FOSSILS IN WASHINGTON

by

Vaughn E. Livingston, Jr.

State of Washington
ALBERT D. ROSELLINI, Governor
Department of Conservation
EARL COE, Director

DIVISION OF MINES AND GEOLOGY
MARSHALL T. HUNTTING, Supervisor

Information Circular No. 33

FOSSILS IN WASHINGTON

By
VAUGHN E. LIVINGSTON, JR.

STATE PRINTING PLANT, OLYMPIA, WASHINGTON
1959

For sale by Department of Conservation, Olympia, Washington.
Price, 25 cents.

FOREWORD

To the amateur naturalist and to anyone who is interested in the mysteries of nature, fossils present challenges to the imagination that are not easily met. Fossil sea shells are often found imbedded in solid rock in such seemingly unlikely places as the high Cascade Mountains in Washington; fossil palm leaves are found in areas of temperate climate in Washington; and elephant and camel bones are found here, where these animals are now living only in zoos. What do these casts, molds, and preserved sea shells, imprints of leaves, and animal bones mean in terms of the geologic history of the earth?

These and related questions are answered by paleontologists, the geological specialists who interpret geologic history from the evidence provided by fossils. Their interpretations are made through discovery, careful study, and classification of the fossilized remains of plants and animals that lived in the geologic past.

Although fossils are the subject of highly specialized studies by paleontologists, they also are interesting to many nonspecialists, beginning students, and amateurs, and it is for these persons that this report has been prepared. The more serious investigator will find use for the detailed reports on fossils in Washington that are cited in the lists of references.

MARSHALL T. HUNTTING, Supervisor
Division of Mines and Geology

August 20, 1959

CONTENTS

ILLUSTRATIONS

FOSSILS IN WASHINGTON

By VAUGHN E. LIVINGSTON, JR.

INTRODUCTION

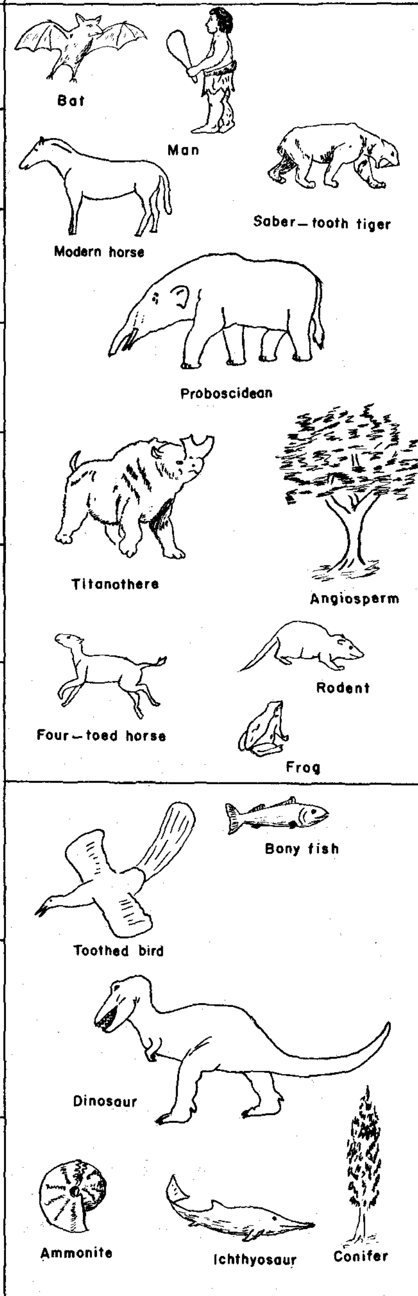
The quest for fossils can be a fascinating one. It not only gives an individual an opportunity to relax in the great outdoors, but also can provide many enjoyable hours of indoor work, cleaning and identifying individual specimens. If collecting is approached with the proper perspective, the fossil hunter will also expand his knowledge of rocks and present-day animals and plants.

Many years ago, people who found fossils thought them to be freaks of nature. Some individuals went so far as to suggest that they were put into the rocks by some evil supernatural being. Other people thought that they were the remains of animals that were killed during the great flood at the time of Noah. It wasn't until the late 1700's that someone discovered that fossils found in a certain bed or layer of rocks were characteristic of that bed and served to distinguish it from other beds. It was further discovered that many of these characteristic fossils had a wide distribution and could be found elsewhere in a continuation of that same bed or layer of rock.

The descriptions of animals and their geologic significance given in this report are short. The amateur fossil hunter wanting more details should consult such books as "Introduction to Historical Geology," by R. C. Moore,

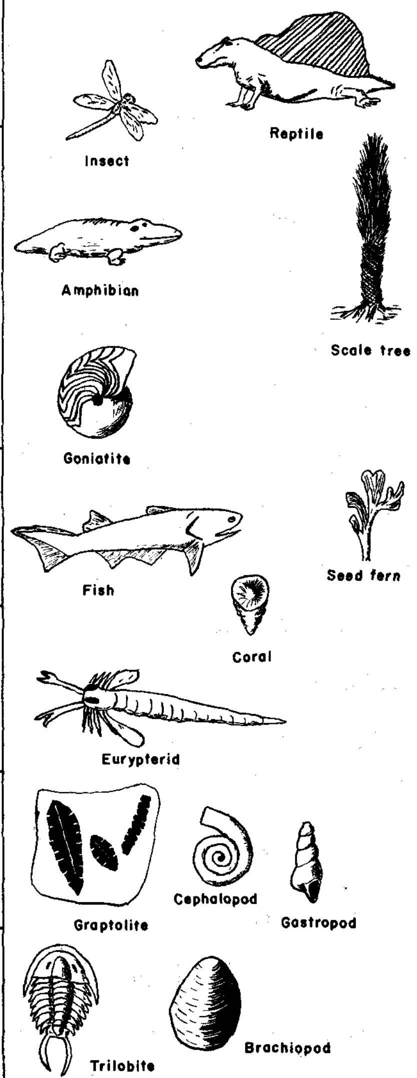
GEOLOGIC TIME TABLE

Time units			Age (yrs.)	Succession of life
CENOZOIC ERA	QUARTERNARY PERIOD	Recent epoch	10,000	
		Pleistocene epoch	1,000,000	
	TERTIARY PERIOD	Pliocene epoch	10,000,000	
		Miocene epoch	25,000,000	
		Oligocene epoch	40,000,000	
		Eocene epoch	60,000,000	
		Paleocene epoch		
MESOZOIC ERA	CRETACEOUS PERIOD		125,000,000	
	JURASSIC PERIOD		150,000,000	
	TRIASSIC PERIOD		180,000,000	



GEOLOGIC TIME TABLE — Continued

Time units		Age (yrs.)	Succession of life
PALEOZOIC ERA	PERMIAN PERIOD	180,000,000	
	PENNSYLVANIAN PERIOD	205,000,000	
	MISSISSIPPIAN PERIOD		
	DEVONIAN PERIOD	255,000,000	
	SILURIAN PERIOD	315,000,000	
	ORDOVICIAN PERIOD	350,000,000	
	CAMBRIAN PERIOD	430,000,000	
PRECAMBRIAN ERA		510,000,000 3,000,000,000 ?	Fossils are rare and are found only in youngest Precambrian rocks. Life consisted of simplest animal forms and low-order plants.



published by McGraw-Hill, New York; "General Zoology," by Tracy I. Storer, published by McGraw-Hill, New York; and "An Illustrated Guide to Fossil Collecting," by Richard Casanova, published by Naturegraph, San Martin, California. A person who spends a few minutes studying these books will discover them to be not only informative but entertaining as well. Merely glancing at the pictures will improve one's understanding of fossils and their relationship to the history of the earth.

Fossil collectors should always keep in mind that the fossils that are found today are evidence of once-living plants and animals. Because the present can often be used as a key to the past, by studying present-day forms of animals or plants it is possible to learn how ancient organisms of the same kinds lived.

In order to better understand what a fossil is, a person should have a general knowledge of its geologic age, mode of preservation, and what type of animal or plant it once was.

Geologic Time

Geologists calculate that the most ancient rocks found at the surface of the earth are between 2½ and 3 billion years old, according to radioactivity dating measurements. As there is no way of knowing how much time elapsed between the origin of the earth and the formation of the oldest known rocks, a part of the earth's history will always remain obscure. As can be seen in the table on pages 2 and 3, geologists have divided geologic time into four main divisions, called eras. The eras have been subdivided into periods, which in turn have been subdivided into epochs. The table also gives the approximate age of these eras, periods, and epochs.

In order to visualize the vast amount of time represented by the geologic time scale, assume that one second of time equals one year of the earth's history. On this reduced time scale the average human life span is one minute, Christ was born about 33 minutes ago, and the earth had its beginning a little over 100 years ago.

We are familiar with the usage of Christ's birth date as a datum plane in reckoning historic time in years B. C. and A. D. In geologic time the datum plane is the base of the Cambrian period. The rocks that were formed during Cambrian time are the first to contain numerous fossils; rocks of Precambrian age are almost entirely devoid of fossils.

Fossilization

Fossils are the remains or traces of animals or plants that have been preserved in rocks or other materials (such as ice or tar) of the earth's crust by natural means. Two things are necessary in order that a fossil may be formed: (1) quick burial in materials such as mud, snow (later turned to ice), water, volcanic ash, or tar, and (2) hard parts such as bones, teeth, or shell that can be preserved. Most fossils are preserved as unaltered hard parts of animals or plants, as altered hard parts, or as molds or casts.

Unaltered hard parts.--Skeletal material or shell that has been preserved with no recognizable change from its original composition. Good examples of this type of preservation are exhibited by fossil clams and snails found in Tertiary formations of western Washington.

Altered hard parts.--Skeletal material or shell that has been altered from its original composition. This alteration can take place in many ways, the most important of which are listed below.

(a) Carbonization.--The tissue of a plant or animal is transformed into a thin film of carbon. Good examples of this are the fossil leaves and other plant parts found in sandstones and shales near Wenatchee, Spokane, Cle Elum, and other localities.

(b) Petrifaction (petrification).--Material such as bone or wood is converted to stone by the filling in of voids or pores and by replacement of the original substance with a foreign material--most commonly, silica. A good example of this transformation is the petrified wood found in the Ginkgo Petrified Forest State Park, near Vantage in Kittitas County.

(c) Permineralization.--In shells and skeletal structures that have a permeable nature (bone, mollusk shells, etc.), the pore space becomes filled with an inorganic material, commonly calcite or silica. There is no alteration of the original material. The fossil increases in weight and usually becomes more resistant to destructive forces. Examples of this kind of preservation are the fossil clams found in the sea bluffs west of the West Twin River in Clallam County. The original shell material has remained unchanged, but the cavity within the shell has become filled with silica.

Molds and casts.--Any organic structure may leave an impression if it is pressed into, or is surrounded by, material that is capable of retaining the imprint. If the organic matter is later removed from its rock prison by solutions or other means, the remaining cavity or impression is a mold. If the mold becomes filled with a mineral substance, the filling is a cast.

An excellent example of a mold is the rhinoceros impression in basalt found near Blue Lake in the Sun Lakes State Park, Grant County. Casts of worm borings and clam neck impressions are common in Tertiary shales of western Washington.

Some trees that were covered by molten lava were preserved. However, in most instances the wood was completely burned by the heat of the lava, leaving a mold in the solidified lava to show where the tree had been. An excellent example of this is found in the lava tunnel in the NE$\frac{1}{4}$ sec. 19, T. 7 N., R. 5 E., on the south flanks of Mount St. Helens. Similar molds can be seen in thick pumice beds near the Ranger Station at Spirit Lake on the north side of Mount St. Helens.

Other types of preservation.--Some unusual cases of preservation have been recorded. Woolly mammoths and rhinoceroses of the ice age have been found encased in glacial ice of northern Siberia and Alaska. Their preservation was so complete that flesh, internal organs, and undigested food in the stomach were almost perfectly preserved. In at least one instance local tribesmen in Siberia were known to have eaten the flesh of one of these frozen prehistoric creatures with no ill effects. Insects showing every detail of morphology and color have been found in amber, which is the fossilized resin of coniferous trees.

Most fossils have been preserved simply by being covered with fine sediment in the sea. This method of fossilization does not prevent the bacterial decay of flesh or soft tissue, but the harder parts of the animal or plant may be well preserved. On land, the most favorable places for fossils to form is in lakes and swamps. Beautifully preserved leaf and insect remains are found in the fresh-water deposits of the Latah formation near Spokane.

Value of Fossils

Stratigraphic markers.--By using fossils to date the layered rocks of the earth's crust, geologists are able to determine the relationship of rocks in one area to those in another area. By noting the occurrence of certain "guide" fossils or characteristic fossil sequences, geologists have been able to correlate strata in Stevens County with strata of the same age in the Appalachian Mountains, in England, the Alps, and other parts of the world.

This method of correlation is particularly important to the petroleum geologist. He looks for evidence that will tell him the age of the strata and when they were folded, faulted, or eroded. By recognizing in well cores and cuttings fossils that are characteristic of a certain age, and by recording the depth at which they occur in different wells, he is able to draw geologic maps and cross sections that help him in his search for oil.

Ancient climate and environment indicators.--By studying certain types of fossils it is often possible to determine the relationship of ancient lands and seas, migration routes of ancient animals, and the climatic conditions that may have existed. For instance, fossil palm leaves found near Cle Elum indicate that about 50 million years ago the climate in central Washington was subtropical to tropical.

Classification of Fossils

For purposes of identification, fossils are classified into two large kingdoms--plant and animal. These in turn are successively subdivided into smaller and more restricted groups, finally ending with the individual. The subdivision of the animal kingdom can be illustrated as follows by the complete classifications of the domestic dog and of man:

Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Mammalia	Mammalia
Order	Carnivora	Primate
Family	Canidae	Hominidae
Genus	*Canis*	*Homo*
Species	*familiaris*	*sapiens*
Individual	Fido	John Doe

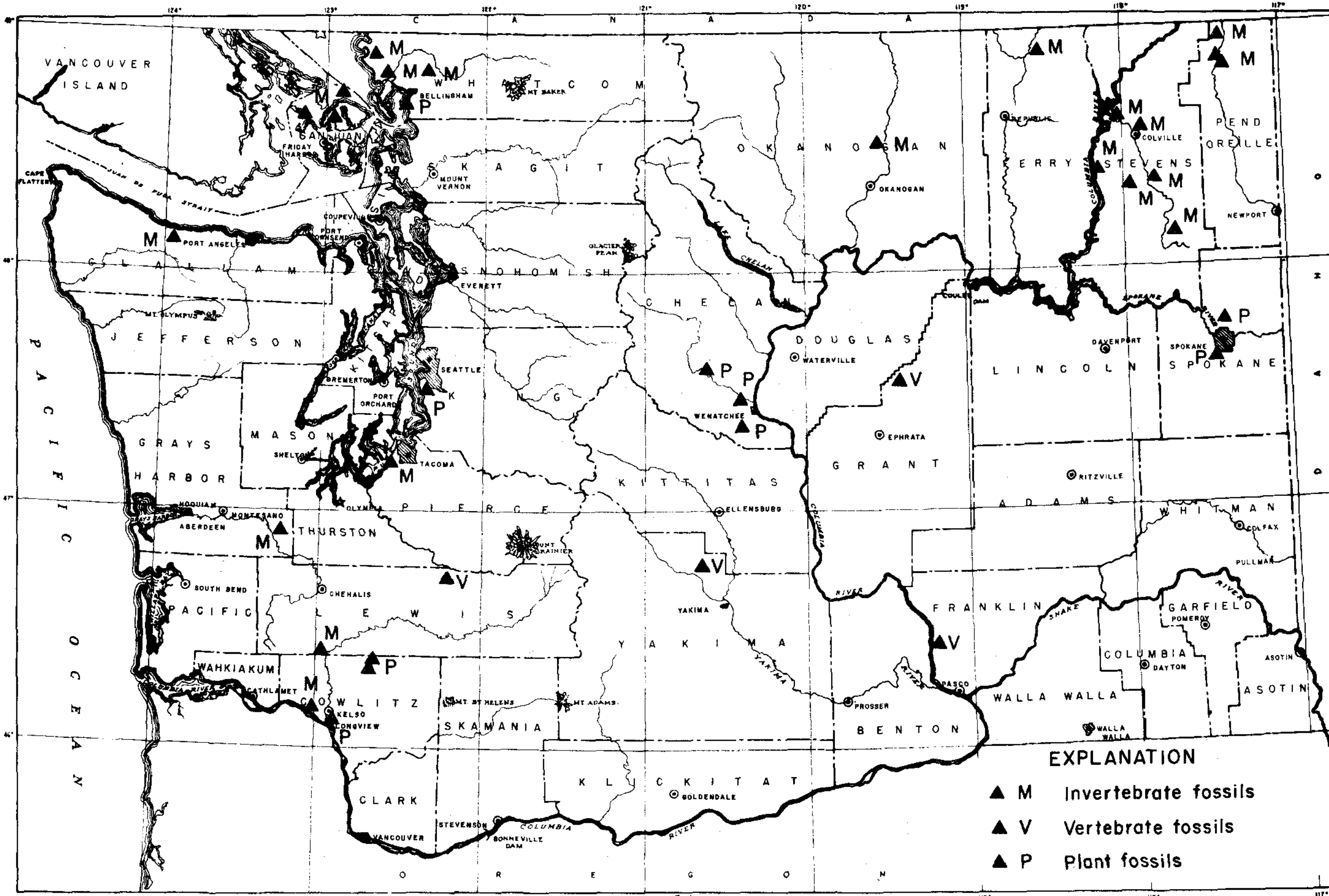


PLATE I.— FOSSIL LOCATIONS DESCRIBED IN THIS REPORT

SOME FOSSIL LOCALITIES IN WASHINGTON

In Washington there are fossil localities representing almost every geologic period. Unfortunately for the collector, most of the localities for fossils of different ages are widely separated. Paleozoic fossils are most abundant in the northeastern part of the state, and Tertiary invertebrate fossils are found mostly in the western part. Vertebrate fossils have been found mostly in the central and southern part. Leaf fossils have the widest distribution in the state. They have been found from north of Winthrop, in Okanogan County, south to the Oregon border, and from Puget Sound to the Idaho border.

Fossils of the Paleozoic Era

Cambrian period.--The Cambrian rocks derive their name from the Cambria (Latin for Wales) district of England, where they were first recognized. In Washington, Cambrian rocks are found in large areas in Stevens and northern Pend Oreille Counties. These rocks were deposited as sediments in an arm of

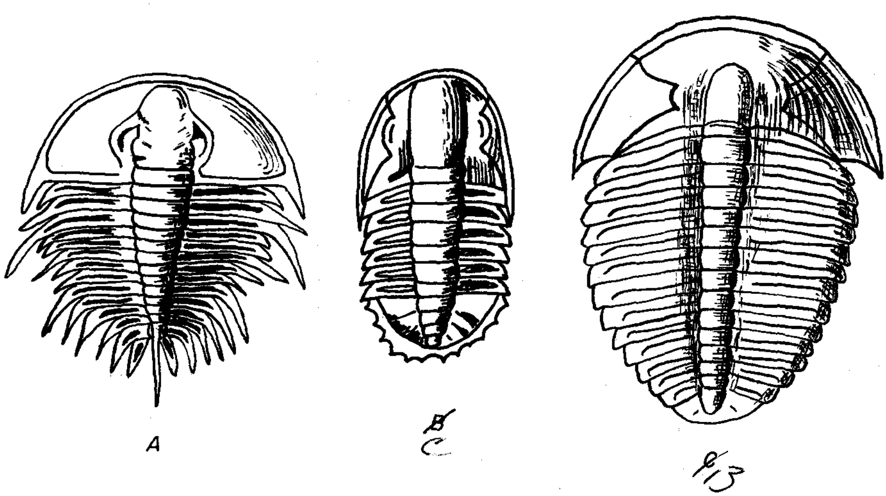


FIGURE 1.— Common Cambrian trilobites from northeastern Washington. *(A) Olenellus. (B) Elrathia. (C) Kootenia* All about twice natural size.

the sea that probably extended from southern California northward through Nevada, Utah, Idaho, eastern Washington, and British Columbia to the Arctic sea.

The most abundant fossils found in Cambrian rocks are trilobites, named from their prominent three-lobed body form. They are an extinct marine animal

FIGURE 2.— Three views of the Cambrian brachiopod *Kutorgina* from northeastern Washington. Natural size.

of the phylum Arthropoda that looked very similar to the modern sow bug or pill bug. Figure 1 illustrates three common trilobites found in northeastern Washington.

Other fossils commonly found in Cambrian rocks are brachiopods (fig. 2) These are bivalved marine animals that superficially resemble a clam. It is easy to distinguish between the two, however, as clam valves are equal or mirror images of each other and the brachiopod valves are unequal, one valve being differently shaped from the other.

Some of the best trilobite and brachiopod fossil localities in Washington are:

The quarries of the Lehigh Portland Cement Company one-half mile southeast of the town of Metaline Falls, Pend Oreille County.

At the south end of the low ridge opposite Addy, Stevens County, on the west side of the Colville River in the SW¼ sec. 13, T. 33 N., R. 39 E. (The fossils are found in a very platy, thin-bedded sandy argillite that crops out along the north side of the road, just a little over two-tenths of a mile south of the west end of the bridge over the Colville River at Addy.)

Near the center of sec. 14, T. 33 N., R. 38 E., about four-tenths of a mile up the East Fork of Stranger Creek from where the road crosses it on Dunn Mountain, approximately 7 miles due west of Addy, Stevens County.

FIGURE 3.— Two views of a Cambrian archaeocyathid. Twice natural size.

One of the most puzzling fossils of the Cambrian period is the archaeocyathid. These fossils resemble a sponge that has been turned to stone (fig. 3). Archaeocyathids can best be seen if the rock containing them is sawed and polished. They are among the oldest fossils found in Washington, being about 500 million years old. The best place to collect archaeocyathids is just past the Vista House road about 1.3 miles north of the intersection of Main and 5th Streets in Colville, Stevens County.

References

McLaughlin, K. P., and Enbysk, B. B., 1950, Middle Cambrian trilobites from Pend Oreille County, Washington: Jour. Paleontology, v. 24, no. 4, p. 466-471.

Moore, R. C., 1949, Introduction to historical geology: New York, McGraw-Hill, 582 p.

Park, C. F., and Cannon, R. S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U. S. Geol. Survey Prof. Paper 202, p. 17-19.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Ordovician period.--The Ordovician period was named after an early Celtic tribe, the Ordovices, who inhabited a district in Wales. In Washington, Ordovician rocks are found in Pend Oreille and Stevens Counties. They were laid down in an arm of the sea that covered roughly the same area as the Cambrian sea.

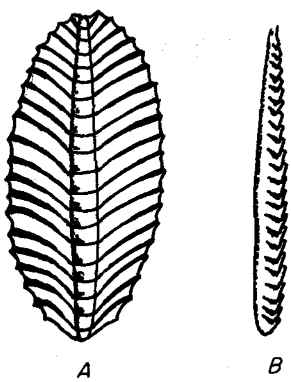


FIGURE 4.— Two common graptolites from northeastern Washington. *(A) Phyllograptus. (B) Didymograptus.* Both natural size.

By far the most abundant fossils found in Ordovician rocks of Washington are the graptolites (fig. 4). These are extinct colonial marine animals, the fossil remains of which are found mostly in black shales and slates. Generally the skeletons have been flattened, so that only the outlines of the animals can be seen. At first glance they may appear to be fossil leaves or grasses, but further study will show that they lack the vein systems of leaves.

Some good Washington localities at which to collect graptolites are:

In road cuts along the King road two-tenths of a mile northwest of its junction with the McKern road east of Rice in Stevens County.

In the west bank of the Pend Oreille River below the Pend Oreille mine, approximately 1 mile north of Metaline Falls, Pend Oreille County.

In the stream banks at the confluence of Slate Creek and the Pend Oreille River about 5 miles northeast of Metaline Falls, Pend Oreille County.

In highway cuts for about 1 mile south of Ledbetter Lake, Pend Oreille County.

References

Park, C. F., and Cannon, R. S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U. S. Geol. Survey Prof. Paper 202, p. 19-22.

Ruedemann, Rudolf, 1947, Graptolites of North America: Geol. Soc. America Memoir 19, 652 p.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Silurian period.--The name, Silurian, is derived from a tribe known as the Silures that inhabited western England and Wales. Rocks of Silurian age have been reported in Pend Oreille County near Metaline Falls; however, the validity of the report is questionable. If Silurian rocks are present, they may be so closely associated with Ordovician and Devonian rocks that recognizing them would be difficult.

Devonian period.--The name, Devonian, is derived from the County of Devon in southwestern England. In Washington, Devonian rocks are found on both sides of the Cascade Mountains. In western Washington, Devonian seas covered the area now occupied by the San Juan Islands, and in eastern Washington they covered about the same area as had Cambrian and Ordovician seas.

The most common Devonian fossils are brachiopods and corals. Some of the fossil corals resemble those living today. Some resemble dead twigs and others closely resemble the modern brain coral. One of the most common fossil corals is the horn coral (fig. 5), which is now extinct. The soft parts of the coral were probably very similar to those of the modern sea anemone and occupied the inside of the "cow-horn"-shaped skeleton.

FIGURE 5.— Typical Paleozoic horn coral. Natural size.

A good locality from which to collect Devonian fossils is at a limestone outcrop on the hillside in sec. 16, T. 40 N., R. 43 E., just northwest of where the road crosses Fence Creek in Pend Oreille County.

References

Park, C. F., Jr., and Cannon, R. S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U. S. Geol. Survey Prof. Paper 202, p. 22, and geologic map in pocket.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

<u>Carboniferous</u> <u>period</u>.--The Carboniferous period was named for the abundant coal beds that are found in rocks of this age in England. In the United States, rocks that represent the same span of time have been divided into the Mississippian and the Pennsylvanian periods. Up to the present time, studies of the Carboniferous rocks in Washington do not justify such a division.

The Carboniferous fossils most commonly found in Washington are brachiopods (fig. 6), corals, and bryozoans (fig. 7). The latter are small aquatic animals that live together in colonies called a zoarium. The zoarium may be an encrustation on a shell or rock, it may look like a twig that has been systematically punctured with pin holes (fig. 7A), or it may appear as a small fan or frond that has been perforated with pin holes (fig. 7B and 7C). The small holes are homes of the individual animals.

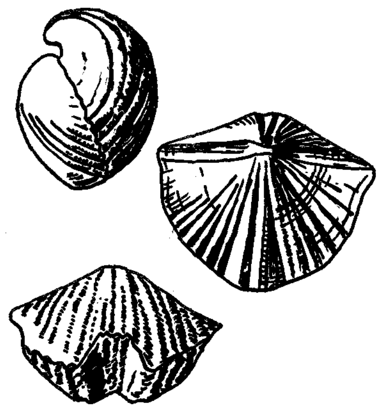


FIGURE 6.— Three views of the Carboniferous brachiopod *Spirifer.* Natural size.

Carboniferous fossils are found in the limestone rocks that crop out in the low hills between the towns of Springdale and Valley in Stevens County There are good collecting localities along the Jackel Road in sec. 19, T. 31 N., R. 41 E., about nine-tenths of a mile north of the Jumpoff School and about

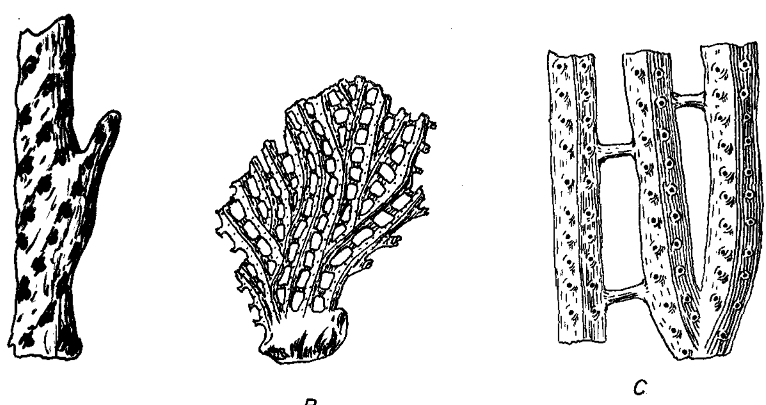


FIGURE 7.— Common bryozoans from northeastern Washington. *(A)* Twig–like. Four times natural size. *(B)* Frond–like. One and one–half times natural size. *(C)* Frond–like. Four times natural size.

seven-tenths of a mile south of the Stroven Road. The outcrops on the west side of the road are several hundred feet away from the road in a cultivated field. On the east side of the road Carboniferous fossils have been found in the old Kulzer clay pit.

Reference

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Permian period.--The Permian period was named for the province of Perm, which is located on the west flanks of the Ural Mountains in Russia. In Washington, Permian rocks are found in the San Juan Islands, along the west slopes of the northern Cascade Mountains, and near Kettle Falls in Stevens County.

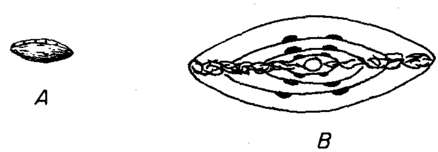


FIGURE 8.— Fusulinid. *(A)* Natural size. *(B)* Four times natural size showing the internal structure as seen through a microscope.

The most accessible collecting locality for Permian fossils is just north of Kettle Falls in Stevens County. Gastropods (snails) and corals are found in outcrops on the hill directly north of town. Other localities are at outcrops of limestone near the center of sec. 16, T. 36 N., R. 38 E., on the west side of and above the Vanasse Road, and in the W½SW¼ sec. 10, T. 36 N., R. 38 E., on the hillside above the Vanasse Road. Good fusulinids (large extinct spindle-shaped protozoans that lived in shells) (fig. 8) can be found at the first two localities. Their shells are about a quarter of an inch to half an inch long and look somewhat like oversize, elongated kernels of wheat. Fusulinids can be identified only by studying their internal structure with a microscope. In order to be examined properly, they must be cemented to a microscope slide and ground down so that they are thin enough for light to pass through them.

Reference

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Fossils of the Mesozoic Era

Triassic period.--The Triassic period was named by a German geologist in 1834. He found that rocks of this age in Germany could be divided into three units, therefore he gave the sequence the name, Trias. Rocks of this age are found in both eastern and western Washington. There are two fossil localities in Ferry County. One is on a hillside above and on the east side of the Kettle River, immediately north of White Creek, about 3.5 miles north of Curlew on Highway 4-A. The other location is on the east side of the road that goes into the headwaters area of Shasket Creek about 1.6 miles from its junction with Highway 4-A, and near the center of sec. 17, T. 40 N., R. 34 E. Fossil clams are common at both places.

In western Washington the best locality is on Davidson Head at the northwest side of San Juan Island, San Juan County, where fossil clams can be found.

Reference

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Jurassic period.--The Jurassic period was named for the Jura Mountains in France and Switzerland, where rocks of this age are richly fossiliferous. Jurassic rocks may be fairly abundant in the northern Cascades of Washington; however, the only known Jurassic fossil localities are relatively inaccessible and difficult to locate.

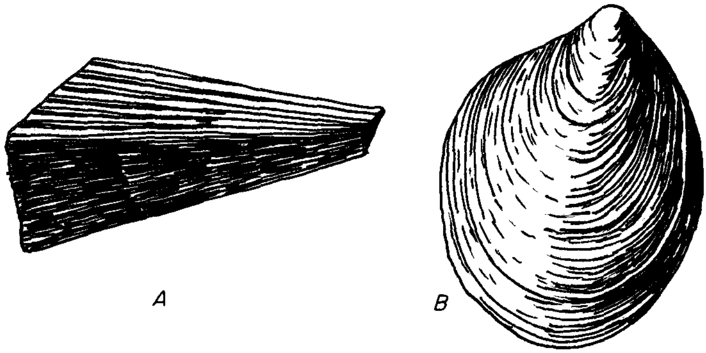


FIGURE 9.— Two common Cretaceous pelecypods from Sucia Island, San Juan County. *(A) Pinna. (B) Inoceramus.* Both are half natural size.

Cretaceous period.--The name Cretaceous was derived from the Latin word, creta, which means chalk. The name was first applied to the extensive formations of chalk that form the white cliffs on both sides of the English Channel. It was during Cretaceous time and the Jurassic and Triassic periods that the great reptiles, the dinosaurs, roamed the world. Washington has Cretaceous rocks in the northern Cascades and in the San Juan Islands. By far the most fossiliferous collecting locality is Sucia Island of the San Juan group. Here clams (fig. 9) and cephalopods (fig. 10) are numerous. A cephalopod is a type of mollusk that has tentacles. Examples are the squid and the octopus.

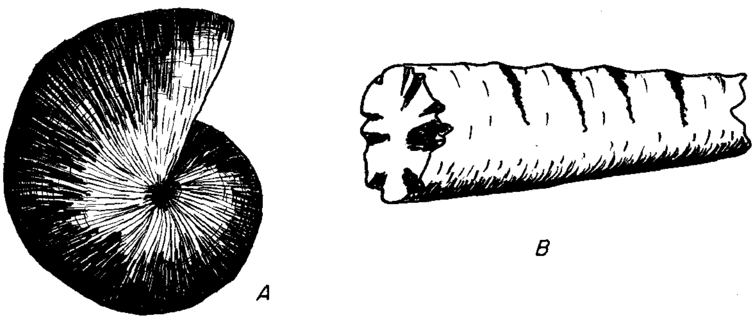


FIGURE 10.— Two common Cretaceous cephalopods from Sucia Island, San Juan County. *(A) Phylloceras. (B) Baculites.* Both natural size.

There are two kinds of fossil cephalopods found on Sucia Island. One is a coiled type (fig. 10A) that looks somewhat like the pearly nautilus. The other is a straight variety (fig. 10B).

References

McLellan, R. D., 1927, The geology of the San Juan Islands: University of Washington Pub. in Geology, v. 2, 185 p.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

Fossils of the Cenozoic Era

Tertiary period.--The Tertiary period comprises all but a small fraction of the time that elapsed during the Cenozoic era, which began about 60 million years ago.. The name, Tertiary, was introduced during the eighteenth century to include the geologically young, relatively unconsolidated deposits that overlie older, more consolidated rocks, then called "Primary" and "Secondary." The Tertiary period was further subdivided into epochs (table on p. 2-3) through study of rocks in the Paris Basin of France.

In Washington, Tertiary rocks cover the southern half of the state and a narrow band that projects north along the eastern edge of Puget Sound toward Canada. The only Tertiary rocks that were deposited as sediments in the sea are found west of the Cascade Range. Most of the rocks of the southern Cascades and the Columbia Plateau are volcanic in origin; that is, they either flowed from cracks in the earth's crust or were blown out of volcanoes. Rocks that were deposited in what were probably fresh-water embayments of the sea are found near Bellingham, Cle Elum, Wenatchee, Black Diamond, Morton, and Packwood. Tertiary lake deposits are found near Spokane and interbedded with the Columbia River basalt flows at various places in the Columbia Basin and in the Yakima Valley.

Tertiary marine fossils are the most abundant fossil type found in Washington. The most common forms are pelecypods (clams and oysters) (fig. 11), gastropods (snails and limpets) (fig. 12), and scaphopods (tooth shells) (fig. 13). Occasionally cephalopods (fig. 14) are found, as well as other less common fossils. The localities where good collecting can be done are too numerous to be listed here; consequently, only a few of the better ones will be described. The reader is referred to the University of Washington publication, "Paleontology of the marine Tertiary formations of Oregon and Washington," by Charles E. Weaver (see references, p.28) for a very good list of Tertiary fossil localities in Washington.

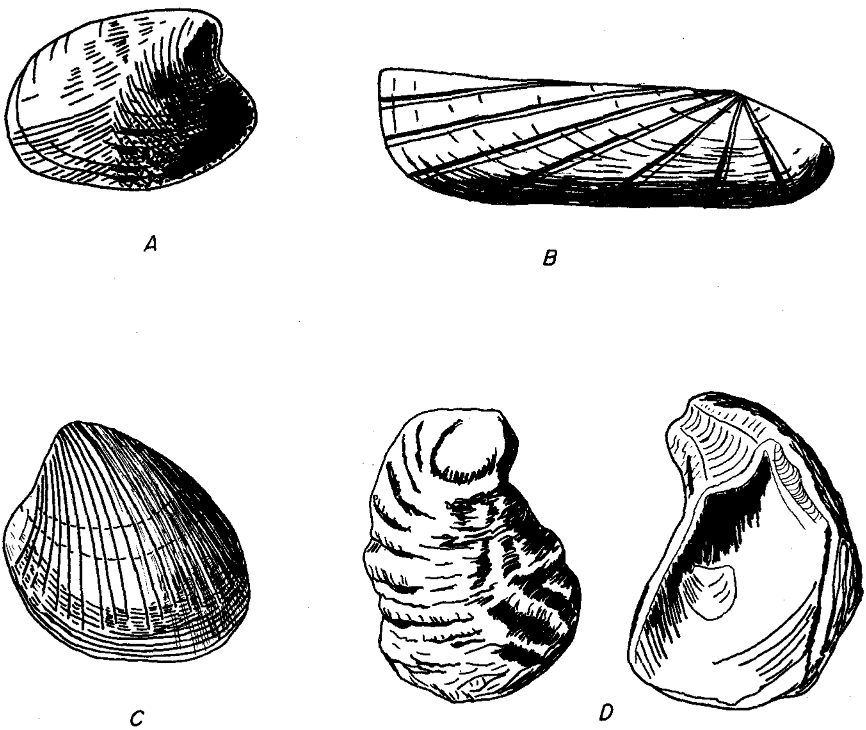


FIGURE 11.— Four common Tertiary pelecypods from western Washington. *(A) Acila.* Natural size. *(B) Solemya.* Natural size. *(C) Venericardia.* Half natural size. *(D)* Two views of *Ostrea.* One–third natural size.

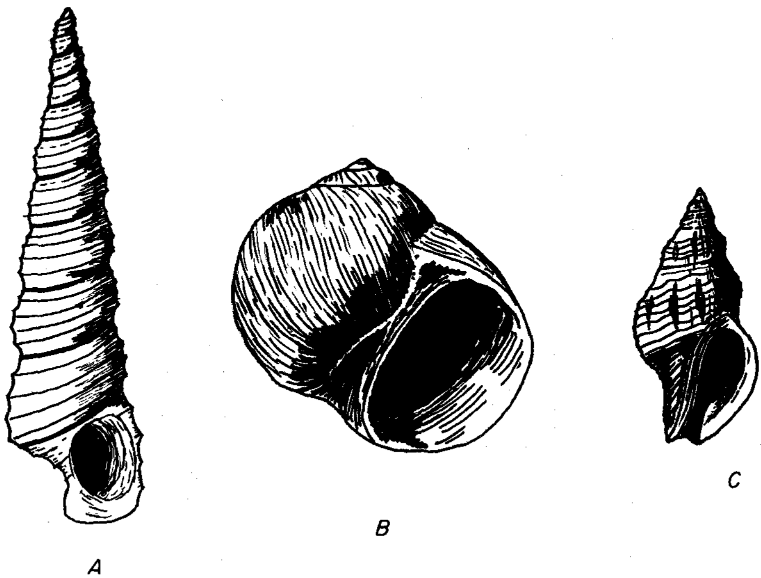


FIGURE 12.— Three common Tertiary gastropods from western Washington. *(A) Turritella.* Natural size. *(B) Polinices.* Twice natural size. *(C) Siphonalia.* Natural size.

One of the most accessible localities is in the bluffs along Highway 9 in Grays Harbor County between the towns of Porter and Malone and extending beyond them in either direction. In addition to pelecypods and gastropods, collectors have found here fossils of echinoderms (sea lilies), foraminifera

FIGURE 13.— Scaphopod *Dentalium* from the Tertiary of western Washington. Two-thirds natural size.

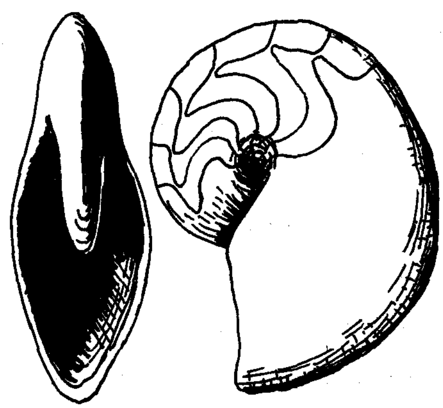


FIGURE 14.— Cephalopod *Aturia* from the Tertiary of western Washington. Two-thirds natural size.

(small single-celled amoeba-like marine animals that live in shells) (fig. 15), and crabs. The foraminifera are so small that a hand lens or strong reading glass is necessary to see the larger specimens. A microscope is the only means of seeing small varieties. The crabs are encased in hard round concretions

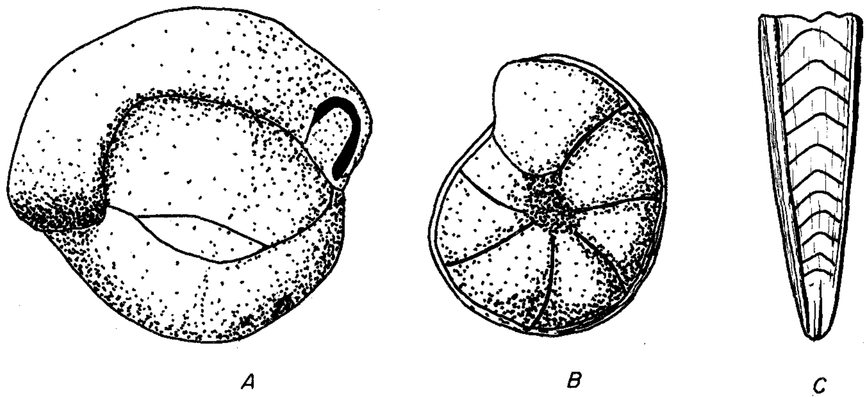


FIGURE 15.— Three common foraminifera from the Tertiary of western Washington. *(A) Quinqueloculina.* *(B) Robulus.* *(C) Plectofrondicularia.* All about forty times natural size.

that look much like ancient cannon balls. Breaking open a concretion is difficult, and the crab inside is likely to be damaged in the process.

Another good collecting locality is along the banks of Olequa and Stillwater Creeks above and below their confluence at Vader in Lewis County. Pelecypods and gastropods are very abundant here.

In Clallam County a good locality is along the bluffs that border the Strait of Juan de Fuca immediately west of the West Twin River. Here, silicified pelecypods and gastropods are abundant.

Many excellent fossil leaf localities are available to the amateur collector in Washington. It is well to look for leaves in any black or platy shale, siltstone, or sandstone. These are the types of rock in which fossil leaves are most often found. Some of the leaves most commonly found as fossils are shown in figure 16. A few of the more accessible localities are:

In the sandstones and shales along Chuckanut Drive, just south of Bellingham in Whatcom County.

In black shales just south of the section line between secs. 27 and 34, T. 39 N., R. 6 E., on Primary State Highway No. 1, not quite

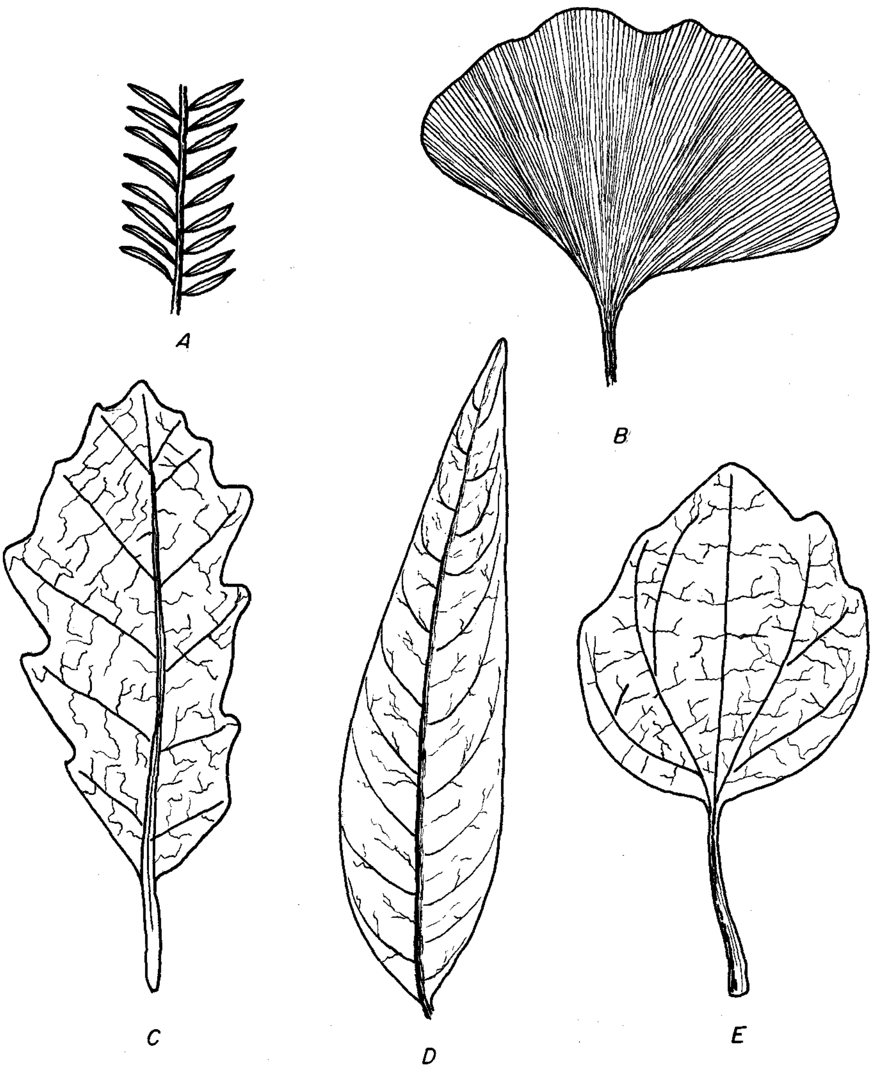


FIGURE 16.— Leaves commonly found as fossils in Washington. *(A) Sequoia. (B) Ginkgo. (C) Quercus* (oak). *(D) Salix* (willow). *(E) Populus* (Poplar). All about half natural size.

1.1 miles south of the Boulder Creek bridge, up the Nooksack River in Whatcom County. These shales contain large palm leaves.

In the bank on the southwest side of the Wenatchee River in the NE¼ NW¼ sec. 17, T. 24 N., R. 18 E., about 1.25 miles up the river from the Peshastin bridge.

In shales and sandstone exposed in a road cut in the SW¼ sec. 22, T. 22 N., R. 20 E., a little more than four-tenths of a mile down the Squillchuck Canyon road from its intersection with the Pitcher Canyon road near Wenatchee.

In sandstone and shale beds exposed along the old highway between Cashmere and Wenatchee, where the road breaks over the Sunnyslope hill in the NE¼NE¼ sec. 19, T. 23 N., R. 20 E., at the old roadside park.

In shales and sandy shales exposed along Deep Creek, half a mile above its mouth, northwest of Spokane.

In shales and sandy shales exposed in cuts of the Spokane, Portland & Seattle Railway and the Chicago, Milwaukee, St. Paul & Pacific Railway tracks in Spokane and west of Latah Creek. Fossil insects are also found in these cuts.

In a shaly sandstone bank on the north side of Highway 1-R, four-tenths of a mile west of the Coal Bank bridge over the Toutle River, in sec. 19, T. 10 N., R. 1 E., in Cowlitz County.

In shaly sandstone road cuts along Highway 1-Q a little less than 1.1 miles north of its intersection with Highway 1-R, in the SW¼ sec. 3, T. 10 N., R. 1 E., in Cowlitz County.

In shales and sandstones exposed in a road cut above the Coweman River in the S½SW¼SE¼ sec. 30, T. 8 N., R. 1 W., about seven-tenths of a mile from the end of the Allen Street Road, just east of Kelso, Cowlitz County.

In shales and shaly sandstones at Steels Crossing, where the old Steels bridge over the Great Northern railroad was located, in the SW¼ sec. 11, T. 23 N., R. 4 E., in King County.

In a sandstone rock quarry in the SE¼NE¼SE¼ sec. 12, T. 14 N., R. 4 E. On the way from Elbe, the road is the first to the right (west) after passing the Mineral junction; or, on the way from Morton, the road is the first to the left (west) after passing Carlson. This road extends west for about 1.1 miles, where it forks. The left (south) fork leads to the quarry, on the south side of the road about two-tenths of a mile past the fork.

The fossils at all these localities are Tertiary in age. There are many other localities in the state that are known to local people and have not been recorded in the files of any organization.

Fossil bones are not nearly so abundant in Washington as are shells and leaves. Consequently, good collecting localities are not known. Bones are an indication of a type of life different from that which has been mentioned before; they represent vertebrate animals (animals that have backbones). The best known collecting areas are in eastern Washington, where the dry climate retards weathering of fossils exposed by erosion. Some of the best places to look for fossil bones of such animals as hipparian (ancestral horse), bison, oreodont (small pig-shaped grazing animal), camel, caribou, and various rodents are:.

In the bedded silts, sands, and gravels along the east side of the Columbia River north of Richland, especially near Ringold.

In the silts and sands exposed along both sides of the Wenas Valley, Yakima County, especially in the SW¼ sec. 10 and the NE¼ sec. 35, T. 14 N., R. 18 E.

Other possible areas are the sandstones and siltstones that compose the sides of Ahtanum Valley, the hills north of Naches, and the hill between Rattlesnake Creek and Nile Creek up the Naches River, all in Yakima County, and the sandstones and siltstones that are exposed in the hills north of Ellensburg in Kittitas County. These rocks are all Tertiary in age.

A very unusual vertebrate fossil was found in Washington in 1935 near the north end of Blue Lake (in Sun Lakes State Park) in Grant County. Some hikers found a large cavity in a basalt flow and after crawling into it found that it contained numerous bone fragments. This find was reported, and later professional paleontologists investigated the cavity and found, after making plaster casts of the interior surface, that it was the mold of an ancient rhinoceros that had been buried by the lava flow.

References

Grant, R. Y., 1941, A John Day vertebrate fossil discovered in the Keechelus series near Tieton reservoir, Washington: Am. Jour. Sci., v. 239, no. 8, p. 590-593.

Knowlton, F. H., 1925, Flora of the Latah formation of Spokane, Washington and Coeur d'Alene, Idaho: U. S. Geol. Survey Prof. Paper 140-A, p. 17-82.

Roberts, A. E., 1958, Geology and coal resources of the Toledo-Castle Rock district, Cowlitz and Lewis Counties, Washington: U. S. Geol. Survey Bull. 1062, 71 p.

Smith, G. O., 1903, Description of the Ellensburg quadrangle [Washington]: U. S. Geol. Survey Geol. Atlas, Folio 86.

__________, 1904, Description of the Mount Stuart quadrangle [Washington]: U. S. Geol. Survey Geol. Atlas, Folio 106.

Smith, G. O., and Calkins, F. C., 1904, Description of the Snoqualmie quadrangle [Washington]: U. S. Geol. Survey Geol. Atlas, Folio 139.

Weaver, C. E., 1942, Paleontology of the marine Tertiary formations of Oregon and Washington: University of Washington Pub. in Geology, v. 5, 803 p.

Quaternary period.--The name Quaternary was applied many years ago by French and German geologists to unconsolidated materials--such as those deposited by streams, glaciers, and lakes--that covered the Tertiary rocks. Materials deposited in swamps, and windblown materials such as dune sands, also are included in this category. Compared to other geologic periods, Quaternary time is very short, dating back a mere million years or so. The outstanding feature of this period is that it was the time of the ice age. Vast ice sheets moved down from the north country into what is now the northern part of the United States. In Washington, lobes of the great Cordilleran glacier, which had its center in British Columbia, Canada, moved as far south as Spokane and Coulee City in the eastern part of the state and just south of Olympia in the western part. According to calculations made by U. S. Geological Survey geologists, 1/ this great ice field began to retreat about 14,000 years ago, leaving the area that it had covered mantled with a layer of glacial drift.

Almost all Quaternary fossils found in Washington indicate a cold climate. The invertebrate animal forms are cold-water types and are usually found closely associated with glacial drift. The vertebrate fossils are mostly cold-weather forms such as woolly mammoth, bison, and caribou.

Some good Quaternary fossil localities in Washington are:

In the marl around Booher Lake, in secs. 3 and 10, T. 35 N., R. 26 E., about 4 miles north of Riverside on Highway 97 in Okanogan County. Snail shells are abundant here.

1/ Crandell, D. R., Mullineaux, D. R., and Waldron, H. H., 1958, Pleistocene sequence in southeastern part of the Puget Sound lowland, Washington: Am. Jour. Sci., v. 256, no. 6, p. 384-397.

At a small lake on Orcas Island, at the NW. cor. sec. 17, T. 36 N., R. 2 W., in San Juan County, where excellent clams and worm tube fossils are found.

In the south side of the Chambers Creek valley at elevations of 30 feet and 110 feet, about 700 and 1,000 feet respectively from the mouth of Chambers Creek, just north of Steilacoom in Pierce County. Clams are found here.

Fossil clams can be found at all the following locations in Whatcom County:

In a road cut 2,008 feet north from the intersection of the Smith Road and the road that passes the Harmony School, in sec. 26, T. 39 N., R. 3 E., about 6 miles northeast of Bellingham.

In a road cut just west of the intersection of the Van Wyck and Dewey roads, at the SE. cor. sec. 4, T. 38 N., R. 3 E., about 3 miles northeast of Bellingham.

In a road cut about seven-tenths of a mile west from the intersection of Birch Bay and Blaine-Ferndale roads, in sec. 31, T. 40 N., R. 1 E., about two-tenths of a mile east of Birch Bay.

In a road cut five-tenths of a mile northeast from the intersection of the Smith Road and Mount Baker Highway, in sec. 28, T. 39 N., R. 3 E., about six-tenths of a mile southwest of North Cedarville.

In the high sea banks on Fish Point about seven-tenths of a mile from the intersection of the Cagey and Lummi Bay roads, in sec. 19, T. 38 N., R. 2 E., on the Lummi Indian Reservation.

An unusual Quaternary fossil find was the skeleton of a small mastodon found near Port Angeles by a farmer excavating a reservoir. Mammoth and

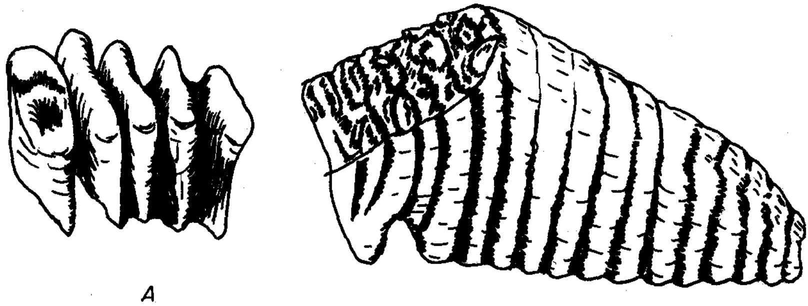


FIGURE 17.— *(A)* Mastodon tooth. *(B)* Mammoth tooth. Both greatly reduced in size.

mastodon teeth (fig. 17) and tusks have been found in scattered localities in both eastern and western Washington.

References

Daugherty, R. D., 1956, Archaeology of the Lind Coulee site, Washington: Proc. Am. Philosophical Soc., v. 100, no. 3, p. 267-276.

Romer, A. S., 1941, Man and the vertebrates: Univ. Chicago Press, 405 p.

Shimer, H. W., and Shrock, R. R., 1944, Index fossils of North America: New York, John Wiley & Sons, 837 p.

FOSSIL COLLECTING

Methods

The most useful tool in collecting fossils is a miner's pick, or geologist's hammer. One end of this instrument has a flat head, and the other end is either an elongated point or wedge. Other tools that can be of great value are: a chisel (for splitting rocks), a center punch (when trying to chip a fossil from solid rock, much energy is needed to drive a chisel into the rock and the chisel is hard to control, whereas a small center punch can be turned about at various angles so that light taps are all that are needed to chip out the fossil), dental picks (for cleaning the fossils), and a small brush (for cleaning the fossils). If a fossil is soft or very fragile, it is best to give it a coating of clear shellac before removal. The shellac should be diluted about half and half with alcohol or paint thinner, so that the coating is thin. The shellac can be carried in almost any bottle. The lid of the bottle should be pierced and the brush inserted in the hole. The brush is held in place by wrapping string or rubber bands around the handle. If this method is used, the bristles will always be in the shellac and will not dry out. The collector should always have sacks or bags in which to transport the fossils. If the fossils are fragile, wrapping them in wet paper and then putting them in a tin can is a very satisfactory method of carrying them.

Recording the Location

All too often, well-preserved fossils are found to be useless because the location where they were found was not recorded. In order that the fossil may be of value scientifically, the exact location as to section, township, and range should be given as well as the location relative to prominent landmarks. The stratigraphic position should be given if possible ("2 feet above the basalt flow," "6 feet below the sandstone-shale contact," etc.). The type of rock in which the fossil was found should also be recorded, along with the date and the collector's name. The collector should scribe on the fossil a number which corresponds to the location number. This will prevent the fossil from becoming lost, location-wise. The best way to do this is to apply a small smear of white enamel, which, when dry, can be written on with ink.

Professional People to Contact

Amateur fossil collectors can be of service to professional geologists and paleontologists by reporting new fossil finds. People who are interested may be contacted at the following addresses:

Department of Conservation
Division of Mines and Geology
335 General Administration Building
Olympia, Washington

U. S. Geological Survey
4 Homewood Place
Menlo Park, California

U. S. Geological Survey
South 157 Howard Street
Spokane 4, Washington

U. S. Geological Survey
Denver Federal Center
Denver 2, Colorado

Department of Geology
Washington State University
Pullman, Washington

Department of Geology
University of Washington
Seattle 5, Washington

Department of Geology
College of Puget Sound
Tacoma 6, Washington

Department of Science
Western Washington College of
Education
Bellingham, Washington

Department of Geography and Geology
Eastern Washington College of
Education
Cheney, Washington

Department of Science and
Mathematics
Central Washington College of
Education
Ellensburg, Washington

Division of Basic Sciences
Whitman College
Walla Walla, Washington

OTHER BOOKS ABOUT FOSSILS

HOW THE WORLD BEGAN. Edith Heal. Thomas S. Rockwell Co., Chicago, 1930.
Tells of the beginning of life upon the earth. Suitable for use in advanced elementary grades and high school.

THE STORY OF OUR ANCESTORS. May Edel. Little, Brown and Co., Boston, 1955.
Gives a possible explanation as to how man became as he is. For junior high and high school ages.

LIFE LONG AGO. Carroll Lake Fenton. The John Day Co., New York, 1937.
A good advanced book for children of grade and junior high school ages.

STORIES READ FROM THE ROCKS. Bertha Morris Parker. Basic Science Education Series. Row, Peterson and Co., Evanston, Ill., 1942.
Advanced grade and junior high school ages.

ANIMALS OF YESTERDAY. Bertha Morris Parker. Basic Science Education Series. Row, Peterson and Co., Evanston, Ill., 1948.
Advanced grade and junior high school ages.

MILLIONS OF YEARS AGO: PREHISTORIC LIFE IN NORTH AMERICA. Edwin H. Colbert. Thomas Y. Crowell Co., New York, 1958.
A well-illustrated, interesting book about fossil hunting for readers 10 to 14 years old.

THE FOSSIL BOOK, A RECORD OF PREHISTORIC LIFE. Carroll L. Fenton and Mildred A. Fenton. Doubleday & Co., New York, 1958.
A well-illustrated volume that high school students and adults will find useful as an encyclopedia of ancient life.

LIFE OF THE PAST. G. G. Simpson. Yale University Press, New Haven, Conn., 1953.
Gives a broad, easily understood, and interesting introduction to the study of fossils.

PREHISTORIC ANIMALS. William E. Scheele. World Publishing Co., Cleveland, Ohio, 1954.
A well-illustrated book that will appeal to all ages.

THE WORLD WE LIVE IN. Time, Inc. (distributed by Simon and Schuster, Inc., New York), 1955.
An excellent general survey of the realm of nature, with two chapters devoted to prehistoric life.

DINOSAUR BOOK. E. H. Colvert. American Museum of Natural History, New York, 1945.
An excellent popularized summary of information about dinosaurs. For people of all age groups.

HANDBOOK OF PALEONTOLOGY FOR BEGINNERS AND AMATEURS. Winifred Goldring. New York State Museum, Albany, N. Y., 1929.
A summary of paleontology for adults.

AN INTRODUCTION TO PALEONTOLOGY. A. Morley Davis. Thomas Murby and Co., London, 1947.
A simplified discussion of the major fossil groups.

MAN AND THE VERTEBRATES. A. S. Romer, University of Chicago Press, Chicago, 1941.
An illustrated introduction to living and fossil animals with backbones.

ANCIENT PLANTS AND THE WORLD THEY LIVED IN. H. N. Andrews. Comstock Publishing Co., Ithaca, N. Y., 1947.
College level.

PRINCIPLES OF INVERTEBRATE PALEONTOLOGY. R. R. Shrock and W. H. Twenhofel. McGraw-Hill Book Co., New York, 1953.
College textbook.

INVERTEBRATE FOSSILS. R. C. Moore, Cecil Lalicker, and A. Fischer. McGraw-Hill Book Co., New York, 1953.
College textbook.