Ross Berglund Honored by Paleontological Society

The Paleontological Society has awarded its Harrell L. Stimpson award to Ross E. Berglund for his work with fossil crabs. Ross was praised for his "unselfish spirit of collaboration with researchers that is a large part of ... professionalism."

Ross has had associations with the Thomas Burke Memorial Washington State Museum at the University of Washington and the Natural History Museum of Los Angeles County. He has published several articles on the fossil crabs of Washington and is currently working on new manuscripts. He is also working on a catalog of fossil collecting sites in Washington.

Ross received his B.S. in geology from Washington State University during World War II. To help with the war effort, he put his knowledge of mineralogy to work at the Boeing Airplane Company, where he spent his entire professional career.

Upon retirement 18 years ago, Ross embarked on a new career in paleontology. He maintains a very well-cataloged collection of fossils, which he amassed during his many years of fieldwork. Every collecting locality is numbered, marked on a topographic map, and entered into his permanent logbook. Each specimen collected is then given a unique number. This makes it both easy and useful for other scientists he contacts to help with research on various specimens.

Ross is noted for teaching visitors to fossil collecting how to record what is needed for good science. He places most of the fossils he collects into the custody of the appropriate specialist for that taxon for research and encourages others to do the same.

Stonerose Center Receives Grant

The Stonerose Interpretive Center in Republic has received a $50,000 grant to complete purchase of the fossil site, build an annex to the Center's current facility, provide additional storage and display cabinets, and develop a computer program for use in identifying the fossils. A visit to the Center and meeting with curator Lisa Barkedale and board member Mary Waring in 1994, Representative Helen Snowman proposed a grant and supported the concept throughout the budgeting process. The funds have been allocated through the Washington State Historical Society's budget.

The Center seeks to further educational interest in the exceptionally rich fossil locality, to encourage scientific study of the materials, and to preserve the fossil beds, which are among the few such localities open to the public for collecting. By the end of July this year, the Center had at least 4,000 visitors. The number of both visitors and collected fossil specimens grows rapidly each year.

Stonerose Center hours are Tuesday through Saturday, 10:00 am to 5:00 pm. The Center will close for the winter October 31 and will reopen May 1, 1996.

NEW DIVISION RELEASE

Crown Jewel Project Reaches Milestone
Raymond Laumania, State Geologist
Washington Department of Natural Resources
Division of Geology and Earth Resources
PO Box 47007, Olympia, WA 98504-7007

A series of events in various communities will enhance public awareness about the importance of protecting the state’s natural resources. Just a few of the events scheduled and sources of more information around the state are:

Chelan - Flintsnappping Demonstration
Oct. 7, 10 a.m. - 4 p.m. Lewis County Museum, 599 NW Front St.

DuPont/Northwest Landing and Historic Site Tour and Train Ride
Views on archaeology, research and excavations and ride a narrow-gauge railroad down Squaxinich Canyon to the dock once used by DuPont. At a brown bag lunch on the beach, hear tales about the history and archaeology of the area. After a return trip on the train, tour some of the most significant and accessible sites.
Oct 5 and 7, 9:30 a.m.; Lowest Landing; Participation is limited to 32 persons each day. Register by calling (253) 924-7003.

DuPont - 1843 Fort Nisqually
The Hudson's Bay Company 1843 Fort Nisqually site will be open for public viewing. Oct. 7, 8, 10 a.m. - 4 p.m. For directions, contact the City of DuPont at (253) 964-8121.

Ephrata - Flintsnappping Demonstration
Oct. 7, 5 - 7 p.m. Public Library. Contact Ray Dirks at (509) 754-3971.

Forbes - Underwater Archaeology
Learn about the recent underwater archaeological survey conducted by NOAA in the Olympic Marine Sanctuary. Oct. 7, 9 a.m. - 3 p.m.

Jay Bay - Makah Coastal Village Exhibit
Oct. 4, 10 a.m. - 4 p.m. Makah Cultural and Research Center. Contact museum staff at (360) 645-7347.


North Bend Archaeological Walking Tour (2 miles)
Tour the historic towns of Moncenis and Cedar Falls and a railroad camp. Oct. 7, 10 a.m. Rattlesnake Lake parking area. Group size is limited. To register, contact Marie Ruby at (206) 233-1515.

Pullman Flintsnappping Demonstration
Oct. 6, 13 - 30 p.m. Museum of Anthropology. Contact Joy Mastinjupse at (509) 335-3951.

Richland - Archaeology at Hanford
Series of lectures including Flood Basalt of the Columbia Plateau, Paleocene Eocene Cataclysmic Floods; and Early Man and the Deenaees of Washington Elephants.
Sept. 30, 10 a.m. - 12:30 p.m. Battelle Auditorium, 502 Battelle Blvd. Contact Mona Wright, (509) 752-5470.

Seattle - Archaeology Day
Children can be archaeologists for a day as they practice archaeological ‘detective work’. Bring artifacts for identification by museum staff. Oct. 1, noon - 3 p.m. Burke Museum, 20005 NE 78th St. Contact Ben Stickle, (206) 525-4500.

Shelton - Historic Walking Tour
Self-guided walking tour of the city’s historic stream and creek systems. Oct. 1, 7, downtown Shelton. Contact Joe Williams at (360) 426-9733.
While supplies last...

The Division is making the following reports available at half price, the amount listed below. However, we offer them free to libraries or teachers who use official letterhead to request the copies. If you need multiple copies, please call us because supplies are limited.

For each order, we still ask the customary $1.00 for postage and handling. Only Washington residents may pay the total price; others may deduct the tax. Check or money order should be made out to the Department of Natural Resources, and sent with the order to the Division of PO Box 47007, Olympia, WA 98504-7007.

BULLETINS


70) Zinc and lead ore deposits in carbonate rocks, Steilacoom County, Washington, by L. W. Mills. 1971. 171 p., 70 figs. $ 1.50

Washington coastal geology and Quillayute Rivers, by W. W. Rau. 1980. 57 p., 2 figs. $ 5.70


Burr, 1939. 395 p. $ 15


INFORMATION CIRCULARS

54) A geologic road map over Chimook, White Pass, and the Canion to Yakima Valley roadways, by N. P. Campbell. 1975. 82 p., figs. $ 1.00

59) Washington gravity base station network, by H. T. L. Nelson. 1963. 81 p., 1 fig. $ 1.00

61) Announced guide to sources of information on the geology, minerals, and ground-water resources of the Puget Sound region, Washington, King County section, by W. H. Reichert, with supplemental references by D. D. Deliber. 1981. 83 p., 1 fig. $ 1.50


REPORTS OF INVESTIGATIONS


40) Tin, tungsten, and molybdenum geochronology of parts of Stevens and Spokane Counties, Washington, by R. B. Running. 1985. 57 p., 10 figs. $ 4.00

DAM SAFETY MEETING

7th Annual Canadian Dam Safety Association Conference Banff, Alberta October 2-5, 1995

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Early Tertiary Flowers, Fruits, and Seeds of Washington State and Adjacent Areas

Wesley C. Wehr
Thomas Burke Memorial Washington State Museum
University of Washington, Seattle, WA 98115-3010

INTRODUCTION

Fossil leaves, particularly those that are very well preserved, are valuable tools and clues in the study of modern and fossil plant relationships and evolutionary trends. Because fossil leaves tend to be the most common type of plant fossil found at most sites in western North America, scientists may have depended too heavily on the fossil leaf record to establish these relationships and trends. This has led to some misappréciations concerning flower-plant (angiosperm) evolution. From their studies of leaves, many earlier palaeobotanists were led to present a far more static picture of angiosperm evolution since the Cretaceous than has actually been the case. We now understand that, in some cases, leaves and wood evolved more slowly than plant reproductive structures.

The early Tertiary flowers, fruits, and seeds found in what is now the Okanogan Highlands recorded a rapid appearance and diversification of many plant lineages in upland habitats of that time. A less well known but important Tertiary record for Washington State is the occurrence of fossil fruits and seeds in the lowland floras and, surprisingly, in marine deposits on the Pacific coastline. Palaeobotanists associate these fossil floras of the highlands with warm temperate to subtropical Eocene environments. In contrast, the lowland terrestrial and marine localities in western Washington commonly contain fossil plants that suggest, from the distribution and phylogenesis of their modern descendants, tropical conditions.

Palaeobotanists have assigned some Eocene leaves to modern genera, and many fossil fruits, seeds, and spores found in close association with these leaves or attached to leafy stems are clearly unlike any known modern genus. This is unlike the early Tertiary localities in Western Washington where the fruits and seeds from the Eocene Lower Creek Flora (Collinson, 1983) are particularly well preserved. More recently, Manchester (1994), in his monograph on the middle Eocene Calman flora from Washington State, described and illustrated new fossil records and occurrences of the genera and species. Thirteen of the 32 taxa illustrated in the plates are previously unreported.

Fossil records. Fifty of the taxa and occurrences cited are new additions to the literature about fossil reproductive structures.

GEOLOGIC SETTING

Compared to the enormous diversity of northwest Tertiary floras, especially that of the early middle Eocene Republic, Washington, flora (more than 300 species of fossil plants), early Tertiary fossil flora, such as that in the Fort Union Formation in Wyoming, Montana, and North Dakota, tend to have low diversity. Palaeocene upland floras are not known (Wing, 1987). Wolfe (1987) has proposed that the first major diversification of many of the temperate climate lineages occurred during the Eocene in uplands like those of the volcanic highlands of the Okanogan. The environmental stresses resulting from geologic processes taking place in the Okanogan Highlands during the Eocene were presumably major factors in the appearance of many of the plant families discussed in this article.

During the Eocene, from about 57 million to about 37 million years ago, northern interior Washington State and interior British Columbia were the scene of intensive volcanic activity. The extent and thickness of volcanic deposits indicate that the region known today as the Okanogan Highlands may have been a mountainous area during much of that period (Wing, 1987). The widespread volcanism and associated tectonic uplift had a significant effect on the topography in that region. Uplift divided lowland areas such as the northern Puget Sound region into upland and lowland interior, whereas the region had formerly been a continuous, fairly gentle slope from the eastern Rocky Mountain region to the Pacific coast. Geologic forces formed a series of down-faulted grabens basins from Republic, Washington, to Smithers, British Columbia. Large volcanic sediments accumulated in basin lakes and incorporated plants and insects (Wolfe and Wehr, 1987).

As the landscape continued to develop through the early Tertiary, changes in the plant life were recorded in various sedimentary sequences. Figure 1 is a generalized framework of the age ranges of the formations in which the flowers, fruits, and seeds discussed in this article have been found. Figure 2 shows the locations of the principal Early Tertiary fossil floras.

Geological processes are responsible for an area's altitude and topography, which, in turn, affect characteristics of regional vegetation. Leaf shape, size, and margination, for instance, are demonstrably influenced by the climate in which plants grow (Wolfe and Wehr, 1991). Fossil leaves are important but indirect evidence of paleoclimate—temperature, precipitation, and seasonality. Using fossil leaves, palaeobotanists and palaeoclimatologists can make some general, but necessarily cautious, speculations about ancient climates.

Figure 1. Generalized correlation chart for Tertiary formations or deposits mentioned in this article.

Geologic uplift of the ancient Oolitic Highlands during the Eocene accompanied the appearance of montane forests, upland lakes, and environments unlike any previously known in the fossil record for North America. The cooler climates in these higher altitude woodlands presumably had a role in the appearance of types of plants not found in the floras of coastal British Columbia (at Vancouver) or in the lowland sites near Bellingham. These later forests contained a number of species (such as palm, fern) found now only in Central and South America, and other plants that today are predominantly subtropical to tropical in distribution (see, e.g., Krajina, 1984).

The changing climate in the Oolitic Highlands likely contributed to an apparently high degree of instability in plant and insect communities that, in turn, resulted in the appearance of a large number of plant or insect species. As a result, the communities of plants and animals have been characterized by a high degree of diversity and a high degree of endemism. During an event of regional or environmental change, each individual plant species will have its own unique genetic capacity of coping with such a change; it is not conceivable that all species within a community will have the same response (Manchester and Meyer, 1987, p. 125).

HOW MODERN ARE NORTHWEST TERTIARY FLORAS?

The answer to this question depends on what you compare them to. Compared to Late Cretaceous and Pliocene floras (about 85 million to 57 million years old), the Tertiary floras of Washington could be called modern. Sycamores, laurels, and magnolias can be traced back to ancestors in the Cretaceous. But many other Cretaceous angiosperms cannot be placed in any modern family—or even order. In contrast, no extinct plant families are found, so far, in the Eocene upland floras, notably at Republic, or in the lowland floras of the western part of the state, and only a few extinct families have been recognized. Of the 63 angiosperm genera represented by the flowers, fruits, and seeds included in this survey, 34, or half, are considered to represent extinct genera in modern families. As a result, the measure, Washington’s Early Tertiary floras have more in common with modern plant taxa than with those of the Age of Dinosaurs.

Macey, M. A.: Madin, I. P.; Meier, D. B., 1985, Relative earthquake hazard map of the Glade Creek quadrangle, Clark County and Multnomah Counties, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-90, 1 sheet, scale 1:24,000, with 6 p. text.


Macey, M. A.; Madin, I. P.; Meier, D. B., 1985, Relative earthquake hazard map of the Mapleton quadrangle, Lane County, Oregon: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-92, 1 sheet, scale 1:24,000, with 6 p. text.

NATIONAL LANDSLIDE AWARENESS DAY

October 11, 1995, has been designated National Landslide Awareness Day by the Association of Engineering Geologists. In late 1994, the Committee on Landslides proposed to the management board of the Association that a day be selected for a concerted effort to disseminate information about this geologic hazard to the general public.

Each section of the association will be presenting a free forum about the landslide hazard in its areas. Among other purposes of this selected day is helping the public be better informed about the landslide hazard reduction efforts of geotechnical engineers. This work is working with the U.S. Geological Survey to ensure that the agency’s efforts are publicized.

Landslide Awareness Day was proposed because a major premise of the International Decade of Natural Disaster Reduction is that application of what is now known about these hazards can significantly reduce human and property loss. The decade reached its midpoint in 1995.

The Division of Geology and Earth Resources lists its reports on landslides and slope stability in its recently updated (free) list of publications, and the Division’s bibliography, both the cumulative versions and those prepared annually for selected counties, contain references to articles and books about these hazards in Washington.
PAPERS ON WASHINGTON GEOLOGY


Krien, B. J.; Hawley, D. L.; Chappelar, F. D.; Mack, P. D.; Chan, A. F., 1995. Spatial and temporal relations between early Tertiary submergence and extension in NW Washington. The landward extent of Eocene fossil flora was characterized by-wind-pollinated conifers as pine, spruce, and hemlock. The rocks contain early Miocene records of many conifer taxa (true fir, hemlock, and cedars, among others) that are now found only in China and Japan.

The understory is not as well represented in the Russian fossil record. Rare records find, such as clumps of lower mottling of coniferous, deciduous, and especially the many species of the rose family (with 30 rosaceous genera recognized to date), are gradually allowing us to draw a more complete picture of the forest in this region. The presence of so many species of fruit-bearing trees and shrubs that, at that time, the Eocene fossil woods was also the scene of large species diversity, especially the various groups of pollinating insects, especially bees, wasps, flies, beetles, and moths (Wehr, in press).

The lowland understory is not very well defined. We know there were ferns in the undergrowth, but there is much left to be studied. (See Muste and Gannaway, 1995.)

The FOSSIL EVIDENCE

Assigning a fossil leaf type to many different and unrelated uncalibrated and leave collections is not a necessary step in fossil leaf identification. In fact, the paleobotanical literature abouts with this kind of conflict in identification. For this reason, the presence of large leaves of flower and seeds have become important clues to the aquatic aspects of the Eocene environment. No fossil leaves have been found.

WHAT WERE VEGATATION LOOK LIKE IN THE EARLY TERTIARY?

There is a wealth of fossil leaf material available from which to start making fossil plant reconstructions—but from what can be reconstructed a lot of certain or interesting if it were not for fossil flowers, fruits, and seeds. Some of the plant lineages (alder, elm, walnut, and hydrangea, for example) that occur in the fossil leaf rich of the Eocene. The leaves in the Pacific Northwest and Eocene lowland flora. The acclimatization of such formerly forested and sub-tropical lineages to upland, cooler climates (alder, walnut, and cedars, among others) and many that are now found only in China and Japan.

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the next pages briefly describe the fossil reproductive structures that have been found in the Lower Tertiary localities in Washington, Oregon, and adjacent parts of Canada that, together with leaves, are helping us understand this part of geo-logic time.

Water-Lily Family (Nymphaeaceae)

The presence of the water-lily family is based on a single Nuphar thomasi from the Princeton (BC) Coalasment Bluff (also known as Tulameen Road, Allenby Formation) locality and permineralized fruits and seeds of an extinct genus, Allen- bya, from the Princeton chert locality (Cavallo-Ferriz and Stockey, 1989). Also Allenbya fructus of closely associa- ted leaves and fruits, for example, is very helpful in recognizing their relationships and affinities.


Open-File and Water-Resources Investigations Reports


OTHER REPORTS ON WASHINGTON GEOLOGY


Mason County Department of Community Development, 1995. Final environmental impact statement comments and responses to comments—Johns Prairie sand and gravel excavation and barge-loading facility: Mason County Department of Community Development, 1 v.

Mason County Department of Community Development, 1995. Final environmental impact statement—Johns Prairie sand and gravel excavation and barge-loading facility: Mason County Department of Community Development, 1 v.

Mason County Department of Community Development, 1995. Final environmental impact statement technical appendices—Johns Prairie sand and gravel excavation and barge-loading facility: Mason County Department of Community Development, 1 v.


Ceratophyllum Family (Ceratophyllaceae)

This is a monotypic family—its consists of a single genus and species, Ceratophyllum marianum Chamisso. Fossil fruits of Ceratophyllum occur in the middle Eocene Rinent Formation near Issaquah (Plate 1, fig. 1) and in the Eocene Green River Formation in Wyoming (Herendine and others, 1990). They are also recorded from the Paleocene Fort Union Formation in Montana (Brown, 1962). This aquatic herb is found worldwide today.

Moonee Family (Menispermaceae)

This family is now mainly tropical and consists of about 65 genera, mostly lianas. It is well represented in the tropical London Clay (southern England) and Clare Formation (Ore-
Selected Additions to the Library of Geology and Earth Resources

May 1995 through July 1997

THESSES
Chandler, Lynn, 1995. Internship with the Darrington Ranger District, Washington Department of Natural Resources. Western Washington University, Bellingham.


Inclu...

in the relative completeness of its original floral structure. The specimen shown in Plate 2, figure 2 is typical of the majority of finds; the side view (Plate 2, fig. 4) is rare.

F. qilinchenis also occurs at Princeton (Whipsaw Creek) (Allenby Formation), Quilchena (Coldwater Beds, Kamloops Group), and McAfee (Tranquille Formation, Kamloops Group) (K. W. Pugh, unpub., BC, written comm., 1995), as well as at Gambout Mountain (Fig. 2).

Elm Family (Ulmaceae)

Chaeotheptes, Zelkova, elm (Ulmus), and an undescended extinct Ulmus genus occur commonly at Republic, but only one type of elm fruit is recorded. Being found only in association rather than in whole plant attachment, the leaf and fruit affinities have been, at best, speculative. However, a recent find at the Princeton One Mile Creek locality of several specimens of a single type of fossil umilaceous leaves and fruits attached to stems has finally resolved at least part of the question at that locality (Manchester, 1989).

“Leaves of the Mexican elm (Chaeotheptes) and of Chinese elm (Zelkova) can be so similar that it is difficult to identify isolated leaves with certainty. Leaves of this general type are common at Princeton. Because this two modern genera are readily distinguished by their different


Extra Copies of U.S. Geological Survey Reports Available

The following U.S. Geological Survey publications on Washington State were to be made available to interested parties at no charge. We have multiple copies of some titles. To obtain copies, write, call, fax, or e-mail with your complete mailing address to:

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OPEN FILE REPORTS


ing fruit morphology, the recent discovery of fossil branches with flowers [Plate A, fig. 5] has been important in the identification of the Princeton elm. These branches show winged fruits of the type found only among species similar to the Mexican elm. This discovery proves that, while not all of the elm family leaves at Princeton correspond to Chiaspoteca. The leaves on modern Chiaspoteca have been considered to be affinities. Zelkova leaves typically have simple leaves, but Chiaspo-
teca may have both simple and compound leaves (S. R. Manchester, Field Museum of Natural History, written comm., 1994).

Cedrela odorata, an extict genus, occurs as leaves and fruits in the Quillifera flora (R. W. Mathews, Simon Fraser Univ., oral commun., 1993).

Oak Family (Fagaceae)
Fagus grandifolia (Kawlowski) Wolfe and Wehr occurs at Rep-ublic and Princeton as isolated leaves. Fossil fruits of this extinct fagacean genus have been found at the Reser Creek [Klondike Mountain Formation] near Republic (Plate 2, fig. 7). The fruits are of the type Eocene (34.1 m.y.) Florissant (Colorado, Florissant Formation) flora consists of simple leaves and fruits preserved in association to vegetative shoots (Manchester and Crane, 1983). This interest link between fruits and foliage is necessary when attempting to reconstruct a whole plant.

Quercus (oak) is represented in the Republic flora by two leaf specimens from a single leaf fossil of the One Mile Creek (Princeton) flora (Maria Gandolfo, Cornell Univ., written comm., 1994). The oldest known oaks (Quercus palaeocarpos Archangelsky) occur in the Clarino Formation (Manchester, 1994). Although Eocene oaks are unknown from Washington, acorns have been found in the Miocene fossil flora of the Columbia River basin in Xyakima Canyon (K. Pigg, Arizona State Univ., written comm., 1995). Oak-like acorns and leaves also occur in these Miocene interbeds at Bristol, near Thorp, Kittitas County (D. Q. Hopkins, Burke Museum, oral commun., 1994).

Birch/Alder Family (Betulaceae)
Betulaceae leaves are common at many Tertiary Washington localities, in fact, Minus puripilus (Berry) Wolfe and Wehr leaves are the most common leaf type found at Republic, and birch (Betula leopoldae Wolfe and Wehr) leaves dominate the organic remains from the Olive Creek Formation at Olalla (Stockey, 1986). Betulaceae leaves, especially when they are not well preserved, can be difficult to identify. Closely associated fruits and seeds, pollen very similar to those of modern birch and alder occur at Republic, Princeton, and Mcabee and further confirm the presence of these genera in the Middle Eocene.

A few hazel-like fruits have been found at Republic. Similar fossil nuts from Palaeocline localities (in Mull, Scotland, in Montana, and in northwest Greenland) have been re-

plicates of Corylopsis similar to Corylopsis, a very democratic one. In fact, many of the existing and com-

mon fossil taxa (in the Republic cover photo) and elsewhere were made by sharp-eyed collectors that had the persistence to keep searching the fossil-bearing rock until something worth-while appeared. Fossil plants can be found in a variety of sedi-

mentary environments that range from the large-lake fossil found in the updike lake beds of the Okanagon highlands to the silts and sandstones in the marine environments of western Washington. The hunt for exciting new kinds of fossils continues, as plants or insects or vertebrates, can take place anywhere one can reasonably expect to find such re-

 mains preserved.

ACKNOWLEDGMENTS
This article has benefited from technical reviews by, or con-

versations with Lisa Barksdale, Ross Berglund, Victor Call, James Goedert, Donald Hopkins, Kirk Johnson, Estella Leopold, V. S. Mallory, Steven Manchester, Jeffrey Myers, Ruth Stockey, and many other botanists. Photographs by photographers Lisa Barksdale, Donald Hopkins, Steven Man-
tchester, Jeffrey Osborn, Mary Randlett, Ruth Stockey, and Alan Yan.

SELECTED REFERENCES


Cevallos-Ferriz, S. R. S. Stockey, R. A. Stockey, 1988a, Permineralized fruits and seeds from the Princeton Chert (middle Eocene) of British Columbia—Canada: American Journal of Botany, v. 75, p. 1099-
1105. The Group near E. E. West Branch Creek, Oregon, in the Clarino Formation. A single fossil seed of Cupressus was found in a mass of carbonized lichens with small fragments of woody debris in deep-water strata of the lower Oligocene part of the Makah Formation at Shipwreck Point, Clallam County (Goedert and Cevallos-Ferriz, 1991). Cevallos-Ferriz, S. R. S. Stockey, R. A. Stockey, 1988b, Permineralized fruits and seeds from the Princeton Chert (middle Eocene) of British Columbia—the west coast of Canada—Canada: Canadian Journal of Botany, v. 66, p. 303-312.

217.

297.

379.


Washington Geology, vol. 23, no. 3, September 1993
Calycites ardensiana Crane (extinct genus)

This fossil wood (Plate 5, fig. 5) has been compared to similar fruits of Abelia, a genus in the honeysuckle family (Caprifoliaceae). Calycites is a form genus (a “catch-all” name that is used for flowers whose affinities are unknown). This species is similar to a type described from the early Eocene of England. Four examples have been found at Republic. It has also been recorded from the Paleocene of Mull, Scotland, the Fort Union Formation of Wyoming, and in the Eocene Clarno Formation of Oregon.

The presence of Calycites ardensiana is in early Eocene floras of Europe and western North America, suggesting that the flora was widespread during the Paleogene (Crane, 1988).

Pittilloptillites wilsonii Stockey and Manchester (extinct genus)

This superbly preserved fossil flower (Plate 5, fig. 6) is from an unnamed middle Eocene beds at Horsey, BC, contains pollen that is very similar to that of the extinct pollen taxon Pittilloptillites macgregorioides. The flower is distinctly different morphologically from the only known other type of fossil flower that contains similar pollen—a flower from the Eocene of Texas tentatively assigned by Crepet and Daghian (1981) to the giannt family. Four extant but unrelated angiosperms families have pollen with ornamentation that is similar to these, and the Texas and Texas plants. The fact that none of these Pittilloptillites-producing flowers is closely related indicates that this type of pollen may have arisen concomitantly during the Denver, oral commun., 1995). Paleocarya wolfi Manchester winged fruits occur in the Eocene Puget Group near Durham in King County. Engelhardia-like fruits also occur near Durham (J. A. Wolfe, Univ. of Arizona, oral commun., 1992). Engelhardia is presently restricted to Malaysia and the Himalayas.

A Playacarya-like floral structure is recorded from the Rosslyn Formation at Ronald, near Cle Elum. Playacarya currently occurs only in eastern China and Japan.

Hydrangea Family (Hydrangeaceae)

Hydrangeas have been found in the Eocene Chuckanut Formation near Bellingham (S. R. Manchester, oral commun., 1994) and at two localities in the Eocene Puget Group near Issaquah (J. A. Wolfe, oral commun., 1991).

Curtin Family (Grossulariaceae)

Well-preserved Ribes (currant, gooseberry) fruits occur in the Princeton chert flora. Ribes leaves have been found in the nearby Princeton localities at One Mile Creek and Coolston Bluff (or Tulameen Road). A primitive form of Grossularia leaf, collected at One Mile Creek, may represent an undescribed genus.

Rose Family (Rosaceae)

A Rubus fruit is recorded from the early Eocene London Clay flora (Collinson, 1983). The London Clay flora contains remains of many fossil fruits and seeds whose descendent are mainly temperate; this leads us to believe that the flora represents a typical climate during the Eocene. Some, however, have characteristics of those found in more temperate regions.

While 16 genera of rosaceous leaves occur at Republic, no rosaceous fruits or seeds have been recognized there. The Princeton chert locality, however, contains superbly preserved flowering specimens of Paleosor (Plate 3, fig. 6), the oldest known flower in the rose family. Its structure suggests that it was pollinated by insects (Cevello-Ferriz and others, 1995).

An especially remarkable find was made in the 1950s in the Yakima Canyon Miocene interbeds by T. H. Tuggle—a silicified flower.

The numerous rosaceous genera and species found in the Okanagan Highlands, especially at Republic and Princeton, indicate that the rose family was undergoing a major diversification in upland warm-temperate/subalpine forests during the early middle Eocene. More than 25 rosaceous genera and more than 30 rosaceous species have been identified, and at least 20 types have not yet been thoroughly studied.

The prunoid group (cherries) is especially well represented at Republic and Princeton and, to a lesser degree, in the Miocene. Three family—Praum (cherries) are well-permineralized fruits and seeds are found in the Princeton chert (Cevello-Ferriz and Stockey, 1991). At least two species of cherry leaves occur at Princeton and One Mile Creek locality. Pr Armenia also occurs in the Clarno Formation and Miocene beds. There is a good record of the Prunioidea (a subfamily of Rosaceae) fruits in the European Tertiary (Manchester, 1994).

Loosestrife Family (Lythraceae)

Two genera of lythraceous fruits and seed remains occur in the Princeton chert flora (Cevello-Ferriz and Stockey, 1988b). (Decodon seeds are common in the Princeton cherts; this is not surprising, considering that a mature Decodon plant can produce 2 million tiny seeds.) One of these genera, Decodon albens, is Cevello-Ferriz and Stockey, also occurs in the Princeton flora as a Decodon-like leaf at Tulameen Road locality. The presence of lythracea, based on leaves, fruits, and seeds, supports the idea that plants at the Princeton chert and Tulameen Road localities inhabited the margins of aquatic environments. Modern swamp willow (Decodon verticillatus) now grows near lakes and marshes. The other type of lythraceous fruit found in the Princeton chert flora resembles that of the wetland plant looserstrife Lythrum.

Decodon fruits also occur in the Clarno Formation and Miocene beds and are well represented in many European Tertiary fossil records (Manchester, 1994). Neither Decodon nor Lythrum is now native to the Northwest.

Myrtle Family (Myrtaceae)

Pigg and others (1993) have reported permineralized guava fruits and seeds (Paloemomyrtus praeclara Pigg, Stockey, and Maxwell) from the Princeton chert locality. The family is now widely distributed, ranging from areas with temperate to tropical climates.

Pea Family (Leguminosae/Fabaceae)

Legume pods, seeds and leaves occur in the lower and middle Eocene Swick Formation at Bleevert Pass, in the Rosslyn Formation at Ronald, and in the Chuckanut Formation at Kelso (D.Q. Hopkins, Burke Museum, oral commun., 1995). The only record of this family in the Okanagan Highlands flora is a single legume leaflet found at Republic.

Soapberry Family (Sapindaceae)

Sapindaceae winged fruits (formerly called "Acer arenarium" Heer) have recently been redescribed as a new genus, Desvaria, by Manchester (1994). These fruits occur at Republic (Plate 3, fig. 7). Princeton (Wispaw Creek), Quilchena, and McAbee.

On the basis of three examples (three from Republic and one from Princeton) of (tricolour or three-part) winged fruits, another extinct new genus, Holonia (Plate 3, fig. 8), has been described by Wolfe and Wehr (1987). These fruits were previously assigned to the modern Chinese maple family genus Dimeronia.

Fossil seed-bearing capsules similar to those of Nothracena, now native only to China, occur commonly at Republic (Plate 3, fig. 9).

Wehrwoolga, the oldest known sapindaceous fossil, occurs only at the Princeton chert locality (Plate 3, figs. 10-11). This superbly preserved flower contains the original pollen. Although its floral and pollen morphology are similar to that of the maple family (Aceraceae), detailed features indicate a closer affinity with the Sapindaceae (Erwin and Stockey, 1990).
Maple Family (Aceraceae)

Seven species of maple have been described from Republic. Of these, six are based on their winged fruits, and one species, *Acer washingtonensis*, has been named from leaf material (Walter and Tamar, 1987). An undescribed new species of winged fruit from Republic (Plate 4, fig. 1) probably represents an early new record for the silver maple lineage (J. A. Wolfe, Univ. of Arizona, oral commun., 1991). Four of the Republic species also occur in essentially coeval deposits at Princeton. Acer species also are present in the Gumbo Mountain flora.

Dogwood Family (Cornaceae)

The presence of a fossil of the extinct genus *Mastissodiarium* in the upper Eocene Quimper Formation at Oak Bay in Elam County (also found at Claren) suggests a tropical climate for that flora and for the marine invertebrate fauna.

“A Mastissodiarium-like fruit in the Princeton chert appears to most closely resemble *Mastissodiarium* [also found in the Claron beds]” (B. LePage and R. A. Stockey, Univ. of Alberta, written commun., 1995).

Palaeophytoctene fruits are present in the middle Eocene Sauck Formation near Blewett Pass. A fossil fruit similar to the extinct genus *Herbertia* occurs in the Clackamas Formation near Bellingham. This genus was first described from the Clarno Formation nut beds (Manchester, 1994). The presence of herbertian fruits in the Roysly, Clackamas, and Swack floras and in marine deposits at the Elwha River supports other fossil evidence (tropical plants and marine invertebrates, as well as the tropical implications of the Clarno) that these floras represent lowland tropical climates.


Palaeophytoctene fruits are common in the Clarno nut beds. They occur in the Oligocene Gray Butte (southwest of Clarno), Dogot Gulch (a few miles north of Clarno) (John Day deposits), and Willamette floras of southwestern Oregon (Manchester, 1994). A single *Palaeophytoctene* fruit is recorded from the Eocene Eugene Formation at Eugene (G. Retallack, Univ. of Oregon, oral commun., 1992).

Grape Family (Vitaceae)

Fossil seeds of the modern grape genus *Ameghloperia* occur in the Princeton chert flora (Cevallos-Ferriz and Stockey, 1998), and grape seeds have been found at the Vermilion Bluff (Allleny Formation) locality at Princeton. A single vitacean seed has been recorded from the Republic flora (Plate 4, fig. 3, M.3). Siliquified grape seeds also occur in the interbeds between the Miocene basin flows in Yakima Canyon. These provide a 15-million-year-old fossil record for grapes in the same area where vineyards and the Washington State wine industry flourish today.

A single fossil grape seed is recorded from the Eocene Swack Formation at Blewett Pass. Seeds of this new tropical and subtropical family are common in the Clarno Formation and Lendon clay floras.

Olive Family (Oleaceae)

Fruiting winged seeds occur in the Quilchena flora (Plate 4, fig. 4). Although *Fruiting* seeds are also recorded from Eocene floras in California (Chalk Bluffs flora, John Formation), Tennessee (Clafus flora, Clafus Group), Oregon (Clarno Formation), and Colorado (Green River Formation), they are absent from Eocene floras of Europe and Asia. Together, these North American fruits represent the oldest unequivocal records, based on fruits and leaves, of *Fruiting* and the olive family (Call and Dilcher, 1992).

“Many fruits of the buckwheat, oats, and other grasses such as the timothy, are present in the fossil flora of the Princeton Formation in the Clarno beds” (B. LePage and R. A. Stockey, Univ. of Alberta, written commun., 1995).

Gardenia/Coffee, Quinine Family (Rubaceae)

The Rubaceae family is now distributed worldwide, especially in tropical to warm temperate settings. The fossil record of this family is rather poorly known. The earliest record of fruits of the Rubiaceae is from the Clarno Formation (Manchester, 1994). The fossil record in the Okanagan Highlands during the middle Eocene consists of a single fruit from Republic.

Catalpa Family (Bignoniaceae)

This family is mainly tropical, primarily distributed in South America. Bignoniaceae fossil seeds have been found in the Republic flora (Plate 4, fig. 5). Similar fossil seeds have been recorded from the Palmerville Part Union Formation of Montana (Brown, 1962).

Morning Glory Family (Convolvulaceae)

Flower-like fossil fruits (Plate 4, fig. 6) previously assigned to the sanac family genus *Asaronia* (Asaraceae) have recently been restudied and assigned to Porana, a tropical genus in the Convolvulaceae now found in Asia, northern India, and Burma (5. R. Manchester, Univ. of Florida, oral commun., 1995).

Well-preserved *Porana* fruits occur at Whitlaw Creek at Princeton (K. Pugh, Sardis, BC, written commun., 1995).

Aram Lily/Calla Lily Family (Araeceae)

Kerstoepea, an extinct genus in the Araeceae, occurs in the Princeton chert flora as fruits and seeds. Araeceae is a monotypic family now found in tropical and subtropical and temperate areas (Cevallos-Ferriz and Stockey, 1988a).

Mystery Plants

The following are distinctive flowers, fruits, and seeds, but their affinities are still unknown.

*Pteronemolus* wadei Manchester (extinct genus)

Although some of the scientific names given to fossil plants may sound meaningless to a nonspecialist, when they were transferred to their Greek or Latin roots, the names can be quite apt. *Pteronemolus*, for example, breaks down into *pterow* (winged) and *eodes* (stranger), which aptly describes this odd fossil fruit (Plate 4, fig. 5). We haven’t the writer’s idea as to what it might be related to. It is present in the Eocene Clarno Formation in Oregon and at Republic, but it has not been found with any attached or even closely associated leaves.

Princetonia albenopsis Stockey and Pigg (extinct genus)

This superbly preserved fossil fruit (Plate 5, figs. 2-4) has been found only at the Princeton chert locality. Its unique combination of floral reproductive characters suggests it may represent an extinct family of aquatic Magnoliidae (Stockey and Pigg, 1991).

“A well-preserved coelocryptous *Phormia*-like Eocene fungus (form division Fungi Imperfecti) has been found causing a black spot on the Republic floras. Both the Princeton chert, Pathogenesis and decay of fruits and seeds by this coelocryptous mold...appear comparable to modern fungal blight (Note) (G. Hill-Rackett and R. A. Stockey, Univ. of Alberta, written commun., 1995).

Maple Family (Aceraceae)

Seven species of maple have been described from Republic. Of these, six are based on their winged fruits, and one species, *Acer washingtonianum*, has been named from leaf material (Wulf and Tanna, 1987). An undescribed new species of winged fruit from Republic (Plate 4, fig. 1) probably represents a new and rare species of the silver maple lineage (J. A. Wolfe, Univ. of Arizona, oral commun., 1991). Four of the Republic species also occur in essentially conical deposits at Princeton. Acer seeds are also present in the Gumboot Mountain flora.

Dogwood Family (Cornaceae)

The presence of a fossil of the extinct genus *Mastissiodora* in the upper Eocene Quinnem Formation at Oak Bay in recorded in the Elgin County (also found at Clarno) suggests a tropical climate for that flora and the marine invertebrate fauna.

"A Mastissia-like fruit in the Prinecten chert appears to most closely resemble *Mastissiodora* [also found in the Clarno beds]" (B. E. LePage and R. J. Stockey, Univ. of Alberta, written commun., 1995).

Palaeocarya fruits are present in the middle Eocene Swaksa Formation near Blevett Pass. A fossil fruit similar to the extinct genus *Palaeocarya* occurs in the Chukakin Formation near Bellingham. This genus was first described from the Clarno Formation nucells (Manchester, 1994). The presence of *Palaeocarya* fruits in the Roslyn, Chukakin, and Swaksa floras and in marine deposits at the Elwha River supports other fossil evidence (tropical plants and marine invertebrates) as well as the tropical implications of the Clarno that these fossils represent lowland tropical climates.


Palaeocarya fruits are common in the Clarno nucells. They occur in the Oligocene Gray Butte (southeast of Clareo), Dugout Gulch (a few miles north of Clareo) (John Day deposits), and Willamette floras of northern Oregon (Manchester, 1994). A single Palaeocarya fruit is recorded from the Eocene Eugenia Formation at Eugene (G. Retallack, Univ. of Oregon, oral commun., 1992).

Grape Family (Vitaceae)

Fossil seeds of the modern grape genus *Amelobium* occur in the Prinecten chert flora (Cevallos-Ferriz and Stockey, 1980), and grape seeds have been found at the Vermilion Bluff (Albany Formation) locality at Princeton. A single vitaceous seed is recorded from the Republic flora (Plate 4, fig. 3, loc. B4131). Sclerified grape seeds also occur in the interbeds between the Mocene and the Mifen formations in the Yakima Valley. These provide a 15-million-year-old fossil record for grapes in the same area where vintners and the Washington State wine industry flourish today.

A single grape fossil seed is recorded from the Eocene Swaksa Formation at Blevett Pass. Seeds of this type tropical and subtropical family are common in the Clarno Formation and Laxon clay floras.

Olive Family (Oleaceae)

Frasinus winged fruits occur in the Quinichena flora (Plate 4, fig. 4). Although Fraxins are also recorded from Eocene floras in California (Chalk Bluffs flora), some from Tennessee (Clairborne Bluffs, Claiborne Group), Oregon (Clarno Formation), and Colorado (Green River Formation), they are absent from Eocene floras of Europe and Asia. Together, these North American fruits represent the oldest unequivocal records, based on fruits and leaves, of Fraxins and the olive family (Call and Ditrich, 1992).

As mentioned by Mathews and Droolie (1971), the attachment of these seeds at Quinichena to the pile that bore them is a rare occurrence in the fossil record and suggests that they were not transported far from the site they grew in prior to being entombed in the sediments in which they were preserved" (V. Call, Florida Natural History Museum, written commun., 1995).

Gardenia/Coastella, Quinine Family (Rubaceae)

The Rubaceae are now distributed worldwide, especially in tropical areas with warm temperate settings. The fossil record of this large family is rather poorly known. The earliest record of fruits of the Rubiaceae is from the Clarno Formation (Manchester, 1994). The fossil record in the Okangan Highlands during the middle Eocene consists of a single fruit from Republic.

Catapla Family (Bignoniaceae)

This family is mainly tropical, primarily distributed in South America. Bignoniaceous fossil seeds have been found in the Republic flora (Plate 4, fig. 5). Similar fossil seeds have been described from the Palaeocene Fort Union Formation of Montana (Brown, 1962).

Morning Glory Family (Convolvulaceae)

Flower-like fossil fruits (Plate 4, fig. 6) previously assigned to the samac family genus *Aspogon* (Anacardiaceae) have been recently restudied and assigned to *Porana*, a tropical genus in the Clarno Formation (Curcu, 1985).

Well-preserved *Porana* fruits occur at Whistab Creek at Princeton (K. Pugh, Sardis, BC, written commun., 1995).

Arum Lily/Calla Lily Family (Araceae)

Kratosperma, an extinct genus in the Araceae, occurs in the Princeton chert flora as fruits and seeds. Araceae is a monotypic family now found in tropical and subtropical and in some temperate areas (Cevallos-Ferriz and Stockey, 1988a).

Mystic Plants

The following are distinctive flower, fruits, and seeds, but their affinities are still unknown.

*Pteronemophyllum* weebrii Manchester (extinct genus)

Although some of the scientific names given to fossil plants may sound meaningless to a nonspecialist, when they are translated from their Greek or Latin roots, the names can be quite apt. *Pteronemophyllum*, for example, breaks down into *pterion* (winged) and *epyctis* (stranger), which aptly describes this odd fossil fruit (Plate 4, fig. 1). We haven't the writer the time to discuss what it might be related to. It is present in the Eocene Clarno Formation in Oregon and Republic, but it has not been found with any attached or even closely associated leaves.

*Prickcionis* allenbyensis Stockey and Pigg (extinct genus)

This superbly preserved fossil flower (Plate 5, figs. 2-4) has been found only at the Princeton chert locality. Its unique combination of floral reproductive characters suggests it may represent an extinct family of aquatic Magnoliidae (Stockey and Pigg, 1991).

A well-preserved coelocysteous *Pleisocoele* fungus (form division Fungi Imperfecti) has been found causing a fungal blight described from the Republic floras of the Princeton chert. Pathogenicity and decay of fruits and seeds by this coelocysteous mold...appear comparable to a modern fungal blight syndrome" (G. Hill-Rackette and R. J. Stockey, Univ. of Alberta, written commun., 1995).
Calycites arundinaceus Crane (extinct genus)

This fossil fruit (Plate 5, fig. 5) has been compared to similar fruits of *Abelia*, a genus in the honeysuckle family (Caprifoliaceae). *Calycites* is a form genus (a 'catch-all' name that is used for flowers whose affinities are unknown). This species is similar to a type described from the middle Tertiary of England. Four examples have been found at Republic. It has also been recorded from the Paleocene of Mull, Scotland, the Fort Union Formation of Wyoming, and in the Eocene Clarino Formation of Oregon.

The presence of *Calycites arundinaceus* is extinct Tertiary flora from Europe and western North America fauna emphasizes the strong floristic similarities that existed between these two regions during the Paleogene (Crane, 1988).

Pittosporum lanfolium Stockey and Manchester (extinct genus)

This superbly preserved fossil flower (Plate 5, fig. 6) from an unnamed middle Eocene beds at Horsetly, BC, contains pollen that is very similar to that of the extinct pollen taxon *Pittosporum lanfolium maclurei* from Oregon. This flower is distinctly different and morphologically from the only known other type of fossil flower that contains similar pollen types—a flower from the Eocene of Texas tentatively assigned by Crepet and Daghian (1981) to the gentry family. Four extant but unrelated angiosperm families have pollen with ornamentation that is similar to these from the Palaeogene and Texas plants. The fact that none of these *Pittosporum* producing flowers is closely related indicates that this type of pollen may have arisen concurrently during the Devonian, oral commun., 1995]. *Paloearcocyx wolfei* Manchester winged fruits occur in the Eocene Puget Group near Durham in King County, England. *Engelhardtia*-like fruits also occur near Durham (J. A. Wolfe, Univ. of Arizona, oral commun., 1992). *Engelhardtia* is presently restricted to Malaysia and the Himalayas.

A *Placypus*-like floral structure is recorded from the Roslyn Formation at Ronald, near Cle Elum. *Placypus* currently occurs only in eastern China and Japan.

Hydrangea Family (Hydrangeaceae)

Hydrangea flowers have been found in the Eocene Chuckanut Formation near Bellingham (S. R. Manchester, oral commun., 1994) and at two localities in the Eocene Puget Group near Issaquah (J. A. Wolfe, oral commun., 1991).

Currant Family (Grossulariaceae)

Well-preserved Ribes (currant, gooseberry) fruits occur in the Princeton chert flora. Ribes leaves have been found in the nearby Princeton localities at One Mile Creek and Coolain Bluff (formerly Tulameen Road). A primitive form of *Grossularia* leaf, collected at One Mile Creek, may represent an undescribed genus.

Rose Family (Rosaceae)

A Rubus fruit is recorded from the early Eocene London Clay flora (Collinson, 1983). The London Clay flora contains remnants of many fossil fruits and seeds whose descendants are mainly tropical; this leads us to believe that the flora represents a tropical climate during the Eocene. The same conclusion is reached by others who have studied the Clarno fossil flora. Therefore, palynologists conclude that plant species that occur in Washington or in the London Clay and the Clarno were adapted to tropical settings. Some of the Washington plants found with the 'tropical taxa' however, have characteristics of those found in more temperate regions.

While 16 genera of roseaceous leaves occur at Republic, no roseaceous fruits or seeds have been recognized there. The Princeton chert locality, however, contains superbly preserved flowering specimens of *Paleosorbus* (Plate 3, fig. 6), the oldest known flower in the rose family. Its structure suggests that it was pollinated by insects (Ceavallos-Ferriz and others, 1995). An especially remarkable find was made in the 1950s in the Yakima Canyon Miocene interbeds by T. H. Tuggle—a silicified rose stem.

The numerous roseaceous genera and species found in the Okanagan Highlands, especially at Princeton and Pinetown, indicates that the rose family was undergoing a major diversification in upland warm-temperate/subtropical forests during the middle Eocene. More than 25 roseaceous genera and more than 30 roseaceous species have been identified, and at least 20 types have not yet been thoroughly studied.

The prunoid group (cherries) is especially well represented at Republic and Princeton and, to a lesser degree, in the Clarno Formation. Prunus species are characterized by petals (cherries) and the flowers have a single ovary with one (stamens); fruits and seeds are found in the Princeton chert (Ceavallos-Ferriz and Stockey, 1991). At least two species of cherry leaves occur at the Princeton One Mile Creek locality. Prunus fruits also occur in the Clarno Formation wood beds. There is a good record of the *Prunusidae* (a subfamily of *Rosaceae*) fruits in the European Tertiary (Manchester, 1994).

Loosestrife Family (Lythraceae)

Two genera of *Lythraceae* fruits and seeds remain in the Princeton chert flora (Ceavallos-Ferriz and Stockey, 1988b). (Decodon seeds are common in the Princeton cherts; this is not surprising, considering that a mature *Decodon* plant can produce 2 million tiny seeds.) One of these genera, *Decodon albensis* Ceavallos-Ferriz and Stockey, also occurs in the Princeton flora as a *Decodon*-like leaf at the Tulameen Road locality. The presence of loosestrife, based on seeds, fruits, and seeds, supports the idea that plants at the Princeton chert and Tulameen Road localities inhabited the margins of aquatic environments. Modern swamp willow (*Decodon verticillatus*) now grows near lakes and marshes. The other type of *Lythraceae* fruit found in the Princeton chert flora resembles that of the wetland plant loosestrife *Lythrum*.

Decodon fruits also occur in the Clarno Formation and are well represented in many European Tertiary fossil records (Manchester, 1994). Neither *Decodon nor Lythrum* is now native to the Northwest.

Myrtle Family (Myrtaceae)

Pigg and others (1993) have reported permineralized guava fruits and seeds (*Psidium communis*), *P. guajava*, *P. maxwellii* from the Princeton chert locality. The family is now widespread, ranging from areas with temperate to tropical climates.

Pea Family (Leguminosae/Fabaceae)

Legume pods, seeds and leaflets occur in the lower and middle Eocene Swauk Formation at Blevett Pass, in the Roslyn Formation at Ronald, and in the Chuckanut Formation at Bellingham (D. Q. Hopkins, Burke Museum, oral commun., 1995). The only record of this family in the Okanagan Highlands flowers is a single legume leaflet found at Republic.

Soapberry Family (Sapindaceae)

Sapindaceous winged fruits (formerly called *Acer* arctium (Heer)) have recently been redescribed as an extinct new genus, *Desermocy*, by Manchester (1994). These fruits occur at Republic (Plate 3, fig. 7), Princeton (Whisp Creek), Quilchena, and McAbee.

On the basis of four examples (three from Republic and one from Princeton) of trifoliate (or three-plant) winged fruits, another extinct new genus, *Bohlicina* (Plate 3, fig. 8), has been described by Wolfe and Wehr (1987). These fruits were previously assigned to the modern Chinese maple family genus *Diponteria*.

Fossil seed-bearing capsules similar to those of *Knoeleaceae*, now native only to China, occur commonly at Republic (Plate 3, fig. 9).

Wehrhorstia, the oldest known sapindaceous flower, occurs only at the Princeton chert locality (Plate 3, figs. 10-11). This superbly preserved flower contains the original pollen. Although its floral and pollen morphology are similar to that of the maple family (*Aceraceae*), detailed features indicate a closer affinity with the *Sapindaceae* (Erwin and Stockey, 1980).
ing fruit morphologies, the recent discovery of fossil branches with fruits (Plate 3, fig. 5) in the Kurozumidai Formation of Japan has been important in the identification of the Princeton elm. These branches winged fruits of the type found only among species closely related to the Mexican elms. This discovery proves that, many of the elm family leaves at Princeton correspond to Capiptalea. The leaves on modern Capiptalea are closely associated with the Capiptalea genus in the fossil record. The fruit is relatively inseparable and compared to that of many extinct Capiptalea species and most closely resembles that seen in Capiptalea heterophylla and related taxa.

**SUMMARY AND CONCLUSION**

**Manchaster** (1987), in his exhaustive monograph of the fossil record of the walnut family (Juglandaceae), has discussed why fossil reproductive structures (in this instance, fruits) are so difficult in assigning a fossil plant to either an extant or an extinct genus.

In the Juglandaceae, the most important structure for generic level determinations is the fruit. Each modern genus is defined such that it can be recognized on the basis of its fruit, with or without information from other organs. In the Juglandaceae it is difficult to stereotype according to its taxonomic utility. Wolfe (1959) indicates that there is a more or less typical type of leaf for each genus and section in the Juglandaceae. However, information on the other parts is less useful. On this basis, he and other paleobotanists have applied modern generic names to fossil leaf impressions. However, some architectural patterns are shared by more than one genus, leading to problems in the identification of fossils. In the early Juglandaceae, such problems are compounded by the presence of extinct genera (diagnosed by the foliage similarity to contemporaneous genera). However, consideration of one type of organ to the exclusion of all others would lead to an incomplete and perhaps misleading concept of family history.

When many early Tertiary fossil plants are reconstructed from the parts of the plants that we have been able to find, they tend to look very similar. We see these early plants as a collection of elements and features—that are not unique to each genus. We are only beginning to discover new fossils and to understand the evolution of these features. When we consider the evolution of these features, we find that they do not change. We see these early fossils as a collection of elements and features that are not unique to each genus. We are only beginning to discover new fossils and to understand the evolution of these features. When we consider the evolution of these features, we find that they do not change.

The opportunity for fossil collectors, professional or ama-
teur, to obtain fossils in the region is a very democratic one. In fact, many of the exciting and informa-
tion fossils at Repub (cover photo) and elsewhere were by sharp-eyed collectors who had the persistence to keep searching the fossil-bearing rocks until something worthwhile appeared. Fossil plants can be found in a variety of sedimentary environments that range from the warm-lake volcanics found in the upland lake beds of the Okangan Highlands to the stolitones and sandstones in the marine environments of western Washington. The hunt for exciting new fossils of plants or insects or vertebrates, can take place anywhere one can reasonably expect to find such remains preserved.

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**SELECTED REFERENCES**


Washington Geology, vol. 23, no. 3, September 1993

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Ceratophyllum Family (Ceratophyllaceae)

This is a monotypic family — it consists of a single genus and species, Ceratophyllum maricacan Chamisso. Fossil fruits of Ceratophyllum occur in the middle Eocene Retsen Formation near Issaquah (Plate 1, fig. 1) and in the Eocene Green River Formation in Wyoming (Herendeen and others, 1990). They are also recorded from the Paleocene Fatt Union Formation in

Montana (Brown, 1962). This aquatic herb is found worldwide today.

Moonseed Family (Menispermaceae)

This family is now mainly tropical and consists of about 65 genera, mostly lianas. It was well represented in the tropical London Clay (southern England) and Clarno Formation (Oregon).
However, the degree of similarity between these Tertiary terrestrial and modern flora can be misleading. Many of the Eocene genera are precursor genera—that is, they are not quite like a modern genus but are just similar enough that we give them basal status and call them Eocene (like Mesozoic cer- most like a modern cherry, or Paracerasuchus (primitive hawthorn). These names suggest the primitive, ancestral state and anatomy of the genera. To make these Eocene genera taxonomically synonymous with modern genera would be to assume that all the parts of the fossil plant would prove to be essentially identical to those of the modern plant. At this point, we have to make those assumptions only from isolated plant parts.

WHAT KINDS OF VEGETATION LOOK LIKE IN THE EARLY TERTIARY?

There is a wealth of fossil leaf material available from which to start making fossil plant reconstructions—but from the question to this would be a lot less certain or interesting if it were not for fossil flowers, fruits, and seeds.

Some of the plant lineages (alder, elm, walnut, and hydrangea, for example) that occur in the fossil leaf floras of the Oligocene Highland are also represented in the Paleocene and Eocene lowland floras. The acclimatization of such formerly arid or xerophytic lineages to upland, cooler climates of the mountains (or coastal floras) may have been associated with changes in climate or altitude gradients (Wig, 1987, citing J.A. Wolfe, personal communication, 1986).

Plant fossils—of all kinds—are permitting us to sketch a preferred vegetation history for the Oligocene and Eocene Highland of Washington. More than 450 species of plants (Wehr and Hopkins, 1949; Wehr and Schoon, 1982) are now known from the Oligocene Highland of Western Washington. A preponderance of plants in the north area was characterized by such wind-pollinated conifers as pine, spruce, and hemlock. The rocks contain early records of many conifer taxa (true fir, hemlock, and cedar, among others) and many that are now found only in China and Japan.

The understory is not as well represented in the Republican fossil record. However, there are finds, such as cleavers, hemlock, dogwood, and grape, and especially the many members of the rose family (with over 30 rosaceous genera recognized to date), are gradually allowing us to draw a more complete picture of the forest in this region. The presence of so many types of fruit-bearing trees and shrubs suggests that, at that time, the Oligocene Highland was also the source of many species of fruit (wild edible, possibly cultivated, and domesticated). Habitat use by these diverse plants and insects, especially bees and butterflies, is also now becoming apparent (Wehr, in press). The lowland understory is not well defined. We know there were ferns and lilies, but there is much left to be studied. (See Muste and Gannaway, 1995).

THE FOSSIL EVIDENCE

Assigning a fossil leaf type to many different and unrelated plant families has not been an easy task. One of the major problems of fossil leaf identification is that the paleobotanical literature abounds with this kind of conflict in identification. For this reason, the presence of a Eocene flora of so many kinds of closely associ- lates and fruits, and especially is very helpful in recogniz- ing their relationships and affinities.
Figure 1. Generalized correlation chart for Tertiary formations or deposits mentioned in this article.

Geologic uplift of the ancient Okanogan Highlands during the Eocene accompanied the appearance of montane forests, upland lakes, and environments unlike any previously known in the fossil record for North America. The cooler climates in these higher altitude landscapes presumably had a role in the appearance of types of plants not found in the floras of coastal British Columbia (at Vancouver) or in the lowland sites near Bellingham. These latter forests, however, contained some of the same species (salal, palm ferns) found now only in Central and South America, and other plants that today are predominantly subtropical to tropical (e.g. salmonberry, 1906; C.R.J. Hesse, 1994).

The changing climate in the Okanogan Highlands likely contributed to an apparently high degree of instability in plant and insect communities that, in turn, resulted in the appearance and rapid adaptation of many important groups of plants. However, in trying to determine the exact role that climatic changes may have had in the appearance of vegetational and floristic assemblages, we should keep in mind that: "During an event of climatic or environmental change, each individual plant species will have its own unique genetic capability of coping with such a change; it is not conceivable that all species within a community will have the same response." (Manchester and Meyer, 1987, p. 125).

HOW MODERN ARE NORTHWEST TERTIARY FLORAS?
The answer to this question depends on what you compare them to. Compared to Late Cretaceous and Paleocene floras (about 85 million to 57 million years old), the Tertiary floras of Washington could be called modern. Sycamores, laurels, and magnolias can be traced back to ancestors in the Cretaceous. But many other Cretaceous angiosperms cannot be placed in any modern family—or even order. In contrast, no extinct plant orders are found, so far, in the Eocene upland floras, notably at Republic, or in the lowland floras of the western part of the state, and only a few extinct families have been recognized. Of the 68 angiosperm genera represented by the flowers, fruits, and seeds included in this survey, 34, or half, are considered to represent extinct genera in modern families. Thus, we can measure, Washington’s Early Tertiary floras have far more in common with modern plant taxa than with those of the Age of Dinosaurs.

NATIONAL LANDSLIDE AWARENESS DAY
October 11, 1995, has been designated National Landslide Awareness Day by the Association of Engineering Geologists. In late 1994, the Committee on Landslides proposed to the management board of the Association that a day be selected for a concerted effort to disseminate information about geologic hazards to the general public. Each section of the association will be presenting a free forum about the landslide hazards in its area. Among other purposes of this selected day is helping the public be better informed about the landslide hazard reduction efforts of geological societies. This is working with the U.S. Geological Survey to ensure that the agency's efforts are publicized.

National Landslide Awareness Day was proposed because a major premise of the International Decade of Natural Disaster Reduction is that application of what is now known about these hazards can significantly reduce human and property loss. The decade reached its mid-point in 1995.

The Division of Geology and Earth Resources lists its reports on landslides and slope stability in its recently updated (free) list of publications, and the Division's bibliography, both the cumulated versions and those prepared annually for selected counties, contain references to articles and books about these hazards in Washington.
While supplies last...
The Division is making the following reports available at half price, the amount listed below. However, we offer them free to libraries or teachers who use official letterhead to request the copies. If you need multiple copies, please call us because supplies are limited.

For each order, we still ask the customary $1.00 postage and handling. Only Washington residents must pay the total price; others may deduct the tax. Check or money order should be made payable to the Department of Natural Resources, and sent with the order to the Division at PO Box 470079, Olympia, WA 98504-7007.

BULLETTINS
37. Stratigraphy and formations of the Sospec Creek area, southern Olympic Peninsula. By W. R. Rau. 1966. 66 p., 9 figs. $7.50


INFORMATION CIRCULARS
59. Washington gravity base station network, by H. T. Nilsen. 1983. 8.3 p., 1 fig., 4 tables. $1.00
61. Annotated guide to sources of information on the geology, minerals, and groundwater resources of the Puget Sound region, Washington, King County section, by W. H. Reichert, with supplementary references by D. D. Delehanty. 1983. 83 p., 8 figs. $75
68. Compilation of earthquake hypocenters in western Washington, 1979-1980, by L. N. Sisson, R. S. Crosson, and M. J. Weinberg, 1985, 19, 6 figs. $4.00

REPORTS OF INVESTIGATIONS

DAM SAFETY MEETING
7th Annual Canadian Dam Safety Association Conference Banff, Alberta October 2-5, 1995
For more information, contact:
H. S. Williams
Williams Projects Ltd.
128 12th Ave SE
Calgary, AB T2G 4E3 CANADA
Phone: 403-265-1472, Fax: 403-269-4244

Early Tertiary Flowers, Fruits, and Seeds of Washington State and Adjacent Areas
Weesie C. Wehr
Thomas Burke Memorial Washington State Museum
University of Washington, Seattle, WA 98115-3010

INTRODUCTION
Fossil leaves, particularly those that are very well preserved, are valuable tools and clues in the study of modern and fossil plant relationships and evolutionary trends. Because fossil leaves tend to be the most common type of plant fossil found at most sites in western North America, scientists may have depended too heavily on the fossil leaf record to establish these relationships and trends. This has led to some misconceptions about flowering-plant (angiosperm) evolution. From their study of leaves, many earlier palaeobotanists were led to present a more static picture of angiosperm evolution because the Cretaceous has then been a case of the Tertiary. It is now the case, in some cases, leaves and wood evolved more slowly than plant reproductive structures.

The early Tertiary flowers, fruits, and seeds found in what is now the Okanagan Highlands record a rapid and inconve...
Crown Jewel Project Reaches Milestone

Raymond Laumania, State Geologist
Washington Department of Natural Resources
Division of Geology and Earth Resources
PO Box 2070, Olympia, WA 98507-2070

A flyer announcing the latest development in the project.

WASHINGON ARCHAEOLOGY WEEK (October 1-7, 1995)

A series of events in various communities will enhance public awareness of the importance of protecting the state’s archaeological resources. Just a few of the events scheduled and sources of more information around the state are:

- Chelatchi - Flintknapping Demonstration
- Archaeological Site Tour and Trail Blazing
- Walk through the rainforest and explore the history of the area.
- Visit the Reptile Park - Adventure Dwell.
- Fort Varnum - Candlelight Tour of Fort Nisqually
- Visit the Museum on the Washington's history.

More information on these and other events can be found at the Washington Archaeology Week website.

HOW TO FIND OUR MAIN OFFICE

1. Look for the Division of Geology and Earth Resources building.
2. Enter the building and follow the signs to the main office.
3. Find the receptionist and ask for further directions.

Our area code has changed! The Division's new area code is 360. If you use the old code, you must use the new one to reach our main office.

Do you want to get off our mailing list? The Division pays for printing and postage for Washington Geology from an always-tight budget. Help us use our resources well by letting us know if you no longer wish to receive the journal. We will take your name off the list immediately.
Ross Berglund Honored by Paleontological Society

The Paleontological Society has awarded its Harrell L. Strimple award to Ross E. Berglund for his work with fossil crabs. Ross was praised for his "unselfish spirit of collaboration with researchers that is a large part of ... professionalism."

Ross has had associations with the Thomas Burke Memorial Washington State Museum at the University of Washington and the Natural History Museum of Los Angeles County. He has published several articles on the fossil crabs of Washington and is currently working on new manuscripts. He is also working on a catalog of fossil collecting sites in Washington.

Ross received his B.S. in geology from Washington State University during World War II. To help with the war effort, he put his knowledge of mineralogy to work at the Boeing Airplane Company, where he spent his entire professional career.

Upon retirement 18 years ago, Ross embarked on a new career in paleontology. He maintains a very well-cataloged collection of fossils, which he amassed during his many years of fieldwork. Every collecting locality is numbered, marked on a topographic map, and entered into his permanent logbook. Each specimen collected is then given a unique number. This makes it both easy and useful for other scientists to contact him for help with research on various specimens.

Ross is noted for teaching those new to fossil collecting how to record what is needed for good science. He places most of the fossils he collects into the custody of the appropriate specialist for that taxon for research and encourages others to do the same.

Stonerose Center Receives Grant

The Stonerose Interpretive Center in Republic has received a $50,000 grant to complete purchase of the fossil site, build an annex to the Center's current facility, provide additional storage and display cabinets, and develop a computer program for use in identifying the fossils. After a visit to the Center and meeting with curator Lisa Barkerdale and board member Mary Waring in 1994, Representative Helen Sommers proposed a grant and supported the concept though the budgeting process. The funds have been allocated through the Washington State Historical Society's budget.

The Center seeks to further educational interest in the exceptionally rich fossil locality, to encourage scientific study of the materials, and to preserve the fossil beds, which are among the few such localities open to the public for collecting. 

By the end of July this year, the Center had at least 4,000 visitors. The number of both visitors and collected fossil specimens grows rapidly each year. Stonerose Center hours are Tuesday through Saturday, 10:00 am to 5:00 pm. The Center will close for the winter October 31 and will reopen May 1, 1995.

NEW DIVISION RELEASE


INSIDE THIS ISSUE

1. Early Tertiary flowers, fruits, and seeds of Washington State and adjacent areas, p. 3
2. Selected additions to the library of the Division of Geology and Earth Resources, p. 18