

A PALEONTOLOGICAL STUDY OF THE GOLD BLUFFS AREA
OF PRAIRIE CREEK REDWOODS STATE PARK, CALIFORNIA

by

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ABSTRACT

On the western edge of Prairie Creek Redwoods State Park, California, a gently-dipping, 800 foot thick sequence of late Cenozoic sedimentary deposits including conglomerates, sandstones and siltstones, forms a series of coastal cliffs known as Gold Bluffs. Although this sequence has been examined to some extent in the past and mined for gold, relatively little is known about its precise geologic age, history, and fossil content.

The Gold Bluffs sequence contains abundant fossilized plant remains which are found in six horizons within it. These remains include peat-like deposits, leaf impressions, carbonized leaves, cones, and logs. Eighteen plant types, including members of family Marchantiaceae, Dryopteris cf. D. dilatata, Picea cf. P. sitchensis, family Cupressaceae, Sequoia cf. S. sempervirens, Umbellularia cf. U. californica, Acer cf. A. circinatum, Acer cf. A. macrophyllum, Rhododendron cf. R. macrophyllum, Galtheria cf. G. shallon, Vaccinium cf. V. ovatum, Holodiscus cf. H. discolor, Rosa cf. sp., Alnus cf. A. oregona, Quercus cf. Q. chrysolepis, Salix cf. S. sessilifolia, Ceanothus cf. C. thyrsiflorus; and members of family Cyperaceae have been recognized in the present study. Two species of fresh-water pelecypods, Margaritifera

cf. M. margaritifera and Anodonta cf. A. nuttalliana, and a section of a possible vertebrate rib have also been recognized. The flora and fauna represented in the fossil record of the Gold Bluffs are comparable to species presently living in Prairie Creek Redwoods State Park and nearby areas of northwestern California.

The formation of the Gold Bluffs deposit on a flood plain is suggested by a predominantly riparian flora and river dwelling pelecypod fauna. Such sedimentary features as the lenticularity of the conglomerate, sandstone and siltstone along with the occurrence of poorly sorted sandstone and conglomerate that contain areas of cross bedding and channeling further suggests formation of this deposit on a floodplain. The conglomerates and sandstones may have been formed on the bottoms of meandering river channels and the formation of the siltstones may have taken place on the bottoms of oxbow lakes. The reported occurrence of this deposit running continuously to the south bank of the Klamath River suggests that the ancestral Klamath River may have deposited these sediments. Paleoclimatic conditions ranging from 14 to 110 inches of rain per year and temperature extremes of 22° F. to 95° F. are suggested by comparing the ecologic extremes exhibited by the living equivalents of the Gold Bluff flora. During the present study no evolutionary trends in the flora or fauna have been recognized.

The Gold Bluffs fossil assemblage may be of somewhat similar age and paleoecology to unstudied fossil occurrences reported in roadcuts to the east of Prairie Creek Redwoods State Park and in the area on the south side of Big Lagoon. The close similarity of the flora and fauna to species presently living in the area, the rather poor consolidation of the sedimentary rocks, and the absence of extensive deformation suggests that the sediments are of recent geologic origin--possibly late Pliocene to Pleistocene in age.

TABLE OF CONTENTS

	<u>Page</u>
Abstract	
Introduction	1
Physiography	5
Geology of the Gold Bluffs	8
Lithology	8
Systematic Description of Flora	10
Systematic Description of Fauna	20
Discussion	25
Paleoecology	25
Equivalent Deposits	28
Age	29

Fig. 1 Geologic Index Map

Fig. 2 Locality Map of Gold Bluffs

Fig. 3 Generalized Geologic Column

Fig. 4 Flora and Fauna Distribution Chart

Plate I to X Photographic Cross Section of Gold Bluffs

Plate XI to XIII Photographs of Fossils

CONTENTS

EZRA S. B.

MILLERS FALLS

INTRODUCTION

Prairie Creek Redwoods State Park is located along highway U.S. 101 forty-four miles north of Eureka, thirty-nine miles south of Crescent City and eight miles south of the Klamath River (fig. 1). In order to preserve the last herd of Roosevelt Elk living adjacent to the shores of the Pacific Ocean as well as an excellent example of a climax temperate redwood rainforest including the tallest known trees, it has been proposed that Prairie Creek Redwoods State Park and adjoining areas be set aside as a national park. Along the western boundary of Prairie Creek Redwoods State Park a series of coastal cliffs makes up a geologic exposure known as the Gold Bluffs. In 1850, with the discovery of gold and platinum placers in some of the lower sedimentary beds of the Gold Bluffs, the first interest in the geologic content of the cliffs was generated. The gold and platinum grains are of very small size and well mixed with beach sands which have a black character due to a high content of magnetite and chromite grains. The discovery of gold in the Gold Bluffs set off a small scale gold rush known as "The Gold Bluffs Excitement" and soon several recovery operations were started. These recovery operations continued on and off until 1964. Although \$25,000 worth of gold was reportedly recovered in a year by

one of the earlier operations, all of the recovery operations eventually proved uneconomical because of the difficulty of separating the finely divided gold flakes from the beach sands.

In addition to rocks of the Franciscan formation and Quaternary stream deposits Prairie Creek Redwoods State Park and many of the adjoining areas, especially to the east, are underlain by a series of alluvial deposits. MacGinitie¹ has reported such deposits running continuously from the south side of the Klamath River to many of the hills in the northwestern corner of the Hoopa Indian Reservation to an elevation of nearly 3,000 feet. These deposits are best exposed in the Gold Bluffs. Dr. Young² of the Geology Department of Humboldt State College, has applied the name Gold Bluffs formation to the series of alluvial deposits making up most of the Gold Bluffs. In the Gold Bluffs exposure the Gold Bluffs formation is bounded on the north side by a rather poorly defined contact with the highly metamorphosed sandstones and graywackies of the Jurassic Franciscan formation. Six miles to the south the deposit is bounded by a sharp

¹MacGinitie, Harry D., The Flora of the Weaver-
ville Beds of Trinity County, California, Carnegie
Institute of Washington Publication No. 465, p. 105,
Oct. 15, 1937

²Young, J. C., Oral communication, 1967.

but unconformable contact with the much sheared and folded South Fork Mountain Schist member of the Franciscan formation.

From a survey of the literature available, it becomes apparent that little work has been done on the make-up and origin of the Gold Bluffs formation. Apparently, the first geologic study of the Gold Bluffs was made by Chase in 1872-4. Aside from reporting the recovery of a vertebra and identifying some of the minor mineral constituents, his work mainly dealt with observations and descriptions of the gold recovery operations then in progress. Diller, in 1902, briefly mentioned the sedimentary deposits in the Gold Bluffs and dated them as Miocene in his work on the development of the Klamath Mountains. MacGinitie, in 1937 also briefly mentioned the Gold Bluffs deposit in his report on the flora of the Weaverville fossil beds. He reported finding Picea cf. P. sitchenensis, Acer cf. A. macrophyllum, Salax cf. S. sessilifolia, Umbellularia cf. U. californica, Alnus cf. A. rubra and Quercus cf. Q. chrysolepis. He also dated the deposit as being of Upper Pliocene or Lower Pleistocene age.

The present study has concentrated on the composition and distribution of fossilized remains in the area of the Gold Bluffs north of the point where the state

park road enters onto the beach and south of the mouth of Fern Canyon (fig. 2). The Gold Bluffs exposure to the north and south of this area, for the most part is made up of conglomeratic sediments and with one exception in a locality about a mile north of the mouth of Fern Canyon seems to be devoid of fossilized materials. For the purposes of this study localities were established by roughly dividing the cliff into 1,000 foot sections starting from a base point in Home Creek where it crosses the state park road. The sections were measured by odometer along the state park road that runs nearly parallel to the base of the cliff. Each of these sections were then assigned a number and all the specimens taken within a section were appropriately numbered. Although Young³ has reported finding several fossil bearing localities within the Gold Bluffs formation in road cuts to the east of highway U.S. 101, observations for the present study were made only in the Gold Bluffs exposure.

³Young, J.C., oral communication, 1967.

PHYSIOGRAPHY

A study of the topography of the area in and around the western edge of Prairie Creek Redwoods State Park reveals several interesting surface features. The drainage pattern in this area is of a well developed trellis type. A drainage system such as this could have resulted from the alignment of streams along faults and joints. The alignment of the major tributaries has been in a southeast direction which closely corresponds with alignment along portions of Redwood Creek, Maple Creek, Klamath River and Trinity River as reported by Young.⁴ Although two apparent faults are exposed in the Gold Bluffs (Plates V and IX) no alignment of streams is apparent along their projected trends.

Another interesting physiographic feature of this area is the almost complete lack of a talus debris at the base of the fairly high, soft and rapidly eroding face of the Gold Bluffs. The absence of an expected talus like deposit might be explained by the rather recent development of the beach. Chase⁵, in describing

⁴Young, J.C., oral communication, 1967.

⁵Chase, A.W., "The Auriferous Gravel Deposit of Gold Bluffs," American Journal of Science, Vol. 7, Jan.-June 1874.

the area to the south of Ossagon Creek in 1874 has stated, "many of the bluffs are absolutely vertical and in some instances overhanging. At low water there is a narrow beach but when the tide is full the sea washes directly against the base of the cliffs." Such wave action at the base of the cliffs would probably quickly remove any rock material coming off the face of the cliffs. The rather rapid development of this beach might be a result of an increased load of sediments transported by the Klamath River and its tributaries possibly as the result of hydraulic mining and logging operations that have taken place within their water sheds in the 94 years since Chase wrote his description of Gold Bluffs. These sediments may have been transported southward from the mouth of the Klamath River by a southward moving eddy of the Davidson Current during the spring and winter as reported by Burt and Wyatt (1964)⁶. The Klamath River as a source of these beach sands is also suggested by the decreasing width of the beach to the southward or away from the mouth of the river (fig. 3).

Another physiographic feature can be seen in the continental shelf twenty to forty miles west of the Gold Bluffs (Fig. 1). In this area a series of submarine canyons and gullies making up the Trinidad

⁶Burt, W.V., Wyatt, B., "Drift Bottle Observations of the Davidson Current Off Oregon," Studies on Oceanography, pp. 156-165, Oregon State University, 1964.

Submarine Canyon are located. The relatively close geographic relationship between the Klamath River, the rather extensive alluvial deposits making up much of the Gold Bluffs and the Trinidad Submarine Canyon suggests that an ancient river-submarine canyon relationship may have once existed here. If such a relationship existed then the ancestral Klamath River may have acted as the transporting and depositing agent for the Gold Bluffs formation.

GEOLOGY OF THE GOLD BLUFFS

Lithology

Although some general lithologic observations have been made (Fig. 3 Plates I to X), no attempt has been made to extensively map or investigate the petrographic make-up of the Gold Bluffs formation during the present study. Aside from gold and platinum placers, chromite and magnetite grains, the Gold Bluffs formation contains clasts of sedimentary, igneous and metamorphic origin which have been accumulated into beds of conglomerate, sandstone and siltstone. The conglomerate beds are generally gray or brownish and range in thickness from a few feet to one hundred feet. The conglomerates are poorly stratified and consist of poorly-sorted pebbles and cobbles ($1/8$ inch to 6 inches in diameter) which are embedded in a coarse sand matrix. As with the siltstones and sandstones the conglomerate has been cut in places by river channelings which have been filled with sediments of a different character. Like the sandstone and siltstone the conglomerate has been bonded together more by compaction than by cementation.

The poorly stratified sandstones, which form layers up to fifty feet in thickness, generally are not as massive as either the conglomerate or siltstone. Most of the sandstones are either reddish-brown or

gray and have varying amounts of finer silts mixed in them. In places the sandstones are extensively crossbedded. The sandstone layers (especially near their margins) have been the best fossil producers in the Gold Bluffs formation.

The clay-rich unstratified siltstones for the most part are gray in color and usually form massive uniform deposits that are bluff formers. Although not exclusively restricted to these sediments, angular carbonized wood fragments that range in size from less than an inch to logs that are over two feet in diameter can usually be found in the siltstones.

		Thickness	
		75	Undifferentated massive siltstones of gray color
		40	Brown sandstone containing layers that are clay rich
Locality 150		90	Undifferentiated gray siltstone
<u>Acer cf. macrophyllum</u> <u>Sequoia cf. sempervirens</u> <u>Alnus cf. oregonia</u> Cyperaceae Mammalian cf. rib <u>Margaritifera cf. margaritifera</u>		50	Reddish-brown sandstone containing cross bedding in places
Locality 180		50	Gray to brown unsorted bluff forming conglomerate containing snad lenses of a reddish character
Bryophyta <u>Acer cf. macrophyllum</u> <u>Acer cf. circinatum</u> <u>Rhododendron cf. macrophyllum</u> <u>Holodiscus cf. discolor</u> <u>Alnus cf. oregonia</u> Cyperaceae <u>Margaritifera cf. margaritifera</u> <u>Anodonta cf. nuttalliana</u>		25	Red snadstone containing cross beddings and lenses of finner sediments in places
Localitys 220 and 230		20	Whitish pebble conglomerate
<u>Picea cf. sitchensis</u> <u>Quercus cf. chrysolepis</u> <u>Salix cf. sessilifolia</u> Cyperaceae Peat layers		15	Uniform fine grained gray siltstone
Locality 240		100	Grayish to red unsorted pebble conglomerate containing lenses of fine grained snads and cross beddings in places
Locality 270		20	Gray siltstone containing cross bedding in places
<u>Dryopteris cf. dilatata</u> Peat layers		70	Unsorted gray to reddish pebble conglomerate containing lenses of finer sediments and grades into red-brown sands in places
Locality 280		45	Gray unsorted bluff forming cobble conglomerate
Pinaceae seeds <u>Picea cf. sitchensis</u> <u>Sequoia cf. sempervirens</u> <u>Umbellularia cf. californica</u> <u>Rosa cf. sp.</u> <u>Alnus cf. oregonia</u> Cyperaceae Cupressaceae <u>Margaritifera cf. margaritifera</u>		90	Gray and brown siltstones intermixed with layers of brown sandstone and containing lenses and cross beddings in places
Key		50	Very poorly sorted pebble conglomerate
Siltstone  Sandstone  Conglomerate 			

State Park Road Enters Beach

Fig. 3 Generalized Geologic Column

SYSTEMATIC DESCRIPTION OF FLORA

During the present study, eighteen species of plants have been recognized in the sedimentary section of Gold Bluffs. Of these 50 percent were trees, 37 percent were shrubs, and 13 percent were herbs. Specimens were identified to their closest, living equivalent species by comparing them with specimens in the herbarium of Humboldt State College and by comparing them with the descriptions given in Jepson⁷ and Munz⁸ whose taxonomy for the vascular plants of California has been utilized in this study. It may be possible in some or all cases that evolutionary trends have made the collected fossils extinct at the species or subspecies level, as Dr. Anderson⁹ has suggested.

Division Bryophyta

Class Hepaticopsida

Order Marchantiales

Family Marchantiaceae

Towards the south side of locality 180, in a series of massive gray sediments a rather rich layer of what appear to be Bryophyte thalli have been

⁷Jepson, W.L., A Manual of the Flowering Plants of California, University of California Press, 1963.

⁸Munz, P.A., A California Flora, University of California Press, 1965.

⁹Anderson, D., Plant taxonomist, Humboldt State College, oral communication, 1967.

recognized. In these specimens Bryophytes are suggested by sheet-like growths that have dichotomous branching and have irregularities in their surfaces much like air pores. The only local modern genera to attain the size of the carbonized forms are Marchantia and Conocephalum which inhabit moist shady environments.

Division Pterophyta

Class Filicinae

Order Filicales

Family Aspidiaceae

Dryopteris cf. D. dilatata Gray

Plate I Fig. 1

At locality 270 several carbonized leaflets of fern pinna, very similar to what MacGinitie¹⁰ thought were the fern Dryopteris cf. D. dilatata, were found in a gray sandstone layer. The fern remains were inter-mixed with plant fragments of the family Cyperaceae. D. dilatata is now found growing from the Atlantic coast to Alaska and across Eurasia.

Division Coniferophyta

Order Coniferales

Family Pinaceae

Plate I Fig. 2

¹⁰MacGinitie, oral communication, 1966.

Two well preserved carbonized conifer seeds apparently belonging to the family Pinaceae were found in locality 280. Because of the similarities in the seeds among the members of this family further identification is not reliable, but one or both of the seeds could be Pseudotsuga menziesii, Picea sitchensis (whose cones have been found in this locality) or Pinus muricata or Pinus contorta. All of these species have very similar seeds and inhabit areas not too far distant from Gold Bluffs.

Picea cf. P. sitchensis Carr

Plate I Fig. 3

Carbonized cones of this species were found in locality 220 and 280. Although the cones had been compressed in a direction paralleling the bedding plains their preservation was remarkably good. This species now has a coastal distribution from Mendocino County, California, to Southern Alaska.

Family Cupressaceae

Plate I Fig. 4

A tip of a carbonized branchlet having scale needles like those of Thuja cf. T. plicata and Chamaecyparis cf. C. lawsoniana were found in locality 280. Thuja plicata can be identified by scale needles that have the stomata arranged in a figure eight pattern. Unfortunately, carbonization has not preserved

the surface texture of this specimen well enough to make determinations of the distribution of stomata. T. plicata is now found growing in moist places from Mendocino County, California to Alaska. C. lawsoniana is now found growing on moist slopes and canyons from Del Norte County, California to Western Oregon.

Family Taxodiaceae

Sequoia cf. S. sempervirens Endlicher

Plate I Fig. 5 a, b, c, d

Impressions of a branchlet and needles of a preserved female cone of Sequoia cf. S. sempervirens were found in locality 150. In locality 280 a carbonized branchlet and a double winged seed similar to those of this species were found. Dr. MacGinitie¹¹ thought that there was a strong possibility that most or all of the carbonized wood that occurs in many localities through the Gold Bluffs exposure belongs to this species. The richest of these wood producing horizons is in locality 300 and contains many fragments ranging in size from extremely small fragments to logs over two feet in diameter. Because the wood of S. sempervirens is very resistant to decay it seems logical that the wood of this species would be capable of remaining as wood within the sediments long enough for the carbonizing process to have taken place. According to

¹¹Ibid.

Dr. MacGinitie¹² the cellular structures in the wood are lost during carbonization so that positive identification of the wood becomes impossible. All of the wood fragments observed during the present study exhibited annular growth rings which would classify them as far as the order Coniferales. It is interesting to note that almost all of the observed wood fragments have apparently been compacted in a direction paralleling the bedding plains of the deposit. Most of the logs have been aligned in an east-west direction which might be an indication of the direction of flow taken by the depositing stream. S. sempervirens now lives in the coastal fog belt from the Santa Lucia mountains of California to the southwestern tip of Oregon.

Division Anthophyta

Class Dicotyledoneae

Family Lauraceae

Umbellularia cf. U. californica

Plate I Fig. 6

Umbellularia cf. U. californica leaves impressions were found as well preserved specimens in locality 280. This species is now found in many different environments from San Diego County, California to southern Oregon.

¹²Ibid.

Family Aceraceae

Acer cf. A. circinatum Pursh

Plate I Fig. 7

Leaf impressions of Acer cf. A. circinatum were found in locality 180 intermixed with leaf impressions of Acer cf. A. macrophyllum and Alnus cf. A. oregona. A. circinatum leaf impressions were distinguished from those of A. macrophyllum by their smaller size and their more evenly divided and numerous lobes. A. circinatum is now found growing from Mendocino County, California northward to British Columbia.

Acer cf. A. macrophyllum Push

Plate II Fig. 1

Leaf impressions of Acer cf. A. macrophyllum were found in localities 150 and 180. Many good leaf impressions are present in several different horizons within locality 180. This species is now found growing in many different environments west of the Sierra Nevada Mountains and northward to southern Alaska.

Family Ericaceae

Rhododendron cf. R. macrophyllum Don

Plate II Fig. 2

Leaf impressions of Rhododendron cf. R. macrophyllum were found in locality 180 intermixed with Acer cf. sp. Alnus cf. sp. and Holodiscus cf. sp. leaves. The present range of this species is from near the coast in Monterey

County, California to Del Norte and Siskiyou Counties, California.

Galtheria cf. G. shallon Pursh

Plate II Fig. 3

Leaf impressions of Galtheria cf. G. shallon were found in localities 150 and 180. G. shallon is now found growing near the coast from Santa Barbara County, California to Del Norte County, California.

Vaccinium cf. V. ovatum Pursh

Plate II Fig. 4

A carbonized leaf of Vaccinium cf. V. ovatum was found at locality 280. The size shape and cirrations of the leaf compares very closely with Humboldt State College herbarium specimens of V. ovatum. This species is now found living in areas from Santa Barbara County, California to Del Norte County, California.

Family Rosaceae

Holodiscus cf. H. discolor Pursh

Plate II Fig. 5

The impressions of leaves of Holodiscus cf. H. discolor were found in locality 180. This species is now found living in a great number of different environments from Los Angeles County, California northward to British Columbia.

Rosa cf. sp.

Plate II Fig. 6

In locality 280 a single carbonized prickly resembling many of those in the genus Rosa was found. This thorn is recurved in much the same way as many of the modern local wild rose thorns. The fossilized specimen, with a length of 12 mm fits into a size range in Munz that belongs only to R. eglanteria, which has been introduced from Europe within the past 150 years. It is possible that this prickly is of R. nutkana which is common locally and seems to inhabit a similar habitat as suggested by the other species with which the specimen was found. R. nutkana is presently found below 1500 feet in the Redwood forests of Mendocino County, California northward to southern Alaska.

Family Betulaceae

Alnus cf. A. oregona Nuttall

Leaf impressions of Alnus cf. A. oregona were particularly abundant in several horizons of locality 150 where they formed several layers of solid leaf impressions several inches thick. Leaf impressions of this species were found in locality 180 and carbonized leaves were found in locality 280. Preserved female catkins were found in locality 150 and carbonized female catkins were found in locality 280. During the

present study more specimens of this species were found than any other single species. This species now lives as a tree or shrub mostly along stream banks from Santa Cruz County, California to Alaska.

Family Fagaceae

Quercus cf. Q. chrysolepis Liebm

In locality 220 a rather rich layer bearing carbonized leaves resembling those of Q. chrysolepis were recognized. This species is now found growing in moist slopes and canyons from lower California to Oregon.

Family Salicaceae

Salix cf. S. sessilifolia Nuttall

Carbonized leaves of Salix cf. S. sessilifolia were found at locality 220. This species is now found growing from Lower California to northern Oregon.

Family Rhamnaceae

Ceanothus cf. C. thyrsiflorus Eschscholtz

A carbonized leaf of Ceanothus cf. C. thyrsiflorus was found at locality 280. The leaf was identified to this species by the three prominently raised veins. This species is now found living in the coast ranges from Santa Barbara County, California to southern Oregon.

Class Monocotyledoneae

Family Cyperaceae

In localities 90, 150, 180, 220 and 280 impressions and carbonized roots, stems and leaves were found. Unfortunately, no flower parts upon which further identification would have to be based were found. The rushes or sedges are a widely dispersed group, with many members living in wet places.

In an attempt to better determine the composition of the flora Dr. MacGinitie unsuccessfully tested for pollen grains in samples of sediments taken during the present study in locality 280.

SYSTEMATIC DESCRIPTION OF THE FAUNA

It would seem logical to assume that some of the richer plant horizons within the Gold Bluffs exposure must have been capable of attracting and feeding a much greater number and variety of animals than has been represented in the fossil record. According to Dr. Houck¹³ high acidity resulting from the breakdown of plant remains would favor the dissolving of bone material rather than its preservation. The acidity of some of these localities must have been quite high at times for there apparently was a rather rapid accumulation of much plant material in areas having rather stagnant water conditions. The creeks coming off the Gold Bluffs now have a summer ph of 5 as does a stagnant pond containing much plant matter near the Mad River mouth. It is also possible that chemical and physical make-up of many of the sediments may not have favored the preservation of animal remains.

Phylum Chordata

Class Mammalia

In 1874 Chase¹⁴ reported finding a fossil vertebra. Unfortunately, this specimen was not identified nor was the horizon from which it was taken identified.

¹³Vertebrate zoologist, Humboldt State College, oral communication 1967.

¹⁴Chase, p. 384.

According to Dr. Hertlein¹⁵ of the California Academy of Science this specimen was probably lost in the San Francisco fire of 1906. Dr. Young¹⁶ reported finding some bone fragments in a gravel conglomerate layer approximately a quarter of a mile south of the point where the state park road comes onto the beach. These specimens were so badly weathered as to be unrecoverable. During the present study the apparent cast of a section of a large rib was identified by Dr. Houck¹⁷. In this case, bone material is suggested by the surface texture. The specimen resembles a rib by its curvature and by its oval cross sectional shape.

Phylum Mollusca

Class Pelecypoda

Order Eumellibranchia

Family Margaritiferidae

Margaritifera cf. M. margaritifera Linnaeus

Plate XIII fig. 7

In locality 180 an apparently single horizon bearing fresh water plecypods intermixed with an assemblage of Alnus cf. sp. and Acer cf. sp. leaf impressions has been located among the larger chunks of tan sandstone coming off the face of the bluff. This horizon seems

¹⁵ Oral communication 1967.

¹⁶ Oral communication 1966.

¹⁷ Oral communication 1967.

to be associated within six inches stratigraphically of a layer of half rounded concretions which have not been observed in any other area of the Gold Bluffs exposure.

Of the plecypods recognized in the locality 180 horizon six of the nine specimens appear to be Margaritifera cf. M. margaritifera. These were tentatively identified by Dr. De Martini¹⁸ by their thin and elongated kidney shaped valves. In localities 150 and 280 a single faint impression of what appears to be M. margaritifera on the basis of the shapes of their exposed valves. Preservation of all the specimens from locality 180 has been accomplished by an almost complete replacement of the original calcium carbonate shell material by orange iron oxide compounds which now form casts of the specimens. All of the specimens were preserved with their valves still articulated, although in several cases the valves have been completely opened up. Such opening of the valves while maintaining articulation might represent individuals that had been transported for short distances down stream after death had occurred.

¹⁸Invertebrate zoologist, Humboldt State College , oral communication 1966.

Ctyroky,¹⁹ has reported finding plecypod fossils very similar to Margaritifera sp. in the upper Cretaceous beds of Southern Bohemia. According to Roscoe,²⁰ Margritifera sp. is one of the longest living of all animals (up to 140 years) and among the most widely distributed fresh water organisms. It occurs in the circumpolar paleoarctic and Neararctic zones from 40° N to 50° N latitude. Locally Dr. De Martini has reported finding M. margritifera living in Mad River, Redwood Creek, Trinity River and Prairie Creek.

In his studies of the population inhabiting the Kettle River near Boyds, Washington, Roscoe²¹ reported that M. margritifera is found predominantly as a river dweller, although occasionally as a lake dweller. In the Kettle River the mussel is found living in waters ranging in velocity from still to a velocity at which the molluscs are washed downstream. Roscoe found that the mussels seemed to prefer a water depth of from 1.5 feet to 5 feet with most of the individuals living at a depth of 3 feet.

¹⁹Ctyroky, p., Margaritifera (Pseudunio) modelli n. sp., A New Niad from Upper Cretaceous of Southern Bohemia, Arch Mollusk enkunde, 94; pp. 115-120, 1965.

²⁰Roscoe, E. J., Redelings, S. The Ecology of the Fresh-water Pearl Mussel Margaritifera Margaritifera, Sterkiana, pp. 19-32 No. 16, Dec. 1964.

²¹Op cit.

Family Unionidae

Anodonta cf. A. nuttalliana Lea

Plate XIII Fig. 8

Three specimens of Anodonta cf. A. nuttalliana were taken from the same horizon in locality 180 and the Margaritifera cf. M. margaritifera specimens. These specimens were preserved in much the same manner as the Margaritifera cf. sp. specimens, with the valves opened up but still articulated and the shell material had apparently been replaced by iron oxide compounds. These specimens were identified by Dr. Hertlein²² by comparing them with specimens in the California Academy of Sciences collection. Because of taxinomic problems involved with the species within the genus Anodonta, apparently little or no valid specific work has been done on the ecology of A. nuttalliana. This species is found mostly in slowly moving fresh water streams from the lower drainage of the San Joaquin River to some of the rivers in southern British Columbia. Apparently their living conditions do not differ greatly from those of M. margaritifera. Locally Dr. De Martini²³ has found A. californiensis living in the Eel River.

²²Dr. Hertlein, L., California Academy of Sciences, oral communication 1967.

²³Dr. De Martini, oral communication 1967.

DISCUSSION

Paleoecology

Geographic, lithologic, physiographic and palientologic evidence strongly suggests that the Gold Bluffs formation was deposited on the flood plain of what may have been the ancestral Klamath River. With the present mouth of the river nine miles away from the exposure of Gold Bluffs and with deposit of stream gravels and sediments extending continuously from the area of the south bank of the Klamath River to many of the hills to the south (as reported by MacGinitie,²⁴ Chase²⁵ and Young²⁶) a close association between the river and the Gold Bluffs formation is established. The predominant orientation of the carbonized logs in a north-east-southwest direction through many beds of the Gold Bluffs deposit and the way in which many of the conglomerate cobbles are imbercated suggesting that they were layed upon each other from a northeast direction in fern canyon suggests that the depositional stream flowed in a northeast-southwest direction. If this suggested direction of flow is projected inland

²⁴MacGinitie op. cit., p. 105

²⁵Chase, A. W., Gold Deposits in the Lower Klamath River, Stilliman's Journal, Vol. 6, p. 57, 1873.

²⁶Young, J.C., oral communication 1967.

it is found to intersect the present course of the Klamath River. The presence of subrounded river type conglomerates, in the Gold Bluffs, of similar size and composition to those now being deposited on the Klamath River flood plain further suggests an ancient connection between the formation and the river.

The existence of many large and small areas of fine grained deposits of fine grained grey silts suggests that at times there must have been some kinds of lakes developed on the flood plain of the river. Possibly the smaller of these grey deposits were formed on the bottoms of oxbow lakes. The larger of these deposits could have resulted from silt accumulations on the bottoms of lakes created by dammings of the river or at the heads of estuaries where the velocity of a river would rapidly decrease, the river would drop its load of silt; but where the salinity would be low enough to prevent the growth of marine organisms. If some of these large accumulations of fine silts were deposited at the heads of estuaries then slight salinity changes might have acted to folliculate the clay silt particles out of the freshwater.

The presence of cross bedding and river-like channelings in the Gold Bluffs exposure is also suggestive of a river valley deposit. That these filled river channels occur at different levels suggests that the river may have meandered across its flood plain at different times.

Physiographically the association between the Klamath River and the Gold Bluffs formation is suggested by the apparent association of the Trinidad Submarine Canyon with the river. Unlike several of the other local river-submarine canyon associations the mouth of the Klamath River does not enter directly in to the head of its supposed associated submarine canyon. Instead the head of the canyon is a considerable distance to the south of the present mouth of the Klamath or west of the Gold Bluffs deposit; which suggests that the river may have flowed out through the Gold Bluffs vicinity in order to get to the head of the canyon.

The occurrence of the river dwelling Anodonta cf. nuttalliana and Margaritifera cf. margaritifera in the fossil record of the Gold Bluffs is certainly very strong evidence that the formation of this deposit involved the actions of a river. It is also highly significant that most of the flora represented in this exposure have modern equivalents that occupy either riparian environments or are commonly found in canyons or valleys which would usually contain a river such as the one that supposedly deposited this deposit.

It is possible to get a suggestion of what the elevation and climate were like by selecting the minimum and maximum precipitation and temperature ranges and the maximum elevation ranges for the modern

equivalent species as given in Munz (Fig. 4). The climate so derived would have had from 14 to 114 inches of rain per year, and have had a temperature range of 22° F. to 95° F. and be at an elevation below 1200 feet. Some of the stream conditions can be deduced from the tolerances of Margaritifera margaritifera for water temperatures ranging from 32° F. to 54° F+. The velocity must have been variable in order to account for the depositions of cobbles up to six inches in diameter and the fine grained sediments.

With an elevation of less than 1200 feet and with species like Sequoia sempervirens that are found only in the coastal fog belt it seems logical to assume that the deposition of this formation may have taken place within a relatively short distance of the coast. As no marine or brackish water fossils have been recognized there is no way of deducing just how far from the marine environment this deposition took place.

Equivalent Deposits

Several local fossil bearing deposits have resemblances to the lithology and fossil make-up of the Gold Bluffs beds. Dr. Young²⁷ has reported finding several fossil localities in the area to the east of Prairie Creek Redwoods State Park. These deposits are most probably

²⁷Young, J.C., oral communication 1967.

within the Gold Bluffs formation. Another possibly comparable deposit can be found on the south side of Big Lagoon. The reddish-brown sandstones of the area south of Big Lagoon, in which MacGinitie²⁸ has reported finding Sequoia sp., Alnus sp. and Rubus sp., are almost indistinguishable from many sandstones found in the Gold Bluffs. Other localities that have produced some floral elements that are somewhat comparable to the Gold Bluffs deposit can be found on Point St. George, the Agate Beach area of Patricks' Point State Park and the upper beds at Crannell road cut near U.S. 101.

Age

Apparently the first attempts at dating the Gold Bluffs formation were made by Diller²⁹ who dated the lowest or most southerly beds as belonging to the Miocene. This Miocene dating was apparently made on the basis of lithologic position and composition of the deposit rather than fossil evidence. In 1937 Dr. MacGinitie³⁰ using palientologic evidence, dated the Gold Bluffs exposure as belonging to the Upper Pliocene or Lower

²⁸MacGinitie, H.D., written communication 1966.

²⁹Diller, op. cit., p. 32.

³⁰MacGinitie, op. cit., p. 105.

Pleistocene. MacGinitie³¹ has recently stated that this exposure is of the latest Pliocene. During the present study all fossil evidence has pointed to the relative youth of this deposit. All of the recognized plant species seem to be very close to their modern equivalents growing in and around the Gold Bluffs area. With specimens apparently so close in space and structure, one can only assume that they must also be close in time too. In other words this deposit is most probably of late Pliocene to Pleistocene in age.

³¹MacGinitie, oral communication, 1966.

Plate I



A

150 | 160



160 | 170

170 | 180

Plate II



180|190



190|200

Plate III



200 | 210



Plate IV



210 | 220



220 | 230

Plate V

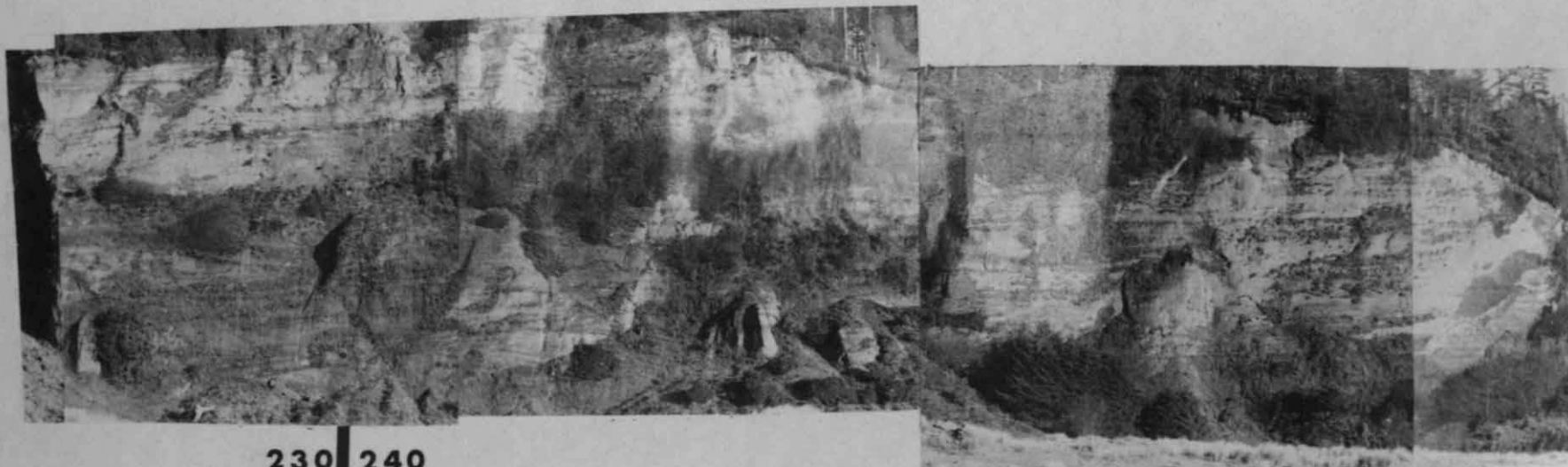


Plate VI



250 | 260

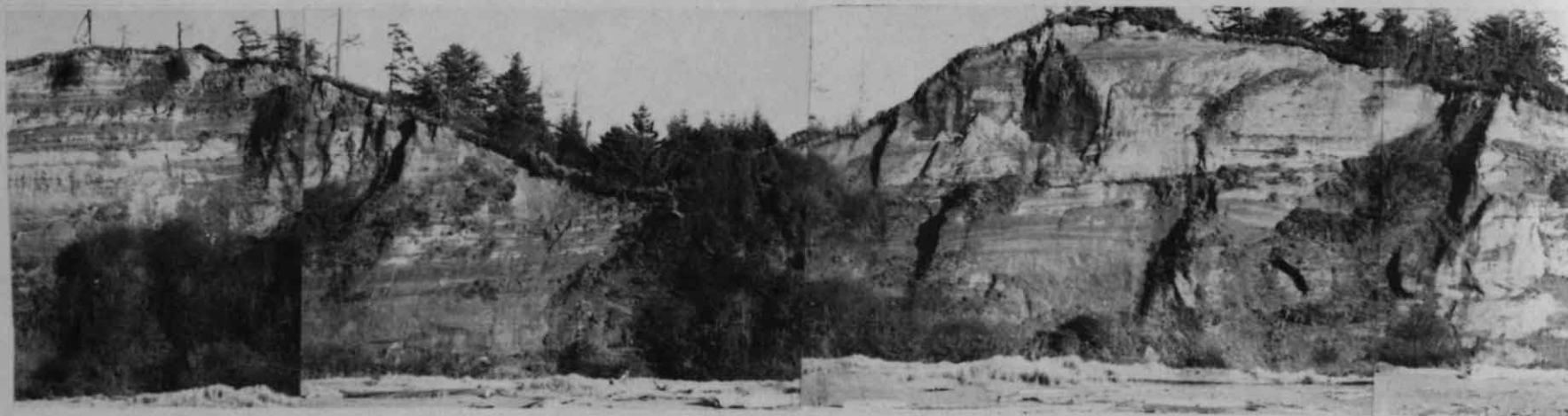
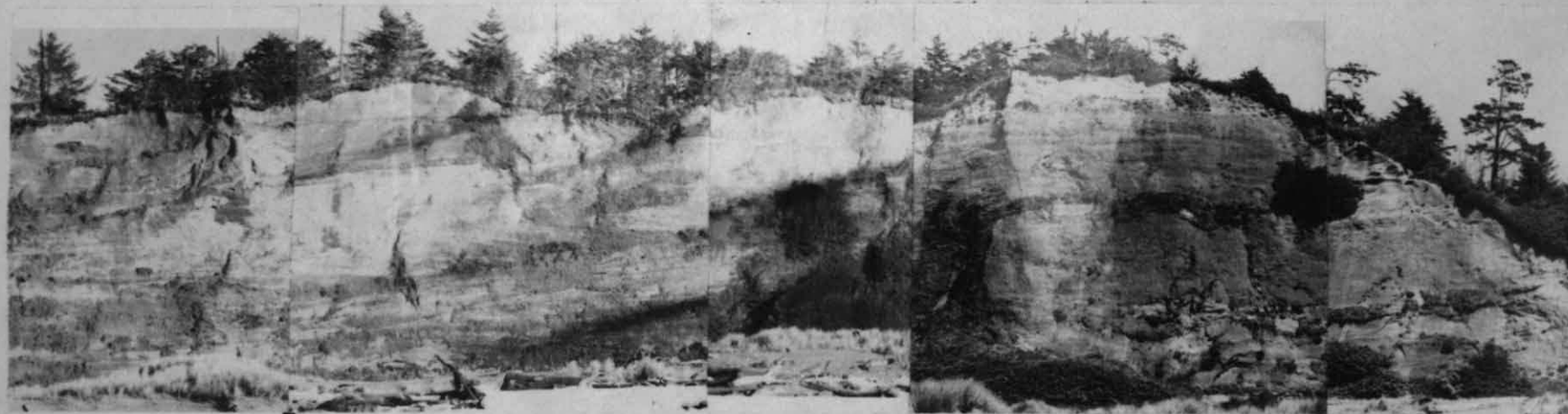


Plate VII



260 | 270



270 | 280

Plate VIII



280|290

Plate IX



290 | 300



300 | 310

Plate X



310 | 320



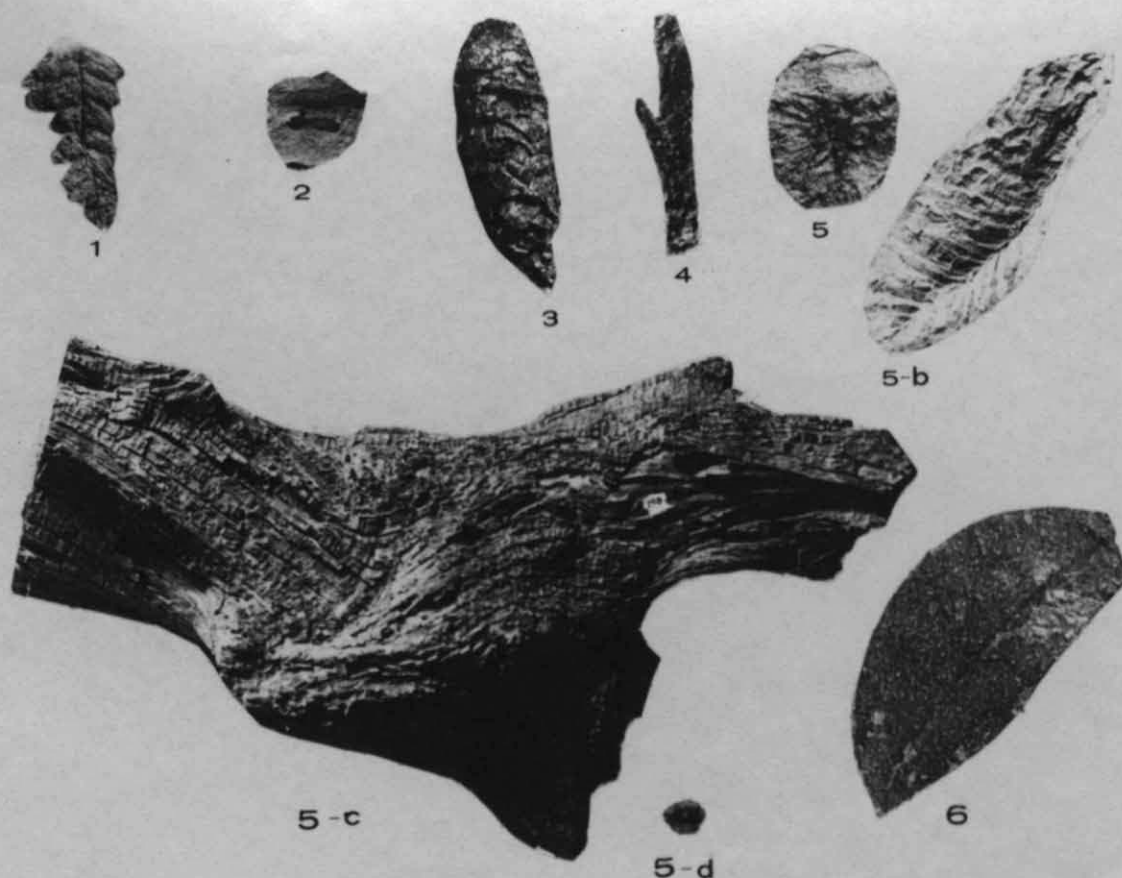


Plate XI

Fig. 1 Dryopteris cf. dilatata leaflet

Fig. 2 Pinaceae seed

Fig. 3 Picea cf. sitchensis cone

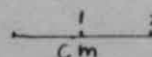
Fig. 4 Cupressaceae branchlet

Fig. 5 Sequoia cf. sempervirens cone

b branchlet

c wood

d seed

Fig. 6 Umbellularia cf. californica leafFig. 7 Acer cf. circinatum leaf

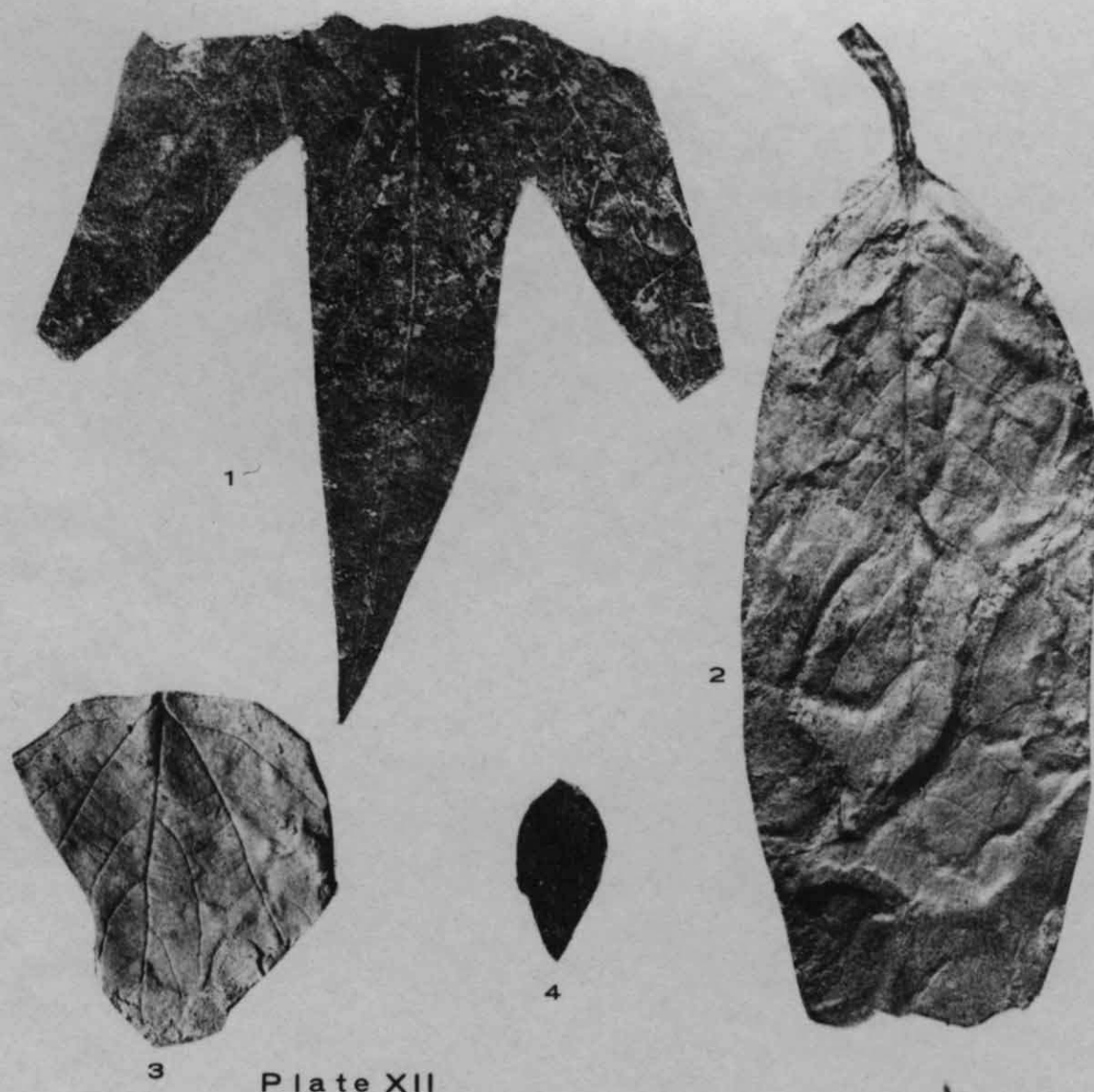
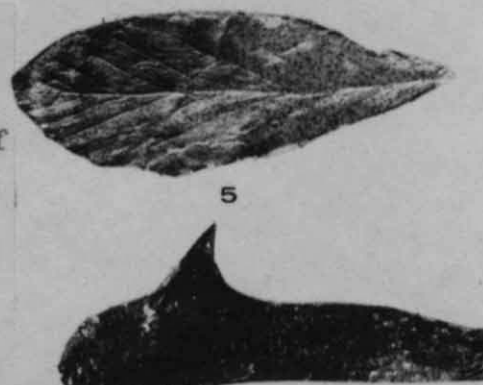


Plate XII

- Fig. 1 Acer cf. macrophyllum leaf
 Fig. 2 Rhododendron cf. macrophyllum leaf
 Fig. 3 Galtheria cf. shallon leaf
 Fig. 4 Vaccinium cf. ovatum leaf
 Fig. 5 Holodiscus cf. discolor leaf
 Fig. 6 Rosa cf. sp. prickles



6
 1 2
 cm

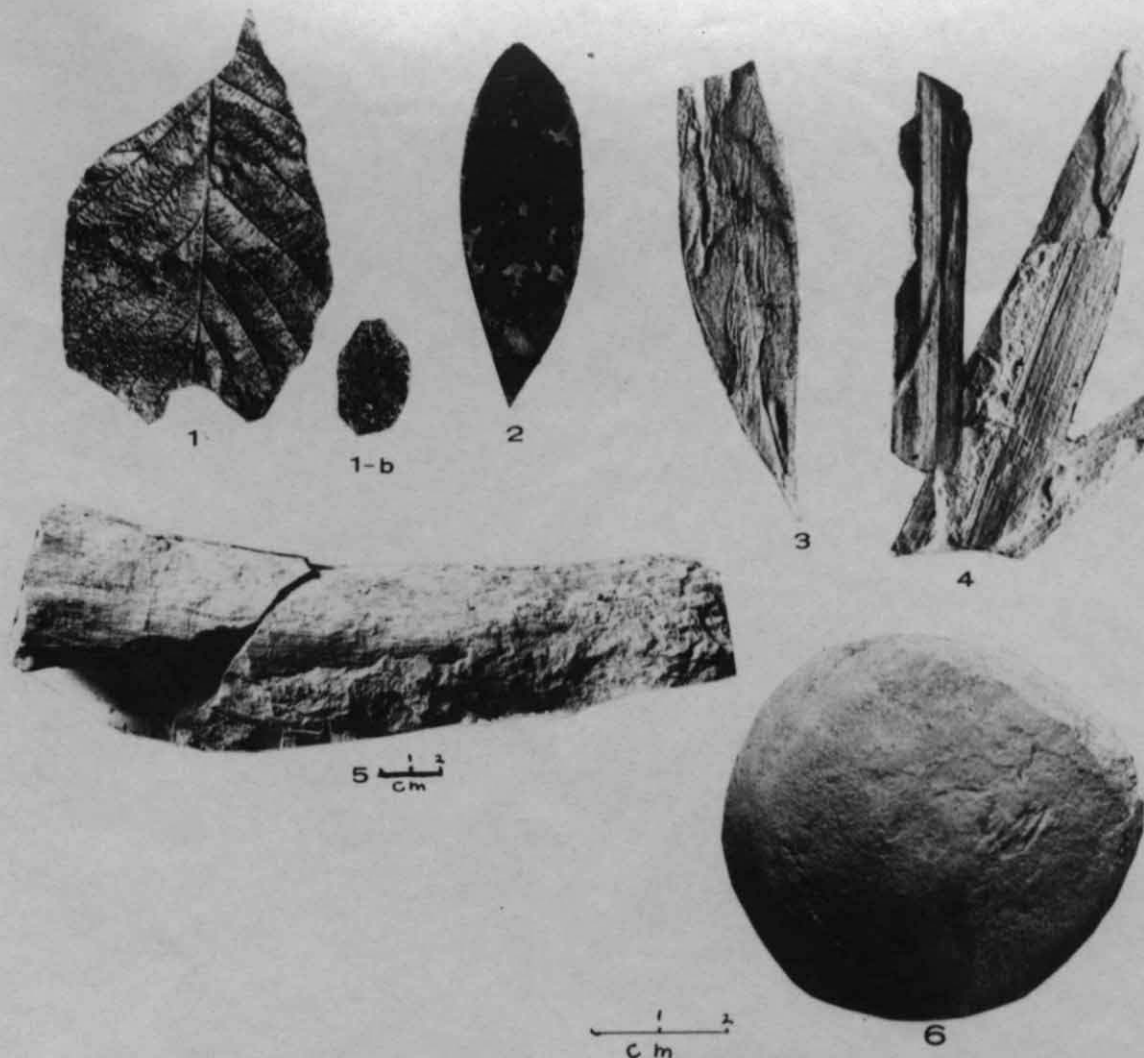


Plate XIII

Fig. 1 Alnus cf. oregona leaf

b catkin

Fig. 2 Quercus cf. chrysolepis leafFig. 3 Salix cf. sessilifolia leaf

Fig. 4 Cyperaceae leaves

Fig. 5 Mammalian cf. rib

Fig. 6 Concretion from locality 180

Fig. 7 Margaritifera cf. margaritiferaFig. 8 Anodonta cf. nuttalliana