OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 43, NUMBER 1 **JANUARY 1981**


OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 43, NUMBER 1 JANUARY 1981

Published monthly by the State of Oregon Department of Geology and Mineral Industries (Volumes 1 through 40 were entitled *The Ore Bin*).

Main Office: 1005 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Paul F. Lawson, Supervisor

Subscription rates: 1 year, $4.00; 3 years, $10.00. Single issues, $.40 at counter, $.50 mailed.
Available back issues of *The Ore Bin*: $.25 at counter, $.50 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology*, 1005 State Office Building, Portland, OR 97201.

COVER PHOTO

Oblique aerial photograph of Portland (foreground), Portland Hills (Tualatin Mountains), and Tualatin Valley (behind hills). Article beginning on next page discusses Portland Hills Silt, which once covered much of this area. Copyrighted photograph courtesy Delano Photographics, Inc.

DOGAMI laboratory policy revised

The greatly increased need for systematic rock-chemistry data for Oregon has prompted the Oregon Department of Geology and Mineral Industries to enlarge the scope of its laboratory facilities. The Department lab is managed by Assayer-Spectroscopist Gary Baxter.

Effective January 1, 1981, the Department's revised purposes and procedures include the following:

The laboratory will be primarily research oriented, with the view of providing necessary support for staff geologists in a manner analogous to the library, cartographic, and editorial sections of the Department.

The laboratory is continuing its service to the public on routine assays and analyses, but it can no longer perform the analyses in-house. Instead, gold and silver assays and heavy-metal and other analyses are now being farmed out to commercial labs on an annual-bid basis. The Department performs random quality-control checks and crushing and grinding. A new price list, schedule, and other procedural instructions will be published at a later date.

Departmental lab capabilities continue to be oriented toward fire assay, geochemical analysis of metals, future improvement of geochemical capabilities for soil and rock, and intermediate preparation (grinding, crushing, sectioning) of farmed-out analyses such as XRD, XRF, and IHA. Where appropriate, the Department relies fully on counterpart laboratories, especially for physical testing and complete testing capabilities with regard to gas or water.

Space needs have been accommodated by moving some facilities to the new Department warehouse, including the grinder, crusher, rock cutter, and table space.

Among the benefits of these changes are a better focus of lab work on samples and projects that will lead to increased mineral-resource development in Oregon; improved quality of the existing lab, enabling cleaner conditions and more quality-control efforts for both public and Department sample analyses; better utilization of other labs through improved coordination and sample-preparation capabilities; and reduced competition with private laboratories. □

DOGAMI gets new address

As part of the remodeling program of the State Office Building in Portland, new room numbers have been assigned to the Portland offices of the Oregon Department of Geology and Mineral Industries. The administrative and professional staff, editing, laboratory, and cartography are still in the same offices on the tenth floor, but the new room number is 1005. The Department's library and business office are on the ninth floor in rooms 901 and 906, respectively. The Department's new mailing address is 1005 State Office Building, Portland, Oregon 97201. Our phone number is still the same: (503) 229-5580. □

CONTENTS

The petrology and stratigraphy of the Portland Hills Silt—a Pacific Northwest loess

by Rodney T. Lentz, Bureau of Land Management, P.O. Box 194, Battle Mountain, Nevada 89820

ABSTRACT

This investigation examines the petrology and stratigraphy of the Portland Hills Silt on the basis of field observations and detailed lateral and vertical sampling. The formation is uniform both in texture and composition. The average grain-size distribution indicates 79 percent silt-, 16 percent clay-, and 5 percent sand-sized particles; very poor sorting; and a fine-skewed grain-size distribution. The median grain size fines westward from about 0.041 mm (0.002 in.) near the Portland basin, to 0.022 mm (0.001 in.) on the west slope of the Tualatin Mountains. Quartz and feldspar constitute 35 and 36 percent, respectively, of the total mineral composition. Clay minerals (15 percent), coarse-grained micas (6 percent), rock detritus and volcanic glass (5 percent), and heavy minerals (3 percent) make up lesser quantities. The heavy-mineral suite is composed of hornblende (41 percent), opaques (17 percent), epidote (15 percent), augite (10 percent), a variety of metamorphic species, and very minor hypersthene. The deposit is essentially massive. However, deeper exposures may reveal up to four 2- to 8.5-m (7- to 28-ft)-thick silt units which are tentatively correlated with major glacial deposits of western Washington: the Orting and Struck Drifts and the upper and lower tills of the Salmon Springs Drift. The distributional, textural, and morphological character of the Portland Hills Silt strongly indicates a loessial origin from the sediments of the Columbia River Basin.

INTRODUCTION

The Portland Hills Silt was named by Lowry and Baldwin in 1952. However, the unique formation, a massive, yellowish-brown micaceous silt, was first noted in 1896 by J. S. Diller. It has since been a topic of some puzzlement, much discussion, and a fair share of tempered debate.

Although physical descriptions of the silt are generally in agreement, there is some controversy regarding its origin. The dissonance arises from minor structural and textural details reported in the silt—notably, the presence of bedding and/or scattered pebbles. Depending upon the interpretation of these features, the silt has been variously interpreted as (1) water deposited (Diller, 1896; Libbey, Lowry, and Mason, 1945; Wilkinson, Lowry, and Baldwin, 1946; Lowry and Baldwin, 1952); (2) wind transported (Darton, 1909; Libbey, Lowry, and Mason, 1944; Theisen, 1958; Trimble, 1963; Livingston, 1966; Schlicker and Deacon, 1967) and (3) a combination of fluvial and eolian deposition (Baldwin, 1964; Beaulieu, 1971; Niem and Van Atta, 1973).

The diversity of these theories may be blamed largely upon difficulties inherent in field study. Poor exposure is probably the greatest obstacle facing a field geologist in the Portland area. In addition, other sedimentary formations of very similar texture and composition commonly underlie or overlie the Portland Hills Silt. These include the laterized Helvetia Formation (Schlicker and Deacon, 1967), the Troutdale-equivalent sediments of the Tualatin Valley (Schlicker and Deacon, 1967), and especially the lacustrine Willamette Silt (Allison, 1953). Exposures on steeper slopes may be further confounded by small- or large-scale mass movement. This is especially true on the abrupt eastern flank of the Tualatin Mountains, where the Portland Hills Silt as well as the clayey Helvetia and residual basalt formations are subject to landsliding. Finally, until this study, little was known about the silt's sedimentary structure, texture, composition, and stratigraphic relations.

The following article summarizes a master's thesis designed to obtain the data that were lacking and to resolve the controversy over the origin of the Portland Hills Silt.

LOCATION OF THE STUDY AREA

Although the field investigation for this study included reconnaissance and sampling throughout the Portland-Tualatin Valley region, Oregon and Washington, the major area of sampling and mapping was confined to approximately 230 km^2 (90 mi^2) in the vicinity of the Tualatin Mountains (Figure 1).

METHODS

Two major types of samples, uniform- and variable-depth samples, were collected during the field study. Both types were obtained either by channel sampling from outcrop or by hand augering. In each case, the resulting sample was a composite taken over a 30-cm (1-ft) vertical interval.

Uniform-depth samples were generally taken from unweathered near-surface material between 1.5 and 2.0 m (5 and 7 ft) in depth from throughout the study area. Variable-depth samples were collected at regular intervals to depths of 2 to 14 m (6 to 45 ft) from hand-augered sections and/or key outcrops. Several oriented samples were also obtained for analysis of fabric and sedimentary structures.

Standard techniques were used to obtain the various petrological and granulometric data presented herein.

STRATIGRAPHIC RELATIONSHIPS

The stratigraphic relationships between the Portland Hills Silt and its major boundary formations in the Tualatin Mountains are illustrated in Figures 2 and 3.

Portland Hills Silt overlies the deformed Miocene Columbia River Basalt Group (Trimble, 1963) and the deeply weathered and laterized Helvetia Formation. The silt also overlies quartzite-bearing conglomerate and vitric sandstone of the Troutdale Formation on the eastern flank of the mountains.

Because of poor exposure and the lithologic similarity between the Portland Hills Silt and the Tualatin Valley equivalent of the Troutdale Formation, definite stratigraphic relationships between these units were difficult to establish. However, subsurface data reported by Schlicker and Deacon (1967) indicate that both the Tualatin Valley sediments and the Troutdale Formation proper show analogous stratigraphic relations. It is assumed, therefore, that the Portland Hills Silt unconformably overlies both the Troutdale Formation proper and its Tualatin Valley equivalent.

In the Portland area, late Tertiary volcanic rocks consisting of olivine basalts and pyroclastics were named the Boring Lava

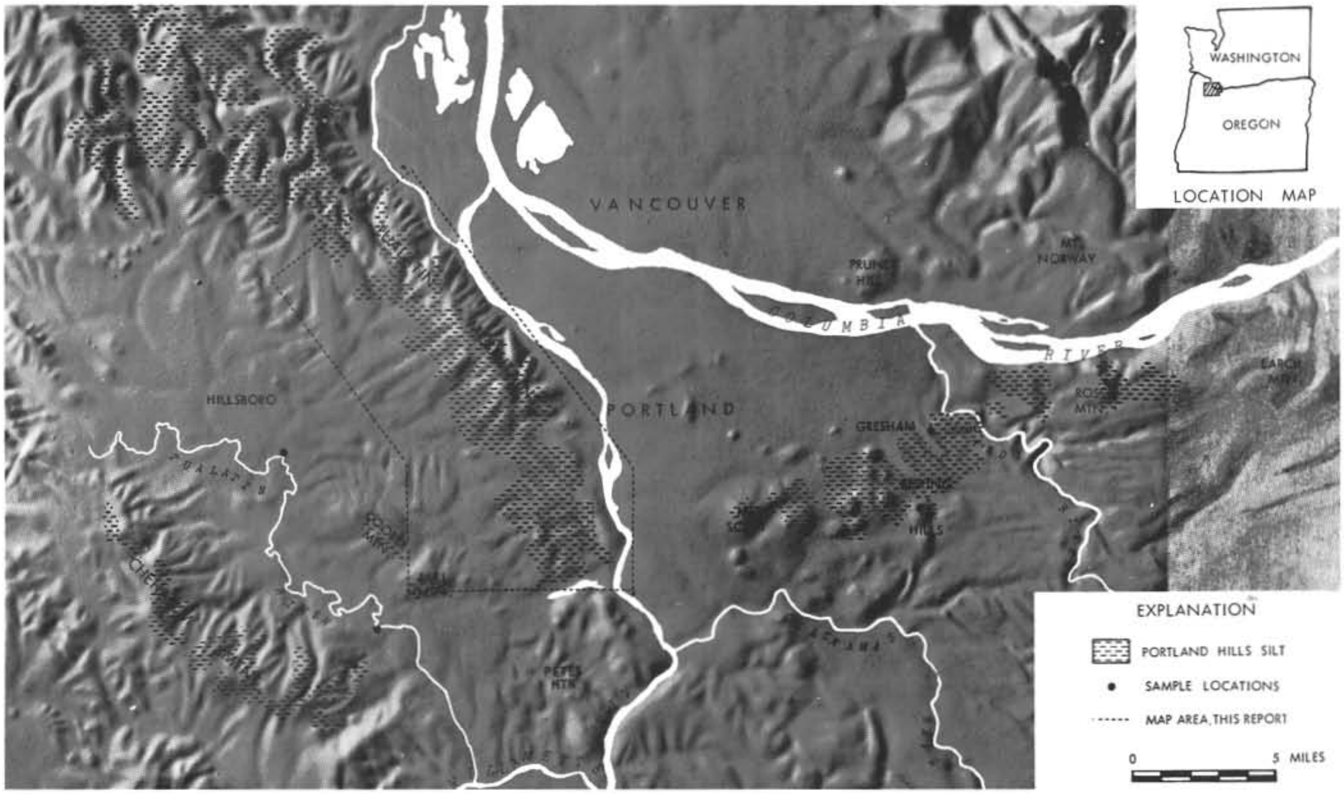


Figure 1. Distribution of the Portland Hills Silt, Portland and vicinity, Oregon and Washington.

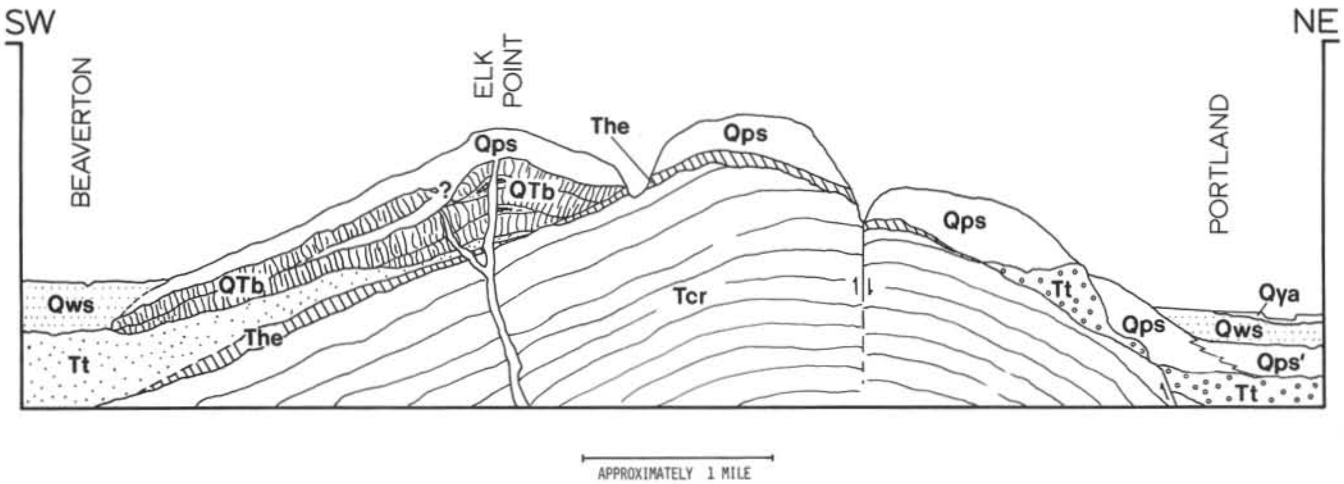


Figure 2. Sketch cross section of the Tualatin Mountains showing surficial stratigraphy. Cross section has extreme vertical exaggeration.

EXPLANATION

- **Qya** — **YOUNG ALLUVIUM**
- **Qws** — **WILLAMETTE SILT**
- **Qps / Qps** — **PORTLAND HILLS SILT** Qps' = Equivalent silts of the flood plain
- **QTb** — **BORING LAVA**
- **Tt** — **TROUTDALE FORMATION** Open circles = conglomerate and vitric sandstone. Dot pattern = Tualatin Valley equivalent
- **The** — **HELVETIA FORMATION**
- **Tcr** — **COLUMBIA RIVER BASALT GROUP**

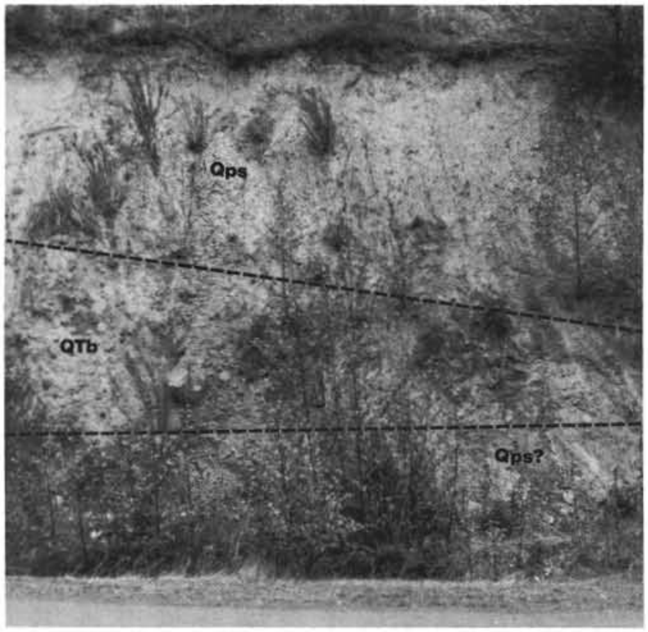


Figure 3. Roadcut showing Boring Lava (QTb) interstratified with the Portland Hills Silt (Qps), near Elk Point, sec. 1, T. 1 S., R. 1 W.

by Treasher (1942). These rocks are, for the most part, older than the Portland Hills Silt. In at least one outcrop, however, the silt appears to be interbedded with the Boring Lava (Figure 3).

The Willamette Silt, named by Allison in 1953, was studied in detail by Glenn (1965). The formation consists chiefly of bedded silts and fine sands which mantle the Willamette and Tualatin Valleys up to elevations of 92 to 107 m (300 to 350 ft). Glenn attributes the origin of these sediments to the ponded waters of unusually large floods similar to the Spokane floods described by Bretz and others (1956).

Because of lithologic and possibly genetic similarities, the stratigraphic relationship between the Portland Hills Silt and the Willamette Silt was of great importance to this study. To examine this relationship, geologic sections were described and sampled from a line of auger holes at various elevations on the western flank of the Tualatin Mountains. One bore hole located at an elevation of 84 m (275 ft), SW¼SW¼ sec. 51, T. 1 N., R. 1 W., confirmed the superposition of the younger Willamette Silt. That section revealed 3 m (10 ft) of Willamette Silt which, in the Tualatin Valley, is characterized by high clay (average 28.7 percent) and low hornblende (average 27.5 percent of heavies) contents (Lentz, 1977). The underlying Portland Hills Silt, however, was distinguished by relatively lower clay (average 18.9 percent) and higher hornblende (average 41 percent of heavies) percentages. Separating the units was an unconformity which was delineated by the oxidized and mottled remnant of a soil profile developed upon the Portland Hills Silt. An increase of organic carbon and concretionary shot below the contact confirmed the presence of a paleosol.

PORTLAND HILLS SILT

Distribution and thickness

Tualatin Mountains: Although the Portland Hills Silt appears to be almost a universal soil constituent throughout the mountains—even residual soils derived from Columbia River basalt or Boring Lava contain tell-tale flecks of mica in their surface horizons—only areas displaying more than 0.5 m (1.6 ft) of material are considered here.

The silt typically mantles flatter ridge crests and slopes above approximately 152 m (500 ft) on the eastern flank of the mountains but locally extends down to between 60 and 92 m (200 and 300 ft) on some spurs. Presumably, remnants of the formation are present even below these elevations where they may or may not be covered by younger alluvium. The silt is present up to 366 m (1,200 ft) on the crest of the mountains. Micaceous sediments of the Portland Hills Silt are more extensive on the broader, western flank of the mountains. However, the abrupt hill slopes and valley walls have been stripped of the deposit. The silt extends down to elevations between 92 and 107 m (300 and 350 ft), where it is generally overlain by Willamette Silt or younger stream alluvium.

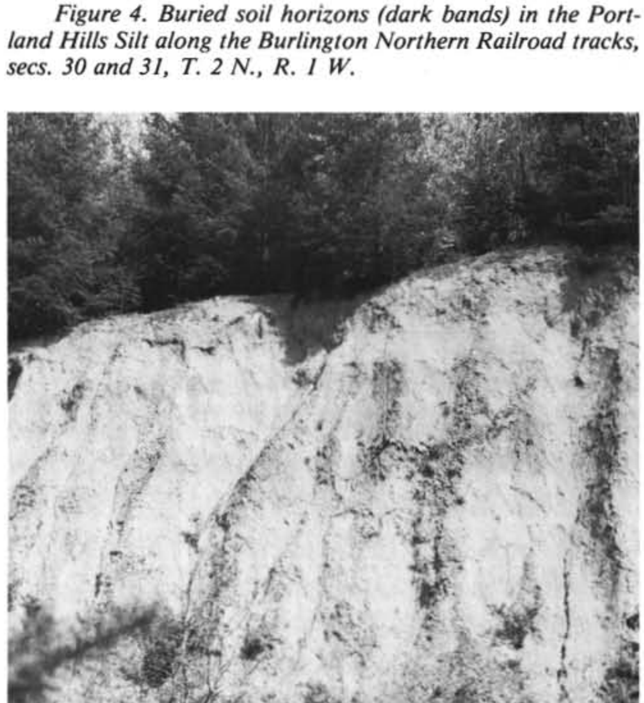
Information concerning the total depth of the Portland Hills Silt and its geographic variation is extremely limited, mainly because of the small number of outcrops which expose the base of the formation. Assorted data sources, however, indicate a gross thinning of the deposit westward. The depth of the silt decreases from approximately 37 m (120 ft) on the east side of the Tualatin Mountains to 15 m (50 ft) and less on the western flank (Lentz, 1977).

Outlying areas: Figure 1 shows the areal distribution of the Portland Hills Silt in the greater Portland area. Beyond the Tualatin Mountains, the silt is generally less than 12 m (40 ft) thick and occurs with similar topographic relationships. The deposit thins and finally pinches out in the Chehalem Mountains to the southwest and near Scappoose, Oregon, to the northwest (Theisen, 1958).

Paleosols

The Portland Hills Silt is, in outcrop, essentially massive. Nonetheless, deeper exposures may show up to four thick silt units which are marked by darker, reddish or brownish paleosols (Figure 4). The best example is a 14-m (45-ft)-deep,

Figure 4. Buried soil horizons (dark bands) in the Portland Hills Silt along the Burlington Northern Railroad tracks, secs. 30 and 31, T. 2 N., R. 1 W.



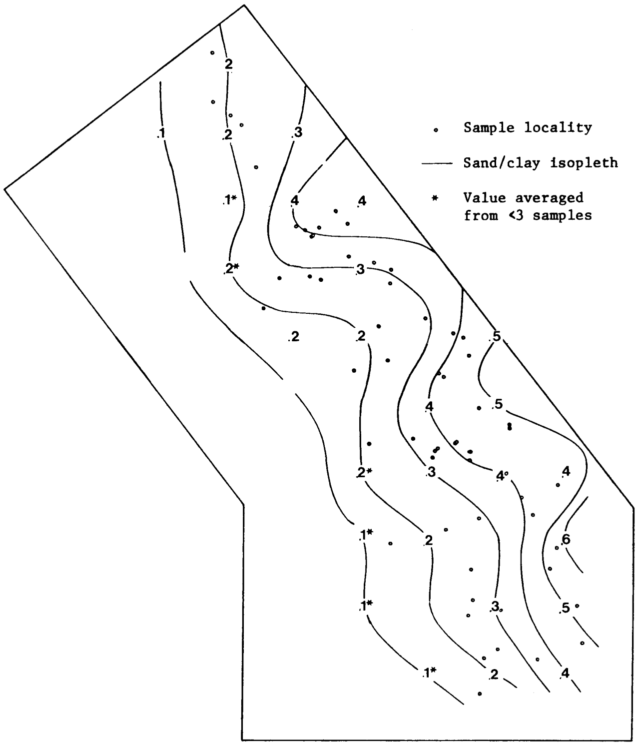


Figure 5. Areal variation of average sand/clay ratios from 67 Portland Hills Silt samples. Area outlined in this map corresponds to study area shown in Figure 1.

auger-supplemented roadcut, located on the crest of the Tualatin Mountains in SW¼SE¼ sec. 23, T. 1 N., R. 1 W. This section displays four silt units which vary in thickness between 2 to 5 m (7 to 16.5 ft). Except within soil profiles (present and buried), the textures and appearances of these beds are very similar. Petrographic analysis, however, does indicate that the surface unit has a higher percentage of hornblende and a lower augite and epidote content than the other three units. These values are substantiated by heavy-mineral analyses of the uniform-depth samples.

When unweathered, the Portland Hills Silt is a light yellowish-brown (10YR6/4-6.5/4). Paleosols in the formation, however, like their modern-day counterparts, are characterized by relatively darker, reddish- or brownish-colored B horizons (10YR6/6-8/5 when dry). The horizons are commonly mottled, showing irregular patches of yellowish-brown and reddish- or rust-orange-stained silt. They frequently show interconnected and, at depth, nearly vertical grayish streaks which represent relict blocky or prismatic jointing. High clay contents (about 25 to 30 percent) and abundant concretionary shot are also typical of these profiles. Though an organic-rich A horizon is rarely preserved in the paleosols, which is typical of buried soils (Yaalon, 1971), organic carbon is often relatively abundant in these zones.

Lateral variation

A distinct fining of the Portland Hills Silt occurs from east to west along the full length of the Tualatin Mountains. Plots of both the phi median and graphic mean (Folk, 1968) reveal a trend toward decreasing grain size from northeast to southwest, approximately perpendicular to the strike of the hills. This trend is confirmed by plotting the sand-to-clay ratios of 67 samples taken from widespread locales throughout the Tualatin Mountains (Figure 5).

Age

The Portland Hills Silt is older than the overlying Willamette Silt and, for the most part, younger than the underlying Boring Lava. Carbon-14 age dates reported by Glenn (1965) indicate a maximum age for the Willamette Silt of about 34,000 years. Trimble (1963) assigned a late Pliocene to late(?) Pleistocene age to the Boring Lava on the basis of stratigraphy. Remanent magnetism of these basalts was recently studied by Burch (1977, personal communication), who found both normal and reversed polarities in samples from the Tualatin Mountains and around the Portland area. Because the Boring Lava is also overlain by the Willamette Silt, and because the Matuyama epoch is the first significant magnetic reversal older than that deposit,[1] these lavas are, in part, probably at least as old, that is, 700,000 years or more.

If the lower portion of the Portland Hills Silt is interbedded with the Boring Lava, it, too, may be as old. Deposition of the loess, then, probably occurred between approximately 34,000 and 700,000 (?) years B.P.

CORRELATION

Quaternary paleosols are generally correlated with intervals of nonglaciation (Ruhe, 1969; Flint, 1971; Yaalon, 1971). For this reason, it is believed that units of the Portland Hills Silt and their associated soils are correlative with glacial stages of the Pacific Northwest. Moreover, the relative thickness and development of the paleosols, as compared to the contemporary soils, suggest more than just incipient or short-term weathering. Individual silt units, then, are probably correlative to the major glacial episodes and their corresponding deposits, while their associated paleosols represent the intervening periods of nonglaciation.

Birkeland and others (1970) summarized the Quaternary stratigraphy of western Washington, indicating four major glacial advances which are younger than 700,000 years but which predate the Olympia interglaciation (beginning 34,000 years B.P.). These are represented by the Orting Drift (650,000 years B.P.), the Stuck Drift (300,000 years B.P.), and the lower (85,000 years B.P.) and the upper (42,000 years B.P.) till of the Salmon Springs Drift. The Portland Hills Silt units described in this paper may be directly correlative with these deposits.

LITHOLOGY

Structure

The Portland Hills Silt is nearly devoid of primary depositional features. Fewer than five percent of the outcrops examined in the Portland-Tualatin Valley region showed any trace of mechanically derived structures. Radiographs of six sedimentary peels and thin silt slabs taken from massive silt confirm these observations.

Finely bedded and laminated zones of very limited vertical and lateral extent are even rarer than outcrops exposing thick bedding and paleosols in the formation. These structures were formed by localized ponding or reworking of the silt by slope wash.

Conversely, diagenetic or epigenetic structures are common in the silt. These include the variably colored shotlike concretions that are 0.5 to 10 mm (0.02 to 0.39 in.) in diameter and the blocky or vertical jointing which are characteristic of

[1] The Blake Reversed Event reported by Smith and Foster (1969) lasted only a very short time, 108,000-114,000 years B.P.

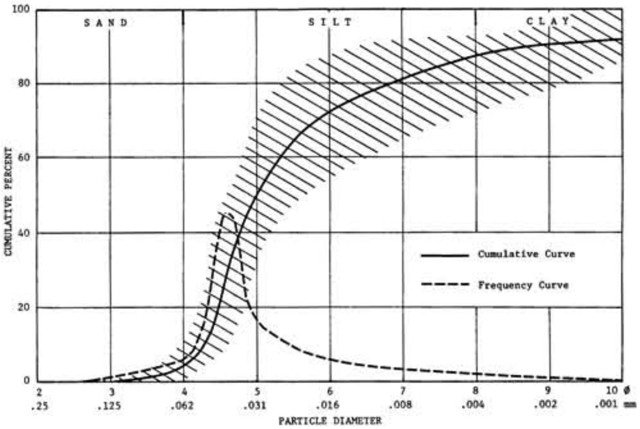


Figure 6. Range of cumulative frequency curves of 20 unweathered Portland Hills Silt samples. Also shown is a typical cumulative frequency curve and its corresponding frequency distribution curve.

the weathering profile of the silt. A few apparently stratified exposures showing fine, reddish-brown banding are present locally. These bands are believed to represent segregations of hydrated iron oxides caused by fluctuations or entrapment of ground water, particularly that associated with landsliding.

Texture

The grain-size distribution in 20 geographically widespread Portland Hills Silt samples is summarized in Figure 6. The shaded area encloses all of the cumulative grain-size curves for these samples. Inspection of individual cumulative curves shows a unimodal distribution for nearly all samples and a very narrow modal range between 4.3 and 4.8 phi in the coarse-silt fraction. The data illustrate a remarkable textural consistency for the Portland Hills Silt throughout the Tualatin Mountains (Figure 7).

Table 1 lists the textural parameters and other characteristics of the 20 samples described above. Folk and Ward textural parameters (Folk, 1968) indicate that the Portland Hills Silt is poorly sorted to very poorly sorted,

Table 1. *Textural data from 20 widespread samples taken at uniform depth from unweathered Portland Hills Silt.*

Textural Parameter	Mean	Range	Standard Deviation
Percent sand	4.88	1.32-11.25	2.28
Percent silt	79.09	68.95-67.73	5.86
Percent clay	16.06	6.47-27.06	6.07
Mode*	4.53	4.3-4.8	0.17
Median	5.12	4.57-5.66	0.31
Folk (1968)			
Mean	5.79	4.80-6.60	0.55
Sorting	1.95	1.13-2.79	0.50
Skewness	0.61	0.52-0.72	0.07
Kurtosis	1.54	0.80-2.30	0.52
Moment measures			
Mean	5.98	5.19-6.67	0.48
Standard deviation	2.27	1.55-2.88	0.39
Skewness	1.64	0.92-2.63	0.45
Kurtosis	5.33	2.81-9.61	1.91

* Determined from cumulative curve.

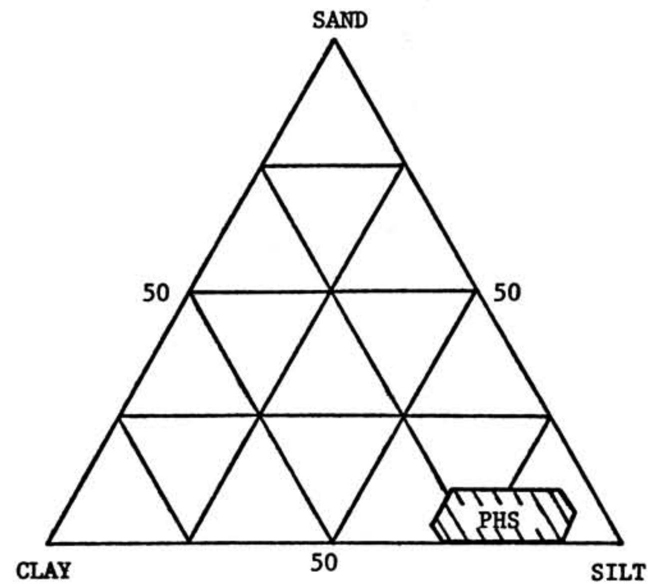


Figure 7. Textural boundaries enclosing 95 percent of all Portland Hills Silt samples. Sand, silt, and clay ranges were derived statistically by adding and subtracting twice the standard deviation from the mean of each.

strongly fine skewed, and very leptokurtic to extremely leptokurtic. The marked peakedness is exemplified by the frequency distribution curve in Figure 8.

Analyses of 47 additional uniform-depth Tualatin Mountain samples were completed to augment those 20 described above. The mean sand, silt, and clay percentages for all 67 samples varied only slightly from the original data, with 4.9 percent sand, 77.2 percent silt, and 18.9 percent clay.

Except for larger (2- to 10-mm [0.08- to 0.4-in.]) concretionary aggregates or shot, coarse material in the Portland Hills Silt is rare. Outsized clasts are believed to represent only extraneous material derived by colluvial or alluvial processes (Trimble, 1963). Contamination most likely occurred during the accumulation of the silt or as the result of post-depositional reworking.

Figure 8. Selected cumulative frequency curves from worldwide loess deposits (Swineford and Frye, 1955; Young, 1967) compared with the curve of a typical Portland Hills Silt sample.

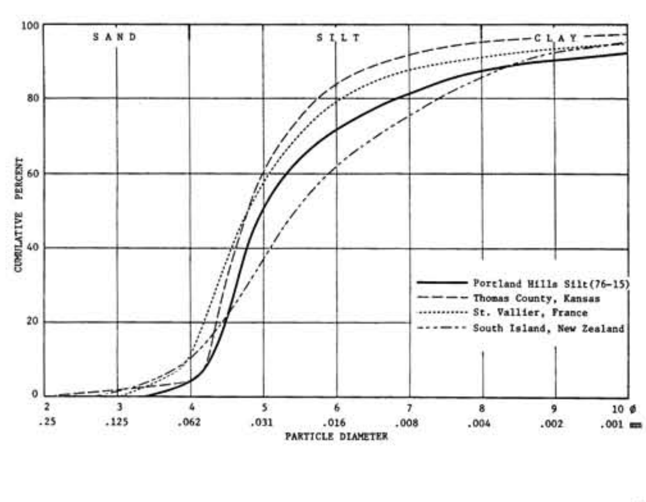


Table 2. *Average percent and grain morphology of light minerals in nine Portland Hills Silt samples.*

Minerals	Average Percent	Shape*	Rounding*	Surface Texture*
Quartz	40.6	eq.-el.	A-sA	fr.
Chert	0.9	eq.	sA-sR	sm.
Alkali feldspar	18.3	eq.-el.	A-sA	etch.
Plagioclase	25.5	eq.-el.	A-sA	etch.
Volcanic glass	2.5	el.	A	sm.
Acid rock fragments	2.8	eq.	sR	sm.-irreg.
Mafic rock fragments	0.2	eq.	sR	sm.-irreg.
Mica group	6.7	platy	sR-R	sm.
Others	2.3	–	–	–

Table 3. *Average percent and grain morphology of heavy minerals in 17 Portland Hills Silt samples.*

Minerals	Average Percent	Shape*	Rounding*	Surface Texture*
Hornblende	40.8	el.	sA-sR	fr.
Lamprobolite	2.8	el.	sA-sR	fr.
Tremolite	1.0	el.	sA-sR	fr.
Actinolite	0.1	el.	sA-sR	fr.-sm.
Augite	9.9	el.-eq.	A-R	etch.-sm.
Hypersthene	0.5	el.	sA-sR	fr.-etch.
Epidote Group	14.9	eq.-el.	sA-sR	etch.-sm.
Garnet	1.4	eq.	sA	sm.
Sphene	0.2	eq.	sR	etch.(?)
Zircon	0.6	eq.-el.	sR-R	pol.
Kyanite	0.3	tabular	sA	sm.
Tourmaline	0.3	el.	sR	pol.
Pyrophyllite	T(?)	–	–	–
Staurolite	0.2	–	–	–
Andalusite	T	–	–	–
Sillimanite	T	el.	sA-sR	sm.
Monazite	0.2	eq.	sR	sm.
Mica Group	3.2	platy	R-wR	sm.
Apatite	0.2	eq.-el.	sR-R	pol.
Hematite	6.4	eq.	R	irreg.
Leucoxene	0.5	eq.	R	irreg.
Magnetite/ilmenite	8.7	eq.	sA-R	sm.-fr.
Rock fragments	2.1	eq.-el.	sR-R	sm.
Volcanic glass	0.5	el.	A	sm.
Others	3.4	–	–	–

* T = trace; eq. = equant; el. = elongate; R = rounded; A = angular; s = sub-; w = well; etch. = etched; fr. = fresh; sm. = smooth; pol. = polished; irreg. = irregular

Fabric

Thin-section studies indicate an apparently random distribution of all particles in the silt, with larger grains being nearly evenly distributed throughout a finer silt and clay matrix. Although elongated grains appear randomly oriented in most views, fabric analysis of three widespread samples shows that the preferred orientation for mica plates is less than 30 degrees from the horizontal.

Particle morphology

Morphological characteristics of individual mineral constituents of the Portland Hills Silt are summarized in Tables 2 and 3. Electron microscopy of quartz grains in the Portland Hills Silt revealed surface textures which are characteristic of glacial or glacial-fluvial environments. These include the more indicative features (Krinsley and Margolis, 1969), which are angularity, extreme relief, and a large variation in size of conchoidal breakage patterns. Textures such as these are typical of loess particles (Cegla and others, 1971) and are very similar to those found in Columbia River sediments (Lentz, 1977).

COMPOSITION

Mineral components

Tables 2 and 3 list the average percentages and grain morphology of light and heavy minerals in the Portland Hills Silt.

Light minerals: Quartz, predominantly as clear, monocrystalline fragments, makes up about 40 percent of the total light-mineral fraction in the Portland Hills Silt. Lesser quantities of plagioclase (An_{10-30}) and alkali feldspars (orthoclase and microcline) combined compose approximately another 40 percent. Minerals of the mica group, acid rock fragments, and volcanic glass constitute successively smaller portions. Carbonates are entirely absent in the formation, even in unoxidized zones or deep auger holes.

Heavy minerals: Grain counts show a strong predominance of blue-green hornblende in the Portland Hills Silt heavy-mineral suite. Less prevalent are, in decreasing order of abundance, the opaque minerals (hematite, magnetite, ilmenite, and leucoxene), epidote-group minerals, augite, mica, lamprobolite, and rock fragments. A variety of metamorphic-mineral species, hypersthene and possibly pyrophyllite, compose between a trace and 2 percent each of the total fraction. Although zoisite and clinozoisite are also present, yellow-green pistacite is the dominant mineral of the epidote group.

Clay minerals: Clay minerals in the Portland Hills Silt were previously studied by A. J. Gude, III (Trimble, 1963). He found kaolinite and illite clay minerals along with another clay which he described as possibly montmorillonite or chlorite.

The present investigation tends to confirm Gude's work. X-ray diffraction studies of three Portland Hills Silt samples indicate the following clay minerals in approximate order of abundance: mixed-layer montmorillonite or montmorillonite, illite, and disordered kaolinite.

Total mineral composition: Total average mineral composition of the Portland Hills Silt was calculated on the assumption that the proportions indicated in the light- and heavy-mineral analyses are roughly constant throughout the coarser part (>0.004 mm [2×10^{-4} in.]) of the size distribution. Based on this assumption, quartz composes almost 35 percent of the total mineral composition. Plagioclase constitutes up to 21 percent, while alkali feldspars and clay minerals total about 15 percent each. Mica-group minerals, rock fragments, volcanic glass, and chert compose approximately 6, 2.5, 2, and 1 percent, respectively. Heavy minerals comprise the remaining 3 percent.

Fossil components

No mega- or microfossils were identified in the Portland Hills Silt at any time during the field or laboratory study. Occasionally, however, somewhat leached terrestrial gastropod shells were discovered in or near the ground surface. Although previously reported in the formation (Wilkinson and others, 1946; Lowry and Baldwin, 1952), diatoms and sponge spicules were not found in the coarse silt and sand fraction (>0.053 mm [0.002 in.]) of any samples studied.

SUMMARY AND CONCLUSIONS

Previous workers (Ruzek and Carpenter, 1922; Treasher, 1942; Wilkinson and others, 1946; Lowry and Baldwin, 1952; Theisen, 1958; Howell, 1962; Trimble, 1963; Schlicker and Deacon, 1967; Beaulieu, 1971) have long presumed that the Portland Hills Silt was derived from the sediments of the adjacent Columbia River basin. The similarities in grain morphology, heavy-mineral components, and their frequencies between the Portland Hills Silt and sediments of the Columbia River substantiate these views.

The present investigation offers data which strongly support a loessial origin for the Portland Hills Silt. As in previous works (Darton, 1909; Theisen, 1958; Trimble, 1963; Schlicker and Deacon, 1967), the concept here is based primarily upon two major aspects of the deposit: (1) its distributional character, and (2) its striking physical resemblance to other loess deposits.

The data clearly establish the massive character and the remarkable uniformity of the deposit both in color and texture, the distinct fining and thinning of the silt from east to west away from the Columbia River source, and the near absence of primary depositional structures and "water-laid" pebbles. Moreover, new data indicate the following additional similarities between the Portland Hills Silt and its loessial counterparts: (1) like surface textures of constituent particles; (2) a marked conformity in grain-size distributions, as illustrated by Figure 8; and (3) the existence and the morphology of paleosols in the silt (Ruhe, 1969).

Dry easterly winds could have easily whipped up glacial outwash silts along the extensive flood plain of the Columbia River valley. Slowed by tree-covered slopes, the wind would then have deposited the dust about the southwestern margin of the broad Portland basin, and, to a lesser extent, upon the adjacent hills north and south of the area now covered by the city of Portland.

During accumulation of the silt, colluvial and alluvial processes would have continued, adding coarser material from older, upslope deposits and locally reworking the silt. At lower elevations, the eolian silt would have become intertongued with water-laid sands and silts of the flood plain (represented as "Qps" in Figure 2). Loess would have collected more rapidly and to greater depths nearest its valley source. A corresponding decrease in grain size would have accompanied the leeward (west) thinning of the deposit.

Though the prevailing surface winds of today are primarily westerly (Highsmith, 1973), thinning and fining of the Portland Hills Silt indicates that easterly or northeasterly winds would have been responsible for its deposition. These may have been the glacially stimulated anticyclones postulated by Theisen (1958), or intense pressure-gradient winds like the easterly winds from the Columbia River Gorge today, or perhaps a combination of these.

REFERENCES

Allison, I. S., 1953, Geology of the Albany Quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 37, p. 12-13.

Baldwin, E. M., 1964, Geology of Oregon, 2nd ed.: Eugene, Oreg., University of Oregon Cooperative Book Store, 165 p.

Beaulieu, J. D., 1971, Geologic formations of western Oregon: Oregon Department of Geology and Mineral Industries Bulletin 70, 72 p.

Birkeland, P. W., Crandell, D. R., and Richmond, G. M., 1970, Status of correlation of Quaternary stratigraphic units in the western conterminous United States: Quaternary Research, v. 1, p. 208-227.

Bretz, J. H., Smith, H. T. U., and Neff, G. E., 1956, Channeled scabland of Washington: new data and interpretations: Geological Society of America Bulletin, v. 67, no. 8, p. 957-1049.

Cegla, J., Buckley, T., and Smalley, I. J., 1971, Microtextures of particles from some European loess deposits: Sedimentology, v. 17, p. 129-134.

Darton, N. H., 1909, Structural materials in parts of Oregon and Washington: U.S. Geological Survey Bulletin 387, 33 p.

Diller, J. S., 1896, A geological reconnaissance in northwestern Oregon: U.S. Geological Survey 17th Annual Report, pt. 1, p. 447-520.

Flint, R. F., 1971, Glacial and Quaternary geology: New York, N.Y., John Wiley, 892 p.

Folk, R. L., 1974, Petrology of sedimentary rocks: Austin, Tex., Hemphill, 182 p.

Glenn, J. L., 1965, Late Quaternary sedimentation and geologic history of the north Willamette Valley, Oregon: Corvallis, Oreg., Oregon State University doctoral dissertation, 231 p.

Highsmith, R. M., Jr., and Bard, R., 1973, Atlas of the Pacific Northwest, 5th ed.: Corvallis, Oreg., Oregon State University Press, 128 p.

Howell, P. W., 1962, Depositional environment of the Portland Hills Silt: Geological Society of the Oregon Country News Letter, v. 28, no. 4, p. 17-20.

Krinsley, D., and Margolis, S., 1969, A study of quartz sand grain surface textures with the scanning electron microscope: Transactions of the New York Academy of Science, ser. 2, v. 31, no. 5, p. 457-477.

Lentz, R. T., 1977, The petrology and stratigraphy of the Portland Hills Silt: Portland, Oreg., Portland State University master's thesis, 144 p.

Libbey, F. W., Lowry, W. D., and Mason, R. S., 1944, Preliminary report on high alumina iron ores in Washington County, Oregon: Oregon Department of Geology and Mineral Industries Short Paper 12, 23 p.

Libbey, F. W., Lowry, W. D., and Mason, R. S., 1945, Ferruginous bauxite deposits in northwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 29, 97 p.

Livingston, V. E., Jr., 1966, Geology and mineral resources of the Kelso-Cathlamet area, Cowlitz and Wahkiakum Counties, Washington: Washington Division of Mines and Geology Bulletin 54, 110 p.

Lowry, W. D., and Baldwin, E. M., 1952, Late Cenozoic geology of the lower Columbia River Valley, Oregon and Washington: Geological Society of America Bulletin, v. 63, no. 1, p. 1-24.

Niem, A. R., and Van Atta, R. O., 1973, Cenozoic stratigraphy of northwestern Oregon and adjacent southwestern Washington, *in* Beaulieu, J. D., Field Trip Committee Chairman, Geologic field trips in northern Oregon and southern Washington: Oregon Department of Geology and Mineral Industries Bulletin 77, p. 75-132.

Ruhe, R. V., 1969, Quaternary landscapes in Iowa: Ames, Iowa, Iowa State University Press, 255 p.

(Continued, bottom of first column, p. 10)

"WELL, THERE GOES THE NEIGHBORHOOD!"

DOGAMI reports on progress of geothermal assessment program

The Oregon Department of Geology and Mineral Industries has released Open-File Report 0-80-14, *Progress Report on Activities of the Low-Temperature Assessment Program 1979-1980*, prepared by Department staff for the U.S. Department of Energy.

The 79-page preliminary report contains summaries of geothermal research activities that were completed through August 1980. These studies are focused on nine areas in the Cascades and central and eastern Oregon: La Grande, Western Snake River Plain, northern Harney Basin, southern Harney Basin, Alvord Desert, Lakeview, Powell Buttes, Belknap-Foley Hot Springs, and Willamette Pass-McCredie Hot Springs. The reports include geologic summaries, geothermal gradient and heat flow data, bibliographies, and listings of the data that will be contained in the final reports.

Detailed, full reports on all areas will be released as open-file reports in stages, beginning in January 1981. They will also contain compilations of geologic data in the form of maps, water chemistry data, temperature gradient measurements, and available geophysical surveys.

Open-File Report 0-80-14 may be purchased for $3.00. Address orders to the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201, or 2033 First Street, Baker, OR 97814. Payment must accompany orders of less than $20.00. □

(Portland Hills Silt, *continued from p. 9***)**

Ruzek, C. V., and Carpenter, E. J., 1919, Soil survey of Multnomah County, Oregon: U.S.D.A. Bureau of Soils Bulletin 11, 98 p.

Schlicker, H. G., and Deacon, R. J., 1967, Engineering geology of the Tualatin Valley region, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 60, 103 p.

Smith, J. D., and Foster, J. H., 1969, Geomagnetic reversal in Brunhes normal polarity epoch: Science, v. 163, no. 3867, p. 365-367.

Swineford, A., and Frye, J. C., 1955, Petrographic comparison of some loess samples from western Europe with Kansas loess: Journal of Sedimentary Petrology, v. 25, no. 1, p. 3-23.

Theisen, A. A., 1958, Distribution and characteristics of loess-like soil parent material in northwestern Oregon: Corvallis, Oreg., Oregon State College master's thesis, 65 p.

Treasher, R. C., 1942, Geologic history of the Portland area: Oregon Department of Geology and Mineral Industries Short Paper 7, 17 p.

Trimble, D. E., 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geological Survey Bulletin 1119, 119 p.

Wilkinson, W. D., Lowry, W. D., and Baldwin, E. M., 1946, Geology of the St. Helens quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 31, 39 p.

Yaalon, D. H., 1971, Paleopedology: origin, nature, and dating of paleosols: Jerusalem, Israel, Israel University Press, 350 p.

Young, D. J., 1967, Loess deposits of the west coast of South Island, New Zealand: New Zealand Journal of Geology and Geophysics, v. 10, p. 647-658. □

BLM announces right-of-way regulation that could save money

A little-noticed regulation that went into effect in July 1980 could save money for certain companies and individuals currently using unauthorized rights-of-way.

Gary Rundell, Bureau of Land Management (BLM) realty specialist, said on December 2, 1980 that the regulation provides that certain fees will be waived if an application for the right-of-way is filed with BLM during a four-year grace period that ends in July 1984. Full fees for applications will be charged after that date.

"Normally, a right-of-way applicant would be required to pay all past rental fees for the period of unauthorized use," Rundell said. "The applicant would also have to pay other charges for application processing and construction monitoring."

If the unauthorized right-of-way was in use prior to October 21, 1976, there will be no charges to an applicant for past rental fees and monitoring, Rundell said.

Also, processing fees will not exceed a minimum set by the government, he added. The minimum varies according to the length or size of the right-of-way.

"This amounts to a pardon for qualified unauthorized right-of-way users," Rundell said. "There are thousands of miles of unauthorized rights-of-way in the west. Nationwide, the regulation could save unauthorized users millions of dollars if taken advantage of."

Most of the unauthorized rights-of-way involve communication facilities (radio, television and telephone); power lines; roads, including those across public lands to private residences; and oil, gas, and water pipelines, Rundell said. Others affected by the regulation include reservoirs, canals, ditches, and irrigation pumping facilities. □

PUBLICATIONS ORDER

Omission of price indicates publication is in press. Minimum mail order 50¢. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $20.00.

Fill in appropriate blanks and send sheet to Department (see address on reverse side).

YOUR NAME ____________________

ADDRESS ____________________

____________________ Zip__________

Amount enclosed $__________

OREGON GEOLOGY

____ Renewal ____ Subscription ____ Gift

____ 1 Year ($4.00) ____ 3 Years ($10.00)

NAME ____________________

ADDRESS ____________________

____________________ ZIP __________

(If Gift, From: ____________________)

ORDER FORM - CUT ON DASHED LINE

Available publications

MISCELLANEOUS PAPERS	Price	No. Copies	Amount
1. A description of some Oregon rocks and minerals, 1950: Dole	$ 1.00	____	____
4. Laws relating to oil, gas, and geothermal exploration and development in Oregon			
Part 1. Oil and natural gas rules and regulations, 1977, rev. 1980	1.00	____	____
Part 2. Geothermal resources rules and regulations, 1977, rev. 1979	1.00	____	____
5. Oregon's gold placers (reprints), 1954	.50	____	____
8. Available well records of oil and gas exploration in Oregon, rev. 1980: Olmstead and Newton	2.00	____	____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	1.50	____	____
13. Index to *The Ore Bin*, 1950-1974	1.50	____	____
14. Thermal springs and wells, 1970: Bowen and Peterson (with 1975 supplement)	1.50	____	____
15. Quicksilver deposits in Oregon, 1971: Brooks	1.50	____	____
16. Mosaic of Oregon from ERTS-1 imagery, 1973	2.50	____	____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	2.00	____	____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	____	____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	____	____
GEOLOGIC MAPS			
Geologic map of Galice quadrangle, Oregon, 1953	1.75	____	____
Geologic map of Albany quadrangle, Oregon, 1953	1.00	____	____
Reconnaissance geologic map of Lebanon quadrangle, 1956	1.50	____	____
Geologic map of Bend quadrangle and portion of High Cascade Mountains, 1957	1.50	____	____
Geologic map of Oregon west of 121st meridian, 1961	2.25	____	____
GMS-3: Preliminary geologic map of Durkee quadrangle, Oregon, 1967	2.00	____	____
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00	____	____
GMS-5: Geologic map of Powers quadrangle, Oregon, 1971	2.00	____	____
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50	____	____
GMS-7: Geology of the Oregon part of the Baker quadrangle, Oregon, 1976	3.00	____	____
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00	____	____
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00	____	____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	2.50	____	____
GMS-12: Geologic map of the Oregon part of the Mineral quadrangle, 1978	2.00	____	____
GMS-13: Geologic map of the Huntington and part of the Olds Ferry quadrangles, Oregon, 1979	3.00	____	____
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	2.00	____	____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	2.00	____	____
5. Prospects for natural gas production or underground storage of pipeline gas	5.00	____	____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	.50	____	____
Mining claims (State laws governing quartz and placer claims)	.50	____	____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	3.00	____	____
Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975	5.00	____	____
Sixth Gold and Money Session and Gold Technical Session Proceedings, 1978	6.50	____	____
Back issues of *The Ore Bin*	25¢ over the counter; 50¢ mailed	____	____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for 1.00	____	____

OREGON GEOLOGY

1005 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

Available publications (continued)

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	1.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v. 2	1.25		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	2.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	1.25		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	1.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
57. Lunar Geological Field Conference guidebook, 1965: Peterson and Groh, editors	3.50		
63. Sixteenth biennial report of the Department, 1966-1968	1.00		
65. Proceedings of Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
68. Seventeenth biennial report of the Department, 1968-1970	1.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley	2.50		
76. Eighteenth biennial report of the Department, 1970-1972	1.00		
77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
86. Nineteenth biennial report of the Department, 1972-1974	1.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		
98. Geologic hazards of eastern Benton County, 1979: Bela	9.00		
99. Geologic hazards of northwestern Clackamas County, Oregon, 1979: Schlicker and Finlayson	10.00		
100. Geology and mineral resources of Josephine County, Oregon, 1979: Ramp and Peterson	9.00		
101. Geologic field trips in western Oregon and southwestern Washington, 1980	9.00		
SPECIAL PAPERS			
1. Mission, goals, and purposes of Oregon Department of Geology and Mineral Industries, 1978	2.00		
2. Field geology of SW Broken Top quadrangle, Oregon, 1978: Taylor	3.50		
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray and others	7.00		
4. Heat flow of Oregon, 1978: Blackwell, Hull, Bowen, and Steele	3.00		
5. Analysis and forecasts of the demand for rock materials in Oregon, 1979: Friedman and others	3.00		
6. Geology of the La Grande area, Oregon, 1980: Barrash and others	5.00		
7. Pluvial Fort Rock Lake, Lake County, Oregon: Allison	4.00		
8. Geology and geochemistry of the Mt. Hood volcano, 1980: White	2.00		
SHORT PAPERS			
18. Radioactive minerals prospectors should know, 1976: White, Schafer, Peterson	.75		
21. Lightweight aggregate industry in Oregon, 1951: Mason	.25		
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00		
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	2.00		
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00		