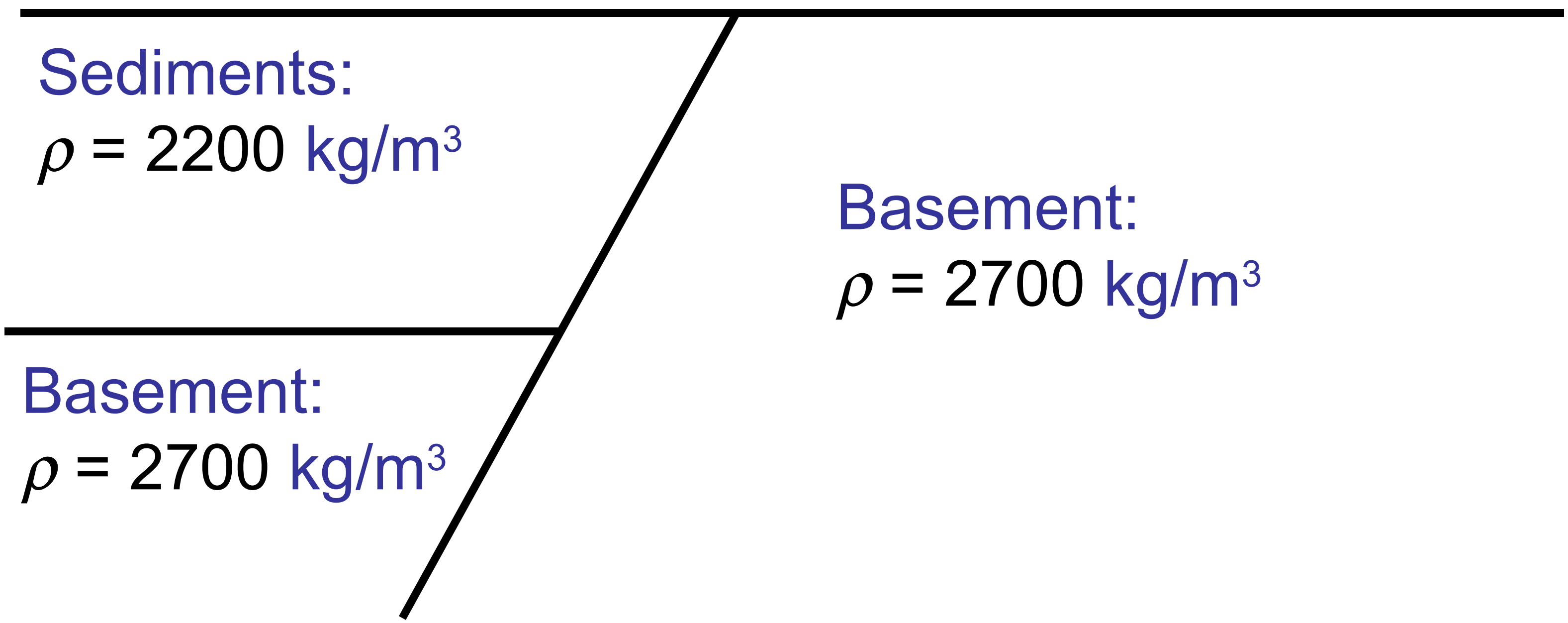
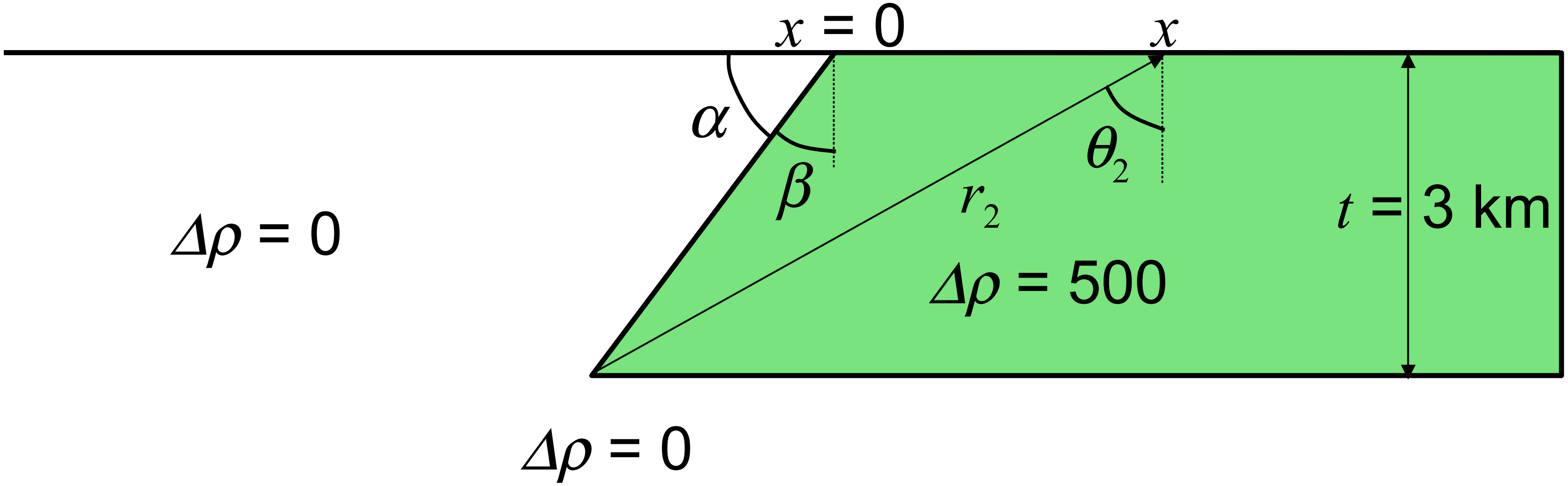
Gravity on a Dipping Fault

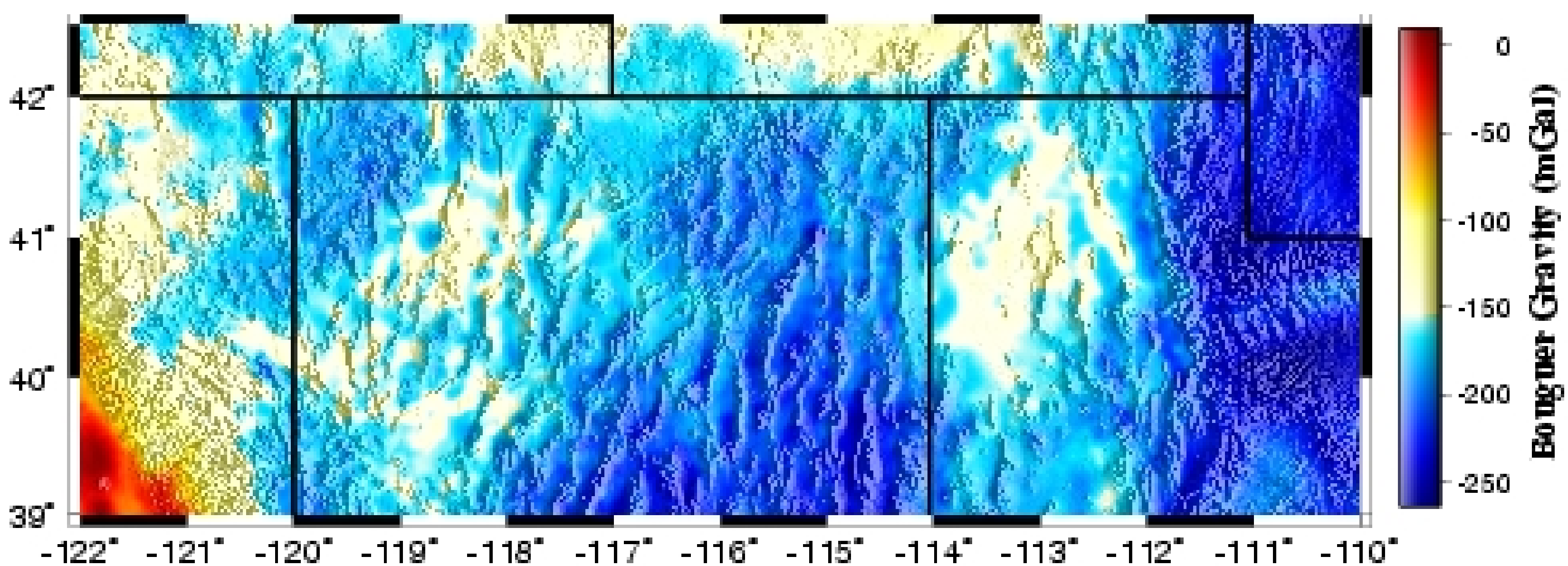
Recall:

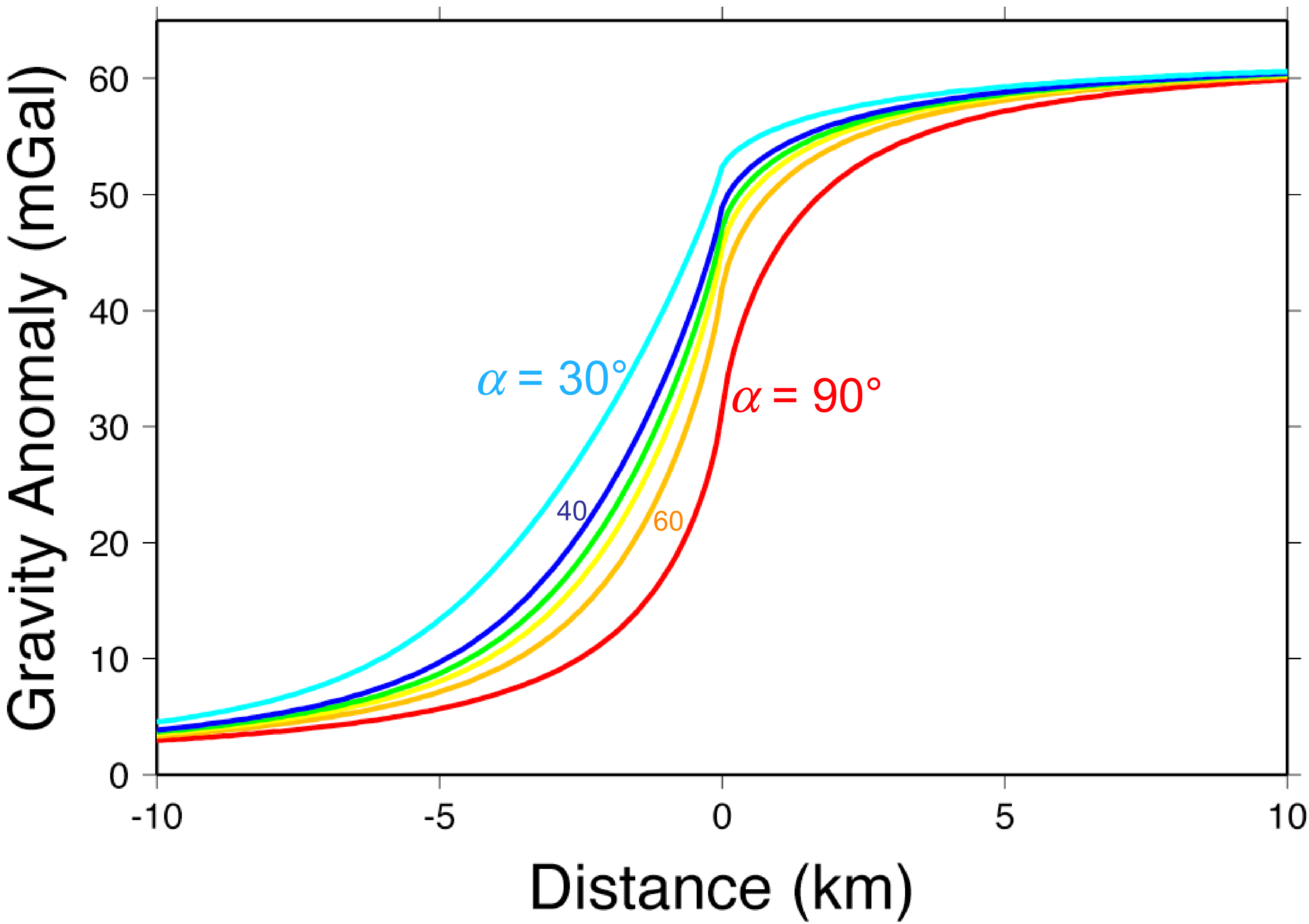
$$\vec{g} = -4\pi G \iiint_{Vol} \rho \, dV$$



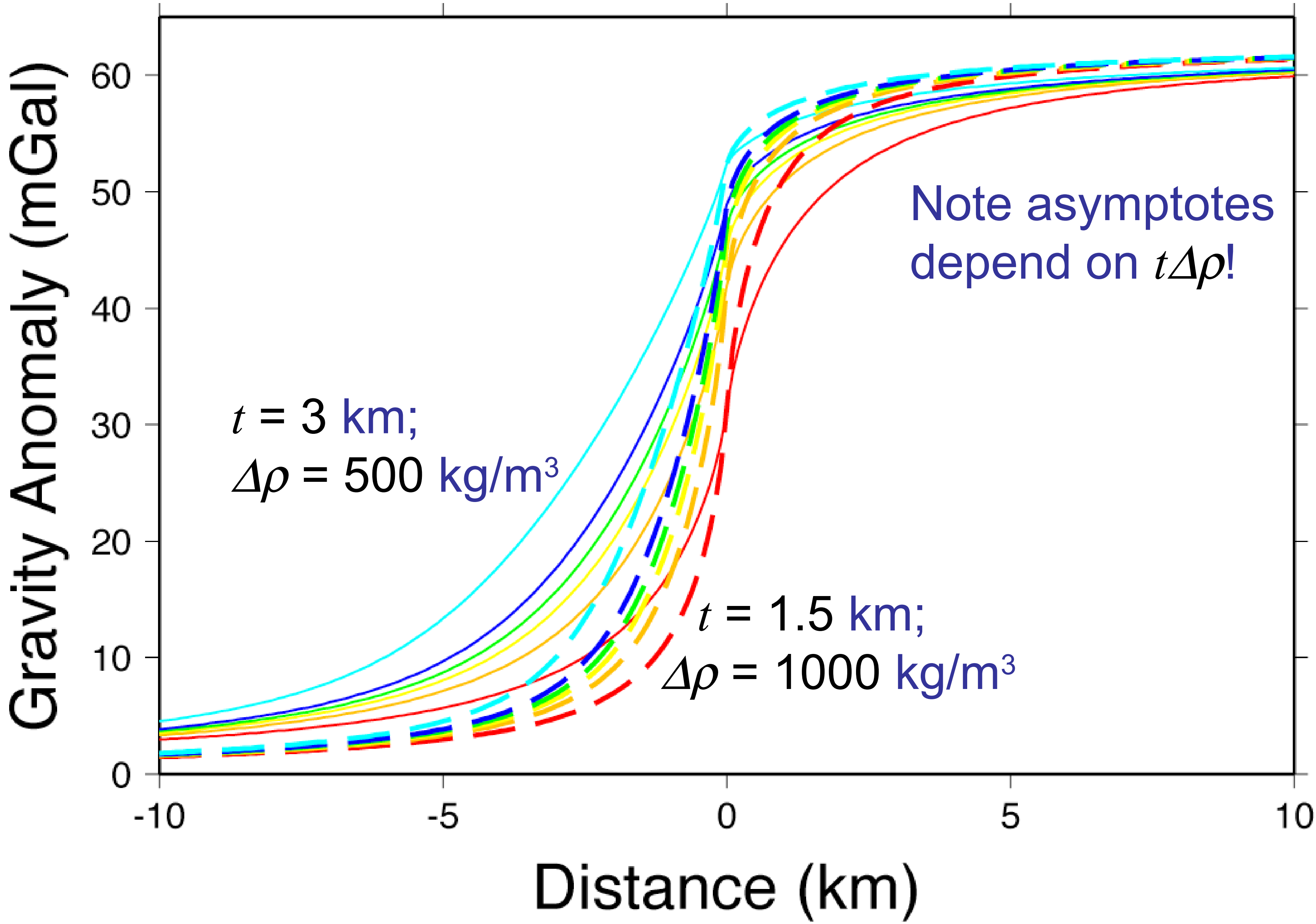


$$g = 2G\Delta\rho\left[\frac{\pi t}{2} + \theta_2 t + x\left(\theta_2 - \frac{\pi}{2}\right)\sin\beta\cos\beta + x\cos^2\beta\ln\left(\frac{r_2}{x}\right)\right]$$





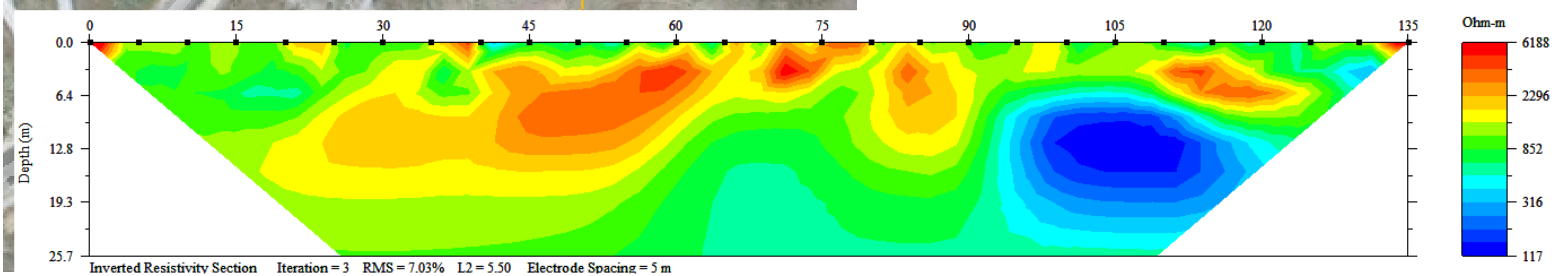
Gravity Anomaly (mGal)
60
50
40
30
20
10
0
-10
-5
0
5
10
Distance (km)
α = 30°
α = 90°
40
60

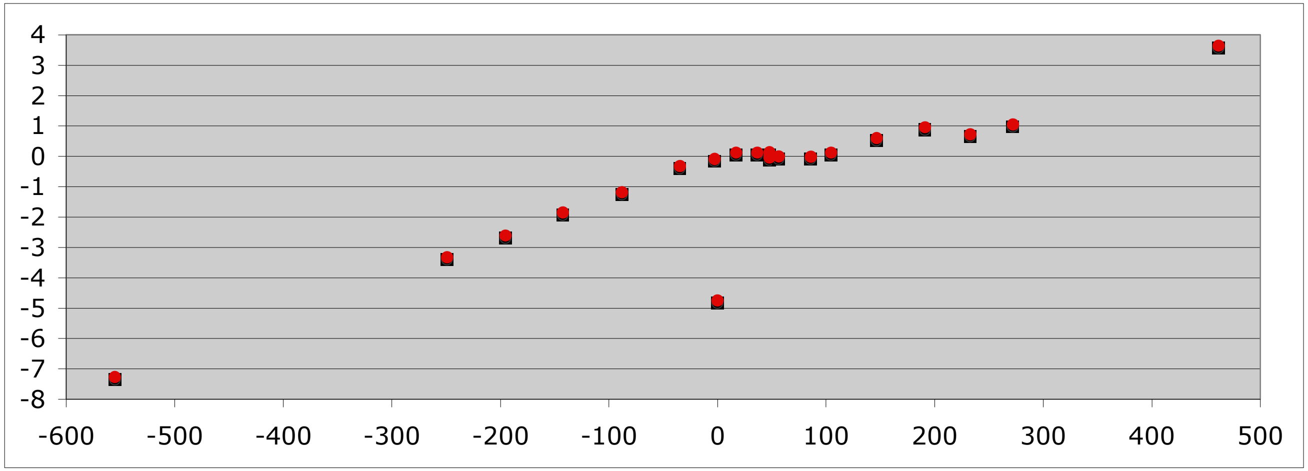


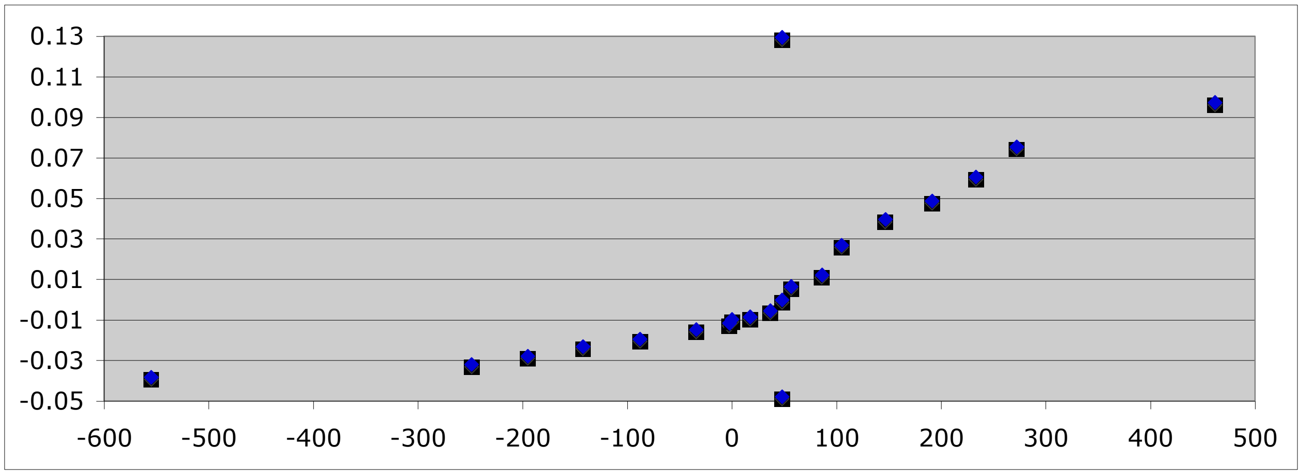
Gravity Anomaly (mGal)
60
50
40
30
20
10
0
-10
-5
0
5
10
Distance (km)
Note asymptotes depend on $t\Delta\rho$!
t = 3 km;
$\Delta\rho$ = 500 kg/m^3
t = 1.5 km;
$\Delta\rho$ = 1000 kg/m^3

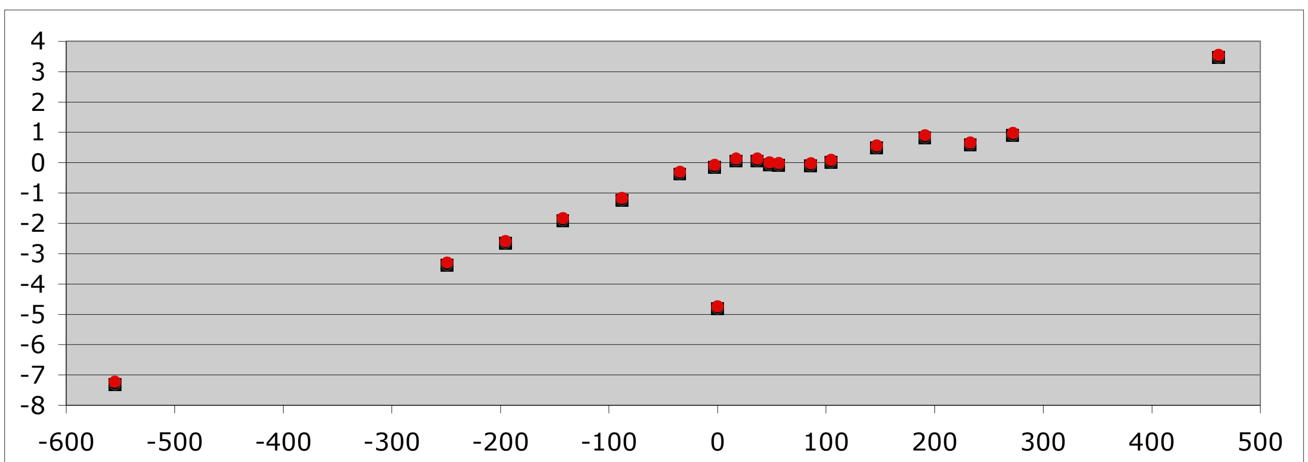
Example: Green Canyon

A low-resistivity anomaly consistent with Paleozoic bedrock suggested the mapped trace of the ECF is ~30 m east of the true fault location, near the dotted line.



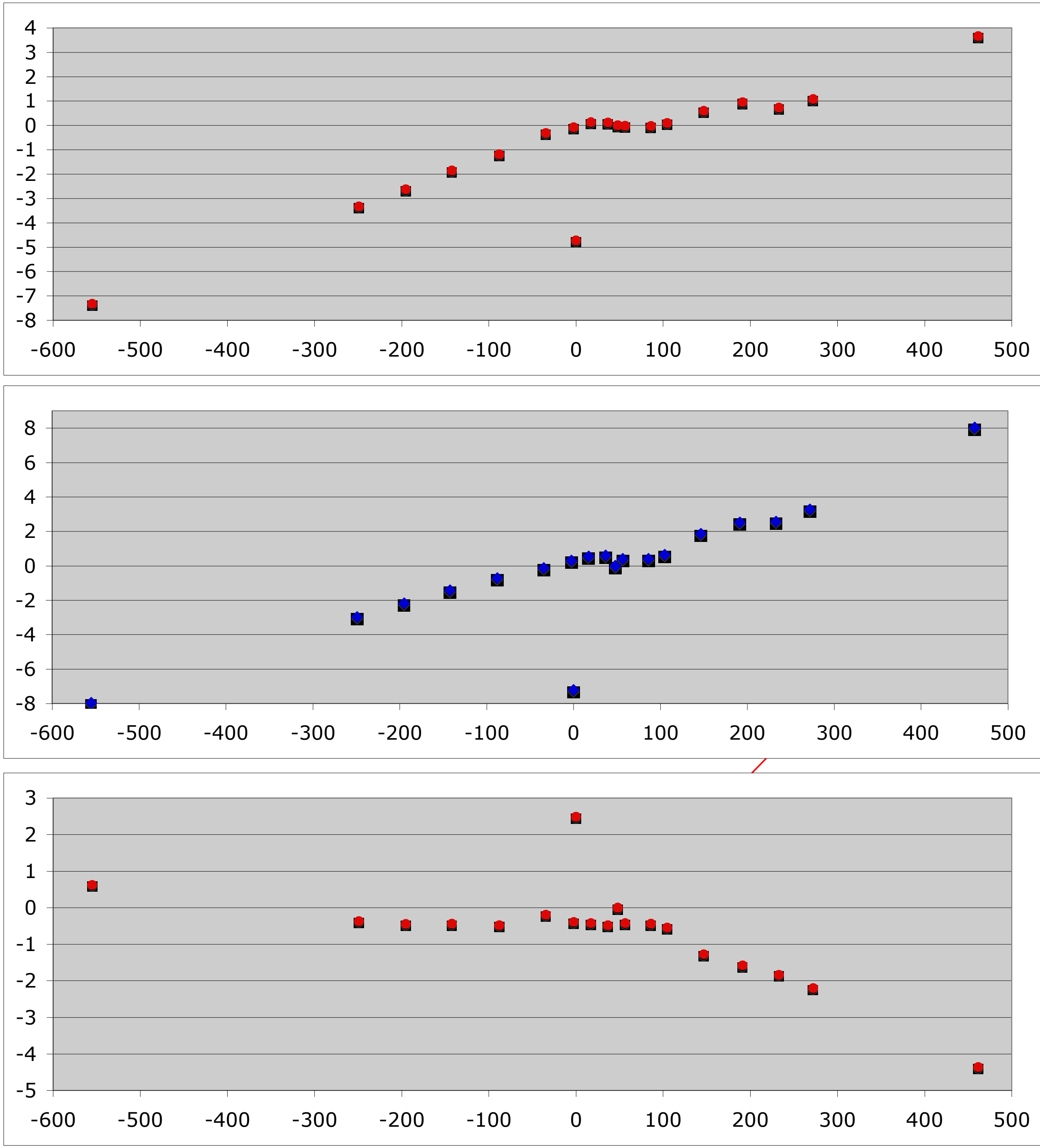




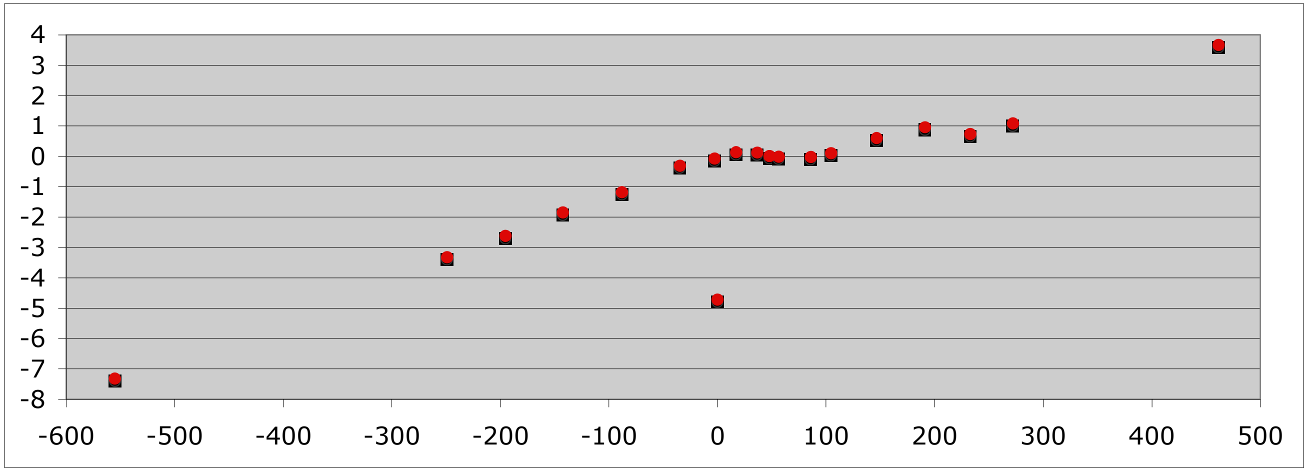


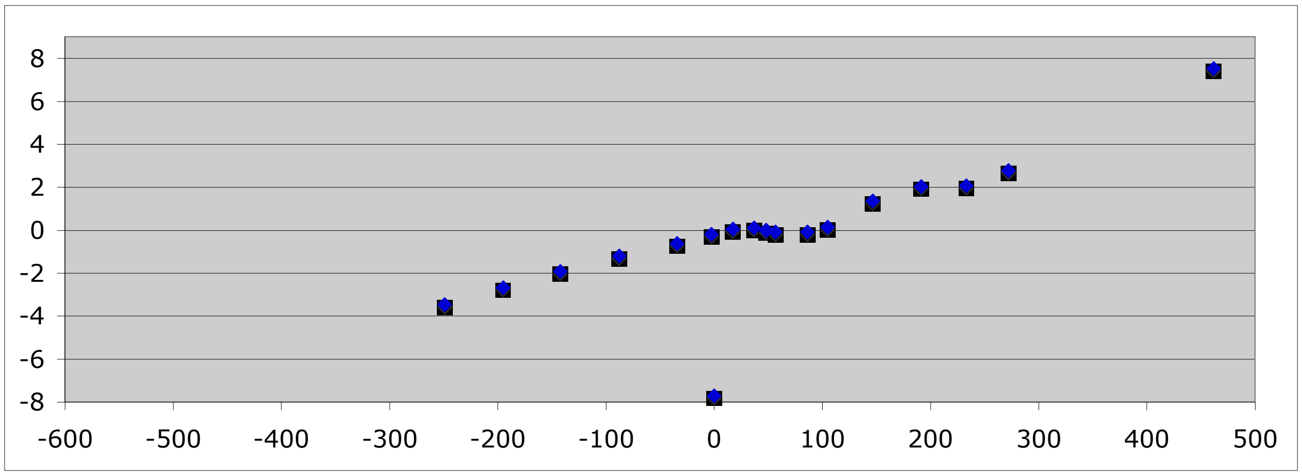
Example: Green Canyon

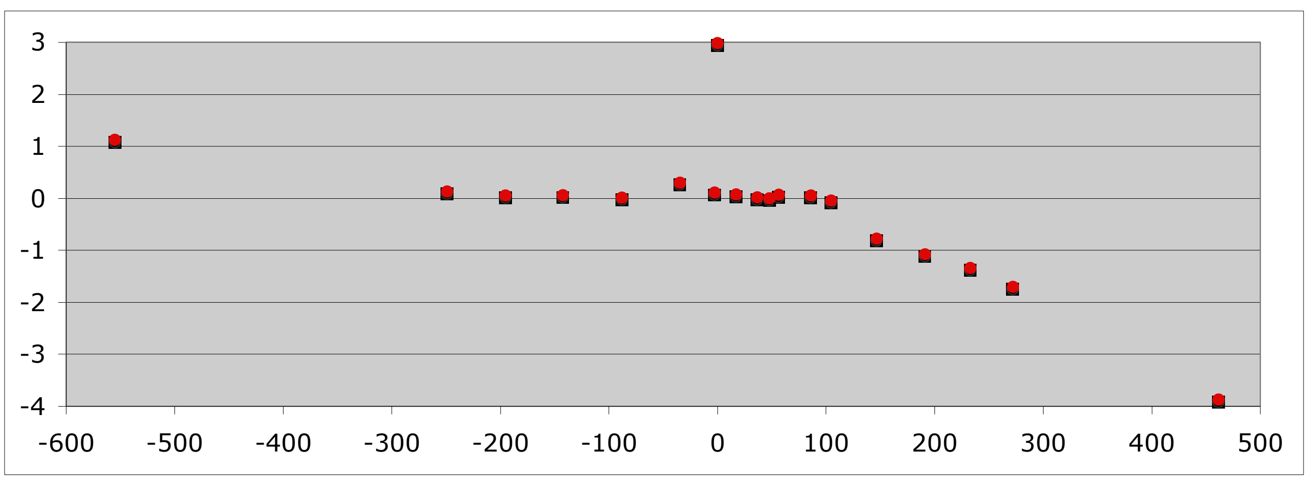
The drift correction was correlative with the measurements, which is a bit worrying… But only a small fraction (~2%) of the observations so we needn't worry about it too much.



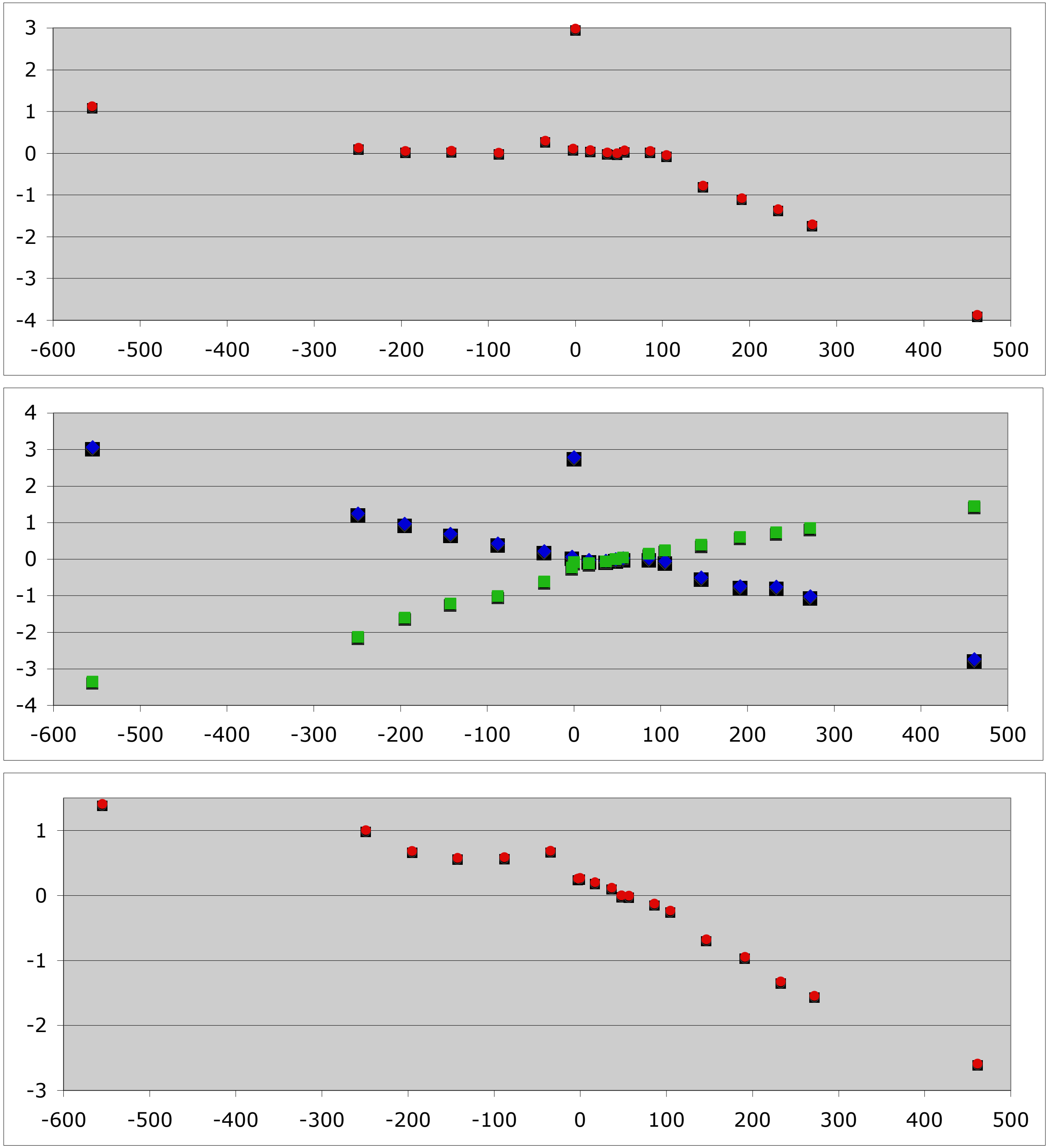
The free air correction is actually larger than the raw obs (as is generally true in high-relief areas). The gravity base site appears as a worrisome outlier in both the correction & anomaly though. Inspection reveals a ~1.6m height error in week-one (non-RTK) GPS measurement of the elevation.



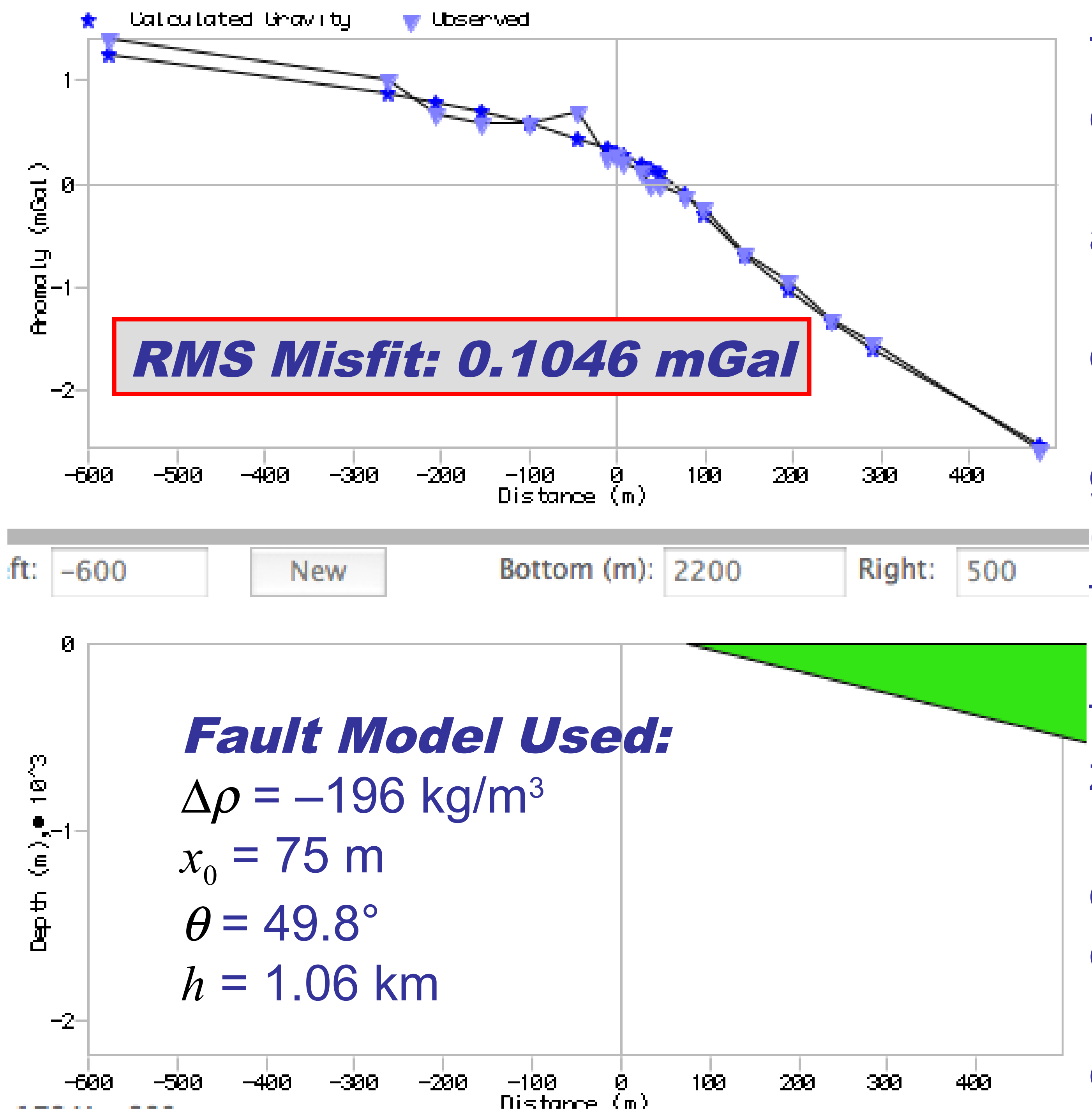




The error was corrected by interpolating the heights at the nearest geophones (which were about the same elevation) to the x-position of the gravity base. The free air correction and anomaly with elev corrected at the gravity base are cleaner, but the western-most site may have a similar height error.



The complete Bouguer anomaly looks reasonable, and similar to what we might expect at a normal fault, save for a few outlier points (e.g., Grav 6 at x = –34.4 m). However we have no valid reason to throw these out at this stage.



The density contrast between basin sediments and Paleozoic bedrock clearly dominate the measured gravity. Misfit (largely in the footwall) may partly reflect fault damage-zone effects, but probably mostly out-of-plane effects &/or measurement errors.

The x_0 = 75 m model prediction for the projection of the East Cache Fault to the surface at Green Canyon reinforces the possibility that fault trace is a few tens of m further west than previously mapped, and thus that the low resistivity, high chargeability anomaly found on the eastern side of the resistivity/IP profile is Paleozoic bedrock in the footwall of the fault. The model is very sensitive to choice of x_0: Putting the fault trace at ~10 m where it is mapped (& keeping other parameters the same) yields an RMS misfit of 0.1443 mGal; in my experience, a model with (19 – 4 =) 15 degrees of freedom that yields a 38% larger misfit than the minimum error solution can be ruled out at very high confidence. However given the scale of mass averaging and likely near-surface complexities & geometrical effects associated with fault rupture, the most we can really say with confidence is that a fault trace somewhere west of the mapped trace is favored by the data.

Geology 5660/6660
Applied Geophysics

23 Mar 2018

Last Time: *Gravity Modeling*

• Anomalies for a ***fault-bounded basin***:

$$\Delta g_z = 2G\Delta\rho\left[\frac{\pi t}{2} + \theta_2 t + x\left(\theta_2 - \frac{\pi}{2}\right)\sin\beta\cos\beta + x\cos^2\beta\ln\left(\frac{r_2}{x}\right)\right]$$

have asymptotes that depend on $\Delta\rho t$ where t is thickness, and transition location, slope & shape depends on β & t.

• Example reduction of data from Green Canyon showed how outliers may indicate errors (in this case in height)

• Problems with measurement recording & positioning result in problems for analysis: Careful data collection is crucial!

• Showed East Cache Fault is likely about 30 m west of the mapped trace, consistent with inference from resistivity…

For Mon 26 Mar: ***Burger*** 429-454 (§7.1-7.4)