123°00′ R.3 W

Based upon the Lebanon topographic map issued by The U. S. Geological Survey, 1943

Ira S. Allison* and Wayne M. Felts**

Introduction

General The present map of the Lebanon quadrangle is published as a further contribution toward the completion of a geologic map of the State. Maps of the adjoining Albany quadrangle (Allison, 1953) and other quadrangles within the State have been published previously, and still others are in preparation. The Lebanon area is of especial interest because (a) it includes the western foothills of the Cascade Mountains at the eastern border of the Willamette Valley lowland, and (b) the rocks include a number of Tertiary

volcanic materials, Oligocene marine sediments, and a fourfold sequence

Responsibility

A preliminary map of the quadrangle was used by Felts (1936) in his master's thesis at Oregon State College. Revisions based on additional field work in doubtful areas were made by Felts in 1938 and by Allison in 1941. The present description was prepared by Allison. Costs of publication were borne by the State of Oregon Department of Geology and Mineral Industries.

Formation boundaries were located in the field by compass, aneroid barometer, and pace traverses, and were plotted directly on the map. Continuous lines are used where the positions are reasonably certain within distances of 100 to 200 feet, and broken lines where the boundaries are concealed or are otherwise obscure. The limits of certain of the high-level gravel terrace remnants and the boundary between the Stayton lavas and Mehama volcanics were especially difficult to determine at many places on account of poor exposures, brush, timber, and landslides, and hence may be locally incorrect. In spite of certain deficiencies of which the authors are fully aware, the map is believed to convey a reasonably accurate picture of the major features of the area.

Previous work

The north edge of the quadrangle is included in a map of the North Santiam River Valley by Thayer (1939), but no other mapping is known to have been done in the area. Marine fossils from the west side of Peterson Butte were collected by Washburne (1914, pp. 91-92); fossil leaves from Franklin Butte have been studied by Sanborn (1947); and the Pleistocene deposits have been differentiated by Allison (1936, 1953); but this is the first treatment of the geology of the quadrangle as a whole.

Geography

OREGON

The Lebanon quadrangle is located at the east edge of the Willamette Valley, about 60 to 75 miles south of Portland, Oregon. It lies between latitudes 44° 30' and 44° 45' N. and longitudes 122° 45' and 123° W. Most of the quadrangle lies in Linn County; a small part at the northwest corner is in Marion County

Scio and Lebanon are the

Accessibility

The area is easily reached by the South Santiam Highway (US 20) from Albany, Oregon, and secondary roads pass within a mile or two of all points in the quadrangle. The main line of the Southern Pacific Railway crosses the northwestern part of the area (Diller, 1915), and branch lines reach into the interior.

Topography and drainage

In general the western part of the area lies in the Willamette Valley lowland physiographic province, while the eastern part is in the foothill section of the Cascade Mountain province. Where the foothills are composed of resistant basaltic rocks, as near Lebanon, the boundary between these provinces is abrupt, but elsewhere the boundary is more or less indistinct. The lowland ranges in elevation from about 200 feet to about 400 feet above sea level. In its origin it is an erosional basin subsequently floored with a series of Pleistocene and Recent alluvial deposits that now form gently sloping valley-plains and terraces.

The foothill area ranges in elevation from a few hundred feet to nearly 1300 feet above sea level on Prospect Mountain. It comprises a series of westerly projecting spurs separated and more or less dissected by the valleys of the North Santiam River, Thomas Creek, Crabtree Creek, Beaver Creek, Onehorse Slough, Hamilton Creek, and the South Santiam River. These spurs are composed mainly of basalt flows, tuffs, and breccias characteristic of the Western Cascades. The westerly slopes of the spurs near Scio reflect in part the westerly dips of the underlying basalts.

The southern extremity of the Salem Hills, extending into the northwestern corner of the quadrangle, may be considered an extension of the Western Cascades as they exhibit similar stratigraphy and structure. Peterson Butte, the highest point in the quadrangle (1430 feet above sea level), is an outlier protected by a core and radiating dikes of intrusive basalt. The principal drainage is by the North and South Santiam rivers which converge near the western edge of the area. Most of the small streams from the east join the South Santiam River enroute.

Stratigraphic Geology

The rocks of the Lebanon quadrangle include the marine Oligocene Eugene formation; terrestrial sandstones, tuffs, and breccias of the Mehama volcanics, probably Oligocene or older; the Stayton lavas of Miocene age; basic dikes and pipes also considered Miocene; Pleistocene alluvial deposits of the Lacomb, Leffler, Linn, and Willamette stages; and Recent alluvium.

Eugene formation

Distribution: Marine Oligocene sediments crop out on the sides of Peterson Butte, in Golden Valley 2 to 3 miles east of Lebanon, and in the hills in the northwest corner of the quadrangle. Presumably they underlie the alluvium in the intervening areas.

Petrographic character: These sediments are mainly sandstones with subordinate quantities of granule and pebble conglomerate. The grains in the sandstones average about 0.2 mm in diameter, and are composed chiefly in order of abundance of devitrified volcanic glass, quartz, feldspar, and pieces of basaltic rock, cemented with secondary silica and limonite. Small pieces of chert, flakes of mica, and crystals of diopside, hypersthene, pargasite, and magnetite constitute about 5 percent of the rock. Many of the grains by their roundness show considerable transportation, although others retain good crystal or cleavage outlines. Certain layers in Peterson Butte are essentially lapilli breccias which show poor sorting and rounding.

Thickness: A continuous section of at least 600 feet and perhaps as much as 1000 feet of Eugene sandstones crops out in the slopes of Peterson Butte. The beds dip in easterly directions of from 4° to 13°. Six miles to the northeast in Golden Valley about 400 feet of Eugene sandstones are exposed dipping 4° to 5° NE. Assuming that the deposits are continuous, a total thickness of the Eugene formation in the southern part of the quadrangle is estimated to be at least 2000 feet. In the extreme northwest corner of the quadrangle, Eugene sandstones dip 18° NE. The thickness of the section at this locality was not

Stratigraphic relations: The Eugene formation in the northwest part of the quadrangle is cut by basic intrusives and is overlain unconformably by the Stayton lavas. In Golden Valley east of Lebanon, it is likewise overlain by such lava and the contact between the two formations is notably irregular. Moreover the sediments there dip gently to the east whereas the lavas dip northwest. Farther east the stratigraphic position of the marine beds beneath the lavas is replaced by breccias and tuffs of the Mehama volcanics, probably terrestrial in origin and of uncertain structure. The eastward dip of the Eugene formation would tend to carry the marine rocks under at least part of the Mehama volcanics to the east. However, the coarse character of the marine clastics in close proximity to the Mehama volcanics suggests that the two may be partly contemporaneous and that the Mehama volcanics may have formed the shoreline of the Oligocene sea in this area.

Age and correlation: As noted by Washburne (1914), fossils obtained from Peterson Butte seem to be identical with the fauna of the Eugene formation in the vicinity of Eugene, Oregon. Most of the Eugene formation now is considered to be middle Oligocene in age; as extended downward by Vokes and others (1951) west of Eugene, it includes some lower Oligocene.

Inasmuch as the Eugene formation in the type area is also similar in lithology, structure, and stratigraphic position, and can be traced almost

______ * Chairman, Department of Geology, Oregon State College.

**Senior Geologist, The Texas Company. (See paragraph on "Responsibility.")

continuously northward approximately along the strike past the Cobura Hills (Vokes and others, 1951) and past Brownsville into the Lebanon quadrangle, the correlation is reasonably certain, especially as no other fossiliferous marine formation is known along that part of the Willamette Valley.

The beds in the northwestern part of the quadrangle can be traced to the type Illahe locality of Thayer (1939, pp. 6-7) on the west side of the Salem Hills, where a comparable Oligocene marine fauna has been obtained. The name Eugene formation is to be preferred on account of its priority (Smith, 1924, 1925, 1926; Schenck, 1927, 1928).

Mehama volcanics

Distribution and name: The type area of the Mehama volcanics as described by Thayer (1939, p. 7) is in the vicinity of Mehama, Oregon, in the North Santiam River valley, about 7 miles northeast of the Lebanon quadrangle. Their presence near Thomas Creek in the northeast part of this quadrangle was also recognized by Thayer. Hence the name is used here for rocks of similar lithology and stratigraphic position that extend southward across the full length of the Lebanon quadrangle, where they form a large part of the foothill spurs of the Western Cascades. The tentative names of "Scio beds" and "Berlin volcanics" used by Felts (1936) are abandoned.

Petrographic character: The Mehama volcanics in the lower slopes of Prospect Mountain, Franklin Butte, and Hungry Hill consist largely of thin-bedded, locally cross-bedded, tuffaceous sandstones and siltstones with occasional lenses or layers of pebble conglomerate. Conglomerate composed mainly of rounded pebbles of porphyritic andesite appears to become more abundant in the valleys of Crabtree Creek and the Roaring River (its tributary) just east of the quadrangle. The siltstones and sandstones range in composition from bed to bed from almost pure volcanic glass to almost pure quartz, with various intermediate mixtures of the two. Some quartz-rich sandstones contain 1 to 2 percent muscovite. The quartz grains are generally angular but perfect bypyramidal crystals have been found among them. The lack of wear on the grains and the association of quartz and muscovite with glass shards indicate derivation from volcanic eruptions of mixed crystal and vitric ash rather than from an older sandstone or from a granitic terrain. In general, quartz is more abundant in the lower part of the stratigraphic section and nearly white ash in the upper part.

Most if not all of the sandstones are water-laid; some of them are clearly fluviatile. On the other hand, some of the varicolored volcanics in the south eastern quarter of the quadrangle show such lack of sorting, rounding, or bedding that they must be classed as air-laid volcanic breccias. These were called the Berlin volcanics by Felts (1936, pp. 36-38). Their relation to the stratified tuffs farther north is not known, but they appear to be more basic in composition than the tuffs and not directly related. The breccias and tuffs are here mapped together, however, for lack of any good boundary between them.

Thickness: About 500 vertical feet of Mehama volcanics are exposed on the sides of Prospect Mountain, Franklin Butte, and Hungry Hill. The formation in this part of the quadrangle strikes N. 50° W. and dips about 6° NE. By projecting the outcrop at Hungry Hill northeastward in the direction of the dip to Prospect Mountain, the total thickness exposed is estimated to be about 1500 to 2500 feet. Maximum thickness of the formation is not known The 500-foot section measured on Franklin Butte shows about 250 feet of sandstone, siltstone, and tuffs at the top. Below this is the Scio flora zone in about 100 feet of white, bedded tuffaceous shale. At the base of the section are about 150 feet of micaceous sandstones in which a fragment of a marine fossil

In the southeast corner of the quadrangle, the Mehama volcanics appear to dip northeast at angles of from 5° to 12°, but their total thickness could not be determined.

Stratigraphic relations: The relation of the Mehama volcanics to the Eugene formation is uncertain, but as Thayer (1939, p. 7) suggested, the Mehama volcanics may be in part the terrestrial equivalent of the marine beds to the west. The upper part presumably overlies the Eugene formation. Both are overlain unconformably by basalt flows of the Stayton lavas. The sediments and lavas have different dips and the erosional contact between them is irregular. Dikes and pipelike intrusions of basalt, presumably related to the Stayton lavas, cut the Mehama volcanics at several places; some of them in areas of breccia may have been vents in Mehama time.

Fossils: Fossil wood is widespread in the Mehama volcanics. Fossil leaves have been obtained principally from outcrops on the west and south sides of Franklin Butte and from a low cliff beside Crabtree Creek about half a mile east of the east edge of the Lebanon quadrangle. The leaves were studied by the late Dr. Ethel Sanborn, paleobotanist of Oregon State College.

According to Sanborn (1947) the Scio flora of 1184 specimens from Franklin Butte includes 16 species, of which 7 are new. About three-fourths of the leaves are Prunus franklinensis, a cherry tree of Oriental affinity. The identified flora is as follows:

Equisetum oregonense Newberry (horsetail)
Pteris silvicola C. C. Hall (fern) Sequoia langsdorfii (Brongniart) Heer (redwood) Populus lindgreni Knowlton (poplar) Salix sp. (catkins only of a willow) Engelhardtia oregana Sanborn (a nut tree)
Phoebe oregonensis (Sanborn's new name for Laurus grandis Lesquereux) Platanus aceroides Göeppert (sycamore or plane tree) Amelanchier similis Newberry (service berry) Prunus franklinensis Sanborn (cherry) Tilia williamsi Sanborn (linden or basswood) Grewia oregana Sanborn Vitis florissantella Cockerell (grape) Tetracera oregona Chaney and Sanborn Vaccinium scioensis Sanborn (huckleberry) Vaccinium prearboreum Sanborn (huckleberry) Fraxinus scioensis Sanborn (ash)

This assemblage of plants, characteristic in general of middle latitudes, indicates a warm temperate climate in a moist coastal environment (Sanborn, 1947, pp. 12-15).

A new leaf locality whose flora has not been described occurs in the Mehama volcanics in the southeastern part of the quadrangle in sec. 34, T. 11 S., R. 1 W.

Age and correlation: At many places in the Cascade Mountains volcanic tuffs and breccias of uncertain age underlie basalt flows which are thought to be equivalent to the Columbia River basalt of middle Miocene age. In the Columbia River gorge these pyroclastics are called the Eagle Creek (Williams, 1916, p. 80) or the Warrendale (Smith, 1919, p. 98) formation. As indicated above, their relations in the Lebanon quadrangle are not sufficiently clear to permit an unequivocal age assignment, but on the basis of their stratigraphic relations and their fossil leaves, their reference to the Oligocene appears most reasonable. The lower part of the formation may range downward

Sanborn (1947, p. 12) called the age of the fossil flora from Franklin Butte ". . . one of transition between the Upper Oligocene and Lower Miocene."

Stayton lavas

Distribution: The Stayton lavas, named by Thayer (1939, pp. 7-8) for their outcrops in the Stayton quadrangle immediately north of the Lebanon quadrangle, extend in broken areas entirely across the map from north to south. The principal areas are on the hills west of Marion, in the upland northeast of Scio, on the tops of Prospect Mountain, Franklin Butte, and Hungry Hill, and in Ridgeway Butte and vicinity east of Lebanon. These areas appear to be parts of a formerly continuous sheet of lava subsequently separated by erosion.

Petrographic character: In the Lebanon quadrangle the Stayton lavas are mainly dark gray to black, dense or vesicular, hypocrystalline, slightly porphyritic basic rocks composed of plagioclase, augite, magnetite, olivine, apatite, and green, yellow, or brown glass, but they differ in detail from flow to flow and from place to place. The plagioclase, ranging from basic labradorite to andesine, occurs in an intersertal arrangement in laths as much as 1.6 mm long. It has inclusions of bluish apatite and shows occasional zoning. Alignment of the laths indicates flow structure. Augite in anhedral to euhedral grains, mostly 0.1 to 0.3 mm long, appears to be a high-iron, low-soda variety. Magnetite is present as nearly subhedral to euhedral crystals and as feathery crystallites in the glass. Olivine occurs in small phenocrysts, usually corroded, partially converted in reaction rims to orthorhombic pyroxene, or altered to serpentine.

The rock in the railway quarry a mile south of Marion is somewhat unusual in that it contains pale yellow olivine phenocrysts as large as 4 by 9 mm in cross-section and a high percentage of glass with much breccia

Most of the flows of the Stayton lavas are true basalts but some of them approach andesite as shown by the feldspars and the index of refraction of the

Thickness: As only the eroded western edge of the sheet of Stayton lavas is included within the Lebanon quadrangle, their thickness locally is not great but may reach 500 to 600 feet in Prospect Mountain and in the area

Stratigraphic relations: The Stayton lavas are nearly flat-lying upon a rolling erosion surface developed upon the earlier sedimentary and pyroclastic rocks. As the underlying sediments dip more steeply than do the lavas, and in different directions, the lavas clearly are unconformable upon them. The

relief of the contact, best shown by the map itself, is fairly low in most places but is locally steep. North of Scio a part of the Stayton lavas is overlain by a Pleistocene gravel terrace remnant. A small amount of Fern Ridge tuff of Pliocene age which overlies the lavas farther east may be present beneath residual soil in the northeast corner of the quadrangle north of Thomas Creek (Smith, 1924), but none is shown on the map.

Age and correlation: There is no direct evidence for the age of the Stayton lavas except that they are younger than the Eugene formation and the Mehama volcanics. They are thought to be continuous, however, with the Columbia River basalt (Schlicker, 1954), which usually is assigned to middle Miocene time.

Intrusive rocks

A number of small intrusive masses of roundish or elongate outline are shown on the map; other smaller bodies were noted in the field, and probably still others were unnoticed. Most of them are believed to be pipelike bodies which represent vents by which the Stayton lavas were extruded; some are dikes. They transgress both the Eugene formation and the Mehama volcanics.

The most interesting of these in Peterson Butte has the form of a complex plug and an array of radiating and branching dikes that now resemble flying buttresses on the sides of the butte. The central part of the butte shown on the map as igneous rock contains some blocks of sediments. Apparently the core is an irregular mass shaped like a "devil's club" and should be classified as the neck of an ancient volcano. The present butte, however, composed mainly of the marine Eugene formation, is not to be confused with the supposed volcano formed above the site.

Samples from the dikes on Peterson Butte are medium-grained, dark gray, crystalline rocks that contain abundant phenocrysts of augite, olivine, and plagioclase as much as 2 by 4 mm in diameter. In thin section the rocks are seen to be holocrystalline, felsophyric rocks with the above-named phenocrysts set in an intersertal groundmass of plagioclase needles, magnetite, and augite. The plagioclase in the phenocrysts, zoned from bytownite to andesine, makes up about 10 percent of the rock, whereas small crystals of basic andesine constitute about 45 percent. Euhedral phenocrysts constitute about 20 percent, and small anhedral grains of augite another 15 percent. Olivine, which is fractured, partially resorbed and rounded, bordered by reaction rims of augite, and partially serpentinized, comprises about 3 percent of the rock. According to mineral composition, texture, and occurrence, the rock is a basalt porphyry.

Pleistocene alluvial deposits

Lacomb gravels: The oldest gravels of the area lie on the upland at the eastern edge of the map between 400 and nearly 700 feet above sea level. They are named the Lacomb gravels for the town of Lacomb which is situated iust beyond the eastern border of the quadrangle (Allison, 1953, p. 9). Only a few square miles of such gravels lie within the area, as they occur at the dissected western edge of a high-level fan. This fan can be traced eastward about 3 miles to an elevation of about 875 feet near the mouth of the canyon of Crabtree Creek. The fan stands about 200 feet above the present level of Crabtree Creek which flows along the northeast side of the gravel. A smaller stream has developed a valley in the crease on the southeast side of the fan.

Two additional patches of gravel near Beaver Creek east of Griggs are thought to be remnants of Lacomb gravel, and the gravels on the hill at Jefferson Cemetery in the northwest corner of the quadrangle also are assigned to the Lacomb stage of alluviation because they are too high to fit into the projected profile of the gravels of the next younger stage.

The Lacomb gravels in the type area are rather coarse as they include cobbles and even boulders as much as 2 feet in diameter, although the bulk of the material is in the pebble range. The coarse particles consist mainly of basalt with some chert and petrified wood; the fines between them and in local lenses consist of particles of tuff. Bedding and cross-bedding are clearly fluviatile. The pebbles in the gravel near Jefferson include considerable andesite and dacite derived from the Cascade Mountains.

The gravel near Lacomb has been oxidized and decomposed at the surface to a reddish-brown clayey soil that closely resembles the residual soils developed on basalt flows. Small pebbles even far below the surface have been converted to clay ghosts that can be cut easily with a knife. Larger cobbles and boulders are decomposed on the exterior but retain fairly solid cores within the zones of exfoliation.

The thickness of the Lacomb gravels is difficult to determine owing to the lack of a single complete section, but from Lacomb southwestward for a distance of 1.2 miles they extend through a vertical range of about 185 feet. After deducting 70 feet per mile westerly slope that now characterizes the flattish top of the deposit near Lacomb, the apparent thickness is only about 100 feet. In other places figures of as much as about 150 feet may be obtained. As the gravel has a tendency to spread down the slopes, its bottom limit is difficult to locate and hence is somewhat generalized on the map.

The high topographic position of the Lacomb gravels, the advanced degree of dissection and removal they have undergone, the 200-foot subsequent deepening of Crabtree Creek valley, and the great depth of weathering of the gravels themselves indicate considerable age and so they are assigned by Allison (1936, 1953) to early Pleistocene time.

Leffler gravels: The Leffler gravels extend continuously from the type locality in the Stayton quadrangle (Thayer, 1939, p. 28; Allison, 1953, pp. 9-10) southwestward into the northern part of the Lebanon quadrangle east of Shelburn where perched terrace remnants evidently were preserved from erosion by the underlying basalt. Other areas of Leffler gravels occur near Gilkey, in a bench a mile wide south of Crabtree Creek, in a welldefined terrace extending from a point east of Lebanon northward nearly 7 miles, beside Beaver Creek near Salt Lake school, in Stolz Hill and Sand Ridge near Peterson Butte, and in two remnants in the northwestern corner of the quadrangle. These areas are spread out in such a way as to indicate that most of the lowland within the quadrangle was formerly covered with such gravels to levels between about 300 feet above sea level on the northwest and 400 to 500 feet or more in the lower reaches of the individual valleys on the east and southeast. Most of the present remnants on the borders of the valleys are only a few tens of feet thick.

The Leffler gravels differ in texture from place to place but are composed mostly of pebbles. Some gravel near Crabtree Creek is coarser than average and that on Sand Ridge in the lee of Peterson Butte, somewhat finer. The gravel is partly local in origin and partly the product of the North Santiam and South Santiam rivers heading high in the Cascade Mountains.

The gravel is weathered to depths of many feet. On well-drained areas a loose, deeply oxidized reddish-brown soil has been formed; on poorly drained flattish areas, as near Brewster, oxidation is shallower but a clayey soil and subsoil has formed, and the pebbles are decomposed to such an extent that subsurface drainage is poor.

On the basis of the position of the Leffler gravels, the depth of their weathering, and the extent of the subsequent erosion, they are assigned to middle Pleistocene time. In the North Santiam River valley they appear to be a valley-train deposit from the Mill City glacier which is thought to correspond in age to the Kansan or Sherwin glacial stage (Allison, 1936, 1953; Thayer, 1939).

Linn gravels: The type locality of the Linn gravels is just outside the northern edge of the quadrangle a few miles northeast of Shelburn (Allison, 1953, p. 11). These gravels continue in a terrace from that point southwestward beneath Shelburn and also in a corresponding terrace on the opposite side of the North Santiam River near Marion. They extend from the vicinity of Crowfoot school southeast of Lebanon northwestward across the lowland between Lebanon and Albany. Typically they form broad valleyplain terraces 25 or 30 feet above the major streams and 10 or 15 feet above the smaller creeks. They extend below the present stream levels and are at least 30 feet thick. In the main they are pebble and granule gravels, moderately well sorted and rounded, and show typical fluvial structures. They include various Cascade Mountain rock types.

The Linn gravels were weathered enough to form some clay at the surface, to soften the outside portions of the pebbles, and to reduce greatly the permeability of the gravel to water. Unlike gravels of the earlier stages, a large part of the original deposit is still present. West of Lebanon it retains the form of a fan from the South Santiam River. Another fan from the North Santiam River encroaches on Thomas Creek valley in the vicinity of West Scio.

The lower reaches of the Linn gravels pass underneath a cover of Willamette silt and are therefore older. Their moderate weathering and good preservation, however, show that they must belong to the later part of Pleistocene time. Accordingly they are assigned to the Detroit (in the North Santiam River valley) or Tahoe (in the Sierra Nevada of California) glacial stage which may be equivalent to an early Wisconsin or lowan stage in the glacial chronology of the north central States (Allison, 1936).

Willamette silt: A sheet of silt called the Willamette silt (Allison, 1953, p. 12), not more than about 15 feet thick within the Lebanon quadrangle, covers the earlier deposits to an elevation of nearly 400 feet above sea level but for mapping purposes its upper limit was set near the 300-foot contour where its thickness is only about 3 feet or less. A former cover of Willamette silt has been removed by erosion from a belt of Linn gravels northwest of Lebanon, as for example near Spicer. The remaining silt is a part of a widespread deposit which covers most of the Willamete Valley lowland farther west and north.

The silt consists of quartz, feldspars, pyroxenes, amphiboles, micas, and a wide variety of other minerals, mostly in angular grains or cleavage fragments. Associated with the silt are chips, blocks, and boulders of

came from the glacial Columbia River in late Pleistocene time (Allison, 1935). The silt is weathered to depths of 3 to 5 feet, mostly to Amity, Dayton, and Holcomb soils (Kocher, 1924).

Recent deposits Recent deposits consist of landslides and alluvium. Slides are mapped only on the north side of Prospect Mountain but they are common elsewhere, as on the south side of Hungry Hill and on the hills east of Lebanon. They are apt to give a deceptive impression of the structure. The slides on Prospect Mountain are favored by the combination of lava flows resting on tuffs, a northerly component of dip which conducts water to the surface and thereby promotes slippage, and shade and brush which help to retain moisture. The alluvium in the present valley bottoms consists mainly of gravel and sand along the rivers and of silt and clay along the minor streams. The soils on it range from wet clayey soils to well-drained, sandy, and gravelly loams.

only by icebergs floating in fairly deep water. Such erratics have been

found near Shelburn, in Richardson Gap, in Golden Valley 2 miles east of

Lebanon, near Tallman, and elsewhere. The erratics and much of the silt

Structural Geology

The Eugene formation and the Mehama volcanics strike in a northwesterly direction and dip at low angles of from 4° to 18°. The gentle dip appears to be a homoclinal structure that is modified only by minor warpings and local disturbances. The overlying Stayton lavas are nearly horizontal, but in places dip at low angles. These low dips may represent the original slopes of the lava flows rather than later earth movements. Slump blocks in the Stayton lavas show a variety of false dips.

The unconformity between the Stayton lavas and the underlying sediments and pyroclastics is the chief structural feature of the quadrangle. Unconformities occur also between the Pleistocene alluvial deposits and the older formations. No faulting was discerned. Landslides are common in the Mehama volcanics.

Economic Geology

The mineral resources of the Lebanon quadrangle include basalt rock, sand and gravel, clays, and water. Basalt from the Stayton lavas is quarried for crushed rock, riprap, and other purposes as demand requires; the quality is excellent. Sand and gravel are taken from the rivers at convenient places; somewhat weathered material of lower quality is available in the gravel terraces. Clays are widespread but are not used now. The water supply (Piper, 1942) is furnished in large part by the surface streams and to a smaller extent by numerous, comparatively shallow wells. The waters are soft or only slightly mineralized. No metallic ores are known within the area and the prospects of oil and gas are considered poor.

Geologic History

The earliest phases of the geologic history in the Lebanon quadrangle are somewhat in doubt, but one of the first events probably was the outbreak of explosive vulcanism which with the aid of wind and running water spread pyroclastic materials over the region.

In middle Oligocene time a shallow sea covered at least the western part of the quadrangle. As its sediments are sandstones and conglomerates largely of volcanic origin, its eastern shoreline probably was near at hand and doubtless shifted back and forth in accordance with variations in filling, in submergence, and in withdrawal of the marine waters. On lowlands near the shore, similar sediments, some of them enclosing fossil leaves, may have been deposited by streams and other terrestrial agents. Such deposition on land may likewise have continued after the Oligocene sea had disappeared from the area. The time relations are not entirely clear but the marine Eugene formation and the nonmarine Mehama volcanics are thought to have been formed in some such way.

Later these materials were slightly folded and were subjected to long continued erosion which truncated the tilted beds to a gently rolling surface of moderate relief. In Miocene time the Stayton lavas were extruded upon that uneven surface, probably from many local vents including the pluglike mass and dikes in Peterson Butte. Tuffs equivalent to the Fern Ridge tuffs in the Stayton quadrangle to the north may have been deposited on the basalt in the northeastern part of the area and afterward removed by erosion. Other events that may have occurred in late Tertiary time cannot be determined within the limited area of the Lebanon quadrangle.

By early Pleistocene time the topography must have resembled that of the present except that the lowland then may have been a hundred feet or more higher than it is now. At that time the streams started to aggrade their valleys with gravel, presumably derived from glaciers in the Cascade Mountains. Crabtree Creek built a bouldery gravel deposit across the site of Lacomb and the eastern part of the quadrangle, and other streams filled the lowland of that time with gravel to the level of the top of the hill at Jefferson Cemetery. Then the regimen changed; deposition ceased, erosion was renewed, and the bulk of the Lacomb gravels was taken away. Crabtree Creek cut its valley along the north edge of the fan into the underlying tuffs, and the lowlands elsewhere were deepened more nearly to their present form.

A second stage of alluviation, the Leffler stage, filled the lowlands again but at a lower level. Part of the gravel came from the Mill City glacier which terminated in the North Santiam River valley near Mehama. The Leffler alluvial stage was succeeded by another interglacial stage during which most of the Leffler gravels also were removed.

Then came the Linn stage when the Santiam rivers and their tributaries built up their valleys and spread the present low-level gravel fans in the lowlands. These deposits were exposed only long enough to become somewhat weathered and partially eroded before the lowland was submerged in a freshwater lake (Allison, 1935, 1953, p. 12; Condon, 1871, 1910; Diller, 1896, pp. 484-487; Smith, 1919, p. 104) to the elevation of about 400 feet above sea level, and the sheet of Willamette silt and ice-borne erratics was spread over much of the area. When the lake disappeared, weathering and erosion began again. The rivers cut through the silt into the underlying gravels and broadened their bottom-land valleys in Recent time to widths of as much as 3 miles. In addition, the South Santiam River or its flood waters stripped the silt off a comparable width of Linn gravels in a belt extending from the vicinity of Lebanon to Albany. Erosion, offset in part by deposition from the decline of seasonal floods, continues at present along the major streams.

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