The Use of a Shallow Seismic Reflection Profile as an Aid in Groundwater Model Development at the Rocker Timber Framing Treatment Plant Operable Unit Rocker, MT

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Introduction

Shallow seismic reflection profiling was helpful in the development of a groundwater flow model at the Rocker Timber Framing Treatment Plant Operable Unit (RTFTP/OU). Evaluation of drillers logs, well cores, and field mapping defined the major hydrogeologic units at the site.(ARCO,1995; Hydrometrics Inc., 1988) Two major hydrogeologic units exist at the site; an upper unit is composed of unconsolidated alluvial material, and a lower unit consisting of mixed Tertiary age clays, silts, and gravels. Although numerous wells exist on or near the site, only one was completed within the interpreted Tertiary horizon. A seismic reflection profile was used to establish the thickness and structure of the underlying Tertiary materials.

Data Acquisition

The seismic data used for this project were recorded using a standard common midpoint (CMP) roll along method. The line used was laid out using 48 takeouts, 24 being used for recording each shot. A five meter station spacing was used for receiver stations. The receiver groups consisted of a 2.5 meter in line array of three 40 HZ geophones overlapping at each takeout. The lines were shot off end with the shot stations moving forward by five meters each shot. Four lines were shot in all. The source for the line was a 16 pound sledge hammer and a metal strike plate. Stations were surveyed with a Philadelphia rod and level. A 24 channel Bison model 9024 seismograph was used to record the data. Table I. shows the recording parameters used to acquire the data.

Table I. Recording Parameters	
Station Spacing	5 meters
Record Length	500 ms
Sample rate	1 ms
High cut filter	120 HZ
Low cut filter	32 HZ
Field summing	9 shots

Data Processing

One of the keys to successfully processing shallow seismic reflection data is the presence

Bill Elliott of Indiana University provided daily updates of his field mapping results, without which the work at Harrison would not have been successful. Bill also sacrificed his car in service to our cause. Bruce Douglas, Greg Olyphant and Lee Suttner, also from Indiana University, provided valuable insights and assistance.

Jack Truckle, mine geologist at the Golden Sunlight Mine lead our tour and provided supporting materials. We are also indebted to Jerry Harrington, mine manager of the Golden Sunlight Mine.

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of visible reflectors in the shot records. Line One showed at least one reflection; an event at approximately 220 ms.(Figure 1.) Unfortunately no other reflections in line one were immediately obvious due to the presence of the air blast and groundroll. A large amount of time was spent attempting to filter the data in a manner that would remove enough of the air blast to

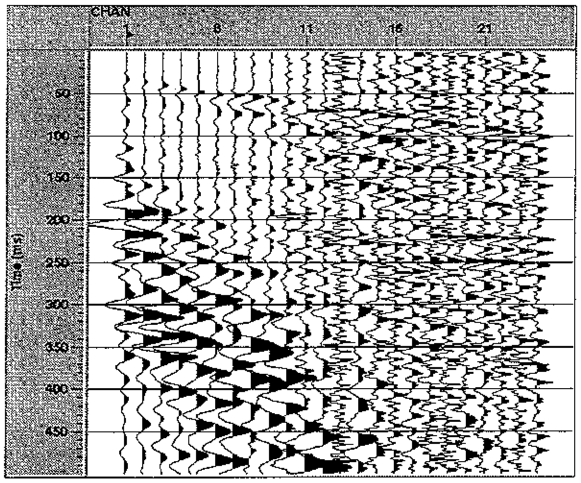

Figure 1. Sample Shot Gather

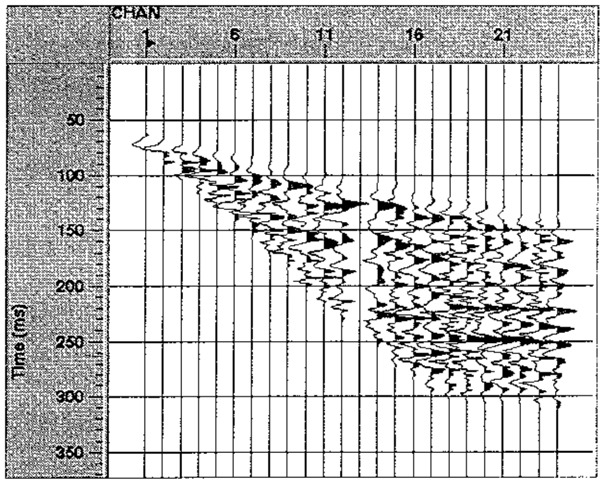

Figure 2. Muted Shot Gather

allow identification of other reflectors. This was not successful and the decision was made to severely mute the data keeping only the area of visible reflections. (Figure 2.) Table II. shows the processing flow that was finally used on the data.

Table II. Processing Steps
Geometry Assignment
Datum Statics
Editing
Trace Equalization
True Amplitude Recovery(TAR)
Spiking Deconvolution
Bandpass Filtering
Velocity Analysis
Normal Moveout Correction(NMO)
Residual Statics
Common Midpoint(CMP) Stacking
Time to Depth Conversion

The resulting depth converted CMP stack shows a strong lower reflector at about 150 meters at the eastern end of the line. The reflector increases in depth, in segments, to about 225 meters at

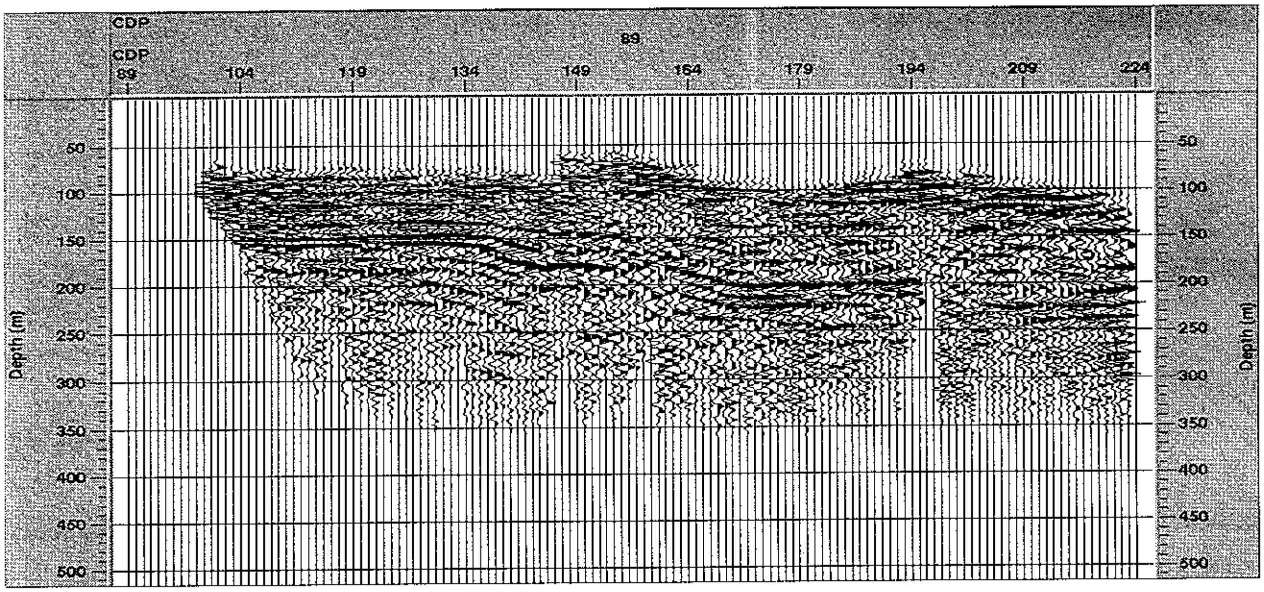

Figure 3. Line One Depth Section

the western end. (Figure 3)

The most plausible interpretation for this reflector is that it results from the contact between the Tertiary sediments and more consolidated bedrock possibly the weathered granitic bedrock that outcrops to the east. Velocities for this lower horizon range from 2800 to 3000 meters/sec.

Groundwater Modeling

Previous attempts to model the site were limited by the lack of information regarding the Tertiary layer at the RTFTP/OU. There was a great deal of confusion involving not only the thickness of the Tertiary layer but also the depth and thickness of the upper alluvial layer. The Remedial Investigation Report (ARCO, 1995) speculates as to the presence of a large paleovalley of incised Quaternary age materials. Field investigation failed to produce any evidence of this feature to the south or north of the site, for this reason this feature is not included in the model. The seismic profile while providing only an estimated thickness at least provided a starting point. A three dimensional flow model could now be created that incorporates the interaction between the alluvial aquifer and the Tertiary aquifer. Although the Tertiary sediments have a lower hydraulic conductivity than the alluvial materials, their relative thickness results in approximately equal transmissivities. It is therefore important to consider the impact of the Tertiary layer in designing a flow model.

A conceptual model was developed based on the hydraulic properties of the three layers. The upper alluvial layer was divided into two layers 30 feet thick. The reason for dividing this layer was the completion depth of the monitoring wells, which were completed at two different levels. These wells can be used to calibrate the model to observed head values. The third layer was the Tertiary layer that was modeled as 300 to 500 feet thick based on the seismic profiles.

An initial steady state model was created using MODFLOW (McDonald and Harbaugh, 1988) a three dimensional finite difference groundwater flow model. Sources and sinks used in the model included Silver Bow Creek and an average precipitation rate of 12 inches/year. The resulting model, although simple was sufficient to evaluate the conceptual model. The computed flow gradient (0.0026) is very close to the gradient derived from observed water levels in the monitoring wells on the site (0.0025) and model head values are within five percent of observed values, with a small model flow budget discrepancy.(ARCO, 1995)

Discussion

Modeling the site without an estimate of Tertiary thickness would not have provided a reliable model of groundwater flow through the site. The seismic profile provided an estimate of the thickness Tertiary aquifer without the expense of drilling to depths of over 600 feet. By combining this new estimate with the previously estimated hydraulic parameters. (Hydrometrics Inc.1988)

Further seismic work at the site could include some higher resolution reflection profiles designed to image shallower in the subsurface. This could help in possibly locating Tertiary age channels which being more transmissive could serve to channelize groundwater flow.

Acknowledgments

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Seismic reflection investigation to support or undermine the existence of a normal fault in Rocker, Montana

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INTRODUCTION

The miners that explored the areas surrounding Butte, Montana discovered in the late 1800s that the veins of gold, silver and copper could only be found up to a certain boundary on the West side of Butte—a north—south boundary that apparently ran through the town of Rocker. Mines dug to the West of Rocker were repeatedly unsuccessful and before long, all mining to the immediate west was discontinued. The old miners blamed the disappearance of the metals to a normal fault, extending perpendicular to the Silver Bow Creek and just east of Rocker, with the western side dropped. In time, this fault became known to the miners and locals as The Rocker Fault (Debra Hanneman, personal communication; ARCO, 1995).

The Rocker fault has found its way onto several maps of the region (ARCO, 1995) and the theory of its existence has been adopted by numerous consultants and geologists studying the area. Despite the fact that no previous investigation has been specifically designed to determine if the subsurface features of the area match a structural environment indicative of faulting through the Tertiary—aged sediments found there, many aspects of the area have been sampled and examined extensively. This study has combined previously gathered information with newly acquired geophysical and geologic data to visualize the features lying below the town of Rocker, in order to consider the feasibility of the Rocker Fault's existence.

BACKGROUND

The town of Rocker lies seven miles west of Butte along the Silver Bow Creek of southwestern Montana. Immediately south of the creek and the center of Rocker are the remains of the Rocker Timber Framing and Treating Plant, which operated from 1909 until 1957. When it was still in operation, the plant treated wood that was to be used in the underground mines with preserving chemicals such as creosote and arsenic solutions. After the facility closed down, these chemicals were improperly contained, and since then have been seeping into the ground and the Silver Bow Creek, creating environmental hazards in the immediate and surrounding areas. The Rocker Timber Framing and Treatment Plant has been identified as part of the Silver Bow Creek Superfund site since 1983 (ARCO, 1995). In the last fifteen years, ARCO, the current owners of the site, have financed a number of studies of the Rocker site that have included water testing and the drilling of wells.

All areas examined in this study lie in an east—west alluvial valley, within the Upper Silver Bow Creek drainage basin. The site itself is nearly flat. Late Cretaceous granitics, known as the Butte Quartz Monzonite (Derkey and Bartholomew, 1988; Smedes, 1964), crop out in the hills surrounding Rocker to the Northeast, Southeast, and West. The region is characterized by a complex system of volcanic intrusions and metamorphic zones, and hydrothermal activity and secondary mineralization, were responsible for the ore deposits appearing throughout the area. Tertiary sediments overlying the granitics are deposited in complicated sequences that include lake bed deposits, paleochannel deposits, mudstones, and volcanic tuffs. Above the Tertiary sediments and filling much of the Silver Bow Creek drainage basin, are Quaternary alluvial deposits. Some Quaternary deposits have cut down into the Tertiary material. Conclusive studies of the stratigraphy beneath the Rocker site do not exist. Core samples taken from the site by ARCO (1995) suggest that the Quaternary—Tertiary contact below the surface becomes more shallow to the West, and domestic wells dug within a kilometer to the south of Rocker reach granitic material at their maximum depths.

Proponents of the Rocker Fault generally place it along Canada Creek, which flows into the Silver Bow Creek about half a mile east of the Rocker site. Previous studies (ARCO, 1995; Derkey and Bartholomew, 1988; Smedes, 1964) identified faults in the region resulting from late Cretaceous west—east extension as well as later faulting sequences that have offset both the Cretaceous and Tertiary deposits (Constenius, 1996). If the Rocker Fault existed, it would probably resemble the sequences of normal faults identified in the granitics elsewhere in the region (Constenius, 1996). These faults are almost exclusively listric in character, and the Tertiary sediments above the