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an introduction to The Geologic History of Missouri

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INTRODUCTION.--This short paper has been prepared in response to the numerous requests which the Missouri Geological Survey has received for information on the general geology of Missouri. It is intended for the layman and purposely omits most of the technical details with which the professional geologist is concerned.

MAJOR ROCK TYPES.--Geologists recognize three major types of rocks: igneous, sedimentary, and metamorphic. Igneous rocks, such as granite, porphyry and basalt, are those which were once molten and formed by action similar to that of present-day volcanoes. Sedimentary rocks are those that have been deposited by seas, lakes, streams, glaciers, and winds. These rocks are commonly in parallel layers or stratified, as shown in many of the outcrops of limestone, sandstone, and shale. Metamorphic rocks are exposed in Missouri only as "imported" fragments brought in by the glaciers. This third rock type consists of those rocks which form a different type of rock. For example, the sedimentary rock limestone is altered to the metamorphic rock, marble; shale becomes slate or schist, granite becomes gneiss. The so-called "slates" and "marbles" of Missouri are not true slates or marbles as defined by geologists, but rather are respectively hard brittle shales, and limestones which take a high polish. It should be emphasized that only the geologists define marble as being necessarily metamorphic; in trade usage, marble is a carbonate rock, commonly calcium carbonate, which will take a high polish and has a pleasing appearance.

GENERAL GEOLOGIC HISTORY.--The oldest rocks which crop out in Missouri form the granite and porphyry knobs and mountains of Iron, Madison, Reynolds, Shannon, Washington, and Wayne Counties in the southeastern part of the state. At one time these igneous rocks were the surface rock over all the state; after these molten rocks cooled, ancient streams eroded and carved them to create a vast plain interrupted by occasional knobs, mountains, and valleys.

Later, the entire area was covered by seas into which streams emptied their loads of mud, clay, sand, and gravel. Waves and shore currents wore away similar material from the beaches and shorelines and the debris was swept seaward to fall to the bottom. As sea organisms died, their remains settled to the bottom to form a litter composed mainly of the shells or bony parts. This thick accumulation eventually hardened and was naturally cemented to form many of the common rocks in Missouri. Mud and clay became shale; sand became sandstone; gravel became conglomerate; and the remains of sea organisms became an important constituent of limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate).

Through the rest of this article, the rocks deposited in the sea will be referred to as marine sediments to distinguish them from igneous rocks upon which they lie.

The marine sediments are stratified or bedded like a huge layer cake. The rocks which were first deposited are the oldest and are at the bottom; the last rocks to be laid down are the youngest and, therefore, are at the top. Distinctive layers called formations can be traced for hundreds of miles to states as far away as Texas, New York, and Montana.

Only large bodies of water could have deposited such huge and uniform areas of rock. We know that these large bodies of water which one covered Missouri were seas by evidence contained in the rocks. The remains of corals, "shell fish," and other organisms which live only in seas are preserved as fossils in the rocks. Ripple marks identical to those made in present-day seas are common, especially in the sandstones of the Ozarks.

The area that is now Missouri was alternately sea bottom and dry land at many times during its geologic history. Marine sediments probably at one time covered all of the ancient granite and porphyry surface, including the highest hills and mountains. The igneous hills are visible to us today only because later erosion has partly removed the overlying rocks in the southeastern part of the state.

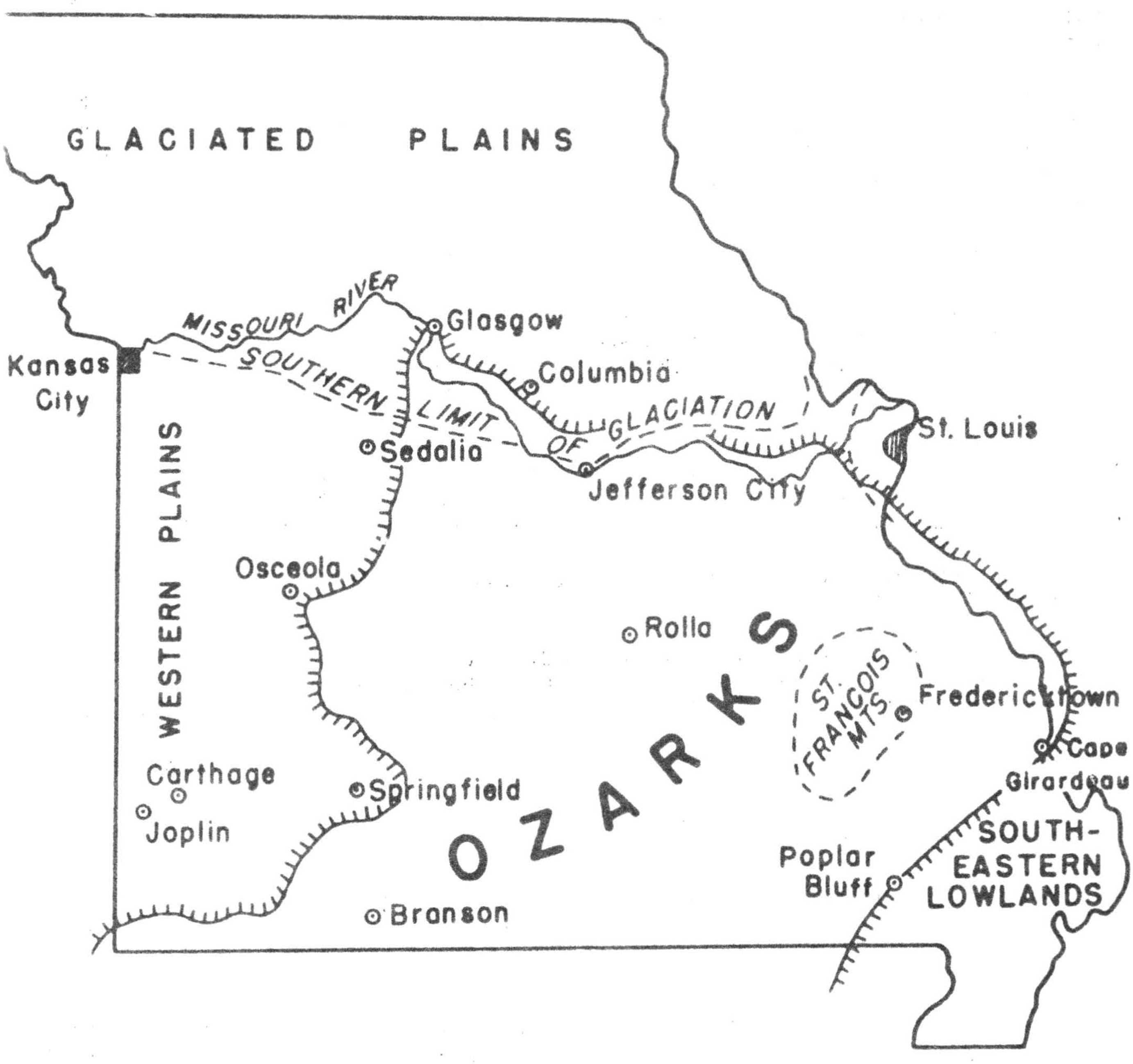
Much of the landscape of today is the result of three major geologic influences: The uneven arching or uplifting of the bedrock, the erosion and weathering of the various types of rocks, and in the northern part of the state, the result of glaciers spreading a thick mantle of clay, sand, and gravel over the bedrock.

For a short discussion of the geologic history of Missouri, it is convenient to divide the state into four major geologic regions: (1) The Ozarks, (2) the plains to the west of the Ozarks, (3) the glaciated area of the northern half of the state, (4) the Lowlands of southeastern Missouri. These four regions are discussed in the order given above.

THE OZARKS.--There is no general agreement concerning the boundaries of the Ozarks, especially the western margin. As shown on Plate I (page 3), the Ozarks are defined by the Missouri Geological Survey as being bound on the north by the bluffs of the Missouri River Valley. The eastern margin is a line extending from St. Charles southward into Illinois, following the hills adjacent to the Mississippi River. At a location approximately east of Cape Girardeau, the boundary returns to Missouri. It then swings southwesterly along the bluff line through Poplar Bluff into Arkansas. The western margin is shown on Plate 1.

The Ozarks have two major geologic characteristics that are not widespread or common in the bordering areas: (1) As the result of repeated uplifts and erosion, the topography is one of hills, plateaus, and deep valleys. (2) Because of the uplifts and resulting deep erosion, the younger upper layers of rock have been eroded away and the surface rocks are older than those commonly exposed outside of the Ozarks. In other words, the rocks exposed on the surface in the Ozarks are generally blanketed by overlying layers of younger rocks in the remainder of Missouri.

Plate I
MAJOR GEOLOGIC REGIONS
of
MISSOURI



Several rock types typical of the Ozarks which are less common in the younger rocks of the surrounding areas are listed below:

(1) Dolomite (calcium-magnesium carbonate) is a common Ozark rock; outside of the Ozarks, its brother, limestone (calcium carbonate) is the more common. Both dolomite and limestone are locally called "limerock," and finely-crystalline, light colored dolomite is often referred to as "cotton rock." In the Joplin area, "cotton rock" is defined as limestone containing an appreciable amount of disseminated silica.

(2) Many of the Ozark rocks contain much chert (flint). Chert is composed of silicon dioxide or silica, the same chemical compound that constitutes most sand and sandstone. Chert is not easily destroyed by weathering, and as dolomites and sandstones are weathered away, the chert remains as a thick gravel and boulder blanket.

(3) Igneous rocks (granite and porphyry) crop out only in the Ozarks. The total sum of the various uplifts was greatest in the St. Francois Mountain area, centered around St. Francois, Iron, and Madison Counties (Plate I). As a result, streams have eroded away the marine sediments and exposed the ancient granite and porphyry knobs mentioned at the beginning of this article. It should be re-emphasized that these igneous knobs, hills, and mountains were not pushed up individually, but rather, are heights which withstood the effects of erosion prior to the invasion of the ancient seas. These seas buried the hills under a blanket of marine sediments and later erosion laid them bare by removing the sediments--just as an archaeologist digs away the accumulations of centuries to discover ancient cities far below the surface. Similar igneous knobs and hills underlie all the state, but they are blanketed by younger sedimentary rocks which are as much as 3,500 feet thick in extreme northwestern Missouri, and more than 4,700 feet thick in the southeastern Lowlands.

Some of the streams which took part in eroding away the sediments blanketing the igneous knob are still following courses which they established thousands of years ago. As these streams cut through the sediments, they encounter the relatively hard knobs and, because their courses were already established, they were forced to cut into the granite or porphyry. As a result, "shut-ins" have been developed where streams flow from broad valleys cut in marine sediments to suddenly constricted or narrow valleys where the streams were forced to cut through hard and resistant igneous knobs.

The Elephant Rocks at Graniteville were formed from granite which tended to fracture at right angles in large oblong masses. Later weathering rounded off the sharp edges and corners to produce the masses which resemble a group of resting elephants.

Many of the Ozark stream valleys are unusually crooked for their size and depth. Such valleys are called "entrenched meanders" and are believed to have originated in the following manner:

During the time interval when dinosaurs became extinct and the small ancestors of the modern horse appeared, the Ozarks were worn down to a plain on which sluggish streams developed crooked meandering channels similar to the present-day Mississippi River. When the Ozarks were later uplifted, the streams stayed in their old channels and cut deep valleys which resulted in the entrenched meanders of today.

Springs, caves, and sinkholes are common in the Ozarks and bordering areas where ground water has been especially active in dissolving openings in the soluble dolomites or limestones. Springs tend to form where solution has opened channels along bedding planes of layered rocks or along cracks in the rocks and these openings come to the surface in stream beds or valley walls. Springs may also flow from beds of permeable material such as sandstone. If underground channels are large, caves result, and where roofs of caves collapse, sinkholes are produced. Sinkholes may also be created where the solution of percolating waters has enlarged vertical cracks or joints in the bedrock, and these vertical channels reach the surface or near enough to the surface to allow the soil to settle.

It should be emphasized that the Ozarks cannot be defined as being a large area, all of which is higher than the remainder of Missouri. It is true that the porphyry knob, Taum Sauk Mountain, in Iron County is the highest known point in the state with an elevation of over 1,400 feet, but there are also appreciable areas less than 1,000 feet above sea level, while outside of the Ozarks significant areas at elevations exceeding 1,200 feet are not at all unusual.

Although the Ozarks are not necessarily higher than the remainder of the state, they do have greater local contrasts in elevation. For example, the vertical distance between an Ozark stream and the adjacent uplands may be as much as 400 feet, or in the igneous knob area, as great as 800 feet. Outside the Ozarks, local contrasts in altitude seldom exceed 200 feet except along the Missouri and Mississippi rivers.

THE PLAINS TO THE WEST OF THE OZARKS.--The sedimentary rock layers dip or slope outward from the Ozarks in all directions. To the north, many of these sedimentary layers are covered by glacial material; to the west, only a thin mantle composed of soil and partly disintegrated rocks covers the bedrock. The westerly slope of the rocks causes progressively younger or higher layers of sedimentary rocks to be visible as one crosses the Plains going west from the Ozarks.

The bedrock of the Plains immediately adjacent to the Ozarks is cherty (flinty) limestone, with layers of shale in the lower part. Some layers of this limestone are very pure; thus large limestone quarries are common as in the vicinity of Springfield, Osceola, and Sedalia. In extreme southwestern Missouri, this limestone extends westward across the state line from McDonald, Newton, and Jasper Counties, and is quarried in the vicinity of Joplin and Carthage.

These limestones are similar to the dolomites of the Ozarks in being cherty, and containing many springs, caves, and sinkholes. However, they differ from the Ozark dolomites in containing many more fossils of greater variety and more advanced stage of development.

Still farther to the west, west of a line drawn through Jasper, Cedar, St. Clair, Benton, Pettis, and Saline Counties, the bedrock is younger than that in the eastern plains, and is composed of limestone, shale, sandstone, and conglomerate. Some of these beds were deposited by seas, some in lagoons or swamps, and some (especially the sandstones and conglomerates) were laid down in the beds of ancient streams. In these sediments are beds of coal and deposits of oil and gas. The oil and gas-bearing strata are much younger or represent much higher layers of sedimentary rocks than the rocks of the Ozarks.

THE GLACIATED PLAINS OF NORTHERN MISSOURI.--The southern limit of the major glaciation in Missouri is near the Missouri River (Plate I). To the west of Jefferson City, glaciation extended south of the river to near the latitude of northern Pettis County. East of Jefferson City the southern limit of glaciation is north of the river along a line connecting Jefferson City with central St. Charles County. Two major glaciers covered parts or all of northern Missouri; a third glacier entered Missouri from Illinois and affected only eastern St. Charles and St. Louis Counties.

Beneath the glacial material much of the bedrock in the Glaciated Plains is identical to that of the unglaciated portion of Missouri lying to the west of the Ozarks. Immediately north of the Ozarks is a broad band of limestone which is a continuation of that quarried in west-central and southwestern Missouri. This band extends from western Pettis and eastern Saline Counties eastward into St. Charles and St. Louis Counties, and from St. Charles County northward through Clark County into Iowa. In eastern Lincoln, Ralls, and Pike Counties, the bedrock has been arched upward into a gentle fold which extends in a northwesterly direction. Erosion has stripped the younger limestone rocks off the top of this fold and has exposed some of the same rock layers as those that crop out in the Ozarks.

In north-central and northwestern Missouri, the bedrock is similar to that previously mentioned in the western part of the unglaciated plains, i.e., beds of limestone, shale, sandstone, and conglomerate. These are also coal-bearing and in the northwestern part of the state contain some oil and gas.

Before the glaciers advanced into northern Missouri, and possibly during the interval between the two glacial advances, large rivers cut valleys as great as 300 feet deep into the bedrock. As the glaciers advanced and then melted, they deposited their loads of clay, sand, gravel, and boulders which they had accumulated on their journeys southward from Canada. The glaciers forced streams out of their bedrock valleys and filled these valleys with glacial debris which geologists call "drift." Through much of their extent, bedrock valleys are completely obliterated by the drift and can be traced only by records from deep wells.

Along much of the Missouri and Mississippi Rivers upstream from the central part of the state, the bluffs are capped with a thick, yellow silt which forms vertical bluffs where eroded. This material, called "loess", is believed to have been swept from the broad stream valleys and deposited by winds in a manner similar to the drifting of soil in present-day dust storms. The deposition of loess is believed to have taken place during the retreat of the glaciers.

Had it not been for the glaciers, northern Missouri would not contain the excellent farm land of today; the weathered drift contains the proper ingredients to form an ideal soil as nature adds plant organic material.

THE SOUTHEASTERN MISSOURI LOWLANDS.--This area, which will be referred to as the Lowlands, includes Stoddard, Dunklin, New Madrid, Mississippi, Pemiscot, and parts of Butler, Bollinger, Scott, and Cape Girardeau Counties.

The Lowlands owe their existence to three major geologic events: The intermittent sinking of that area, the relatively late invasions of seas which reached northward only to this corner of Missouri, and the shiftings of the Mississippi River. Long after the seas had permanently withdrawn from the rest of Missouri, an arm of the last sea to reach the state extended up from the area of the present Gulf of Mexico and covered the Lowlands which were in the process of sinking or downwarping. This sea deposited a thick accumulation of sand, clay, and shale which was later easily eroded by the Mississippi River.

The Mississippi has from time to time wandered over much of the Lowland area, at one time flowing west of Crowley's Ridge or along the eastern edge of the Ozarks. The Lowlands are still in a state of geologic unrest as shown by the recent (geologically!) New Madrid earthquakes of 1811-12.

SUGGESTED REFERENCES

The following may be ordered from the Missouri Geological Survey, Post Office Box 250, Rolla, Missouri 65401:

1. List of Publications (free).
2. Index to topographic maps (free); Topographic May Symbol Sheet (free); individual topographic maps (50¢ each).
3. Geologic Map of Missouri ($1.00).
4. Mineral Resources Map of Missouri ($1.00).
5. Shaded Relief Contour Map of Missouri (50¢).
6. Volume 39, Caves of Missouri ($2.50).
7. Volume 40, The Stratigraphic Succession in Missouri ($1.00).
8. Educational Series No. 1, Missouri's Ice Age Animals (50¢).
9. R.I. 26, Guidebook to the Geology of the St. Francois Mountain Area ($1.00).
10. R.I. 30, Cryptoexplosive Structures in Missouri ($1.00).
11. R.I. 37, Guidebook to the Geology between Springfield and Branson Missouri (50¢).

The following University of Missouri publications may be ordered from the University Book Store, University of Missouri, Columbia, Missouri 65201:

1. Common Rocks and Minerals of Missouri, Missouri Handbook No. 1 (35¢).
2. Common Fossils of Missouri, Missouri Handbook No. 4 (50¢).
3. The Geology of Missouri, University of Missouri Studies, Vol. XIX, No. 3 ($3.00).

1966 MISSOURI MINERAL PRODUCTION 1/

Mineral		Quantity	Value (thousands)
Barite	short tons	337,076	$ 4,280
Cement:			
Portland	thousand 376-pound barrels	13,848	46,228
Masonry	thousand 280-pound barrels	382	1,075
Clays	thousand short tons	2,329	5,989
Coal (bituminous)	thousand short tons	3,582	14,834
Copper (recoverable)	short tons	3,913	2,831
Iron ore (usable)	thousand short tons	1,887	26,450
Lead (recoverable)	short tons	132,255	39,981
Lime	thousand short tons	1,494	17,910
Natural gas	million cubic feet	113	26
Petroleum (crude)	thousand 42-gallon barrels	97	2/
Sand and gravel	thousand short tons	10,702	13,540
Silver (recoverable)	thousand troy ounces	------	-----
Stone	thousand short tons	35,240	53,393
Zinc (recoverable	short tons	3,968	1,151
Value of items that cannot be disclosed: (Asphaltic sandstone & petroleum)		XX	288
Total		XX	$ 227,970

XX Not applicable.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Included with "Value of items that cannot be disclosed."