Gravity and Aeromagnetic Gradients within the Yukon-Tanana Upland, Black Mountain Tectonic Zone, Big Delta Quadrangle, east-central Alaska

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R.W. Saltus and W.C. Day

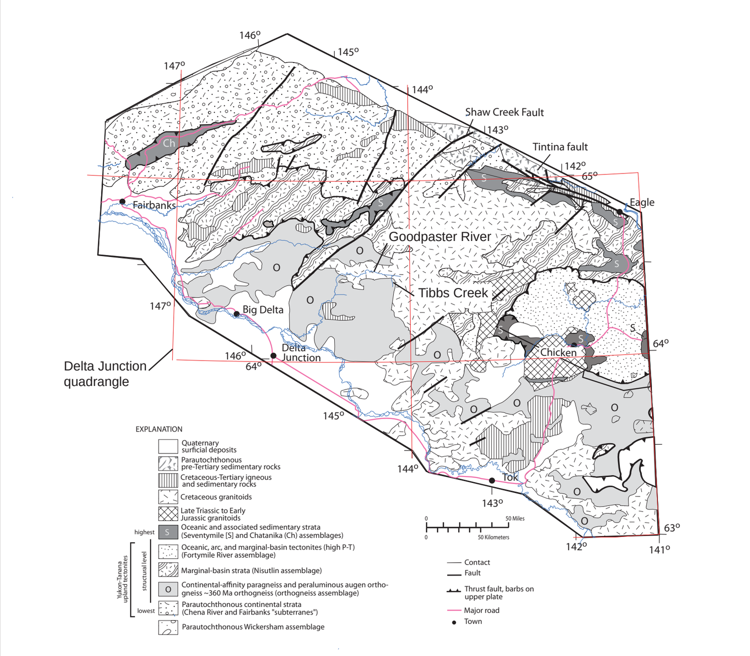
R.W. Saltus making a gravity measurement during the smoky 2004 field season

Abstract

The Yukon-Tanana Upland is a complex composite assemblage of variably metamorphosed crystalline rocks with strong North American affinities. At the broadest scale, the Upland has a relatively neutral magnetic character. More detailed examination, however, reveals a fundamental northeast-southwest-trending magnetic gradient, representing a 20-nT step (as measured at a flight height of 300 m) with higher values to the northwest, that extends from the Denali fault to the Tintina fault and bisects the Upland. This newly recognized geophysical gradient is parallel to, but about 100 km east of, the Shaw Creek fault. The Shaw Creek fault is mapped as a major left-lateral, strike-slip fault, but does not coincide with a geophysical boundary.

A gravity gradient coincides loosely with the southwestern half of the magnetic gradient. This gravity gradient is the eastern boundary of a 30-mGal residual gravity high that occupies much of the western and central portions of the Big Delta quadrangle. The adjacent lower gravity values to the east correlate, at least in part, with mapped post-metamorphic granitic rocks.

Ground-based gravity and physical property measurements were made in the southeastern-most section of the Big Delta quadrangle in 2004 to investigate these geophysical features. Preliminary geophysical models suggest that the magnetic boundary is deeper and more fundamental than the gravity boundary. The two geophysical boundaries coincide in and around the Tibbs Creek region, an area of interest to mineral exploration. A newly mapped tectonic zone (the Black Mountain tectonic zone of O'Neill and others, 2005) correlates with the coincident geophysical boundaries.



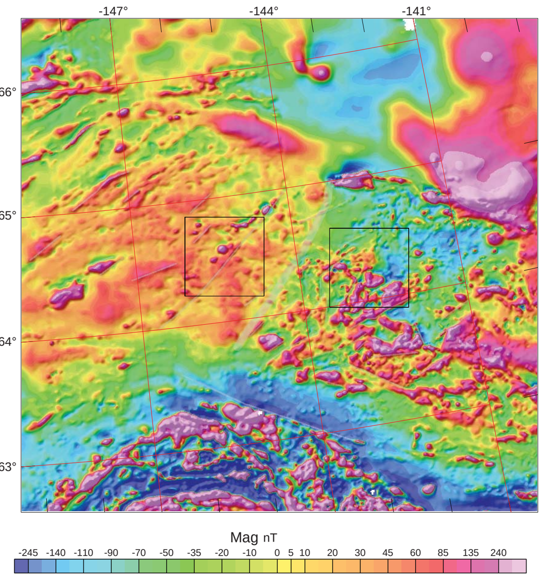
Simplified bedrock geologic map of the Yukon-Tanana Upland (modifed after Dusel-Bacon and others, 2006)

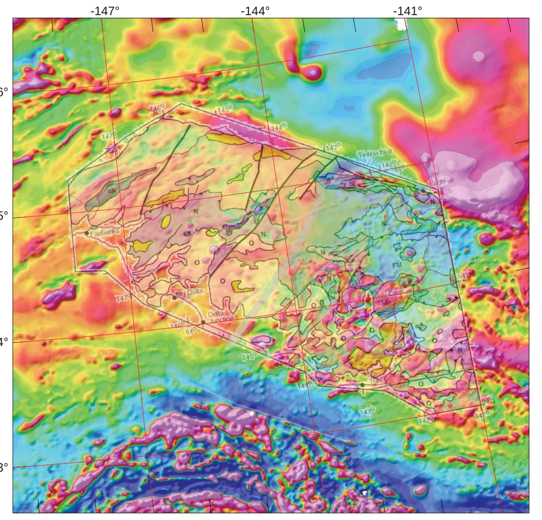
Aeromagnetic data

Aeromagnetic data are shown for the region surrounding the Big Delta quadrangle of east-central Alaska. Note that the color scale is non-linear to stretch anomaly zones at the middle of the scale. These data are clipped from the Alaska data compilation of Saltus and Simmons (1997).

The upper panel includes lines of maximum gradient, hand-drawn on the map to indicate significant magnetic property boundaries. The two small boxes outline regions analyzed in Panel 3.

The lower panel includes a screened version of a regional geologic map (O'Neill and others, 2005) for comparison with the aeromagnetic anomalies.



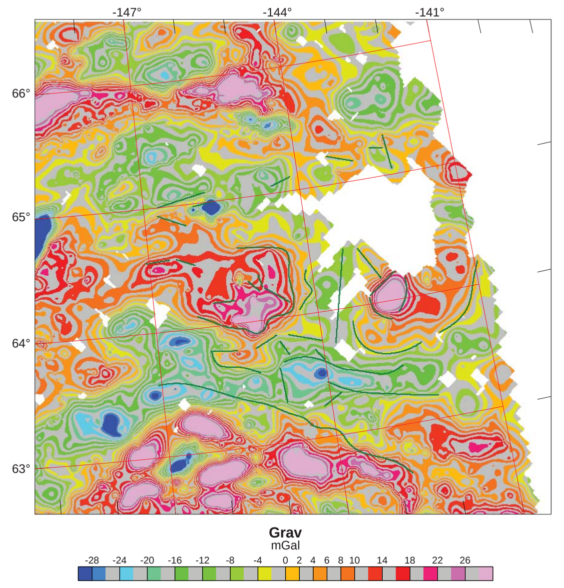


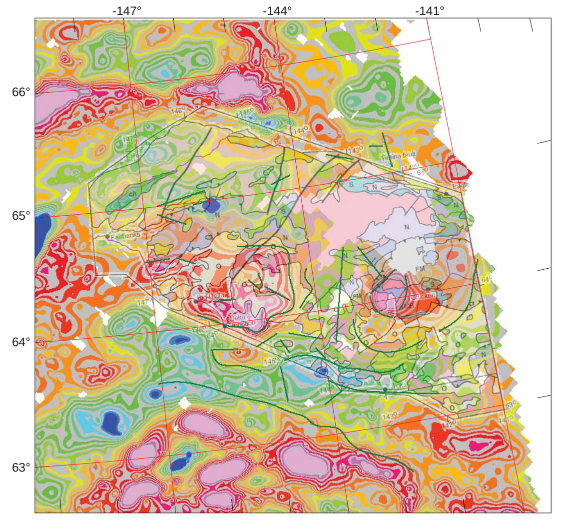
Gravity data

Wavelength-filtered (200 km high-pass) complete Bouguer gravity data are shown for the region surrounding the Big Delta quadrangle of east central Alaska. The color scale is linear with alternate gray bands to help emphasize gradients at all anomaly levels. These data are from a state-wide compilation by Bob Morin, USGS (2005, written communication).

The upper panel includes lines of maximum gradient, hand-drawn on the map to indicate significant density boundaries.

The lower panel includes a screened version of a regional geologic map (O'Neill and others, 2005) for comparison with the gravity anomalies.



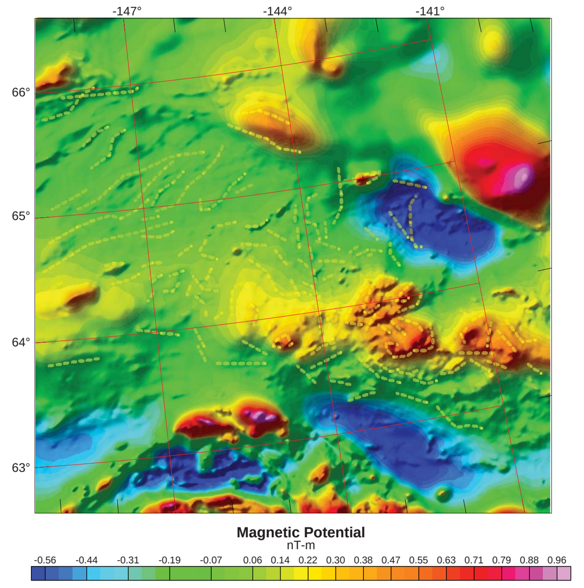


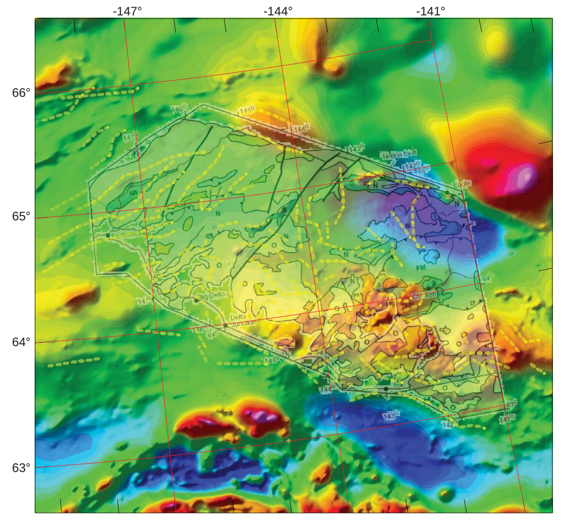
Magnetic Potential

Magnetic potential values are shown for the region surrounding the Big Delta quadrangle of east-central Alaska. Magnetic potential is derived directly from observed aeromagnetic data by mathematical transformation in the frequency domain. The resulting field emphasizes long-wavelength (generally deeper) features.

The upper panel includes lines of maximum gradient, hand-drawn on the map to indicate significant magnetic property boundaries.

The lower panel includes a screened version of a regional geologic (O'Neill and others, 2005) for comparison with the aeromagnetic anomalies.



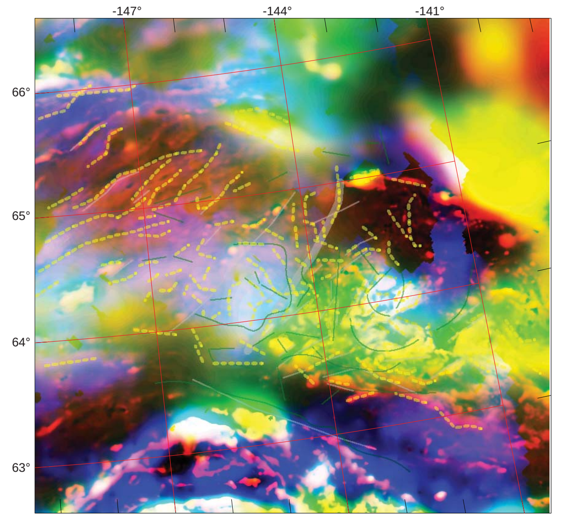


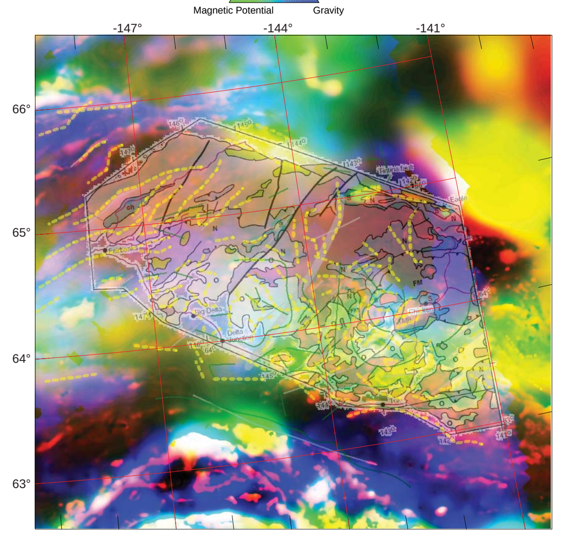
RGB Composite

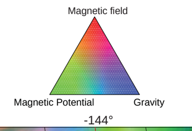
A red-green-blue (RGB) composite geophysical map is shown for the region surrounding the Big Delta quadrangle of east-central Alaska. Aeromagnetic anomalies are depicted as shades of red, magnetic potential anomalies as shades of green, and gravity anomalies are in shades of blue. The three color bands combine to form a composite image. Dark areas represent regions where all the constituent values are low; conversely, light regions indicate high anomaly values. In many cases geophysical composite maps provide useful guidelines for mapping of geologic and/or tectonic zones.

The upper panel includes lines of maximum gradient from each of the three constituent data sets shown to the left.

The lower panel includes a screened version of a regional geologic (O'Neill and others, 2005) for comparison with the geophysical anomalies.

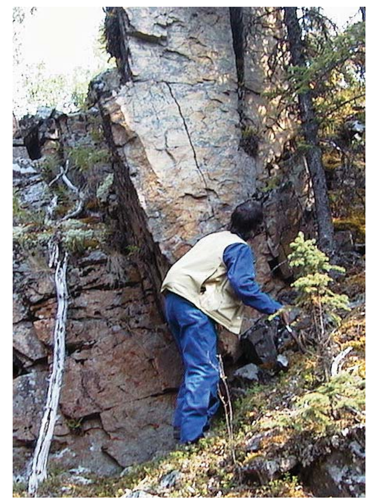




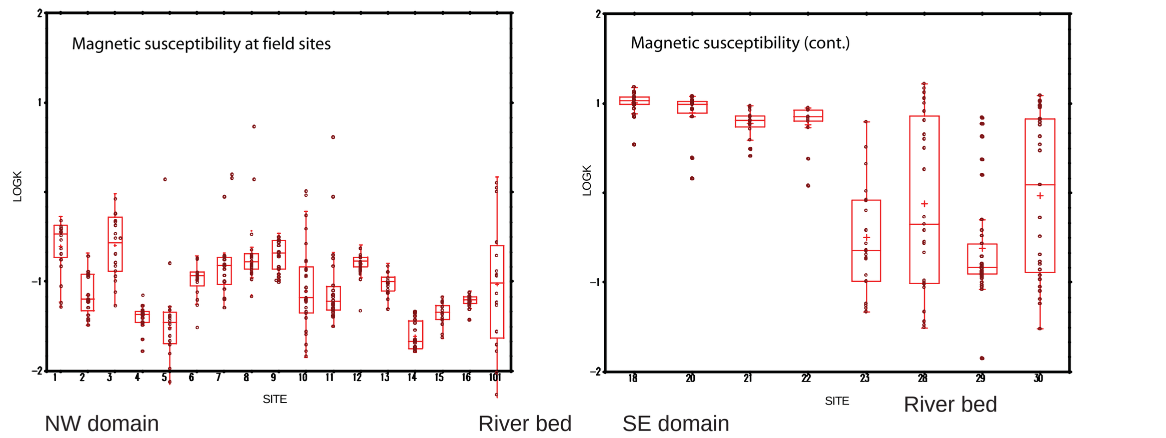


Panel 2

Tintina project personnel, summer 2004: Mike O'Neill, Warren Day, Larry Gough, Arnie Johnson (pilot)



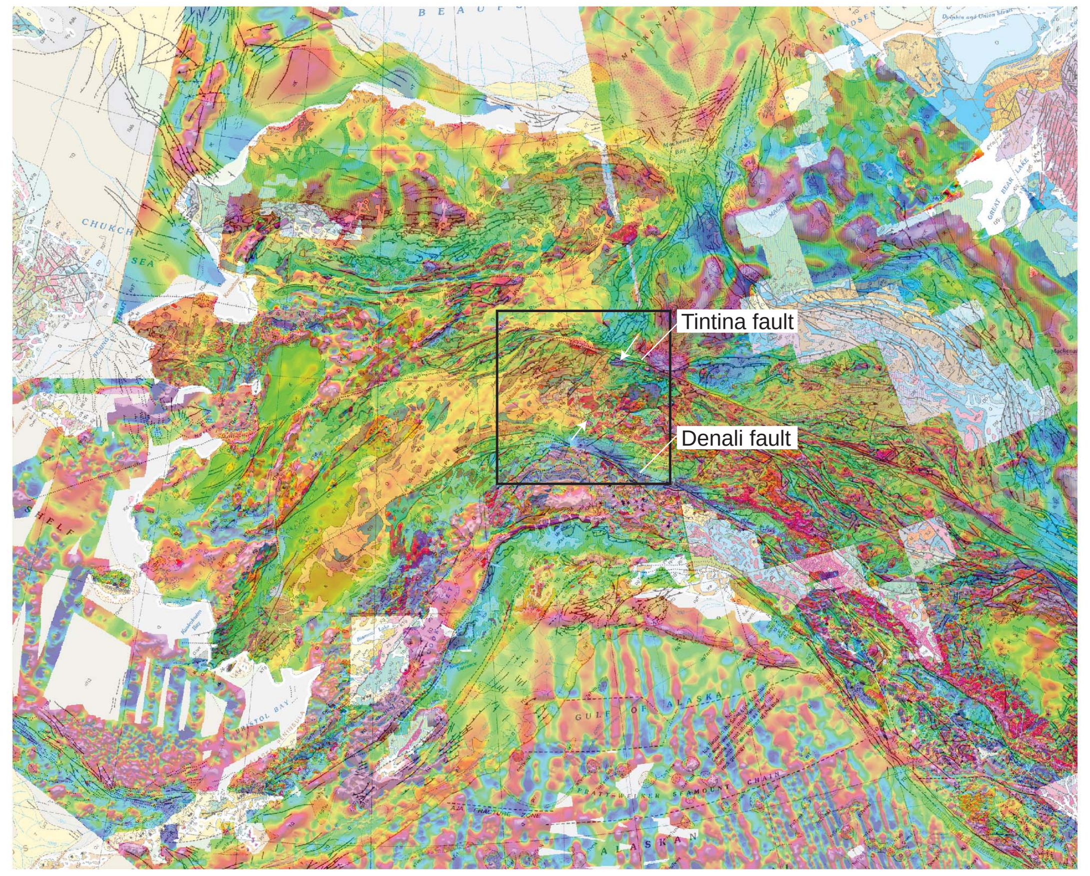
Mike O'Neill investigates igneous intrusions in the Black Mountain Tectonic Zone



Box and whisker plots of *in situ* magnetic susceptibility measurements. Dots show individual spot measurements at each site. Values are in mSI, plotted in log scale. Box and whiskers show the central mean, standard deviation, and normal range of the data. Points outside the whiskers are statistical outliers. All sites are coincident with gravity measurement sites. Sites 1-16 are within the NW aeromagnetic domain and are made on outcrop and rubblecrop at each site. Site 101 is along gravity transect 2 on the road east of Delta Junction and consists of measurements made on rocks in a stream bed. Sites 18-22 are on outcrop and rubble crop in the SE aeromagnetic domain at the east end of gravity traverse 1. Sites 23-30 represent measurements on rocks in the Goodpaster River bed (on eastern end of profile grav 1 and on all of profile grav 3).

Panel 5

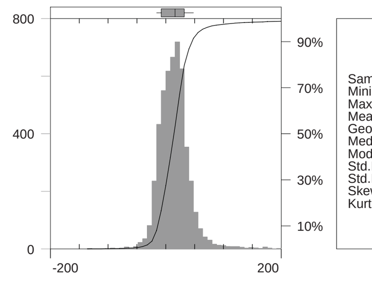
Regional Aeromagnetics and Geology



These data were extracted from the Magnetic Anomaly Map of North America (NAMAG, 2002). The black box shows the approximate area of detailed geophysical maps in Panel 2. The geologic information is from the new Geologic Map of North America (Reed and others, 2005).

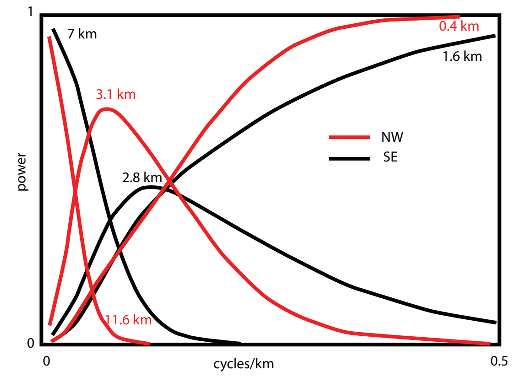
A NNE-SSW trending boundary (which falls between the white arrows on the figure), extending between the Denali and Tintina faults, separates regions of contrasting aeromagnetic character within the Yukon-Tanana Upland. This boundary is visible at the scale of North America and represents a significant geophysical feature.

Panel 1



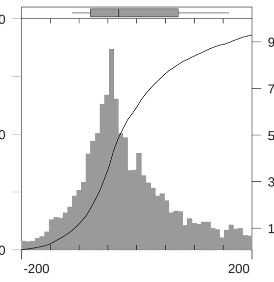
NWmag	
Samples:	5041
Minimum:	-135.76
Maximum:	738.66
Mean:	18.88
Geo.Mean:	18.50
Median:	14.45
Mode:	28.65
Std.Dev.:	47.02
Std.Err.:	0.6622
Skew:	6.356
Kurtosis:	63.99

Histogram analysis of aeromagnetic data values typical of the zone northwest of the aeromagnetic boundary zone. The values cluster tightly (standard deviation of about 47 nT) about a mean value of about 19 nT, and are relatively symmetrical (low skew) about this mean. The distribution is "too tall" (high kurtosis) relative to a bell-shaped, normal data distribution.



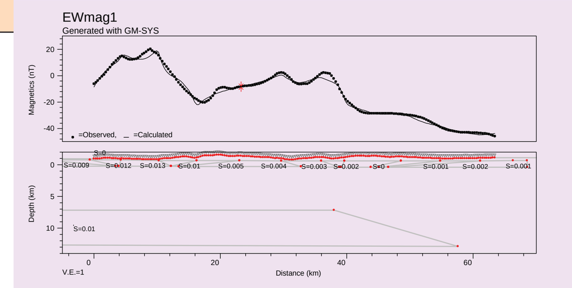
These curves represent the results of matched filtering on the data boxes outlined in Panel 2. A high-pass, band-pass, and low-pass filter is defined in each case. The northwest zone can be separated into three distinct bands with depths of 0.4 km, 3.1 km, and 11.6 km. The southeast zone can also be separated into three bands (1.6 km, 2.8 km, and 7.0 km), but the central band has low power and is probably not significant. This analysis suggests that the broad step in magnetic values between the two regions may arise primarily from contrasts within the upper 5 km or so of

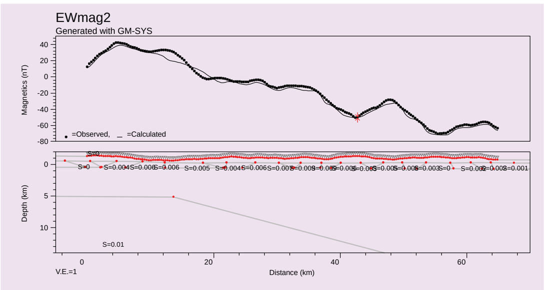
Histogram analysis of aeromagnetic data values typical of the zone southeast of the aeromagnetic boundary zone. The values have a broader range then those in the northwest zone (standard deviation of 120 nT) and are centered roughly on zero (2.3 nT). Although the histogram appears asymmetric, this distribution has a lower skew (1.8 vs. 6.3) than does the northwest zone. This distribution is closer to the bell-shaped normal ideal (lower kurtosis) than the northwest zone shows, but it appears that it may consist of two separate, superimposed bell-shaped populations – a tightly peaked distribution with a mean of about -50 nT and a broader distribution with a mean of about 0 nT.



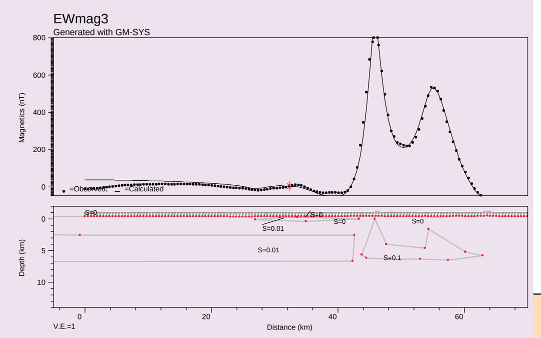
SEmag	
Samples:	5041
Minimum:	-549.90
Maximum:	1066.81
Mean:	2.31
Geo.Mean:	60.50
Median:	-29.82
Mode:	-549.90
Std.Dev.:	120.2
Std.Err.:	1.694
Skew:	1.836
Kurtosis:	7.077

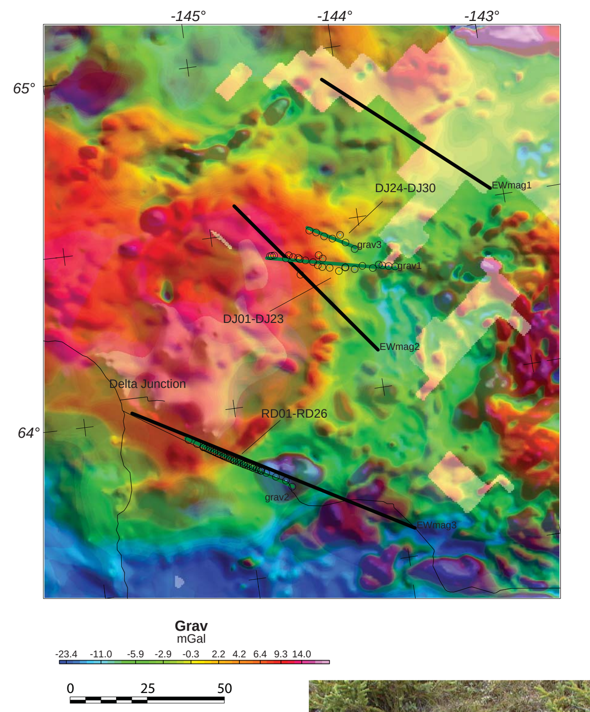
Panel 3



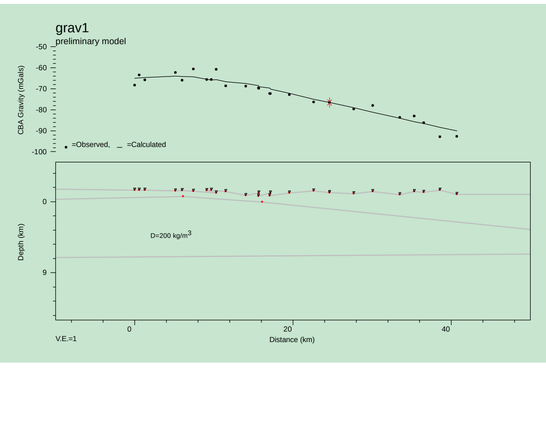


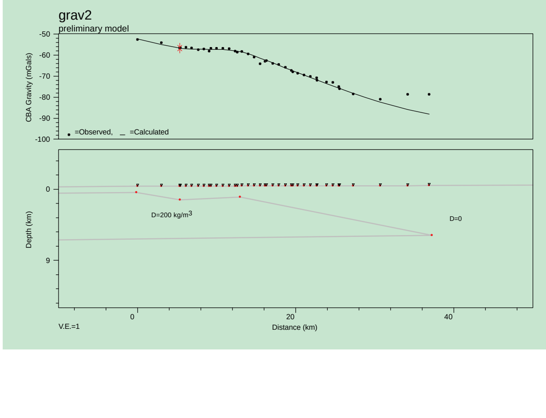
Two-dimensional aeromagnetic models for three transects that span the NNE-SSW regional magnetic domain boundary. Magnetic transects 1 and 2 both depict an east-dipping zone that contributes to the regional ~20-nT step in magnetic values across this boundary. Superimposed on this regional step are shorter-wavelength variations modeled by magnetic property variations in the near surface.





Two-dimensional gravity models for two transects across the gravity gradient that partially coincides with the NNE-SSW regional magnetic domain boundary. The data (gravity observations shown by open circles on the map) are from observations made in August 2004 by the authors . The preliminary models suggest a regional dip to the east for the density interface.





Lacoste & Romberg G-550, PLGR & Garmin 12 GPS units used in fieldwork

Acknowledgements

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Panel 4

Observations and Conclusions

1. A NNE-SSW (N35E) "step" of about 20 nT in regional aeromagnetic data values marks a distinct boundary that crosses the Yukon-Tanana upland between the Denali and Tintina faults.
2. Regional aeromagnetic values are systematically higher on the NW side of this boundary.
3. Preliminary analysis and modeling suggests that this boundary reflects an east-dipping contact of a thick (~5 km) crustal zone within the upper crust (upper 10 km).
4. A gravity gradient (high to the northwest) coincides with a portion of the N35E magnetic gradient in the SE corner of the Big Delta quadrangle.
5. Regional gravity lows appear to relate to the amount of postmetamorphic granitoid in a given region of the crust. In other words, the gravity lows map the granitic intrusions.
6. This implies that most of the granitic complex is non-magnetic to weakly magnetic.
7. However, discrete portions of the granitic complex are highly magnetic (including the Mt. Harper pluton).
8. The N35E magnetic step is a more fundamental, through-going crustal feature than the gravity high and gradient.
9. In the Black Mountain zone the magnetic step and the gravity gradient coincide – this coincidence may relate to mineralization in that region.
10. Short-wavelength (shallow) aeromagnetic highs correspond to the location of the north-south to NE-SW gravity gradient. These may reflect more magnetic (more mafic?) rocks along this boundary.

Logistical support by pilot Arnie Johnson

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Panel 6

http://pubs.usgs.gov/of/2006/ofr-2006-1391/