THE GEOLOGY OF THE BUTTE FALLS QUADRANGLE, OREGON

by

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THE GEOLOGY OF THE BUTTE FALLS QUADRANGLE, OREGON

FIELD WORK AND ACKNOWLEDGMENTS

The field work upon which this report is based was done during the months of June, July, and August of 1940. It was undertaken as a cooperative project of the State Department of Geology and Mineral Industries and the Oregon State College Department of Geology. Preliminary field work was carried on during the first month by members of the Geology Summer Camp, and the more detailed work during the latter two months, by a field party for the State Department of Geology and Mineral Industries. Members of the latter group were Dr. W. D. Wilkinson, John Eliot Allen, Wayne Lowell, Wallace Lowry, Herbert Harper, Richard Meade, Robert Littleton, Stewart Jones, and the author.

To all those who have aided in the preparation of this paper, the author wishes to express his gratitude.

Sincere thanks are extended to Dr. W. D. Wilkinson, who directed the author in his field work and generously submitted advice and criticism for the writing of the paper, and to all the members of the field parties who aided in the mapping of the area.

The author wishes also to thank Dr. I. S. Allison for information and advice regarding certain details of the geology of the area, and Miss Jean Bowman for her generous assistance in the study of the flora.

PREVIOUS WORK

Little information is available on the geology of the area under consideration. The few published records to date are by Wells and Waters (1), Callaghan (2), Callaghan and Buddington (3), and Wilkinson (4), and these concern chiefly the economic mineral deposits of the region.

1. Wells, F. G., and Waters, A. C.; Quicksilver Deposits of Southwestern Oregon, U. S. Geol. Survey Bull. 850, 1934.
2. Callaghan, Eugene; Some Salient Features of the Volcanic Sequence of the Cascade Range in Oregon, Amer. Geophysical Union, Trans. 14th Annual Meeting, pp. 243-247, June, 1933.
3. Callaghan, Eugene, and Buddington, A. F.; Metalliferous Deposits of the Cascade Range, Oregon, Geol. Survey Bull. 893, 1938.
4. Wilkinson, W. D.; Advance Report on Some Quicksilver Prospects of the Butte Falls Quadrangle, Oregon: G.M.I. Short Paper, State Dept. Geol. & Mineral Industries, No. 3, 1940.

GEOGRAPHY

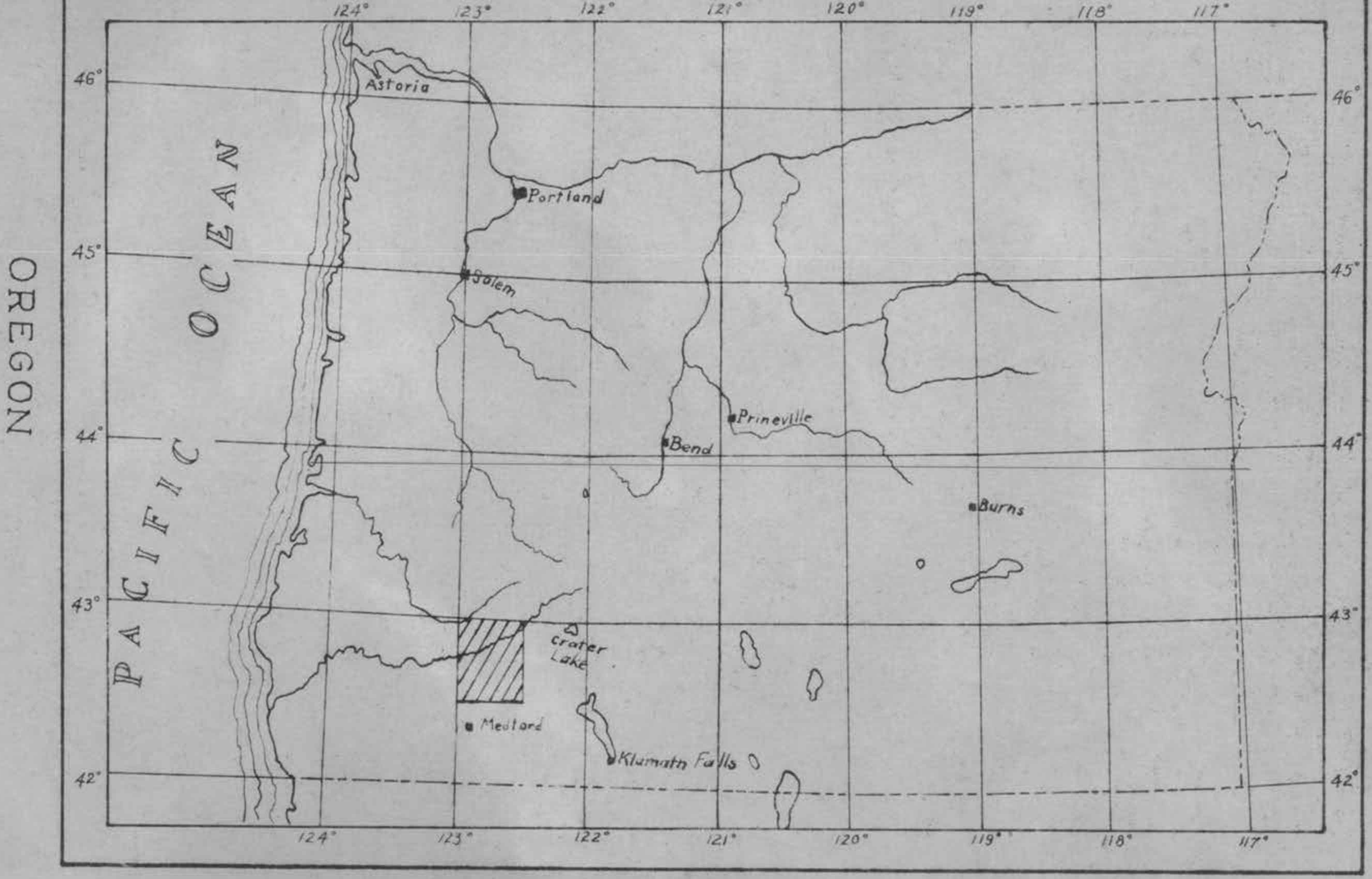
Location and accessibility

The Butte Falls quadrangle, located in southwestern Oregon between 42°30' and 43° north latitude, and 122°30' and 123° west longitude, includes portions of both Douglas and Jackson counties. This quadrangle covers approximately 900 square miles and is named from the small town of Butte Falls in its southeastern corner.

The Crater Lake Highway (State Highway #62) follows the Rogue River valley northeast across the area, and a hard surfaced road extends from Gold Hill eastward to it. These roads make the region easily accessible from the south, west, and northeast. It can be reached from the northwest by way of the Tiller-Trail Cut-off. Forest Service, State, and county roads extend through most of the more mountainous areas, and well maintained Forest Service trails can be found along most of the ridges and creeks in those regions which are not covered by roads.

Climate and vegetation

The climate is mild in the Rogue and Umpqua valleys, becoming cooler in the higher regions. These valleys and others of comparatively low elevation are highly suitable for residence, but the higher areas are comforable only



Location of the Butte Falls Quadrangle

during the summer months.

According to meteorological records taken at the Tiller Ranger Station during the past three years, January is ordinarily the coldest month and July is the warmest. The mean temperature for January in that period was 41.7°; and for July, 70.8°. The highest temperature recorded was 109°, and the lowest, 18°. Table I shows variations in temperature and rainfall from month to month, from June 1937 to June 1940, with the exceptions of October, November and December in 1937, during which months, no records were taken.

There appear to be two climatic seasons, one warm and dry, the other cool and wet. The mean annual rainfall for the past few years has been approximately 32 inches, of which about 80 per cent fell during the period from November to April. Because Tiller is sheltered on nearly every side by mountains, the total rainfall there is not so great as in portions of the area which are not so well protected.

Light snows fall in the valleys during the winter months, but are soon melted. On the higher points and in the more timbered areas the snow reaches depths of several feet and often the snow lingers until middle summer. The snowline is ordinarily around 2,500 feet during the colder season.

TABLE I

Year	Month	Temperature(F°)			Rainfall	
		Mean	Max.	Min.	Monthly	Annual
1937	June	64.6°	99°	34°	0.20	
	July	68.8	95	37	0.62	
	August	65.9	106	31	0.05	
	September	61.0	103	26	1.40	
1938	January	36.9	50	23	3.34	
	February	34.5	57	18	11.46	
	March	45.0	67	30	6.54	
	April	53.5	82	25	2.82	
	May	56.6	94	31	1.05	
	June	64.0	96	34	0.25	
	July	69.8	106	47	0.09	
	August	66.2	95	39	0.00	
	September	65.0	99	42	1.14	
	October	59.2	82	27	1.05	
	November	47.5	80	19	5.71	
	December	45.0	79	19	3.32	36.77
1939	January	44.5	75	21	2.71	
	February	50.7	80	21	5.62	
	March	47.0	81	27	2.65	
	April	54.5	85	29	0.39	
	May	58.0	96	26	1.45	
	June	65.0	90	33	0.89	
	July	74.5	107	39	0.56	
	August	76.2	109	39	0.46	
	September	64.0	100	32	0.36	
	October	59.1	81	35	3.46	
	November	46.7	81	27	0.05	
	December	42.5	80	19	7.02	25.62
1940	January	43.9	63	21	2.82	
	February	46.0	65	30	8.81	
	March	50.2	80	29	4.62	
	April	53.3	87	33	1.35	
	May	60.6	89	34	0.84	

Mean annual temperature 55.2°
Mean annual rainfall 31.19 inches.

The region is well forested except for valleys in the southern and southwestern parts of the area, and occasional bald buttes and ridges. Most of the trees are evergreens, those of commercial value being Douglas fir (Pseudotsuga taxifolia), red cedar (Thuja plicata), and some sugar pine (Pinus lambertiana). Western yellow pine (Pinus ponderosa), and noble fir (Abies nobilis) are less numerous. Douglas fir is the most abundant, covering the ridges and foothills, interspersed with occasional patches of sugar pine and cedar on the ridges and flats of medium elevation.

Broad-leaved types consist of white and black oak, maple, mountain mahogany, aspen, alder, balsam and chinquipin.

The slopes where timber is scarce are ordinarily overgrown with brush, and even in heavily timbered areas, underbrush is quite thick. The flatter ridges however, are more open and park-like. On the south slope of the Rogue-Umpqua divide and on the hillsides south of Rogue River, the brush consists mostly of manzanita, madrone, and buck brush. On the north slope of the divide are found thickets of vine maple and hazel, and to the east of Butler Butte on the crest of the divide are large patches of huckleberry bushes. These thickets and brush patches make travelling on foot extremely difficult except along Forest Service and game trails.

Population and industries

The area is sparsely populated, with 75 per cent of the occupants residing in the valleys of the southern half. No figures were obtained as to the total population, but there are probably not more than 2,500 residents in the entire region. According to the 1940 census, Butte Falls is the only incorporated town, with 339 persons.

Agriculture is probably the most important occupation, but great numbers of logs are being hauled to the various mills to be made into lumber. The agricultural pursuits consist mainly of cattle raising, fruit growing, and the production of grain and hay crops. Vegetables are grown for home and local consumption.

A large part of the logging and lumbering is done in or near the town ofButte Falls, although the industry seems to have declined there in the past few years. Other localities showing activity in this type of work are the Tiller and Trail districts.

Mining is of less importance, but shows promise of becoming one of the major industries in the near future.

GEOLOGY OF THE GENERAL REGION

The Butte Falls quadrangle is made up of a series of formations including metamorphic, sedimentary, and igneous rocks, ranging in age from early Paleozoic (1) to Recent.

The geology of the general area is similar to that of regions on the western foothills of the Cascades both to the north and to the south, but there are many local variations.

Some of the periods of late Paleozoic, early Mesozoic, and late Mesozoic are not represented by any of the exposed formations. This is due mainly to the shutting off of marine waters by highlands during some of these periods, and too, formations once exposed have been covered by later deposits or were entirely stripped away before the deposition of the later rocks. A combination of these latter posibilities may have been the case. The former presence of some of these absent formations is indicated by foreign boulders and pebbles in some of the sediments and agglomerates.

The formations, beginning with those of Paleozoic age on the western edge, generally rise in elevation and stratigraphic position eastward towards the crest of the Cascades. Their ages, descriptions, and relationships are shown in the table on the following page, and their distribution may be seen in the included areal geologic map of the quadrangle.

1. Diller, J. S., and Kay, G. F.; U. S. Geol. Survey, Geol. Atlas, Riddle Folio, Oregon, No. 218, p. 2, 1924.

STRATIGRAPHIC COLUMN

ERA	PERIOD	FORMATION	DESCRIPTION
CENOZOIC	QUATERNARY	Quaternary Alluvium	Recent alluvium and Pleistocene pumice deposits
		unconformity	
	TERTIARY	Intercanyon Basalts	Late Pliocene (?) gray olivine basalt flows
		unconformity	
		Whaleback Basalts	Gray basalt flows near Abbott Butte
		Olsen Peak Basalts	Gray, Olsen Peak basalt flows
		unconformity (?)	
		Rhyolite Group	Late Miocene (?) rhyolite and dacite flows
		Basalt Group	Dark basalt flows, Eocene to Miocene
		unconformity	
		Agglomerate Group	Late Eocene (?) agglomerates, tuffs, and breccias
		unconformity	
		Umpqua Formation	Middle Eocene sandstones, conglomerates, and shales
		unconformity	
MESOZOIC	UPPER JURASSIC	Quartz Diorites	Quartz diorite, quartz monzonite, and granodiorites
		unconformity	
		Dothan Formation	Slightly metamorphosed slates, conglomerates and shales.
		?	
		Galice Formation	Slates, metamorphosed sandstones, and conglomerates
		unconformity (?)	
		Greenstones	Hydrothermally altered Gabbros
		unconformity	
PALEOZOIC	DEVONIAN	May Creek Formation	Micaceous schists and slates.

TABLE II

DESCRIPTIVE GEOLOGY

Paleozoic Rocks

May Creek Schists

The oldest rocks exposed in the area are micaceous schists and slates of probable Devonian age, which were described by J. S. Diller and G. F. Kay as the May Creek schists (1). These schists are exposed on the western edge of the quadrangle, covering some seventy-five or eighty square miles. They enter the area along the western border of T. 35 S., R. 2 W., and extend northward across the western tier of townships. The easternmost extension is in the South Umpqua valley, about two miles northeast of Tiller.

The schists of this area consist of metamorphosed sediments, differing only locally from those of the type locality in the Riddle quadrangle (2). They vary somewhat as to appearance and composition in different outcrops, but the commonest type is a dark-colored hornblende schist. This variety contains numerous lenses of quartz-

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1. Diller, J. S., and Kay, G. F.: loc. cit.
2. Diller, J. S., and Kay, G. F.: Ibid, p. 2.

ite in the planes of schistosity, as are shown in similar rocks of the Riddle area (1), and appears gneissic due to the alternating white and dark layers.

Associated with the schists, and mapped as part of the same formation, are metamorphosed siliceous rocks which are thought to be meta-rhyolites. They occur along the western side of Evans Creek valley and appear to have been intruded through the former May Creek sediments. Determination of their exact relationship, however, is impracticable due to the destruction of structural evidence by metamorphism.

Microscopically, the various samples differ in both texture and mineral composition. Specimen RM-34, a hornblende schist from Sec. 34, T. 30 S., R. 2 W., shows a granular texture, consisting principally of hornblende, quartz and muscovite.

Quartz and green hornblende are present in approximately equal amounts, together making up about 80 per cent of the slide. The latter is pleochroic with extinction angles of from 14° to 19°, while the former appears in sutured grains showing a slight strain extinction. Muscovite occurs in elongate crystals, oriented parallel to the schistosity. It is slightly pleochroic, and contains a few highly birefringent inclusions of zircon.

1. Diller, J. S., and Kay, G. F., loc. cit.

Secondary quartz crosses the section in tiny veinlets, and hematite stains may be seen under reflected light.

Another specimen from Section 30 of the same township (RM-31) is a highly foliated mica schist. The section is cut at right angles to the schistosity and a photomicrograph (fig. 2) shows the amounts and relations of the mineral constituents. Quartz appears in irregular sutured grains making up 75 per cent of the slide, while pleochroic biotite forms about 20 per cent. The remaining minerals are magnetite and muscovite.

The biotite occurs in long, slightly bent crystals, oriented parallel to the schistosity. It contains pleochroic halos which probably represent zircon inclusions.

Other samples differ in degree of schistosity and show varing percentages of the same mineral constituents, sometimes with the addition of one or more other minerals. The two described, however, are typical of the commonest varieties, and are fairly representative of all the schists of the area.

At no place was the base exposed, but the thickness of the formation is estimated to range from a few hundred to a little over 1000 feet.

The general strike is to the northeast, and the dip ranges from 9° to 70° to the southeast. Local dips to the south and southwest appear, however, where they have been

Fig. 1. Typical quartzite lenses in the May Creek schists.

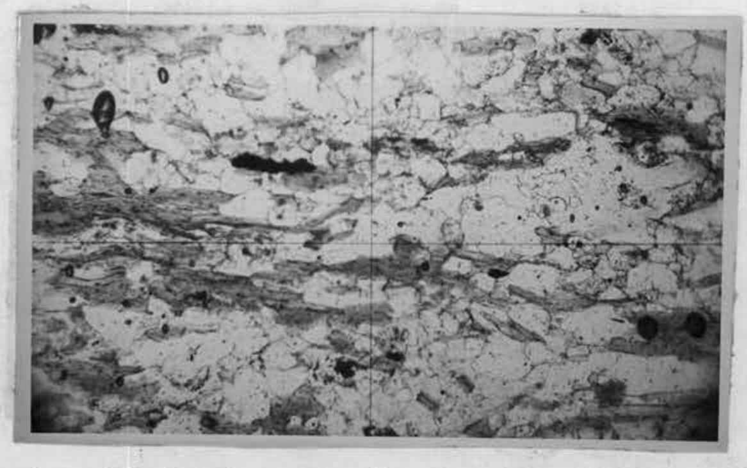

Fig. 2. Photomicrograph of a May Creek schist. Minerals are quartz, biotite, muscovite, and magnetite. Plane polarized light, magnification 32X.

altered by faulting and folding within the formation. Such faults and folds are common, the former being best shown at the War Eagle and Red Cloud mines. An extreme example of drag folding and some faulting occurs in a road cut east of Sprignett Creek, approximately on the western boundary of the quadrangle. These structures are shown in photographs taken at that locality (figs. 3 and 4).

Mesozoic Rocks

The Mesozoic rocks of the Butte Falls area, like those of the Riddle quadrangle (1), are principally Jurassic in age, consisting of metamorphosed sediments and igneous rocks, and some unmetamorphosed acidic intrusives. They are exposed only in the western part of the quadrangle, covering a total area of a little more than 30 square miles.

Galice Formation

The Galice formation, which is thought to be equivalent to the Mariposa formation of California (2), apparently rests unconformably upon the May Creek schists. It

1. Diller, J. S., and Kay, G. F.: U. S. Geol. Survey, Geol. Atlas, Riddle Folio, Oregon, No. 218, p. 3, 1924.
2. Diller, J. S.: Mesozoic Sediments of Southwestern Oregon, Am. Jour. Science, 4th Ser., v. 23, no. 138, pp. 401-421, June, 1907.

Fig. 3. Drag folds in the May Creek schists.

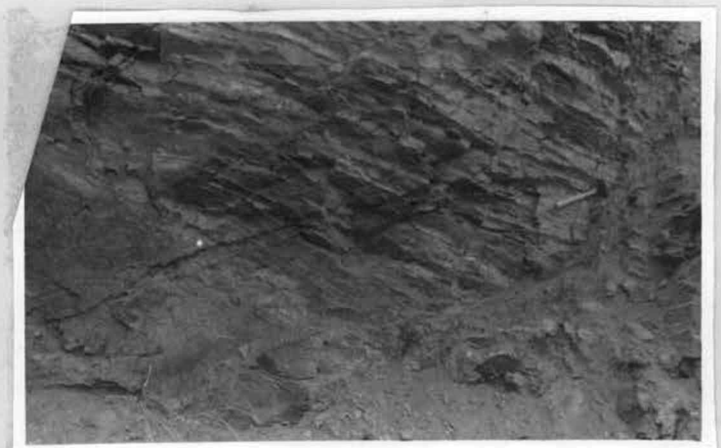

Fig. 4. A small fault associated with the drag folding (in fig. 3) in the May Creek formation.

occurs in the northwestern corner of the area in two strips trending northeast, one across Coffee Creek between Texas Gulch and Granite Creek, and the other across the South Umpqua valley at the mouth of Coffee Creek. These strips average about a mile in width, and are continuations of two such strips in the northeast corner of the Riddle quadrangle (1).

The rocks consist mainly of fine-grained slates, with minor amounts of interbedded sandstone and conglomerate, and occasional veinlets of quartz parallel to the stratification of the beds. The slates show some schistosity with a distinct slaty cleavage ordinarily being present within them, and the indurated sandstones and conglomerates are definitely stratified.

The slates are dark as to color, with contrasting lenses of white quartzite, while the sandstones and conglomerates are from medium to dark-gray. The soil weathered from these rocks varies from a fine, dark to light-colored, sandy material. It does not differ greatly from that overlying the schists, however, and so does not serve as a criteria for locating the contacts between the two formations.

1. Diller, J. S., and Kay, G. F.: U. S. Geol. Survey, Geol. Atlas, Riddle Folio, Oregon, No. 218, geologic map, p. 7, 1924.

The sandstone layers are ordinarily less than a foot in thickness, and the conglomerate varies from 5 to 15 feet, averaging about 10 feet. The formation as a whole is estimated to average approximately 500 feet in thickness.

Almost everywhere the strata have been greatly compressed and tilted, and small folds and crenulations are common, especially in the slates. The prevailing strike is to the northeast and the dip is toward the southeast. Angles of from 20° to 65° were recorded, with an average of about 45°.

The conglomerates contain pebbles ranging in size from one to several inches in diameter and are evidently the source bed for the most of the placer gold coming down Coffee Creek. Assays of as high as $5.00 per ton in gold are reported from them.

Dothan Formation

The rocks thought to belong to the Dothan formation (1) barely make their appearance in the extreme northwestern corner of the region. They occur as a strip of slightly metamorphosed sandstone, shale, and conglomerate, trending northeast across the northern part of the Coffee Creek valley at the mouth of Texas Gulch.

1. Diller, J. S.: Mesozoic Sediments of Southwestern Oregon, Am. Jour. Science, 4th ser., v. 23, No. 138, pp. 401-421, June, 1907.

The rocks here consist chiefly of gray, somewhat lithified sandstone with minor amounts of light-colored shale and conglomerate in which the pebbles are principally of a cherty nature.

There is apparently no sharp contact between the Dothan and the Galice formations in this area, and the structural relationship between the two is not clearly shown. The rocks, however, occur as extensions of the separately-mapped formations in the Riddle quadrangle where the Dothan is thought to overlie the Galice, unconformably (1). For that reason, a similar distinction is made in this quadrangle. In a recent article, Taliaferro (2) states that the ages are reversed and the Dothan is evidently the older of the two formations, but he offers no definite proof of the correlation. Until such proof is furnished, no change will be made in their stratigraphic sequence here.

Greenstones

Along Elk Creek, between Tiller and Drew is an ir-

1. Diller, J. S., ibid, p. 412.
2. Taliaferro, N. L.: Correlation of the Jurassic of Southwestern Oregon and California, Geol. Soc. America, Cordilleran Section, April 18, 1941, p. 23.

regular mass of metamorphosed igneous rocks which correspond to the lower, intrusive phase of the greenstone group in the Riddle quadrangle. In that area, this oldest member of the greenstone group is mapped with the younger phases as falling between the Galice and Dothan formations, but is thought to be possibly as old as late Paleozoic in origin. It is not found in direct contact with either the Galice or Dothan in the Butte Falls region, but following Diller's example (1), and taking into consideration the altered condition of the rocks, they are treated here as late Jurassic, but older than both of those formations.

These greenstones are hydrothermally altered gabbros in which the mafic minerals have been partially or wholly changed to serpentine and chlorite. In some instances, the rocks have a comparatively fresh appearance, but in most cases they are so strongly serpentinized and chloritized as to make the original rock almost indeterminable.

RM-38, an average greenstone sample from along the Tiller-Drew highway, megascopically shows the effect of hydrothermal alteration in having a highly leached outer portion and an apparently little-altered center. The

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1. Diller, J. S., and Kay, G. F.: U. S. Geol. Survey, Geol. Atlas, Riddle Folio, Oregon, No. 218, pp. 4-6, 1924.

original rock appears to have been an ordinary basalt which was first attacked by the hot solutions along the fractures, with the leaching proceding outward from them. Serpentine, chlorite, and magnetite are most obvious in these cracks, and are least noticeable in the fresher center portion of the specimen.

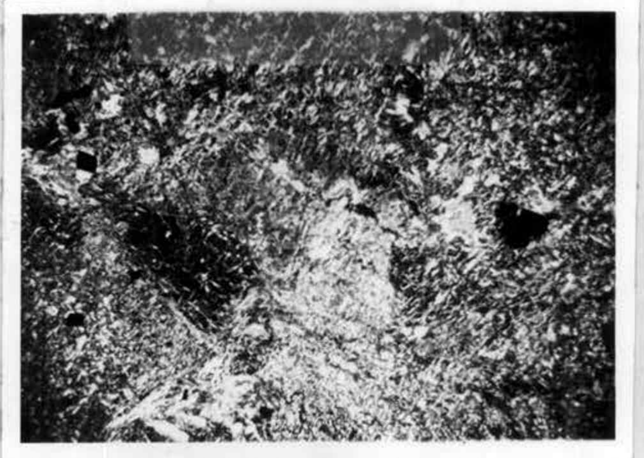

Fig. 5. Photomicrograph of a greenstone sample showing altered condition. Note the fractured augite relic. Nichols crossed magnification 32 X.

In the thin section the effect of the metamorphism is more apparent, as is shown in the photomicrograph of the slide (fig. 5). The entire section is masked to some extent by masses of serpentine and chlorite, but relics of large augite crystals are still discernible.

The augite occurs in groups of closely related grains which become simultaneously extinct. The grains are separated by altered areas along what were apparently fractures in the original crystals. The areas covered by such groups of grains indicates that the original crystals were as much as 4 mm. in length.

Augite is the only recognizable primary mineral constituent, and those resulting from the metamorphoses of the original rock are serpentine, chlorite, magnetite, and calcite. The relative amounts of these minerals are: 70 per cent serpentine, 15 per cent augite, 5 per cent magnetite, 5 per cent chlorite, and 5 per cent calcite.

Thin sections of other rocks of the formation appear much the same, with the nature of the primary minerals being partially or wholly masked by serpentine and chlorite alteration. Those in which the primary constituents can still be recognized have similar relics of augite and probably plagioclase crystals.

Due to the absence of deforming forces at the time of their metamorphosis, no schistosity is shown in the greenstones. There has been, however, fracturing and some faulting both before and since this alteration took place, forming great numbers of cracks and small faults. Many of these are filled with chlorite and serpentine, which indicates their presence before the time of hydrothermal alteration, but the younger fractures contain none of this secondary material.

The greenstones weather to a rather fine, brown-colored, sometimes clayish soil, and vegetation in the region where these rocks are present consists mostly of shrubs and grass, leaving bald, brownish ridges. This makes the contacts between it and neighboring formations easy to trace.

Quartz Diorite Group

The only Mesozoic formation of strictly igneous origin is a siliceous intrusive group consisting of quartz diorites, quartz monzonites, and granodiorites. It occurs in several small irregular patches, all of which are on or near the western boundary of the quadrangle, covering a total area of about 25 square miles.

The group is similar to one of late Jurassic or early Cretaceous rocks in the Riddle quadrangle (1), and is definitely younger than both the Galice and Dothan. This statement is based on the lack of metamorphic effects within the formation, as all the other rocks older than Eocene have been noticeable deformed. The presence of dioritic dikes in these metamorphosed formations furnishes further proof as to the later origin of the quartz diorites.

The rocks of this formation appear as ordinary granites to the naked eye, which probably accounts for the

1. Diller, J. S.; and Kay, G. F.; op. cit. p. 6.

name "Granite Creek" being applied to a small fork of Coffee Creek whose bed is strewn with large, well-rounded granitic-looking boulders. Microscopic examinations of these rocks show them to be mainly quartz diorites with some granodiorites and quartz monzonites, all of which are probably differentiations of the same magma.

A specimen from near Tiller (RM-32) is a quartz-mica diorite with an equigranular texture. It is approximately 70 per cent feldspar, 15 per cent quartz, 8 per cent biotite, 5 per cent hornblende, and the remaining 2 per cent, magnetite and apatite.

The feldspars are principally oligoclase and andesine, with only a trace of microcline. They show extraordinary zoning, and the centers of some of the zoned plagioclase crystals are slightly altered to calcite. The quartz occurs in granular grains, some of which show a slight strain extinction, and both brown biotite and green hornblende appear in pleochroic crystals.

A thin section of another sample from the same locality (T. 30 S., R. 2 W.) shows it to be a granodiorite. This specimen (WL-154) is about 60 per cent plagioclase, 10 per cent orthoclase, 15 per cent quartz, 10 per cent hornblende, 3 per cent biotite and 2 per cent magnetite. The feldspars are zoned, as in RM-32, and are altered to calcite and kaolin.

The principal difference in the two specimens is the lack of orthoclase in the former one.

Pegmatite dikes cut the May Creek schists and the quartz diorites, and dioritic dikes occur in all the formations older than this intrusive group. The pegmatites are found mainly in the Ramsay Creek region in T. 35 S., R. 2 W. They range from veins 2 inches in thickness to dikes up to 2 feet thick. Their mineral constituents are mainly quartz, feldspar, and muscovite, but the relative amounts of these minerals vary in the different intrusive bodies.

The rocks of this formation are overlain by a soil mantle of from one to fifteen feet thick, and friable material is noted in roadcuts to extend as deep as 30 feet beneath the surface. The soil is light-colored and coarsely granular, and can be readily distinguished from that weathered from the schists by both its coarse texture and light color.

Tertiary Rocks

Tertiary formations, consisting of non-marine sediments and the overlying volcanics, cover more than 75 per cent of the quadrangle. The sediments are Eocene in age (1) and the volcanics range from upper Eocene to late

1. Diller, J. S.; U. S. Geol. Survey, Geol. Atlas, Roseburg Folio, Oregon, No. 49, 1898.

Pliocene (1).

Umpqua Formation

In the southwest corner of the quadrangle, around Sams Valley and Beagle, is found an area of thinly bedded sandstones, shales, and conglomerates. At the southern edge where it occurs as an extension of the Umpqua formation in the Medford quadrangle (2), it forms an area about 6 miles across, from east to west, which gradually tapers to a point in the Evans Creek valley to the north. These rocks rest unconformably upon an old erosion surface of Paleozoic schists and disappear beneath the volcanic rocks to the east.

The predominating sandstones are usually massive, and are ordinarily a medium gray in color, although buff, cream, and red-colored layers are common. The textures range from fine-grained to pebbly, and often grade into conglomerate. The grains are usually angular, but some are partially rounded, indicating a short distance of transportation. They are usually poorly cemented, and

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1. Callaghan, E.: Some features of the volcanic sequence in the Cascade Range in Oregon, Amer. Geophysical Union, Trans., 14th Ann. Meeting, pp. 243-249, June, 1933.
2. Wells, F. G.: U. S. Geol. Survey, Preliminary Geologic map of the Medford Quadrangle, Oregon, 1939.

the rocks are often quite soft, but in some localities, they have been silicified and are very hard. Much volcanic glass, muscovite, and some tuffaceous material are included.

The soil weathered from the sandstones is usually gray, but is sometimes yellow or brown according to the color of the underlying rocks at that locality. This soil is not particularly good for farming, as it is quite coarse and does not tend to hold moisture. Drainage is poor in areas underlain by these sandstones as is shown by the number of intermittent streams on the geologic map.

The characteristic topography is shown just north of Sams Valley where these sandstones form a rude table land rising about 1100 feet above the lowlands around Sams Valley and Beagle, and partially surrounded by bluffs, which are at some points over 100 feet high.

The conglomerate layers range from a few inches to about 20 feet in thickness, made up of well-rounded, poorly-sorted pebbles and boulders. These range in size from a fraction of an inch to some 12 inches in diameter, and consist of quartzite, quartz-diorite, and basalt. An excellent exposure showing the range in size and composition of these pebbles is found approximately 8 miles northwest of Beagle, near the bridge which spans Table Rock Creek. This particular outcrop shows potholes as much as 3 feet deep where boulders have been removed and the resulting holes further enlarged.

Throughout the Umpqua are found layers of shale which range from light gray to black in color. In most instances they are sandy in texture, and are often tuffaceous. One of the best exposures of true shale occurs in a road cut three miles north of Beagle where the overlying sandstones have been cut away. The dip of these beds is 9° to the southeast. Another exposure in a creek bottom, about 3/4 mile to the east yielded a few fossil leaves. They also contain carbonaceous material and are the source of much of the fossil wood found in the formation.

The maximum thickness of the Umpqua in this quadrangle is probably not over 1500 feet, whereas on Little River in the Roseburg quadrangle, it reaches a maximum of 12,000 feet (1). Stratification is often horizontal, but dips up to 15° were recorded. The general dip is approximately 7° eastward, beneath the Tertiary lavas.

No fossils were found in the formation other than leaves and the fragments of petrified wood which are very common in the soil mantle on slopes and in creek beds. Coal beds occur in several localities, the largest of which are, one near the War Eagle Mine, associated with cinnabar, and another in Sec. 4 of the same Township, near the headwaters of Table Rock Creek.

1. Diller, J. S.: U. S. Geol. Survey, Geol. Atlas, Roseburg Folio, Oregon, No. 49, 1898.

The Agglomerate Group

The only other formation that is thought to be entirely Eocene is a group of tuffs, mudflows, agglomerates and tuffaceous breccias. This pyroclastic group is very similar to, and is tentatively correlated with, the Calapooya formation of the Blackbutte-Elkhead area (1). It shall be referred to in this paper as the agglomerate group.

The lower facies of the series are found in the western part of the area overlying the Umpqua formation. They consist of greenish and buff-colored tuffs, often somewhat silicified, and what are apparently waterlaid volcanics. These water-laid volcanics are made up of deeply weathered, angular to rounded boulders and pebbles imbedded in a tuffaceous matrix. The abundance of well rounded boulders causes them to resemble ordinary conglomerates although they are not stratified. These boulders are deeply weathered, but appear to be mainly andesite. They range in size from a few millimeters to about 18 inches in diameter. Pebbles from the Umpqua formation are rare.

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1. Wells, G. F., and Waters, A. C.: Quicksilver Deposits of Southwestern Oregon, Geol. Survey Bull. 850, p. 11, 1934.

One of the best exposures of this type of material is found south of Long Branch Creek in Section 19. Here, it forms prominent cliffs across the canyons of some of the small tributaries of Long Branch, showing pitting and undercutting produced by former stream erosion. The volcanic conglomerates of this locality (the Meadows district) have been described as "similar to the lower facies of the Calapooya formation, but better sorted; containing pebbles of aphanitic and porphyritic andesite, with phenocrysts of zoned feldspars" (1).

The tuffs appear to be slightly higher stratigraphically than the rocks just described, and can be divided into two different types. The first is a buff to white, glassy material from which fossil leaves were collected at three localities, all in T. 35 S., R. 1 W. The largest collection and greatest variety of leaves were obtained in section 24 of that township. Here, there is an exposed thickness of 10 feet of buff-colored, tuffaceous siltstone in which well-bedded individual layers range from 0.5 mm. to 0.5 inches. Conformably overlying this platy variety is a white, silicified rhyolitic tuff amounting to approximately 50 feet in thickness. It has been

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1. Wells, F. G., and Waters, A. C.: Quicksilver Deposits of Southwestern Oregon, Geol. Survey Bull. 850, p. 14, 1934.

fractured into slabs which are several inches thick (from 1/2 to 8 inches) and up to 18 or 20 inches in length. These blocks litter the slope both above and below the exposure of thin-layered material. They are stained brown on the exposed surfaces and along fractures, but upon being broken, show a fresh white, glassy face. Fossil leaves are found between the horizontal layers, similar to those in the stratigraphically lower beds.

A small coal deposit is associated with the fossil leaves, and was evidently responsible for the digging of a pit which exposes the lower fossiliferous beds.

The second main type, a green, locally-silicified tuff, appears to belong to the upper facies of the agglomerate group, grading upward into a true agglomerate. Both the tuffs and volcanic conglomerates contain much glassy material, and together they make up about 300 feet of the great thickness of the agglomerate group.

The upper facies are composed primarily of flow breccias and tuffaceous agglomerates, appearing in patches of varying size, over nearly all of the area. A peculiar feature of these patches is that, for the most part, they form the comparatively flat floors for many creek bottoms. Apparently at the base of the upper facies, is the green, locally silicified tuff, containing only minor amounts of agglomeritic material. It grades upward into the more common variety composed mainly of fragments with a small

Fig. 6. Close-up of an agglomerate outcrop.

Fig. 7. An agglomerate cliff showing results of undercutting by former stream action.

percentage of tuffaceous cementing material.

South of Rogue River, especially along Indian Creek and near the mouth of Big Butte Creek, the more tuffaceous material is quite extensive. In the higher regions, however, it is displaced by the flow types.

Good exposures typical of the tuffaceous agglomerates appear in the cuts along the new strip of highway just north of Trail, and in the bottom of Trail Creek along this highway. The rocks here show stratification, apparently dipping about 14° to the southeast. The layers are from 1 inch to 6 feet thick, with thin layers of weathered material alternating with the thicker, less weathered portions. Numerous fragments of carbonaceous matter can be seen in the road cuts.

Stratigraphically higher within the formation, thick masses of flow breccia prevail. They tend to form ridges on which often can be found bluffs and pinnacles formed by differential erosion of the flows. This tendency is well illustrated east of Elk Creek in Sec. 17 T. 31 S., R. 1 W., where the bluffs are as much as 100 feet high, showing irregular, vertical jointing at intervals of from 2 to 10 feet. In the valley bottoms below such bluffs, great boulders of breccia are found, having toppled off and rolled down. Some of these boulders, as great as 10 or 15 feet in diameter, have been rolled for a distance of one-half to three-fourths of a mile by the small streams in whose beds they now rest.

The rocks of this part of the formation are strikingly dissimilar in appearance from place to place, but vary little in mineral composition. Some outcrops show very good flow structure while others have no apparent arrangement of the included fragments. The color is usually green, but changes locally to white, purple, or black.

A megascopic examination of these rocks from various points in the area, shows them to consist generally, of a fine greenish matrix in which are imbedded badly weathered irregular pieces of basalt and andesite. The color of these fragments seems to vary with the degree of weathering, which accounts for much of the dissimilarity in appearance of different outcrops and in specimens taken from the same outcrop.

The comparatively unweathered grains are usually black, changing to green in the more weathered samples. The green discoloration appears only on the surface at first, but as the degree of alteration increases, gradually moves toward the center. The extreme cases of weathering show the fragments to have been totally altered to white kaolin. Within some hand specimens all three colors (black, green, and white) are shown in different grains, representing each of these stages of weathering.

In the thin sections, a finely-crystalline to glassy groundmass may be seen with numerous crystals of plagioclase and angular fragments of basalt and andesite, some meta-rhyolites, and in one case, crystalline limestone.

The microscopic examination of a sample (HH-130) from Sec. 1, T. 32 S., R. 2 W., shows it to be a brecciated rock composed of basaltic fragments, feldspar crystals and magnetite grains, in a glassy matrix. The feldspars in the matrix are principally andesine and labradorite, occurring in euhedral crystals with combinations of Carlsbad, albite and pericline twinning. These plagioclase crystals are large (from 2 to 5 mm. in length) often zoned and contain inclusions of magnetite and glass. Their size indicates that they crystallized before reaching the surface.

The basaltic fragments are irregular in outline and vary in texture from medium-grained porphyritic to fine-grained pilotaxitic. They contain feldspar laths and phenocrysts, with numerous grains of magnetite and have been discolored by iron oxide stains. The degree of decomposition differs in the various fragments, but some alteration effects are present in all of them. In those which have been most effected, the original constituents cannot be recognized and even in the little-altered pieces, the kaolin coating and the iron oxide stains make their determination difficult.

In addition, there is one fragment of rhyolitic material which is probably representative of the old meta-rhyolites included with the May Creek schists.

RM-61, a specimen from Sec. 13, T. 30 S., R. 1 W., differs only slightly from the sample just described. The principal differences are the less-weathered appearance and the variety of rock fragments in the one under consideration. These fragments are all basaltic, but three types of basalt are indicated by the textures. The first is a medium-grained material with a diabasic texture, the second is pilotaxitic, and the third, hyalopilitic. These fragments are irregular in shape, like those in HH-130, but are not altered to as great an extent.

The other mineral constituents of the two are very similar. The plagioclase crystals are approximately the same as to size and general appearance, and the matrix of both are glassy. Both specimens show vitroclastic structure resembling that of the welded tuffs of eastern California (1).

B-107 is one of several samples taken from the new road cuts just north of Trail. Microscopically it is seen to contain basalt and probably trachyte fragments in a glassy matrix. Also imbedded in this matrix are plagio-

1. Gilbert, C. M.: Welded tuff in Eastern California, Geol. Soc. Amer. Bull., v. 49, p. 1842, 1938.

clase phenocrysts and feldspar microlites.

The rock fragments are angular to sub-rounded in outline, and are often so severely altered that the original textures and mineral compositions are completely masked. The basalt is pilotaxitic and is composed of plagioclase and finely disseminated magnetite. The trachytic pieces contain window crystals of orthoclase and plagioclase in a microcrystalline groundmass.

An interesting specimen (WL-18) was taken from Sec. 9, T. 33 S., R. 2 W., Megascopically it resembles the three just described, but in the thin section proves to be strikingly different in composition. The rock fragments, instead of being dominantly basalt, are chiefly crystalline limestone. In one section, several foraminifera, which are thought to be Fusulina, may be seen in these calcitic fragments (fig. 9). Other rock fragments of basalt or andesite appear, but are too greatly altered to be definitely determined.

The groundmass is glassy, containing microlites of feldspar, and other mineral constituents are magnetite and secondary calcite.

The examination of this sample shows it to have been of volcanic origin, and the presence of fossiliferous limestone fragments indicates that Paleozoic (?) limestones were present in the region around the vent from which the material was derived. They were apparently torn from the walls of the conduit along with the younger basaltic pieces, and were cemented together by glass.

The general dip of the group as a whole is to the east, ordinarily amounting to only 3 or 4°, but occasionally rising to as high as 26°. The total thickness is estimated to be 4,000 feet. At no place could it be measured, but as the general dip is to the east and the elevation rises in that direction, it may be even greater. The lowest point at which the formation is exposed is about 1400 feet in the southwest corner of the area, and the highest, approximately 4,200 feet northeast of Butler Butte. Near the eastern edge of the quadrangle agglomerate outcrops were recorded at elevations of 3700 and 3900 feet, so it is evident that the formation thickens from west to east.

Beds of agglomerate are incompetent, and are responsible for many slump areas. The winter rains make the tuffaceous and ashy layers oozy, causing the beds to slip along the plane of the dip. This is especially noticeable on the eastern slopes of ridges, the most striking example being along the new highway between Trail and the Divide Guard Station. Several localities show repetition of bedding due to faulting of these rocks. The most notable example is found just south of Shady Cove, where a series of three north-south faults creates a stair-step effect.

The soil mantle overlying these agglomerates is often quite thick, due to the great extent of alteration within the formation. This deep weathering and the consequent thick layer of soil are the result of a humic climate favoring decay, the absence of glaciation, and the rather heavy forestation. The first item caused the rapid decomposition of the rocks, while the latter two are reasons for its not being quickly eroded. The porous conglomerates at the base of the formation are easily decomposed and even in the upper members, outcrops which can be easily cut with a pick, are common. Despite this almost complete alteration, the original structure within the rocks is retained, and phenocrysts and pebbles which have been entirely changed to kaolin have their original, sharp outlines.

The soil is generally fine, with abundant pebbles and cobbles. Its color is gray or light green, according to the underlying rocks, but with an occasional lense of dark red or purple. The red color is usually only local, and appears to be the result of the weathering of small lenses of red volcanic ash.

The green color over nearly all the formation may be attributed to the presence of ferric iron and is probably due to arid conditions at some time during the weathering of the beds. Roasting of this green material produces

Fig. 8. An agglomerate cliff and talus slope. Same locality as Fig. 7.

Fig. 9. Photomicrograph of agglomerate sample WL-18, showing foraminifera in limestone fragment. Nicols crossed, 32 X.

a reddish brown residue.

These agglomerates indicate the beginning of widespread Tertiary vulcanism. The presence of some sorting in the conglomerates, and the pillow structure in some of the lower flows suggest that much of the lower facies was deposited in water, and associated with these deposits are beds which were probably mud flows. The tuffs and tuffaceous breccias of the middle members are the result of explosive vulcanism, while the upper layers were formed dominantly by flows from the vents.

Silicified and carbonized wood is common throughout the formation. Tree trunks 2 or 3 feet in diameter and several feet long are not unusual, and portions of limbs and general fragments of small size are nearly everywhere. In the rocks showing flow structure, this fossil wood is ordinarily oriented parallel to the flow lines. In Sec. 31, T. 31 S., R. 1 W., at the junctions of Flat Creek and Elk Creek, an outcrop of green, silicified flow breccia has been eroded to expose a tree trunk some 15 feet long. This tree is oriented approximately east and west, and lies nearly horizontal, parallel to the flow structure in the breccia.

The fossil flora of the region consists of incomplete specimens, not too well preserved. For this reason, specific identification was impracticable.

The fossil leaves studied were varied, and representatives for each genera were limited to not more than 5 or 6 specimens. With so few specimens, determinations and comparisons were difficult.

Tentative generic determinations include sterculia, pinus (needles and a cone), sequoia, alnus, quercus, magnolia, ulmus, acer, ficus, platanus, and salix. A flora of this type would suggest a moderate to sub-tropical climate with abundant rainfall. Similar floras found in fossil leaf localities throughout the state have been studied in detail and have been classed as Tertiary in age. Since the leaves from the Butte Falls area have been generically checked with those of other localities and found to be in close similarity (1), they are tentatively considered as early Tertiary in age.

1. Sanborn, Ethel I.: Personal communication, 1941.

Older Basalts

The most extensive group of rocks is one composed of a thick series of dark-colored basalt flows, ranging in age from upper or post-Eocene to middle or late Miocene. These basalts are distributed throughout the area except for the extreme western border, and apparently rest unconformably upon the agglomerates and older formations. The true structural relationship between the agglomerates and basalts, is not definitely shown, but physiographic evidence points to the existence of at least an erosional unconformity.

These older basalts are described by Callaghan (1) who differentiates them from his younger High Cascade basalts and andesites, as the basalts of the western Cascades. They are sometimes dense, equigranular, as to texture, but are usually porphyritic. The denser varieties fracture conchoidally, and nearly all show well developed columnar structure (fig. 10). The columns are ordinarily pentagonal, greatly resembling those of the Columbia River basalts. In places they appear in sheer cliffs often as much as 200 feet high, and in others, their slightly rounded tops protrude a foot or more from the ground, appearing like thousands of irregularly placed

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1. Callaghan, E.: Op. cit. p. 245.

short fence posts. One such area, on the flat-topped ridge south of Rogue Elk, consists of several acres thoroughly studded with these column tops.

Apparently at the base of the group is a greenish black, deeply weathered basalt flow. It appears in the southwestern portion of the area, occurring in low, rounded ridges, and as isolated remnants, capping the agglomerates and Umpqua sandstones.

These rocks are medium-grained, but the fracturing and the high degree of weathering cause them to appear much coarser. Microscopic examinations show the following description of a sample (W-71) to be generally applicable to the rocks of this phase of the basalt group.

The thin section has the porphyritic texture of nearly all the basalts of the area, and the term which most nearly describes it is pilotaxitic. The groundmass is composed of minute feldspar laths with some interstitial augite.

Phenocrysts of plagioclase, hornblende, augite, and olivine make up approximately 40 per cent of the section, those of plagioclase being the largest and most numerous. These latter phenocrysts are up to 3 mm. in length and as high as 2 mm. wide. They consist of labradorite and andesine with extinction angles ranging from 0° to 14°, and are twinned according to the albite and pericline laws.

Basaltic hornblende phenocrysts form about 8 per cent

Fig. 10. Basalt-agglomerate contact. Note the columnar structure in the basalt.

Fig. 11. A basalt cliff showing vertical columnar jointing.

of the slide, appearing in pleochroic, reddish-brown, euhedral crystals, the true characters of which are partially masked by the iron oxide which stains a large part of the section. This type of hornblende has evidently been formed by the oxidation of the iron in the original, ordinary hornblende(1). Where extinction angles can be measured, they are between 2° and 9°. Two photomicrographs of the slide show the texture and the nature and relative amounts of the mineral constituents. Figure 12 includes a group of altered hornblende crystals and figure 13 consists of a little-altered hornblende fragment, augite and plagioclase phenocrysts in an aphanitic groundmass.

Magnetite occurs as dust and small grains in the groundmass, and as larger crystals often included in the hornblende.

Augite crystals are common, often included in plagioclase, and a few euhedral crystals of olivine are shown, most of which are altered to iron oxide in the fractures and along the margins.

Overlying this weathered basalt is an amygdaloidal variety with limited vertical and horizontal extent, ap-

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1. Rogers, A. F., and Kerr, P. F.: Thin-Section Mineralogy, McGraw-Hill Company, p. 241, 1933.

pearing only along Big Butte Creek and Trail Creek.

The amygdules are sometimes round, but usually elonggate, and can be described for the most part as pipe amygdules. They are mostly zeolites and radiating pectolite crystals as great as 6 inches in length are not uncommon. There is another generation of secondary material occurring as cavity fillings, consisting of quartz geodes (fig. 14), and a green staining material (probably ferric iron). The geodes are numerous and commonly a foot or greater in diameter. The green mineral stains the interior of the geodes and the rock immediately surrounding the fractures in which it is found, and is evidently the result of the same conditions which caused the green color in the agglomerates.

The thickness of this flow is not more than 90 or 100 feet. No definite indication as to the structure was found, and the exact relationship to the older, weathered variety was nowhere observed.

The variety of basalts showing the widest distribution occurs as thick series of flows, mainly on the Rogue-Umpqua divide. They are dark, medium to fine-grained rocks, differing locally in appearance, but generally similar in composition. Their age in relation to the amygdaloidal variety is difficult to determine, but they are thought to be of later origin. Exposures range in elevation from about 500 feet in the Rogue River valley area, to 6,140 feet on Abbot Butte. They evidently formed an irregular surface, not entirely covered by later flows and were further exposed by erosion of the younger rocks. Typical specimens are often glassy, slightly porphyritic, and have a greenish-black color due to the presence of olivine and pyriboles. An olivine basalt specimen (H-118) from Sec. 34, T. 32 S., R. 1 W., is representative of this particular part of the group.

Microscopically, the texture is diabasic, holocrystalline. Phenocrysts of plagioclase (labradorite and andesine) make up 25 per cent of the section, showing albite and Carlsbad twinning, some zoning, and containing inclusions of magnetite, olivine, and augite. The zoned spars are often altered to calcite at their centers, indicating that the cores are more basic than the margins.

Other phenocrysts are olivine, about 5 per cent of the slide, and augite, 8 per cent. The once-euhedral olivine crystals are highly fractured and are altered to serpentine, and some to iron oxide, in these fractures and along their boundaries.

Magnetite occurs in subhedral to euhedral crystals of varying sizes, forming 5 per cent of the total mineral constituents. The remainder of the slide is a medium-grained

Fig. 12. Photomicrograph of basalt sample W-71, including a group of basaltic hornblende crystals and magnetite grains in a micro-crystalline groundmass. Plane polarized light, magnification 32 X.

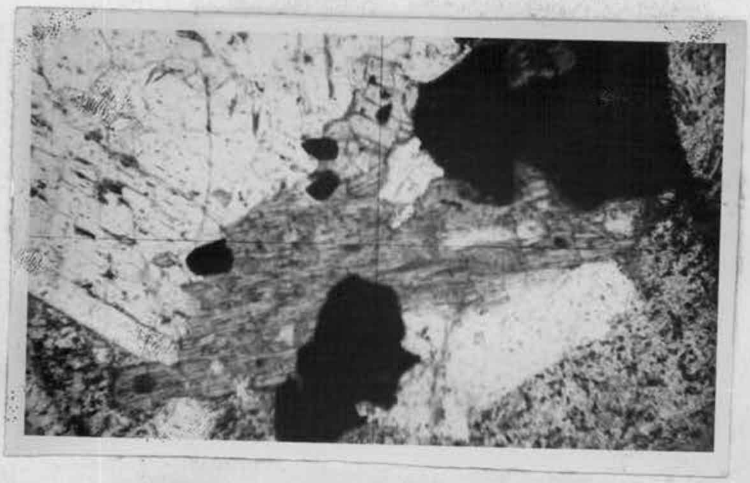

Fig. 13. Photomicrograph of the same basalt sample. Crystals are hornblende, magnetite, plagiocalse, and augite. Plane polarized light, magnification 32 X.

groundmass of lath-shaped feldspars with interstitial augite grains.

The order of crystallization of the phenocrysts appears to have been magnetite, olivine, augite, and plagioclase, with the plagioclase in the groundmass having been formed last.

Capping the ridges in the vicinity of Rogue Elk are black basalts in which the feldspar phenocrysts can be easily seen without the aid of a hand lens. They overlie the older olivine basalts, possibly unconformably, and are made up of two flows of similar appearance, evidently separated by a very small time interval. Each flow approaches 500 feet in thickness, and a scoriaceous section occurs at the contact. Together they form flat-topped ridges, partially surrounded by high cliffs in which vertical jointing is well developed. There are three such ridges in the vicinity mentioned, separated by Rogue River and Big Butte Creek valleys, each having an elevation of approximately 3000 feet. The former surface has evidently been dissected by the streams whose valleys now separate the patches.

Hand specimens of this fresh-looking basalt show a fine black groundmass with numerous phenocrysts of white feldspars. These phenocrysts are tabular in shape, and are oriented with their long axes in that direction of flow. Their length is often up to 4 mm. but the average is about 1 mm. The size of crystals apparently varies but little in different portions of the flows.

A typical specimen of this variety of basalt (B-50) shows a hyalopilitic texture, with a microlitic groundmass consisting of feldspar laths and occasional tiny augite grains, in a glassy base.

The phenocrysts are plagioclase, some augite, and a few rare crystals of olivine showing alteration to iron oxide. The plagioclase is labradorite, with some andesine, and shows albite and pericline twinning. Both the laths and larger crystals are well arranged with the laths being oriented around the phenocrysts (fig. 15). The labradorite phenocrysts contain inclusions of augite, and the augite in turn includes apatite and magnetite. This indicates the order of crystallization to have been the accessory minerals (apatite and magnetite), followed by phenocrysts of olivine, augite, and plagioclase, and last, the minerals of the groundmass.

Approximately 70 per cent of the section is groundmass, and of the total mineral constituents, about 65 per cent is feldspar, 10 per cent is augite, 12 per cent magnetite, 10 per cent glass, and the remaining 3 per cent, apatite and olivine.

The youngest member of the older basalt group is a very black, dense basalt, occurring mainly in small isolated patches capping ridges and peaks of agglomerate and basalt of earlier origin. One of the most extensive and thickest exposures is at Pickett Butte.

Occasional outcrops have a medium-grained texture, but the general appearance is aphanitic. A microscopic examination of a specimen (B-193) from just southeast of Tiller shows it to have trachytic texture (fig. 16). It consists of a large amount of glassy groundmass in which are needle-like microlites of feldspars and minute grains of augite.

Phenocrysts of plagioclase surrounded by crystals of augite and the feldspar microlites, indicates the order of crystallization to have been plagioclase phenocrysts, followed by augite, and later the needle-like feldspars in the groundmass.

The glass is slightly altered and is stained by limonite, and magnetite occurs sparingly in small euhedral crystals. The plagioclase is labradorite, with albite twinning and extinction angles of 1° to 12°.

The extent of the area covered by this dense, black basalt is apparently much smaller than it was at one time and present thicknesses are less than 50 feet in most localities.

As a whole, the older basalt series makes up a thickness of several thousand feet, with a general dip of a few (3 to 5) degrees to the east. They have undergone much faulting and some folding, producing local dips of 15 to

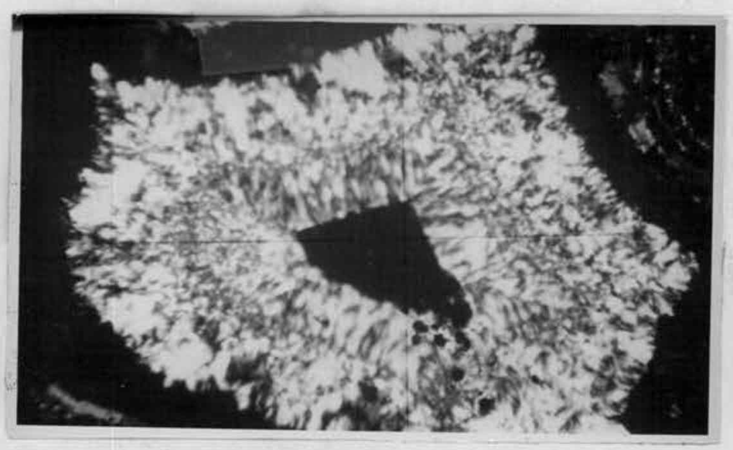

Fig. 14. Photomicrograph of a small quartz-filled cavity in an amygdaloidal basalt sample. Note the banded structure. Nicols crossed, 32 X.

Fig. 15. Photomicrograph of porphyritic basalt section. Phenocrysts are plagioclase and olivine. Note the orientation of tiny feldspar laths. Nicols crossed, 32 X.

20 degrees in varying directions.

This wide area of basalts constitutes what was once an expansive lava plateau. It seems comparable to the Columbia River basalt plateau of central and eastern Oregon, and the rocks themselves compare favorably both as to appearance and composition. This region, however, has been dissected to a ma ture topography, which may be explained by its having been subjected to a more active and energetic type of erosion, rather than having been eroded over a longer period of time. The move active erosion here may be attributed to the greater amount of rainfall on the western slopes of the Cascades than on the leeward side of these mountains, especially since the construction of the later Cascade cones.

Sources of a number of these lava flows are highlands and former volcanic cones such as **Abbot** Butte, Round Top (in Township 35 S., R. 1 E.), Vestal Point, Pickett Butte, and Olsen Peak. Around these points, the old basalts show principally initial dips, changed only by the regional tilting undergone by the entire area. The ridges extending outward from them often indicate the approximate slopes of the former surface of the flows. A small area around Pickett Butte shows the original surface of the flow of black vesicular basalt, with no soil mantle, little vegetation, and occasional undrained depressions.

It greatly resembles, on a small scale, the area of recent lava flows to be seen at McKenzie Pass (1).

The basalts on and near these peaks and buttes are nearly all vesicular, tending to become more frothy in appearance with nearness to the old sources.

Abbott Butte is the most outstanding example of these former cones. It stands well above any other point in the area and is made up of some 3,500 feet of older basalts. This and some of the other high basalt points have not been covered by any of the later flows, but have had younger rhyolites and basalts plastered against them.

The soil formed by the decomposition of the old basalts is ordinarily black in color and varies from a few inches to 25 or 30 feet in thickness. It is much thinner than that ordinarily found overlying the agglomerates due to the greater resistence of the basalts to weathering, and to the shorter time in which they have been subjected to weathering agents.

1. Lobeck, A. K.: Geomorphology, McGraw-Hill Publishing Company, picture, p. 50, 1939.

Fig. 16. Photomicrograph of specimen B-193. Exhibits a trachytic texture. Nicols crossed, 32 X.

Fig. 17. Initial dip of older basalt surface west of Olsen Peak.

The Rhyolite Series

Also of Tertiary age is a somewhat less extensive group of rocks of rhyolitic nature. Their position in the stratigraphic column, in relation to the basalts, is questionable, for nowhere could the exact relationship be determined.

In places the rhyolites directly overlie the agglomerates, usually unconformably and in others are in contact with the basalts. No great differences in topography are shown between the basalts and rhyolites, for each shows generally mature surfaces, and the extent of weathering is practically the same in both. These reasons plus the forestation and the soil mantle covering most of the basalt and rhyolite areas, make a determination of the exact relationship impossible without further field examination. They may be either early Tertiary (older than the basalts just described) or late Tertiary (younger) in age. It is even possible that they belong stratigraphically between some two layers of these basalts, but a tentative classification places them immediately higher in the column, as middle or late Miocene.

Exposures of these rhyolitic rocks appear chiefly in the mountainous areas north of Rogue River, from approximately a mile west of Diamond Rock to as far east as the eastern border of the quadrangle. Patches occur south of

Rogue River, but are not important, either as to area or thickness. Some of the larger areas north of the Rogue, however, cover up to 15 or 20 square miles.

The group consists of porphyritic rhyolites and latites, tuffaceous rhyolites, and rhyolitic breccias. At the base is a buff to cream-colored tuffaceous rhyolite, which in places is largely tuff, and in others contains little tuffaceous material. The tuffaceous rhyolites show some flow structure, and are commonly platy. Some of them however, are massive. The flow structure shown indicates that this phase of the rhyolite group, at least partially originated as flows into which tuffaceous material was deposited while the lava was pouring out over the land surface.

Near the top, this portion of the series grades into a brown, tuffaceous rhyolitic breccia, becoming highly vesicular, and is overlain by a pumiceous variety.

These rocks include pumice fragments up to 3 inches in length, oriented parallel to the flow lines of the lava. Megascopically, they greatly resemble the Harney rhyolites of central Oregon, but show better arrangement of the included fragments (1), indicating their origin as a rhyolitic flow (fig. 18). This type, however, is not extensively distributed, and appears principally in the western most

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1. Lowry, W. D.: Geology of the Bear Creek Area, Oregon, Oregon State College, Thesis, p. 45, 1940.

rhyolite patches.

The ordinary variety is a white, glassy rhyolite which forms a number of the higher peaks of the area, such as Butler Butte, Ragsdale Butte, and Elkhorn peak. It also tends to form rather uniform slopes around sharp pinacles such as Diamond Rock. The characteristic talus from rocks of this sort is thin, scale-like plates, from which the peak, Shell Rock, in T. 33, S., R. 1 E. was apparently named. In fact, the name "Shell Rock" is commonly used by residents of the area, who are not familiar with technical rock names, when referring to the rhyolites.

This type is siliceous and grades locally into brecciated phases. Some of these breccias are white, resembling the material just described, except for the fragments contained, while others are brown in color, showing definite flow structure. An excellent example of this brecciation is shown at Needle Point (fig. 26).

The youngest rocks of this series are blue-gray, platy latites of limited areal extent, with occasional lenses and veinlets of vitrophere. They are found mostly among the rhyolitic rocks of Elk Creek, Bitterlick Creek, and in the region around Hawk Mountain. Some of the vitrophyre resembles dense black basalt at the first glance, but in reality is almost an obsidian.

The entire series is exposed on the slope along the power line from the forks of Hawk and Timber Creeks to the crest of Hawk Mountain. The total thickness here is approximately 2500 feet which is the maximum recorded for the rhyolites in any one locality. It consists of about 1700 feet of tuffaceous rhyolites, 500 feet of light-colored rhyolite and breccia and 150 to 200 feet of the blue-gray latite.

The general dip of the rhyolites is approximately the same as that of the basalts, being 4° or 5° to the east, although faulted areas and initial dip slopes cause the rocks to be locally inclined in various amounts and directions. For example, in Sec. 25, T. 32 S., R. 1 E., a dip of 30° to the southeast was recorded, while at Diamond Rock the dip is 2° to the east.

The lower portion of the rhyolites is more highly faulted and fractured than are the upper flows. The tuffaceous rhyolites nearly everywhere show complicated systems of fractures which have been filled with iron oxide, causing them to appear dark brown, contrasting sharply with the white to buff-colored rocks in which they are found. In one locality crystals of goethite were reported but the commonest filling and staining material is limonite.

This limonite staining is associated with cinnabar mineralization in the fractures of the rhyolites which form the country rock of the Ash claims (1). It is described by Wells and Waters (2) as "irregular iron ribs up to 1½ inches wide and limonite stained chalcedony in spherical masses 2 to 3 inches in diameter."

Petrographic examinations of the rocks of the rhyolite group show the common, light-colored varieties to be true rhyolites, while the brown and blue-gray phases can be more accurately classed as latites. Both types contain phenocrysts of quartz and feldspar in a fine groundmass. In the latter type, however, the feldspars are principally plagioclase, while in the former they are orthoclase.

D-31, an example of the ordinary rhyolites, megascopically shows a white, aphanitic groundmass in which the quartz phenocrysts are larger and more numerous than are the feldspars. The quartz crystals are clear, with a vitreous luster, and some are as large as 3 mm. in length, while the tabular feldspars do not exceed 1 mm. in length, and are not so easily seen in the white groundmass.

The texture is felsophyric in the thin section, with a fine groundmass of devitrified glass, and phenocrysts of orthoclase, quartz, and biotite.

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1. Wilkinson, W. D.: Advance Report on Some of the Quicksilver Prospects in the Butte Falls Quadrangle, Oregon, State Dept. Geol. & Min. Ind., G.M.I. Short Paper, no. 3, p. 4, 1940.
2. Wells, F. G., and Waters, A. C.: op. cit. p. 48.

The quartz occurs in rounded crystals with a few radial aggregates of chalcedony. These crystals are somewhat fractured, and contain inclusions of glass, as do the alkali feldspars, which in addition contain magnetite and some biotite. The biotite phenocrysts are pleochroic and contain inclusions of zircon and apatite. They are frequently stained brown by limonite and hematite alterations, as is much of the groundmass.

A brown latite (B-40) from Sec. 30, T. 34 S., R. 1 W. shows a felsitic groundmass of devitrified glass, partially masked by secondary iron oxide and magnetite dust.

The phenocrysts are andesine and quartz with a subordinate amount of orthoclase. The andesine is twinned according to the albite and Carlsbad laws, and encloses tiny crystals of apatite and magnetite. The quartz is clear, with irregular crystal outlines, and contains inclusions of apatite, glass, and magnetite. Similar inclusions are also present in the orthoclase which shows some alteration to kaolin.

The rock exhibits vitroclastic structure (1) with the glass shards showing the effects of compression between phenocrysts (fig. 19).

1. Gilbert, C. M.: Welded Tuff in Eastern California, Geol. Soc. America, Bull., vol. 49, p. 1842, 1938.

Fig. 18. Phyolite sample, showing size and arrangement of included pumice fragments. Natural size.

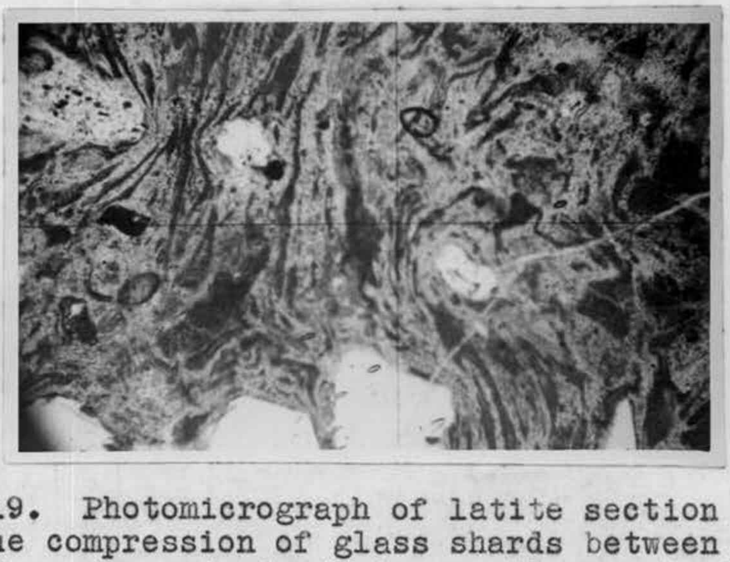

Fig. 19. Photomicrograph of latite section showing the compression of glass shards between crystals of quartz and plagioclase. Plane polarized light, 32 X.

A specimen of the blue-gray latite (A-35) exhibits a pilotaxitic texture in the thin section. The groundmass contains oriented masses which appear to be devitrified glass, and the phenocrysts are of plagioclase, augite, quartz, and a little orthoclase. The plagioclase is acid andesine, twinned according to the Carlsbad law, with extinction angles from 0 to 6 degrees. The feldspar crystals are all clear, most of them are subhedral, and some show faint zoning.

The augite occurs in green, slightly pleochroic crystals with prismatic cleavage. It is older than either feldspar or quartz phenocrysts, quartz being the youngest and present only in minor amounts.

Two generations of magnetite are present, first, large, euhedral crystals, and second, disseminated magnetite dust. This dust plus secondary iron oxide stains, give the groundmass a nearly opaque appearance, which is increased by the serpentinization of the augite. L-111, an example of the youngest member of the rhyolite group, is a feldspar vitrophyre. Megascopically it appears as a very dense black rock, somewhat resembling obsidian, but lacking the vitreous luster. It is crossed by numerous tiny, white veinlets of calcite.

The texture shown in the thin section is hyalopilitic, with a fine felted groundmass made up of microlites of feldspar in a glassy base. The section is approximately

90 per cent groundmass, with only rare phenocrysts, all of which are plagioclase. These phenocrysts are rather small in comparison to those in the other porphyritic rocks, and in this case are oligoclase. They show albite twinning and an average extinction angle of 2°.

No ferro-magnesian minerals are present, but magnetite, occurring as disseminated dust and as small grains, makes up about 7 per cent of the section. The one secondary mineral is calcite which fills the numerous, small veinlets, crossing the section with no apparent systematic arrangement.

The rhyolites, like the basalts, are commonly of local origin, having been derived from sources such as Butler Butte and similar highlands, and from feeder dikes. Evidence confirming this is found in the vesicular, cindery character of the rocks, and in the dip slopes around such highlands. However, other sources in the higher regions to the east of the quadrangle were evidently responsible for some of the lavas making up the series.

Younger Basalts

The younger basalts described here include flows of gray olivine basalts (Callaghan's "Rocks of the high Cascades" of Pliocene or early Pleistocene age)(1). They are ordinarily separated from the older rocks by a distinct unconformity, and differ among themselves principally in position, physiography, and environment of origin. In contrast to the older rocks, they reflect only initial dips.

Olsen Peak Basalts.

The unit mapped as Olsen Peak basalts consists of approximately 32 square miles of somewhat weathered gray rocks, immediately surrounding the peak of that name. They overlie the older basalts but everywhere except on the western slope of the peak the contact is concealed by a later flow. Both they and the older basalts seem to have flowed from Olsen Peak itself, and their respective dips differ but little at the contact.

Megascopically they appear generally coarser-grained than most of the other younger basalts, and contain a larger percentage of more uniform sized plagioclase crystals. These feldspars show some arrangement as to orientation and considerable alteration.

Specimen B-73 from Olsen Peak is found to be of pilotaxitic texture. It is composed mainly of uniform laths

1. Callaghan, E.: Some Features of the Volcanic Sequence of the Cascade Range in Oregon, American Geophysical Union, Trans., 14th Annual Meeting, pp. 243-247, June, 1933.

of plagioclase and small grains of olivine.

The plagioclase laths are often zoned and are nearly always altered to kaolin at their centers. They consist of albite and combined albite and Carlsbad twins of labradorite, andesine, and some oligoclase.

The olivine is largely altered to iron oxide and iddingsite. These iron oxide alterations appear brilliant red under reflected light and are noted to form a light red mask over most of the thin section.

Physiographically these basalts form a nearly mature surface on and around Olsen Peak, which has been dissected by the streams flowing outward in a radial pattern.

Exposures occur from 3200 to 5000 feet in elevation on the slope of the peak, giving an estimated total thickness of 1200 feet.

These rocks are generally more weathered than other phases of the younger basalts and the overlying soil mantle is thicker, comparing more favorably to that over the older lavas. The soil is sometimes gray in color, but is usually of reddish-brown hue, due to the influence of the alteration products of the olivine.

Later Tertiary Basalts

The lavas included under Tbl (later Tertiary basalts) are found around Whaleback and Round Top, southwest of Abbott Butte. They consist of thin flows of gray olivine basalt which has been plastered around the higher points of older lavas.

The area over which they occur is approximately 20 square miles, which represents only part of the original extent of these Whaleback and Round Top flows.

Thin sections of these basalts show them to have a diabasic texture, consisting of small aggregate grains of augite as interstitial material between laths of feldspar.

Olivine occurs in small grains and in large crystals with the original outlines obscured by iron oxide alteration. The iron oxide consists of hematite and small grains of magnetite.

The feldspars are mostly labradorite, showing albite twinning and extinction angles as great as 12°. They are in excess of the augite making up about 70 per cent of the slide.

These Whaleback lavas are found at approximately the same elevation as the Olsen Peak basalts to the south, but are apparently of later origin. This statement is based on the smaller amount of dissection of the surface, a fresher appearance, the thinness of the overlying soil mantle, and the distinct unconformity separating them from the older lavas. From this evidence they are considered as a separate unit within the younger basalt group.

Gray boulders ranging in diameter from a few inches to 6 feet are quite common in the soil mantle. At one locality, approximately a mile northeast of Whaleback, they line a bowl-shaped depression in which rushing water can be heard some 40 or 50 feet beneath the surface. The thin layer of light-gray soil is very fine in texture, powdering to a fine dust in the road beds during the dry summer months.

The Intercanyon Basalts

The Intercanyon basalts in this area represent the western margins of late Tertiary or early Quaternary gray olivine basalt flows, occurring as tongue-like extensions down the Rogue River and Big Butte Creek valleys. They are dated by Callaghan (1) as Pliocene or Pleistocene in age, and are treated here as late Pliocene.

The Rogue River lobe extends westward in that valley as far as McCloud, forming a strip which averages less than a mile in width. It consists of approximately 500 feet of lava and has been cut through by Rogue River to expose the old basalts and agglomerates. This particular

1. Callaghan, E.: op. cit., p. 246.

flow has been described by Smith (1) as having poured from Mount Mazama.

The Big Butte Creek tongue extends approximately the same distance westward, reaching nearly to the juncture of Big Butte and McNeil Creeks, averaging about two miles in width. This flow forms the flat, terrace-like structure on which Butte Falls is located, and has been partially cut through by Big Butte Creek. It is thought to have been derived from Mt. McLaughlin to the southeast.

Specimens L-82 and L-83 from near Butte Falls are characteristic of the rocks of both strips. This is especially true of the former sample which appears quite porous with a gray groundmass in which crystals of olivine can be seen, some of which are green, while others are stained brown. L-83 is more compact with brown and black crystals of altered olivine contrasting sharply with the fine gray groundmass.

In the thin sections these two specimens show a diabasic texture, with many small grains of augite interstitial between laths of feldspar. The olivine ranges from tiny grains to crystals 3 mm. in length. These crystals

1. Smith, W. D.: Summary of the Salient Features of the Geology of the Oregon Cascades, Univ. Oregon Bull., n.s. v. 14, no. 16, Dec., 1917.

Fig. 20. Intercanyon lava surface near Butte Falls, with a 1° dip to the northwest.

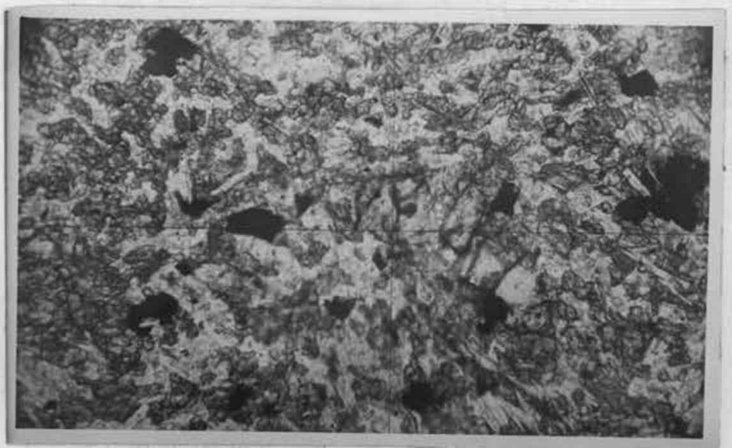

Fig. 21. Photomicrograph of Intercanyon basalt, sample L-83. The texture is diabasic and the minerals shown are olivine, augite, magnetite, and plagioclase. Nicols crossed, 32 X.

are often euhedral, and frequently show a red iron oxide stain. In specimen L-83 many of them are almost entirely altered to opaque grains of magnetite.

The feldspar laths consist of labradorite and andesine which show albite and Carlsbad twinning, with some examples of a combination of both types. They show a definite tendency towards parallel orientation, which is destroyed in the regions immediately surrounding the olivine crystals.

This indicates that the order of crystallization was augite first, followed by olivine and then by plagioclase, with the iron oxide occurring later as a product of decomposition.

The thickness of these gray lavas varies from 10 to 600 feet, gradually thickening to the east. Dips are from 1 to 3 degrees to the west in the Rogue River area and 1° to the northwest in the vicinity of Butte Falls.

They form terrace-like flats (fig. 20) which have been little dissected by erosion, but where such partial dissection has taken place, narrow gorges, cliffs and cascades are characteristic. The region around Cascade Gorge offers an excellent example of the physiographic feature. As a whole, the topographic age of these Intercanyon lavas is very young in comparison to the mature stage shown by the older rocks, and is definitely younger than that of either the Olsen Peak or Whaleback lava surface.

Fig. 22. Basalt dike cutting a basalt flow along the Crater Lake Highway west of Cascade Gorge.

Fig. 23. Basalt exposure showing columnar jointing, resembling a plug.

Tertiary Intrusives

Nearly all the formations of the area are cut by basalt, rhyolite, or diorite intrusives. The exceptions (the rocks in which no dikes were reported) are the Jurassic sediments, the younger basalts, and the Quaternary alluvium and washed pumice deposits.

The basalt intrusives are dikes which cut Tertiary beds, most of which are either agglomerates or other basaltic rocks. The greatest number of these basalt dikes occur in the northern half of the quadrangle with a strike of a few degrees east of north. A few may be found in the southern half of the area generally having the same trend. Some, however, in both sections are oriented nearly east-west, and a few bear slightly west of north.

They are mostly vertical and range in thickness from 2 to 10 feet and ordinarily are exposed for a length of not more than 100 feet. In a few cases, however, they may be traced for as much as a quarter of a mile, and one just south of Falcon Butte outcrops over a distance of two miles.

Effects of baking are shown in the rocks surrounding some of these basalt dikes, especially where they have cut through the agglomerates. Calcite and zeolite mineralization was noted in connection with two east-west dikes along the Tiller-Trail highway, a few hundred feet south of the Divide Guard Station.

One basalt dike was found in the May Creek schists near Railroad Gap, and one, a basalt porphyry, was reported in the Umpqua formation in the Meadows district (1). In a few localities, dikes of basalt apparently cutting through rhyolite were reported, which would indicate that the rhyolites are older than some of the basaltic intrusives. For example, three parallel basalt dikes are found in an area of rhyolite, approximately a mile southeast of Elkhorn peak. This locality is not more than three miles from the western margin of the Whaleback lava area, and the dikes could be associated with that flow. The dike rocks, however, resemble the older basalts except for being slightly coarser-grained.

The textures of these basaltic dike rocks range from fine to coarse-grained, but ordinarily are not noticeably coarser than the basalt flow rocks. The characteristic horizontal columnar jointing is at right angles to the walls.

Two specimens taken from T. 32 S., R. 1 E., show the usual differences in texture and mineral composition in the different dikes. L-152 comes from a basalt dike in agglomerate, which strikes N17°W, across Elk Creek in Sec-

1. Wells, F. G., and Waters, A. C.: op. cit., p. 52.

tion 26. Specimen WL-135 was taken from another dike, striking N50°W. in Section 10.

The former is a greenish-gray basalt with an aphanitic groundmass and occasional green phenocrysts of hornblende up to 12 mm. in length. Tiny white veinlets of calcite cross the rock, usually at right angles to the slender hornblende crystals.

Microscopically, it has a porphyritic holocrystalline texture, with mineral constituents of plagioclase, hornblende, magnetite, apatite, and calcite.

The phenocrysts are hornblende, showing extinction angles of from 8° to 17), in a felty groundmass composed of needle-like microlites of feldspar.

The accessory minerals are gray apatite and black, shiny magnetite. Both occur in limited amounts of small euhedral crystals.

Tiny, subparallel veinlets of secondary calcite cross the section at regular intervals, following a system of small fractures which were evidently formed after the rock cooled.

The second specimen (WL-135) is a coarse-grained, black basalt, appearing equigranular under the hand lens, but in the thin section is seen to be porphyritic. It consists of plagioclase, augite, and hornblende phenocrysts and magnetite grains in a groundmass of tiny feldspar laths. The groundmass makes up about 50 per cent of the slide and is followed in amount by the phenocrysts of plagioclase. These phenocrysts are labradorite, showing albite (fig. 24) and some pericline twinning. The augite phenocrysts are fractured, and with the few crystals of pleochroic hornblende, form approximately 20 per cent of the section.

The accessory minerals (apatite and magnetite) together make up only 2 or 3 per cent of the total mineral constituents.

The exact ages of these dikes is questionable, but they are thought to be contemporaneous with some of the basalt lavas, and are definitely younger than the agglomerates. They are probably the result of several periods of intrusive activity.

The rhyolitic dikes are less numerous. They cut the agglomerates and other rhyolites, and to further complicate the basalt-rhyolite relationship problem, may occasionally be found cutting the older basalts. The basalts intruded by these acidic dikes are however, among the earliest of the older basalts, and it is probable that the rhyolites are younger than at least this particular phase of the older lavas.

Those cutting the agglomerates and basalts a re from 2 to 6 feet thick and are seldom exposed for any great distance, while those contemporaneous in the rhyolites are up to 15 feet in thickness and in one case, near Hawk Mountain,

Fig. 24. Rhyolitic dike cutting a basalt flow along Crater Lake Highway west of McLeod.

Fig. 25. Photomicrograph of basalt dike (?) rock, Note albite twinning in plagioclase. Mineral constituents are plagioclase, augite, hornblende, and magnetite. Crossed nicols, 32 X.

nearly a half a mile in length. All are vertical as to dip, and some show the same type of horizontal, columnar jointing which is characteristic of the basaltic dikes.

The agglomerates cut by these acidic dikes nearly always show the effects of contact metamorphism in discoloration and general baked appearance of the immediately surrounding material. Such exomorphic effects are also shown in a few cases where the basalts have been cut by these intrusives.

The diorite instrusives occur in four small, slightly elongate patches in T. 31 and 32 S., R. 2 E. The exact type of intrusive represented by these rocks is questionable, as is their age. They are considered however, to be slightly younger than the older basalts.

Thin sections show these diorites to be of medium-grained, diabasic texture. WL-99, described in the following paragraphs, is an average specimen.

Plagioclase is the principal mineral constituent, consisting of labradorite and a trace of oligoclase with extinction angles of from 0 to 8°, showing some alteration to kaolin. Green, pleochroic hornblende occurs in crystals showing hydrothermal alteration to serpentine. There is some augite but it shows no such alteration. Together these pyroboles make up 25 per cent of the rock. Quartz is present only as a minor constituent, appearing in minute, rounded grains, and a few crystals of apatite and magnetite occur as accessory minerals.

Quaternary Deposits

The only beds in the area definitely Quaternary in age are washed pumice beds and the recent alluvium. The former consist of stratified gravels containing volcanic ash, pumice, and carbonized wood. They occur principally in the Rogue River valley, but some were reported in the South Umpqua and Jackson Creek valleys.

Along Rogue River, they appear in patches from Rogue Elk east to the edge of the quadrangle, gradually increasing in thickness and width to the east till they form a blanket over the intercanyon lava surface. North of Prospect, this blanket is so complete that the lavas can be seen only where streams have cut through the pumice beds.

In mapping, they were included with the recent alluvium, and designated as "Qal".

The beds along the South Umpqua River and Jackson Creek are less extensive and contain little besides pumice, silt, and volcanic ash. These beds are not extensive enough to be considered a mappable unit, and are merely noted as being present.

The material in both localities is evidently of similar origin both as to time and source, and is probably the equivalent of that making up the pumice deposits of the eastern Cascades (1). It is apparently the result of eruptions of Mt. Mazama which spread the pumice and ash over a considerable area, clogging the streams and causing them to deposit their load in the form of terraces. In both localities the beds are from 100 to 200 feet above the present stream level, indicating the approximately equal amount of erosion in the two valleys since the time of the deposition of this material.

Recent alluvium occurs principally along Rogue River and its major tributaries, namely: Big Butte Creek, Evans Creek, Reese Creek, and Long Branch Creek.

This alluvium is the result of the rapid erosion of the streams in their upper reaches and the deposition of their load when they became overloaded, or decreased in gradient in the lower valleys. Most of this material is found in the southwest quarter of the quadrangle, either immediately along Rogue River, or at points where tributaries reach the comparative flatness of that river valley.

The alluvium consists of unstratified gravels, sands, and silts varying in thickness from 2 to 50 feet. It was

1. Diller, J. S., and Kay, G. F.: U. S. Geol. Survey, Geol. Atlas, Riddle Folio, Oregon, No. 218, p. 6, 1924.

mapped only where beds were of sufficient vertical and horizontal extent to form mappable unites.

GEOLOGIC HISTORY

The geologic history of the area during the Paleozoic and Mesozoic eras can be considered as generally similar to that of the Riddle area during the same eras.

The history can be interpreted in part as far back into the Paleozoic as Devonian, during which time the fine May Creek sediments are thought to have been deposited. They are of marine origin (1), indicating that the regeion was submerged during at least part of the Paleozoic.

The presence of limestone fragments (see description of specimen WL-18, page 37) in the agglomerates of Sec. 10, T. 33 S., R. 2 W., suggests that Paleozoic limestones were once present and is further evidence that the region was under water during much of the era.

Little record of early Mesozoic events is shown in the quadrangle, but late Jurassic was marked by the deposition of the marine sediments of the Dothan and Galice formations. During this part of the Mesozoic era, and probably prior to the deposition of the Galice and Dothan sediments, the original gabbroid rocks of the greenstones

1. Diller, J. S., and Kay, G. F.: Ibid, p. 7.

were intruded. The end of the Jurassic period was characterized by folding and faulting which resulted in alteration of the gabbros to greenstones and the metamorphosis of the May Creek, Dothan, and Galice sediments. This was accompanied or immediately followed by the intrusion of the rocks of the quartz diorite group.

No record of the remainder of the Mesozoic is present, but this area probably compared to regions to the north, south, and west in which the land subsided during Cretaceous and more sediments were laid down, with an uplift at the end of the period. The Klamath Mountains were raised at this time, and the uplift formed the Onion Springs Mountain divide in the Riddle area (1). Mesozoic and Paleozoic rocks form the Rogue-Umpqua divide (a continuation of the one just mentioned) nearly as far east as Diamond Rock, which is evidence that this uplift extended at least that far into the Butte Falls quadrangle.

Since early Eocene time, the highlands of the Klamath Mountains and the Onion Springs Mountain divide have shut off marine waters from the Rogue River valley area (2), and the Umpqua sandstones, conglomerates, and shales of

1. Diller, J. S., and Kay, G. F.: Ibid., p. 7.
2. Diller, J. S., and Kay, G. F.; loc. cit. p. 7.

this region were probably laid down in a lake basin. These sediments were evidently derived from highlands to the southeast (1), and the granitic, basaltic and cherty pebbles in the conglomerates suggest that the highlands were composed of these types of rocks.

The climate during most of early Tertiary was evidently warm and vegetation was undoubtedly quite rank, but the redness of some of the Umpqua sandstones suggest that a part of middle Eocene was arid. Proof of the extensive forestation during much of the period is in the large quantities of fossil wood and leaf material found in both the Umpqua formation and the agglomerates.

The remainder of the Tertiary consisted of periods of volcanic activity followed by times of relative quiet. There were at least four such major epochs, the earliest actually represented being the explosive activity which resulted in the forming of the agglomerates. The andesitic and basaltic fragments in the agglomerates indicate that these rocks were once present in the area, but were mostly stripped away before the explosive activity began. The volcanic conglomerates contain rounded boulders which were evidently derived in part from the erosion surface, while the upper agglomerates include fragments which ap-

1. Smith, W. D., and Packard, E. L.: Salient Features of the Geology of Oregon, Jour. of Geol. v. 27, no. 2, pp. 79-120, July, 1919.

pear to have been torn from the older rocks in the walls of the conduits.

During the time of explosive activity, dust and fragmental materials were blown into the air, with the finer particles falling farther from their sources than did the heavier ones. Other explosive material evidently fell near the vents, still molten enough to weld together and flow like other lava, forming flow breccias. The earliest of this explosive material fell during a time of active erosion resulting in the deposition of the volcanic conglomerates as stream terraces. Vents were evidently local and rather closely spaced.

The period of quiet following these volcanic outbursts saw the surface of the agglomerates severely dissected before volcanic activity started again; this time in the form of basalt flows from such sources as Round Top and Abbott Butte. Varying periods of time occurred between individual basalt flows, some of them long enough to form slight erosional unconformities. This type of igneous activity occurred intermittantly from late Eocene to middle Miocene (?) accompanied by the intrusion of the numerous basalt dikes.

Following the black basalt flows, or possibly occurring between some two of the younger ones, rhyolitic lavas poured out over the area in thin but extensive sheets. They were largely from local vents and were interspersed with explosive outbursts which formed the tuffs and interbeds of rhyolitic breccia. The last of this group of siliceous lavas was local vitrophyre flows. Associated with these upper Miocene (?) rhyolitic lavas was some intrusive activity and considerable normal faulting.

From the end of Miocene (?) till at least the latter part of Pliocene, apparently no igneous activity occurred in the area. Instead, erosional forces were at work dissecting the older rock surfaces and forming a number of the valleys which are now present. It was over part of this surface that the Whaleback and Olsen Peak gray olivine basalts were extruded, and later, down some of these valleys, that the Mt. Mazama and Mt. McLaughlin intercanyon basalts flowed.

The intercanyon flows marked the last of Tertiary (or possibly the first of Quaternary (1)) igneous activity, during which time this portion of the Cascades had been built by the piling up of great thicknesses of these Tertiary lavas.

The only definitely Quaternary igneous activity that is now represented in the quadrangle, was the explosive outbursts of Mt. Mazama which resulted in the deposition of a pumice blanket which has been partially reworked to

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1. Smith, W. D: Summary of the Salient Features of the Geology of the Oregon Cascades, Oregon Univ. Bull. v. 14, no. ly, pp. 44-45, 1917.

From the time this pumice blanket was spread over the region around Mt. Mazama to the present, the area has been in a state of quiescence. Erosion has been proceeding at a moderate rate, with alluvial beds being deposited in the lower valleys.

PHYSIOGRAPHY

The quadrangle lies in the western foothills of the Cascade Range and may be divided topographically into two parts. The southwestern section is a relatively smooth area with wide flat valleys and comparatively gentle slopes. Most of the remainder is rugged and mountainous. The lowest point is on the northwest border where the South Umpqua river flows out of the quadrangle at an elevation of 965 feet, and the highest is at Abbott Butte with an elevation of 6140 feet, giving a range of 5,175 feet.

The dominating topographic feature is the Rogue-Umpqua divide which extends across the area in a general northeast-southwest direction. Peaks rising from this divide range from 4500 to 6200 feet in elevation, with the crest of the divide gradually declining from northeast to southwest, dropping about 2,000 feet between the Abbott Butte and Railroad Gap Lookouts.

Drainage is principally to the west and the two major units are the Rogue and South Umpqua River systems. Rogue River and its tributaries drain the region south of the main divide, about two-thirds of the entire area, while the South Umpqua system carries off the water from the northwestern portion. Big Butte Creek, Elk Creek, Trail Creek, and the East Fork of Evans Creek are the principal tributaries of Rogue River, while the South Umpqua depends mostly on Jackson Creek and Elk Creek for its water supply from within this quadrangle.

Both rivers show some seasonal variation in volume, but due to the heavily forested areas in which they head, the immediate rainfall run-off there is not great, and winter and spring floods are not particularly destructive.

The physiographic age of the general area is mature and the region can be described for the most part as a maturely dissected lava plateau.

The uplands have been mostly reduced to ridges or divides separated by the main streams, the Rogue and Umpqua, and their well-developed tributaries. These streams are still vigorous, for they make the descent from the highlands of the western Cascades to the lower elevations to the west.

Variations in physiography occur however, in different parts of the area. On the western border, in regions underlain by the Umpqua or older formations, stages of late maturity have been reached locally in the erosion cycle. For example, the lower Rogue River valley broadens into a wide flat plain, and the surrounding uplands consist of low rolling hills.

In contrast to these local areas approaching old age are the youthful regions of little-dissected Intercanyon basalts. These regions are characterized by a few narrow, rugged steep-walled valleys, carved in a nearly flat lava plain.

The present appearance and the past history of this part of Rogue River valley has greatly depended on the types and ages of the rocks through which it is cut. This large valley was evidently partially formed by middle Tertiary time, with the older rocks being less resistant and therefore more quickly eroded than the Tertiary lavas. In late Pliocene or early Pleistocene the upper valley was filled to a depth of several hundred feet with the Intercanyon lavas and later pumice deposits, causing local rejuvenation. This produced a period of renewed erosional activity in the history of the river, with greater deposition of sediments in the lower valley.

As a result, three stages of development are shown in the valley in crossing the quadrangle. Along the eastern border and nearly as far west as McLeod, it is extremely youthful, and from this point southwest to Shady Cove appears mature. The remainder of the valley widens, and reflects the stage of late maturity or early old age.

Another problem in stream development is shown in the Meadows district, where Evans Creek has apparently captured the headwaters of what was once upper Table Rock Creek. Wells and Waters (1) have attributed this capture of headwaters to the impeding of downward cutting in Table Rock Creek by volcanic rocks. It is the author's opinion, however, that the cause of this piracy was one or more normal faults extending approximately east-west across the southward flowing creek, with the downthrow side to the north. This would have caused the waters to the north of those faults to drain along the fault lines westward to join Evans Creek which was moving very slowly eastward by headward erosion.

Evidence of this piracy is found in the peculiar behavior of the stream. It flows south over Umpqua beds, till it suddenly makes a right angle turn to flow westward in a narrow gorge, across what was once a north-south

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1. Wells, F. G., and Waters, A. C.: Quicksilver Deposits of Southwestern Oregon, Geol. Soc. Amer. Bull., 850, p. 23, 1934.

Fig. 26. Panoramic view from Needle Point towards the east and southeast. Shows physiographic features typical of entire area.

Fig. 27. Mt. Thielson and Crater Lake rim as seen from Round Top.

ridge of hard May Creek schists. Also, the headwaters of Table Rock Creek, flowing southward in a direction in line with upper Evans Creek, appear inadequate to have produced some of the features of the valley in which it now flows, indicating the former presence of a larger stream.

Field examination showed minor faulting associated with some mineralization along the road which follows Evans Creek westward out of the area, while topographic evidence and an examination of areal photographs substantiate this theory of faulting.

From this evidence, it seems unlikely that the erosion of Evans Creek alone has produced the cutting of the deep, narrow canyon and it is nearly certain that faulting was responsible for at least speeding up the process.

In general, the area is characterized by lava masses rising from 1000 to 4500 feet above the valleys, creating the aspect of monadnocks above an uplifted and maturely dissected penaplain. No evidence of penaplanation was found, however, and these peaks are thought to represent old lava cones rather than erosional remnants.

STRUCTURE

In general the structure of the region is simple, consisting for the most part of homoclinal dips, a limited number of folds, and a large number of normal faults.

Paleozoic and Mesozoic formations have been subjected to a greater number of deforming stresses than have the younger rocks. Therefore, as a rule, they show higher dips, and more faults than the later formations, and contain most of the folding that was observed.

The May Creek schists and the Dothan and Galice formations generally trend northeast, having only slight local changes in strike. Dips vary greatly in these old rocks, but average 40° or more to the southeast.

The Umpqua formation has a general dip of 7° to the east, with varying local dips in other directions. For example, these beds in the Meadows district dip strongly to the northwest as a result of faulting. The Umpqua formation as a whole is said to have been folded into broad anticlines and synclines which were beveled by erosion before the deposition of the pyroclastics (1). Little folding has been found in Umpqua in the Butte Falls area, and no erosional unconformity is definitely shown between it and the agglomerate beds.

The older Tertiary lavas, amounting to approximately 6,000 feet in thickness, have a general north-south trend, with a homoclinal eastward dip of from 2° to 10°. This eastward dip is attributed by Smith (2) to the sinking of

1. Wells, F. G., and Waters, A. C.: op. cit., p. 11.
2. Smith, W. D.: Summary of the Salient Features of the Geology of the Oregon Cascades, Oregon Univ. Bull., v. 14, no. 16, p. 45, 1917.

the earth's crust subsequent to the piling up of thousands of feet of lava during late Tertiary time. Faulting or sinking associated with the migration of a great batholith is another possibility. This tilting evidently occurred before the time of the younger basalt flows in the area, for their original structure has not been affected by any such action and they usually dip to the west rather than to the east.

The local dips of the agglomerates vary widely in amount and direction, which may be attributed partially to faulting, but primarily to the overlapping flows from closely spaced local vents. But, where no such factors have influenced them, the dips conform with the homoclinal eastward tilt of most of the older Cascade flows.

As has been stated in previous paragraphs, the gray olivine basalts show a definite contrast in structure to the older lavas. The youngest of these, the Intercanyon basalts, exhibit this contrast best, with their persistent 1° to 2° westward or northwestward dip opposing the regional, eastward tilt shown by the agglomerates, black basalts, and rhyolites. It is thus evident that there has been little deformation in the area since Pliocene time.

Numerous faults were observed, all being of a normal type, and the presence of others is suggested by alignment of valleys, apparent vertical offsets, and general topography. The amount of displacement is ordinarily difficult to determine, but movements up to 200 feet have been noted.

The pattern is discontinuous, but a northwest trend is common to a great number of these faults. They occur in nearly all the rocks of the area as a result of at least two periods of faulting. Those in the Paleozoic and Mesozoic formations were largely formed at the end of the Jurassic period, while the ones in the Tertiary lavas were produced as a result of deformation probably during late Miocene.

ECONOMIC GEOLOGY

Cinnabar

The mineral of greatest economic importance in the quadrangle is cinnabar. It occurs in epithermal deposits as a result of hydrothermal action, in rocks that have been fractured or faulted. As a result of the hot solutions, the country rock around such mineralized areas has been severly altered, and brown ribs of siliceous iron oxides and carbonates usually appear in it as surface indications of the mineralized zone. These ribs are often found in the rocks of the lower rhyolite group, but are not always an indication of the presence of a quicksilver deposit.

The cinnabar occurs in streaks along fractures and in fault gouge, as specks in the iron ribs, and is often disseminated in the fault breccia.

The associating sulphides are pyrite, marcasite, and possibly arsenopyrite, and the usual gangue mineral is calcite. Samples from the Roxana Group of claims show minute marcasite bodies as a matrix surrounded by halos of cinnabar (1).

In every case these mercury deposits are in or near the Tertiary volcanics, making up a part of the cinnabar belt described by Wells and Waters (2), as extending from Southern California to Morton, Washington, Where deposits occur in rocks other than the Tertiary volcanics, they are never at any great distance from the western margin of these lavas.

The rocks in or near which nearly all the cinnabar is found are rhyolites, or rocks closely resembling rhyolites, and the mineralization can be approximately dated as late Miocene.

The mines which are now in operation are the War Eagle and the Red Cloud. Other properties have shown much development, but these two have the only commercial equipment that has been installed.

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1. Wilkinson, W. D.: Advance Report on Some Quicksilver Deposits of the Butte Falls Quadrangle, Oregon, State Dept. Geol. & Min. Ind., G.M.I. Short Paper, no. 3, p. 9, 1940.
2. Wells, F. G., and Waters, A. C.: op. cit. p. 25.

The War Eagle, Roxana, Chisholm, Quicksilver Producers Co., Red Cloud, and Niverson properties are in the May Creek and Umpqua formations. All but the last two are within the Meadows district, and show mineralization along two systems of faults, the one north-south having been cut by an approximately east-west set.

The Trail or Rogue Elk mining district includes several claims along Rogue River in the vicinity of Rogue Elk. The properties examined were the Rogue Elk, Ash, Rayomes Land, and Poole Claims, all in Twps. 33 and 34 S., R. 1 W., and R. 1 E.

Mineralization occurs in faulted and fractured areas in the agglomerates, lower rhyolites, and in one case, old basalts. It is usually associated with small rhyolitic and possibly andesitic dikes which cut through these formations. The faults are not consistent as to direction or dip in the different properties, but seem to be slightly separated representatives of a single fault zone. In every case there is a complicated network of tiny faults and fractures showing iron ribs, with an occasional fault with considerable displacement.

All these claims have been described in detail by Wilkinson (1) in an advanced report on the quicksilver

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1. Wilkinson, W. D.: op. cit. pp. 1-9, 1940.

prospects of the quadrangle, and by Wells and Waters (1) in a publication on all the quicksilver deposits in southwestern Oregon.

Gold

Gold is obtained principally from the Al Sarena mine and some small scale placer workings, rating next to cinnabar in economic importance.

The Al Sarena mine is located in Sec. 29, T. 31 S., R. 2 E. approximately 20 miles northeast of Rogue Elk. It is owned by the Al Sarena Mining Company and includes 21 or 22 claims, none of which are patented.

The following description is based on field work and on reports by Callaghan (2) and Sopp (3).

The mine is on the headwaters of Elk Creek at an elevation of approximately 4,000 feet. Rocks exposed in the mine workings and in the immediate vicinity are tuff-breccias and rhyolites with dikes of rhyolite and basalt or andesite, all of which have been severly altered by epithermal solutions. Pyrite has been changed to hema-

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1. Wells, F. G., and Waters, A. C.: op. cit. pp. 1-58.
2. Callaghan, E., and Buddington, A. F.: Metalliferous Deposits of the Cascade Range, Oregon, Geol. Surv. Bull. #893, pp. 23-24, 1924.
3. Sopp, G. P.: Personal Report on Geology of Al Sarena Mine, Oregon, July, 1940.

tite and a generally leached appearance prevails in the country rock in the immediate mine vicinity.

Gold is found in brecciated fault zones associated with quartz, galena, sphalerite, pyrite, and arsenopyrite. The sulphides often occur in euhedral crystals, especially pyrite and galena. One specimen shows cubes of galena up to 1/2 inch in length, associated with tiny cubes and octahedrons of pyrite. The mineralization was evidently contemporaneous to that of the cinnabar deposits in late Miocene (?) time.

Nearly all the production has been from a vein striking N.45°W. with a vertical dip. Most other veins have northwest strikes, and all have relatively steep dips. They contain narrow gouge seams near one or both walls, commonly "frozen" to the walls. The walls themselves often require timbering, and are not always definite in outline.

The total underground workings amount to a little more than 5000 feet, and the ore is mined by shrinkage stope methods. The ore dressing equipment consists of a jaw crusher, ball mill, jig, classifier, two concentrating tables, a cyanide leaching plant, and a battery of flotation cells. Power is furnished by diesal engines and compressors. Water is obtained from Elk Creek, and the timbering material is available from the estimated 12,000 board feet on the mining claims.

The production at the present is small, due to the but recent reopening of the mine, but can be expected to increase in the near future. The total production up to 1918 was $24,000, mostly in gold, but including some silver and lead.

Placer gold is mined in various parts of the quadrangle, principally in the Coffee Creek, Sams Creek, and Upper Cow Creek regions. It is produced on a small scale and by various individuals, which makes an accurate estimate of the total amount obtained annually from the quadrangle impracticable.

Other Minerals

Copper was produced at one time from the Rowley mine in Sec. 4, T. 32 S., R. 2 W. The ore mineral was chalcopyrite occurring in brecciated fault zones in the May Creek schists. The mineralization can be assigned to the same period as that of the cinnabar, and the mineralized zone is in the same belt, along the western margin of the Tertiary lavas.

Two deposits of chromite occur in the greenstones near Drew, but are small in magnitude, and the claims are not recorded.

Mineral springs, zeolites, calcite, and reported beryllium deposits are very interesting, but none are now of commercial importance. The quartz geodes, agates, and fossil wood which are quite plentiful, are gathered, polished and often sold by the great number of agate collectors in the vicinity.

Summary

At this time, cinnabar and gold are the most important economic minerals, but their production is limited. The only chromite deposits that have been reported are too small to be of commercial importance, but further investigations may result in the discovery of larger bodies. However, the amount of development work being done, and the present world-wide interest in mineral production indicate and excellent possibility for the advancement of the mining industry in this area.

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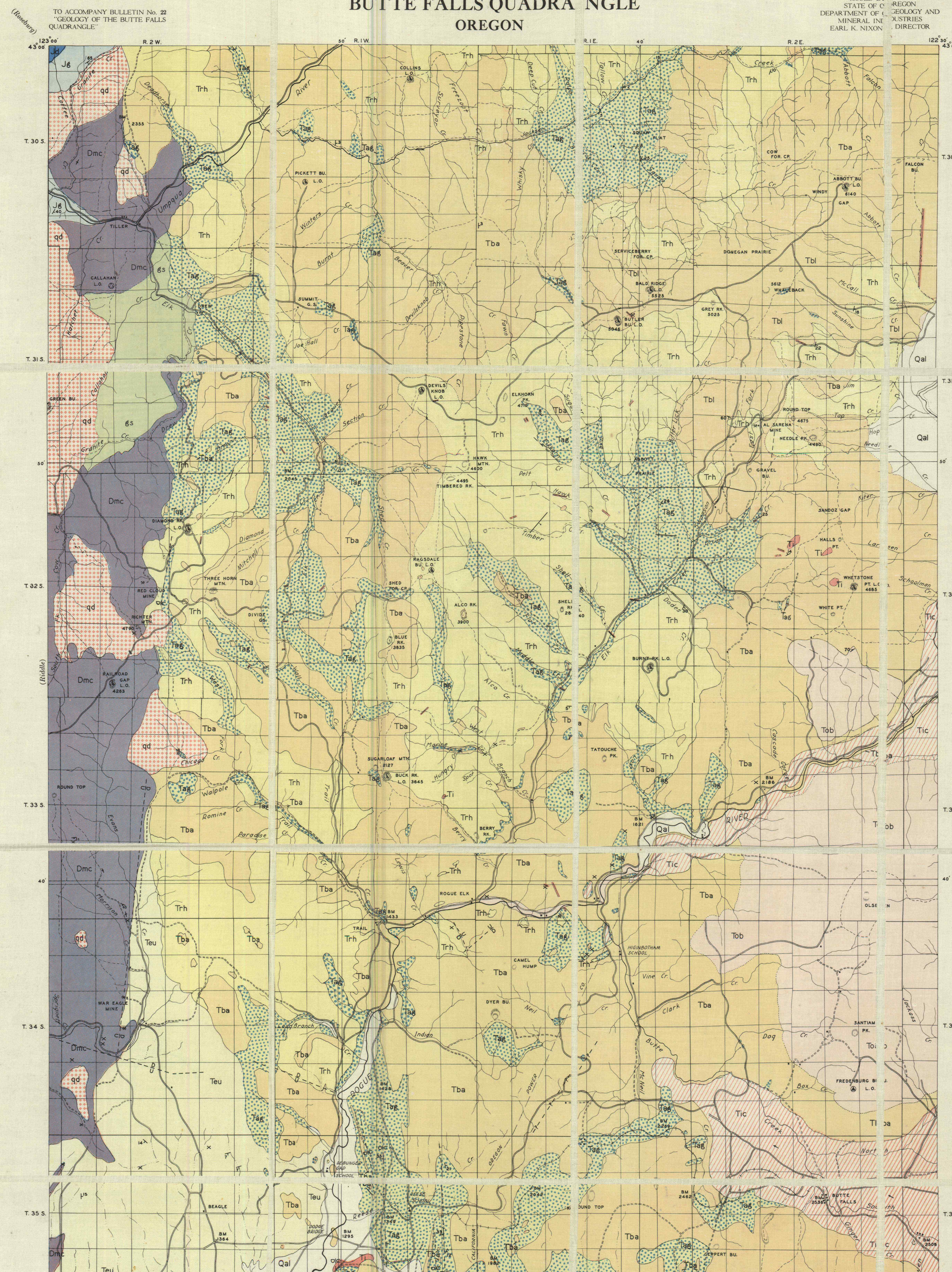
PLATE I

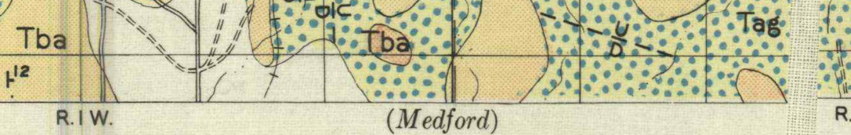
RECONNAISSANCE GEOLOGIC MAP
OF THE
BUTTE FALLS QUADRANGLE
OREGON

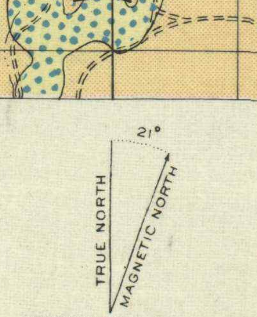
TO ACCOMPANY BULLETIN No. 22
"GEOLOGY OF THE BUTTE FALLS
QUADRANGLE"

ISSUED BY THE
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND
MINERAL INDUSTRIES
EARL K. NIXON, DIRECTOR



Base by United States Forest Service
Umpqua National Forest Map—1939





Geology by W. D. Wilkinson,
John Eliot Allen, Wayne Lowell,
Wallace Lowry, Murl Hutchinson,
Herbert Harper, Robert Littleton,
Richard Meade, Stewart Jones.

Datum mean sea level

1941

EXPLANATION

QUATERNARY

Qal
Alluvium
(Stratified gravel, sand, silt and pumice)

UNCONFORMITY

TERTIARY

Tertiary volcanic rocks

Ti
Intrusive
(Diorite sills and basalt dikes)

UNCONFORMITY

Tic
Later basalt flow
(Light gray intracanyon olivine basalt flows)

UNCONFORMITY

Tbl
Basalt flows
(Light gray Abbot Butte basalt flows)

Tob
Basalt flows
(Gray Olsen Peak basalt flows)

UNCONFORMITY (?)

Trh
Rhyolite
(White to buff rhyolite flows, tuffs and breccias)

Tba
Older basalt flows
(Black, coarse textured basalts)

UNCONFORMITY (?)

Tag
Agglomerate
(Green agglomerates, tuffs and flow breccias)

UNCONFORMITY (?)

Sedimentary rocks (Eocene)

Teu
Umpqua formation
(Buff sandstones, shales and conglomerates)

UNCONFORMITY

JURASSIC

Intrusive rocks

Qd
Quartz diorite
(Intrusive masses, dikes and related rock)

UNCONFORMITY

Metamorphic rocks

jd
Dothan formation
(Hard sandstones, shales and conglomerates)

UNCONFORMITY (?)

jg
Galice formation
(Slightly metamorphosed shales, some sandstones and conglomerates)

UNCONFORMITY

gs
Greenstones
(Slightly metamorphosed basalts, gabbros and related rocks)

UNCONFORMITY

DEVONIAN ?

Dmc
May Creek formation
(Mica schists and slates)