Shot Information

1.) Shot spacing: 6 m – Total of 39 shots
    a. First 6 shots occur before the line. See "Table 3" for description of geometry and shooting process.
2.) See Table 1 and Figure 2 for shot geometry
    a. Red Dots represent shots
3.) See Table 1 and Figure 2 for geophone geometry
    a. Blue trianges represent geophones
4.) 8 gauge shotgun blanks out of a Betsy Seisgun
5.) Shots were fired ~0.5m below surface

Receiver/Station Information

1.) Lat/long of northern-most shot location: 42.725791° N, 108.594372° W
    a. Azimuth of line: ~170°
2.) N/A
3.) ?
4.) See Figure 2 for the layout of the seismic line. The purpose of this experiment was to image a steeply south dipping strike slip fault at the interchange of Dallas and Derby Domes. The goal was to image the fault at depth, and confirm the geometry of the fault assumed from mapping done previously in the area. The steep dipping nature of the fault, along with that of the strata to the south of the fault made imaging the fault itself difficult. Instead, a washout zone of weak reflections was imaged, as well as a lateral velocity change in the refraction data.

Seismic Processing

Introduction

Previous studies of the basin margin folds along the southeastern flank of the Wind River Mountains have utilized a number of methods to interpret and analyze the significant faults and structures of the area including: geologic mapping, fracture analysis, limited well log analysis, and geologic cross sections (Abercrombie, 1989; Willis and Groshong, 1993; Gay, 1999; Brocka, 2007; Clements, 2008); however, only few studies have employed seismic techniques to image the structures at depth and constrain interpretations (Skeen and Ray, 1983; Alward, 2010; Tiffany, 2011; Thomas, 2012; Onen, 2013). Alward (2010) and Thomas (2012) both used seismic reflection and refraction techniques to study the geometry of the Spring Creek Fault in the Schoettlin Mountain and Red Canyon quadrangles respectively. Tiffany (2011) was able to image and estimate the amount of throw on the Carr Reservoir Fault in the Del Monte Ridge quadrangle using the same techniques. Onen (2013) conducted a 2D seismic reflection and refraction experiment to image potential fault duplexing on the footwall of the Derby Dome back limb fault. For this study, a 2D seismic reflection experiment was set up to image what has been interpreted by Brocka (2007) as a strike-slip fault in the Dallas–Derby Dome interchange area displaying ~280 m of lateral offset. The fault may have had a significant influence on the offset of Dallas and Derby Dome. Imaging the fault could provide insight as to what is controlling the en echelon pattern of the basin margin folds.

The seismic reflection experiment was conducted in July, 2013, along the X-X' profile labeled in **Figure 1**. The location was selected such that the seismic profile would cross the projection of the E-W trending strike-slip fault from Brocka (2007). The equipment used for the experiment includes: 1) 104 Geometrics receivers (geophones), 2) three 24-channel and two 16-channel Geometrics geode data acquisition boxes, 3) a Betsy Seisgun source to fire 400 grain 8 gauge blanks, and 4) all of the associated cabling connecting the setup to the field laptop computer. The survey used a modified rolling spread design with a total spread length of 388 meters and a total of 37 shots recorded. The geophones were spaced two meters apart with shots taken every 6 meters starting 36 meters before the first geophone, creating 32 fold data (**Fig. 2**). See **Table 1** for a complete description of the experiment design and parameters.

Methodology

Field Methods

Prior to setting up the geophones and other equipment, the positions for the geophones and shot locations were measured, flagged, and surveyed using real time kinematic satellite navigation techniques. Next, 0.5 meter-deep holes were drilled using a hydraulic tow hitch auger at each shot location. Once the equipment was set up for data acquisition, the shot holes were filled with water to increase coupling and the signal-to-noise ratio with the Betsy Gun when fired into the hole. The data was recorded after each successful shot on the field laptop computer using Geometrics *Seismodule Controller*™ software.

Seismic Reflection Processing

The seismic reflection data was processed and analyzed using the Geo2x VisualSUNT_22Pro software. First, the data collected in the field was converted from SEG2 to Seismic UNIX (SU) format. Once the files were converted, the geometry was defined for the receiver spacing, shot spacing, source spacing, elevation, and location for the profile line. Bandpass filters were then applied to minimize noise (such as biological noise, ground roll, and source air waves) and to remove parts of traces that are not reflections. Next, manual muting was performed on each shot gather by deleting ground roll and air waves that were not eliminated in the filtering. The geometry was then entered and the data was sorted into CDP (common depth point) gathers. After sorting the data, the stacking velocity was determined to estimate the NMO (normal move-out) correction. The minimum and maximum velocities used in the experiment were 1000 m/s and 3800 m/s with an interval of 200 m/s. The final stacked files were examined and the “best” one, chosen based on the coherence and quantity of the reflectors in each section, was selected for analysis.

Results and Interpretations

Reflection Processing Results

The final processed images for seismic profile X-X’ show the results of the data processed with VisualSUNT and are displayed in terms of both time and depth (**Figs. 3 and 4 respectively**). The images have a horizontal exaggeration of ~4.49x. The seismic profile displays strong reflectors near the surface that are interpreted as the sandy beds of the Jurassic Morrison and Sundance formations. The thicknesses of the units are approximately 105 m and 75 m respectively, which correlate well with the thickness of the strong set of reflectors on the seismic profile. The reflectors become less clear at greater depths, possibly due to deformation accommodated by the less competent Jurassic Gypsum Springs formation.

The strong sets of reflectors near the surface at the southwestern portion of the profile are likely multiples created from the seismic waves reflecting repeatedly off the same sandy units of the Morrison and Sundance formations. Each matching set of repeated reflectors is spaced evenly by ~90 milliseconds, or 108 meters. Using t=2z/v (t=time, z=depth in meters, v=velocity in meters/second) the depth to the top repeated reflector in the set of multiples was calculated from the two-way travel time of each subsequent set of multiples. For example, the two-way travel time to the top reflector was determined from the seismic profile and the depth was calculated to be 109.9 m using v=2400 m/s. Next, the two-way travel time to the repeat of that top reflector was determined and depth was similarly calculated using t=4z/v (essentially doubling the time, which would be expected from a signal bouncing twice between the surface and a given reflector). The calculated depth with respect to the first multiple was found to be 108.7 m, very similar to the 109.9 m found for the actual depth of the first reflector and matching that of the first reflector in the depth profile. This was repeated for the second multiple, using t=6z/v (tripling the time) and found a depth of 105.8 m. The similarity in these values indicates that the reflectors are indeed multiples.

After analyzing the profile with no vertical or horizontal exaggeration in *Move*®, it appears that there is a discrete zone showing apparent offset of reflectors (**Fig. 5**). This also happens to be the area where the strike-slip fault projects to, and thus is interpreted as the location of the fault. There are also some fairly strong reflectors dipping steeply to the southwest in the northeastern portion of the profile. Based on proximity to the fold hinge of Dallas Dome, shallow dips are expected in this area and thus these reflectors may be an indication of either ground roll contamination or deformation. The reflectors are not quite strong or coherent enough to be ground roll and appear to flatten out towards the southwest. They appear to be truncated and offset by the fault trace at an elevation of ~1350 m, suggesting that they may be a product of deformation near the fault zone. {These steeply dipping reflectors by be fault interface reflections which suggest that the fault might start to dip a bit at depth. Below this elevation, the trace of the fault is lost. A longer spread length and a stronger source would be necessary to image the fault at greater depths. This would be important to determine if the fault continues down to the Precambrian basement and offer insight as to whether the fault was generated as a preexisting basement weakness or if it formed in the cover rocks. Basement control would suggest that similar structures occur in the other interchange zones but are simply not visible on the surface.

The beds below the strong reflectors near the surface appear to be significantly deformed as there are no clear, consistent reflectors observed at depth. Some of the reflectors appear to dip in both directions, potentially indicating folding of the units. **Cosgrove and Ameen (2000)** created a sandbox model of deformation in response to strike-slip faulting in the basement showing the complexity of folding in the cover rocks (**Fig. 6**). There is no evidence that the strike-slip fault imaged in this study penetrates the Precambrian basement, but if some basement weakness is controlling the fault then folding similar to their model would be expected.

Discussion

Data Acquisition Challenges

The primary challenges associated with data acquisition were transportation to the site of the experiment, site preparation, and noise. Rugged terrain covered in sage brush and limited access on ATV roads posed difficulties primarily involving transportation of the hydraulic tow hitch auger. With limited vehicle access, some light hiking was required to access the site of the profile line. Drilling of the holes at each shot location was difficult due to hard, dry, compacted dirt and hot weather conditions. The location of the seismic line, however, was positioned along one of the ATV roads allowing for relatively easy setup of the geophones, cables, and acquisition boxes. The proximity of the location to Hwy. 287 along with gusts of wind introduced noise that was picked up by the receivers.

Data Processing Challenges

Source related noise posed a considerable challenge during data processing. Filters were applied in order to remove source-related noise from ground roll and air waves. Any remaining noise required manual muting of the data to delete any ground roll that was not filtered out. A portion of the signal was lost during this process, but was necessary to reduce the amount of noise as much as possible. Some ground roll, however, still exists in the profile, potentially covering meaningful signal.

Conclusions

The images produced from processing the seismic data confirmed the presence of a fault structure, interpreted as the strike-slip fault mapped by Brocka (2007). The expectation was to at least see some deformation in the fault zone projected from the surface trace to the X-X' profile line. Due to the data acquisition and processing challenges, the resolution of the final image was decreased considerably. Despite these challenges, the following conclusions were made from the 2D seismic reflection experiment:

1. The seismic profile successfully images the strike-slip fault that was the target of the experiment. The apparent offset of reflectors marks a discrete zone that is interpreted as the location of the fault. This correlates well with the intersection of the projection of the fault trace.
2. The variation in dip angle of reflectors may be attributed to deformation generated by motion along strike-slip fault. Some very steeply dipping reflectors are observed in the northeastern portion of the profile, which lie very close to the fault indication possible deformation during faulting.
3. The clear, horizontal reflectors on the southwest end of the profile are interpreted as sets of multiples. These multiple reflectors are covering up potentially useful data, thus limiting interpretations.
4. A future seismic survey with a longer spread could potentially image the fault at greater depths. This would be important to determining whether a preexisting basement weakness is a possible control on the faulting and the en echelon offset of the basin margin folds off the southeastern flank of the Wind River Mountains.

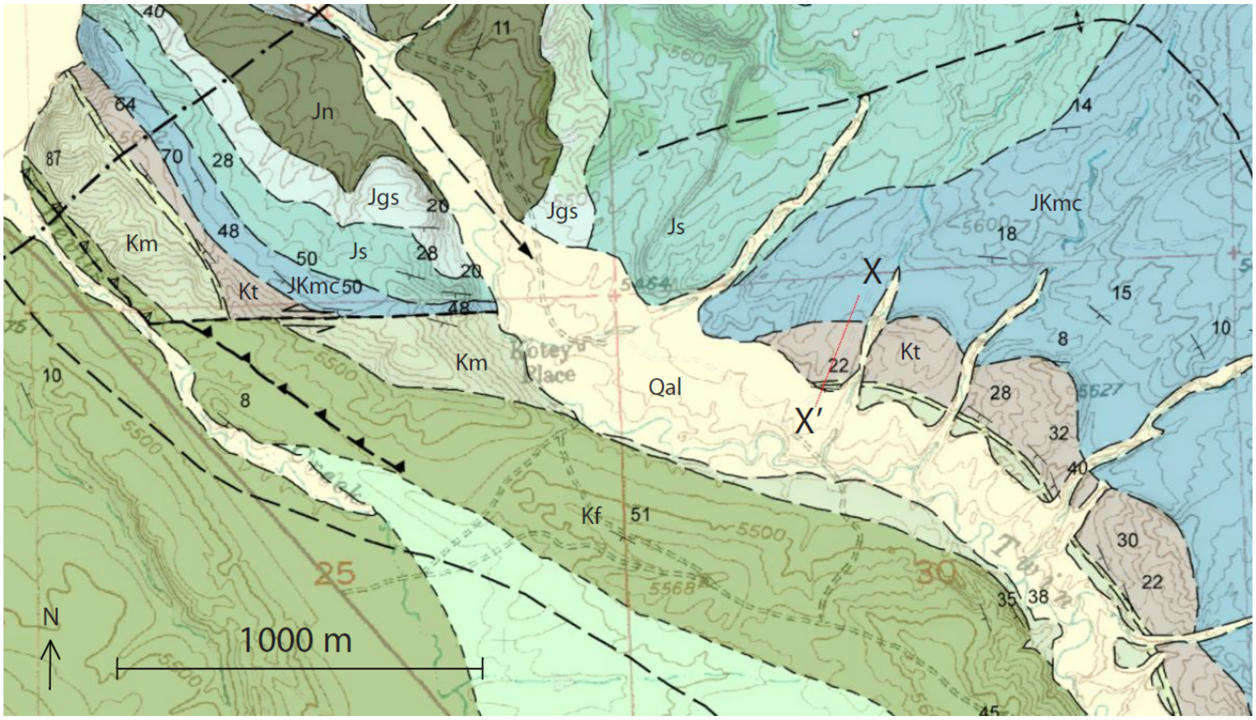

Figure 1: Map of the seismic profile X-X' showing the projection of the strike-slip fault through the northeast portion of the profile.

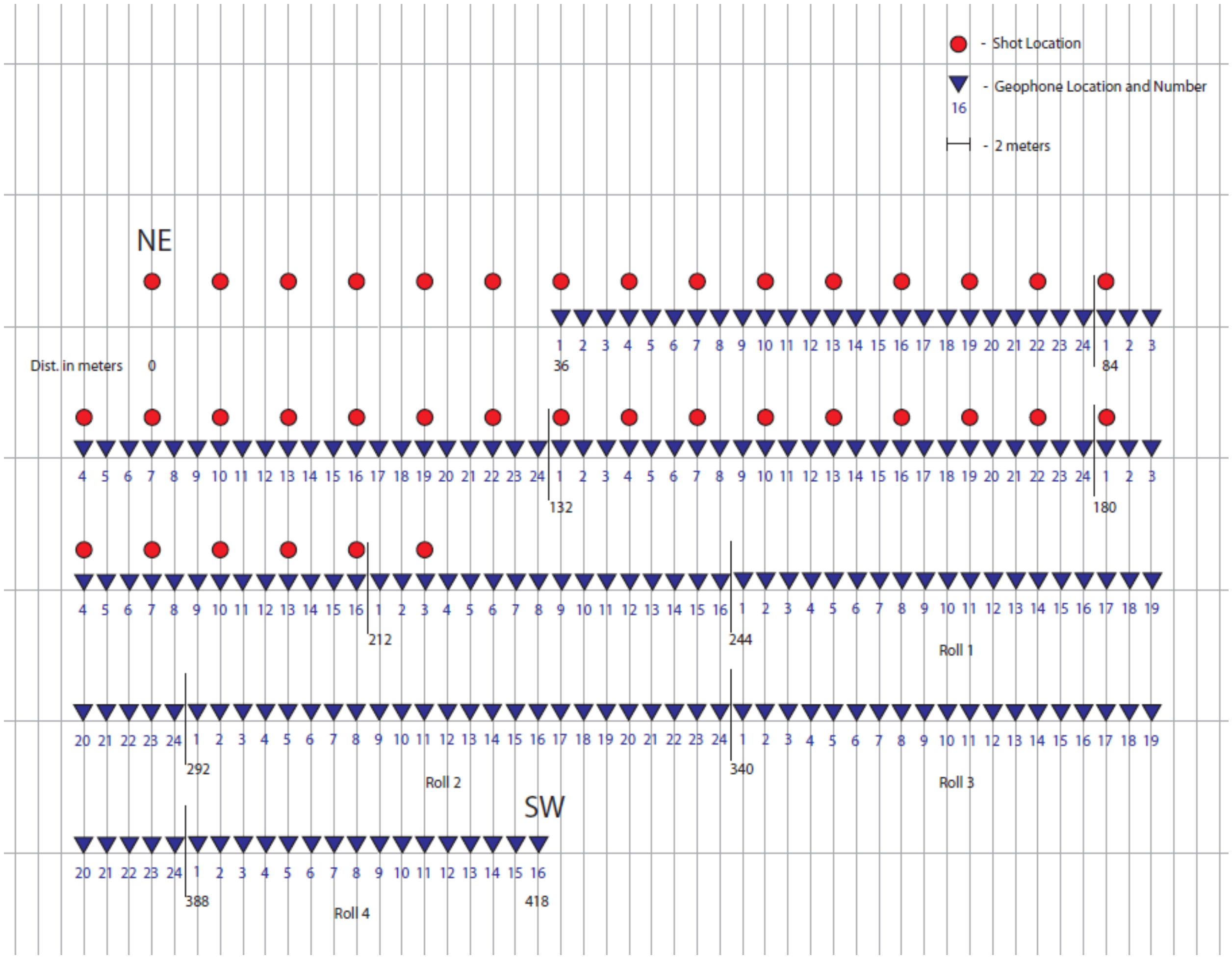

Figure 2: Schematic of the seismic reflection experiment showing the geophone placement, shot locations, and the rolling spread design. Shot from X to X' (NE to SW).

Table 1 – X-X' data acquisition parameters (Modified rolling spread)

Source Type:	Betsy SeisGun – 400 grain 8 ga. blanks
Source Depth:	~ 0.5 m
Receiver Type:	104 Geophones (40 Hz Geometrics Receivers)
Data Recording System:	3 – 24 Channel Geodes and 2 – 16 Channel Geometrics Geodes
Recording Time:	1 s
Sampling Interval:	0.25 ms
Source Spacing:	6 m
Receiver Spacing:	2 m
Total Spread Length:	388 m
Total Shots Fired:	37
CMP Fold:	32

Procedure

A modified "rolling spread" design was used for this experiment. Shots were fired up to the first geophone, and then a designated portion of the line was moved to the end of the spread. The steps for this procedure were:

1. 6 shots fired
2. 48 m of geophones and associated cable moved to end of line and reconnected
3. 8 shots fired
4. 48 m of geophones and associated cable moved to end of line and reconnected
5. 8 shots fired
6. 48 m of geophones and associated cable moved to end of line and reconnected
7. 8 shots fired
8. 32 m of geophones and associated cable moved to end of line and reconnected
9. 7 shots fired

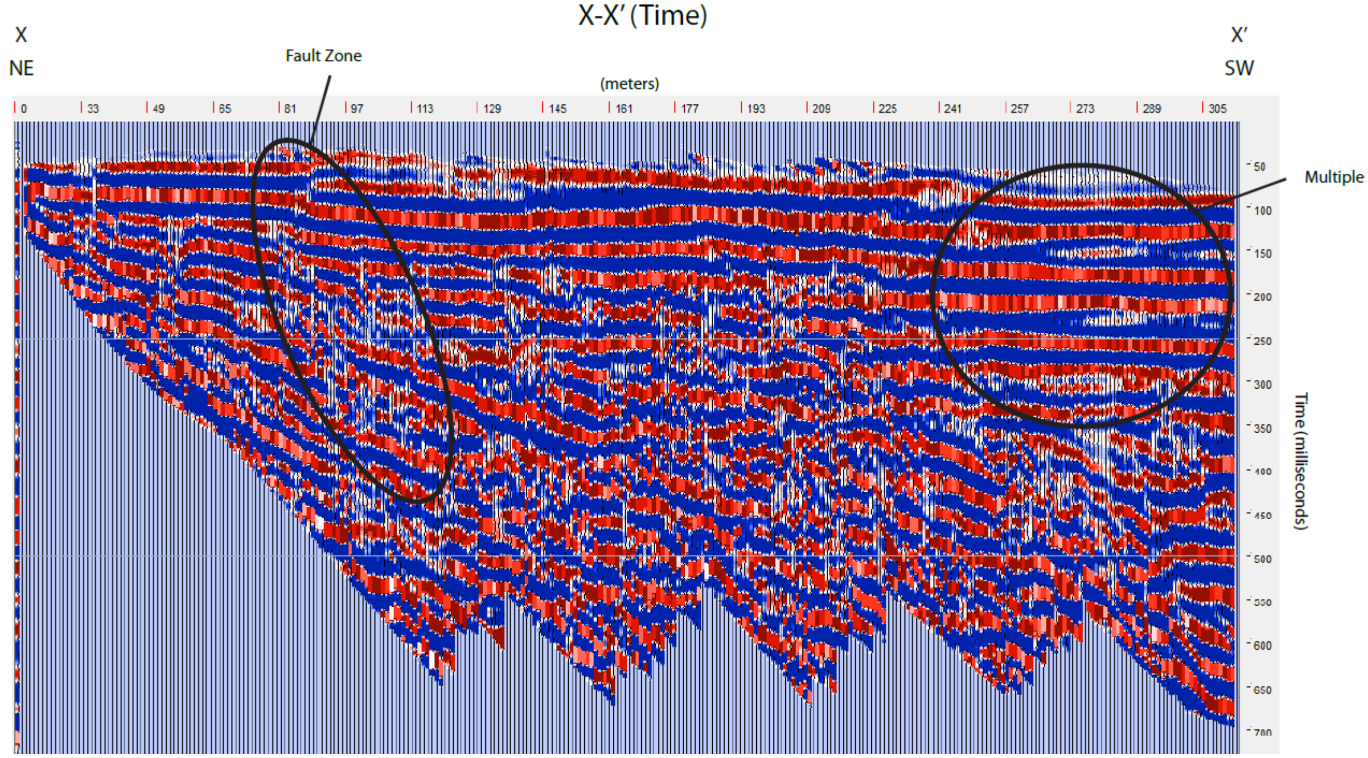

Figure 3: Seismic reflection profile X-X' displayed in two-way travel time (TWTT). The circled areas indicate the locations of the strike-slip fault and the multiple reflectors.

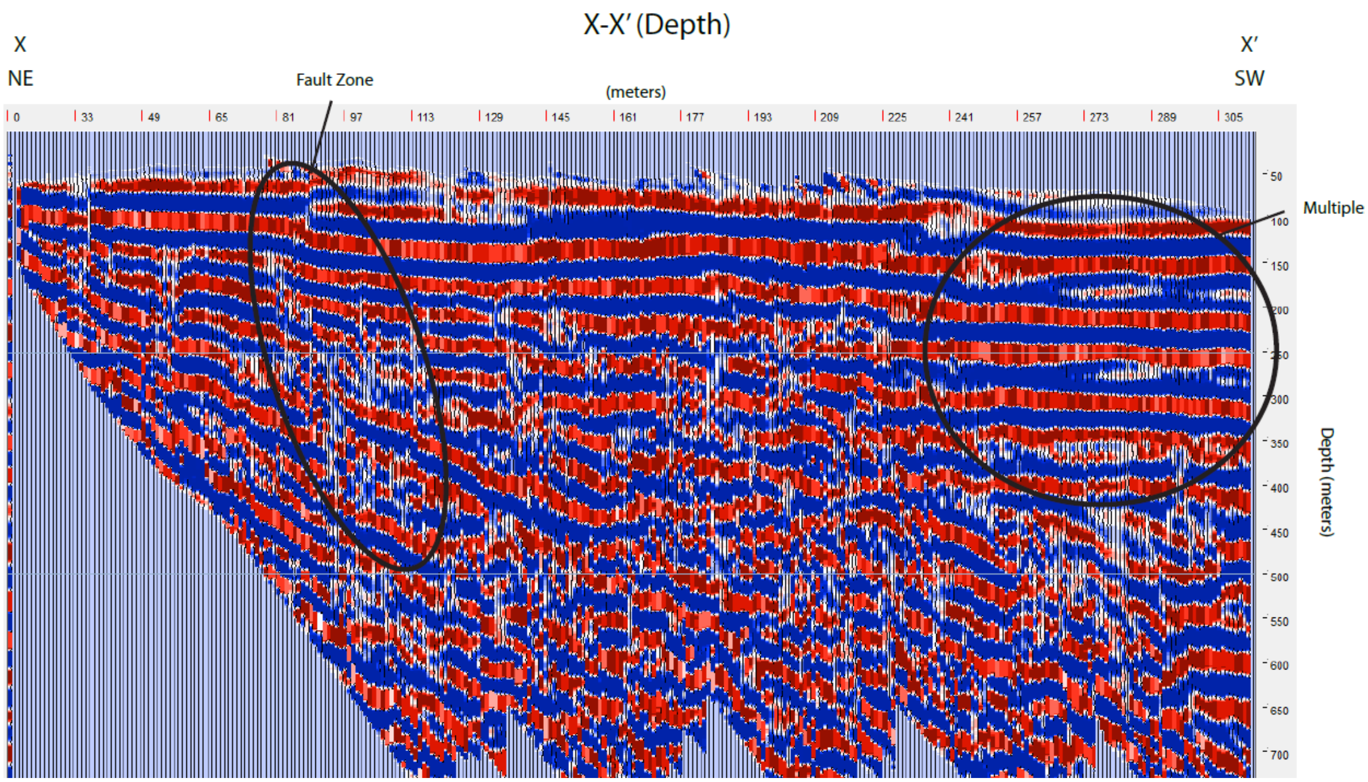

Figure 4: Seismic reflection profile X-X' displayed in depth in terms of meters. The circled areas indicate the locations of the strike-slip fault and the multiple reflectors.

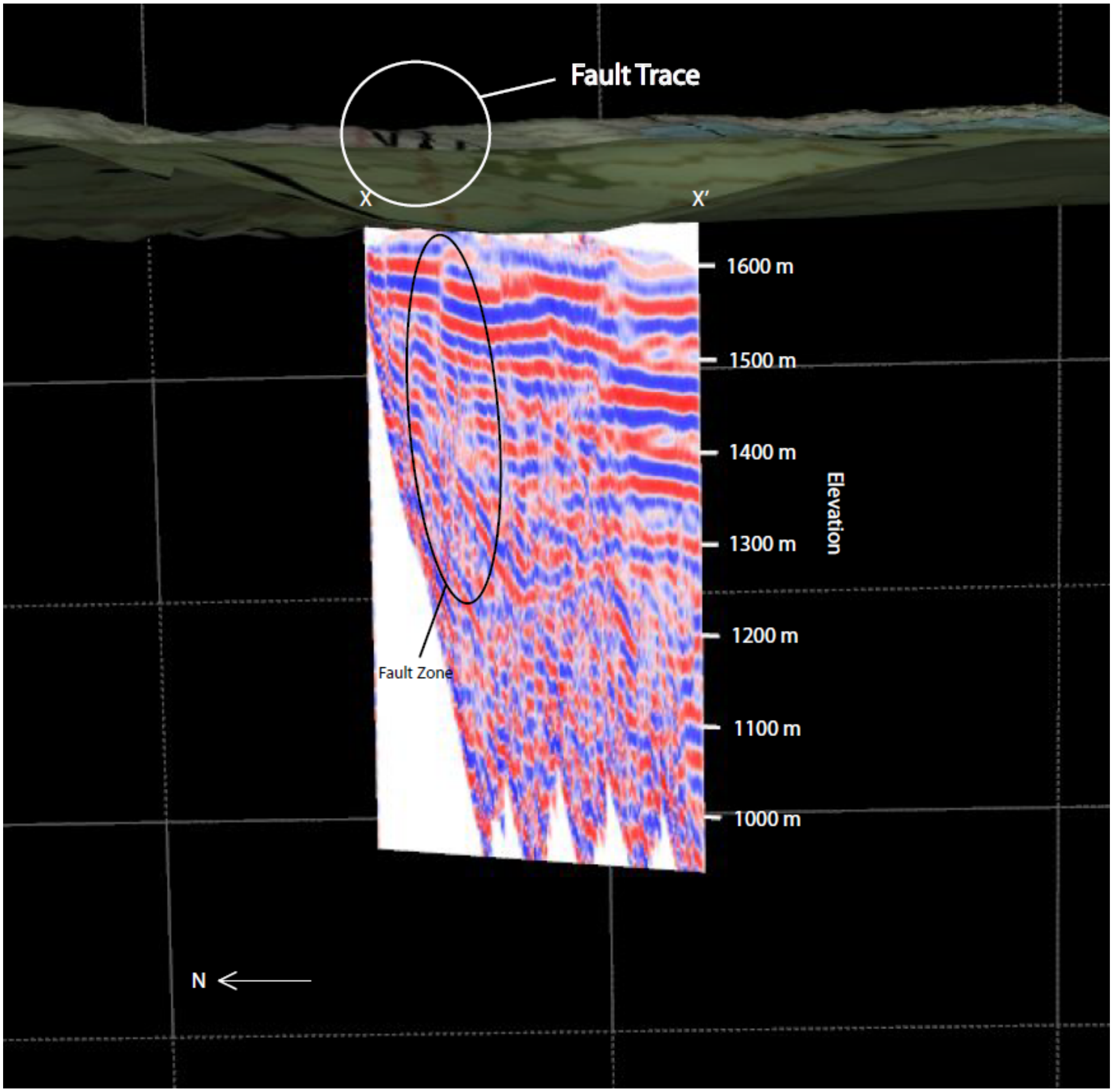

Figure 5: 3D view of seismic profile X-X' looking to the east directly down the trace of the strike-slip fault mapped by Brocka (2007). The projected fault trace correlates very well with the interpreted location of the fault in the seismic profile.