A.G.E.S.
Brochure Series 005

State of Arkansas
Arkansas Geological Survey
Bekki White, State Geologist

Geology of the Saline County Xenolith and surrounding area

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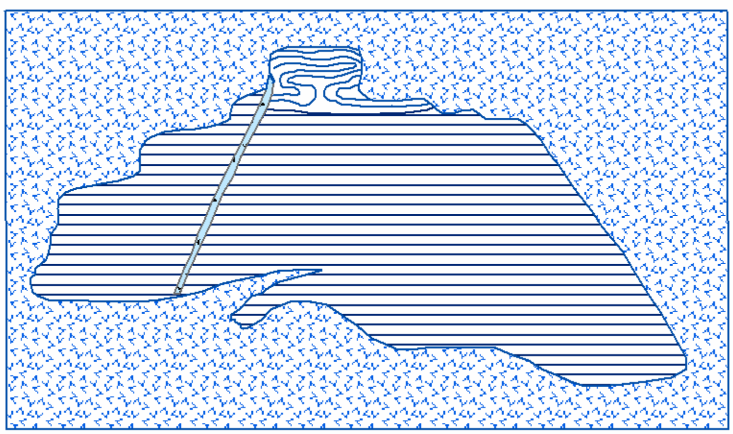
Xenolith – " a foreign inclusion in an igneous rock."

Glossary of Geology
American Geological Institute
1987

(from the Greek words *Xenos*, meaning guest or stranger, and *Lithos*, meaning stone.)



"Flat-iron" xenolith, as figured by J.F. Williams (1891)

Introduction

Located in Saline County, Arkansas, at the south edge of the community of Bauxite, this natural outcrop of nepheline syenite contains several geologically interesting features, including a xenolith. Sloping west, the outcrop encompasses about one-quarter acre near the center of section 21, Township 2 South, Range 14 West. In early 1990, the Aluminum Company of America (ALCOA) donated the outcrop along with approximately five surrounding acres of land to the Arkansas Geological Commission so that the site can be preserved for educational purposes.

Outcrop of nepheline syenite at xenolith locality.

History of the site

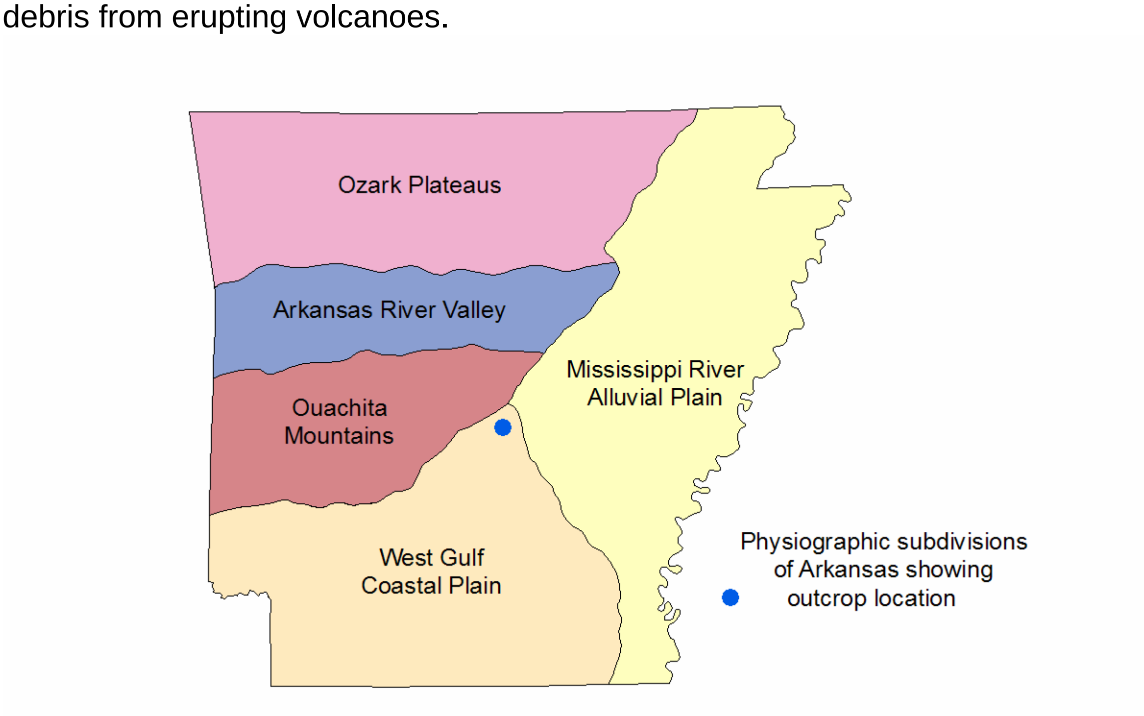
The outcrop and its geologic features were first described by J. Francis Williams in 1891 in The Igneous Rocks of Arkansas, Arkansas Geological Survey Annual Report for 1890, Volume II. Williams discussed the outcrop and xenolith in some detail and included a sketch of the xenolith (see title page). However, for many years the outcrop location remained unknown to most scientists. In the late

1960's employees in the mining division of ALCOA, suspecting that the site was on their property, began a concerted search. Soon afterward the outcrop was rediscovered and was visited by a staff member of the Arkansas Geological Commission, who in turn told Dr. Kern Jackson of the Geology Department, University of Arkansas at Fayetteville about it. Joel H. Marks, a graduate student working under Dr. Jackson, sampled the outcrop in the early 1970's and completed a master's thesis concerning the igneous rocks in 1977.

To obtain specific directions to the site, contact the staff of the Arkansas Geological Commission. We request that no samples be collected or removed from the outcrop without obtaining specific written permission from the state geologist. When possible a guide will be provided for groups at no charge.

Regional Geology

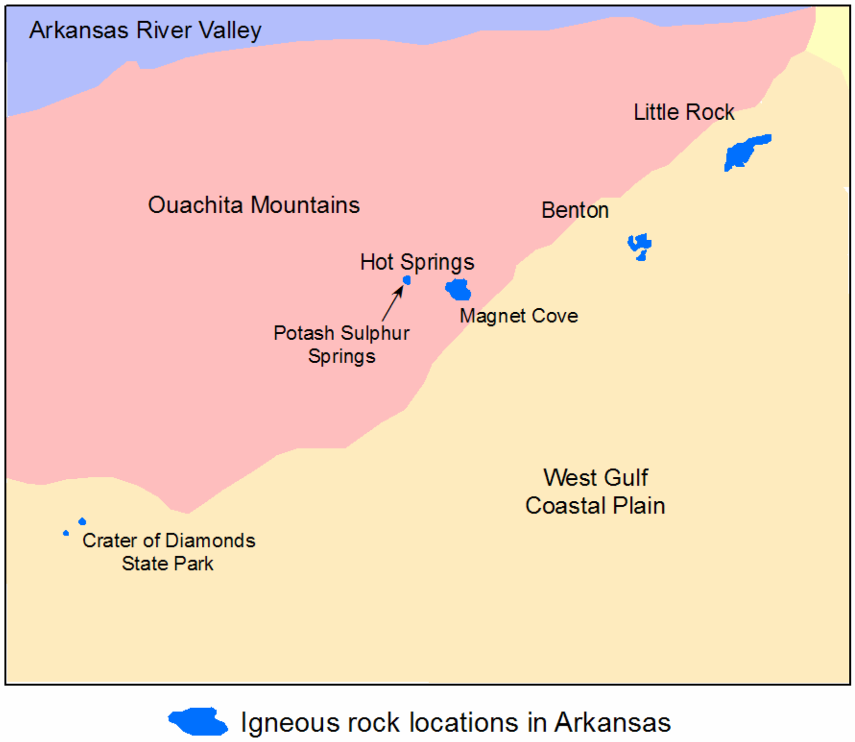
This outcrop is in the northern part of the West Gulf Coastal Plain (see Physiographic Map of Arkansas) near the boundary with the Ouachita Mountains. The sedimentary rocks of the nearby Ouachita Mountains are predominately shale, sandstone, chert and novaculite. They were deposited as sediments in the ocean over a time span of some 200-225 million years extending from about 510 to 285 Ma (millions of years ago) and they represent a number of different sedimentary depositional environments, including deep ocean trenches, deep-water deltas or fans and stagnant ocean deeps. While most of the sediments consisted of continental erosional debris, a small volume consisted of air-fall debris from erupting volcanoes.



The sedimentary materials in the oceanic basin, after being converted into rocks, were faulted, folded and uplifted into their present disarray by orogenic (mountain building) forces to form the ancestral Ouachita Mountains. This event started near the end of the Pennsylvanian Period, about 295 Ma. However, the orogeny did not take place overnight, but rather over a span of millions of years. Repeated fracturing, rehealing, folding and faulting and refolding deformed the rocks to their present highly complex state. During this same time, quartz veins began to form and some were fractured, rehealed, fractured again and reformed. Eventually the mountain building processes slowed to a point where erosion of the mountains thus built became the dominant geologic process. As erosion continued, the Cretaceous seas began to encroach onto the southern edge of the Ouachita Mountains about 140 Ma, in the area of the present counties of Sevier, Howard, Pike and Clark.

From 100 to 85 Ma a new series of events began which altered the surface geology of more than half of Arkansas. The activity started in eastern Arkansas, in the area now occupied by the Mississippi River Alluvial Plain. The same area had been a weak site in the heart of the North American continent where almost 400 million years earlier; the continent had tried to split apart and failed, forming a failed rift system known as the Reelfoot rift. The new events were triggered by reactivation of the old failed rift system which began to subside again, allowing the mid-Cretaceous sea to invade the Mississippi embayment as far northward as Cairo, Illinois. As the rift subsided tensional stress caused the crustal rocks along the western margin to weaken. The weakened condition of the crust permitted magma (molten rock) generated at a depth greater than 20 miles below the earth's crust (in the mantle) to move upward toward the surface through weak zones. Near Murfreesboro, Arkansas some magma reached the surface before they solidified as igneous rock. The pipe-like bodies at Magnet Cove and Potash Sulphur Springs and the explosion breccia just northwest of Benton show no evidence of having reached the surface; they are intrusive rather then extrusive.

The largest known body of igneous rock underlies major portions of Pulaski and Saline Counties east and south of Interstate Highway 30. Because of its large size and because it too solidified below the surface it may be called a batholith. Here in central Arkansas, as the magma was forced upward through the crust it began to react chemically with the crust by melting and resorbing the overlying sedimentary rocks. As magma moved upward into the roof of the chamber blocks of roof rock were dropped or stoped into the liquid. Some were resorbed (partially or wholly melted) into the magma, others reacted with the molted rock and some were merely baked. A few pieces of these foreign rocks, or xenoliths, are seen in some active quarries and much more rarely in natural outcrops. All the while, the magma was cooling and slowing changing from the liquid to the solid state. Before reaching the surface, it froze in place as the rock geologists call nepheline syenite, slowly releasing its heat the overlying sedimentary layers.



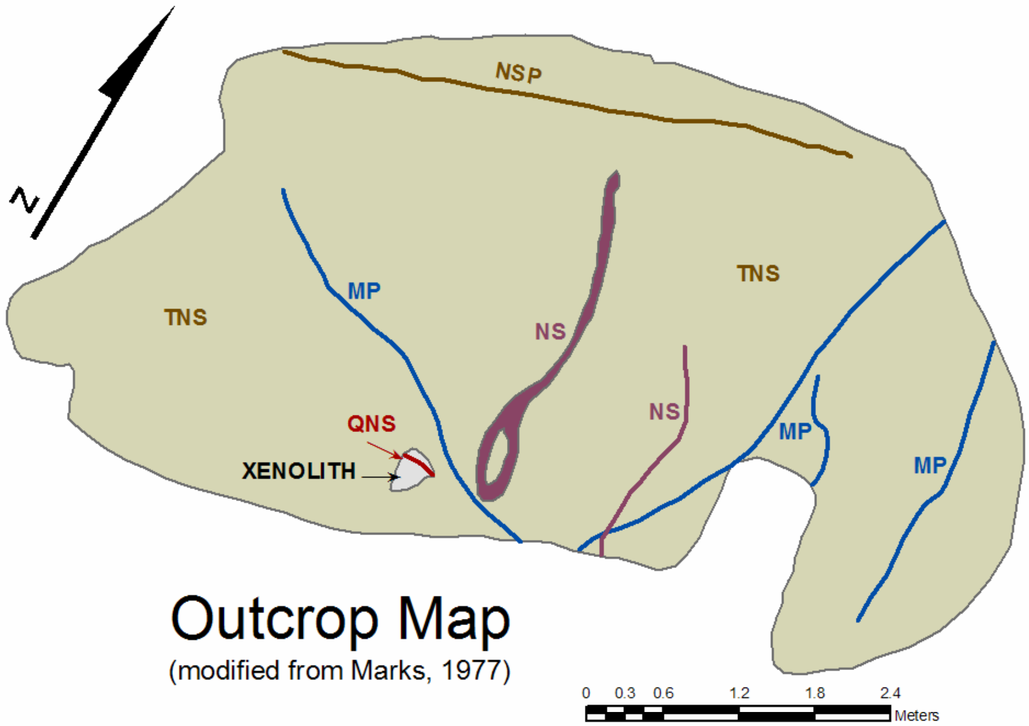
As the body continued to cool, pressures from residual hot liquids moving below caused fractures and cracks to form in the solidifying mass. Stress due to shrinkage may also have broken the brittle mass. Both types of fractures were invaded by mineralized fluids which solidified to form thin sheet-like igneous bodies called dikes. Some dikes cooled quickly, causing them to be fine-grained, whereas others cooled more slowly allowing individual crystals in the liquid to grow larger.

When the seas receded in Late Cretaceous time, erosion again became an active agent. About 65 Ma, the oceans again inundated Arkansas, but by this time erosion had removed the overlying sedimentary rocks to expose some of the topographically higher masses of igneous rock (cupolas). In the area from Little Rock to Benton, this part of geologic time is represented by sediments characteristic of the shoreline and near-shore areas of a shallow sea (Midway Group). Locally, reefs grew along the margin of the sea and around scattered islands composed of nepheline syenite. As tropical storms battered the coast and islands, salty sea spray soaked the land. Chemical weathering begins to affect the syenite, leaching silica and altering the mineralogy of the rock by a process called laterization (tropical weathering). Eventually bauxite, the ore of aluminum, was formed. After some 10 million years, the marine seas began to recede again and river systems began to deposit predominantly non-marine sediments across the relatively flat former coastal area. Freshwater sands, layers of plant debris (now present as a low-rank coal called lignite) and clays of overbank, flood-plain and river-channel systems were deposited. The river systems were active for some 20 million years and encased the bauxite deposits in sediments of the Wilcox Group. About 24 Ma, erosion again became locally the most significant geologic agent. More recently, during the glacial and interglacial stages of the Quaternary (beginning about 1.6 Ma) tremendous sheets of sand, rock flour, and gravel were spread out across much of this are. Valleys were first filled with these sediments then the sediments were partially eroded. Local Deposits of rounded sand and gravel consisting of novaculite, milky quartz and chert from the Ouachita Mountains attest to the vigorous reworking activity of the Arkansas River during this time. Presently we are in a state of generally mild erosion in this area, which is stabilized by a moderate to heavy vegetative cover.

What can we see at this site and why is it special or unusual?

Since much of geology is an observational science, let's look at this outcrop and see how it supports the geologic story just related. To do this, refer to the outcrop map in this folder. The first and most obvious feature at the site is the trachytic nepheline syenite host rock (TNS on the map), which composed the bulk of the outcrop. It was once a molten liquid in which crystals formed as the liquid cooled. The most abundant mineral in nepheline syenite is an alkali silicate called feldspar. Feldspar has a blocky plate-like shape and is cream in color. Molten rock is mobile, and platy or elongate minerals tend to become aligned parallel to the direction of flow. A search around the outcrop will reveal several areas where the feldspar crystals are aligned, exhibiting flowage or trachytoidal texture. As an igneous mass cools and solidifies, it becomes brittle. Fractures easily develop and commonly become filled with liquid from below or with liquid left between the crystals of the solidifying host rock. This second liquid then will cool and crystallize to form dikes. A variety of such dikes are present here, including two crosscutting dikes of different textures (A on map).

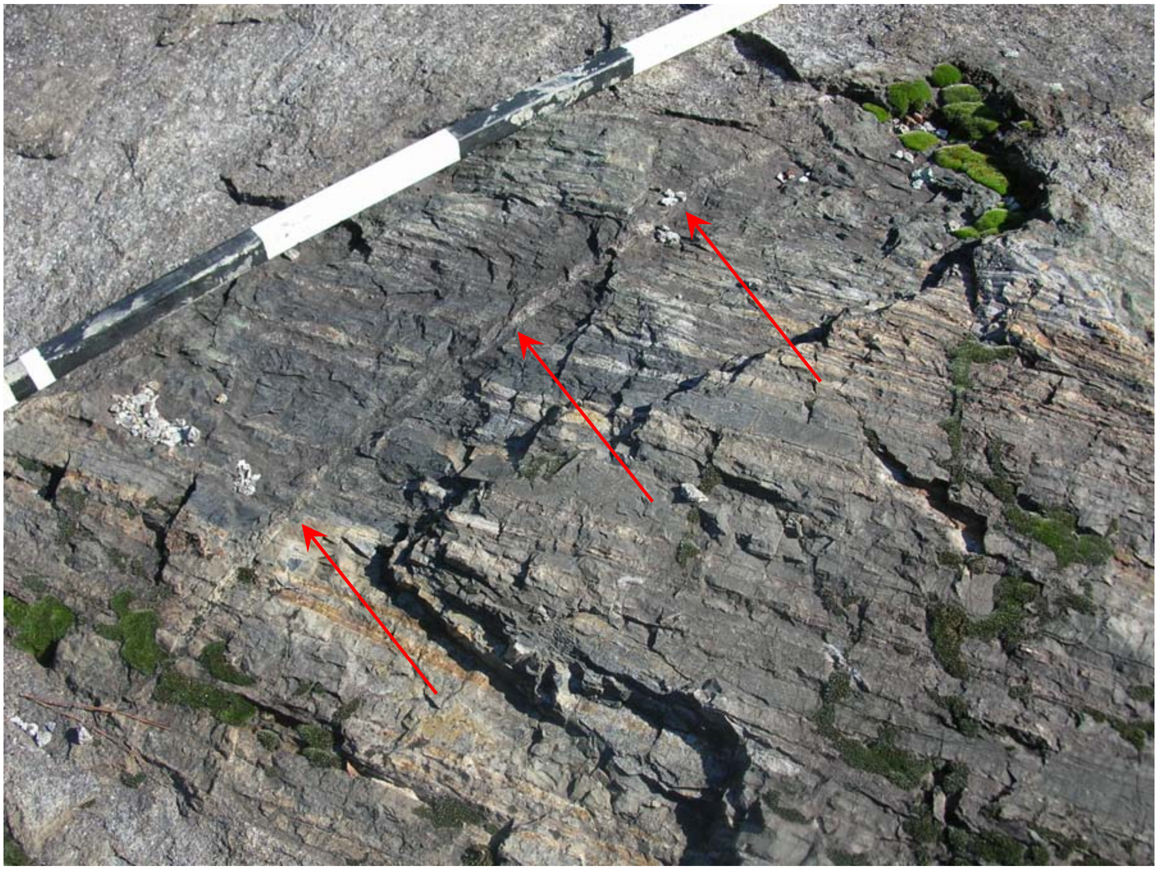
The roof of the magma chamber was composed of sedimentary rocks of the Ouachita Mountains. As the magma forced its way upward, blocks and pieces of the roof material broke off and sank into the molten liquid. Some were resorbed, but others were baked and cooked in a process called contact metamorphism. By reacting with the magma, shale became hornfels (a fine-grained dense metamorphic rock) and sandstone was chemically metamorphosed to feldspar.



Outcrop Map

(modified from Marks, 1977)

TNS	Trachytoidal nepheline syenite. The host rock of this outcrop displays frow stucture and differential weathering of minerals.
NSP	Nepheline syenite pegmatite dike. Coars-grained dike fills fractures in trachytoidal nepheline syenite.
NS	Nepheline syenite dike. Medium to fine grained dikes fill fractures in trachytoidal nepheline syenite.
MP	Micropulaskite dike. Fine-grained nepheline-poor syenite dikes fill fractures in trachytoidal nepheline syenite.
QNS	Quartz nepheline syenite dike. Thin dike which fills a fracture in the xenolith has been termed "granite" by some geologists.



Xenolith containing quartz nepheline syenite (QNS) dike.

When you look at the xenolith on this outcrop, notice the following features:

1. Layering like a sedimentary rock
2. Folding similar to a type and style which may be seen in the sedimentary rocks of the Ouachita Mountains
3. Differences between the contact-metamorphosed xenolith and normal interbedded shale and sandstone you may have seen in outcrops in the Ouachita Mountains
4. Greenish color
5. Difference in grain size of the host rock next to the xenolith and away from it
6. Dikelets crosscutting the xenolith
7. Knife-edge contacts between host rock and xenolith.

Each one of these features is part of a key to unlocking the local geologic history.

Sharp contact of xenolith with syenite.

Folding similar to that seen in the Ouachita Mountains.

References

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