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OREGON

STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

GEOPHYSICAL MEASUREMENTS IN THE VALE, OREGON
GEOTHERMAL RESOURCE AREA

Richard Couch*, William French*, Michael Gemperle*, and Ansel Johnson**

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, ob-
tained 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 communi-
cation). 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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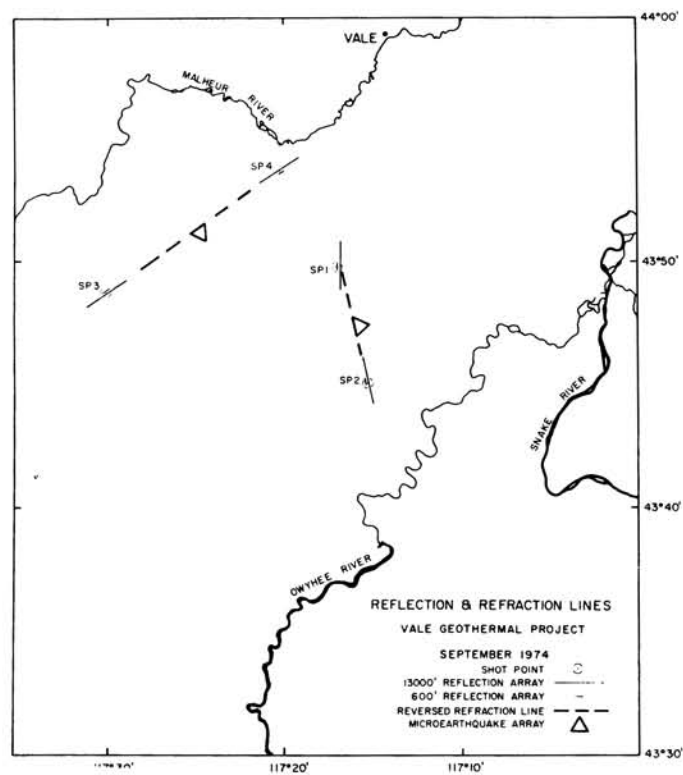
Figure 1. Map of the location of seismic reflection and microearthquake arrays and seismic refraction lines.
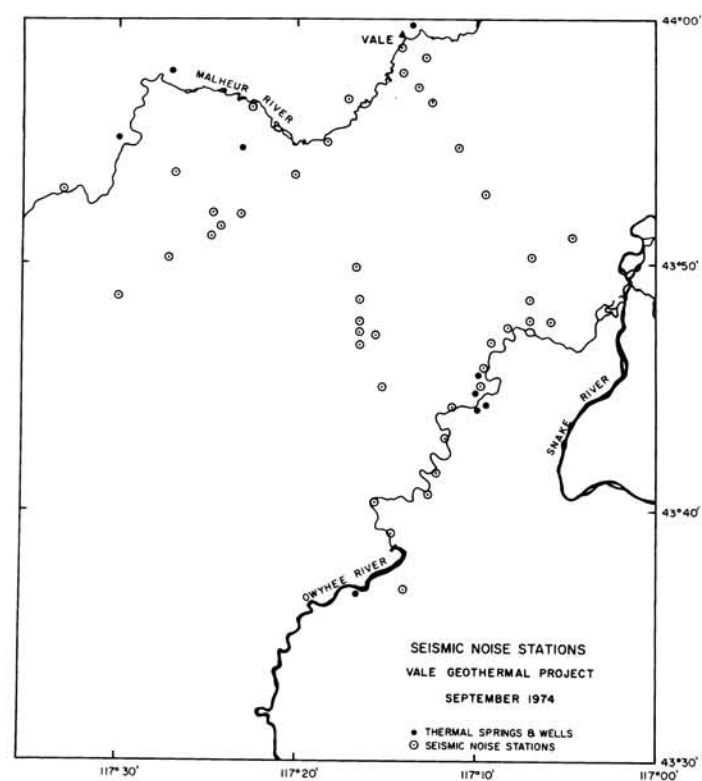

Figure 2. Map of the location of 42 seismic noise measurements made in the vicinity of Vale, Oregon.

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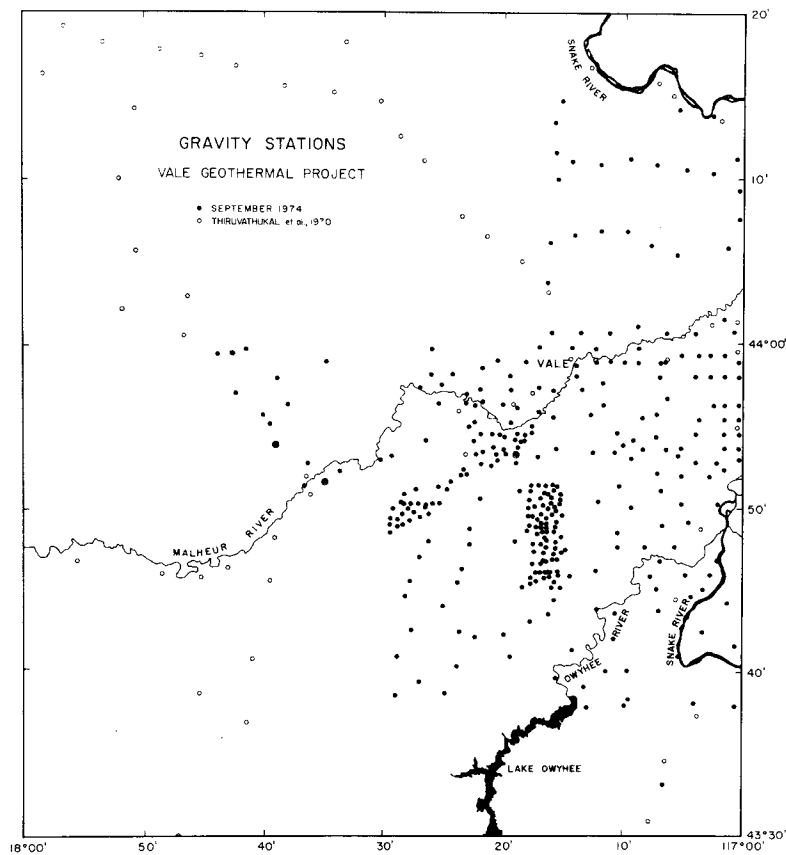
Figure 3. Map of gravity stations in the vicinity of Vale, Oregon.

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.

Acknowledgments

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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.

Figure 1 shows the location of four seismic reflection arrays deployed sequen-
tially during the survey. The bars show the location and orientation of the 13,000-
foot arrays and the small circles indicate the shot points (SP). A series of charges
detonated in cased drill holes 30 feet deep at each shot point permitted testing of
different filter and gain settings.
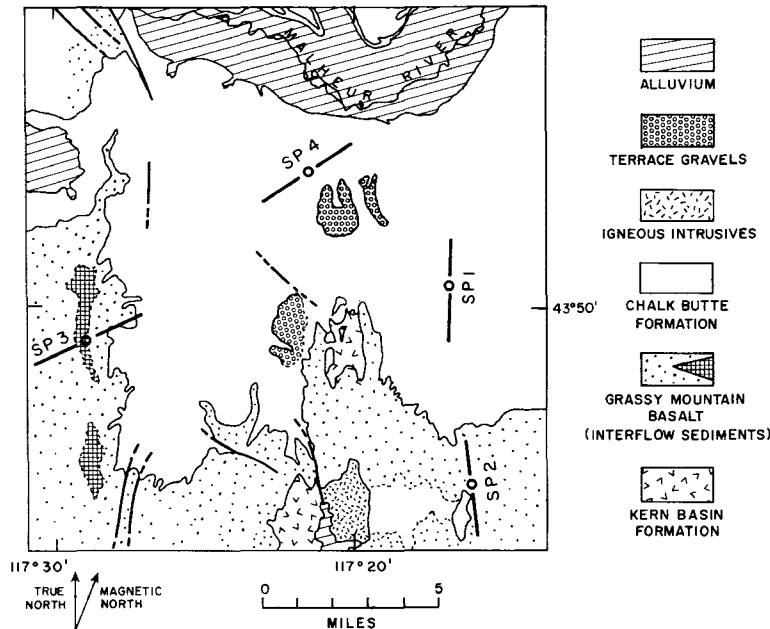
Figure 1. Generalized geologic map of study area near Vale, Oregon
showing location of shot points (SP) and seismic array orientations.
(Map after Corcoran and others, 1962)

Shallow Refraction Data

Seismic reflection techniques include methods of data reduction which identify
both refraction and reflection events present on the records (e.g., Grant and West,
1965). The first arrivals at a sufficient distance from shot points represent critically
refracted compressional waves or "head waves." Because instrument gains were high
during the field measurements it was possible in most cases to pick refraction arrivals
on the original records.

Figure 2 shows plots of time of first arrival versus distance from the shot point
for the four seismic lines and the surface topography along the seismic reflection array.
Time corrections for topography were not made in this preliminary analysis because
data on seismic velocity and variations in thickness of the near-surface weathered
zone were not available. The data points plotted in Figure 2, however, are very
nearly linear. Analysis of the refraction data in Figure 2 gives the subsurface layer
thicknesses and velocities listed in Table 1.

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SHOT POINT 1

580 FT/SEC ? 580 FT./SEC.?
6858 FT/SEC. 6111 FT/SEC.
14,744 FT/SEC. 12,739 FT/SEC.

N 2° 52' E

SHOT POINT 2

1513 FT/SEC ? 1513 FT/SEC.?
15,678 FT/SEC. 12,667 FT/SEC.

N 11° 30' E

ARRIVAL TIME (SECONDS)
1.2 1.0 0.8 0.6 0.4 0.2 0

ELEVATION (FEET)
3500 3250 3000 2750 2500

SHOT POINT 3

410 FT/SEC ? 410 FT/SEC ?
10,000 FT/SEC. 16,667 FT/SEC.

N 56° E

SHOT POINT 4

12,651 FT/SEC ? 12,651 FT./SEC.
6765 FT/SEC. 7123 FT./SEC.
1788 FT/SEC. ? 1788 FT/SEC.?

N 31° 15' E

ARRIVAL TIME (SECONDS)
1.2 1.0 0.8 0.6 0.4 0.2 0

ELEVATION (FEET)
3500 3250 3000 2750 2500 2250

6000 3000 0 3000 6000
HORIZONTAL DISTANCE FROM SHOTPOINT (FEET)

6000 3000 0 3000 6000
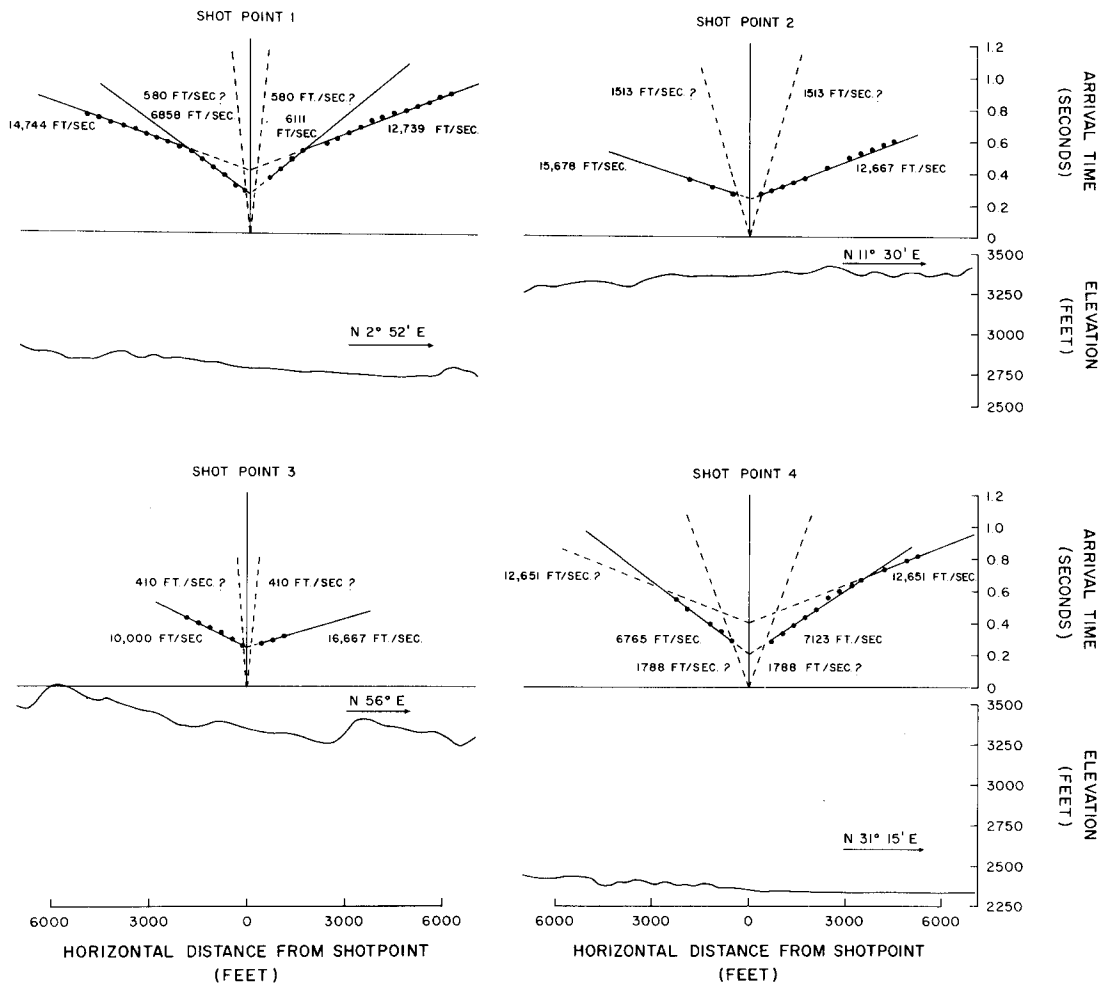HORIZONTAL DISTANCE FROM SHOTPOINT (FEET)

Figure 2. Topography and travel-time curves along seismic reflection lines 1, 2, 3 and 4. Points along the T-T curves represent first arrivals of refracted waves.

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Table 1. Layer velocities and thickness from seismic
refraction measurements

	Layer	Velocity ft/sec	Thickness ft
Line 1	1	580	70
	2	6,463	540
	3	13,664	-
Line 2	1	1,513	183
	2	14,011	-
Line 3	1	410	50
	2	12,500	-
Line 4	1	1,788	199
	2	6,939	767
	3	12,651	-

The first layer in each case is the thin zone of weathered material at the sur-
face. On all records the first motion of the trace nearest the shot point results from
a refraction at the interface immediately below this zone (Figure 2). Thus, the direct
wave from the shot through the weathered zone was not recorded as a first arrival. It
was necessary, therefore, to estimate the velocity of the weathered zone by extrapo-
lating the travel-time curve from the value at the closest geophone to time zero. The
reciprocal of the slope of this line provides an upper limit to the velocity of the
weathered zone. Because calculated thicknesses are directly related to calculated
velocities, the thicknesses shown for the first layer represent maximum estimates. On
lines 2 and 4, for example, the calculated maximum thickness of the weathered zone
is 200 feet but the actual thickness may be considerably less.

Velocities calculated for the weathered layer are extremely low. Lester (1932)
and Domenico (1974) discuss low velocities observed in loose unconsolidated material
above the water table. They verify by theory and actual observation that velocities
less than that of sound waves in air (1,180 ft/sec) are possible in loose material con-
taining air in a free state. The amount of air can be less than 1 percent of the total
material and still produce the velocities calculated for the surface layer in this study.
This is consistent with the near-surface soil conditions during the field study.

Below the weathered zone velocities expected for consolidated materials are
observed. On lines 1 and 4, layer 2 has a velocity between 6,000 and 7,000 ft/sec.
This is a typical velocity observed in lithified sediments. Below this and immediately
below the weathered zone on lines 2 and 3, velocities from 12,000 to 14,000 ft/sec
appear abruptly. It seems apparent that these higher velocities represent the basalt
which crops out on lines 2 and 3 (see Figure 1).

On line 1, 70 feet of weathered material and 540 feet of sediment overlie the
basalt. An analysis of measurements of the Earth's total magnetic field made along
the reflection array indicate a surface source along lines 2 and 3 and suggest a depth
to magnetic basement of 500 to 700 feet along line 1. The total 610 feet of sediment
on line 1 calculated from the refraction data is in good agreement with the depth
calculated from the magnetic data.

Though data quality is poor, reflection events are present and are indicated
by dots on the records. The change in curvature from one hyperbola to a later one
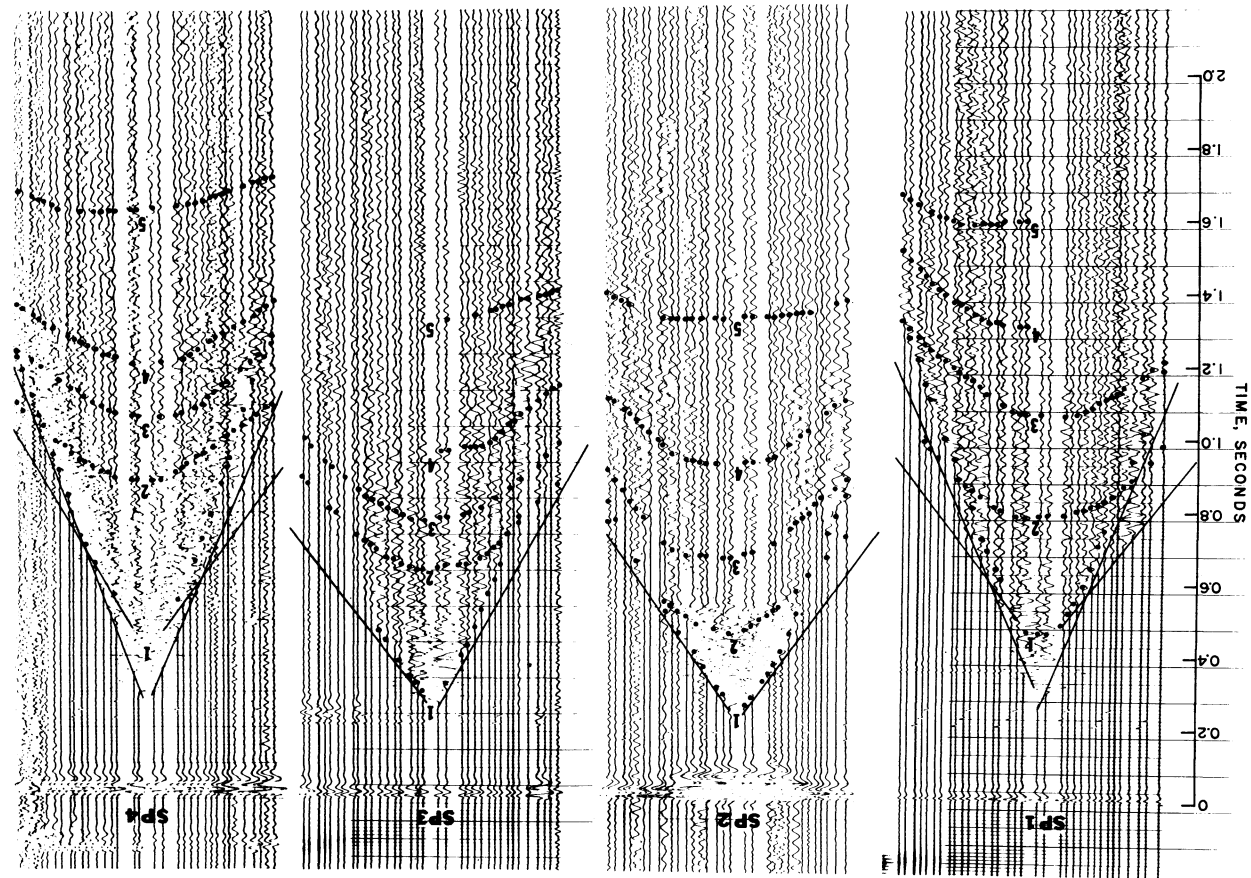
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Figure 3. Filtered reflection records obtained at SP 1, 2, 3, and 4. Solid lines represent refracted arrivals and dots represent arrivals of reflected waves.

is a function of the average velocity and thickness of material between the corre-
sponding reflecting interfaces. The interval velocities and thicknesses were esti-
mated using the T^2-X^2 technique (see Grant and West, 1965, p. 141-148). In most
instances, it was possible to trace hyperbolas across both sides of the records. Inter-
val velocities and thicknesses were calculated from both sides of the record for the
same interval and then averaged. When, because of lack of coherent reflections, it
was not possible to extend a hyperbola to both sides of the record, only the interpre-
table side of the record was used (e.g., see reflectors 4 and 5 on shot point 1). The
five reflection events which are consistent for all four shot points are identified by
dots in Figure 3.

Table 2 shows results of the analysis of the reflection records. Interval A is the
interval between reflectors 1 and 2, B is between 2 and 3, C is between 3 and 4, and
D is between reflectors 4 and 5. The calculated velocities of each of the intervals
are correlatable from shot point to shot point. The cross sections shown in Figures 4,
5, and 6 use calculated thicknesses for each interval. Refraction evidence discussed
earlier was used for the upper layers on each line. The approximate bottom to the
weathered zone is shown by a wavy line just below the surface on each section. Dips
in each instance are low, and thicknesses between shot points are consistent.

Table 2. Interval velocities and layer thicknesses from seismic
reflection measurements

	Velocities (ft/sec)			
	Interval			
	A	B	C	D
Line 1	14,028	7,193	8,772	25,000
Line 2	12,415	9,283	9,176	22,491
Line 3	11,430	8,229	8,375	18,344
Line 4	14,225	8,151	8,586	19,230

	Thicknesses (ft)			
	A	B	C	D
Line 1	2,168	1,035	1,101	3,600
Line 2	1,220	823	1,266	4,376
Line 3	2,110	568	770	3,320
Line 4	2,670	793	773	3,809

The marked contrast of velocities between intervals has definite lithologic impli-
cations. Table 3 shows a suggested relation between the seismic intervals discussed
here and the stratigraphic sequence of Corcoran and others (1962) for the Mitchell
Butte quadrangle.

It is emphasized that not all reflectors chosen in this investigation are contacts
between geologic formations. Velocities calculated are interval velocities and are
therefore an average of a large thickness of material. Formations mentioned which
are predominantly sediment also may contain thin interbedded basalts. These basalts
presumably have velocities much higher than the surrounding sediment. The entire

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Table 3. Seismic velocity intervals and suggested lithology

Interval	Approx. velocity (ft/sec)	Approx. thickness (ft)	Suggested lithology	Stratigraphic sequence*
Layer 2 from refraction on lines 1 and 4	6-7,000	At least 750	Sediment	Chalk Butte Fm.
A	11-14,000	2-3,000	Basalt	Grassy Mtn. Basalt
B and C	7-9,000	1½-2,000	Sediment	Kern Basin Fm. Deer Butte Fm.
D	18-25,000	3-4,000	Basalt	Owyhee Basalt Sucker Creek Fm.

* From Corcoran and others 1962

formation, however, will show an average velocity close to that of sediment. Likewise, basalt formations with thin interbedded sediments will have a velocity characteristic of basalt when large thicknesses are considered. These interbedded layers are important, though, because they represent sharp changes in lithology and are therefore capable of producing strong reflections. This implies that reflectors may represent sharp lithologic changes within geologic formations and are not necessarily the actual contacts between geologic formations.

Figure 1 is a portion of the geologic map of the Mitchell Butte quadrangle compiled by Corcoran and others (1962). The four seismic reflection lines have been added to the map. Lines 1 and 4 rest upon Chalk Butte sediments whereas older Grassy Mountain Basalt is at the surface on line 2 and 3. Generally, beds at the surface near the lines dip in a northeasterly direction toward the Snake River Basin.

The three cross sections (Figures 4, 5, and 6) are in good agreement with an extrapolation downward of the surface geology. In Figure 4 it is seen that material with a seismic velocity of 12,415 ft/sec (i.e., basalt) crops out on line 2 and shows an apparent dip of about 3.3° to the north. On line 1 about 600 feet of sediment overlies the basalt. Figure 4 shows that the sediment at the surface on line 1 has an apparent dip of approximately 1.8° in a northwesterly direction toward line 4. Since the geologic map shows that the center of line 4 is approximately on strike with the center of line 1, this low apparent dip is reasonable. Basalt with a seismic velocity of 11,430 ft/sec is seen at the surface on line 3. Figure 6 shows that this basalt has an apparent northeasterly dip of approximately 2.4° toward line 4. Again, this is in agreement with the geologic map.

Below the Chalk Butte sediments and the Grassy Mountain Basalt, correlations on the three cross sections all tend to indicate that the low dip toward the Snake River Basin continues. Below about 2,500 feet of Grassy Mountain Basalt, approximately 2,000 feet of lower-velocity material is encountered. This interval probably represents the Kern Basin and Deer Butte Formations, which are both predominantly sediment.

The deepest interval investigated consists of approximately 4,000 feet of very high-velocity material (approximately 20,000 ft/sec). Following the stratigraphic sequence outlined by Corcoran and others (1962), this material corresponds to the Owyhee Basalt. The reflection representing the bottom of this interval (reflector 5)
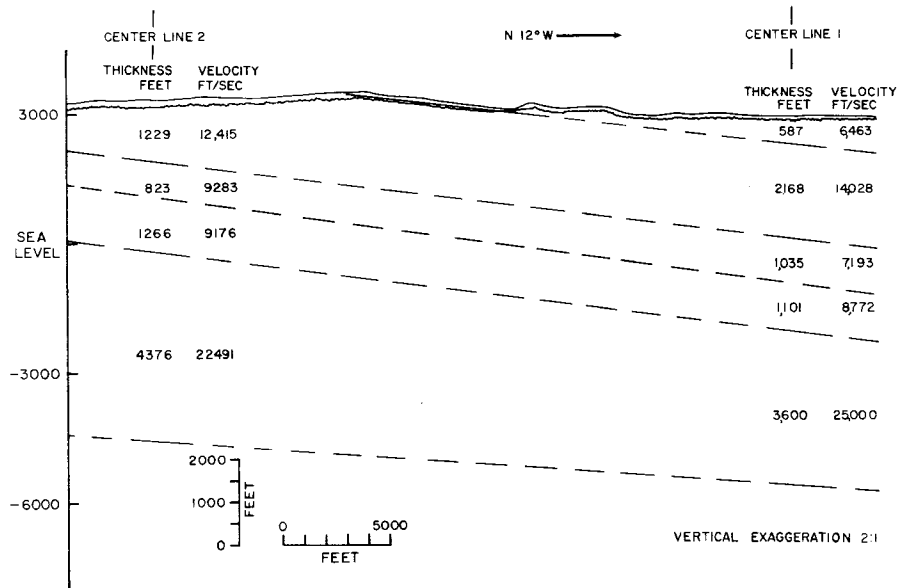
CENTER LINE 2   N 12°W ⟶   CENTER LINE 1

THICKNESS   VELOCITY   THICKNESS   VELOCITY
  FEET   FT/SEC   FEET   FT/SEC
3000

    1229   12,415   587   6,463

     823   9283   2168   14,028

    1266   9176   1,035   7,193

                                                        1,101   8,772

    4376   22491
-3000

                                                        3,600   25,000

                    2000
-6000   1000
                       0   0   5000   VERTICAL EXAGGERATION 2:1
                            FEET

Figure 4. Cross section showing seismic velocities and thicknesses calculated
        for SP 1 and SP 2.

CENTER LINE 1   N 35°W ⟶   CENTER LINE 4

THICKNESS   VELOCITY   THICKNESS   VELOCITY
  FEET   FT/SEC   FEET   FT/SEC
3000
    587   6,463   767   6,939

    2168   14,028   2670   14,225

    1,035   7,193

    1,101   8,772   793   8,151

                                                    733   8,586
-3000
    3,600   25,000

                                                    3,809   19,230

-6000   2000
               1000
                  0   0   5000   VERTICAL EXAGGERATION 2:1
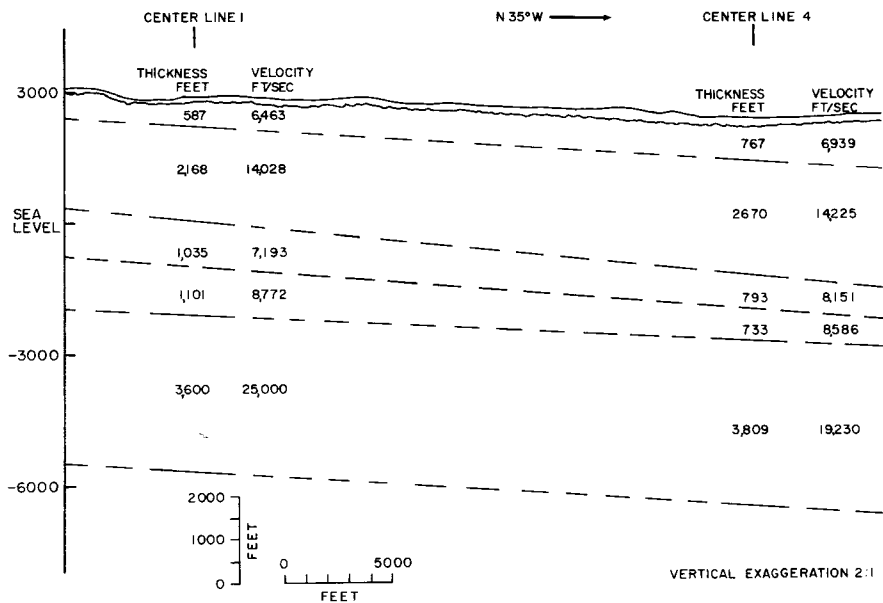   FEET

Figure 5. Cross section showing seismic velocities and thicknesses calculated
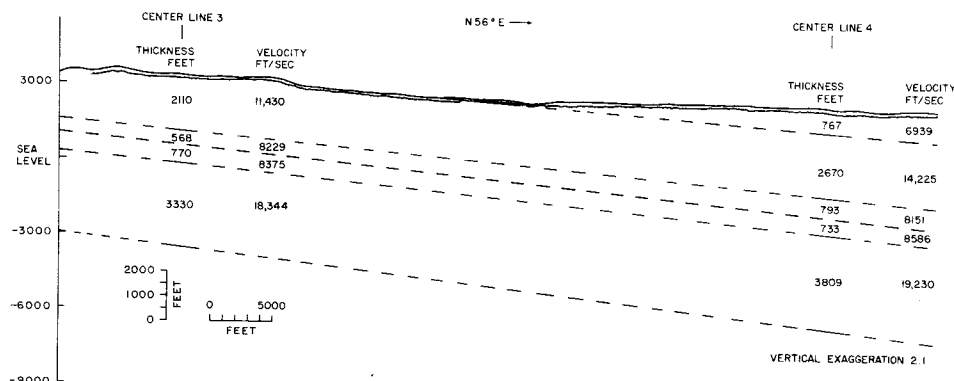   for SP 1 and SP 4.

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Figure 6. Cross section showing seismic velocities and thicknesses calculated for SP 3 and SP 4.

is very distinct on reflection records 1, 2, and 4. Such a strong reflection is expected in going from massive basalt flows to the underlying sediments of the Sucker Creek Formation. Reflector 5 is therefore believed to be near the top of the Sucker Creek Formation. This puts the limit to the seismic section for this study at a depth of about 9,000 feet.

Acknowledgments

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PRELIMINARY GRAVITY MAPS OF THE VALE AREA, MALHEUR COUNTY, OREGON

Kevin Larson* and Richard Couch**

Introduction

A gravity survey, conducted during August and September 1974 and July 1975 yielded approximately 380 stations in an area between 43°37' and 44°15' N. lat. and 117°00' and 117°30' W. long. This area of approximately 2,700 sq. km., which adjoins the western edge of the Snake River downwarp and consists largely of volcanic terrane, is considered a potential geothermal resource area. Because of the current high interest in geothermal energy and the Vale geothermal resource area in particular, this paper presents preliminary free-air and simple Bouguer anomaly maps of the area prior to formal interpretation. This effort, initiated under the Vale project described by Couch and others (1975) and currently supported by the U.S. Geological Survey, is continuing as a joint effort of the Department of Geology at the University of Oregon and the Geophysics Group, school of Oceanography at Oregon State University.

Field and Data Reduction Techniques

Wordon Gravity Meter 575, a Master gravimeter, calibrated just prior to the field work, was used to obtain measurements of gravity at 380 locations in the Vale area. The gravity base station at the Ontario ariport, Oregon (Rinehart and others, 1964; Berg and Thiruvathukal, 1965) provided the primary reference for all field stations. Berg and Thiruvathukal (1965) tied the Ontario base station to the international gravity base station located at the Carnegie Institution, Washington, D.C. Because Rinehart and others (1964 and Berg and Thiruvathukal (1965) report slightly different values for the Ontario base station, a new tie is planned for the near future. The value of gravity at the base station adopted for this preliminary report is 980,303.82 mgl. The establishment of a number of secondary base stations, tied to the Ontario base station, permitted the measurement of gravity at field stations along loops which extended from one secondary base station to another. Station spacing along the loops was approximately 2 to 4 miles.

USGS benchmarks, spot elevations on USGS 15-minute and 7.5-minute topographic maps, and barometer altimetry provided elevation control. The estimated uncertainty in the elevation control provided by the three methods is ±1, ±5 and ±10 feet respectively. Ties to points of known elevation every two hours provided corrections for temperature and barometric changes which occurred during the periods of measurement. USGS 15-minute and 7.5-minute topographic maps provided horizontal position control. The estimated uncertainty in position is ±.01 minute of latitude and longitude.

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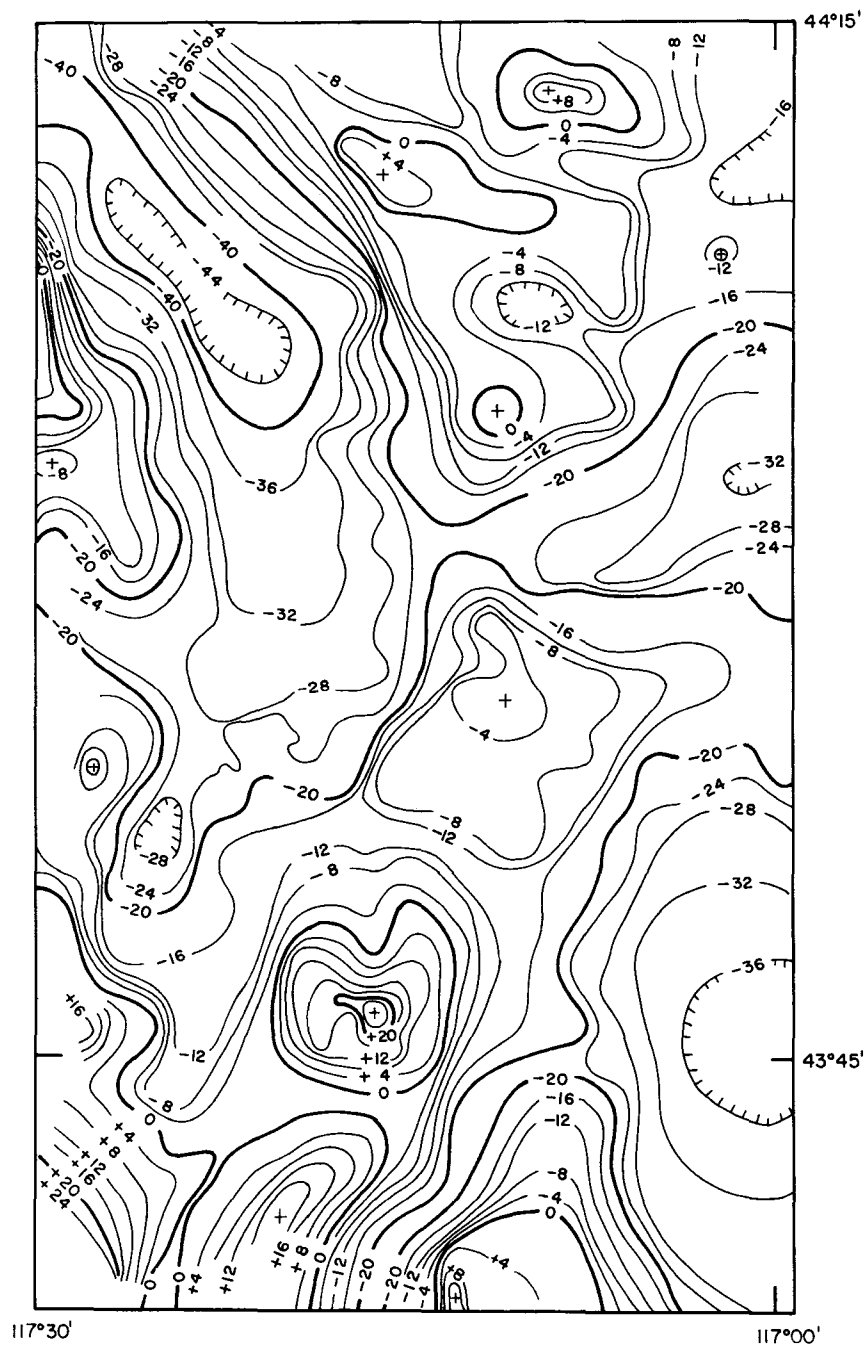**Geophysics Group, School of Oceanography, Oregon State University

Figure 1. Free-air gravity anomaly map of the area between 43°37.5' and
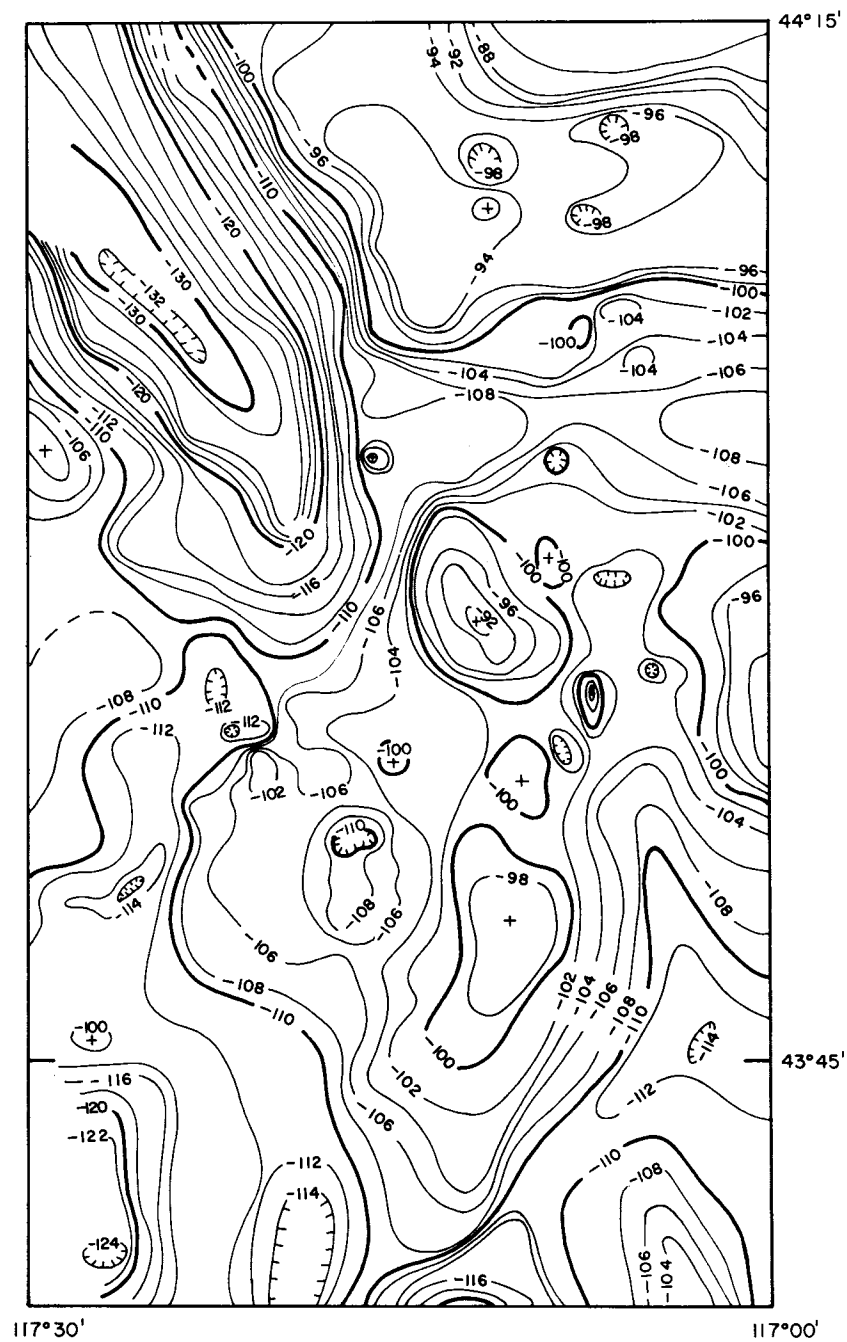44°15' N. lat. and 117°00' and 117°30' W. long.

Figure 2. Simple Bouguer anomaly map of the area between 43°37.5' and
44°15' N. lat. and 117°00' and 117°30' W. long. Bouguer reduction
density is 2.67 gm/cm³.

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The observed gravity (OG) was corrected for meter drift and tidal gravity changes. The International Gravity Formula (IGF) TG = 978049.0(1 + 0.0052884 $\sin\theta$ - 0.0000059 $\sin2\theta$ where θ is the latitude, yields theoretical gravity (TG). The equation F.A. = OG - TG + (.09411549 - 0.000137789 $\sin^2\theta$)h - 0.67 X $10^{-8}h^2$, where h is the elevation in feet above sea level, yields the free-air gravity (F.A.) anomaly; and the equation SB = FA - 0.012774 dh, where d is the Bouguer reduction density, yields the Bouguer anomaly. Bouguer anomalies in this report assume a reduction density of 2.67 gm/cm^3.

The Free-air Gravity Anomaly Map

Figure 1 shows the free-air gravity anomaly map for the area between 43°37.5' and 44°15' N. lat. and 117°00' and 117°30' W. long. The contour interval is ·4 mgl and heavy contours occur at intervals of 20 mgl. Anomaly amplitudes range from -46 mgl in the northwest portion of the mapped area near Jamieson, Oregon, to +26 mgl in the southwest portion of the area near Negro Rock Canyon. A series of con- tiguous gravity highs which trend approximately north-south are observed in the cen- ter of the area. A series of relative gravity lows flank the gravity highs on the east and west. The average free-air anomaly over the area is negative, indicating a small mass deficiency.

The Simple Bouguer Gravity Anomaly Map

Figure 2 shows the simple Bouguer anomaly map for the area. The contour interval is 2 mgl and heavy contours occur at 10 mgl intervals. The Bouguer reduc- tion density for the map is 2.67 gm/cm^3. Gravity anomaly amplitudes range from -132 mgl in the northwest part of the mapped area to -84 mgl in the northeast part. The marked gravity low in the northwest is elongate and trends approximately N30°W. A series of gravity highs locate a relative gravity high in the south-central and east- central parts of the area. A broad relative gravity high is also noted in the northeast part of the area.

General Remarks

The gravity maps show anomalies with a general north-south trend consistent with observed surface structures in the area. Topography causes part of the observed anomalies, and topographic effects are more evident on the free-air gravity anomaly map. The gravity low in the northwest portion of both maps occurs in the valley which extends from Vale to Brogan, Oregon. The relative gravity high in the north- east is coincident with the hilly terrain of that area. Both field work and interpre- tation are continuing.

Acknowledgments

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Couch, R., French, W., Gemperle, M., and Johnson, A., 1975, Geophysical measurements in the Vale, Oregon, geothermal resource area: Ore Bin, v. 37, no. 7, August.

Rinehard, W., Bowen, R. C., and Chiburis, E. F., 1964, Airport gravity base station network in Oregon: Ore Bin, v. 26, no. 3, p. 37-56, 1964.

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CENTRAL OREGON FIELD TRIP GUIDEBOOK REPRINTED

A popular guidebook, abundantly illustrated by photographs and colored geologic maps and outlining five geologic field trips to see interesting volcanic features in central Oregon, has been reprinted. The guidebook is the Department's Bulletin 57, "Lunar Field Conference Guidebook," published in 1965 when the area around Bend and in the nearby Cascade Range was used as an outdoor laboratory for studying the lunar surface prior to Moon landings. The subjects of the 51-page guidebook are trips to 1) Devils Hill, Broken Top, and Lava Butte; 2) Newberry Volcano; 3) Hole-in-the-Ground and Fort Rock; 4) Belknap Crater, Yapoah Crater, and Collier Cone; and 5) Crater Lake. The publication can be obtained from the Department's offices in Portland, Baker, and Grants Pass for $3.50.

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BUREAU OF LAND MANAGEMENT GETS NEW OREGON DIRECTOR

Murl W. Storms has been appointed Oregon State Director of the Bureau of Land Management by BLM Director Curt Berklund in Washington, D.C. Storms, a 26-year veteran resource manager for BLM, succeeds Archie D. Craft, who recently was appointed Assistant Director for Technical Services in the BLM head office in Washington, D.C.

As new State Director, Storm's responsibilities include management of 16 million acres of national resource lands in Oregon and Washington.

Storms is a graduate of the University of Washington, where he received his B.S. degree in Forestry in 1949. In 1962 he received an M.S. degree in Natural Resources Administration from the University of Michigan. Much of his career since 1955 has been spent in Oregon, most recently as Chief, Division of Resources, Oregon State Office, 1966-1971. From 1971 until his present appointment, he was Chief of BLM's Division of Forestry in Washington, D.C.

Storm takes the oath of office August 19 in Roseburg, Oregon during dedication of the new BLM district office there.

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SOUTHEASTERN-OREGON REPORTS RELEASED ON OPEN FILE

"Geothermal significance of eastward increase in age of upper Cenozoic rhyolite domes in southeastern Oregon," by N. S. MacLeod, G. W. Walker, and E. H. McKee, has been placed on open file by the U.S. Geological Survey as USGS open-file report No. 75-348. This preliminary report summarizes available data and its geothermal implications and is an extension of earlier work (see July 1974 The ORE BIN). A copy of the 22-page report is available for inspection at the Department's library in Portland, where copies may also be purchased for $2.50.

The U.S. Geological Survey has issued Open-file report USGS 75-346 entitled "Gravity and magnetic profiles and maps, Crump Geyser area, Oregon," by Donald Plouff and Arthur Conradi, Jr. Grump Geyser area, a Known Geothermal Resource Area, is situated in Warner Valley in southeastern Lake County. The report consists of 12 plates and a 2-page text. A copy is available for inspection at the Department's library. Reproducible copy is at the USGS Library, 345 Middlefield Rd., Menlo Park, Calif., 49025.

Two sets of geophysical data on the Alvord Valley area recently received from the U.S. Geological Survey can be consulted at the Oregon Department of Geology and Mineral Industries library. Reproducible copy is on file at: U.S. Geological Survey, 678 U.S. Court House, Spokane, Washington 99201. The open-file materials is:
1. "Audio-magnetotelluric apparent resistivity maps for part of Harney County," by C. L. Long and D. I. Gregory. Five plates, scale 1:62,500.
2. Principal facts and preliminary interpretation for gravity profiles and continuous truck-mounted magnetometer profiles in the Alvord Valley, Oregon," by Andrew Griscom and Arthur Conradi, Jr. 20 pages, 18 plates, 9 tables.

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USBM ISSUES MINERAL SUPPLY/DEMAND DATA

A concise, statistical supply/demand profile for 84 mineral and fuel commodities in the United States during the decade 1964-1973 is given in a special publication just issued by the U.S. Bureau of Mines.

The 96-page report, titled "Minerals in the U.S. Economy," covers 47 metals, 32 nonmetals, and five fuels. Annual statistics are tabulated on U.S. and world output, foreign and domestic components of the U.S. supply, and demand by major use categories. "Flow" diagrams for each commodity show, at a glance, relationships in 1973 among international suppliers, U.S. imports, domestic production, government and industry stockpiles, and consumption categories.

Much of the material has appeared previously in the Minerals Yearbook and and other Bureau publications. However, it has now been assembled for the first time in condensed form, with the new flow diagrams added.

A single copy of "Minerals in the U.S. Economy" can be obtained without charge from the Publications Distribution Branch, Bureau of Mines, 4800 Forbes Ave., Pittsburgh PA 15213. Requests should specify the complete title.

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ERDA SUBMITS FIRST PLAN TO CONGRESS

The Energy Research and Development Administration (ERDA) has submitted to Congress its "Energy Research, Development and Demonstration Plan."

ERDA outlined five major changes in the nation's energy research and development efforts that must be made "rapidly and simultaneously" to help solve the energy problems confronting the nation. The following changes in priorities are urged:

Emphasis on overcoming the technical problems inhibiting expansion of high-leverage existing systems, notably coal and light-water reactors.

An immediate focus on conservation efforts.

Acceleration of commercial capability to extract gaseous and liquid fuels from coal and shale.

Inclusion of the solar-electric approach among the "inexhaustible resource" technologies to be given high priority.

Increased attention to underused new technologies that can be rapidly developed.

ERDA emphasized that the priorities from now to 1985 are:

(1) To preserve and expand our major existing energy systems: coal, light-water reactors (the highest nuclear priority), and gas and oil from new sources and enhanced recovery techniques.

(2) To increase efforts on conservation, to increase the efficiency of energy use in all sectors of our economy, and to extract more usable energy from waste materials.

Copies of Volume 1 of the full ERDA report to Congress may be obtained from the Assistant Administrator for Planning and Analysis, Energy Research and Development Administration, Washington, D.C. 20545.

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HISTORICAL MATERIAL ON MINING WANTED BY OHS

Oregon Historical Society would appreciate donations of materials on early-day mining activities in Oregon or the Pacific Northwest. Old publications, letters, records, and photographs connected with mining are desired. Names of miners and location of mining activities are needed to give the photographs historic value.

Before sending your historical items, write a letter of inquiry, listing the material you have available, to: Library, Oregon Historical Society, 1230 S.W. Park, Portland, Oregon 97205.

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MOUNT HOOD BIBLIOGRAPHY AVAILABLE

A bibliography on the geology of Mount Hood, by Mike McCarthy, student at Portland State College, has been issued as open-file report No. O-75-5. References are listed alphabetically by author, and most include a brief summary of the contents. The report contains more than 80 references to literature on Mount Hood, spanning nearly 150 years from early exploring expeditions in the West to present-day studies. The bibliography is preliminary and subject to corrections and additions. Copies are available from the Department's Portland office for $1.00.

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AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. All sales are final — no returns. Upon request, a complete list of Department publications, including out-of-print, will be mailed.)

BULLETINS

26. Soil: Its origin, destruction, preservation, 1944: Twenhofel. $0.45
33. Bibliography (1st suppl.) geology and mineral resources of Oregon, 1947: Allen . 1.00
35. Geology of Dallas and Valsetz quadrangles, Oregon, rev. 1964: Baldwin . . . 3.00
36. Papers on Tertiary foraminifera: Cushman, Stewart & Stewart. vol. 1-$1.00; vol. 2-1.25
39. Geology and mineralization of Morning mine region, 1948: Allen and Thayer . . 1.00
44. Bibliography (2nd suppl.) geology and mineral resources of Oregon, 1953: Steere. 1.00
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey 1.25
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch . . . 1.00
52. Chromite in southwestern Oregon, 1961: Ramp 5.00
53. Bibliography (3rd suppl.) geology and mineral resources of Oregon,1962:Steere,Owen 3.00
57. Lunar Geological Field Conf. guidebook, 1965: Peterson and Groh, editors . . 3.50
60. Engineering geology of Tualatin Valley region, 1967: Schlicker and Deacon . . 7.50
61. Gold and silver in Oregon, 1968: Brooks and Ramp 7.50
62. Andesite Conference Guidebook, 1968: Dole 3.50
64. Geology, mineral, and water resources of Oregon, 1969 . . . . 3.00
65. Proceedings of the Andesite Conference, 1969: McBirney, editor (photocopy). . 10.00
66. Geology and mineral resources of Klamath and Lake Counties, 1970. . . . . 6.50
67. Bibliography (4th suppl.) geology and mineral industries, 1970: Roberts . . . 3.00
68. Seventeenth biennial report of the Department, 1968-1970 . . . . 1.00
69. Geology of the southwestern Oregon Coast, 1971: Dott 4.00
70. Geologic formations of western Oregon, 1971: Beaulieu 2.00
71. Geology of selected lava tubes in the Bend area, 1971: Greeley 2.50
72. Geology of Mitchell quadrangle, Wheeler County, 1972: Oles and Enlows . . 3.00
73. Geologic formations of eastern Oregon, 1972: Beaulieu 2.00
75. Geology, mineral resources of Douglas County, 1972: Ramp 3.00
76. Eighteenth biennial report of the Department, 1970-1972. . . . . 1.00
77. Geologic field trips in northern Oregon and southern Washington, 1973. . . . 5.00
78. Bibliography (5th suppl.) geology and mineral industries, 1973: Roberts and others 3.00
79. Environmental geology inland Tillamook Clatsop Counties, 1973: Beaulieu. . . 7.00
80. Geology and mineral resources of Coos County, 1973: Baldwin and others . . . 6.00
81. Environmental geology of Lincoln County, 1973: Schlicker and others 9.00
82. Geol. Hazards of Bull Run Watershed, Mult. Clackamas Counties, 1974: Beaulieu 6.50
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin 4.00
84. Environmental geology of western Linn Co., 1974: Beaulieu and others. . . . 12.00
85. Environmental geology of coastal Lane Co., 1974: Schlicker and others . . . 12.00
86. Nineteenth biennial report of the Department, 1972-1974 . . . . 1.00
87. Environmental geology of western Coos and Douglas Counties, Oregon, 1975 . . in press
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp . . in press

GEOLOGIC MAPS

Geologic map of Oregon west of 121st meridian,1961: Wells and Peck $2.00; mailed - 2.50
Geologic map of Oregon (12" x 9"), 1969: Walker and King 0.25
Geologic map of Albany quadrangle, Oregon, 1953: Allison (from Bulletin 37). . . 1.00
Geologic map of Galice quadrangle, Oregon, 1953: Wells and Walker 1.50
Geologic map of Lebanon quadrangle, Oregon, 1956: Allison and Felts 1.50
Geologic map of Bend quadrangle, and portion of High Cascade Mtns., 1957: Williams 1.50
GMS-1: Geologic map of the Sparta quadrangle, Oregon, 1962: Prostka 2.00
GMS-2: Geologic map, Mitchell Butte quadrangle, Oregon: 1962 . . . . . . 2.00
GMS-3: Preliminary geologic map, Durkee quadrangle, Oregon, 1967: Prostka . . 2.00
GMS-4: Gravity maps, Oregon onshore & offshore; [set only]: at counter $3.00, mailed 3.50
GMS-5: Geology of the Powers quadrangle, 1971: Baldwin and Hess 2.00
GMS-6: Preliminary report, geology of part of Snake River Canyon, 1974: Vallier. . 6.50

The Ore Bin

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Available Publications, Continued:

SHORT PAPERS

18. Radioactive minerals prospectors should know, 1955: White and Schafer $0.30
19. Brick and tile industry in Oregon, 1949: Allen and Mason 0.20
21. Lightweight aggregate industry in Oregon, 1951: Mason 0.25
24. The Almeda mine, Josephine County, Oregon, 1967: Libbey 3.00

MISCELLANEOUS PAPERS

1. Description of some Oregon rocks and minerals, 1950: Dole 1.00
2. Oregon mineral deposits map (22 x 34 inches) and key (reprinted 1973): 1.00
4. Rules and regulations for conservation of oil and natural gas (rev. 1962) 1.00
5. Oregon's gold placers (reprints), 1954 . . . . 0.50
6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton 3.00
7. Bibliography of theses on Oregon geology, 1959: Schlicker 0.50
   (Supplement) Bibliography of theses, 1959 to Dec. 31, 1965: Roberts 0.50
8. Available well records of oil and gas exploration in Oregon, rev. 1963: Newton . 1.00
11. A collection of articles on meteorites, 1968 (reprints from The ORE BIN) . . . 1.50
12. Index to published geologic mapping in Oregon, 1968: Corcoran 0.50
13. Index to The ORE BIN, 1950-1974 . . . . in prep
14. Thermal springs and wells, 1970: Bowen and Peterson 1.50
15. Quicksilver deposits in Oregon, 1971: Brooks 1.50
16. Mosaic of Oregon from ERTS-1 imagery, 1973: 2.50
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975 . . . 2.00

OIL AND GAS INVESTIGATIONS

1. Petroleum geology, western Snake River basin, 1963: Newton and Corcoran . . . 3.50
2. Subsurface geology, lower Columbia and Willamette basins, 1969: Newton . . . 3.50
3. Prelim. identifications of foraminifera, General Petroleum Long Bell No. 1 well. . 2.00
4. Prelim. identifications of foraminifera, E. M. Warren Coos Co. 1-7 well: Rau . . 2.00

MISCELLANEOUS PUBLICATIONS

Landforms of Oregon: a physiographic sketch (17" x 22"), 1941 . . . . 0.25
Mining claims (State laws governing quartz and placer claims) 0.50
Oregon base map (22" x 30") 0.50
Geologic time chart for Oregon, 1961 . . . . free
Postcard – geology of Oregon, in color . . . . 10¢ each; 3 – 25¢; 7 – 50¢; 15 – 1.00
The ORE BIN – Annual subscription . . . . ($8.00 for 3 yrs.) 3.00
          Available back issues, each . . . . 25¢; mailed 0.35
          Accumulated index – see Misc. Paper 13