Guidebook and Road Log to the St. Maries River (Clarkia) Fossil Area of Northern Idaho

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Idaho Department of Lands
Moscow, Idaho 83843

Information Circular 33
September 1979
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PREFACE

Visitors to the St. Maries River area will have a diversity of backgrounds, and this guidebook and road log cannot cover all points of special interest. Rather it is our intent that the book provide a sufficient body of information for its users to appreciate the natural development of the area during later Cenozoic time. The scientific importance of this distinctive new fossil area is presently recognized for several areas of ongoing research, as has been indicated by the contributors to the preceding symposium on Late Cenozoic History of the Pacific Northwest (see also Smiley and others, 1975). Because of the diversity and complexity of research projects that are available, some of the studies are well advanced, whereas others are yet to be covered in more than a preliminary manner. We wish to emphasize, therefore, that this guidebook is a progress report on the present status of research and understanding of a significant new fossil area that has been under investigation by many different specialists during the past several years.

The guidebook and road log was originally prepared for the symposium, Late Cenozoic History of the Pacific Northwest, at the annual meeting of the Pacific Division, American Association for the Advancement of Science (AAAS), held at the University of Idaho, June 3-7, 1979.
Guidebook and Log Road Log to the St. Maries River (Clarkia) Fossil Area of Northern Idaho

by

Charles J. Smiley
William C. Rember

INTRODUCTION

The St. Maries River is a small stream that flows north-westward through a hilly terrane in the western foothills of the Northern Rocky Mountains (Figure 1). The trend of the river valley may be controlled by faults, one of which seems to form its northeastern boundary. From about 3 miles (5 kilometers) south of Clarkia (Figure 2) to the town of Santa, a distance of 17 miles (27 kilometers), the valley bottom is relatively broad and flat and is bordered by rounded hills and knolls of metamorphic rocks that rise up to 500 feet (150 meters) above the valley floor (Figures 3 and 4). A loess soil of Quaternary age has mantled the underlying rocks to a depth of 2 to 4 feet (1 meter). Cool-temperate coniferous forests cover the hillsides, and hardwood (dicot) trees occupy the more open riparian and forest-border areas.

At some time during the Paleogene a hill-and-valley topography developed on the basement rocks, and the Proto-St. Maries River drainage system became established at the present site of the St. Maries River. Later, during Neogene time, lava dammed the river valley, forming the Miocene Clarkia Lake (Smiley and Rember, in press). Sedimentary infilling of this lake has resulted in the flat valley floor that remains a distinctive local feature of the St. Maries River and its larger tributary streams.

The presence of fossil plants has been known to area residents for many years. But the true significance of the fossil area had not been recognized until the early 1970's when Francis Kienbaum, owner of the Fossil Bowl race track near Clarkia, exposed an abundant accumulation of fossils during construction of his facilities. This site is the type fossil locality (P-33) in the Clarkia deposits, and it is also the location of the measured type section of the lacustrine sediments (Smiley and others, 1975; Smiley and Rember, in press). At first our activities centered around this outstanding fossil site. Early efforts were devoted to collecting plant and animal remains for taxonomic purposes and to sampling microstratigraphically the plant megafossils and pollen for an analysis of seral changes of the Miocene vegetation. More recently we have expanded our research to other sites and have discovered four new fossil localities in the Clarkia Lake deposits. The preservation and diversity of organisms found in these deposits provide an opportunity for interdisciplinary research of a degree that is unique in the Miocene of North America.

PRESERVATION AND SIGNIFICANCE

LAMINATIONS AND MICROSTRATIGRAPHY

The exposures of richly fossiliferous, finely laminated, lacustrine deposits are ideal for microstratigraphic studies of the complete life cycle of a Miocene lake and of seral changes in bordering vegetation as the lake silted in. A layer-by-layer analysis of plant megafossils was conducted through 27 feet (8 meters) of the type-section at P-33 (Figures 3 and 6). This column, measuring 1 foot by 1.5 feet (30 cm by 45 cm), contained a total of 10,749 plant megafossils that were identified and tabulated stratigraphically (Smiley and Rember, in press). The abundance of fossils in some layers is exemplified by 1.5 cubic foot block that contained 1,294 distinct and identifiable plant megafossils. Gray originally identified the plant microfossils (pollen and spores) from P-33 (Smiley and others, 1975) and later sampled at intervals of 2 inches (5 cm) through this section. Ultimately, this microstratigraphic integration of plant megafossil and microfossil data should provide a clearer picture of Miocene vegetation and seral changes than has heretofore been available in this part of the world. A preliminary study of siliceous microfossils by John Williams at the University of Idaho (written communication) resulted in extracting a diversity of diatoms.
Figure 1. Topographic map of the St. Maries River area of northern Idaho, showing the postulated maximum extent of the Miocene Clarkia Lake. The approximation of the lake boundary is based on the present 2,960-foot contour, which marks the general position of the topographic break between the flat valley floor, underlain by lacustrine clays, and the adjacent slopes of the schistose knolls and hills. See Figure 2 for the area outlined in the southeast corner of the map.
Figure 2. Map of the Clarkia-Emerald Creek portion of the St. Marys River valley, showing the postulated boundaries of this part of the Miocene Clarkia Lake. Pertinent geologic features are also indicated. See Figure 1 and the Road Log.
and sponge spicules. The type-section was recently sampled at intervals of 1 foot (30 cm) by Smiley for an analysis of the diatoms by J. P. Bradbury.

MICROSCOPY OF LEAVES

Plant megafossils include leaves which are preserved as complete cellular compressions, and some of them can be lifted intact from bedding surfaces for microscopic examination. Conifer shoots and cones, in addition to dicot leaves and fragments of moss, can also be removed in a hydrofluoric acid bath as intact threedimensional specimens. More than 100 species of ligneous (woody) plants are known to occur as fossils in the Clarkia Lake deposits, and leaves of many of these can be compared megascopically, microscopically, and chemically with organs of similar living species. Phytooliths have also been observed in some of the leaf specimens that were prepared by Huggins (Smiley and others, 1977) for cellular analysis of leaf cuticles and crushed mesophyll.

ORGANIC CHEMISTRY OF LEAVES

The new area of research on Miocene plants being developed by Niklas and Giannasi (1977) concerns remnant organic chemical constituents in leaf compressions. This study also involves comparisons of the fossil chemistry with the chemical profiles of living relatives. These two scientists have recently begun a study of the well-preserved, taxonomically diversified and numerically rich Clarkia flora. The preservation of leaves as intact cellular compressions with original green and aurumnal pigments, and their occurrence in water-saturated and unoxidized lacustrine clays, led to original expectations that an essentially undisturbed leaf chemistry was retained in the Miocene leaf fossils from Clarkia. Niklas and Giannasi (written communication) have since verified their first expectations from subsequent laboratory analyses using mass spectroscopy and chromatography.

AFFINITIES WITH MODERN PLANTS

Most of the plant species identified in the Clarkia flora were first described from the megascopic (architectural) characters of leaf imprints in other Miocene floras of western North America. The degree of biological affinity that exists between a Tertiary plant species and its presumed living counterpart has long remained a matter of question and conjecture; Have Miocene species survived essentially unchanged to the present day? Or do they represent extinct species that were the direct ancestors of nearly identical descendants in modern forests? Or are they completely extinct taxa and not closely related to any living species? With the fossil material that is now available in the Clarkia deposits, clarification of these relationships and an answer to these questions for at least some of the Miocene species should be forthcoming from the supplemental evidence of cellular anatomy, phytoliths, and organic chemistry. To illustrate: leaves of one of the dominant Clarkia species are remarkably like the living American beech Fagus grandifolia; but this Clarkia species has distinctive fruits, cellular anatomy, phytoliths, and organic chemistry, and the combined evidence indicates that it is actually an extinct genus that is related to beech only at the family level (Smiley and Huggins, in preparation).

INSECTS

The Clarkia insects, studied by Standley Lewis (written communication), are preserved commonly as compressions or impressions of intact bodies. Their records will add appreciably to our understanding of the Miocene insect fauna in this part of the world. Some taxa appear to have been forest-dwelling insects that were blown out into Clarkia Lake from their habitats on nearby slopes. Such forest habitats normally preclude their representation in the fossil record, and some of the Clarkia insects represent rare Miocene records of their respective families or genera. The original coloration of some beetle elytra (metallic greens, blues, purples, black) may be seen when the fossils are first uncovered, but the colors of insects as well as leaves tend to blacken shortly after they are exposed. A diversity of insects, including stink bugs, click beetles, scarab beetles, ants, weevils, wasps, "March flies," caddis flies, and katydids, is known to have inhabited the area in earlier Miocene time. Indirect evidence of insect activity, such
as insect mining, galling, and teratological distortions, commonly can be found on the fossil leaves.

**FISH**

Two dominant kinds of fish, a sunfish and a cyprinid fish, are common at two levels of the type-locality. A single specimen of the cyprinid has also been found at P-37 in the Emerald Creek embayment. The fish are preserved as intact specimens showing an outline of the complete articulated skeleton surrounded by a darkened profile of the body. Such fossils, studied by G. R. Smith and R. R. Miller (written communication), add to our knowledge of the evolutionary trends and past distribution patterns of these two groups of fresh-water vertebrates. They also provide additional data for interpreting the lacustrine environment.

**GEOLOGIC FACTORS**

The geologic significance of the Clarkia Lake deposits and associated Tertiary basalts is potentially high. Of particular importance is the recognition that the St. Maries River drainage system and surrounding hilly topography was developed originally in Tertiary time, probably more than 20 million years ago (Figures 1-4). The detailed petrographic, chemical, paleomagnetic, radiometric, and stratigraphic analyses of the volcanic vent near Clarkia (Figure 2), the valley basalt flows between Clarkia and Santa, and the basalt pile known to exist downstream from Santa should provide significant new data in relation to the volcanic geology of the Columbia Plateau region, especially for the area along its eastern border.

**NOTES OF SPECIAL INTEREST**

**PRE-TERTIARY BASEMENT ROCKS**

The basement rocks of the St. Maries River area are predominantly mica schists of the Wallace Group of the Belt Supergroup (Hietanen, 1963; Clark, 1963). In this area the schists locally contain garnets of high quality, and some stream beds contain concentrations of pure garnet sand. Star garnets can be collected on national forest land along the Emerald Creek tributary (see posted road signs in the area)

A ridge forming the south watershed of the St. Maries River south of Clarkia has a core of granitic rocks (exposed in highway roadcuts between Bovill and Clarkia) that were intruded into the Precambrian schists during Late Cretaceous time, apparently as part of the Idaho batholithic complex (Figure 2). This ridge of older rocks remained as high ground in Miocene time when it served as a topographic delimitation of the Miocene Clarkia Lake.

**PRE-NEogene TOPOGRAPHIC DEVELOPMENT**

The existence of knolls and hills of Precambrian schist along the valley of the St. Maries River and their relations to the Tertiary basalts and sediments of the valley bottom (Figures 2 and 4) show that a hill-and-valley topography was established prior to the accumulation of the early Miocene lacustrine sediments and basalts at the lower elevations. Numerous roadcuts through the knolls bordering the valley floor and through the higher hills and mountains beyond expose the Precambrian schists at various elevations that may

![Figure 4. Panoramic view of the St. Maries River valley near Clarkia and Locality P-33 (the exposure on the left). The townsite of Clarkia is in the distant valley bottom near the right of the photograph. The low forested ridge immediately beyond Clarkia is a basalt pile about 300 feet (90 m) thick that contains a small rock quarry which exposes near-vent pyroclastics and basalt flows. Other knolls and hills are of Precambrian schist, and the valley is underlain by Miocene lacustrine clays and alluvial sands up to 300 feet (90 m) thick. The view is a composite of two photographs taken about 100 feet (30 m) apart.](image-url)
have been little different in the Miocene from the
topographic setting of today. It seems apparent from
the occurrence of the basalts and the Clarkia Lake
deposits in the present valley bottom that a Proto-St.
Maries River drainage system, not much different from
that of the present, was already in existence in early
Neogene time.

NEOGENE VOLCANIC ACTIVITY

A comprehensive study of the Neogene volcanic rocks
along the valley of the St. Maries River has yet to be
done. Preliminary data (Charles Knowles, personal
communication) suggest that at least some of the
basalts are essentially chemical equivalents of
Wanapum basin flows (Priest Rapids) of the Columbia
Plateau. The basalts of the Clarkia area are known to
rest on sediments containing a Clarkia flora (P-38), and
at one locality they appear to represent a dike-sill com-
plex that cuts through the Clarkia fossil beds (P-34).
That at least some of the basalts are younger than the
sediments is apparent from these geological relations
(Figure 2).

The damming of the Proto-St. Maries River valley in
Miocene time, probably by basalt flows, was a require-
ment for the catastrophic formation of Clarkia Lake.
Three likely dam sites exist along the river valley (Figure
1): one about 4 miles (6 kilometers) downstream from
Santa, where the broad valley abruptly changes to a
narrow valley of entrenched meanders deeply cut into a
basalt pile of considerable thickness; another near
Santa, where the valley is narrowed as the result of
basalt extrusions; and another just north of Clarkia,
where the valley’s width also has been restricted by the
accumulation of basalt near the local volcanic vent

The precise timing of these volcanic events in the
creation and sedimentary infilling of Clarkia Lake is yet
to be clarified. A study of the basalt pile north of Santa
has not been made in the necessary stratigraphic detail.
The vent locality near Clarkia contains basalts that ap-
ppear to be identical in hand specimens to the nearby
dike-sill complex at P-34 and seem to indicate an age
younger than the episode of Clarkia sedimentation.
The intruded basalts at P-34 and the nearby vent are
on strike with one of two parallel dikes mapped by
Hietanen (1963) suggesting a genetic relationship
(Figure 2). A roadcut near Clarkia Ranger Station has
exposed basalt with an exquisite tubular (pillowed)
structure, suggestive of a flow front that has moved into
clear water. Hand specimens of this basalt resemble the
dike, vent, and pillowed basalts across the valley on the
east, and the flow near the ranger station also rests on
sands that resemble those underlying the pillowed
basalt at P-38. The tubular basalt structure indicates the

presence of surface water at some time after the deposi-
tion of the sandy sediments.

Potassium-argon dates obtained on the basalts at
P-34 do little to clarify the time in the sedimentary-
volcanic relations. Dates obtained from Geochron
Laboratories indicate an Early Miocene age of approx-
imately 22 m.y. However, a second set of potassium-
argon dates, obtained through the services of William
Greenwood (personal communication) of the U. S.
Geological Survey, indicate a medial Miocene age of
about 15.4 m.y. The floral and paleoclimatic evidence
seem to indicate an Early Miocene age of perhaps 20 or
more million years for the lacustrine sediments and con-
tained fossils.

NEOGENE SEDIMENTATION AND FOSSILS

Excellent exposures of Clarkia deposits provide evi-
dence of quiet water, offshore lacustrine sedimentation
(P-33 south of Clarkia), nearshore sedimentation (P-37
and P-40 in the Emerald Creek embayment), and lake-
border, possibly deltaic, sedimentation (P-34 and P-38
north of Clarkia).

The vertical sequence of sediments exposed at P-33
shows a temporal change from alluvial sands at the base
to finely laminated lacustrine clays and volcanic ashes in
the middle to probable floodplain deposits at the top
(Figures 5 and 6). A complete life cycle of the Miocene
lake seems to be represented here. Our microstrati-
graphic analysis of plant megafossils through this sec-
tion has provided evidence of serial changes in the valley
bottom and lake-border vegetation as the lake came in-
to existence and silted in. The composition of the
floodplain and lake-margin vegetation changed as the
environment was modified catastrophically by the sud-

Figure 5. Photograph taken from Idaho Highway 3 of the Clarkia type
fossil locality P-33. See Figure 6 for the section at this locality.
den appearance of a lake where none had existed before and followed by the progressive infilling of the basin until the lake disappeared.

The most abundant fossils at type-locality P-33 are leaves and reproductive structures of ligneous plants. The more than 100 species identified from plant megafossils represent a forest of humid warm-temperate requirements; most of the genera are now extinct in western North America. The sunfish and cyprinid fish are common fossils at two levels of the type-section. Insect remains are occasionally found as impressions or compressions of complete bodies in the same beds that contain the fish. Microfossils are abundant, diversified, and well-preserved and include pollen and spores mainly of taxa represented by plant megafossils, diatoms, sponge spicules, dinoflagellates, and microfragments of insect exoskeletons.

Evidence of higher energy deposition including cut-and-fill activity can be observed at lake-border sites near P-34 and P-38 north of Clarkia (Figure 2). Here can be found relatively coarse and cleanly washed glacial sands containing fragmental plant debris, lenses of sand in thinly laminated clays, and soft cobbles of sediment containing Miocene plant fossils in some of the sand units. The plants in these coarser deposits north of Clarkia represent a restricted, mainly riparian, facies of the diversified fluvial that was preserved at the offshore depositional site at P-33: balsam cypress (Taxodium), poplar (Populus), willow (Salix), alder (Alnus), chestnut (Castaedia), oak (Quercus), Fagaceae gen. nov., moonseed (Cocculus), avocado (Persea), sycamore (Platanus), and cherry (Prunus).

The two localities in the Emerald Creek embayment (P-37 and P-40) are mainly plant fossil sites containing florules of the Clarkia flora (Figure 2). These new localities have not been studied to the extent of P-33, and the known taxonomic diversity is not as great as at the type-locality. A site of deposition nearer the shore than at P-33 seems to be indicated by the lower diversity of taxa, the somewhat coarser sediments, and the thicker bedding. The preservation of plant fossils at both Emerald Creek sites is the same as at P-33, and plants most commonly found include bald cypress (Taxodium), dawn redwood of Asia (Metasequoia), pine (Pinus), poplar (Populus), alder (Alnus), birch (Betula), chestnut (Castaedia), oak (Quercus), Fagaceae gen. nov., moonseed (Cocculus), tulip tree (Liriodendron), magnolia (Magnolia), laurel (Lindera, Persea), sweet gum (Liquidambar), sycamore (Platanus), honey locust (Gleditsia), black locust (Robinia), maple (Acer), and tulpepo (Nyssa).

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>THICKNESS</th>
<th>UNIT NO.</th>
<th>SEDIMENTS</th>
</tr>
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<tbody>
<tr>
<td>Covered</td>
<td>30</td>
<td>5</td>
<td>Ashy silts. No distinct bedding except at base.</td>
</tr>
<tr>
<td>Exposed</td>
<td>18</td>
<td>2</td>
<td>Ash</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3</td>
<td>Laminated clays, thick ash layers.</td>
</tr>
<tr>
<td>Subsurface</td>
<td>15</td>
<td>1</td>
<td>Interbedded sands and clay. Thin ash beds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coarse sand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BASEMENT (?Schist)</td>
</tr>
</tbody>
</table>

![Figure 6. Measured type section at Locality P-33, containing the subsurface lower portion (a drill-core section), the exposed middle portion, and the main soil and forest-covered upper portion (Figure 5). From Smiley and others, 1973.](image)

MIOCENE TOPOGRAPHY AND VEGETATION

The Miocene terrane of the St. Marys River area was a narrow valley of the Proto-St. Marys River and tributary streams in a hilly topography that was established on the Precambrian basement rocks of the region (Figure 1-4). The plant cover, best represented at type-locality P-33, was a mixed mesophytic forest of hardwoods and conifers as dominant trees and shrubs (Plates 1-4). Several taxa appear to have been woody vines (liane) that probably were climbers on other plants of the forest (greenbriar, moonseed, rose, poison ivy, creeper, grape). Some of the smaller plants of the forest were royal and polygody ferns, mosses, hornetails, and cattails.

On the basis of preferred habitats of living relatives of Clarkia taxa, three major habitats appear to have been represented in the area prior to the damming of
the valley and the establishment of Clarkia Lake (Smiley and Rember, in press). With the sudden appearance of the lake and the progressive infilling of the lake basin these three habitats were modified significantly: (1) mesic bottomlands, (2) moist well-drained slopes, and (3) edaphically drier, probably rocky or sandy sites with thin soil cover. Each habitat seems to have been occupied by a distinctive association of plant taxa.

Swamp Association

The Swamp Association is a mesic bottomland forest that has a close correlative in the border areas of the modern bald cypress swamps of southeastern United States. Following the establishment of Clarkia Lake, the swamp forest developed as the dominant lake-border association during progressive infilling of the lake basin. Clarkia plants that are most indicative of the Swamp Association are bald cypress (*Taxodium*), white cedar (*Chamaecyparis*), swamp poplar (*Populus*), swamp live oak (*Quercus*), sweetbay (*Magnolia*), laurel (*Lindera, Persea*), sycamore (*Platanus*), honey locust (*Gleditsia*), silver maple (*Acer*), lobolly bay (*Gordonia*), and water tupelo (*Nyssa*).

Floodplain-Slope Association

The vegetation on the mesic slopes of the valley floor and on the mesic slopes of the valley sides and surrounding hills was similar to modern forests of the Appalachian slopes in southeastern United States. On the other hand, the presence of several taxa that are no longer native to North America provides a distinct "Asian" character to the Miocene slope forests of the St. Maries River area (e.g., *Metasequoia, Cunninghamhapia, Pierocarya, Zelkova, Cercidiphyllum, Platanus*, and *Paulownia*). Wang's (1961) list of plants in and around the present relict stand of *Metasequoia* in the upper Yangze River area of China show a remarkable genetic resemblance to the mixed mesophytic forests that occupied the slopes surrounding Clarkia Lake. The following forest plants are most characteristic of this association:

**Conifers**
- *Abies* (fir)
- *Cunninghamia* (Asian)
- *Metasequoia* (Asian)
- *Sequoia* (redwood)
- *Tsuga* (arborvitae)

**Angiosperms**
- *Acer* (maple)
- *Ailurop* (alders)
- *Betula* (birch)

**Castanea** (chestnut)
- *Cocculus* (moonseed)
- *Corylus* (hazel nut)
- *Diospyros* (persimmon)
- *Fagaceae gen. nov.*
- *Halesia* (silver bell tree)
- *Hydrangea* (hydrangea)
- *Ilex* (holly)
- *Liquidambar* (sweet gum)
- *Liriodendron* (tulip tree)
- *Magnolia* (magnolia, cucumber tree)
- *Nyssa* (tupelo)
- *Ostrya* (hop hornbeam)
- *Quercus* (oak)
- *Siliquastrum* (greenbrier)

Drier Slope Association

A few Clarkia taxa, usually of rare occurrence, seem to be indicative of somewhat drier edaphic conditions than the plants of more mesic requirements listed above. These probably inhabited sites of thin soil cover such as sandy or gravelly banks on bottomlands, rocky barren slopes of hills, or steep hillsides facing south or west. Some probably were vines that grew as climbers on plants of other habitats as well. Fossil representation of these less mesic taxa include pine (*Pinus*), white oak (*Quercus*), hickory (*Carya*), service berry (*Amelanchier*), hawthorn (*Crataegus*), mock orange (*Philadelphus*), indigo bush (*Amorpha*), rose (*Rosa*), poison ivy (*Ribes*), sumac (*Rubus*), and grape (*Vitis*).

**COMPARISONS WITH MODERN FOREST**

Trees that now inhabit the area form coniferous forests on the hills with dicots concentrated on forest-border and riparian sites of the valley bottoms. In contrast, the Miocene forests were dominated by hardwoods (dicots). During the time of Clarkia Lake the local forests were composed of many genera that are now extinct in western North America. Most of these "exotics" are now found in continental margin areas of humid maritime influence, such as eastern North America and eastern Asia.

Warmer climate conifers of the earlier Miocene Clarkia flora include members of the family Taxodiaceae (*Cunninghamia* and *Metasequoia* of eastern Asia, *Sequoia* of western North America, and *Taxodium* of eastern North America) that have since been replaced in local forests by cooler climate conifers such as arborvitae or red cedar (*Thuja*), ponderosa, white and lodgepole pine (*Pinus*), grand and subalpine fir (*Abies*), larch (*Larix*), Douglas fir (*Pseudotsuga*), hemlock (*Tsuga*), yew (*Taxus*), and spruce (*Picea*).
Most of the Miocene dicots were representatives of genera that now prefer much warmer climates than presently prevail in northern Idaho. Indicative of this are Clarkia fossil representations of such plants as magnolia, laurel, lobolly bay, silver bell tree, water tupelo, water locust, and persimmon. Ligneous dicots in the Clarkia area today are species of cooler climate plants such as willow, poplar, aspen, maple, dogwood, mountain ash, and elderberry.

During Miocene time the northwest regional forests appear to have been western extensions of a humid temperate hardwood forest that probably extended from the Atlantic to the Pacific Oceans. One significant difference distinguished the western from the eastern forests of that time: the presence in the west of the east Asian taxa for which there are no fossil records east of the Rocky Mountains. During the last 10-12 million years of Neogene time, when orogenic activity in the Rocky Mountain and Sierra-Cascade areas produced a rainshadow over the western interior, the Miocene forests of humid climatic requirements became extinct in the western part of the continent (see section, Orographic Factors). Neogene climatic changes were not as pronounced in maritime regions as they were in the western interior, and forests equivalent to those of Miocene age have survived to the present in areas of persistent maritime influence.

OROGRAPHIC FACTORS

Northern Idaho presently occupies the western slopes of the Northern Rocky Mountains. On the west are the basalt plains of the Columbia Plateau, and beyond are the Cascade Mountains (crest elevation 6,000-7,000 feet) that now serve as a climatic barrier to the moist westerly winds off the Pacific Ocean. Snoqualmie Pass at an elevation of 3,000 feet (900 m) has an annual precipitation of 100 inches (about 2,600 mm). Eastward, the central Columbia Basin at an elevation of 800-1,000 feet (240-300 m) has an average annual precipitation of less than 10 inches (250 mm). The land rises eastward from the plateau to the Continental Divide of the Rocky Mountains, which forms the Idaho-Montana border. In the St. Maries River area where elevations are commonly 2,000-3,000 feet (760-900 m), the annual precipitation averages 25-26 inches (about 650 mm). Thus, orographic effects on precipitation are readily apparent across the Pacific Northwest region at the present time.

This orographic effect on regional climates seems to have prevailed throughout Tertiary time for the western slopes of the Northern Rocky Mountains. The Eocene Challis flora of northern Idaho (Edelman, 1974) represents a temperate deciduous dicot and conifer forest of a cool upland area (Figure 7), whereas lowland floras of comparable age to the west contained subtropical palms and evergreen dicots (e.g., Swauk, Roslyn, Chukanut, and Puget floras). That the orographic effect prevailed also in Miocene time can be demonstrated by comparing the past floral records of eastern Oregon and central Washington (Chaney and Axlnrod, 1939; Smiley, 1963) with the Miocene floras of eastern Washington and northern Idaho (Knowlton, 1926; Brown, 1937; Smiley and others, 1975). This is evident not only from floristic differences but also from comparative leaf size, especially of species that were regionally distributed in Miocene time; leaves are commonly twice the size in the easternmost floras than in the lowland floras of the drier Columbia Plateau area.

The preservation of leaves as intact cellular tissue and the retention of original pigmentation and organic chemistry indicate that the lacustrine sediments and contained fossils have remained water saturated and unoxidized since their deposition in the waters of Clarkia Lake some 20 million years ago. A persistent orographic effect with higher precipitation over northern Idaho can explain how Miocene fossils along the eastern border of the Columbia Plateau have remained.

<table>
<thead>
<tr>
<th>TIME UNITS</th>
<th>BASALTS</th>
<th>N. IDA FLORAS</th>
<th>OTHERS FLORAS</th>
<th>CLIMATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil A</td>
<td>Sedgwick Mtn.</td>
<td>8.8</td>
<td>Tule Elk, Saddle Ridge</td>
<td>Cooler temperature</td>
</tr>
<tr>
<td>Lower</td>
<td>Ojito</td>
<td>5.8</td>
<td>L. Eellsburg, Antelope</td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>White</td>
<td>4.9</td>
<td>Maryhill, E. Ellensburg, W.</td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>Columbia River Basalt</td>
<td>3.8</td>
<td>Bridge Creek, De Creek</td>
<td></td>
</tr>
<tr>
<td>Subdivision</td>
<td>Columbia</td>
<td>2.8</td>
<td>Chelan, Barnaby</td>
<td></td>
</tr>
<tr>
<td>Eocene</td>
<td>Columbia River Basalt</td>
<td>1.8</td>
<td>Swauk, Wm.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. Relation of the Clarkia fossil beds and flora to the basalt stratigraphy of the Columbia Plateau to the west (after Myrsk, 1978; Swanson, 1978). The times of some other Tertiary floras of the Pacific Northwest region and the general climatic conditions indicated are included.
so well preserved, while similar fossiliferous deposits on
the xeric lowlands to the west have become oxidized
and the organic material has been leached away by the
periodic action of meteoric water.

CLIMATIC COMPARISONS

Similar associations of forest plants are assumed to
exist under generally similar environmental conditions.
Although the requirements of individual taxa could
change through the course of time, a characteristic
association composed of numerous species will likely
persist through millions of years, provided that condi-
tions remain conducive to their continuing existence as
a society of associated plants. Most of the genera in the
Clarkia flora and many species that appear to have close
affinities with Clarkia plants have persisted to the pre-
sent as associated taxa in the southeastern United States
and in the upper Yangtze River area of China. Modern
forest associations of North America that are most like
the Clarkia flora exist in and around the southern end
of the Appalachian Mountains, in the general area
where the hill-and-valley topography descends to the
coastal plains. We assume, therefore, that the Miocene
forests of northern Idaho probably existed under a
climatic regime that was little different from that which
now prevails in and around the southern Appalachian
Mountains.

The present climate of southeastern United States is
warm-temperate with short mild winters and humid
summers. Climatic data from several weather stations in
this region show an average annual precipitation of 50
to 55 inches (1,270-1,400 mm) that is evenly distri-
buted throughout the year and a humid growing season
of not less than 240 days between killing frosts. In
contrast, the St. Maries River area now has a continental
climate of seasonal extremes: an average annual pre-
cipitation of 25 inches (640 mm), long and severe
winters, and an average growing season of 137 days.
Climatic deterioration in this region seems to have been
pronounced since Early Miocene time, in reductions of
about 100 days in the growing season and 25 to 30
inches in precipitation and in a change from a summer-
water to a summer-dry regime.

LACUSTRINE PALEOECOLOGY

The exposure at P-33 contains a 30-foot (9 meter) sec-
tion of finely laminated lacustrine deposits (Figures 5
and 6). At the base of the exposure is a sandy turbidite
that appears to represent a prior episode of alluvial
deposition, and at the top are poorly bedded silts that
probably represent a post-lacustrine return to flood-
plain conditions. Such evidence suggests that the
Miocene damming of the river valley created a lake
which was about 30 feet deep at the site of P-33. Subse-
quently the sedimentation in the lake gradually diminished
the water depth here, until the lacustrine cycle was ter-
ninated by complete infilling.

The absence of tracks and trails on bedding surfaces
seems to indicate the absence of an epifauna on the lake
bottom, and the undisturbed fine laminations similarly
indicate the absence of an infrafauna within the lake bed
deposits. These factors, plus the unoxidized state of
the sediments and fossils, suggest an original stagnation
of lake-bottom water resulting in anaerobic or toxic
conditions.

The fine laminations are suggestive of classical varves
and thus of seasonal accumulations. But there are ex-
amples where part of a leaf rests on the surface of one
layer and the intact specimen has been bent so that the
other part of the leaf is preserved on a different surface
three or four laminae above. This suggests that the fine
laminae of the lacustrine deposits accumulated rapidly
and were probably storm related rather than seasonal.
In addition, a more rapid infilling periodically occurred
during the numerous episodes of air-fall deposition of
volcanic ash. From such evidence we have estimated
that the lacustrine cycle exposed at the type-locality,
representing about 30 feet of sediments, may not have
taken more than a few decades to accumulate (Smiley
and Rembert, in press).

A Miocene lacustrine biota soon became established
in the ephemeral waters of Clarkia Lake. In addition to
the remains of forest plants and insects that were blown
out onto the open water from the surrounding land, the
lake sediments contain fossils of animals and plants of
the lacustrine community itself. A single specimen of a
Unionid clam and two specimens of a snail species that
appears to represent the gastropod family of Vivipar-
idae are found at P-33 with the numerous sunfish and
cyprinid specimens. The microfragments of insect exo-
skeletons that are ubiquitous throughout the lake
deposits probably resulted from passage through the
digestive systems of fish and birds. Gray (Smiley and
others, 1975) noted at least one species of Dinoflagel-
late in pollen extracts from the type-locality. Abundant
diatoms and spicules of fresh-water sponges are also
present in the laminated deposits.

SUMMATION

The topography seen in the St. Maries River area to-
day seems to have been modified little since it
developed on the Precambrian basement rocks probably
more than 20 million years ago. The valley bottom of
the Proto-St. Marys River was filled in by Miocene sedimentation in Clarkia Lake and by outpourings of basaltic lavas, resulting in the flat valley floor that can still be seen today (Figures 3 and 4). The striking change in forest composition that has taken place since Early Miocene time indicates that the regional climate has undergone a deterioration from an essentially maritime regime that prevailed prior to uplift of the Cascade Range to a continental regime of seasonal extremes, as the Cascades rose and as the world climates cooled in later Neogene time (Figure 7). The unusual preservation of the fossils in this area, occurring as intact cellular material retaining original pigmentation and organic chemistry, indicates a subsequent local climate that has been conducive to the retention of an unoxidized and water-saturated condition since the time of their burial. In contrast, similar Neogene floras on the Columbia Plateau to the west are now found preserved mainly as imprints, following the oxidation and leaching of the organic material as the climate there changed to near-desert conditions. The present orographic effect on local climate for the western slopes of the Rocky Mountains in Idaho, inferred also from Eocene (Challis) and Miocene (Clarkia Ovatt Creek) floras, seems to have been a persistent factor in regional climates throughout Tertiary time.

ACKNOWLEDGEMENTS

Support for our preliminary research has been provided by grants from the Idaho Research Foundation. We have received professional advice from geologists John Bond, John Bush, and Charles Knowles; from botanists Doyle Anderegg, Douglas Henderson, and Richard Naskali; and from foresters Frederic Johnson and Chi-Wu Wang. Other contributors are noted where appropriate in this guidebook.

REFERENCES CITED


ROAD LOG TO CLARKIA FOSSIL AREA, IDAHO
ROAD LOG

This road log has been prepared as a supplement to the guidebook for field trips to the St. Maries River (Clarkia) fossil area near Clarkia and Emerald Creek. The original field trip was organized as part of the symposium, *Late Cenozoic History of the Pacific Northwest*, for the annual meeting of the Pacific Division, American Association for the Advancement of Science (AAAS), held at the University of Idaho, June 3-7, 1979. We have included explanatory notes of geological interest and notes of botanical interest compiled by Richard J. Naskali and Douglas M. Henderson of the Department of Biological Sciences, University of Idaho.

ROAD LOG NOTES: GEOLOGY AND BOTANY

This road log, which includes a reference map and explanatory notes of geologic and botanic interest, is for a field trip from Moscow, Idaho, to the St. Maries River (Clarkia) fossil beds in the area of Clarkia and Emerald Creek.

<table>
<thead>
<tr>
<th>Log Points</th>
<th>Miles</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>00.0</td>
<td>START. Juncture of U. S. Highway 95 and Idaho Highway 8, South Main Street, Moscow. Agricultural crops along the route from Moscow to Bovill are mainly soft white winter wheats, peas, lentils, barley, occasionally winter rape (<em>Brassica Napus</em>), and alfalfa on some benches. Most of the wheat is exported to Asia and the Middle East where it is used for noodles, cookies, pastries, and similar food products. The dry peas of the Palouse region represent more than 90 percent of domestic production, and the U.S. is the major world exporter of this commodity and lentils. Seeds of the Australian winter pea are exported for An pate in Japan and for &quot;poor man's noodles&quot; in the Middle East and are used domestically as food for squaws in New York and as &quot;green manure&quot; crops in the southern states. Barley is used mainly as a feed grain for livestock or as malting barley. Rape seeds are exported to England for use as birdseed or are processed in Montana for the extraction of drying oils. Lentils (<em>Lens culinaris</em>) are for domestic consumption or are exported to Europe and the Middle East. Alfalfa is grown as a forage crop.</td>
<td></td>
</tr>
<tr>
<td>G1, B1 00.0-11.3</td>
<td>Hills of Cretaceous granites on the north (left) and Precambrian metamorphic rocks on the south (right). The valley bottoms of an old Miocene topography have been filled with basalt and interbedded &quot;Laah&quot; sediments probably of Middle Yakima age. These hills and valleys have been mantled by Pleistocene loess called the Palouse Soil. Between Moscow and Troy are remnant stands of ponderosa pine (<em>Pinus ponderosa</em>) that appear to be part of the primeval forest that was cleared 50 to 70 years ago for agriculture.</td>
<td></td>
</tr>
<tr>
<td>Log Points</td>
<td>Miles</td>
<td>Notes</td>
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<td>------------</td>
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</tr>
<tr>
<td>G2</td>
<td>13.4</td>
<td>Several roadcuts through Miocene basalts and sedimentary interbeds, covered by Palouse Soil.</td>
</tr>
<tr>
<td></td>
<td>20.4</td>
<td></td>
</tr>
<tr>
<td>G3</td>
<td>15.6</td>
<td>On left, loess-filled stream channel cut into basalts.</td>
</tr>
<tr>
<td>B2</td>
<td>17.3</td>
<td>On right, a frost pocket with a dense stand of spruce (<em>Picea engelmannii</em>), subalpine fir (<em>Abies lasiocarpa</em>), and larch (<em>Larix occidentalis</em>). Elsewhere in the area, the original dominants probably were grand fir (<em>A. grandis</em>), Douglas fir (<em>Pseudotsuga menziesii</em>), and ninebark (<em>Physocarpus monnaceus</em>), with ponderosa pine and larch probably seral.</td>
</tr>
<tr>
<td>G4</td>
<td>22.8</td>
<td>Townsite of Deary. On left is an apparent volcanic vent of undetermined age, called Potato Hill. Potato Hill volcanic rocks contain fragments of what appear to be older metamorphic and granitic rocks.</td>
</tr>
<tr>
<td>G5</td>
<td>24.3</td>
<td>Roadcut through Potato Hill volcanic rocks.</td>
</tr>
<tr>
<td>B3</td>
<td>25.7</td>
<td>On right is an artificial pond, with dense aquatic macrophytes including cattail (<em>Typha</em>), water lily (<em>Nuphar luteum</em>), and <em>Potamogeton amplifolius</em> as dominant species.</td>
</tr>
<tr>
<td></td>
<td>27.2</td>
<td>Townsite of Helmer. Roadcuts in the area expose Precambrian schists and gneisses. A National Forest campground is 3 miles to the south.</td>
</tr>
<tr>
<td>B4</td>
<td>28.4</td>
<td>On the left is Hog Meadow. This appears to be a filled lake. The essentially impervious nature of the underlying lacustrine clays and silts has prevented the natural establishment of trees. Dense stands of <em>Styrax chilense</em> (iris family) and Camas lily (<em>Camassia quamash</em>).</td>
</tr>
<tr>
<td>G6</td>
<td>29.4</td>
<td>Roadcuts in ‘‘Latah clays.’’ Clays are used for refractory bricks and as filled in high-grade paper products. Developed by Simplot Company.</td>
</tr>
<tr>
<td>G7</td>
<td>31.4</td>
<td>On left, Bovill clay pits of Simplot Company.</td>
</tr>
<tr>
<td>B5</td>
<td>31.7</td>
<td>From here to Bovill and northward, the climax species of the forest usually is grand fir. Large trees of western white pine (<em>Pseudotsuga menziesii</em>) emerge above the canopy of this highly disturbed forest. White pine is an important seral species in this setting.</td>
</tr>
<tr>
<td></td>
<td>32.5</td>
<td>Turn left (north) on Idaho Highway 3, through Bovill.</td>
</tr>
<tr>
<td>Log Points</td>
<td>Miles</td>
<td>Notes</td>
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<tr>
<td>-----------</td>
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<td>-------</td>
</tr>
<tr>
<td>B6</td>
<td>32.9</td>
<td>On left, north side of Bovill, are mills for cedar shakes, power line poles, and lumber.</td>
</tr>
<tr>
<td>G8</td>
<td>34.8</td>
<td>Roadcuts are through weathered garnetiferous mica schists of the Precambrian Belt Supergroup (Wallace Group) that underlies the region.</td>
</tr>
<tr>
<td>B7</td>
<td>35.0</td>
<td>Frequent pockets and stands of lodgepole pine (<em>Pinus contorta</em>) that are seral on burned areas.</td>
</tr>
<tr>
<td>B8</td>
<td>35.3</td>
<td>Valley bottoms with cold air drainage have climax stands of Engelmann spruce and subalpine fir. A climax vegetation of grand fir is on the slopes.</td>
</tr>
<tr>
<td>B9</td>
<td>36.3</td>
<td>On the right are two large trees of white pine. The ridge on the left contains a pure stand of larch that has been infested with the larch case-beaters (<em>Coleophora lariella</em>). This insect defoliates the trees shortly after spring leafing. <em>C. lariella</em> spread from Massachusetts as far west as Minnesota by 1957, at which time it &quot;leapfrogged&quot; 1,700 miles to infest the larch forests near St. Maries in northern Idaho. This infestation has since radiated outward and currently involves about 50 percent of the range of western larch.</td>
</tr>
<tr>
<td>G9</td>
<td>37.3/</td>
<td>A series of roadcuts through Cretaceous granitic rocks intruded into Precambrian metamorphic rocks. This ridge served in Miocene time to delimit the southern extent of Clarkia Lake.</td>
</tr>
<tr>
<td></td>
<td>42.6</td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>38.0</td>
<td>Mixed stands of western red cedar (<em>Tsuga plicata</em>) and western hemlock (<em>Tsuga heterophylla</em>) represent the climax forest in this area of high moisture. Important seral conifers include Douglas fir, larch, ponderosa pine, and white pine. On the right, the cool valley bottom contains Engelmann spruce and subalpine fir.</td>
</tr>
<tr>
<td>B11</td>
<td>38.3</td>
<td>On left, the ridge contains the remnant of an old-growth stand of hemlock and cedar. The hemlock is all that remains after selective logging for the cedar some 50 to 70 years ago.</td>
</tr>
<tr>
<td>B12</td>
<td>41.7</td>
<td>Latah-Shoshone County Line. On left, the slopes contain dense stands of grand fir. The cooler valley on the right contains spruce mixed with fir.</td>
</tr>
<tr>
<td>G10</td>
<td>43.7</td>
<td>Roadcuts are through Precambrian rocks on the north flank of the granite-cored ridge.</td>
</tr>
<tr>
<td>G11</td>
<td>44.4</td>
<td>Flat valley floor underlain by Clarkia deposits, near the south end of the Miocene Clarkia Lake.</td>
</tr>
<tr>
<td>Log Points</td>
<td>Miles</td>
<td>Notes</td>
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<tr>
<td>------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>G12</td>
<td>44.7- 45.4</td>
<td>Several roadcuts pass through knolls of Precambrian basement rocks that rise above the valley fill of Miocene lake deposits.</td>
</tr>
<tr>
<td>G13</td>
<td>45.7</td>
<td>Clarkia type-locality P-33 on left of highway, on the north curve of the Fossil Bowl race track owned by Francis Kienbaum. The south end of the track is cut into a hill of weathered Precambrian schist. The gully at left (west) end of fossil site seems to mark the position of a fault.</td>
</tr>
<tr>
<td>G14</td>
<td>47.2</td>
<td>On left, roadcut passes through the nose of a spur of Precambrian rocks along the edge of Clarkia Valley.</td>
</tr>
<tr>
<td></td>
<td>47.4</td>
<td>Townsite of Clarkia. Turn off Idaho Highway 3 through town to localities P-34 and P-38 just north of townsite.</td>
</tr>
<tr>
<td>G15</td>
<td>48.1</td>
<td>Rock quarry, with Precambrian rocks cut by a diorite dike. Turn left (west) to fossil and volcanic vent localities.</td>
</tr>
<tr>
<td>G16</td>
<td>48.4- 49.0</td>
<td>Turn right (north) at road junction to a small rock quarry cut into the flank of a Miocene volcanic vent. Enroute are roadcuts through Precambrian basement rocks. The quarry contains basalt flows, volcanic ash, scoriaceous cinders and bombs, and charred wood. Bus turnaround, and return to Mile Point 48.4.</td>
</tr>
<tr>
<td></td>
<td>49.6</td>
<td>(equals Mile Point 48.4). On right can be seen Clarkia locality P-38.</td>
</tr>
<tr>
<td>G17</td>
<td>49.8</td>
<td>Rock quarry and roadcut of P-38. Pillow basalts overlying coarse glass-shard sands containing a Clarkia floras. White pebbles and boulders in the area represent later Neogene deposits that can be found throughout the region. Common fossils are leaves of Fagaceae gen. now., chestnut, hazel nut, alder, oak, and bay.</td>
</tr>
<tr>
<td>G18</td>
<td>49.9- 50.3</td>
<td>Enroute to locality P-34 are several roadcuts exposing basalts, metamorphic rocks, and Clarkia sediments at essentially the same topographic level.</td>
</tr>
<tr>
<td>G19</td>
<td>50.3</td>
<td>Clarkia locality P-34. Roadcut of sand, silt, and laminated clays, with lenses of sand indicating scour and-fill activity during the time of deposition. The thin basal sheet seems to be a sill associated with the thicker dike at right where sediments are blackened. Common fossils are Fagaceae gen. now., bald cypress, poplar, willow, alder, birch, chestnut, moonseed, magnolia, bay, sycamore, cherry, and oak. Return to Mile Point 47.4 (Idaho Highway 3).</td>
</tr>
<tr>
<td>Log Points</td>
<td>Miles</td>
<td>Notes</td>
</tr>
<tr>
<td>------------</td>
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<td>-------</td>
</tr>
<tr>
<td>52.4</td>
<td></td>
<td>(equals Mile Point 47.4). Turn right (north) on Idaho Highway 3, down the valley of the St. Maries River, enroute to the Emerald Creek fossil beds in a west embayment of the Miocene Clarkia Lake.</td>
</tr>
<tr>
<td>B13</td>
<td>52.7</td>
<td>National Forest Work Center, located on a flow of Miocene valley basalt. This was the prime site of efforts to control the white pine blister rust, Cronartium ribicola. Efforts formerly centered around the eradication of species of Ribes (currant) that serve as an alternate host for the blister rust fungus. White pines in the area show varying degrees of resistance to blister rust, and bags can be seen on some of them to trap the pollen for hybridization experiments and eventual control.</td>
</tr>
<tr>
<td>G20</td>
<td>53.3</td>
<td>On left, roadcut through tubular pillow basalts of a Miocene valley flow. Across the valley on the east is a local basalt pile several hundred feet high, probably part of the Miocene volcano.</td>
</tr>
<tr>
<td>G21</td>
<td>55.4</td>
<td>On left, a small roadcut through a basalt flow of different chemical composition from other basalts of the area.</td>
</tr>
<tr>
<td>G22, B14</td>
<td>56.0</td>
<td>On right, a roadcut through Precambrian rocks. This is another example of a knoll of basement rock rising above the level of the Miocene valley sediments and basalts. On left are large trees of black cottonwood (Populus trichocarpa) that are common along the valley of the St. Maries River.</td>
</tr>
<tr>
<td>B15</td>
<td>57.2</td>
<td>Plant of the Diamond Match Company, utilizing the white pine of the area.</td>
</tr>
<tr>
<td>G23</td>
<td>57.8</td>
<td>Garnet sand shipping point, Sunshine Mining Company. Turn left (west) here to the Emerald Creek fossil beds and garnet collecting area. Miocene valley basalts are exposed in the area.</td>
</tr>
<tr>
<td>B16</td>
<td>58.0</td>
<td>Thin-leaf alder (Alnus incana) is common along Emerald Creek.</td>
</tr>
<tr>
<td>G24</td>
<td>58.9</td>
<td>On right (north) a recent rock quarry shows a basalt sheet terminating against convoluted valley sediments.</td>
</tr>
<tr>
<td></td>
<td>60.9</td>
<td>Road juncture at confluence of East and West Emerald Creeks. The garnet sand separating mill is on the left. Take the right fork across the bridge to the fossil beds.</td>
</tr>
<tr>
<td>G25, B17</td>
<td>61.2</td>
<td>Clarkia site P-37 is off the side road to the right. Sunshine Mining Company restored the valley bottom after commercial dredging for garnet sands. The surrounding</td>
</tr>
<tr>
<td>Log Points</td>
<td>Miles</td>
<td>Notes</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>G26, B18</td>
<td>62.3</td>
<td>Roadcut on National Forest land containing Clarkia site P-40. Fault fracturing occurs at the right end of the exposure. Unoxidized deposits can be seen at the base of the cut. Common fossils are dawn redwood, bald cypress, pine, poplar, alder, birch, chestnut, oak, Fagaceae gen. nov., moonseed, tulip tree, magnolia, bay, sweet gum, sycamore, maple, honey or water locust, black locust, and tupelo. Serial stands of lodgepole pine here are in the successional sequence following recent forest fires.</td>
</tr>
<tr>
<td></td>
<td>62.3-</td>
<td>Forest roads across country, crossing hills of Precambrian rocks to an overview site of Clarkia valley above type-locality P-33.</td>
</tr>
<tr>
<td>G27</td>
<td>66.3</td>
<td>Overview of Clarkia valley, showing general area of Miocene Clarkia Lake and surrounding hilly topography. The warm-temperate climate of the past has changed to the cool-temperate of the present, and the Miocene forests dominated by hardwoods have been replaced by the coniferous forests of today. Descend into the valley and turn right (south) on Idaho Highway 3 for return to Moscow.</td>
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PLATES
Plate 1: 1—Taxodium; 2—Chamaecyparis; 3—Sequoia; 4—Oitis; 5—Gleditsia; 6—Pinus, seed; 7—Robina (?) 8—Metasequoia and Abies; 9—Betula; 10—Chamaecyparis, cone; 11—Pinus. All photographs are natural size.
Plate 2: 1—*Quercus*, acorn in cup; 3—Fagaceae gen. nov.; 4—*Castanea*, staminate ament; 5—*Quercus*? or *Castanopsis*?; 6—*Acer*; 7—*Acer*, samara; 8—*Liquidambar*. All photographs are natural size.
Plate 3: 1—Magnolia(?); 2—Magnolia; 3—Persea; 4—Cocculus. All photographs are natural size.
Plate 4: 1—*Platanus*, leaf and stipule; 2—*Nyssa*; 3—unknown legume pod; 4—Cyprind fish; 5—*Gleditsia*?; attached leaflets. All photographs are natural size.