better. Here is located the greatest orchard acreage at the present, although several fine old orchards are still to be found in the low lands. Eternal vigilance against spring frost is the price paid for these orchards, however.

An additional characteristic of the precipitation of this complex climatic region, and one which has played an important part in shaping its economic history, is its variability in amount, monthly and annually. There is a noticeable difference in total precipitation from year to year. In 1907 the heaviest rainfall in the history of the Ashland station occurred, with a total of 28.87 inches. Two years previously the lowest amount was recorded, when but 11.99 inches fell for the entire year. Months likewise show this variability. In January of 1881 a total of 12.29 inches fell, more in one month than in the entire dry year previously mentioned. August, ordinarily a rainless month, may suddenly find itself with 2.71 inches. November may have a trace or it may have 8.10 inches. Such fluctuations mean that the rainfall is not dependable for ordinary types of agriculture. Under natural conditions the Rogue River Valley would be an area of agricultural risk. With this variability of rainfall, together with a low average total and bad seasonal distribution, it is easy to see why the agricultural specialization of the valley has awaited the development of irrigation.

Thus far little has been said about the landscape and the part climate has played in its appearance. Broadly speaking there are three types of native vegetation associations within the area. The Coast Range section is composed of the typical vegetation and forest types of the humid Pacific mountains, including spruce, cedar, and Douglas fir. The Cascade section includes yellow pine, and hemlock in response to the lesser rainfall to the east. The valley proper supports a typically sclerophyllous vegetation in response to the light winter rains and hot dry summers. On northerly slopes where the winter snows remain longer into the summer, and where the rate of evaporation is not so great, coniferous stands mixed with a number of broadleaved species such as oak, ash, maple, aspen, and cottonwood, give rise to definite forest slopes. Southerly exposures may be nearly bare, except for needle grass and fox tail, which mature early and then are yellow and parched the balance of the summer, together with open stands of oak, mistletoe laden, and occasional thickets of madrona, manzanita, or buck brush. These open hardwood patches give rise to a park landscape whose grasses provide excellent forage most of the year under a setting of evergreen oaks and madrona that can scarcely be excelled for landscape charm, strikingly reminiscent of the Mediterranean.

Another feature of the valley which has shaped the landscape and to a large extent the economic adjustments, and which is traceable quite directly to climatic influences, is the soil.

Generally speaking the soils of the Rogue River Valley are prevailingly low in nitrogen content, due to a deficiency of organic matter brought about as a natural floral response to the semi-arid conditions of most parts of the valley. Likewise there is a slight tendency toward alkalinity in some sections, and everywhere there is high percentage of natural lime, more for example, than one finds in the original parent rock. This characteristic is to be expected as the lowland soils of the valley belong to that great subdivision of lime-accumulating soils typical of the arid and semi-arid regions of the west. This means that the soils have not been leached of soluble plant minerals, in fact minerals from the subsoil have been brought to the surface to some extent through capillary action. Such soils are likely to be excessively productive if the natural water deficiency can be overcome, as has been amply accomplished here by irrigation.

Climatic influences over a long period of time have also made possible a reclassification of soils here for purposes of regional anaylsis. The Soil Survey map for Jackson County shows 45 different kinds. Reclassification on a maturital basis, in which climatic influences supercede geologic, reduces the number of generalized soil types to four, with a high degree of correlation in crop distribution. (1) The undifferentiated mountain soils are mostly wasteland, timberlands, or forage lands. (2) The residual-colluvial foothill soils are youthful and still bear a resemblance to the parent rock. These are the dominant orchard lands, with rich soils, good air drainage, and a maximum of sunny slope, ideal conditions for forcing an extensive pear crop. (3) The arid and semi-arid desert soils of the valley floor are post mature in age, representing an older floor of the valley. These soils, known generally as the Agate Desert, represent waste land, abandoned orchard plots, and even abandoned grazing lands in the heart of a valley pressed for agricultural soils and with irrigation canals crossing at intervals. The adverse feature is a lime-bound "B" horizon that forms a hard-pan inimical to drainage, a feature quite directly due to the interplay of an arid climate on a flat soil type, covering a long period of time. (4) The recent flood-plain alluvial soils are found along the rivers and streams. They represent both an overflow hazard and a frost hazard, with the result that they have recently been given over largely to truck crops, forage crops, small fruits and berries.

These observations are somewhat sketchy, but they do indicate some of the features of the natural landscape and the regional economic development pattern of this particular valley, that are largely traceable to the influence of the elements of weather and climate.

The Bearing of the Post-Paleozoic Sedimentary Record on the Occurrence of Gas in the Rattlesnake Field, Washington[1]

By HAROLD E. CULVER and RALPH L. LUPHER
State College of Washington

In an attempt to locate a large supply of water under artesian pressure for irrigation purposes in the Cold Spring area in 1912 a well was put down into the Columbia basalt series and began to produce natural gas. Since then the flow of gas has been continuous and for the past few years a commercial operation has been serving several towns in the Yakima Valley from gas delivered by some fifteen wells. So long continued a flow of even the modest proportions obtaining here has naturally awakened considerable interest in the source of the gas and the present paper is an attempt to evaluate some of the data which bear on the question.

Gas is taken at approximately the same stratigraphic zone in all wells that have been drilled, although a secondary source has been found in a few wells and gas taken from both. The main zone lies about 700 feet below the surface, the second some four or five hundred feet lower. Both are in porous basalt unassociated with sediments.

Since the gas could not conceivably have originated in the basalt, but must have migrated there from its source, and since further, it seems unlikely that it has migrated downward from the thin sedimentary zone some two hundred feet above the gas producing basalt, the question of what kinds of rock lie concealed beneath the extensive Columbia River

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alts is important in considering the
rce of the gas in the Rattlesnake Hills.
ne of the implications of several possi-
ties are here presented.

The predominance of metamorphic rocks
l associated plutonic rocks along the
thern and eastern margins of Columbia
sin does not prove that these rocks im-
diately underlie the basalts in the cen-
l part of the Basin. In the marginal re-
n the pre-basalt surface today shows
ief of at least two thousand feet. West-
rd and southward the basalt increases
thickness and there is no evidence to
licate the amount of relief of the pre-
salt surface. At Union Gap, near Yak-
a, the test well of the Miocene Petrole-
Company shows the presence of some
00 feet of basalt below river level,
ile the adjacent Rattlesnake Hills up-
t shows an additional thickness of more
an 1,500 feet, giving a total thickness
this region of at least 5,000 feet for
basalt flows.

South and west of this central portion
the Basin the marginal rocks are no-
ly different in character from those on
north and east. Here are both Meso-
c and Tertiary marine beds as well as
ntinental beds whose extensions be-
ath the basalt are at least as plausible
those of the rocks from the north and
st.

Thick sections of marine Mesozoic sedi-
ntary beds are exposed in Central Ore-
n to within 75 miles of Columbia River.
ey have been penetrated by the drill
ar Fossil, Oregon, thus proving their ex-
nsion about twenty-five miles north-
rd. There seems to be nothing to sug-
st that they may not have originally
tended still farther north, and that
ey may not now be concealed beneath
thick basalt flows. In addition, it
ould be noted that the supposedly Cre-
eous beds near Fossil have been shown
contain some natural gas. The postulat-
extension to the Pasco area would cer-
tainly provide an adequate source for the gas known to be there.

The distribution of Mesozoic marine sedimentary rocks in the Pacific Northwest reveals some pertinent paleogeographic facts. Upper Triassic marine rocks are extensively exposed in the Wallowa Mountains of northeast Oregon and in central Oregon. It would be a remarkable coincidence if the northern shore line of this marine embayment lay along the present political boundary of Washington.

The central Oregon region was invaded by the sea at least four times during the Jurassic period. Similar and in part contemporaneous invasions are recorded north of the Canadian border, some extending as far east as western Alberta. The Lower Jurassic deposits are known in central Oregon and along the coast of British Columbia, but the faunas are not sufficiently known to establish contemporaneity of sea invasions. During the early Middle Jurassic a sea spread over central Oregon as far east as the Silvies River and at the same time marine waters invaded southern British Columbia and extended eastward to Alberta.[2] Again in the earliest Upper Jurassic came a similar invasion. Faunas of Proplanulitan age have been reported at several places across southern British Columbia and in southwestern Alberta.[3] On the opposite side of the State of Washington Proplanulitan faunas are known in the extensive Mesozoic section of central Oregon and in the Seven Devils region of Idaho.

It would be a strange coincidence if each of these invasions enclosed the State of Washington three sides without advancing upon its borders.

Cretaceous marine beds are known in the Pasayten area of the Cascades and are widely distributed in north central Oregon. Hence it is reasonable to assume that the embayments in which these rocks were deposited may have been connected across the Columbia Basin rather than completely around it.

West of the Cascade Mountains are extensive early Tertiary marine sediments. While these seem to be marginal to continental beds of the same age along the Cascade front their eastward extension in the depressed Columbia Valley area has not been determined. Whether or not there was a marine embayment in the Pasco region during Mesozoic time there seems to be no reason for thinking there may not have been such an embayment during early Tertiary time. Here again, because of the known gas in some of the Tertiary sediments west of the mountains, an extension into the Pasco region might provide adequate source beds for the gas of the Rattlesnake Hills.

This compilation of paleographic data indicates that unique conditions prevailed if post-Paleozoic seas have not entered the central Columbia Basin region.

In the consideration of possible source beds for the gas of the Rattlesnake Hills field it is of course not necessary to confine ourselves to marine beds since gas may presumably be developed in beds of continental origin as well. Northwest of the central Columbia Basin region lies the Roslyn coal field with a thick section of coal-bearing continental sedimentary rocks which are exposed rather widely in Kittitas County and adjacent parts of Chelan and Yakima Counties. The eastern limit of the exposures from the vicinity of Wenatchee southward is fixed by the overlying basalts of the Columbia series. That the basalt covers a considerable thickness of the continental beds is obvious, but it is by no means clear how far east of the present margin of the exposures the beds were originally deposited. In the drilling test made by the Norco Company on Wenatchee Heights, the sandstones of this series are proved to be more than two thousand feet thick, and it is inconceivable that so great an accumulation would have no corresponding eastward extension. In the direction of Rattlesnake Hills an extension of 60 miles from the known outcrops of the sediments would bring them well beneath the uplifted basalts now furnishing the gas of this interesting field. While there is no positive evidence to support such an hypothesis, it is reasonable to entertain the idea that such an extension actually exists. Not only do these coal-bearing beds provide abundant gas but the reported oil seeps in the Wenatchee area are in this Eocene series and hence these strata furnish an additional possible source for the gas of the Rattlesnake field.

One other possibility remains to be considered. This is the presence of interbasalt beds of such character and thickness as to provide both the source and the reservoir rocks for the field. Such beds are a commonplace in the Columbia Basin. The original Ellensburg zone is probably the best known, but others, of even greater thickness are described from all parts of the basin. In fact it is a rare section of the basalts which does not show some trace of sediments which were deposited during intervals between the emission of flows. For the purpose at hand, however, it is better to confine ourselves to the sedimentary zones of large dimensions. Such beds are well known at the head of Grand Coulee, in the Latah area of Spokane County, and farther to the southeast in the Payette region of western Idaho. In the last-named area, particularly, is the occurrence of interest. Here thickness of several thousand feet is reliably reported by drillers over a rather wide area. Of even more importance than their dimensions is their gas content. In several instances the penetration of the gas zone in these beds resulted in the wrecking of drilling rigs. While no commercial gas wells have been developed as yet, the certain occurrence of great quantities of gas under considerable pressure is of especial importance in connection with this study.

It remains to consider what correlation, if any, can be established between the

hick beds of the Payette region and the ossible source beds of the Rattlesnake as. Present drilling operations in the asalt of the Rattlesnake field have penerated some fifteen hundred feet beneath he surface in this area. This is well elow the position of other interbasalt edimentary sections so far recorded in he Columbia Basin or adjoining areas. If t be assumed that all of these interbasalt ediments were deposited at the same time, r even approximately the same time, it would appear unlikely that any such strata would be found below the zone already enetrated in the Rattlesnake drilling. There is, however, no reason to suspect uch contemporaneity in sedimentation ver the whole area, and it is plausible to expect interbasalt beds at any stratigraphic position within the whole section. From another point of view, it is also easonable to consider that a Rattlesnake Hills correlative of the thick Payette sediments lies beneath much greater thickness of basalt than appears in the Idaho section. This point involves consideration of the date of the subsidence of the central part of Columbia Basin, a phase of the subject far out of the scope of this paper. From the foregoing compilation, it is clear that consideration of interbasalt beds as a source of the Rattlesnake field gas is well justified.

The gas of the Rattlesnake field is a fact. The presence of some small amount of oil seems well substantiated also. Hence an attempt to evaluate some of the known features of post-Paleozoic stratigraphy seems desirable so as to provide a starting point for future work. It is not in accord with the purpose of the authors to suggest which of the several possibilities seems, on present data, the most probable. On the contrary, it has been consistently pointed out that there are few data which point directly to any conclusion.

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[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

[2] McLearn, F. H., Some Canadian Jurassic faunas: Roy. Soc. Canada, Trans., 3rd. ser., Vol. 21, pp. 61-73, 1927.

[3] McLearn, F. H., Idem.
Buckman, S. S., Jurassic Ammonoidea. Mesozoic paleontology of Blairmore Region, Alberta: Nat. Mus. Canada, Bull. 58, pp. ...., 1929.

Abstracts of Papers Read Before Geological Section N. W. S. A. December 29-30, 1937[1]

[1] Abstracts of papers presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

DISCOVERY OF FOSSIL FISH IN THE LATAH FORMATION

By VERNON E. SCHEID
University of Idaho

The discovery of fish in the Latah formation is announced. Parts of 12 skeletons have been found at a road cut outcrop on the north bank of the Clearwater River, 11½ miles east of Lewiston, Idaho. The skeletons have not yet been determined accurately but are considered to belong to the genus Leuciscus. They indicate that the fish were from 4 to 12 inches long. Scales were also found. Associated with the fish are fossil leaves of cypress, sequoia, sweet gum, sycamore, and red bud trees.

COMPILATION OF MAPS FROM AERIAL PHOTOGRAPHS BY A RADIAL LINE RESECTION METHOD

By JOHN B. MILLER
University of Idaho

A method is given for the construction of maps from aerial photographs by a radial line resection method as outlined by G. S. Druhot.[2] A straight line which represents approximately the course of the airplane is extended across a series of pictures. This is used to orient pictures as an assembly tracing is made. Working centers of the picture are established successively on the tracing by a method analogous to plane table resection. Points are intersected to bring detail into position. Information available from pictures is valuable in all mapping work, but is particularly valuable in mapping inaccessible mountainous areas and thickly forested regions.

CURIOUS SURFACE MARKINGS ON BASALT NEAR McCALL, WASHINGTON

By OTIS W. FREEMAN
College of Education, Cheney, Washington

One of the numerous scabland channels that was carved by glacial flood waters in the surface of the Columbia Plateau extends southwestward from Lamont and is followed by the S. P. & S. Railway. Near the railway siding called Macall in eastern Adams County, about 15 miles south of Lamont, are some curious surface markings on basaltic flows exposed in the scabland channel. Apparently these flows were among the last that covered the Columbia Plateau in Washington. Some of the rock surfaces show pahoehoe structures, a characteristic of the younger flows.

On the face and top of a five to ten foot cliff are some curious cracks. These are arranged in fairly good geometric designs, usually polygons. In some of the four to eight sided polygons are two or three similar smaller designs whose sides were parallel to those of the enclosing polygon with lichens partially filling the cracks. The discoverers believed that these designs had been carved by human beings. At first glance the designs do resemble somewhat deep scratches and gougings made by man. However, no rock fragments have been found that might have been left from the work, nor any worn stone tools. Furthermore, the designs are not like Indian rock carvings, as there are no pictures of animals nor of human beings and their activities. The designs generally occur on the smooth surface of lava ellipsoids. It appears to the author that as the uneven surface of the lava quickly cooled the crust became too small for the inside of the mass and so cracked superficially to the depth of ½ inch to one inch. Although weathering has enlarged the cracks and brought the markings out more prominently into relief, the appearance of the rock surface suggests that the cracks dated from the first cooling of the lava. The process would seem to resemble somewhat cracking of the surface of a loaf of French bread. Incidentally, the inside of the lava, as in the bread, is filled with holes from gas bubbles.

A few miles away from this outcrop are three or four dikes of basalt etched out into relief by erosion. The dikes are of basalt that has cooled into columns that lie perpendicular to the walls and which present an appearance somewhat like a pile of wood. Many stone walls were built by early cattlemen in this region for corral purposes. These dikes were thought to be artificial by local residents, but are clearly intrusive. It is impossible to state whether the recent lava flows containing the curious markings emerged from one or more of these dikes or not.

STATE LINE EARTHQUAKE

By BENJ. H. BROWN
Walla Walla, Washington

On July 15, 1936, at 11:05 P. M., an earthquake shock was felt in the region around Milton, Oregon, and Walla Walla, Washington. Many chimneys were broken, several houses moved an inch or two, loose objects and shelf wares were scattered about with some damage. Hundreds of concrete and plastered walls were crecked. One two-story concrete house was restored by making it over into a one-story house. The warden's brick house at the peniten-