Geology 559 Term Paper: A Geophysical Analysis of the Rock Canyon Fault Zone

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Section 1: Introduction

Gravity and magnetic data can be used to find many different types of underground objects. Gravity data can be used to determine the size and location of:

- Hydrocarbon deposits,
- Faults,
- Ore bodies,
- Bedrock,
- Cavities,
- Buried river channels,
- Landfills, and
- Possible volcanic activity

In addition, magnetic data can be used to determine the size and location of:

- The depth of burial of magnetized rocks (such as for archaeological digs and locating ore bodies),
- Geologic features, such as faults, and
- Volcanic or intrusive igneous rocks in the area

In this study, gravity and magnetic surveys were conducted along a small traverse near the outlet of the Rock Canyon watershed (see Figure 1 and Figure 2). The Rock Canyon location is an area known to have faults. An abundance of data is also available for the survey location.

The Rock Canyon survey location is located along the Wasatch fault zone, which extends from southern Idaho to central Utah. It is also located in an area where surface rupture, ground shaking, or liquefaction could effect the homes and buildings of the millions of people who live in this fault zone (Benson and Mustoe, 1995).

These properties made it an interesting and ideal location to perform gravity and magnetic surveys. After the gravity and magnetic surveys were performed, the results were plotted. The results from the gravity and magnetic surveys were corrected for drift and other factors, and then models were created of the subsurface to attempt to locate the size, depth, and composition of the fault. The results from the models were then compared with previous projects in this same area (such as Benson and Mustoe, 1991).

Figure 1: Area surrounding Rock Canyon, UT

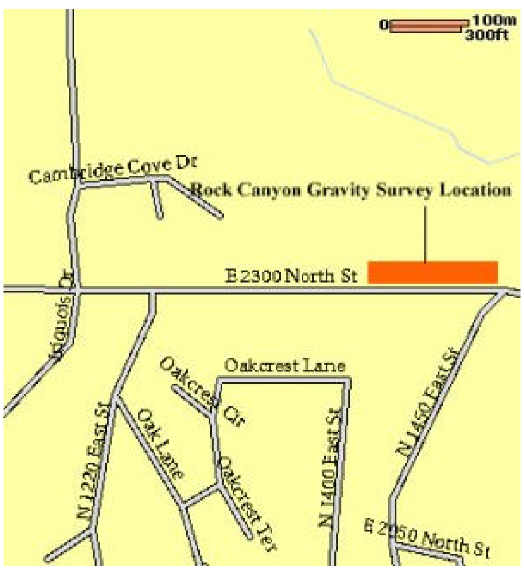

Figure 2: Location of the gravity and magnetic surveys

Section 2: Data Collection

Gravity Data Collection

A Worden gravimeter, with a precision of 0.01 mGals, was used in the gravity survey. Gravity readings were taken and recorded at 20-foot intervals, starting at the base station and proceeding west. Including the base station, gravity readings were taken at 14 locations on an east-west traverse. Gravity measurements were taken twice at the base station…once at the beginning of the survey and once at the end…so drift and tidal corrections could be made to the gravity values (See Figure 3). All the data begins at the base station and traverses west from there, as you will see in the following sections.

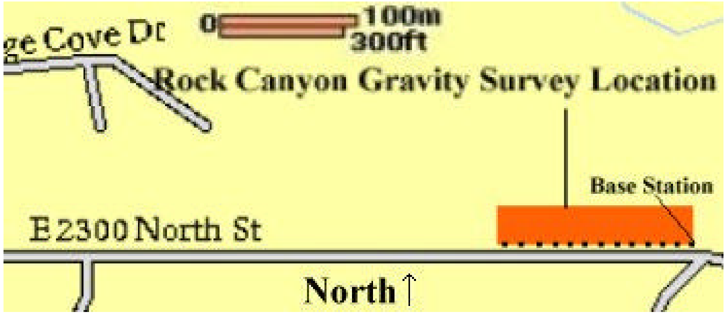

Figure 3: Rock Canyon gravity and magnetic survey points

Magnetic Data Collection

In addition to collecting gravity data, magnetic data was also collected at each of the survey locations. A proton procession magnetometer with a precision of 1 nT was used for performing the magnetic readings along the east-west traverse in Figure 3.

Section 3: Data Reduction

Gravity Data Reduction

After taking gravity readings, several corrections were applied to the gravity data. These corrections include:

- **The Free air Correction**: Calculated by multiplying the elevation changes from the base station (in feet) by 0.094.

- **The Bouguer Correction**: Calculated by multiplying the elevation change from the base station (in feet) by the average density of the surrounding rocks by 0.01277. The density of the surrounding rocks was assumed to be 2.0 g/cm^3, and this turned out to be a good assumption.

- **The Latitude Correction**: Equal to 0 for each point on the survey since the survey was on an east-west traverse. If the traverse had been a north-south traverse, the latitude correction would have been calculated.

- **The Terrain Correction**: Calculated using Hammer's method described on pages 331-335 of Burger (1992).

- **The Drift Correction**: Calculated by visiting the base once every two hours and correcting each reading back to the original base reading.

- **The Regional Correction**: Calculated by determining a regional trend in the data and subtracting this regional trend from the drift-corrected data.

As described in Benson and Mustoe (1991), a second-order polynomial was fitted to the drift-corrected gravity data. This second-order regional was then subtracted from the drift-corrected data to provide the final residual gravity anomalies at each survey location.

Occasionally, it is useful to use Parasnis' (1962) method to determine the density of the surrounding rocks associated with the Bouguer and terrain corrections. This method was used and a density of 5.24 g/cm^3 was calculated. This value is quite different than the value calculated by Benson and Mustoe (1991) for the same area. Therefore, the original value of 2.0 was retained for all the density-dependent gravity corrections. The density value would have been more accurate if more survey points had been taken. 13 survey points are probably not enough to determine an accurate density using Parasnis' method.

The corrected residual gravity anomalies are shown in Figure 4.

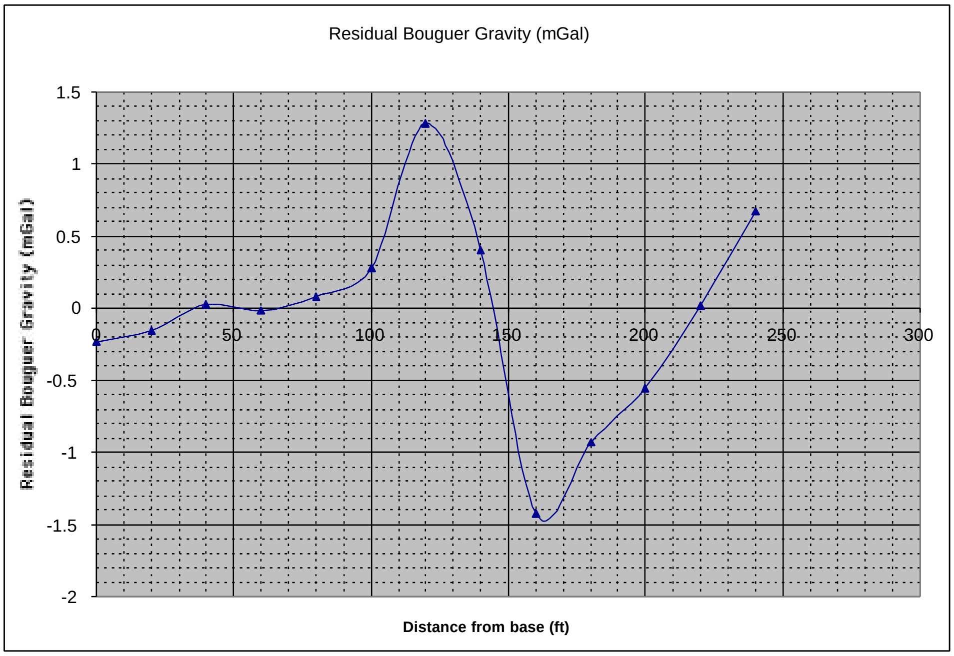

Figure 4: Residual gravity anomay values. The traverse is from east to west.

Magnetic Data Reduction

Unlike gravity surveys, magnetic surveys don't require lots of data corrections. The magnetic data was simply corrected for drift and diurnal shifts. This correction was made by taking a base reading at the beginning of the survey and one at the end of the survey. Taking the two readings allow you to make a correction similar to the gravity drift correction.

The corrected magnetic anomaly values are shown in Figure 5.

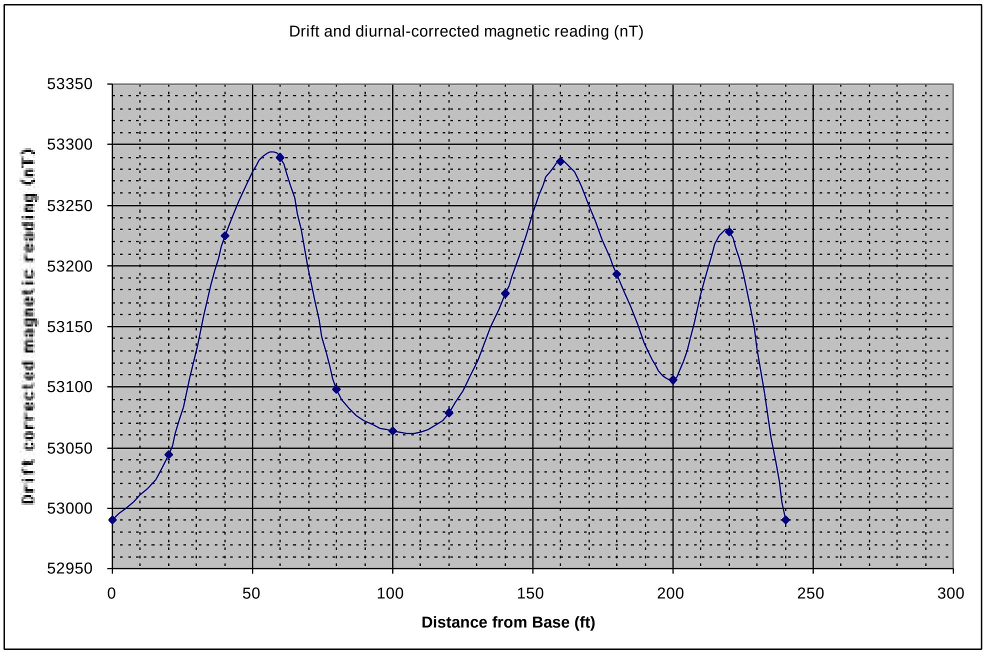

Figure 5: Corrected magnetic values. The traverse is from east to west.

Section 4: Data Interpretation

Gravity Data Interpretation

After correcting the gravity values and obtaining the residual anomaly values, the next step was to find out what the data means. From previous studies of this area (Benson and Mustoe, 1991) and from surface features, it was assumed that a fault existed across the traverse. Also, Figure 4 seemed to suggest that the fault was centralized at about 150 feet west of the base station.

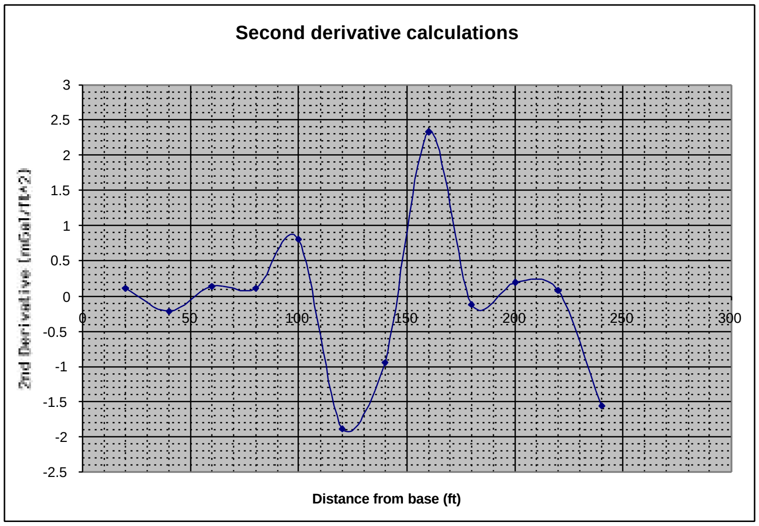

Figure 6: Second derivatives of the gravity curve along the surveyed area

Stanley's method, described on pages 374-375 of Berger (1992), was used to determine the depth of the fault and the dip of the fault's contact. The second derivatives of the residual Bouguer anomaly, shown in Figure 6, were first computed. Then, the depth and dip of the fault's contact were determined as shown in Table 1. The results were verified using the GravModel gravity-modeling program.

Table 1: Calculations for the depth and dip of the fault

Dip of Fault Contact:	84.00409	Degrees
t=(xmax-xmin)*sin(alpha)/-2:	14.92	Ft
Max Bouguer Anomaly:	1.283681	mGals
Min Bouguer Anomaly:	-1.42809	mGals
Max BA - Min BA (=A):	2.711774	mGals
A/2:	1.355887	mGals
3A/4:	2.033831	mGals
x(3/4) = h	9	Ft
D:	16.46	Ft
d:	1.54	Ft

Magnetic Data Interpretation

The magnetic survey gave further insight into the subsurface properties of the surveyed area. The three peaks in Figure 5 suggest that there are not only one, but three faults located along the east-west traverse. In addition to the main fault, there are two smaller faults east and west of the main fault, as in Figure 7.

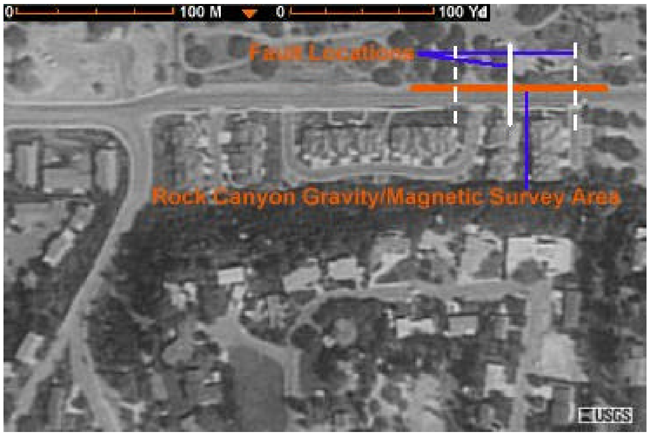

Figure 7: Aerial photo of the gravity/magnetic survey area showing possible fault locations

The peaks in the magnetic data may correspond to mineralization along the fault planes. Benson and Mustoe (1991) suggested that this mineralization might be composed of small amounts of hematite and limonite separated from the quartzite material in the fault blocks. As suggested in Benson and Mustoe, input values for the magnetic model were as follows:

Table 2: Input values for the magnetic model

Earth's magnetic field	53,000 nanoteslas
Inclination angle	65 Degrees
Susceptibility contrast	0.075 SI
Strike length	3050 m
Profile angle (w/r/t North)	74 degrees

The final model, verified using the GravModel and MagModel modeling software, is shown in Figure 8.

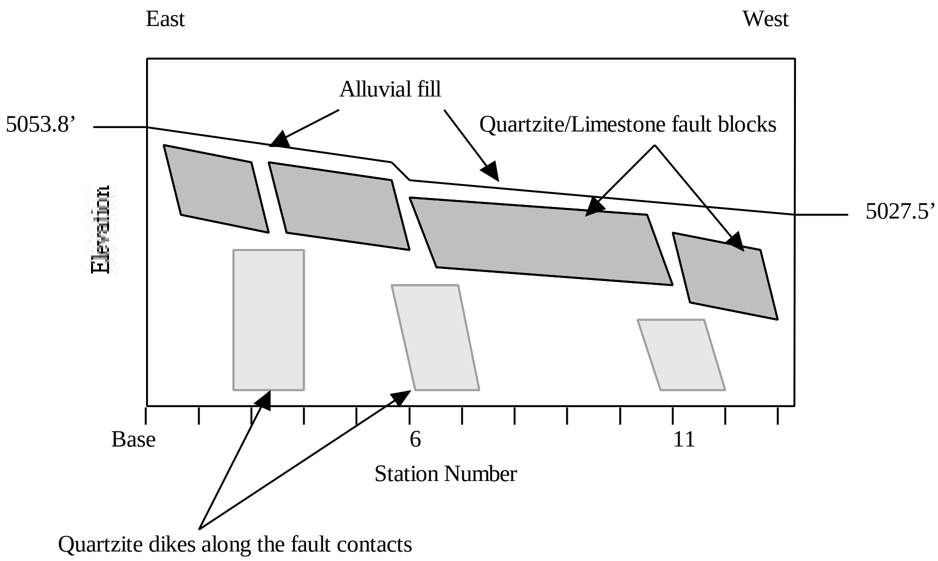

Figure 8: Final model of the surveyed area

Section 5: Conclusions

In this study, the gravity and magnetic data at the Rock Canyon location were collected, reduced, interpreted, and modeled to determine subsurface anomalies.

The gravity data, previous research, and observed data from the site showed that a major fault existed between stations 8 and 9 of the surveyed traverse. The magnetic data suggested that minor faults exist between stations 3 and 4 and 11 and 12 of the surveyed traverse, as shown in Figure 7 and Figure 8.

From the gravity and magnetic geophysical data, it was determined that a fault and two minor faults occur along the gravity/magnetic survey traverse. This analysis is supported by previous research, such as the research by Benson and Mustoe (1991).

References

Benson, A. K. & Mustoe, N. B. 1991. Delineating Concealed Faults and Shallow Subsurface Geology along the Wasatch Front, Utah, USA, by Integrating Geophysical and Trench Data: *Quarterly Journal of Engineering Geology*, **24**, 375-387.

Benson, A. K. & Mustoe, N. B. 1995. Analyzing Shallow Faulting at a Site in the Wasatch Fault Zone, Utah, USA, by Integrating Seismic, Gravity, Magnetic, and Trench Data: *Engineering Geology*, **40**, 139-156.

Berger, H. R. 1992. *Exploration Geophysics of the Shallow Subsurface:* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 331-335, 374-375.

Parasnis, D. S. 1962. *Principles of Applied Geophysics:* Methuen, London, 70-71.

Appendix: Calculations and Models