Geomorphology and Soils Willamette Valley, Oregon

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Contents

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Geomorphology and Soils, Willamette Valley, Oregon

C. A. Balster and R. B. Parsons

Probably the first mention of the topography of the Willamette Valley in a formal report was by Captain William Clark. He wrote in his journal (*28*)[1] of the Lewis and Clark Expedition on April 3, 1806:

> I provailed on an old man to draw me a sketch of the Multnomar[2] River and give me the names of the nations resideing on it which he readily done, . . . The fourth Nation is the Cal-lar-po-e-wah which is very noumerous and inhabit the country on each side of the Multnomar from its falls as far up as the knowledge of those people extend. They inform me also that a high mountain passes the Multnomar at the falls, and above the country is an open plain of great extent.

Although the above statement hardly qualifies as a discourse on geomorphology, it is a particularly apt description of the valley in its grossest aspects.

Many subsequent authors have described the features of the Willamette Valley in more or less detail, but none have presented a map or discussed the sequence of landforms that characterizes the area. The soils of the valley have been mapped (*6, 7, 11, 12, 13, 21, 29, 30, 33*), but no attempt has been made to generalize the relations of the soils to the landforms.

This report is designed to describe and outline the extensive geomorphic surfaces of the Willamette Valley and to discuss the general relation of the soils to the surfaces. Demonstrating the time sequence of landscape development and establishing the relation of the soils of the valley to the geomorphic units is the primary purpose of this publication. As a result, it is hoped that soil genesis will be better understood and soil mapping facilitated.

Climate and Vegetation

Precipitation varies widely within the Willamette Valley (Fig. 1) and surrounding areas. The Willamette Valley is in the rain shadow of the Coast Range. Table 1 summarizes climatic data for various stations in the area (*8*). Summers (June, July, August, and September) are characteristically dry and cool with about 3 inches of precipitation (*8*). Average July temperature is about 66° F. Precipitation during October and November is about 9 inches, and that in winter (December, January, and February) is about 18 inches. Average January temperature is about 40° F., and little snow accumulates during most winters. About 8 inches of precipitation falls during the spring months of March, April, and May.

Habeck (*9*) used notes from original land surveys in the valley to reconstruct the nature and distribution of native vegetation. Oregon white oak (*Quercus garryana*) was the principal tree of the drier locations in the valley and on the south slopes of surrounding hills. Oregon ash (*Fraxinus oregona*), black cottonwood (*Populus trichocarpa*), and various willows (*Salix spp.*) were the trees of the wetter locations in the low valleys. Red alder (*Alnus rubra*) and white alder (*Alnus rhombifolia*) occupied the moist foothill valleys. Douglas-fir (*Pseudotsuga menziesii*), minor grand fir (*Abies grandis*), and bigleaf maple (*Acer macrophyllum*) occupied the hillslopes where moisture was adequate. There were occasional groves of Douglas-fir and grand fir on the valley floor. Extensive areas of grassland occupied the flat areas of the valley, many of which had scattered Oregon white oak as either individual trees or open groves.

Agricultural practices have altered the original vegetation pattern and, to a small degree, the population of genera in the valley. It is probable, however, that the distribution has been subjected to much greater change than have the members of the floral assemblage.

[1] Italic numbers in parentheses refer to Literature Cited, page 17.

[2] Multnomah River was the name applied to the Willamette River by the personnel of the Lewis and Clark Expedition. Clark's spelling, Multnomar, persists throughout his journal.

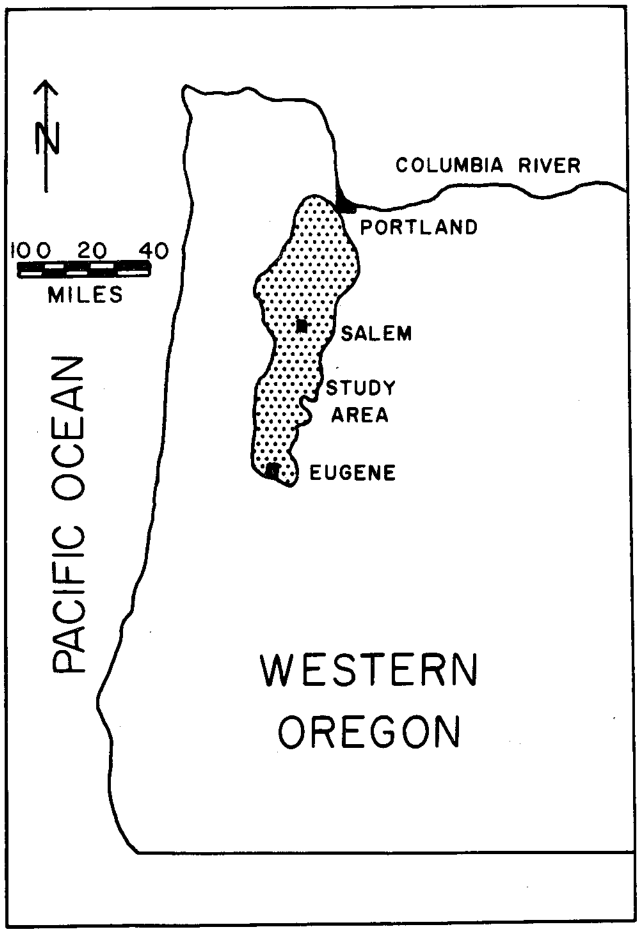

Table 1. Climatic Data for Localities in Willamette Valley, Oregon (*8*)

Locality	Mean ann. temp.	Mean ann. precipitation	Elev.
	degrees F.	*inches*	*ft.*
Corvallis	53.2	37.3	225
Eugene	52.4	37.5	361
Albany	53.1	40.7	213
Salem	53.1	39.8	195
Falls City	51.3	72.7	450
Forest Grove	52.1	46.4	200
Hillsboro	52.1	38.3	174
Estacada	52.0	57.3	414

Figure 1. Location of the study area. The stippled area includes approximately the Willamette Valley and the surrounding areas that were mapped.

Definition of Terms

Several terms used in the discussion of the geomorphology need to be defined for clarity. Usage is according to the following definitions:

Landscape—The landscape is the surface of the earth; the landforms of a region in the aggregate. Although the term may be used to include the biological part of the earth's surface features, the emphasis here is upon the geometric configuration of the "mineral" surface.

Landform—A landform is a simple part of the landscape, such as a hillslope, a flood plain, a ridgetop, or a scarp.

Geomorphic unit—A geomorphic unit is a unit of landforms as mapped. Transposition of information from the earth's surface requires generalization. A unit, as mapped, may include areas of other geomorphic units that are too small to differentiate. In some instances, a unit may group several landforms that could be separated into several units if mapping were done at a larger scale.

Geomorphic surface—A geomorphic surface is a landform or group of landforms that represents an episode of landscape development. Very often a surface represents a composite of several smaller episodes. For example, a stream terrace and the bordering landforms that resulted from dissection may be grouped together as a single surface. If more detailed study of developmental history is desired, the terrace and its bordering landforms can be considered separately.

Throughout the discussion that follows keep in mind that, in general, the higher a geomorphic surface is in the landscape, the older it is. There are exceptions to this generality; they are noted when they become an important departure from the sequence of events.

Geology

Physiography

The Willamette Valley lies between the Cascade Range on the east and the Coast Range on the west. With few exceptions, it is an area of low relief lying between elevations of about 50 and 450 feet above sea level. It is about 110 miles long and about 35 miles wide in its northern part. Average width is about 25 miles.

The Willamette River flows generally northward to the vicinity of Newberg, where it turns rather abruptly eastward. Between Newberg and Canby, it follows a course of about N 80° E until it again turns northward through Oregon City and Portland to the Columbia River. It flows a total distance of 187 miles from its origin at the confluence of the Middle Fork and the Coast Fork of the Willamette River to its juncture with the Columbia River, 113 air miles distant. Its major tributaries entering from the east are the Clackamas River, the Mollala-Pudding River system, the North and South Santiam rivers, the Calapooyia River, and the McKenzie River. The Coast Fork and the Middle Fork of the Willamette flow into the valley from the south and join near the city of Springfield. Major tributaries on the west side of the valley are the Long Tom River, Marys River, Luckiamute River, Rickreall Creek, Yamhill River system, and the Tualatin River.

The Willamette River descends from an elevation of 440 feet at the confluence of the Middle Fork and the Coast Fork to about 20 feet at its juncture with the Columbia River. Average gradient over its entire course is 2.3 feet per mile, but it ranges from a maximum of 12 feet per mile near its headwaters to a minimum of about 0.2 foot per mile. Several changes in gradient are apparent in the longitudinal profile (Fig. 2). The waterfall at Oregon City is an abrupt break in the continuity of the river profile, which indicates failure of the stream to adjust to a change in base level. The several small irregularities in gradient along the southernmost reaches of the stream probably represent deposits of alluvium from former floods that have not yet been uniformly distributed along the channel.

The valley is divided into two more or less natural subdivisions by the Salem Hills-Eola Hills topographic high area. The southern part of the valley is typified by very low relief and slightly incised valleys. The northern valley is more completely dissected and the streams have incised their valleys several times deeper than those of the southern valley.

Prominent ridges and hills rise above the valley in its northernmost part and disrupt the otherwise low-relief topography. Many of the toeslopes of these hills merge with the lower nearly flat parts of the valley and make determination of boundaries between geomorphic units approximate at best. Scattered hills that appear to have been partially buried by alluvium rise abruptly from the floor of the southern part of the valley.

Unlike most valleys, the general level of the Willamette Valley does not gradually decline toward the mouth. A slight northward decrease in elevation is evident until the broad prairies gradually begin to rise in the general area between Salem and Newberg. This has probably been caused by continual deformation along a structural trend extending across the valley in the vicinity of Oregon City, Tualatin, and Chehalem Mountain.

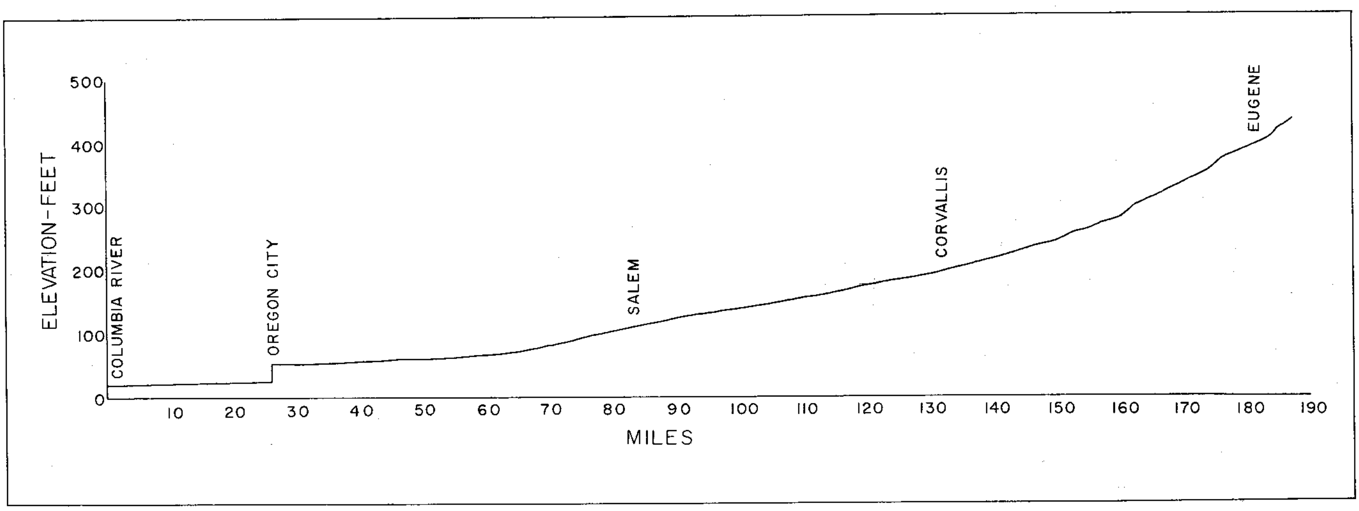

Figure 2. Longitudinal profile of the Willamette River extending from its confluence with the Columbia River to the juncture of the Middle Fork and the Coast Fork of the Willamette.

Piper (*18*) concluded that structural deformation was evident from the configuration of the bedrock floor of the valley and from the variable thickness of the alluvial fill. The falls at Oregon City suggest that uplift must have occurred relative to the bedrock floor of the valley at Woodburn, which is about 154 feet below sea level (*18*).

The flood plain of the Willamette River is narrow in relation to total valley width. In the southern part of the valley the stream occupies the westernmost part of the valley floor and is incised only about 15 to 25 feet below the general level of the plains. Incision becomes greater as the river flows northward across the valley, until a maximum of about 120 feet of relief between the upper valley plain and river is attained near Canby. The flood plain of the river is narrowest and most deeply incised near Canby.

General geology

The part of the Coast Range that borders the Willamette Valley is predominantly underlain by shales and sandstones of Eocene age (*32*). Extensive areas are underlain by extrusive volcanic rocks, and small areas are underlain by intrusive igneous rocks (*22, 23, 32*). There are small areas of Oligocene, Miocene, and Pliocene rocks (*31*). For the most part, the terrane of the Coast Range is typified by rocks of relatively low resistance to weathering that erode to rounded landforms.

Most of the Cascade Range that borders the Willamette Valley on the east is underlain by volcanic breccias, tuffs, and lava flows (*17*). These rocks range from Late Eocene to Pliocene in age; composition varies between basaltic and rhyolitic but is predominantly andesitic. Minor glacial deposits (*17*) of Pleistocene age have been recognized in the Cascade Range, but in the area bordering the Willamette Valley the deposits are restricted to major tributary valleys. Gravel that is at least partly glacial outwash is common along the Santiam River system. Other streams flowing from the Cascades probably have transported less glacial outwash.

The Willamette Valley floor is underlain by rocks ranging from Eocene to Miocene in age that were beveled by erosion during formation of the valley. Knowledge of these beds that underlie the valley is scant because they are covered by alluvium of Quaternary age, and few wells have been drilled deep enough to penetrate them.

Quaternary deposits in the valley are known only slightly except for the upper few feet of sediment. Old, very weathered gravel, which has been assigned to the middle and late Pleistocene (*3*), occurs on scattered remnants of high terraces along the valley flanks. The gravel deposits have been named Leffler Gravel and Lacomb Gravel (*3*) where they occur along the east side of the valley near the North and South Santiam rivers.

The main part of the valley has been deeply incised since the Leffler and Lacomb gravels were deposited and has been refilled with a thick sequence of alluvium. Maximum depth of incision probably approaches 400 feet below the present surface of the old gravel. Only the upper part of this later sequence of alluvial deposits is well known. Near the top of this deep fill, a partially cemented coarse gravel deposit occurs at about the present level of the Willamette River. The sediments above this gravel unit immediately underlie extensive areas of the valley bottom, and they served as the materials in which the soils formed.

Allison (*3*) named the entire unit above the cemented gravels Willamette Silts. The stratigraphic sequence, however, appears to be more complex than formerly believed. A silty and sandy unit with remnants of an extensive paleosol lies immediately above the gravel unit. The paleosol often has a clay texture and probably represents an extended period of weathering and, at the very least, an important unconformity. A unit of variable thickness, composed of silty and sandy sediments with a predominantly basaltic mineral assemblage, lies on the paleosolic unit. Overlying this unit with basaltic minerals is one of faintly bedded, micaceous, quartzose, silty material which was apparently intended by Allison to be the type lithology of Willamette Silts. These silts are commonly, in turn, overlain by a thin unit of clay. The surface unit of sediment is a light-colored silty material that covers much of the valley. These latter two units, the clay and the silt, overlie the micaceous silts unconformably and extend far beyond the faintly bedded micaceous silts. The unconformable relation and disparate distribution indicate a lack of depositional continuity between the micaceous silts and the uppermost units (*16*).

The younger parts of the valley were developed in the sequence of sediments described in the preceding paragraph by cutting and removing the older materials and redepositing alluvium in their place. Each of the younger valley levels has its own deposits of mixed alluvium.

Geomorphic Surfaces

High-altitude aerial photographs (1 inch = 1 mile) were used for mapping the geomorphology. These small-scale photographs permitted mapping the Willamette Valley floor and immediately adjacent areas on a reasonable number of sheets. Their use limited the size of areas that could be delineated, which resulted in a degree of generalization that has been valuable in understanding the geomorphic history of the valley. On the other hand, small details of geomorphology have been ignored and a certain degree of generalization has been introduced in the relation of soils to geomorphic surfaces. A more detailed study of geomorphology should be used to relate specific soils to geomorphic surfaces.

Each geomorphic unit has been named for a locality in which that particular landscape is well expressed. Each name is intended to be unique and has been chosen to exclude names of established soil series or stratigraphic units used in western United States.

To a large degree, the geomorphic surfaces fit a time sequence, but there are exceptions that are noted in the discussions of individual units. Following is a diagrammatic arrangement of the geomorphic surfaces in the order of their age (also see Fig. 3). The oldest surface (Eola) is assigned the first position; the youngest surface (Horseshoe) ranks as last in the group.

1. Eola (Eo)
2. Dolph (Do)
3. Quad (Qu)
4. Calapooyia (Ca) — Looney (Lo)
5. Senecal (Se) (Ser) — Mass movement (M)
6. Champoeg (Ch)
7. Winkle (Wi)
8. Ingram (In) — Luckiamute (Lu)
9. Horseshoe (Ho)

Looney unit. The southern margin of the Salem Hills near Looney Butte is typical of landscapes that were mapped in the Looney unit. This geomorphic unit is a complex group of valleys and intervening ridges that compose a completely dissected, predominantly steeply sloping terrain. Slope gradients may occasionally exceed 100 percent. By far the greatest part of the Looney unit must be considered an unstable landscape.

Determination of an age for the Looney unit is precluded by the nature of its definition. Steep broken topography mapped as Looney may join any other two surfaces of various ages or it may make up large areas of mountainous country so completely dissected that it contains no recognizable extensive geomorphic surfaces. It is well known that erosion is active on parts of Looney landforms at the present time. It is very probable that other small parts can be correlated with the oldest surfaces in the area. The span of time covered, variability of age, and rough broken topography are characteristic of the Looney unit and make it very useful in mapping extensive dissected terrain in mountainous areas.

The Looney unit could be subdivided into several smaller units if it were mapped in detail. Small valley flats and remnants of old surfaces are apparent in some localities. At least two, and sometimes three, significant gradient breaks are apparent on many slopes (*5*).

Eola unit. The Eola unit consists of remnants of the oldest stable geomorphic surfaces in the area. The crests and upper parts of the Salem Hills, Waldo Hills, Eola Hills, Red Hills of Dundee, and of the hills in the vicinity of Lacomb are representative of this unit. The Eola Hills are designated as the type locality; the area near Popcorn School, 4 miles NW of Salem, is particularly representative of the unit.

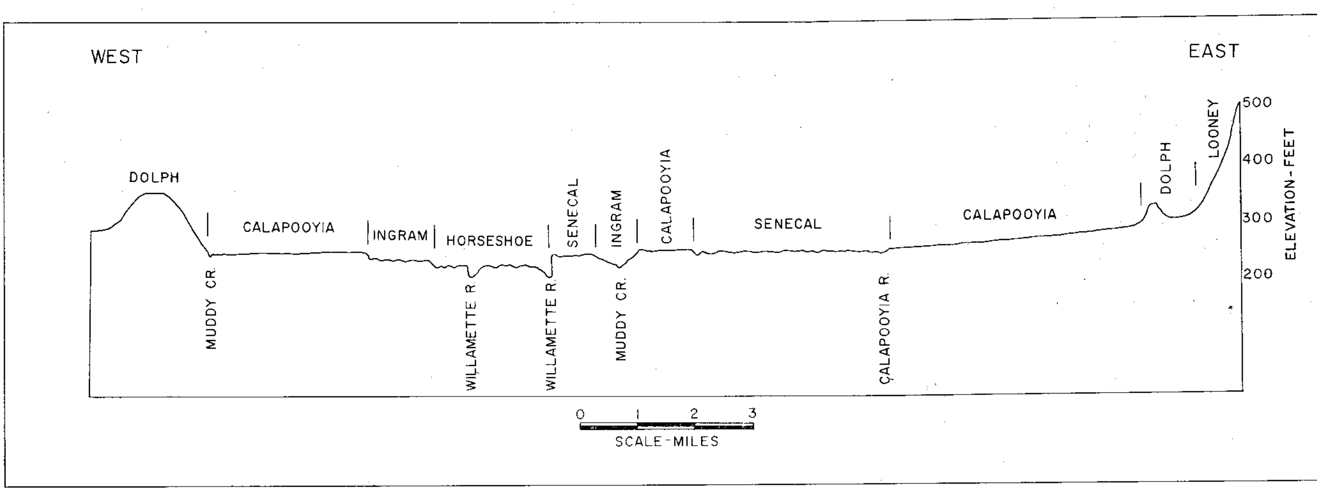

Figure 3. Topographic profile across the Willamette Valley approximately along latitude 44° 30′ N. Geomorphic units are identified above the profile and show the relation typical of the southern Willamette Valley area.

Relief on the Eola unit is moderate. Typical remnant landforms have rounded hill and valley topography with as much as 200 feet of local relief. Slope gradients range up to 20 percent on landscapes that have not been recently modified.

Allison (*3*) named two deposits of deeply weathered gravel, Lacomb and Leffler, and assigned them to early and middle Pleistocene, respectively. It appears that both deposits occur under the Eola surface and that the age of the landscape is probably middle Pleistocene.

The Eola surface has been extensively modified and only small remnants of the original landscape now remain. Landforms of the Looney unit generally adjoin the remnants of the Eola surface. Relief between remnants of the Eola unit and the next younger Dolph unit may be as great as 800 feet.

Dolph unit. The Dolph unit is the next youngest group of landforms below the Eola unit and is named for Dolph Corner, which is about 3 miles north of Dallas.

Topography of the Dolph surface varies, but locally the surface is well above the general level of the valley floor as extensive flats. Most of these flats have been dissected to form a rolling topography composed of a complex group of landforms that could be further divided into about three units for detailed mapping. In many places dissection has formed landscapes that are mapped as Looney if they are large enough to warrant delineation. Numerous small pediments that grade from broken topography of the Looney unit down to the main valley floor are also included in the Dolph unit. The boundary between these Dolph pediments and the steep Looney slopes is usually marked by a distinct change in slope gradient. The small valleys and their sideslopes that have been formed by dissection of the flats are also included in the Dolph unit.

Characteristics of the Dolph surfaces progressively change over the length of the valley. Extensive flats underlain by very weathered gravel, sands, and clays are well expressed near Alvadore. Similar flats near Corvallis have a layer of light gray, massive silt above weathered gravel. At Dolph Corner the surface is immediately underlain by weathered gravel and numerous erratics (*1, 2*) are scattered on the surface. Farther north, near McCoy, thick massive or contorted silts with numerous erratics completely mask any weathered gravel that may be there. More rounded landforms characterize the Dolph surface in the northern parts of the valley. Strath terraces along the eastern margin of the Willamette Valley in Linn County were also mapped as Dolph.

Most of the erratics that caused Allison (*3*) to relate the Willamette Silts to glacial meltwaters are associated with the Dolph surface and the massive unbedded silts that occur beneath it. The bedded Willamette Silts seem to be entirely restricted to the Calapooyia and Senecal surfaces, which are much younger.

Most of the weathered gravel so common beneath the Dolph surface probably correlates with the Lacomb and Leffler deposits. It seems, then, that the age of the Dolph surface should be considered to be middle Pleistocene.

Quad unit. The Quad unit is similar in morphology to the topographically slightly lower Calapooyia unit. The Quad unit is not extensive. For lack of a better known type locality, the quadrangle on the campus of Oregon State University serves as a source for the name.

The most satisfactory explanation of the Quad unit seems to be that faulting uplifted an area of Calapooyia surface before cutting of the landform was complete. The latest deposits that are present on the Calapooyia surface are lacking on the Quad unit. The higher elevations and the different deposits that underlie the Quad surface justify it as a unit for mapping.

Characteristically, the Quad surface has only a few feet of relief except along the slightly dissected scarp that marks its boundaries. For this reason, it belongs to the group of surfaces associated with the Willamette Valley floor.

The Quad unit is obviously somewhat older than the Calapooyia surface. It is probably much younger than the Dolph surface. Weathering of materials underlying the soils of the Dolph surface is extreme compared to the weathering of materials underlying the Quad landforms. Inadequate as the state of weathering is for estimating age, it is the only criterion available here other than placement in vertical sequence. On the basis of morphology and state of weathering, the Quad surface is considered to be more closely related to the Calapooyia unit than to the Dolph unit. A late Pleistocene age seems most reasonable.

Calapooyia unit. The Calapooyia unit is an extensive landscape on the main valley floor. The Calapooyia unit is best expressed in the southern part of the valley and is particularly prominent along the eastern side of the Calapooyia River, from which it takes its name.

Absence of appreciable local relief is characteristic of the Calapooyia topography. Maximum difference in elevation usually does not exceed 2 or 3 feet. In the southern part of the valley, the surface declines in a northwesterly direction at a rate of about 5 feet per mile. As is expected on a surface with these characteristics, drainage is unorganized, or very poorly organized at best; and drainage of surface water is extremely slow.

The Calapooyia unit is typically expressed by a tonal pattern on aerial photographs of light-colored areas enclosed in a dark-toned background. The light-colored areas are poorly drained depressions separated by slight relief from the intervening, slightly higher and better drained, dark-colored areas. Depressions are typically circular or ovate, although irregular shapes are common.

By far the greatest acreage of Calapooyia surface is in the southern part of the valley. Greater incision of the Willamette River in the northern part of the valley resulted in increased dissection of the Calapooyia surface.

The Calapooyia surface is a product of deposition of a thin mantle of materials on a valley floor surface that was eroded from earlier materials, predominantly Willamette Silts (*3*). Allison postulated that the valley floor was formed by deposition of Willamette Silts. Detailed investigations, however, show that the Calapooyia surface extends many miles beyond any parallel-bedded silts that can be safely assigned to Willamette Silts. Therefore, it must be concluded that the Calapooyia surface is considerably younger than the Willamette Silts. At least three important events occurred between the deep incision of the valley below the Dolph surface and deposition of the final units on the Calapooyia. First, the deeply incised valley was filled by a great thickness of alluvium, which was then covered by Willamette Silts. Second, the depositional surface of the Willamette Silts, which very likely had been exposed long enough for a soil to develop, was eroded. Third, clay was deposited over the eroded plain and subsequently was covered by a thin mantle of silt to form the Calapooyia surface. Erosion during the second episode completely removed any silts that may have been deposited in the southernmost part of the valley and cut deeply into the underlying gravel. The uppermost clay and silt units of most of the area south of Harrisburg lie directly on the older gravel deposits. Willamette Silts are also absent in the vicinity of Canby and were probably completely removed by erosion to expose the underlying alluvium.

No samples of wood or charcoal have been found in the Willamette Silts. Samples from the underlying units have all been beyond the reach of radiocarbon dating. An absolute age for the Calapooyia surface is unavailable, but its development probably took place during late Pleistocene.

Senecal unit. Modification of the Calapooyia surface and the development of drainage produced the landscape of the Senecal unit. The area around Senecal Creek near Woodburn has been chosen as the type expression of the unit and furnishes its name.

In the southern part of the Willamette Valley, organization of drainage of the Calapooyia surface has resulted in minor incision of the drainways. Consequently, modification of the Calapooyia surface has been minor. Locally, it appears that the drainage organization has been produced by overland flooding of a nearby major stream shortly after deposition of the final blanket of silty material.

If it is assumed that the Calapooyia landscape of the Halsey Quadrangle was a plane surface after deposition, it can be represented by the following equation:

$$y = b_O + b_E X_E + b_N X_N$$

where y = elevation above sea level

b_O = elevation at the southwest corner of the Halsey Quadrangle at 44° 15′ north latitude and 123° 15′ west longitude

b_E = the slope gradient in the eastward direction

X_E = coordinate distance east of the southwest corner of the Halsey Quadrangle

b_N = the slope gradient in the northward direction

X_N = coordinate distance north of the southwest corner of the Halsey Quadrangle.

Analysis of elevations of 47 benchmarks located on the Calapooyia and Senecal surfaces results in the following values for the above equation:

$$y = 308.34 \text{ ft.} + 2.11\, X_E - 4.397 X_N$$

Statistical analysis shows that most of the variance in elevation can be attributed to slope of the surface. By removing the effects of slope from the variance, the standard deviation from the sloping plane is found to be only 8.7 feet. This variation includes differences of elevation that result from dissection, original relief, and any original curvature of the surface that may have existed.

If these data are used to determine the proper geographic orientation of the surface, it is found that the slope gradient is in a direction N 25° W at about 4.9 feet per mile. This remarkably plane surface slopes obliquely to the main Willamette Valley at this location.

Farther north in the valley, incision of streams and drainageways into the Calapooyia surface has resulted in two kinds of modification. The organization of drainage with little or no incision results in small areas of the Senecal unit surrounding major drainageways to their outer fringes. Deeper incision resulting in the deep, narrow valleys could be mapped as Ingram unit with a larger map scale. However, it was necessary to include them in the Senecal unit for this study.

There is a marked change in the character of the Senecal landforms between the area south of the Salem Hills and the area north of the Salem Hills and east of the Willamette River. The Senecal surface south of the Salem Hills is typified by very slight relief and organization of drainage with little incision. The Senecal surface north of the Salem Hills and east of the Willamette River is typified by more deeply incised drainage with only minor amounts of the slightly incised organized drainage of the southern part of the valley. North of Salem and west of the Willamette River, Senecal landscapes include both of the above kinds of landforms. Extensive plains with only slight relief are cut by deeply incised valleys of the major streams.

Senecal (rock floored—Ser). A small area of the Senecal unit, near West Linn, has been mapped separately because it has a shallow bedrock floor. It is the only place in the entire valley where there are no Pleistocene sedimentary units between bedrock and the surface. This fact seems to have great significance as evidence of the structural development and sedimentation in the valley.

Although there is not enough evidence to draw any firm conclusions at this time, it appears that moderate structural deformation within the valley during and since late Pleistocene has been a controlling factor in the development of valley landscapes. Additional data from deep boreholes or by seismic methods could corroborate or refute this hypothesis.

Age of the Senecal surface is probab'y not greatly different from that of the Calapooyia. The erosion that developed the Senecal from the Calapooyia surface probably required only a short time. Its minimum age must be greater than that of the Winkle, which is the oldest surface that has been dated by radiocarbon samples. A late Pleistocene age is reasonable.

Champoeg unit. The Champoeg unit is a modification of the Calapooyia and Senecal surfaces that represents more severe dissection but is of smaller extent than the Senecal unit. An area about 2 miles SW of Newberg, near Champoeg Park, serves as the type locality for the unit.

Small, pediment-like landforms make up the greater part of the Champoeg unit. Apparently, the base level toward which the landscape was progressing remained stable only long enough to allow the beginning stages of development of a lower level valley bottom. Rejuvenation and subsequent incision left only small remnants of the backslopes and toeslopes of the pediments.

Relief on the Champoeg surface varies greatly from north to south in the valley. In the vicinity of Newberg, relief between the Senecal surface and the lowest point on the Champoeg surface may be as much as 70 feet. A gradual decrease southward results in such low relief in the southern part of the valley that identification of the Champoeg surface is questionable.

Development of the Champoeg unit marks a major downcutting episode in post-Calapooyia time within the Willamette Valley. Specific age has not been determined, but it is probably late Pleistocene. Discovery of materials for radiocarbon dating may allow assignment of an absolute age. However, since the deposits underlying the Winkle surface are barely within reach of radiocarbon dating techniques, the possibility of obtaining a date seems remote.

Winkle unit. The Winkle unit is one of the more extensive surfaces on the valley floor. Its type locality is at Winkle Butte, about 10 miles south of Corvallis.

Most of the Winkle unit has the morphology of abandoned flood plains of aggrading streams. Low-relief, subparallel corrugations of old channels are still apparent at many places on Winkle landscapes. They suggest a braided, overloaded stream channel in some localities and generally reflect the size of the channel of the stream that was responsible for their formation. In other words, a fine pattern with low relief reflects the work of a small stream; a coarser pattern of larger channels reflects cutting by a larger stream. Some areas of the Winkle surface were formed by the Willamette River; others were formed by smaller streams such as the Luckiamute River or even Muddy Creek. The dependence of morphology of the surface on the parent stream explains the variability of the Winkle surface.

A few areas of the Winkle surface are old lakebeds filled with peat or muck deposits. Lake Labish, near Salem, is an excellent example. These old lakebeds represent the final stages of the formative processes of the Winkle surface.

Several age dates for the Winkle surface and its underlying alluvium have been obtained. Reckendorf and Parsons (*20*) studied a hearth site buried beneath the Winkle surface which yielded charcoal 5,250 $\pm$ 270 years old. Deeper sediments at the same site yielded wood fragments that gave an age of 10,850 $\pm$ 240 years before present.[3] Glenn (1963, unpublished Ph.D. thesis, Oregon State University) gives a date of 34,410 $\pm$ 3,450 as a maximum age of Willamette Silts. The sample location falls within an area of Winkle surface, which suggests that the Winkle unit may be as old as 34,410 $\pm$ 3,450 years. Glenn cites a date of 12,240 $\pm$ 330 years from Onion Flat. Thus, sedimentation beneath the Winkle unit began at least 12,240 $\pm$ 330 years ago and may have begun as long as 34,410 $\pm$ 3,450 years ago.

A thin band of pumice, undoubtedly from Mt. Mazama (*35*), commonly occurs within the upper few feet of the alluvium that underlies the Winkle surface. A thin pumice bed also occurs within the upper few feet of peat at Lake Labish, near Salem, and Onion Flat, near Sherwood. The latter stages of alluviation that resulted in the Winkle surface were most likely contemporaneous with the formation of Crater Lake.

South of the Salem area, relief between the Winkle surface and the Senecal surface amounts to only a few feet. This difference in elevation increases rapidly northward until it exceeds 25 feet at Lake Labish and attains a maximum of about 70 feet near Canby. Relief between the Winkle surface and the next lower Ingram surface remains nearly the same throughout the valley. This disparate relief between the Winkle and Senecal surfaces from the northern to the southern parts of the valley may be indicative of a major tectonic event with greater uplift in the northern end of the valley. Piper (*18*) notes that the bedrock floor of the valley is anomalously low in the central part of the valley and suggests that warping was responsible.

[3] Dates determined by Isotopes, Inc., Westwood, New Jersey; sample No. I-1564.

The Winkle surface represents an important interval of time in the history of the Willamette Valley. It is extensive and represents a major diastrophic event. Almost all of the time represented by the Wisconsin stage of glaciation and by postglacial time may be included in the sequence of events since the beginning of the Winkle episode.

Ingram unit. The Ingram unit includes the higher of two flood plain levels of the Willamette River and its tributaries within the main valley floor. It is named for Ingram Island, along the Willamette River northwest of Harrisburg.

The topography of the Ingram surface along the Willamette River typically is undulating with a maximum of about 8 feet of relief. The relief is a result of corrugations developed by overbank channeling, and a crude directional orientation of ridges and intervening channels is perceptible.

Surfaces of the Ingram unit that are associated with smaller streams have correspondingly less relief simply because there was less water to cut the channels. Thus, the Ingram unit contains landscapes with a limited variety of relief characteristics. These characteristics are related to the stream that flowed through the particular area to form the surface.

The Willamette River commonly floods the lower parts of the Ingram surface, but seldom, if ever, floods the higher ridges. Thus, the Ingram surface can probably no longer be considered the flood plain of the river but should be called a low terrace. Flooding of the Ingram unit along the smaller streams of the area is not so easily categorized. Some areas of Ingram are often completely flooded, while others seldom, if ever, suffer complete inundation. The seemingly inconsistent patterns of flooding probably result from the many small streams within the Willamette Valley that have longitudinal profiles with segmented gradients.

Radiocarbon dating has given ages ranging from 555 ± 100 years (*5*) to 3,290 ± 120 years[4] for the upper level of the Luckiamute unit (see col. 2). Direct correlation of the surfaces then assigns the same age to the Ingram unit. If the youngest date from the Winkle surface, 5,250 ± 270 years, is compared with the oldest date from the Ingram surface, the disparity in time is not great. The change in the stream system that caused abandonment of the Winkle surface as a flood plain occurred between 3,290 ± 120 years and 5,250 ± 270 years before present. The partial abandonment of the Ingram surface as a flood plain probably occurred not more than 555 ± 100 years ago.

Horseshoe unit. The Horseshoe unit is the lower of the two flood plain levels of the Willamette River. It is named for Horseshoe Island, between Corvallis and Peoria.

[4] Dates determined by Isotopes, Inc.; sample No. I-1475.

The Horseshoe surface has low relief and includes the channel and associated features of the Willamette River. Point bar deposits, channel fillings, and abandoned meanders are common features of the Horseshoe unit. Typically, the surface is underlain by coarse or moderately coarse alluvium. Identification from aerial photographs is often aided by the fact that many areas of the Horseshoe unit are not vegetated or support young, dense stands of phreatophytes, such as willows or cottonwoods.

Annual flooding of the Willamette River inundates the entire Horseshoe surface and results in relatively rapid changes in the landscape. Abandonment of channels, cutting of new channels, and lateral migration of meanders annually adds areas of the valley to the Horseshoe unit.

The Horseshoe unit generally was not mapped along the valleys of streams that are tributary to the Willamette River because of the small size of the areas. Exceptions are large areas of Horseshoe surface along the Santiam River system. In addition, many of the tributary streams do not have two identifiable levels of flood plain. This alone suggests that the Horseshoe level began to form only a short time ago, perhaps since settlement of the valley during the middle of the 19th century.

Luckiamute unit. The Luckiamute unit is composed of flood plains of streams that flow out of terrains composed of Eola, Dolph, and Looney units. The name was derived from the Luckiamute River valley above the town of Pedee. The unit was designed to distinguish between the valley floors of streams tributary to the Willamette and the main valley floor. Deposits of the tributary streams are influenced by local bedrock to a much greater extent than those of the main valley. Topography of the Luckiamute surface is typical of the flood plains of small streams. Transverse to the valley, they approach a horizontal, flat profile; along the valley length, they generally parallel the present-day channel of the stream. Other than minor corrugation by channeling, relief is absent.

The Luckiamute unit is divided into at least two levels in many tributary valleys, but the size of the area occupied by each unit prohibits mapping at the small scale used for this study. In the Willamette Valley, the two levels were mapped as the Ingram and Horseshoe units and discussed separately.

In many valleys, the two separate levels of the Luckiamute unit cannot be recognized. Within some valleys, given segments may have two distinct levels, but other segments may have only a single level. These apparent discrepancies can be explained by differential uplift or variation in the competence of the underlying materials along the course of the valley.

Small alluvial fans extending out of small valleys onto surfaces of the main valley have been included in the Luckiamute unit. Such fans are characterized by alluvium derived from local materials underlying the small drainage systems, and they contain sediments of variable composition. In this sense the fans are most closely related to the Luckiamute unit.

Since the Luckiamute surface can be correlated directly with the Ingram and Horseshoe units in the Willamette Valley, the age of the Luckiamute unit may be presumed to bracket the age of the latter two units. Radiocarbon dates are presented in the discussion of the Ingram and Horseshoe units.

Mass movement. The hilly areas associated with the Willamette Valley have many features resulting from mass movement. Small slump blocks and their resulting scars are common throughout the hills. Mud-flows occur on steep slopes of many areas and often follow well-defined channels to the bottom of the valley. The total area affected by mass movement is tremendous, but most of the individual features are too small to be conveniently mapped.

Parcels of terrain resulting from mass movement that are large enough to map occur in several places within the Willamette Valley area. Typically, they have hummocky, irregular topography with poorly drained depressions. The scar from which the material came usually is cup-shaped. At some places, the scar and the deposit may be separated by some distance. In other places there is a scar with no associated deposit and the supposition must be that the material was subsequently removed or so modified that it is no longer identifiable. As mapped, many of the areas are the result of coalescence of many individual deposits from separate events.

No formal name has been designated for the unit that includes the areas of mass movement. The unit is not related to the landscape or the sequence of events in the way the other units are. Mass movement is a continual process and cannot be placed in the time sequence. It was felt that the features related to mass movement were worthy of note on the map for their significance to erosion processes, soil distribution, and engineering planning and not for their contribution to the geomorphic history of the area.

Large areas of mass movement are almost restricted to the Looney landscape where it occurs between Eola and later surfaces. A few areas large enough to map are found within the Looney unit where it lies between the Dolph surface and much younger surfaces such as Ingram or Horseshoe.

Soils

Because geomorphology and soil landscapes are often directly related, soil scientists have long recognized the necessity of using geomorphology as a helpful tool in mapping soils (*24*). Early soil survey reports (*6, 12*) usually divided the soil landscape in a survey area by applying such terms as alluvial bottomland, terrace, fan, bench, rolling uplands, and rough mountainous land. In some instances, the gross geomorphic separations were used as soil mapping units. Now the term "rough mountainous land" is used only in reconnaissance soil survey legends (*24*). However, terms such as lava flow, terrace escarpment, tidal flat, and dune land are used as miscellaneous land types in detailed soil surveys.

The purpose of this part of the paper is to discuss some of the relations between the geomorphic units and the soils of the Willamette Valley. Detailed profile descriptions of soils considered as representative of each geomorphic surface are presented in the Appendix. Family and subgroup classifications (*25*) for the series are presented in Table 2.

Looney unit soils. As a result of wide variations in climate, vegetation, slope, parent material, and age, soils common to the Looney unit show a great range in profile characteristics. The soil series selected as representative of this unit are Apt*[5], Honeygrove*, Peavine*, McCully*, Kinney*, and Chehulpum*.

[5] Soil series names followed by an asterisk are tentative.

Apt* soils are Haplohumults that occur on the mountainous topography of the Coast Range at elevations of 500 to 1,500 feet and have developed in colluvium from Eocene sandstones. Slope gradient ranges from 3 to 50 percent. Apt* soils have a dark brown clay A horizon and a dark brown clay Bt horizon. Thickness of the sola exceeds 5 feet.

Honeygrove* soils are similar to Apt* soils but occur on less dissected slopes of 5 to 40 percent, have a dark reddish brown clay A horizon, and a dark red (2.5YR3/6) clay Bt horizon. Honeygrove* soils differ from Apt* soils primarily because of landscape stability and, hence, relative age.

In a roadcut in the Coast Range, as many as nine lithologic discontinuities were observed in a vertical sequence of both Apt* and Honeygrove* soils. At this site, Honeygrove* soils are developed in several increments of fine-textured alluvium deposited along a 12 percent slope which had been truncated by more recent steeper slopes. The Apt* soil series is represented toward the top of the slope, where the redder colored soil thinned, and the solum is directly over sandstone. The Apt* soils obviously developed from more recent sediments deposited over sandstones of the Tyee formation.

Chehulpum* soils (Haploxerolls) are representative of soils developed on 3 to 40 percent slopes of the Looney unit within the Willamette Valley. Sola thickness is less than 20 inches over a IIR horizon composed of

Table 2. CLASSIFICATION OF SOILS REPRESENTATIVE OF THE VARIOUS GEOMORPHIC SURFACES, WILLAMETTE VALLEY, OREGON

		Classification[1]	
Geomorphic surface	Series	Family	Subgroup
Looney	Apt*[2]	clayey, mixed, mesic	Typic Haplohumult
	Chehulpum*	loamy, mixed, mesic, shallow	Entic Haploxeroll
	Honeygrove*	clayey, mixed, mesic	Typic Haplohumult
	Kinney*	fine-loamy, mixed, mesic	Andic Haplumbrept
	McCully*	fine, mixed, mesic	Typic Haplumbrept
	Peavine*	clayey, mixed, mesic	Typic Haplohumult
Eola	Laurelwood*	fine-silty, mixed, mesic	Ultic Haploxeralf
	Jory*	clayey, mixed, mesic	Xeric Haplohumult
Dolph	Steiwer*	fine-loamy, mixed, mesic	Ultic Haploxeroll
	Hazelair*	very fine, mixed, mesic	Aquultic Haploxeroll
	Salkum	fine, mixed, mesic	Ultic Haploxeralf
	Willakenzie*	fine-loamy, mixed, mesic	Ultic Haploxeralf
Quad	Willamette	fine-silty, mixed, mesic	Pachic Ultic Argixeroll
Calapooyia	Dayton	fine, montmorillonitic, mesic	Typic Albaqualf
	Concord	fine, montmorillonitic, mesic	Typic Ochraqualf
Senecal	Aloha*	fine-silty, mixed, mesic	Aquic Xerochrept
	Woodburn*	fine-silty, mixed, mesic	Aquultic Argixeroll
Champoeg	Amity	fine-silty, mixed, mesic	Argiaquic Xeric Argialboll
Winkle	Malabon*	fine, mixed, mesic	Pachic Ultic Argixeroll
	Salem	fine-loamy over sandy or sandy skeletal, mixed, mesic	Pachic Ultic Argixeroll
Ingram	Chehalis	fine-silty, mixed, mesic	Cumulic Ultic Haploxeroll
Horseshoe	Newberg	coarse-loamy, mixed, mesic	Fluventic Haploxeroll
Luckiamute	Abiqua*	fine, mixed, mesic	Cumulic Ultic Haploxeroll
	Bashaw*	very fine, montmorillonitic, mesic	Typic Pelloxerert

[1] Classified by A. O. Ness, State Soil Correlator, SCS, Portland, Oregon. Classification is based on "Supplement to Soil Classification System (7th Approximation), 1967.

[2] Series names followed by an asterisk are tentative series.

sedimentary bedrock. In some places, a cambic horizon has developed where the soil material has been stable for a sufficient time (*14*). Red clay films on bedrock fractures suggest that landscape modification removed a former red soil.

Witzel* soils are commonly found on buttes and other steep, active (*5*) slopes in the Willamette Valley. Witzel* soils have dark brown and dark reddish brown, gravelly silty clay loam A and B horizons which overlie, at depths of 15 to 20 inches, a IIR horizon (*15*) composed of fractured basalt bedrock.

Kinney* soils are well-drained, cobbly, very acid Haplumbrepts developed in till or colluvium over basic igneous rocks on slopes of 3 to 70 percent at elevations of 1,000 to 3,500 feet in the Cascade Mountains. Thickness of the sola ranges from 36 to 60 inches. The geomorphic surfaces have apparently been stable long enough to permit development of a B horizon and a thick, dark A1 horizon.

McCully* soils are well-drained, fine-textured Haplumbrepts developed in colluvium or alluvium-colluvium over basic igneous rocks on slopes of 4 to 30 percent in the Cascade Mountains. Thickness of the sola ranges from 36 to 60 inches. McCully* soils differ from Kinney* soils by having redder (5YR), relatively stone-free, fine-textured sola.

Peavine* soils are Haplohumults with a dark brown (7.5YR3/2) silty clay loam A horizon and a yellowish red (5YR4/6) clay or silty clay B2t horizon which overlies weathered sedimentary rocks. Thickness of Peavine* sola is less than 40 inches. Peavine* soils, in some places, have basalt or diabase stone lines generally in the B1 horizon. These soils are mapped extensively in the Coast Range but also occur on the Eola unit along the edges of the Willamette Valley.

Studies of soils in the Coast Range (*5, 15*) have shown that the deep, red soils having a Bt horizon are found primarily on stable ridgetops and pediment remnants (Eola unit). Soils such as Hullt* and Klickitat* occur on more sloping, less stable positions. Shallow, rocky soils, such as Witzel*, Chehulpum*, and Kilchis, occur on steep, actively eroding slopes. Valley fill composed of weathered alluvium from upslope may produce soils, such as McCully* or Blachly*, with low base saturation and weakly expressed horizons (*15*).

In areas of the Looney unit where faulting has occurred, base-rich ground water seeping from the faults may result in black or very dark gray, somewhat poorly or poorly drained soils on fairly steep slopes (*14*). These soils are extensive in both the Coast Range and the Cascades. Soils which are known to reflect the emergence of base-rich ground water are in the Panther* and Philomath* series. Old landslide areas or saddles in the Looney unit may also contain dark, base-rich soils (*15*).

Eola unit soils. Jory* and Laurelwood* are representative of soils found on the Eola unit. These soils may also occur on small, stable remnants of the Eola unit in a landscape primarily composed of the Looney unit.

Jory* soils are well-drained, fine-textured Haplohumults with a dark reddish brown (5YR3/4) silty clay loam A horizon and a dark reddish brown or dark red (2.5YR3/4 or 3/6) clay Bt horizon. Jory* soils developed on slopes of dominantly 2 to 12 percent in alluvium-colluvium from basic igneous rocks. Depth to bedrock may be as much as 20 feet or more. Stone lines (*15*), which represent concentrations of lag, are common in Jory* soils and indicate cyclic erosion and deposition. A Jory* soil on a stable pediment remnant in the Coast Range has a minimum age of 9,570 years B. P. (*5*). Thorp and Smith (*27*) suggest that Oregon soils similar to Jory* soils have probably been developing since middle or early Pleistocene time. Jory* soils, therefore, may be considered old and probably have been subjected to several changes in vegetation and climate.

Laurelwood* soils have a dark brown A horizon and a yellowish brown, silty clay loam Bt horizon. They developed in materials thought to be loess (*26, 34*). However, the presence of rounded peds that appear to have been burned and of stones in the sola make it difficult to believe that this material is solely of eolian origin. Alluvial processes have probably contributed slopewash materials to the sola. The silty mantle often overlies red paleosols.

In general, the soils of the Eola unit are red or yellowish red Ultisols with a Bt horizon. However, even though the Eola unit represents the highest and, hence, oldest geomorphic unit, one cannot presume that all the soils are equally well developed. Soils developed in recent slopewash on active slopes may be Inceptisols, Alfisols, or perhaps Mollisols. In Laurelwood* soils, the "loess" deposit over the red paleosol is a later soil parent material deposited after development of the Eola surface. The more recent soils, then, are like the soils of the Dolph or even the Senecal level. The red paleosol probably represents a soil related to the Eola episode of geomorphic development.

Dolph unit soils. Soils of the Dolph unit include Salkum, Willakenzie*, Steiwer*, Hazelair*, Veneta, Carlton, and others. Dolph unit soils are commonly Alfisols or Mollisols having 7.5YR hues and many of them have Bt horizons.

Hazelair* soils are Aquultic Haploxerolls that exhibit dark brown or dark yellowish brown silty clay loam A and silty clay B2 horizons that overlie a clay IIC horizon at depths of 17 to 18 inches. Sedimentary bedrock, the IIIR horizon, is usually at depths of 30 to 35 inches. These moderately well-drained soils ordinarily occur on slopes of 0 to 12 percent. The upper deposit has been shown to be pedisediment (*4, 14*). The very firm, massive, grayish brown (2.5Y5/2) clay IIC2 horizon of Hazelair* soils may range in thickness from 10 inches to 17 feet (*14*) and occurs discontinuously. Hazelair* soils occur in erratic patterns in association with Steiwer* and Chehulpum* soils.

Salkum soils are well-drained Ultic Haploxeralfs developed above very weathered gravel on slopes of 2 to 8 percent. These soils have a very dark brown (7.5YR2/2) silty clay loam A horizon over a dark brown (7.5YR4/4) silty clay B2t horizon. Salkum soils are geographically associated with soils of the Eola unit. Some soils over weathered gravel associated with the Eola unit may be included in the Salkum series. However, Salkum soils primarily occur on the Dolph level.

Stone lines of relatively fresh, rounded gravel have been observed in Salkum sola at several localities, indicating a lithologic discontinuity. Hence, the upper horizons may be considerably more recent than the underlying weathered gravel. In another area, A and B horizons are continuous over both a red clay IIB2tb horizon and a weathered gravel. The IIB2tb horizon is abruptly terminated, so the A and B horizons directly overlie the weathered gravel. The gravel contains numerous thick red clay films, even though the IIB2tb horizon is no longer coextensive with the weathered gravel. The A and B horizons have apparently formed in a more recent mantle over the remnant of a paleosol. Again, this suggests that the parent materials and, hence, the sola (or parts of the sola) do not reflect the age that ordinarily would be inferred from geomorphic position. It is possible to have comparatively young, weakly developed soils on modified old surfaces.

The Willakenzie* series is typical of the Dolph unit. Willakenzie* soils are similar to Salkum soils. They have a dark brown (7.5YR3/2) silty clay loam A horizon and a dark brown (7.5YR4/4) silty clay loam B2t horizon. Weathered sedimentary bedrock, the IIC horizon, occurs at 30 to 35 inches. Salkum soils differ from Willakenzie* soils by having a thicker epipedon and a silty clay rather than a silty clay loam Bt horizon. Willakenzie* soils seem to have formed largely under oak forest, and large areas of Salkum soils developed under "prairie" vegetation (*9*).

Soils in the Steiwer* series occur on the Dolph unit but lack the B2t horizon of Willakenzie* soils. A probable explanation is that Steiwer* soils have developed in recent pedisediment (*4, 14*) resulting from modification of the Dolph unit and, as yet, have not had sufficient time to develop Bt horizons.

Quad unit soils. As far as we know, the only soils found on the Quad unit are Willamette, Woodburn*, and Amity, although further field work may identify additional series. Helvetia* soils in Washington County may be on the Quad unit. Willamette soils are well-drained Argixerolls with very dark brown (10YR2/2) silt loam A horizons over dark brown (10YR3/3) silty clay loam B2t horizons. Willamette soils occur on slopes of 0 to 3 percent, but slopes may be as great as 20 percent along terrace escarpments or where drainageways have deeply incised the Quad, Senecal, or Champoeg surfaces. Depth to the Bt horizon seems to be greater in the southern Willamette Valley, suggesting a thickening of the A horizon by deposition subsequent to the deposition of Willamette Silts (*3*).

Calapooyia unit soils. Dayton and Concord are typical soils on the Calapooyia unit. Dayton soils are Albaqualfs (formerly Planosols) with a grayish brown (2.5Y5/2) silt loam A2 horizon and abundant iron-manganese concretions over a dark grayish brown (2.5Y4/2) clay IIB2t horizon. The sola may overlie Willamette Silts, a reddish paleosol, gravel, or bedrock. A recent study (*16*) has reported that the materials which comprise the A2 and B2 horizons of Dayton soils are not coextensive and, hence, the horizons are primarily depositional rather than developmental as previously thought by Allison (*3*) and by Pomerening and Knox (*19*). Dayton soils occur in large bodies in the southern Willamette Valley and on Dayton Prairie in Yamhill County.

Concord soils replace Dayton soils on the Calapooyia unit north of Salem. Concord soils (Ochraqualfs) resemble Dayton soils but have a thicker A2 horizon and a thinner silty clay or clay Bt horizon and lack an abrupt A2-B2t boundary. The light-colored tonal pattern on aerial photographs of the Calapooyia unit contains the poorly drained Dayton or Concord soils. Intervening darker toned, slightly higher convex areas are usually Amity soils.

In view of the genesis of Dayton soils (*16*), it is suggested that the A2 and B2t horizons of Concord soils could be also largely depositional. Truncation of the clay deposit of Dayton soils and the later emplacement of a thicker deposit in which an A2 horizon formed could produce sola similar to Concord sola. Or, perhaps, the initial clay deposit was thinner and the upper mantle thicker in soils now classified as Concord.

Senecal unit soils. The Woodburn* and Aloha* series may be considered typical of soils on the Senecal surface. Other soils which also occur on this surface as drainage associates are in the Willamette, Amity, Holcomb, Dayton, and Concord series. In the part of the Willamette Valley south of Salem, where dissection of the Senecal surface has been moderate, Amity and Concord soils are extensive, and Woodburn* and Willamette soils are concentrated mostly among natural levees and on higher knolls. However, between Salem and Canby in the northern valley, Woodburn* soils are dominant on the Senecal unit.[6]

Woodburn* soils are moderately well-drained Argixerolls on 0 to 3 percent slopes. Slope gradients may range up to 20 percent along terrace scarps. Woodburn* soils have a very dark brown (10YR2/2) silt loam A horizon and a dark brown (10YR4/3) heavy silt loam B2t horizon. A brittle layer may be present in the B3t horizon.

Aloha* soils are somewhat poorly drained Xerochrepts with a thin, dark brown (10YR3/3) silt loam Ap horizon and a dark yellowish brown (10YR4/4) heavy silt loam B2 horizon. The B2 and B3 horizons are brittle, and there are clean pale-colored sand and silt particles on ped surfaces. Aloha* soils differ from Woodburn* soils primarily in being more poorly drained, having a thinner A horizon, and lacking a Bt horizon. Aloha* soils are limited to the northern part of the Willamette Valley.

The brittle characteristics in Woodburn* soils is not consistent throughout the Willamette Valley and, apparently, is better expressed in the valley north of Salem. The somewhat brittle nature of a pre-Willamette Silt deposit, the basaltic stratigraphic unit discussed under the section on General Geology, may be related to the brittle B3 and C horizons in Woodburn* and Aloha* soils. This basaltic stratigraphic unit approaches the surface in the northern Willamette Valley. In the southern Willamette Valley, the basaltic deposit is buried more deeply by Willamette Silts. Therefore, the brittle material of Woodburn* and Aloha* soils could be inherited from the parent material.

We have seen obsidian "working chips," thought to result from arrowhead manufacture by pre-settlement Indians, buried in a horizontal position at 18 inches in a Woodburn* soil. This evidence strongly suggests that the soil material above 18 inches is a subsequent surficial deposit as proposed by Norgren.[7] Although there is no morphologic evidence of a discontinuity, the obsidian chips indicate that at one time the ground surface was 18 inches below its present level and that soil development above the obsidian chips possibly postdates the development below. The surficial deposits may help to explain the thick epipedon or the seemingly unusual depth to the Bt horizon in some Woodburn* and Willamette soils.

Holcomb soils have been studied in association with Dayton soils on the Senecal unit in Linn County. Holcomb soils seem limited to slightly elevated areas immediately adjacent to streams, and Dayton soils occur farther from the streams. A probable explanation for this distribution is thickening of surficial deposits by

[6] Personal communication, Lynn H. Williams, Soil Conservation Service, 1967.

[7] J. A. Norgren, unpublished M.S. thesis, Oregon State University, Corvallis, 1962.

overbank alluvium and development of natural levees with slight relief. A horizon sequence of A11, A12, A2, IIB2t, IIB3t, and IIIC would result. This horizon sequence is similar to that of Dayton soils (*16*), but the A1 horizon is thicker and darker in the Holcomb soils.

Champoeg unit soils. Soils which are known to occur on the Champoeg unit are Amity, Woodburn*, Briedwell*, Quatama*, and Aloha*. Soils in other series may occur on the Champoeg unit, but they are either unknown to the authors or have not been fully recognized as yet by other soil scientists. For illustrative purposes, Amity soils suffice. They also occur on the Calapooyia and Senecal units.

Amity soils are somewhat poorly drained Argialbolls developed on 0 to 4 percent slopes. These soils are typified by a very dark grayish brown (10YR3/2), silt loam A1 horizon over a dark gray (10YR4/1) silt loam A2 horizon. Amity soils resemble Concord soils but have a thicker, darker A1 horizon, a thinner A2 horizon, a silty clay loam rather than a silty clay B2t horizon, and lack an A&B horizon. Amity soils occur on convex slopes, whereas Concord soils occur primarily on concave slopes or nearly flat topography.

Woodburn* and Amity soils occur on three geomorphic units: Quad, Senecal, and Champoeg. These surfaces are separated by enough relief to belong in separate geomorphic units and, therefore, represent some differences in age or elapsed time during the geomorphic evolution of the Willamette Valley. It is also possible that the deposits associated with the surfaces may be different, and the soil parent materials, therefore, would have been different. If the surface, age, and parent material are variables, it follows that the soils on the surfaces can be expected to be different. Various combinations of the soil-forming factors—climate, vegetation, parent material, topography, and time—produce different soils. It is, therefore, hard to believe that soils in the same series can occur on three geomorphic surfaces that differ in age and may differ in parent material. However, landform alone is not sufficient to separate soils into different series (*24*). Further research may be warranted on the soils of these surfaces to determine whether or not additional series should be recognized due to the effect of different age and parent material on soil characteristics.

Winkle unit soils. Soils of the Winkle unit include Labish*, Malabon*, Coburg*, Awbrey*, Sifton, Salem, Clackamas, and Courtney. The soil that contained the hearth (*20*), which yielded a C^{14} date of 5,250 ± 270 years B. P., most closely resembles the Coburg* series on the Winkle unit.

Salem soils are extensive and therefore are chosen as representative of the soils of the Winkle unit. Salem soils are Pachic Ultic Argixerolls that occur on 1 to 3 percent slopes and generally have very gravelly substrata that mark discontinuities within the soil. Salem soils have a very dark brown (10YR2/2) gravelly silt loam A horizon and a gravelly silty clay loam B2t horizon over a dark brown (10YR3/3) very gravelly clay loam IIB3t horizon. The very gravelly lower horizons were probably deposited as bars during the development of the Winkle surface. Swales between the bars may contain the more poorly drained associates of Salem soils.

A situation that may prove especially troublesome to soil surveyors is the distribution of soils along the margins of the Winkle-Senecal surfaces. Many different soils may occur where Winkle scour was not deep enough to remove Senecal sediments, (e.g., Willamette Silts) and thickness of the Winkle alluvium varies in a short horizontal distance. In these areas, prudent selection of profiles to be examined in deciding the most logical placement of the map delineation is suggested. Perhaps further study is necessary to evaluate the extent and characteristics of soils that occur along the margins of the geomorphic surfaces.

Ingram unit soils. This geomorphic unit is the oldest in the Willamette Valley which characteristically has soils without a Bt horizon. Soils on this surface are in the Chehalis, McBee*, Wapato, and Cloquato* series. Horizon development is limited to organic accumulation in the A horizon and the formation of a B horizon.

The Chehalis series typifies this geomorphic unit. Chehalis soils are well-drained Haploxerolls on 0 to 3 percent slopes. They have a dark brown (10YR3/3) silty clay loam A horizon over a dark brown (10YR3/3) silty clay loam B horizon. Chehalis soils occur on the high flood plain and along major tributaries of the Willamette River. Chehalis soils also are in minor stream valleys (Luckiamute unit), particularly in the Coast Range where the yellowish brown micaceous sediments from the Tyee formation may accumulate as local rather than general alluvium.

Areas where Ingram development has not completely removed Winkle sediments have been studied in Lane County. A soil profile which was examined had a very dark brown (10YR2/2) silty clay A horizon over a dark brown (10YR3/3) silty clay IIB2t horizon. Gravel at 26 inches, probably a lag concentrate, marks the discontinuity between the Ingram and Winkle sediments. Since Ingram alluvium has not been in place long enough for the development of a B2t horizon, the IIB2t horizon may represent the truncated remnant of a soil formed in material associated with the Winkle unit. Numerous grains of pumice (probably Mazama) and pieces of charcoal were found in the IIB3t horizon, as has been observed in Winkle sediments at other locations. Again, as in the Senecal-Winkle example, the presence of older sediments under the more recent sediments of younger geomorphic surfaces presents a problem to soil surveyors, especially those who attempt to use geomorphic surfaces as an indicator of soil distribution.

Horseshoe unit soils. Organic accumulation and weak structural development are the only evidences of soil formation in soils on the Horseshoe unit. Some of these soils may be post-settlement and are surely younger than soils of the Ingram unit which has a C^{14} date of 555 ± 100 years (*5*). Soil series of the Horseshoe unit include Newberg, Camas, and Cloquato*. The Camas series includes soils developed in gravelly alluvium; the Newberg, those in sandy loam textures; and the Cloquato*, those in alluvium having silt loam textures. These soils are frequently flooded.

Newberg soils are somewhat excessively drained Fluventic Haploxerolls with a dark brown (10YR3/3) sandy loam A horizon, a dark brown (10YR3/3) sandy loam AC horizon with weak subangular blocky structure, and a brown (10YR4/3) loamy sand or sandy loam stratified C horizon.

Luckiamute unit soils. Due to the diverse distribution of the Luckiamute unit in tributary valleys, many varied parent materials of alluvial origin from both the Cascades and the Coast Range have contributed to the soils included in this delineation. In addition, the Luckiamute unit as mapped may include surfaces equivalent to the Ingram and Horseshoe units which represent different ages. Therefore, many soils may be represented in the Luckiamute unit. Among them are soils in the Chehalis, McBee*, Wapato, Cove, Bashaw*, Abiqua*, McAlpin*, and Waldo series. In narrow valleys extending into the Coast Range, Knappa, Hebo, Nehalem, Chitwood, and Nestucca soils could be expected. Chehalem* soils on fans and narrow flood plains could also be included in the Luckiamute unit. The Abiqua* series is typical of soils of this unit.

Abiqua* soils are well-drained, fine-textured Cumulic Haploxerolls developed in alluvium primarily derived from basic igneous rocks. Slope gradients range from 0 to 5 percent. Abiqua* soils have a very dark brown (10YR2/2) silty clay loam A horizon over a dark reddish brown (5YR3/2) silty clay B2 horizon. A radiocarbon date of 555 ± 100 years B. P. was obtained from a log under an Abiqua* solum on the Luckiamute unit (*5*). Although moderate medium subangular blocky structure had formed in the B horizon, a Bt horizon had not developed in this length of time. A Coburg* soil on the Winkle unit had developed a Bt horizon in a period of less than 5,250 years (*20*).

Bashaw* soils occur on the Ingram, Luckiamute, Winkle, Calapooyia, and Dolph units. Bashaw* soils are poorly drained, fine-textured soils developed on nearly level or slightly concave flood plains, fans, and terraces. The native vegetation was primarily rushes, sedges, and grass.

Bashaw* soils are Pelloxererts with a black (10YR2/1) or very dark gray (10YR3/1) clay A horizon, 25 to 30 inches thick, over a very dark gray (N3/) clay Clg horizon. Bashaw* soils are very sticky, very plastic, and have common slickensides in the Clg horizon.

The occurrence of Bashaw* soils over a wide range of geomorphic surfaces of varying age and from diverse parent materials is not too surprising. A clay soil, such as Bashaw*, with poor internal drainage and particularly in a flat or concave topographic position with ample moisture, can be expected to produce abundant vegetation. Poor drainage and accompanying poor aeration inhibit decomposition of vegetative matter since the most active micro-organisms that decompose organic materials are aerobic. Hence, organic matter rapidly accumulates. Soils with a high content of montmorillonitic clay shrink and swell with varying moisture content as evidenced by the slickensides in Bashaw* soils. Churning of the profiles effectively inhibits horizon differentiation and within a short period of time (less than 555 years for the alluvium of the Luckiamute unit) sola resembling Bashaw* soils on the Calapooyia or even the Dolph unit have been formed.

Hawkins and Kunze (*10*) found that soluble sulfate salts affect the distribution of Ca-P and A1-P in several Texas Vertisols. The C/P of A horizon organic matter was also found to vary among the four soil series studied. Some Bashaw* soils contain selenite (hydrous calcium sulfate) which is a soluble sulfate salt. If further research indicates significant chemical or mineralogic differences among soils presently classified in the Bashaw* soil series, additional soil series may be justified. Any future research on the Bashaw* soil series must certainly consider the diverse geomorphic occurrence of this soil.

Summary

The landforms of the Willamette Valley area can be grouped into nine major mapping units and four minor units that can be conveniently delineated. The major mapping units conform to a time sequence with two exceptions—the Looney unit, which brackets a long span of time, and the Luckiamute unit, which brackets the ages of two units for convenience in mapping.

It should be emphasized that each of the units, as mapped, contains small areas of modified or atypical landforms. The scale of the map prohibits delineation of all possible details of the landform units. Small modifications of a landform are commonly not extensive enough or significant enough to warrant the establishment of a separate mapping unit. Many factors combine to cause a map representation to be less than ideal. All soils are not modal representatives of a soil series. Neither are all localities within a landform delineation representative of the conceptual landform unit.

The soils of the Willamette Valley, in general, show increasing development on each successively older geomorphic surface. The youngest soils are Haploxerolls developed in the recent alluvium of the Horseshoe and Ingram units. Argixerolls occur on the Winkle, Senecal, and Quad units. The Dolph unit is typified by Haploxeralfs. Haplohumults on the Eola unit complete the developmental sequence.

Modification of the landforms has altered many of the original soils, which is clearly indicated by the numerous lithologic discontinuities observed in Willamette Valley soils. All soils within one geomorphic delineation need not have the same degree of profile development. For example, Willakenzie* soils have an argillic horizon and are often associated with Steiwer* soils which lack an argillic horizon. The Steiwer* soils have developed in a more recent pedisediment which resulted from the modification of the Dolph surface.

In many places, soil and geomorphic boundaries coincide. However, association with a landform alone does not constitute a soil series criterion. Other soil characteristics are often associated with differences in landform. If variation in soil age or parent material has resulted in diverse morphologic, chemical, or mineralogic characteristics, additional soil series are justified. These new soil series can be related to geomorphology and, hence, landform can serve as a valuable aid in soil mapping. If the sola are similar, however, the soils are differentiated as phases within a soil series.

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Appendix

Detailed Representative Profile Descriptions

Representative Profile of the Abiqua Series—Tentative

Landform: Luckiamute
Slope gradients: 0 to 5%
Associated soils: McAlpin*, Waldo
Distribution: Upland valleys along margins of Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Very dark brown (10YR2/2) silty clay loam, dark brown (7.5YR3/2) dry; moderate very fine granular structure; hard, friable, slightly sticky, slightly plastic; many roots; medium acid (pH 5.8); abrupt smooth boundary.
A3	6-21	Very dark brown (10YR2/2) silty clay loam, dark brown (7.5YR3/2) dry; moderate fine and very fine subangular blocky structure; hard, firm, sticky, plastic; many roots; thin discontinuous darker colored coatings on ped surfaces; medium acid (pH 5.6); clear smooth boundary.
B21	21-36	Dark reddish brown (5YR2/2) silty clay, dark reddish brown (5YR3/4) dry; weak medium prismatic and moderate medium subangular blocky structure; very hard, firm, very sticky, very plastic; common roots; thin continuous slightly darker coatings on ped surfaces; strongly acid (pH 5.4); diffuse smooth boundary.
B22	36-54	Dark reddish brown (5YR3/2) silty clay, reddish brown (5YR4/4) dry; very weak medium prismatic and moderate medium subangular blocky structure; very hard, firm, very sticky, very plastic; few roots; thin continuous dark reddish brown (5YR3/4) dry coatings on ped surfaces; common fine and very fine fragments of weathered rock; strongly acid (pH 5.3); diffuse smooth boundary.
B3	54-72	Dark brown (7.5YR3/2) silty clay loam, reddish brown (5YR4/3) dry; moderate medium subangular blocky structure; hard, firm, sticky, plastic; very few roots; many fine and very fine fragments of weathered rock; strongly acid (pH 5.3); many feet thick.

Described by: Lynn H. Williams

Representative Profile of the Aloha Series—Tentative

Landform: Senecal
Slope gradients: 0 to 12%
Associated soils: Willamette, Woodburn*, Amity, Quatama*
Distribution: Southern part of Tualatin Valley and northern Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 8	Dark brown (10YR3/3) silt loam, pale brown (10YR6/3) dry; moderate fine subangular blocky structure; friable, slightly hard, nonsticky, slightly plastic; common roots; common fine shot; medium acid (pH 6.0); abrupt smooth boundary.
B1	8-15	Dark brown (10YR4/3) silt loam, light yellowish brown (10YR6/4) dry; common medium faint dark grayish brown, brown, dark brown (10YR4/2, 5/3, 7.5YR3/2) mottles; moderate fine subangular blocky structure; friable, slightly sticky, slightly plastic; common roots; medium acid (pH 5.8); clear smooth boundary.
B21	15-22	Dark yellowish brown (10YR4/4) silt loam, pale brown (10YR6/3) dry; common fine faint dark grayish brown, brown, and dark brown (10YR4/2, 5/3, 7.5YR3/2) mottles; moderate fine subangular blocky structure; hard, firm, slightly sticky, slightly plastic; common roots; few thin clay films in pores; few black coatings; few medium shot; medium acid (pH 5.8); clear wavy boundary.
B22	22-31	Dark yellowish brown (10YR4/4) heavy silt loam, pale brown (10YR6/3) dry; many medium distinct mottles of dark brown, dark gray and dark yellowish brown (7.5YR4/2, 10YR4/1, 3/4) moist; weak medium subangular blocky and moderate fine subangular blocky structure; hard, firm, slightly sticky, slightly plastic, slightly brittle; few roots; common black coatings; most vertical ped surfaces and all pores have a few thin questionable clay films; common fine shot; medium acid (pH 5.8); gradual smooth boundary.

(*Continued on page 20*)

Aloha Series—*Continued*

Horizon	Depth	Morphology
	Inches	
B3	31-46	Variegated brown and dark brown (10YR5/3, 4/3) silt loam, pale brown (10YR6/3) dry; many medium and fine distinct mottles of dark grayish brown and reddish brown (10YR4/2, 5YR4/4) moist; weak coarse subangular blocky structure; firm, slightly sticky, slightly plastic, brittle; very few roots; common medium black coatings; common fine shot; common micaceous fragments; few thin clay films on vertical ped surfaces; over 60 percent of the horizon exhibits gray clean sand and silt particles in a patchy pattern along ped surfaces and in the larger pores; medium acid (pH 5.8); gradual wavy boundary.
C1	46-60	Dark yellowish brown (10YR3/4) silt loam, pale brown (10YR6/3) and yellowish brown (10YR5/4) dry; common coarse dark grayish brown (10YR4/2) mottles and streaks; few black coatings; massive; firm, slightly sticky, slightly plastic, brittle; micaceous; medium acid (pH 6.0); gradual irregular boundary.
C2	60-65	Dark yellowish brown (10YR4/4) very fine sandy loam, light yellowish brown (10YR6/4) dry; massive; friable, with common firm nodules; nonsticky, nonplastic.

Described by: George E. Otte

Representative Profile of the Amity Series—Established

Landform: Champoeg, also Senecal, Calapooyia
Slope gradients: 0 to 4%
Associated soils: Concord, Woodburn*, Aloha*
Distribution: Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0-7	Very dark grayish brown (10YR3/2) silt loam, grayish brown (10YR5/2) dry; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; abundant roots; medium acid (pH 5.8); clear smooth boundary.
A12	7-16	Very dark grayish brown (10YR3/2) silt loam, grayish brown (10YR5/2) dry; moderate medium subangular blocky structure; hard, friable, slightly sticky, slightly plastic; abundant roots; medium acid (pH 5.8); clear smooth boundary.
A2	16-22	Dark gray (10YR4/1) silt loam, light gray (5Y7/1) dry; common fine faint brown and black mottles; weak medium subangular blocky structure; soft, very friable, slightly sticky, slightly plastic; common roots; common brown and black medium concretions; medium acid (pH 5.8); clear wavy boundary.
B21t	22-28	Grayish brown (10YR5/2) silty clay loam, pale brown (10YR6/3) dry; common fine faint brown and black mottles; weak medium prismatic and moderate very coarse subangular blocky structure; hard, friable, sticky, plastic; few roots; clean silt and sand grains on surfaces of prisms; common moderately thick clay films in pores and on all vertical ped surfaces and on some horizontal ped surfaces; medium acid (pH 6.0); gradual wavy boundary.
B22t	28-35	Light olive brown (2.5Y5/4) silty clay loam, very pale brown (10YR7/4) dry; common fine distinct reddish brown, gray, and black mottles; weak coarse prismatic and moderate coarse subangular blocky structure; very hard, firm, sticky, plastic; very few roots; common moderately thick clay films in pores and on vertical ped faces; slightly acid (pH 6.2); wavy diffuse boundary.
C	35-72	Olive brown (2.5Y4/4) silty clay loam, very pale brown (10YR7/4) dry; common fine faint mottles; massive; hard, friable, slightly sticky, slightly plastic; thick clay films in some pores; slightly acid (pH 6.4).

Described by: George E. Otte

Representative Profile of the Apt Series—Tentative

Landform: Looney
Slope gradients: 3 to 50%
Associated soils: Honeygrove*, Bohannon*, Digger*, Trask
Distribution: Central and northern Coast Range

Horizon	Depth	Morphology
	Inches	
A11	0- 2	Very dark brown (10YR2/2) clay, grayish brown (10YR5/2) dry; strong fine granular structure; friable, slightly sticky, slightly plastic; 5 percent pebbles; many roots; strongly acid (pH 5.2); abrupt smooth boundary.
A12	2- 8	Dark brown (10YR3/3) clay, grayish brown (10YR5/2) dry; strong very fine subangular blocky structure; friable, slightly sticky, slightly plastic; thin patchy darker colored coatings; 3 percent pebbles; many roots; strongly acid (pH 5.2); clear smooth boundary.
B1t	8-19	Dark yellowish brown (10YR3/4) clay, brown (10YR5/3) dry; moderate very fine subangular blocky structure; slightly firm, sticky, slightly plastic; few thin clay films; 5 percent pebbles; common roots; very strongly acid (pH 4.7); clear smooth boundary.
B21t	19-24	Dark brown (10YR4/3) clay, yellowish brown (10YR5/4) dry; moderate very fine subangular blocky structure; firm, sticky, plastic; few thin and moderately thick clay films; 15 percent pebbles; common roots; very strongly acid (pH 4.7); clear smooth boundary.
B22t	24-37	Dark brown (7.5YR4/4) silty clay, brown (7.5YR5/4) dry; moderate very fine subangular blocky structure; firm, sticky, plastic; common thin reddish brown clay films; 20 percent sandstone pebbles and cobbles; few roots; very strongly acid (pH 4.6); gradual smooth boundary.
B23t	37-49	Dark brown (7.5YR4/4) silty clay; strong brown (7.5YR5/6) dry; moderate very fine subangular blocky structure; firm, sticky, plastic; common moderately thick clay films; 30 percent sandstone pebbles and cobbles; few roots; very strongly acid (pH 4.6); clear smooth boundary.
B3	49-63	Yellowish brown (10YR5/4) silty clay loam, very pale brown (10YR7/4) dry; moderate very fine subangular blocky structure; slightly firm, sticky, slightly plastic; few thin clay films; 50 percent pebbles and cobbles; few roots; extremely acid (pH 4.4).

Described by: John F. Corliss

Representative Profile of the Bashaw Series—Tentative

Landform: Ingram, Winkle, Calapooyia, Dolph
Slope gradients: 0 to 1%
Associated soils: Wapato, Cove
Distribution: Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
A11	0-3	Very dark gray (10YR3/1) clay, dark gray (10YR4/1) dry; many fine distinct yellowish red (5YR4/6) mottles; moderate medium and fine subangular blocky structure; very hard, firm, very sticky, very plastic; common roots; medium acid (pH 5.8); abrupt smooth boundary.
A12g	3-14	Black (N2/) clay, very dark gray (N3/) dry; few fine distinct yellowish red (5YR5/6) mottles; massive when wet, but weak coarse prismatic and weak coarse angular blocky structure when moist or dry; very hard, very firm, very sticky, very plastic; common fine red and black concretions; few small slickensides; common very fine roots; medium acid (pH 6.0); clear smooth boundary.
A13g	14-31	Black (N2/) clay, very dark gray (N3/) dry; few fine distinct yellowish red (5YR4/6) mottles; massive; very hard, very firm, very sticky, very plastic; few slickensides; common fine red and black concretions; few very fine roots; neutral (pH 6.6); gradual smooth boundary.
C1g	31-48	Very dark gray (N3/) clay, dark gray (N4/) dry; common medium faint light olive brown (2.5Y5/6) mottles; massive; very hard, very firm, very sticky, very plastic; common large slickensides; few very fine roots; neutral (pH 7.0); abrupt smooth boundary.
C2g	48-60	Dark grayish brown (2.5Y4/2) clay or sandy clay, light brownish gray (2.5Y6/2) dry; many medium distinct strong brown (7.5YR5/6) and dark reddish brown (5YR3/2) mottles and few medium faint dark gray (N4/) mottles; massive; very hard, firm, sticky, plastic; neutral (pH 7.0).

Described by: Lynn H. Williams

Representative Profile of the Chehalis Series—Established

Landform: Ingram and Luckiamute
Slope gradients: 0 to 3%
Associated soils: Wapato, McBee*
Distribution: Flood plain of the Willamette River and major tributary valleys

Horizon	Depth	Morphology
	Inches	
Ap	0- 9	Dark brown (10YR3/3) silty clay loam, brown (10YR4/3) dry; cloddy, weak fine subangular blocky structure; hard, friable, sticky, plastic; many roots; neutral (pH 6.6); abrupt smooth boundary.
B2	9-37	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; very dark brown coatings on peds; moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; common roots; few thin clay films in pores; slightly acid (pH 6.4); gradual smooth boundary.
C1	37-63	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; weak medium subangular blocky structure; hard, sticky, plastic; few roots; slightly acid (pH 6.4); gradual smooth boundary.
C2	63-80	Dark yellowish brown (10YR3/4) silty clay loam, brown (10YR5/3) dry; massive; hard, friable, sticky, plastic; slightly acid (pH 6.4).

Described by: Lynn H. Williams

Representative Profile of the Chehulpum Series—Tentative

Landform: Looney, inclusions in Dolph
Slope gradients: 3 to 40%
Associated soils: Steiwer*, Hazelair*
Distribution: Foothills of Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
A11	0- 4	Very dark brown (10YR2/2) silt loam, dark grayish brown (10YR4/2) dry; moderate medium subangular blocky and moderate fine granular structure; slightly hard, friable, sticky, plastic; many roots; medium acid (pH 5.9); clear smooth boundary.
A12	4-12	Very dark brown (10YR2/2) silt loam, dark grayish brown (10YR4/2) dry; moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; many roots; common fine sandstone fragments; medium acid (pH 5.9); abrupt smooth boundary.
IIR	12-20	Horizontally bedded fine-grained sandstone.

Described by: Lynn H. Williams

Representative Profile of the Concord Series—Established

Landform: Calapooyia, Senecal
Slope gradients: 0 to 1%
Associated soils: Dayton, Amity
Distribution: Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Very dark grayish brown (10YR3/2) silt loam, light brownish gray (10YR6/2) dry; moderate fine subangular blocky and moderate fine granular structure; hard, friable, sticky, plastic; abundant fine roots; common fine brown concretions; medium acid (pH 6.0); abrupt smooth boundary.
A21	6- 9	Dark gray (10YR4/1) silt loam, gray (10YR 6/1) dry; common fine distinct dark brown (7.5YR4/2) mottles; moderate medium subangular blocky structure; hard, friable, sticky, plastic; abundant fine roots; common fine very dark brown concretions; medium acid (pH 5.8); clear smooth boundary.
A22	9-15	Dark gray (10YR4/1) heavy silt loam, light gray (10YR7/1) dry; common fine distinct dark brown (7.5YR4/4) mottles; weak medium prismatic and moderate medium subangular blocky structure; hard, friable, sticky, plastic; few fine roots; common fine very dark brown concretions; medium acid (pH 6.0); clear smooth boundary.
A&B	15-19	Gray and dark gray (10YR5/1 and 4/1) light silty clay, light gray (10YR7/1 and 10YR6/1) dry; darker colors in ped interiors; common fine distinct dark brown (7.5YR4/4) mottles; weak medium prismatic and moderate medium subangular blocky structure; hard, friable, sticky, plastic; few fine roots; many fine very dark brown concretions; slightly acid (pH 6.2); clear smooth boundary.
B2t	19-24	Grayish brown (2.5Y5/2) heavy silty clay, light brownish gray (2.5Y6/2) dry; common fine distinct yellowish brown (10YR5/6) mottles; strong fine prismatic structure and strong medium and fine angular blocky structure; extremely hard, firm, very sticky, very plastic; very few roots; few thin and moderately thick clay films on ped surfaces and in pores; many fine very dark brown and few black concretions; slightly acid (pH 6.4); clear wavy boundary.
B3t	24-29	Dark grayish brown (2.5Y4/2) silty clay, light brownish gray (2.5Y6/2) dry; many fine distinct dark yellowish brown (10YR4/4) mottles; massive; very hard, firm, sticky, plastic; very few fine roots; common moderately thick clay films along lines of weakness and few in pores; few fine dark brown and black concretions; neutral (pH 6.6); gradual smooth boundary.
IIC	29-60	Dark grayish brown (2.5Y4/2) silt loam, light gray (2.5Y7/2) dry; many medium distinct dark yellowish brown (10YR4/4) mottles; massive; friable, sticky, plastic; few black stains; neutral (pH 6.6).

Described by: Lynn H. Williams

Representative Profile of the Dayton Series—Established

Landform: Calapooyia
Slope gradients: Level to concave slopes of 0 to 1%
Associated soils: Concord, Amity, Woodburn*, Willamette
Distribution: Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Dark gray (10YR4/1) silt loam, light brownish gray (10YR6/2) dry; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; abundant fine roots; many black concretions; medium acid (pH 5.6); abrupt wavy boundary.
A2	6-16	Grayish brown (2.5Y5/2) silt loam, light gray (10YR7/2) dry; common fine distinct mottles; weak medium prismatic structure and weak medium subangular blocky structure that appears massive when wet; slightly hard, friable, slightly sticky, slightly plastic; abundant fine roots; abundant fine and medium black concretions; medium acid (pH 5.8); abrupt wavy boundary.
IIB2t	16-36	Dark grayish brown (2.5Y4/2) clay, light brownish gray (10YR6/2) dry; moderate coarse prismatic and weak coarse blocky structure that appears massive when wet; very hard, very firm, very sticky, very plastic; few very fine roots; common slickensides throughout matrix; thin clay films on prism surfaces; common pale silt coatings on prism faces in upper 3 to 4 inches; common fine and few medium black concretions; medium acid (pH 6.0); clear wavy boundary.
IIIB3t	36-44	Dark grayish brown (2.5Y4/2) silty clay, pale brown (10YR6/3) dry; moderate coarse prismatic and weak coarse blocky structure; very hard, very firm, very sticky, very plastic; common thick dark grayish brown (2.5Y4/2, moist) clay films arranged in a lenticular pattern the matrix of which is composed of C horizon material; few fine concretions; slightly acid (pH 6.2); gradual wavy boundary.
IIIC	44-60	Brown, dark yellowish brown, and yellowish brown (10YR5/3, 4/4, and 5/6) silty clay loam, very pale brown (10YR7/4) dry; common fine distinct mottles; massive; hard, friable, sticky, slightly plastic; thick dark grayish brown (2.5Y4/2, moist) clay films along pores and fractures; slightly acid (pH 6.2).

NOTE: It is questionable if the IIB2 horizon contains clay films, as the clay coatings when viewed in thin section are not continuous, have poor extinction, and merge gradually with the matrix without an abrupt boundary between the "film" and matrix. These relationships suggest that the clays have been pressure oriented. However, the clay films in the IIIB3t horizon are illuvial and represent clay translocation subsequent to deposition of the IIB horizon.

Described by: Roger B. Parsons

Representative Profile of the Hazelair Series—Tentative

Landform: Dolph
Slope gradients: 3 to 20%
Associated soils: Willakenzie*, Dupee*, Steiwer*, Panther*
Distribution: Margin of Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 7	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; moderate fine subangular blocky structure; hard, friable, sticky, plastic; many fine roots; medium acid (pH 5.8); abrupt smooth boundary.
A12	7-11	Dark yellowish brown (10YR3/4) silty clay loam, brown (10YR5/3) dry; moderate fine subangular blocky structure; hard, friable, sticky, plastic; many fine roots; medium acid (pH 5.6); abrupt smooth boundary.
B2	11-18	Dark brown (10YR4/3) silty clay, brown (10YR5/3) dry; few fine distinct mottles in the lower part; moderate fine subangular blocky structure; firm, very sticky, plastic; many fine roots; few fine thin clay films in some pores; few fine siltstone and sandstone fragments; strongly acid (pH 5.4); abrupt smooth boundary.
IICI	18-24	Light olive brown (2.5Y5/4) clay, light gray (2.5Y7/2) and pale yellow (2.5Y7/4) dry; many fine distinct mottles of yellowish brown (10YR5/4) and grayish brown (10YR5/2); weak coarse prismatic structure that appears massive when wet; very firm, very sticky, very plastic; few fine roots; many fine and very fine yellowish brown weathered siltstone and sandstone fragments; strongly acid (pH 5.2); clear smooth boundary.
IIC2	24-30	Grayish brown (2.5Y5/2) clay, light gray (2.5Y7/2) dry; massive; very firm, very sticky, very plastic; few fine roots; common fine and very fine weathered siltstone and sandstone fragments; strongly acid (pH 5.2); abrupt wavy boundary.
IIIR	30-40	Brownish yellow (10YR6/6) sandstone with light gray (10YR7/1) lenses and light brownish gray (10YR6/2) clay in fracture planes.

Described by: George E. Otte

Representative Profile of the Honeygrove Series—Tentative

Landform: Looney
Slope gradients: 5 to 40%
Associated soils: Apt*, Bohannon*, Digger*, Kilchis
Distribution: Western slopes of the Oregon Coast Range

Horizon	Depth	Morphology
	Inches	
A1	0- 6	Dark reddish brown (5YR2/3) clay, reddish brown (5YR4/3) dry; strong very fine granular structure; friable, slightly sticky, slightly plastic; many roots; few fine concretions; few fine charcoal fragments; slightly acid (pH 6.4); clear wavy boundary.
A3	6-12	Dark reddish brown (5YR3/4) clay, reddish brown (5YR4/4) dry; strong very fine subangular blocky or granular structure; friable, slightly sticky, slightly plastic; many roots; few cobbles (3%); few fine charcoal fragments; slightly acid (pH 6.1); clear irregular boundary.
B11	12-19	Dark reddish brown (5YR3/4) clay, reddish brown (5YR4/4) dry; few thin patchy redder and darker coatings; strong very fine subangular blocky structure; friable, sticky, slightly plastic; many roots; few fine charcoal fragments; medium acid (pH 5.7); clear wavy boundary.
B12	19-27	Yellowish red (5YR3/6) clay, yellowish red (5YR4/6) dry; moderate fine and very fine subangular blocky structure; friable, sticky, plastic; common roots; common thin clay films; medium acid (pH 5.6); clear wavy boundary.
B21t	27-36	Dark red (2.5YR3/6) clay, red (2.5YR4/6) dry; moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; few roots; nearly continuous thin clay films on larger peds; few small rock fragments; strongly acid (pH 5.5); gradual smooth boundary.
B22t	36-72	Dark red (2.5YR3/6) clay, red (2.5YR4/6) dry; moderate fine subangular blocky structure; hard, friable, sticky, plastic; few roots; nearly continuous moderately thick dark red clay films on peds and in pores; few small sandstone fragments; strongly acid (pH 5.4); gradual smooth boundary.
B23t	72-95	Dark red (2.5YR3/6) clay, red (2.5YR4/6) dry; moderate fine subangular blocky structure; friable, sticky, plastic; few (3%) small rock fragments; sparse roots; continuous thick dark red clay films; strongly acid (pH 5.4); gradual smooth boundary.
B3t	95-105	Dark red (2.5YR3/6) clay, red (2.5YR4/6) dry; moderate to weak fine subangular blocky structure; friable, sticky, plastic; very few roots; nearly continuous moderately thick dark red clay films on peds; few (5%) small sandstone fragments; strongly acid (pH 5.3).

Described by: John F. Corliss

Representative Profile of the Jory Series—Tentative

Landform: Eola, inclusions in Looney
Slope gradients: 2 to 30%
Associated soils: Nekia*, Salkum
Distribution: Low foothills of Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Dark reddish brown (5YR3/4) silty clay loam, reddish brown (5YR4/4) dry; moderate fine and very fine granular structure; slightly hard, friable, sticky, plastic; many roots; few medium red and black concretions; medium acid (pH 5.6); abrupt smooth boundary.
A12	6-16	Dark reddish brown (5YR3/4) silty clay, reddish brown (5YR4/4) dry; weak coarse subangular blocky and moderate fine and very fine granular structure; slightly hard, friable, sticky, plastic; many roots; few medium red and black concretions; medium acid (pH 5.6); clear wavy boundary.
A3	16-19	Dark reddish brown (5YR3/4) clay, yellowish red (5YR4/6) dry; moderate coarse and medium granular structure; hard, firm, sticky, plastic; many roots; few medium red and black concretions; strongly acid (pH 5.4); clear wavy boundary.
B21t	19-29	Dark reddish brown (2.5YR3/4) clay, reddish brown (2.5YR4/4) dry; strong medium and fine subangular blocky structure; very hard, very firm, very sticky, very plastic; few roots; few thin clay films on ped surfaces; many fine red and black concretions; strongly acid (pH 5.3); clear smooth boundary.
B22t	29-48	Dark reddish brown (2.5YR3/4) clay, reddish brown (2.5YR4/4) dry; strong medium subangular blocky structure; very hard, very firm, very sticky, very plastic; many fine red and black concretions; many moderately thick and thick clay films; strongly acid (pH 5.1); gradual smooth boundary.
B23t	48-100	Dark red (2.5YR3/6) clay, red (2.5YR4/6) dry; moderate medium subangular blocky structure; very hard, firm, very sticky, very plastic; many thin clay films; many medium prominent black coatings on ped surfaces (30%); strongly acid (pH 5.3).

NOTE: In the profile described, two stone lines at different depths were observed in a deep road cut approximately 600 feet directly east of soil pit. Also on the south facing slope directly north on opposite slope, a stone line was observed which decreased in depth up the slope.

Described by: Lynn H. Williams

Representative Profile of the Kinney Series—Tentative

Landform: Looney
Slope gradients: 3 to 70%
Associated soils: McCully*, Henline*, Minniece*
Distribution: Foothills of western Cascade Mountains

Horizon	Depth	Morphology
	Inches	
A11	0-4	Very dark brown (10YR2/2) cobbly loam, dark brown (10YR4/3) dry; moderate fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and medium roots; many medium and fine shot; 30 percent pebbles and cobbles; strongly acid (pH 5.3); clear smooth boundary.
A12	4-10	Very dark brown (10YR2/2) cobbly loam, dark brown (10YR4/3) dry; moderate medium and fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; many medium and fine shot; 30 percent pebbles and cobbles; strongly acid (pH 5.1); abrupt wavy boundary.
B1	10-15	Dark brown (10YR3/3) cobbly clay loam, dark brown (10YR4/3) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many medium roots; few thin clay films; many medium and fine shot; 30 percent pebbles and cobbles; strongly acid (pH 5.6); clear wavy boundary.
B21	15-20	Dark brown (7.5YR3/4) cobbly clay loam, brown (7.5YR5/4) dry; weak medium subangular blocky structure; slightly hard, friable, sticky, and plastic; common roots; thin continuous clay films on peds and in root channels and larger pores; many coarse sand particles; 30 percent pebbles and cobbles; very strongly acid (pH 4.6); gradual smooth boundary.
B22	20-40	Dark yellowish brown (10YR4/4) cobbly clay loam, yellowish brown (10YR5/4) dry; weak coarse and medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common roots; moderately thick clay films in some of the larger pores; common coarse sand particles; 30 to 35 percent pebbles and cobbles; very strongly acid (pH 4.6); clear wavy boundary.
C	40-53	Dark yellowish brown (10YR4/4) cobbly loam, pale brown (10YR6/3) dry; massive or very weak medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; few roots; many coarse sand particles; 30 to 40 percent pebbles and cobbles; very strongly acid (pH 4.8); abrupt irregular boundary.
IIR	53-57	Variegated light olive brown (2.5Y5/4), pale yellow (2.5Y7/4), yellow (2.5Y7/6), and dark red (2.5YR3/6); very weathered basic igneous agglomerate; very strongly acid (pH 4.8); many feet thick.

Described by: Lynn H. Williams

Representative Profile of the Laurelwood Series—Tentative

Landform: Eola
Slope gradients: 3 to 45%
Associated soils: Nekia*, Cascade, Delena*, Helvetia*
Distribution: Tualatin and Columbia drainages in northwest Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0-11	Dark brown (10YR3/3) silt loam, brown (10YR5/3) dry; moderate fine granular structure; slightly hard, very friable, nonsticky, slightly plastic; many fine roots; common medium concretions; medium acid (pH 5.8); abrupt smooth boundary.
B1	11-23	Dark brown (7.5YR3/4) silt loam, brown (7.5YR5/4) dry; weak coarse and medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; few fine concretions; medium acid (pH 5.6); clear smooth boundary.
B21t	23-32	Dark brown (7.5YR4/4) silty clay loam, light brown (7.5YR6/4) dry; strong medium subangular blocky structure; hard, firm, sticky, plastic; common fine roots; many thin dark brown (10YR3/3) clay films; few fine distinct black coatings; medium acid (pH 5.6); clear smooth boundary.
B22t	32-43	Yellowish brown (10YR5/4) silty clay loam, light yellowish brown (10YR6/4) dry; strong medium subangular blocky structure; hard, firm, sticky, plastic; few fine roots; many thin and few moderately thick clay films; few fine distinct black coatings; medium acid (pH 5.6); clear smooth boundary.
B3t	43-52	Yellowish brown (10YR5/4) silty clay loam, light yellowish brown (10YR6/4) dry; weak coarse and medium subangular blocky structure; hard, friable, sticky, plastic; common moderately thick clay films; common fine distinct black coatings; strongly acid (pH 5.4); clear smooth boundary.
IIB21tb	52-62	Dark reddish brown (5YR3/4) silty clay; weak coarse and moderate fine subangular blocky structure; hard, friable, sticky, very plastic; common thick clay films on peds and in pores; many fine and medium distinct black mottles; strongly acid (pH 5.4); clear smooth boundary.
IIB22tb	62-72	Yellowish red (5YR4/6) silty clay; weak coarse and moderate medium subangular blocky structure; very hard, firm, very sticky, very plastic; common moderately thick clay films in pores and on ped surfaces; many fine and medium distinct black mottles; a few igneous rock fragments; strongly acid (pH 5.4).

Described by: George E. Otte

Representative Profile of the Malabon Series—Tentative

Landform: Winkle
Slope gradients: 0 to 7%
Associated soils: Salem and Coburg*
Distribution: Low terraces in the Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 7	Dark brown (10YR3/3) silt loam, grayish brown (10YR5/2) dry; cloddy from recent plowing; slightly hard and hard, slightly sticky, slightly plastic; abundant fine roots; medium acid (pH 5.8); abrupt smooth boundary.
B1	7-17	Dark brown (10YR3/3) silty clay loam; weak medium prismatic and moderate medium, fine, and very fine subangular blocky structure; hard, friable, sticky, plastic; common fine roots; medium acid (pH 6.0); clear wavy boundary.
B2t	17-34	Dark yellowish brown (10YR3/4) silty clay loam, with ped coats of dark brown (10YR3/3); moderate coarse subangular blocky structure; firm, sticky, plastic; common fine roots; few black coatings on peds; common medium clay films; slightly acid (pH 6.2); gradual wavy boundary.
B3t	34-60	Brown (10YR4/3) clay loam; massive; friable, sticky, plastic; few fine roots; medium clay films on surfaces that only partly define moderate coarse subangular blocks and in pores; contains soft, yellowish brown (10YR5/6) pumice grains; layer of pumice 2 cm. thick at 58 inches depth; slightly acid (pH 6.2); diffuse wavy boundary.
C1	60-80	Dark grayish brown (10YR4/2) loam; massive; friable, slightly sticky, slightly plastic; thin clay films in pores; slightly acid (pH 6.4); gradual smooth boundary.
C2	80-92	Dark brown (10YR3/3) fine sandy loam; massive; friable, slightly sticky, slightly plastic; pH 6.4.

Described by: Ellis G. Knox

Representative Profile of the McCully Series—Tentative

Landform: Looney
Slope gradients: 2 to 70%
Associated soils: Jory*, Hullt*, Minniece*, Kinney*
Distribution: Foothills of western Cascade Mountains

Horizon	Depth	Morphology
	Inches	
A1	0- 6	Dark reddish brown (5YR3/2) clay, dark brown (7.5YR4/4) dry; strong medium and fine granular structure; slightly hard, friable to firm, slightly sticky, slightly plastic; many roots; many medium concretions; many coarse sand fragments; strongly acid (pH 5.4); abrupt smooth boundary.
A3	6-10	Dark reddish brown (5YR3/2) clay, dark brown (7.5YR4/4) dry; strong medium and fine granular structure; slightly hard, friable, sticky, plastic; many roots; few thin clay films; common medium reddish concretions; common light-colored sand grains; strongly acid (pH 5.2); clear wavy boundary.
B21	10-24	Dark reddish brown (5YR3/4) clay, yellowish red (5YR4/6) dry; weak medium subangular blocky structure; hard, friable, sticky, plastic; many roots; few thin clay films; few small concretions; few light-colored sand grains; very strongly acid (pH 4.6); clear smooth boundary.
B22	24-49	Dark reddish brown (5YR3/4) clay, yellowish red (5YR4/6) dry; weak coarse and medium subangular blocky structure; hard, firm, sticky, plastic; common roots; continuous thin clay films; few concretions; few light-colored sand grains; very strongly acid (pH 4.6); gradual smooth boundary.
B3	49-57	Dark reddish brown (5YR3/4) clay, reddish brown (5YR4/4) dry; weak medium and fine subangular blocky structure; hard, friable, sticky, plastic; few roots; few thin clay films; few small concretions; common light-colored sand grains and gravel; very strongly acid (pH 4.6); clear wavy boundary.
IIC	57-108	Variegated dark brown (10YR4/3), dark yellowish brown (10YR4/4); dark brown (7.5YR4/4) and very dark grayish brown (2.5Y3/2) gravelly loam; massive; friable, sticky, plastic; very strongly acid (pH 4.6); many feet thick.

Described by: Lynn H. Williams

Representative Profile of the Newberg Series—Established

Landform: Horseshoe, inclusions in Luckiamute
Slope gradients: 0 to 3%
Associated soils: Camas, Cloquato*
Distribution: Along main drainage channels in Washington and the Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0-7	Dark brown (10YR3/3) sandy loam, brown (10YR4/3) dry; moderate fine granular structure; soft, very friable, nonsticky, nonplastic; few fine roots; medium acid (pH 6.0); clear smooth boundary.
AC	7-19	Dark brown (10YR3/3) sandy loam, dark yellowish brown (10YR4/4) dry; weak fine subangular blocky structure; soft, very friable, nonsticky, nonplastic; few fine roots; medium acid (pH 5.8); clear smooth boundary.
C1	19-28	Brown (10YR4/3) coarse sandy loam, pale brown (10YR6/3) dry; massive; soft, friable, nonsticky, nonplastic; few roots; medium acid (pH 5.8); clear smooth boundary.
C2	28-48	Dark grayish brown (10YR4/2) loamy sand, pale brown (10YR6/3) and light brownish gray (10YR6/2) dry; single grain; loose, nonsticky, nonplastic; few roots; medium acid (pH 5.8); gradual smooth boundary.
C3	48-64	Dark grayish brown (10YR4/2) coarse loamy sand, light brownish gray (10YR6/2) dry; single grain; loose, nonsticky, nonplastic; medium acid (pH 6.0).

Described by: George E. Otte

Representative Profile of the Peavine Series—Tentative

Landform: Eola and Looney
Slope gradients: 5 to 70%
Associated soils: Panther*, Honeygrove*, Melby*, and Olyic*
Distribution: Western side of Willamette Valley and Coast Range footslopes in northwest Oregon

Horizon	Depth	Morphology
	Inches	
A1	0- 4	Very dark brown and dark brown (7.5YR2/2 and 7.5YR3/2) silty clay loam, dark brown (7.5YR4/2 and 4/3) dry; moderate fine granular structure; friable, sticky, plastic; abundant very fine and fine roots; few fine shale fragments; medium acid (pH 5.6); clear smooth boundary.
A3	4-10	Dark brown (7.5YR3/2) silty clay loam, brown (7.5YR4/4) dry; moderate fine subangular blocky structure; firm, sticky, plastic; abundant very fine and fine roots; few fine shale fragments; medium acid (pH 5.5); clear wavy boundary.
B1t	10-15	Dark reddish brown (5YR3/4) silty clay, yellowish red (5YR4/6) dry; moderate fine subangular blocky structure; firm, very sticky, very plastic; many fine and medium roots; few thin clay films on ped surfaces and in pores; very strongly acid (pH 4.8); clear wavy boundary.
B2t	15-26	Yellowish red (5YR4/6) silty clay, yellowish red (5YR5/6) dry; moderate medium subangular blocky structure; firm, very sticky, very plastic; many medium roots; common thin clay films on ped surfaces and in pores; many very fine shale fragments; very strongly acid (pH 4.6); clear wavy boundary.
B3t	26-36	Yellowish red (5YR4/6) silty clay, yellowish red (5YR5/6) dry; moderate fine subangular blocky structure; firm, very sticky, very plastic; common fine roots; thin nearly continuous clay films on ped surfaces and in pores; many variegated brown and yellow shale fragments; very strongly acid (pH 4.6); gradual wavy boundary.
C1	36-49	Fractured shale and yellowish red (5YR4/6) silty clay loam, yellowish red (5YR5/6) dry; weak fine subangular blocky structure; firm, sticky, plastic; common fine roots; 80 percent variegated brown and yellow shale fragments; many thin clay films on ped surfaces and on shale fragments; very strongly acid (pH 4.6); gradual wavy boundary.
C2	49-64	Fractured shale and light yellowish brown (10YR6/4) to brownish yellow (10YR6/6) silty clay loam, yellow (10YR7/6) dry; massive; firm, sticky, plastic; few medium roots; 80 percent firm angular shale fragments; many moderately thick yellowish red (5YR4/6) clay films on shale fragments; very strongly acid (pH 4.6); gradual wavy boundary.
R	64-84	Light yellowish brown (10YR6/4) to brownish yellow (10YR6/6) fractured shale.

Described by: George E. Otte

Representative Profile of the Salem Series—Established

Landform: Winkle
Slope gradients: 1 to 3%
Associated soils: Malabon*, Coburg*, Sifton, Clackamas, Courtney, Awbrey*
Distribution: Willamette Valley and tributary valleys in central western Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 9	Very dark brown (10YR2/2) gravelly silt loam, dark grayish brown (10YR4/2) dry; cloddy, weak medium and fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; 10 to 15 percent pebbles; slightly acid (pH 6.2); gradual smooth boundary.
B2t	9-18	Very dark brown (10YR2/2) gravelly silty clay loam, brown (10YR4/3) dry; moderate medium subangular blocky structure; hard, friable, sticky, plastic; many roots; 10 to 15 percent pebbles; few thin and moderately thick clay films; slightly acid (pH 6.4); abrupt smooth boundary.
IIB3t	18-30	Dark brown (10YR3/3) very gravelly clay loam, brown (10YR5/3) dry; massive; hard, firm, slightly sticky, plastic; common roots; thin clay films on sand grains; 70 to 80 percent pebbles; slightly acid (pH 6.6); clear smooth boundary.
IIIC	30-60	Grayish brown (10YR5/2) very gravelly sand, pale brown (10YR6/3) dry; single grain; loose, very friable, nonsticky, nonplastic; few roots; 70 to 80 percent pebbles; slightly acid (pH 6.2); many feet thick.

Described by: Lynn H. Williams

Representative Profile of the Salkum Series—Established

Landform: Dolph, perhaps Eola
Slope gradients: 2 to 8%
Associated soils: Willakenzie*, Jory*, Nekia*
Distribution: Western Oregon and Washington

Horizon	Depth	Morphology
	Inches	
Ap	0- 8	Very dark brown (7.5YR2/2) silty clay loam, dark brown (7.5YR4/4) dry; moderate very fine granular structure; friable, hard, sticky, plastic; abundant fine roots; strongly acid (pH 5.2); abrupt smooth boundary.
A3	8-17	Dark brown (7.5YR3/2) silty clay loam; moderate fine and medium subangular blocky structure; friable, hard, sticky, plastic; abundant fine roots; very strongly acid (pH 5.0); clear, smooth boundary.
B1	17-22	Dark brown (7.5YR4/4) heavy silty clay loam, brown (7.5YR5/4) dry; weak very coarse prismatic and moderate medium subangular blocky structure; friable, hard, sticky, plastic; abundant fine and medium roots; common worm casts; few dark colored clay films; very strongly acid (pH 5.0); clear smooth boundary.
B21t	22-27	Dark brown (7.5YR4/4) silty clay, strong brown (7.5YR5/6) dry; moderate coarse and medium subangular blocky structure; firm, very hard, sticky, very plastic; very few very fine roots; few thin clay films; very strongly acid (pH 5.0); clear smooth boundary.
B22t	27-36	Dark brown (7.5YR4/4) silty clay, strong brown (7.5YR5/6) dry; weak coarse subangular blocky structure; firm, sticky, very plastic; very few very fine roots; common moderately thick clay films; strongly acid (pH 5.2); abrupt smooth boundary.
IIC1	36-50	Variegated light gray (7.5YR7/1), dark brown (7.5YR4/4), yellowish red (5YR4/6), brown (7.5YR5/2), strong brown (7.5YR5/8) strongly weathered gravelly silty clay or silty clay loam; massive; firm, sticky, plastic; thick clay films in some pores; common black ped coatings; pebbles are firm and can be cut easily with a spade; very strongly acid (pH 5.0); gradual smooth boundary.
IIC2	50-65	Variegated strong brown and brown (7.5YR5/8, 5/2, and 5/4), and reddish brown (5YR4/4) gravelly and cobbly clay loam or silty clay loam; massive; firm, sticky, plastic; few thin clay films in pores; very strongly acid (pH 5.0); stones and pebbles are so strongly weathered they can be easily broken in the hand.

Described by: Lynn H. Williams

Representative Profile of the Steiwer Series—Tentative

Landform: Dolph
Slope gradients: 0 to 20%
Associated soils: Hazelair*, Chehulpum*, Willakenzie*, Yamhill*
Distribution: Sloping areas adjacent to the Willamette Valley floor

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; moderate fine subangular blocky and moderate fine granular structure; firm, hard, sticky, plastic; abundant very fine roots; few very fine shale fragments; abrupt smooth boundary.
B1	6-10	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; moderate very fine subangular blocky structure; friable, hard, sticky, plastic; abundant very fine roots; many very fine shale fragments; clear wavy boundary.
B21	10-19	Dark brown (10YR3/3) silty clay loam, brown (10YR5/3) dry; moderate very fine subangular blocky structure; friable, hard, sticky, plastic; common fine roots; few fine shale fragments; gradual wavy boundary.
B22	19-27	Dark yellowish brown (10YR3/4) silty clay loam, brown (10YR5/3) dry; moderate fine subangular blocky structure; firm, hard, sticky, plastic; few fine roots; many very fine shale fragments; abrupt irregular boundary.
IIR	27-40	Strong brown (7.5YR5/6) to reddish yellow (7.5YR6/6) variegated shale with sandstone lenses; reddish brown clay films along fractures.

Described by: George E. Otte

Representative Profile of the Willakenzie Series—Tentative

Landform: Dolph
Slope gradients: 5 to 20%
Associated soils: Peavine*, Dupee*, Panther*, Hazelair*
Distribution: Western Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
A1	0- 4	Dark brown (7.5YR3/2) silty clay loam, brown (7.5YR5/3) dry; weak medium and fine granular structure; hard, friable, slightly sticky, slightly plastic; abundant roots; very few fine concretions; medium acid (pH 6.0); clear smooth boundary.
B1	4-12	Dark brown (7.5YR3/4) silty clay loam, strong brown (7.5YR5/6) dry; moderate medium and fine subangular blocky structure; hard, friable, sticky, plastic; abundant roots; medium acid (pH 6.0); clear wavy boundary.
B21t	12-18	Dark brown (7.5YR4/4) silty clay loam, strong brown (7.5YR5/6) dry; weak medium and moderate fine subangular blocky structure; hard, friable, sticky, very plastic; few thin clay films in pores and on some ped surfaces; medium acid (pH 6.0); clear smooth boundary.
B22t	18-26	Dark brown (7.5YR4/4) silty clay loam, strong brown (7.5YR5/6) dry; weak medium subangular blocky and moderate fine subangular blocky structure; firm, very sticky, very plastic; few very thin clay films on ped surfaces; medium acid (pH 5.0); gradual wavy boundary.
B23t	26-32	Dark brown (7.5YR4/4) silty clay loam, strong brown (7.5YR5/6) dry; weak medium and moderate fine subangular blocky structure; firm, very sticky, very plastic; many thin clay films on ped surfaces and in pores; strongly acid (pH 5.4); abrupt wavy boundary.
IIC	32-36	Yellowish red (5YR5/6) silty clay loam, weak fine angular blocky structure; friable, very sticky, very plastic; 80 percent siltstone fragments; common thick clay films on siltstone fragments; very strongly acid (pH 4.7); abrupt smooth boundary.
IIR	36-54	Hard, fractured siltstone.

Described by: George E. Otte

Representative Profile of the Willamette Series—Established

Landform: Quad, Senecal, Champoeg
Slope gradients: 0 to 12%
Associated soils: Amity, Woodburn*
Distribution: Willamette Valley (Oregon) and southwest Washington

Horizon	Depth	Morphology
	Inches	
Ap	0- 6	Dark brown (10YR3/3) silt loam, grayish brown (10YR5/2) dry; moderate medium and coarse granular structure; slightly hard, friable, slightly sticky, slightly plastic; abundant roots; many worm casts; few small and medium reddish brown concretions; abrupt smooth boundary.
A12	6-16	Dark brown (10YR3/3) silt loam, grayish brown (10YR5/2) dry; weak to moderate medium subangular blocky and moderate fine granular structure; compact and nearly massive in spots; hard, friable, slightly sticky, slightly plastic; many roots; abundant worm casts; few very fine reddish brown concretions; gradual wavy boundary.
A3	16-24	Dark yellowish brown (10YR3/4) light silty clay loam; weak coarse prismatic and weak medium and fine subangular blocky structure; slightly hard, friable, sticky, plastic; common roots; common worm casts; some grayish bleached silt coating on peds; few fine reddish brown and black concretions; gradual wavy boundary.
B1	24-32	Dark yellowish brown (10YR3/4) light silty clay loam; weak medium prismatic and moderate medium and fine subangular blocky structure; friable, sticky, plastic; common roots; few worm casts; common gray silt coatings on peds; common fine reddish brown and black concretions; clear wavy boundary.
B2t	32-45	Dark brown (10YR4/3) silty clay loam; moderate medium prismatic and moderate medium subangular blocky structure; friable, sticky, plastic; common roots; few thin clay films in pores and continuous thin clay films on prism faces; common bleached silt coatings on peds; gradual wavy boundary.
B3t	45-53	Brown (10YR4/3) light silty clay loam; weak coarse subangular blocky structure; friable, slightly sticky, slightly plastic; few roots; few moderately thick clay films on some ped faces and pores; common fine reddish brown and black concretions; few faint gray mottles; gradual wavy boundary.
C	53-60	Brown (10YR5/3) heavy silt loam; weak coarse prismatic structure to massive; friable, slightly sticky, slightly plastic; few fine roots; few clay films in pores and on prism faces; few faint mottles (10YR4/2).

Described by: Gerald H. Simonson

Representative Profile of the Woodburn Series—Tentative

Landform: Senecal, also Quad, Champoeg
Slope gradients: 0 to 12%
Associated soils: Amity, Willamette, Aloha*, Quatama*
Distribution: Willamette Valley, Oregon

Horizon	Depth	Morphology
	Inches	
Ap	0- 9	Very dark brown (10YR2/2) silt loam, brown (10YR5/3) dry; cloddy with very weak granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; common medium and fine reddish brown and black concretions; slightly acid (pH 6.2); abrupt smooth boundary.
A12	9-17	Dark brown (10YR3/3) silt loam, brown (10YR5/3) dry; moderate fine granular structure; hard, friable, slightly sticky, slightly plastic; many roots; common clean silt and sand grains on ped surfaces; few thin very dark brown (10YR2/2) coatings on ped surfaces; few reddish brown and black concretions; slightly acid (pH 6.2); clear smooth boundary.
B21t	17-25	Dark brown (10YR4/3) heavy silt loam, brown (7.5YR5/4) dry; moderate coarse and medium subangular blocky structure; hard, friable, sticky, plastic; common roots; few thin clay films on peds; few reddish brown and black concretions; few black stains on ped faces; slightly acid (pH 6.1); clear smooth boundary.
B22t	25-32	Dark brown (7.5YR4/4) heavy silt loam, brown (10YR5/3) dry; few fine and medium distinct mottles; dark gray (10YR4/1) light brownish gray (10YR6/2) dry; moderate medium and coarse subangular blocky structure; hard, friable, sticky, plastic; common roots; continuous moderately thick clay films on ped surfaces and in pores; peds are quite brittle; few fine black concretions and stains on ped faces; medium acid (pH 6.0); abrupt smooth boundary.
B31t	32-39	Dark brown (10YR4/3) silt loam, brown (10YR5/3) dry; distinct dark grayish brown (10YR4/2) mottles in a few root channels, thin dark grayish brown (10YR4/2) coating on plane surfaces, light gray (10YR7/2) dry; nearly massive; very hard, very firm, brittle, slightly sticky, slightly plastic; few roots; continuous moderately thick clay films on plane surfaces and in some root channels and pores; few fine and medium black concretions and few black coatings on plane surfaces; medium acid (pH 6.0); gradual smooth boundary.

(*Continued on page 31*)

Woodburn Series—*Continued*

Horizon	Depth	Morphology
	Inches	
B32t	39-54	Dark brown (10YR4/3) silt loam, pale brown (10YR6/3) dry; nearly massive, with some indistinct vertical planes of weakness; very hard, very firm, brittle, slightly sticky, slightly plastic; continuous thin clay films on planes of weakness, common moderately thick clay films in pores and old root channels; few black concretions; medium acid (pH 6.0); gradual wavy boundary.
C1	54-68	Dark brown (10YR4/3) silt loam, pale brown (10YR6/3) dry; massive; very hard, very firm, brittle, slightly sticky, slightly plastic; common moderately thick clay films in the larger pores and old root or worm channels; few black coatings in pores and root channels; medium acid (pH 6.0); gradual wavy boundary.
IIC2	68-80	Dark brown (10YR4/3) very fine sandy loam, pale brown (10YR6/3) dry; massive; very hard, firm, slightly brittle, slightly sticky, slightly plastic; few thin clay films in the larger pores and root channels; few small black stains or coatings in pores and channels; medium acid (pH 6.0); abrupt wavy boundary.
IIC3	80-92	Dark brown (10YR4/3) fine sandy loam, pale brown (10YR6/3) dry; single grain; loose, friable, nonsticky, nonplastic; medium acid (pH 6.0).

Described by: Lynn H. Williams