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PLANT FOSSILS IN THE CLARNO FORMATION, OREGON

By

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Introduction

The Clarno formation was originally described by Merriam (1901) from outcrops at Mitchell and Clarno's Ferry, Oregon. Since that time the formation has been found to be very widely distributed throughout central Oregon (Wilkinson, 1959). It is composed of an unknown thickness of volcanic rocks and interfingering terrestrial sediments which contain a newly discovered vertebrate fauna and an abundance of fossil plant remains.

Wilkinson (1959) and Taylor (1960) describe several distinctive rock types that make up the Clarno formation. Of special importance are the beds of tuff ranging from coarse gritty tuffaceous sandstones to fine-grained tuffaceous shales, some of which are water-laid and contain fossil leaves. Another important unit in which plant remains are found, is composed of volcanic conglomerates and breccias of mud-flow origin. Associated with the conglomerates and breccias are andesite and basalt flows. Welded tuffs occur at several horizons. Plugs, dikes, and sills of andesite, rhyolite, and dacite are characteristic of the Clarno formation and are topographically expressed on the landscape as prominent buttes and ridges.

The range in age of the Clarno formation has not been determined with certainty. In the few places where its base is observed, it lies unconformably on Cretaceous deposits, and it is overlain unconformably by the upper Oligocene-lower Miocene John Day formation.

Up until recently, writers have generally favored a middle to upper Eocene age for the Clarno formation, the assignment being based almost entirely on fossils found in the vicinity of the type locality at Clarno's Ferry. Thus, R. A. Scott (1954) in his excellent monograph on the fossil nuts and fruits occurring 1½ miles east of Clarno's Ferry, suggests an age somewhat older than upper Eocene. Until recently, animal fossils were thought to be of such rare occurrence in the formation that Stirton (1944) used a single tooth, presumably belonging to the genus Hyrachyus, to establish a middle Eocene age for the Clarno formation. Recently an extensive deposit of animal fossils near the type locality was discovered by the late A. W. Hancock and is being studied by J. A. Shotwell of the University of Oregon. Preliminary work suggests an upper Eocene or, possibly, lower Oligocene age for these fossils, but the stratigraphic relationship of the vertebrate bed to the plant locality is problematical (Taylor, 1960).

Plant fossils have been found at many other places in the Clarno formation in addition to those occurring at the type locality (see accompanying map). Comparison clearly shows the non-contemporaneity of many of the florules and suggests that the age of the Clarno formation is of an appreciably greater range than that proposed by many previous authors. Since some of these localities have not been described in detail in the literature previously, it would seem to be of value to summarize our present state of knowledge of the Clarno flora. Descriptions of the localities are presented below in the order of decreasing age of the

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flora. Numbers refer to locality numbers on the map.

Clarno Flora Localities

West Branch Creek Locality:

Most of the generalizations in the more recent literature concerning the Clarno flora are based on the leaf remains found on West Branch Creek in Wheeler County. Howard (1955) has suggested that the best collecting areas are in tuffaceous and shaly sediments in secs. 20, 29, and 30, T. 11 S., R. 21 E. The notable fossils from West Branch Creek are the large multilobed leaves of Platanophyllum angustiloba which is thought to be an ancestor of the modern sycamore. The author considers this species to be characteristic of middle to upper Eocene floras in Oregon. Chaney (cited in Scott, 1954) has furnished the following list of genera from this locality, but complete results of his study have not been published.

Astronium	Celastrus	Nectandra	Ficus
Rhus	Alchornia	Vitus	Alangiophyllum
Catalpa	Casearia	Persea	Platanophyllum
Cordia	Cinnamomum	Abuta	Gouania
			Meliosma

It may be noted that the indicated composition of the flora from this locality differs appreciably from that present at Pilot Rock (described on pages 58-60). The West Branch Creek flora is considered to be the oldest in the Clarno formation.

M. Pabst (1948) has studied the ferns from this locality and identified the following species:

Lygodium kaulfussii	Lastrea (Goniopteris) fischeri
Anemia elongata	Salpichlaena anceps
Dennstaedtia	Woodwardia latiloba
Pteris? sp.	Hemitelia pinnata
Dryopteris sp.	

A close correlation with species of the Paleocene of the Rocky Mountains was indicated, and a middle to upper Eocene age was suggested for the West Branch Creek flora.

Clarno type locality:

One and one-half miles east of Clarno's Ferry (SE¼ sec. 27, T. 7 S., R. 19 E.), Wheeler County, near the type locality of the Clarno formation is a remarkable occurrence of fossil fruits and seeds. These fossils have been described by Scott (1954), Scott and Barghoorn, (1955), as previously noted, and correlated with flora of the Ypresian (upper lower Eocene) London clay. The specimens were assigned to eight genera, the most common fossil being a small walnut (Juglans clarnensis). Leaf impressions are also present in rocks at this locality but are of more limited occurrence. Chaney (1936) has noted the presence of a cycad, provisionally assigned to the genus Dioon, at this locality. Further description of the fossil leaves at this locality are wanting in the literature, however.

In addition to fruits, nuts, and leaves, silicified wood may also be found in this area. Some of this wood contains representations of fungi, two species having been described by Scott (1955). In the same paper, Scott indicated that he had identified more than 25 species of fossil wood from this locality, but they were not described.

The author has also collected fossil wood from this area. Palm, walnut (Juglans), Cinnamomum, sycamore, (Platanus), and wood from several other as yet unidentified genera are present. Significantly, gymnosperm wood was absent. This locality is probably one of the few plant fossil localities in the entire world that offers the opportunity of correlating species identifications from fruits, wood, and leaves of a plant. The age of this locality is considered to be middle upper Eocene.

Cherry Creek and Currant Creek localities:

The first fossil plants studied in the Clarno formation were obtained from two localities in Jefferson County, Cherry Creek (T. 10 S., R. 19 E.) and Currant Creek (T. 9 S., R. 18 E.), the exact geographical locations of which are not precisely described in the literature. Collections from these localities were first studied by Newberry (1883, 1898), and Lesquereux (1883) and subsequently by Knowlton (1902). Although the determinations are mainly of historical interest, and undoubtedly require revision in the light

of newer work, they are included here for comparison with the lists of fossils from other Clarno localities.

Cherry Creek:		
Lygodium kaulfussii	Quercus furcinervis	Diospyros alaskana
Allantodiopsis erosa	americana	Phyllites wascoensis
Equisetum oregonense	Cercis tenuinervis	Phyllites sp.
Salix schimperi	Magnolia culveri	Currant Creek:
Juglans rugosa	Cinnamomum dilleri	Pteris pseudopinnaeformis
Juglans? bendirei	Rhamnus cleburni	Goniopteris lesquereuxi
Hicoria? oregoniana	Platanus basilobata	Equisetum oregonense

More recently, Arnold (1952) has described the remains of a silicified tree fern, Osmundites chandleri, from this same general area. This striking fossil was found 9½ miles east and 3 miles north of the small town of Ashwood (T. 9 S., R. 18 E.), on or near the east-west line separating sections 15 and 22. This same area yields scattered remains of silicified wood, none of which have been described in the literature, and stems of a fern provisionally referable to the genus Eorhachis.

Post fossil wood locality:

On the Clarno surface, north and east of Post in Crook County, considerable silicified plant remains may be found. Arnold (1945, 1952) has described a fern stem, Osmundites oregonensis, which is closely related to the fern stems obtained near Currant Creek. The locality is in the northwestern corner of sec. 27, T. 16 S., R. 20 E., 8 miles due east of Post on a small tributary of Crooked River, known locally as Lost Creek, that flows into it from the north.

The author has obtained silicified wood from two areas, one of which is 8 miles due east of Post and the other 3 miles north of the first. Neither of these yielded any coniferous woods in contrast to the Mitchell and Hampton Butte fossil wood localities (see below). Seventeen species have been differentiated, but only a few have been identified with any certainty. The predominant fossil is a sycamore (Platanus), similar to but not identical with any living sycamore with which the author is acquainted. Palm wood and roots, Quercus (one specimen only), and a wide rayed wood apparently referable to Cryptocarya are notable. Other genera provisionally identified were Juglans (identical with that occurring at Clarno's Ferry), Vitus, Rhamnus, Magnolia, Ocotea, and Nyssa. Several woods, though not identified as to genera, appear to be identical with specimens obtained from the type locality. It is concluded that the fossil-bearing stratum in this area is slightly younger than that at Clarno's Ferry, or upper Eocene.

Pilot Rock localities:

The most extensively studied flora, outside of the type locality, is that obtained from two locations on East Birch Creek about 10 miles southeast of the town of Pilot Rock in Umatilla County. Leaf impressions (see illustrations) were obtained from a variably textured sandstone dipping 26° due east. The basal beds are an unfossiliferous white tuff, while the sediments are unconformably overlain by northwesterly dipping Columbia River basalt (middle Miocene). Extensive collections were made by students of the late Dr. Ethel Sanborn of Oregon State College from the NE¼ sec. 7, T. 2 S., R. 33 E., and the SW¼ sec. 12, T. 2 S., R. 32 E. Notes left by Dr. Sanborn and subsequent studies by the author show the presence of the plants listed on the following page.

The only published reference to the composition of the flora at this locality is that of G. M. Hogenson (1957), who includes a third location in the NW¼ NE¼ sec. 31, T. 2 S., R. 33 E. He reports determinations of 7 species made by R. W. Brown of the U. S. Geological Survey, which are in general agreement with those reported here. From the composition of this flora, the age of the locality is considered to be intermediate between that of the Comstock and Goshen floras of Western Oregon, namely lower Oligocene, and younger than that of the type locality at Clarno's Ferry.

Species identified:

Cinnamomum acrodromum	Ilex oregona	Anona prereticulata
Platanus aceroides	Siparuna ovalis	Laurophyllum merrilli*
Glyptostrobus dakotensis	Siparuna standleyi	Ficus quisamburgii
Equisetum oregonensis	Callichlamys zeteki	Magnolia reticulata
Laurus princeps	Mallotus oregonensis	Magnolia californica
Ocotea eocernua	Magnolia leei*	Goniopteris lesquereuxi
Sabalites eocenica*	Ficus goshensis	Allantodiopsis erosa
Cordia rotunda	Persea praelingue*	Asimina eotriloba

New species recognized:

Tetracera prescandens
Cryptocarya eocenica*
Litsea oregonensis*

Specimens identified only as to genera:

Thuites sp.	Aralia (Platanophyllum)
Ficus cf. F.hispada Linne	Rhamnus cf. R.pseudogoldianus Hollick
Oreodaphne sp.	Credneria sp.
Calyptranthes cf. C.arbutifolia C. and S.	Aristolochia cf. A.mexicana C. and S.
Nectandra cf. N.presanguinea, C. and S.	Cryptocarya sp.
Ocotea sp.	Dillenia sp.

* Species illustrated.

Arbuckle Mountain localities:

A group of Clarno formation localities yielding abundant remains of palms (Sabalites) occurs in the vicinity of Arbuckle Mountain in Morrow County about 20 miles southeast of Heppner. Two small collections, numbered PF61 and PF62 in the department museum include Magnolia sp., Sabalites eocenica, Salix?, and Laurophyllum. Fossils from PF61 were collected in 1945 by C. O. Clark on the headwaters of Johnson Creek, a tributary of Butter Creek, near the divide with Willow Creek in sec. 19, T. 4 S., R. 29 E. Fossils from PF62 are probably from the same general area, but exact location is not available.

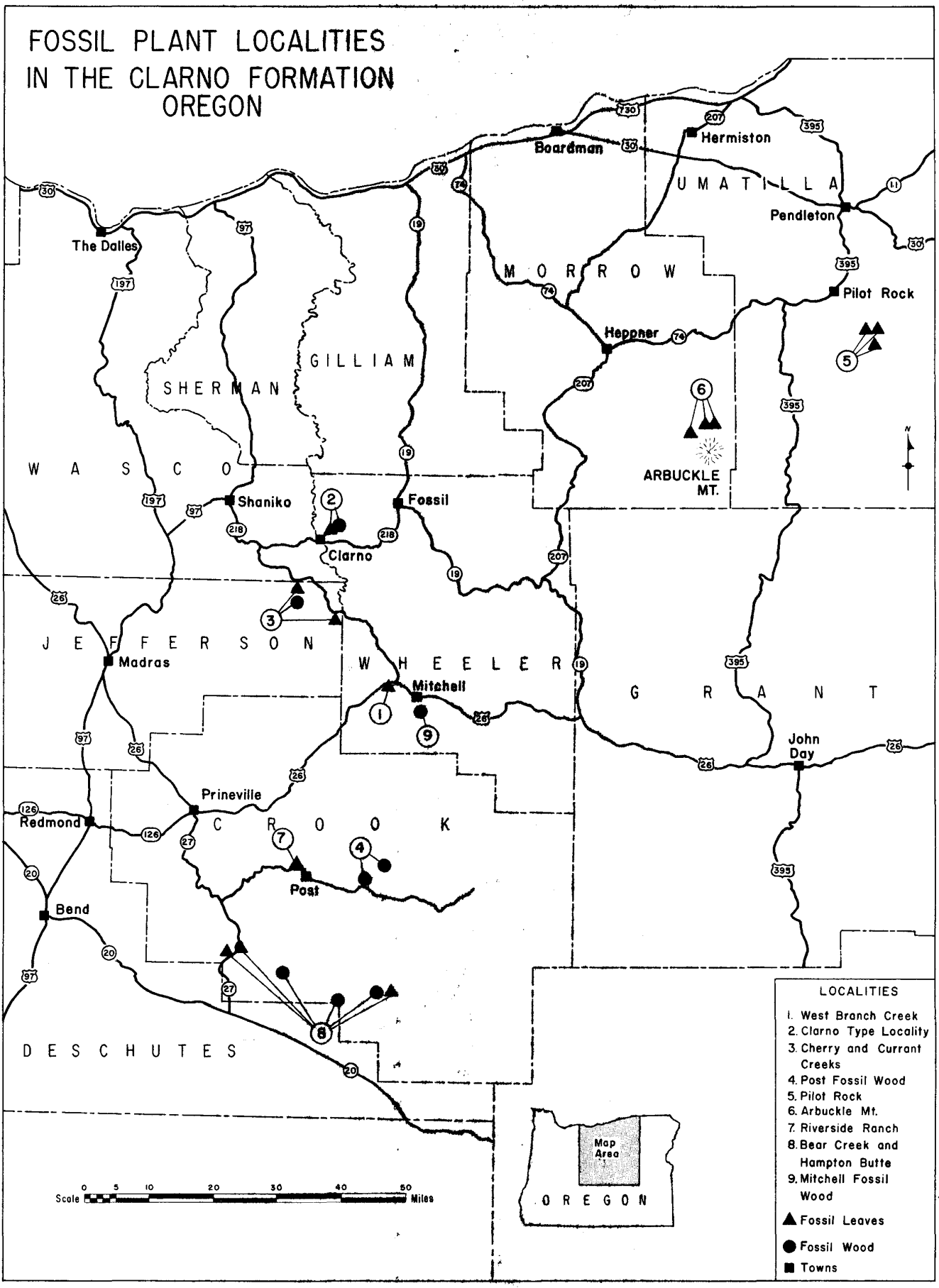
Another location known as the Arbuckle Mountain locality, briefly mentioned by Chaney (1948), was discovered by J. E. Allen (1947) during a coal survey for the department. His notes describe the location as being 1½ miles northwest of Arbuckle Mountain at the junction of the Heppner-Ukiah road with the Arbuckle corral road in the NW¼ SW¼ sec. 19, T. 4 S., R. 29 E., 24 miles southeast of Heppner. Fossil leaves were picked up, over a distance of several hundred feet, from a shaly bed in sandstone which crosses the road junction. It is possible that this locality is the same as PF62.

Allen also mentions that leaf imprints occur in sandstone and shale beds associated with the coal at three mines in the vicinity of the Arbuckle Mountain locality. These are: mine No. 1 in the SW¼ NE¼ sec. 20 and mine No. 3 in the SW¼ NE¼ sec. 19, both in T. 4 S., R. 29 E., and at mine No. 7 in the NW¼ SW¼ sec. 34, T. 4 S., R. 28 E.

Allen's mine No. 7 (Willow Creek prospects) was described previously by Mendenhall (1909) of the U. S. Geological Survey, who submitted specimens of fossil plants to F. H. Knowlton for determination. Knowlton reported the following species which he regarded as "upper Clarno" or upper Eocene.

Monocotyledenous plant ("unknown to me")
Glyptostrobus cf. G.europaeus Heer
Quercus consimilis? Newberry
Populus sp.?

Hogenson (1957) collected fossil leaves in the Arbuckle Mountain area from "a shale bed underlying massive sandstone bed which forms a ridge top" in the NE¼ NW¼ sec. 20, T. 4 S., R. 29 E. The fossils from this location were identified by R. W. Brown as set forth on page 61.


FOSSIL PLANT LOCALITIES
IN THE CLARNO FORMATION
OREGON
Boardman
Hermiston
UMATILLA
Pendleton
The Dalles
MORROW
Pilot Rock
Heppner
GILLIAM
SHERMAN
WASCO
ARBUCKLE MT.
Shaniko
Fossil
Clarno
JEFFERSON
Madras
WHEELER
Mitchell
GRANT
John Day
Prineville
Redmond
CROOK
Post
Bend
DESCHUTES
Scale 0 5 10 20 30 40 50 Miles
Map Area
OREGON
LOCALITIES
1. West Branch Creek
2. Clarno Type Locality
3. Cherry and Currant Creeks
4. Post Fossil Wood
5. Pilot Rock
6. Arbuckle Mt.
7. Riverside Ranch
8. Bear Creek and Hampton Butte
9. Mitchell Fossil Wood
Fossil Leaves
Fossil Wood
Towns

SABALITES EOCENICA (Lesq) Dorf (PALM)

MAGNOLIA LEEI Knowlton (MAGNOLIA)

LAUROPHYLLUM MERRILLI Chaney and Sanborn (LAUREL)

CRYPTOCARYA EOCENICA, new species

LITSEA OREGONENSIS, new species

PERSEA PRAELINGUE Sanborn (AVOCADO)

(All specimens approximately one-half natural size)

SOME TYPICAL FOSSIL LEAVES FROM THE CLARNO FORMATION
NEAR PILOT ROCK, OREGON

Aneimia sp.	Quercus banksiaefolia Newberry
Glyptostrobus dakotensis Brown	Magnolia sp.
Sabalites sp.	Carpites verrucosus Lesquereux
Numerous other dicotyledonous leaves	

Although the fossils from the Arbuckle Mountain localities have not been studied completely, it seems likely that they are contemporaneous with the Pilot Rock flora.

Riverside Ranch locality:

A small assemblage of leaf fossils, closely related in composition to those obtained from Cherry Creek, has been described by Chaney (1927). They were obtained on the Riverside Ranch, 34 miles up the Crooked River from Prineville, "one-half mile north of the highway on the west bank of Wickieup Creek" in Crook County. Although only 5 species were characterized (Pinus sp., Quercus furcinervis americana, Sassafras sp., Platanus cf. nobilis, and Rhamnus cleburni), they hold considerable significance. It is questionable if any of these species are present in the Clarno's Ferry, West Branch Creek, or Pilot Rock collections. It appears that this locality is lower to middle Oligocene in age.

Bear Creek and Hampton Butte localities:

A number of authors (Mote, 1939; Bowman, 1940; Lowry, 1940; and others) have suggested division of the Clarno formation in southern Crook County into a lower and upper member on lithologic grounds. A younger age for an upper division seems also to be justified on the basis of plant fossil differences. Two fossil leaf localities near the junction of the road in the upper Bear Creek Valley (secs. 9 and 17, T. 18 S., R. 17 E.) are mentioned by Lowry (1940). A few specimens from this locality were present in collections at Oregon State College. Although the collection is meager and preservation is only fair, the following could be identified: Thuites sp. Knowlton, Pinus knowltoni, Cercidiphyllum crenatum, Quercus clarnensis, Carpinus grandis, Ostrya oregoniana, Platanus sp., Alnus (?) sp., and Pteris sp. Many of these occur in the Bridge Creek flora (John Day formation) (Chaney 1927, 1952) and it is possible that these localities might be more properly referred to the John Day because of this.

A few miles to the southeast may be found extensive deposits of fossil wood. These have a composition which is closely related to that of the previously mentioned leaf locality, but which also contains a few subtropical species not present in the John Day. The best collecting appears to be in the Hampton Butte area in sec. 36, T. 19 S., R. 19 E., 12 miles north of the Bend-Burns highway. The silicified wood in this area is frequently colored in green or carnelian shades and therefore is highly prized by hobbyists. Approximately three-fourths of the specimens collected by the author in this area were coniferous, half of these being a species of pine similar to that occurring in the John Day formation, but definitely not identical. Cypress and Taxodium (bald cypress) or Sequoia (redwood) also appeared to be present. Of the angiosperms, more than half were a Quercus of the live-oak type. Eleven other genera were distinguished, including Cinnamomum, Magnolia, Ocotea, and Platanus. Palm, tree ferns, Juglans, and most other Clarno type-locality genera were absent.

Specimens of fossil wood were also collected at Lowry's (1940) petrified wood locality (SW corner sec. 8, T. 19 S., R. 18 E.). This locality yielded only conifers (Pinus and Taxodium or Sequoia) and sycamore (Platanus), but there is little question about its contemporaneity with the Hampton Butte locality because of the distinctive coloring of the specimens. Bowman (1940) reported the presence of three fossil leaf horizons in the valley of the south fork of Camp Creek (T. 19 S., R. 21 E.), but preservation was poor and only Platanus and Equisetum could be identified. All of the wood studied was either in situ or traceable to its original source.

Mitchell fossil wood locality:

Silicified wood, similar in appearance and composition to that obtained from the Hampton Butte and Bear Creek areas, may be found 1½ miles south of Mitchell in sec. 15, T. 12 S., R. 21 E., on the east side of Nelson Creek. The locality was discovered by Howard (1955) and mapped as upper Clarno. The wood has been eroded from tuffs and breccias reminiscent of Lowry's and Bowman's "Upper Clarno" member of the Clarno formation. More than half of the specimens from this area are pine, identical with that

found in the vicinity of Hampton Butte. Of the 12 or more angiosperms found at this locality, at least 6 are also identical with those at Hampton Butte. Insufficient work has been done to characterize them completely, but there is little doubt that the flora from both this and the Hampton Butte locality are much more closely related to the subsequent John Day flora than the earlier Clarno type flora. A middle to upper Oligocene age for these localities appears to be justified on the basis of the present evidence.

Conclusion

An examination of the plant fossils from 9 groups of Clarno formation localities in Central Oregon shows such a diversity of composition that it must be concluded that this formation was laid down over a considerable period of time. Best estimates on the basis of floral evidence suggest a range from middle-upper Eocene to middle-upper Oligocene. This conclusion also coincides with that of some of the more recent lithologic studies (Wilkinson personal communication).

Bibliography

Allen, J. E., 1947, Heppner coals, Morrow County, Oregon: Oregon Dept. Geology and Min. Industries mine-file report, 9 pp., incl. maps (unpublished).

Arnold, C. A., 1945, Silicified plant remains from the Mesozoic and Tertiary of Western North America: Mich. Acad. Sci. Papers 1944, vol. 30, pp. 3-34.

_____, 1952, Fossil Osmundaceae from the Eocene of Oregon: Paleontographica, vol. 92, pp. 63-78.

Bowman, F. J., 1940, The Geology of the north half of Hampton Quadrangle, Oregon: unpublished Oreg. State Coll. master's thesis, 71 pp.

Chaney, R. W., 1927, Additions to the paleontology of the Pacific Coast and Great Basin regions of North America: Carnegie Inst. of Wash., Pub. 346, pp. 58-59.

_____, 1936, Cycads from the Upper Eocene of Oregon (abs.): Geol. Soc. Am. Proc., p. 397.

_____, 1948, The Ancient forests of Oregon: Oreg. State System of Higher Educ., Eugene, Oregon, 56 pp.

_____, 1952, Conifer dominants in the Middle Tertiary of the John Day Basin: The Paleobotanist, vol. 1, pp. 105-113.

Hogenson, G. M., 1957, Geology and ground-water resources of the Umatilla River Basin area, Oregon: U. S. Geol. Survey open-file report, March, 1957, pp. 20-21, 23-24.

Howard, C. B., 1955, Geology of the White Butte area and vicinity, Mitchell Quadrangle, Oregon: unpublished Oreg. State Coll. master's thesis.

Knowlton, F. H., 1902, Fossil flora of the John Day Basin, Oregon: U. S. Geol. Survey Bull. 204.

Lesquereux, L., 1883, Cretaceous and Tertiary floras: U. S. Geol. and Geog. Survey Terr. Mon. VIII, pp. 239-255.

Lowry, W. D., 1940, The Geology of the Bear Creek area, Crook and Deschutes Counties, Oregon: unpublished Oreg. State Coll. master's thesis, 78 pp.

Mendenhall, W. C., 1909, A Coal prospect on Willow Creek, Morrow County, Oregon: U. S. Geol. Surv. Bull. 341, pp. 406-408.

Merriam, John C., 1901, A Contribution to the geology of the John Day Basin: California Univ. Dept. Geol. Sci. Bull. vol. 2, no. 9, pp. 269-314.

Mote, R. H., 1939, The Geology of the Maury Mountain region, Crook County, Oregon: unpublished Oreg. State Coll. master's thesis, 79 pp.

Newberry, J. S., 1883, Proc. U. S. National Museum, vol. 5, pp. 502-513.

_____, 1898, Later extinct floras of North America: U. S. Geol. Survey Monograph 35.

Pabst, M. B., 1948, Ferns of the Clarno formation: unpublished Univ. Calif. (Berkeley) master's thesis.

Scott, R. A., 1954, Fossil fruits and seeds from the Eocene Clarno formation of Oregon: Paleontographica, 96B, pp. 66-97.

_____, 1956, Cryptocolax, A New genus of fossil fungi from the Eocene of Oregon: Amer. Journal of Botany, vol. 43, pp. 589-593.

Scott, R. A., and Barghoorn, E. S., 1955, The Occurrence of Euptelea in the Cenozoic of western North America: J. Arnold Arboretum, vol. 36, pp. 259-265.

Stirton, R. A., 1944, A Rhinoceros tooth from the Clarno Eocene of Oregon: Journal of Paleontology, vol. 18, pp. 265-267.

Taylor, E. M., 1960, Geology of the Clarno Basin, Mitchell Quadrangle: unpublished Oreg. State Coll. master's thesis.

Wilkinson, W. D., (compiler), 1959, Gield guidebook, trips along Oregon highways: Oregon Dept. Geology and Mineral Industries Bull. 50.

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ATOMIC RESEARCH PROGRAM AT ALBANY

The U. S. Bureau of Mines has announced plans to build an atomic-research facility at its Metallurgy Research Center in Albany, Oregon. The structure, to be completed within a year, will house 100,000 curies of radioactive cobalt for use in studying the effects of gamma radiation on the properties of minerals and fuels. Preliminary studies by the Bureau of Mines have already indicated that gamma irradiation may help advance mineral processing techniques by altering certain properties of minerals and speeding up chemical reactions.

All safety factors will be incorporated into the design and operation of the laboratory. The radioactive cobalt will be sealed in capsules and housed in a cell-like structure with 4-foot walls of heavy-density concrete. Experiments will be conducted by means of viewing windows and remote-controlled manipulators. Materials removed from the cell will have no residual radioactivity.

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OFFSHORE EXPLORATION PERMITS GRANTED

The State Land Board issued offshore exploration permits to the Shell Oil Company and the Gulf Oil Corporation on June 13, 1961. Shell Oil Company was granted a 120-day permit to conduct seismic shooting in Oregon waters. The seismic boat operated by Shell will carry a representative for the Fish Commission and the Game Commission, who will observe effects of explosives on marine life during the shooting. Gulf Oil Corporation was issued a 90-day permit to conduct nonexplosive seismic surveys. Permits for exploration are non-exclusive and give no preference for leasing.

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MINING NEWS

Eastern Oregon

Rare Metals Corporation has leased the Hulin Quicksilver Claims adjacent to Cave Creek in the Burnt River area in Baker County. A small amount of preliminary exploratory work was done on the property this spring by company geologists.

Test work on a portion of the Pine Creek Placers north of Halfway in Baker County is being continued by the McDonald brothers.

Bill Wood and Bill Close have brought in a drag line in order to continue test work on the O'Brien Creek placer in the Eage Creek area in Baker County.

Southwestern Oregon

Cleanup work is about completed at the Joe-Joe Placer (Ruble) Mine on Upper Coyote Creek, Josephine County, after 3½ months of winter and spring hydraulic operation. The owner-operators, J. E. Fitzpatrick and J. E. Inman, calculate they have "piped" approximately 150,000 cubic yards of gravel through their sluice boxes. Work of cleaning fine gold from crevices in the fractured slaty shale bedrock is tedious but profitable.

A gold-saving circuit has been installed at the Roy Houck & Sons Corp. gravel operation on Foots Creek where dredge tailings are being crushed and screened for highway construction near Gold Hill. The concentrates are recovered from the minus ¼ inch material by means of under currents and a pair of Clark Bowl concentrators. The crushing plant has been operating on a 2-shift basis at the rate of about 500 yards per hour. Work at the project is nearly completed. Gold is being recovered from the concentrates by the Zinc Creek Mining Company mill located in the Illinois Valley between Cave Junction and O'Brien.

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OREGON THESES ADDED TO DEPARTMENT LIBRARY

The following unpublished material has been added to the department library since issuance of a similar list in the October, 1960, Ore.-Bin:

Bateman, Richard L., 1961, The Geology of the south-central part of the Sawtooth quadrangle, Oregon: Univ. of Oregon master's thesis, 97 pp., illus., geol. map. (Area in northern Harney County, contains southernmost extension of the pre-Tertiary inlier of central Oregon, consisting of complexly folded Middle and Late Jurassic marine graywackes, siltstones, and mudstones, overlain by Tertiary basalts and Danforth welded tuff.)

Carnahan, Gary L., 1962, Geology of the southwestern part of Eagle Cap quadrangle, Wallowa Mountains, Oregon: Oregon State Univ. master's thesis, 98 pp., illus., geol. map. (Lower Sedimentary Series, Martin Bridge, and Hurwal formations in overturned anticline represent continuous deposition of about 11,000 feet of Upper Triassic sediments. Overlain unconformably by Columbia River basalt and sculptured by Pleistocene glaciers.)

Howard, John K., 1961, Stratigraphy and structure of the Cape Sebastian-Crook Point area, southwest Oregon: Univ. Wisconsin master's thesis, 52 pp., illus., geol. map. (Area on coast in Curry County. Highly folded and sheared sandstones, greenstone, and serpentine of probable Late Jurassic-Early Cretaceous age overlain by gently folded Late Cretaceous rocks composed of a massive sandstone unit grading into alternating sand-shale unit. Diagnostic marine fossils found in both units.)

Johnson, Arvid M., 1961, Stratigraphy and lithology of the Deer Butte formation, Malheur County, Oregon: Univ. of Oregon master's thesis, 144 pp., illus. (Seven members are recognized: composed of basalts, breccias, and interbedded lacustrine and fluvial sediments, determined to be of late Miocene to possibly early Pliocene age on the basis of the vertebrate fossils.)

Patterson, Peter V., 1961, Geology of the northern third of the Glide quadrangle, Oregon: Univ. of Oregon master's thesis, 83 pp., illus., geol. map. (Lower Eocene marine sedimentary rocks and pillow basalt of Umpqua formation, middle Eocene marine sandstone and siltstone of Tyee formation, late Eocene-early Oligocene Fisher formation of marginal marine-terrestrial sediments and volcanic rocks, Miocene (?) basalt flows, and post Eocene intrusives.)

Payton, Clifford C., 1961, The Geology of the middle third of the Sutherlin quadrangle, Oregon: Univ. of Oregon master's thesis, 81 pp., illus., geol. map. (Map area underlain by early Eocene marine sedimentary and volcanic rocks of Umpqua formation in which 6 units are recognized, unconformably overlain by middle Eocene marine Tyee sandstone.)

Pigg, John H., Jr., 1961, The Lower Tertiary sedimentary rocks in the Pilot Rock and Heppner areas, Oregon: Univ. of Oregon master's thesis, 67 pp., illus., geol. map. (Mapped area underlain by pre-Tertiary metamorphic complex, Eocene sediments, Eo-Oligocene Clarno lavas, and Miocene Columbia River basalt. Makes unit distinction between pre-Clarno sedimentary section and Clarno basaltic lavas.)

Prostka, Harold, 1960, Preliminary report on the geology of the Sparta quadrangle, Oregon: Oregon Dept. Geology and Min. Industries unpublished preliminary report, 5 pp., geol. map. (Summarizes relation of Clover Creek greenstone to other pre-Tertiary rocks in area and interprets age of the greenstone as wholly Triassic.)

Russell, Robert G., 1961, Geology of the Cedar Mountain quadrangle, eastern Oregon (Malheur County): Univ. of Oregon master's thesis, 41 pp., illus., geol. map. (Basaltic to rhyolitic lavas, volcanic sediment, and arkosic sandstone, including silicic lavas and Deer Butte formation [late Miocene], Grassy Mountain formation [Pliocene], and Quaternary basalt and alluvium. Dating of Miocene and Pliocene rocks based on Barstovian and Hemphillian faunas.)

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