GUIDEBOOK 79-3

STATE OF ARKANSAS

ARKANSAS GEOLOGICAL COMMISSION

Norman F. Williams, State Geologist

# FIELD TRIP GUIDE TO THREE MAJOR MINES IN CENTRAL ARKANSAS

LITTLE ROCK, ARKANSAS
1979

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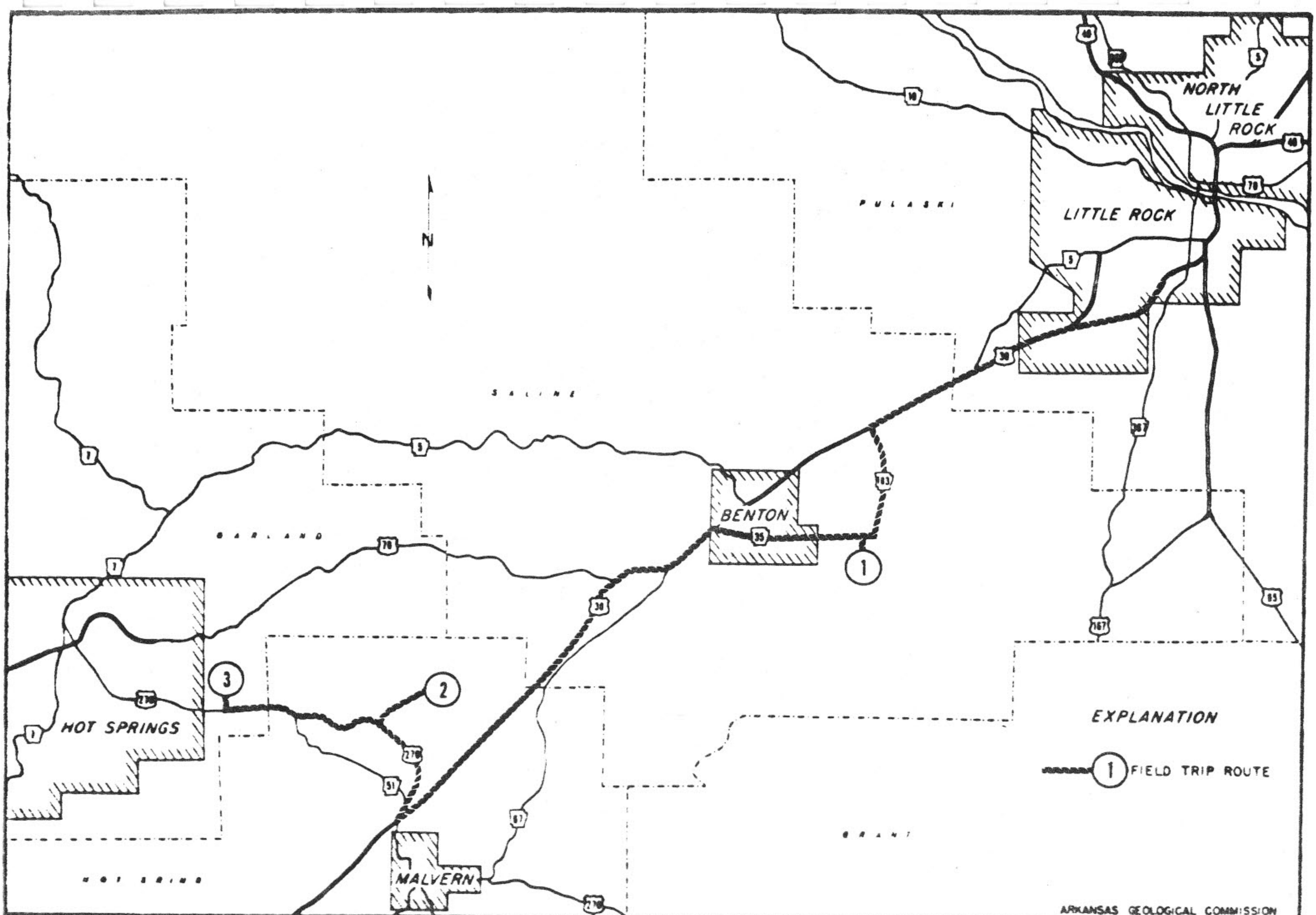



INDEX MAP SHOWING ROUTE OF THE FIELD TRIP

Figure 1

## FIELD TRIP GUIDE TO THREE MAJOR

## MINES IN CENTRAL ARKANSAS

### SUMMARY

**STOP 1.** Aluminum Company of America's strip mines in Saline County; where Alcoa mines bauxite from the Wilcox Formation of Eocene age to supply their alumina plant at Bauxite.

**STOP 2.** Baroid Division of National Lead Company's strip and underground mine in Hot Spring County; where Baroid mined barite from the lower portion of the Stanley Formation in the Chamberlain Creek Syncline.

**STOP 3.** Union Carbide Corporation's Wilson Springs vanadium deposits in Garland County; where the company strip mines vanadium ore for processing to vanadium pentoxide in their plant located near the mines. The ore is derived from mineralized Arkansas Novaculite which occurs adjacent to the igneous intrusions in the area.

### DESCRIPTION

**STOP 1.** (30 min.) Raw Materials Headquarters of Alcoa.

Bauxite, the major ore of aluminum, was first identified in Arkansas by John C. Branner, State Geologist, in 1887, and has been mined commercially since 1899. Arkansas bauxite production in 1978 was over 1.9 million tons and for many years Arkansas has produced more than 90 percent of the domestic bauxite in the U. S. The primary use of bauxite is for making aluminum metal. Other important uses are in chemicals, abrasives, refractories, and alumina cements. Alumina is produced by two plants: Reynolds' plant at Hurricane Creek and Alcoa's plant at Bauxite. Aluminum metal is produced at two plants by Reynolds; the Jones Mill Reduction plant on Lake Catherine and the Gum Springs plant at Arkadelphia.

In addition to these two major producers of bauxite in Arkansas there are two minor producers. The American Cyanamid Company mines and ships high grade dried bauxite and kaolinite clay to the chemical and abrasive industry; and the Porocel Corporation processes bauxite for the chemical industry.

The Arkansas bauxite area covers approximately 275 square miles and is located in Pulaski and Saline Counties, central Arkansas. There are two principal mining districts; in Pulaski County south of Little Rock, and the larger and more productive district around Bauxite in Saline County.

The bauxite deposits are centered around intrusives of nepheline syenite. These nepheline syenites, and related igneous rocks of Late Cretaceous age, were intruded into highly folded Paleozoic beds. Subsequent erosion exposed some parts of these intrusives to weathering; and subsequently they were partially buried by sediments of Tertiary age. The bauxite deposits of central Arkansas are the result of lateritic weathering of the nepheline syenite during early Eocene times.

According to Gordon, Tracey, and Ellis (U. S. Geological Survey Prof. Paper 299) the bauxite deposits can be classified into four types:

(1) residual deposits on the upper slopes of partly buried nepheline syenite hills;

(2) colluvial deposits at the base of the Berger Formation (lowermost formation of the Wilcox Group);

(3) stratified deposits within the Berger Formation;

(4) conglomeratic deposits at the base of the Saline Formation (overlies the Berger Formation in the Wilcox Group).

Bauxite in the various mines differs considerably in its character and physical properties. Most of the bauxite is pisolitic, and ranges from very hard to soft and earthy. Generally, it is hard at the top of a deposit, firm to mealy in the middle, and clayey though not plastic at the base. In color it ranges from a light gray through tan and brown to red. Color is not necessarily an index of grade nor of the amount of iron present, as some of the brick-red bauxite has very little iron. The principal mineral in the bauxite is gibbsite (aluminum trihydrate). The chief impurities are silica, iron, and titanium. A significant concentration of gallium is present and is recovered as a valuable by-product. In the future other by-products of alumina production may be utilized.

Briefly these possibilities are:

(1) the recovery of titanium, iron, and columbium from the black sands and red muds which are waste products from the alumina plants;

(2) the recovery of both the iron and alumina from the large deposits of high-iron bauxite;

(3) the recovery of alumina from the vast deposits of high-alumina clays associated with the bauxite deposits (estimated to total over 100 million tons).

The A. P. Green Refractories Company mines kaolinite clay that is found associated with the bauxite deposits for production of high heat duty refractories and in the manufacture of alum.

Bauxite reserves in the area in 1950 were estimated at about 70.7 million long tons averaging 50 percent alumina and 9 percent silica, but assuming no cutoff on iron. Of this total about 62.2 million tons occur in Saline County and 8.5 million tons in Pulaski County.

**STOP 2.** (30 min.) Office of Baroid Division of National Lead Company, The Chamberlain Creek Barite Deposit.

The two companies that mined this deposit produced 8.5 million tons of barite from it. Exploitation of the deposit began in 1939 when the Magnet Cove Barium Corporation started mining and milling operations, utilizing flotation to concentrate the ore. The Baroid Sales Division of the National Lead Company started mining and milling barite in 1942.

The office of Baroid Division of the National Lead Company is on the southern limb of the syncline and the Magnet Cove Barium Corporation's shaft is on the northern limb of the syncline. They originally removed the shallow ore along the syncline by stripping, but the depth of their ore forced them to go exclusively to underground mining and in 1976 production from this deposit ceased. Baroid has tentative plans to begin stripping operations again in the near future.

In the milling operations the ore is ground to 325 mesh and processed by froth flotation. The concentrates produced run about 98 percent $BaSO_4$ with a loss of only about 10 percent of the original values. All of the barite produced from this deposit is used as a weighting agent in oil well drilling muds.

The Chamberlain Creek barite deposit is a stratiform deposit at the base of the Stanley Shale (Missippian). This zone is essentially conformable with the bedding of the enclosing sediments and averages 60 feet in thickness. Structurally, the deposit lies in an asymmetrical syncline. The syncline plunges southwest toward the Magnet Cove intrusive one mile to the west and is truncated at its eastern end by erosion giving the orebody a spoon-like shape. The maximum length of the orebody is 3200 feet and its maximum width is 1800 feet. Some of the ore is nodular, but most of it has a dark gray, dense appearance resembling limestone. The barite is intimately mixed with minor amounts of fine-grained quartz, pyrite, and shale. A typical analysis of high-grade ore would be 85 percent $BaSO_4$, 11 percent $SiO_2$, and 3 percent iron oxide and alumina. The average mill feed is about 60 percent $BaSO_4$.

**STOP 3.** (30 min.) Arkansas Operations, Mining and Metals Division of Union Carbide.

Mining was started at the Wilson Springs vanadium operation in 1966 and it is the only mine in the United States developed for vanadium as the only product. Union Carbide produced 127,758 tons of vanadium ore in 1978. Although the Wilson Springs area was investigated in the 1950's for uranium and columbium, the economic vanadium potential was not determined until 1960. Two open pit mines have been developed.

The ores contain approximately one percent vanadium pentoxide which is recovered in this plant by hydrometallurgical methods. The majority of the vanadium produced is alloyed in steel.

The ore deposits occur in the vicinity of the contact between the Potash Sulfur Springs alkalic igneous complex and the surrounding Paleozoic sedimentary rocks. The intrusive complex, which was probably emplaced in Late Cretaceous time has a crude "ring" structure similar to Magnet Cove. The partial outer ring is alkali syenite and fenite, and much of the central part of the complex is feldspathoidal syenite. Jacupirangite, fasinite, malignite, nordsjoite, naujaite, ijolite, and carbonatite occur as late stage intrusives of the igneous complex.

See the article in this guidebook for more details of the area.

# THE CHAMBERLAIN CREEK BARITE DEPOSIT

Berton J. Scull

The occurrence of barite in the Ouachita Mountains of Arkansas has been known since 1890. With the development of the use of ground barite as a weighting agent in oil well drilling muds, interest was shown in the Arkansas deposits, and in 1939 the Magnet Cove Barium Corporation found that an acceptable drilling mud barite could be obtained from the ore by flotation. The company then began producing barite from the Chamberlain Creek syncline deposit near Magnet Cove in Hot Spring County, and in 1941 the Baroid Division of the National Lead Company started mining and milling operations on a portion of the same deposit. Annual production from this deposit expanded rapidly from 2,500 short tons in 1939 to a peak of 468,000 short tons in 1957. Although production has declined since 1957 because of decrease in drilling activity and competitive sources, Arkansas remains a major barite producer.

The barite region of Arkansas comprises about 2700 square miles in the southern part of the Ouachita Mountain system and the northernmost part of the West Gulf Coastal Plain of Arkansas. The most important occurrence is the Chamberlain Creek deposit.

The Chamberlain Creek syncline deposit is in the Magnet Cove district in the northeast part of the Malvern quadrangle and lies wholly within Hot Spring County. The Paleozoic rocks exposed in the district range from the Ordovician (Bigfork Chert) to the Mississippian (Stanley Shale). The Mesozoic is represented by the Magnet Cove igneous rocks and the Cenozoic is represented by the lower Tertiary Midway Formation, which overlaps the Paleozoic rocks on the southeast side of the district. Structurally, the district incorporates the eastern end of the Mazarn Basin, part of the Zigzag Mountains, the northernmost part of the Trap Mountains, and the Magnet Cove ring dike complex which truncates the Chamberlain Creek syncline on the southwest. The major barite deposit is located in the Stanley Formation in this syncline, one of the southwestward plunging synclines of the Zigzag Mountains.

**Local Structure.** The Chamberlain Creek syncline from where it is truncated on the southwestern end by the Magnet Cove intrusives in the eastern part of Sec. 17, T. 3 S., R. 17 W. extends northeastward with a subsymmetrical outline for about two miles. Structurally the syncline is decidedly asymmetrical, with the southeast limb being steeper and locally overturned (Fig. 5).

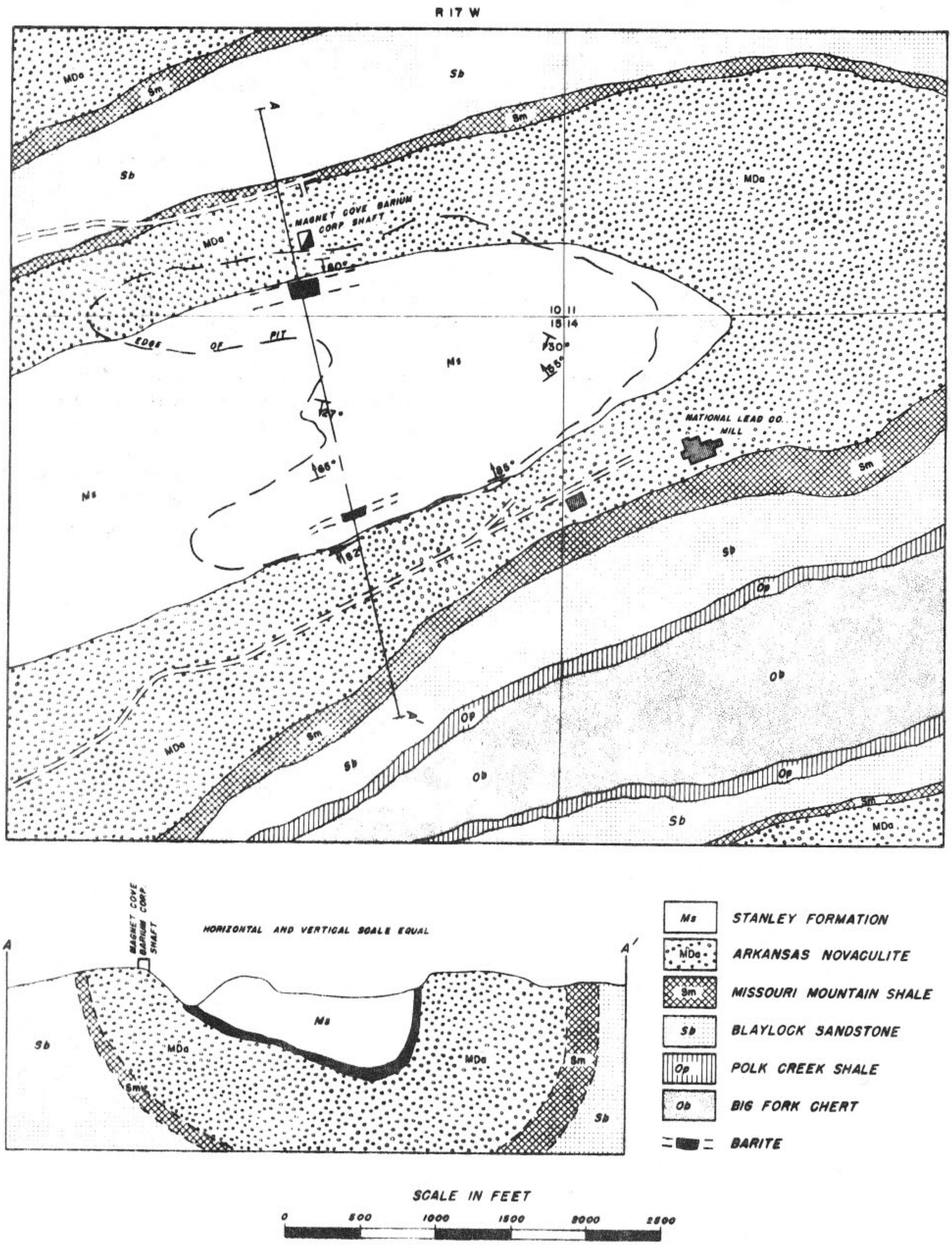
In the rock exposures made available by the underground mining operations, many more local structures can be seen than anywhere in the district. Underground, minor structures in the form of V and chevron folds, rollovers, and normal and reverse faults are common. The displacement along the faults is ordinarily only a few inches. These local structures have no appreciable effect on the concentration of the barite, although there is a slight increase in the grade of the ore along the axes of some of the folds.

**Stratigraphic Relations.** The barite ore in this deposit lies near the base of the Stanley Formation being separated from the underlying Arkansas Novaculite Formation by a bed of black shale varying in thickness from 2 to 22 feet.

In the area of the mine workings there is a maximum of 600 feet of shale, sandstone, and siltstone of the Stanley Formation overlying the black shale unit. This Formation is probably about 2,000 feet thick near the contact with the Magnet Cove intrusion.

**The Ore Bodies.** The barite deposit in the Chamberlain Creek syncline is located in the northeastern part of the structure. It has a maximum length of 3,200 feet and apparently is restricted to that portion of the syncline in which the axial trend is nearly eastward. The maximum width of the ore body (1,800 feet) occurs at the west end of the deposit. Because of natural truncation, the width diminishes eastward. The ore body has been completely eroded away at the eastern tip of the structure. The average thickness of the mineralized zone is about 300 feet and the average thickness of commercial concentration is about 60 feet. The maximum thickness of commercial ore occurs just north of the axis of the syncline where it has a thickness of 80 to 100 feet.

The available drill hole information and the exposures in the surface and underground mine workings show that in this thicker portion the mineralized zone is split into two bodies separated




GEOLOGIC MAP OF THE CHAMBERLAIN CREEK BARITE DEPOSIT
HOT SPRING COUNTY ARKANSAS

AFTER S. J. SCULL 1958

ARKANSAS GEOLOGICAL COMMISSION

**Figure 5**

by an essentially barren shale lens 5 to 15 feet thick. This is the only place in the commercial ore zone where a persistent barren or non-productive unit occurs.

With respect to texture and structure there are several types of barite ore. The major types in order of decreasing abundance are: finely crystalline in beds and lenses, dense microcrystalline in beds and lenses, nodular, and coarsely granular in lenses. These major types grade into each other laterally, pinch out, grade into low baritic sediments, or grade into non-baritic sediments. The thicker (1 to 3 feet) units ordinarily grade into low grade baritic shales and siltstones or nodule-bearing shales and siltstones. They do not pinch out as true lenses.

The nodular type ore makes up from 3 to 30 percent of the ore body, depending on the section measured. Coarsely crystalline barite is rare in this deposit. Most of the ore is of the gray to dark gray dense variety. Much of it has, superficially, a close resemblance to a dense limestone.

**Origin.** The origin of the barite in Arkansas has been the subject of two Ph.D. dissertations: B. J. Scull, University of Oklahoma, 1956 (published 1958, Arkansas Geological and Conservation Commission, Information Circular 18) and R. A. Zimmermann, University of Missouri, 1964.

Scull postulated that all of the Arkansas barite deposits were lower Upper Cretaceous in age, derived from the sub-silicic Upper Gulf Coastal Plain igneous suite and, with the sulfide deposits in the Ouachita Mountains, represented a minerogenetic province. Zimmermann concentrated on the deposits in the Stanley Formation (several thousand times greater in volume than the combined other types of deposits) and postulated that they are of sedimentary origin, and thus Mississippian in age.

# GEOLOGY OF THE WILSON SPRINGS VANADIUM DEPOSITS

## Garland County, Arkansas

J. S. Hollingsworth.
Union Carbide Corporation

## INTRODUCTION

The vanadium deposits currently mined by Union Carbide Corporation at Wilson Springs, Garland County, Arkansas, are the only deposits mined specifically for vanadium in the United States. The geologic setting of these deposits is described in this report.

The Wilson Springs operation takes its name from Wilson Mineral Springs (formerly known as Potash Sulfur Springs), which is located near the edge of the small circular alkalic intrusive also named after these springs. J. F. Williams described the igneous rocks of the area in 1890 and noted that a large hotel existed near the springs. The building was first abandoned and later destroyed by a fire in the early 1930's.

Interest in the economic potential of the Wilson Springs area was primarily initiated in 1950 by the discovery of anomalous radioactivity and one boulder containing small amounts of uranian pyrochlore (Erickson and Blade, p. 83). Several investigations were conducted by the U. S. Geological Survey, the Atomic Energy Commission, the Arkansas Geological Commission, and private mineral interests. Only trace amounts of uranium were indicated by drilling and trenching adjacent to the "discovery boulder." Geochemical determinations by the U. S. Geological Survey and others indicated significant concentrations of niobium and vanadium in the vicinity of the uranium prospect (Beroni, 1955).

Union Carbide geologists first investigated the Wilson Springs area for vanadium in 1960. After obtaining mineral leases, a preliminary core drilling program during 1961-1962 disclosed vanadium ores. Development drilling was resumed in 1964; and by September, 1965, sufficient reserves were indicated to justify the construction of the Wilson Springs Vanadium Plant.

## GEOLOGY

The location and general geologic setting of the Wilson Springs vanadium deposits are shown in Figures 6 and 7. The dominant feature of the area is the Potash Sulfur Springs[1] igneous complex, which intruded folded and faulted Paleozoic rocks. The distribution and description of the various rock types are generalized, with modifications, from D. W. Pollock (1966) who performed field and petrographic investigations of the intrusive. The highly variable contact rocks have been studied in detail by V. J. Hoffmann and D. M. Hausen of Union Carbide Corporaiton.

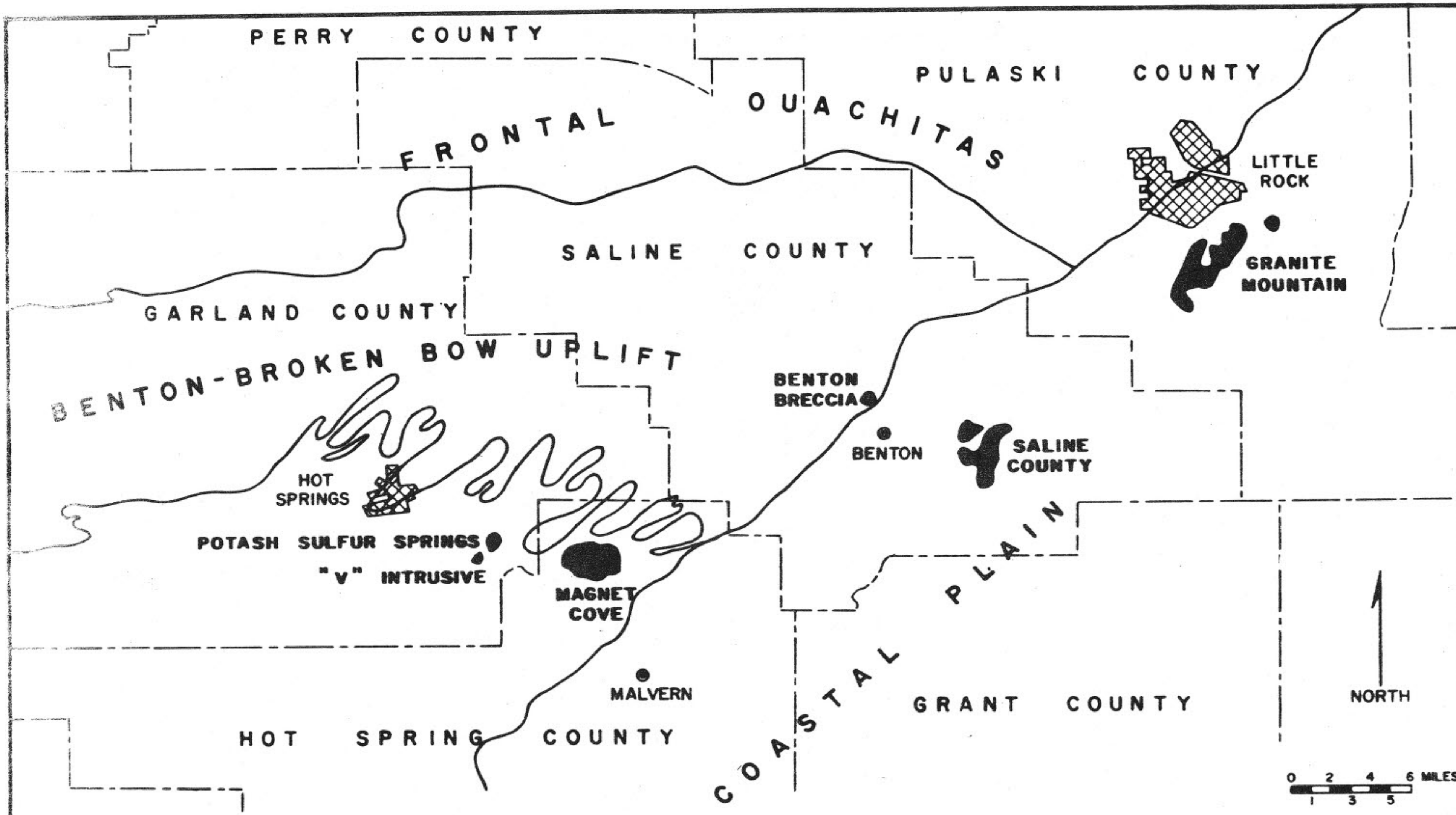
### Igneous Rocks

The Potash Sulfur Springs intrusive is a circular alkalic igneous complex exposed for somewhat less than a mile in diameter, that probably was emplaced in early Late Cretaceous time (Zartman and Marvin determined the Magnet Cove intrusive to be 95 ± 5 million years). The complex has a crude ring structure similar to the Magnet Cove intrusive exposed about 6 miles to the east. The outer ring of the complex is alkali syenite and fenite. Much of the central part of the complex is nepheline syenite. Disconnected exposures of jacupirangite, melteigite, and ijolite are present throughout the area. Near the center of the complex a calcite-cemented breccia crops out and carbonatite has been encountered in a few drill holes. Carbonatite is also present as dikes and as irregular masses in the subsurface near the margins of the intrusive. Several igneous and sedimentary rock breccias, commonly with feldsphathic matrix, are present within and near the margins of the intrusive.

Saprolite, highly weathered rock averaging about 40 feet in thickness, is developed over much of the igneous area, but the outer portion of the nepheline syenite ring supports a low ridge.

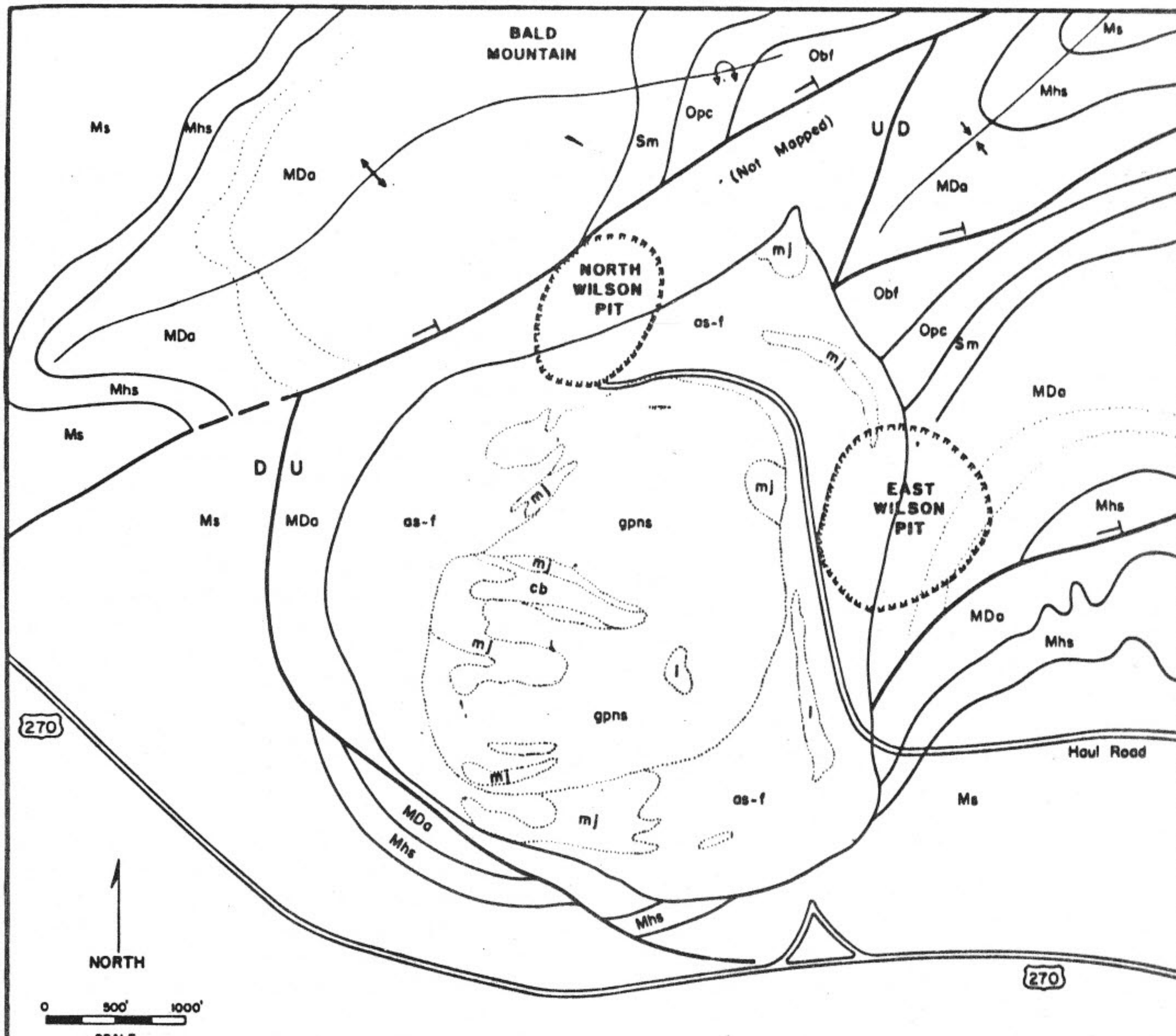
The basic rocks of the Potash Sulfur Springs complex include jacupirangite, pyroxenite, and members of the melteigite-ijolite series. Nepheline content varies from traces in jacupirangite to a maximum of 60 percent in ijolite. Biotite jacupirangite contains small amounts of magnetite and titanite with biotite as the only major constituent. The pyroxenite contains aegirine-diopside, ferroaugite, and biotite. Locally these rocks have been intensely chloritized. The melteigites have aegirine-

[1] The name Potash Sulfur Springs is used throughout geological literature for the intrusive and is retained herein.




**LOCATION MAP SHOWING POTASH SULFUR SPRINGS INTRUSIVE AND OTHER EXPOSED ALKALIC INTRUSIVES OF CENTRAL ARKANSAS**

Figure 6




## GENERALIZED GEOLOGIC MAP OF THE POTASH SULFUR SPRINGS INTRUSIVE AND VICINITY, GARLAND COUNTY, ARKANSAS

MODIFIED FROM PURDUE AND MISER (1923) AND POLLOCK (1966)

**SEDIMENTARY ROCKS**

| | | |
|---|---|---|
| MISSISSIPPIAN | Ms | STANLEY SHALE |
| MISSISSIPPIAN | Mhs | HOT SPRINGS SANDSTONE |
| DEVONIAN AND MISSISSIPPIAN | MDa | ARKANSAS NOVACULITE (upper, middle, lower) |
| SILURIAN | Sm | MISSOURI MT. SHALE |
| ORDOVICIAN | Opc | POLK CREEK SHALE |
| ORDOVICIAN | Obf | BIGFORK CHERT |

**IGNEOUS ROCKS**

| | |
|---|---|
| as-f | ALKALI SYENITE AND FENITE |
| gpns | GARNET PYROXENE NEPHELINE SYENITE |
| I | IJOLITE |
| mj | MELTEIGITE, PYROXENITE & JACUPIRANGITE |
| cb | CALCITE CEMENTED BRECCIA |

THRUST FAULT — ANTICLINE

U/D FAULT — SYNCLINE

Figure 7

diopside with 14 to 40 percent nepheline. In one variety of melteigite, titanium-rich andradite (garnet) makes up 30 to 60 percent of the rock. Garnet and pyroxene are present in the ijolites. Secondary minerals such as calcite, orthoclase, zeolites, and pyrite may be up to 55 percent of these rocks.

The nepheline syenite contains 7 percent aegirine-diopside and 7 percent garnet with about 32 percent nepheline. Calcite, secondary orthoclase, and zeolites are present in variable amounts.

The alkali syenite and fenite ring represents 51 percent of the exposed complex. The alkali syenites are medium to coarse grained with 80 to 98 percent orthoclase. Much of the rock in this zone is a product of alkali-metasomatism and, therefore, should be termed fenite rather than syenite. The contact between the fenite and the surrounding sedimentary rock is irregular, and residual blocks and zones of metamorphosed sedimentary rocks are frequently found. Relict bedding can be seen in some fenite exposures. Aegirine is a common accessory mineral in the fenite, and occasionally makes up 80 to 90 percent of the rock. Locally, biotite, apatite, or siderite may be major constituents in the border fenites.

Calcite carbonatite has been encountered beneath the saprolite cover by several drill holes in the central part of the complex. Biotite, aegirine, pyrite, pyrrhotite, and magnetite are the most common accessory minerals. A few feldspar-carbonate veins, similar to the veins at Magnet Cove, have been encountered.

Dikes and sills of various sizes and attitudes are frequent within the igneous mass but appear to be more abundant in the surrounding sedimentary rocks. A large variety of rock types is present ranging from phonolites and trachytes to the very basic varieties including ouachitite, monchiquite, and fourchite. Outside the igneous complex, most of the dikes are partially or completely argillitized, often to depths of several hundred feet—only the texture remains to identify the origin of such clays. Many dikes are xenolithic; a large irregular dike mass in the North Wilson pit contains rounded as well as angular fragments of the adjacent rocks.

### Stratigraphy

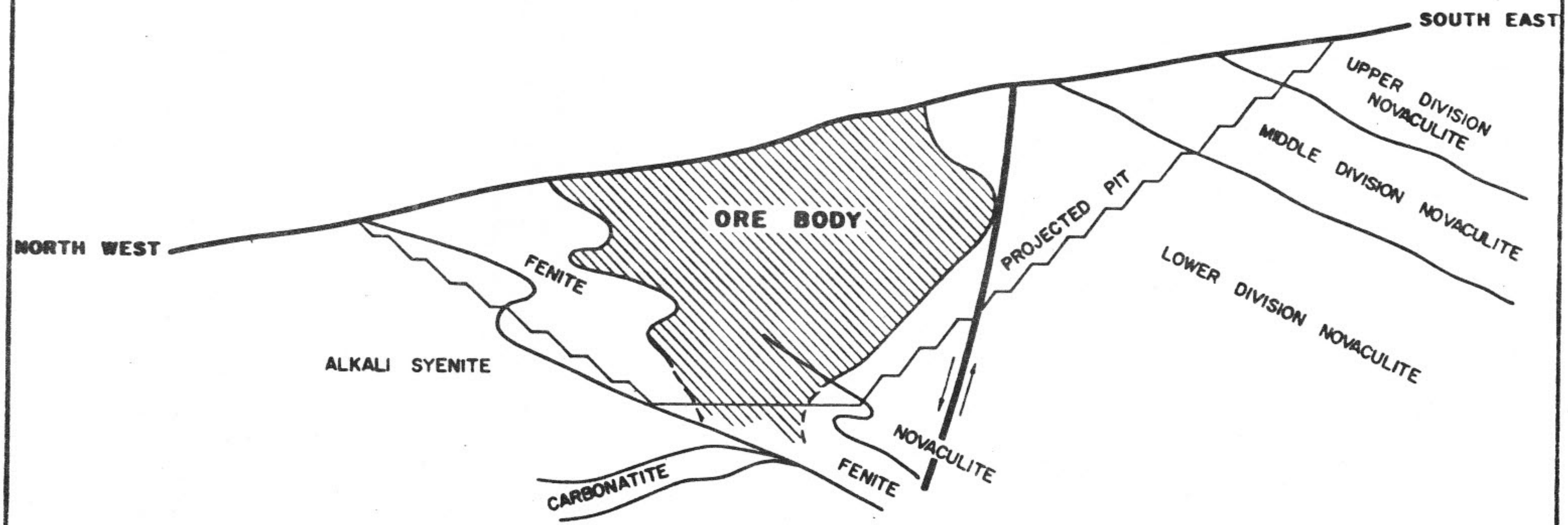
The sedimentary rocks in the immediate vicinity of the Potash Sulfur Springs intrusive range from Ordovician (Bigfork Chert) to Mississippian (Stanley Shale) in age. The approximate observed thicknesses of these units and a brief description are shown in the accompanying table.

Within 1000 feet of the igneous rocks, the Arkansas Novaculite has been recrystallized by thermal metamorphism to a very fine to medium grained quartzite. Closer to the intrusive, the siliceous units contain cristobalite, wollastonite, tremolite, aegirine, miserite, and calcite in a highly variable metamorphic rock suite. The shale units have been metamorphosed to hornfels. Large areas of shale have been argillitized, at least in part by hydrothermal solutions, thus many of the stratigraphic units cannot be distinguished in the immediate vicinity of the ore deposits.

### Structure

The Potash Sulfur Springs intrusive is located on a southwest plunging anticlinal nose of the Zigzag Mountains. The sedimentary rocks were intensely folded and faulted during the Late Pennsylvanian Ouachita orogeny. These structures trend about N 65 E. Several anticlines and at least three thrust faults are present in the area (Figure 7). The northernmost anticline at Bald Mountain is overturned to the north for much of its length.

The Potash Sulfur Springs intrusive considerably distorted the older Ouachita structural fabric. Minor faulting is quite common within 1,000 feet of the intrusive contacts. One large concentric fault is shown on the geologic map (Figure 7) and many others have been noted (Figure 8). Some of the older Ouachita faults were re-opened, altered, and mineralized by the intrusive, especially the thrust fault at the north edge of the North Wilson pit.




DIAGRAMMATIC CROSS SECTION
OF THE EAST WILSON PIT

NOT TO SCALE

Figure 8

## TABLE I

## STRATIGRAPHIC UNITS IN THE VICINITY OF THE POTASH SULPHUR SPRINGS INTRUSIVE

| AGE | FORMATION | DESCRIPTION | APPROXIMATE LOCAL THICKNESS IN FEET |
|---|---|---|---|
| Mississippian | Stanley Shale | Dark gray platy shale with thick beds of fine-grained clayey sandstone. | over 1,000 |
| Mississippian | Hot Springs Sandstone | Light gray, very-fine grained sandstone interbedded with dark gray shale. | 90 |
| Devonian and Mississippian | Arkansas Novaculite | Upper Division: medium to thick bedded white novaculite and ferruginous sandstones. Some gray shale interbeds are present and the base is marked by 1–2′ of conglomerate. | 75 |
| | | Middle Division: thin bedded novaculite interbedded with dark gray fissile shale—strongly argillitized in the immediate area. | 120 |
| | | Lower Division: white and black massive novaculite. | 380 |
| Silurian | Missouri Mountain Shale | Pale red to greenish gray shale, 1–2′ of ferruginous fine-grained sandstone at base may represent the Blaylock Sandstone. | 100 |
| Ordovician | Polk Creek Shale | Black, fissile, graphitic shale with thin beds of limy chert. | 130 to 200 |
| Ordovician | Bigfork Chert | Gray and black chert regularly interbedded with gray siliceous shale. | over 300 |

South North

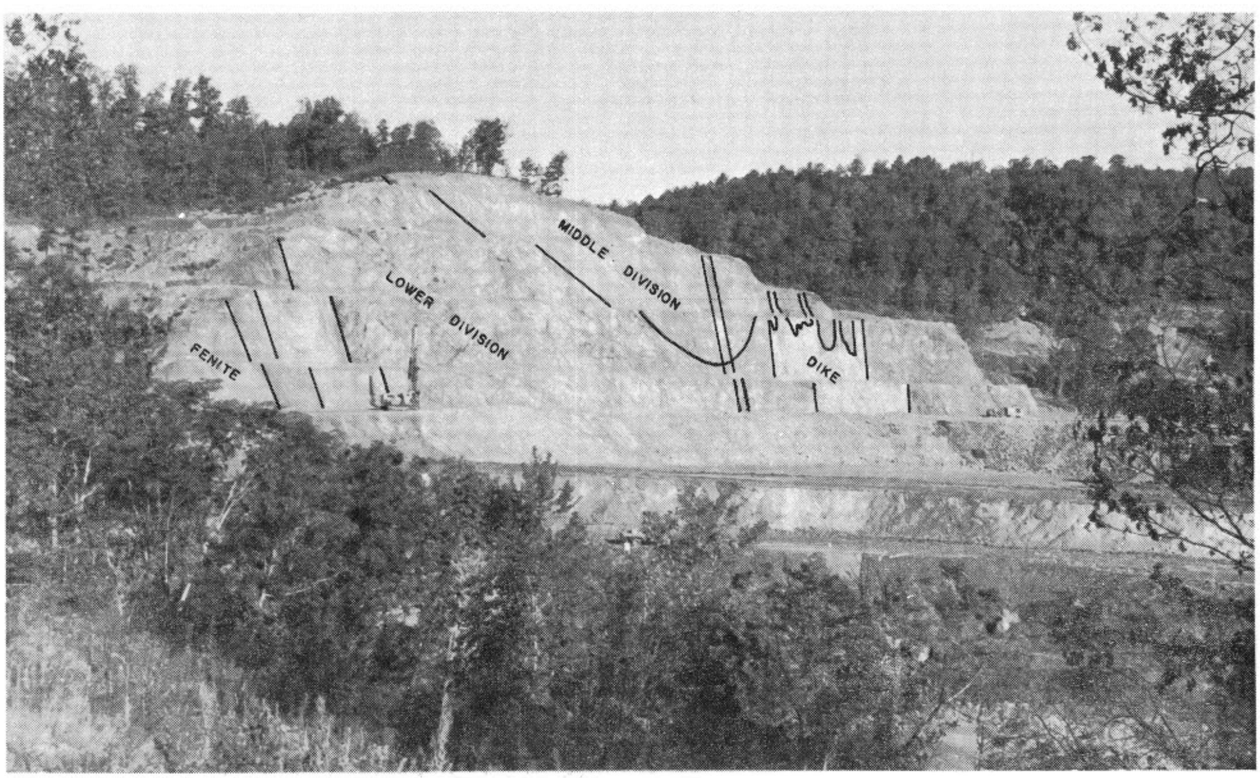



**Figure 9 View of the North Wilson Pit looking northwest at the north-south high wall. Description in text.**

The high west wall of the North Wilson pit shown in Figure 9 displays the structural complexity of the near-contact areas. On the far right is a shattered zone probably representing an anticline. A broad fault zone left of the xenolithic dike cuts the bottom of a syncline. The contact between the Lower and Middle Divisions of the Arkansas Novaculite in the center marks the north limb of an anticline. Southward the Middle Division shales and cherts reappear in a syncline with two or three small faults and numerous dikes. Farther south fenite replaces the novaculite along an irregular contact.

## ORE DEPOSITS

The vanadium ore deposits of the Wilson Springs area occur near the contact between the alkalic igneous rocks and the surrounding sedimentary rocks. Two ore bodies are being developed by separate open pits. Other deposits are present in the area that will be developed at a later date.

The vanadiferous ores occur as local concentrations within large, irregular areas of argillic alteration. Fenite, feldspathic breccias, and metamorphosed sedimentary rocks have all been altered and mineralized in such areas (Figure 8). Iron oxides are common near the present surface, and pyrite is present at depth.

The ores contain about one percent $V_2O_5$ which very rarely occurs as discrete vanadium minerals. Montroseite ($VO \cdot OH$) and such secondary minerals as fervanite ($2Fe_2O_3 \cdot 2V_2O_5 \cdot 5H_2O$) and hewettite ($CaO \cdot 3V_2O_5 \cdot 9H_2O$) have been noted. The vanadium occurs as a vicarious element in several rock-forming minerals and their alteration products.

Even though the Wilson Springs area has been investigated as a potential niobium deposit (Fryklund, Harner, and Kaiser, p. 55), the niobium content of the ores being mined is low, generally under 0.10% $Nb_2O_5$. Titanium occurs in minor quantities, mainly as anatase, which contrasts sharply with the higher values in the titanium prospects at the Magnet Cove intrusive.

Close control of the vanadium content must be maintained to derive optimum metallurgical results in the processing of the ore. The varying nature of the ore requires close spaced test drilling, generally 20 foot centers, directly ahead of mining. Visual inspection is of limited value in ore control due to the variability of values and the non-descript nature of the ore.

## REFERENCES


1. Beroni, E. P., 1955, Maps of Wilson's Prospect, Garland County, Arkansas: Open filed at U. S. Geol. Survey and Ark. Geol. Comm.
2. Danilchik, Walter, and B. R. Haley, 1964, Geology of the Paleozoic area in the Malvern quadrangle, Garland and Hot Spring Counties, Arkansas: U. S. Geol. Survey, Misc. Geol. Inv. Map I-405.
3. Erickson, R. L. and L. V. Blade, 1963, Geochemistry and petrology of the alkalic igneous complex at Magnet Cove, Arkansas: U. S. Geol. Survey Prof. Paper 425, 95 pp.
4. Fryklund, V. C., Jr., R. S. Harner, and E. P. Kaiser, 1954, Niobium (columbium) and titanium at Magnet Cove and Potash Sulfur Springs, Arkansas: U. S. Geol. Survey, Bull. 1015-B.
5. Pollock, D. W., 1965, The Potash Sulfur Springs alkali complex, Garland County, Arkansas: Manuscript and Map filed at Ark. Geol. Comm., also Abs: Mining Engr., 1965, No. 12, p. 45-46.
6. Purdue, A. H., and H. D. Miser, 1923, Description of the Hot Springs quadrangle, Arkansas: U. S. Geol. Survey Geol. Atlas, folio 215.
7. Stone, C. G., and P. J. Sterling, 1964, Relationship of igneous activity to mineral deposits in Arkansas: Ark. Geol. Comm., Misc. Rept.
8. Williams, J. F., 1891, The igneous rocks of Arkansas: Ark. Geol. Survey Ann. Rept., 1890, v. 2, 457 p.
9. Uranium in Arkansas, 1958, Ark. Geol. Comm., Misc. Rept.
10. Zartman, R. E., and R. F. Marvin, 1965, Age of alkalic intrusive rocks from eastern and mid-continent states: U. S. Geol. Survey, Prof. Paper 525-A, p. A 162.