Critical Minerals of Arkansas

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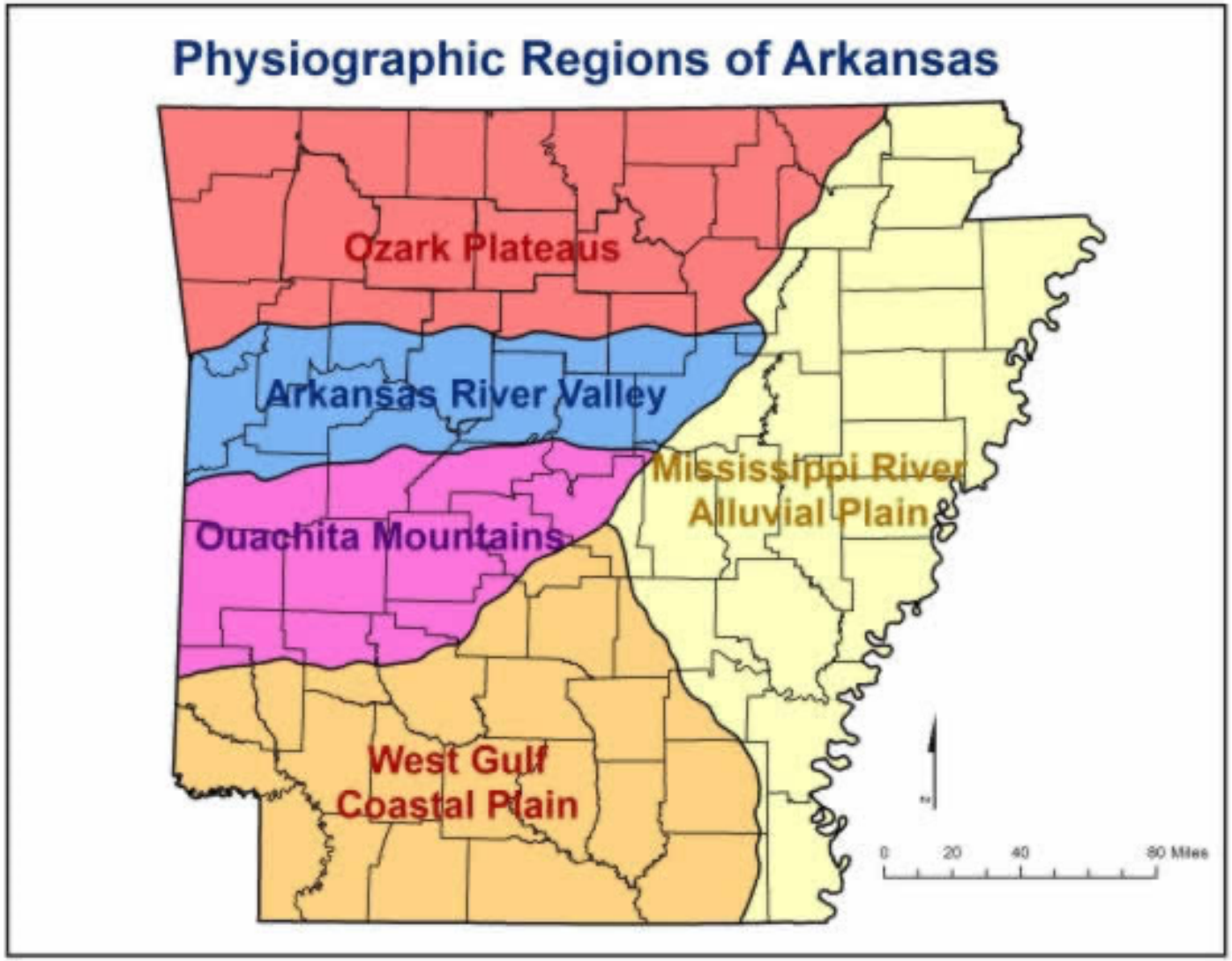
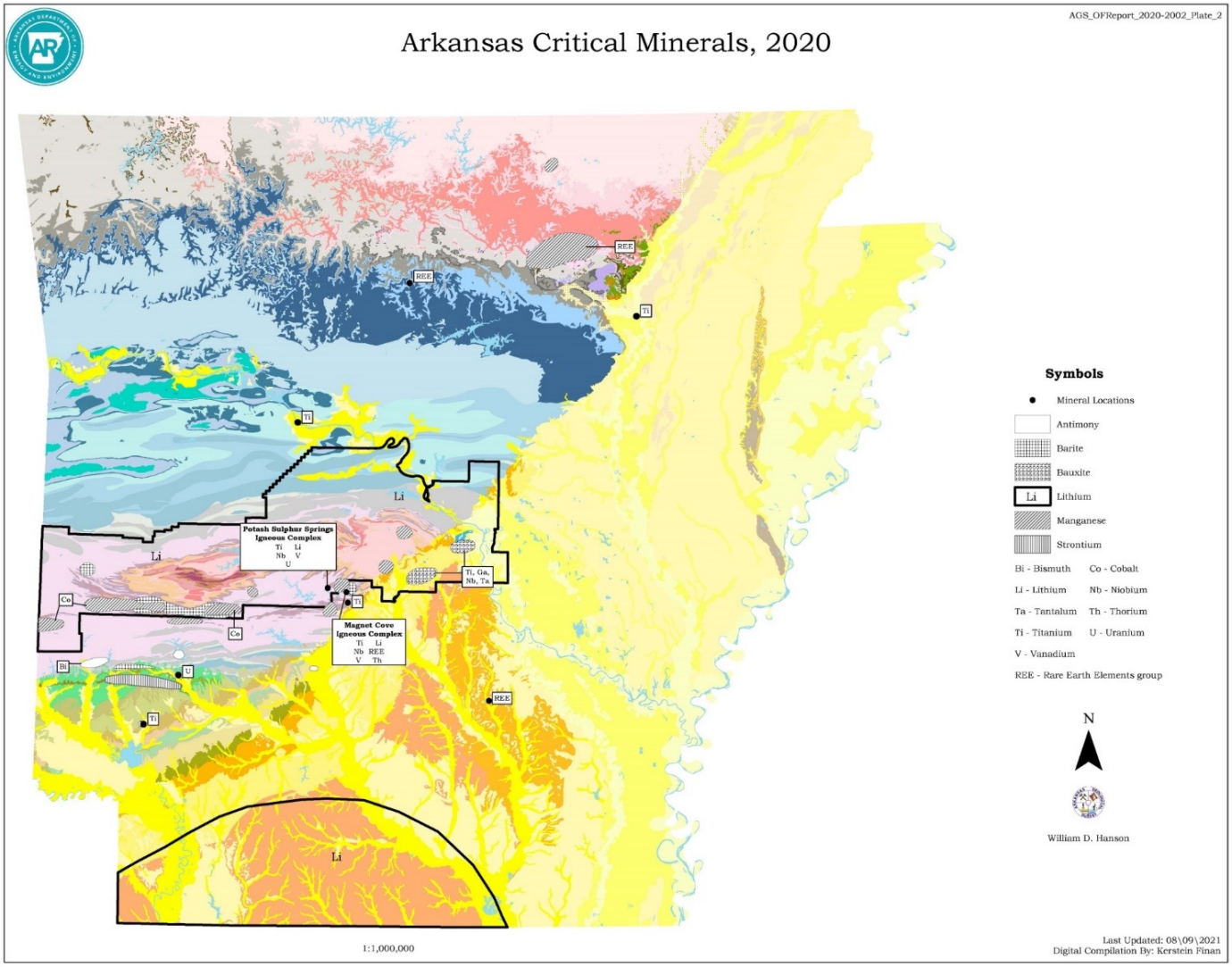
ARKANSAS
ENERGY & ENVIRONMENT


Physiographic Regions of Arkansas
Ozark Plateaus
Arkansas River Valley
Ouachita Mountains
Mississippi River
Alluvial Plain
West Gulf
Coastal Plain
0
20
40
80 Miles


AGS_OFReport_2020-2002_Plate_2
Arkansas Critical Minerals, 2020
REE
Ti
Li
Potash Sulphur Springs Igneous Complex
Ti Li
Nb V
U
Ti, Ga, Nb, Ta
Co
Magnet Cove Igneous Complex
Ti Li
Nb REE
V Th
Bi
U
Symbols
Mineral Locations
Antimony
Barite
Bauxite
Lithium
Manganese
Strontium
Bi - Bismuth
Co - Cobalt
Li - Lithium
Nb - Niobium
Ta - Tantalum
Th - Thorium
Ti - Titanium
U - Uranium
V - Vanadium
REE - Rare Earth Elements group
N
William D. Hanson
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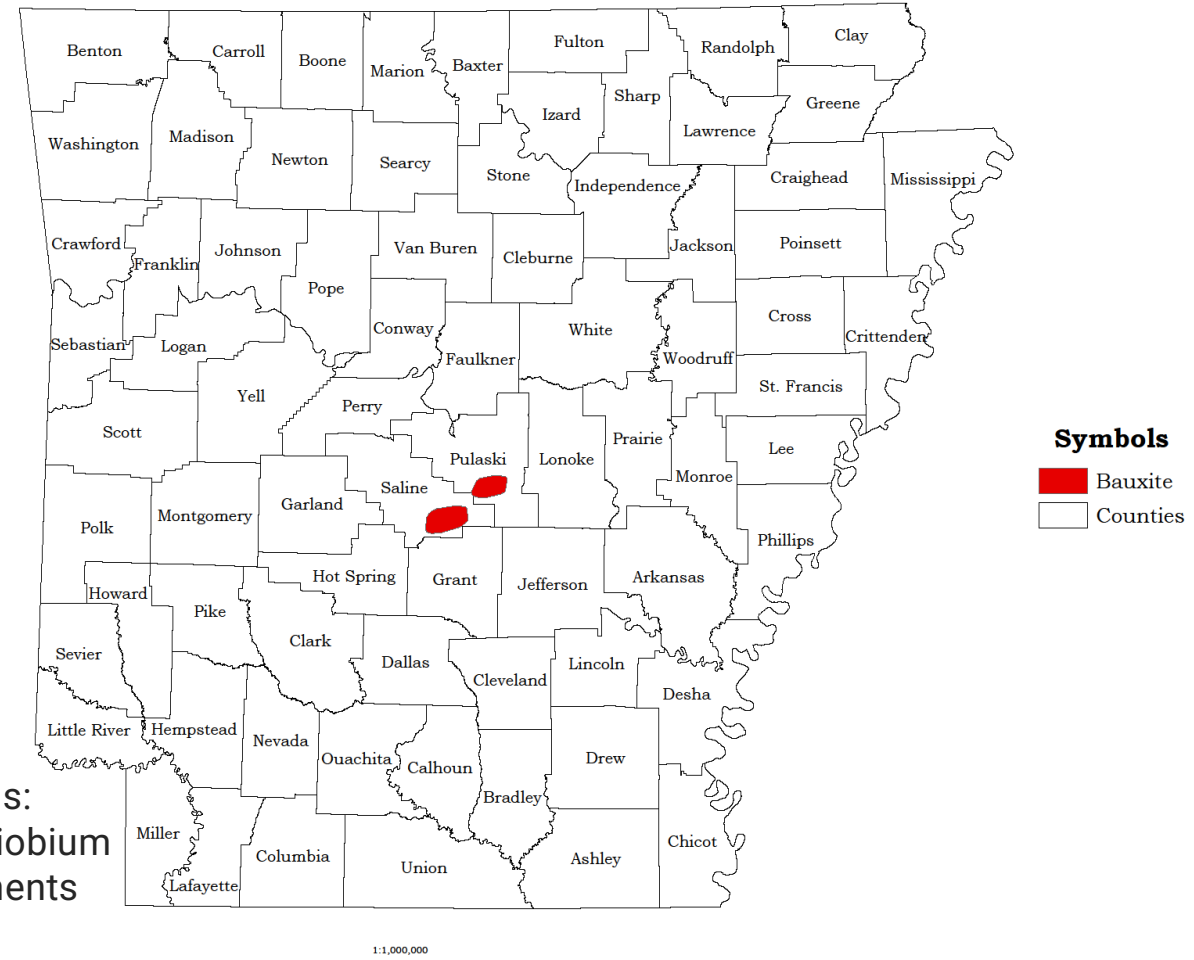
Last Updated: 08\09\2021
Digital Compilation By: Kerstein Finan

Critical Minerals of Arkansas

Aluminum - Bauxite

Pulaski and Saline Counties



Associated minerals: titanium, gallium, niobium and rare earth elements

Aluminum (Al) - Bauxite

Bauxite discovered in 1888

Bauxite produced from 1898 – 1990 for Al

Pulaski and Saline Counties, area of production ~275 sq mi in the Gulf Coastal Plain.

Total production > 70 million long tons from Tertiary age deposits.

Highest yearly production 1944 – 6 million long tons

Source - by product of the Cretaceous batholith composed mostly of nepheline syenite that is at or near the surface in central Arkansas.

Gibbsite, boehmite, and diaspore most common Al-bearing minerals.

Types of Deposits – residual, colluvial, stratified and conglomeratic

Associated minerals include Gallium, Titanium, and Niobium

Gallium – produced from 1947 – 1983, average content 0.0086% or 2.75 oz/ton
Niobium – no production – US Bureau of Mines estimate in 1954 of 150 million lbs. of Nb metal.
Titanium – no production

Gallium (Ga)

Gallium is a by-product of bauxite mining.

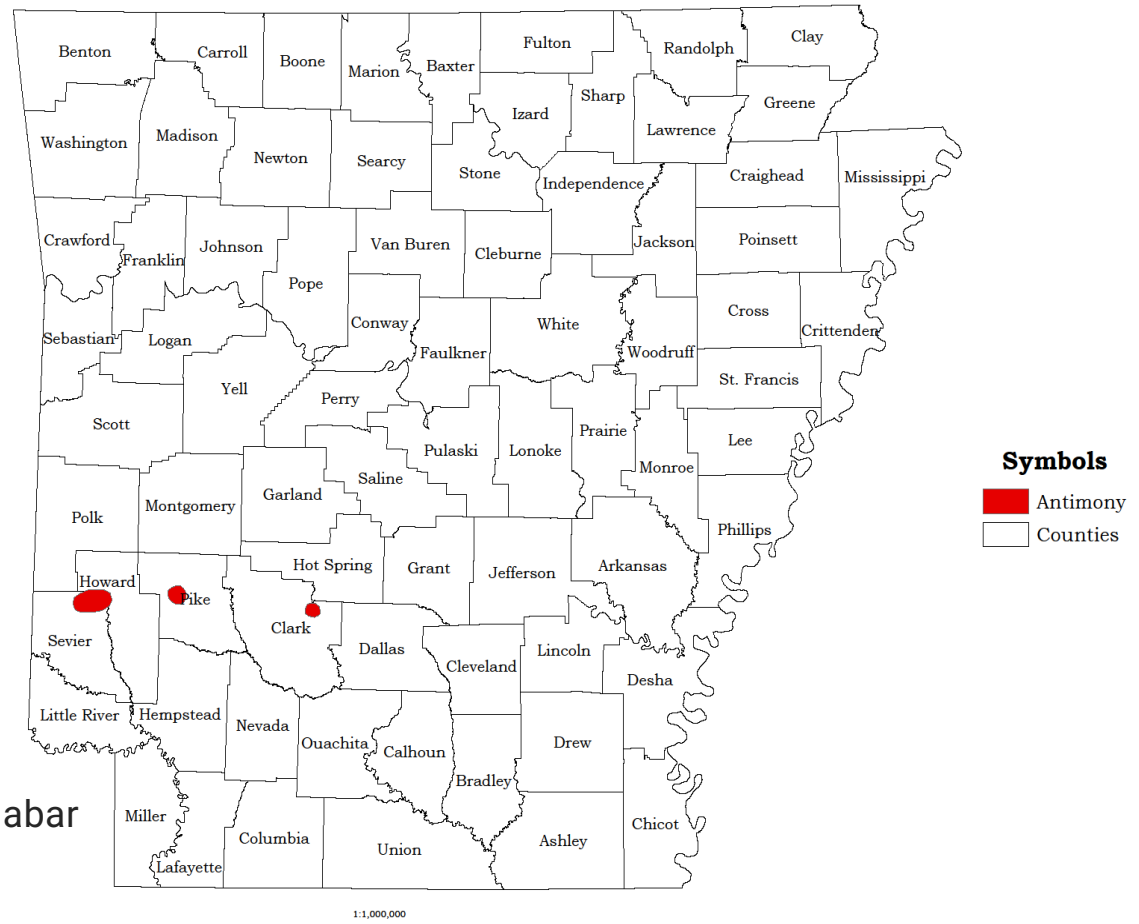
Produced from 1947 to 1983.

The average Ga content of the bauxite was 0.0086% or 2.75 oz/ton.

Critical Minerals of Arkansas

ANTIMONY

Clark, Pike, and Sevier Counties



Associated minerals: copper, iron, zinc, cinnabar and bismuth

Antimony (Sb)

Mined from 1873-1947

Sevier, Pike and Clark Counties, Ouachita Mountain region

Production through 1947 was 5390 tons

US Bureau of Mines resource estimates of 5000 tons of concentrates from 27 mine sites now abandoned.

Two principal antimony minerals present are stibnite and stibiconite.

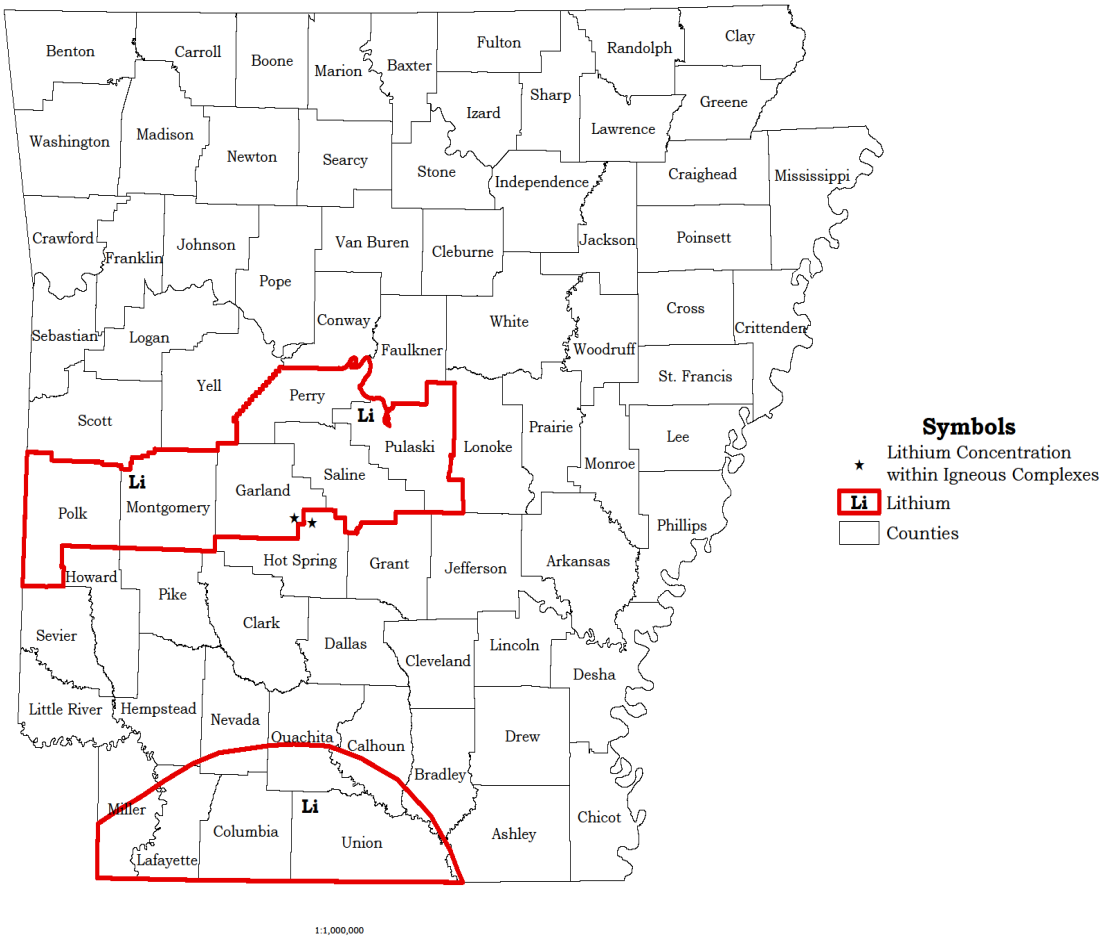
Associated minerals include copper, iron, zinc, bismuth, and cinnabar.

Critical Minerals of Arkansas

Polk, Montgomery, Garland, Saline, Perry, and Pulaski Counties in the Ouachita Mtns.

Miller, Lafayette, Columbia, Union, Nevada, Ouachita, Calhoun Bradley and Ashley Counties in the Gulf Coastal Plain

LITHIUM



Lithium (Li) **Critical Minerals of Arkansas**

Lithium occurs in two provinces within the state.

In the Gulf Coastal Plain, the primary resource area in south Arkansas includes Union and Columbia Counties.

Lithium occurs in oil-field brines produced from the Smackover Formation, Jurassic age. Brines from the Smackover Formation are reported to contain up to 445 parts per million lithium.

Bromine Brine is the primary product. Arkansas is the leading producer of bromine in the nation.

Reserve figures keep changing but are estimated to be in the millions of tons of lithium contained in the brines of south Arkansas. The USGS has plans to assess this resource in the near future.

An operational extraction pilot plant in south Arkansas has a rated production of 20 tons of lithium chloride/year. A second similar extraction plant is being planned. Permits are being altered to produce lithium carbonate presently.

Other occurrences include a limited area in Polk and Montgomery Counties, hydrothermal quartz veins throughout the Ouachita Mountain region, and alkaline igneous complexes.

Lithium occurring in a limited area of Polk and Montgomery Counties is associated with the manganese oxide deposits occurring there.

The primary lithium mineral occurring in the hydrothermal quartz veins are cookeite, taeniolite and lithophorite.

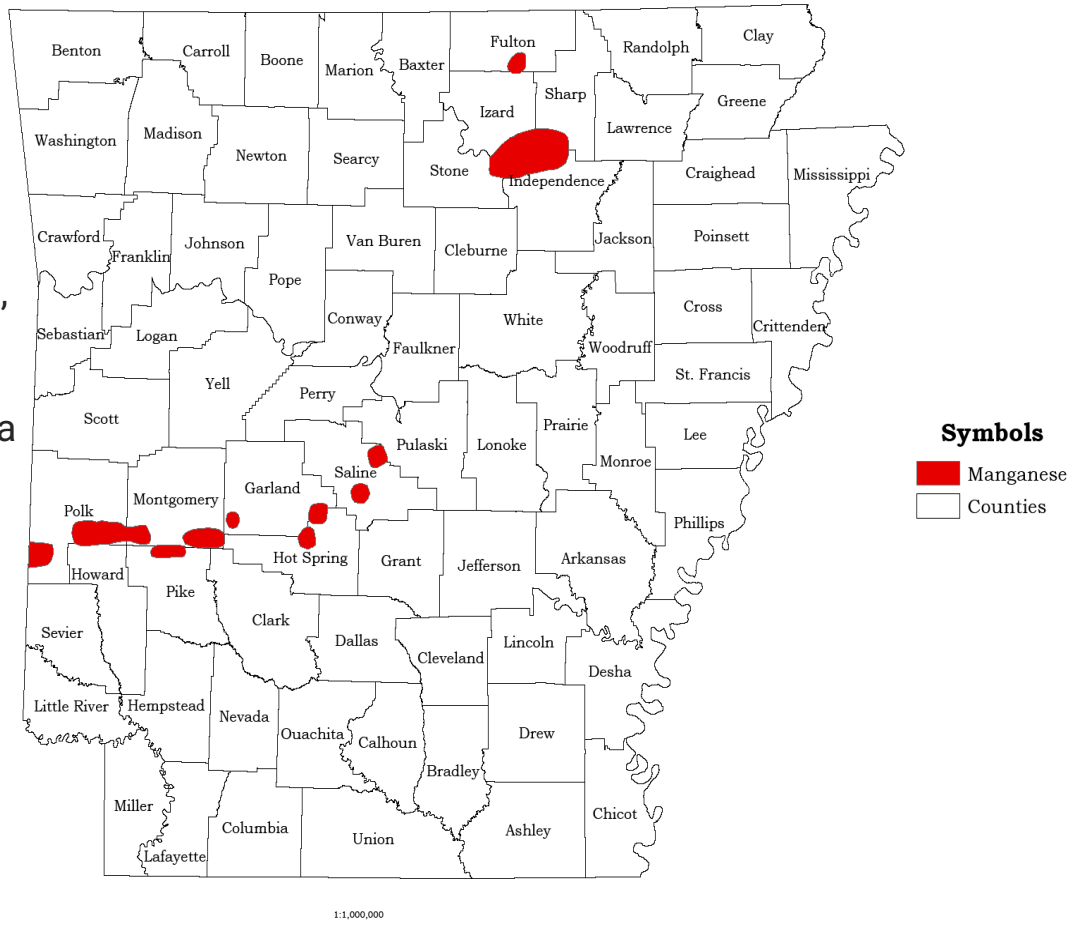
Critical Minerals of Arkansas

Stone, Izard, Independence and Fulton Counties in the Ozark Mtns.

Polk, Montgomery, Pike, Garland, Saline, Hot Spring and Pulaski Counties in the Ouachita Mtns.

Associated minerals: rare earth elements, lithium, and cobalt

MANGANESE



Manganese (Mn)

Manganese occurs in two physiographic provinces, the Ozark and Ouachita Mountains.

Most of the mining effort was centered in the Ozarks in the Batesville District, an area of about 100 sq. miles in northern Independence County, southern Izard County, and southeastern Stone Counties.

About 98% of the manganese mined in the state came from this district.

The Batesville District ore deposits are classified into 4 main types: manganiferous limestone, in situ clay, clay-talus residual and placer which occur mostly in the Upper Ordovician and Lower Silurian Formations.

The Batesville District deposits were worked starting in 1847 and stopped in 1959.

Production in 1958 was > 150 tons of milling-grade ore.

The US Bureau of Mines resource figures for this district are 200 million tons at 4 to 9 % manganese.

In the Ouachita Mountains, occurrences have been noted in Pulaski, Saline, Hot Spring, Garland, Pike, Montgomery, and Polk Counties, although mining was confined to Polk and Montgomery Counties.

Manganese oxides occurs in the Devonian/Mississippian Arkansas Novaculite and the Mississippian Stanley Shale and is found in pockets and veins from ½ inch to 10 feet thick.

Principle minerals are psilomelane, pyrolusite, manganite and wad associated with clay and iron oxide.

Associated critical minerals include rare earth elements, lithium, and cobalt.

Cobalt (Co)

Cobalt is associated with manganese-bearing sites in Polk, and Montgomery Counties in the Ouachita Mountain region, and Independence, Stone, and Izard Counties in the Ozark's Batesville Manganese District.

In 1983 analysis of 140 samples collected in the Ouachita Mountains by the US Bureau of Mines determined cobalt ranges from 0.05 to 1.2% combined with copper, lithium, and nickel in 40% of the deposit samples.

Cobalt is concentrated in lithophorite. Resource estimates range from 1 million to 6.4 million tons.

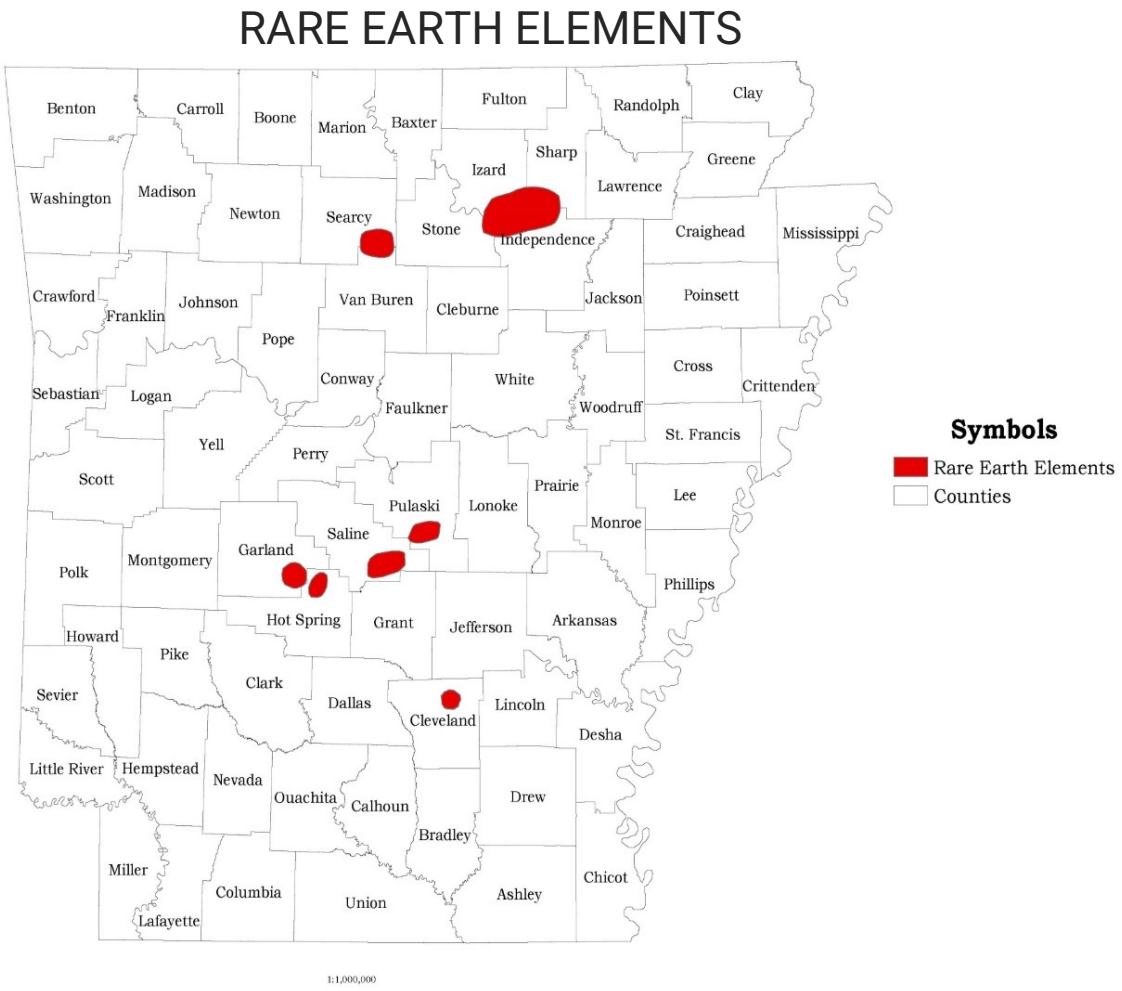
Associated minerals include manganese, lithium, nickel, and copper.

Critical Minerals of Arkansas

Searcy, Van Buren, Stone, Izard, and Independence Counties in the Ozark Mtns

Garland, Hot Spring, Saline, Pulaski and Cleveland Counties igneous complexes

Associated minerals: Phosphorites



Rare Earth Elements – REE's

This group of elements consists of scandium, yttrium, and the lanthanum group elements.

They are known to occur in two different rock types, igneous and sedimentary, in the state.

In Hot Spring County, Garland, Pulaski, Saline, and Cleveland Counties, REE's are associated with alkali igneous complexes.

Samples analyzed from auger drilling in the central region of Magnet Cove, Hot Spring County, show up to 4.3% combined rare earth elements.

Selected samples of bastnaesite collected from Magnet Cove by the Arkansas Geological Commission contained over 30% combined lanthanides.

Sedimentary deposits where REE's occur are in the Batesville Manganese District (Stone, Izard, and Independence Counties) and in Searcy and Van Buren Counites.

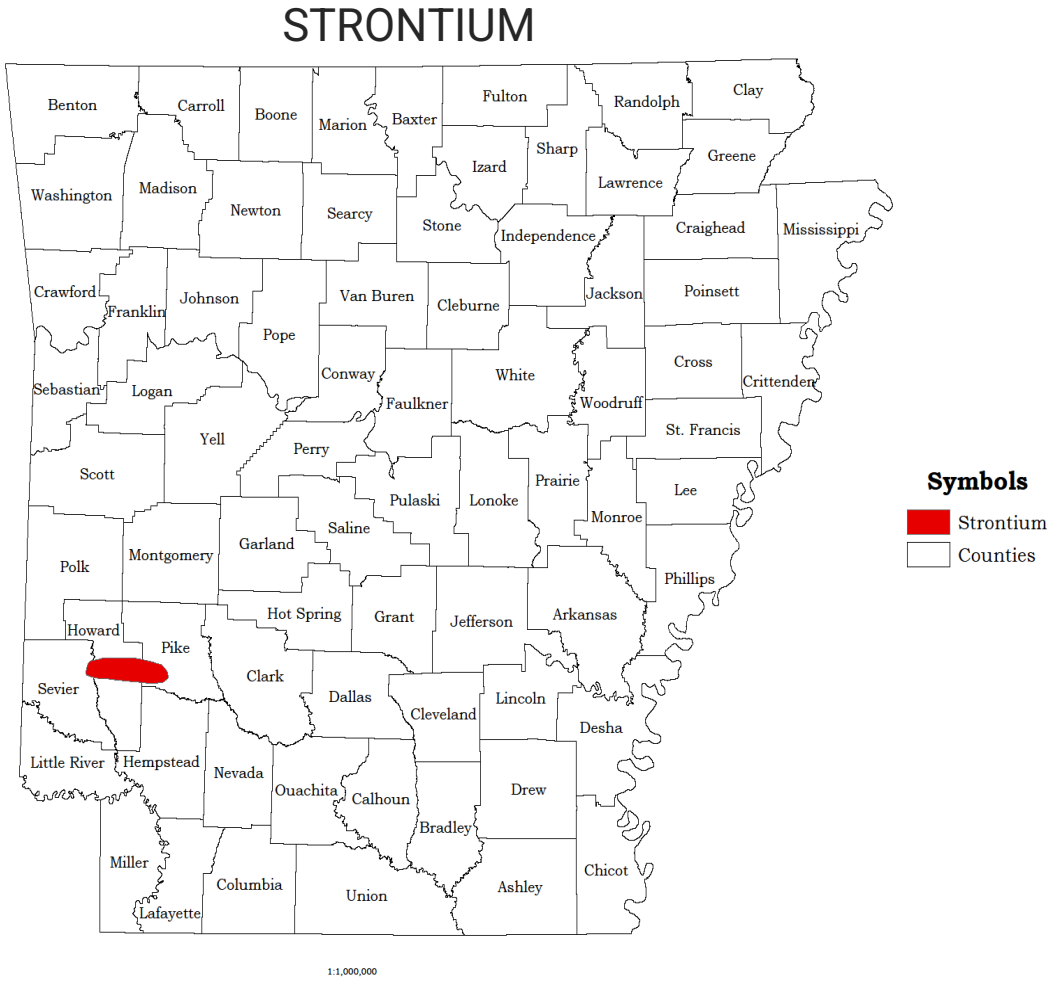
The phosphorite from this district has an average REE content of 1692.2 ppm.

Mining of phosphate-rich rock in Van Buren County took place following investigations during 1963 for a short time. Only a few thousand tons of phosphate ore was mined during this time.

No mining has taken place on the phosphate deposit in Searcy County.

Critical Minerals of Arkansas

Sevier, Howard and Pike Counties



Strontium (Sr)

Strontium, an evaporite mineral, occurs in the De Queen Limestone member of the Trinity Group, Lower Cretaceous in the West Gulf Coastal Plain, Howard and Pike Counties.

The strontium-bearing minerals are celestine ($SrSO_4$) containing 56.4% strontium oxide and strontianite ($SrCO_3$) containing 70.1% strontium oxide.

The first report of celestine in the state was by the US Geological Survey in 1929.

In 1941, 1500 pounds of celestine was collected by the W.F. Hintze Company.

During 1942 and 1943, a prospecting and exploration project was conducted. Test pits and 750 test holes were drilled over a 30 square mile area in Howard County.

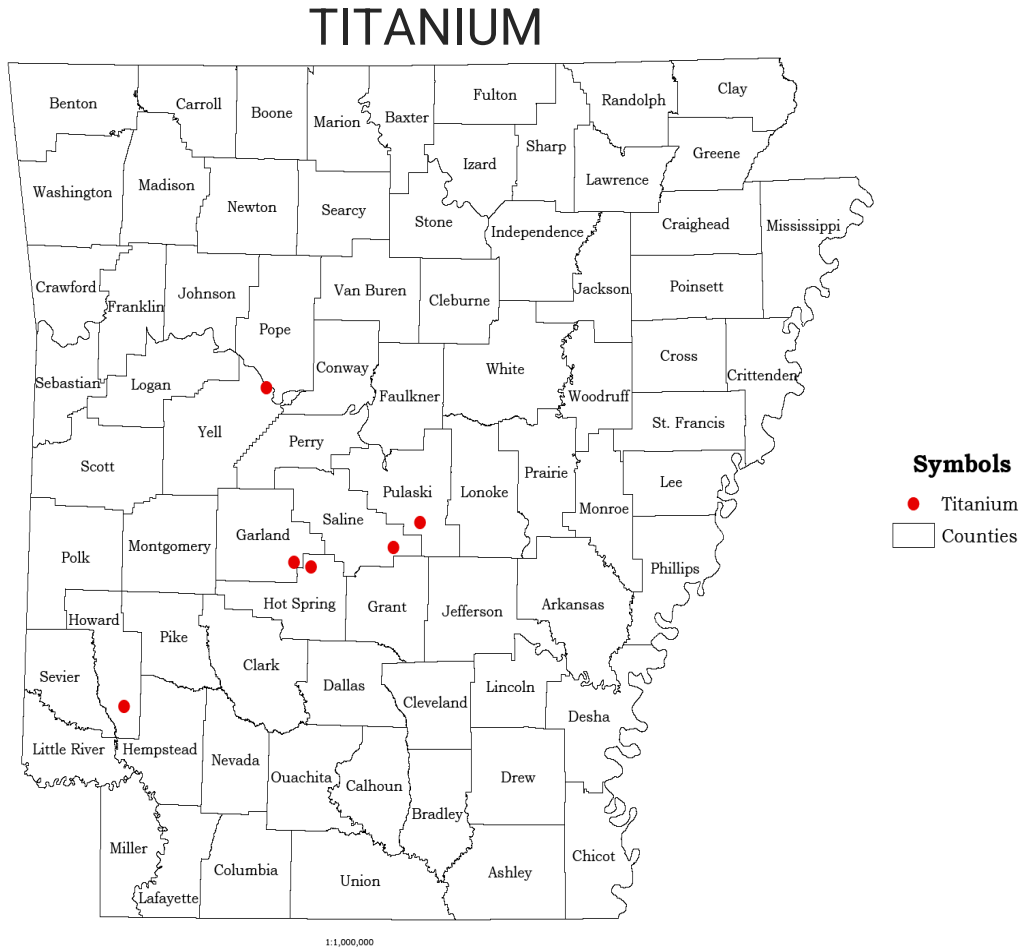
Afterwards, 90 tons of ore were mined by open-pit methods and sent to Nacagdoches, TX for processing.

Since then, no further mining has taken place in the state.

Critical Minerals of Arkansas

Yell, Pulaski, Saline, Hot Spring, Garland, and Howard Counties

Associated mineral: niobium



Titanium (Ti)

Critical Minerals of Arkansas

Titanium occurs in Pulaski, Saline, Hot Spring, Garland, Pike, Howard, Sevier, and Little River Counties and alluvial sands on the Arkansas and White Rivers.

Titanium is present primarily in the minerals anatase, brookite, rutile (all TiO_2), ilmenite ($FeTiO_3$), perovskite ($CaTiO_3$) and titanite ($CaTiSiO_5$).

The most important ore minerals in Arkansas are rutile, brookite, and ilmenite**.**

In Pulaski and Saline Counties, the Ti-bearing minerals are associated with the igneous intrusive rocks and subsequent bauxite deposits.

Rutile, brookite, and perovskite are present at Magnet Cove in Hot Spring County in two types of deposits: feldspar-carbonate-rutile veins in igneous rocks of the intrusion and from brookite-quartz veins in altered Arkansas Novaculite contact metamorphic zone adjacent to the intrusion rim.

Perovskite is associated with late-stage carbonate-rich bodies piercing the interior of the Magnet Cove alkali igneous intrusion.

Rutile was mined from open pits in Magnet Cove from 1932–1944. About 5,400 tons of concentrate were recovered. US Bureau of Mines investigations show 8 million tons of Ti-bearing material containing 4 to 8% TiO_2 in the Magnet Cove area.

In Garland County titanium values were noted during the mining of vanadium ore at Potash Sulphur Springs but were not recovered.

Additionally, placer deposits are noted in Hot Spring and Howard Counties and along the Arkansas River.

In southern Howard County, an investigation by the Arkansas Geological Commission estimated about 110,000 tons of Ti-bearing minerals within 50 feet of the surface.

During 1939-1940, 12.8 tons of ilmenite was processed from sands along the Arkansas River in Yell County.

Associated mineral is niobium.

Niobium (Nb)

Niobium occurs in two physiographic provinces, the Gulf Coastal Plain and the Ouachita Mountains and is association with Cretaceous alkali igneous complex and contact metamorphism.

In the Ouachita Mountains, niobium occurs at Potash Sulphur Springs, Garland County and Magnet Cove, Hot Springs County.

In the Magnet Cove area, there are substantial deposits of niobium-bearing titanium minerals, rutile (TiO_2), brookite (TiO_2), and perovskite ($CaTiO_3$).

Perovskite may contain up to 9% niobium. Crystals of the rutile and brookite average 2% and maximum of 5% niobium.

The niobium at Potash Sulphur Springs is present in the mineral pyrochlore ($(Ca, Na)_2 Nb_2O_6 (OH, F)$).

The US Bureau of Mines estimate 12 million pounds of niobium contained in the rutile-brookite deposits at Magnet Cove.

In the Gulf Coastal Plain, Nb occurs in Pulaski and Saline Counties and is associated with the titanium-bearing minerals in bauxite deposits.

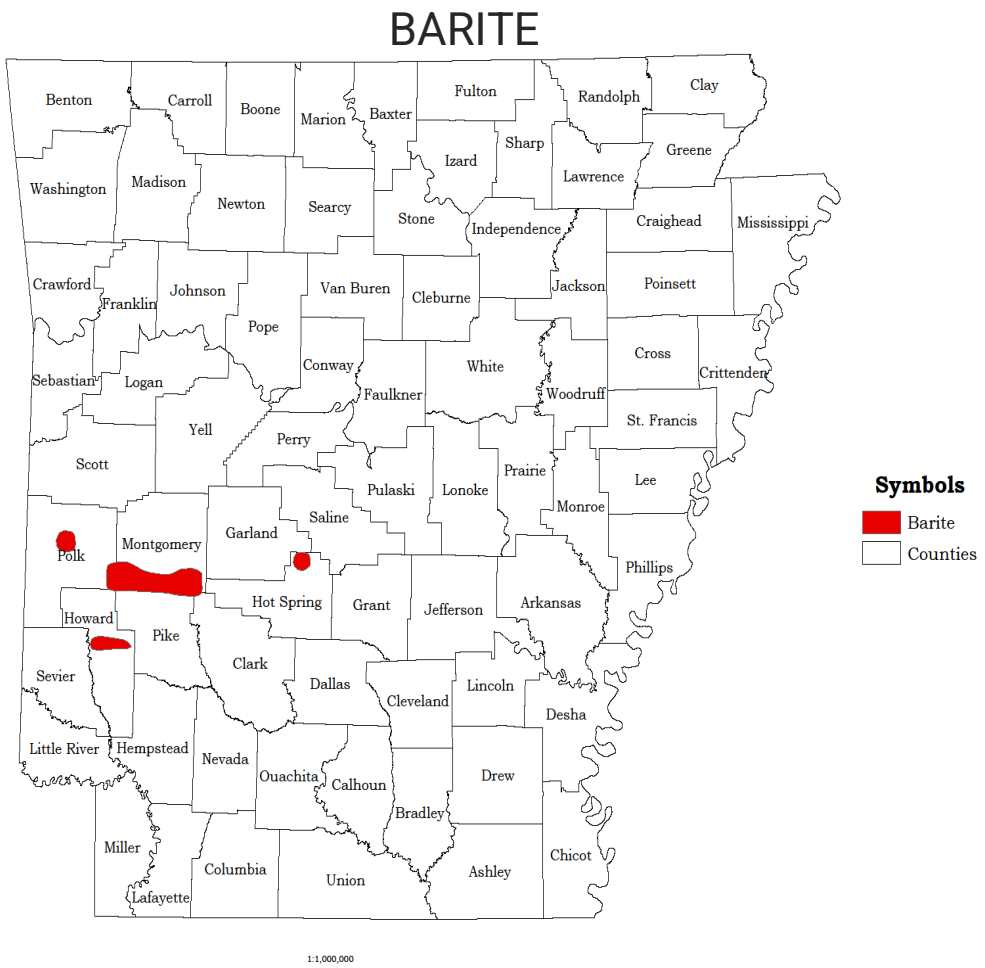
Arkansas bauxite is reported to contain niobium values from 0.02 to 0.1% and average 0.05%.

In 1954, the US Bureau of Mines estimated the bauxite deposits and waste fines contained up to 150 million pounds of niobium metal.

Associated critical minerals include rare earth elements, lithium, titanium, vanadium, uranium, and thorium.

Critical Minerals of Arkansas

Polk, Montgomery, Howard, Pike and Hot Spring Counties



Barite ($BaSO_4$)

Barite occurs in the Ouachita Mountain region, specifically in Hot Spring, Montgomery, and Polk Counties and in Howard County in the Gulf Coastal Plain region.

Barite was first discovered in Montgomery County in 1888, and near Magnet Cove in Hot Spring County in 1900.

Mining began in 1939 near Magnet Cove. During 1944-1966, the Chamberlain Creek deposit at Magnet Cove was the Nations' leading producer from stratiform deposits.

Total production of barite from Arkansas is 9 million tons (1939-1983) with 8 million tons coming from the Chamberlain Creek deposit.

Reserves are estimated to be in the millions of tons.

Deposits occur in the Mississippian Stanley Formation with minor occurrences in the Arkansas Novaculite and in the West Gulf Coastal Plain Lower Cretaceous Trinity Group deposits.

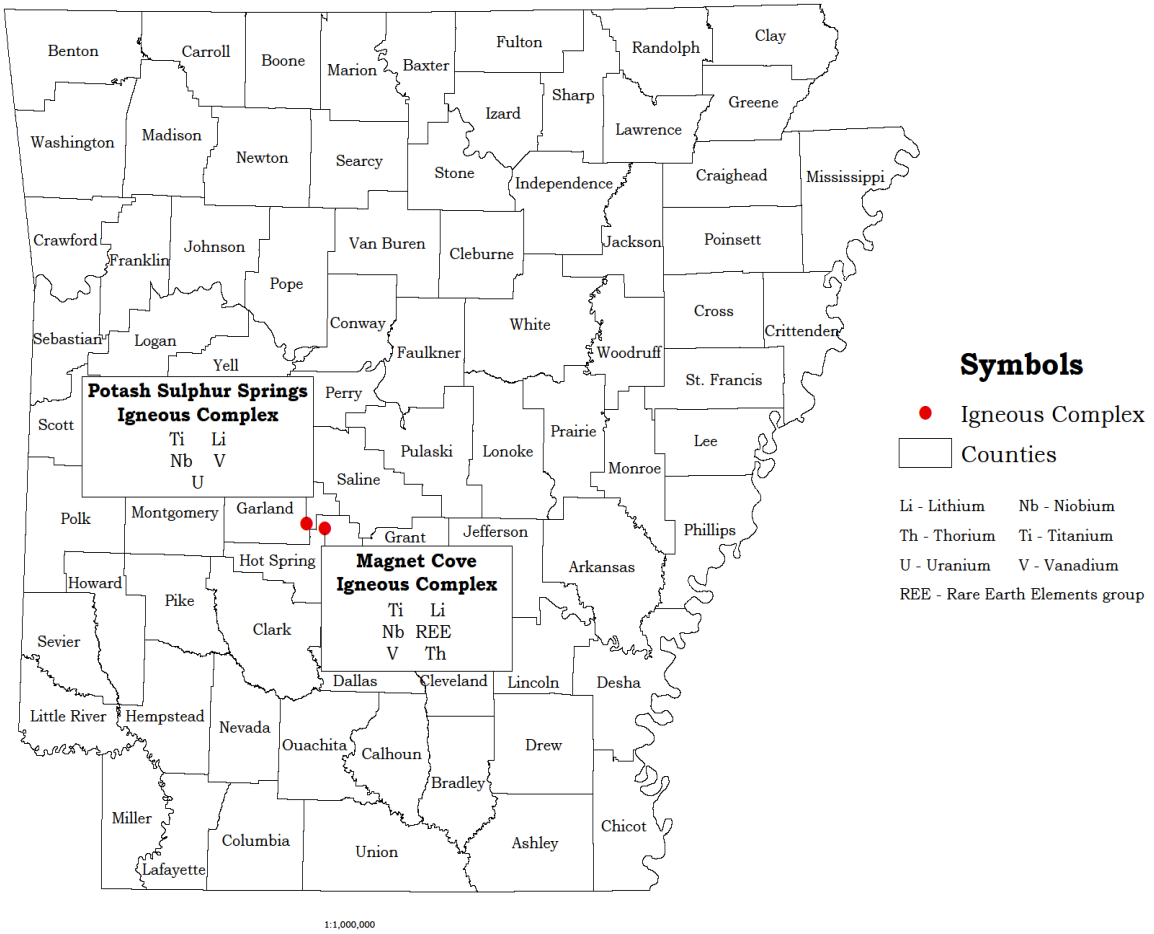
During the 1970-1980's, barite was mined from the Fancy Hill district in Montgomery County. Other active mines during this time were near Pigeon Roost Mountain, northeast of Glenwood, Montgomery County and near Dierks, Howard County.

The Arkansas Geological Survey has all the mine plans Milchem Corp. amassed on the Fancy Hill deposit in Montgomery County which includes are over 165 maps and figures with core analysis.

Critical Minerals of Arkansas

Pulaski, Garland and Hot Spring Counites

ARKANSAS IGNEOUS COMPLEX



Vanadium (V)

During the 1950's while searching for radioactive minerals, vanadium was discovered to be in economic quantities at Potash Sulphur Spring igneous complex, Garland County, and Magnet Cove igneous complex, Hot Spring County.

In 1962, Union Carbide delineated several ore-grade deposits in highly altered Paleozoic rocks from the contact metamorphic zone around Potash Sulphur Springs complex.

The Christy deposit at the adjacent Magnet Cove igneous complex also has ore-grade material occurring in recrystallized and altered Arkansas Novaculite.

The principal ore minerals are vanadiferous goethite with some minor amounts of vanadium-bearing brookite.

Approximately 4.8 million tons of 1.2% V_2O_5 has been processed from Arkansas ore.

The last production of V_2O_5 was in 1990.

The T deposit and Spaulding deposit at Potash Sulphur Springs contain ore grade rock that has not been mined to date.

Minerals associated with the vanadium are titanium, niobium, molybdenum, with lesser amounts of tantalum, uranium, complex rare earth oxides and fluorine.

Thorium (Th)

During the 1950's exploration for radioactive elements discovered anomalies in the Magnet Cove area in Hot Spring County and Saline Counties.

In Saline County thorium and uranium are present in a vein of quartz-feldspar rock. A selected sample analyzed 0.019% uranium and 1.5% thorium. There has been no mining of thorium or uranium in the state.

Uranium (U)

During the 1950's, uranium anomalies were discovered in Marion, Garland and Pike Counties.

Several locations yielded samples containing 0.1% or more uranium oxide.

At Potash Sulphur Springs, Garland County, uranium was discovered to be associated with the igneous intrusion. The uranium mineralization is found the contact of the Cretaceous igneous complex within folded Paleozoic novaculite and shale beds.

Soil samples assayed up to 0.4% uranium from this site by the Atomic Energy Commission.

The Rankin prospect in Pike County consists of radioactive carbonized wood fragments in the Cretaceous Trinity Group.

The highest assay obtained at the Rankin Prospect was 0.24% uranium oxide.

The highest assay obtained at the Bear Hill prospect in Marion County, from Paleozoic black shales was 2% uranium oxide.

No mining in the state for radioactive ore has occurred.

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Recent involvement by the AGS

Current projects involving critical minerals at the AGS include:

EMRI and STATEMAP project mapping and sampling for rare earth elements in the Batesville Manganese District in the upper Ordovician to lower Mississippian aged units

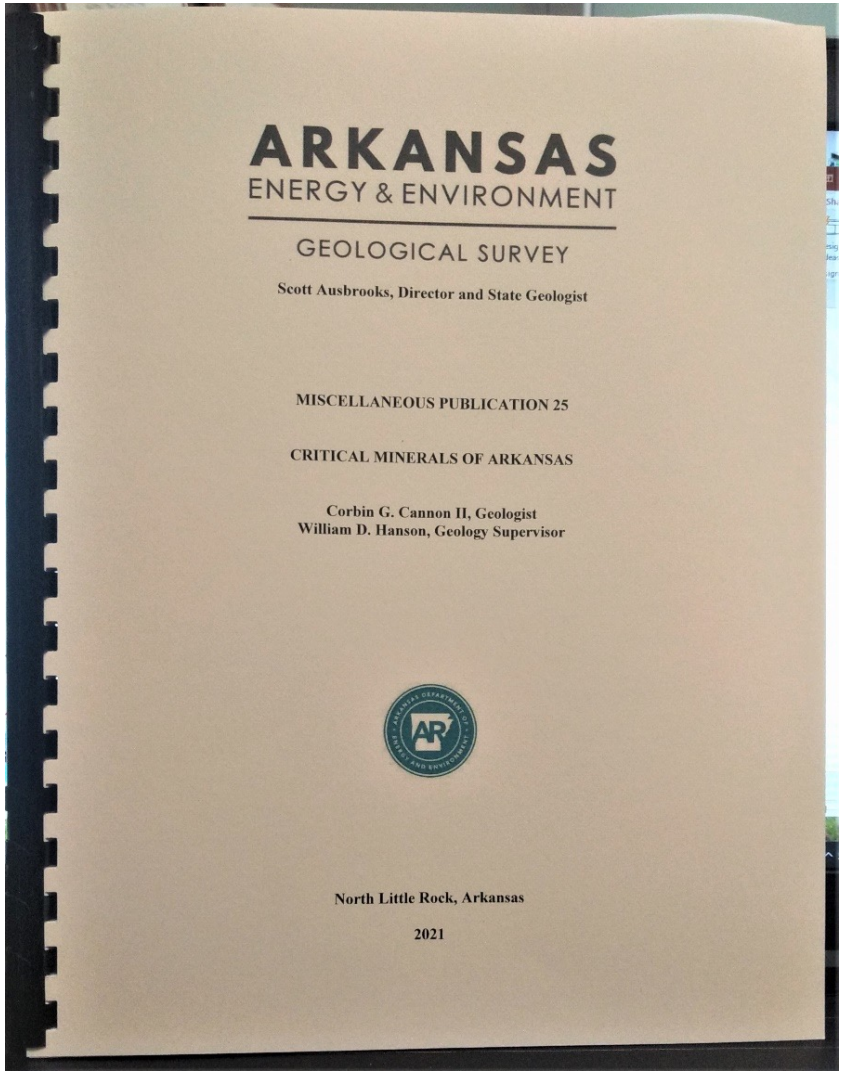
USGS and EMRI project to obtain geophysical data in part of the state is planned for this winter

a geochemical study sampling Devonian, Pennsylvanian, Cretaceous, and Tertiary age units for rare earth element potential.

New Publication….

MP-25

Critical Minerals of Arkansas



KEEP IN TOUCH

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