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SAWTOOTH RIDGE: A NORTHEAST OREGON VOLCANIC CRATER

Peter V. Patterson*

Introduction

Sawtooth Ridge lies about 20 miles northeast of Baker, Oregon in sections 10 and 11, T. 7 S., R. 42 E. (figure 1). The structure in its entirety is shown on the U.S. Geological Survey $7\frac{1}{2}$-minute topographic quadrangle preliminary map Keating NE (1968) (plate 1). It consists of a shield portion

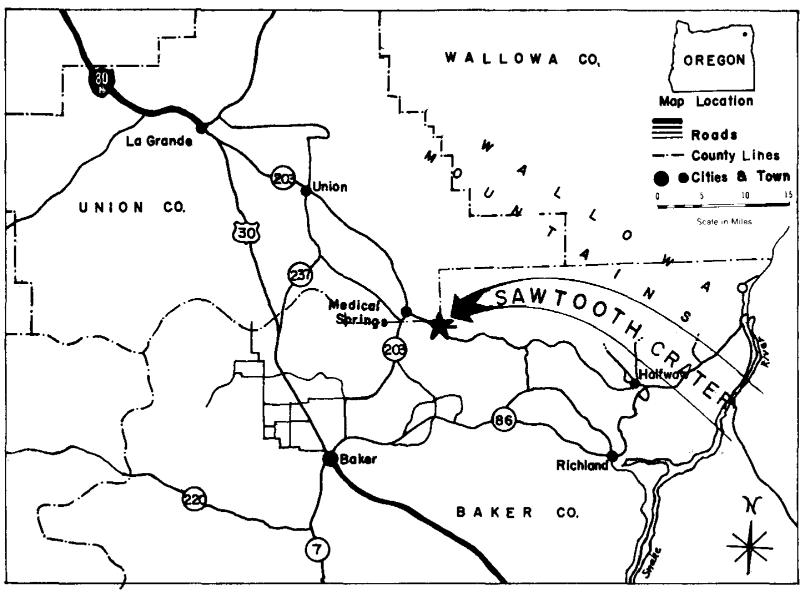

Figure 1. Location map of Sawtooth Ridge.

* Geologist, Watershed Planning Staff, Soil Conservation Service, Portland, Oregon

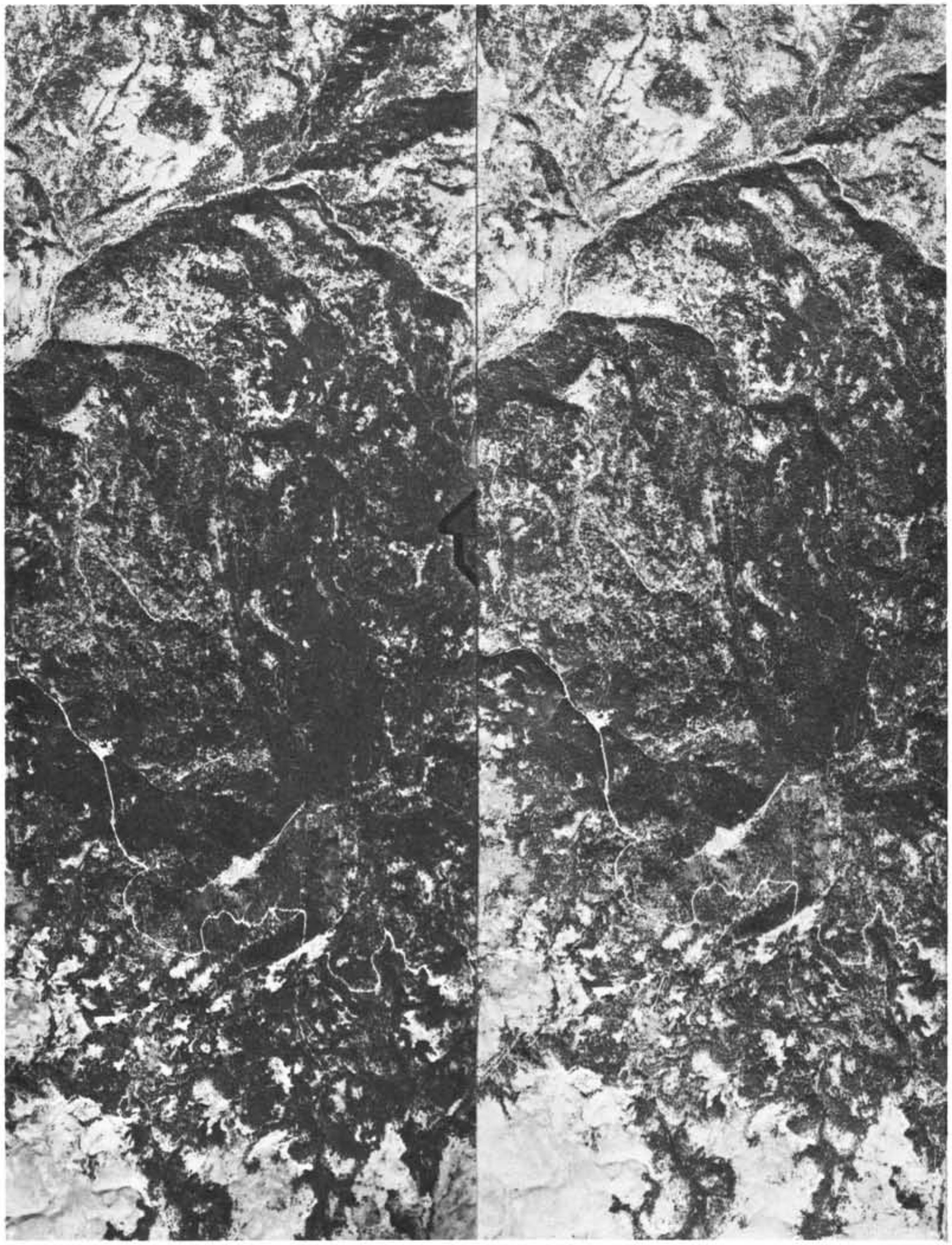

Figure 2. Stereographic plates of crater and surrounding area
Scale: 1" = approximately 4000'.

approximately 3 miles in diameter, with a central crater separated by two radial dikes extending from the source spine. The average crater diameter is approximately 5000 feet. It is located on the southwestern margin of the Wallowa Mountains and can be reached by a U.S. Forest Service road from Medical Springs.

The geology of this area has been described by James Gilluly (1937), N. S. Wagner (1958), R. L. Bateman (1961), and H. J. Prostka (1962). Bateman recognized the shield nature of this feature and developed the detailed stratigraphic sequence for the area. The purpose of this paper is to describe the crater structure and to show its relationship to the surrounding geology. Structures of this magnitude and degree of preservation are relatively rare, particularly in this area of Oregon (figure 2).

Stratigraphic Sequence Underlying the Crater

The area of interest is located on the southwest flank of the Wallowa Mountains uplift. The albite granites which are exposed farther to the east are assumed to form the deeper part of the geologic "basement" beneath the crater. Overlying this unit are the pre-Tertiary volcanics and sediments of the Clover Creek Greenstone (Ptcg). These rocks are exposed along Big Creek approximately 2 miles northwest of the crater and also along the upper reaches of Clover Creek about 1 mile to the southeast (plate 2). At greater distances they almost circumscribe the structure. As described by Prostka (1962), these rocks consist of "basaltic to rhyolitic volcanic flows, coarse- to fine-grained volcanic wackes, sandstones, tuff, and subordinate amounts of chert, conglomerate, and limestone, all of which have been slightly to moderately metamorphosed."

Overlying the pre-Tertiary rocks are several hundred feet of sequential flows of olivine basalt (Tob) which have been assigned to the upper Miocene by fossil-leaf dating. These basalts form a broad plateau which dips gently away from the Wallowa uplift. The rock is grayish-brown and the flows range from 30 to 100 feet in thickness, with well-developed columnar jointing.

Description of the Crater

The Sawtooth shield and crater overlie the olivine basalts and the Clover Creek group (figure 3). The shield consists of discontinuous flows of platy andesite (Taif) which range in thickness from 20 to 50 feet. As described by Bateman (1961) "the flows of platy andesite surrounding Sawtooth Ridge have a gentle dip away from their source. Felted texture is most common and results in the platy fracture which is most common in most outcrops." Generally the dip of the plate surfaces increases to 30° to 40° in or near the crater rim. No tuffaceous or pyroclastic beds were observed within or on the andesites of the shield.

Figure 3. Profile view of the crater, looking east from Oregon State Highway 203.

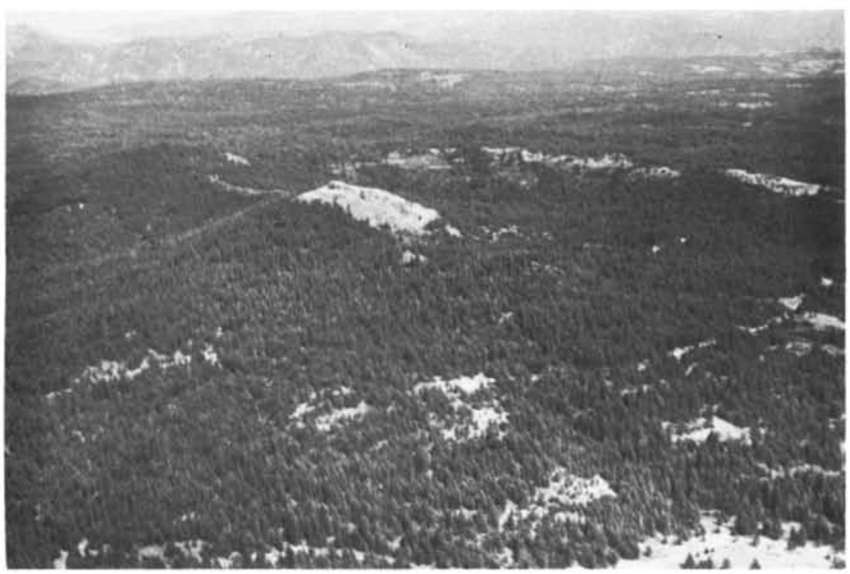

Figure 4. Oblique aerial view to the northeast, showing the central spire, radial dikes, and the southeast rim.

The Sawtooth Crater is roughly circular in shape and covers 650 acres within the rim (figures 4 and 5). The rim circumference is approximately 19,000 feet. The height of the rim above the crater floor ranges from 100 to 400 feet, with the central spire rising to an elevation of 420 feet above the floor. Two radial dikes (figure 6) extend northeast and southwest from the spire and divide the crater into two equal basins along this axis. The northeast dike is the better preserved and is probably the origin of the name "Sawtooth Ridge." This feature rises 300 feet from the crater floor, the last 70 feet being a vertical wall. Breaching has occurred in each basin. Considerable rim erosion has taken place in the northwest basin, whereas the southeast basin has breached to form a narrow andesite-bound defile with resulting excellent rim profile preservation. The radial dikes extend from the central spire to the rim and terminate in what appears to be rim horns or secondary plugs. No extension of the dikes was apparent beyond the rim termination.

Three rock units were observed within the crater proper. The rim cap, central spire, and radial dikes are composed of platy andesite (Taif) like that in the shield section. This material is best exposed in the central spire, the northeast dike, and the southeast rim, which is almost completely capped by this resistant material. The central spire and dikes are characterized by steeply dipping to vertical platy joints (figures 7 and 8). The plates range in thickness from $\frac{1}{4}$ to 2 inches and separate rapidly on subaerial exposure.

Two outcrops of pyroclastic ejecta (Tp) are located within the crater (plate 1). The area on the floor immediately south of the central spire shows definite bedding planes dipping steeply away from the spire. Extensions of this outcrop were found in three backhoe exploration pits farther to the south and west where the angle of dip was significantly less. The second outcrop is located high on the north rim immediately beneath the platy andesite. Unfortunately, no bedding planes were evident at this location. The presence of a pyroclastic fraction was observed in backhoe pits well up the south rim, significantly above the crater floor. These rocks consist of sand- to pebble-sized pumice, cinders, and andesite fragments. Embedded within this material are numerous 2- to 6-inch scoria bombs. The individual grains are angular to subrounded. Gross color has the appearance of "salt and pepper" owing to the light pumice and the darker cinders and andesite. These pyroclastics are moderately to well cemented with some zones having a welded appearance. The lateral extent of this unit is obscured by the colluvial aprons; however, the presence of the outcrop along the rim above the crater floor seems to indicate lateral subrim extension. This is consistent with the conical emplacement of pyroclastics and lava flows during the build-up of a composite volcanic cone.

The lower interior slopes and the floor are mantled with colluvial aprons of platy andesite, pyroclastics, and their developing soil profile of clayey silt (Qcd).

Figure 5. Oblique aerial photograph showing rim curvature, dike, and central plug.

Figure 6. Northeast radial dike as seen from the central plug. Maximum relief above talus apron is approximately 70 feet.

Figure 7. Platy andesite of the northeast dike.

Figure 8. Platy andesite of the central plug.

Formation of the Crater

Most crater formation can be ascribed to one or a combination of the following four processes: impact, explosion, collapse, or differential erosion. In the case of the Sawtooth structure, the existence of the massive central plug and the well-defined radial dikes would preclude impact and explosion as modes of formation. Although the collapse theory can by no means be ruled out, the presence of the plug and dikes and the absence of precollapse ejecta surrounding or downwind from the crater seem to discount this origin.

The author feels that the observed geologic conditions are probably most consistent with the differential erosion process of crater formation. The presence of less resistant pyroclastic deposits, both on the crater floor and immediately underlying the platy andesite high on the northeast rim, provides the necessary erosional unit. It is recognized that their lateral extent is limited; however, a circular or conical type of deposition extending generally outward from a central vent is a reasonable explanation. With this initial structure, normal erosional processes would result in the present form once the protective andesite shield had been breached.

Summary

The objective of this report has been to locate and describe a well-defined crater structure in the Miocene lavas of northeastern Oregon. The preliminary reconnaissance indicates that the structure is erosional; however, the theory for a collapse origin cannot be positively discarded without further detailed investigations. The general geomorphic form is similar to previously described structures in south-central and southeastern Oregon.

The existence of such a well-defined feature in this particular part of the state is relatively unknown. Further investigation of the crater is anticipated; this should add considerably to knowledge of the origin and emplacement of the late Cenozoic lavas in northeastern Oregon.

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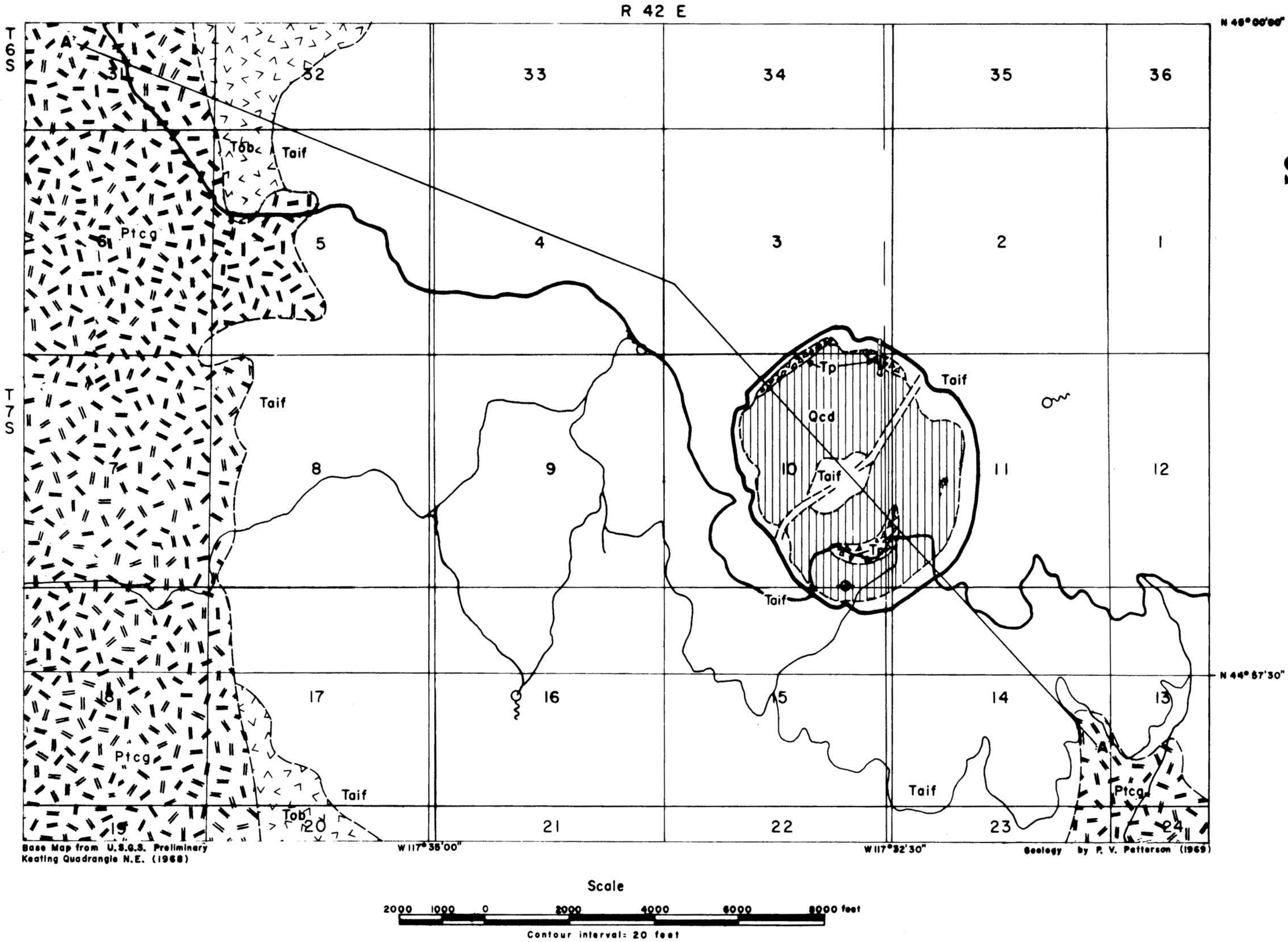
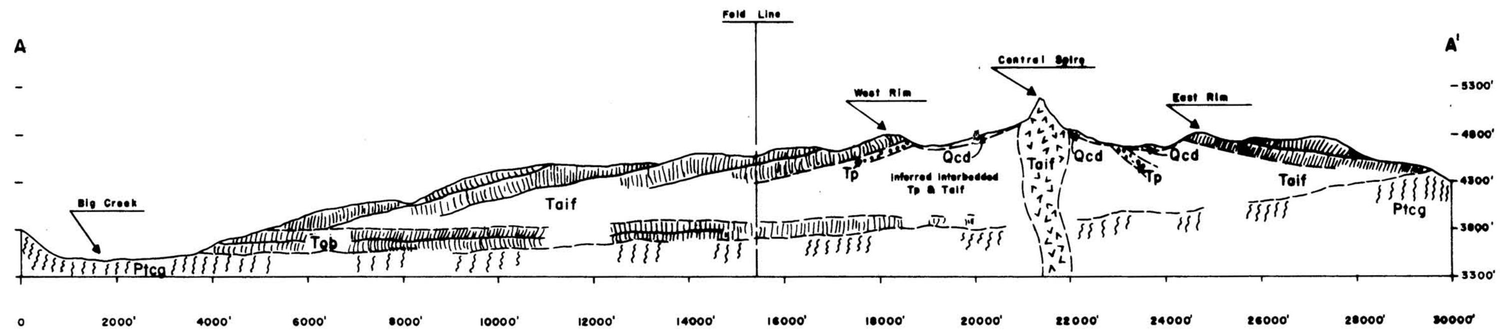
Plate 1. Geologic Map and Structure Section of SAWTOOTH CRATER Baker County, Oregon



Structure Cross Section

Vertical Exaggeration: 2 X



LEGEND

Cenozoic

- Qcd — Colluvial debris. Includes andesite talus, pyroclastic float and associated soil mantle
- Taif — Andesite intrusives and flows. Includes the central plug, radial dikes and surrounding shield flows. Structure predominantly platy.
- Tp — Pyroclastic debris. Beds of sand to pebble size pumice, andesite cinders, and associated ejecta. Generally dipping away from the central plug.

Pre-Tertiary

- Tob — Olivine basalt. Flow on flow of vesicular, columnar, jointed basalt
- Ptcg — Clover Creek Greenstone, (after Gilluly -Baker Quadrangle). Altered flows, pyroclastics and sediments forming the local basement.

Approximate formation contact.

Topographic rim of crater

Attitude of flows and pyroclastic beds.

Horizontal bed

Trace of structure section

Springs

Major / Minor — Access Roads

WORM-BORED POPLAR FROM THE EOCENE OF OREGON

By Irene Gregory*

That faithful, true-to-life detail may be retained during the process of petrification is shown by the photographs on the opposite page. The beautifully preserved and undisturbed chips of wood filling this worm burrow were formed in a poplar tree living about 40 million years ago during the Eocene in Oregon. The specimen (much enlarged) is of the genus Populus in the willow family (Salicaceae).

The worm tunnel was made by an insect larva of the flat-headed borer type of today. Its strong mandibles enabled it to carve out from the living poplar wood the typical crescent-shaped chips pictured "floating" in the clear chalcedony that was deposited in the borrow during petrification by silica-bearing ground waters.

The process of petrification of wood is not yet well understood, but, by this means, original cell structure is retained through some mineral (commonly silica) infiltrating the plant tissues. The nearly perfect preservation of detail that can result provides one of our most accurate tools for fossil-wood research.

In the specimen illustrated, structural features appear as clearly as in living wood, and minute anatomical details are retained in even the smallest chips carved out by the borer.

Some of the typical anatomical features of poplar wood preserved in this fossil specimen include growth rings delineated by somewhat larger vessels at the beginning of each ring; vessels small and in short radial rows of two to several; rays fine and close; and parenchyma limited to terminal.

As with many Tertiary woods of the Pacific Northwest, the over-all aspect of this specimen more clearly resembles Asiatic Populus of today than it does our living North American members of this genus. The living forests of Asia seem to have retained their Tertiary character, not only in the kinds of trees present but also in the anatomy and general aspect of their woods.

The specimen pictured is one of an assemblage of silicified Eocene woods occurring in an outcrop of the Clarno Formation in Crook County, Oregon. Woods from this area are being collected and studied by the author.

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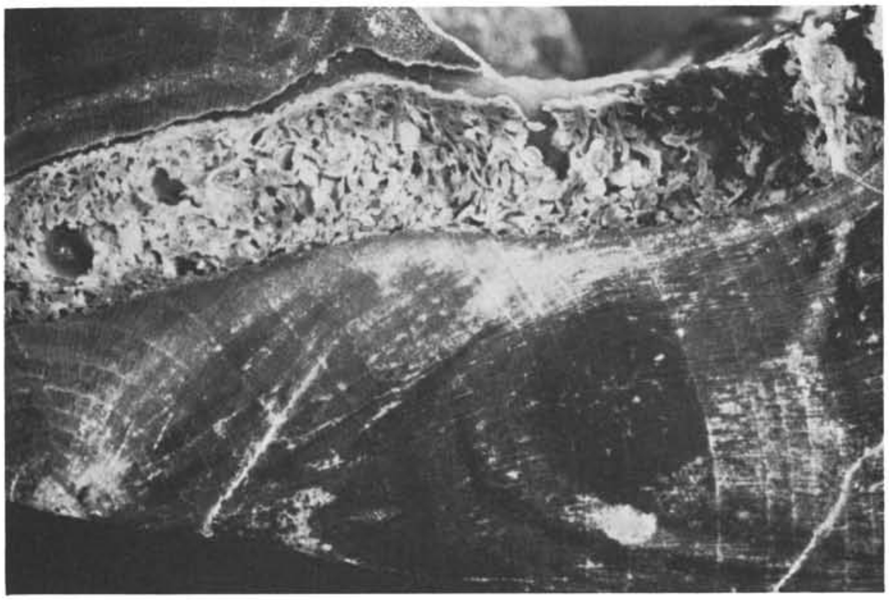
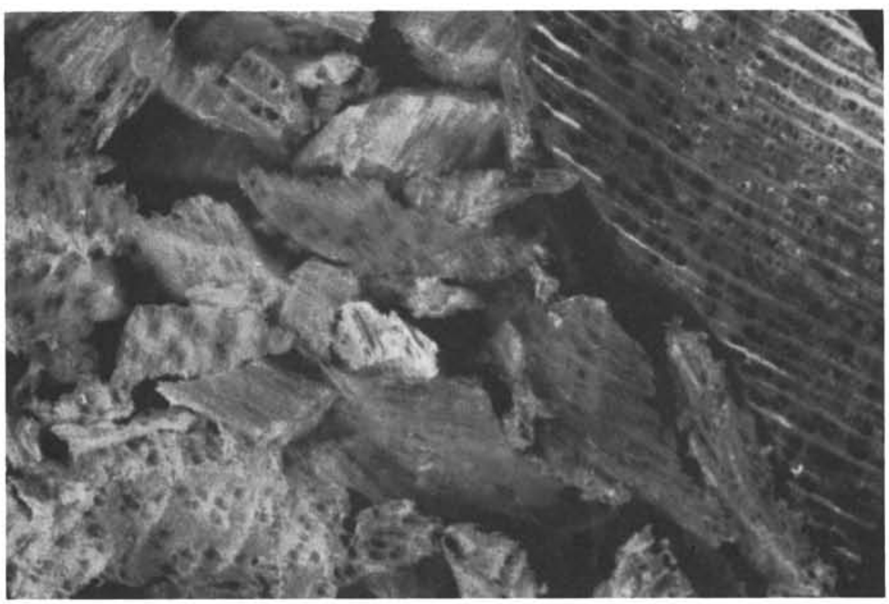
* Authority on fossil woods of Oregon and author of several articles in The ORE BIN.





Photomicrographs of silicified poplar wood showing tunnel and chips made by a wood borer during the Eocene Epoch. Upper picture 2.5 X enlargement; lower picture (portion of upper) 35 X enlargement. (Specimen preparation by Fred Roner and photography by Thomas J. Bones.)

See page opposite for story.

Oblique aerial view looking west across the Willamette River in the vicinity of Oregon City, showing the present valley of the Tualatin River on the left and the former route through Lake Oswego on the upper right. (Delano Photographics)

GEOMORPHOLOGY OF THE LAKE OSWEGO AREA, OREGON

Roger B. Parsons*

Baldwin (1957) has reported drainage changes of the Willamette and Tualatin Rivers near Lake Oswego, Oregon, and indicated that the Lake Oswego channel probably was formed during Illinoian time. The channel is considerably younger than Illinoian. Baldwin apparently did not fully consider the sequential geomorphic relations in establishing the Pleistocene chronology of the Lake Oswego area.

The purpose of this paper is to show how geomorphology may lead to a better understanding of the genesis of the Lake Oswego area and to provide an explanation for a seemingly unusual soil occurrence along the Tualatin River.

Regional Geomorphology

Geomorphic surfaces recently have been studied and mapped in the Willamette and the Tualatin River valleys (Balster and Parsons, 1968). The surfaces were mapped on high-altitude aerial photographs and visually traced throughout approximately 3000 square miles of the study area. Surfaces of particular interest in the Lake Oswego area, from oldest to youngest, are Senecal, Champoeg, Winkle, Ingram, and Horseshoe. Soils have been related to the geomorphology and can be arrayed in a developmental sequence with decreasing horizonation as one progresses to successively younger surfaces. However, Chehalis soils occur on both Winkle and Ingram surfaces.

Steep, active slopes in the Willamette Valley were mapped as the Looney unit typified by Looney Butte in Marion County. Areas of Looney cannot be placed in a chronological sequence and soils exhibit a wide range of development. Dolph and Eola surfaces (figure 1) are primarily remnants of once-extensive middle Pleistocene landscapes. Areas of these surfaces occur on Petes Mountain and south of the Tualatin Valley. Soils on Dolph and Eola surfaces are generally red, strongly acid, and have well-differentiated horizons. Since Dolph and Eola surfaces predate the Lake Oswego

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* Research Soil Scientist, Soil Conservation Service, and Assistant Professor, Oregon State University, Corvallis.

sequence, they are included in this discussion to complete the local geomorphology.

The Senecal surface constitutes the modified main valley floor as typified along Senecal Creek in Marion County. Deposits associated with the Senecal surface are Linn Gravel, Willamette Silts, and strata recently named Diamond Hill, Wyatt, Malpass, and Greenback (Balster and Parsons, in press). The Diamond Hill paleosol may be correlative to the well-known Troutdale Formation in the northern Willamette Valley. Soils that occur on the Senecal surface are in the Willamette, Woodburn, Amity, Concord, Holcomb, and Dayton series (Parsons, Simonson, and Balster, 1968). Dayton soils have been shown to be derived from the contrasting Greenback and Malpass deposits (Parsons and Balster, 1967).

The Champoeg surface is a lower lying modification of the Senecal surface and consists primarily of small, pediment-like landforms and deposits of sand and gravel. An area near Champoeg Park, about 2 miles southwest of Newberg, serves as the type locality. The base level to which the Champoeg surface was developing was stable for only a short time during the late Pleistocene (Balster and Parsons, 1968). Champoeg surface is not readily identified in the Willamette Valley south of Salem.

The Winkle surface occurs throughout the Willamette Valley and is the oldest surface obviously associated with present drainage systems. An area south of Winkle Butte in Benton County is the type locality. Soils developed on the Winkle surface have been dated (Reckendorf and Parsons, 1966) by C^{14} methods at 5,250 ± 270 years B.P.* Wood from deeper sediments beneath the Winkle surface has yielded a date of 10,850 ± 240 years B.P. (Balster and Parsons, 1968). The Winkle surface consists of terraces, abandoned lake beds, wind gaps, and the flood plain of the Tualatin River. In several localities, strata largely composed of pumice have been observed within soil profiles. The pumice is probably from Mount Mazama, since the ages for the Winkle surface are approximately correlative to dates for the Mazama eruption.

The Ingram surface is the high flood plain of the Willamette and most tributary rivers. Ingram Island in Benton County provides the name and type locality for the surface. The bar and swale topography of the Ingram surface, with point bars and oxbow lakes, is typical of recent flood plains. In general, the bars are not flooded, but swales may be inundated depending on the severity of flooding, the presence of log jams, dams, and other factors. This recent alluvium has been dated at approximately 555 years (Balster and Parsons, 1968). Direct correlation of surfaces suggests a possible maximum age for Ingram alluvium of 3,290 ± 120 years B.P. (Balster and Parsons, 1968). A study is presently being conducted on Ingram and Winkle surfaces in Lane County which should provide useful information about soil-geomorphic relationships on the high flood plain and low terraces.

The Horseshoe surface includes the present stream channels and annual

*Before present

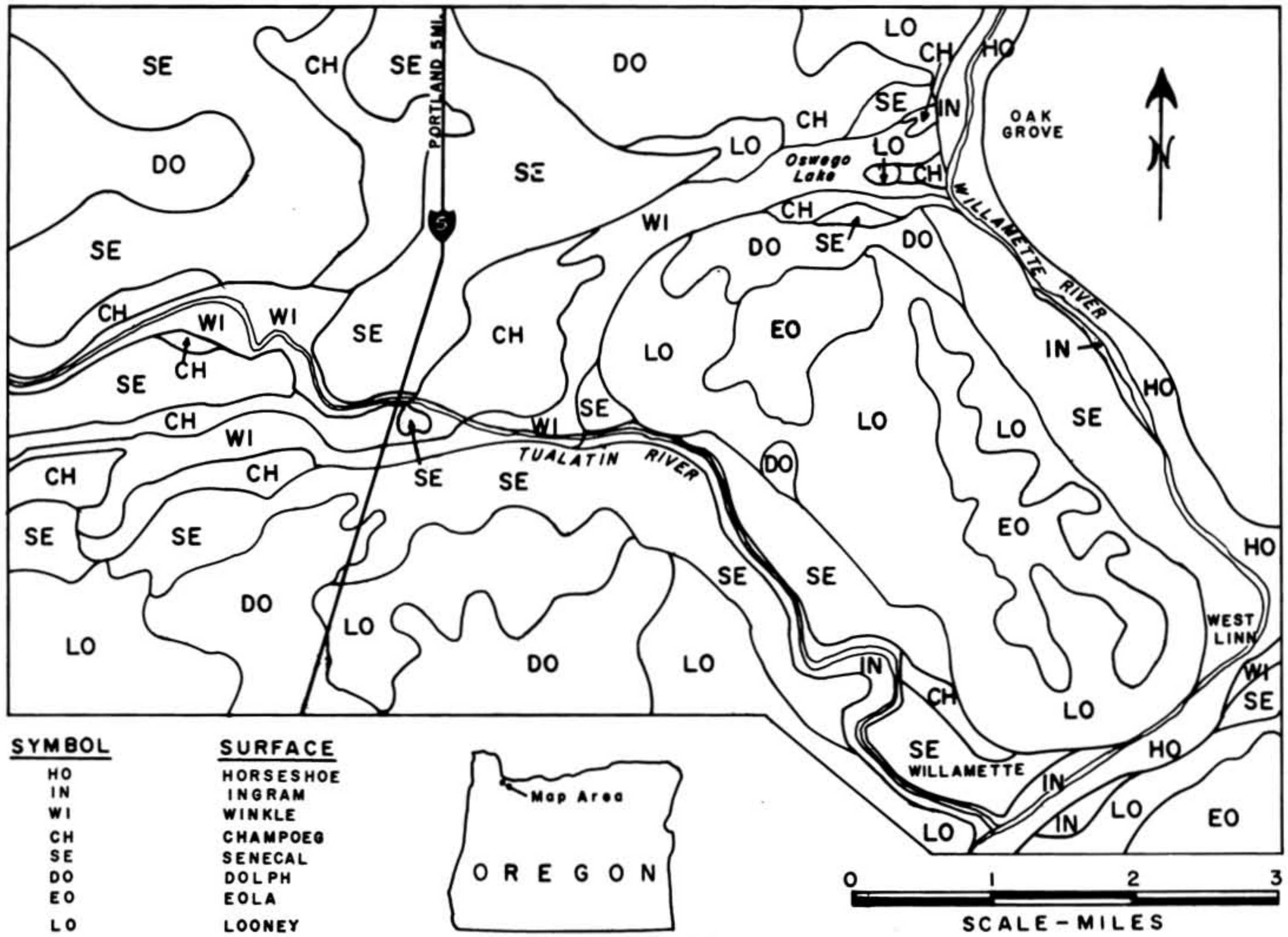

Figure 1. Geomorphic map of the Lake Oswego area.

flood plains and is believed to be post-settlement in age (Balster and Parsons, 1968). Horseshoe Island in the Willamette River in Benton County serves as the type locality. Sediments associated with the Horseshoe surface are primarily coarse-textured. Organic accumulation and weak structural development are the only evidences of soil formation.

Since in most localities the Winkle surface is a terrace, a question arises as to why the Winkle surface is a flood plain along the Tualatin River. Chehalis soils are generally encountered on the Ingram surface and lack the development of soils that occur on the older Winkle surface. However, Chehalis is the well-drained soil series on the Winkle surface along the Tualatin River.

Lake Oswego Geomorphology

The Lake Oswego valley between the Portland Hills and Petes Mountain had developed by the time the Senecal surface was formed. Small remnants of the Senecal surface are preserved along the edge of the Lake Oswego valley (figure 1) and truncate the older Dolph and Eola geomorphic surfaces.

Geomorphic relations may substantiate Baldwin's (1957) interpretation that the post-Troutdale (Senecal) drainage of the ancestral Willamette River flowed through the area presently occupied by the town of Willamette along the present lower reaches of the Tualatin River and joined the Tualatin River near the town of Tualatin at the west end of Lake Oswego. However, an alternative is that the Tualatin, during stages of development of the Senecal surface, flowed along its present course, joined the Willamette River at the town of Willamette, and the combined rivers then cut the rock-floored Senecal in the vicinity of West Linn and Oregon City. Subsequent uplift in the Petes Mountain area could have displaced the Tualatin River northward to the Champoeg-Winkle channel through Lake Oswego. Post-Senecal uplift of the Parrot-Chehalem Mountain area is suggested by bedding in Willamette Silts that gradually dips to the south in the vicinity of St. Paul. The Senecal surface rises gradually between Salem and Newberg and may have been caused by continued deformation along a structural trend across the valley from Oregon City to Chehalem Mountain (Balster and Parsons, 1968). Tectonic activity in the area has been described in some detail by Schlicker and Deacon (1967).

The flood event that eroded the present Oswego channel (Schlicker and Deacon, 1967) and truncated Willamette Silts on Senecal surface deposited the torrentially cross-bedded Portland Sands (Baldwin, 1957). This sand (and gravel) is associated with the Champoeg geomorphic surface. It is possible that the bedrock-floored Senecal surface in the vicinity of West Linn was completely scoured of Pleistocene alluvium during the flood torrent (Baldwin, 1957) which brought in the Portland Sands during the Champoeg episode.

The ancestral Tualatin River remained in its Champoeg channel and re-excavated Lake Oswego throughout the Winkle episode. The Winkle-age Tualatin channel effectively removed the Portland Sands, the lacustrine sand described by Schlicker and Deacon (1967). Then some mechanism, perhaps uplift of the area to the north or even backwater from the Columbia River, diverted the Tualatin from its Winkle-age Lake Oswego channel. A new Tualatin channel incised the Senecal surface, northwest of the town of Willamette, and was apparently the easiest course to the Willamette River. Baldwin (1957) suggests that plugging of the Lake Oswego channel by Portland Sands was probably responsible for the diversion of the Tualatin River. However, if the torrentially cross-bedded Portland Sands are a deposit related to the constructional Champoeg surface in the area, then the Winkle-age ancestral Tualatin River was able to make a course through the Portland Sands and Lake Oswego. Baldwin (1957) apparently did not consider the geomorphic development that occurred between the time the Portland Sands were deposited and the development of the present lower Tualatin channel, or in other words, the Winkle episode.

The Ingram surface has developed upstream on the Tualatin River to about the NW$\frac{1}{4}$ section 20, T. 2 S., R. 1 E., or about 4 miles upstream from its confluence with the Willamette River. The remainder of the present-day Tualatin flood plain is Winkle surface which is deeply incised by the meandering Tualatin channel. The channel is comparatively straight on the lower reaches of the Tualatin River where the Ingram surface has developed. The Tualatin River above Section 20 has a hanging valley. Horseshoe surface, the channel itself, is unable to carry the large volume of flood water. Therefore, the channel quickly fills to overflow and inundates the Winkle surface. Periodic flooding with accompanying sedimentation effectively inhibits soil horizonation. With continual renewal by additional alluvium, particularly alluvium containing considerable quantities of organic matter, soil development is retarded. Hence, Chehalis and other soils lacking B horizons with clay illuviation are encountered on Winkle surface in the Tualatin Valley, whereas more developed soils are commonly found on Winkle throughout the Willamette Valley (Balster and Parsons, 1968).

Summary

Geomorphology provides a means of developing a sequence of events. Study of soils and geomorphology in the Tualatin Valley indicates that the abandonment of the Lake Oswego channel was not nearly as long ago as Baldwin suggests but may have been between 3290 and 5250 years ago. Throughout the Willamette Valley, Winkle surfaces now exist as terraces, peat bogs, or wind gaps. Examples of Winkle surfaces in the Willamette Valley area are Richardson Gap in Linn County, Lake Labish in Marion County, typical stream terraces in Benton County, and Lake Oswego in

Clackamas County.

Pleistocene stages in the Lake Oswego area are late Wisconsin and Recent. The Senecal and Champoeg surfaces are late Wisconsin, whereas the Winkle and Ingram surfaces are about 5250 and 555 years old, respectively.

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REYNOLDS METALS ACQUIRES ALCOA PROPERTIES

Reynolds Metals Co. announces that it has acquired from the Aluminum Co. of America bauxite properties in Washington and Oregon, some of which are adjacent to present Reynolds holdings. Counties where property was acquired include Columbia, Washington, and Multnomah in Oregon, and Cowlitz in Washington.

Deposits of high-iron bauxite were discovered by the State of Oregon Department of Geology and Mineral Industries in the Tualatin Hills of Washington County in 1943. After the results of test drillings in this area were published (Department Bulletin 29, "Ferruginous bauxite deposits in northwestern Oregon," by F. W. Libbey and others), Alcoa Mining Co. conducted a long-range exploration and drilling program which led to the acquisition of the properties recently purchased by Reynolds.

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Geologic map of Bend quadrangle, and reconnaissance geologic map of central portion, High Cascade Mountains, Oregon, 1957: Williams . . .	1.00
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