AN ABSTRACT OF THE THESIS OF

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The Lebanon Quadrangle is, physiographically, divided into two dissimilar parts, the valley lowland portion in the western half and the Cascade foothills in the eastern half. The valley portions of the quadrangle possess very little relief due to extensive alluvial deposits. The higher foothill portions of the area have undergone considerable dissection and hence show a rougher topography, a relief of 300-900 feet being common.

Dra inage of the area is effected principally by the North and South Santiam rivers which are local tributaries to Willamette River.

The geologic column includes: (1) Eugene formation--a series of east dipping marine sandstones, shales and conglomerates of Oligocene age outcropping on Peterson Butte and east of Lebanon. (2) Berlin Volcanics, an undifferentied series of a ir-laid tuffs and breccias overlying the Eugene formation. The chief outcrops occur in the southeast portion of the quadrangle. (3) Scio beds--a series of fluviatile sandstones, tuffs and conglomerates occurring in the east central portion of the quadrangle, prevailingly dipping northeast about 12 degrees. These beds contain an abundance of fossil leaves and are thought to occupy approximately the same stratigraphic position as do the Berlin Volcanics in the southeast portion of the quadrangle. (4) Stayton lavas--a series of olivine basalt flows commonly dipping about 2 degrees in northwestern direction. Unconformably overlying the older formations. The gabbo of Peterson Butte is thought to be an intrusive phase of this same igneous activity. T hese rocks are regarded as Miocene in age. (5) Quaternary alluvial deposits--a series of gravels and silts corresponding to Nebraskan, Kansan, Illinoian, Wisconsin, and Recent stages. These stages are represented by separate deposits that were set apart by considerable intervals of erosion. Each of these deposits exhibits a distinctive topographic position and degree of weathering.

The chief economic products are soils, water, water power, road metal, gravel, and clay.

THE GEOLOGY OF THE LEBANON QUADRANGLE, OREGON

by

Wayne Moore Felts

A THESIS

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INTRODUCTION

Geographical Relationships. The Lebanon Quadrangle, described in this paper, extends from latitude 44° 30′ N to latitude 44° 45′ N, and from longitude 122° 45′ W to longitude 123° 00′ W, and includes one sixteenth of a "square degree" which fraction at this latitude is equal to approximately 207 square miles. Most of this area, except the extreme northwest corner which is in Marion County, is located in Linn County, Oregon. The largest settlement in the area is the city of Lebanon (pop. 1,851) from which the quadrangle has been named.

Physiography and General Geology. The western part of the quadrangle is in Willamette Valley proper, a lowland cut into early Tertiary sediments and subsequently floored with a series of Pleistocene and Recent alluvial deposits. These Quaternary formations are expressed as nearly flat valley plains or terraces whose heights depend on their relative ages, the higher terraces being expressions of the older formations.

The relatively smooth surfaces of these alluvial deposits are interrupted in places by steep sided buttes such as Peterson Butte in the extreme southwest corner of the area. Some of these buttes are old basaltic and diabasic volcanic necks that have been intruded through the Tertiary sediments underlying the valley floor, and others are buttes of old sediments protected from erosion by cappings of basalt.

The surface features in the eastern part of the area are those common to the foothill region of the Cascade Mountains. The relief ranges generally between two hundred and nine hundred feet and the lithology is characterized mainly by tuffs, breccias, and basalts such as are found in the older portions of the Cascade Mountains exposed elsewhere, notably in the Columbia River Gorge. The andesites and andesitic tuffs of the later Cascades lie to the east entirely beyond the limits of this quadrangle.

Drainage. The area is well drained by the local tributaries to the Willamette River, mainly the North Santiam and the South Santiam Rivers which converge and join Willamette River near Jefferson, not far from the extreme northwest corner of the area. The South Santiam and its tributaries drain most of the central, southern, and eastern parts of the area. The main tributaries to the South Santiam River in ascending order from north to south are Thomas, Crabtree, Onehorse, and Hamilton Creeks. The North Santiam River drains only the northwest corner of the area. A narrow strip along the west is drained by sloughs and creeks that empty directly into Willamette River.

Climate. The climate is mild and equable but characterized by a wet and dry season. About eighty percent of the entire precipitation is received during the wet season which begins in October and continues to the latter part of April or the middle of May. Very little rain falls between the middle of June and the first of September. July and August are normally very dry, the average precipitation for these months being slightly less than one half inch. The precipitation averages about 60 inches a year.

The mean annual temperature is 52.3 degrees F. with a known maximum of 103 degrees F. in summer, and a minimum of 15 degrees below 0 F. in the winter. Two hundred and five consecutive frost-free days can be expected in the valley portions of the area.

Culture. Since the first settlement of this region, about 1840, agriculture has been the principal industry. Wheat, oats, hay, corn, and hops are the principal crops raised. Some of the hillside soils are admirably suited for the raising of fruits and nuts, and walnuts especially are fast becoming an important crop from this area.

After the opening of the railroads, and more recently, truck roads, logging and lumbering have become an industry of considerable importance in the foothill region along the eastern side of this area. At the present time, considerable logging is being done on the slopes of Prospect Mountain just east of Scio.

The quadrangle is well served by railroads, as the main line of the Southern Pacific from San Francisco to Portland crosses the northwest corner of the area, and three spur roads of the same company serve the outlying sectors.

A line from Lebanon to Sweet Home is operated by the owners of the Oregon Electric Railroad.

A system of fine market roads connects with the paved Santiam Highway which runs diagonally through the area from the northwest to the southeast. No point in the entire area is more than 2 miles distant from a road.

TOPOGRAPHY

Surface Features. This quadrangle can be divided into two distinct areas on the basis of the topography. These physiographic districts comprise: (1) Willamette Valley lowland in the western part of the area, and (2) the Cascade foothills in the eastern part. The Willamette Valley lowland, in this area, extends from the western edge of the quadrangle to an irregular line extending southward from Shelburn through Scio, Gilkey, Barr Bridge, and Lebanon to the south edge of the quadrangle. It includes the valley plains and terraces of the Willamette, North Santiam, and South Santiam rivers and their major tributaries. The foothill region extends from the a bove mentioned line to and beyond the eastern boundary of the area.

The foothill portion of the area is characterized by a higher elevation, 400 to 1200 feet above sea level, a greater average relief, and a much more rugged topography than occurs in the valley lowland. Dissection of this upland surface by the major tributaries of the South Santiam has resulted in a series of ea st-west ridges sloping to the west, and separated from each other by broad alluviated valleys.

East of Shelburn and north of Scio, a long broad-topped ridge slopes down from the east with an average gradient of 150 feet to the mile. This gradient appears to be also the average dip of the basalt flows composing the ridge, so the surface slope in this case reflects the underlying structure. The south edge of this hill is an escarpment of considerable height that marks the north wall of the valley occupied by Thomas Creek. Near Shelburn, a patch of old gravel several square miles in area is perched upon the nose of this basaltic ridge. A small tributary to Thomas Creek occupies a well developed valley that marks the contact between these two surfaces.

Directly south of Thomas Creek is a ridge very similar to the one just described, but due to its less resistant lithology much greater dissection had taken pla ce and the ridge has been broken up into three main divisions, Prospect Mountain, Franklin Butte, and Hungry Hill. This greater degree of dissection is due in the main to the softer tuffs and sandstones that underlie relatively thin basalt flows. Apparently the basalt flowed out onto a very irregular surfa ce or the contact has been folded as none of the tuffs found at an elevation as high as 800 feet above sea level on Franklin Butte and Prospect Mountain are in evidence on the ridge to the north of Thomas Creek. Instead the basalt extends down to the alluviated surface of the valley floor 325 feet above sea level.

Between Franklin Butte and Prospect Mountain is one of the most striking physiographic features of the entire area, Richardson Gap. This gap is a wind gap about one half mile wide at the narrowest place and floored with the gently sloping surface of a gravel fill. Prospect Mountain rises abruptly to an elevation of 1100 feet on the west. It is possible that this gap is an abandoned water course of Crabtree Creek which has subsequently been captured by a stream occupying the position of the present Crabtree Creek below the gap, but proof of such a history is lacking. It is more probable that this gap has been formed by headwa rd erosion by small opposing streams tributary to Thomas and Crabtree Creeks in much the same manner as the gap between Franklin Butte and Hungry Hill is being cut at the present time.

South of Crabtree Creek, due to the lack of a thick and extensive basaltic covering and to the softer rocks which outcrop in this district much more dissection has taken place. In the area between Crabtree and Onehorse Creeks where the quantity of basalt is small the soft tuffs and sandstones have been cut into low rolling hills. South of Onehorse Creek where pyroclastics are associated with minor amounts of basalt differential erosion of the softer tuffs and breccias has produced more relief than occurs in strictly basaltic or strictly sedimentary areas. Nevertheless this southeast portion of the quadrangle is generally more subdued than the areas covered by a sheet of basalt. Ridgway Butte and other similar hills in the southeast portion of the area owe their prominence to a covering of basalt.

The oldest alluvial surface, probably early Pleistocene in age, is perched on the foothills between Crabtree and Beaver Creeks. This surface covers an area of approximately 8 square miles on the rolling upland north and west of Lacomb. This surface slopes from 625 feet above sea level down to 500 feet near the edges of the upland where rapid gullying by headward eroding streams is taking place. The southern part of this surface is shown in Figure 2.

The valley portion of the area varies in elevation from 225 to a little above 400 feet above sea level. Except where interrupted by buttes of basic intrusives and older rock the relief is very small. It is expressed chiefly as initial or nearly initial slopes of the alluvial deposits or as low scarps between the different alluvial deposits which form the valley plains or terraces.

The oldest surface exposed in the valley lowland consists of remnants of a terrace composed, as is the older alluvial surface in the foothills, of old deeply weathered gravels. This is well exhibited on Sand Ridge in the extreme southwest corner of the quadrangle and in Sec. 31, T. 9 S., R. 1 W., east of Shelburn in the northern part of the area. The nature of the materials comprising this terrace, and the alignment and profile of the remnants suggests that this surface is all that remains of a once extensive fan deposit largely removed by later erosion. The elevation of

Fig. 1. Terrace of Sand Ridge gravel perched on northwest slope of Franklin Butte. Santiam surface in foreground.

Fig. 2. Surface of Sand Ridge gravels one-half mile southwest of Lacomb. Surface of Lacomb gravels in middle distance.

these deposits ranges from about 500 feet above sea level in the eastern part of the quadrangle to about 300 feet above sea level in the northwestern part. In most places this terrace is "rock defended" by the underlying basalt or older sediments which retard undercutting by streams. Locally strea m erosion has reduced the surface of this old fan to a gently rolling surface of low hills and shallow ravines, so only the profile alignment of the hill tops suggests the fan character of the original surface, but elsewhere flattish portions of from a half acre to nearly a square mile in area remain. These may be remnants of the original surface of this fan. Portions of this surface are shown in Figures 1, 2, and 3.

At an elevation of 300 feet or higher this old surface grades into, or more frequently, is separated from the next younger surface by an escarpment of from fifteen to fifty feet in height. This next younger surface is the most extensive of the alluvial surfaces in the area and comprises fans of coarse gravel brought down by the North Santiam and South Santiam rivers. The fan character of this surfa ce is especially clear west and northwest of Lebanon. The load of material brought down by the South Santiam was evidently spilled out between Ridgway and Peterson Buttes and spread to the west and northwest across the Willamette Valley lowland far beyond the limits of this quadrangle. This may be conveniently called the Santiam surface or the

Santiam fan. This fan slopes from 350 feet above sea level near Lebanon to less than 250 feet near East Knox Butte School, or about 10 or 12 feet to the mile. In the northern part of the area near West Scio the load of material brought down by the North Santiam River apparently wa s carried around the point of the ridge just to the east of Shelburn and spilled into the valley of Thomas Creek, forcing the creek southward against the north side of Hungry Hill. This fan in the northwest corner of the area is the southwest portion of the great Stayton fan which fills the Stayton basin to the north of the quadrangle.

This surface has not undergone the degree of dissection that characterizes the older surfaces. The major streams have cut trenches into this surface to a depth of 5 to 50 feet. The tributary streams and streams consequent to the fan surface have cut but very shallow trenches.

A low escarpment sometimes separates this extensive system of coalesced fans from the next younger surface. This surface, except where gullied by recent erosion, is a smooth terrace of silt sloping gently down valley. Within the area this terrace is rather limited in extent, the best exposures being near Crabtree, Balm, and Griggs. This silt, however, generally overlaps the lower slopes of the extensive fans of the next older surface and thus merges into it physiographica lly as the older profile passes beneath the silt. The age of this silt, and hence its surface is thought to be Wisconsin.[1] As explained on a subsequent page, the earlier alluvial deposits and hence their surfaces are assigned to Nebraskan (?), Kansan, and Illinoian stages of the Pleistocene.

The youngest surface consists of strips along the courses of the major streams, commonly a half mile wide but as much as three miles near the junction of the North Santiam and South Santiam Rivers. It is separated from the older surfaces by an escarpment that varies from five to fifteen feet in height. This surface includes the present flood plain and is characterized by channeled surfaces subject to periodic flooding by spring freshets. The age of a large amount of this surface may be considered as Recent, but remnants of a terrace between the modern flood plain and the silt terrace suggest a possible intermediate surface of late Wisconsin or early Recent age.

Thus the valley section of the quadrangle presents a large area of little relief----much of it in fact appears to the unaided eye to be nearly a level surface. The local relief consists mainly of recent trenches or gullies and the escarpments at the limits of the various valley terraces. The valley lowland section contains, however, the maximum relief of the entire quadrangle, from 325 feet above sea

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1/ Allison, I.S. Pleistocene Alluvial Stages of Northwest Oregon. Sci. n.s. Vol. 83, 1936 in press level on the surface of the Santiam fan to an elevation of 1430 feet on the summit of Peterson Butte, a vertical difference of 1105 feet in a horizontal distance of somewhat less than a mile. Miller Butte and Cemetery Hill in the extreme northwest corner of the quadrangle are hills of tuffs and basalts that rise to a conspicuous height above the general surface of the va lley.

Drainage. The drainage of the area is effected principally by the Santiam River, a local tributary to the Willamette River which is the master stream controlling the drainage of the entire area. The Santiam River is composed of two very dissimilar branches, the North and South forks. The total amount of water contributed by each fork is approximately the same, but the flow of the South fork is very irregular, the river falling very low in the summer time and being subject to excessive and violent floods. The North Fork, on the other hand, maintains a well established flow during the low water season.

An area of about 22 square miles in the extreme northwest corner of the quadrangle is drained by the North Santiam river. A pproximately 145 square miles are drained by the South Santiam and its tributaries. As the South Santiam river skirts the northeast edge of the Santiam fan, practically all of these tributaries join the South Santiam river from the foothill region to the east of the river. A n area of approximately 40 square miles on top of the Santiam fan is drained by Oak Creek which empties into the Calapooya River and by other small creeks which empty directly into Willamette River. These small streams are consequent to the surface of the Santiam fan.

The foothill portion of the area is well drained as the slopes are steep enough to provide a rapid runoff. In the valley portion of the quadrangle however, are large areas which are poorly drained. The reasons for this poor drainage are: (1) low slopes and consequently sluggish runoff, (2) "claypans", "ironpans", and similar underlying impervious layers which prevent surface water from sinking to the level of the ground water, and (3) rise of the water table to the surface of the land in wet seasons.

The U.S. Geological Survey has maintained guaging stations at Mehama on the North Santiam, and at Waterloo on the South Santiam. Both of these stations are situated on the upstream borders of the quadrangle and the records do not show the effect of the drainage of the Lebanon Quadrangle. An idea of the size of these streams as they enter the quadrangle may be obtained from the following guage readings.

North Santiam River at Mehama

Runoff in second feet Sep. 1927--Sep. 1928			sec. ft./sq. mile	Runoff	
max.	min.	mean		in.	acre feet
33000	626	3750	5.63	76.71	2,720,000

The maximum guage reading during the above period was 13.7 feet. The maximum guage reading recorded was November 20, 1921, with 62000 sec. ft. discharge reading at reading of 17.5 feet. The minimum recorded was 420 sec. ft. with a guage reading of 1.45 on September 18, 1924.

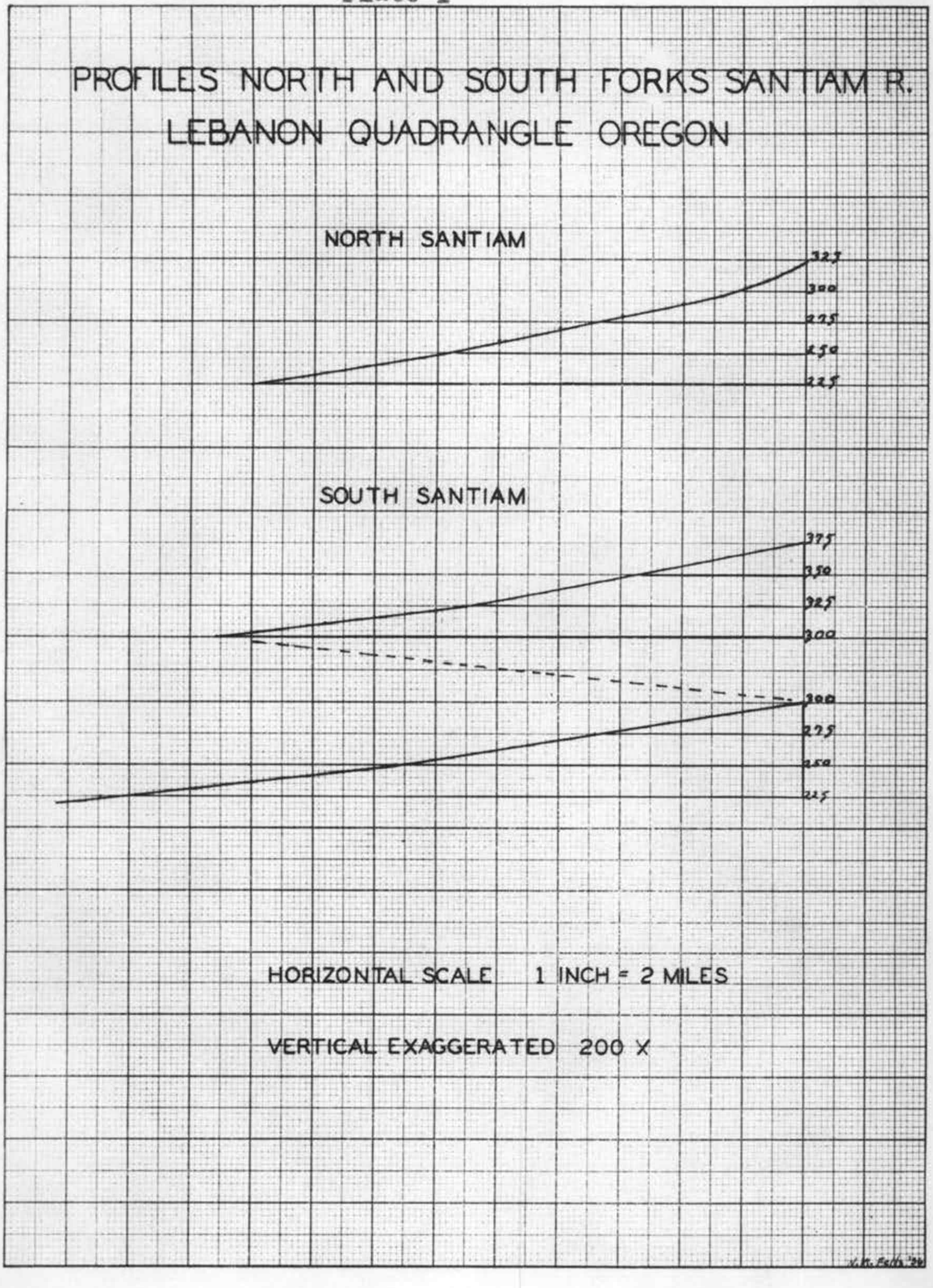
South Santiam River at Waterloo

Runoff in second feet Sep. 1927-Sep. 1928			Sec. ft./sq. mile	Runoff	
max.	min.	mean		in.	acre feet
31800	126	3210	5.02	68.23	2,330,000

The maximum guage reading during the above period was 13.5 feet, the minimum 2.05 feet. The maximum recorded was 60,000 second feet with a guage reading of 19.4 on February 21, 1927. The minimum recorded was 100 second feet during the months of September, October, and November, 1925. No guage reading recorded for this period.

Profiles of the North Santiam and South Santiam rivers appear on the accompanying diagram.

Plate I


PROFILES NORTH AND SOUTH FORKS SANTIAM R.
LEBANON QUADRANGLE OREGON
NORTH SANTIAM
325
300
275
250
225
SOUTH SANTIAM
375
350
325
300
300
275
250
225
HORIZONTAL SCALE 1 INCH = 2 MILES
VERTICAL EXAGGERATED 200 X

DESCRIPTIVE GEOLOGY

The rocks of the Lebanon Quadrangle, both igneous and sedimentary, will be described on the following pages in the order of age. The oldest rocks exposed in the area are marine sandstone, shale, and conglomerate herein assigned to the Eugene formation of Oligocene age. Following these marine deposits is a series of sandstones and tuffs of terrestrial origin herein described as the Scio beds. A series of volcanics are mapped as the Berlin beds. These volcanics are followed by the Stayton basalts and accompanying intrusive phases of the same igneous activity. Following the basalts are a series of Pleistocene and Recent alluvial formations.

EUGENE FORMATION

Distribution and General Relations. The marine sandstone, sandy shales and pebble conglomerates are not exposed over wide areas in the quadrangle. The total area of the outcrops of the rocks belonging to this division is less than three square miles, but outcrops in areas immediately adjacent to the quadrangle as near Brownsville, Knox Butte, and Parrish Gap point to the probability that a large part of the area is underlain by these rocks. Within the quadrangle outcrops of sandstone and sandy shale bearing marine fossils occur in parts of sections 19, 21, 28, 29, and 30 T. 12 S., R. 2W. on the west, south, and southeast slopes of

Peterson Butte. Rocks of a nature very similar to those outcropping on Peterson Butte but containing lenses of pebble conglomerate occur directly east of Lebanon in the central parts of sections 7 and 8, T. 12S., R. 1 W., in what is known locally as Golden Valley. The thin bedded snadstone members of the rocks outcropping in this locality carry fragmentary marine fossils. Outcrops of fossiliferous rocks of the same type occur on the hills near Brownsville, just south of the area, and on Knox Butte and near Parrish Gap near Jefferson north and west of the area, but detailed studies of these rocks have not been made.

The largest outcrops of the marine sandstone on Peterson Butte (Figure 3) consist of beds of buff sandstone and sandy shale on the west and south slopes of the butte in parts of sections 19, 30, and 29, T. 12 S., R, 2 W., and similar beds with lenses of pebble conglomerate in the southwest corner of section 21 and the northwest corner of section 28, same township and range. More extensive outcrops of the same beds occur on the south slopes of the butte beyond the limits of the quadrangle. Small outcrops of sandstone apparently shattered and originally more or less enclosed by the gabbro are exposed in a few localities on the southwest slopes of the butte. These small outcrops are probably xenoliths exposed by erosion. They occur at high elevations on the butte and are not of sufficient size to show on the geologic map.

Fig. 3. Northwest slope of Peterson Butte, Sand Ridge in middle distance, and portion of Santiam surface in foreground.

Fig. 4. Outcrop of Eugene formation on north wall of Golden Valley.

The previously mentioned outcrop in Golden Valley provides the best exposure of marine rocks in the quadrangle. The rocks outcrop on both walls and the floor of the valley for a distance of nearly one and one half miles. Natural cliffs along these walls, and a small quarry near the west end of the valley provide excellent sections for examination. One of these outcrops on the north wall of the valley is shown in Figure 4.

<u>Petrographic Character</u>. The sandstone outcropping on the butte and in Golden Valley is a fine to medium grained, brown to buff colored rock. The sizes of the grains in the sandstones ranges from less than 0.05 mm. up to more than 0.5 mm. with the average size about 0.2 mm. In the pebble conglomerate the grains range in size up to 10 or 12 mm. The sandstone members comprise more than three quarters of the rocks exposed, however.

The grains making up this sandstone are quartz, feldspar, vitric tuff, light colored micas, small grains of basic rock and various minor constituents. The following table, a mineralogical analysis of the sandstone outcropping in the small quarry at the west end of Golden Valley is thought to be representative of the sandstone members of this formation. The sandy shale and the pebble conglomerate members have a similar mineralogic composition.

Essential Minerals		Heavy Minerals	
quartz	40%	diopside	0.65%
feldspars and tuff fragments not differentiated	45%	hypersthene	0.15%
small fragments of chert	2%	magnetite	0.10%
small fragments basaltic rock	10%	pargasite	0.10%
micas	2%		

The cementing material is chiefly secondary silica with minor amounts of limonite. Clay minerals derived from the partially decomposed feldspars and tuffs are very abundant.

Most of the grains of quartz, feldspar, chert, basalt, and possibly of vitric tuff are well rounded. They evidently have suffered considerable transportation. On a few of the heavy minerals, however, so little rounding has taken place that the crystal outlines are plainly visible. The grains of pyroxene, though, seem to be cleavage fragments, possibly of different origin and history. With the exception of the vitric tuff grains and the feldspars, both of which are badly decayed, the minerals are remarkable free from corrosion and are quite fresh.

Structural and Stratigraphic Relations. In these rocks the bedding is manifested both as partings, usually in a smooth plane surface, and by textural differences between the different beds. These beds vary greatly in thickness, from a quarter of an inch in the thin bedded sandy shale members, up to four feet, the maximum observed, in the sandstone members. The pebble conglomerate lenses range from two to eighteen inches in thickness. The maximum thickness exposed within the area, calculated from the section exposed on the north wall of Golden Valley is close to 410 feet, but the real thickness may be thousands of feet.

In Golden Valley these beds are the lowest exposed and are overlain by the pyroclastics and associated basalts described herein as the Berlin Volcanics and the Stayton basalt. The contact between the marine beds and these later formations is best observed at an altitude of 800 feet on the north side of the Golden Valley road in the north-central portion of the north half of the SW ¼ Sec.8, T. 12 S., R. 1 W. The marine beds below the contact are dipping 11 degrees, north 75 degrees east. The basalts above dip to the north west. Bedding in the pyroclastics is difficult to see.

The attitude of the bedding surfaces exposed on Peterson Butte as might be expected on the slopes of such a volcanic neck is extremely variable. The average dip on the northwest side of the butte is 9 degrees north 45 degrees east. In the northeast corner of the NW ¼ Sec. 28, T. 12 S., R. 2 W., on the east side of the butte they dip about 10 degrees in a general northwest direction. Nearer the butte the beds seem to dip away from the intrusive mass but no accurate readings were obtained.

On Peterson Butte these sediments are cut by the gabbro intrusive mass comprising the bulk of the butte and are extensively covered by recent slope wash and fans.

Age and Correlation. These rocks were described as "Miocene" by Washburne[1] in 1914, who says, "Miocene sandstone and sandy shale are exposed at a few localities on Peterson Butte, 3 miles southwest of Lebanon, especially on the west side of the butte, where the small fossil fauna found is thought to represent a phase of the upper division of the Miocene." The following list of species collected from this locality were determined by Dall.

"Spisula albaria Conrad	Venericardia castor Dall
Marcia oregonensis Conrad	Cardium cf. ciliatum
Macoma sp.	Fusinus sp.
Solen sp.	Crepidula sp.

Neverita sp."

None of the above fossils is a typical fossil of the Eugene Oligocene, but most of them, as shown by the following lists, occur in the typical localities of the Eu-

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1/ Washburne, C.W., Geology and Oil Prospects of Northwestern Oregon. U.S.G.S. Bull. 590, 1914.

gene formation.[1] This fact plus a similar lithologic character and a similar stratigraphic position tend to place these beds, tentatively at least, in the Eugene Oligocene horizon.

The following lists of the fauna from some of the typical sections of the Eugene formation were taken from Washburne[2] and are reproduced here for a comparison with the fossil fauna obtained from the Peterson Butte locality.

South side of Kelly Butte, bank of Willamette River, one half mile northwest of Springfield, Lane County.

"*Spisula albaria* Conrad
Thracia condoni Dall
Diplodonta parilis Conrad
Phacoides acutilineatus Conrad
Solen curtus Conrad
Macoma sp.
Chione sp.
Cardium coosensis Dall
Natica sp.
Crepidula ungana Dall
Fragments of a crab

1/ Schenck, H.G. Marine Oligocene of Oregon. Univ. Cal. Pub. in Geology Vol. 16 No. 12.

2/ Washburne, C.W. Geology and Oil Prospects of Northwestern Oregon. U.S.G.S. Bull. 590, 1914.

Note: The lists from Washburne, rather than those of Schenck, were used because the determinations were made in both instances by Dall. Schenck has no lists of the fossil fauna from Peterson Butte.

West side of Judkins Point, Eugene, Lane County

Fusinus oregonensis Conrad
Chrysodomus sp.
Natica sp.
Spisula albaria Conrad
Thyasira bisecta Conrad
Phacoides acutilineatus Conrad
Fragments of Macoma
Schizothoerus
T hracia trapezoidea Conrad

Lower part of section in the river bluff exposed at Springfield, Lane County (Not Springfield Junction)

Marcia oregonensis Conrad
Leda whitmani Dall
Spisula albaria Conrad
Acila conradi Meek
Solen curtus Conrad
Thyasira sp.
Paradione sp.
Trochita inornata Gabb
Fusinus oregonensis Conrad
Bittium sp.
Crepidula cf. ungana Dall

Fairmount Quarry, Eugene

Marcia oregonensis Conrad
Spisula albaria Conrad
Chione sp.
Sanguinolaria sp.
Mulina cf. oregonensis Dall
Thracia sp."

The fossil 'Venericardia castor Dall' is regarded as an Oligocene form in northwestern Washington.[1/] This fossil is perhaps the best one for correlation purposes from the Peterson Butte locality as the others are either too

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1/ Washburne, C.W. Geology and Oil Prospects of Northwestern Oregon. U.S.G.S. Bull. 590, 1914.

long ranged for accurate dating or are too imperfect for proper identification. The fossils occurring in the sandstone in Golden Valley are likewise very imperfectly preserved. A fragment of a large peleceypod, probably Spisula sp., was obtained from the small flagstone quarry near the west end of the valley.

These beds along the eastern edge of the Willamette Valley have since the time of Washburne's paper been referred to the Oligocene. Hannibal and Arnold[1] in 1913, about the same time as Washburne was doing his work in the valley, referred these beds to the lower Oligocene. Later papers by Schenck[2] have placed them higher in the Oligocene.

From the foregoing meager paleontologic data, it is impossible definitely to assign these beds to the Eugene horizon. However, since the fossils obtained are also to be obtained from the type Eugene localities, and since the Eugene formation has been traced northward approximately along the strike of the beds past the Coburg Hills to a point not far south of the southern limits of the Lebanon Quadrangle, it is proposed to assign these

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1/ Arnold, Ralph and Hannibal, H. The Marine Tertiary Stratigraphy of the North Pacific Coast of America. Am. Philos. Pros. Vol.52,p.590, 1913

2/ Schenck, H.G. Marine Oligocene of Oregon. Univ. Cal. Pub. in Geology Vol. 16 No. 12, 1927 beds tentatively to the Eugene horizon of the Oligocene.

SCIO BEDS

A series of sandstones and water-laid tuffs and breccias, mapped as the Scio beds occurs in the east central part of the quadrangle. The relations of these beds to the marine formation described above is uncertain as no contact has been found within the area studied.

Distribution. These rocks outcrop between the elevations of 325 and 600 feet on the south slopes of Hungry Hill, between the 300 and 650 foot contours on Franklin Butte, between the 300 and the 800 foot contours on the west and south slopes of Prospect Mountain, and up to elevations of 500 feet on the hills near Providence Church and Nelson's Bridge.

Petrographic Character and Origin. The petrographic character of these rocks varies widely both as to texture and composition. Variations occur from a very fine grained white tuffaceous shale composed of partially decomposed vitric tuff grains, through a sandstone composed principally of quartz and mica grains, to a conglomerate containing elements up to 3 cm. across. Near the base of the formation on Powell Hill, and at a few points on the southwest slopes of Franklin Butte, a quartz mica sandstone occurs. Some of these beds contain as much as 96 per cent of quartz, much of it so angular as to show perfect crystals of bipyramidal habit. Weathered vitric tuff shards and about 2 per cent of muscovite accompany the quartz. The angularity of the grains suggests a crystal tuff rather than an older sandstone or a gra nitic terrain as the source of the material.

Stratigraphically higher in the formation, upon the slopes of Franklin Butte, the beds show less quartz and mica and become more tuffaceous. About 75 feet of this tuffaceous rock near the middle of the section is a well defined white sandy shale composed of vitric tuff grains ranging in size up to 0.2 mm. This well defined series of beds contains large numbers of fossil leaves remarkably preserved. Because collectors of these leaves and paleobotanists have referred to the localities from which these leaves have been obtained as the Scio localities, the use of the term Scio beds seems appropriate.

Above this horizon on Franklin Butte, Prospect Mountain, and on the hills near the junction of Crabtree Creek and Roaring River the tuff grains become larger, quartz and mica appear again but not nearly so abundantly as in the lower beds, and lenses of pebble conglomerate occur in scattered locations.

The sudden and extreme variations in texture and composition both laterally and vertically, fluviatile crossbedding, the presence of fossil leaves, and the angularity of the grains, showing very little transportation, all strongly suggest fluviatile deposition although some of the tuffs may be aeolian.

Stratigraphic and Structural Relations. These fluviatile rocks apparently overlie the marine Oligocene although a contact between the two formations has not been observed. It is possible that the high quartz phase may represent a reworked or transition zone between the marine sandstone and these tuffs, but no marine fossils have been found in them. On Knox Butte, just to the west of the quadrangle, similar water-laid tuffs occur higher on the butte than do marine sandstones from which fossils have been obtained by local collectors. Fossiliferous sandstone is exposed by the Santiam River near Jefferson to the north of Knox Butte, but no contact exposing the relations of these formations has been observed by the writer.

The leaf bearing beds and the overlying coarser tuffs and conglomerates are overlain unconformably by a series of basalt flows that are presumably middle Miocene in age.

The relations of this formation to the air-laid Berlin tuffs and breccias and undifferentiated volcanics occurring in a somewhat similar stratigraphic position in the southeastern part of the quadrangle is problematical. The fluviatile rocks can be traced from the north and the volcanics from the south to the valley occupied by Beaver Creek, but the actual contact can not be observed. It is possible that the two are phases of the same formation. At any rate there is no known evidence of any great difference in age.

The dip of the fluviatile rocks as exposed on Franklin Butte (Figure 5) and on Prospect Mountain is consistently about 12 degrees, north 40 degrees east. This differs from that of the marine beds in Golden Valley in direction, as the marine beds dip mostly to the east and these to the northeast. Dips from other localities are unreliable because of large scale slumping.

A calculated thickness of about 1000 feet is exposed from the base of the quartzose beds exposed near Franklin Butte School to the base of the overlying basalt on Prospect Mountain at the east boundary of the quadrangle although the maximum single section exposed is about 500 feet on the west slope of Prospect Mountain. The total thickness is unknown.

Age and Correlation. In view of their position and structure these fluviatile rocks are probable later than the marine formation and they are certainly older than the overlying basalt which may be considered middle Miocene. The a ge of these deposits would thus be between the Eugene Oligocene and middle Miocene. The leaves occurring in the Scio phases are now being studied by Dr. Ethel Sanborn who says the leaves are about the same as those occurring in the Bridge Creek flora of eastern Oregon which Chaney and

Fig. 5. South slope of Franklin Butte showing east-dipping Scio beds.

Fig. 6. Outcrop of Berlin Volcanics near Berlin P.O.

Sanborn[1] now assign to the upper middle Oligocene. Exact dating by these fossil leaves is not possible at the present stages of their study.

BERLIN VOLCANICS

An undifferentiated complex of coarse tuffs, breccias, and basalts occurs in the southeast portion of the quadrangle. The area occupied by this complex is south of Beaver Creek and east and north of the South Santiam river. The best exposures of the coarse tuffs and breccias are near Berlin, (Figure 6) just a short distance east of the southeast corner of the quadrangle, and along the hills bordering Onehorse Creek, hence the name.

Petrographic Character. The petrographic character of this complex is, as might be expected, extremely varied. Vitric tuffs showing both primary and secondary oxidation predominate. The oxidation and weathering effects have given brilliant colors ranging from green and cream through several shades of pink and red to brownish hues for these tuffs and for the clays derived from them. The grains of vitric tuff in the coarser breccias range up to three inches in size, but sizes of from 0.5 to 2 cm. are more common.

Closely associated with these tuffs and breccias are minor amounts of olivine basalts occurring chiefly as flow remnants a nd dikes, but they may not be an in-

1/ Oral communication with Drs. Chaney and Sanborn.

tegral part of the original formation.

Stratigraphic and Structural Relations. In most localities the bedding of these tuffs is obscure due to the nature of the materials and to the method by which they were deposited. However beds dipping to the north east can be observed in the outcrops of this formation on the hills just north of One horse Creek. Very elaborate folds and faults appear in some of the fresh road cuts made through some of the finner textured of these tuffs and breccias. These structures are probably due in the main to repeated landslides of the past.

As stated above, the relations between these beds and the fluviatile deposits to the north are obscure. At the head of Golden Valley, however, these tuffs and the basalt definitely overlie the marine beds. This contact has been previously described under the description of the stratigraphy of the marine beds.

Age and Correlation. The age of these volcanics, as stated previously, must be close to that of the fluviatile deposits described as the Scio beds. The volcanics are definitely underlain by the marine beds and overlain by the basalt flows. On the basis of lithology and stratigraphic position these volcanics may perhaps be correlated with the Mehama formation described by Thayer,[1/]

1/ Thayer, Thomas. The North Sa ntiam Section of the Oregon Cascades. Ph.D. Thesis on file Calif. Inst. Technology.

and the Warrendale and other similar formations in the Cascades noted by Hodge.[1]

STAYTON LAVAS

The Stayton lavas consist of flows of olivine basalts overlying the older formations. The basalts of this area can be traced to the type locality described by Thayer,[2] and hence the name.

Distribution. The Sta yton lavas occur in the Lebanon Quadrangle as cappings of the higher hills and ridges in the foothill portions of the area. The largest exposures of these lavas occur in Secs. 33, 34, 35, and 36, T. 9 S., R. 1 W., Secs. 1, 2, 3, 4, and 5, and parts of 7, 8, 9, 10, 11, and 12, T. 10 S., R. 1 W., on the long ridge north of Thomas Creek and east of Shelburn, and in parts of Secs. 13, 14, 15, 22, 23, 24, 25, 26, and 36, T. 10 S., R. 1 W. on Prospect Mountain. Lesser outcrops of these lavas also cap Franklin Butte, Hungry Hill, Miller Butte, and portions of Cemetery Hill in the northern part of the area. In the southern part of the area similar cappings occur on Ridgway Butte and on the higher hills to the east along the divide between Hamilton and

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1/ Hodge, E.T. Progress in Oregon Geology Since 1925. Northwest Sci. 6-44-53, June, 1932

2/ Thayer, Thomas. The North Santiam Section of the Oregon Cascades. Ph.D. Thesis on file Calif. Inst. Technology.

Onehorse Creeks. In places along Hamilton Creek near Reed School and along the South Santiam river near Waterloo the basalt occurs at elevations as low as 400 feet above sea level. North of Scio the basalt extends down to the valley filling at an elevation of 350 feet above sea level.

Stratigraphic and Structural Relations. The Stayt on lavas in general exhibit a west-northwest dip of about 2 degrees. Local variations from this dip due to variations in initial dip, large scale slumping or other causes, are numerous. Slumping occurs wherever a combination of favorable conditions such as underlying partially decomposed clayey tuffs, steep slopes, and lubrication by ground waters exists. Notable examples of such slumps are in evidence on the south slopes of Hungry Hill and the Hamilton-Onehorse divide, on the east slopes of Franklin Butte, and on the northwest slopes of Prospect Mountain.

The contact between these lavas and the older forma tions is unconformable a nd also very irregular. The contact occurs at an elevation of 800 feet above sea level on the west slope of Prospect Mountain, while on the ridge to the north of Thomas Creek one and one half miles distant the basalt extends to the alluviated surface of the valley at an elevation of 350 feet above sea level. The irregular nature of this contact is further shown along the hills of the Hamilton-Onehorse divide where the contact varies between 400 and 900 feet above sea level and on Hungry Hill where the contact varies between 300 and 600 feet above sea level. The irregular nature of these contacts is shown to best advantage on the accompanying geologic map.

In most localities these lavas are overlain only by their residual soils but on Cemetery Hill and at other places within the quadrangle the lavas are overlain by Quaternary alluvial formations.

Petrographic Character. The Stayton lavas consist in the main of olivine basalts, but minor amounts of flow breccia and palagonite are exposed in the Southern Pacific quarry on Miller Butte and in the NE ¼ Sec. 2 T. 10 S., R 1 W.

The rocks of this formation range from these pyroclastic materials and thin brecciated glassy flows through all degrees of vitrophyric and felsitic textures to a coarse basalt porphyry closely resembling the coarser intrusive rocks. The range in mineral composition is very slight in the more crystalline phases of the flows, but, of course, in the more glassy phases certain of the minerals prominent in the more phaneritic rocks enter into the composition of the glass and are therefore not apparent. An examination of the crystalline phases discloses that all are normal basalts containing 50 per cent or more of basic plagioclase, usually labradorite, and olivine is present in all sections studied. The pyroxenes are usually augite.

The following descriptions and photomicrographs of rocks taken from representative locations within the area show the close similarity existing between samples taken from widely separated localities.

Sample number 1 was taken from near the center portion of the flow capping the Hamilton-Onehorse divide in the NE ¼ of Sec. 15, T. 12 S., R. 1 W. Megascopically this rock is a fine grained, rather dense melaphyr with rusty oxidized phenocrysts about one mm. in diameter in a fresh appearing groundmass.

The texture of this rock is hiatal or porphyritic with phenocrysts of euhedral olivine, augite, and olivine replaced by chrysotile, lathlike crystals of labradorite, and small crystals of magnetite in a ground mass of brown glass and small crystals of augite, olivine, and plagioclase.

The apparent order of crystallization of the component minerals is magnetite, olivine, augite, and labradorite. The serpentine is probably deuteric, replacing olivine. The accessory inclusions are earlier than the olivine. Hornblend occurs as a reaction rim on an augite crystal. The lath shaped minerals are oriented in a well developed flow structure.

The quantitative mineralogical composition of this rock is given by the following table:

Essential Minerals	Calculated percentages
labradorite	34.1
magnetite	10.8
ground mass	44.2
Accessory Minerals	
olivine	0.7
augite	1.1
titanite	
apatite	
Secondary Minerals	
serpentine (chrysotile)	9.1
brown hornblende	

The groundmass was not differentiated. If it were, the percentages of olivine, labradorite, and augite would be increased.

From the above mineralogical composition the above described rock would be classified as follows:

Grout: normal basalt

Hodge: C 1-2 V 1

Shand: basalt, sub-aluminous type

Sample number 2 was obtained from a thin flow located on the north wall, about 10 feet above the floor of the Southern Pacific ballast quarry, located in the NE ¼ Sec. 5, T. 10 S., R. 2 W., on the extreme southeast point of Miller Butte.

Megascopically this rock is a glassy, dense, extremely heavy melaphyr. Phenocrysts of olivine up to 8

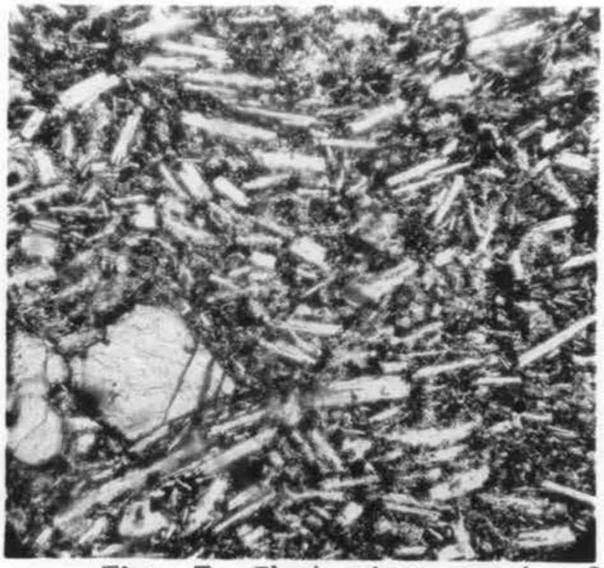

Fig. 7. Photomicrograph of sample number 1.
Plane polarized light 50 X.

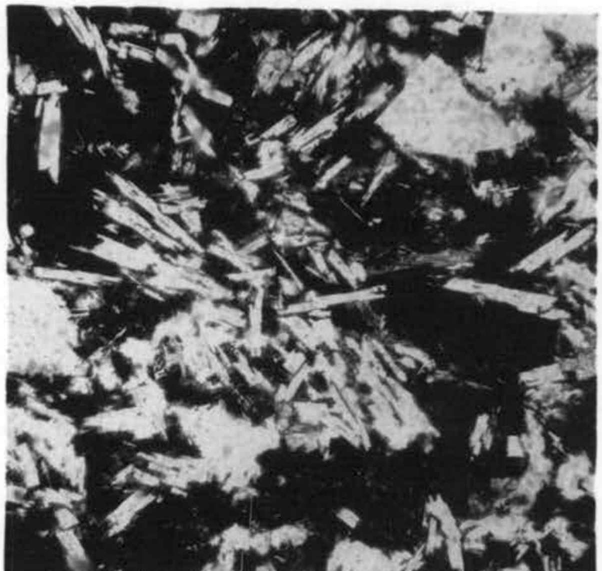

Fig. 8. Photomicrograph of sample number 2.
Plane polarized light 50 X.

by 4 mm. are in evidence.

The texture of this rock is intersertal, with needles of plagioclase enclosing grains of olivine and pyroxene in a groundmass of black glass. Considerable quantities of magnetite are disseminated through the glass and are responsible for the black color.

The apparent order of crystallization was olivine, pyroxene, and plagioclase. The accessory inclusions occur in the olivine and feldspar grains.

The calculated mineralogical composition of this rock is presented by the following table:

Essential Minerals	Calculated percentages
Groundmass (glass and fine crystals)	52.6
labradorite	21.9
magnetite	13.4
olivine	11.2
A ccessory Minerals	
pyroxene	0.3
apatite	
titanite	
Secondary Minerals	
leucoxene	tr.

Magnetite, perhaps in part titaniferous occurs as feathery trichites and similar crystallites in the glass. The anhedral pyroxene is probably augite. The olivine is nearly colorless and is of the magnesian or forsterite veriety. The glass where free from included magnetite is green in color. The large percentage of dark colored glass is apparent in Figure 8.

From the above mineralogical composition the rock described above would be classified as follows:

Grout: normal basalt

Hodge: C 1-2 V 11

Shand: basalt sub-aluminous type

Sample number 3 is from the extreme SE corner of Sec. 3, T. 10 S., R. 1 W. on the escarpment that faces Thomas Creek.

Megascopically this rock is a dense grayish melaphyr. It is fine grained with no megacrysts visible in the hand specimen. In the field it occurs near the middle of a thick flow.

The texture is aphyric or intersertal with needles of plagioclase and crystals of augite and magnetite in a groundmass of glass, pyroxene, spars, and magnetite.

The apparent order of crystallization is magnetite, plagioclase, and the groundmass. There is evidently overlapping crystallization in the groundmass between olivine, plagioclase, and the pyroxenes.

The mineralogical composition of this rock is given by the following table:

Essential Minerals	Calculated percentages
labradorite	48.0
magnetite	9.1
augite	6.5
groundmass	35.6

Accessory Minerals

olivine
titanite
apatite

From the above mineralogical composition this rock would be classified:

Grout: normal basalt

Hodge: C 1-2 V 1

Shand: sub aluminous basalt

Sample number 4 was obtained from the extreme NW corner of Sec. 26, T. 10 S., R. 1 W., on the summit of Prospect Mountain.

Megascopically this rock is a dense melaphyr containing rusty looking phenocrysts in an unaltered groundmass.

The texture is hiatal with crystals of olivine and augite plus areas of serpentine, plagioclase laths and magnetite in a groundmass of glass and small crystals of spars and pyroxene.

The order of crystallization is magnetite, olivine, plagioclase, and augite. Overlapping between the last two is evident. The alignment of the feldspar laths in flow structure is apparent in figure 10.

The mineralogical composition of this rock is:

Essential Minerals	Calculated Percentage
labradorite	32.5
magnetite	5.6
augite	3.0
groundmass	52.0
olivine	2.0

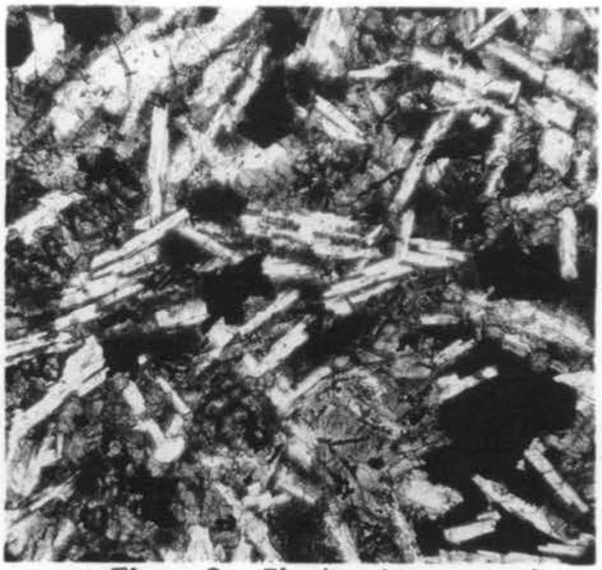

Fig. 9. Photomicrograph of sample number 3.
Plane polarized light 50 X.

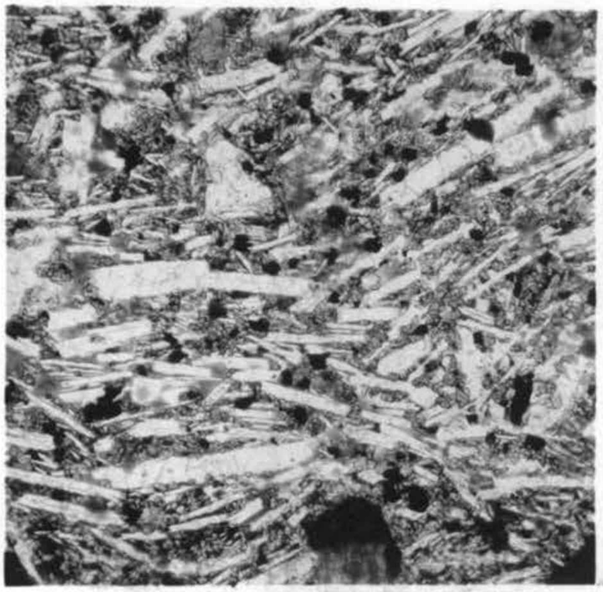

Fig. 10. Photomicrograph of sample number 4.
Plane polarized light 50 X.

Accessory Minerals   Calculated Percentages

serpentine-------------------- 4.6
titanite
apatite

From the above mineralogical composition this rock would be classified:

Grout: normal basalt

Hodge: C 1-2 V 2

Shand: sub aluminous basalt

From the above detailed descriptions it is evident that so far as studied the rocks of the Stayton lavas are very similar in mineralogical composition throughout the area. All may be classed as normal basalts. The chief varia tions are in texture and these are well within the normal ranges to be expected in lava flows.

INTRUSIVE ROCKS

The intrusive rocks of the Lebanon Quadrangle consist of basalt dikes and sills found with the Berlin volcanics and intruded into the older rocks at various localities, and the olivine gabbro core of Peterson Butte.

The rock of the Peterson Butte intrusive is a coarse grained melanocratic rock, very dense and fresh or unweathered in appearance. This rock is ophitic or diabasic in texture with phenocrysts of euhedral augite (up to 3 mm. in diameter), zoned plagioclase, and corroded olivine in a groundmass of plagioclase laths, small crystals of augite, and a serpentinized glass. It will be noted that two generations of plagioclase occur, bytownite laths and larger zoned crystals of undetermined composition. Crystals of magnetite are scattered evenly through the groundmass.

The apparent order of crystallization is magnetite, olivine, bytownite laths, zoned plagioclase, and augite. The accessory apatite and titanite crystals are earlier than the olivine.

The quantitative mineralogical composition of the rock is as follows:

Essential Minerals	Calculated Percentages
augite	29.0
bytownite	50.1
magnetite	5.8
zoned plagioclase phenocrysts	8.9
olivine	2.0

Accessory Minerals	Calculated Percentages
apatite	
titanite	
magnetite	
Secondary Minerals	
serpentine ------------------	3.9
limonite --------------------	tr.

The greenish serpentine in the groundmass probably replaces glass. It differs somewhat in structure and color from the olive-green serpentine of the chrysotile variety contained in the olivine as veins. The small amounts of limonite present are apparently derived from further weathering of the serpentine.

According to the above mineralogical composition this rock would be classified:

Grout: olivine gabbro

Hodge: B 3-4 V 2

Shand: sub aluminous sub-gabbro

Fig. 11. Photomicrograph of Peterson Butte gabbro. Plane polarized light 50 X.

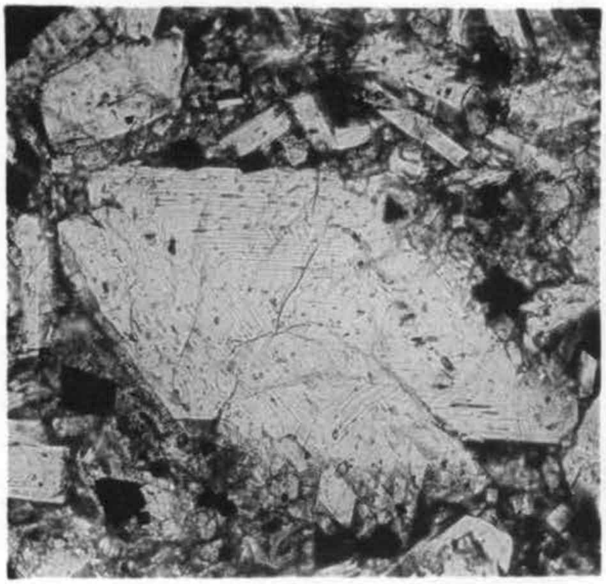

Fig. 12. Photomicrograph of zoned plagioclase phenocryst in Peterson Butte gabbro Plane polarized light 50 X.

QUATERNARY DEPOSITS

General Features. The Quaternary deposits in the Lebanon Quadrangle consist of a series of alluvial deposits ranging in age from early Pleistocene to Recent. These deposits are separable into at least five and possibly six stages or substages each characterized by a distinct topographic expression and by a different degree of weathering. The topographic expression of these different deposits has been discussed previously under the general heading of topog raphy. The deposits of these separate stages will be described on the following pages in order of age.

LACOMB GRAVELS

Distribution. The gravels of the Lacomb stage occur on the rolling surface north and west of Lacomb in parts of sections 13, 14, 23, 24, 25, 26, and 36, T. 11 S., R. 1 W., hence the name. These gravels occur as low as 500 feet in this area, but the surface where they are best exposed varies between 600 and 625 feet above sea level.

Gravels occuring on the top of Cemetery Hill in the extreme northwest part of the quadrangle near Jefferson may possibly belong to this stage as the elevation at which they lie is a little high to fit into the projected profile of the next younger stage.

Petrographic Character. These gravels are very deeply weathered, so deeply, in fact, that only the larger basaltic and siliceous boulders remain. The finer gravel, (figure 14) a large part of which possible was originally tuffaceous has been weathered to a red soil of the Aiken[1/] silty clay loam type. The boulders are mostly basaltic in character although a few scattered chalcedonic chert -like fragments occur. These boulders range in size from exfoliate cores 2 or 3 inches across up to sub-angular fragments 18 t o 22 inches in diameter. The chert elements are noticeable due to their extreme resistance to corrosion. The soil to which these gravels have weathered closely resembles one of the residual soils developed in areas of basalt flows probably on account of its age and the preponderance of basalt in the original deposit.

Stratigraphic and Structural Relations. These gravels were apparently deposited as a pediment or fan deposit upon a surface cut across the older sediments. Thus the gravel overlies the tuffs in an unconformable manner. Nowhere in the area is the gravel in contact with the basalt flows that occur on the tops of the higher hills, but since they are composed of fragments of this basalt and lie on a surface cut far below the basalt they are clearly younger that the basalt flows. The thickness of these deposits varies from a few inches to several feet on the rolling surface north and west of Lacomb.

1/ Kocher, A .E. et al. Soil Survey of Linn Counry, Oregon. U.S. Bureau of Chemistry and Soils Bull. 25 Series 1924.

(The figure originally designed for this page has been combined with another.)

Near the edges of the Lacomb surface greater thickness are exposed. Southwest of Lacomb in the SW ¼ Sec. 25, T. 11 S., R. 1 W. a thickness of about 35 feet is exposed. The gravels of the next younger Pleistocene stage locally have been deposited against the gravels of the Lacomb stage, but the other Pleistocene deposits do not reach so high a level.

Age and Correlation. From the above facts it is evident that the age of the Lacomb gravels must be considerably later than that of the basalt flows and earlier than that of the oldest of the well defined terrace gravels. Though these gravels may be as old as Pliocene, they are considered by reason of their deep weathering and by analogy to later deposits to be a stage of early Pleistocene alluviation, probably Nebraskan.

SAND RIDGE GRAVELS

Next younger than the gravels of the Lacomb stage is another deposit of deeply weathered coarse gravel occurring as high terrace deposits. Patches of this stage are scattered throughout the quadrangle showing that at one time this deposit extended over a large portion of the lowland area. Sand Ridge from which this stage is named is a prominent terrace of these gravels in the extreme southwest corner of the quadrangle.

Distribution. The largest area showing deposits of this stage occurs in parts of sections 13, 14, 15, 16, 22, 26, 27, 34, 35, and 36, T. 11 S., R. 1 W., as a ter-

Fig. 13. Contact between Scio beds and Sand Ridge gravels NE $\frac{1}{4}$ Sec. 13, T. 11 S., R. 1 W.

Fig. 14. Weathered Lacomb gravels exposed $\frac{1}{4}$ mile west of Lacomb.

Fig. 15. Sand Ridge gravels exposed north of Beaver Creek NW $\frac{1}{4}$ Sec. 36, T. 11 S., R. 1 W.

race bordering the upland upon which the Lacomb gravels were deposited. The upper limit of this terrace is about 500 feet above sea level. This terrace slopes west northwest about 40 feet to the mile. Erosion by streams, principally Beaver Creek, locally produces steeper slopes on the remnants of this terrace. To the west, directly across Beaver Creek, in parts of sections 18, 19, 20, 21, 28, 29, 30, 32, 33, and 34. same township and range, is a continuation of this same terrace.

In the northern part of the area, east of Shelburn in parts of sections 31, 32, and 33, T. 9 S., parts of sections 5 and 6 in T. 10 S., R. 1 W., and in the E ½ Sec. 1 T. 9 S., R. 2 W., is a well developed terrace of about 4 square miles. This terrace ranges in elevation from 516 to 400 feet and slopes downstream about 40 feet per mile.

Other remnants of the same set of gravel terraces occur: (1) just west of Peterson Butte on Sand Ridge at an elevation of 360 feet in parts of sections 24 and 25, T. 12 S., R. 3 W., (2) on Stolz Hill on the east side of Peterson Butte in parts of sections 21, 22, and 27, T. 12 S., R. 2 W., and on Peterson Butte itself in the southeast corner of the SE ¼ Sec. 20, T. 12 S., R. 2 W. In the northern part of the area similar remnants occur (1) in parts of sections 23 and 24, T. 10 S., R. 2 W., and in parts of sections 18 and 19 T. 10 S., R. 1

W., on the north slope of Hungry Hill and the northwest slope of Flanklin Butt e, (2) on Cemetery Hill near Jefferson, (3) on the small hill in the center of Sec. 36, T. 9 S., R. 3 W., and (4) on the ridge running southeast from Miller Butte toward Cemetery Hill one quarter of a mile northeast of Cemetery Hill.

Petrographic Character. The gravels of this stage are composed of large pebble, cobble, and boulder sizes, mainly of basalt and andesite. Small percentages of other rock types, principally chert, jasper, and other siliceous rocks also occur. The deposit has weathered to a considerable degree. Cobbles as large as 8 or 10 inches in diameter (Figure 15) are weathered so deeply as to be easily cut by a shovel. Numerous new road cuts through the deposits expose these pebbles shaved through as neatly as the clayey matrix in which they occur. This clayey matrix has apparently been derived from the more complete weathering of the smaller size pebbles and other interstitial matter. Not all the pebbles and boulders of this deposit are as deeply weathered as those described above but no fresh pebbles or boulders were seen in any of the exposures visited. Road cuts show the gravel of this stage to be weathered to an advanced degree down to the depths of at least 25 feet below the surface, the maximum exposed. These gravels in well aerated areas bear a distinct soil type classified by soil scientists as Salkum soil.[1] Where clay has been reprecipitated along the water table forming an impervious claypan in the subsoil the waterlogged soil so formed is classified as Holcomb. The Salkum and Holcomb soils thus furnish valuable clues to the character of the underlying materials where exposures are poor or lacking. The total thickness of this deposit is unknown but is greater than 25 feet, the depth exposed in the NW ¼ Sec. 36, T. 11 S., R. 1 W.

Structural and Stratigraphic Relationships. The gravels of the Sand Ridge stage consist of fan deposits along the western front of the Cascade Range. These deposits are considered to be fan deposits on account of their coarse nature, their profile or slope, and their wide areal distribution. They were deposited on the older rocks of the area (Figure 13) and for the most part have been removed by subsequent erosion. Only areas that have been protected from undercutting by hard rock remain. Bedding has been obscured by weathering and no special structures such as delta structure have been observed. As stated under "Topography" the slope of the original surface of these deposits has been calculated as being about 200 feet in a distance of 11 miles or slightly less than 20 feet to the mile. The general direction of slope is north-

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1/ Kocher, A.E. et al op. cit.

westerly. Locally slopes as high as forty feet to the mile have been observed, but they exist only for short distances and are probably due mainly to subsequent stream erosion.

Gravels, sands and silts of later stages are deposited within the valleys cut into these and older deposits. Thus the stratigraphically younger gravels are topographically below the scattered benches of the once extensive old gravels.

Age and Correlation. The gravels of this stage have been referred to the Kansan stage of the Pleistocene by Allison[1] in the course of regional studies in northwestern Oregon. The assignment of this age to these deposits is based upon their topographic position and upon their profile of weathering. As the Lacomb deposits are not well developed or extensive in the quadrangle these Sand Ridge gravels are clearly the oldest well developed formation in the series of Pleistocene deposits exposed in the area.

Recognition and correlation of these deposits within the quadrangle is based upon the following criteria: (1) topographic position. These gravels occur at elevations of from 350 to 500 feet above sea level and characteristically form benches or terraces moderately sculptured by erosion into a rolling terrain. An escarpment of

1/ Allison, I.S. Pleistocene Alluvial Stages of Northwestern Oregon. Science (in press) such magnitude as to command immediate attention in the field is usually present at the bounding elevations of the exposures. (2) Degree of weathering. The gravels of this stage are more deeply weathered than any of the younger gravels with which they might be confused. The gravels of this stage can be distinguished from those of the Lacomb stage on the basis of the degree of weathering only with difficulty, although Holcomb and Salkum soil types are generally less advanced than the Aiken type characteristic of the Lacomb stage.

SANTIAM GRAVELS

The deposits of the Santiam stage are very similar to those of the preceding stage as to composition and probable manner of origin. They are named for the fact that they are mainly fan deposits of both of the forks of the Santiam River. The chief differences between the deposits of this stage and those of the Sand Ridge stage are, aside from age, in the degree of weathering and in topographic expression.

Distribution. The Santiam deposits are the most widespread of any single geologic unit in the quadrangle as they cover about forty percent of the entire area. The deposits are confined to the valley lowland in the western part of the quadrangle and the valleys leading thereto. The chief exposures are north and west of Lebanon along the South Santiam river, and in the vicinity of Shelburn and

Scio along the North Santiam river and Thomas Creek. Much of the areas covered by the silts and reworked materials of later stages of the Pleistocene are underlain by Santiam gravels so the extent of the deposits of this stage is considerably greater than shown by the areal map.

Petrographic Character. The gravels of the Santiam stage are composed of pebbles, cobbles, and boulders of basalt and andesite with minor amounts of other rocks found in the Cascade Range. Compared with the older gravels of the Lacomb and Sand Ridge stages these gravels are relatively unweathered, yet even they are not fresh. Some of the smaller sizes are weathered sufficiently to crumble under the pressure exerted by one's hand but the larger sized are fairly fresh in the interior but show a thin zone of surficial alteration. The characteristic soil types found on these gravels are the Holcomb and Clackamas, but large areas of silty soil belonging to the next younger stage lap up onto the lower reaches of these gravels.

Stratigraphic and Structural Relations. The gravels of the Santiam stage are fan deposits made by the principal streams of the area, the North Santiam and South Santiam rivers, and Thomas and Crabtree creeks.

Much of the present surface of the Santiam fans is apparently near the original surface of the deposits. The slope of this surface (Figure 16) and hence of the fan is between 10 and 12 feet to the mile--in a northwesterly

Fig. 16. Surface of Santiam deposits in Richardson's Gap. Prospect Mountain on right.

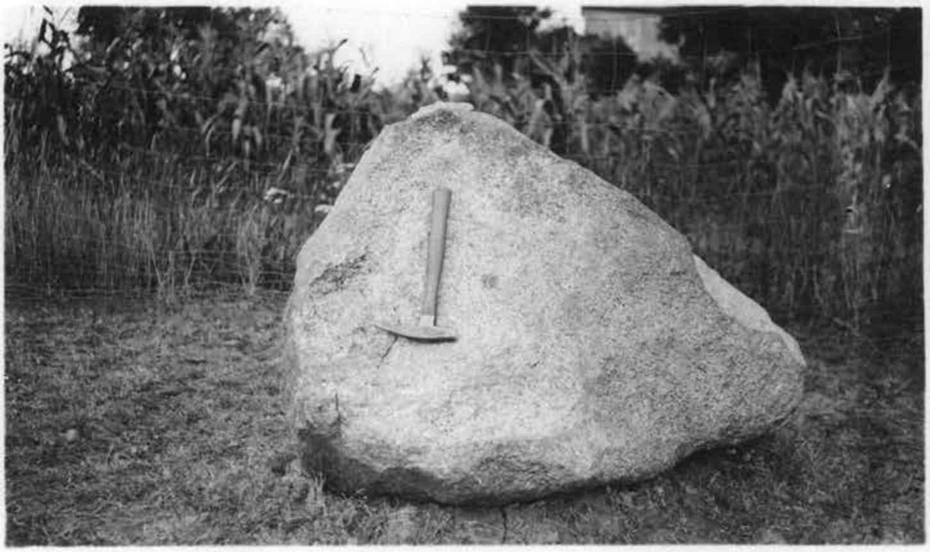

Fig. 17. Granite erratic deposited with thin Willamette silt on Santiam gravels in Richardson's Gap.

direction along the South Santiam and in a southwesterly direction along the North Santiam river.

The Santiam deposits were laid down within the areas eroded out of the Sand Ridge and older deposits and hence are thought to be unconformable with those of the older formations. A section of nearly 50 feet of these gravels is exposed by the South Santiam river just east of Lebanon north of the highway bridge. The Santiam is in many places overlain with the silts of the next later stage which lap onto the lower reaches of the fans.

Age and Correlation. Upon the basis of topographic and stratigraphic position and upon the degree of their weathering these and similar deposits elsewhere in the Willamette Valley have been referred to the Illinoian stage of the Pleistocene by Allison. Within the area this stage may be recognized by the characteristic topography and profile of weathering. The moderately weathered condition of the gravels of this stage as compared with that of the older stages make recognition of the deposits fairly easy.

WILLAMETTE SILTS AND ASSOCIATED DEPOSITS

The deposits of the Willamette stage are different from those of the earlier stages in the nature of the materials deposited, source of these materials, and the method of deposition. A characteristic soil known as the Willamette type is formed in well aerated situations as a surface phase of the deposits of this stage, hence the name. The Willamette materials cover large areas in the quadrangle but are not as extensive as the deposits of the Santiam stage.

Distribution. One of the best exposures of the Willamette deposits occurs in parts of sections 1 and 12, T. 11 S., R. 2 W., along the east side of the South Santiam river just east of Crabtree and Balm. Here the Willamette is represented by a well developed terrace deposited within a trench cut into the Santiam gravels.

Elsewhere in the area silts belonging to this stage lap upon the Santiam gravels and cover the earlier formation with a thickness of silt verying from a few inches to several feet. The upper limit of the easily recognized silts where they overlap the older rocks is about 325 feet above sea level but erratics and presumably some silt extend to somewhat higher elevations. Thus the lower portions of the Santiam gravels pass under the younger silts and in many places the two stages merge physiographically. Thus there are large areas of Santiam gravels thinly veneered with the later silts. The main areas of this type are on the large fan to the north and west of Lebanon, but the silts in that area are not shown separately on the map.

Petrographic Character. and Origin. The material of the Willamette deposits is chiefly fine and silt. In the main silt areas material coarser than fine sand comprises a small fraction of one percent of the total of these deposits. The coarse fragments included in the silt range from sand sizes up to fragments weighing several hundred pounds, (Figure 17) and are composed of a variety of material ranging from grains of basalt and quartz sand which could have been obtained from local sources to small fragments of pink orthoclase granite, muscovite schist, quartzite, garnet, and tourmaline. Some of these minerals and rock fragments could not have been derived from sources within the drainage basin of the Willamette River and have been assigned to glacial Columbia River.[1/] The erratic fragments of granite and other rocks were probably deposited from melting icebergs floating in the water from which the silts and sands of this stage were deposited. Much of the clay material obtained near the surface of these deposits is secondary in origin. Gravels such as those east of Marion, found with these silts were probably deposited by the Santiam River contemporaneously with the silt deposition.

Stratigraphic and Structural Relations. The silts of the Willamette stage were deposited both within a trench cut into the older deposits and upon the lower reaches of the older gravels. The structural form of this deposit is mainly that of a sheet of material deposited out of an

1/ Allison, I.S. Glacial Erratics in the Willamette Valley. Bull. G.S.A. Vol. 48 pp. 615-632, 1935 extensive open body of water rather than that of a stream-laid fan or piedmont deposit such as those of the preceding stages. A soil zone on the surface of the buried Santiam gravels is exposed in the river cut at Green's Bridge. This soil zone shows the interval between the Santiam and Willamette stages was one of considerable duration. The thickness of the silt as exposed by river trenches and dug well varies from a few inches to several feet.

Age and Correlation. On the basis of the degree of weathering of the erratics, the weathering of their matrix, and the topographic and stratigraphic relations of the deposits, Allison has assigned the silts containing the erratics to the Wisconsin glacial stage.

Recognition of the deposits of this stage is relatively easy because of their distinctive petrographic character and topographic position. The recent alluvium of the stream flood plains locally is petrographically similar, in some phases, to the deposits of the Willamette stage but the deposits of this alluvium are topographically lower and characterized by channeled surfaces.

RECENT DEPOSITS

Deposits of Recent alluvium occur within the trenches cut into the older deposits by the streams of the area. These are flood plain deposits consisting of materials reworked from all of the older deposits. Within the trench in which the flood plain is deposited but above the level of normal flood waters are remnants of an intermediate terrace possibly representing a post-Wisconsin or early Recent stage of alluviation. These remnants, however, have been included on the map with the Recent deposits.

QUATERNARY PALEONTOLOGY

The various deposits of alluvial filling of Willamette Valley contain an abundance of fossil mammalian remains. Bones of elephants, mastodons, and horses predominate, although remains of giant sloths, dogs, and bison have been found.[1] Most of the fossils reported are from deposits of the Wisconsin and later stages.

In the Lebanon Quadrangle, elephant remains have been found (1) in the city of Lebanon, (2) in T. 12 S., R. 1 W. east of Lebanon, and (3) on Swan's place just east of Peterson Butte. These elephants have been determined as Elephas columbi,[2] later renamed Archidiskodon.[3] The remains from Lebanon came out of material mapped as Recent alluvium. The other remains came from the thin layer of silt on the

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1/ Felts, W.M. A Contribution to the Pleistocene Paleontology of the Willamette Valley. Manuscript on file Dept. Geol. O.S.C. 1936

2/ Hay, O.P. The Pleistocene of the Western Region of North America and its Vertebrated Animals. Carnegie Inst. Wash. Publ. 322B

3/ Osburn, H.F. Final Conclusions on the Evolution, Phylogeny and Classification of the Proboscidea. Proc. Amer. Philos. Soc. 44:17-35, 1925

Santiam gravels and are considered as probably Willamette in age.

At the present stage of the studies of both the geology and paleontology of this region these fossils are of little or no value for correlative purposes.

GEOLOGIC HISTORY

The geologic record of the Lebanon Quadrangle begins with the rocks of the Eugene formation. Judging from the amounts of conglomerate and from the shallow water pelecypod fauna, it is probable that the outcrops of the Eugene formation in Golden Valley and on Peterson Butte represent deposits made close to the shore of the Oligocene sea which covered a large part of northwestern Oregon. The amounts of tuffaceous material in these deposits point toward the probability of explosive igneous activity somewhere to the east of the sea receiving these deposits.

An uplift terminating the marine deposition and lifting the marine beds above the level of the water closely followed the deposition of the Eugene beds. About the same time the explosive igneous activity increased resulting in extensive deposits of tuffaceous material over the older rocks. This material is now exposed as the Berlin forma tion. Streams cut into the sandstones and tuffs and made extensive deposits of this reworked material. These fluviatile deposits (Scio beds) are either upper Oligocene or lower Miocene in age and carry an abundance of well preserved fossil wood and leaves. These leaves are found at the present time in tropical and sub-tropical climates. Upon this basis a climate similar to that found in Central America at the present time is postulated for this area during the time that the Scio beds were being deposited.

Following the deposition of the Scio beds and prior to the outpouring of the basalt a movement tilted the Scio beds to the northeast and apparently added a north component to the easterly dip of the Eugene beds. A period of active erosion followed this uplift. Rejuvenated streams were then able to cut into the tuffs and sandstones to a considerable depth producing a region of rather rugged topography. Portions of this old surface show up at present as the contact between these rocks and the overlying basalt flows.

Following this time of erosion came a period of extensive igneous activity but of a more quiet nature than that which produced the extensive deposits of tuff. This activity produced large quantities of basaltic rock which flowed over the irregular surface of the older rocks. Accompanying these flows are minor quantities of flow breccia and basic tuffs. Probably also contemporaneous with these basalt flows, the Stayton lavas, are the numerous dikes of basalt to be found in the Berlin tuffs and the gabbro core of Peterson Butte.

Judging from the remnants of the flows, the topography of the area following the cessation of this basaltic activity must have been that of a "lava plain" sloping to the northwest and extending far out into what is now the Willamette Valley. The lowest points on this basalt surface presumably determined the courses of the streams flowing through the quadrangle and superimposed them over the older rocks and surfaces without regard to former drainage patterns.

A long period of erosion followed the development of this basalt surface. During this time the area was sculptured to nearly the same form as it now exhibits, but due to the lack of extensive alluviation in the valley portions the relief must have been greater and the topography rougher.

Closing this long period of erosion which probably lasted entirely through the Pliocene came the various events of the Pleistocene. The first of these was the deposition of the piedmont fan gravels of the Lacomb stage upon the erosion surface cut across the older rocks far below the level of the basalt.

A period of erosion, lasting long enough for the streams to cut deep trenches through the Lacomb gravels, followed. Within these trenches and out over the valley portions of the Quadrangle the Sand Ridge gravels were then deposited as large fans of the North and South Santiam rivers. Later these fans, except patches perched upon resistant rock, were stripped out by erosion and a thick deposit of gravels was made within the area eroded from the Sand Ridge gravels and older rocks. This later deposit, laid down in the Illinoian stage and mapped as the Santiam gravels, has not been eroded to a great degree, indicating a much shorter time has elapsed from the time of deposition of these gravels to the present time than had elapsed during the erosion interval between the Sand Ridge and Santiam stages. The interval of time was long enough, however, for some entrenchment of the larger streams and the formation of a soil upon the Santiam surface.

Within the trenches cut into the Santiam gravels and upon the lower reaches of these gravels were deposited the silts of the next stage. These silts are mapped as the Willamette silts and are referred to the Wisconsin stage. They are regarded as having been deposited from a sort of "Willamette Sound," a settling basin or flood ponding from the ice jammed Columbia River. Locally, as exhibited east of Marion and upstream, gravels from the Santiam rivers were added to the silts of this stage. Angular erratic fragments in this silt indicate the presence of icebergs drifting in the ponded waters from which the silts were being deposited.

Following the deposition of the silts and the retreat of the glacial flood waters in Late Wisconsin time erosion of these deposits has persisted till the present time. This erosion has resulted in a trenching of the older Willamette deposits to a depth of from a few inches on the fan surfaces to about 20 feet along the major streams. Material is deposited on the flood plains during freshet periods but much channeling and undercutting of the banks also occurs, the net result being a removal of more material than is deposited. However, a possible time of alluviation during this period is suggested by the remains of an alluvial terrace between the Willamette deposits and the present flood plain.

ECONOMIC GEOLOGY

The area included in the Lebanon Quadrangle is primarily an agricultural area and some of the chief problems of concern to agriculture have a geological foundation. Drainage of the soils in the valley lowland regions, irregation of these soils during the summer dry season, and prevention of excessive flooding during the season of the annual freshets are such problems.

Drainage and irrigation of the more permeable soils such as those of the Willamette type can be effected by irrigation with water pumped from wells, according to Piper.[1] He states that such a method would assist in the

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1/ Piper, A.M. Ground Water Resources of the Willamette Valley, Oregon. Preliminary statement U.S.G.S. & O.S.A.C. Agri. Exp. Sta. 1935 drainage of cultivated land through depressing the water table. It is obvious that such a method would not be practicable in areas underlain by a "claypan" subsoil such as characterizes Holcomb and Dayton silty clay loam soil types. The drainage and irrigation of these poorer soil types at the present time is not economically feasible because of: (1) the poor yield obtained from such soils, (2) the necessity of breaking up the clay layer in the subsoil, and (3) the large amounts of better soil available.

In the area north and west of Lebanon on the Santiam and younger surfaces a gravity system for the irrigation of a large area using water from the South Santiam river could be installed at a relatively low cost. At present however the demand for irrigation does not seem to warrant the expenditure necessary for the development of this gravity system.

Prevention of excessive floods within the entire Willamette Valley by the construction of storage dams at strategic points along the Willamette River and its principal tributaries is one point in a program to develop the Willamette Valley now being undertaken by the Corps of Engineers, U.S.A. It is planned to retain the flood waters in the storage basins created by these dams and use them to maintain a steady flow during the low water periods. If such a plan is put into effect a possible site for one of these dams on the South Santiam river exists just above the storage basin of the Mountain States Power Company's dam near Waterloo. At this point the river runs on basalt and a good foundation could probably be secured. Whether or not the storage basin created would be adequate is unknown.

Water power is being used at Lebanon for the generation of electric power for local use by the Mountain States Power Company. Similar low-head installations could be made to meet the demand at small cost. The Albany ditch carries water from a dam at Lebanon on the South Santiam to Albany. Water from this source had been used by the same company for power at Albany. Potential sites for larger, high head, installations are located upstream farther into the Cascades than the eastern boundary of the area extends.

The problem of domestic water supply for a population many times that now living in the quadrangle is not acute. Waters of the North Santiam river and South Santiam river, Thomas and Crabtree Creeks could supply a large urban population. Work is under way now to supply the city of Salem with water from the North Santiam river. As the costs of such water installations are prohibitive to small communities, domestic water for the cities of Lebanon and Albany are taken from the South Santiam river in open ditches. The city of Scio obtains water from a rather deep well (over 200 feet) and scattered rural dwellings depend on shallow "dug" wells for their supply. The quality of water from most of these wells is excellent.

The mineral resources of the quadrangle include clay, sand, gravel, basaltic road metal and possible building stone in addition to the chief resources: soil, water, and water power.

The clays occurring in this area are red burning brick and tile clays. They occur in the soils of the later alluvial stages and are somewhat silty. Clays occurring in the weathered tuffs of the Berlin and some phases of the Scio beds do not contain silt and are almost "ball clays." It is probable however that the iron content of the clays derived from these tuffs would tend to make them fuse at a low temperature.

Sand and gravel, especially the gravel, are plentiful in most sections of the quadrangle but material concrete aggregate is taken from gravel bars in the North and South Santiam rivers. The river gravels are cleaner and have been freed of a large amount of soft weathered mater ial which materially lessens the value of pit gravels for aggregate. Gravel for purposes other than concrete can be obtained from pits in any of the gravel deposits of the Lacomb, Sand Ridge, Santiam and Willamette stages. Some of the older weathered gravels make excellent road surfacing as they form a natural macadam.

Basalt suitable for "crushed gravel" and road metal for modern hot oil mix pavements occurs at scattered localities through the area. Miller Butte, the Thomas Creek escarpment north of Scio, the west side of Ridgway Butte, and the W.P.A. quarry near Berlin are excellent locations from which this basalt could easily be obtained.

Flagstones have been quarried from the sandstone in Golden Valley and basalt is being used for retaining walls in W.P.A. road construction near Lebanon, but most of the rock in this area is too somber for building stone.

The value of these resources of course depends on the demand for them which at the present time is slight. Brick and tile requirements are satisfied by a plant near Albany, most of the sand and gravel is taken from the rivers at convenient points, and road metal is quarried close to the road under construction as occasion requires.

The existence of oil and gas within the rocks of this area is considered a remote possibility by Washburne.[1/] This conclusion is supported on the following facts: (1) no known source rocks for petroleum exist within the region in which this quadrangle is located, (2) considerable igneous activity has taken place since the last marine rocks were deposited, (3) the beds dip uniformly to the east and northeast indicating truncation of any possible structures unless

1/ Washburne, C.W. Reconnaissance of the Geology and Oil Prospects of Northwestern Oregon. U.S.G.S. Bull. 590, 1914 in very deeply buried older rocks (4) no oil in any quantity has been observed in seeps or has been found by the wells of "wildcat" prospecters drilled in the vicinity of this area. One of these unsuccessful wells was drilled near Corvallis, 15 miles west and the other near Jefferson about 5½ miles north north west of the quadrangle.

No mineralization has been observed by the writer within the area. No quartz veins, sulfide stringers or other indications of mineralization so common to the epithermal deposits of the high Cascades were seen and none has been reported. A mineral spring, locally known as a "soda spring" exists near Waterloo just south of the quadrangle but the actual mineral contents of the waters are unknown. East of the quadrangle on both the North and South Santiam rivers, back in the higher Cascades a prevailingly low grade, epithermal mineralization exists, but the production, chiefly in gold, has been very small and is even more sporadic than that of other similar districts in the Casca des, namely Bohemia and Blue River in Oregon and Silver Star in Washington.

Plate 2

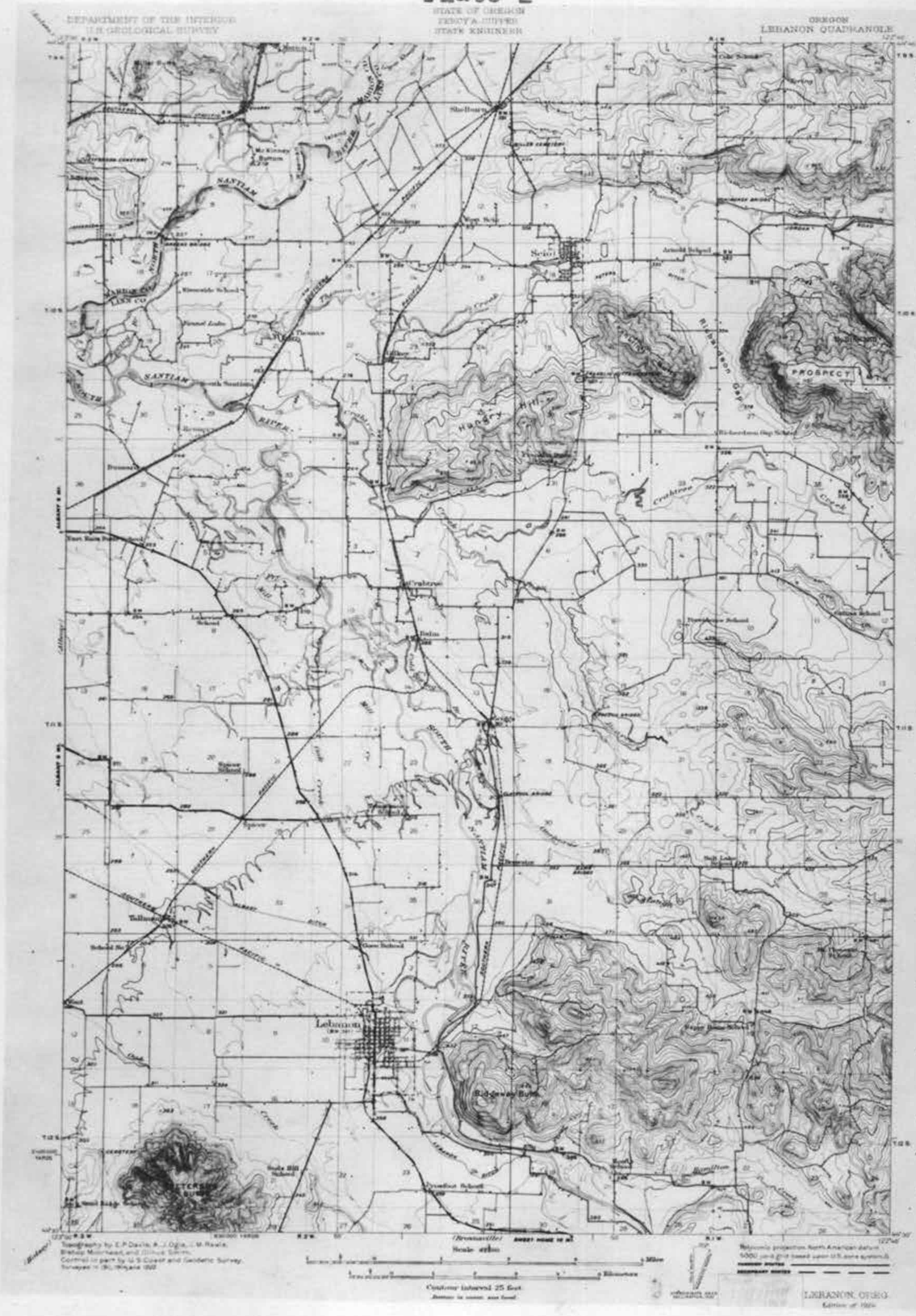

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
STATE OF OREGON
PERCY A. CUPPER
STATE ENGINEER
OREGON
LEBANON QUADRANGLE
PROSPECT
Contour interval 25 feet
LEBANON, OREG.

Plate 3

AREAL GEOLOGY

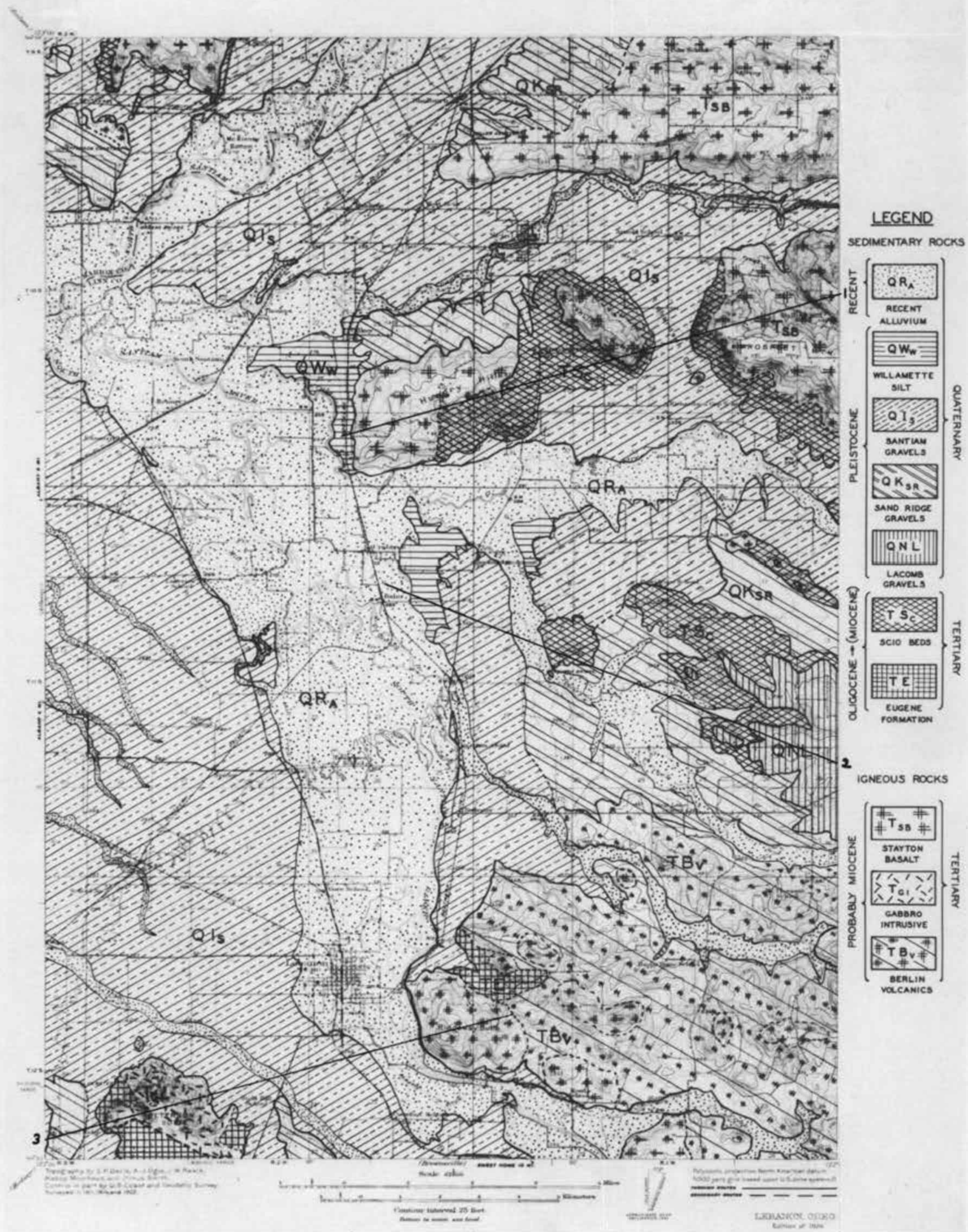
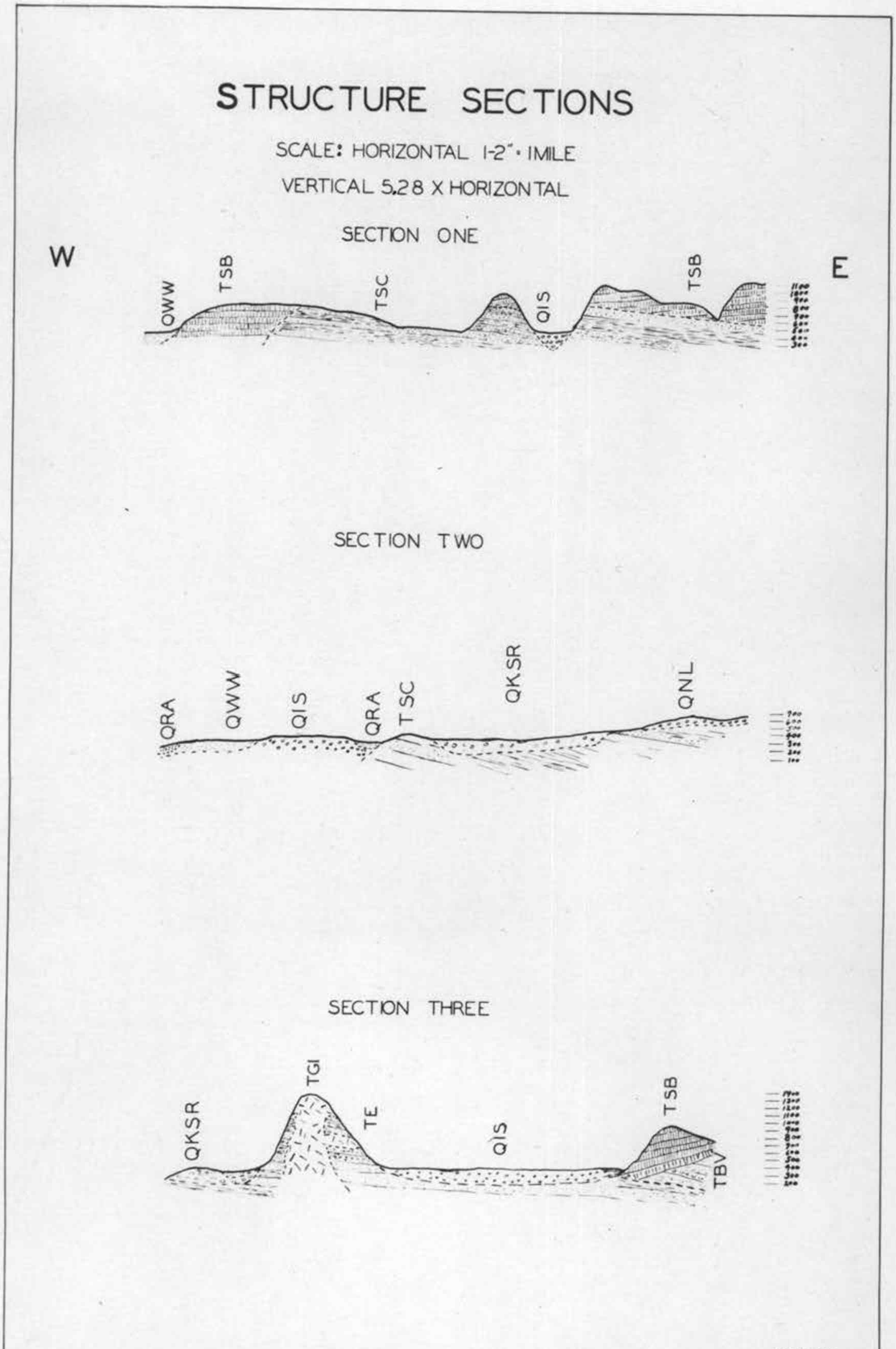


Plate 4


STRUCTURE SECTIONS
SCALE: HORIZONTAL 1-2" • 1MILE
VERTICAL 5.28 X HORIZONTAL
SECTION ONE
W
E
QWW
TSB
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QIS
TSB
SECTION TWO
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QWW
QIS
QRA
TSC
QKSR
QNL
SECTION THREE
QKSR
TGI
TE
QIS
TSB
TBV

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