Hydrangea Fossils from the Early Tertiary Chuckanut Formation

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Introduction

Flowers are among the rarest of fossils, and the diversity of floral remains in Washington deposits partly explains our state's reputation as a paleobotanical treasure house (Wehr, 1995; Wehr and Manchester, 1996; Pigg and Wehr, 2002). This floral record is expanded by the discovery of *Hydrangea* fossils in the early Tertiary Chuckanut Formation near Bellingham.

The first Chuckanut Formation *Hydrangea* specimen was an incomplete sterile flower found near Chuckanut Drive in Skagit County in 1987 by Burke Museum affiliate paleobotanist Don Hopkins. In 2000, Harold Crook collected a better specimen at this site (Fig. 1A) from strata near the base of the 6,000 m thick Chuckanut Formation. These beds are probably late Paleocene, as indicated by fossil pollen (Griggs, 1970; Reiswig, 1982) and fission track ages of detrital zircons (Johnson, 1984). A well-preserved *Hydrangea* leaf fossil (Fig. 1B) was found in 1996 in a utilities excavation near Bellingham in rocks of the Padden Member, the youngest stratigraphic unit in the Chuckanut Formation. This leaf fossil is probably late Eocene, but the age of the Padden Member has not been clearly established (Mustoe and Gannaway, 1997).

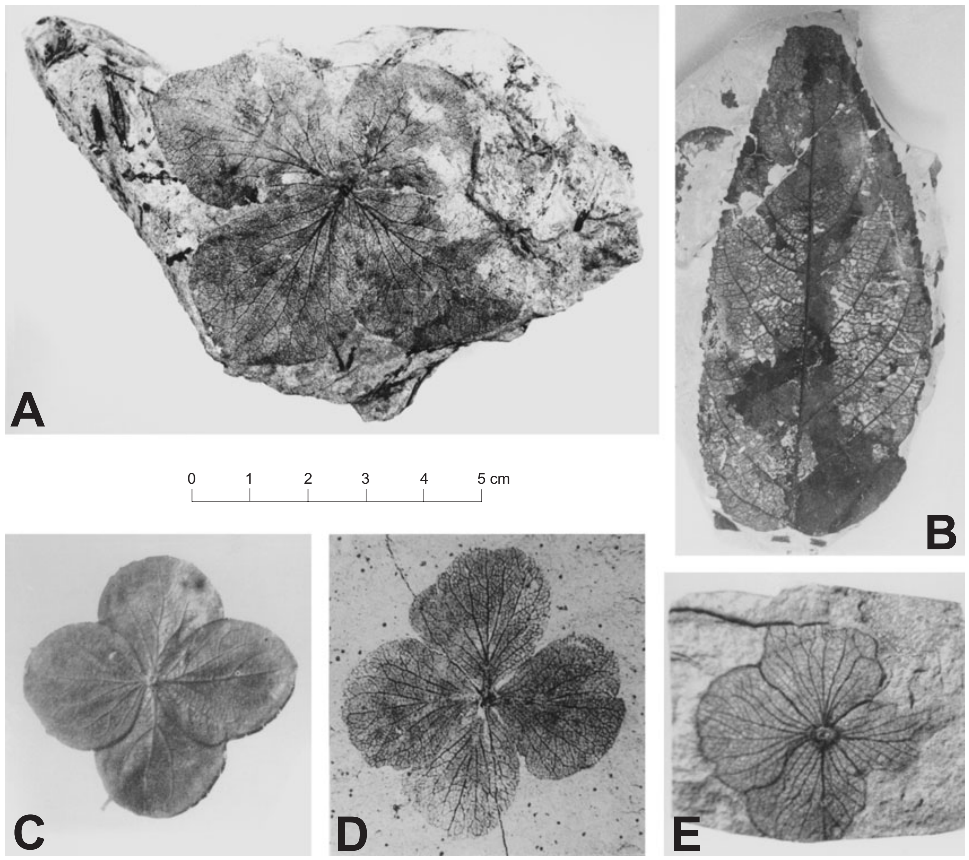

Figure 1. **A**, *Hydrangea* sterile floret, Chuckanut Formation, late Paleocene(?) Bellingham Bay Member, WWU-02-2-7, collected by Harold Crook from site WWU CD-5, Chuckanut Drive, Skagit County; **B**, *Hydrangea* leaf, Chuckanut Formation, late Eocene(?) Padden Member, not numbered, collected by Elaine Mustoe, site WWU-BK1, Bellingham; **C**, Sterile floret from extant *Hydrangea strigosa* Rehder, location and specimen number not recorded (Brown, 1937); **D**, *Hydrangea* sp., Eocene Clarno Formation, UF9962 (University of Florida), Gonser Road Clarno locality 238, central Oregon (Manchester, 1994); **E**, *Hydrangea bendirei* (Ward) Knowlton, Miocene Latah Formation, U.S. National Museum specimen 36979, from a railway cut in downtown Spokane (Knowlton, 1926).

Modern Hydrangea

A member of the Hydrangaceae family, the genus *Hydrangea* is comprised of 23 extant species of shrubs, small trees, and climbing plants (McClintock, 1957, 1973; Nevling, 1964; Lawson-Hill and Rothera, 1995). Although hydrangeas are prized by Pacific Northwest gardeners because of their showy clusters of blue or pink blossoms, none of the ornamental cultivars are native to the region. Two species, *Hydrangea arborescens* and *H. quercifolia* are endemic to the southeastern U.S., and 11 species of evergreen climbers grow in mountain areas of South and Central America. The main occurrence of *Hydrangea* is in temperate forests of eastern Asia—they can be found in Tibet, central and southern China, Japan, the Philippines, Taiwan, Java, and Sumatra.

Hydrangea flower heads (inflorescences) are composed of conspicuous four-petaled sterile florets (Fig. 1C) together with tiny fertile flowers. The latter may be grouped together near the center (Fig. 2) or distributed throughout the flower head. The sterile flowers may serve as an attractant and landing platform for pollinating insects (Lawson-Hill and Rothera, 1995). In many cultivated subspecies, the large, globular blossom clusters contain few, if any, fertile flowers. Sterile florets are well-represented in the fossil record, but some deposits preserve remains of the fertile flowers (Manchester, 1994).

Hydrangea foliage is either deciduous or evergreen, depending on the species. Most leaves are ovate or elliptic, arising from the stem in opposite pairs. Most species have serrate leaf margins, but a few species have smooth-edged ('entire') leaves. *Hydrangea quercifolia* of North America and *H. sikokiana* of Japan have pinnately lobed leaves. Leaf surfaces are glossy, smooth, matte, or hairy, according to the species.

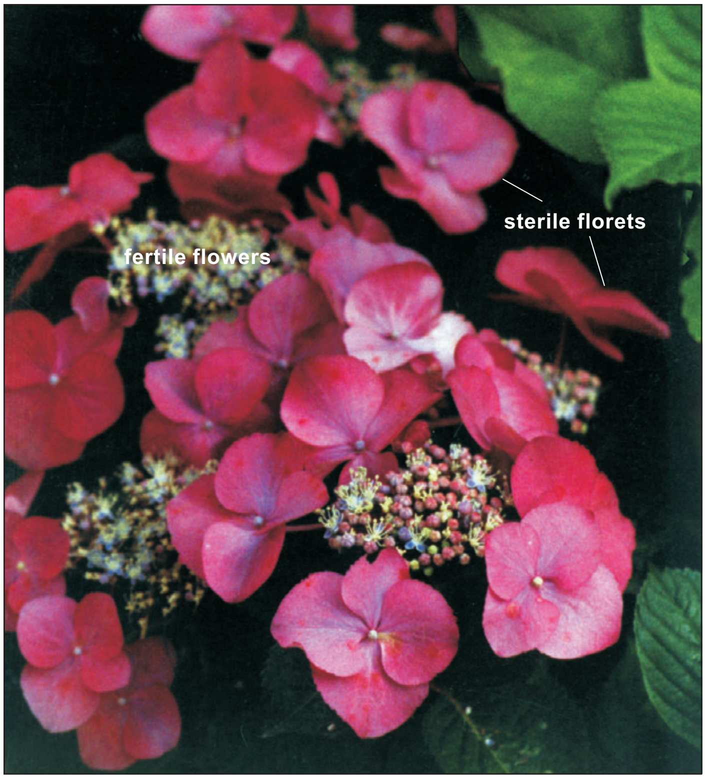

Figure 2. Flower head of an extant *Hydrangea macrophylla*, a lacecap variety, showing four-petaled sterile florets and small fertile flowers. *Photo courtesy of Jari Roloff.*

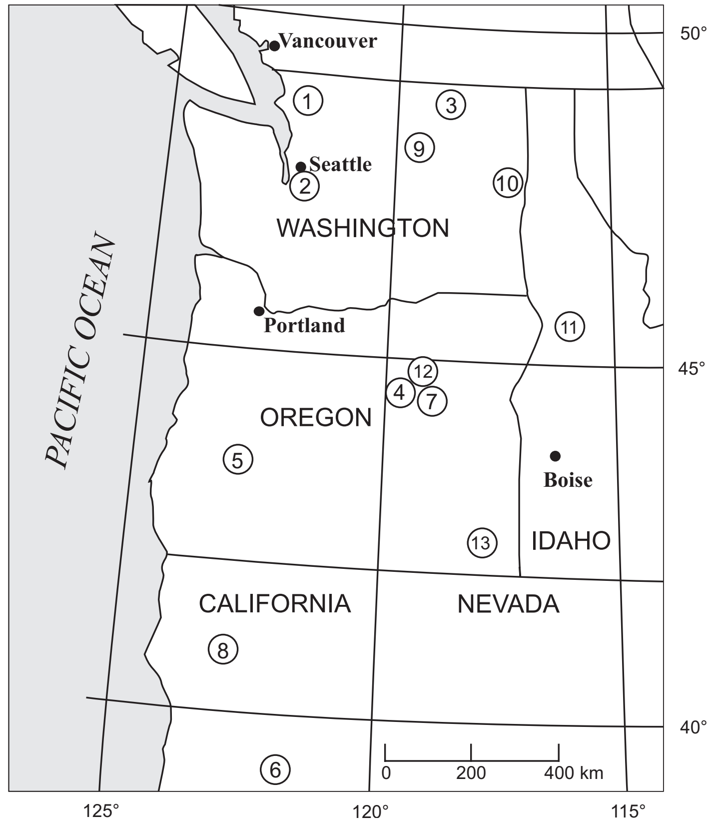

Figure 3. Occurrences of *Hydrangea* fossils in the Pacific Northwest. Eocene: 1, Chuckanut Formation; 2, Puget Group (Wehr, 1995); 3, Republic flora (Wehr and Hopkins, 1994); 4, Clarno Formation (Manchester, 1994); 5, Goshen flora (Chaney and Sanborn, 1933); 6, Chalk Bluffs flora (MacGinitie, 1941). Oligocene: 7, John Day Formation (Meyer and Manchester, 1997); 8, Weaverville flora (MacGinitie, 1937). Miocene: 9, Grand Coulee flora (Berry, 1931); 10, Latah Formation (Knowlton, 1926); 11, Whitebird flora (Berry, 1934); 12, Mascall Formation (Knowlton, 1902); 13, Trout Creek flora (MacGinitie, 1933; Arnold, 1937).

GEOLOGIC RANGE

Hydrangea fossils have previously been reported from paleofloras that range in age from Paleocene to Miocene (Fig. 3). Hollick (1925, 1936) described *Hydrangea* specimens from Paleocene and Eocene rocks of Alaska. Eocene *Hydrangea* leaves are preserved in the Goshen paleoflora of west central Oregon (Chaney and Sanborn, 1933) and the Chalk Bluffs and Weaverville paleofloras in northern California (MacGinitie, 1937, 1941). Wehr (1995) noted the presence of undescribed *Hydrangea* specimens from two localities in the Eocene Puget Group of western Washington. Flower imprints have been collected from the Eocene Clarno Formation (Fig. 1D) and Oligocene John Day Formation of Oregon (Manchester, 1994; Meyer and Manchester, 1997) and from Oligocene fossil beds at Florissant, Colorado (LaMotte, 1952). Miocene occurrences of fossilized *Hydrangea* flowers and foliage in Washington include the Latah Formation near Spokane (Fig. 1E; Knowlton, 1926) and at Grand Coulee (Berry, 1931). Other Miocene examples come from Whitebird, Idaho (Berry, 1934), and the Mascall and Trout Creek paleofloras of Oregon (Knowlton, 1902; MacGinitie, 1933; Arnold, 1937). *Hydrangea* fossils have also been reported from the Miocene Shantung flora of China (Hu and Chaney, 1940)

DISCUSSION

Hydrangea fossils occur in both subtropical and temperate paleofloras, demonstrating climatic tolerances that are much greater than that of extant hydrangeas. The geographic distribution of extant *Hydrangea* species (Fig. 4) is strikingly different from the currently known ranges of fossil species.

The presence of *Hydrangea* remains in both the oldest and youngest strata of the Chuckanut Formation provides evidence of the ability of the genus to adjust to climatic change during the early Tertiary. Mustoe and Gannaway (1997) used the Climate-Leaf Multivariate Program (CLAMP) method of Wolfe (1993) to study paleoclimate of the Chuckanut Formation. They calculated a mean annual temperature (MAT) of 15°C and a mean annual range of temperature (MART) of 10°C for the Bellingham Bay Member, which is at the base of the formation. These results are indicative of subtropical rain forest, as confirmed by the presence of abundant palm leaf fossils (Mustoe and Gannaway, 1995). The paleoclimate of the Padden Member, which is at the top of the formation, is quite different, with a MAT of 12°C and a MART of 18°C. The cooler climate and greater seasonal difference represent a warm temperate environment more like conditions where *Hydrangea* flourishes today. A similar trend is recorded in central Oregon, where *Hydrangea* fossils occur in both the Eocene subtropical Clarno paleoflora and in the warm temperate Bridge Creek paleoflora of the Oligocene John Day Formation. The same trend is true of other occurrences (Fig. 3), where *Hydrangea* fossils are present in Paleocene and Eocene subtropical paleofloras and in warm temperate paleofloras of later epochs. Our knowledge of the response of *Hydrangea* to paleoclimatic influences is limited by the fact that plant remains are likely to be preserved only under favorable geologic

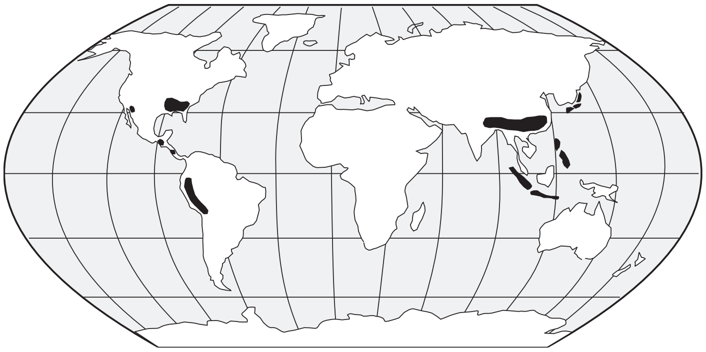

Figure 4. Geographic range of extant *Hydrangea*. Adapted from Lawson-Hill and Rothera, 1995.

conditions, and few regions have palefloras that span a broad age range.

Perhaps *Hydrangea* had broad climatic tolerances during the early Tertiary, contemporaneously inhabiting both subtropical and temperate environments. This interpretation is supported by the observation that two types of *Hydrangea* leaves have been found at middle Eocene fossil beds at Republic, Washington, a warm temperate paleoflora (Wolfe and Wehr, 1991; Wehr and Hopkins, 1994). Alternately, the genus may have initially evolved in subtropical forests and migrated to temperate environments during the Eocene. The latter interpretation is consistent with the observation that *Hydrangea* fossils have not been found in the middle Eocene temperate floras at McAbee and Princeton, British Columbia. More study is required to answer this question.

Meanwhile, *Hydrangea* fossils provide a reminder of the possible pitfalls of using floristic analysis to determine paleoclimate. Floristic analysis compares plant fossils to extant taxa that are inferred to be their nearest living relative. The climatic tolerances of the living plants are assumed to be similar to those of ancient ancestors. According to this hypothesis, *Hydrangea* fossils would be considered indicators of temperate climate. *Hydrangea* fossils are also a reminder of a second source of error: the search for a nearest living relative works only if the taxonomy of plant fossils can be correctly ascertained. *Hydrangea* leaves bear resemblances to those of other plant families, making identification problematic unless venation is preserved in detail. LaMotte (1952) lists instances where *Hydrangea* remains have been incorrectly assigned to the genera *Celastrus* (a tropical vine), *Fraxinus* (ash family), *Juglans* (walnut family), and *Rhus* (sumac family). The flowers are more distinctive, but in the past *Hydrangea* fossils have been misidentified as *Marsilia*, *Porana*, and *Euonymus* (genera from three families of tropical vines).

Both of these sources of error are avoided with vegetational analysis, which uses morphological features of dicotyledonous leaves as an indicator of climate. The CLAMP method (Wolfe, 1993, 1995) is the best-known example of this technique, but several alternative computational schemes have been proposed (Wing and Greenwood, 1993; Gregory and McIntosh, 1996; Herman and Spicer, 1997; Wilf, 1997). Each method has its supporters and detractors, and the reliability of each technique is a subject of debate. For example, calculations of the MAT for the Clarno paleoflora range from 14.3° to 18.8°C depending on the method that is used (Wiemann and others, 1998). Like the difficulty of forecasting next week's weather, the determination of ancient climates is presently a less-than-certain endeavor.

ACKNOWLEDGMENTS

Don Hopkins and Harold Crook deserve credit for reporting their discoveries of *Hydrangea* fossils. Steven Manchester (Florida Museum of Natural History) identified the fossil flower found by Crook, and Jack Wolfe (University of Arizona) recognized the identity of a leaf fossil collected several years earlier by Elaine Mustoe. Burke Museum Paleobotany Curator Wes Wehr deserves special mention for his many years of study of fossil flowers from the Pacific Northwest, providing a regional database that is essential for interpreting new specimens. The author thanks Wes Wehr and Kitty Reed for their careful manuscript reviews.

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BOOK REVIEW: Boom Towns and Relic Hunters of Northeastern Washington—A Comprehensive Guide to Ghost Towns in Six Historic Counties

by Jerry Smith
Elfin Cove Press, 2002, 136 p.
7 x 10-inch softcover, perfect bound, $19.95

Mr. Smith's book provides a good starting point for persons interested in exploration and relic hunting in our state's northern tier of ghost towns. The descriptions are very helpful for locating these sites, many of which are overgrown and on the verge of disappearing altogether. The before-and-after photos are particularly helpful. The sections devoted to the early history of Ruby City, Loup Loup, and Nighthawk contain interesting quotes from historic newspaper articles boosting the region's development. The chapter on metal-collecting ethics and equipment provides a nice tie-in for hobbyists using the book as a source for places to explore.

The author includes some in-text warnings concerning entering abandoned mines, however if the book is issued in subsequent revisions, I suggest including highlighted verbiage similar to that in *Discovering Washington's historic mines*[1]. My advice is to stay out of abandoned mines altogether unless accompanied by a guide familiar with the mine and its structural condition.

Errata:

Page 54. The Boundary Red Mountain Mining Co. stock certificate is not related to mining near the town of Boundary (Stevens Co.) described on same page. The mine is located at the 7000 foot elevation in northern Whatcom county about a mile south of the British Columbia border. The certificate is signed by W. E. Zoebel, listed as secretary of the company in the 1922 report to stockholders (DGER mine file).

Page 112. The Brown Bear mine at the summit of Hart's Pass is not operating during the summer, nor is the New Lite property of Western Gold located in the Barron basin. These properties had been idle for a considerable length of time prior to DGER field work there in the summer of 2001. Some placer miners have recreational sites under work on Slate Creek and its tributaries.

Fritz E. Wolff
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[1] Northwest Underground Explorations, 1997, Discovering Washington's historic mines; Volume 1—The west central Cascade mountains: Oso Publishing Company [Arlington, Wash.], 230 p.