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GEOPHYSICAL MEASUREMENTS IN THE VALE, OREGON GEOTHERMAL RESOURCE AREA

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Introduction

During the period September 15 to September 22, 1974, personnel of the Geophysics Group at Oregon State University, the Earth Science Department at Portland State University, and the Department of Geology at the University of Oregon completed a series of geophysical measurements in the Vale, Oregon geothermal area. The field crews, composed of four co-principal investigators, eight staff, and ten students, obtained measurements at four seismic reflection stations, along two refraction lines, and at two microearthquake array stations. In addition, gravity measurements were obtained at 340 stations, seismic noise measurements at 42 stations, and four short magnetic traverses were made in the vicinity of the refraction lines. The expedition had the following four purposes: 1) To obtain basic data on the geologic structure of the Vale geothermal area; 2) To test the applicability of seismic techniques, singly and in combination, to geothermal exploration; 3) To obtain structural control for a subsequent gravity and aeromagnetic study of the area; and 4) To train students in geothermal exploration techniques. This paper outlines the geophysical measurements made during the September 1974 field program. Publication of partial results of the study is anticipated subsequent to completion of each different phase of the project.

The Geophysical Measurements

Figure 1 shows the location of four seismic reflection sites south and southwest of Vale, Oregon in the Cow Hollow and Sand Hollow areas. Charges of 2.5 to 100+ pounds of Tovex were detonated in 30-foot cased holes at the shot points SP1, SP2, SP3, and SP4. The seismic waves were detected by a 13,000-foot reflection array and recorded on magnetic tape by a 36-channel seismic reflection system. The 13,000-foot reflection array was centered about shot points 1, 2, 3, and 4. Shot size and array arrangement were designed to obtain reflections to a depth of 4 km. The planned penetration depth of 4 km was based on an estimate of the maximum depth of economic recovery of geothermal fluids (G. Bodvarsson, personal communication). The surficial geology in the survey area (Corcoran and others, 1962; Newton and Corcoran, 1963; Kittleman and others, 1965, 1967) suggests a thick sequence of volcanics which abut or overlie the sedimentary strata of the Snake River downwarp. It is difficult to estimate reflection penetration depths in volcanic areas; consequently, the actual depth reached is not yet known.

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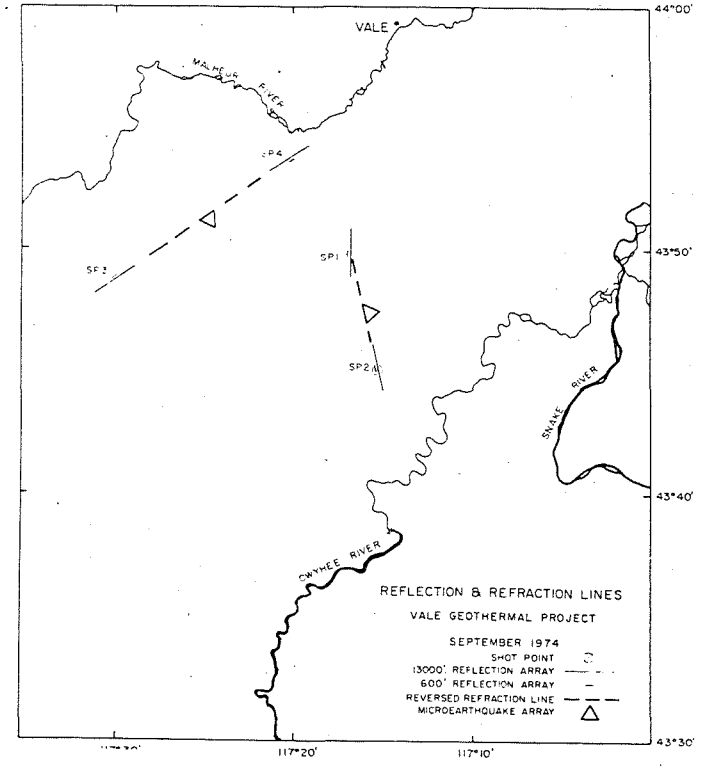

Figure 1. Map of the location of seismic reflection and microearthquake arrays and seismic refraction lines.

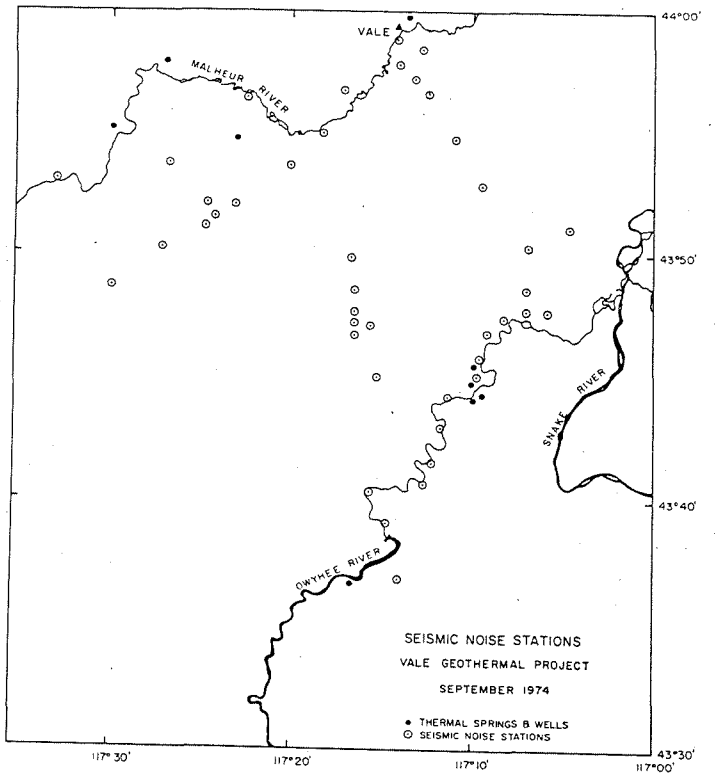

Figure 2. Map of the location of 42 seismic noise measurements made in the vicinity of Vale, Oregon.

Refraction stations extending 6 miles south of shot point 1 (or when reversed, 6 miles north of shot point 2) and 10 miles northeast of shot point 3 (or when reversed, 10 miles southwest of shot point 4) recorded refracted seismic waves from charges detonated during the reflection measurements. The arrivals were recorded on magnetic tape and on chart recorders at stations along the refraction lines shown in Figure 1. Arrivals were obtained over the complete length of line when the largest charges were detonated. The data should yield two reversed refraction lines. Thumper lines were completed at shot points 1, 2, and 3. These lines provide data on the near-surface layers and are the starting points for the refraction analysis.

Figure 1 also shows the location of two microearthquake arrays. The arrays consisted of 2 Hz geophones, 4 vertical and 1 horizontal, located at the apexes of a triangle with sides approximately 1.6 km long. Eighty hours of continuous measurements were made at two array locations, one in the Sand Hollow area and one in the Cow Hollow area. Rodents severing the sensor cables reduced the total number of hours below the number expected. However, because of the low background level of seismic noise in the area, operating gains were higher than anticipated; consequently, each array effectively surveyed a larger area or could detect smaller shocks than planned. Array arrangement and operating gains suggested that microearthquakes of magnitude 0.5 could be detected and approximately located to a radius of more than 30 km.

Tellurometer measurements located all primary reflection, refraction, and microearthquake stations.

Seismic noise measurements, made with a calibrated system to yield noise amplitude spectra in the frequency range 1 to 100 Hz, were completed at 42 locations in the Vale geothermal area. The station locations as shown in Figure 2 extend from near Vale Butte south to the Owyhee Reservoir and from Vale west to Harper. Fourteen stations are in the Cow Hollow and Sand Hollow areas in the immediate vicinity of the seismic refraction lines. Several of the stations are located next to thermal springs mapped (Bowen and Peterson, 1970) in the area. Thirty of the stations have short duration samples, ten have sample periods longer than a day, and several other stations were repeated to test for diurnal variations.

Magnetic surveys were run along the reflection spreads at shot points 1, 2, and 3 to obtain information on lateral variations and variations to depth of magnetic basement, presumably basalt, in the array areas. The sample interval varied from 100 feet to 350 feet, depending on the area. A 4-mile magnetic traverse was also run across Double Mountain to enable a comparison to be made of measured magnetic anomalies and the magnetic signature of a known intrusive outcrop.

Figure 3 shows the location of approximately 300 gravity stations established during the field study and approximately 55 previously established stations (Thiruvathukal and others, 1970). The stations were positioned at established bench marks or located during the surveying of the reflection-refraction stations. Elevations were determined by locating stations at known points or by using paired precision altimeters.

Project Status

Lillie, French, and Couch (1975), in their report on the preliminary results of the analysis of the seismic reflection measurements, list the interval velocities and thicknesses of approximately 9,000 feet of section in the Cow Hollow and Sand Hollow areas. Their results indicate that the seismic reflection information, obtained in volcanic terrane, is consistent with the available geological and well-log data.

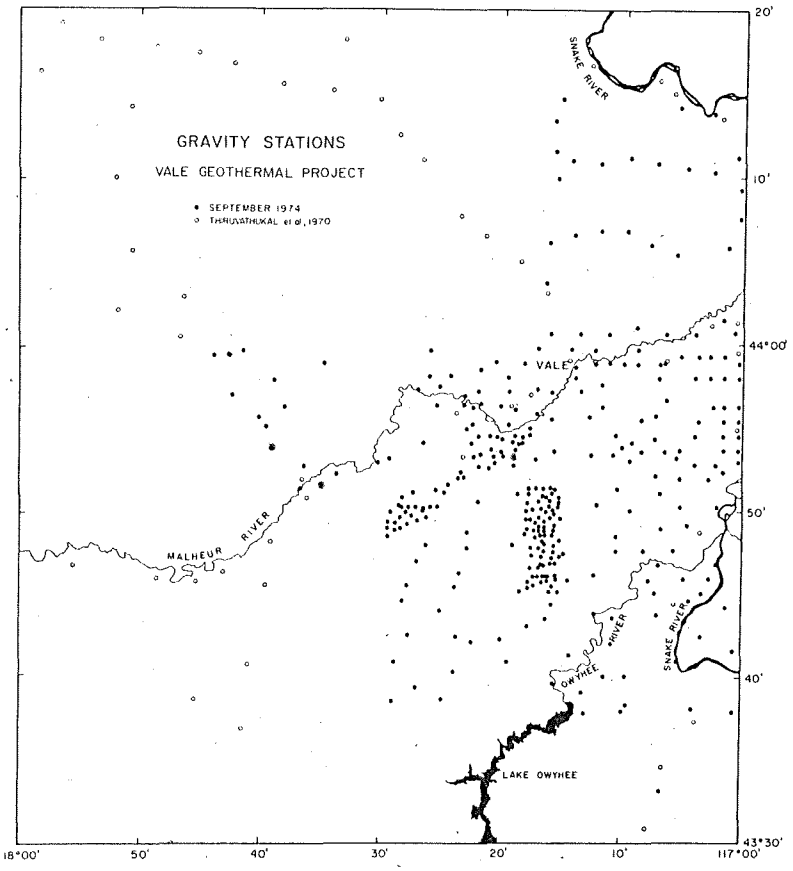

Figure 3. Map of gravity stations in the vicinity of Vale, Oregon.

The reduction and preliminary analysis of the seismic refraction, microearthquake and seismic noise measurements is expected to be completed by May 1976.

Larson and Couch (1975) show free-air and simple Bouguer gravity anomaly maps of the Vale region of Malheur County. The maps outline the gravity anomalies in the eastern portion of the study area (Figure 1) where the areal density of the gravity stations is relatively uniform. The measurement of gravity in Malheur County is continuing. Completion of new free-air and Bouguer maps of the study area are planned for May 1976.

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PRELIMINARY RESULTS OF A SEISMIC REFLECTION STUDY IN THE MITCHELL BUTTE QUADRANGLE, OREGON

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Introduction

In September 1974 personnel of the Geophysics Group of Oregon State University, the Department of Earth Sciences of Portland State University, and the Department of Geology of the University of Oregon conducted a geophysical survey of the Vale, Oregon Known Geothermal Resource Area.

Seismic reflection measurements were made during the survey to test the ability of the seismic reflection techniques to provide information on subsurface structure in volcanic areas where geothermal resources commonly occur, to provide seismic velocity and structural constraints for contemporary and continuing gravity and magnetic studies of the area, and to develop new techniques of geophysical exploration for geothermal resources particularly applicable to very complex volcanic terrane. This brief report outlines the preliminary results of the analysis of the seismic reflection measurements made during the survey.