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Cover Photo: Wes Wehr, paleobotanist with the Thomas Burke Memorial Washington State Museum in Seattle, and school children split the Eocene fossil-bearing lakebed rocks at Republic, Washington, where many fossil flowers, fruits, and seeds have been found. The deposit is an easy walk from the center of town and is open to the public. See the article starting on p. 3. Photo by Mary Randlett.

Crown Jewel Project Reaches Milestone

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After a lengthy evaluation process under the National Environment Policy Act (NEPA) and the State Environment Policy Act (SEPA), on June 30, 1995, the Draft Environmental Impact Statement, Crown Jewel Mine, Okanogan County, Washington, was issued by the lead agencies, U.S. Department of Agriculture Forest Service and the Washington State Department of Ecology.

The proponent, Battle Mountain Gold Company, gave the first briefing to state agencies in Olympia on January 21, 1992. A Notice of Intent to Operate was filed on February 6, 1992. Because the gold deposit is located on private land and land administered by the Forest Service and Bureau of Land Management (BLM), both state and federal jurisdictions were asserted. To facilitate the NEPA/SEPA process, a Memorandum of Understanding (MOU) became effective July 22, 1992, among the Forest Service, BLM, and Washington Departments of Ecology and Natural Resources. Because of wetlands issues, the U.S. Army Corps of Engineers was added to the MOU on April 15, 1993.

Following scoping, numerous multi-agency interdisciplinary meetings have been held since early 1992 to identify the issues and then track the detailed studies and evaluations. The Division of Geology and Earth Resources' contribution to the process was mainly in surface mine reclamation and the geochemical characteristics of mine tailings, ore, and waste rock.

Public comments were taken at briefings on August 15 in Ellensburg and August 17 in Oroville. Written comments to the Forest Service were due by August 29.

Progress reports on the Crown Jewel project will appear in future issues of *Washington Geology*. ■

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

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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 studies of leaves, many earlier paleobotanists 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 record 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 Olympic Peninsula. Paleobotanists 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 physiognomy of their modern descendants, tropical conditions.

Paleobotanists have assigned some Eocene leaves to modern genera. However, many fossil flowers, fruits, and seeds found in close association with these leaves or attached to leafy stems are clearly unlike any known modern genera. This is what M. E. J. Chandler and E. M. Reid concluded when they studied the fruits and seeds from the Eocene London Clay (Collinson, 1983). More recently, Manchester (1994), in his monograph on the middle Eocene Clarno Formation fruits and seeds, has carefully documented how many of these fossils represent extinct genera that now can be assigned only to modern families at best.

Fossilized reproductive structures—flowers, fruits, seeds, pollen, cones—record, even more vividly than leaves, the apparently swift and dramatic evolution and diversification that many lineages have undergone since their appearance in the Cretaceous (Wolfe, 1987). Washington's fossil plants are helping us describe a crucial time in angiosperm development.

This article reviews finds in the Pacific Northwest and discusses the significance of many of the plant families found in early Tertiary localities in Washington State, British Columbia, and Oregon. Many of the fossil flowers, fruits, and seeds discussed and illustrated in this article represent 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), earlier Paleocene floras, such as those in the Fort Union Formation in Wyoming, Montana, and North Dakota, tend to have low diversity. Paleocene upland floras are not known (Wing, 1987). Wolfe (1987) has proposed that the first major diversification of many present-day 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 epoch (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 and coastal British Columbia from the interior; this whole 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 graben basins from Republic, Washington, to Smithers, British Columbia. Largely 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, paleobotanists and paleoclimatologists can make some general, but necessarily cautious, speculations about ancient climates.

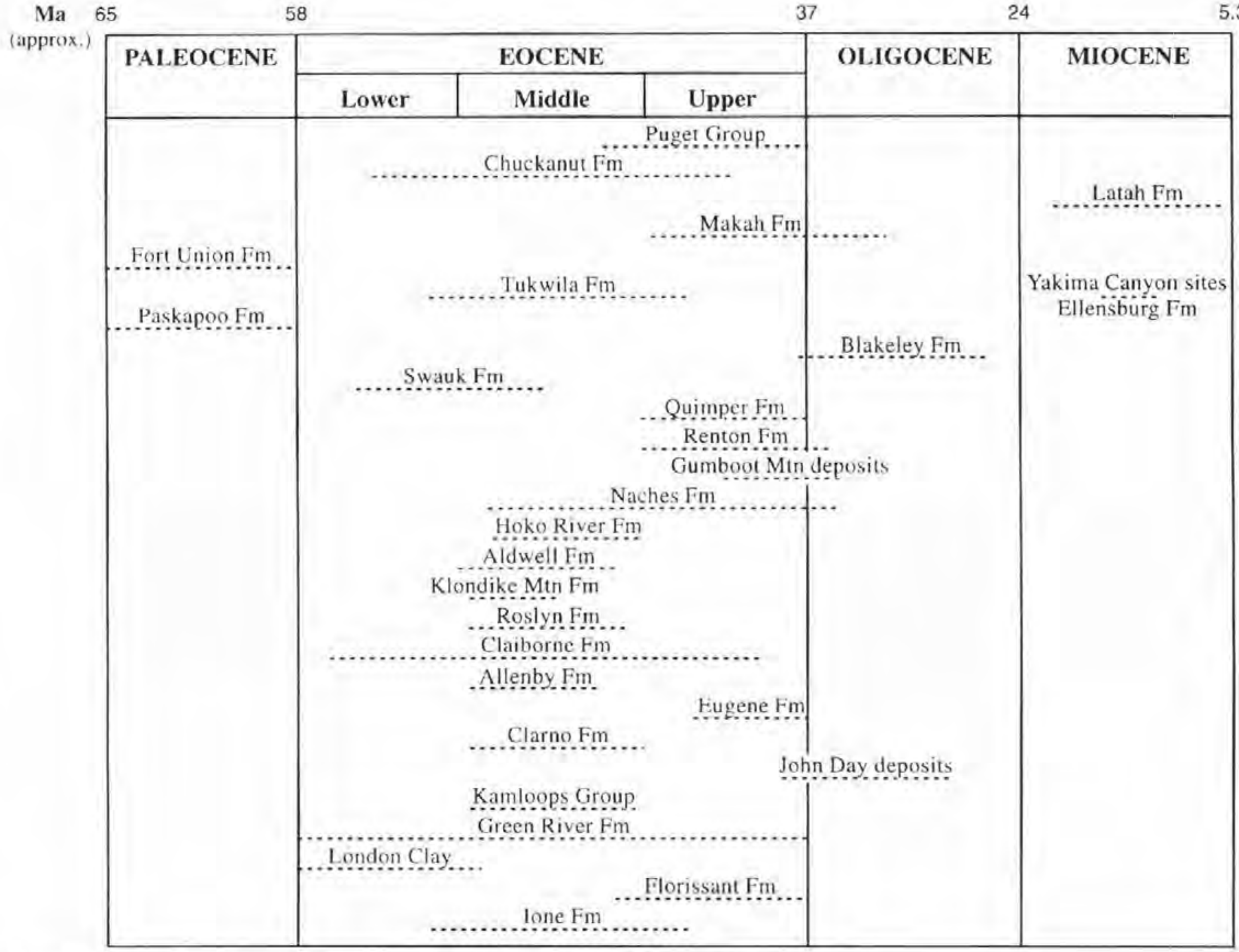


Figure 1. Generalized correlation chart for Tertiary formations or deposits mentioned in this article.

Geologic uplift of the ancient 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 forests 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 contained some species (sabal palm, ferns) found now only in Central and South America, and other plants that today are predominantly subtropical to tropical (Pabst, 1968; Wehr and Hopkins, 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. By this measure, Washington's Early Tertiary floras have far more in common with modern plant taxa than with those of the Age of Dinosaurs.

However, the degree of similarity between these Tertiary floras and modern floras 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 names like *Paleorosa* (ancient rose), *Paraprunus* (almost like a modern cherry), or *Paracrataegus* (primitive hawthorn). These names suggest the primitive, ancestral status 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 would have to make those assumptions only from isolated plant parts.

WHAT DID 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 the answer to this question 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 upland floras of the Okanogan Highlands are also represented in the Paleocene and Eocene lowland floras. The acclimatizing of such formerly lowland tropical and subtropical lineages to upland, cooler climates (as represented by the Republic flora) may have taken place along altitudinal gradients (Wing, 1987, citing J. A. Wolfe, personal commun., 1986).

Plant fossils—of all kinds—are permitting us to sketch a preliminary portrait of the Eocene Okanogan Highlands forest. More than 450 species of plants (Wehr and Hopkins, 1994; Wehr and Schorn, 1992) are now known from the Okanogan lakebed deposits. This middle Eocene forest canopy record was characterized by such wind-pollinated conifers as pine, spruce, and hemlock. The rocks contain early records of many conifer types (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 Republic fossil record. However, rare finds there, such as clematis, wild currant, mock orange, hydrangea, 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 Okanogan Highlands was also the scene of an important and rapid diversification of various groups of pollinating insects, especially bees, wasps, flies, beetles, and moths (Wehr, in press).

The lowland understory is far less well defined. We know there were ferns and shrubs, but there is much left to be studied. (See Mustoe and Gannaway, 1995).

THE FOSSIL EVIDENCE

Assigning a fossil leaf type to many different and unrelated families is not unusual in the history of fossil leaf identification. In fact, the paleobotanical leaf literature abounds with this kind of conflict in identification. For this reason, the presence in the Republic flora of so many kinds of closely associated fruits and leaves, for example, is very helpful in recognizing their relationships and affinities.

Figure 2. Index map of sites where early Tertiary flowers, fruits, and seeds have been found in the Pacific Northwest. 1, Horsefly; 2, McAbee; 3, Quilchena; 4, Princeton; 5, Republic; 6, Bellingham; 7, Neah Bay; 8, Shipwreck Point; 9, Elwha River; 10, Oak Bay; 11, Issaquah; 12, Durham; 13, Ronald; 14, Blewett Pass; 15, Thorp; 16, Ellensburg; 17, Yakima Canyon; 18, Gumboot Mountain; 19, Clarno; 20, Mitchell. • is a city or town; x is a river, canyon, or other topographic feature.

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 geologic time.

Water-Lily Family (Nymphaeaceae)

The presence of the water-lily family is based on a single *Nuphar* rhizome from the Princeton (BC) Coalmont Bluff (also known as Tulameen Road; Allenby Formation) locality and permineralized fruits and seeds of an extinct genus, *Allenbya*, from the Princeton chert locality (Cevallos-Ferriz and Stockey, 1989; also Allenby Formation). These fruits and seeds have become important clues to the aquatic aspects of the Princeton environment. No fossil nymphaeaceous leaves have been found.

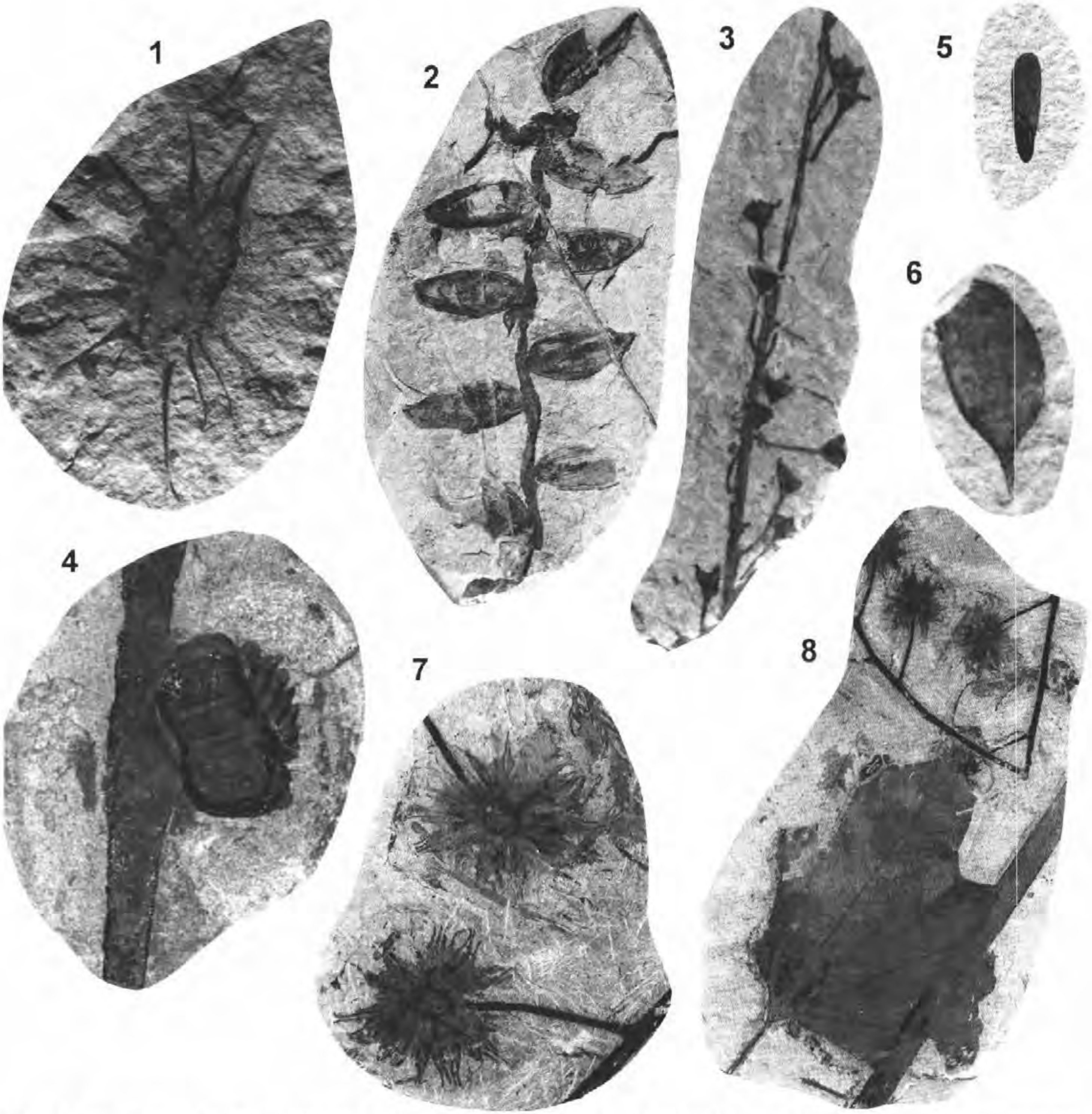


Plate 1. Early Tertiary fruits and seeds from Washington. UWBM, University of Washington Burke Museum. Magnifications approximate. **1.** *Ceratophyllum* fruit, UWBM 77802A, loc. B5506, Issaquah, x3. **2.** *Cercidiphyllum/Joffrea* fruits, UWBM 76903, loc. A0307, Republic, x1.3. **3.** *Trochodendron* fruits, UWBM 94570A, loc. B4131, Republic, x1.3. **4.** *Nordenskioldia* fruits, UWBM 74314, loc. B 4213, Republic, x4. **5.** *Liquidambar* seed, UWBM 77561A, loc. A0307B, Republic, x2.75. **6.** *Eucommia* fruit, UWBM 77562A, loc. A0307, Republic, x2.75. **7, 8.** *Macginicarpa* fruits, UWBM 76881, loc. B4131, Republic; 7, x1.5; 8, x1.2.

Ceratophyllum Family (Ceratophyllaceae)

This is a monotypic family—it consists of a single genus and species, *Ceratophyllum muricatum* Chamisso. Fossil fruits of *Ceratophyllum* occur in the middle Eocene Renton 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 Fort 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 is well represented in the tropical London Clay (southern England) and Clarno Formation (Oregon) floras. Fossil fruits of *Odontocaryoidea* occur in the Roslyn Formation at Ronald (Kittitas County); they are also present in the Clarno Formation nut beds (Manchester, 1994). *Odontocarya*, the closely related modern genus, now grows in the West Indies and from Panama to the Amazon Basin tropics. The presence of *Odontocaryoidea* in the Roslyn flora along with fossil menisperm leaves supports the suggestion that a lowland tropical climate and flora were present there during the middle Eocene.

The Trochodendroid Group

These wind-pollinated angiosperms are unusually well represented in the Republic flora (Klondike Mountain Formation) by both leaves and fruits of *Cercidiphyllum* (katsura)/*Joffrea* (an extinct genus) (Plate 1, fig. 2), *Trochodendron* (Plate 1, fig. 3), and *Nordenskioldia* (an extinct genus) (Plate 1, fig. 4). The leaves of these genera are difficult to tell apart. However, the deposits have also yielded some fruits and seeds in close association with the leaves. The reproductive structures of these genera are characteristic and easily identified. Their presence is helping scientists determine which trochodendroid trees were living in the area during the middle Eocene.

Fossil fruits and seeds of *Cercidiphyllum elongatum* Brown occur in the upper Eocene Tukwila Formation at Steel's Crossing at Tukwila south of Seattle.

The *Cercidiphyllum*-like leaves and fruits found at Republic have been referred to the modern genus, *Cercidiphyllum* (Wolfe and Wehr, 1987) and, more recently, to the extinct genus *Joffrea* (Wolfe and Wehr, 1991). However, since *Joffrea* was originally described on the basis of a remarkably complete 'whole plant' reconstruction found in the Paleocene Paskapoo Formation of Alberta (Stewart and Rothwell, 1993), the assignment to *Joffrea* of the isolated leaves and fruits found at Republic is problematic.

Cercidiphyllum fruits have also been identified from the upper Eocene Quimper Formation at Oak Bay, Clallam County (S. R. Manchester, oral commun., 1994).

Nordenskioldia fruits have been found at Republic and at the Blakeburn mine locality at Princeton. These two essentially coeval occurrences represent the first Eocene records of these fruits in North America.

Closely associated *Nordenskioldia* fruits and leaves also occur near Spokane in the Miocene Latah Formation lakebeds that were deposited in the periods between eruptions of the Miocene lava flows. Until these fossil fruits were identified as belonging to *Nordenskioldia*, the associated leaves were assigned to genera in several unrelated families: *Populus*, in the willow family (Salicaceae); *Cocculus*, in the moonseed family (Menispermaceae); and *Hedera* (ivy) in the ginseng family (Araliaceae). During the 19th century, they were assigned to the buckthorn family (Rhamnaceae).

Witch-Hazel Family (Hamamelidaceae)

Even though the witch-hazel family is well represented in the Republic fossil leaf record by the modern genus (*Corylopsis*, (winter-hazel) and by three extinct genera (*Langeria*, aff. *Fothergilla*, and aff. *Hamamelis*), only a few isolated *Liquidambar* (sweet gum) fossil seeds have been found at Republic (Plate 1, fig. 5).

Fossil fruits of *Exbucklandia* occur commonly in the Oligocene Gumboot Mountain flora (unnamed unit) in Skamania County. Similar fruits are also recorded from the Eocene and Oligocene Rujada flora in the Little Butte Volcanic Series near Eugene, Oregon, and from the Miocene Latah Formation near Spokane. *Exbucklandia* now grows in mountainous areas in the eastern Himalayas to southern China, on the Malay Peninsula, and in Sumatra.

Eucommia Family (Eucommiaceae)

The Eucommia family consists of a single species, *Eucommia ulmoides*, now native to China. Although leaves and fruits of this species, as its name suggests, resemble those of elm, *Eucommia* fruits are distinctive. A single example (Plate 1, fig. 6) is known from the Republic flora. The Quilchena (BC) flora in the Coldwater Beds of the Kamloops Group contains *Eucommia* fruits found in close association with leaves (R. W. Mathewes, Simon Fraser University, oral commun., 1995).

> "The presence of polymerized latex strands in the fossils that are very similar to those found in the leaves and fruits of the modern species confirms the identification of the fossils of the Republic and Quilchena floras" (V. Call, Florida Museum of Natural History, written commun., 1995).

Sycamore Family (Platanaceae)

Fossil leaves of the extinct platanaceous genus *Macginitiea* are common at Republic, as are fossil sycamore fruits that are assigned to the extinct genus *Macginicarpa*. A rare example from Republic consists of *Macginitiea* leaves and *Macginicarpa* fruits (Plate 1, figs. 7 and 8) in well-preserved attachment. This specimen confirms that the isolated leaves and fruits belong together and represent one species.

Linden Family (Tiliaceae)

A single fruit of *Craigia*, a tiliaceous genus native to China, is known from the Eocene Tukwila Formation at Steel's Crossing near Seattle (S. R. Manchester, oral commun., 1994). A single fossil fruit from Republic (Plate 2, fig. 1) has been assigned to *Craigia*. *Craigia* fruits are similar enough to those of elm, golden rain tree (*Koelreuteria*), and *Ptelea* (genera in four unrelated families) that only an expert can tell them apart when they are recovered as fossils.

The Republic fossil record for linden consists of three specimens of *Tilia johnsoni* (Wolfe and Wehr, 1987), a species erected on the basis of fossil leaves. None of the fruiting bracts characteristic of modern *Tilia* have been found in the Okanogan Highlands localities. Fossil leaves of the extinct tiliaceous genus *Plafkeria* occur at Republic.

Cocoa Tree Family (Sterculiaceae)

Because the fossil flower *Florissantia* has never been found with any attached leaves, it has a long history of having been assigned to many different unrelated families: the hydrangea family, verbena family (*Holmskioldia*), morning glory family (*Porana*), and honeysuckle family (*Viburnum*). *Florissantia* flowers recently found in the Bridge Creek (John Day Formation) Oligocene flora of Oregon contain diagnostic pollen that allows tentative assignment of the flower to an extinct genus (*Florissantia*) in the cocoa tree family (Manchester, 1992). One illustrated example of *Florissantia quilchenensis* Mathewes and Brooke from Republic (Plate 2, fig. 3) is unique

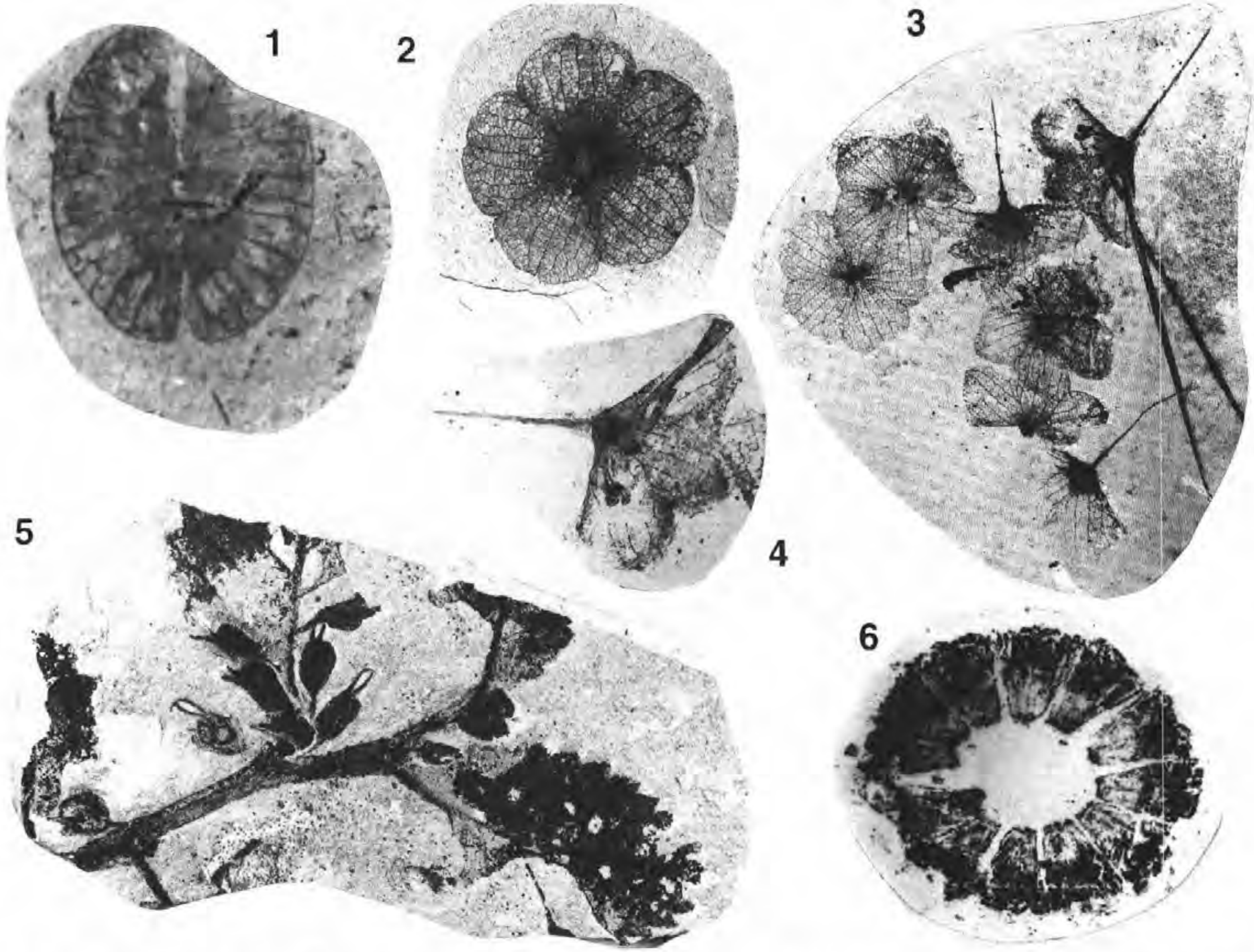


Plate 2. Early Tertiary flowers, fruits, and seeds from Washington and British Columbia. UWBM, University of Washington Burke Museum; SR, Stonerose Interpretive Center collection. Magnifications approximate. **1.** *Craigia* fruit, UWBM 76625, loc. A0308, Republic, x2.75. **2–4.** *Florissantia* flowers: 2, UWBM 54390, loc. B2737, Republic, x1.5; 3, SR 87-26-4, B2737, Republic, x1; 4, SR87264, loc. B2737, x1.5. **5.** *Chaetoptelea* fruits, UWBM 54113A, loc. B3389, One Mile Creek, near Princeton, BC, x2.5. **6.** *Fagopsis* fruit, U.S. National Museum USNM 32690, loc. 11019, Resner Canyon (near Republic), x5.

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.

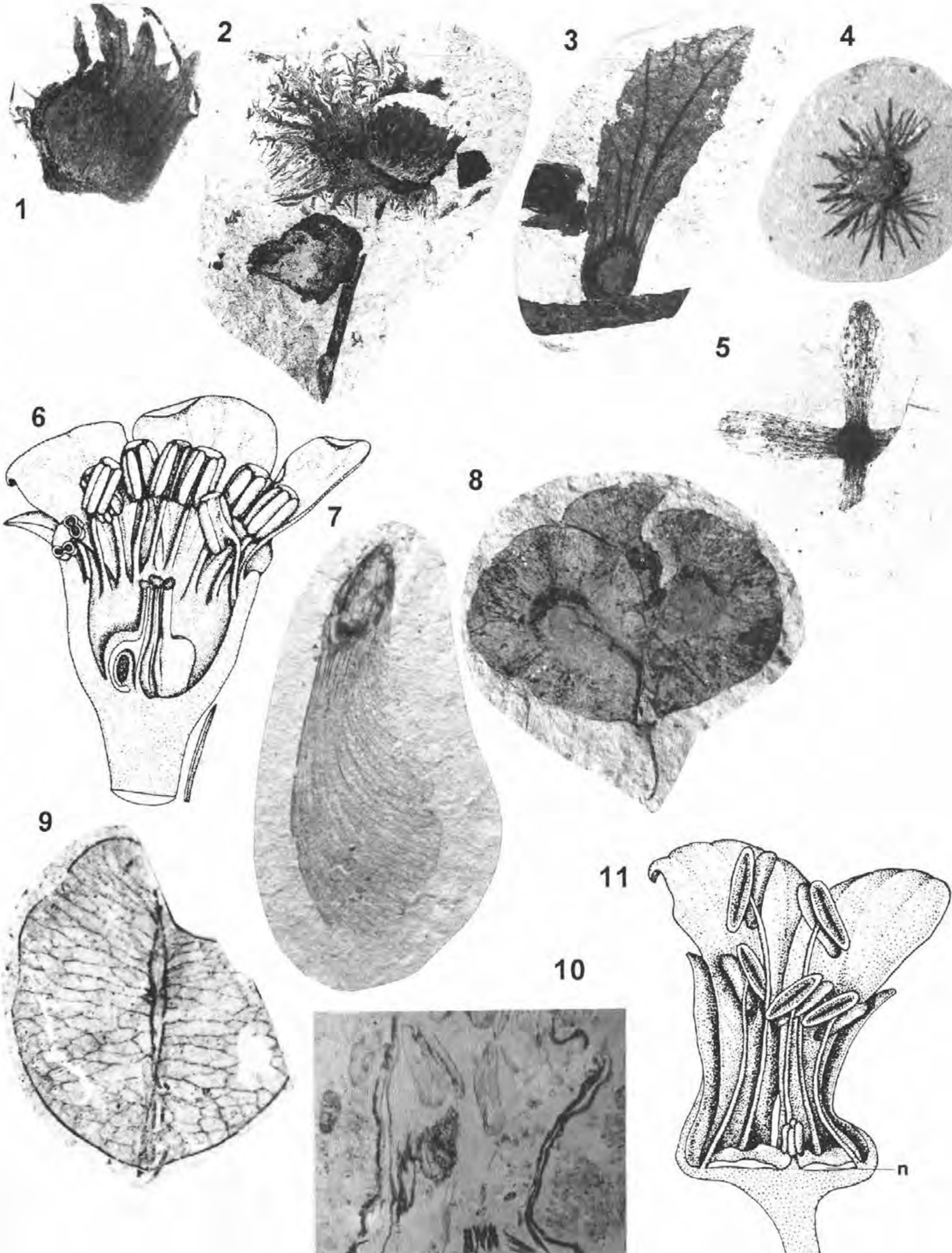
F. quilchenensis also occurs at Princeton (Whipsaw Creek) (Allenby Formation), Quilchena (Coldwater Beds, Kamloops Group), and McAbee (Tranquille Formation, Kamloops Group) (K. W. Pugh, Sardis, BC, written commun., 1995), as well as at Gumboot Mountain (Fig. 2).

Elm Family (Ulmaceae)

Chaetoptelea, *Zelkova*, elm (*Ulmus*), and an undescribed extinct ulmaceous 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 ulmaceous 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 (*Chaetoptelea*) 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 the two modern genera are readily distinguished by their differ-

Plate 3. *(Facing page)* Early Tertiary flowers, fruits, and seeds from Washington and British Columbia. UAPC-ALTA, University of Alberta Paleobotany Collections; UWBM, University of Washington Burke Museum. Magnifications approximate. **1.** *Corylus* involucre, UWBM 71062A, loc. A0307, Republic, x2. **2.** aff. *Corylus* cupule, UWBM 78140A, loc. A0307, Republic, x2. **3.** aff. *Carpinus* fruit, UWBM 71161, loc. B2737, Republic, x2.5. **4.** *Palaeocarpinus* fruit, UWBM 77466, loc. B4294, Princeton, BC, x 3.5. **5.** *Cruciptera* fruit, UWBM 56729, loc. B2737, Republic, x1.5. **6.** Sketch of *Paleorosa* flower (sectioned), UAPC-ALTA, Princeton chert, loc. P1122, Princeton, BC, x25. **7.** *Deviacer* fruit, UWBM 67457, loc. B4131, Republic, x2.5. **8.** *Bohlenia* trilocular fruit, UWBM 39729A, loc. A0307, Republic, x 3. **9.** *Koelreuteria* fruit, UWBM 39190, loc. A0307, Republic, x5. **10–11.** *Wehrwolfea* flower (sectioned), UAPC-ALTA P1397, locality P1122, Princeton; 10, thin section of chert, x33; 11, sketch of sectioned flower, x33.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ing fruit morphologies, the recent discovery of fossil branches with attached leaves and fruits [Plate 2, fig. 5] has been important in the identification of the Princeton elm. These branches show winged fruits of the type found today only among true elms and especially similar to the Mexican elms. This discovery proves that many, if not all, of the elm family leaves at Princeton correspond to *Chaetoptelea*. The leaves on modern *Chaetoptelea* are similar to the Princeton fossils. *Zelkova* leaves typically have simple teeth, but *Chaetoptelea* may have both simple and compound teeth" (S. R. Manchester, Florida Museum of Natural History, written commun., 1994).

Cedrelospermum, an extinct genus, occurs as leaves and fruits in the Quilchena flora (R. W. Mathewes, Simon Fraser Univ., oral commun., 1995).

Oak Family (Fagaceae)

Fagopsis undulata (Knowlton) Wolfe and Wehr occurs at Republic and Princeton as isolated leaves. Fossil fruits of this extinct fagaceous genus have been found at Resner Canyon (Klondike Mountain Formation) near Republic (Plate 2, fig. 5). The holotype of *Fagopsis* from the early Oligocene (34.1 m.y.) Florissant (Colorado, Florissant Formation) flora consists of simple leaves and fruits preserved in attachment to vegetative shoots (Manchester and Crane, 1983). This positive 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 and a single fossil leaf example from the One Mile Creek (Princeton) flora (Maria Gandolfo, Cornell Univ., written commun., 1994). The oldest known acorns (*Quercus paleocarpus* Manchester) occur in the Clarno Formation (Manchester, 1994). Although Eocene acorns are unknown from Washington, acorns have been found in the Miocene sedimentary rocks between some of the Columbia River basalt flows in Yakima Canyon (K. Pigg, Arizona State Univ., written commun., 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)

Betulaceous leaves are common at many Tertiary Washington localities. In fact, alder (*Alnus parvifolia* (Berry) Wolfe and Wehr) leaves are the most common leaf type found at Republic, and birch (*Betula leopoldae* Wolfe and Wehr) leaves dominate the One Mile Creek flora at Princeton (Crane and Stockey, 1986). Betulaceous leaves, especially when they are not well preserved, can be difficult to identify. Closely associated fruits, seeds, and pollen very similar to those of modern alder and birch occur at Republic, Princeton, and McAbee and further confirm the presence of these genera in the middle Eocene.

A few hazelnut-like fruits have been found at Republic. Similar fossil nuts from Paleocene localities (in Mull, Scotland, in Montana, and in northwest Greenland) have been referred to *Corylus* (hazelnut). However, since these fossil nuts have lacked the diagnostic husks (involucres), identification has been uncertain. When their identification is uncertain, *Corylus*-like fossil nuts are sometimes referred to as *Coryloides*, a generic name that indicates their similarity to modern hazelnuts (Manchester, 1994).

"The unique occurrence of a hazelnut fruit in its husk at Republic [Plate 3, fig. 1] provides unequivocal evidence of the presence of *Corylus* before the radiation of other extant genera in the tribe Coryleae (*Carpinus*, *Ostrya*). The Republic specimen represents the earliest record of the genus *Corylus* based on closely associated fruits and the characteristic fruit-bearing husks. The fruit is relatively unspecialized compared to that of many extant *Corylus* species and most closely resembles that seen in *Corylus heterophylla* and related taxa" (P. R. Crane, Field Museum, Chicago, written commun., 1988).

A *Corylus*-like fruit and cupule (Plate 3, fig. 2) recently found at Republic appears to represent a new species.

A *Carpinus*-like fruit-bearing bract (Plate 3, fig. 3) from Republic may represent an extinct genus in the *Carpinus* group. Further evidence that the early middle Eocene was a critical time in the evolution of the birch family is the presence at Republic and Princeton of a betulaceous bract that represents an extinct genus, *Palaeocarpinus* (Plate 3, fig. 4). This taxon is first recorded in the Paleocene deposits at Reading, England.

Walnut Family (Juglandaceae)

Although the walnut family is one of the best represented and diverse groups in Eocene floras in western North America, it occurs at Republic and in the One Mile Creek flora at Princeton as a few isolated leaflets of Chinese walnut (*Pterocarya*). *Pterocarya occidentalis* Manchester fruits occur in the Oligocene Gumboot Mountain flora, Skamania County (Manchester, 1987). *Pterocarya* (Chinese walnut) now is found only in China and the Caucasus to Iran. At Republic, a single fruit of the extinct genus *Cruciptera* has been found (Plate 3, fig. 5) (Manchester, 1991). *Cruciptera* fruits occur in the middle Eocene Puget Group near Durham in King County. They also occur at West Branch Creek near Mitchell, Oregon, in the Clarno Formation.

A single fossil seed of *Cruciptera* was found in a mass of cold-seep limestone 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 Campbell, 1995).

Fossil walnuts (*Juglans*) and hickory nuts (*Carya*) have not yet been found at Republic, but the nuts are not uncommon elsewhere in Washington State. Fossil walnuts (*Juglans lacunosa* Manchester) have been found in the Oligocene Blakeley Formation at Eastgate near Seattle and in the earliest Oligocene Jansen Creek Member of the Makah Formation near Neah Bay, Clallam County (Manchester, 1987). Opalized hickory nuts (*Carya washingtonensis* Manchester) were discovered in the early 1940s in the Badger Pocket–Squaw Creek area near Ellensburg by Carl Clinesmith as part of a nut hoard in a fossilized sycamore; some Miocene rodent was evidently preparing for winter (Manchester, 1987). This unique nut cache is on display at the Burke Museum at the University of Washington.

Palaeocarya (an extinct genus) is represented in the upper Eocene Renton Formation at Maple Valley near Issaquah by a single fossil fruit (K. Johnson, Museum of Natural History, Denver, oral commun., 1995). *Paleocarya wolfei* Manchester winged fruits occur in the Eocene Puget Group near Durham in King County. *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 *Platycarya*-like floral structure is recorded from the Roslyn Formation at Ronald, near Cle Elum. *Platycarya* 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 Coalmont 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 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 those who study the Clarno fossil flora. Therefore, paleobotanists 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 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 *Paleorosa* (Plate 3, fig. 6), the oldest known flower in the rose family. Its structure suggests that it was pollinated by insects (Cevallos-Ferriz and others, 1993).

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

The numerous rosaceous genera and species found in the Okanogan Highlands, especially at Republic and Princeton, indicate that the rose family was undergoing a major diversification in upland warm-temperate/subtropical 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 McAbee flora. Three kinds of *Prunus* (cherry) permineralized fruits and seeds are found in the Princeton chert (Cevallos-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 nut beds. There is a good record of the Prunoideae (a subfamily of Rosaceae) fruits in the European Tertiary (Manchester, 1994).

Loosestrife Family (Lythraceae)

Two genera of lythraceous fruit and seed remains occur in the Princeton chert flora (Cevallos-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 allenbyensis* Cevallos-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 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 loosestrife *Lythrum*.

Decodon fruits also occur in the Clarno Formation nut 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 (*Paleomyrtinaea princetonensis* 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 leaflets occur in the lower and middle Eocene Swauk Formation at Blewett 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 Okanogan Highlands floras is a single legume leaflet found at Republic.

Soapberry Family (Sapindaceae)

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

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

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

Wehrwolfea, 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 those of the maple family (Aceraceae), detailed features indicate a closer affinity with the Sapindaceae (Erwin and Stockey, 1990).

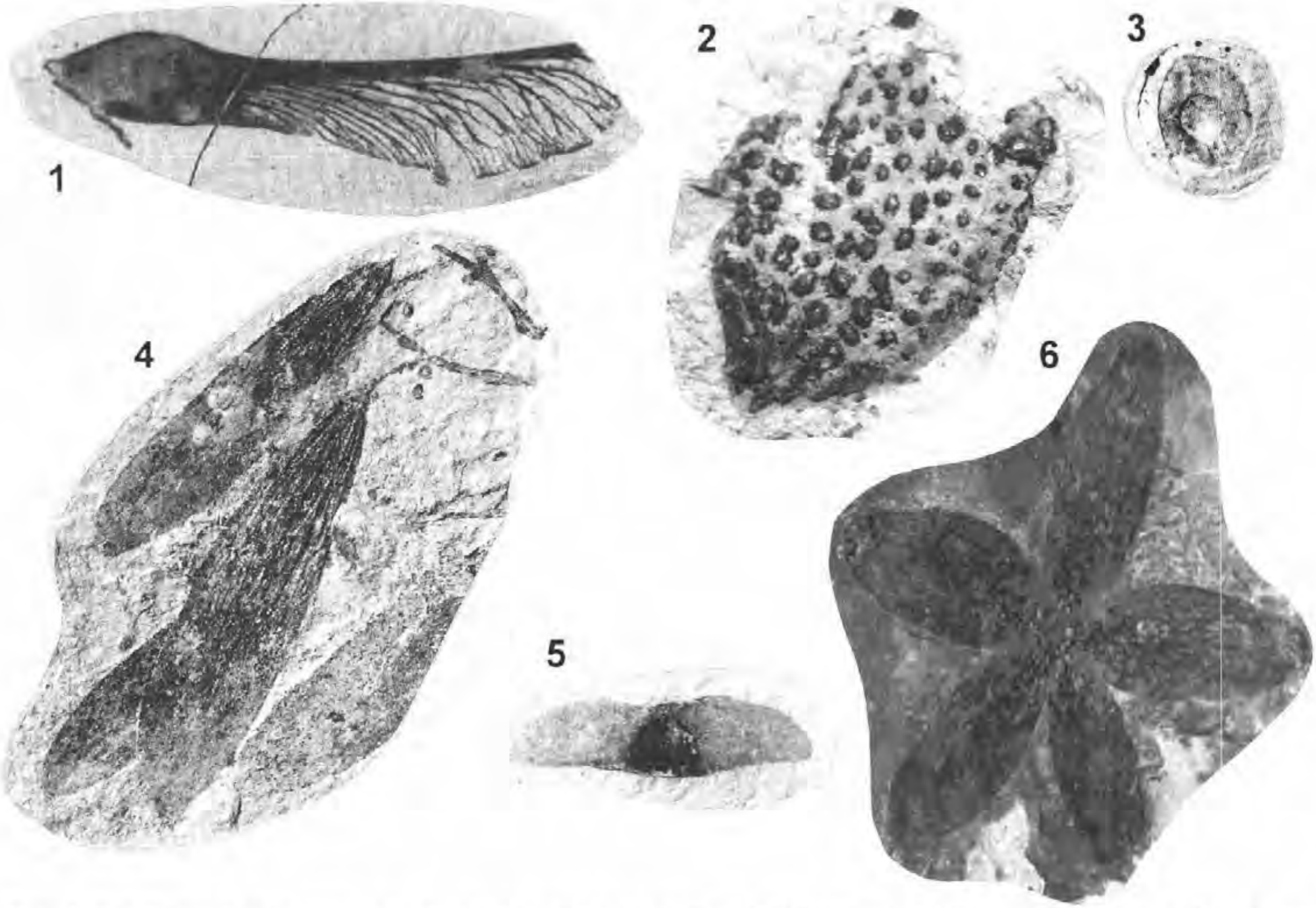

Plate 4. Early Tertiary fruits and seeds from Washington and British Columbia. UWBM, University of Washington Burke Museum. Magnifications approximate. **1.** *Acer* fruit, UWBM 36957A, loc. A0307, Republic, x3. **2.** *Palaeophytocrene* fruit, UWBM 71108A, loc. A0307, Republic, x 3. **3.** *Vitis* (grape family) seed, UWBM 78161, loc. B4131, Republic, x3. **4.** *Fraxinus* fruit, R. W. Mathewes collection, Quilchena, BC, x2.75. **5.** Bignoniaceae fruit, UWBM 74320, loc. B4131, Republic, x5. **6.** *Porana* fruit, UWBM 54199, loc. B3266, Princeton, BC, x1.6.

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 (Wolfe and Tanai, 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* fruits also are present in the Gumboot Mountain flora.

Dogwood Family (Cornaceae)

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

> "A *Mastixia*-like fruit in the Princeton chert appears to most closely resemble *Mastixicarpum* [also found in the Clarno beds]" (B. LePage and R. A. Stockey, Univ. of Alberta, written commun., 1995).

Fossil fruits resembling those of *Nyssa* (tupelo gum) occur in the middle Eocene Naches Formation near Taneum Creek south of Ronald in Kittitas County and in the Chuckanut Formation near Maple Falls northeast of Bellingham in Whatcom County.

Icacinaceae Family

This family comprises trees, shrubs, and lianas, almost all of which inhabit tropical rain forests today. The *Palaeophytocrene* fossil fruit (Plate 4, fig. 2) is an ancestral form of modern *Phytocrene*, a climbing or twining shrub found today mainly in Malaysia but also in Asia. *Palaeophytocrene* fruits have been found in the Chuckanut Formation near Bellingham (B. Archibald, Vancouver, BC, oral commun. 1995); they occur commonly in the middle Eocene Clarno Formation of Oregon and the early Eocene London Clay. Their occurrence at Republic (two examples) and at Quilchena, BC, is an interesting surprise because these two floras are considered to have been warm-temperate to subtropical, rather than tropical.

Palaeophytocrene fruits also occur in the middle Eocene Roslyn Formation (Kittitas County). They have been found in the middle Eocene Aldwell Formation marine deposits at the Elwha River (Clallam County).

Palaeophytocrene fruits are present in the middle Eocene Swauk Formation near Blewett Pass. A fossil fruit similar to the extinct genus *Idiocarpa* occurs in the Chuckanut Formation near Bellingham. This genus was first described from the Clarno Formation nut beds (Manchester, 1994). The presence of icacinaceous fruits in the Roslyn, Chuckanut, and Swauk 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.

A fruit of *Palaeophytocrene* cf. *P. pseudopersica* Manchester occurs in the Hoko River Formation (Eocene; Narizian) (R. Berglund, Burke Museum, written commun., 1995).

Palaeophytocrene fruits are common in the Clarno nut beds. They occur in the Oligocene Gray Butte (southwest of Clarno), Dugout Gulch (a few miles north of Clarno) (John Day deposits), and Willamette floras of northwestern Oregon (Manchester, 1994). A single *Palaeophytocrene* 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 *Ampelocissus* occur in the Princeton chert flora (Cevallos-Ferriz and Stockey, 1990), and grape seeds have been found at the Vermilion Bluff (Allenby Formation) locality at Princeton. A single vitaceous seed (*Vitis*) is known from the Republic flora (Plate 4, fig. 3). Silicified grape seeds also occur in the interbeds between the Miocene basalt 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 Swauk Formation at Blewett Pass. Seeds of this now tropical and subtropical family are common in the Clarno Formation and London Clay floras.

Olive Family (Oleaceae)

Fraxinus winged fruits occur in the Quilchena flora (Plate 4, fig. 4). Although *Fraxinus* fruits are also recorded from Eocene floras in California (Chalk Bluffs flora, Ione Formation), Tennessee (Claiborne flora, 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 *Fraxinus* and the olive family (Call and Dilcher, 1992).

> "As mentioned by Mathewes and Brooke (1971), the attachment of these fruits at Quilchena to the panicle 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/Coffee, Quinine Family (Rubiaceae)

The Rubiaceae family is now distributed worldwide, especially in tropical to 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 Okanogan 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. Bignoniaceous fossil seeds have been found in the Republic flora (Plate 4, fig. 5). Similar fossil fruits have been recorded from the Paleocene Fort Union Formation of Montana (Brown, 1962).

Morning Glory Family (Convolvulaceae)

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

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

Aram Lily/Calla Lily Family (Araceae)

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

Mystery Plants

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

Pteronepelys wehrii 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. *Pteronepelys*, for example, breaks down into *pteron* (winged) and *epelys* (stranger), which aptly describes this odd fossil fruit (Plate 5, fig. 1). We haven't the faintest idea at this time 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 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 coelomycetous *Phoma*-like Eocene fungus (form division Fungi Imperfecti) has been found causing a blight on a *Princetonia allenbyensis* of the Princeton chert. Pathenogenesis and decay of fruits and seeds by this coelomycetous mold...appear comparable to a modern fungal blight syndrome" (G. Hill-Rackette and R. A. Stockey, Univ. of Alberta, written commun., 1995).

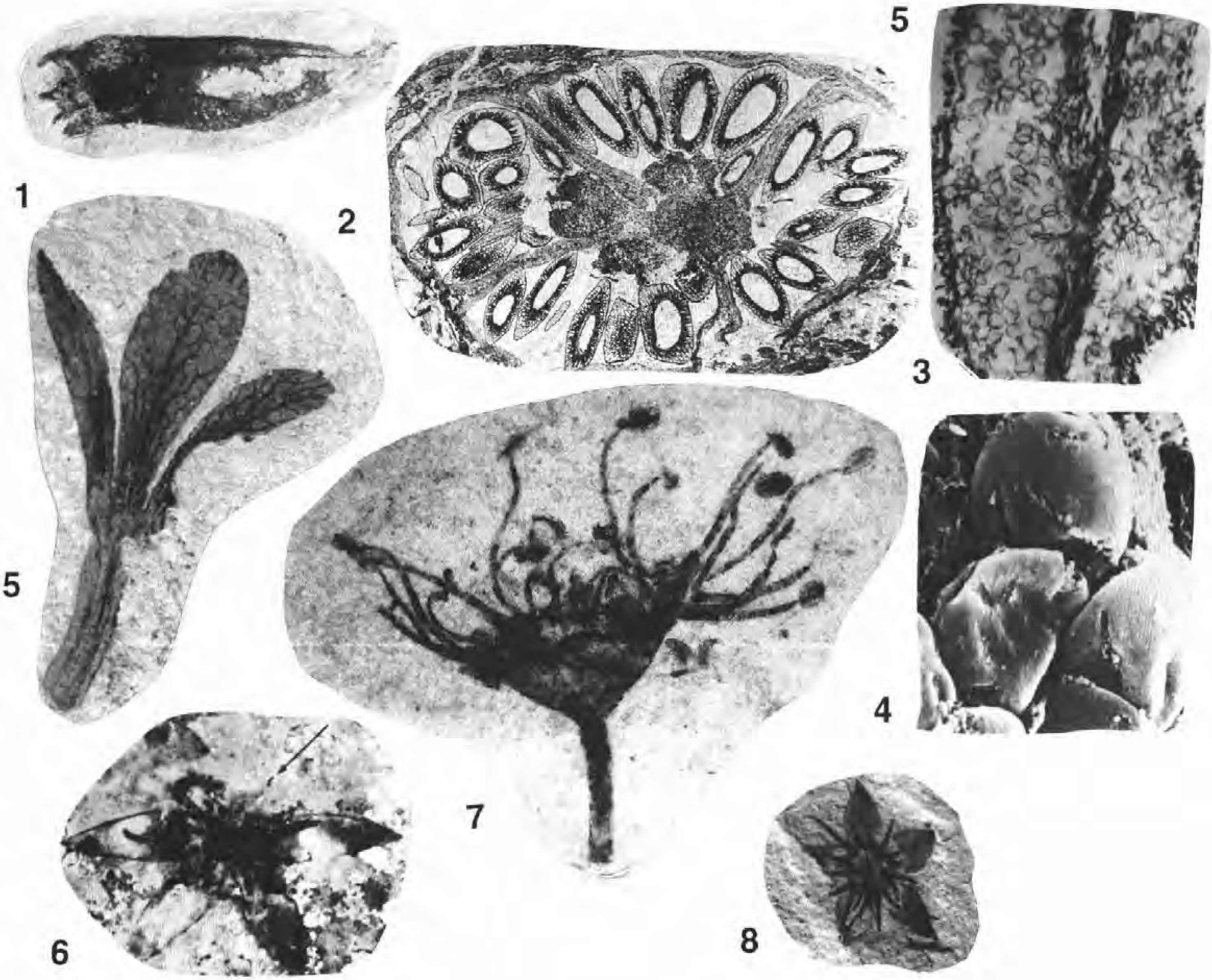

Plate 5. Early Tertiary flowers and fruit from Washington and British Columbia. UWBM, University of Washington Burke Museum; UAPC-ALTA, University of Alberta Paleobotany Collections; SR, Stonerose Interpretive Center collection. Magnifications approximate. **1.** *Pteronepelys* fruit, SR 92-7-17A, loc. B4131, Republic, x2.5. **2–4.** *Princetonia allenbyensis*, Princeton chert, loc. P1122; 2, section through fruit with seeds, P3928B, x9; 3, section showing anthers with pollen, P2152A, x140; 4, pollen, P2151A, x15,000. **5.** *Calycites* ("*Abelia*") flower, UWBM 36773, loc. B4131, Republic, x5. **6.** *Pistillipollianthus* flower, UAPC-ALTA S6557, Horsefly, BC, x2.7. **7.** indeterminate flower, UWBM 56531, loc. B2737, Republic, x5. **8.** indeterminate flower SR 92-17-18, loc. B4131, Republic, x1.5.

Calycites ardtunensis 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 early 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 Clarno Formation of Oregon.

The presence of *Calycites ardtunensis* in early Tertiary floras of both Europe and western North America further emphasizes the strong floristic similarities that existed between these two regions during the Paleogene (Crane, 1988).

Pistillipollianthus wilsonii Stockey and Manchester (extinct genus)

This superbly preserved fossil flower (Plate 5, fig. 6) from unnamed middle Eocene beds at Horsefly, BC, contains pollen that is very similar to that of the extinct pollen taxon *Pistillipollenites macgregorii* Rouse. 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 Daghlian (1981) to the gentian family. Four extant but unrelated angiosperm families have pollen with ornamentation that is similar to these Horsefly and Texas plants. The fact that none of these *Pistillipollenites*-producing flowers is closely related indicates that this type of pollen may have arisen convergently during the early Tertiary and may have been produced by other families (Stockey and Manchester, 1988).

These next flowers were found at Republic: unidentified flower (type I) (Plate 5, fig. 7), and unidentified flower (type II) (Plate 5, fig. 8).

SUMMARY AND CONCLUSION

Manchester (1987), in his exhaustive monograph of the fossil history of the walnut family (Juglandaceae), has discussed why fossil reproductive structures (in this instance, fossil fruits) can be of critical importance 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....Foliage in the Juglandaceae is difficult to stereotype according to its taxonomic utility. Wolfe (1959) indicates that there is a more or less typical type of leaflet for each genus and section in the Juglandaceae that differs from the leaflets of other taxa. On this basis, he and most 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 Tertiary, such problems are compounded by the presence of extinct genera (diagnosed from fruits) with foliage similar to modern 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" (Manchester, 1987, p. 5-7).

When many early Tertiary fossil plants are reconstructed from the parts of them that we have been able to find, they tend to look strange. We see that these early Tertiary plants are unique combinations of elements and features—there are no exact modern analogues. It is as if we expected to find an otter but got a platypus. The explanation is quite simple—through time the flowers, seeds, and fruits changed more rapidly than wood and leaves. Each locality is a geologic snapshot of this process; we find features in various stages of modernization. Modern plants likely combine features in ways that their descendants will not. When it comes to botanical evolution, Nils Bohr, the great physicist, was right when he said:

> "Prediction is very difficult—especially when it involves the future."

As we attempt to understand how modern plants evolved over millions of years to become the ones we are now familiar with, we turn to the fossil record for clues and insights. But that record is fragmentary and difficult to interpret much of the time. Using the available fossil evidence, paleobotanists and evolutionary biologists attempt to reconstruct plant lineages. They cannot, of course, anticipate what kinds of startling and revealing finds will be made. What important fossil plants, flowers, and insects are still entombed in those volcanic sediments of the old lakebeds at Republic, or in the more tropical terrestrial, or in the marine sedimentary sections of western Washington?

The opportunity for fossil collectors, professional or amateur, to make contributions to our understanding of the past is a very democratic one. In fact, many of the exciting and informative fossil finds at Republic (cover photo) and elsewhere were made by sharp-eyed collectors who had the persistence to keep splitting the fossil-bearing rocks until something wonderful appeared. Fossil plants can be found in a variety of sedimentary environments that range from the water-laid volcanic ash found in the upland lake beds of the Okanogan Highlands to the siltstones and sandstones in the marine environments of western Washington. The hunt for exciting new kinds of fossils, whether they are plants or insects or vertebrates, can take place anywhere one can reasonably expect to find such remains preserved.

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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 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 surveys. The committee 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 midpoint in 1995.

The Division of Geology and Earth Resources lists its reports about landslides and slope stability in its recently updated (free) list of publications, and the Division's bibliographies, 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 for postage and handling. Only Washington residents must pay the total price; others may deduct the tax. Check or money order should be made out the the Department of Natural Resources, and sent with the order to the Division at PO Box 47007, Olympia, WA 98504-7007.

BULLETINS

43.	Eocene stratigraphy of the lower Cowlitz River–eastern Willapa Hills area, southwestern Washington, by D. A. Henriksen. 1956. 122 p., 2 pl., 49 figs.	$ .70 .05 $ .75
47.	Coal reserves of Washington, by H. M. Beikman, H. D. Gower, and T. A. M. Dana. 1961. 115 p., 62 figs. [*Reprinted with* 15-p. addendum by H. W. Schasse, T. J. Walsh, and W. M. Phillips. 1984.]	$ 1.62 .13 $ 1.75
53.	Stratigraphy and foraminifera of the Satsop River area, southern Olympic Peninsula, Washington, by W. W. Rau. 1966. 66 p., 9 figs.	$ .70 .05 $ .75
70.	Zinc and lead ore deposits in carbonate rocks, Stevens County, Washington, by J. W. Mills. 1977. 171 p., 70 figs.	$ 1.39 .11 $ 1.50
72.	Washington coastal geology between the Hoh and Quillayute Rivers, by W. W. Rau. 1980. 57 p., 74 figs.	$ 2.32 .18 $ 2.50
75.	Geology of the Wenatchee and Monitor quadrangles, Chelan and Douglas Counties, Washington, by R. L. Gresens. 1983. 75 p., 3 pl., scale 1:24,000.	$ 2.32 .18 $ 2.50
76.	Bibliography and index of the geology and mineral resources of Washington, 1963–1980, compiled by C. J. Manson and Debbie Burnetti. 1983. 398 p.	$ 2.09 .16 $ 2.25
77.	Selected papers on the geology of Washington, edited by J. E. Schuster. 1987. 406 p.	$ 7.41 .59 $ 8.00
78.	Engineering geology in Washington, edited by R. W. Galster, chairman. 1989. [2 v.], 1,234 p.	$13.90 1.10 $15.00
79.	Bibliography and index of the geology and mineral resources of Washington, 1981–1985, compiled by C. J. Manson. 1990. 484 p.	$ 5.79 .46 $ 6.25

GEOLOGIC MAPS

GM-15.	Slope stability map of Thurston County, Washington, by E. R. Artim. 1976. 1 sheet, scale 1:125,000.	$ .46 .04 $ .50
GM-16.	Relative ground settlement hazards of Thurston County, Washington, by E. R. Artim. 1976. 1 sheet, scale 1:125,000.	$ .46 .04 $ .50
GM-17.	Relative potential for differential settlement, Gig Harbor Peninsula, Pierce County, Washington, by Mackey Smith. 1976. 1 sheet, scale 1:31,250.	$ .46 .04 $ .50
GM-18.	Relative slope stability of the Gig Harbor Peninsula, Pierce County, Washington, by Mackey Smith. 1976. 1 sheet, scale 1:31,250.	$ .46 .04 $ .50
GM-19.	Geologic factors affecting waste disposal practices, Gig Harbor Peninsula, Pierce County, Washington, by Mackey Smith. 1976. 1 sheet, scale 1:31,250.	$ .46 .04 $ .50

INFORMATION CIRCULARS

54.	A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways, by N. P. Campbell. 1975. 82 p., figs.	$ .93 .07 $ 1.00
59.	Washington gravity base station network, by T. H. Nilsen. 1976. 83 p., 1 fig., 4 tables.	$ .93 .07 $ 1.00
61.	Annotated 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. Dethier. 1978. 63 p., 8 figs.	$ .70 .05 $ .75
65.	Compilation of earthquake hypocenters in western Washington—1976, by R. S. Crosson and L. L. Noson. 1978. 13 p., 2 figs.	$ .23 .02 $ .25
72.	Compilation of earthquake hypocenters in western Washington—1978, by L. L. Noson and R. S. Crosson. 1980. 18 p., 5 figs.	$ .23 .02 $ .25
79.	Compilation of earthquake hypocenters in western Washington—1979, by L. L. Noson, R. S. Ludwin, and R. S. Crosson. 1985. 19 p., 4 figs.	$ .23 .02 $ .25

REPORTS OF INVESTIGATIONS

26.	Coastal wells of Washington, by W. W. Rau and C. R. McFarland. 1982. 4 sheets.	Free
27.	Geology of the Grande Ronde lignite field, Asotin County, Washington, by K. L. Stoffel. 1984. 79 p., 1 pl., scale 1:48,000, 71 figs.	$ 1.85 .15 $ 2.00
28.	Tin, tungsten, and molybdenum geochemistry of parts of Stevens and Spokane Counties, Washington, by B. B. Bunning. 1985. 57 p., 30 figs.	$ .93 .07 $ 1.00

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

WASHINGTON ARCHAEOLOGY WEEK (October 1–7, 1995)

A series of events in various communities will enhance public awareness about 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:

Chehalis – Flintknapping Demonstration
Oct. 7, 10 am–4 pm, Lewis County Museum, 599 NW Front St.

DuPont/Northwest Landing – Archaeological and Historic Site Tour and Train Ride
View a video on archeological research and excavations and ride a narrow-gauge railroad down Sequalitchew Canyon to the dock once used by the DuPont Company. At a brown bag lunch on the beach, hear talks on 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 & 6, 9:30 am, Northwest Landing. Participation is limited to 32 persons each day. Register by calling (206) 924-7063.

DuPont – 1843 Fort Nisqually
The Hudson's Bay Company 1843 Fort Nisqually site will be open for public visitation. Oct. 7 & 8, 1–4 pm. For directions, contact the City of DuPont at (206) 964-8121.

Ephrata – Flintknapping Demonstration
Oct. 5, 7 pm, Public Library. Contact Kay Dirks at (509) 754-3971.

Forks – Underwater Archaeology
Learn about the recent underwater archaeological survey conducted by NOAA in the Olympic Marine Sanctuary. Oct. 7, 9 am–3 pm, Olympic Natural Resource Center. Contact June Robinson at (360) 417-2364.

Neah Bay – Makah Coastal Village Exhibit
Oct. 4–7, 10 am–5 pm, Makah Cultural and Research Center. Contact museum staff at (360) 645-2711.

Newhalem – Archaeology of the Upper Skagit River
Slide show and artifact identification. Oct. 7, 1–4 pm, North Cascades Park Visitor Center. Contact Bob Mierendorf, (360) 873-4590, ext. 23.

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

Pullman – Flintknapping Demonstration
Oct. 6, 1:30–3 pm, Museum of Anthropology. Contact Joy Mastrogiuseppe at (509) 335-3936.

Richland – Archaeology at Hanford
Series of lectures, including Flood Basalts of the Columbia Plateau; Pleistocene Cataclysmic Floods; and Early Man and the Demise of Washington Elephants. Sept. 30, 10 am–12:30 pm, Battelle Auditorium, 902 Battelle Blvd. Contact Mona Wright at (509) 372-1079.

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 pm, Burke Museum, small fee. Contact the museum information line at (206) 543-5590.

Shelton – Historic Walking Tour
Self-guided walking tour of town's historic stream and creek systems. Oct. 1–7, downtown Shelton. Contact Joe Williams at (360) 426-9731.

Skykomish – Iron Goat Trail Interpretive Hike
Stroll into the past on the Iron Goat Trail as it follows the abandoned Great Northern Railway route near Stevens Pass. Oct. 7, 10 am, Iron Goat Trailhead. Contact trail information line at (206) 283-1440.

Tacoma – Candlelight Tour of Fort Nisqually
Eavesdrop on the past as volunteers and staff in period dress go about life as if it were 1855. Oct. 6 & 7, 7 pm, Fort Nisqually, Point Defiance Park. Advance tickets, small fee. Contact Melissa McGinnis at (206) 591-5339.

Vancouver – Hudson's Bay Company Conference
This conference on the history of Hudson's Bay Company operations in the Pacific Northwest covers all aspects of fur trade-era history from international relations to Native American cultures to local case studies and biography. Sept. 29–Oct. 1, Red Lion Inn at the Quay. Contact Fur Trade Conference at (360) 737-2044.

Vancouver – Fort Vancouver Candlelight Tour
Experience times past at this Hudson's Bay Company fort. Oct. 6 & 7, 7 pm. Contact Rick Edwards at (360) 696-7688, ext. 3.

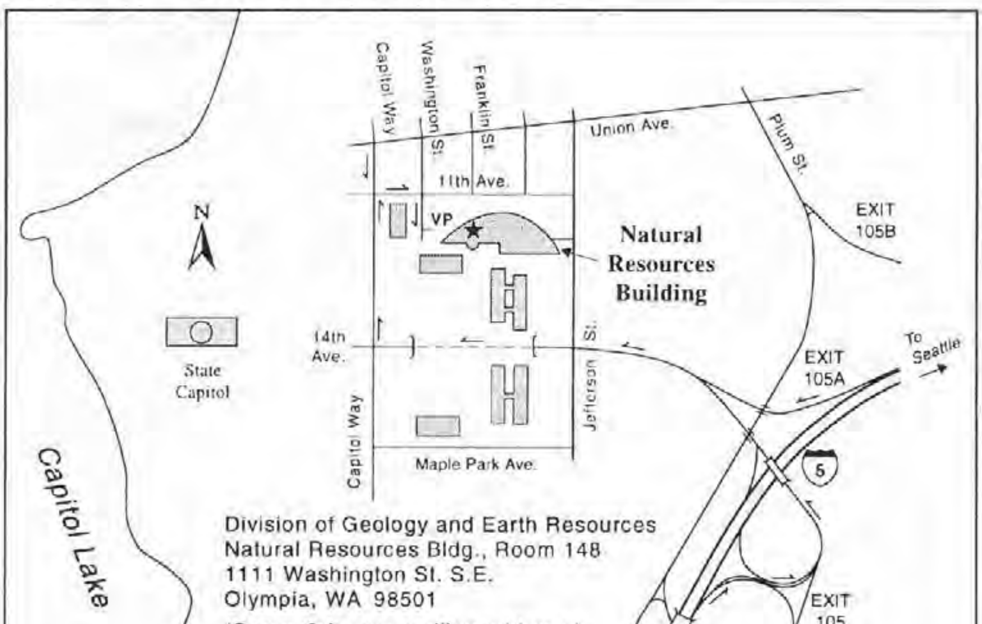
Vancouver – Covington Archaeological Site Tour
Walking tour of a Native American archaeological site with replica longhouse, artifact display, and discussion of local preservation issues. Oct. 7, 2–5 pm, 8510 NE 76th St. Contact Rudy or Tim Podhora at (360) 254-9218 or 892-6039.

For More Information

To find out about events in your community, contact your local historical society or library. Several Washington organizations also offer general information:

Office of Archaeology and Historic Preservation – (360) 753-5010
Governor's Office of Indian Affairs – (360) 753-2411
Association for Washington Archaeology – (206) 323-1343
Mid-Columbia Archaeological Society – (509) 586-4806

HOW TO FIND OUR MAIN OFFICE



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-curated 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 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 Barksdale 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, 1996.

NEW DIVISION RELEASE

Geologic Map of the West Half of the Twisp 1:100,000 Quadrangle, Washington, Open File Report 95-3, compiled by Joe D. Dragovich and David K. Norman, geochronology by W. McClelland. This 63-page report includes three data appendices, 1 plate, scale 1:100,000. Price $3.24 + .26 tax = $3.50.

WASHINGTON STATE DEPARTMENT OF
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Jennifer M. Belcher - Commissioner of Public Lands
Kaleen Cottingham - Supervisor

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