OKLAHOMA GEOLOGICAL SURVEY

CARL C. BRANSON, *Director*

GUIDE BOOK X

Common Minerals, Rocks, and Fossils of Oklahoma

By

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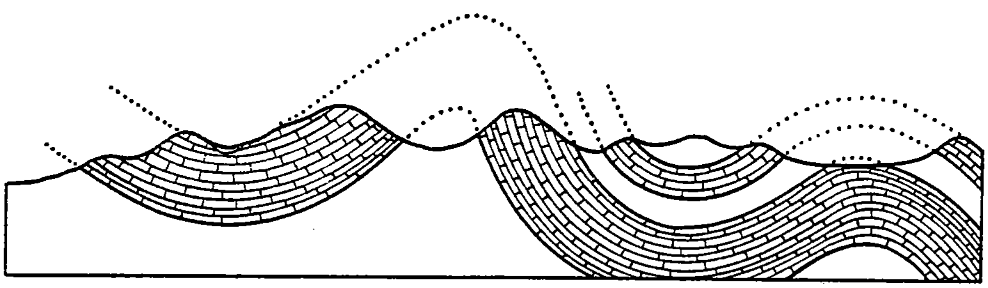

FRONTISPIECE. *Anticlinal and synclinal folds in sedimentary rocks of the Arbuckle Mountains, Murray County. Originally deposited as flat-lying layers on the floors of ancient oceans, these rocks were later folded into low mountains by horizontal pressures acting in the crust of the Earth. The mountains are now deeply eroded. Extending through the central part of the photograph is a long upward-arched fold or anticline. Another anticline is outlined at upper right by a ridge of white limestone, and these two anticlines are separated by a downward-bent fold or syncline. The structural cross section is drawn diagonally across the photograph from lower left to upper right. It shows the broad folds, and indicates by dotted lines those parts which have been eroded away. Thick limestone beds, shown by block pattern, form the ridges. The remaining beds are weakly resistant shales, sandstones, and thin limestones. The aerial photograph covers six square miles.*

(Aerial photograph by Dr. F. A. Melton)

ILLUSTRATIONS

TABLES

CONTENTS

FIGURE 1. *Aerial view of a large Oklahoma oil refinery. Crude oil pumped from wells is transported by railroad, truck, and pipeline to refineries like this, and processed to make gasoline, lubricating oil and grease, asphalt, and wax. In Oklahoma there are 17 refineries having a total capacity of 350,000 barrels of crude oil per day.*

(Photograph courtesy of Continental Oil Company, Ponca City)

Introduction

THE collection of twenty minerals, rocks, and fossils described in this booklet is intended for use by students in the secondary schools of Oklahoma. As all the specimens are from Oklahoma, the collection serves to acquaint the student with some of the geologic materials that occur in the State.

A study of the specimens will be an introduction to the study of geology itself, for the professional geologist looking for oil and gas, minerals, ground water, or metallic ores will use his knowledge of these same rocks and fossils in the discovery of useful economic products.

Mineral Production in Oklahoma

ALWAYS a prominent mineral-producing state, even since its first settlement by white men, Oklahoma has been foremost in the Nation in the production of certain commodities at different times during past years. Oklahoma produced more petroleum than any other state during the years 1915-1918, 1920-1922, and 1927; and Oklahoma was far ahead in the production of zinc from 1918 onward through the 1920's, yielding one-third to one-half the annual total of the United States. At present Oklahoma ranks sixth among the states in the total annual value of all minerals produced.

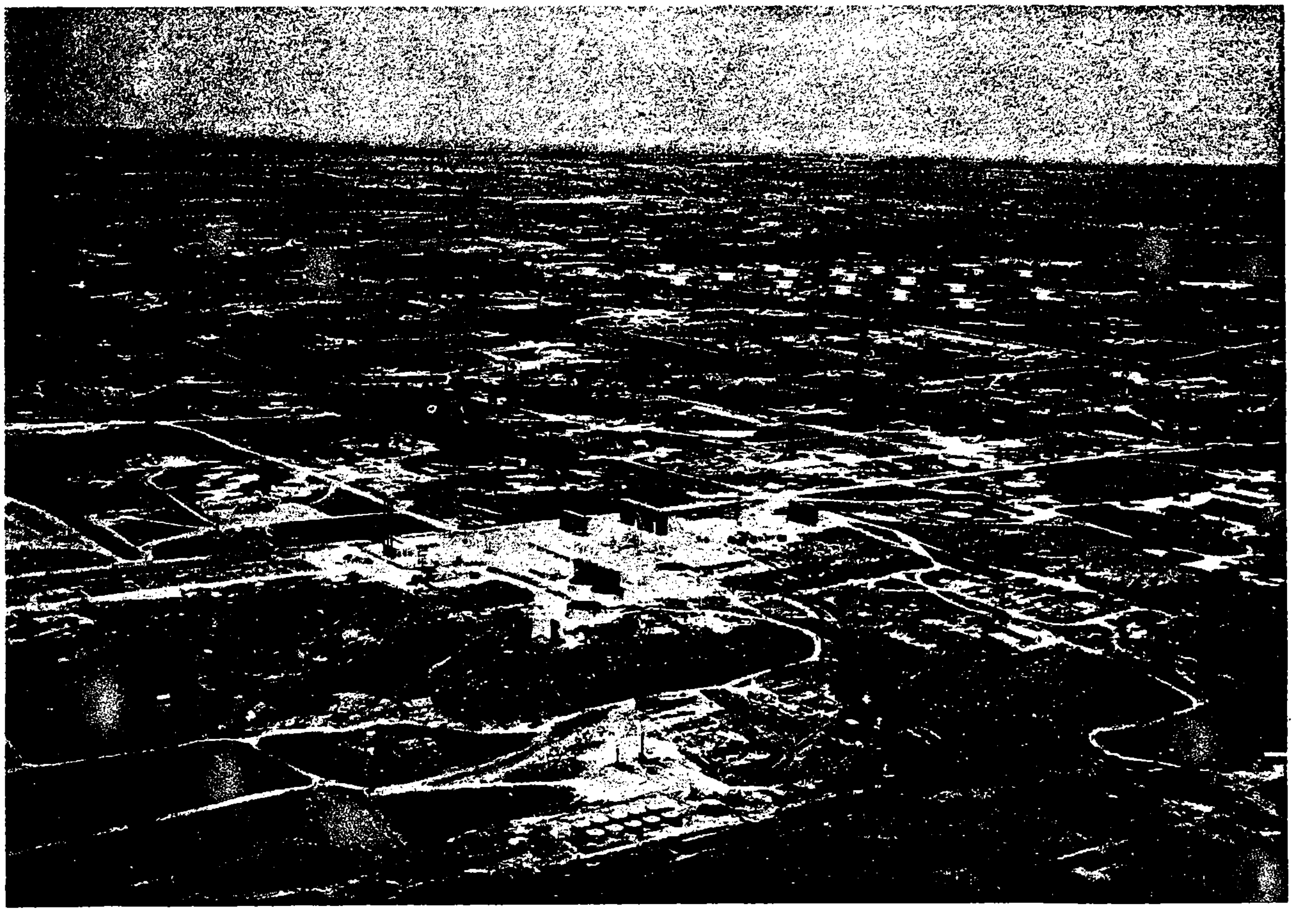

FIGURE 2. *An oil field in central Oklahoma. Each derrick marks a drilled well. In foreground is a natural gasoline plant, and in background are many storage tanks. Oil and gas are Oklahoma's most important mineral resources. In 1958 we produced 200 million barrels of oil valued at $3 per barrel or a total of 600 million dollars. In the same year we produced 700 billion cubic feet of natural gas valued at 64 million dollars.*

(U. S. Army Air Corps photograph)

The average value of all mineral production in Oklahoma for the years 1957-1959 is about $775 million per year. Oil, gas, natural-gas liquids, and natural gasoline (figs. 1, 2) have the greatest production and value, but also produced in substantial quantities are coal, lead, zinc, limestone (fig. 3), granite, sand and gravel, portland cement, and gypsum. Ranked nationally, Oklahoma is the third leading producer of natural gas and the fourth leading producer of oil and natural-gas liquids. Production and value of mineral commodities in Oklahoma for 1957 and 1958 are given in table I.

In 1959 Oklahoma became a producer of helium, which is recovered from natural gas in the Panhandle. By the end of 1960 it is expected that Oklahoma will be the leading state in the production of this lightweight noninflammable gas.

Geologic History of Oklahoma

THE origin of and occurrence of rocks, minerals, and fossils are results of geologic processes that have been at work since the formation of the earth. We are interested in these processes and especially in how, during the geologic past, they have helped in the building of Oklahoma.

Table I.—Mineral Production in Oklahoma, 1957-58[1]

	1957		1958	
	Short tons (unless otherwise stated)	Value (thousands)	Short tons (unless otherwise stated)	Value (thousands)
Asphalt, Native (thousand short tons)	[2]	[2]	43	$ 203
Clays (thousand short tons)	641	$ 642	576	579
Coal (thousand short tons)	2,195	14,165	1,629	10,858
Lead	7,183	2,054	3,692	864
Natural gas (million cubic feet)	719,794	59,743	732,100	70,347
Natural-gas liquids:				
Natural gasoline and cycle products (thousand gallons)	460,644	25,329	441,104	26,029
LP-gases (thousand gallons)	587,140	21,824	657,047	25,822
Petroleum, Crude (thousand 42-gallon barrels)	214,661	650,423	202,699	599,989
Pumice (thousand short tons)	[2]	[2]	[2]	[2]
Salt, Common (thousand short tons)	7	63	4	41
Sand and gravel (thousand short tons)	4,960	4,507	7,232	5,859
Stone (thousand short tons)	12,016	14,064	10,794	12,232
Tripoli	22,236	67	[2]	[2]
Zinc	14,951	3,469	5,267	1,074
Value of items that cannot be disclosed:				
Clay (bentonite), cement, gypsum, lime, manganese (1957)	....	14,573		15,819
Total[3]		$809,004		$767,856

[1] Production as measured by mine shipments or mine sales (including consumption by producers).
[2] Included with "Value of items that cannot be disclosed."
[3] Total adjusted to avoid duplicating values of clays and stone.

FIGURE 3. *Crushed limestone is important as an aggregate in the building of roads, dams, bridges, and buildings. Each year about 10 million tons valued at $12 million is produced in Oklahoma. Shown above is the large quarry and plant of the Dolese Bros. Company at Richards Spur near Lawton.*

(U. S. Army photograph)

Geologic time throughout the world is expressed by a "Geologic Time Chart," in which names are given to rocks according to their age (table II). Major divisions of time are called eras. The oldest rocks belong to the Precambrian era, when primitive forms of life first appeared upon the earth. Successively younger eras are the Paleozoic, Mesozoic, and Cenozoic. During these stages of time, various forms of life developed slowly and produced the more complex plants and animals that we know now.

Throughout the long span of geologic time, Oklahoma has been built up by a succession of rocks beginning in Precambrian time and continuing through the Paleozoic, Mesozoic, and Cenozoic eras. At different times in the past, the area that is now Oklahoma was first a vast field of volcanoes, then a region that was completely covered by ocean waters, except for a few islands and low-lying coasts, and finally it emerged as a part of the North American continent.

The first chapter in the geologic history of Oklahoma was the formation of granites and other rocks formed from molten material in Precambrian time. These rocks are at the surface in the Arbuckle and Wichita Mountains, and they extend beneath the surface throughout the State as a "basement rock" on which younger deposits rest. The Precambrian rocks are generally less than a mile below the surface in northeastern Oklahoma, but they are five or six miles deep in parts of western and southern Oklahoma.

In the Arbuckle Mountains the granites are 1,350,000,000 years old. They are our oldest rocks. This number—one billion three hundred and fifty million—is so large that it is difficult to understand. If you start counting with the number one and count at the rate of one number per second,

TABLE II.—GEOLOGIC TIME CHART

Eras		Periods and Epochs	Life	
CENOZOIC	QUATERNARY	RECENT	Age of man	Age of Mammals
		PLEISTOCENE		
	TERTIARY	PLIOCENE	Mammals increase, reptiles decrease, birds abundant, horse develops.	
		MIOCENE		
		OLIGOCENE		
		EOCENE		
		PALEOCENE		
MESOZOIC		CRETACEOUS	Dinosaurs abundant, and birds increase. Deciduous trees and ferns.	Age of Reptiles
		JURASSIC	Dinosaurs, a few mammals, and first bird. Ferns and conifers abundant.	
		TRIASSIC	First dinosaurs and first mammal. Ferns, rushes, and conifers.	
PALEOZOIC		PERMIAN	Amphibians abundant, fin-backed reptiles, true conifers, and scale trees.	Age of Amphibians
		PENNSYLVANIAN	Cockroaches, large insects and amphibians. First reptiles and land snails. Scale trees and ferns.	
		MISSISSIPPIAN	Fishes, amphibians, and crinoids. Scale trees and ferns.	
		DEVONIAN	Fishes abundant, amphibians appear, scale trees develop.	Animal Life in Oceans
		SILURIAN	Fishes and air-breathing animals appear. Land plants.	
		ORDOVICIAN	Graptolites and corals. Algae in oceans.	
		CAMBRIAN	Trilobites abundant. Plant life in oceans.	
PRECAMBRIAN			Fossils few. Life consists of simple one-celled animals and low-order plants.	

day and night, it would take you 42 years to finish. Then remember that you are dealing with rocks measured in years, not seconds, and you will begin to realize the truly ancient age of the Arbuckle Mountain granites.

Some of the granites and the rhyolitic lava rocks of the Wichita Mountains (fig. 4) are much younger, about 500 million years old. They are a part of the basement rock series that underlies much of Oklahoma. In the Wichita Mountains are many pink and gray granites which are extensively quarried for monuments and building stone.

FIGURE. 4. *Mount Scott, a granite mountain that stands more than 1,000 feet above the surrounding plain and rises to an altitude of 2,464 feet, is the tallest in the Wichita Mountains. Nearby are many granite quarries.*

Beginning in Cambrian time, and continuing through the Paleozoic era, most of the area of Oklahoma was covered by inland seas. Into these seas were brought thick deposits of sand, clay, and lime mud; and these deposits were consolidated into sandstone, shale, and limestone having a total thickness of about eight miles or 40,000 feet (fig. 5). Animals such as brachiopods and trilobites (fig. 6) lived in the sea water, and their shells or imprints are preserved as fossils in the consolidated rocks.

Rocks of Paleozoic age are the most important to us. They crop out over about 75 percent of Oklahoma, and they occur in all areas even though covered by younger deposits. These rocks contain practically all the gas, oil, coal, lead, and zinc in the State. Also produced are clay, limestone, gypsum, and glass sand which are used for making bricks, portland cement, crushed stone, plasters, wall board, lime, and glass products.

Ancient seas also covered much of Oklahoma during the Mesozoic age. Rocks of this age occur in the Panhandle and in the southeastern area along Red River. They contain the bones of dinosaurs and the shells of fossil sea urchins and large cephalopods that nowhere are found in older rocks.

FIGURE 5. *View of Rich Mountain in southern Le Flore County. Massive steeply dipping sandstone beds of Mississippian age form this hogback ridge. It rises 1,800 feet above the valley in foreground to an altitude of 2,800 feet at the top. Rich Mountain is the highest point in the Ouachita Mountain region of southeastern Oklahoma.*

A great uplift in the central part of the North American continent about 65 million years ago elevated the Rocky Mountains and drove the seas southeastward out of Oklahoma. Sediments laid down since that time, during the Cenozoic age, are mostly sand, clay, and gravel deposited in streams and lakes. Fossil bones of camels, elephants, horses, and saber-toothed cats have been found in these sediments, mostly in western Oklahoma.

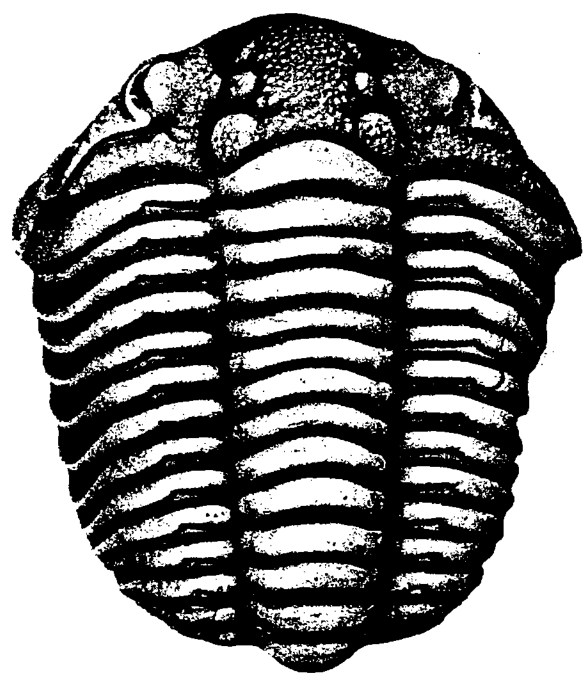

FIGURE 6. *A trilobite*—Calymene—*from the Henryhouse limestone (Silurian) in the Arbuckle Mountains. Fossils of this kind are distant relatives of crabs and lobsters, and are found only in sedimentary rocks deposited in salty sea water. Twice natural size.*

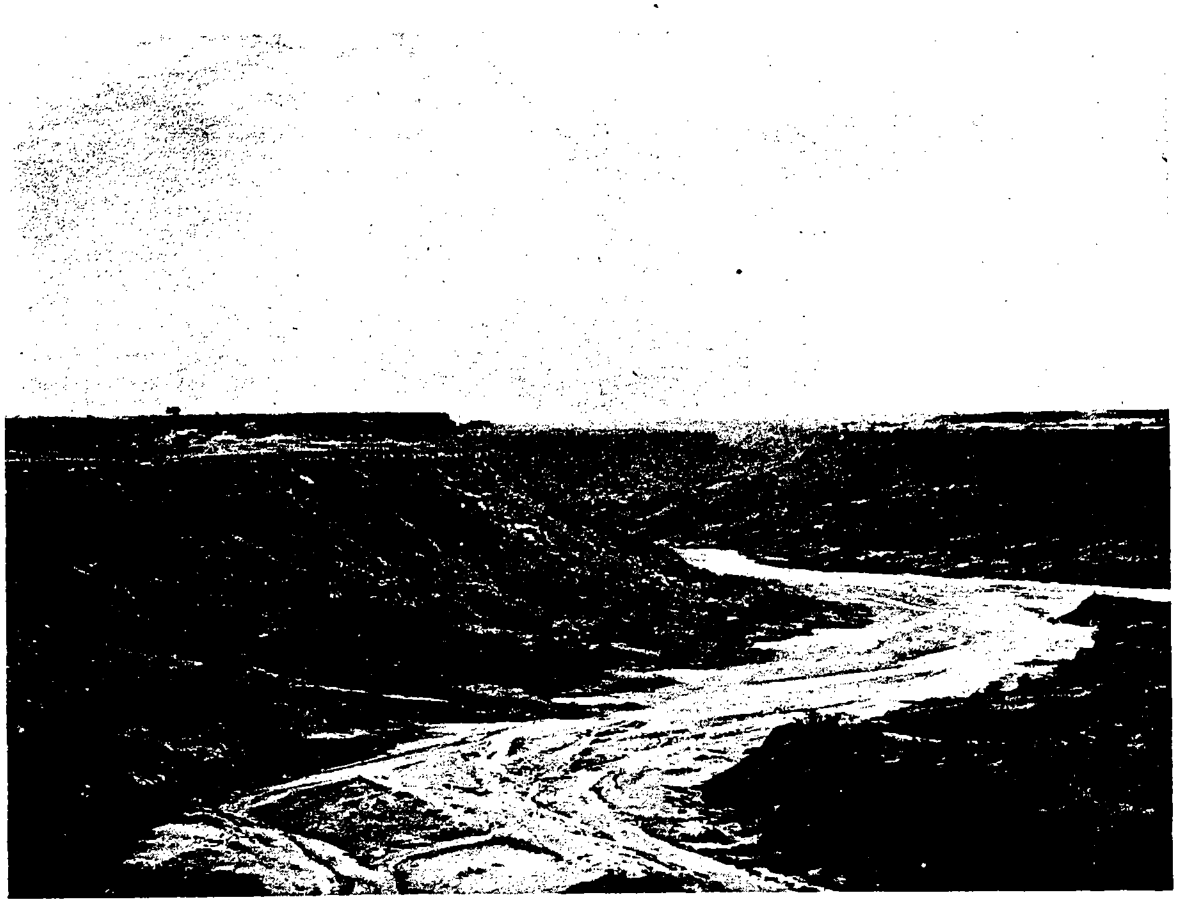

FIGURE 7. *Salt Creek Canyon, Blaine County. White ledges of horizontally bedded gypsum make prominent escarpments in many parts of western Oklahoma. These beds occur now just as they were deposited from inland seas of Permian age about 225 million years ago.*

Minerals

A MINERAL, according to scientific definition, is a natural inorganic substance with a characteristic chemical composition. Nearly all minerals have a definite geometrical arrangement of component atoms, and because of this property they may, under favorable conditions of growth, attain smooth planes called *crystal faces.* Such forms of minerals are called *crystals.*

Most minerals are deposited from water solutions. The principle of deposition of minerals from solution is shown by the evaporation of salt water. After a certain amount of water has evaporated, some salt crystals will precipitate. This phenomenon occurs because there is more salt present than the remaining amount of water can dissolve, so the excess is precipitated. The same conditions occur in nature. Mineral salts are contained in sea water, in streams, and in water stored within the earth. When any of these waters evaporate, the excess materials are deposited. It is known that in the geologic past vast amounts of halite (rock salt), gypsum, and limestone were precipitated from seas which had invaded the continents. Materials deposited in this manner composed an important part of the rocks known in Oklahoma (fig. 7).

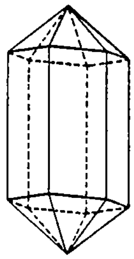

FIGURE 8. *Quartz crystal. Idealized drawing of a perfectly formed six-sided crystal that grew from a natural water solution.*

Mineral-bearing solutions may be hot, having been heated at some depth below the surface of the Earth. Many of these solutions consist mainly of hot water with a small amount of dissolved minerals. Some hot solutions consist of molten rock, or *magma,* like that of lava from volcanoes. The cooling of these solutions results in the precipitation of minerals.

1. *Milky quartz* occurs generally in the form of irregular veins. It is locally abundant as veins cutting sandstone in McCurtain County of the Ouachita Mountain region, and as veins cutting granites in the Wichita Mountains of southwestern Oklahoma. This mineral variety is distinguished from other types of quartz by its cloudy white appearance. Along its edges, small well-developed crystals of clear quartz may be found in some specimens (figs. 8, 9). All varieties of quartz have: the same chemical composition (SiO_2); a vitreous or glassy luster; a hardness of 7.0, so that they easily scratch glass or steel; a specific gravity of 2.65; and a pronounced conchoidal or shell-like fracture.

2. *Chert* has a dull luster and normally is gray, brownish, greenish, or black. It is a fine-grained or cryptocrystalline variety of quartz, found chiefly in the form of nodules or beds associated with limestone or shale. It is abundant in the zinc-lead ores of Oklahoma, where the crushed chert is recovered from the lead and zinc concentrates and sold for various construction purposes. Much chert occurs in the Ouachita Mountains, Ozark region, and Arbuckle Mountains of Oklahoma.

Chert is also found in the form of pebbles, both in present and past stream channels, and in conglomerates deposited near the shore lines of ancient seas.

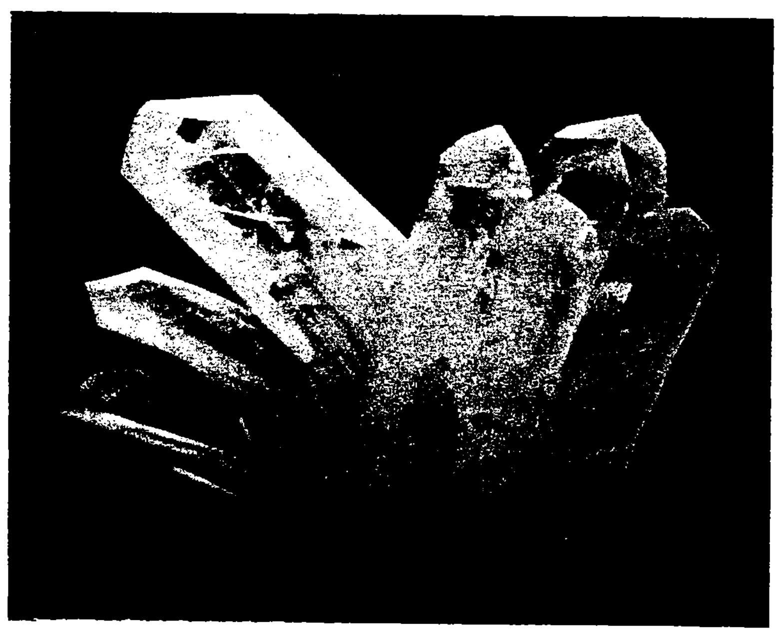

FIGURE 9. *Cluster of quartz crystals from the Ouachita Mountains, from the collection of Dr. H. D. Miser. The six-sided crystals grew outward from a common base, each terminating in a set of small faces that meet at a sharp point. One-half natural size.*

3. *Calcite* is made of calcium carbonate, $CaCO_3$. It is found in many crystal forms (fig. 10) and many colors. It has vitreous or glassy luster, white streak, hardness of 3, specific gravity of 2.72, and perfect three-way cleavage which produces six-sided solids (rhombohedrons) that resemble distorted cubes. A drop of dilute hydrochloric acid applied to calcite will effervesce vigorously, because of the liberation of carbon dioxide gas.

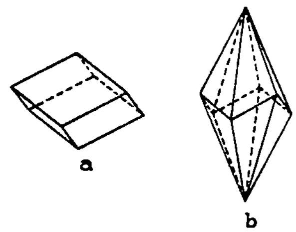

FIGURE 10. *Calcite crystals. On the right (b) is a scalenohedron, known as "dog-tooth spar" in the zinc district of northeastern Oklahoma. On the left (a) is a rhombohedron, the most common crystal form of calcite. All cleavage fragments of calcite have a rhombohedral form, regardless of the shape of the original crystal.*

Calcite crystals are found with the zinc-lead ores of Ottawa County, where they are known as "dog-tooth" or "nailhead" spar. Calcite is the most important constituent of limestone, found in many parts of Oklahoma; and in these limestones, veins and small crystals of calcite may generally be found. Thin veins of calcite also occur in the igneous rocks of the Wichita Mountains.

4. *Selenite,* or crystallized gypsum (fig. 11), is colorless and shows good cleavage in three directions. Although resembling some varieties of mica, for which selenite may be mistaken, a careful examination will quickly reveal several differences. Whereas mica can be bent, and will spring back upon release of pressure, selenite cannot be bent far without breaking. Furthermore, mica can be split only into thin leaves, but gypsum will cleave along three different planes, yielding flat plates having the outline of a parallelogram. There is also a vast chemical difference, mica being a silicate mineral whereas gypsum is a sulfate mineral.

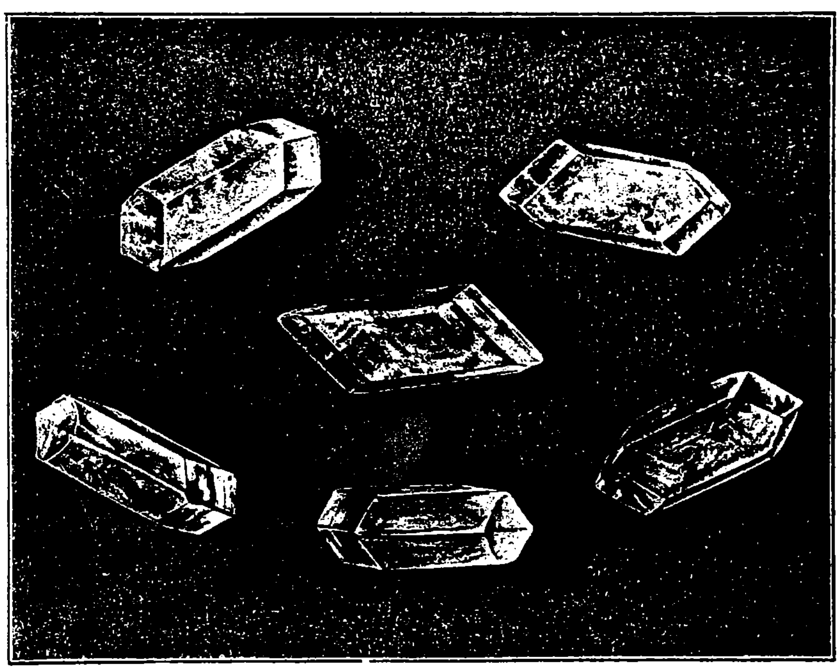

FIGURE 11. *Selenite crystals from western Oklahoma. These transparent crystals of pure gypsum are deposited by ground water that has flowed through beds of rock gypsum.*

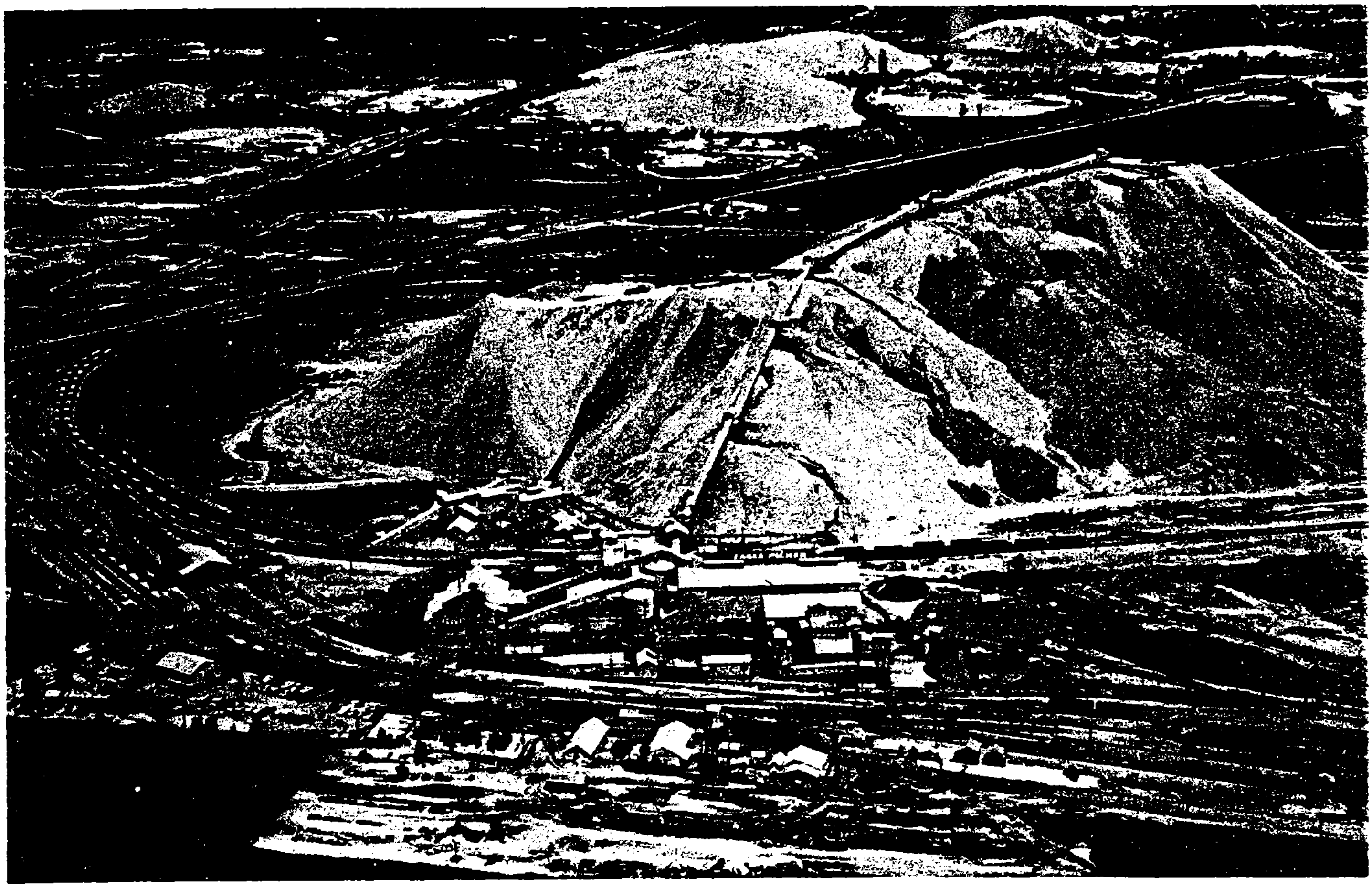

FIGURE 12. *Zinc mining near Miami, Ottawa County. The large piles are of waste rock or chat from which zinc and lead ores have been milled. In foreground is the central mill of the Eagle-Picher Company. From 1918 onward through the 1920's, Oklahoma was the leading zinc producer in the United States, yielding one-third to one-half the annual national total. Peak production of 283,000 tons of zinc metal was reached in 1925, and Oklahoma was the greatest zinc producer in the world.*

The physical properties of selenite are as follows: streak white; hardness 2.0 (can be scratched with a fingernail); specific gravity 2.32. Selenite is found in veins and seams in the Permian rocks of western Oklahoma, in association with bedded deposits of rock gypsum.

5. *Magnetite* is iron oxide (Fe_3O_4). It has the following physical properties: metallic luster; black streak; hardness 5.5-6.5; specific gravity 5.16-5.18; cleavage not distinct but structure generally massive or granular; color iron-black. Some types of magnetite (lodestones) are naturally magnetic, and some are not, but all specimens are strongly attracted to a magnet. Magnetite is an important ore of iron. The Oklahoma deposits, which occur in the Wichita Mountains, are small in comparison with the size of the present-day workable deposits.

6. *Hematite* is iron oxide, Fe_2O_3. It has the following physical properties: metallic to earthy luster; reddish-brown streak; hardness 5.5 to 6.5; specific gravity 4.9 to 5.3. The color of some types of hematite is blackish-red but normally it is reddish-brown. There is a large hematite deposit north of the Wichita Mountains and northwest of Lawton in a sandstone bed. Here the hematite has an *oolitic,* or fish-egg, structure, because it is in the form of thin layers which coat the sand grains and cement them together. This deposit has been worked in the past for making a red paint pigment.

7. *Limonite,* or brown iron ore, is a hydrous iron oxide, $Fe_2O_3;nH_2O$. It has the following physical properties: silky to dull and earthy luster; yellowish-brown streak; hardness 5.0; specific gravity 4.0; earthy, solid, or cellular structure. Limonite is brown to brownish-yellow. It occurs in small quantities throughout the State, but it is particularly abundant in the eastern part of the Arbuckle Mountains in Johnston County. In some places in the world limonite is used extensively as an iron ore. Limonite deposits of the Appalachian region, Missouri, and elsewhere supplied the American steel industry until extensive mining of the Lake Superior hematite deposits began in 1854.

FIGURE 13. *Well-formed cubic crystals of galena from Picher, Ottawa County, Oklahoma. These crystals grew slowly in an open cavity from ore-bearing solutions that carried lead and sulfur. One-half natural size.*

8. *Galena* is a lead sulfide (PbS). It has the following physical properties: metallic luster; lead-gray streak; hardness 2.5; specific gravity 7.5; lead-gray color; and perfect cubic cleavage. Galena is the most important ore of lead. It occurs in Oklahoma as an ore in the lead-zinc district of Ottawa County (figs. 12, 13). Small amounts are found in the limestones of northeastern Oklahoma and in the Arbuckle Mountains, and in certain metalliferous veins of the Ouachita and Wichita Mountains.

9. *Sand-barite rosettes* (fig. 14) result from the growth of barite crystals in sandstone. Barite is barium sulfate ($BaSO_4$). It was precipitated from sea water while sandstone was being deposited, the barite growing in the form of simple or compound tabular crystals. The rosettes now occur as individuals scattered through loosely consolidated sandstone beds. When the sand grains are washed away by rain, the heavy barite concretions are left behind on the surface. The rosette superficially resembles a rose. It is not a fossil of any kind, however, but is a concretionary form of a well-known mineral. Sand-barite rosettes are uncommon throughout the world, and the central Oklahoma localities have become famous for mineral collecting.

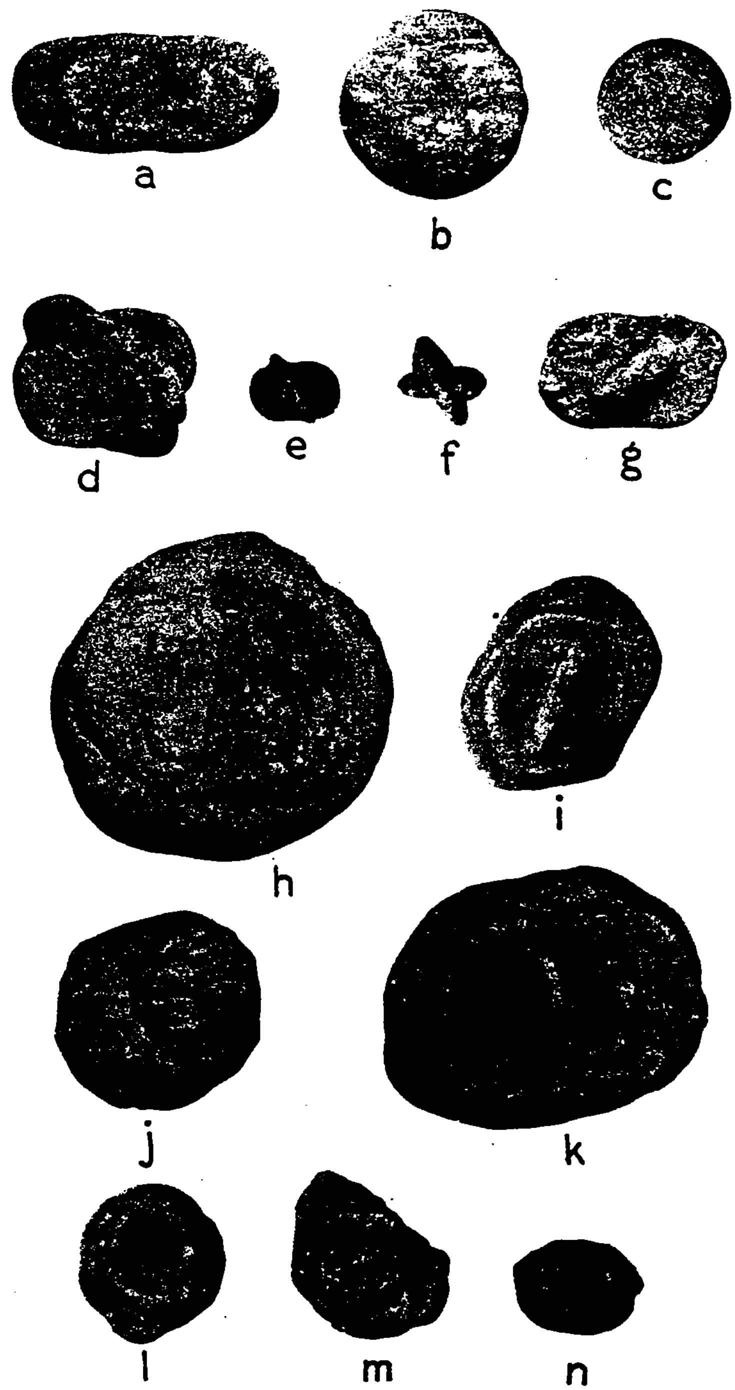

FIGURE 14. *Sand-barite rosettes from Permian sedimentary rocks in central and southwestern Oklahoma. The shape of the rosette is determined by the number of tabular barite crystals and their arrangement. Some consist of a simple tablet (c), two interpenetrating tablets (d, e, f, g), or compound rosettes (h, i, j, k). Specimen* m *is a rosette of pure barite; all others are barite incorporating 50 percent sand. All figures ¾ natural size.*

FIGURE 15. *A small granite quarry. Blocks are cut from many quarries in the Wichita Mountains near Snyder and Granite, and from one quarry in the Arbuckle Mountains near Mill Creek. The large blocks are sawed into slabs and then polished for monuments and building trim.*

Rocks

A ROCK is a compacted aggregate of minerals. Three great groups of rocks are recognized: (1) igneous, (2) sedimentary, and (3) metamorphic. Within each group there are hundreds of types of rocks, each being classified principally according to its mineral composition and texture.

Igneous rocks are formed from a hot liquid called magma, and undoubtedly the first rocks formed on the Earth were of this type. Sedimentary rocks have been derived from them by weathering, and metamorphic rocks have been formed from both types by heat and pressure.

Representatives of each rock type are known in Oklahoma. Most common at the surface are sedimentary rocks, which cover more than 95 percent of the State. Igneous and metamorphic rocks occur in the Wichita Mountains, Arbuckle Mountains, Ouachita Mountains, and in a small area near Spavinaw, Mayes County. Igneous rocks are present under the ground in all parts of the State, forming, together with metamorphic rocks, a "basement complex" upon which the younger sedimentary rocks have been deposited.

Igneous Rocks

The word *igneous* means "of fire" or "born of fire." This term is applied to all rocks which have cooled from magma, a hot silicate melt that originates in the crust of the Earth. When magma comes to the Earth's surface from volcanoes or from underground chambers, it is known as *lava.*

The geologic classification of igneous rocks is based chiefly on mineral composition and texture.

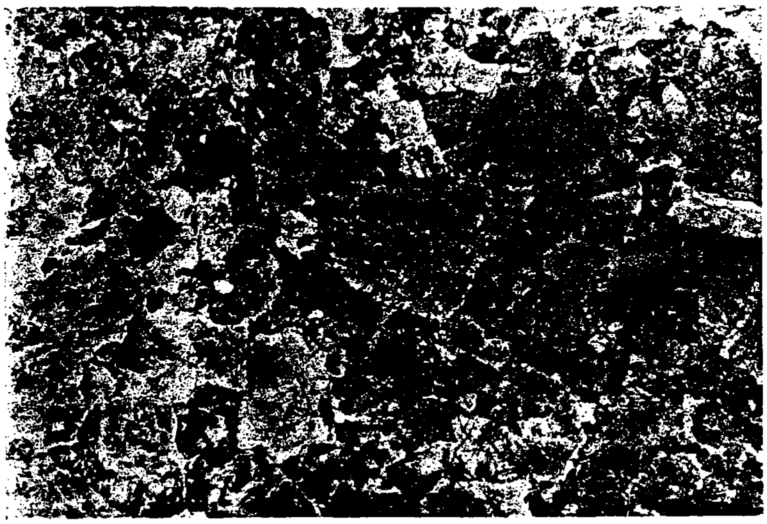

FIGURE 16. *Polished surface of coarse-grained granite from the Wichita Mountains. The smaller clear grains are quartz; they are enclosed by larger grains of feldspar. Photograph is 1.5 natural size.*

10. *Red granite.* Granite (fig. 16) is the most abundant of all igneous rocks. It is a medium- or coarse-grained rock composed chiefly of orthoclase feldspar and quartz. It is formed within the crust of the Earth by slow cooling of magma, the slow rate of cooling allowing the growth of relatively large mineral grains. Red granite is abundant and is extensively worked in the Wichita Mountains and Arbuckle Mountains of Oklahoma. Value of the marketed stone is about $600,000 per year. Polished granite from Oklahoma is sold widely throughout the United States.

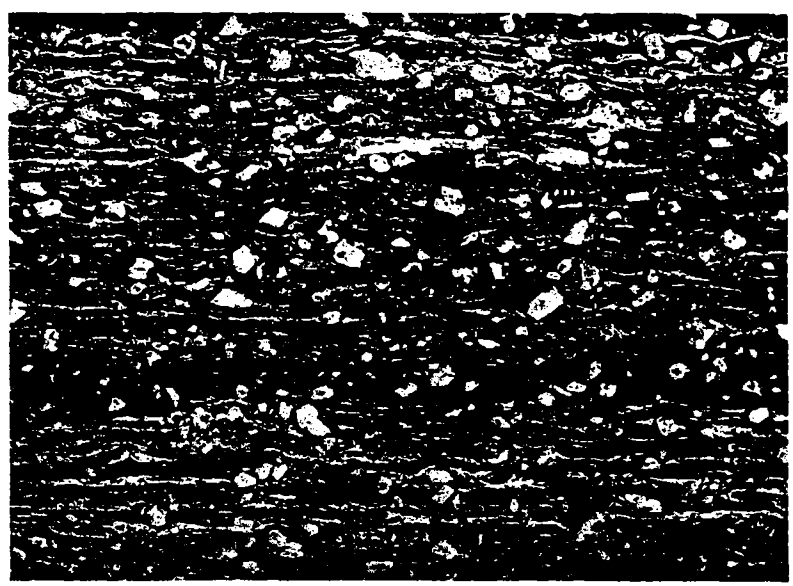

FIGURE 17. *Rhyolite from the Arbuckle Mountains. The light-colored crystals of feldspar are embedded in a strongly banded groundmass of fine-grained quartz and feldspar. This is an ancient lava rock, extruded as thick deposits upon the land before the first Paleozoic seas invaded Oklahoma. Natural size.*

11. *Rhyolite* (fig. 17) is a fine-grained rock of the same mineral composition as granite. It differs from granite only in its having a finer texture; granites cooled slowly at considerable depths, whereas rhyolite cooled rapidly near or upon the Earth's surface. There are several rhyolites cropping out in Oklahoma. One of them is known as the *Colbert porphyry,* which occurs in the East and West Timbered Hills of the Arbuckle Mountains, near Turner Falls, south and west of Davis, Murray County. Here the rock is brick-red and strongly fractured, and contains medium-sized crystals (phenocrysts) of quartz and feldspar surrounded by a fine-grained *groundmass.* Similar rocks occur at Medicine Bluff and Saddle Mountain in the Wichita Mountains.

Sedimentary Rocks

Sedimentary rocks are formed by the weathering and breaking down of igneous, metamorphic, or other sedimentary rocks. The fragments of rock produced by weathering are then transported by water, wind, or ice. This material is then deposited, compacted, and cemented to form a sedimentary rock. Most sedimentary rocks in Oklahoma were deposited in ancient seas.

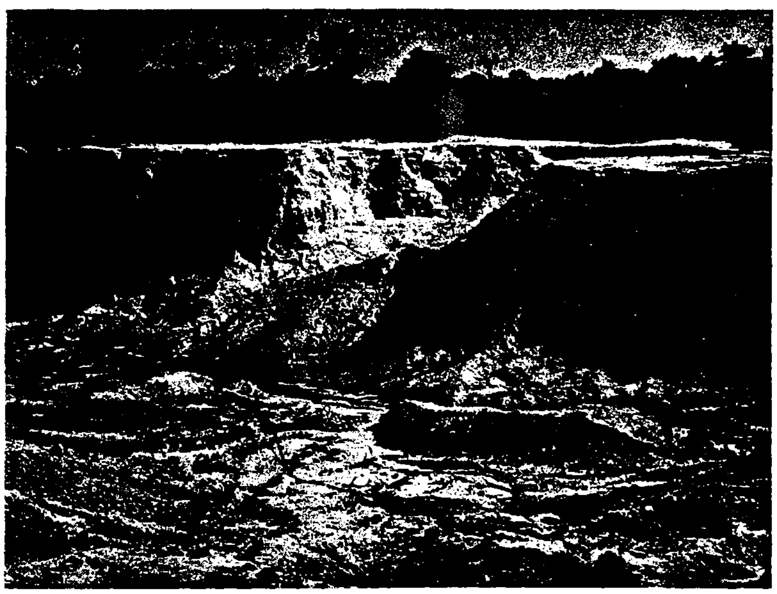

FIGURE 18. *Sandstone beds of Ordovician age in the Arbuckle Mountain region. The white sand is made up almost entirely of quartz grains, and the deposit is nearly pure silica. Worked in a quarry face 65 feet high by the Pennsylvania Glass Sand Corporation at Mill Creek, Johnston County, the sand is used extensively for making glass.*

12. *Sandstone* is composed mainly of quartz sand grains which have been derived from older rocks and transported to a sea, lake, or beach. Common colors are red, brown, and gray. Red and brown colors are due to iron oxides, hematite and limonite, in the cement. Sandstones are abundant throughout Oklahoma, and where they are well consolidated and well bedded, they are used as building stone. Deep under the ground in Oklahoma, sandstone beds are important reservoir rocks for oil and gas.

Thick beds of pure white sandstone in the Arbuckle Mountain region have been worked for fifty years as a source of high-purity silica sand for making glass (fig. 18). The manufacture of bottles, containers, and window glass is an important industry in Oklahoma.

13. *Limestone* is a rock made up largely of calcium carbonate, the mineral calcite. Both animals and plants contribute to the building of many limestones. The St. Clair limestone, exposed at Marble City, Sequoyah County (fig. 19), is composed of medium-sized or coarse crystals of calcite together with fragments of several kinds of fossils. It is a high-grade stone used in the manufacture of lime. Even-textured limestone that will take a polish is known to the stone industry as "marble."

In many parts of Oklahoma limestone is crushed and used extensively for making concrete structures and roads. It also is used as a building stone.

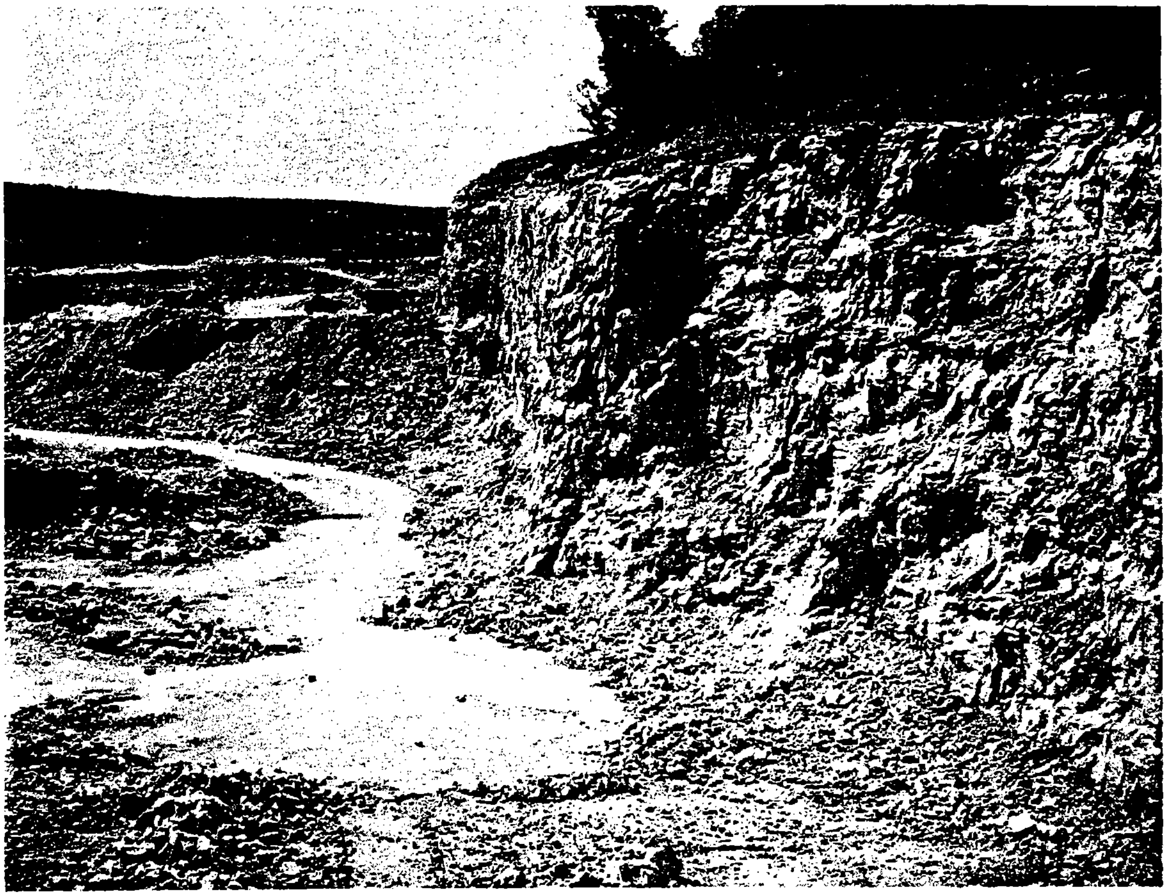

FIGURE 19. *High-purity limestone in quarry face of St. Clair Lime Company, Marble City. High-purity limestone is needed for making chemicals that help purify water and to make steel, glass, aluminum pans, and acetylene. Most of the stone is now worked from an underground mine.*

14. *Shale* is a fine-grained sedimentary rock. Clay minerals and quartz are the more abundant constituents; they have been derived from the weathering of older rocks and carried in suspension by water. The particles were later deposited in seas or lakes, and on deltas, and still later they were compacted into rock.

Shales are characterized by being plastic when wet and by being thinly bedded. They may have any color from white to black, but gray, green, red, and black are more common.

The raw material for brick, tile, and pottery is provided by shale; it is also a basic material for the manufacture of cement (fig 20). Oklahoma shale is used extensively for making these products.

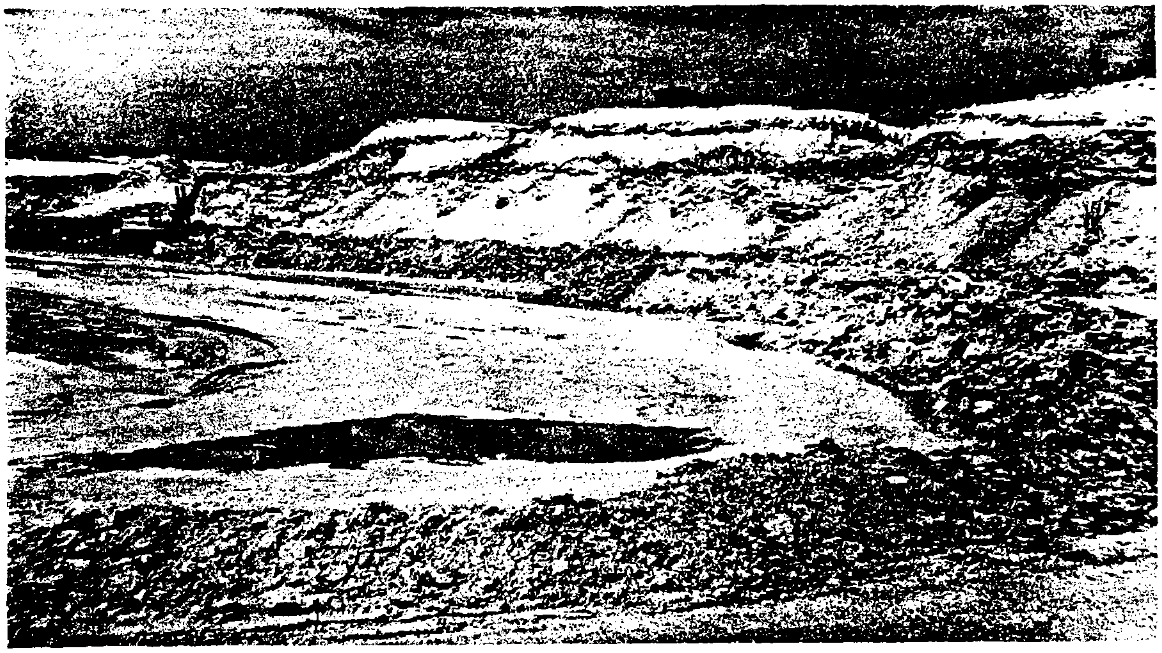

FIGURE 20. *Shale quarry of the Ideal Cement Company, Lawrence, Pontotoc County. Nearly 100 feet of shale, capped by white limestone, is worked in the quarry face. It is mixed with limestone and burned to make portland cement. Shale is also extensively used in Oklahoma for making vitrified brick and tile.*

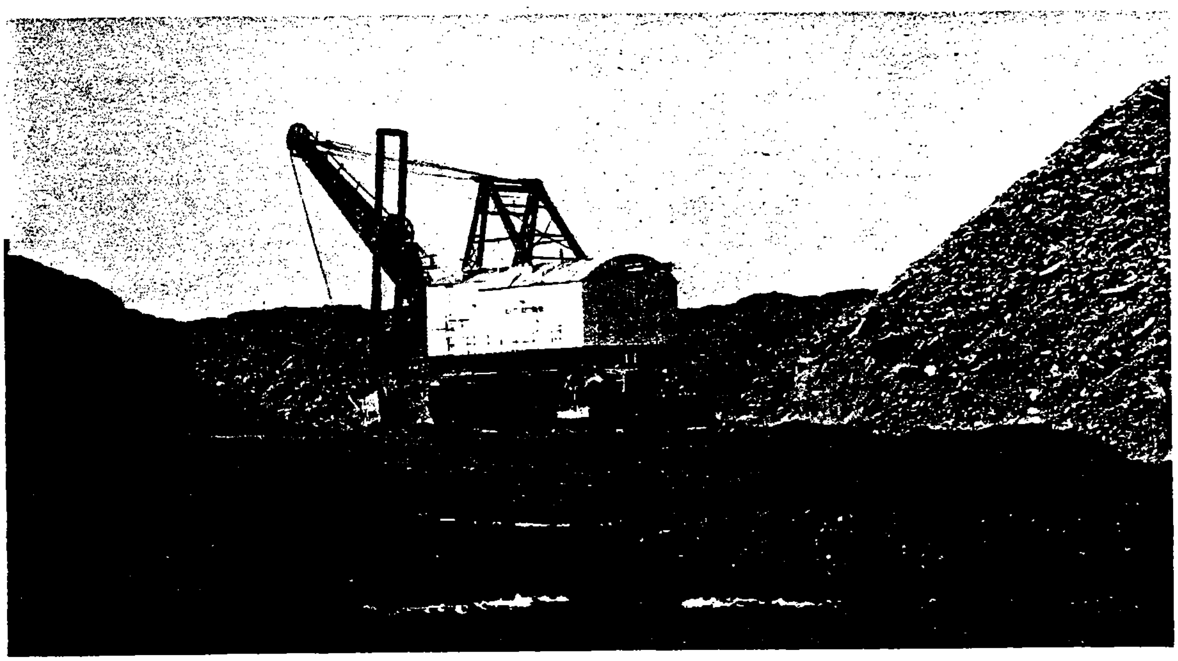

FIGURE 21. *Production of coal by strip mining in northeastern Oklahoma. The overburden of shale and sandstone above the coal seam—the black band seen on the floor in the foreground—is removed or "stripped" by powerful shovels and draglines. Coal has been produced in Oklahoma since 1872, and is the first mineral mined in the State. Production from the 12 leading counties for the past 87 years has totalled 180 million tons valued at 550 million dollars.*

15. *Coal* is natural carbonaceous rock, derived from vegetable matter, which has undergone certain chemical and physical changes. Vegetable matter is known to have contributed to the formation of coal because some coal contains well-preserved leaves and stems of plants. It is also believed that this woody material accumulated slowly under water in swamp-like areas, free from air, before being covered by later sediments.

The kind of coal formed depends upon the amount of pressure to which the rocks were subjected. Soft, or *bituminous,* coal has been only slightly metamorphosed, whereas hard coal, or *anthracite,* has been subjected to high pressures, and has undergone resulting changes which drove off contained gases and other volatile matter, leaving almost pure carbon.

Oklahoma coals are mostly of the bituminous variety, but near the Arkansas line the folding of the rocks has been greater and the coal in that region is of a higher or semi-bituminous grade. The coal seams are mined either by surface stripping (fig. 21) or by underground mining. Annual production is about two million tons.

16. *Rock gypsum* is a relatively soft rock that occurs in great abundance in twelve counties of western Oklahoma, where it was deposited from the saline waters of ancient Permian seas. Some deposits are 15-100 feet thick and are of considerable economic importance (fig. 22). They are used in making plaster of paris, special cements, sheet rock, portland cement, and many other products. Four quarries in western Oklahoma produced 450,000 tons of rock gypsum in 1959.

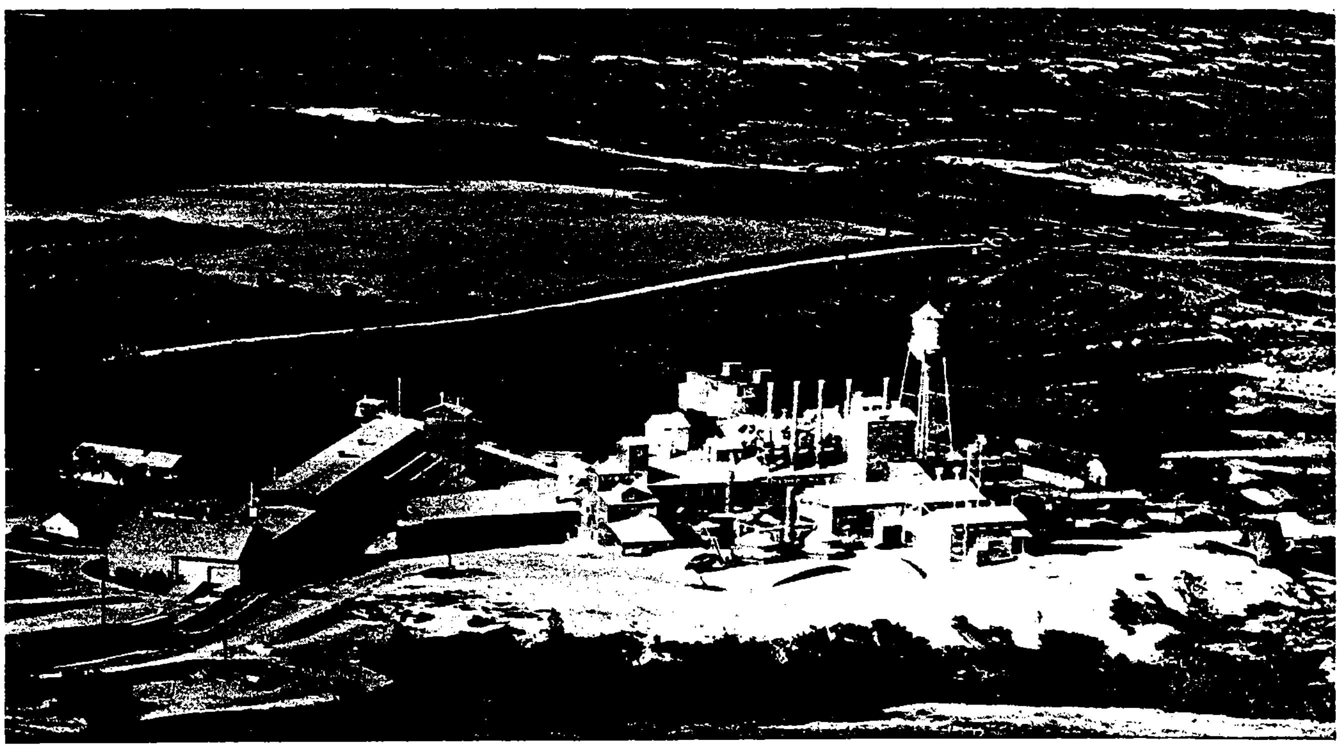

FIGURE 22. *Plant of United States Gypsum Company at Southard, Blaine County. Two ledges of gypsum are blasted from open-face quarries such as the one seen as a narrow white band just above and back of the water tank. Gypsum is made of calcium sulfate with chemically combined water. Part of the water is given off when heated, and the stone is easily powdered, but when water is added again it becomes a plaster and hardens on drying. Nearly pure rock gypsum at the Southard plant is used to make nearly 200 different products.*

(Aerial photograph courtesy of U. S. Gypsum Company)

Metamorphic Rocks

Metamorphic rocks are those which have been changed by heat and high pressure. The principal change is recrystallization, which causes the grains to become larger.

17. *Quartzite* is one of the few types of metamorphic rocks known in Oklahoma. It occurs only in the Wichita Mountains, near the town of Meers, Comanche County. It is dull gray and is composed essentially of quartz grains thoroughly cemented by silica. The explanation for its metamorphism is that the sandstone was intruded, at depth, by a magma which recrystallized the sandstone to a quartzite.

In general, a quartzite is harder and more compact than a sandstone; a quartzite will break through the grains as well as through the cement. A sandstone breaks through its cement, around the sand grains.

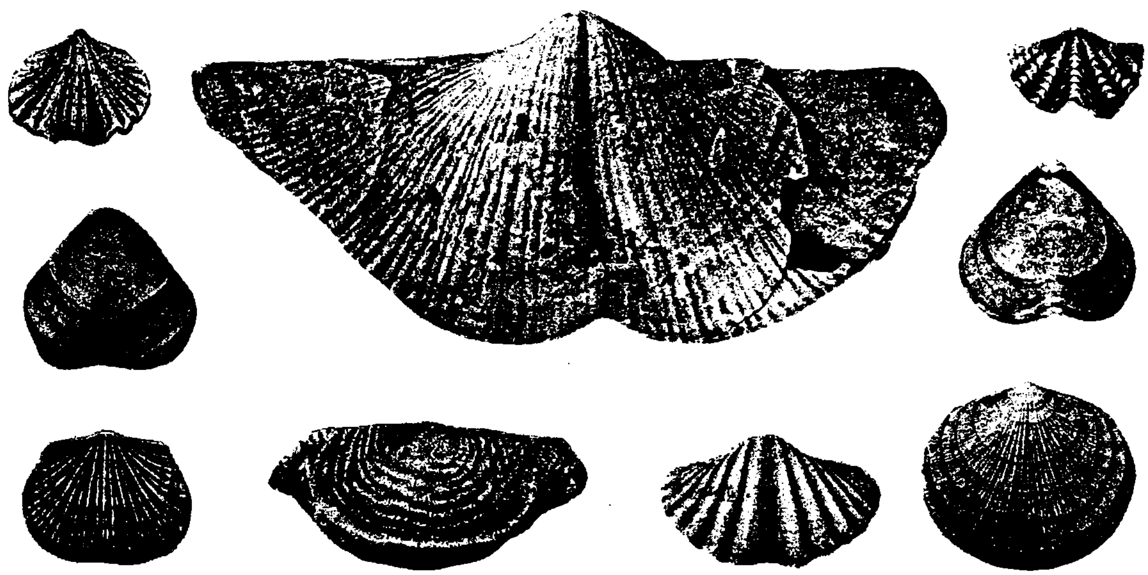

FIGURE 23. *Brachiopods from ancient marine limestones of Oklahoma. Largest specimen is from the Mississippian of northeastern Oklahoma; smaller specimens are from Silurian and Devonian limestones of the Arbuckle Mountains. Natural size.*

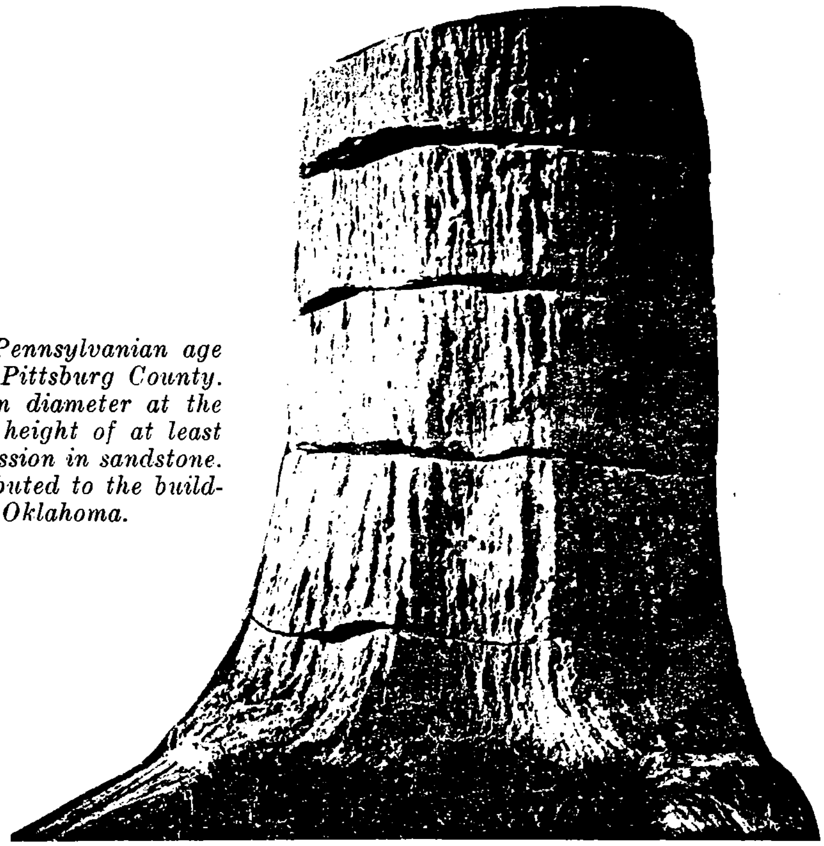

FIGURE 24. *Fossil tree trunk of Pennsylvanian age from a coal mine near McAlester, Pittsburg County. Measuring more than three feet in diameter at the base, the tree probably grew to a height of at least 50 feet. It is preserved as an impression in sandstone. Fragments of trees like this contributed to the building of coal seams in eastern Oklahoma.*

Fossils

A FOSSIL consists of a skeleton, a shell, an imprint, or any other evidence of *prehistoric life*. There are two principal requirements in the definition of a fossil: it must be some form or evidence of the former existence of life, either plant or animal; and it must have lived and died before historical records were first kept by man.

18. *Brachiopods* are marine animals with two valves, or shells, enclosing the living organism. Most shells are composed of calcium carbonate, which was secreted by the brachiopod. These shells grew in size each year. Although they have many different shapes, all are characterized by having two valves of unequal shape, but each valve is symmetrical and can be divided into two *equal* parts. Brachiopods are abundant in many Paleozoic limestones and shales of Oklahoma (fig. 23).

19. *Pelecypods* are small animals which live in mud, on tide flats, sandy beaches, and in lime oozes, in marine or fresh water. Clams and oysters are the more common representatives of this group. Clams have two shells or valves, which are mirror images of each other; the animal lives inside and is protected by these valves. Numerous oyster shells are found in some limestones of Cretaceous age in southeastern Oklahoma.

20. *Fossil wood* is found in Devonian, Mississippian, Pennsylvanian, Permian, Cretaceous, and Tertiary formations in Oklahoma. The cellular structure of this ancient wood is commonly so well preserved that the kind of tree can be identified from the arrangement and form of the cells. The woody structure is preserved either by a process called carbonization, or by replacement with fine-grained silica introduced from ground waters. Silicified wood of the giant fossil tree, *Callixylon,* from the Woodford formation in the Arbuckle Mountains, may be seen in the restored state at the campus entrance of East Central State College at Ada (fig. 25).

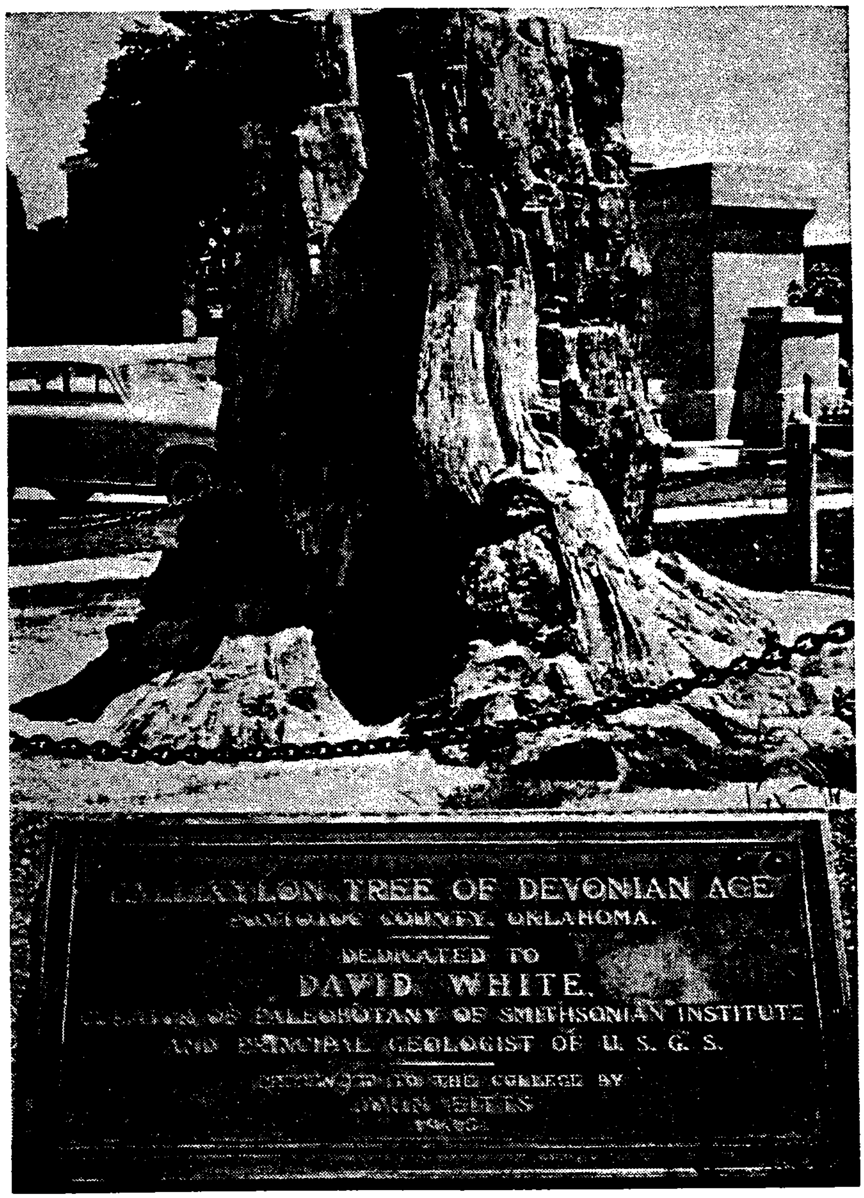

FIGURE 25. *The oldest fossil tree in Oklahoma is* Callixylon, *from the Woodford formation of Late Devonian age. It is at least 350 million years old, and is a representative of the first forest trees of the world. Pieces of the tree were replaced by flinty silica which preserved the wood structure in great detail, so that the fragments could be reconstructed as shown. Picture taken at the entrance to East Central State College, Ada.*

OKLAHOMA GEOLOGICAL SURVEY Carl C. Branson, Director

Educational Series Map 1, 1957