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SEISMIC REFLECTION INVESTIGATION
OF THE
ONTARIO, OREGON, AREA

by

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INTRODUCTION

As a portion of an extensive investigation of the geothermal potential of the Ontario, Oregon, area, a high resolution seismic reflection survey was undertaken. The geothermal study was designed to be site specific in that the goal was to delineate a drilling site. It was anticipated that the seismic reflection survey might define any faulting in the area that might have significant control on the geothermal system.

The general model envisioned for the geothermal system relies on an insulating blanket of sediments and volcanics (Applegate and Donaldson, 1977) to provide a significantly higher than normal geothermal gradient. The local porosity and permeability characteristics of the actual reservoir would be, perhaps, enhanced by proximity to faulting.

The exploration program was laid out to gain information on any faults cutting across the area. Thus originally a three-sided box was laid out and finally the fourth-side was closed in. A couple of short lines were shot which, it was hoped, would add specific controls on the system. The optimum program could not be laid out, however, due to logistical constraints. These logistical constraints included power lines, sewer lines, gas lines, irrigation lines, etc.

FIELD TECHNIQUES

The high resolution seismic reflection method is a slight modification of standard petroleum exploration techniques. The primary modifications are closer detector spacings and smaller charges resulting in higher frequency data. The closer detector spacings minimize spatial aliasing and allow a more vertical travel path for the seismic energy. Smaller charges yield a higher percentage of high frequency energy. The detector spacing is modified as a function of the depth of interest.

For the Ontario study, a detector spacing of approximately 100 ft was chosen as a compromise to allow the detection of deeper structures while taking advantage of the stacking techniques unique noise attenuation properties, and yet still allowing the mapping of shallow structure. The charge size was kept small to enhance the high frequencies, to attempt to avoid "ringing" of volcanics, and due to logistical constraints.

Two major problems were anticipated and indeed present. These were complex geology--interbedded volcanics and sediments-- and logistical problems including utilities and traffic. Every effort was made to design the field techniques and processing techniques to minimize the geological noise, and numerous precautions were taken to minimize the effects of utilities and traffic.

The field equipment utilized was a Quantum Electronics DAS-1 digital recorder. Data were recorded in digital form on magnetic tape with a low-cut filter of 50 hz and an anti-aliasing high-cut filter. The sample interval was 1 ms. The detectors were a single 30-hz geophone per channel. The data were recorded 6-fold. The energy source was from 0.4 to 0.8 lbs of 75% dynamite in 10-ft deep drill holes. The charge holes were generally drilled with a truck-mounted auger system.

DATA PROCESSING

Data processing was subcontracted to Applied Research Concepts, Inc. (ARC), Houston, Texas. The processing sequence began with demultiplexing and reformatting. The data were then sorted into common depth point gathers. Then a number of different processes were applied to enhance the data. Two complete processing runs were made. The output of the first run was utilized in modifying the processing sequence. Static and normal moveout corrections were made to correct the data for elevation variations and also for the geometry of the seismic spread. Other processes included deconvolution. Deconvolution in effect shrinks the seismic wavelet so that the resolution is improved. The data were filtered with a time-variant filter. The purpose of the time-variant filter is to minimize noise that is not part of the seismic signal. Autostatics were also applied to correct for any inadequacies in the regular statics program. Then the data were stacked (6-fold) to enhance the signal to noise ratio. The stacking velocities were determined from velocity analyses at approximately every 15th shotpoint.

INTERPRETATION

Six seismic lines were shot to approximate the outline of a box around Ontario. Due to logistical constraints, the corners of the box were not tied, so it was extremely difficult to map any horizon completely around the box.

Approximately 10.5 miles of seismic data were acquired. The data quality ranged from poor to good. In general the shallow data is good, while the deeper data are of much poorer quality. Several fault structures were mapped with varying degrees of confidence.

Each of the seismic lines will be discussed individually. Fault breaks will be graded from A (very good) to D (very poor). This data is then incorporated on a fault map (Plate I).

Line A was of little use. The data are generally poor except for some alignments shallow in the section. On the basis of the poor data, one questionable fault (grade-D) was picked.

Line B is a north-south line. The southern portion of the line is straight while the northern part curves along the river. The data quality is generally fair. Line B has a possible fault (B) at the south end of the section. Correlative data are two very parallel and very straight drainages on the east side of the river. Based on this evidence, we believe there is a good possibility that the fault exists. Preliminary processing showed an additional, parallel feature in the immediate vicinity. However, later processing obscured the feature. The northern part of the line is poor. However, there are some possible fault indications. None appear to be definitive enough to be strongly supported without additional data.

Line C is reasonably good throughout its length, and has the best quality data at depth. Three fault cuts of varying quality are indicated on the seismic section. The eastern-most fault was B- to C+. However, the amount of offset is very minor and could possibly represent a small rollover expecially in the shallow section. The middle fault is given an A rating and is indicated by reflection terminations, some possible diffractions, and some rollover (anomalous dip) into the fault. The control on this fault appears to extend it clearly into "seismic basement" at a depth of approximately 6000 ft. The seismic basement appears to be massive volcanics due to similarity with other known structures. The western-most fault on line C was given a B rating. Again the throw is minor in the shallow section, but the fault appears to offset seismic basement.

Line F is of reasonable quality throughout. Three significant faults are indicated, and some subsidary faults are possibly present. Spatially these faults are not well controlled because they cross the line at rather low angles which tends to smear the contact. The eastern-most fault (A) is down to the east and is the best controlled fault on the line. Some ambiguity results from the relationship of apparently subsidary features that appear to feather into the main trace. The two western faults on the line create a relatively broad zone of poor data.

The western fault (A) is down to the west and is only moderately constrained. An additional down to the west fault may be slightly east of the western fault on line F. This is suggested by data from line H. These two western faults may represent a zone of faulting or a merger of the two faults at depth.

Line H is a line of excellent quality data in the shallow section. Three faults are indicated on this line. The southern-most fault (A) is down to the south and its location is constrained to a depth of qpproximately 2600 ft. The center fault (B) is down to the south also and may merge into the southern-most fault at depth. The northern fault (A) is down to the north and is reasonably well located. The data on this line and on some additional lines suggest that there may be some thin interbedded volcanics in the shallow section (at a depth of about 650 ft on the southern part of line H).

Plate I is a map showing the afore discussed fault cuts as they are projected to the surface and what is felt to be the most plausible manner of connecting the various breaks into a regional fault pattern. A number of factors are considered in the procedure of connecting various fault breaks. Some of these are: 1) the character of the fault (throw, dip, apparent age, etc), 2) the pattern of the fault breaks (direction of throw, etc), and 3) other data on the structural grain of an area. Regional trends of geomorphic expressions and mapped faults with strikes of N55^{o}W to N60^{o}W were also observed and incorporated in the analyses.

The southern set of three faults is well constrained. These three faults (labelled I, II, & III) appear to define a prominent horst block with a NW-SE trend. These faults appear to fit well with the regional geologic trends. Displacements for these features are indicated on the map where they were picked. Since the displacement may vary with depth, the depth from which the value is obtained is also indicated.

Faults IV and V are the next ones further north, and the reliability is less due to less control on the features. Fault IV is relatively well-defined on line B. A second fault cut on line B that could correspond to fault V was indicated on the original processing. However, additional processing obscured this cut, and raised some questions on the cut for IV. The cuts on line C are also relatively well-defined for both faults IV and V. Their existence is supported by other evidence such as the geomorphic and geologic data.

Faults VI and VII are based on questionable data. Fault VI is constrained by a reasonable cut on line C and a very poor cut on line D. Both faults need additional supporting evidence to be interpreted with confidence.

The data from the shallow section are generally good to excellent on most lines. On some lines where all of the data is very poor, near-surface geologic conditions and/or cultural noise may have played a prominent role. In other cases where the data quality varies significantly along the line other problems may be present in addition to the aforementioned. These include variation in thickness and makeup of volcanics within the section, and the variation of the general stratigraphy. Specifically, the acoustic basement in the area appears to be the thick sequence of Columbia River volcanics.

CONCLUSIONS

The seismic survey defined several faults and thus can be labelled a success. Due to the data quality and geometric constraints, a higher level of confidence is associated with faults I, II, and III than the others. Based on the total data package, however, these is significant evidence to support faults IV and V.

Thus based on seismic evidence, one has two possible targets. One is, perhaps, technically better than the other due to the spatial control on the faulting. Technically the best target is north of fault III. At a slightly lower level of technical confidence is the area north of faults IV and V. Either site offers a viable target for a geothermal well.

REFERENCES

Applegate, J. K., and P. R. Donaldson, 1977, Characteristics of selected geothermal systems in Idaho, in The earth's crust: Amer. Geophy. Union, Memoir 20, pp. 676-692.