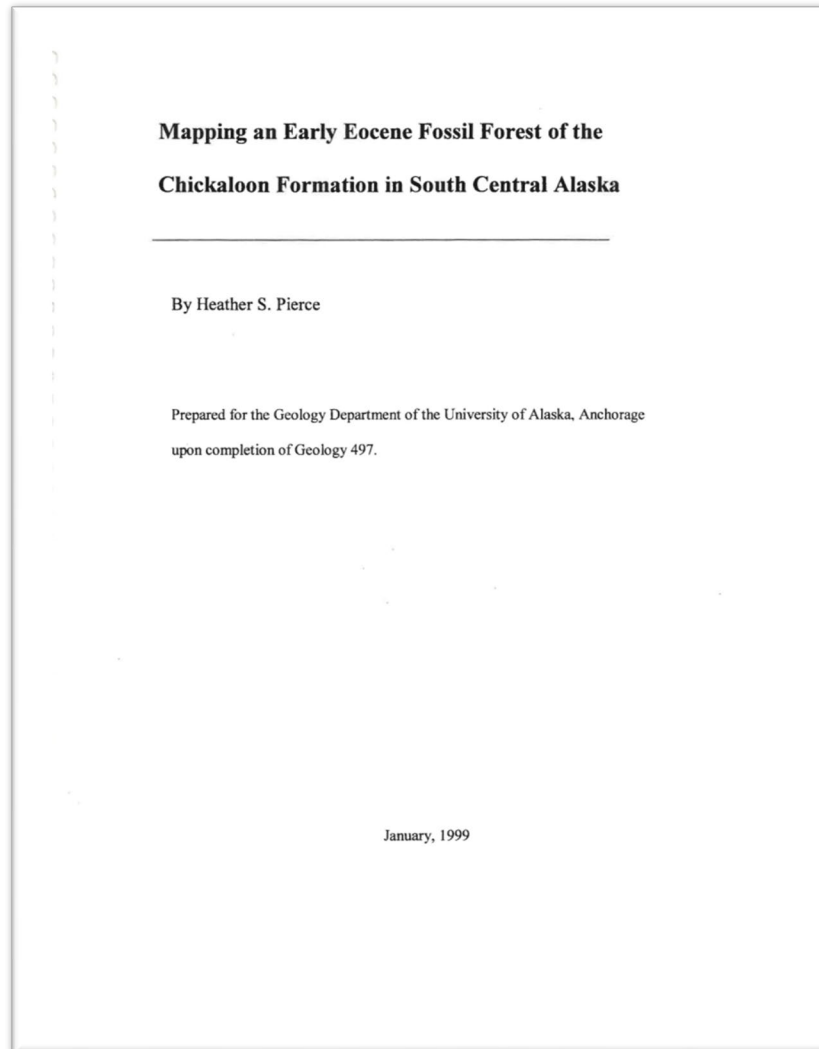


Mapping an early Eocene fossil forest of the Chickaloon Formation in Southcentral Alaska

Heather S. Collins*

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Mapping an Early Eocene Fossil Forest of the Chickaloon Formation in South Central Alaska

By Heather S. Pierce

Prepared for the Geology Department of the University of Alaska, Anchorage
upon completion of Geology 497.

January, 1999

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Abstract

The Chickaloon Formation is located in the Wishbone Hill district of south central Alaska. The Wishbone Hill district is a unique area not only for the multitude of plant fossils, but also for the impressive 55 million-year-old fossil forest. Sixty-one preserved trees lie in the Matanuska coal field in the Chickaloon Formation. Three strip mine pits were studied to locate, measure, and map the exposed fossilized trees. Two pits contain three different stratigraphic tree horizons and the third pit contains four. The mean tree length documented was 1.49 meters in length and .086 meters in width. The mean tree spacing distance was 9.49 meters. Fifty-seven percent of the fossilized trees were found in the East Pit. Seventy-seven percent of the trees were preserved in growth position, indicating a high probability of in situ preservation. Until further research can be done to locate the presence of preserved roots, the Chickaloon fossil forest cannot be classified as an in situ. The Wishbone Hill district is a spectacular area, and if left preserved, a remarkable location to for studying ancient fossil forests.

Introduction

Professor Anne Pasch from the University of Alaska Anchorage was working on a project for the Alaska State Department of Natural Resources that I found to be of great interest. She was looking for volunteers, and I signed up to salvage plant fossils for the "Wishbone Hill Fossil Recovery Project" near Sutton, Alaska. Professor Pasch was systematically collecting plant fossils from exposures in abandoned strip mines before they were destroyed due to reclamation activities. The cliff exposures were a hazard to the public because of steep slopes and frequent rock falls. Reclamation, known as the North Jones project, encompassed tearing down a high wall, filling in a deep pit, regrading it to a gentler slope and seeding it. During the summer of 1997, I spent four Saturdays collecting plant fossils. In the course of this project, several trees were seen preserved in growth position in the North Jones project area highwall. The largest tree was 8.6 meters long and 1.25 meters in length. During the reclamation project in 1997, these unusual fossilized trees were all destroyed or buried. Nevertheless, casual observation of strip mines pits to the east and west of the North Jones project showed that additional trees were exposed in growth position. Professor Pasch suggested that with my rock climbing experience I should attempt to survey the steep slopes to determine the extent of the fossilized trees. I agreed to do this during the summer of 1998.

Purpose and Scope

The purpose of this study was to locate, measure, and map the fossilized trees exposed in three of the strip mine pits on Wishbone Hill near Sutton, Alaska. The survey was intended to determine the size and number of fossilized trees in situ, their stratigraphic positions, and if they occurred in one or more horizons.

Regional Geology

The Wishbone Hill district lies in the Matanuska River Valley northeast of Cook Inlet and contains the Matanuska coal field. To the north of the valley are the Castle Mountain Fault and the Talkeetna Mountains, which are made up of granite and gneissic rock. South of the valley lie the Chugach Mountains, which are made up of greenstone, diorite, and interbedded slate and graywacke. These features are shown in Figure 1a.

The major units exposed in the Wishbone Hill district are the Wishbone and Chickaloon Formations. The Chickaloon Formation is of economic importance because of its coal bearing members. From 1915 to 1967, the Wishbone, Chickaloon, and Anthracite Ridge coal districts together produced as much as 6,130,000 metric tons of coal from this field (Flores and Stricker, 1993). Surface and underground coal mines were localized in the Wishbone Hill District (Barnes and Payne, 1956). Surface mining in the Evan Jones Coal Mine, between Moose Creek to the west and Eska Creek to the north of the Wishbone Hill syncline, created the strip-mine highwalls studied in this project.

The Chickaloon Formation is 1,500 meters thick and consists primarily of interbedded sandstone, conglomeratic sandstone, siltstone, mudstone, carbonaceous shale, and coal (Flores and Stricker, 1993). It sits unconformably on the Cretaceous Matanuska Formation and is conformably overlain by the Wishbone Formation. The Wishbone Formation is 900 meters thick and is made primarily of conglomerate, sandstone, and a small amount of siltstone and mudstone (Flores and Stricker, 1993). This formation shows local unconformable

basal contacts where the conglomerate and sandstone cut into the underlying Chickaloon Formation.

Ames, Riegel and Wolfe (1962) performed palynology and megafloras studies and found the Chickaloon Formation to be completely Paleocene in age. Triplehorn (1984) did radiometric age dating of the Chickaloon Formation and found it to be Paleocene and Eocene in age. Wolfe (1966) reported the overlying Wishbone Formation to be of Paleocene and Eocene age. According to Wolfe (1966), the plants of these formations accumulated in a subtropical, warm-temperate climate.

The most outstanding structural feature of the Wishbone Hill area is the canoe-shaped Wishbone Hill syncline, with an axis striking south 55-80 degrees west and plunging to the southwest (Barnes and Payne, 1956). Northeast left-lateral, oblique-slip faults have cut across this syncline. Flores and Stricker (1993) suggest these faults were active from the early stages of the deformation of the Castle Mountain Fault, during Mesozoic through Tertiary time, when the Chickaloon Formation was deposited.

The economic coal beds in the Chickaloon Formation are located in the upper 425 meters. There are a few thin coal beds in the lower section. Barnes and Payne (1956) subdivided the upper part of the Chickaloon Formation into four major coal-bearing groups. The four coal zones are Jonesville, Premier, Midway, and Eska. The coal zones contain coal beds interbedded with carbonaceous shale, bony coal, mudstone, tonstein beds, and ironstone concretions. Figure 1b shows these features. The preserved forest of this study was found in the Premier coal zone of early Eocene age.

Flores and Stricker conducted a detailed sedimentological study of the Chickaloon Formation in 1993. They described the sedimentary, lateral and vertical facies, lithologies, sedimentary structures, associations and suggested a depositional environment for the Wishbone Hill District. They found that the mudstone and siltstone sections contain root marks, plant stems, tree trunks, tree leaves, and animal burrows. The coal and carbonaceous shale sections also contain ironstone concretions, which embody abundant plant fragments and tree trunks. The sediments of the Chickaloon Formation were deposited by west-southwest-flowing meandering to anastomosed streams. Flores and Stricker (1993) studied in detail the Eska-Midway-Premier facies sequence and deduced that the sandstones with crude point bars reflect fluvial deposits of high-sinuosity meandering streams. They suggested that the dominance of sand bedload, trough crossbeds, and lack of channel bars indicates deposition in bedload streams affected by seasonal discharge. The meandering and anastomosed streams possibly were a segment of a fluvial system that drained the Matanuska geosyncline. These streams may have started under alternating base level conditions shaped by basin subsidence, shifting due to sediment compaction, and growth faulting. Flores and Stricker (1993) proposed that the left-lateral, oblique-slip faults controlled the position of fluvial channels and mires. Fluvial channels occupied the downthrown areas, while mire development was prolonged on upthrown areas. They indicated that the flood-plain sediments caused by crevasse splays during flood discharges from meandering streams initiated anastomosis. Progradation of crevasse splays into the flood plain allowed bifurcation and integrating of crevasse channels. This procedure, affected by a high rate of subsidence, enlarged areas of anastomosis and flood-basin lake development. Flores and Stricker (1993) indicated that while the anastomosis developed, a crevasse channel was altered into a major conduit. Through time, this conduit transformed from a low to a high-sinuosity stream, to the onset of a meandering stream, and to the repetition of the fluvial cycle.

Other Fossil Forests

Fossil forests are extremely rare. Therefore, in order to understand the Wishbone Hill forest, I studied and compared descriptions of two well-known fossil forests, and a recently discovered fossil forest in Alaska, to the forest in the Wishbone Hill District.

Yellowstone Fossil Forest

The fossil forest in Yellowstone is located in the northeast section of the National Park in a jagged mountainous region located between 6,000 and 11,000 feet above sea level. The climate in this region is now characterized from cool-temperate to subarctic with a forest made up of conifers and hardwoods. When the trees flourished, in the Eocene epoch, 58 million to 37 million years ago, the area was noticeably different. The countryside was made up of many broad, flat river valleys divided by mild rolling hills. The mean elevation extended from 2,000 to 4,000 feet and the climate ranged from warm temperate in the hills and to subtropical in the valleys. These trees were preserved by a remarkable series of events that turned the ancient forest into stone. Just how this occurred is a matter of hot debate. Dorf (1964) believed each of the twenty-seven distinct layers of petrified trees were preserved in situ by layers of volcanic debris. Fritz (1980) reinterpreted the deposits of the forest to be volcanoclastic sedimentary rocks that were deposited in a complex alluvial system. Fritz's findings indicated that mud flows originated high on the flanks of nearby volcanic vents. These flows uprooted trees near the rims of the volcanoes, and during transportation roots, branches, and bark were broken off. The subsequent mud flow deposits were reworked by braided streams. Braided streams also transported plant debris and oriented the horizontal logs. In 1984, Yuretich entered the debate. His findings indicated that most of the upright tree stumps were buried in place and were not moved long distances by mudflows or braided streams. He listed three possible mechanisms for the burial: (1) burial by mudflow, (2) destruction of trees by rising water from dammed rivers, (3) burial by volcanic ash (Yuretich, 1984). Clearly, there is a debate as to whether the preservation of the trees occurred in situ at Yellowstone National Park.

The fossil forest in the Chickaloon Formation is similar to the Yellowstone fossil forest because it is also unclear if the fossilized trees were preserved in situ. There is no substantial accumulation of volcanic debris found in the Chickaloon Formation to account burial of these trees by lahars or ash. Fritz (1980) interpreted mud flows and braided streams as the depositional mechanism for the Yellowstone fossil forest, whereas Flores and Stricker (1993) described meandering to anastomosed streams as the depositional environment of the Chickaloon Formation. Both the Yellowstone and the Chickaloon fossil forests were presumably preserved by a series of depositional events rather than a single flood, mud flow, or lahar.

Florissant Fossil Forest

Florissant Fossil Beds National Monument contains a buried forest from the Oligocene epoch, 37 to 24 million years ago. Huge sequoia trees are preserved in situ from successive volcanic eruptions that discharged clouds of smoke and ash. One of the giant sequoia stumps preserved measures seventy-four feet in circumference and is the largest known specimen of its kind (Wallner, 1976). Cinnamon-barked trees, pines, hardwoods, cycads, ferns, rosebushes, butterflies, mosquitoes, and lice are a few elements of the Oligocene landscape that have been fossilized in Florissant Fossil Beds.

This fossil forest does not provide a good preservation model for the Chickaloon Formation because no significant amounts of ash have been found. The delicately preserved stumps of sequoia trees in the Florissant Fossil Beds National Monument were exploited by private owners who allowed visitors to dig and remove any fossils they found. The same scenario is occurring in the Wishbone Hill District today. Even though a mining company owns the land, no one is keeping out amateur fossil hunters and the preserved trees and fossils are rapidly disappearing.

Lili Creek, AK

Decker, et al (1997), described another fossil forest on the North Slope of Alaska. An outcrop with six preserved trees is located near the headwaters of Lili Creek, a north flowing tributary of the Meade River in the western North Slope of Alaska. The trees are in growth position and range from 10 to 70 centimeters in diameter and are up to 4.5 meters tall. A horizontal log approximately 1.6 meters long was also measured. The trees are preserved in fluvial mid Cretaceous sediments. No roots were exposed but some trees appeared to be rooted in the upper part of the underlying coal seam or transitional carbonaceous mudstone facies (Decker, 1997). To date, the taxonomic classification, process of preservation, and the preservation position of the trees is open for debate.

The sedimentary lithologies of the Lili Creek fossil forest are similar to the Chickaloon fossil forest in that there are no apparent root systems exposed in either. Coal is an important marker bed in both fossil forests. The Chickaloon fossil forest is 55 million years old, whereas the Lili Creek fossil forest is 97 million years old. The Chickaloon fossil forest contains sixty-one preserved trees and the Lili Creek forest has only six. Fossilized flora elements have been found in the Chickaloon fossil forest but not in the Lili Creek fossil forest.

Methodology

The study area was composed of three highwalls to the east and west of North Jones reclamation project. The East Pit is located to the east of the North Jones project area, and the West Center Pit and the Deep Pit are located to the west of the project, as shown in Plate 4. These pits were previously named during the North Jones Reclamation activities. All fieldwork was completed during the summer of 1998. The original plan was to rappel down the highwalls to map, measure, and sample the preserved trees. Upon the first attempts to rappel down, a debris avalanche was created from the tossing of the climbing rope. It was immediately clear that rappelling on these severely unstable cliffs was too dangerous. It became apparent that these trees would be studied from the ground.

Using a stadia rod, Garmin G.P.S. 38 Personal Navigator®, 300 foot measuring tape and camera, three pits containing the preserved trees were examined. The preserved trees were located by studying the exposures with binoculars and each section containing a fossilized tree was photographed. The distance between each tree was calculated using a 300-foot tape measure, and a G.P.S. reading was taken under the preserved trees. Samples were taken from trees that were accessible. Sketches of each tree with their stratigraphic sections and locations were made in the field. Final maps of the highwalls and preserved trees were drawn using the photographs and sketches. The scale was calculated from the field measurements and estimated from the stadia rod increments seen in the photographs. Forty-nine percent of the tree sizes were estimated from the photos. If these sizes are not exact, then they are underestimated because of the oblique angle of the cliff. Fifty-one percent of the tree sizes were measured

accurately with a measuring tape. Tables 1-3 list the measured sizes of the length and width of the fossilized trees. Width is an approximate measure of the diameter of the tree.

While it was not the main focus of this project, it was almost impossible not to find plant fossils in these pits. During the course of the investigation a small plant fossil collection was made that indicates a subtropical to temperate forest.

Results

In the three pits that were examined, a total of sixty-one fossilized trees were found. Seventy-seven percent of the trees were located in a vertical position and seven percent were tilted. Thirteen percent were horizontal and three percent had an undetermined position. Fifty-seven percent of the trees were found in the East Pit. Of those in the East Pit, seventy-four percent were vertical, fourteen percent were horizontal, six percent were tilted, and six percent had an undetermined position. The Deep Pit contained thirteen percent of the trees and a hundred percent were vertically positioned. The West Center Pit contained thirty percent of the trees. Seventy-two percent of the West Center Pit trees were vertical, seventeen percent were horizontal, and eleven percent were tilted. Tables 1-3 show the measurements of the fossilized trees and their positions, H for horizontal, V for vertical, and T for tilted. The largest tree measured 5.79 meters in length and the smallest tree measured 1.49 meters in length. Fossilized trees in the East Pit and Deep Pit were found in three different stratigraphic tree horizons. The West Center Pit contains four different stratigraphic tree horizons. Each tree horizon was divided into groups of sequentially spaced trees. Table 8 shows the mean spacing distance of the fossilized trees subdivided by groups. The overall mean spacing distance of the fossilized trees is 9.49 meters.

The question still remains as to whether the trees are preserved in situ. Because no attached root systems were found, the Chickaloon fossil forest cannot conclusively be classified as an in situ fossil forest. It is highly unlikely that the large percent of vertical trees were transported and then flipped upright into their growth position; therefore, this fossil forest is most likely in situ. Until further research of the root system is completed, the question of in situ preservation will remain.

Figures 1-56 are photographs of each of the fossilized trees. The stadia rod in the photos is twenty-five feet in length and the gentleman is six feet three inches. Figures 57-77 are photographs of the small fossil collection found during this project. Beneath each photo of the fossil is the listing of the reference used to identify the fossil.

Table 9 lists the twenty-two fossils that were collected and identified. Fossils of oak, dawn redwood, poplar, walnut, hickory, horsetails, and ferns were found which indicate that this fossil forest was made up of a mixed coniferous and deciduous subtropical to temperate forest. Figure 72 shows the only *matonia* fossil found in the Chickaloon Formation. Figure 77, the photograph of the hydrangea was found while collecting for Anne Pasch in the summer of 1997, prior to this project. At first it appeared to be a flower, which is very rare in the fossil record. However, the petal-like structures are specialized sepals. It is the only hydrangea reported from the Chickaloon Formation.

Plates 1-3 are maps of the highwalls in each of the three pits drawn to scale, showing the fossilized trees in stratigraphic position. The key to the stratigraphy is on the bottom of the map. If there is more than one symbol per stratigraphic layer, the beds were interbedded with the indicated lithologies.

Conclusion

The fossil forest of the Wishbone Hill District contains at least 61 fossilized trees, of which seventy-seven percent are in growth position. Presumably there are more fossilized trees in the Wishbone Hill District to be discovered. Further research could determine if new trees have weathered out of the exposure and if roots are present. Fossil forests are extremely rare and numerous tree horizons are even more unusual. Two pits of the Wishbone Hill district contain three different stratigraphic tree horizons, and one pit contains four.

The Wishbone Hill district is a unique area not only for the abundant fossil plants, but also for the exquisitely preserved 55 million-year-old fossil forest. The Chickaloon fossil forest is also unique in that foliar elements are associated with petrified trees. These fossil trees have potential to contribute information about tree spacing, density, and other characteristics of fossil forests that are not ordinarily known. Interest has increased concerning the late Paleocene-early Eocene time period because of recent awareness of global warming at the end of the Paleocene. This fossil forest could help answer questions concerning these and other climatic issues. The Wishbone Hill district is a marvelous area, and if left preserved, a wonderful location to study ancient life.

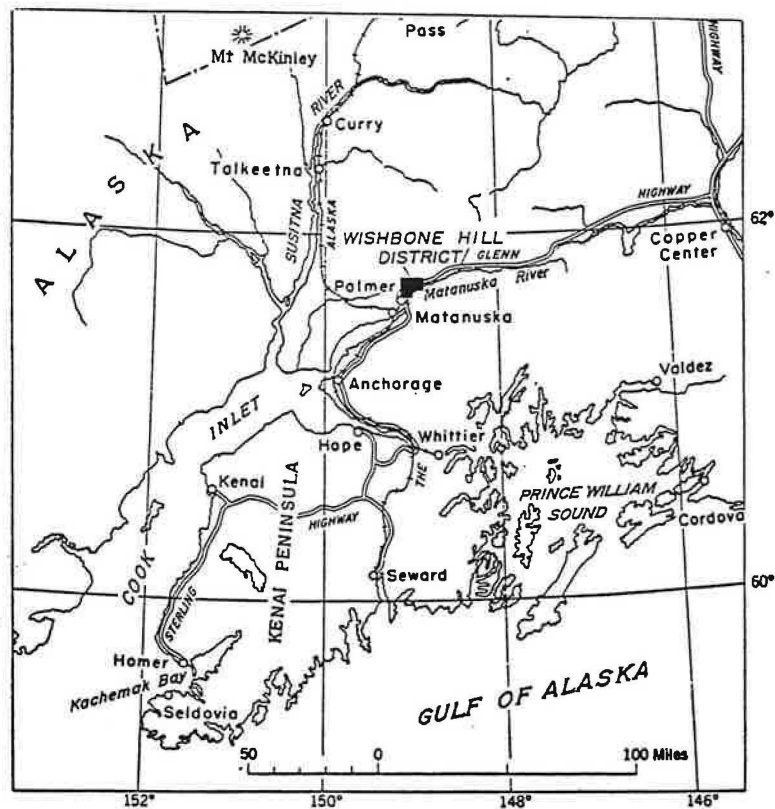


Figure 1a. Map of south central Alaska, showing the Wishbone Hill District. Modified from Barnes and Payne, 1956.

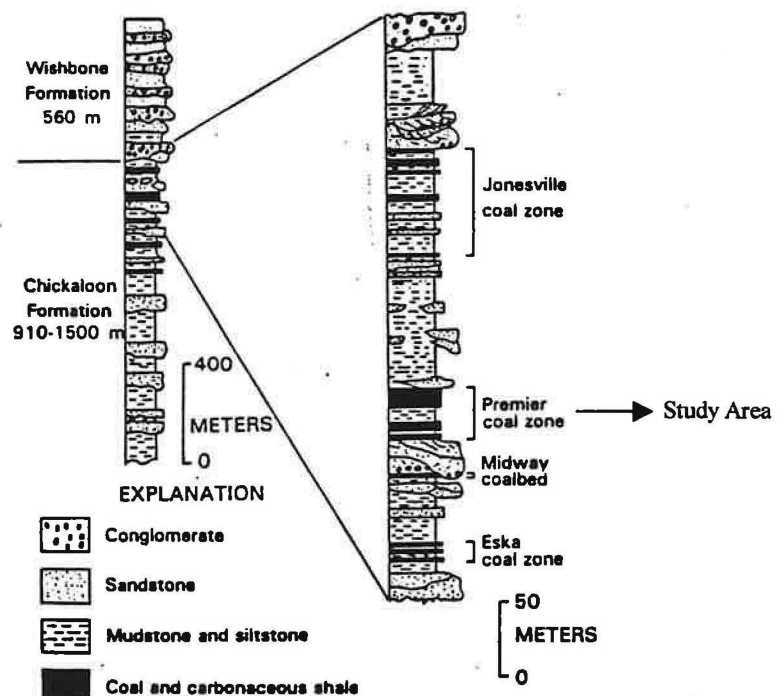


Figure 1b. Composite stratigraphic section showing study interval in the Chickaloon formation. Modified from Flores and Stricker, 1993.

Table 1. Measurements and Positions of Fossilized Trees in the West Center Pit.

Tree Count	Tree no.	Length (m.)	Length (ft.)	Width (m.)	Width (ft.)	V, H, or T
1	1	3.35	11	0.61	2	V
2	2a	3.66	12	1.22	4	V
3	2b	4.27	14	0.61	2	V
4	2c	4.57	15	2.44	8	V
5	2.1	0.61	2	0.61	2	V
6	3	5.79	19	0.46	1.5	T
7	3.1a	0.76	2.5	0.30	1	V
8	3.1b	1.28	4.2	0.23	0.75	H
9	4	0.91	3	0.61	2	V
10	4.1	3.35	11	0.61	2	H
11	4.2	1.22	4	0.30	1	H
12	5a	0.91	3	0.46	1.5	V
13	5b	1.22	4	1.83	6	V
14	6	3.35	11	0.61	2	T
15	7	4.57	15	0.61	2	V
16	7.1	2.13	7	2.44	8	V
17	7.2	1.83	6	1.83	6	V
18	8	2.74	9	2.44	8	V

Table 2. Measurements and Positions of Fossilized Trees in the Deep Pit

Tree Count	Tree no.	Length (m.)	Length (ft.)	Width (m.)	Width (ft.)	V, H, or T
1	1a	0.91	3	0.61	2	V
2	1b	0.61	2	0.61	2	V
3	1c	1.83	6	0.61	2	V
4	2	0.91	3	3.66	12	V
5	3	1.83	6	1.22	4	V
6	4	0.61	2	0.61	2	V
7	5	0.30	1	0.61	2	V
8	6	1.22	4	0.61	2	V

Table 3. Measurements and Positions of Fossilized Trees in the East Pit

Tree Count	Tree no.	Length (m.)	Length (ft.)	Width (m.)	Width (ft.)	V, H, or T
1	1a	0.91	3	1.52	5	V
2	1b	1.34	4.4	0.79	2.6	V
3	2a	0.76	2.5	1.22	4	V
4	2b	0.61	2	1.19	3.9	V
5	2c	1.37	4.5	0.61	2	T
6	3a	0.61	2	0.30	1	?
7	3b	1.22	4	0.61	2	H
8	3c	0.61	2	1.83	6	?
9	4	0.61	2	1.83	6	V
10	5	0.61	2	1.22	4	V
11	5.1	0.61	2	1.22	4	V
12	6	0.30	1	0.61	2	V
13	7	1.22	4	0.61	2	V
14	8	1.83	6	0.91	3	V
15	9a	0.76	2.5	0.46	1.5	V
16	9b	0.61	2	0.30	1	V
17	9c	1.22	4	0.30	1	V
18	10a	1.83	6	0.46	1.5	V
19	10b	0.91	3	0.30	1	V
20	11a	0.61	2	0.91	3	V
21	11b	0.91	3	0.30	1	V
22	12a	0.61	2	0.30	1	V
23	12b	1.22	4	0.30	1	T
24	13	3.96	13	0.61	2	H
25	13.1	0.30	1	0.61	2	V
26	13.2	0.30	1	0.30	1	V
27	14	2.44	8	0.30	1	H
28	14.1	0.30	1	0.30	1	V
29	14.2	0.91	3	0.30	1	H
30	14.3	0.91	3	1.83	6	V
31	15	0.61	2	0.30	1	V
32	16	1.83	6	0.46	1.5	H
33	17	1.22	4	1.22	4	V
34	18	1.52	5	0.30	1	V
35	19	0.61	2	0.91	3	V

Table 4. Statistical Summary of Tree Sizes

	Length (m.)	Length (ft.)	Width (m.)	Width (ft.)
Mean	1.49	4.90	0.86	2.82
Max	5.79	19.00	3.66	12.00
Min	0.30	1.00	0.23	0.75
Range	5.49	18.00	3.43	11.25
Anne				

Table 5. GPS Reading for Deep Pit

Tree no.	Reading
1a-c.	N 61 44. 444' W 148 57. 759'
2 & 3.	N 61 44. 464' W 148 57. 856'
4 & 5.	N 61 44. 501' W 148 58. 036'
6	N 61 44. 325'

Table 6. GPS Reading for the West Center Pit

Tree no.	Reading	Tree no.	Reading
1	N 61 44. 538' W 148 56. 647'	4.1	no reading
2a.	N 61 44. 422' W 148 56. 797'	4.2	no reading
2b.	N 61 44. 402' W 148 56. 786'	5a & b.	N 61 44. 460' W 148 57. 210'
2c.	N 61 44. 542' W 148 56. 774'	6	N 61 44. 469' W 148 57. 203'
2.1	no reading	7	N 61 44. 511' W 148 57. 182'
3	N 61 44. 536' W 148 56. 833'	7.1.	N 61 44. 500' W 148 57. 194'
3.1a	no reading	7.2	no reading
3.1b	no reading	8	N 61 44. 529' W 148 57. 467'
4	N 61 44. 252' W 148 56. 980'		

Table 7. GPS Reading for East Pit

Tree no.	Reading	Tree no.	Reading
1a.	N 61 44. 565' W 148 56. 136'	10a&b.	N 61 44. 557' W 148 55. 987'
1b.	N 61 44. 563' W 148 56. 158'	11a&b.	N 61 44. 530' W 148 55. 982'
2a.	N 61 44. 473' W 148 56. 097'	12a&b.	N 61 44. 530' W 148 55. 919'
2b.	N 61 44. 533' W 148 56. 069'	13 & 13.1.	N 61 44. 527' W 148 55. 847'
2c	no reading	13.2	no reading
3a.b.&c.	N 61 44. 406' W 148 56. 113'	14	N 61 44. 598' W 148 55. 845'
4 & 5.	N 61 44. 525' W 148 56. 143'	14.1	no reading
5.1.	N 61 44. 523' W 148 56. 145'	14.2	no reading
6	N 61 44. 516'	14.3	no reading
		15	N 61 44. 540' W 148 55. 654'
	W 148 56. 120'	16	no reading
7	N 61 44. 588' W 148 56. 060'	17	no reading
8	N 61 44. 589' W 148 56. 021'	18	no reading
9a.b.& c.	N 61 44. 535' W 148 56. 007'	19	no reading

Table 8. Fossilized Tree Spacing Distance

Pit Name	Tree No.(s) in Groups	Mean Spacing (m.)	Mean Spacing (ft.)
Deep	1a-1b-1c	5.49	18.00
Deep	2-3	6.10	20.00
West	1-4-5a	176.78	580.00
West	2a-2b-2c-2.1	52.32	171.66
West	3-3.1a	9.14	30.00
West	3.1b-4.1-4.2	28.65	94.00
West	7.1-7.2-8	103.94	341.00
East	1a-1b-2a-2b-4-5.1-6	11.84	38.83
East	7-8-10a-10b-11b-12a-12b	25.70	84.33
East	9a-9b-9c-11a-13-13.1-14-14.1-14.2-14.3	30.48	100.00
East	15-16-17	11.73	38.50
East	18-19	3.05	10.00
Total Mean Spacing		9.49	31.15

Table 9. Listing of Plant Fossils

Plant:	No.
<u>Equisetinae:</u>	
Equisetum	1
<u>Filicineae:</u>	
Matonia	1
<u>Gymnospermae:</u>	
Metasequoia Cone	2
Metasequoia	5
Glyptostrobus	1
<u>Angiosperm (Monocotyledonae):</u>	
Flabellaria	1
<u>Angiosperm (Dicotyledonae):</u>	
Populus	3
Cocculus	1
Juglans	1
Quercus	1
Hydrangea	1
Carya	2
unidentified seed	1
unidentified leaf	1

West Center Pit Figures



Fig. 1. Tree no. 1



Fig. 2. Tree no. 1



Fig. 3. Tree no. 2a, 2b, and 2c



Fig. 4. Tree no. 2a



Fig. 5. Tree no. 2b



Fig. 6. Tree no. 2c

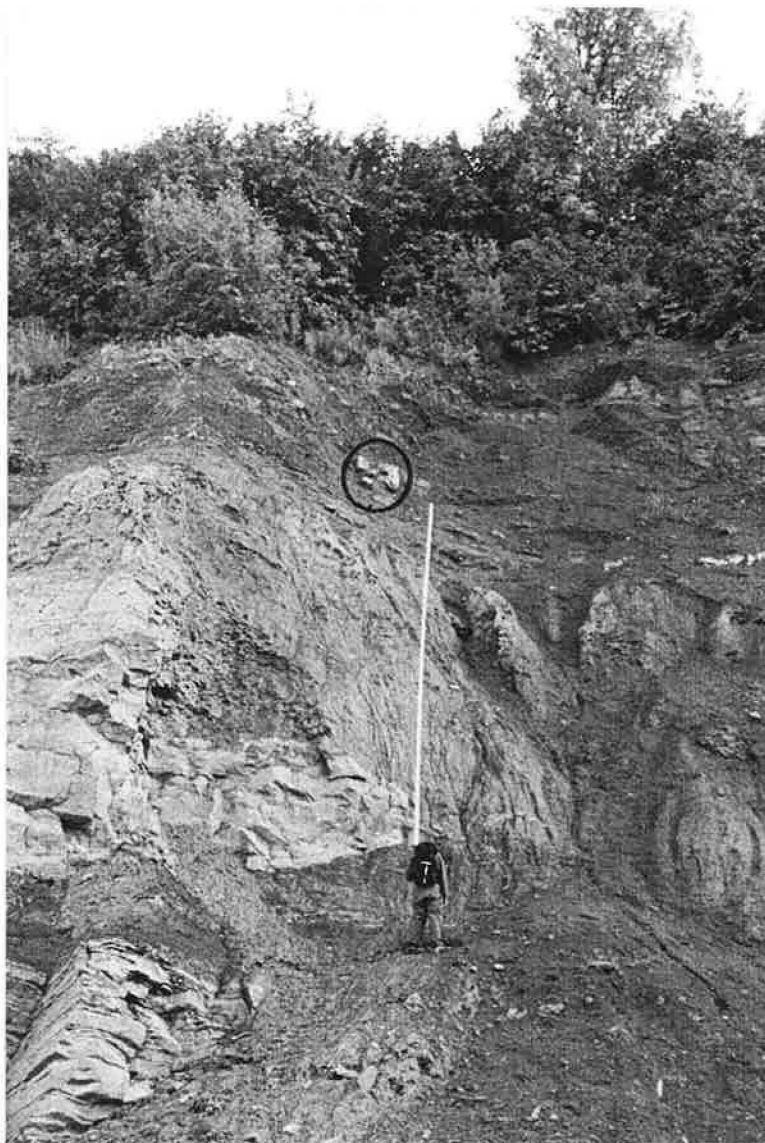


Fig. 7. Tree no. 2.1

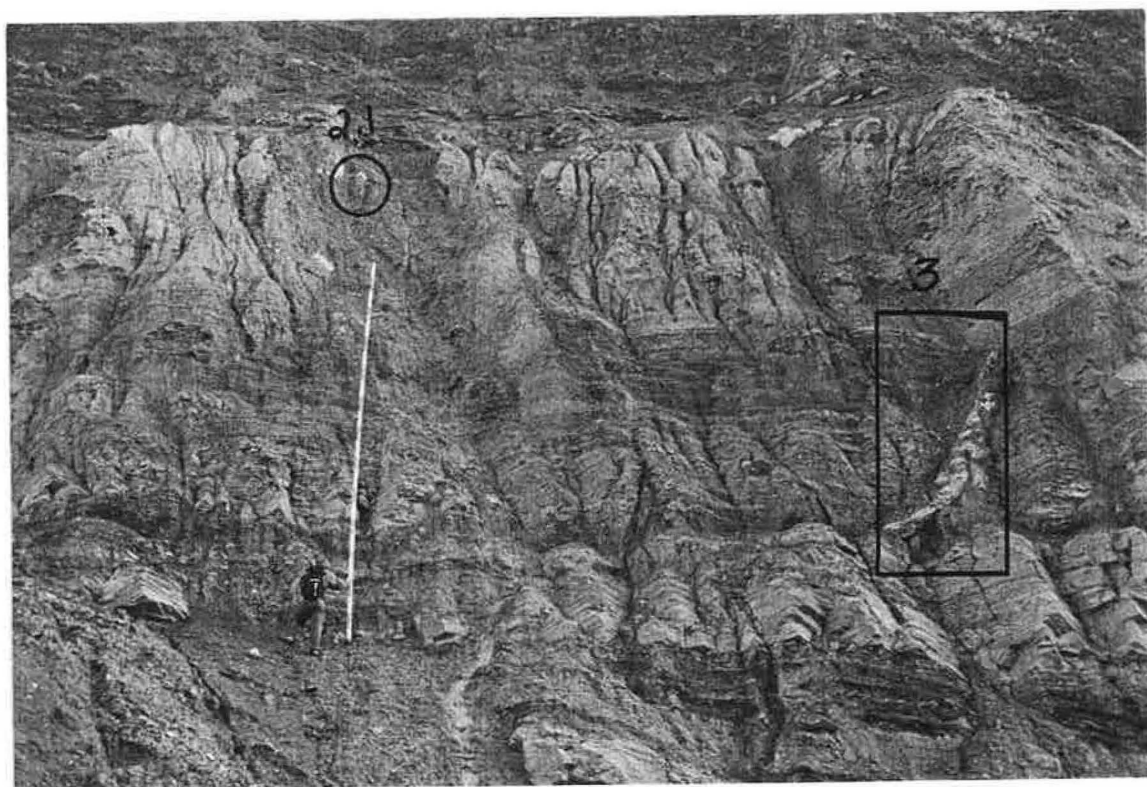


Fig. 8 Tree no. 2.1 and 3



Fig. 9 Tree no. 3

Fig. 10 Tree
no. 3.1a and 3.1b

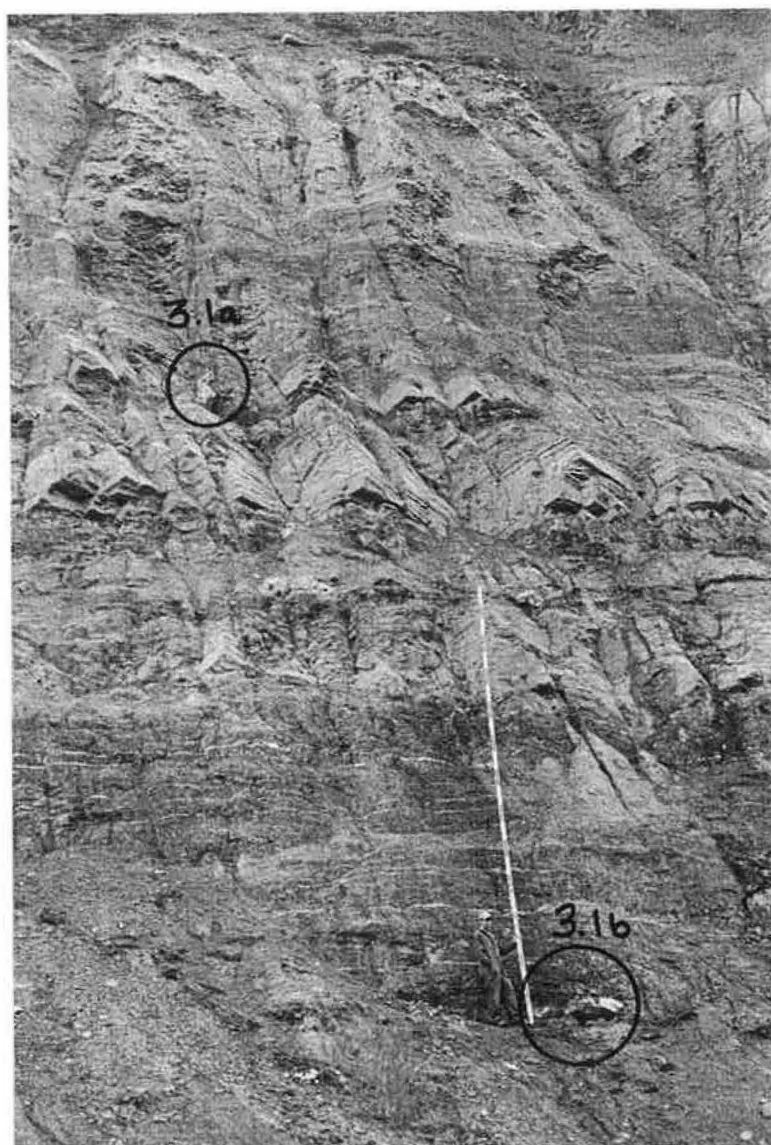


Fig. 11 Tree no. 3.1b

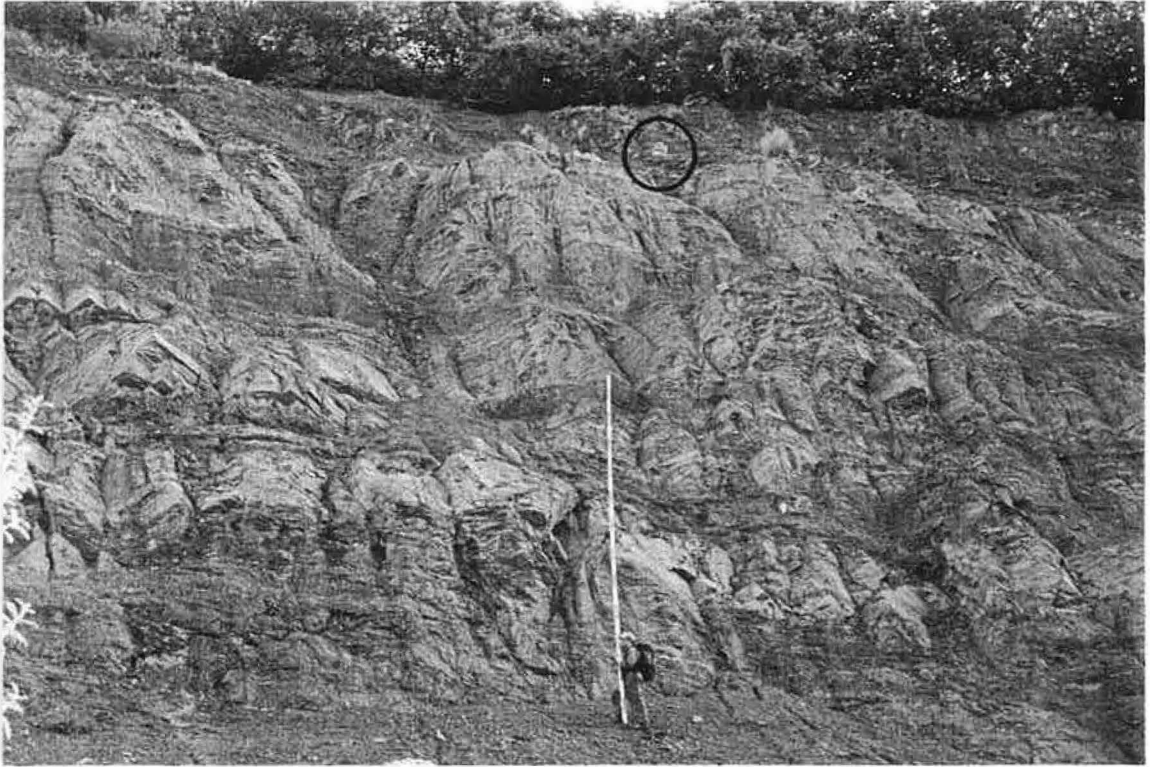


Fig. 12. Tree no. 4



Fig. 13. Tree no. 4.1 and 4.2



Fig. 14. Tree no. 4.1

Fig. 15. Tree no. 5a and 5b



Fig. 16. Tree no. 5a



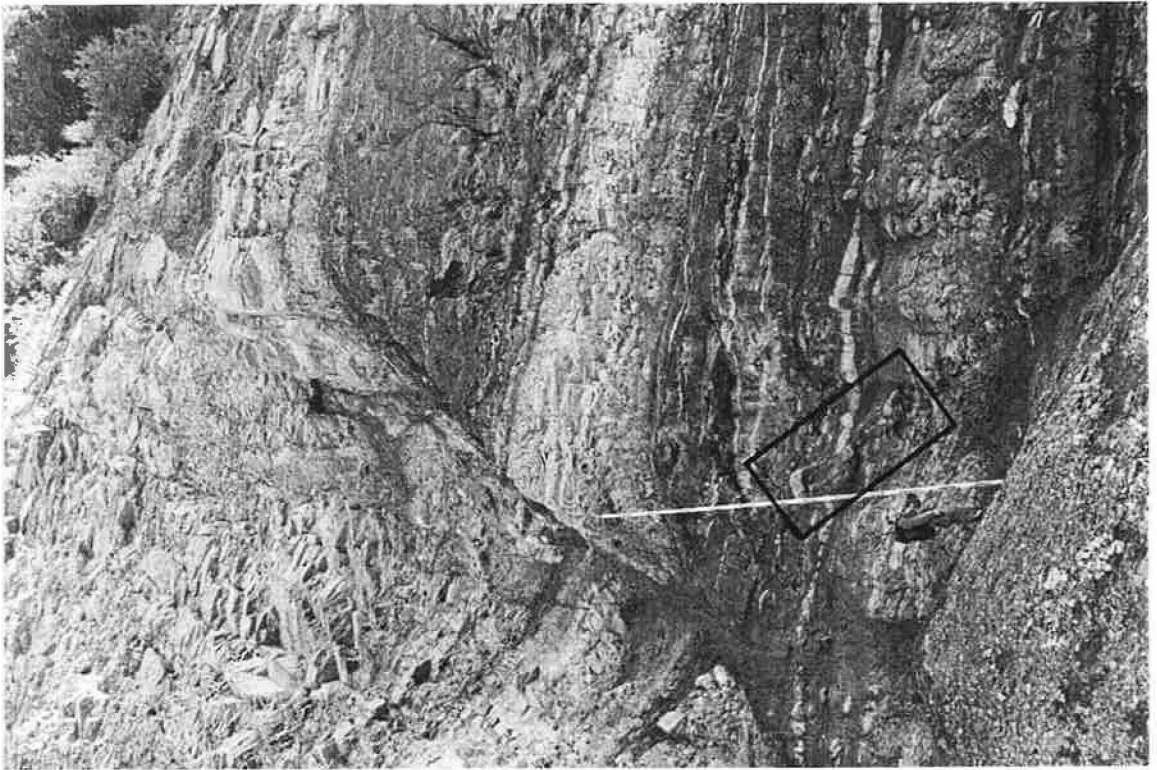


Fig. 17. Tree no. 6



Fig. 18. Tree no. 6



Fig. 19. Tree no. 7

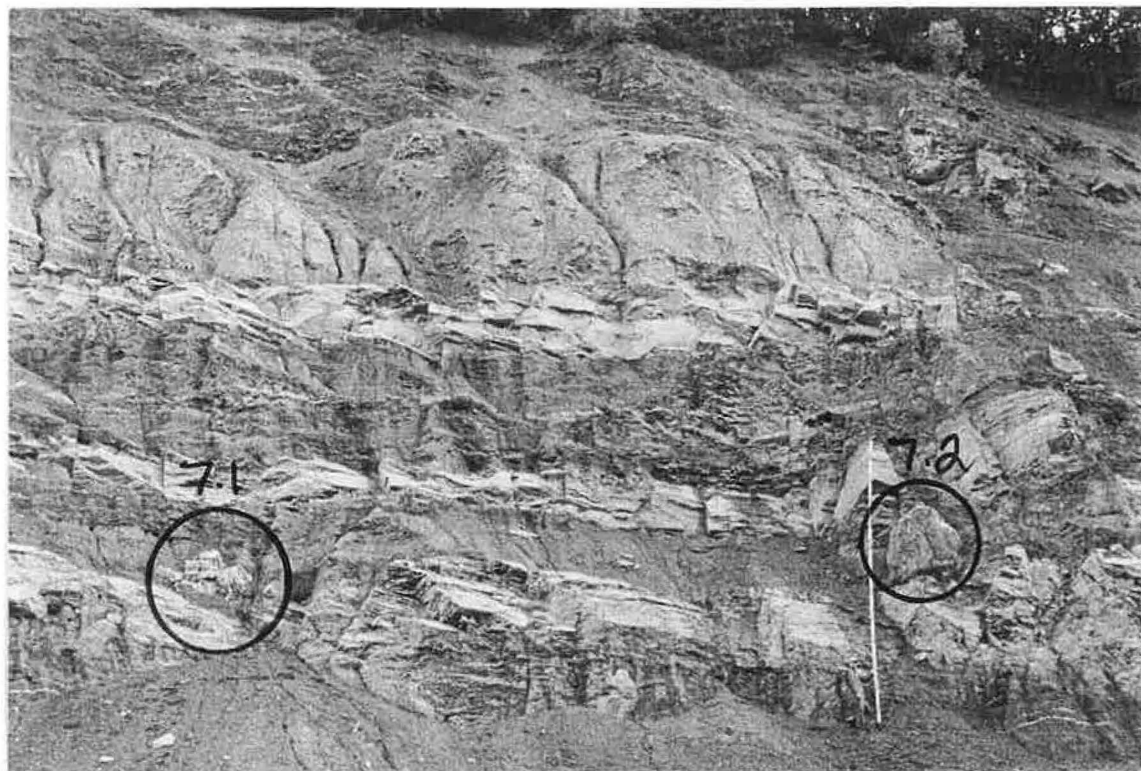


Fig. 20. Tree no. 7.1 and 7.2

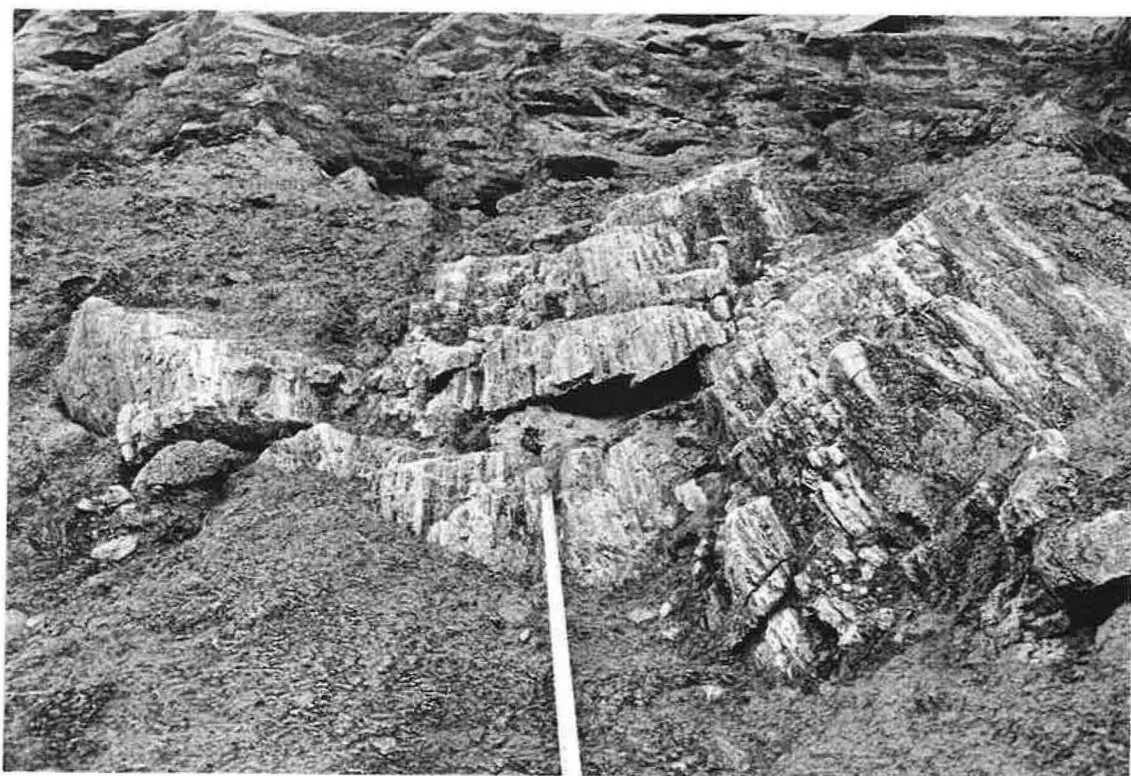


Fig. 21. Tree no. 7.1

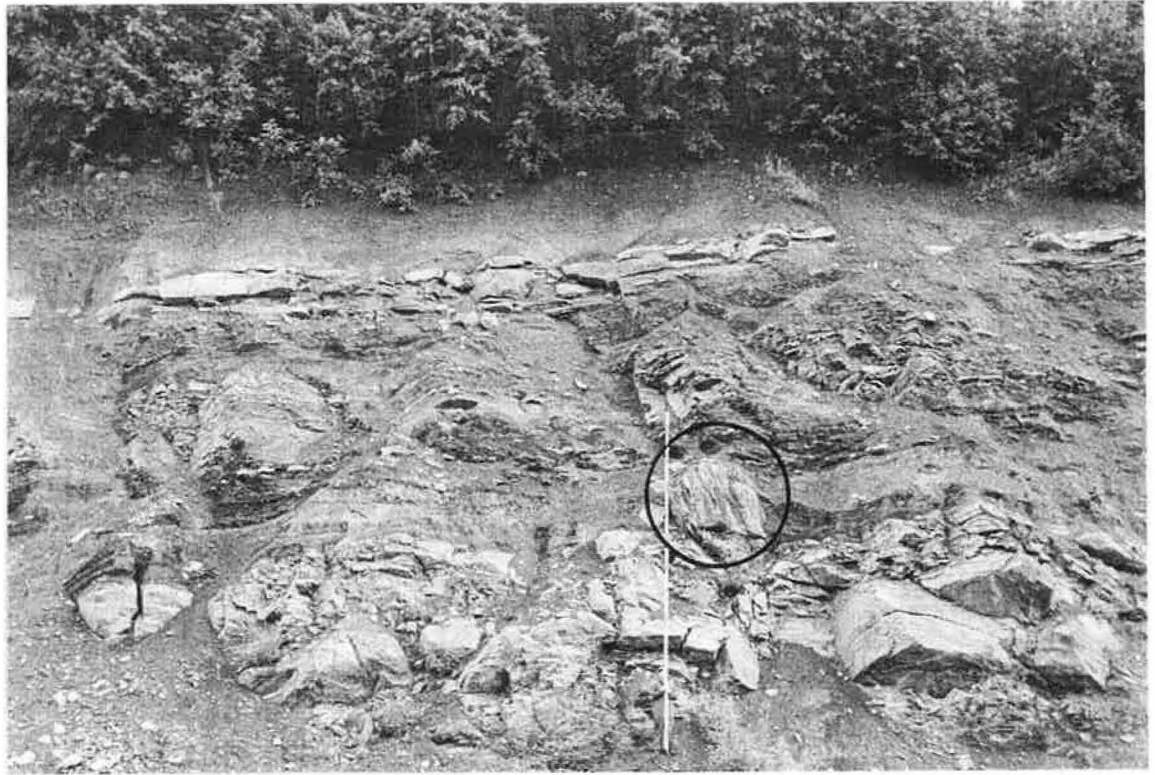


Fig. 22 Tree no. 8

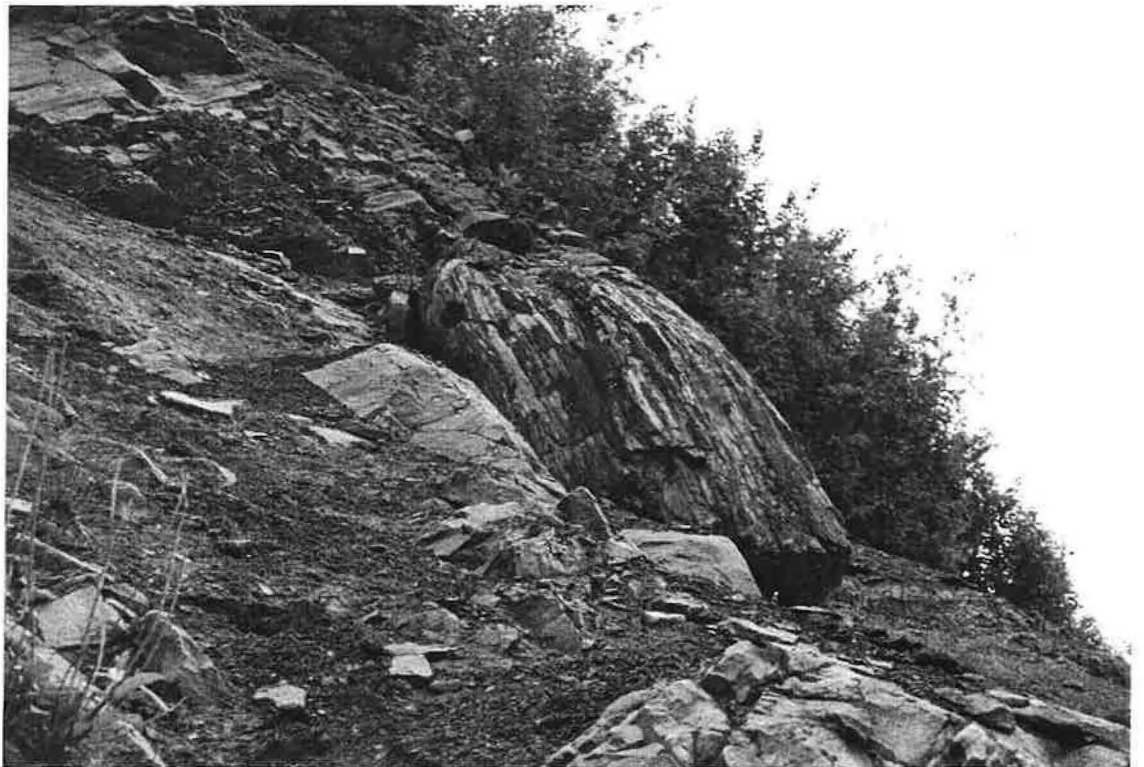


Fig. 23 Tree no. 8

Deep Pit Figures

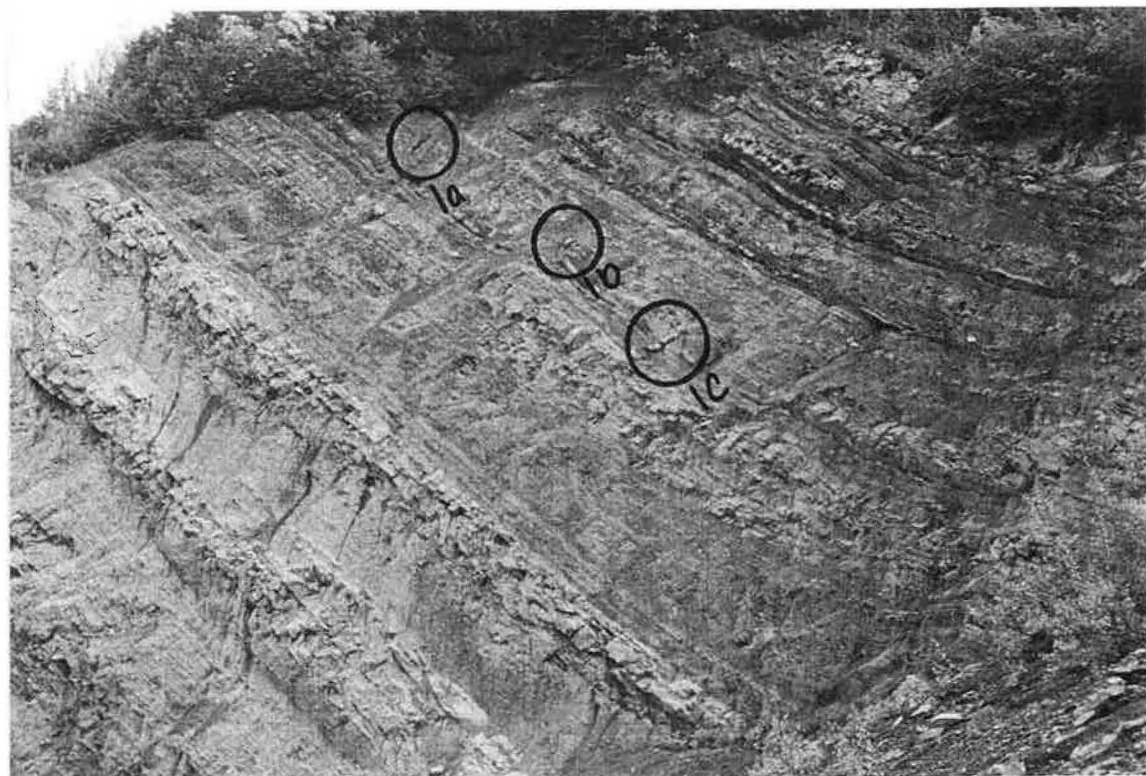


Fig. 24 Tree no. 1a, 1b, and 1c

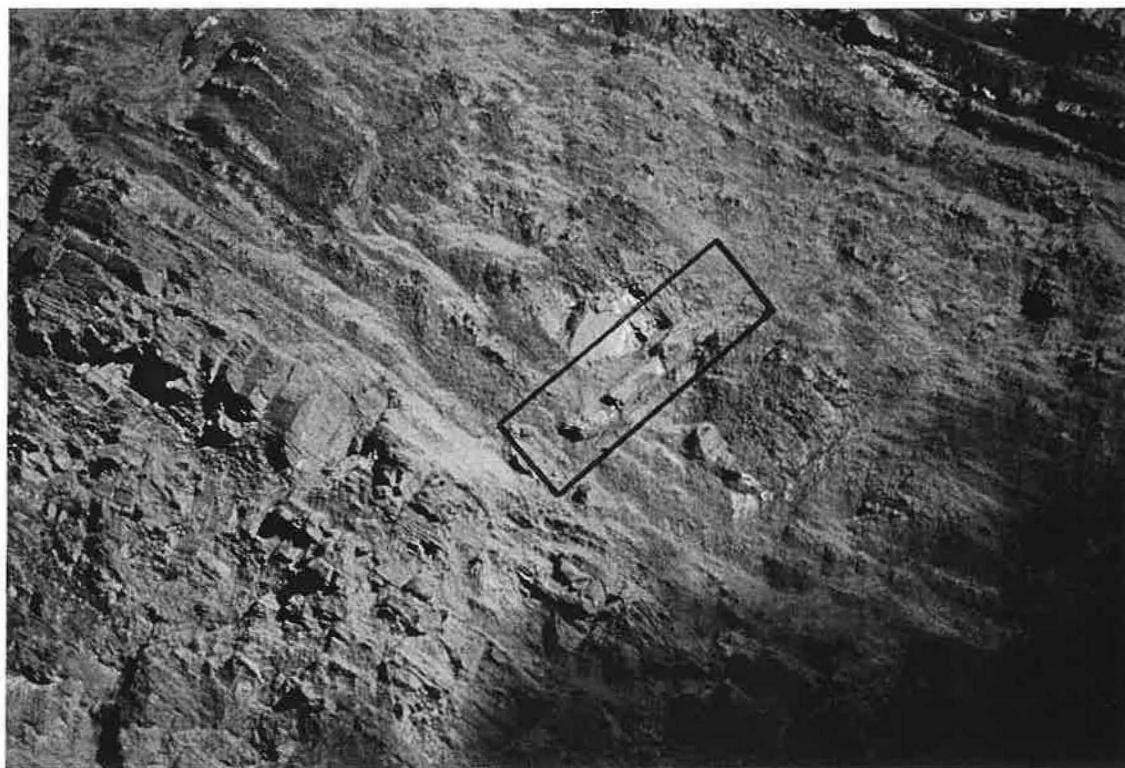


Fig. 25 Tree no. 1c

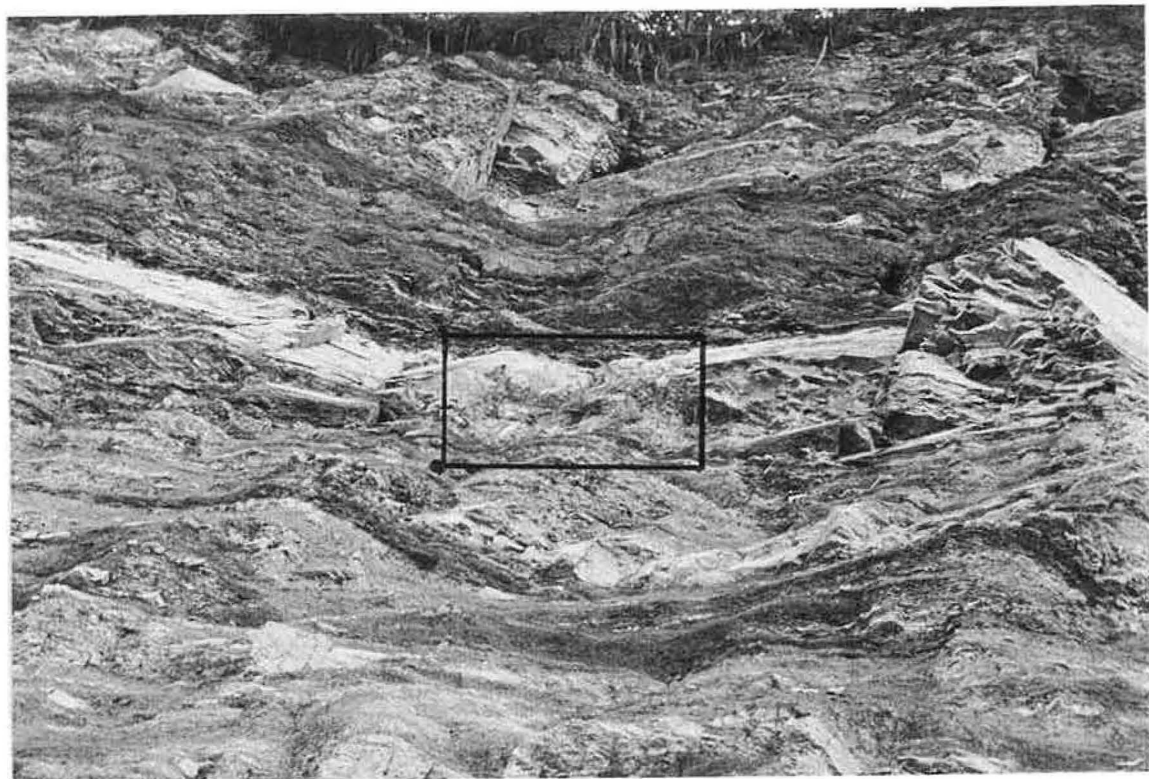


Fig. 26 Tree no. 2



Fig. 27 Tree no. 3

Fig. 28 Tree no. 4 and 5

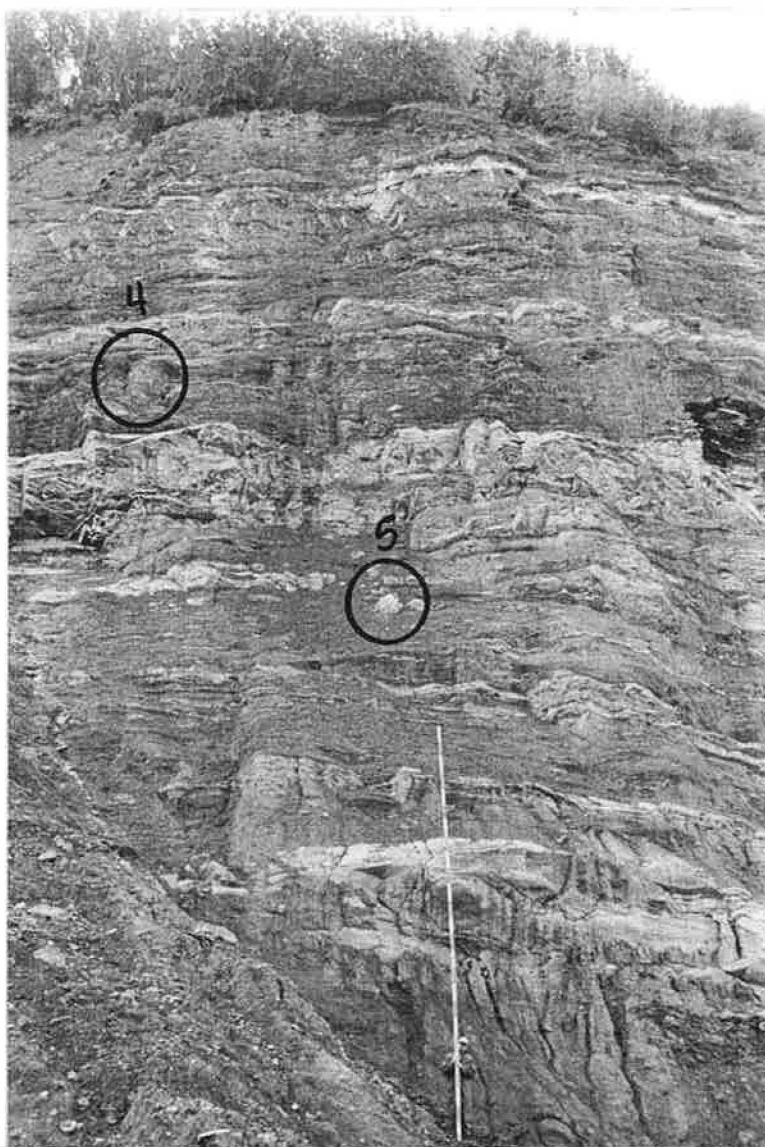


Fig. 29 Tree no. 4



Fig. 30 Tree no. 6

East Pit Figures

Fig. 31
Tree no. 1a

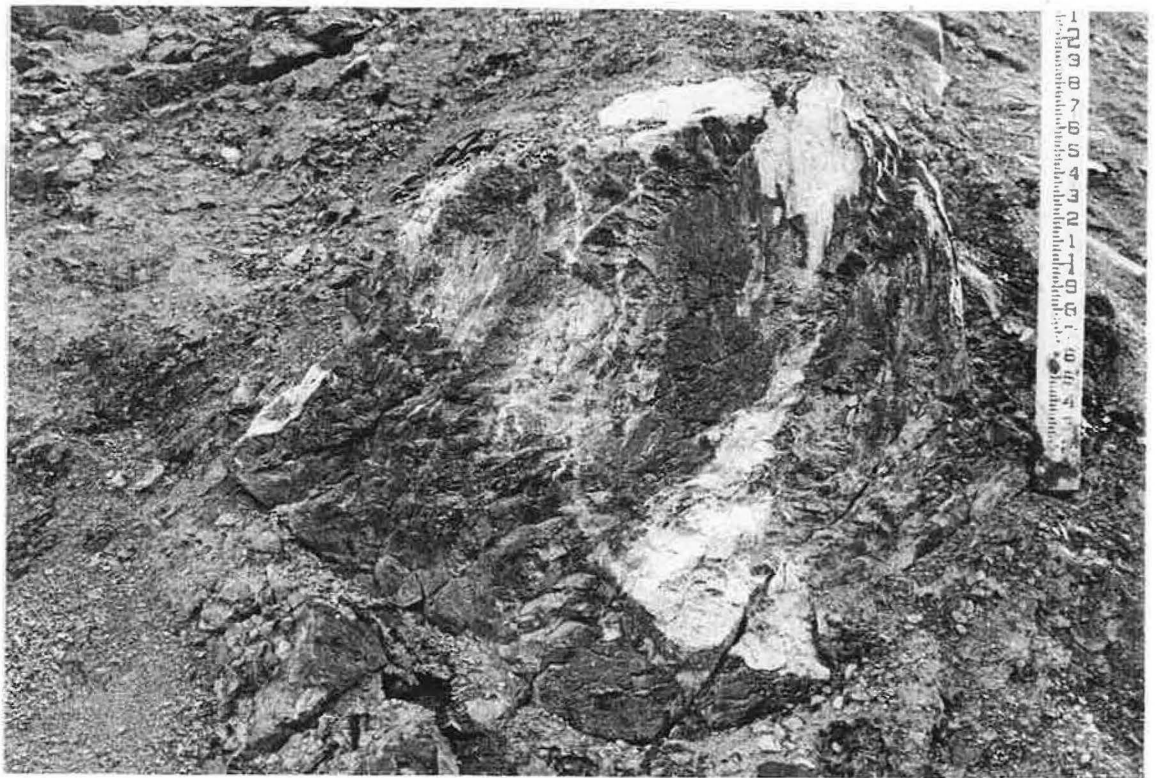


Fig. 32 Tree no. 1b



Fig. 33 Tree no. 2a, 2b, and 2c

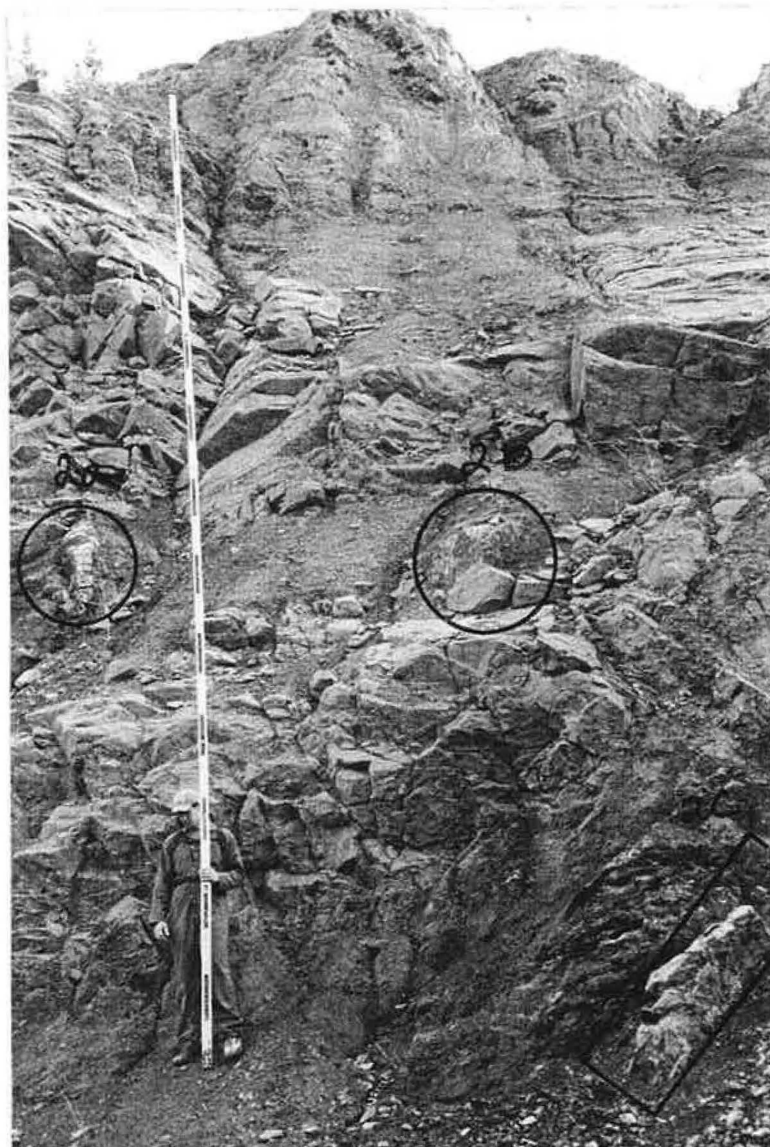


Fig. 34 Tree no.
3a, 3b, and 3c





Fig. 35 Tree no. 3a and 3b

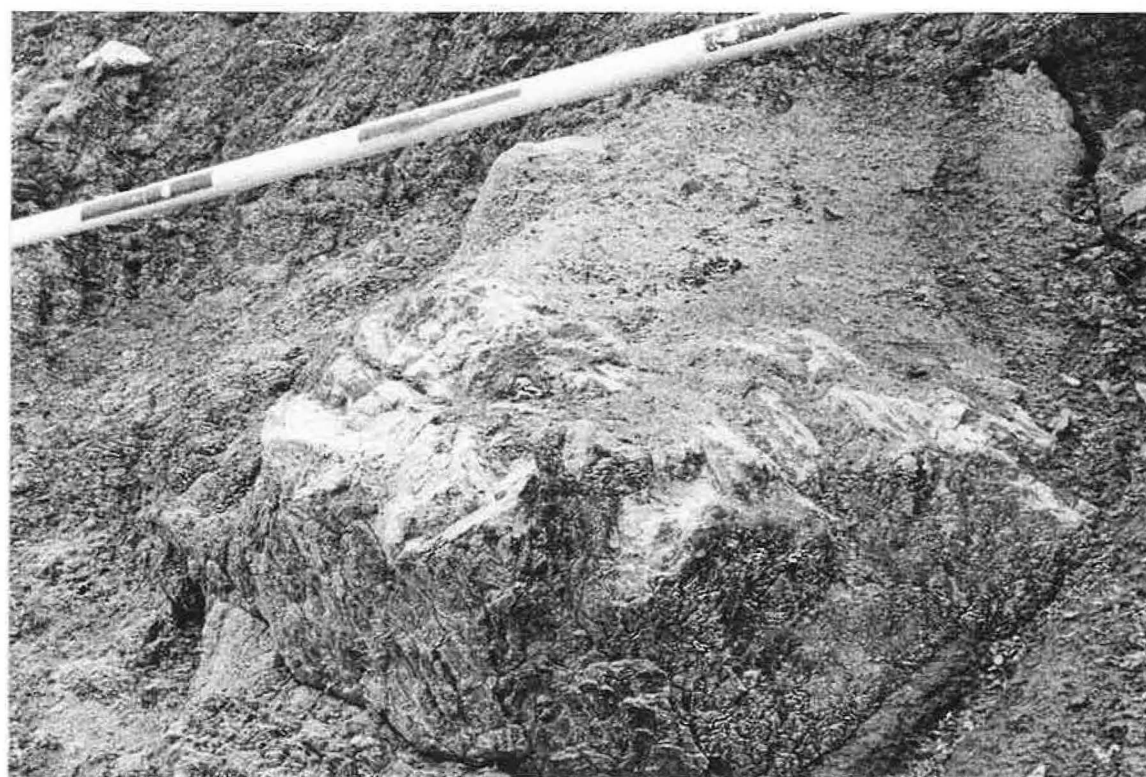


Fig. 36 Tree no. 3c



Fig. 37 Tree no. 4, 5, 5.1 and 6

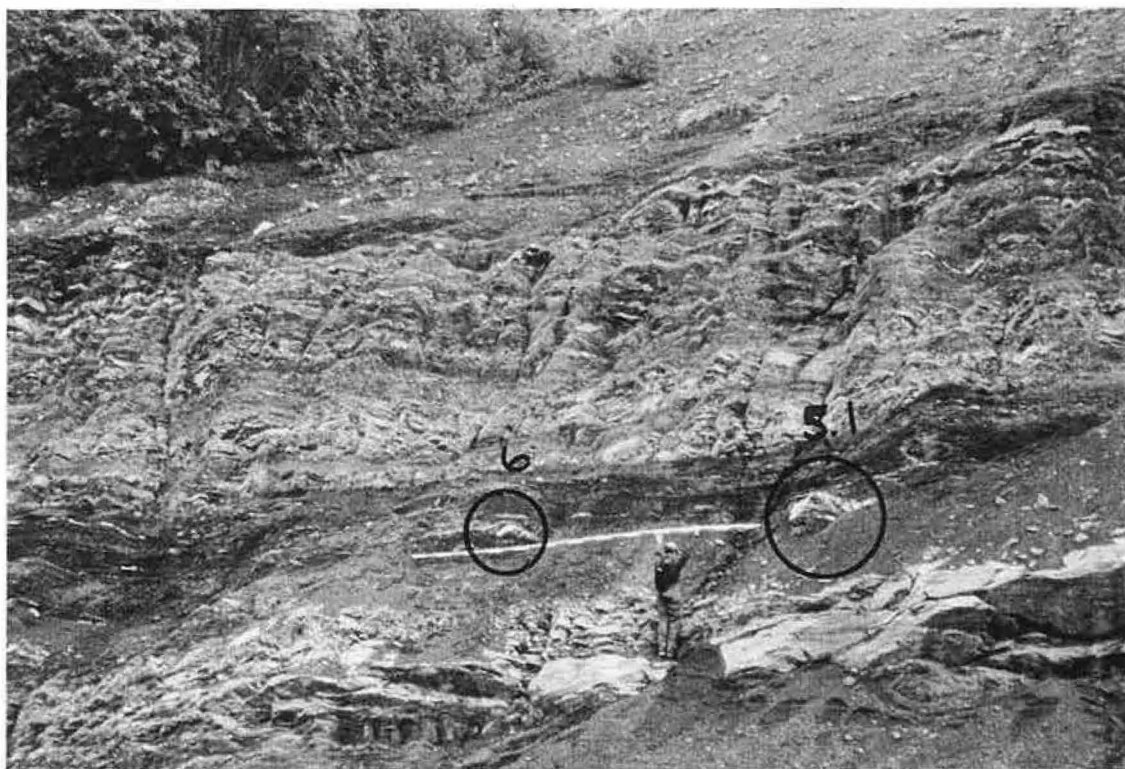


Fig. 38 Tree no. 5.1 and 6

Fig. 39 Tree no. 7

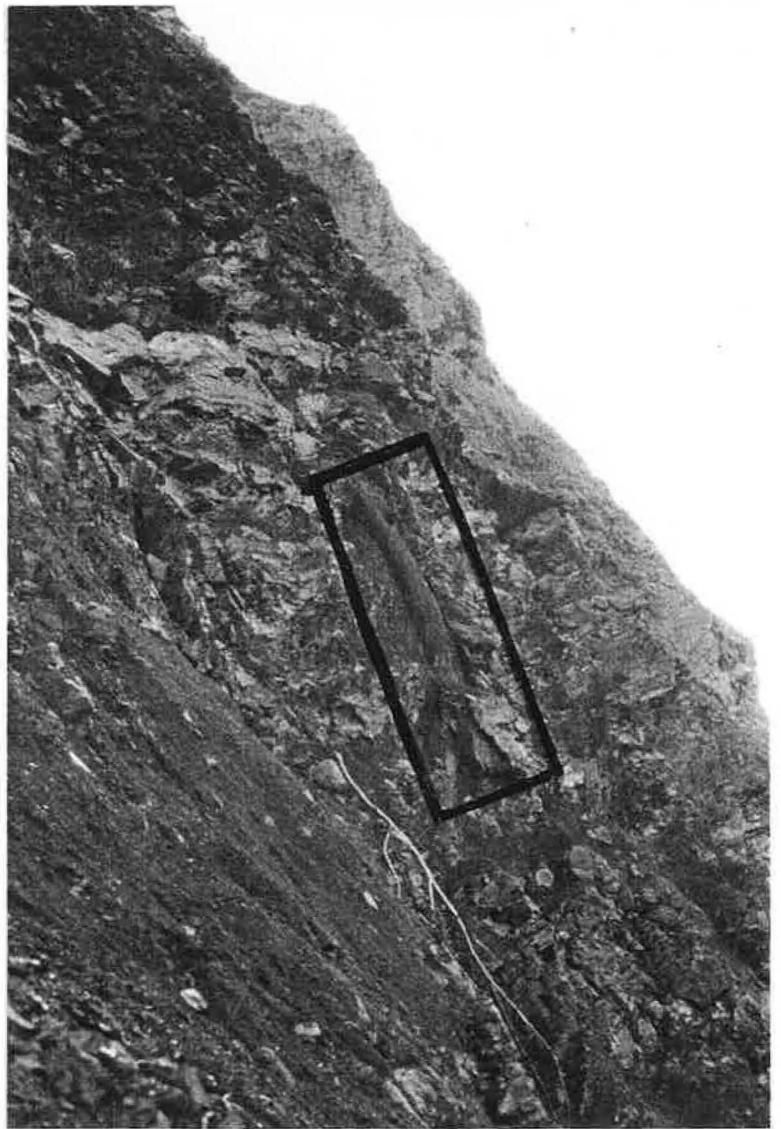


Fig. 40 Tree no. 7



Fig. 41 Tree no. 8



Fig. 42 Tree no. 9a, 9b, and 9c



Fig. 43 Tree no. 9b and 9c

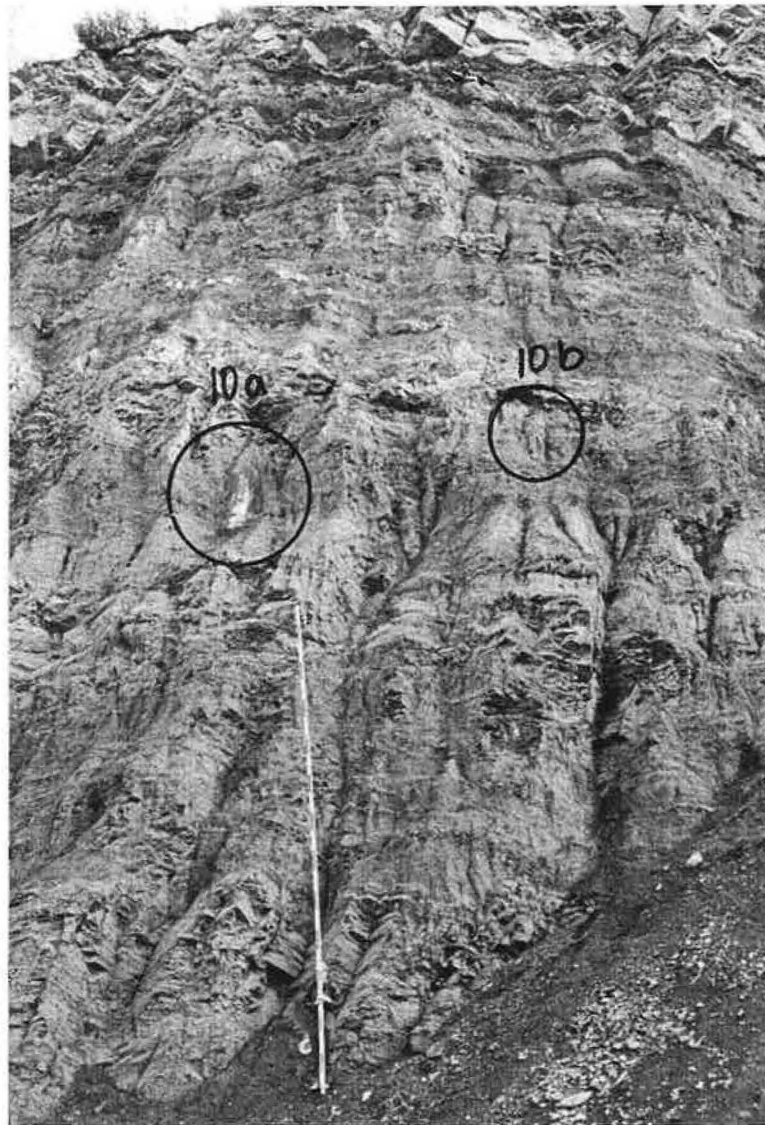


Fig. 44 Tree no. 10a and 10b

Fig. 45 Tree no. 11a and 11b

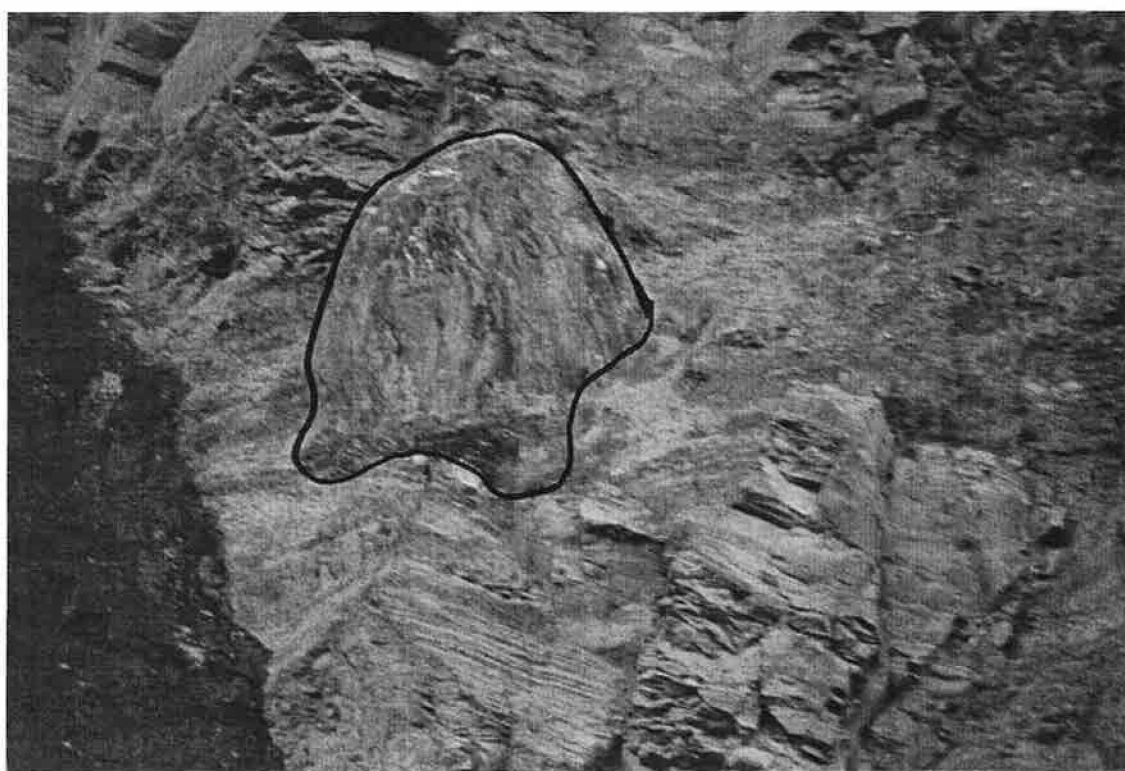
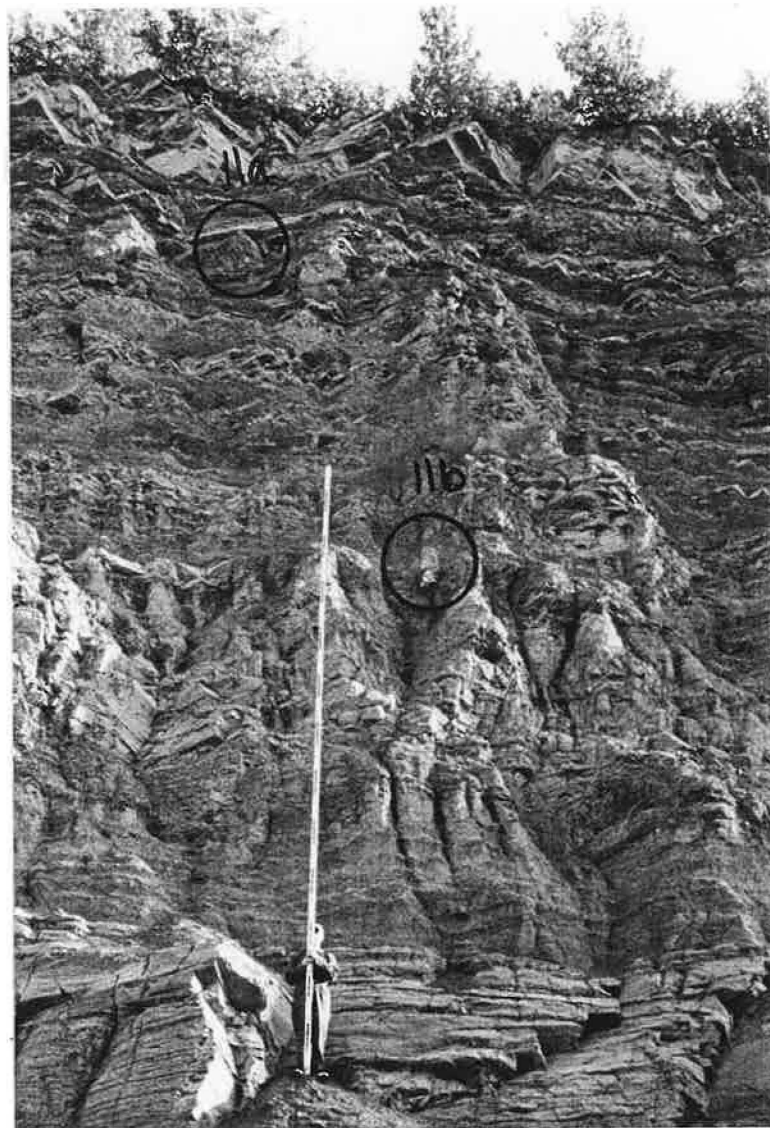


Fig. 46 Tree no. 11a

Fig. 47 Tree no. 12a and 12b

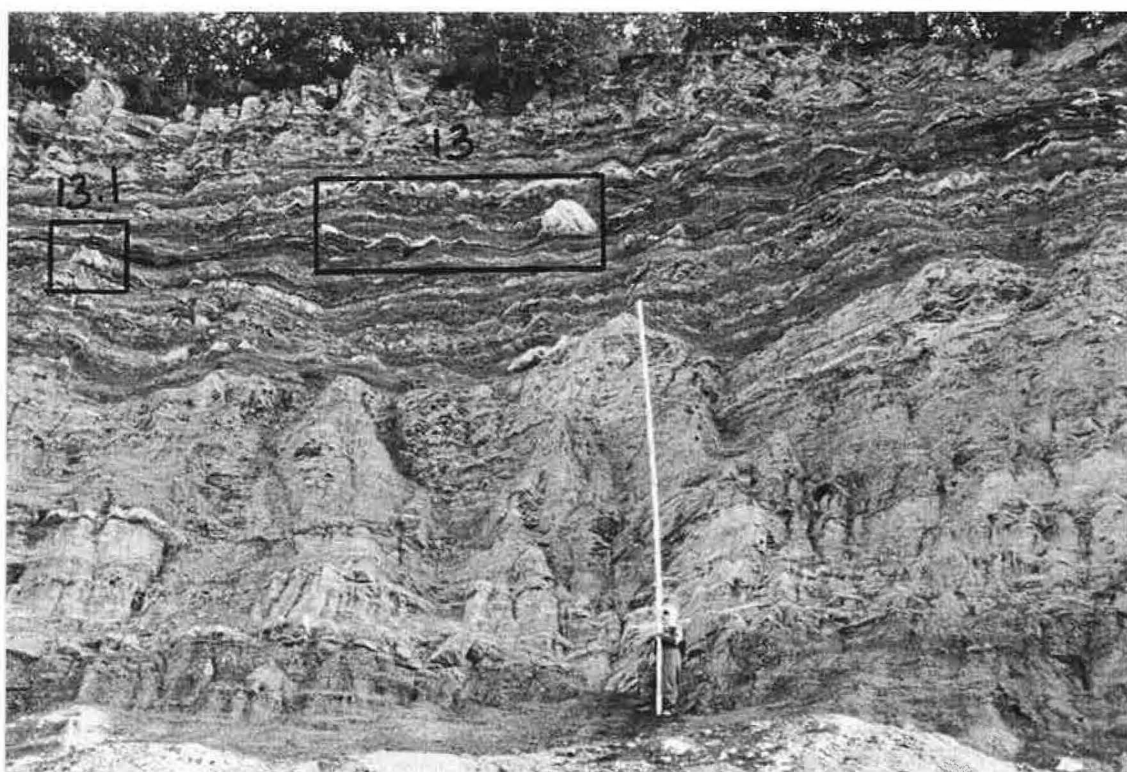
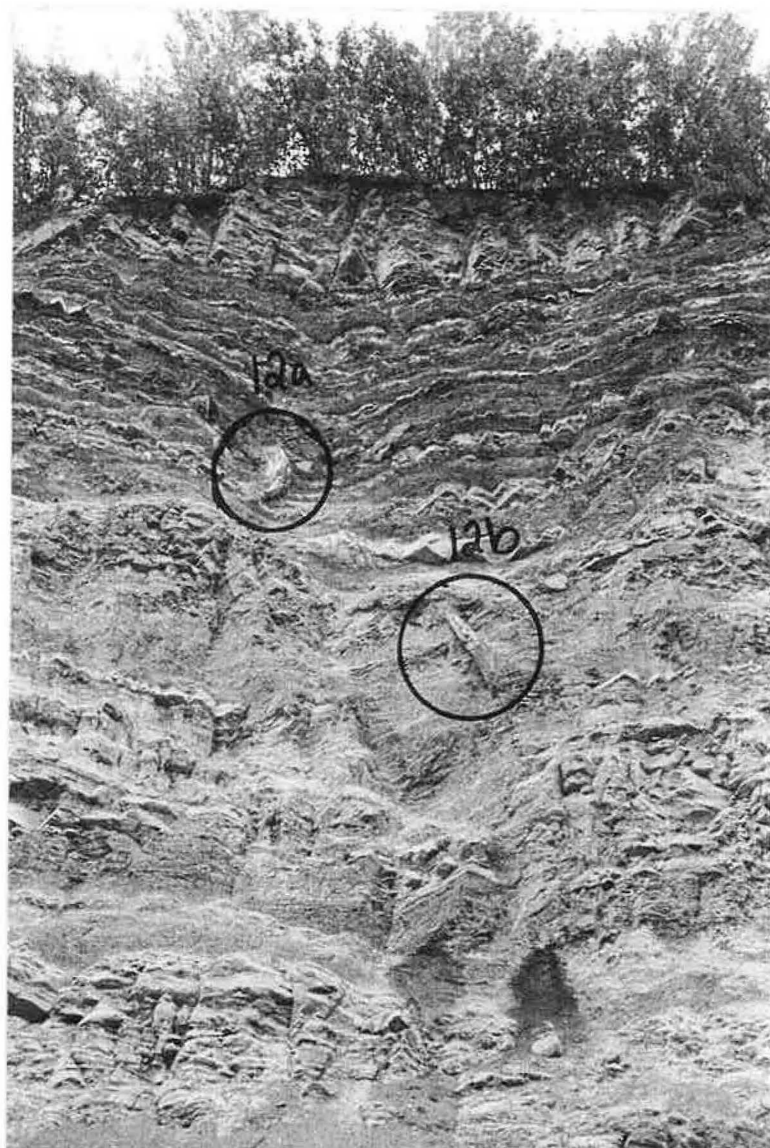


Fig. 48 Tree no. 13 and 13.1

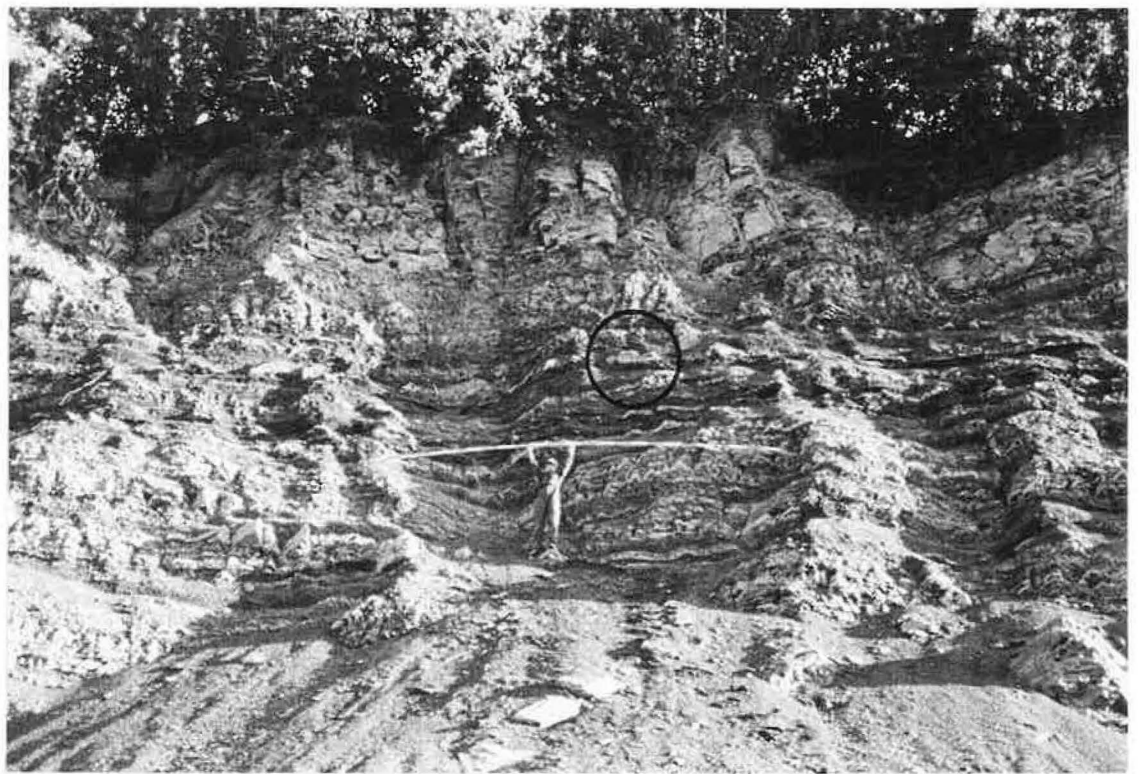


Fig. 49 Tree no. 14



Fig. 50 Tree no. 14.1

Fig. 51

Tree no. 14.2



Fig. 52 Tree no. 14.3

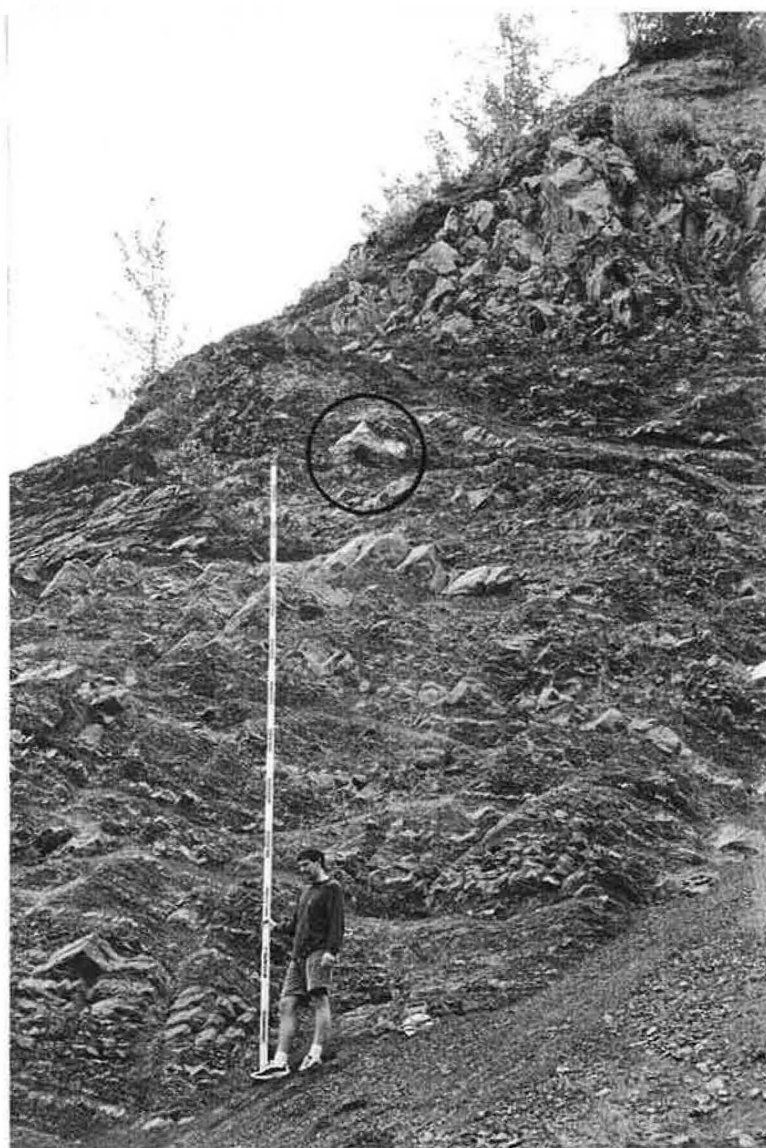




Fig. 53 Tree no. 15, 16, and 17

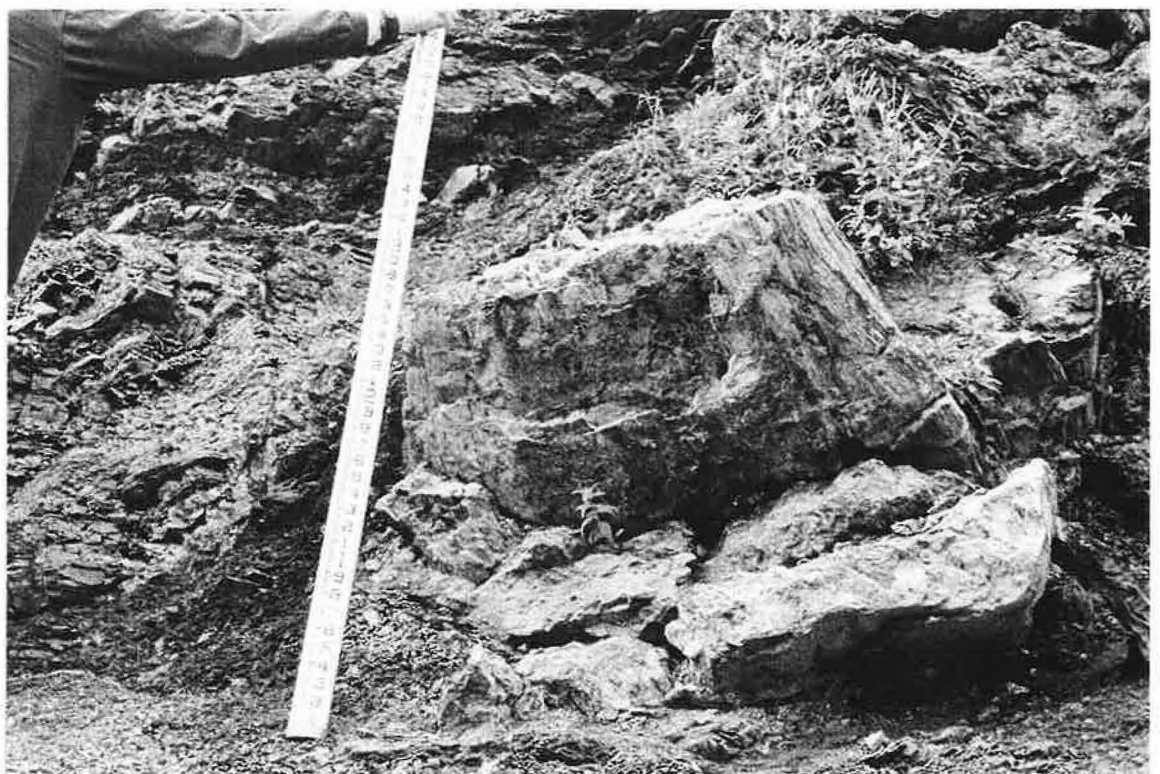
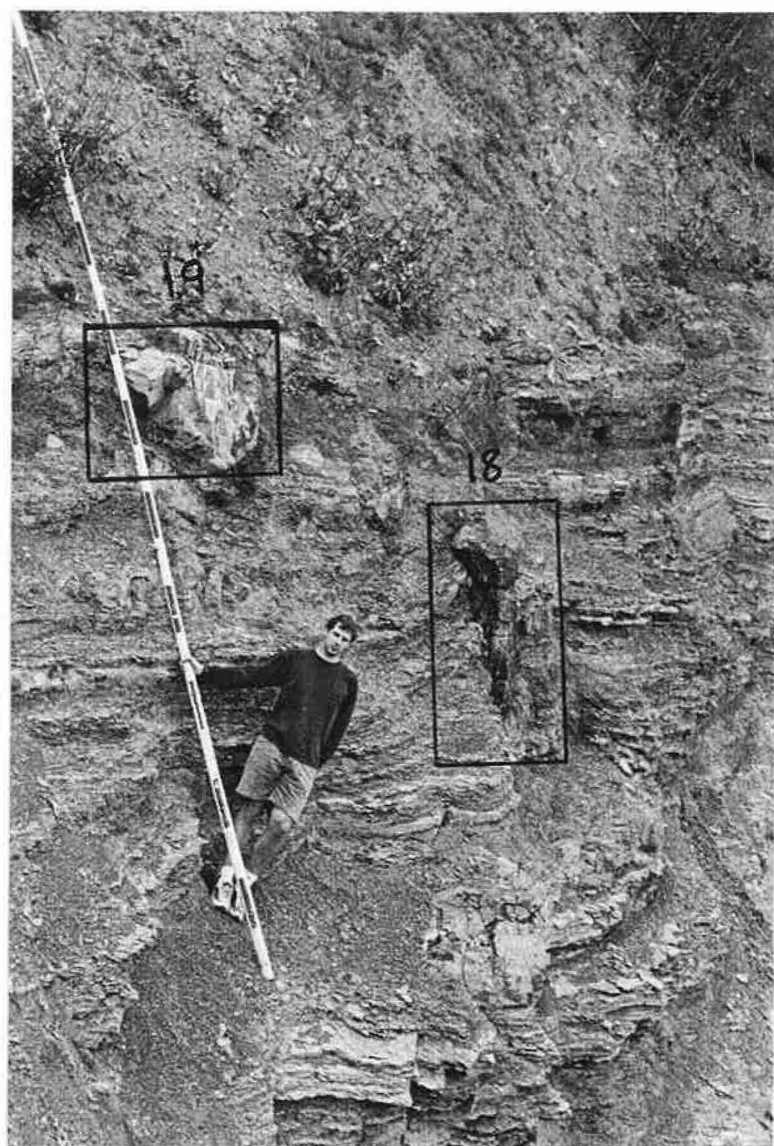


Fig. 54 Tree no. 17

Fig. 55
Tree no. 18



Fig. 56 Tree no. 18 and 19



Plant Fossil Figures

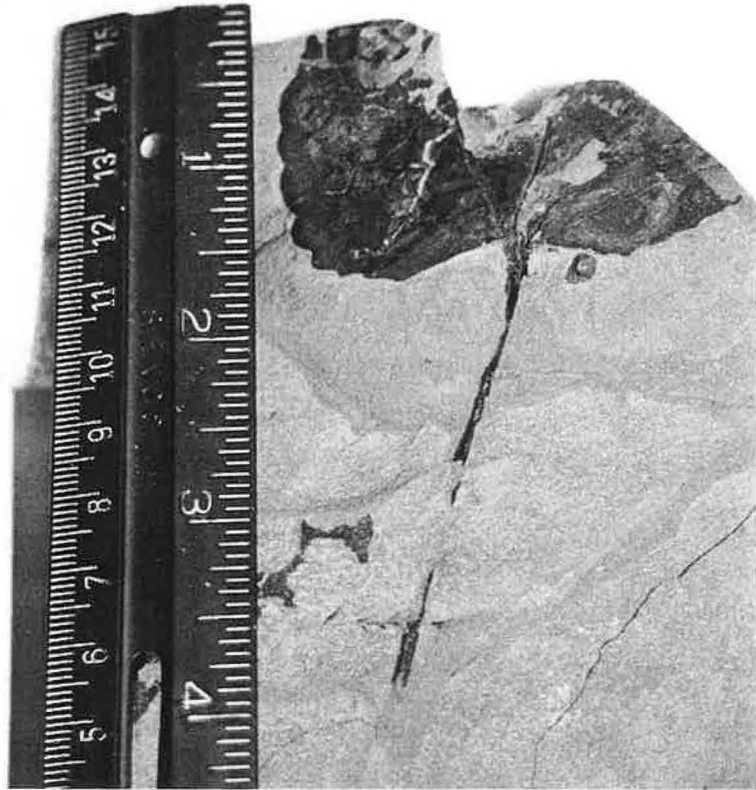


Fig. 57 Cocculella

Wolf pl. 6, no. 5



Fig. 58 Metasequoia Cone

Tidwell pg. 89

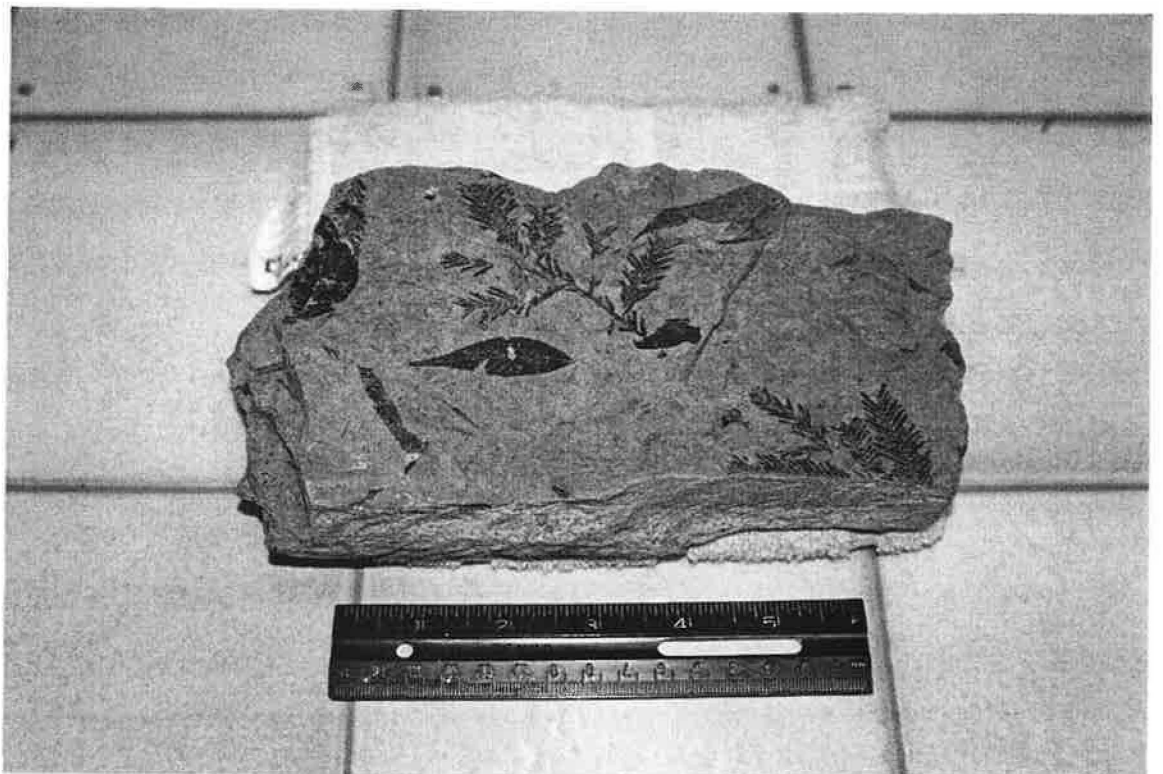


Fig. 59 Metasequoia

Tidwell pg. 89

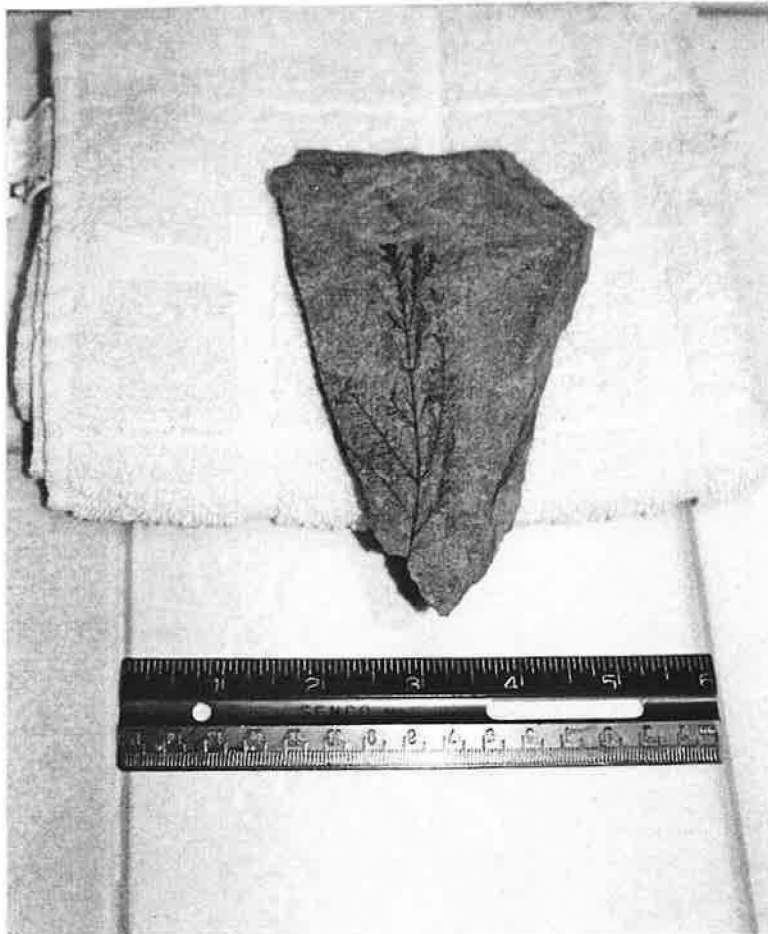


Fig. 60 Metasequoia

Tidwell pg. 89

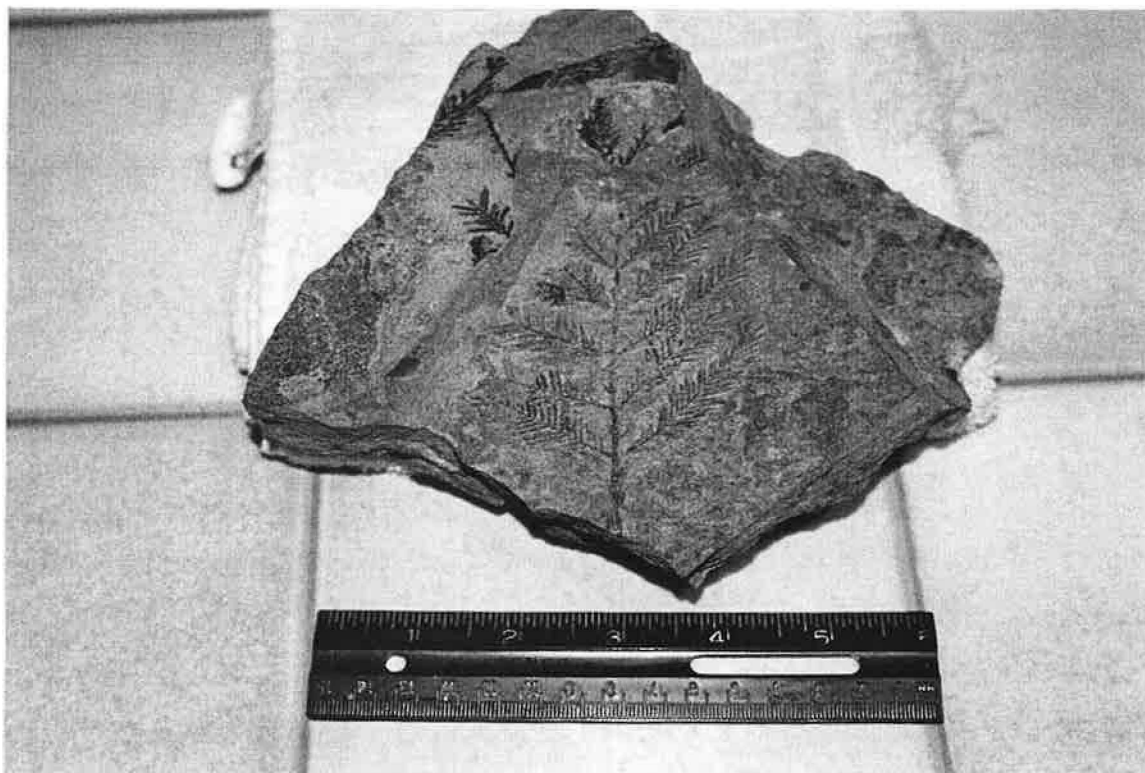


Fig. 61 Metasequoia

Tidwell pg. 89

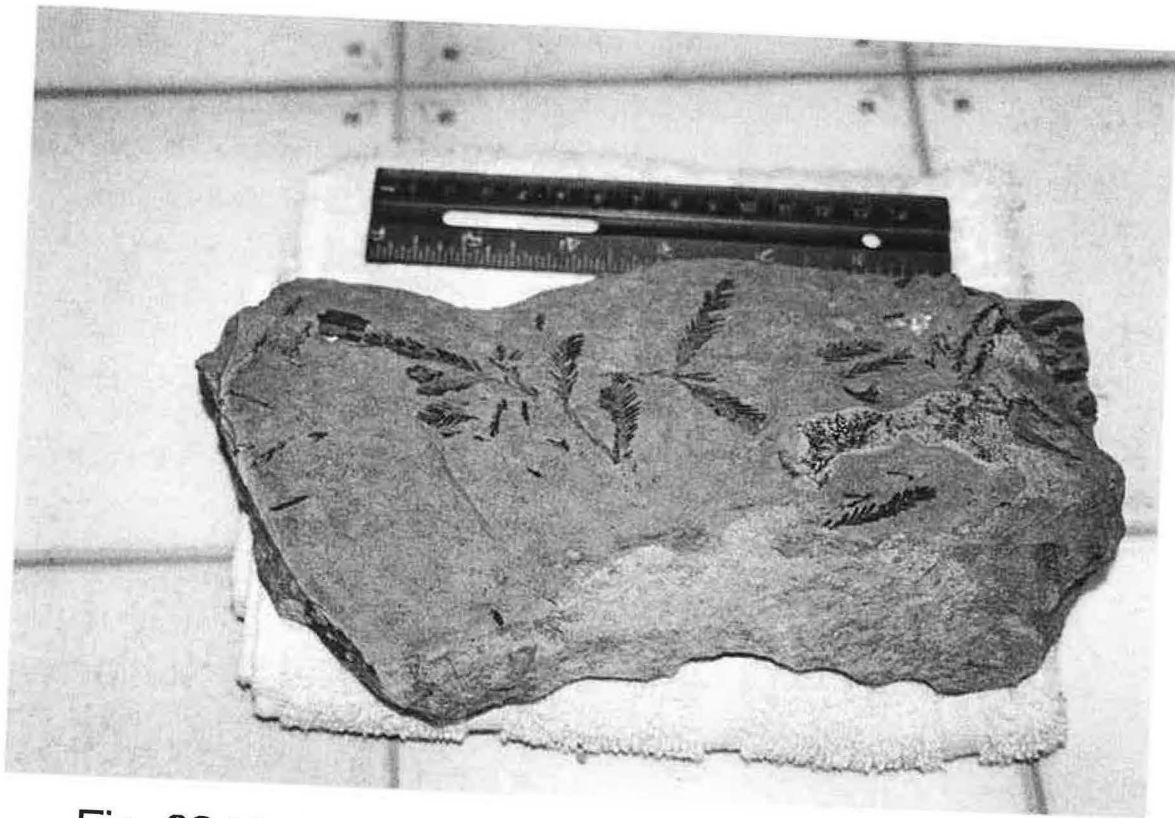


Fig. 62 Metasequoia

Tidwell pg. 89



Fig. 63 Metasequoia

Tidwell pg. 89



Fig. 64 Equisetum

Hollick pl. 7, no. 4

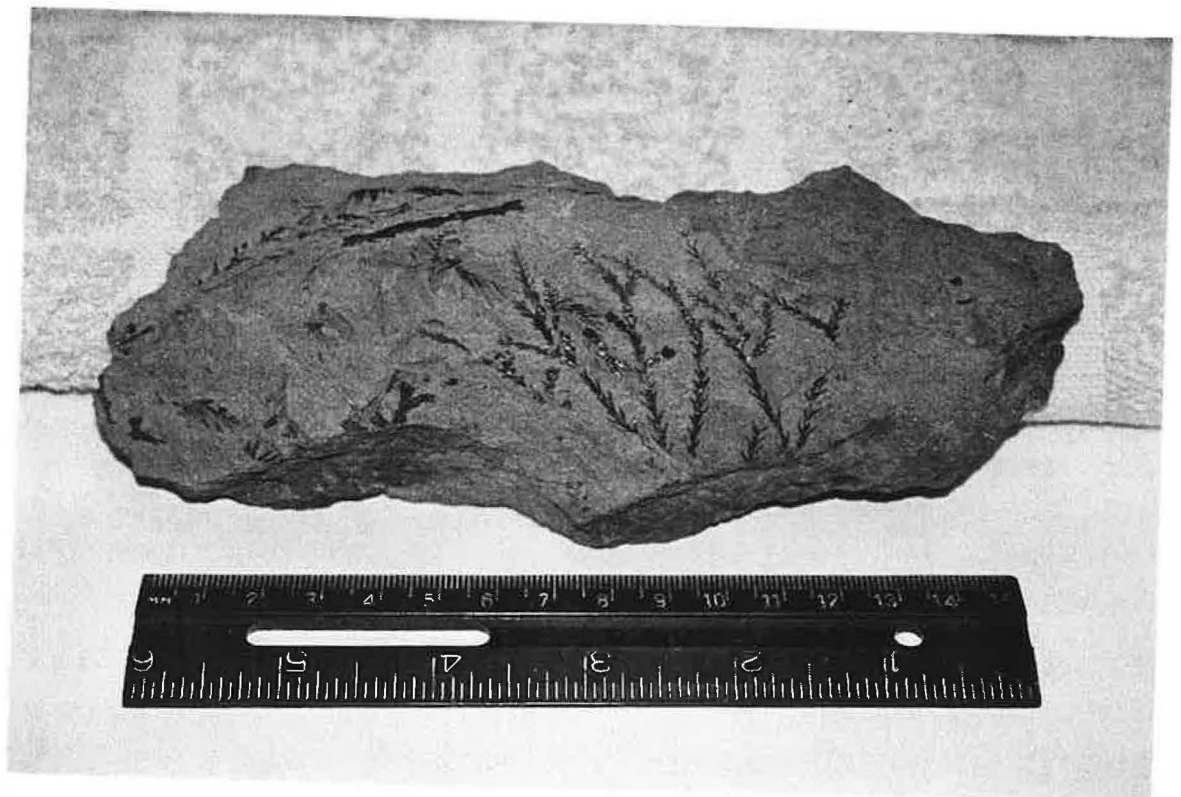


Fig. 65 Glyptostrobus

Hollick pl. 18, no. 1-5

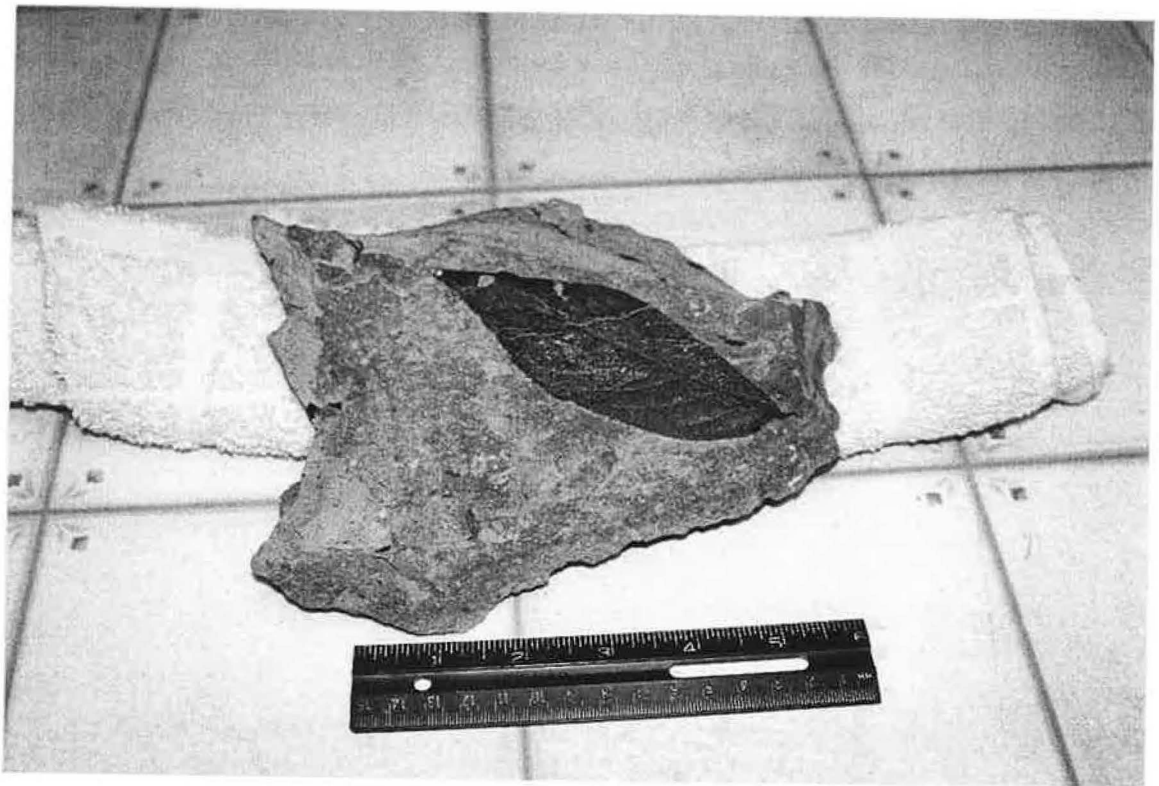


Fig. 66 *Carya*
Tidwell pg. 114

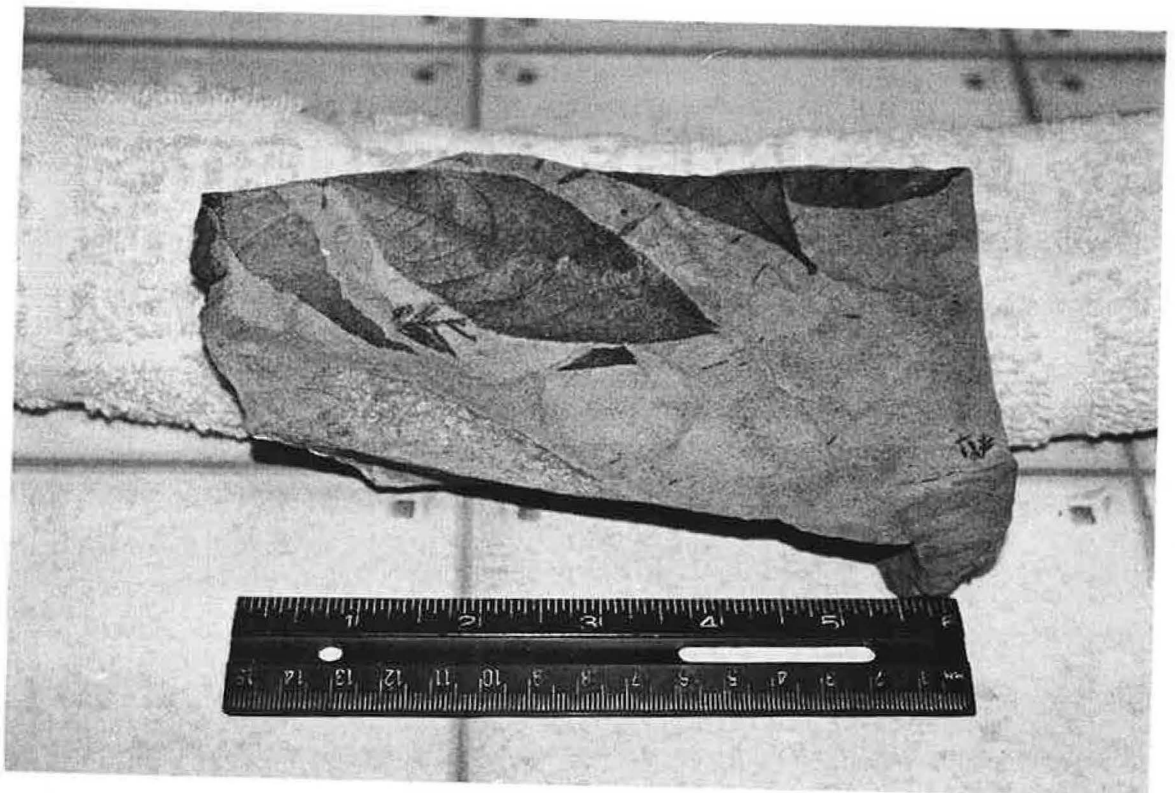


Fig. 67 *Carya*
Tidwell pg. 114



Fig. 68 Populus
Hollick pl. 28, no.2



Fig. 69 Flabellaria ?
Hollick pl. 21

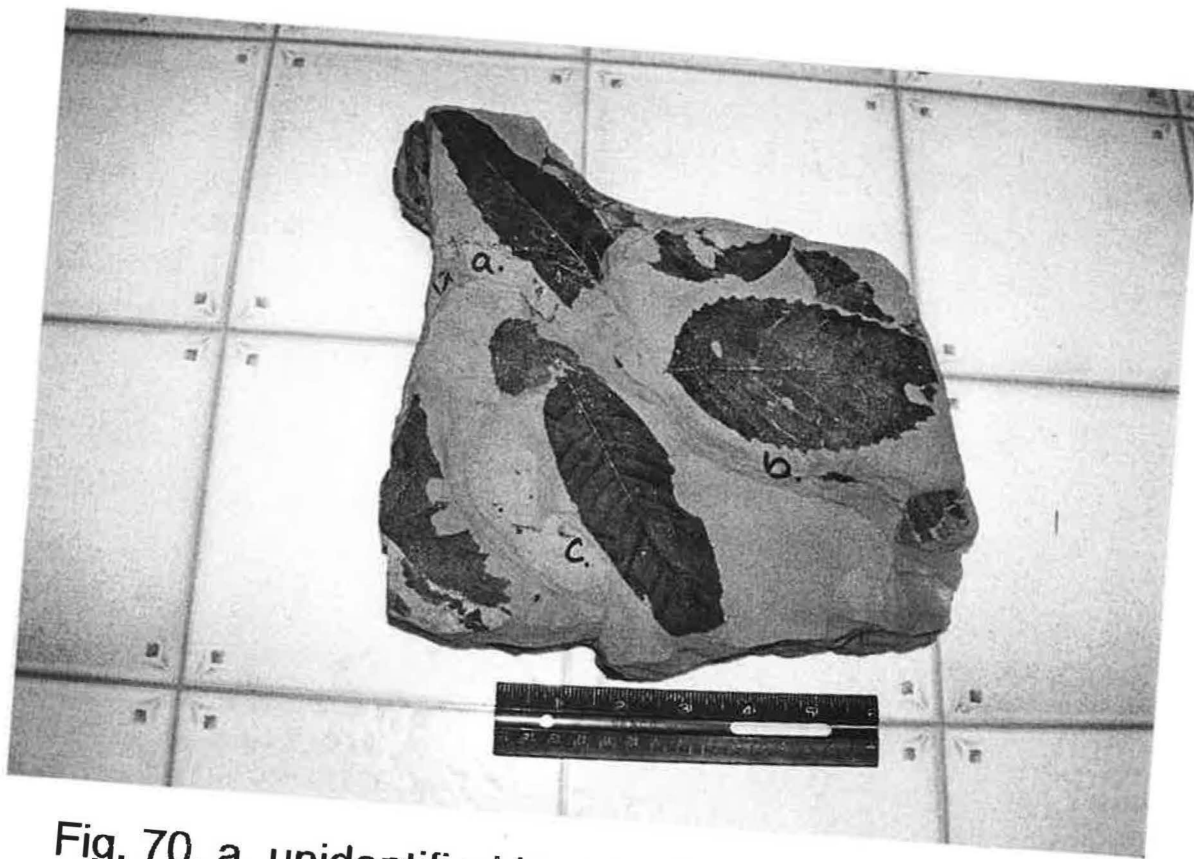


Fig. 70. a. unidentified leaf, b. *Quercus*, c. *Juglans*
Juglans – Hollick pl. 104, no.1

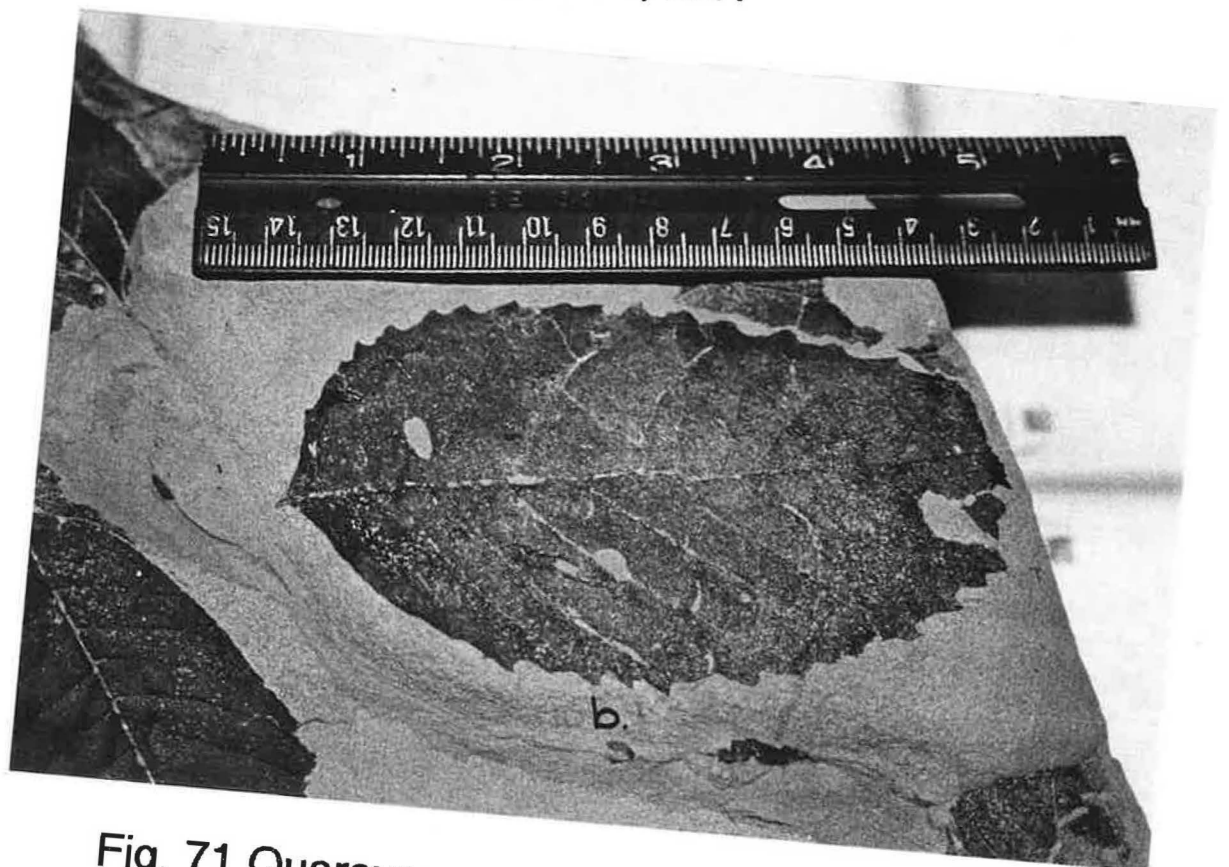


Fig. 71 *Quercus*
 Hollick pl. 55



Fig. 72 Matonia

Tidwell pg. 65

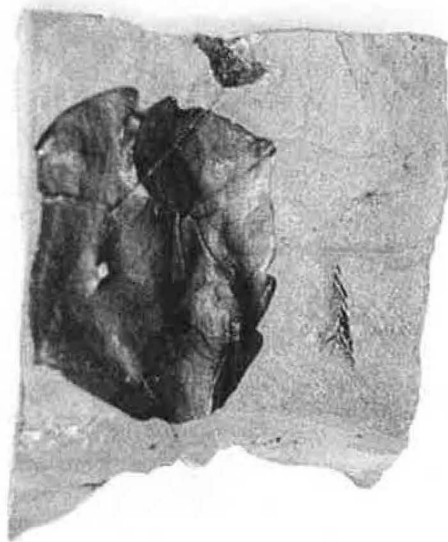


Fig. 73 Populus

Hollick pl. 28, no.2

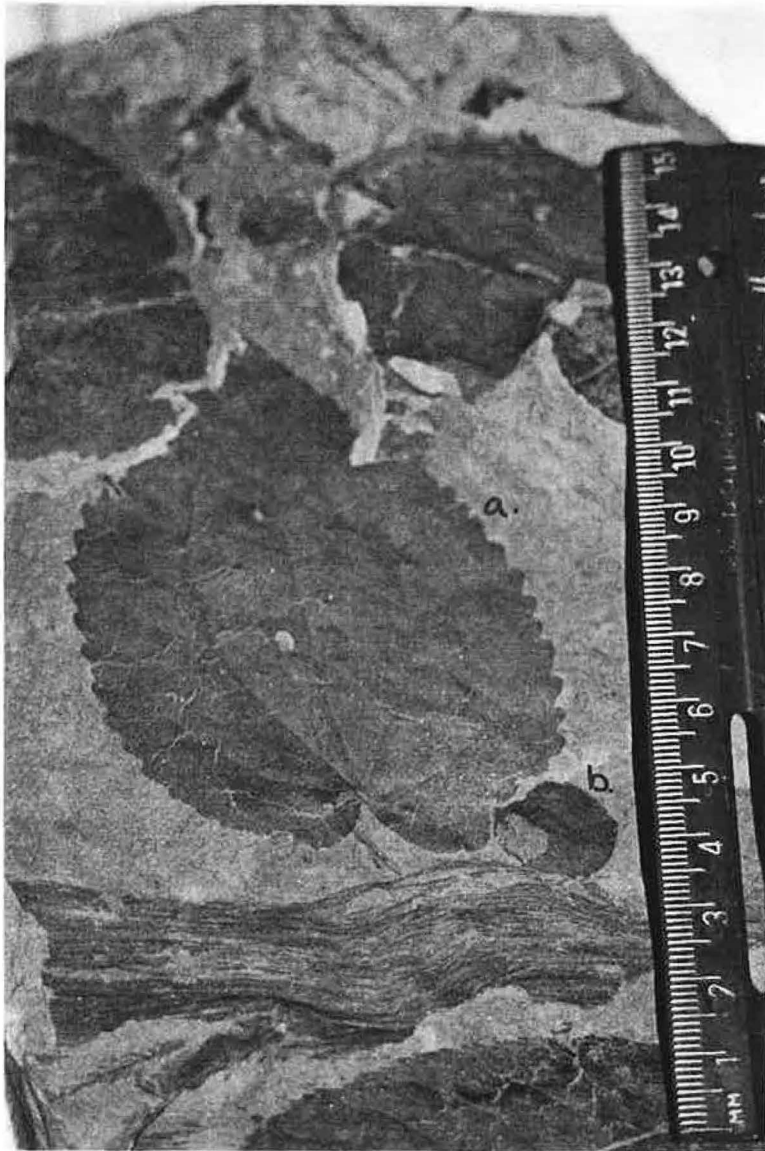


Fig. 74 a. *Populus* b. unidentified seed
Hollick pl. 28, no.1

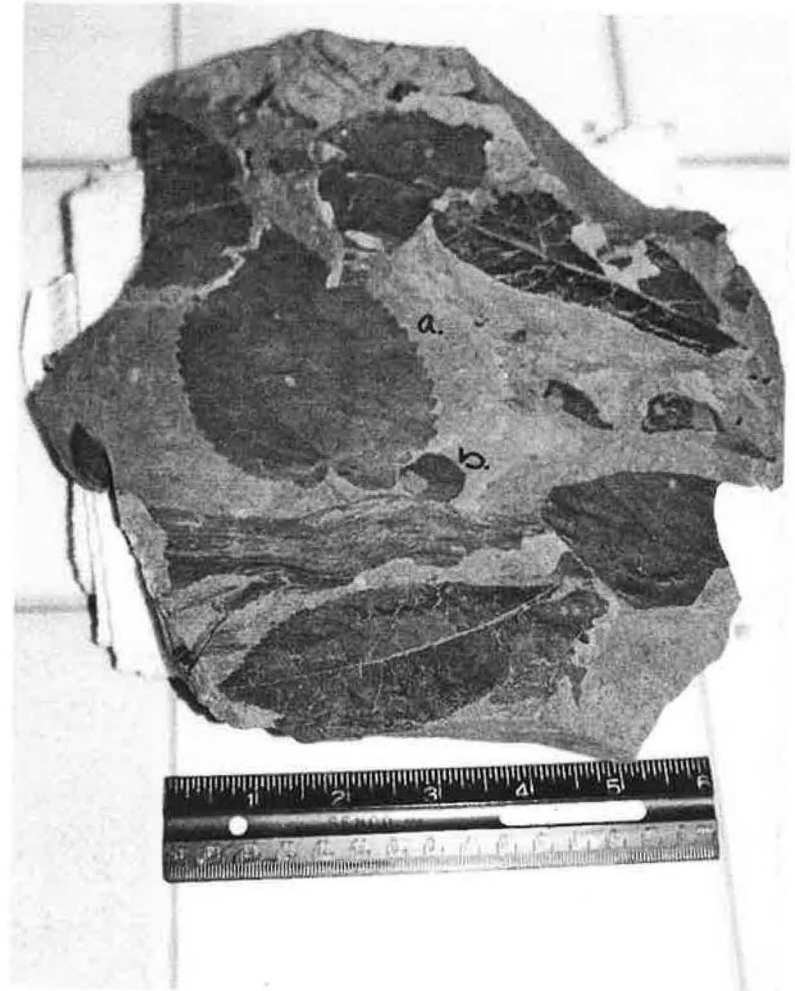


Fig. 75 a. *Populus* b. unidentified seed

Fig. 76

Metasequoia
cone

Tidwell pg. 89

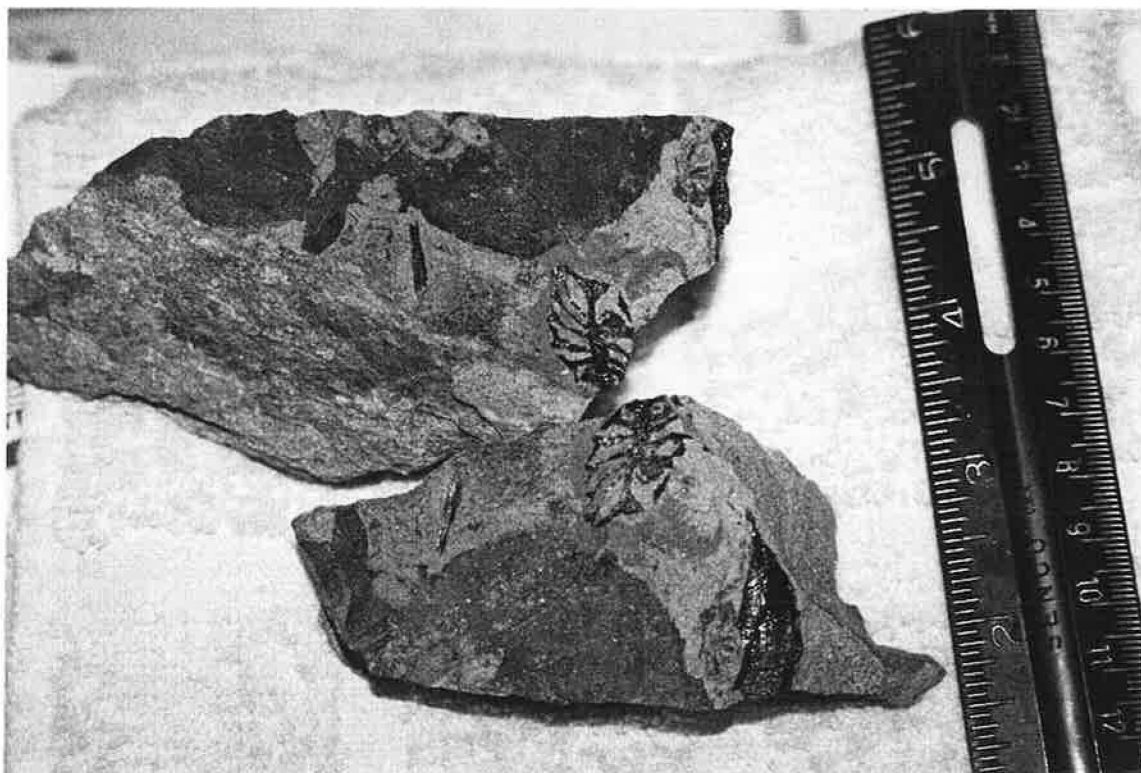
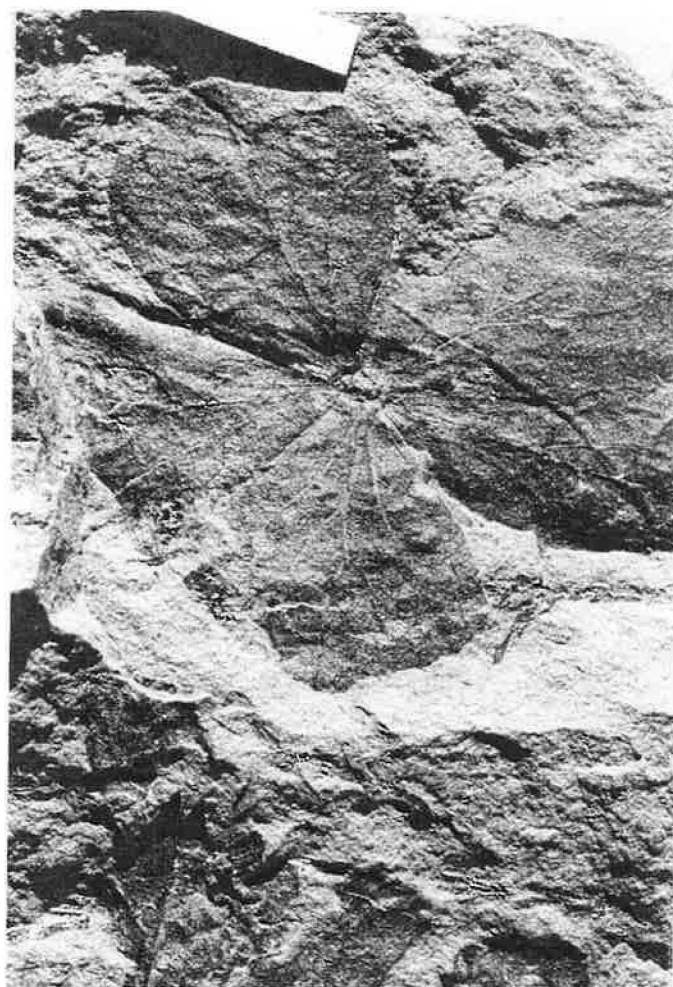


Fig. 77 Hydrangea

Hollick pl. 83, no.4



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