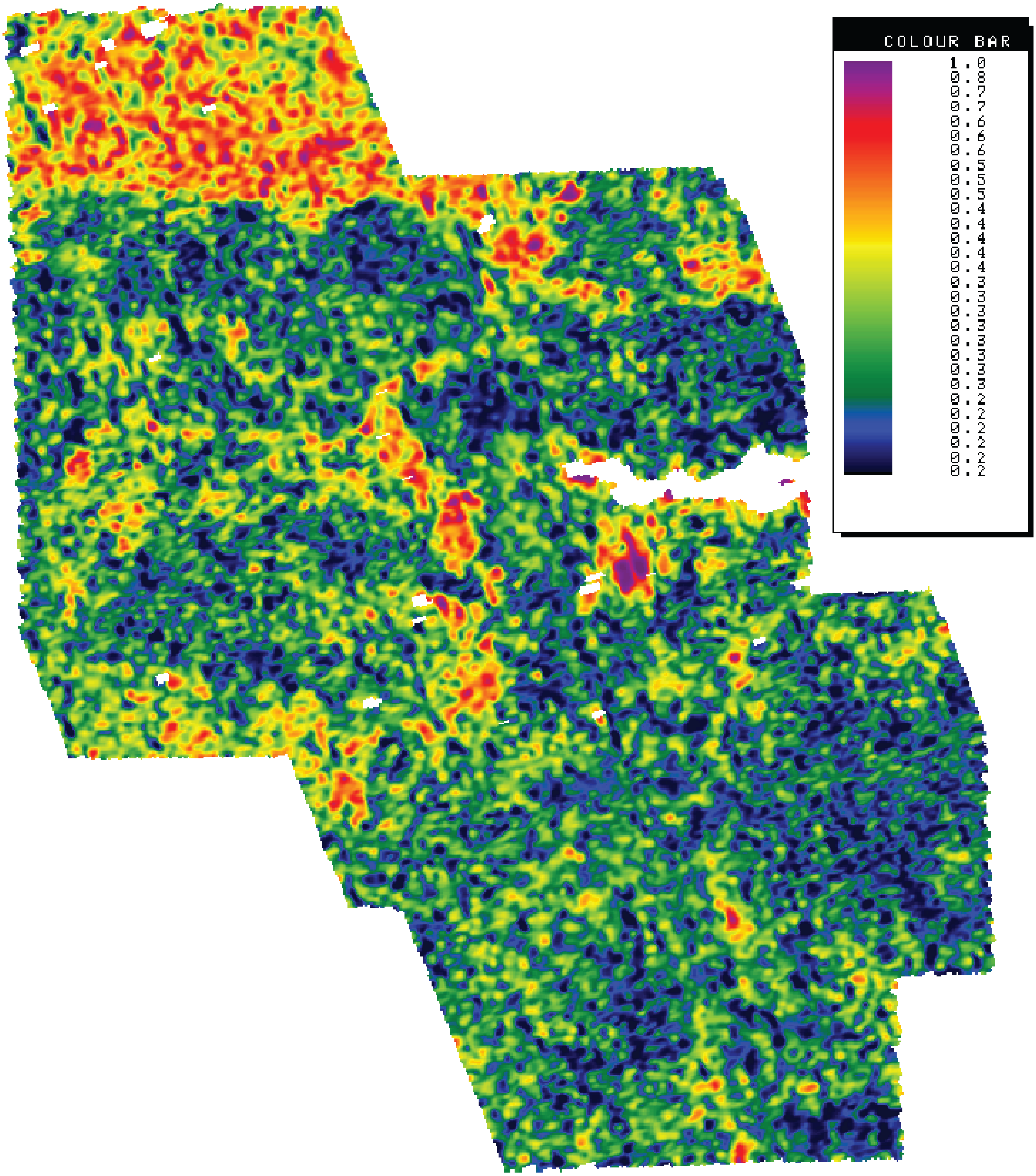

Figure 10. U/Th (eU/eTh) of the Salcha River - Pogo mining area shown with Gaussian color scale. White areas are discussed in text.

Figure 11. Radioelement ternary diagram of the Salcha River - Pogo mining area. Colors represent concentrations of elements as follows: uranium - yellow, potassium - magenta, and thorium- Cyan. Brighter colors signify greater concentration.

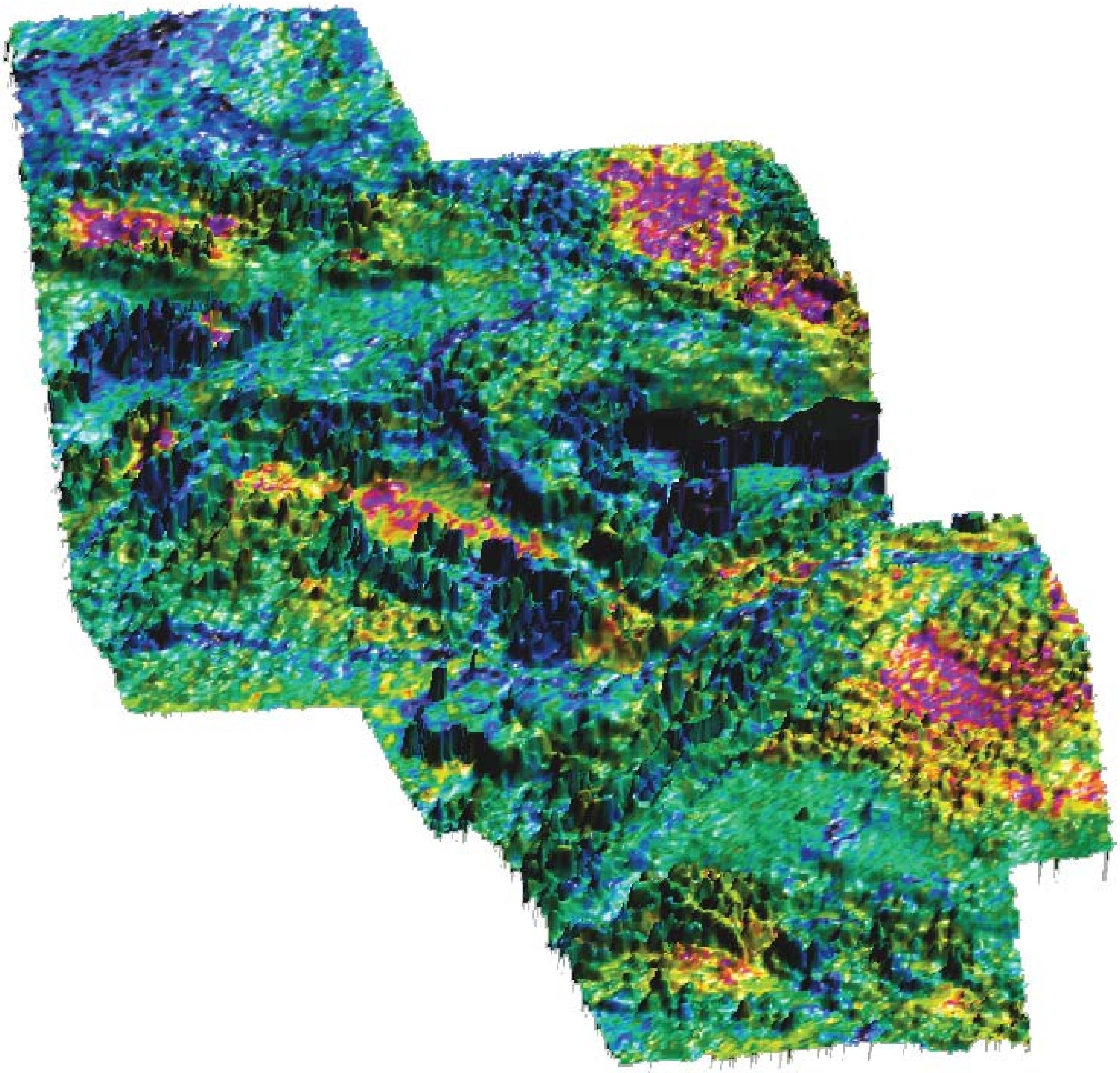

Figure 12. Oblique view of potassium shown in color over total field magnetics shown as height of the Salcha River - Pogo mining area. Magenta represents high potassium; dark blue represents low potassium. High elevation indicates high magnetic reading. The topographic map included will not fit this oblique view.