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THRUSTING OF THE ROGUE FORMATION NEAR MARIAL ON THE LOWER ROGUE RIVER, OREGON

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Introduction

Geologic exploration in the Klamath Mountains of Oregon and California has revealed the presence of large thrust sheets, a feature which adds to the complexity of the regional geology. One of the first to recognize the pattern of thrusting was Irwin (1960, 1964). He showed a thrust fault that placed the Rogue Formation upon the Dothan Formation along a contact that trends northeasterly through the Kerby and Galice quadrangles. The fault crosses the Rogue River a short distance west of the village of Galice. Baldwin (1969) also mapped this fault, and Hotz (1969) described the metamorphic effects on the rock adjacent to the fault. The presence of the thrust is now generally accepted, and a recent fossil discovery in the Dothan Formation (Ramp, 1969) supports Irwin's conclusion that the underlying Dothan is younger than the Galice and Rogue Formations.

Confusion has prevailed in separating the volcanic rock of the Rogue Formation from the bodies of volcanic rock mapped within the Dothan Formation. On the Geologic Map of Western Oregon, which represents an earlier interpretation of the study of the Klamath Mountains, Wells and Peck (1961) assign to the Dothan Formation a northeast trending belt of volcanic rock 20 miles west of Galice. The belt reaches from Gold Mountain on the north across Mule Creek and the Rogue River to Shasta Costa Creek to the south. It is the purpose of this paper to show that this volcanic belt is made up of Rogue volcanic rock, and that it was thrust westward over younger formations as part of the Rogue Thrust Sheet recognized elsewhere to the east. Subsequent downfaulting and erosion in the mapped area has isolated the body from the rest of the Rogue Formation, thus obscuring its relationships with that unit.

Baldwin (1968, 1969) mapped this western volcanic belt as Rogue Formation, but in the area he mapped the critical thrust relationships were covered by younger formations. It was during additional reconnaissance and more specific mapping in the southwestern quarter of the Bone Mountain quadrangle by Rud (1971) that the thrust relationship became more evident.

Mapping is continuing in the Mt. Bolivar-Gold Mountain area by Richard Kent (Portland State University) and in the area just north of Gold Mountain by Nils Johannesen (University of Oregon). The writers are indebted to both for additional information.

Stratigraphy

Introduction

A brief resume of the formations involved is informative. Beds assigned to the Galice Formation lie west of the Powers-Agness fault west of Bald Knob but are not mapped on Figure 1. They also extend farther to the northwest into the Langlois quadrangle (Lent, 1969), Powers quadrangle (Baldwin and Hess, 1971), and Port Orford quadrangle (Koch, 1966).

Colebrook Schist

The Colebrooke Schist is of uncertain age but is tentatively assigned to the Jurassic pending more adequate proof of age. Coleman and Lanphere (1971) discuss the age and mode of emplacement. They assign a metamorphic age of approximately 130 million years to the lower-grade blueschist minerals of the Colebrooke and a metamorphic age of 150 million years to the higher-grade blueschist minerals and amphibolites in scattered small bodies. The place of formation of the higher-grade metamorphic minerals is uncertain and the time and place of accumulation of the original sediments are unknown. Coleman and Lanphere (1971) suggest, however, that the Colebrooke Schist occupies a thrust sheet that was shoved eastward upon beds as young as the Myrtle Group.

Serpentinite and diorite intrusions

Serpentinite and some less obviously altered bodies of peridotite are present in places along the edges of the Rogue Thrust Sheet. Coleman (1971) discusses the tectonic emplacement of such ultramafic bodies. He suggests that most of the serpentinite in this area had its origin in the upper mantle and was emplaced along geosutures created by collisions of the oceanic and continental plates. Emplacement prior to or during the Late Jurassic Nevadan orogeny is suggested by the intrusion of dioritic bodies of that age. Subsequently the serpentinite may have acted as a "tectonic carpet" upon which the Colebrooke Schist was thrust, possibly during Cretaceous time (Coleman, 1969).

Dioritic bodies which intruded the pre-Nevadan formations and the serpentinite during the Nevadan orogeny have been discussed by Koch (1966), Lund and Baldwin (1969), and Dott (1971). Adding to the difficulties in interpreting the position of the serpentinite is the fact that it may have been remobilized one or more times during the Tertiary, thus possibly obscuring its original contact relationships.

Rogue Formation

The volcanic rock which extends southward from Gold Mountain through Mt. Bolivar and Mule Creek drainage and which crosses the Rogue River at Marial to continue southward into Illinois River drainage was called the Dothan volcanics by Wells and Peck (1961). Baldwin (1969), however, examined these rocks and noted that they were intruded and altered more like the pre-Nevadan Rogue Formation than the post-Nevadan flows and tuffs. He assigned them to the Rogue Formation.

The Rogue Formation, named by Wells and Walker (1953), includes approximately 15,000 feet of volcanic rocks that are exposed west of Galice (east of the mapped area, Figure 1). This volcanic section is separated from that lying west of Marial by a 12-mile wide belt of sedimentary rock along the Rogue River assigned to Dothan Formation. In its type area, the Rogue Formation consists mostly of submarine flows, breccias, and tuffs which have been altered to greenstone and intruded by peridotite and quartz diorite.

The Rogue Formation west of Marial (Figure 1) appears to be at least 10,000 feet thick. Unmapped intrusive bodies within the formation are exposed in the West Fork of Mule Creek, along the Rogue River trail downstream from Marial near the mouth of Stair Creek, and near the mouth of Indigo Creek, a tributary of the Illinois River. Although the composition of the intrusive rock was not determined petrographically, much of it appears to be gabbro in hand specimen. Contacts with the greenstone are gradational and it is possible that the rock is a metagabbro. Most of the primary structures of the volcanic rock have been obscured by alteration to greenstone. Epidotization is common along some of the shear zones.

The Rogue Formation in its type area is interfingered in places with the pre-Nevadan Galice Formation (middle Late Jurassic) and shows evidence of deformation prior to deposition of the later Dothan strata (late Late Jurassic). It apparently was thrust westward relative to the underlying Dothan Formation and then was dropped by normal faulting against the Dothan along a fault that crosses the Rogue River at the mouth of Mule Creek.

Dothan Formation

The Dothan Formation is made up of a thick section of graded thick-bedded graywacke with minor amounts of conglomerate, chert, and volcanic rock. The graywacke in many places is made up of rhythmically bedded indurated sandstone which generally dips eastward. Volcanic rock is present in places and it frequently shows the original pillow or fragmental structures. Although the Rogue and Dothan volcanics have been confused in the past, it is the observation of the writers that the Dothan volcanic masses are seldom as large or as altered as those of the Rogue Formation. The Dothan Formation is now generally assigned a Tithonian (Late Jurassic) age (Irwin, 1964, and Ramp, 1969). It is not known to be intruded by dioritic rocks, a point which supports a post-Nevadan age.

Myrtle Group

Because the lithology of the Cretaceous beds in the area mapped is more like the Myrtle Group described by Imlay and others (1959) than the Humbug Mountain Conglomerate and Rocky Point Formations (Koch, 1966) of similar age along the coast, the term Myrtle Group is adopted here.

As described by Imlay and others (1959), the Myrtle Group includes the Riddle and Days Creek Formations. Although the two formations were not differentiated on the map, they can be distinguished in the field. The Riddle contains chert pebble conglomerate and some dark graywackes, and lies on the eastern edge of the outcrop belt. The Days Creek Formation is made up mostly of graded bedded graywacke with minor amounts of conglomerate. The Myrtle Group is mostly Early Cretaceous in age, although the base of the unit may extend into the Late Jurassic (Jones, 1969). The group can be traced southwestward to the lower Illinois River Valley along the front of the Rogue volcanic thrust sheet (Figure 1). Between the larger areas of outcrop, small exposures are present along the Rogue River near Clay Hill, midway between Illahe and Marial, and in a faulted block along Shasta Costa Creek.

Umpqua Formation

In the map area the Umpqua Formation occupies a north-trending syncline. Although the Umpqua Formation has been split into three mappable members pending formal naming as formations by Baldwin (1965), the unit remains undifferentiated in Figure 1. All three members contain some conglomerate near the base and are composed primarily of rhythmically bedded, graded graywacke and siltstone. Distinction between the three members is sometimes difficult in the field and is based largely on stratigraphic position.

The age of the Umpqua Formation ranges from Paleocene and early Eocene in the lower member to middle Eocene in the middle and upper members. Unconformities separate the three members and also separate the Umpqua Formation as a whole from the overlying Tyee Formation. The Umpqua Formation unconformably overlies the Myrtle Group along an undetermined contact (dotted line on map) between Agness and Illahee on the Rogue River. Along the Illinois River-Horse Sign Creek divide near Horse Sign Butte basal black sands assigned to the middle Umpqua by Baldwin (1968) rest on pre-Tertiary rock.

On the accompanying map, the Umpqua Formation is shown to overlie both the Rogue Formation and the Dothan Formation in continuous outcrops, a feature which suggests at first that the proposed thrusting of the Rogue was pre-Umpqua in age. More refined mapping indicates, however, that the involved exposures consist of middle or upper Umpqua only. Hence, the conclusion advanced by Baldwin and Lent (1972) that part of the thrusting may have occurred after the lower Umpqua was deposited is consistent with the distribution of the Umpqua Formation.

Tyee Formation

The Tyee Formation occupies the center of the syncline which in turn occupies a graben. The Tyee is unconformable on all underlying formations and oversteps the Umpqua onto the Rogue Formation at Hanging Rock, a short distance northwest of Marial. At the south end of the basin the Tyee becomes more massive, contains more conglomerate, and loses the graded bedding that is characteristic farther north in the Coast Range. Cross-bedding and the presence of intercalated coal beds indicate a shallow-water nearshore environment of deposition. Bald Knob is the southernmost exposure of Tyee in Oregon.

Structural Geology

Introduction

The stages of tectonism in the area mapped start with deformation of the Rogue and Galice Formations during the Nevadan orogeny. This episode is largely masked by later thrusting, but presumably the ultrabasic rock and dioritic intrusions were initially emplaced at this time. Subsequent basining, volcanism, and deposition formed the very thick sections of graywacke assigned to the Dothan Formation and the associated sedimentary and volcanic rocks of the Otter Point Formation to the west (Koch, 1966). The two units may represent deposition in part of a Late Jurassic island arc system (Coleman to Beaulieu, written communication, 1971).

Contemporaneous or later deformation has converted the Otter Point Formation to a melange as described by Hsu (1968). Thrusting is known to have followed deposition of the Myrtle Group (Blake, Irwin and Coleman, 1967).

Rogue Thrust Sheet

On the geologic map of the Kerby quadrangle (Wells and others, 1949) and the Geologic Map of Western Oregon (Wells and Peck, 1961) the elongate body of volcanic rocks which is situated along the western edge of the large intrusive belt southwest of Galice is assigned to the Dothan Formation. Hotz (1969) has examined the thrust as far south as Hobson Horn in the southern part of the Galice quadrangle, where dioritic intrusives are interpreted to rest with thrust contact upon the Dothan Formation. The senior writer, however, in reconnaissance along the Silver Peak trail in the northern part of the Kerby quadrangle, found sheared volcanic rocks between the diorite and the thrust. Apparently the volcanics in the area are not separated from the intrusions of diorite, gabbro, and serpentinite but actually contain them. It is concluded that the volcanic rocks along the Silver Peak Trail are pre-Nevadan and part of the Rogue Thrust Sheet, and that they are not part of the Dothan Formation as concluded by Wells and others (1949) and Wells and Peck (1961).

The thrust apparently follows the western edge of the Mule Creek volcanic belt southward across Silver Creek, the Illinois River, and Tincup Creek. Near Tincup Creek exposures of the Rogue Formation (as recognized above) lie within eight miles of the exposures of volcanic rock (Rogue Formation of this report) along the Illinois River at the mouth of Collier Creek in the mapped area. The distance of eight miles is considerably less than the separation between the two units along the Rogue River nearer the mapped area, a situation which supports the interpretation that the two units may be genetically related.

It is concluded that the volcanic rocks in the mapped area, which are also intruded (see Rogue Formation), are part of the Rogue Formation, and that, together with the exposures near Galice, constitute part of the extensive Rogue Thrust Sheet.

Evidence suggests that the relative movement of the Rogue Thrust Sheet over the Dothan east of Galice was to the west. Drag folds in the underlying Dothan are displaced westerly, and the Rogue plate climbs in the section so that it overlies the Dothan Formation nearer the source and the Myrtle Group farther west. The Rogue plate is apparently eroded in the intervening area exposing the Dothan between Galice and Marial along the Rogue River.

It might be reasoned that if the Colebrooke Schist plate came from the west, the Rogue plate could have also, but there is little evidence to support such a theory. It is possible to show that relative westward movement of the Rogue may have been achieved by underthrusting of the lower plate during collision of the oceanic and continental plates. If so, then subduction of the oceanic plate may have directed the Dothan and underlying rocks beneath the Rogue Thrust Sheet at the same time that obduction (over-thrusting) caused the Colebrooke Schist to ride eastward over all pre-Myrtle formations and possibly over the lead edge of the Rogue plate as well.

Coleman (1969) describes the role of "tectonic carpets" of serpentinite in thrusting. A considerable quantity of serpentinite is present along the Illinois River, Figure 1, upon which the plates may have slid.

Serpentinite is absent in many places along the thrust in the Bone Mountain quadrangle and also in the Galice and Kerby quadrangles. Serpentinite, diorite and gabbro bodies split the Rogue belt in the Galice and Kerby quadrangles, but only in a few places does the serpentinite furnish a "tectonic carpet" along the thrust margin.

The relationship between the Dothan Formation and the Myrtle Group is obscured by the presence of the Rogue Thrust Sheet as it is recognized in this report. Because the exposures of Rogue represent parts of a regional thrust sheet, it is possible that the immediately underlying Dothan Formation may in places be in thrust contact with the Myrtle Group.

Erosion of edges of the thrust sheets and overlap by later sedimentary formations obscure the thrust fault in the area mapped, but further work in this complex but interesting area should cast further light on geologic events.

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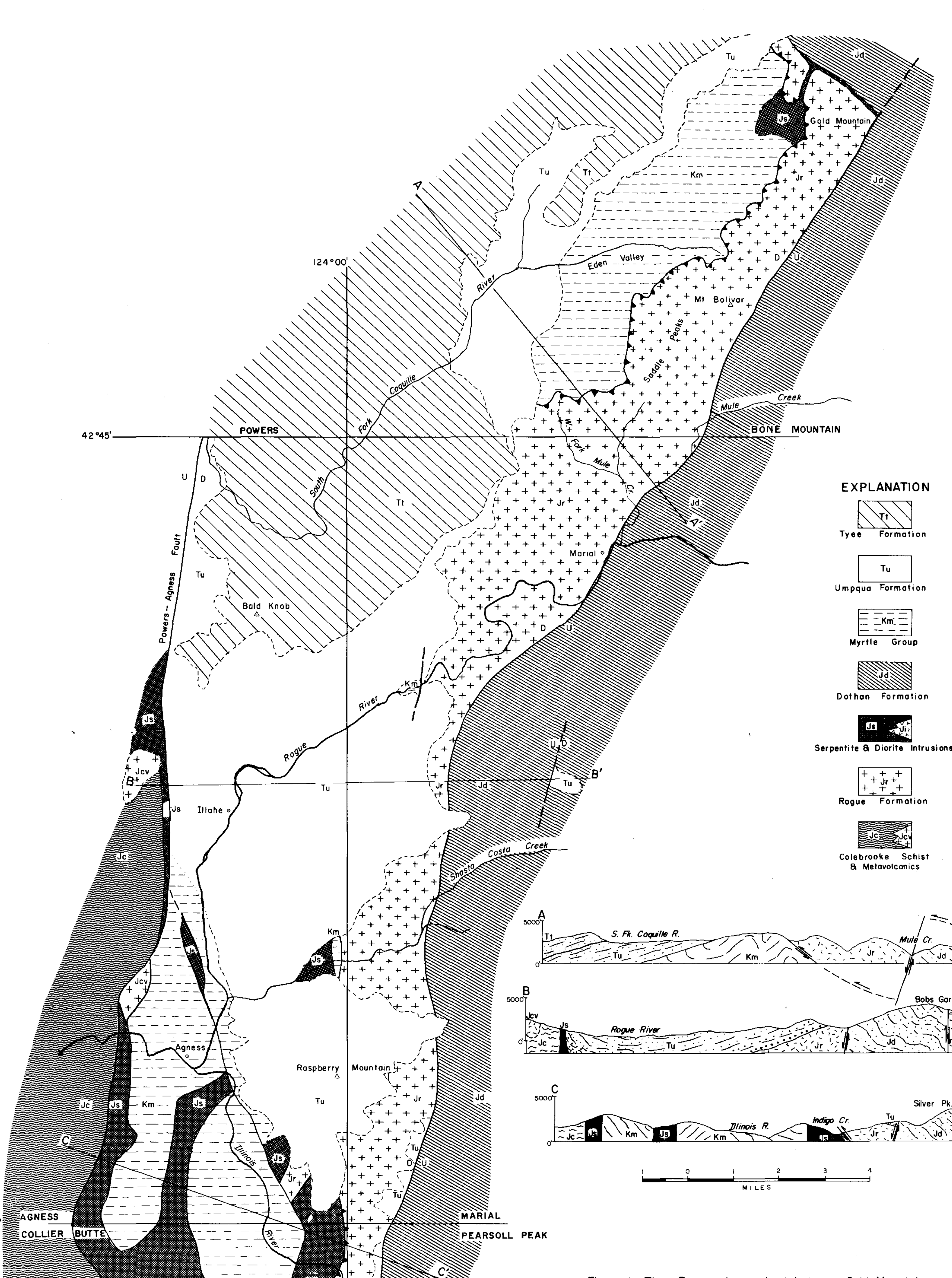

Figure 1. The Rogue thrust sheet between Gold Mountain and the lower Illinois River

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MINED LAND RECLAMATION ACT COPIES AVAILABLE

The Department has prepared copies of HB 3013, popularly referred to as the "Mined Land Reclamation Act," which goes into effect July 1, 1972. The Act is of interest to all operations which extract more than 10,000 cubic yards of minerals or disturb more than two acres per year. The Act requires operators to secure an operating permit, a performance bond and provide an excavation plan and a reclamation plan. Rules and regulations are currently being prepared. The Department of Geology and Mineral Industries will administer the Act. Operators may obtain copies of the Act at the Department's offices in Portland, Grants Pass, and Baker.

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DEPARTMENT REVISES FEE SCHEDULE FOR ASSAY AND SPECTROGRAPHIC ANALYSIS

Chemical Analysis

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Copper-lead-zinc	7.50	Palladium	12.00
Lead-zinc	5.00	Osmium	12.00
Alumina	10.00	Iridium	12.00
Antimony	6.00	Rhodium	12.00
Barium	5.00	Ruthenium	12.00
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* * * * *

SHELDON APPOINTED U.S.G.S. CHIEF GEOLOGIST

Dr. Richard P. Sheldon has been named Chief Geologist of the U.S. Geological Survey to succeed Dr. V. E. McKelvey, who was appointed Survey Director in December 1971 (see December 1971 ORE BIN). Dr. Sheldon has been with the U.S.G.S. since 1947, most recently holding the position of Assistant Chief Geologist for Mineral Resources.

* * * * *

GEOTHERMAL GRADIENT STUDIES IN OREGON

Richard G. Bowen*

Heat flows from the interior of the earth at an average rate of 1.5 microcalories per square centimeter per second. This is equivalent to about 150 Btu's per square mile per second; over the whole earth over a year's time this heat energy is equivalent to that contained in 170 billion barrels of oil. In most of the world this heat is too diffuse to be used, but in some regions, such as the circum-Pacific volcanic belt, heat flow is several times normal. Under some geologic conditions this heat energy is transferred to circulating underground waters, forming a geothermal reservoir. In that way the earth's heat is trapped and stored and can be tapped by drilling, making the heat available for use as either hot water or steam, depending upon the characteristics of the particular reservoir.

Surface manifestations, such as hot springs and geysers, indicate the presence of geothermal reservoirs, but in some regions where these hot waters do not come to the surface they can be detected by the measurement of geothermal gradients or heat flow.

The geothermal gradient is the rate of temperature increase with depth. Normally this is about 1 degree Celcius per 100 feet or more, frequently written as 30°C/Km. In geothermal areas the gradient is often several times the "normal;" for example, at The Geysers geothermal field in California steam at temperatures of about 240°C is reached at 3000 to 4000 feet. This is a geothermal gradient of 200 to 250°C/Km or six times the world "normal."

Geothermal gradients are relatively simple to measure as they are merely a plot temperature and depth, but certain factors must be taken into consideration in order that the geothermal gradient figure be meaningful. For example, the annual change in near-surface temperatures due to variations in solar heating makes it necessary to take the temperature measurements at a depth not influenced by solar heat, generally at least 150 feet. Temperature gradients measured in open holes or in areas of permeable rocks can be affected by upward or downward movement of ground water. If these factors are taken into consideration, geothermal gradients can be a useful tool for outlining prospective geothermal areas.

For thermal gradient measurements to be most useful, however, the thermal conductivity of the rocks should also be determined, as they vary widely in their ability to conduct heat. A rock that is a good insulator, such as loosely compacted tuff, will, for the same amount of heat flow, show a high geothermal gradient; a rock with poor insulating ability, like

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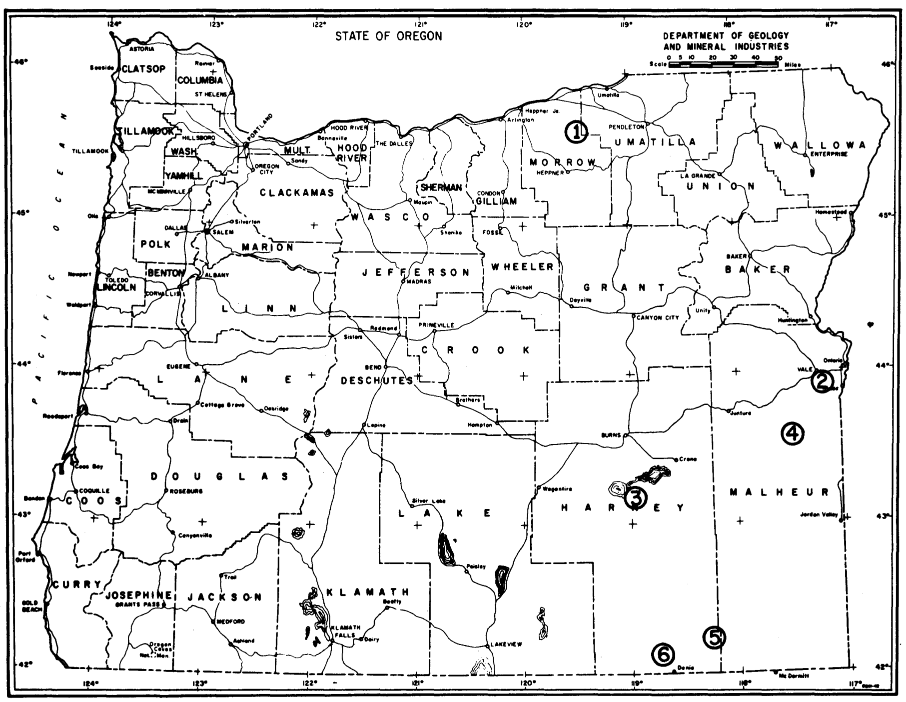
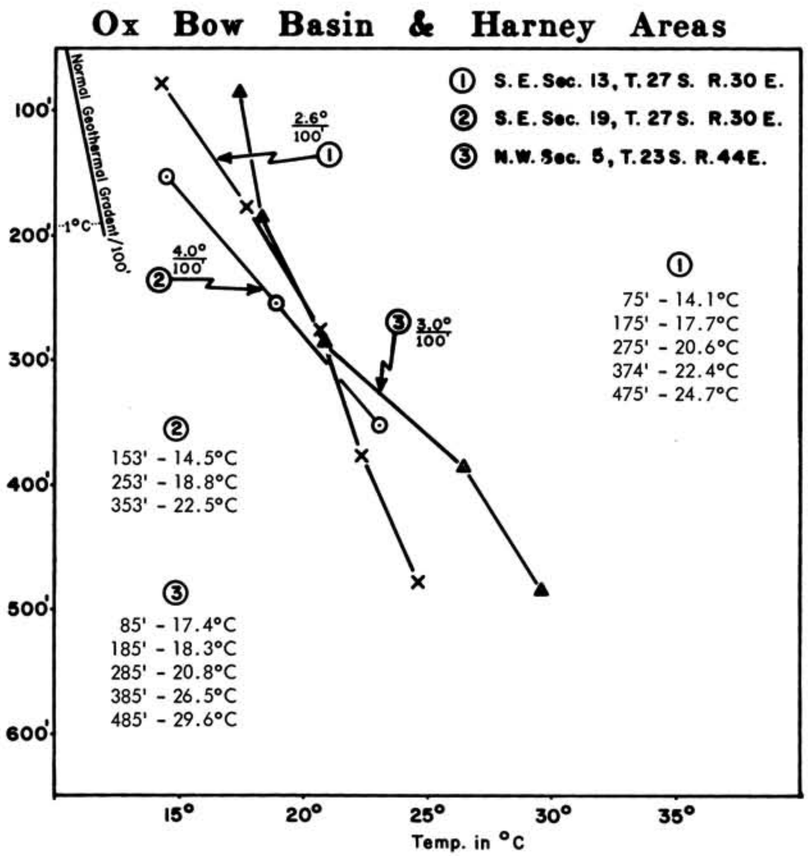
a granite, will show a low geothermal gradient. By combining thermal gradient measurements and thermal conductivity data, a heat-flow determination can be made that will give a more accurate picture of subsurface conditions than would temperature gradient alone.

Heat-flow measurements are very sparse and as yet there are none in Oregon because of the complexity of the conductivity measurements and because of a former lack of economic incentive to make them. The Department of Geology and Mineral Industries has been taking geothermal gradient measurements over the last few years whenever drill holes, made for other purposes, have become available (see map for locations). Although geothermal gradients do not present as accurate a picture as do heat-flow measurements, with some knowledge of the underlying rocks a reasonable estimate of conductivity, and therefore heat flow, can be made.

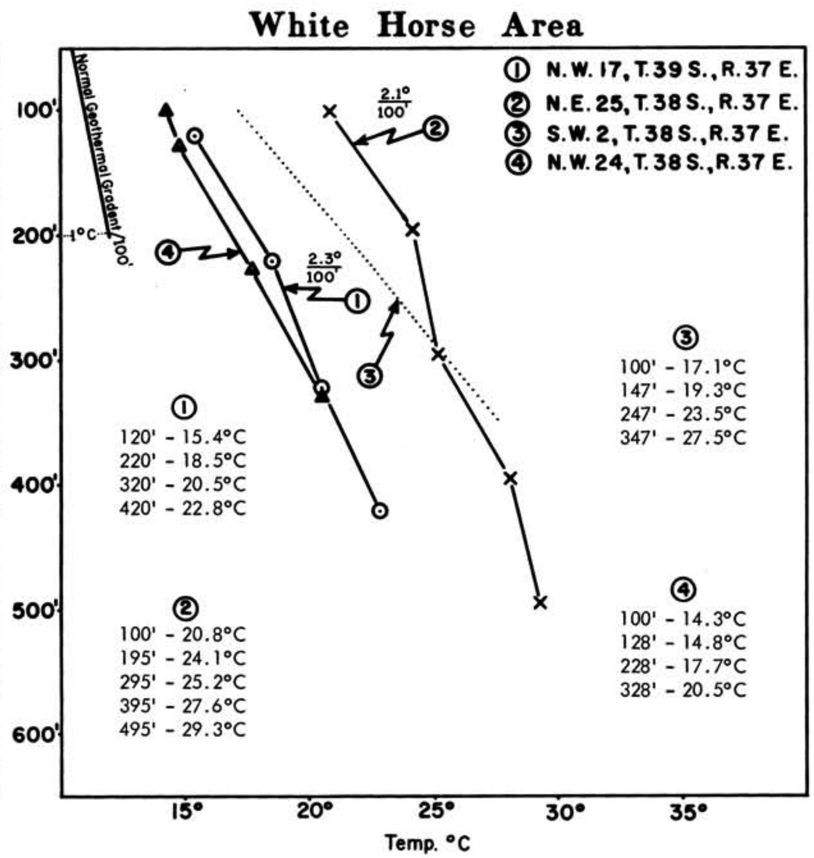
The accompanying graphs show geothermal gradients taken at scattered points in eastern Oregon. They are presented as a progress report. Others will be published from time to time as more data become available.



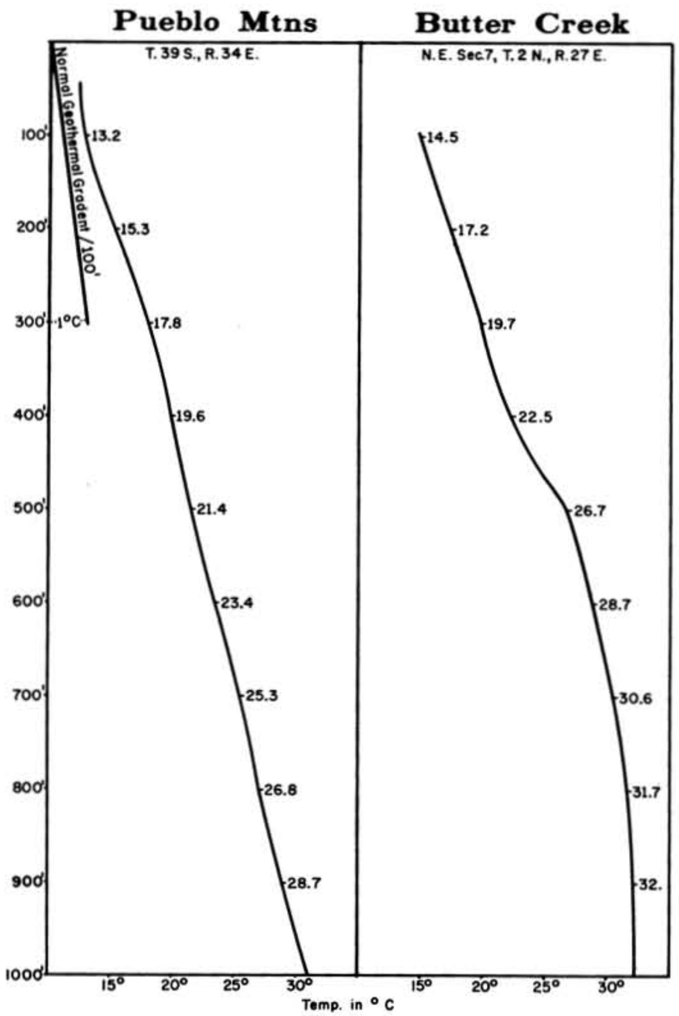
1. Butter Creek
2. Chalk Butte - Cow Hollow
3. Harney
4. Ox Bow Basin
5. White Horse
6. Pueblo Mountains



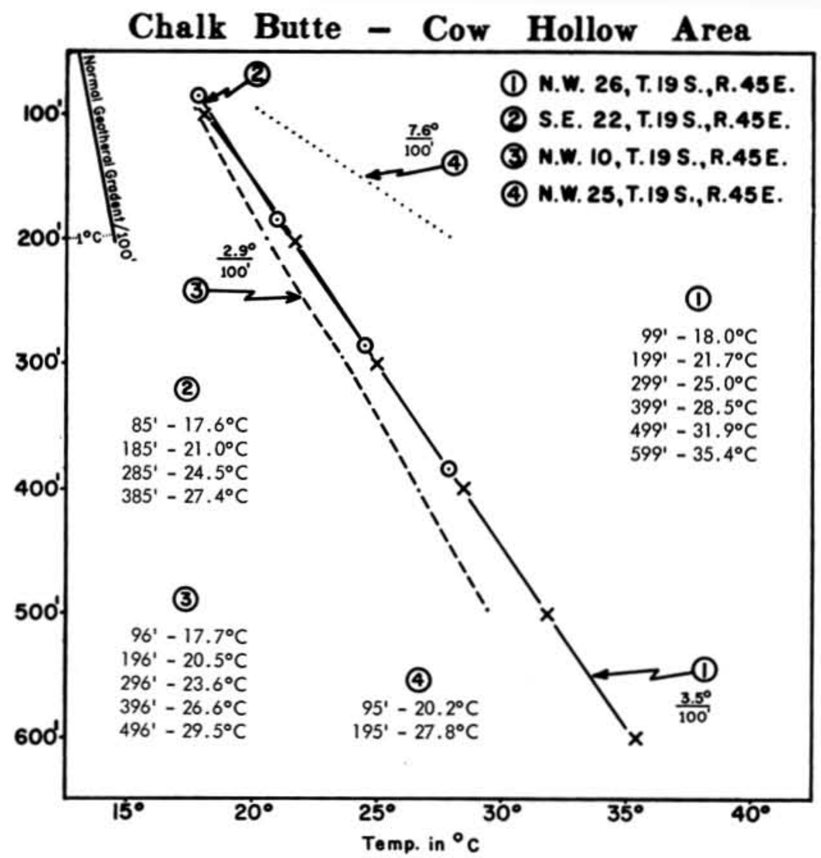
Ox Bow Basin & Harney Areas
① S. E. Sec. 13, T. 27 S. R. 30 E.
② S. E. Sec. 19, T. 27 S. R. 30 E.
③ N. W. Sec. 5, T. 23 S. R. 44 E.
Normal Geothermal Gradient/100'
1°C
2.6° / 100'
4.0° / 100'
3.0° / 100'
①
75' - 14.1°C
175' - 17.7°C
275' - 20.6°C
374' - 22.4°C
475' - 24.7°C
②
153' - 14.5°C
253' - 18.8°C
353' - 22.5°C
③
85' - 17.4°C
185' - 18.3°C
285' - 20.8°C
385' - 26.5°C
485' - 29.6°C
100'
200'
300'
400'
500'
600'
15°
20°
25°
30°
35°
Temp. in °C



White Horse Area
① N. W. 17, T. 39 S., R. 37 E.
② N. E. 25, T. 38 S., R. 37 E.
③ S. W. 2, T. 38 S., R. 37 E.
④ N. W. 24, T. 38 S., R. 37 E.
Normal Geothermal Gradient/100'
1°C
2.1° / 100'
2.3° / 100'
①
120' - 15.4°C
220' - 18.5°C
320' - 20.5°C
420' - 22.8°C
②
100' - 20.8°C
195' - 24.1°C
295' - 25.2°C
395' - 27.6°C
495' - 29.3°C
③
100' - 17.1°C
147' - 19.3°C
247' - 23.5°C
347' - 27.5°C
④
100' - 14.3°C
128' - 14.8°C
228' - 17.7°C
328' - 20.5°C
100'
200'
300'
400'
500'
600'
15°
20°
25°
30°
35°
Temp. °C



Pueblo Mtns
T. 39 S., R. 34 E.
Butter Creek
N.E. Sec.7, T. 2 N., R. 27 E.
Normal Geothermal Gradient /100'
1°C
100'
200'
300'
400'
500'
600'
700'
800'
900'
1000'
13.2
15.3
17.8
19.6
21.4
23.4
25.3
26.8
28.7
14.5
17.2
19.7
22.5
26.7
28.7
30.6
31.7
32.
15°
20°
25°
30°
Temp. in °C



Chalk Butte - Cow Hollow Area
① N.W. 26, T. 19 S., R. 45 E.
② S.E. 22, T. 19 S., R. 45 E.
③ N.W. 10, T. 19 S., R. 45 E.
④ N.W. 25, T. 19 S., R. 45 E.
Normal Geothermal Gradient /100'
1°C
7.6° / 100'
2.9° / 100'
3.5° / 100'
①
99' - 18.0°C
199' - 21.7°C
299' - 25.0°C
399' - 28.5°C
499' - 31.9°C
599' - 35.4°C
②
85' - 17.6°C
185' - 21.0°C
285' - 24.5°C
385' - 27.4°C
③
96' - 17.7°C
196' - 20.5°C
296' - 23.6°C
396' - 26.6°C
496' - 29.5°C
④
95' - 20.2°C
195' - 27.8°C
100'
200'
300'
400'
500'
600'
15°
20°
25°
30°
35°
40°
Temp. in °C

TRANS-ALASKA PIPELINE IMPACT STATEMENT RELEASED

The Department of Interior has released its Final Environmental Impact Statement on the application for right-of-way to construct the oil pipeline from Prudhoe Bay near the Arctic Ocean to the ice-free Pacific port of Valdez. The report is contained in 6 volumes, plus a 3-volume analysis of the economic and security aspects of the proposal, and is the result of three years of study by the Department. Advice and guidance came from a number of other Federal departments, as well as the State of Alaska. Three task forces were set up to study and compile the material concerned with the environmental impact along the proposed land route, the proposed marine tanker route from Valdez to West Coast ports, and possible alternative pipeline routes through Canada.

Copies of the nine volumes may be purchased from the National Technical Information Service, Springfield, Virginia, or are available for inspection at a number of offices, including the following in the Pacific Northwest: Bureau of Land Management, 710 N.E. Holladay St., Portland; Interior Department Field Representative, Pacific Northwest Region, 1002 N.E. Holladay St., Portland; and Bureau of Outdoor Recreation Regional Director, 1000 Second Avenue, Seattle.

* * * * *

GROUND-WATER RESOURCES IN UPPER JOHN DAY RIVER STUDIED

"Potential ground-water resources of the upper John Day River valley, Grant County, Oregon," by T. P. Thayer, has been released by the U.S. Geological Survey as an unpublished Open File Report. The 8-page preliminary study is concerned with the availability of ground-water for irrigating bench lands in the Prairie City basin area. Included in the report are a geologic map and cross sections. A copy of the report may be consulted at the Department's office in Portland.

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