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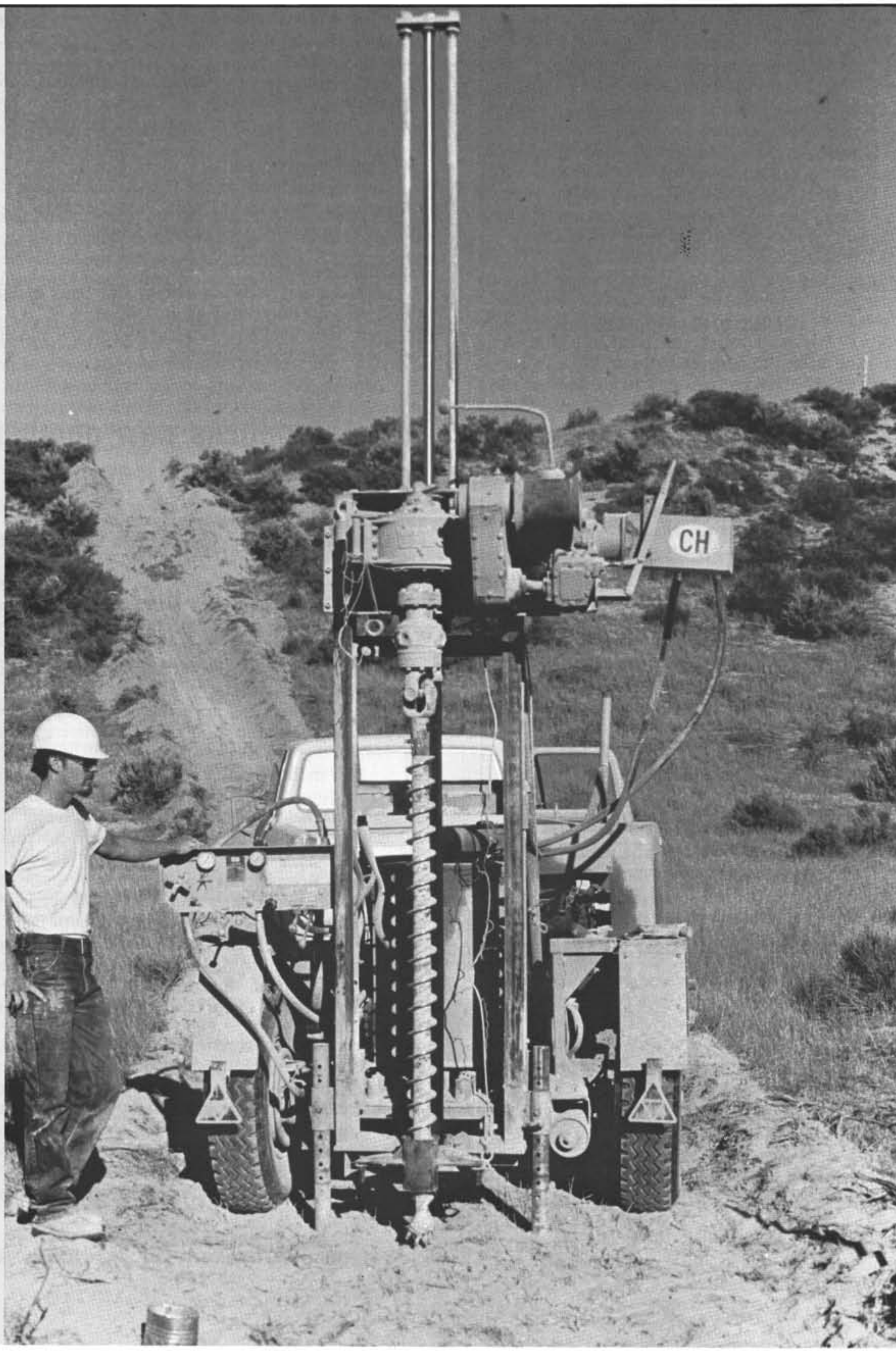

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COVER PHOTO

Diesel-powered auger drill rig used in assessment work on Oil-Dri's diatomite claims and property in the Fort Rock basin near Christmas Valley, Lake County, Oregon. Article beginning on next page discusses the stratigraphy of this area.

OIL AND GAS NEWS

Columbia County

There has been no drilling at the Mist Gas Field since last year. However, Reichhold Energy Corporation, operator of all nine producing wells at Mist, plans to drill Adams 34-28 in sec. 28, T. 7 N., R. 5 W. The well will be just north of the field boundary and 1 mi from the producer Longview Fibre 12-33. The proposed depth is 3,000 ft, to intersect the already productive Clark and Wilson sand of the Cowlitz Formation.

Clatsop County

Work continues on Oregon Natural Gas Development Corporation's Patton 32-9 to sidetrack junk in the hole. A sand, penetrated by the original hole, will be tested.

Douglas County

Testing continues on the Florida Exploration Company's 1-4 well near the town of Drain. Three permitted locations remain for the company in Douglas County.

Yamhill County

Nahama and Weagant Energy Company of Bakersfield, California, will soon spud Klohs 1 in sec. 6, T. 3 S., R. 2 W. The well, permitted to 6,000 ft, will test the anticline underlying the Chehalem Mountains. □

NOAA produces new geothermal resource map of Oregon

A new, comprehensive map of the geothermal resources of Oregon is available now through the Oregon Department of Geology and Mineral Industries (DOGAMI).

The multicolor map (scale 1:500,000) was produced by the National Oceanic and Atmospheric Administration (NOAA) for the U.S. Department of Energy and is based on data compiled by DOGAMI. On a sheet about 4 by 5 ft in size, it presents a summary of the current knowledge about geothermal resources in the state.

The map shows all known thermal springs and wells, identifies heat flow stations, and gives brief descriptions of major geothermal regions. Shading and coloring are used to indicate areas where thermal waters warm enough for direct utilization have been found or are likely to be found at shallow depth. Similarly, those areas where wilderness, national park, or reservation status limits geothermal development are identified.

Printed alongside the map are a county-by-county tabulation of all thermal springs and wells and a separate city map and thermal well list for the City of Klamath Falls.

The new map, *Geothermal Resources of Oregon, 1982*, can be purchased for $3 from the Oregon Department of Geology and Mineral Industries, 1005 State Office Building, Portland, OR 97201. Orders under $50 require prepayment. □

CONTENTS

The geology of economically significant lower Pliocene diatomites in the Fort Rock basin near Christmas Valley, Lake County, Oregon

by G. Kent Colbath and Matthew J. Steele, Department of Geology, University of Oregon, Eugene, Oregon 97403

INTRODUCTION

During the summer of 1981, we were employed by the Oil-Dri Corporation of America to undertake assessment work (under the direction of R.C. Valenta) on its diatomite claims near Christmas Valley, Lake County, Oregon (Figure 1). Oil-Dri specializes in the production of oil and grease absorbents and cat litter. Absorbent products are currently being produced from crushed diatomite at the Christmas Valley plant (Figures 2 and 3).

The assessment work involved detailed examination of surface exposures of diatomite, extensive shallow drilling, and measurement of important physical properties. The material was examined microscopically for evaluation of its potential use in filtration products.

The direct economic implications of this assessment constitute proprietary information and will not be discussed here. In this paper, instead, we present observations that are primarily of academic geological interest. We wish to emphasize, however, that a better understanding of the geology of these diatomite deposits should ultimately aid in the evaluation of their economic utility, both in the Fort Rock basin and elsewhere in eastern and central Oregon.

PREVIOUS WORK

Our area of study is located in the Fort Rock drainage basin, which, according to Baldwin (1976), marks the boundary between the High Lava Plains physiographic province to the north and the Basin and Range province to the south, although Lawrence (1976) places the boundary between these two provinces north of the basin along the Brothers fault zone. Donath (1962) mapped faults along the southern margin of the basin and ascribed their origin to Basin and Range style deformation.

Moore (1937) published an extensive review of eastern Oregon diatomites but omitted the Christmas Valley deposits. Wagner (1969) made brief mention of the production of cat litter at this site.

Hampton (1964) studied ground water in the Fort Rock basin and mapped and described several important rock units in detail for the first time. He included the diatomites which underlie much of the basin floor with several volcaniclastic bodies which crop out along the basin margins within the Fort Rock Formation. He designated the exposure in a ravine on the west side of Seven Mile Ridge as the type section (NE¼SW¼ sec. 33, T. 27 S., R. 17 E.). This outcrop is now largely submerged beneath the waters of Pettus Lake, a small, man-made reservoir which fills much of the ravine. Diatoms from this section were dated as late Pliocene in age by K.E. Lohman (*in* Hampton, 1964). Substantial improvements have been made in correlating nonmarine Pliocene rocks with the marine type section since Hampton's work was published. The late Pliocene as used by both Lohman and Hampton should now be considered equivalent to the entire Pliocene (= Blancan mammal stage), which began approximately 5 m.y. B.P.

The Picture Rock Basalt underlies the Fort Rock Formation and was dated by K-Ar methods as 6.9±0.9 m.y. B.P. A plagioclase separate from pumice within the Peyerl Tuff yielded a K-Ar age of 4.59±0.89 m.y. (Fiebelkorn and others, 1982). According to Hampton (1964), the Peyerl Tuff unconformably overlies the Hayes Butte Basalt, which in turn overlies the Fort Rock Formation. However, Peterson and McIntyre (1970) were unable to distinguish the Hayes Butte Basalt from the Paulina Basalt, which is younger than the Peyerl Tuff. At the western edge of the basin, they did map two small areas where the Peyerl Tuff directly overlies tuffaceous sandstones which may correlate with the Fort Rock Formation.

If the diatom age and the correlation and dating of the Peyerl Tuff are taken at face value, the Fort Rock Formation must be, in general, of early Pliocene age. The diatom age is poorly documented, and further work is clearly in order. Radiometric dating of the basalt capping the Table Rock complex would also clarify the age relationships of this unit. Here we refer to the Fort Rock Formation as early Pliocene in age, while recognizing that further work may demonstrate that it is actually late Miocene in age.

Hampton regarded the Fort Rock Formation as flat-lying, resting unconformably on the folded lavas of Picture Rock Basalt and being overlain in turn by the Hayes Butte Basalt.

Walker and others (1967) separated out the palagonitic tuffs and breccias of the marginal eruptive centers as a discrete map unit but continued to include the diatomites within a map unit dominated by tuffaceous sandstones and other volcaniclastic lithologies. Their cross-section shows this latter unit in conformable contact with the underlying basalts and indicates that these rocks were also involved in the folding along the southern basin margin.

Peterson and Groh (1963) and Heiken (1971) studied several of the volcaniclastic eruptive centers within and surrounding the Fort Rock basin, including Table Rock and Seven Mile Ridge. They ascribed most features observable at these centers to primary eruptive processes. Heiken and others (1981) published a field guide to several of these centers and discussed the Table Rock complex in some detail.

Pleistocene lake features within the basin were mapped by Forbes (1973). Allison (1979) summarized his own extensive work on these Pleistocene lake features and included some important observations on the underlying rocks.

METHODS

Over 100 shallow holes 1.5 to 14 m (5 to 46 ft) deep were drilled with an auger drill and logged on Oil-Dri's plant property and mining claims in the center of the southwestern part of the Fort Rock Basin. This drilling covered almost 5.2 km^2 (2 mi^2) and helped to supplement observations made on the limited surface exposures of diatomite in the area.

Drilling was conducted on the following sections of T. 27 S., R. 16 E.: N½ sec. 23; N½ sec. 14; SE¼NW¼ sec. 15; NE¼SW¼ sec. 15; S½SE¼ sec. 21; W½SW¼ sec. 27; S½ sec. 28. Five additional holes were drilled along the boundary between SE¼ sec. 32, T. 27 S., R. 17 E., and NE¼ sec. 5, T. 28 S., R. 17 E.

Two surface exposures were measured with a Jacob staff

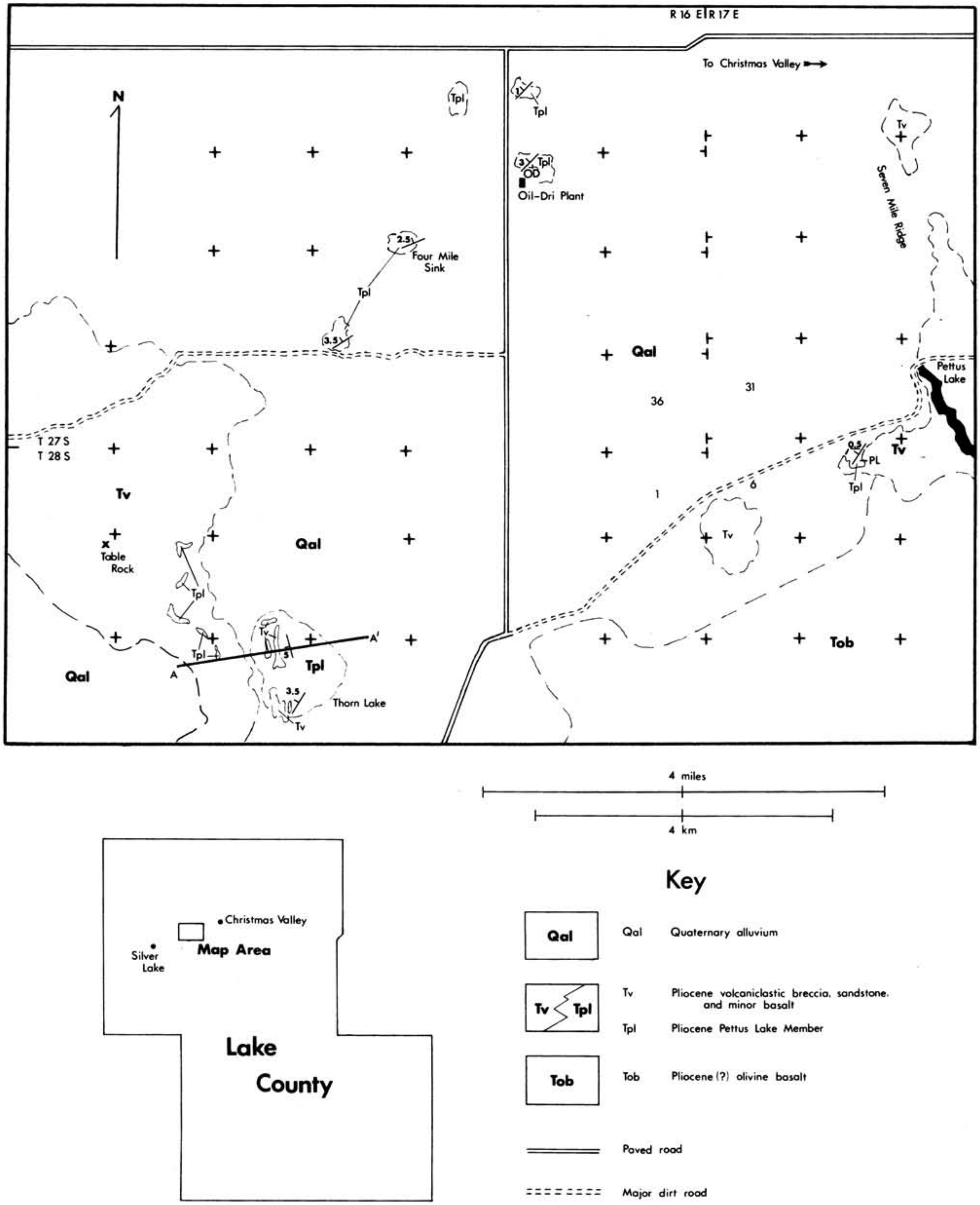


Figure 1. Geologic sketch map of part of southwestern Fort Rock basin. Units Tv and Tpl are part of Fort Rock Formation of Hampton (1964). Unit Tob is partial equivalent of Picture Rock Basalt. Unit Tob contact modified after Walker and others (1967). "PL" indicates location of type section of Pettus Lake Member, "OD" indicates location of supplementary section. Two attitudes within Thorn Lake blowout depression were measured on volcaniclastic breccia beds (unit Tv) and are offset slightly to the east for the purpose of clarity. Letters "A" and "A'" indicate end points of cross-section presented in Figure 8. Crosses indicate corners of sections. Map centered on 44° 10' N., 121° 48' W.

Figure 2. Oil-Dri's Christmas Valley plant, looking south. Absorbent products are currently being produced from crushed diatomite at this plant. Oil-Dri is one of largest employers in Fort Rock basin.

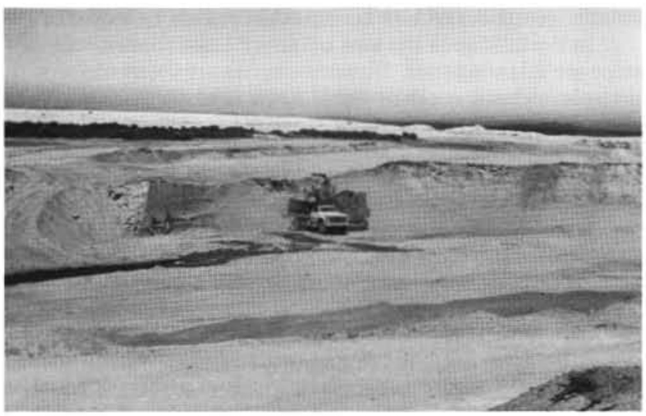


Figure 3. Oil-Dri pit, looking north. Diatomite is quarried along pervasive north-south joint set. OD section was measured at south end of pit, just to left of photograph.

and described in detail. These sections are presented graphically in Figure 4.

The local geology was mapped on aerial photographs and transferred onto a U.S. Department of Agriculture property map that served as the base map for Figure 1. Five of the attitudes indicated on Figure 1 were determined by using a transit and stadia rod on marker beds within blowout depressions and excavations. On two separate surveys within the Oil-Dri plant pit, we were able to repeat our dip determinations to within one tenth of one degree. The dips indicated in Figure 1 have been rounded off to the nearest half a degree, a level of accuracy we consider significant when dealing with gently deformed strata. Using a hand compass, we measured two additional attitudes of exposed breccia layers interbedded with diatomite in the floor of Thorn Lake.

STRATIGRAPHIC NOMENCLATURE

In his description of the Fort Rock Formation, Hampton (1964) considered diatomite a constituent volumetrically less significant than tuff. Our examination of surface outcrops, coupled with extensive shallow drilling, indicates that in the center of the basin diatomite makes up 90 percent or more of the unit in question, with the remaining 10 percent composed primarily of friable, tabular layers of pumice and volcanic ash. We feel that separating the diatomite-dominated part of the section from that composed primarily of more resistant volcaniclastic rocks will serve to greatly clarify stratigraphic relationships in this area. Such a division also neatly separates rocks which are of economic interest (to us) from those which are not.

We propose the new Pettus Lake Member to include the diatomite-dominated rocks of the Fort Rock Formation. The exposure at SE¼NW¼ sec. 5, T. 28 S., R. 17 E. (Figure 1) is here designated the type section (see Figure 4). This exposure is on Bureau of Land Management (BLM) land and is readily accessible. Contact relationships with the volcaniclastic breccia of Seven Mile Ridge are well exposed, and the stratigraphy is similar to that described by Hampton (1964) from the type section of the Fort Rock Formation. A supplementary section from the Oil-Dri pit is probably more representative of rocks in the center of the basin and is also included here.

The new member represents a subdivision of the informal unit mapped by Walker and others (1967) as Tst. The remainder of that unit is here grouped with the palagonitic tuff those authors mapped as QTps and throughout this paper will be collectively referred to informally as the volcaniclastic rocks of Table Rock or Seven Mile Ridge.

STRATIGRAPHY

The Pettus Lake Member of the Fort Rock Formation as defined here consists of white, pale-orange, or pale-gray thickly bedded diatomite with irregularly spaced, tabular interbeds of volcanic ash and pumice, many of which are bioturbated. Layers within the member interdigitate to the east and west with the matrix-supported volcaniclastic breccias and well-cemented tuffaceous sandstones and conglomerates of Seven Mile Ridge and Table Rock (Figure 1). Contact relationships to the north and south of the mapped area are obscured by alluvial cover.

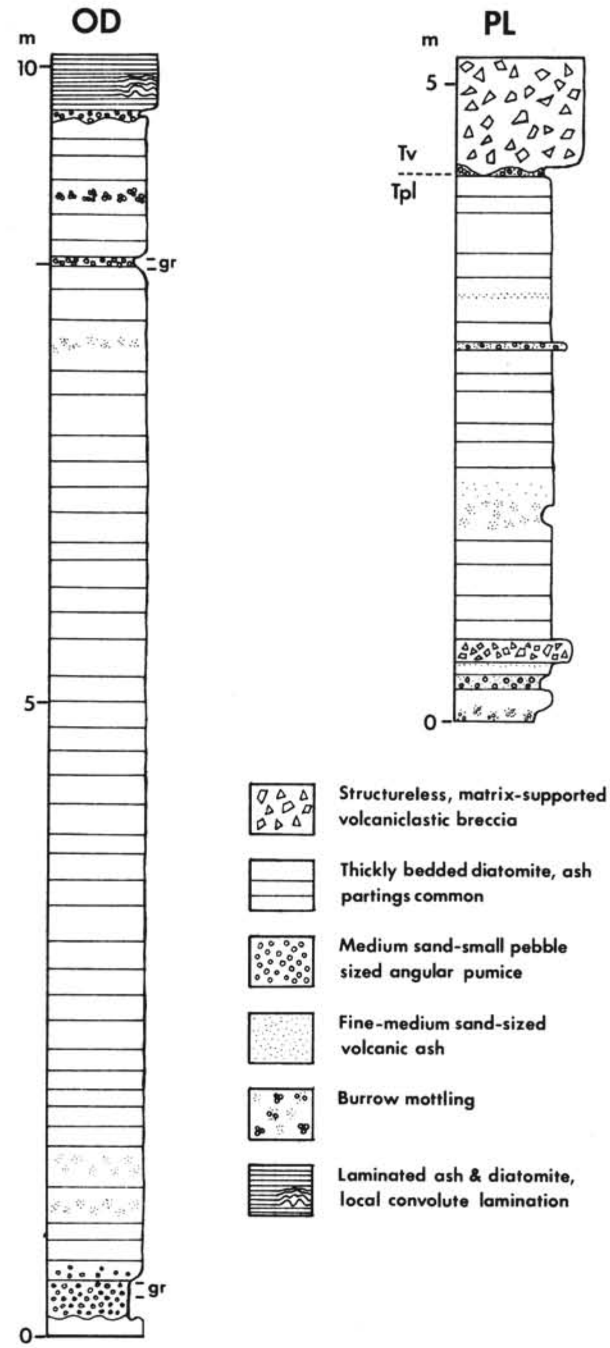
The basal contact of the member is not exposed at the surface anywhere within the basin. Drilling logs from water wells nearest the type section indicate that the diatomites overlie the Picture Rock Basalt. From current information it is not clear whether this contact is conformable or unconformable.

The Pettus Lake Member is conformably overlain by volcaniclastic breccia of Seven Mile Ridge at the type section. Throughout much of the basin, the member is overlain unconformably by a thin veneer of loosely consolidated material.

Diatomite was recorded in logs published by Hampton (1964) from six water wells drilled in the southwestern portion of the Fort Rock basin. Residents of Christmas Valley commonly report diatomite in the bottom of excavations dug for the basements of buildings. Allison (1979) recorded diatomaceous beds in Fossil Lake in the eastern part of the basin which may correlate with the Pettus Lake Member. These diatomaceous beds occur below the major disconformity at the base of the upper Pleistocene lake sequence. The Pettus Lake Member thus probably underlies most of the floor of the Fort Rock basin.

Two stratigraphic sections are presented in Figure 4. The type section (PL) immediately west of Seven Mile Ridge and Pettus Lake characterizes the unit at the basin margin, while the plant section (OD) is more typical of the rocks in the center of the basin. The two sections cannot be correlated. The PL section may be stratigraphically below the OD section, but our data are inconclusive.

By volume, diatomite is the vastly predominant lithology in the central part of the basin. When the attitude of the beds in the Oil-Dri pit is projected to the southeast across the plant property (assuming that no intervening faults or folds are present), it appears that approximately 91 m (300 ft) of the Pettus



← *Figure 4. Measured stratigraphic columns of Pettus Lake Member, Fort Rock Formation. Section PL is type section of Pettus Lake Member, measured in face scraped off by skip-loader on low hill immediately to east of secondary dirt road, SE¼NW¼ sec. 5, T. 28 S., R. 17 E. Supplementary section OD was measured in south end of Oil-Dri's pit just north of plant, NW¼NW¼ sec. 23, T. 27 S., R. 16 E. Note that OD section is on private property and may not be examined without permission from Oil-Dri Corporation of America. Clasts within volcaniclastic breccia are 90 to 95 percent glassy, vesicular basalt and 5 to 10 percent pumice. Symbol "gr" indicates intervals in which pumice exhibits graded lamination.*

Lake Member are truncated by the angular unconformity underlying the thin veneer of loose material penetrated by our drilling. Our drilling sampled approximately 50 percent of the section southeast of the pit, and 8.6 percent of the material proved to be ash and pumice, the remainder diatomite. Although our drilling system did not effectively sample layers much less than 15 cm (6 in) thick, this figure compares closely to the 9.7 percent ash and pumice by volume recorded for the exposed face in the Oil-Dri pit. Water-well drilling logs published by Hampton (1964) record as much as 200 m (655 ft) of diatomite in this part of the basin.

To the east and west, the Pettus Lake Member grades into volcaniclastic rocks (Figure 5). In the floor of Thorn Lake (actually a blowout depression), matrix-supported, volcaniclastic breccia layers 1 m (3 ft) or less thick are interbedded with diatomite (Figure 1). These layers are tabular on a small scale but pinch out laterally over a distance of 100 m (300 ft) or more. Allison (1979) considered these breccias to be clastic dikes. Two of the layers which were examined closely by the senior author of the present paper appear to dip gently to the west, with strikes roughly parallel to color banding in the adjacent diatomite. No splays into the diatomite were observed. We consider these two layers to be in depositional contact with the diatomites, although the possibility that they are actually gently discordant clastic dikes cannot be excluded.

In the hillside to the west of Thorn Lake contact relationships are unambiguous. Diatomite lenses are interbedded with the volcaniclastic rocks of Table Rock as much as 30 m (90 ft) above the present basin floor (Figure 6). Heiken and others (1981) noted these diatomite lenses and suggested that they "were deposited in a crater lake apart from the larger basin" (p. 133). Structural evidence for extensive erosion of the Pettus Lake Member is presented below (see GEOLOGIC STRUCTURE). However, outcrops of the diatomite in the hillside appear to extend beyond the margins of the vent (vent 4) which Heiken and others (1981) assumed impounded the lake. We therefore suggest instead that these diatomite lenses represent erosional remnants which were formerly connected to the main body of a thicker sequence of lake sediments, a conclusion supported by the diatom flora (see PALEONTOLOGY).

Also noteworthy in this regard is the presence of a large

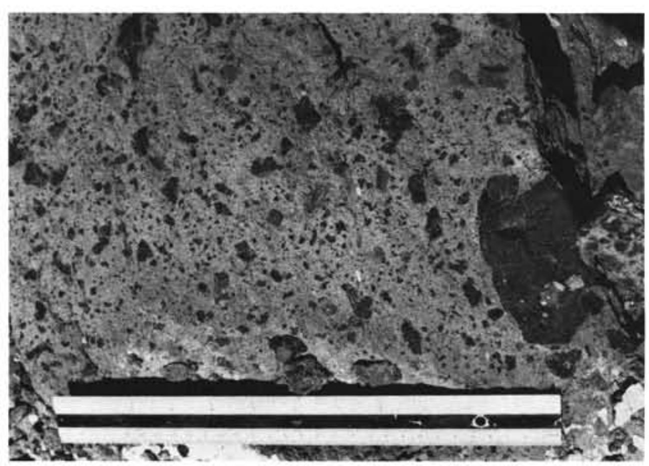


Figure 5. Matrix-supported volcaniclastic breccia of Seven Mile Ridge, from near dam at north end of Pettus Lake. Dark, angular clasts are glassy, vesicular basalt. This structureless breccia unit is typical of those found at both Seven Mile Ridge and Table Rock. Average clast size decreases to west of this locality, where breccias of Seven Mile Ridge interfinger with Pettus Lake Member of Fort Rock Formation (Heiken, 1971). Ruler=30.5 cm (1 ft).

sedimentary dike reported by Allison (1979) in Four Mile Sink (a blowout depression in the SE¼SE¼ sec. 21, T. 27 S., R. 16 E.). This dike strikes to the northeast and is up to 2 m (6 ft) wide, tapering both to the northeast and southwest. Several small- to moderate-sized splays 0.5 m (1.6 ft) wide extend into the surrounding diatomite. The dike is composed of matrix-supported volcaniclastic breccia similar to that observed at Table Rock and Seven Mile Ridge. Angular fragments of diatomite are scattered throughout the dike and show no evidence of alteration. There is no baked zone present along the margins of the dike. The texture of this material, when examined in thin section, confirms that it was injected as fluid-saturated sediment rather than as molten magma.

This dike is located more than 3 km (1.8 mi) from the nearest exposure of the volcaniclastic rocks of Table Rock. As no similar material was encountered in any of the shallow drill holes nearby, the dike was apparently injected from some depth. This illustrates how extensively interbedded these two lithologies are, at least at depth.

A similar relationship prevails at the type locality of the Pettus Lake Member (Figure 4). Five shallow holes 5 to 13 m (16 to 43 ft) deep were drilled to the east of the type section. Breccia layers 0.2 to 5 m (0.7 to 15 ft) thick are interbedded with diatomite layers up to 1 m (3 ft) thick along this transect. This interfingering was also noted by Hampton (1964) in his description of the Fort Rock Formation.

GEOLOGIC STRUCTURE

The Pettus Lake Member underlies much of the southern Fort Rock Basin but is generally poorly exposed. Using a transit and stadia rod, we were able to determine the attitudes of marker beds in five excavations and blowout depressions (Figure 1). The two additional attitudes recorded from breccia beds in Thorn Lake were determined with a hand compass.

Allison (1979) noted the presence of an extensive disconformity between the diatomites and overlying lake sediments of late Pleistocene age. Our data indicate that this contact is actually an angular unconformity. The diatomites have been

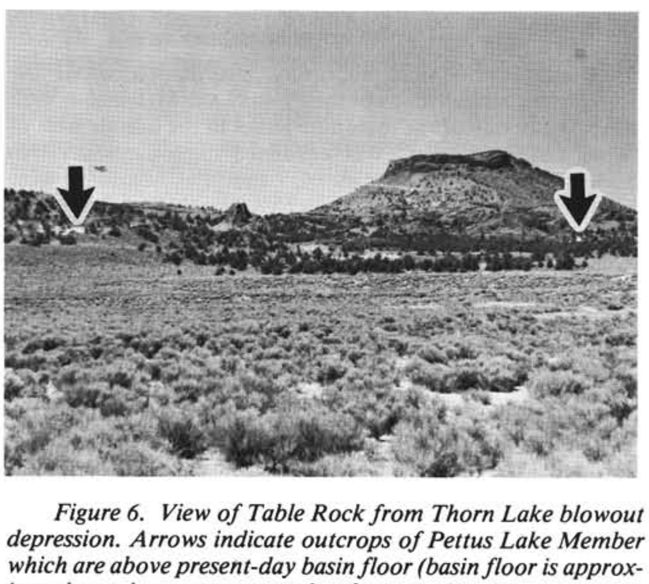


Figure 6. View of Table Rock from Thorn Lake blowout depression. Arrows indicate outcrops of Pettus Lake Member which are above present-day basin floor (basin floor is approximately at lowermost growth of trees). We interpret these diatomite outcrops as erosional remnants of what was formerly a much thicker diatomite sequence. Outcrop on left was sampled for siliceous microfossils. Table Rock is remnant of Pliocene tuff cone capped by basalt which was once ponded in crater at center of cone (Heiken and others, 1981).

Figure 7. Four Mile Sink blowout depression (SE¼SE¼ sec. 21, T. 27 S., R. 16 E.), looking due east. Dark diatomite layer (arrow) illustrates northern component of dip of beds at this locality. Actual attitude is N. 57° E. 2.5° NW. Dipping diatomite beds are overlain unconformably by thin veneer of unconsolidated material.

systematically deformed (Figure 7) and strike north to northeast, with a west or northwest dip of 0.5° to 5°. This finding is surprising, as aerial photos of the basin give no hint of such an underlying structure. Apparently these beds are so uniformly soft that they were evenly planed off during some erosional event. Our drilling encountered only a thin veneer (0.2 to 3 m [0.7 to 9 ft] thick, average 1 m [3 ft] thick) of unconsolidated material resting unconformably on this erosional surface.

The presence of undeformed younger lake terraces on both Table Rock and Seven Mile Ridge adds to the impression that these volcaniclastic bodies are structurally flat-lying. In fact, the high initial dips of the volcaniclastic rocks preclude direct detection of gentle folding, but the intimate interfingering of these units with the diatomite suggests that they must be deformed in like fashion.

Hampton's (1964) assumption that folding ceased with deformation of the basalt underlying these units is clearly incorrect. Neither is it clear, however, that the Pettus Lake Member conformably overlies this basalt, as depicted in the cross-section of Walker and others (1967). We do not have enough data to rule out this interpretation, but the possibility that folding was initiated prior to and continued throughout the time of deposition of the diatomaceous sediments should at least be considered.

This structural information also comes to bear on the interpretation of the geomorphic evolution of this basin. Sometime between the early Pliocene when the sediments were deposited and the late Pleistocene when the lake terraces described by Forbes (1973) and Allison (1979) were developed, an open drainage system must have operated in this area. A tremendous volume of diatomite must have been removed to produce the extensive angular unconformity overlain by a thin veneer of alluvium which we observe.

The volcaniclastic rocks of Table Rock and Seven Mile Ridge were at least partially interbedded with these diatomites and were probably exhumed during the erosional event described above (Figure 8). Peterson and McIntyre (1970) suggested a similar interpretation for similar features southwest of our study area in an adjacent basin.

A fault is present at the north end of the Oil-Dri plant pit. The fault is vertical and strikes N. 70° E. A relative vertical displacement of at least 1.6 m (5 ft), with the north side upthrown, is indicated by drilling information. A sheared zone

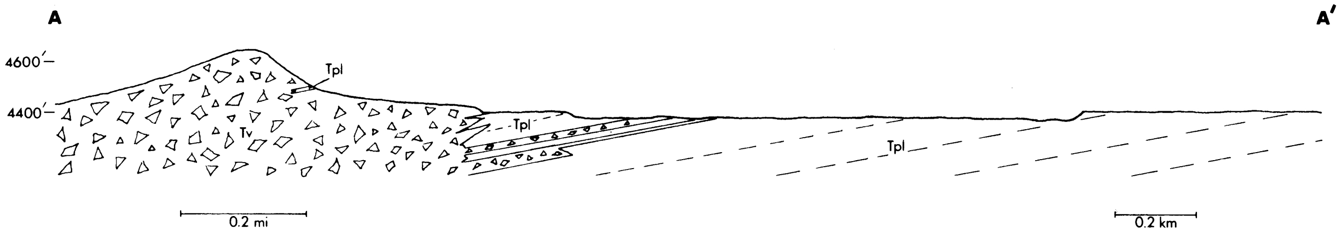


Figure 8. Simplified cross-section through southern end of Table Rock complex and Thorn Lake showing our interpretation of stratigraphic relationship between units Tv and Tpl. No attempt is made to show faulting. Dashed lines indicate dip of bedding within the diatomite. Unit Qal is not shown. Vertical exaggeration = 2×.

3 m (9 ft) wide is evident along the fault. Convolute lamination and numerous small sedimentary dikes emanating from dismembered pumiceous sandstone beds clearly point to a water-saturated condition for the sediments at the time of faulting.

Also present in the area is a pervasive joint system which greatly facilitates mining the diatomite. The predominant joint set is vertical and strikes roughly north-south, with joints generally spaced 1 m (3 ft) apart. In some places thin veinlets of gypsum precipitated along these joints.

PALEONTOLOGY

Fish fossils are fairly common from 1 to 5 m (3 to 15 ft) above the base of the Oil-Dri pit section. We recovered remains of at least seven individuals from six stratigraphic horizons in approximately one hour. All specimens are disarticulated to some degree, and no complete skulls were recovered. This suggests the presence of an active scavenging bottom fauna.

Although the most information is obtained by dealing with diatoms at the species level, the taxonomic treatment required for such an analysis is far beyond the scope of the present study. Relative abundances of diatom genera do help to characterize the ancient lake in which these sediments were deposited, however. Generic identifications were made using Moore (1937), Patrick and Reimer (1966, 1975), and VanLandingham (1964, 1967). No attempt was made to sort out the genera of the family Fragilariaceae. Some members of this family are extremely small, and the group may be somewhat underrepresented in the counts.

Forty-seven drill cutting and surface samples were examined microscopically to evaluate their potential for the production of filter aids. Striking changes in the diatom flora became evident during this evaluation. Samples from six levels within the Oil-Dri pit and two samples from the PL section were prepared in order to document these fluctuations (Table 1). Strew mounts were prepared of disaggregated material, with care taken to obtain a representative distribution of particle sizes. Two slides were prepared per sample, and 100 specimens were counted on each slide under 400× magnification.

The genera listed in Table 1 form an association typical of fresh-water deposits. One species which could be identified, *Stephanodiscus niagarae* Ehrenberg, is common in Klamath Lake today (Moore, 1937).

The centric diatoms listed are all planktonic forms. Many, but not all, of the Fragilariaceae are also planktonic. The remaining pennate genera, including several large forms, are predominantly benthic. Planktonic forms thus exhibit much higher relative abundances than do benthic forms in the samples examined, suggesting that the water within the lake was relatively deep and circulated freely (Patrick, 1948; Patrick and Reimer, 1966).

Further, the predominance of centric diatoms hints that the lake may have been oligotrophic, i.e. relatively nutrient-poor. Stockner and Benson (1967) suggested that a ratio of members of the Fragilariaceae to all centric diatoms of less than 1:1 in lake sediments may be an indicator of oligotrophic conditions. This seems to hold good for many, but not all, modern lakes (Birks and Birks, 1980). Abundant representatives of the genus *Cyclotella* are also characteristic of oligotrophic lakes (Rawson, 1956; Stockner and Benson, 1967).

If conditions were indeed oligotrophic, lack of silica was clearly not one of the factors which limited diatom growth, because ubiquitous volcanic ash and pumice fragments would have provided a ready source of dissolved silica. Very little organic carbon is obvious in the stratigraphic sections described here, although that may merely reflect oxidizing bottom conditions in the ancient lake rather than a dearth of organic matter. Nitrogen and phosphorus are two nutrients which impose important constraints on diatom growth, but their presence is difficult to evaluate in ancient deposits.

The striking fluctuations in the relative abundances of the three genera of centric diatoms are less easily explained. Major changes in the relative abundances of particular planktonic diatom taxa can be produced by fairly small changes in a particular environmental parameter, such as the phosphorous content of the water or the density of grazing zooplankton (Stockner and Benson, 1967; R. Castenholz, personal communication, 1982). Little can thus be concluded in regard to these fluctuations, other than that a dynamic ecological system operated within the lake.

Diatoms also yield important information about the stratigraphic relationships of the Pettus Lake Member. A grab sample from one of the diatomite lenses in the hillside west of Thorn Lake (Figure 6) was examined microscopically. No sponge spicules were counted, and the diatoms were represented as follows: *Melosira*, 39 percent; *Cyclotella*, 37 percent; *Stephanodiscus*, 2.5 percent; family Fragilariaceae, 20 percent; and all other pennate diatoms, 1.5 percent. Such a flora dominated by planktonic taxa strongly suggests deposition in a lake exhibiting free circulation, rather than in a shallow pond within a volcanic crater, and thus supports our contention that the diatomite lenses are erosional remnants of a formerly more extensive lake deposit.

Sponge spicules are present throughout the OD section (Table 1). Although some specimens are ornate, little can be said about their environmental significance. Sponge spicules are consistent with oxygenated bottom conditions within the lake, however, which are also indicated by the disarticulated fish fossils and bioturbated ash layers.

DEPOSITIONAL ENVIRONMENTS

The extensive tabular beds of diatomite containing a fresh-water diatom flora clearly point to a lacustrine origin for the Pettus Lake Member of the Fort Rock Formation. In the center of the basin, interbedded ash and pumice layers are tabular and friable, with no observable paleocurrent in-

Table 1. *Relative abundances of siliceous microfossils from selected samples of the Pettus Lake Member*

	Samples*								
	OD 0.0	OD 0.9	OD 1.8	OD 3.6	OD 5.5	OD 8.5	PL 1.4	PL 1.7	Total
Centric diatoms**									
Cyclotella	128	12	150	5	25	89	12	2	423
Melosira	2	3	19	8	102	9	98	176	417
Stephanodiscus	40	106	1	85	12	24	58	20	346
Pennate diatoms									
Family Fragilariaceae	21	55	21	51	42	68	17	1	276
Cocconeis	—	—	—	1	2	1	2	—	6
Cymbella	2	6	1	1	2	1	4	—	17
Entomoneis	—	—	—	3	—	—	—	—	3
Epithemia	1	—	1	7	2	—	—	—	11
Eunotia	—	—	—	—	1	—	—	—	1
Gomphonema	—	—	—	—	2	—	1	—	3
Navicula	—	1	—	11	4	1	—	—	17
Surirella	1	2	2	3	—	—	—	—	8
Other pennates	3	5	2	18	5	5	8	1	47
Sponge spicules***	2	10	3	7	1	2	—	—	25
Total	200	200	200	200	200	200	200	200	1600

* Sample numbers represent height above base of respective section in meters.
** Counts are of single valves in which more than half of the valve was preserved.
*** Counted only if the tip of the spicule was present.

dicators. These beds probably originated by the settling of volcanic fragments which were erupted directly into the lake rather than transported by streams. It is also noteworthy that these volcaniclastic layers exhibit two distinct lithologies. The pumice layers are composed of gray-blue, medium- to coarse-grained, sand-sized particles of frothy pumice. The volcanic ash layers, on the other hand, are composed of dark, fine, sand-sized particles, many of which are volcanic rock fragments and broken mineral grains. Perhaps two different types of eruptions are recorded by these layers: one type primarily involved juvenile material, the second involved extensive destruction of pre-existing rock. Separate eruptive sources may also be indicated.

The friable sandstone layers at the type section (PL) are generally more heterogeneous than those in the center of the basin. This mixture of grains may reflect some influx from streams, although no sedimentary structures are present which suggest that these layers were deposited above lake level. The presence of interbedded volcaniclastic breccias also suggests that the margin of the lake may have been nearby. The two diatom samples from this section, however, are strongly dominated by planktonic forms (Table 1) and provide no hint of the presence of rooted vegetation or shallow-water conditions. Apparently either the lake had a fairly abrupt margin or the volcaniclastic rocks of Seven Mile Ridge were largely erupted under water.

Hampton (1964) interpreted the matrix-supported volcaniclastic breccias as mudflow deposits, while Heiken (1971) and Heiken and others (1981) considered them phreatic eruptive units. The latter authors based their case for a "hot" origin on the observation that the matrix of these breccias is altered to palagonite.

Two other lithologies are common within the Table Rock complex: (1) fine, graded, tabular laminae of fine- to medium-grained tuff; and (2) cross-bedded couplets of coarse, sand-sized fragments (tops) and reverse-graded tuff breccias or conglomerates (bottoms). Discrete units of these lithologies exhibit cut-and-fill contacts with each other and with matrix-supported breccias throughout the Table Rock complex. Heiken and others (1981) interpreted the graded, finely laminated lithofacies as representing direct air-fall deposition of tuff. They reported antidune structures in the cross-bedded lithofacies and ascribed the origin of these units to deposition by base surges.

Missing from the above descriptions and our own discussion of the Pettus Lake Member are any indications of shoreline conditions along the margins of the early Pliocene lake. If the lake margins were fairly abrupt, any resulting beach deposits would occur in a very narrow band and might easily be overlooked. Stream runoff from the small area occupied by the Table Rock complex might not have produced deltaic deposits to any significant extent. Nonetheless, a careful search for lithofacies characteristic of such marginal environments holds out the most promise for acquiring a detailed understanding of the conditions under which the tuff rings of the Fort Rock basin were erupted.

CONCLUSIONS

(1) The diatomite-dominated lower Pliocene rocks of the Fort Rock basin can be mapped as a separate member of the Fort Rock Formation, here named the Pettus Lake Member. (2) These beds have been systematically deformed and dip 0.5° to 5° to the west or northwest. (3) A thin veneer of alluvium overlies an unconformable erosional surface developed on the Pettus Lake Member beneath much of the basin floor. (4) Sometime between the early Pliocene and latest Pleistocene, an open drainage system operating in the basin eroded a tremendous quantity of diatomite. (5) The diatomites interdigitate to the east and west with volcaniclastic rocks that were at least partially exhumed by the above erosional event. (6) Two distinct types of eruptions may be documented by numerous thin volcaniclastic layers within the Pettus Lake Member. One type involved abundant juvenile material and produced pumice layers, the other expelled rock and mineral fragments and produced fine-grained ash layers. Different eruptive sources may also be recorded by these volcaniclastic layers. (7) The diatomaceous sediments were deposited in a relatively deep, fresh-water, possibly oligotrophic lake with oxygenated bottom conditions.

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REFERENCES CITED

Allison, I.S., 1979, Pluvial Fort Rock Lake, Lake County, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 7, 72 p.

Baldwin, E.M., 1976, Geology of Oregon (revised ed.): Dubuque, Iowa, Kendall/Hunt, 147 p.

Birks, H.J.B., and Birks, H.H., 1980, Quaternary palaeoecology: Baltimore, Md., University Park Press, 189 p.

Donath, F.A., 1962, Analysis of Basin-Range structure, south-central Oregon: Geological Society of America Bulletin, v. 73, no. 1, p. 1-15.

Fiebelkorn, R.B., Walker, G.W., MacLeod, N.S., McKee, E.H., and Smith, J.G., 1982, Index to K-Ar age determinations for the State of Oregon: U.S. Geological Survey Open-File Report 82-596, 40 p.

Forbes, C.F., 1973, Pleistocene shoreline morphology of the Fort Rock Basin, Oregon: Eugene, Oreg., University of Oregon doctoral dissertation, 203 p.

Hampton, E.R., 1964, Geologic factors that control the occurrence and availability of ground water in the Fort Rock Basin, Lake County, Oregon: U.S. Geological Survey Professional Paper 383-B, 29 p.

Heiken, G.H., 1971, Tuff rings; examples from the Fort Rock-Christmas Lake Valley basin, south-central Oregon: Journal of Geophysical Research, v. 76, no. 23, p. 5615-5626.

Heiken, G.H., Fisher, R.V., and Peterson, N.V., 1981, A field trip to the maar volcanoes of the Fort Rock-Christmas Lake Valley basin, Oregon, *in* Johnston, D.A., and Donnelly-Nolan, J., eds., Guides to some volcanic terranes in Washington, Idaho, Oregon, and northern California: U.S. Geological Survey Circular 838, p. 119-140.

Lawrence, R.D., 1976, Strike-slip faulting terminates the Basin and Range province in Oregon: Geological Society of America Bulletin, v. 87, no. 6, p. 846-850.

Moore, B.N., 1937, Nonmetallic mineral resources of eastern Oregon: U.S. Geological Survey Bulletin 875, 180 p.

Patrick, R., 1948, Factors effecting the distribution of diatoms: Botanical Review, v. 14, no. 8, p. 473-524.

Patrick, R., and Reimer, C.W., 1966, The diatoms of the United States, volume 1: Philadelphia, Pa., Academy of Natural Sciences of Philadelphia Monograph 13, 688 p.

——— 1975, The diatoms of the United States, volume 2, part 1: Philadelphia, Pa., Academy of Natural Sciences of Philadelphia Monograph 13, 213 p.

Peterson, N.V., and Groh, E.A., 1963, Maars of south-central Oregon: Oregon Department of Geology and Mineral Industries, Ore Bin, v. 25, no. 5, p. 73-88.

Peterson, N.V., and McIntyre, J.R., 1970, The reconnaissance geology and mineral resources of eastern Klamath County and western Lake County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 66, 70 p.

Rawson, D.S., 1956, Algal indicators of lake types: Limnology and Oceanography, v. 1, no. 1, p. 18-25.

Stockner, J.G., and Benson, W.W., 1967, The succession of diatom assemblages in the recent sediments of Lake Washington: Limnology and Oceanography, v. 12, no.3, p. 513-532.

VanLandingham, S.L., 1964, Miocene non-marine diatoms from the Yakima region in south-central Washington: Nova Hedwigia Beiheft 14, 78 p.

——— 1967, Paleoecology and microfloristics of Miocene diatomites from the Otis Basin-Juntura region of Harney and Malheur Counties, Oregon: Nova Hedwigia Beiheft 26, 77 p.

Wagner, N.S., 1969, Diatomite, *in* Mineral and water resources of Oregon: Oregon Department of Geology and Mineral Industries Bulletin 64, p. 205-210.

Walker, G.W., Peterson, N.V., and Greene, R.C., 1967, Reconnaissance geologic map of the east half of the Crescent [1° × 1°] quadrangle, Lake, Deschutes, and Crook Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-493, scale 1:250,000. □

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