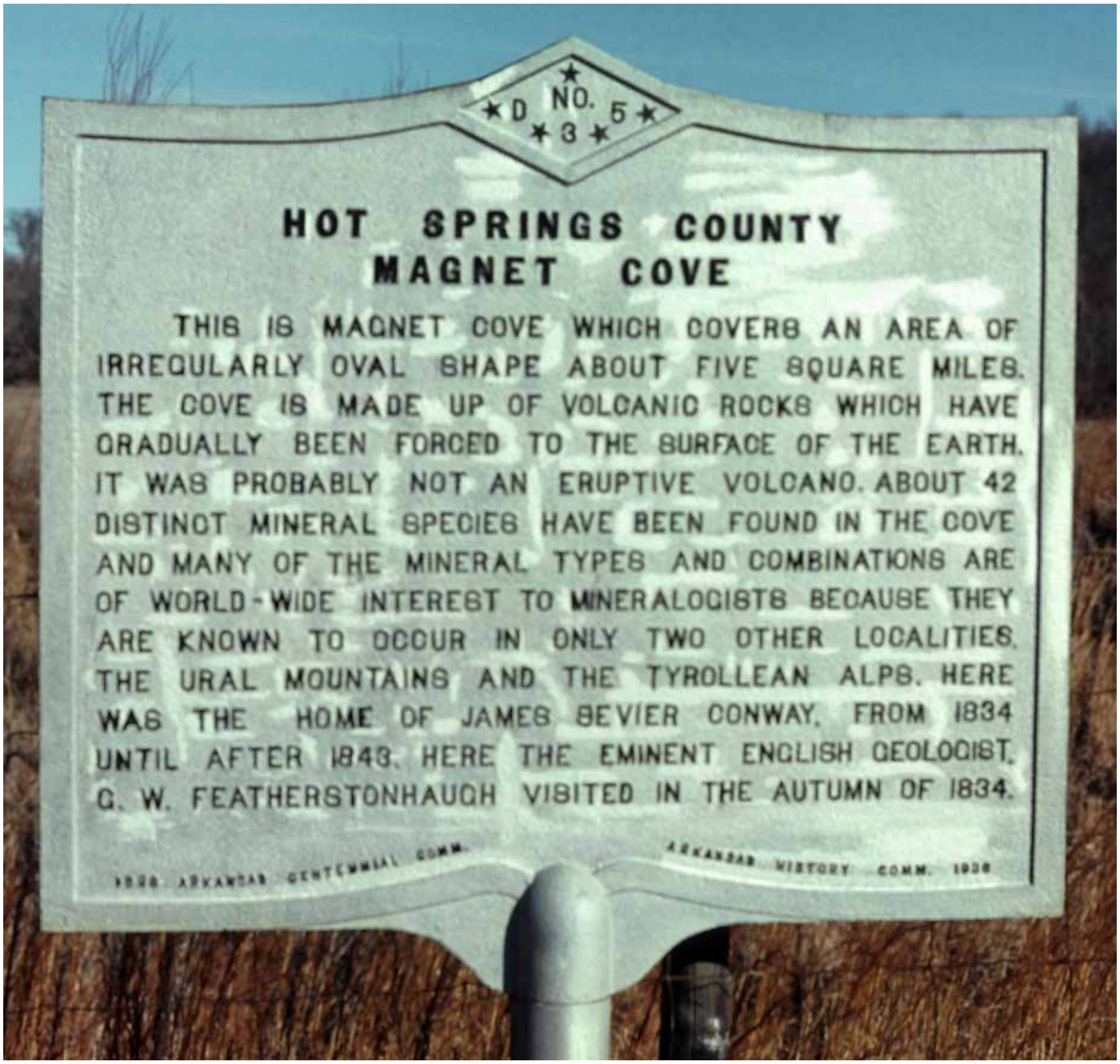

MAGNET COVE, HOT SPRING COUNTY, ARKANSAS:

COLLECTOR AND PROFESSIONAL OBSERVATIONS, STORIES AND PHOTOGRAPHS OF MINERALS FROM THIS CLASSIC MINERAL COLLECTING LOCALITY

By

Arthur E. Smith, Jr.   and   J. Michael Howard

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ACKNOWLEDGEMENTS

Through the years we have received a lot of help identifying minerals and learning about Magnet Cove minerals, their associations, and the intrusion's complex geology. Most of these people are cited in the text and acknowledged in the bibliography. Additional help was received from Karl Estes who generously loaned his micro-mineral collection for the senior author to study and send some specimens for EDS analysis. Henry de Linde tracked down much information on the history of Magnet Cove, particularly the Kimzey family, Diamond Jo Reynolds, and the Diamond Jo quarry. He also read this manuscript in both its early and late stages, and offered many helpful suggestions. Meredith York and Bob Gamble shared their finds from the Jones Mill quarry with the senior author, resulting in new minerals being identified. Henry Barwood generously shared his mineral data with us on Magnet Cove and made suggestions about the chemical formulae. Thanks go to Tony Nikischer of Excalibur Minerals, who did most of our SEM-EDS work. Don Owens, while employed by Union Carbide Corporation, was always interested in the geology and mineralogy of Magnet Cove. He took the junior author under his professional wing. We shared many hours in the field collecting minerals, mapping the Diamond Jo quarry, and discussing geology and life in general. Special appreciation goes to Charles Milton (deceased), Malcolm Ross, Marta Flohr, and Howard Evans (all former mineralogists with the U.S. Geological Survey in Reston, VA) for their mineral identifications and geological work. Thanks are also due those who read the manuscript and provided critical reviews: William Prior of the Arkansas Geological Survey; Ed Raines of Ward, Colorado; Ed O'Dell of Lexington, Kentucky; and Ray Lynch of Mabelvale, Arkansas. Mindat.org (June 2016) is the source of chemical formulae in this manuscript.

COVER PHOTOGRAPH

The Arkansas Centennial Commission, along with the Arkansas History Commission on the Centennial Year of Arkansas Statehood (1936), established a series of road side plaques. This plaque is located on the north side of present day Arkansas Highway 51, east of the Magnet Cove Baptist Church, and celebrates both the unusual geology of Magnet Cove and the nearby home of Sevier Conway, the first governor of Arkansas. That home later was the home of Joe W. Kimzey, State Geologist of Arkansas during World War II. In 1829, Hot Spring County was much larger than present day, and Hot Springs was the county seat. When Garland County was formed in 1873, it included the town of Hot Springs, and Hot Spring County was much reduced in size. Since statehood, Magnet Cove has been in Hot Spring County. It is a common misconception to think Magnet Cove is in Hot Springs County, Arkansas, and therefore mislabel specimens.

MAGNET COVE, HOT SPRING COUNTY, ARKANSAS: Collector and Professional Observations, Stories, and Photographs of Minerals from this Classic Mineral Collecting Locality

By Arthur E. Smith, Jr. and J. Michael Howard

Part 1 – BACKGROUND, GEOLOGY, HISTORY OF MINERALS & COLLECTING

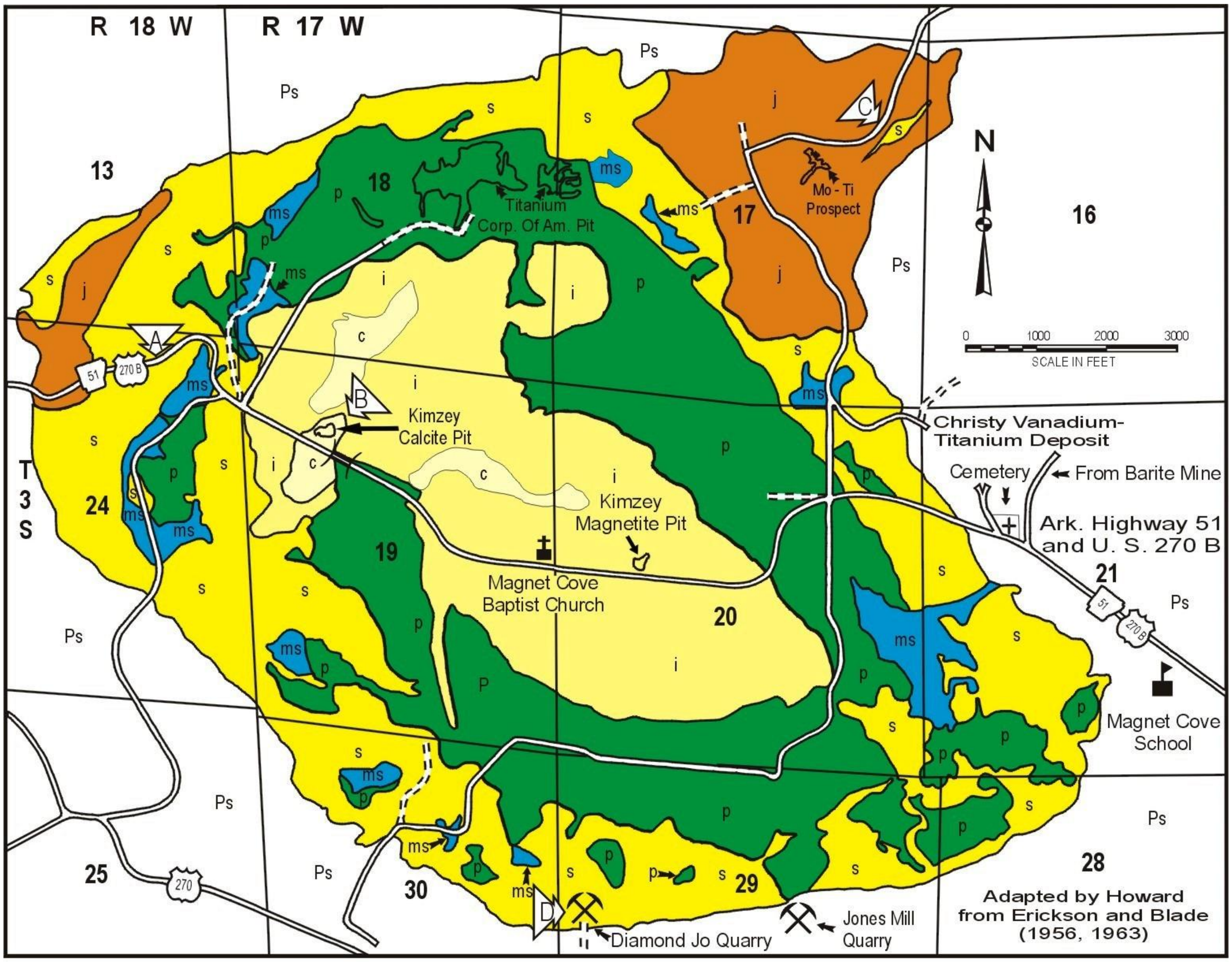
Magnet Cove may be the first non-mining mineral locality west of the Mississippi River to produce mineral specimens in the early 1800s (Macrery 1806). Mineralogically, Magnet Cove became well known by the mid-19th century for the discovery of a variety of titanium-bearing minerals, particularly brookite, rutile, and perovskite. Today, over 100 mineral species are known from this locality (Howard, 1987, revised 2007), including several species first described to science – schorlomite (1846), $Ca_3(Ti,Fe^{3+})_2((Si,Fe^{3+})_3O_4)_3$; kimzeyite (1958), $Ca_3(Zr,Ti)_2((Si,Al,Fe^{3+})_3O_4)_3$; benstonite (1962), $Ba_6Ca_6Mg(CO_3)_{13}$; delindeite (1987), $(Na,K)_2(Ba,Ca)_2(Ti,Fe,Al)_3(SiO_7)O_2 \cdot 2H_2O$; and lourenswalsite (1987), $(K,Ba)_2(Ti,Mg,Ca,Fe)_4(Si,AlFe)_6O_{14}(OH)_{12}$.

INTRODUCTION and GEOLOGY

Magnet Cove is a mid-Cretaceous syenitic intrusive body that is oval in map view and occupies all or portions of sections 16, 17, 18, 19, 20, 29, and 30 of Township 3 South, Range 17 West and sections 13 and 24 of Township 3 South Range 18 West in Hot Spring County, Arkansas. This area is covered by the Malvern North and Lake Catherine 7.5 minute topographic quadrangles. The Cove itself is an elliptical basin with a maximum northwest-southeast diameter of about 3 miles (4.8 km). It encompasses an area of nearly 5 mi^2 (12.0 km^2). The rim of the basin is dissected at only two places, where Cove Creek enters in the northeast and leaves in the south. The rim rocks of the intrusion consist of an outer belt of light-colored nepheline syenites and an inner belt of trachyte/phonolite. Much of the Cove's interior is covered by deep residual and alluvial soils underlain by ijolite. Within the ijolite core are at least two principal masses of carbonatite. Finally, piercing the outer contact between the igneous mass and the Paleozoic country rock are two injections of jacupirangite.

Williams (1891) was the first geologist to map the Magnet Cove Complex. Washington (1900, 1901) described the Magnet Cove intrusion. Erickson and Blade (1963) remapped the area and reported on the petrography and whole rock geochemistry of the complex. They renamed many of the rock types using more current terminology and also made a number of significant corrections to Williams' early map. Particularly important was the recognition that the band of rock on the inner rim, originally thought by Williams and other investigators to be metasedimentary, was trachyte/phonolite, therefore of igneous origin. Erickson and Blade also identified Williams' "tufa" in the Cove's interior as a product of the weathering of carbonatite. Zartman (1977), Naeser and Paul (1969), and Eby (1987) age dated the Magnet Cove intrusion at 100 ± 5 Ma. Work by Flohr and Ross (1990) concentrated on microprobe analyses of the rock-forming minerals and their chemical trends in the various rock types.

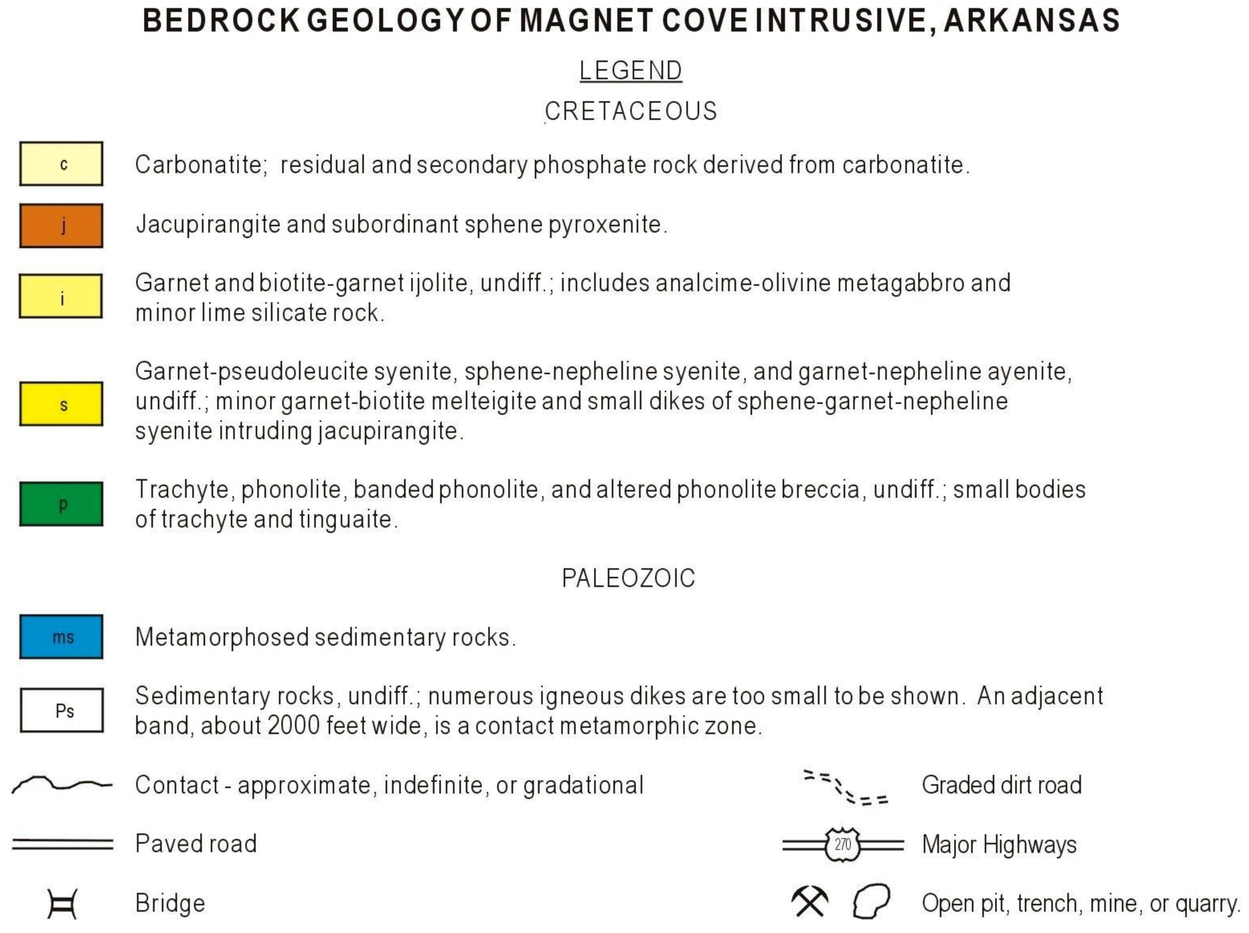
Erickson and Blade (1963) described the structure of the intrusion as being a ring dike. Due to the present level of erosion, little evidence exists for this body to have actually produced a volcano, although Erickson and Blade have the opinion that the trachyte/phonolite represents an early volcanic phase. Erosion during the past 100 Ma is estimated to have removed some 1.5 +/− 0.5 miles (2.4 $^{+}$ 0.8 km) of overlying rock from the surrounding area (Howard, 1974). The intrusion was a piercing body, which due to its diameter, suffered repeated circular collapse of roof rock, resulting in the ring-dike structure. Large blocks of roof and wall pendants are mapped within the outer rim syenites. These consist mostly of altered shale-sandstone sequences derived from the Stanley Shale. On the eastern rim, drilling in the Arkansas Novaculite revealed that igneous rocks underlie it at some shallow depth. Marginal piercing bodies consist of jacupirangite on the northwest and northeast intrusion-Ouachita facies host-rock contact. The intrusion is marginally bounded by Mississippian Stanley Shale, the Mississippian-Devonian Arkansas Novaculite, and, in one location by Silurian Mazarn Shale. The intrusion pierced the nose of the southwestward plunging overturned Chamberlain Creek syncline, part of the east-west trending Zigzag Mountains.



Adapted by Howard from Erickson and Blade (1956, 1963)

Geologic bedrock map of Magnet Cove intrusive complex, Hot Spring County, Arkansas.

Petrologically, the origin of the igneous rocks at Magnet Cove is a part of the general problem of the origin of strongly alkaline silica-undersaturated rocks worldwide. From their study of the whole-rock chemistry of the igneous rocks of Magnet Cove, Erickson and Blade (1963) concluded that the variety of rocks were derived from the differentiation and fractional crystallization of a residual melancratic phonolite magma rich in alkali, lime, and volatiles. The high concentration of volatiles was of great importance to the development of many varieties of unusual rock types – jacupirangite, ijolite, carbonatite, etc. The residual magma is thought to be the derivative of the process of fractional crystallization from regionally undersaturated olivine basalt magma of mantle origin. Morris (1987) noted that Erickson and Blade's model is based on progressive desilication. Although some geochemical relations support this model, more detailed studies including consideration of liquid immiscibility and separate sources, are needed to fully comprehend the petrology of the Magnet Cove intrusive complex (Morris, 1987). Williams (1891) was the first to petrographically describe the igneous rocks of the intrusion. Erickson and Blade (1963) present the most modern and complete petrographic descriptions of the various rock types present in the complex. The reader is referred to their publication for that information.



BEDROCK GEOLOGY OF MAGNET COVE INTRUSIVE, ARKANSAS

LEGEND

CRETACEOUS

c Carbonatite; residual and secondary phosphate rock derived from carbonatite.

j Jacupirangite and subordinant sphene pyroxenite.

i Garnet and biotite-garnet ijolite, undiff.; includes analcime-olivine metagabbro and minor lime silicate rock.

s Garnet-pseudoleucite syenite, sphene-nepheline syenite, and garnet-nepheline ayenite, undiff.; minor garnet-biotite melteigite and small dikes of sphene-garnet-nepheline syenite intruding jacupirangite.

p Trachyte, phonolite, banded phonolite, and altered phonolite breccia, undiff.; small bodies of trachyte and tinguaite.

PALEOZOIC

ms Metamorphosed sedimentary rocks.

Ps Sedimentary rocks, undiff.; numerous igneous dikes are too small to be shown. An adjacent band, about 2000 feet wide, is a contact metamorphic zone.

Contact - approximate, indefinite, or gradational

Graded dirt road

Paved road

Major Highways

Bridge

Open pit, trench, mine, or quarry.

Williams (1891) was the first to present a sequence of the intrusion for the various rock types. Because he did not recognize the lithologies of trachyte/phonolite as igneous in origin, but viewed these rocks as metasediments, he proposed that the ijolite core was the earliest, followed by lamprophyric dike rocks, and finally the nepheline syenites of the rim.

Erickson and Blade (1963) considered all the igneous xenoliths at the Diamond Jo quarry as segregation clots; therefore they were not concerned with the presence of these materials in their samples for whole rock analysis. They also state that the coarse-grained syenite (their nepheline syenite pegmatite) formed by the partial local remelting of the garnet pseudoleucite syenite, as seen at the Diamond Jo quarry. On the basis of the whole rock chemistry, Erickson and Blade envisioned the trachyte-phonolite as first, then the outer sequence of rim syenites, late core intrusion of ijolite, with the last major magmatic phase being the carbonatite and late syenite dikes. Marginal jacupirangite came in after the rim syenites, but with an unknown age relationship with the core ijolite.

However, several lines of more recent evidence lead to a different conclusion. Microprobe analyses by Ross and Flohr (1990) of the pyroxenes and garnets of the core region ijolite and those of the xenoliths of the Diamond Jo quarry show that they are identical in trends. This would not be expected if the xenoliths were simple segregation clots. A careful sampling of this site was made to obtain matrix rock for chemical analysis that did not contain xenoliths. The resultant rock gave a significantly different whole-rock analysis than those for this site presented by Erickson and Blade. Also, detailed mapping at the Diamond Jo quarry by Owens and Howard (1989) disclosed both a scalloped-edge contact between the two major rock types and xenoliths of the coarse-grained syenite with the so-called source rock. This sets an age relationship of the coarse-grained syenite as older than the garnet pseudoleucite syenite, impossible with Erickson and Blade's interpretation. The chemical trends of the individual mineral species also argue against some of the aspects of Erickson and Blade's original intrusive sequence. From the mineral chemistry trends and recent field work it appears the phonolite was first, then the ijolite core, later the complex rim syenites, and finally the central carbonatites and late dikes. The jacupirangite bodies pierced the rim syenites after the emplacement of the core ijolite.

Of particular interest to the problem of intrusion sequence is the discovery by Flohr and Ross (1990) that some rock-forming minerals of the syenites follow distinctly different chemical crystallization trends than those found for other rock types of this intrusion. The abstract of their paper is presented below:

> "Syenites from the Magnet Cove alkaline complex form a diverse mineralogical and geochemical suite. Compositional zoning in primary and late-stage minerals indicate complex, multi-stage crystallization and replacement histories. Residual magmatic fluids, rich in F, Cl, CO_3, and H_2O, reacted with primary minerals to form intergrowths of minerals such as rinkite, fluorite, V-bearing magnetite, F-bearing garnet, and aegirine. Abundant sodalite and natrolite formed in pegmatite segregations within nepheline syenite where Cl- and Na-rich fluids were trapped. During autometasomatism compatible elements such as Mn, Ti, and Zr were redistributed on a local scale and concentrated in late stage minerals. Early crystallization of apatite and perovskite controlled the compatable behavior of P and Ti, respectively. The formation of melanite garnet also affected the behavior of Ti, as well as Zr, Hf, and the heavy rare-earth elements. Pseudoleucite syenite and garnet-nepheline syenite differentiated along separate trends, but the two groups are related to the same parental magma by early fractionation of leucite, the presumed precursor of intergrowths of K-feldspar and nepheline. The Diamond Jo nepheline syenite group defines a different differentiation trend. Sphene-nepheline syenites, alkali syenite, and several miscellaneous syenites do not consistently plot with the other syenite groups or each other on element and oxide variation diagrams, indicating that they were derived from still other parental magmas. Mineral assemblages indicate that relatively high f_{O2}, at or above the fayalite-magnetite-quartz buffer, prevail throughout the crystallization history of the syenites".

Therefore, due to the complexity of the intrusion and apparent multiple sources of parental syenite magma, it may be irrelevant to delve further into detailed discussions concerning an intrusion sequence.

Table 1: PRINCIPAL ROCK TYPES OF MAGNET COVE

Name	**Surface Exposure %**	**Description**
Carbonatite	1.8	coarse-grained igneous calcite with many intergrown minerals
Ijolite	12	plutonic igneous rock with nepheline and 30-60 % mafic minerals
Jacupirangite	10	magnetite- and nepheline-bearing pyroxenite; mafic ijolite
Lamprophyre	0.3	dark-colored porphyritic igneous rocks with a high % of mafic minerals in both groundmass and phenocrysts; nepheline and feldspathoids essential
Phonolite	7	fine-grained equivalent of nepheline syenite
Syenite	28	plutonic igneous rock containing K-feldspar and one or more mafic minerals; quartz, if present, is minor, typically contains nepheline
Trachyte	3.5	fine-grained, generally porphyritic, equivalent of syenite
Trachyte/phonolite	20	undifferentiated fine-grained equivalent of syenite, may have amygdaloidal texture
Dike Rocks	9.4	tinguaite, sodalite trachyte, analcime-olivine gabbro, syenite pegmatite
Metasediments	~8	altered Stanley Shale and Arkansas Novaculite Formations, contained within the intrusive body as roof pendants or wallrock blocks

Extracted from Erickson and Blade (1963).

Detailed petrography of the various igneous rock types by Flohr and Ross (1989) shows that a significant late metasomatic alteration phase also occurred. Nepheline in many rock types and igneous xenoliths, as evidenced at the Diamond Jo quarry, has been converted to gonnardite. Second, non-isotropic hydrogarnet grew on existing garnet in many instances. This late metasomatic activity is attributed to fluids present in garnet pseudoleucite syenite and nepheline syenite and is late in the magmatic activity. Aegirine, biotite, and melanite garnet, all containing relatively high amounts of vanadium and/or titanium, formed during metasomatism, indicating that metasomatic fluid transported these elements.

HISTORY: MINERALS, MINERAL COLLECTING, AND MINING

After the Louisiana Purchase in 1803 and the return of the Lewis and Clark Expedition in 1806, the lure of the open land and potential mineral resources of the Trans Mississippi west was irresistible for explorers, travelers, and eventually settlers. Most likely there had been some travelers and explorers through the Magnet Cove region before 1803 and no doubt their compasses had the same reaction to the magnetite deposits in the central part of Magnet Cove as it did for later travelers and explorers, but it was a foreign country and so they moved on and little if anything was published about the area.

The first published report on minerals of the area was by Macrery (1806), who mostly described the hot springs and the volcanic nature of the land adjacent to the Ouachita River, but some of the minerals mentioned probably came from the Magnet Cove area, 15 miles south southeast of Hot Springs. Later travelers and explorers (Schoolcraft, 1819; Bringier, 1821; Featherstonhaugh, 1835) all mention the magnetite and a few other minerals, few of which are specifically characteristic of Magnet Cove. Featherstonhaugh (1835) remarks on the large size of the magnetite pieces and also “black tourmaline” which has never been found there and may be aegirine, but is more likely the black garnet schorlomite, common in the soil just west of the magnetite deposits as black shiny pieces, very rarely collected with crystal faces. Featherstonhaugh stayed two nights in the Cove in the unfinished cottage of James S. Conway, who was then Surveyor General of the Territory and who, two years later, became the first Governor of Arkansas. The cottage probably was used as a retreat from the hot summers at his plantation near the Red River. Featherstonhaugh remarked on the Cove’s beauty with its covering of hardwood trees. So at that time, it had few settlers.

Between 1847 and 1853 there was a flood of scientific articles on Magnet Cove minerals, kicked off by Shepard (1846, 1847) writing on brookite (arkansite), thomsonite (ozarkite), schorlomite, and later nepheline (eleaolite). Articles supporting or refuting the identifications of these minerals were written by Rammelsburg (1849a,b, 1852), Breithaupt (1849a,b), Miller (1849), Teschemacher (1849), Whitney (1849), Dana (1850a,b, 1851), Hermann (1851), Phillips (1852), and Smith and Brush (1853a,b).

There are two things to note about these articles: All the subject minerals occurred on the surface or in the soil and could easily be picked up, usually without any significant digging or any rock breaking. The brookite crystals were abundant near the surface, particularly along the road where the town of Magnet used to be. The thomsonite, schorlomite and nepheline were all on the surface or in the soil, weathered from ijolites in the central part of the Cove, particularly in the area near the present locations of the Kimzey magnetite pit and the Magnet Cove Missionary Baptist Church.

The second thing of note is that six of the articles were published in German, in Germany. There is an underlying thought that many of the good early specimens from Magnet Cove ended up in Europe, particularly in Germany. Later additional articles were published on Magnet Cove minerals in German publications. This view is supported by Williams (1891) who said W. J. Kimzey sold specimens to foreign scientists and visitors and was later supported by Joe Kimzey in an article by Hudgins (1938). Joe Kimzey stated that Dr. Otto Koonce [sic] shipped one of the best collections to Germany, possibly to the Berlin Museum. Dr. Otto Kuntze sold minerals out of Iowa City, Iowa and had mineral advertisements sporadically in the *American Journal of Science* in the late 1800s.

David Dale Owen (1860) headed the first geological reconnaissance that went through Magnet Cove. It added very little to the geology and mineralogy that was not already known. Shortly after this, during the Civil War in 1862 and 1863, was the first attempt at mining in Magnet Cove. Documents in the Arkansas History Commission file that belonged to Nicholas Murphy show that he had permission to be at the Confederate States of America, War Department, Nitre and Mining Bureau sulfur works near the town of Magnet Cove (de Linde, 1995). This was near the Richardson titanium prospect, west of the iron bridge across Cove Creek and just north of the Creek bank (Fryklund and Holbrook, 1950). The attempt to produce sulfur for gun powder from the pyrite was evidently unsuccessful or maybe Mr.

Murphy was a Yankee or sympathizer because in 1864 another document says he was enrolled for military duty in Little Rock, then under Union control. A later report on pyrite (Day, 1896) discusses a Dr. Reamy's pyrite mine located on the banks of Cove Creek. It may or may not be the same location, but is probably in the same area or nearer to the Mo-Ti prospect.

The first mention of Magnet Cove rutile twins was by Hessburg (1864). They generally occur loose in the soil. In the same year Shepard wrote papers on aegirine and eudialyte which probably came from the syenite pegmatite located on the west bank of Cove Creek, where current Arkansas Highway 51 crosses it. Older photos show an east-west ford across the creek with the road bed sharply turning south on the west side, then gradually rising up the bank which was probably between 20 and 35 feet high before resuming a westerly direction. It may have been the work on this road bed in the creek bank that exposed the syenite pegmatite and associated contact metamorphic rocks. In any case, these seem be the first minerals described that were actually found in place and not just loose in the soil. By 1868 the Magnet Cove Missionary Baptist Church was founded indicating the area was fairly well settled, most probably by farms and residences (Golden, 1968).

In the 1870s, other minerals added to the list were anatase described by Koenig (1876) and altered biotite called protovermiculite (1877). Rath (1876 and 1877) wrote papers in German on rutile paramorphs and twinning. An interest in minerals at Magnet Cove was shown by brief descriptions of the collecting possibilities there and around Hot Springs that were included by Charles Cutter (1874) in *The Hot Springs as they are: a history and guide.*

In 1874 the patriarch of the Kimzey family, J. T. Kimzey, moved to Magnet Cove. He died the next year but his grown sons, William J. and Hodge, soon established themselves as sources for Magnet Cove minerals (See sidebar letter of Hodge Kimzey and Williams, 1891). William's (1891) geologic map shows an F.W. Kimzey house on the upper western flank of Magnet Cove in 1890. The Kimzey family still owns property in this area, but it is not known who F. W. Kimzey was. Later, William J. Kimzey's sons, John, Lawton, and particularly Joe W. Kimzey, followed their father in the selling of Magnet Cove minerals.

JOE WOODS KIMZEY: SELF TAUGHT EXPERT ON MINERALS

The following biographical and interview of Joe W. Kimzey was published in the *Arkansas Gazette,* August 24, 1972, while Mr. Kimzey was still alive; thus the first person tone. The article has been rearranged into two parts, biographical information and the remainder as a first person interview. A few irrelevant details have been omitted during editing.

Joe Woods Kimzey received an honorary Bachelor of Science degree in August 1972 from Ouachita Baptist University. Dr. Joe Nix, Ouachita University chemistry professor who nominated Kimzey, said that he made it possible for many others to get a good education.

He studied law by the light of a coal oil lamp and in 1928 was admitted to the Arkansas Bar of which he still is a member. In the 1920s he served terms in both the State House of Representatives and Senate. As a legislator, Kimzey soon found that his passion for geology came in handy. At the time he held office, Arkansas was beginning to undergo its industrialization period, and new routes to economic growth [began to open. Ed.] When questions arose among state officials concerning the significance of particular minerals, Kimzey was usually called on to make explanations.

During the early 1940s, Kimzey was State Geologist and while serving in this position, he sought to bring mineral industries into the state. He also started the mineral display at the State Capitol Building and today many of the specimens in the state collection bear cards reading "from the Joe Kimzey Collection". He recalled that he had difficulty having the cabinets built because glass was so scarce at that time. More money was spent for the glass than for something to put under it. [The collection is now stored by The Arkansas Geological Survey. Ed.]

Despite his own lack of formal education, he aided in the consolidation of the Magnet Cove School District and served on its board for more than 12 years.

"I have been a lifetime resident of Magnet Cove in Hot Spring County. For most of my 84 years, I have been a native guide to curious scientists and students visiting Magnet Cove to see and study its unique geological makeup".

"I did not get this knowledge from a formal education. It came from some basic information that my father gave me, from my own reading, and from my associations with the numerous geologist and mineralogists who came to study and collect samples at Magnet Cove". Even as a boy I had the reputation for being able to locate and identify the minerals from near home. When scientists, who often came from such distant places as Germany and Russia visited, I frequently found myself showing them around. They'd want to know a certain mineral and they'd ask if I knew where it could be found or what it looked like, so I'd just walk over there and show it to them. They were amazed at my knack for mineral identification but I just learned them like you learn your neighbor's children by the colors of their eyes and their hair".

"Although I did not fully comprehend the theories of the visiting scientists, [I] was always glad to learn what I could, more than just 'that's it'. I still maintain an extensive personal mineral collection, and some of these samples, such as a large twinned crystal of black quartz is of the type highly coveted by museums."

"My health doesn't allow me to [be] very active now but as a boy I would pick up nuggets of rutile which had been worn smooth and use them for playing marbles. Later in life I earned extra money by selling these nuggets to dentists who made false teeth out of them, but using my knowledge for personal gain never appealed to me very much. I preferred instead to aid the scientists and graduate students free of charge. It never ceased to be a hobby with me. It was all right with me if they wanted a $100 specimen of titanium, I'd furnish it. I never tried to put a value on it in money. I just valued it like they did".

In the 1880s additions to the Magnet Cove mineral list were leucite pseudomorphs (pseudoleucite) by Kunz (1886) and perovskite by Saude (1882). F.L. Harvey (1886) wrote *Minerals and Rocks in Arkansas* that included most of the known Magnet Cove mineral species and is illustrated by white on black drawings from A. E. Foote's 1880 catalog. Foote's catalogs for years listed many of the typical common Magnet Cove minerals. Harvey's work can be considered Arkansas' first mineralogy and no other Arkansas mineralogy was as complete for the entire state until Howard (1987, revised 2007) was published.

Certainly the period from about 1870 to 1900 was the heyday for collecting many of the classic Magnet Cove specimens, particularly the large rutile paramorphs after brookite, large eightlings, large well-formed brookite crystals, and good pseudomorphs of leucite that given time weather out of the garnet pseudoleucite nepheline syenite along with other specimens found loose in the soil. On the Richardson farm, near where the Civil War sulfur workings were located, was a plowed field that produced many of the best large rutile paramorph specimens (Fryklund and Holbrook, 1950). Evidently very few of the large paramorphs were found after the middle 1890s. Clarence Bement was assembling one of the most important private mineral collections in the United States during this period that many believe was the "Golden Age" of mineral collecting. Gratacap (1912) gives brief specimen descriptions in his mineralogy of the Bement Collection that by 1912 was already in the American Museum of Natural History. The Magnet Cove specimens may have been obtained from A.E. Foote who listed them in his catalogs. However, any specimens sold to Bement were probably not the mostly unremarkable specimens listed in his catalog. Gratacap illustrates with photographs only two specimens labeled Magnet Cove, a vesuvianite probably from Cove Creek, north of the present Arkansas Highway 51 bridge, and a group of clear quartz crystals that almost certainly are not from Magnet Cove. Magnet Cove minerals listed are: aegirine (good crystals), brookite, eudialyte (flattened crystals, one was lent to

Williams (1891) for crystal measurements), microcline (twisted crystals), monticellite, perovskite, rutile (twinning and complicated intergrowths), schorlomite, and vesuvianite. Conklin (1886) contains a letter from E.S. Dana to Bement acknowledging receipt of 26 Magnet Cove brookite crystals sent for his crystal study. They are illustrated in Dana (1886).

In 1889 William Niven made two collecting trips to Magnet Cove collecting vesuvianite, perovskite, apatite, rutile and brookite for his New York City mineral business (Wilson 2006). Some time during this same period A.E. Foote also collected in Magnet Cove, probably more than once. Numerous specimens with his labels survive, but most examples are mediocre in quality.

The still classic work on Magnet Cove rocks and minerals was completed by J. F. Williams (1891) *The Igneous Rocks of Arkansas.* The part of the work on Magnet Cove is a combination of petrography and mineralogy that sums up all of the previous work and adds important observations and new mineral identifications. He writes that William J. Kimzey was an excellent source of minerals and mentions several that he obtained from him. Williams' volume is said to have often been used as model for later similar studies. Amazingly, his whole remarkable volume was completed in only two years (1889-1990) as unfortunately this promising young geologist died at the age of 29 from malaria he contracted while in Arkansas just before its publication.

MINERAL COLLECTING IN 1885

What follows is a letter from Hodge Kimzey to George Fredrick Kunz written in long hand. It was found in the Arkansas History Commission files by Henry de Linde. The writer was the brother of W. J. Kimzey. The J. T. Kimzey sons who were adults when they came to Magnet Cove in 1874 with their father were both very active in collecting and dealing in Magnet Cove minerals. The letter makes it obvious that Hodge had partners, at least in the magnetite. The writer had good penmanship, good spelling and the writing style all indicates an intelligent and possibly an educated person.

Magnet, Ark.
May 16th, 1885

Mr. G. F. Kunz
Hoboken, New Jersey

My Dear Sir:

Your letter received. Thanks for information in regard to freight rates from this point to New York. I am now collecting the 100 lb lot of miscellaneous minerals which I will gladly send as soon as ready—perhaps this coming week. You have been prompt and honorable with me, and I hope to get your trade as long as you are a dealer in such goods. Your request for garnets I have complied with as far as possible – sending word to every school girl in the Cove to assist me and I flatter myself that I have succeeded in procuring you some of the finest specimens of black garnets that ever came from this vicinity and I dare say there are a few in this lot that can never be eclipsed here as we have hunted out every possible nook in which they usually occur. Now Mr. Kunz, as this lot is made up of different collections, I must impress it upon your mind to examine each parcel separately and be very particular in mentioning the price of each girl's lot. Did you get the small lot I sent you by registered mail? In this lot I also send a parcel of my own and as I am the means of you getting the others I will say to you that I deem it but justice to me to pay full price for mine. Of course the trouble is all upon me after all and as long as you pay me liberally I will take special pains to procure everything – that I can hear in the Cove as it is found. A part of these fine garnets that I send you were intended for Dr. Lawrence and other collectors of Hot Springs but I procured them with the promise also that they would let me have all the fine ones that they may procure.

I send you a parcel from each of the following young ladies to wit:

Miss Mittie Moore Miss Willie Price

Miss Nannie Lankford   Miss Alice Hill
and Dick Price.

You requested me to wait one month for the returns. Certainly with pleasure. Will always be glad to fill orders for one so honorable and liberal as you have proven to be. Would I could say the same of others I have supplied and received nothing in return.

I am in declining health – a pulmonary trouble which is wearing me away. I have spent the last five years traveling with my family with the hope of recuperating my vital processes but alas I have found no special benefit from the change of climate. I spent all I had in the vain endeavor to get my health, about five thousand dollars and now all I ask is enough money for my minerals to "keep the wolf from the door." In case at any time should you see a chance to assist me in the sale of lode-stone or such other minerals as you do not desire, it will be a God-send to me and you shall receive my undying gratitude for the favor. I only get one fourth of the lode-stone for my part for selling it which leaves me a small margin indeed unless I can get large orders. I think I can get two or three hundred pounds of rutile or fragments of brookite crystals. Will you take it? I understand there are manufacturing chemists who work it up. If you can procure me purchases, how much is it worth in the market per pound? I will pay you well in minerals if you can get me up a sale for it. I can also get you a large lot of this yellow or decomposed mica. I am informed that it has a market value and is used extensively in the manufacture of axle grease. Also the lode-stone, it would be a blessing to me if I could sell it in large quantities – by the ton.

Please pardon me for writing you at such length. You wonder, I know if you knew what anxiety I feel in a business (though small and insignificant to many) when in the support of my babies are centered.

Your friend most truly,
Hodge Kimzey

PS, Please lay this letter aside for reference should you be too busy now to answer questions.

Max Bauer (1891) published his work of rutile twinning and paramorphism in the old style of formal German. Probably because of its style, it was not translated to English until Howard (1999) requested it be done by George Megerle. Until then many of us had our labels of the rutile sixlings and some paramorphs after brookite, which are very similar, wrong. Unfortunately many specimens being sold since Howard (1999) are still labeled incorrectly. Howard also noted that one of the illustrations used in William's publication was of a flat rutile eightling twin that was actually a drawing of a specimen previously published by an earlier worker in a paper on Graves Mountain, Georgia, rutile twins.

Mar (1890) determined that the perovskite was the niobium-rich variety dysanalyte and Melville (1892) described natrolite that is associated with the eudialyte syenite pegmatites and contact metamorphic rocks near the current Cove Creek bridge on Arkansas Highway 51.

An interesting narrative of a one-day collecting trip by train and foot to Magnet Cove in 1898 is given by Howland (1903).

A ONE-DAY COLLECTING TRIP TO MAGNET COVE IN 1898

by Frank Howland

In the year 1898 I made my first visit to the well known Magnet Cove of Arkansas. Leaving Little Rock at 4 A.M., I traveled via the Iron Mountain Railroad as far south as Malvern, which at the time was the station where we changed cars, taking what was called the Diamond Jo Road, it being the only road by which Magnet Cove and Hot Springs could be reached. The officials understanding the situation, made our necessity their opportunity, and charged a fare of five cents per mile.

The morning was simply perfect. We reached Cove Creek station at 6 A.M. My first move was to find out just how I could reach the Cove. I was told that by walking two and one-half miles up the creek or five miles over the mountain was all the way they knew of reaching it.

I quickly selected the creek route and started up one of the prettiest little ravines I have ever seen. I crossed and re-crossed the noisy little stream many times on large flat stones that stood high above the water, stopping often to pick up a brookite whose sharp edges had been worn smooth by rolling over and over on the rocky bed of the creek as it journeyed downward.

However poor they were, I could not avoid filling my pockets to overflowing, only to throw them away later in the day when better specimens needed room. On emerging from the ravine, the first object that met my view was a blacksmith leaning lazily in the door of his shop, a typical native, tall, lank, yellow, chewing a snuff stick with evident relish.

I approached him with a "Good morning, sir?" and the question, "Can you tell me if I am near the Cove?" His reply came with a slow drawl: "This yer's the Cove, stranger, or leastwize one edge on't!"

"Do you see yon school-house? Wal, that be about one-third of the way acrost."

I stood dumbfounded. Instead of seeing a rocky basin that would cover a track (sic.) of say fourteen or fifteen acres, I saw stretching out before me hundreds of acres of fine farming land. As I stood wondering, a boy put in an appearance from some quarter (I never knew where) and offered for the sum of one dollar to pilot me to the different locations where each sort of specimens had been most plentifully found. His offer was quickly accepted and our tramp began (The boy could have been Joe Kimzey who lived in the Cove, was knowledgeable about the minerals,, and was 10 years old at this time. Ed).

The home of the lodestone was our first point. The space covered by this ore is about 5 acres. The ground thickly strewn with pieces averaging in weight one to two pounds. There is no hunting after it, all one has to do is to stoop and select such bits as suit his fancy. As I looked over the field the familiar quotation came to mind, "We value most what costs us most." I brought only a small quantity away.

Next we hunted carefully over a large round knoll, which is near the centre of the Cove, hoping to find amethystine quartz. Our search resulted only in failure. I reluctantly left the place empty-handed, although many fine specimens have been found there.

We tramped along picking and poking over the ground, the boy entertaining me with stories of many people who had visited the place from the outside world and of the beautiful specimens taken away by them.

We searched long for vesuvianite on and around the excavation made some years ago by Dr. A. E. Foot of Philadelphia, from which he replenished his stock for vesuvianite to the amount of several thousand dollars. He had certainly cleaned the mine of desirable specimens for we found none worth carrying away. Perhaps my face showed disappointment, at any rate, the boy look up and said, "Never mind mister, I know a woman over there who has a whole hatful of them," pointing to a house about one-half mile away.

The possibility of treasures the lady might possess was a new incentive, so away we trudged. The one-half mile was soon covered and Mrs. Cheek was at home; her "hatful" being willingly displayed. It consisted of two small crystals of vesuvianite – out of the matrix – one of which was very fine, and a fairly good garnet. Her price for the lot was twenty-five cents.

After carefully stowing away my treasures in an inside pocket and saying good-day to Mrs. Cheek, we turned our steps toward the brookite locality, where better luck was in store for us.

Poking around through the loose, weather-beaten stuff, I stumbled on to one of the finest rosette rutiles it has ever been my fortune to see. It is about as large round as a dime and its form is simply perfect, being free from all impurities. (It sounds like a rutile eightling which generally are not found with the brookite crystals. Ed). I was exultant over this find, but stayed a little longer only adding a few fairly good brookites and also a number of poor ones.

The tramp had been so full of interest to me that I had failed to notice the lapse of time, and found upon consulting my watch that whatever more I accomplished that day must be done with dispatch. Accordingly our steps were turned again toward the station, not, however, over the same route by which we had come.

On our return trip we passed a mound of yellow clay where I secured twenty or thirty elaeolites, two extra good ones and many fair ones. (These are nepheline pieces that locally were called sunstones. Ed).

I bought a few good brookites and perofskites of a Mr. McKenzie whose home we passed. (This could actually be William Kimzey).

After this I passed over a tract that interested me, but had no time to examine it – but on a later visit made to the Cove I found several fine brookites associated with quartz crystals. Hurrying on we were soon at the place from which we started in the morning. Here my guide left me with a good-bye and his well earned dollar.

I was passing the blacksmith shop when, "Hello Mister!" arrested my steps. Looking up I saw the blacksmith in exactly the same position he occupied in the morning.

"What did you find?" said he.

I produced the best I had and passed to him. He looked at them and gave vent to a contemptuous, "Uh!" and said one word, "Wait." He disappeared in the shop and quickly returned handing me a piece of smoky quartz that would put Pike's Peak product to shame: a crystal, two inches long, sitting upright on a base of lesser crystals and perfect in every angle.

"Is it for sale?" "Yas," he replied. "Think it is worth fifteen cents?"

The exchange was quickly made, and these he continued producing, a pseudomorph after garnet. "We do not often find here." Twenty cents made it mine. (This may actually be a "pseudoleucite" of J. F. Williams (1891). Ed.)

Darkness was coming on fast, so with what speed there was left in me, I hurried down the ravine fast, not pausing, wishing to reach the station in time to catch the train for home.

When I was comfortably seated in the car, I was conscious of agoneness in the region of my waist-band, which reminded me I had gone dinnerless, making the prospect of a warm supper at home very inviting. Needless to add, my dreams that night were full of Magnet Cove and wonderful specimens.

Edited slightly by A. E. Smith, Jr. and J. M. Howard from Howland, 1903, The Mineral Collector: V. 10, p. 137-139.

If Magnet Cove had significant mineral collecting going on in the early part of the 20th century, it was not reported. Branner (1928) states that the Kimzeys shipped 12 tons of titanium ore, the greater portion was before 1905. The Kimzeys also probably shipped somewhat larger tonnages of magnetite at irregular intervals through the early 1950s, but the total amount was not economically significant. Robert McElwaine told his nephew that he mined the deposit during the 1940's war years (Charles Steuart, personal communication, 2005). The magnetite was ground and mixed with tar and coated pipes to sink them in water. In the 1930's Joe Kimzey had a roofing granule quarry along Cove Quarry Creek on the south flank of Magnet Cove (Glass 1937). Evidently the operations were not very successful and it did not last long.

The Cotton Golden farm (Mo-Ti prospect), located south of Cove Creek and east of the iron bridge, was prospected from 1929 to 1930 by the Southern Acid and Sulphur Company for pyrite and again in the 1940s for molybdenite. The molybdenite was described by Sleight (1941). The last exploration was in 1945 to1947 by the Mo-Ti Corporation (Stroud et al, 1969). The number of mineral specimens produced during this exploration, if any, is uncertain. However, most of the specimens, labeled Mo-Ti prospect, were probably collected in the pyrite vein in adjacent Cove Creek during the 1960s to present.

Minerals new to the Magnet Cove list before 1950 were tainiolite, sodalite, and molybdenite. Tainiolite was described by Miser & Stevens (1938). It was found during prospecting on the Hardy-Walsh brookite deposit. The sodalite variety hackmanite was noted during short-lived roofing granule operations near Stone Quarry Creek and was described by Miser and Glass (1941). The most comprehensive work on Magnet Cove minerals of this time was done by K.K. Landes (1931) on a paragenetic classification of Magnet Cove minerals. It grouped minerals by their mode of occurrence and formation.

Exploration of the brookite deposits was sporadic and continued through the 1940s. Few specimens, mostly unimpressive, were preserved. Collectors took advantage of the situation, searching and digging in the abandoned pits, trenches and cleared areas for many years.

In 1913, exploration on the titanium prospect resulted in the sinking of a 60-foot shaft. However, it was not until after further exploration started in 1931 that the titanium mine was opened in 1932. There was sporadic mining under several operators that continued until 1944 (Fryklund and Holbrook, 1950). The rutile was mined to make welding rod coatings and welds on battleships, but the small amount of niobium in the rutile made the welds brittle and unsuitable for use on armor plates or any other steel uses. Most, if not all, of the matrix specimens containing small rutile paramorphs came from these operations. The US Bureau of Mines and later Batelle both were unsuccessful in discovering any viable extraction methods to remove the niobium impurities from the rutile from this location.

About two miles northeast of Magnet Cove is the large Chamberlain Creek barite deposit that was known since about 1900. In 1940 mining began and eventually two companies, National Lead’s Baroid Division and Magnet Cove Barium Corporation, operated on the deposit creating a major open pit with underground workings. Mining continued until it became uneconomical, due to increased costs of underground mining and the import of cheap Chinese barite. The mine was abandoned in 1977. The huge open pit gradually filled with water (Stone, Howard, and Holbrook, 1982). The deposit is over a mile from the Magnet Cove igneous rocks, but core drilling has shown that the beds containing the barite contact the igneous rocks at depth and so it is often considered part of the Magnet Cove mineral complex by collectors. In the late 1960s and 1970s, mostly from the underground operations, some specimens of colorless to white masses of intergrown tabular barite crystals were recovered. Interesting specimens of orthoclase, variety adularia, on quartz and comby calcite that fluoresces a golden orange color were obtained. Also available in small amounts were some pyrite and quartz crystals. The deposit is the type locality for the mineral benstonite, though it does not occur in distinct crystals (Lippmann, 1962). Large masses of botryoidal marcasite were recovered from the underground workings, but within a year had altered to white powdery melanterite.

The Kimzey calcite quarry carbonatite was being worked by Louisiana Lime Company in the 1940s (Buhlis, 1945) and also was worked again in the early 1960s for chicken scratch. Evidently the latter operations were shut down because the land owner, Joe Kimzey, felt they were not getting paid for all the rare minerals destroyed, but not used. However, this open pit mining on a relatively small scale did expose the carbonatite and made the minerals of the carbonatite available to collectors with permission to enter the quarry or to other collectors, who took the risk of entering and having the wrath of the quarry owners dispensed on them in person or delegated to the local police. Chunks of carbonatite also ended up in Cove Creek and thus were made available to collectors. However, local land owners at times have made collectors leave the creek, making it difficult to collect there also.

MAGNET COVE FIELD TRIP, 1945

Selected quotes from an article in the *Arkansas Mineral Bulletin,* 2, June 1945 and probably written by Richard Buhlis, the secretary, treasurer, and editor of the Arkansas Mineralogical Society of Little Rock. Buhlis was associated with the H. E. Powell Company, a business that had a museum and store southwest of Little Rock. He later became a mineral dealer under his own name in Little Rock.

Members of the State Mineral Society of Texas visited Magnet Cove as guests of the Arkansas Mineralogical Society, Sunday, April 15, 1945….Assembling at Lodestone Hill [now the Kimzey magnetite pit. Ed.] at 9 a.m., the group spent an interesting and profitable hour gathering lodestone, magnetite, schorlomite, and melanite; then proceeded to the Cove Creek bridge near the west end of the Cove on U.S. Highway 270 [now Arkansas Highway 51. Ed.] Here the cars parked and under the guidance of Lawton Kimzey [Joe W. Kimzey's younger brother. Ed.] of Magnet Cove, proceeded to tour Calcite Hill [now Kimzey carbonatite or calcite quarry. Ed.] north of the highway. This hill is a mass of metamorphosed calcite [now considered magmatic carbonatite. Ed.] cut by syenite dikes and ancient hot water vents. It has produced many fine specimens of vesuvianite, apatite, dysanalyte, perofskite [sic], wollastonite, magnetite, and limonite pseudomorphs after pyrite and magnetite. [Kimzeyite had not yet been recognized and described. Ed.] The hill is now being quarried by the Louisiana Lime Company and as the top dirt is removed and fresh surfaces are exposed, a new supply of these minerals may be bagged by the keen eyed rockhound. And, speaking of keen eyes, George Rosenthal, Jr., upheld his reputation by finding one of the most perfect specimens of vesuvianite the Cove ever produced – a first order pyramid, about 1 inch wide.

Other members also found some excellent specimens of vesuvianite, along with limonite pseudomorphs, dysanalyte (niobian perovskite) and magnetite. Mrs. Owens and Mrs. Ford discovered the continuation of a pegmatite dike on the south slope of the hill near the highway and gathered some good specimens of aegirite [aegirine] or acmite crystals.

About 11:45 it was discovered that even rockhounds must yield to the pangs of hunger, so the party adjourned to the Cove Creek bridge for lunch. Here Dick Buhlis, secretary, flew open the rear end of his truck to expose several drums filled with ice and bottles of soft drinks, including Dr. Pepper in honor of Texas.

Following lunch, the group then got into their cars and the party moved north and east, first to the rutile deposits of the Magnet Cove Titanium Company. These deposits are mined by open cut method and the pits gave forth some interesting specimens of rutile (variety nigrine, an iron-rich rutile) and pyrite.

The next stop was at the W. W. Sheldon molybdenite prospect [now known as the Mo-Ti prospect. Ed.] on upper Cove Creek. Due to excessive rains, Sheldon's test pit were filled with water, hiding the best molybdenite seams, but plenty of fine specimens of molybdenite and pyrite were obtained from the dumps around the pit.

Proceeding south to Magnet Cove the caravan passed Brookite Hill, where this titanium mineral occurs in beautiful black crystals in and on milky, clear, and smoky quartz. [Brookite Hill, AKA Moses Hill on the Rutherford property. Ed.]

It was now time to call it a day and a successful day!

Shockley (1948) summed up the known mineralogy of Magnet Cove and added some observations of his own. It was the most authoritative work on Magnet Cove minerals for collectors for quite a few years.

From 1950 to 1970, things were relatively quiet. Collecting in the brookite deposits continued, but it took a lot of tough digging and some luck to be successful (Howard, 1966). Several significant finds were made at all the prospects during this time, but the productive outcrop along the highway across from the town of Magnet was obliterated during this period. Elmer Banion (1959) wrote about collecting in Magnet Cove and its minerals. His collection is now at the geology department of the University of Missouri, Kansas City. In the middle 1960s, a gas pipeline was run through Magnet Cove and the word was that two ladies from Memphis followed the operations closely, and perhaps it is more legend than fact, but they are supposed to have reaped an abundant harvest of specimens including amethyst crystals. Many large, seldom terminated, green, intergrown augite crystals were found at the pipeline crossing of Cove Creek. These were the only specimens readily available for most collectors from the pipeline operation.

In 1963, Erickson and Blade published their petrographic-geochemical study of Magnet Cove igneous rocks. Though not specifically a mineralogical study, the maps, rock descriptions and geochemical analyses presented are significant background data for any collector who wants to understand the occurrence and formation of Magnet Cove minerals.

During this time the Kimzey calcite quarry carbonatite became the type locality for the zirconium garnet, kimzeyite (Milton, Ingram, and Blade 1961). Other minerals new to Magnet Cove were maghemite (Nagota 1961) and earthy monazite (Rose, Blade, and Ross 1958). Joe Kimzey was still selling minerals from his home in Magnet Cove on the north side of the highway, and he continued to do so into the early 1970s. He died after a long bout with cancer in 1975. Joe Kimzey was born in Magnet Cove in 1888. He and his brothers, John and Lawton, were all involved in selling Magnet Cove minerals. Joe's home in Magnet Cove was the Conway house that Featherstonhaugh visited in 1834. When this home and land was purchased by the Kimzey family is not certain, but they did have some connection to the land even in the late 1800s (see Hodge Kimzey letter to G.F. Kunz). Buying minerals from Joe Kimzey in the late 1960s or early 1970s was somewhat unpredictable and it depended on what he thought of you and particularly how he felt that day. At times he was very talkative and congenial. He had some lapidary equipment set up in a shed in the back of the house to try and exploit any lapidary potential of the rocks and minerals. Aside from the black and smoky quartz from Moses Hill, he found little to interest potential buyers. However, he was always enthusiastic about the potential of Magnet Cove and its minerals.

From 1970 to 1990, aside from the continued collector digging in the brookite deposits, some sporadic good collecting was available in Cove Creek when work was done by contractors for the Arkansas Highway and Transportation Department on the bridge on U.S. Route 270 (later Arkansas Highway 51) in the early 1970s and again in 1985 for a pipeline crossing. No doubt there were many earlier periods of good collecting during bridge construction and many renovations, but these have not been documented. There was also a short period of surface collecting in the middle 1970s when the northwest portion of Magnet Cove was cleared, subdivided, and houses built. Large, up to almost baseball-size masses of rutile were collected after rains, but few contained good crystals or had crystal faces. Obviously the area had been well high-graded by earlier surface collectors. Some outcrops contained exposed weathered feldspar dikes with goethite pseudomorphs after pyrite crystals to over 2 cm across. In the 1970s the Runyan property, located on the first novaculite ridge north of the north rim of Magnet Cove, was exploited as a fee area for black, smoky, and "coon-tail" quartz plus a limited number of small brookite crystals (Williams 1979). The junior author visited the Runyan property during this time, and for a fee of 30 cents per pound, you could keep all the smoky quartz you could find. He soon learned to do a lot a digging and then some severe high grading of specimens to actually pay for and remove from the location. The veins were in very tough white Arkansas Novaculite. Mr. Runyan told him the mine was located on an original location discovered when uranium prospectors found higher than background radioactivity associated with the smoky quartz veins. It turned out the radioactivity was due to thorium, not uranium, as all the other sites at Magnet Cove that were examined by this method. The quartz from the Runyan mine is coated with iron oxide bound clay and presents significant problems to clean. Either repeated oxalic acid treatments, being followed by pressure washing, or cooking in muriatic acid is necessary to remove all the iron oxide so that the clay can then be removed by pressure washing.

In 1970 or 1971 the senior author found some small miarolitic cavities at the Diamond Jo quarry on the outer south flank of Magnet Cove. These cavities had a rich suite of minerals, but they were minute and, even though specimens were sent to several renowned collectors, few minerals were identified. In the fall of 1973, which is considered the first meeting of the Coon Creek Association, these cavities were pointed out to the quarry's owner, Henry de Linde, at the quarry. There seemed to be little interest in them at the time. Coincidently, the junior author collected the same material while still in high school in the mid-1960s. After being employed by the Arkansas Geological Commission in 1972, he sent some specimens to Charles Milton in Washington, D.C. Dr. Milton identified the bright orange mineral as labuntsovite. He immediately made a trip to Arkansas and collected additional specimens with the junior author and Charles Stone, at that time geologists of the Arkansas Geological Commission. This eventually resulted in the identification of many of the cavity minerals (Evans, Dwornik, and Milton, 1986 and Smith, 1989) including two new minerals, delindeite and lourenswalsite (Appleman et al. 1987). These events caused the Coon Creek Association to change their primary collecting area from the western Ouachitas to the eastern Ouachitas and Magnet Cove with a stronger emphasis on microminerals. The Coon Creek group, a loose knit group of collectors, geologists and mineral dealers, continued their investigations and collecting in the Christy mine, which was opened in 1981 after core drilling and much ore testing between 1970 and 1977. Vanadium was mined by Union Carbide and later sporadically by Stratcor until 1990, and collecting ended when the pit was reclaimed by 1997. Collecting, when available at Magnet Cove, was somewhat disappointing, though many microminerals new to Magnet Cove were collected including kolbeckite (Barwood 1987). Another interesting find by the junior author, a member of the group, was a vein-like mixture of bastnâsite-(Ce) and synchesite-(Ce) from the Kimzey carbonatite, later identified by Barwood and Howard (1990). Hercynite was also identified from the carbonatite by Barwood. Henderson and Smith (1992) distinguished it from perovskite by its rounded octahedral crystal form, previously confused with both perovskite and magnetite, also present in the host rock.

One of the most ardent Magnet Cove mineral collectors was Clyde Hardin, who collected there as much as he could after his retirement in 1979 until his death in late 2002. He made exceptional finds at the brookite deposits and elsewhere, but is best known for his collecting at Perovskite Hill. Especially notable was a small area of large kimzeyite crystals and baddellyite after kimzeyite, a climax after years of digging. His thoughts and collecting are documented through his letters (Smith, 2003).

In the early 1990s the Midstate or Highway 51 quarry was opened on the outer south flank of Magnet Cove, first exploiting the altered novaculite, later the baked shale, and still later the syenite for road construction rock. In 1998, Martin Marietta purchased the quarry and renamed it the Jones Mill quarry. Except for some gray smoky quartz crystals found in the middle 1990's and numerous small deep blue anatase crystals found in quartz veins during the late 1990's (Estes, 1999; Howard,1999), practically all the other specimens can be considered microminerals. Although collecting is restricted and good collecting of any worthwhile minerals is very sporadic, interesting finds and species new to Magnet Cove have been collected (Barwood, 1998; Estes, 1998; Smith, 1998a, b, 1999b, 2001).

In retrospect, the best collecting years for the large classic rutile paramorphs or twinned crystals in Magnet Cove may be past. More and more potential collecting areas have been obliterated by building or made off limits by their owners (Howard 1999). However, the geology of Magnet Cove is quite diverse and although it has been written off as a collecting area many times, new mineral occurrences are still being documented. By being persistent and being in the right place at the right time, it can still be rewarding for any collector now and in the future.

THE CARBONATITES: LOCALITIES AND MINERALS

INTRODUCTION

The interior central and west central portion of Magnet Cove is marked by three small hills, named East, Middle, and West Tufa hills. On the surface they are composed of so called tufa (Williams 1891), now known as saprolite, the weathering products of the underlying carbonatite (Erickson and Blade 1963). The rock consists of a porous mixture of residual and secondary apatite. These hills are the surface expression of one of the carbonatite bodies delineated by Erickson and Blade (1963). The other carbonatite body is best observed a short distance south of West Tufa Hill and is the best known to collectors because it contains the better documented Kimzey calcite quarry (Calcite Hill) and Perovskite Hill, south of Calcite Hill across Arkansas Highway 51.

The carbonatite generally consists of a coarse-grained, white to pale greenish translucent calcite with accessory perovskite, garnet, and other minerals that occur in scattered irregular areas with nests of carbonate-apatite needles. The contact zone of the carbonatite with adjacent ijolite and included ijolite xenoliths consists of medium- to fine-grained carbonatite. The coarse phase carbonatite is termed sovite in some classifications.

Erickson and Blade (1963) concluded that carbonatite is an intrusive mass and probably was deposited from late-stage, heavily gas charged, magmatic solutions. Other workers (Bell, Kjarsgaard and Simonetti 1998) think the carbonatite formed as an immiscible liquid in the mantle. Core drilling and scattered small outcrops indicate that the subsurface extent of carbonatite is probably more extensive than indicated on the surface geologic map of Erickson and Blade (1963). Also noted by Heinrich (1966) are the carbonate-albite and carbonate-microcline veins in other rocks in the central part of Magnet Cove to the north of the tufa hills. He notes that they may be genetically related to the carbonatites.

Brookins (1967) found that the average composition of the calcite making up the carbonatite differed from that of the average carbonate of a sedimentary rock. The sedimentary carbonate has higher SiO_2, CO_3, FeO, MgO, and H_2O and lower amounts of CaO, SrO, and P_2O_5. Isotopic work on oxygen isotopes indicate that the carbonatite had origins in the mantle with little mixing of crustal rocks.

The tufa hills have generally been off limits to collectors in recent years, but in the early collecting days they were often visited by collectors and mineralogists. Middle Tufa Hill or possibly the former hill at the magnetite mine may have been the source of the amethyst mentioned in an early article (Howland, 1903). The only locality that has been economically exploited and has abundant exposed and unweathered carbonatite is the Kimzey calcite quarry. So at least some of the minerals listed in Table 2 as occurring only from this location may be present, and eventually discovered, in the other carbonatite rocks.

Table 2: MINERALS OF THE CARBONATITES

Mineral	Location	Description	Reference
Anatase	KCQ, PH	Yellowish to pale brown, after perovskite	Williams (1891)
Andradite	KCQ, PH	Dull black dodecahedrons to 4 mm	Smith (1994)
Anhydrite	KCQ	Clear crystals included in kimzeyite	Milton, Ingram & Blade (1961)
Ankerite	KCQ	Rare	Howard (1989)
Aragonite	KCQ	White, tufted acicular, pale yellow fluor.	Shockley (1948)

Baddeleyite	KCQ, PH	Grains and pseudomorphs after kimzeyite	(see text description)
Barite	KCQ	Rare, tabular on calcite	Shockley (1948)
Bastnâsite-(Ce)	KCQ	Tabular, intergrown with synchesite-(Ce)	Barwood & Howard (1990)
Biotite	KCQ	Green pseudohexagonal crystals	Williams (1891)
Brookite	KCQ, PH	Minute to small black crystals	Nizamoff et al (1998)
Calcite	all	Coarse- to fine-grained, white to greenish	Erickson & Blade (1963)
Carbonate-fluorapatite	all	Inclusions and replacements of fluorapatite	McConnell & Gruner (1940)
Fluorapatite	all	Nests of up to 1 mm needles, white-greenish	Williams (1891)
Fluorapophyllite	KCQ	Complex minute crystals in veinlets	Tice, Falster, & Simmons (1998)
Fluorite	KCQ	Purple, intimately associated with calcite	Meurer et al. (1989)
Galena	PH	Dull gray small octahedrons	This article
Goethite	PH	Cubic pseudomorphs after pyrite	Smith (1986)
Gypsum	KCQ	Small amounts in solution cavities	Smith (1986)
Hematite	MTH, PH	Plates, layered masses, iron roses	Williams (1891), Shockley (1948)
Hercynite	KCQ	Black rounded octahedrons	Henderson & Smith (1992)
Kimzeyite	KCQ, MTH, PH	Black to dark brown crystals	Milton, Ingram & Blade (1969)
Magnetite	KCQ, MTH, PH	Black octahedral crystals	Williams (1891)
Monazite-(La)	ETH	Fine-grained in irregular veins	Rose, Blade & Ross (1958)
Monticellite	KCQ	Brown nodular masses and crystals	Williams (1891)
Muscovite	KCQ	Intimately intergrown with phlogopite	Meurer et al. (1989)
Opal	ETH, MTH, WTH	Occurs as gray siliceous “geyserite”	Shockley (1948)
Perovskite	all	Black octahedrons, cubes, and combinations	Williams (1891)
Phlogopite	KCQ	Intergrown with muscovite	Meurer et al. (1989)
Plumbogummite	ETH	Intermixed with Monazite-(La)	Rose, Blade & Ross (1958)
Pyrite	KCQ	Pyritohedrons, cubes, skeletal octahedrons	Smith (1996)
Pyrrhotite	KCQ	With magnetite near contact zones	Fryklund, Harner & Kaiser (1954)
Quartz	MTH	Crystals, and 1 mm spherules, amethyst (?)	Shockley (1948)
Rutile	KCQ, PH	Minute needles	Meurer et al. (1989) (See text)
Spinel	KCQ, MTH	Included in fluorapatite, also alone to 4 mm	Meurer et al. (1989), Smith (2003)
Synchesite-(Ce)	KCQ	Platy, intergrown with bastnâsite-(Ce)	Barwood & Howard (1990)
Vesuvianite	KCQ	Tiny yellow crystals, larger in contact rocks	Williams (1891) Smith (1996)
Zircon	PH	Small crystals loose in soil south of hill	Smith (1996)

Locations: ETH – East Tufa Hill, KCQ – Kimzey Calcite Quarry, MTH – Middle Tufa Hill, PH – Perovskite Hill, WTH – West Tufa Hill.

LOCATION 1: THE KIMZEY CALCITE QUARRY N34.457378^{o}, W92.875317^{o} (Google Earth image 1994), KCQ, KCP

This location was formerly called Calcite Hill, but the original hill was obliterated by mining operations in the 1940’s and 1960’s. Although the area has been posted and is not generally available to collectors, sometimes university student groups and professional geological field trips have been given permission to enter the property. In the senior author’s two visits to the property in the late 1970s and again in the 1980s, he was rather disappointed in the collecting possibilities and had found much more promising carbonatite rubble in the bed of Cove Creek. Here the main collectable minerals in order of decreasing abundance are: magnetite, perovskite, pyrite, monticellite, hercynite, kimzeyite, and rarely vesuvianite. The junior author visited this location both as a teenager and later as a professional geologist before it grew up with vegetation. He recovered a variety of minerals and samples of carbonatite that yielded many good mineral specimens when etched with very weak hydrochloric acid to remove the matrix calcite. Magnetite, perovskite, and kimzeyite on matrix were recovered by this cleaning method.

The best matrix specimens are those that have crystals exposed by natural weathering or are already partly exposed and can be slightly acid etched or enhanced by removing matrix with a dental pick. A large amount of acidizing with stronger acid apparently reacts with the carbonate-fluorapatite and deposits a white coating on all the exposed minerals that is very difficult to remove. The best matrix specimens of magnetite are carbonatite matrix studded with octahedrons from the adjacent Cove Creek. Small single crystals of magnetite and perovskite, often contained within small placer deposits on the downstream side of boulders and tree roots after heavy flooding in Cove Creek, were recovered in the early 1970s. Most of the magnetite crystals are under 2 cm in maximum dimension and are simple octahedrons. Some of the crystals are modified. A George L. English Catalog of March 1901 illustrates an unusual form that was offered with monticellite and perovskite crystals. Magnetite crystals may occur alone or in close proximity to other magnetite crystals, perovskite, and more rarely, andradite and kimzeyite. The perovskite is the niobium-rich variety, dysanalyte. It occurs as black cubo-octahedral crystals mostly under 1 cm with high luster. Most, if not all of the perovskite octahedrons, have cubic truncations of the tips that may be very minute. Cubic perovskite crystals are uncommon at the Kimzey calcite quarry. Pyrite is only common in some areas, probably close to the carbonatite borders with irregular masses of pyrrhotite. Here pyritohedral-cubic crystals over 3 cm occur embedded in fine-grained carbonatite. Skeletal, octahedral, 1 cm crystals are rare in the coarse textured carbonatite with carbonate-fluorapatite.

Monticellite occurs in brown aggregates of very crude crystals and masses up to several centimeters across. Most are usually opaque but some microscopic crystals can be transparent. Well-formed distinct crystals are extremely rare. Even the microscopic crystals are difficult to expose and preserve intact. Williams (1891) has crystal drawings of two specimens. Hercynite crystals have long been undifferentiated from perovskite because they are so similar in appearance. However, they can be distinguished visually because hercynite crystals always lack the cubic truncation present in most perovskite crystals and the edges are very slightly beveled (Henderson and Smith, 1992). Crystals range in size from 2 to 4 mm and may be intergrown with perovskite or magnetite. Hercynite often is associated with green biotite that occurs near the border of the carbonatite. Kimzeyite was first noticed by Joe Kimzey in his calcite quarry and was named after the Kimzey family (Milton, Ingram and Blade 1961). It occurs here as dark brown, fairly high lustered, opaque microscopic crystals usually less than 1 mm in diameter. The crystals appear rounded to the naked eye because they are composed of equally developed dodecahedron and trapezohedral faces. Kimzeyites are usually embedded in masses of fluorapatite crystals or adjacent to the edges of monticellite crystals. They have been confused with the larger, dull black, dodecahedral andradite crystals that have a similar occurrence. Vesuvianite is rare in the carbonatite as yellow-green prismatic microscopic crystals. It occurs near the outer edges of the carbonatite mass (Smith 1996). A fine-grained vesuvianite-rich rock makes up the inner zone of altered ijolite inclusions in carbonatite. Crystals up to 4 cm in length may be present (Fryklund, Harner and Kaiser, 1954). Most of the crystals are prismatic with prisms terminated by pyramids and pinacoids. Rarely there are crystals with little or no prism faces. The crystals are yellow to pale brown and some masses are partly reddish brown. The junior author recovered a mass of bluish white fluorescent aragonite. It appears to be a secondary fibrous deposit complete with small speleothems that formed in a large cavity in the carbonatite.

After a locally heavy rain in the late 1980s, the junior author, accompanied by W.L. Prior of the

Arkansas Geological Survey, discovered a carbonatite boulder exposed in the road ditch about 50 yards west of the Highway 51 bridge on the north side of the highway. It was studded with visible kimzeyite, magnetite, and perovskite crystals. After digging around it for a couple of hours, it was pried from the ground and weighed over 100 pounds. Ultimately it was crushed into less than 1 inch pieces, most of which were examined under a binocular microscope for kimzeyite crystals. Over 1000 kimzeyite-bearing specimens were recovered! Many of these micromount specimens were sold at Tucson Arizona over a 10 year period.

Finally, during the 1986 GSA South Central field trip led by Ellen Mullen Morris and the junior author, a vein of fine-grained yellow mineralization was discovered by J. M. Howard. He sent samples to both H. Barwood and B. Murochick, both Florida phosphate researchers at that time. Murochick sent back X-ray results with an identification of syncysite-(Ce) and Barwood found his sample to contain bastnâsite-(Ce). Both were reported by Barwood and Howard (1990) in a South Central GSA poster session. A. Kidwell, when he saw this mineral at a CCA meeting, told of finding the same material under the Highway 51 bridge and the junior author, upon visiting Kidwell's location, found the remainder of what Kidwell had left with the same vein material enclosed in it. The accompanying carbonatite was of the fine-grained variety, not the more typical coarsely crystalline sovite variety.

CARBONATITE LOCATION 2: PEROVSKITE HILL N 34.456040^{o}, W 92.8759683^{o} (Google Earth image 1994), PH

Perovskite Hill was never a hill, but a break in the gently rising slope of the west flank of the Cove. It is south of the Kimzey calcite quarry across the highway and on the west side of Cove Creek, but over the southern portion of same carbonatite body as Calcite Hill. Although there are exposures of carbonatite around Perovskite Hill, the soil over the hill is evidently fairly thick in most places as indicated by a drill hole documented in Erickson and Blade's Professional Paper 425. Little is known about early collecting at this location. It is mentioned as a specimen-producing location by Williams (1891) and not after that time. In the 1960s and early 1970s, some collectors from Memphis got permission and dug a shallow pit on the site (D. McAlister, 2005 personal communication). Evidently their finds were not widely distributed. When Clyde Hardin started digging there in 1979, he said that the dirt sides of the small shallow pit were studded with crystals, and he just "raked" them with his hand into his one quarter inch mesh collecting screen. It seems that once the surface crystals were picked up few collectors bothered to dig and screen the dirt until recent years. Although the dirt in the Cove is friable when dry, when damp or wet it balls up on any mineral or rock in it. So digging the dirt without wet or dry screening is fruitless and the minerals it contains remain hidden. With his sporadic permission to screen on Perovskite Hill between 1979 and 2001, Hardin recovered many buckets of single crystals and groups of crystals which he was still cleaning and sorting when he died (Smith 2003).

Williams (1891) mentions brookite, zircons, and rutile rosettes (eightlings) from Perovskite Hill which probably did not come from the carbonatite. Hardin's collecting confirms the eightlings and zircons. The brookite crystals may have come from other rocks, probably altered novaculite upslope, and may have been too small to be recovered in his screen. A similar source may be true also for the zircons, but their size and elongate prismatic shape caused a few of them to be retained in the screen. The rutile eightlings here are generally under 1 cm and like the other rutile paramorphs and sixlings from elsewhere, probably weathered from feldspar or feldspar-carbonate dikes in the area, particularly from upslope of the locality.

There is a deep water course that roughly parallels the south side of Arkansas Highway 51 between Perovskite Hill and the Kimzey calcite quarry. A perfect place to find crystals you would think. A search of this area by Clyde and the senior author at different times turned up nothing. However, the junior author reports finding in this drainage several hand sized magnetite clusters, some studded with brilliant 1 cm perovskites.

Most of the minerals found in the Perovskite Hill area are similar to those from the Kimzey calcite quarry, but are generally found in the soil and are larger crystals. The exception is anatase that occurs as larger pale yellowish to pale tan pseudomorphs of perovskite and baddleyite pseudomorphs after kimzeyite. Often perovskite crystals show complete replacement by anatase, but rarely may show only partial replacement. In some specimens with magnetite, there are both anatase pseudomorphs and completely unreplaced perovskite crystals on the same specimen. The form, size, or mineral association does not seem to have any bearing on the replacement. Although these anatase pseudomorphs are more indicative of a Perovskite Hill occurrence, some have been found exposed in carbonatite along Arkansas Highway 51 west of Cove Creek. Very few have been recovered in Cove Creek or the Kimzey calcite quarry. Baddeleyite pseudomorphs after kimzeyite were discovered by Clyde Hardin and identified by Henry Barwood in 1996. The crystals are large and may be difficult to tell from similar sized kimzeyite**,** but they are a dull brown with low luster and not black. Their form is rather crude and they may occur in groups with other minerals. Large kimzeyite crystals were discovered by Clyde Hardin in 1995 and identified by Henry Barwood. These crystals, though also quite crude and dull are many times larger than any kimzeyite crystals recovered from the type locality (Kimzey calcite quarry). The large kimzeyite crystals can be distinguished from the baddelyite pseudomorphs because they are a darker brown or black and slightly more lustrous. These large crystals were found only in one small area of Perovskite Hill. During limited time at the location, searching the carbonatite revealed one pin-head size crystal. It is similar to those at the Kimzey calcite quarry. Perovskite is very common here. It occurs as cubo-octahedrons with either form dominating or being equal. Simple cubes up to almost a centimeter that are rare or absent elsewhere are common, but not abundant. Aggregate groups of perovskite, magnetite, and anatase to over 7 cm across have been recovered. At one of the Memphis Gem and Mineral Shows a few years back, David McAlister showed the junior author a few “very odd” octahedral crystals he had picked from bulk material he had purchased from Clyde Hardin’s heirs. Howard identified them as octahedral galena crystals, approximately 3/8ths inch across. This was the first report of galena from the carbonatite at Magnet Cove to the author’s knowledge.

In recent years the original owners, the Moores, and their heirs who Clyde dealt with, have died and the property has been sold. Presently no collecting is tolerated.

THE SYENITE LOCATIONS

PART 1: DIAMOND JO QUARRY N 34.438380°, W 92.863118° (Google Earth image 2013), DJQ

Located on the outer south flank of the Magnet Cove igneous rocks, the Diamond Jo quarry was opened for construction rock for the Diamond Jo Railroad that is located a short distance to the south in the flats away from Magnet Cove's steeper topography. The Diamond Jo Railroad, originally a narrow gauge line, was constructed from Malvern to Hot Springs in 1875-1876 and made a standard gauge in 1889 (H. de Linde, personal communication, 2006). Joseph "Diamond Jo" Reynolds, who constructed and owned the railroad, had made his fortune from a fleet of Mississippi River Steamboats bearing the diamond symbol with the long direction horizontal and with "Jo" inside. He had hated the bumpy stagecoach ride to the Hot Springs Spas from the closest railroad station at Malvern. He visited the Spas often for therapy.

Reynolds also had an unsuccessful mining venture to the west in the Ouachita Mountains at Silver City and others in other states even further west. The Congress Gold Mine near Prescott, Arizona was one of his successes that came when his own personal fortune had dwindled. He died at that mine in 1891. Diamond Jo Reynolds is not to be confused with A. E. Reynolds who also had western mining interests, particularly in Colorado. The quarry was last worked briefly in 1952 to obtain rock for stabilization at the Blakely dam on Lake Ouachita (Henry de Linde, personal communication, 2007).

The Diamond Jo quarry is a small quarry in garnet-pseudoleucite nepheline syenite and garnet-pseudoleucite pegmatite (Erickson and Blade 1963). The former is pale gray and characterized by rounded black titanium andradite, pseudoleucite (albite and nepheline), nepheline, orthoclase, aegirine (and other pyroxenes) and numerous xenoliths. The syenite pegmatite has a less mafic composition, and is coarser grained and is characterized by large laths of barium sodic orthoclase (Erickson and Blade, 1963).

The quarry was little worked after 1900. An undated photograph in Williams (1891) shows a much smaller quarry than the one at present. So its primary use may have been when the Diamond Jo railroad was widened from narrow to standard gauge.

The Diamond Jo quarry has been a long-time Magnet Cove geological field trip and collecting spot. However, aside from a few of the larger miarolitic cavities the most collectable mineral prior to the 1980s was the thin coating of blue sodalite on joint surfaces of the syenite at the eastern wall of the quarry.

The work of Erickson and Blade (1963) identified orthoclase, aegirine, apophyllite, and pseudowavellite (probably pectolite) from miarolitic cavities. These cavities scattered through the syenite are generally rounded, have a white feldspar rim around them, and range in diameter from 0.5 to 8 cm. It was to examine and collect some of these cavities that the senior author visited the quarry in 1970 or 1971. My experience with microscopic minerals was extremely limited at that time. Although some of the white rimmed cavities were collected then, some smaller, 0.1 to 1 cm, irregular cavities with no white rim were of more interest. These cavities were associated with xenoliths near the center of the quarry. Though the crystals in them are extremely small (usually 0.5 mm or less), bright orange labuntsovite crystals in many of them are striking, even through a hand lens. Two new mineral species described from this site are delindeite, occurring as minute pinkish to pale brown rosettes, and lourenswalsite which are tiny silvery micaceous plates forming spheres. These and other minerals such as kupletskite, eudialyte, titanite, and brookite are summarized in Table 3 and described in Appleman et al. (1987), Evans et al. (1986), Howard (1987, revised 2007), and Smith (1989). Additional minerals identified by Barwood (1995) include benitoite and joaquinnite-(Ce) suspended in masses of cotton-like, white pectolite. There are still some unverified and unidentified minerals from these cavities, but to date the amount of each is so limited it has not been prudent to spend the money, time, and resources to have them properly identified.

Table 3: MINERALS OF THE DIAMOND JO QUARRY SYENITE

Mineral	Occurrence	Description	Reference
Aegirine	cavities & matrix	green, black to brown elongate crystals	Erickson & Blade (1963)
Albite	cavities & matrix	thin crystals, colorless overgrowths	Smith (1996)
Anatase	sandstone xenoliths	deep blue to black microcrystals	Smith (1989)
Andradite	syenite matrix	large black rounded crystals	Erickson & Blade (1963)
Arfvedsonite	cavities	black lustrous prismatic crystals	Howard (1977)
Augite	cavities	black to green prismatic microcrystals	Milton, p.c. (1977)
Barite	cavities	colorless, thin tabular microcrystals	Smith (1989)
Barytocalcite	cavities	colorless pseudorhombohedral crystals	Smith (1989)
Bastnâsite-(Ce)	cavities	yellow pyramidal microcrystals	SEM/EDS
Benitoite	cavities	pink, blue, colorless crystals in pectolite	Barwood (1993)
Britholite	cavities	aggregates of pale pink crystals	Barwood , p.c. (1995)
Brookite	quartz syenite	black equant crystals to 0.5 mm	Smith (1989)
Cafetite (?)	cavities	single deep purple microcrystal	Barwood, p.c. (2006)
Calcite	cavities	rare, rounded scalenohedrons	Smith (1989)
Cancrinite	veinlets	alteration of nepheline	Erickson & Blade (1963)
Catapleite	cavities	thin colorless to tan hexagonal crystals	Smith (1989)
Crandallite	cavities	reported but is pectolite	Erickson & Blade (1963)
Delindeite	cavities	pink to grayish, minute, type locality	Appleman et al. (1987)
Elpidite	quartz syenite cavities	white, elongate prismatic crystals	Smith (1989)
Eudialyte	cavities, matrix	red to pink to brown microcrystals	Smith (1989)
Ferro-hornblende	cavities	thick black lustrous microcrystals	Smith (1989)
Fluorapatite	cavities	white prismatic microcrystals	Smith (1989)
Fluorapophyllite	cavities	colorless, prismatic to tabular	Erickson & Blade (1963)
Fluorite	joint surfaces, cavities	purple, rarely with sodalite	Smith (1989)
Goethite	cavities	tan to pumpkin pseudomorphs	Smith (1989)
Gonnardite	ijolite xenoliths	blocky, after nepheline	Howard (2001)
Gypsum	cavities	colorless crystals filling some cavities	Smith (1989)
Hematite	cavities	thin narrow blades, may be reticulated	EDS-SEM
Joaquinite-(Ce)	cavities	yellow-brown, corroded crystals	Barwood (1995)
Kassite	cavities	pinkish to brown groups thin blades	Evans et al. (1986)
Kassite	cavities	minute tan, yellow or white spheres	EDS-SEM
Kupletskite	cavities	amber to brown, elongate prismatic	Smith (1989)
Labuntsovite	cavities	bright orange, thin to blocky	Milton XRD, Smith (1989)
Lorenzenite	quartz syenite cavities	pale pink, elongated, spanning cavities	Smith (1989)
Magnesioarfvedsonite	cavities	blue to brown primatic microcrystals	EDS-SEM
Molybdenite	cavities	silvery often crumpled thin plates	Smith (1989)
Narsarsukite	cavities	rare, minute yellow equant crystals	Smith (1989)
Natrolite	cavities	colorless elongate terminated crystals	Smith (1989)
Opal	quartz syenite cavities	colorless coatings of hyalite opal	Smith (1989)
Orthoclase	cavities	white, blocky crystals to 5 mm across	Smith (1989)
Orthoclase Ba-Na	matrix	large elongate pale gray crystals	Erickson & Blade (1963)
Pectolite	cavities	white tufts, acicular, and cotton-like	Smith (1989)
Phlogopite	cavities	orange to brown, pseudohexagonal	Smith (1989)
Pyrite	shale xenoliths	masses, striated cubic crystals	Smith (1989)
Quartz	quartz syenite cavities	colorless crystals up to 5 mm long	Smith (1989)
Seidite-(Ce)	cavities	yellow microaggregates, equant crystals	EDS-SEM
Siderophyllite	cavities	black micaceous, uncommon	Smith (1989)
Sodalite	joints and seams	thin coatings on syenite	Erickson & Blade (1963)
Sphalerite	cavities	minute yellow tetrahedrons	Smith (1989)

Stilbite	cavities	pink crystalline aggregates	Howard, p.c.
Tainiolite	cavities	minute tan to silvery platy aggregates	Smith (1989)
Titanite	matrix, rarely in cavities	brown to yellow microcrystals	Erickson & Blade (1963)
Wollastonite	cavities	colorless, prism. crystals, yellow lumin.	Barwood (XRD)
Zircon	cavities	yellow to colorless microcrystals	Smith (1989)
Zircophyllite	cavities	reported	Barwood, p.c. (2005)

Another source of micro-mineral specimens was a large mass of quartz syenite or what Owens and Howard (1989) called "fenite" on top of the quarry. This mass was very porous and highly weathered so special cleaning was required to observe and identify the minerals. The U.S. Geological Survey mineralogists in Reston, Virginia identified the minerals found in it (Flohr and Ross 1985, Ross 1984 and summarized in Smith 1989). The fenite was completely removed by 1990.

Further to the east and also on the outer flank, the Martin Marietta Jones Mill quarry that was working baked and altered sedimentary rocks, reached the syenite/country rock contact a few years ago. Although xenoliths are common in the syenite, cavities have been scarce. Some of the same mineral species have been identified there, but their character and associations have not been similar. However, this is changing as the quarry operations approach the Diamond Jo area. Most recently, one 5 cm cavity in the syenite was collected by the junior author. In it was a cotton-like mass of fibrous minerals, which was later identified as aegirine coated with microcrystals of thorite.

The Diamond Jo quarry is owned by Henry de Linde of Hot Springs. Permission to visit the quarry must be obtained from him.

PART 2: THE EUDIALYTE SYENITE PEGMATITES AND ASSOCIATED CONTACT METAMORPHIC ROCK MINERALS

There are two locations for the eudialyte syenite pegmatites. One is located on the west bank of Cove Creek on the north side of the highway at the State Highway 51 Bridge at N 34.456918°, W 92.875325°. The other is located several hundred yards to the east on the north side of the Branch, a tributary to Cove Creek that parallels the north side of Arkansas Highway 51. Evidently the Cove Creek pegmatite was the most extensive, but most of the surface exposure has been removed by collectors and by many periods of road, highway, bridge, and pipeline crossing excavation. The last two periods of excavation that moved the rock rubble around in the creek bed were in the early 1970s and the middle 1980s. Few very good macro specimens were recovered then and during the years since. The best mineral descriptions are given by Williams (1891). There has been little in the way of macro mineral descriptions from subsequent investigators, probably because good examples were not available.

Microscopic minerals have been described (Nizamoff, Falster, Simmons, and Weber 1998, Smith 1994b, 1996, 1999a, Tice et al. 2001). Apparently the mineralogy and mineral descriptions from the pegmatites are so similar that they are seldom differentiated in Williams (1891) and on specimen labels. Table 4 presents a summary of the minerals from these locations. Aegirine was probably one of the first minerals reported from Magnet Cove though it was called hornblende or schorl and probably found loose in the soil. The most noted aegirine crystals are the large (up to 30 by 3 cm) elongate black crystals with a hint of green. They are particularly noteworthy if they are terminated, but terminated specimens are rare. Small, up to 5 cm, terminated crystals with a sharp or blunt point and with little or no matrix are much more common in collections. Aegirine crystals in the pegmatite and contact metamorphic rocks are common even down to microscopic size, but unless microscopic and terminated in cavities, most are not of specimen interest. Very common are felted coatings and masses of minute green crystals that were originally assumed to be epidote by Landes (1931), but are actually aegirine (Shockley 1948). Astrophyllite is described by Williams (1891) who saw only one specimen and that was given to him by Genth, who, with others, studied astrophyllite in 1890. It occurs in thin brittle plates crowded together in an irregular mass. The poorly developed crystals range in size from 1 to 10 mm. They are a brownish yellow color with perfect cleavage parallel to the basal pinacoid (001). The (001) face has a brilliant luster. Very little has turned up since, so it may just be a local occurrence and probably very rare. Several microscopic yellow plates in a small specimen of what appears to be a contact metamorphic rock were found by Gene Bearss in the 1960s. However, an EDS-SEM indicated it is not astrophyllite, but possibly lamprophyllite. Williams (1891) states the astrophyllite contains some titanium which the lamprophyllite does not have, so obviously they are two different minerals.

Eudialyte (eucolite) is one of the most recognized and sought after minerals from Magnet Cove. It occurs as nodules, rounded masses, and well-formed crystals from 3 to 18 mm in diameter. The eudialyte can be glassy or granular and some may have a somewhat earthy appearance. The color varies from deep rose to pale pink and yellow or brownish. The eudialyte in the latter two colors was called eucolite and was originally thought to be an alteration of eudialyte**,** but analyses of both are the same. The crystals are mostly equant, but some show a rhombohedral form. Williams (1890a) made a crystallographic study with specimens obtained with the help of W. J. Kimzey. He found that some crystals have the negative rhombohedron predominating and that in others the positive rhombohedron predominates. The smaller crystals, usually well under 1 cm in diameter, are the best formed. However, often the best formed crystals do not have the deepest color. Comparing the analyses of the pegmatite eudialyte with other suspected microscopic crystals from garnet pseudoleucite nepheline syenite matrix and miarolitic cavities show a considerable variation in composition.

Microcline occurs as white to pale green, thick tabular crystals. It was first described as microcline and not orthoclase by Des Cloiseaux (1876). The crystals range in size up to 15 by 2 cm and are simple crystals not showing twinning. A few small crystals about 5 cm across were recovered in the 1970s.

Nepheline (eleolite) is very inconspicuous and occurs as gray to reddish brown masses that look much like feldspar and may be labeled as such. It often is missing in the pegmatite because of weathering or possibly alteration by late fluids. Natrolite is intergrown as porous masses that consist of thick (1 to 2 cm) elongated prismatic crystals. Some are terminated and evidently these masses were common in some areas of the pegmatite. The crystals are generally white, but can be colorless or grayish and rarely pinkish. In recent collecting, it is rare, occurring as isolated microscopic crystals or small groups of such crystals, some having terminations in cavities. Pectolite (manganoan) was described by Williams (1890b) as the mineral species manganopectolite, but it actually is just a manganese-rich pectolite. It occurs as thick tabular crystals up to 10 cm long. The crystals are gray and transparent and may be encrusted and partly replaced by a brown manganese-rich weathering material. Shockley (1948) thought that the “manganopectolite” may be a form of thomsonite. Microscopic circular patterns of white fibers on aegirine from the pegmatite are pectolite without manganese. The only specimen of manganopectolite the senior author has ever seen was on Joe Kimzey’s back lawn about 1970. It was a cabinet size specimen with gray 2 cm crystals, but unfortunately I did not have the $25 to purchase it. I have regretted it to this writing and would loved to have a piece analyzed by EDS-SEM and XRD.

Titanite was observed as typical almost flat and somewhat oval crystals and also as elongated crystals by Williams (1891). The most striking are the bright sulfur yellow crystals in matrix that may be up to 5 mm across. Other crystals are bronze to brown, smaller, and may be present in cavities between crystals in the pegmatite. Vesuvianite is from contact metamorphic rocks and commonly occurs at both pegmatite locations. Imperfect crystals and masses up to 8 cm long were common, but complete ones are generally much smaller. The crystals have an oily luster, are yellow to yellowish green to an olive green, and more rarely a reddish or yellowish brown color. Cove Creek in the Arkansas Highway 51 bridge area has masses of intergrown poorly formed crystals that show some color variations and color zoning. The complete crystals along Cove Creek to the north of that location are rare and tend to be doubly terminated bipyramids with little or no development of the prism faces. At the Branch, the crystals are smaller, usually 1 cm or less, and are bipyramidal crystals with well developed prism faces. Vesuvianite crystals from the Branch are now more common.

Other minerals found in the pegmatite and contact metamorphic rocks are given in Table 4. Most are as microscopic crystals or generally not considered to be collectable. The Branch pegmatite was formerly owned by the Moore family. They also owned Perovskite Hill so visitation and collecting was not allowed for many years, with the exception of a very few local collectors. Collecting by breaking the rocks in Cove Creek at the bridge has been difficult in recent years because now everything is mud covered. The creek bed is public property, therefore is open to collectors, despite some local objection.

Table 4: EUDIALYTE SYENITE PEGMATITES AND CONTACT METAMORPHIC ROCKS OF COVE CREEK BRIDGE AND BRANCH AREAS

Mineral	Occurrence	Description	Reference
Aegirine	pegmatite, contact rock	green to black elongated crystals	Williams (1891)
Albite	pegmatite	white, generally inconspicuous	Williams (1891)
Anatase	pegmatite	minute black crystals	Smith (1999b)
Andradite	altered phonolite	pale brown to colorless crystals	Erickson & Blade (1963)
Andradite	pegmatite	small brown crystals	Williams (1891)
Astrophyllite	pegmatite	rare, brilliant yellow brittle plates	Williams (1891)
Augite	pegmatite	black to green prismatic crystals	Tice et al. (2001)
Baddeleyite	pegmatite	alteration rim on eudialyte	Falster et al. (1998)
Barite	pegmatite	colorless crystals, late formation	Tice et al. (2001)
Barytolamprophyllite	pegmatite	tiny pink grains	Falster et al (1998)
Brookite	pegmatite	crystals to 6 mm on aegirine	Howard (1999)
Brucite	pegmatite	probably catapleiite	Williams (1891), Foshag (1923)
Catapleiite	pegmatite	aggregates of hexagonal crystals	Foshag (1923), Falster et al (1998)
Chlorite	pegmatite	green to brown spheres & hemispheres	Smith (1999a)
Epidote	pegmatite	misidentification of green felted aegirine	Shockley (1948)
Fluorapophyllite	pegmatite	white to colorless prismatic crystals	Smith (1996)
Galena	pegmatite, contact rock	tiny crystals and masses	Shockley (1948)
Grossular?	pegmatite	minute pale yellow crystals	Smith (1994b)
Gypsum	pegmatite, contact rock	colorless crystals and masses	Shockley (1948)
Hedenbergite	phenocrysts	crystals in groundmass	Tice et al. (2001)
Johannsenite	pegmatite	molar constituent of aegirine-augite	Tice et al. (2001)
Lamprophyllite	contact rock	yellow blebs and lath-like crystals	EDS-SEM
Låvenite	pegmatite	alteration of eudialyte	Falster et al. (1998)
Magnetite	placer	in bed of Cove Creek	Smith (1996)
Microcline	pegmatite	large thick tabular xls, white - pale green	Landes (1931)

Miserite (?)	contact rock	reported, but not confirmed	A few collectors
Molybdenite	contact rock	grains and small masses	Smith (1996)
Muscovite	pegmatite	small clear and colorless flakes	Smith (1996)
Natrolite	pegmatite	colorless, white, pink crystals & masses	Smith (1994)
Nepheline	pegmatite	short prismatic crystals, very rare	Williams (1891)
Paraumbite	pegmatite	alteration rim around eudialyte	Falster et al. (1998)
Pectolite	pegmatite	white wisps and radiating sprays	Smith (1999a)
Petedunnite	pegmatite	molar constituent of aegirine-augite	Tice et al. (2001)
Phlogopite	contact rock	small brown flakes	Shockley (1948)
Pyrite	pegmatite, contact rock	masses and crystals, not abundant	Smith (1996)
Pyrophanite	pegmatite	black, lustrous, micro discoids & rosettes	Smith (1994)
Pyrrhotite	pegmatite, contact rock	with other sulfides	Tice et al. (2001)
Sphalerite	pegmatite, contact rock	green micro crystals, brown masses	Smith (1996)
Strontianite	pegmatite	white divergent sprays and hemispheres	EDS –SEM
Thomsonite	contact rock	green to brown, concentric structure	Smith (1996)
Titanite	pegmatite	brilliant yellow crystals to 5 mm	Williams (1891)
Titanite	contact rock	dark brown crystals to 2.4 cm	Shockley (1948)
Tobermorite	pegmatite	chert-like appearance	Erickson & Blade (1963)
Vesuvianite	contact rock	yellow to greenish crystals and masses	Williams (1891)
Wollastonite	contact rock	white to colorless crystalline masses	Shockley (1948)
Wollastonite	phonolite	fluorescent amygdules	Erickson & Blade (1963)
Zircon	pegmatite	tiny pale tan crystals in cavities	EDS-SEM

PART 3: THE MARTIN MARIETTA JONES MILL QUARRY N 34.438686^{o}, W 92.856893^{o} (Google Earth image 2013), MMQ, JMQ

This quarry was opened about 1990 by the Mid-State Construction Company and was also known as the Midstate, Mid-State, or Highway 51 quarry. Martin Marietta purchased the quarry in 1998 and renamed it the Jones Mill quarry. Since then the quarry and their operations have been expanded.

The Martin Marietta Jones Mill quarry is located on the outer southeast flank of Magnet Cove. Originally the quarry exploited the Devonian-Mississippian age Arkansas Novaculite. After Martin Marietta bought the quarry, the baked and altered Mississippian age Stanley Shale was the primary rock taken (Howard 2001). In 2000 the quarry reached veins of syenite and since then the main mass of syenite has been exposed in the northwesternmost high wall. Presently mining remains concentrated within the altered Stanley Shale, due to differing crushing characteristics of the igneous rock.

Most of the minerals are microscopic in size and occur in quartz veins, but rarely feldspar and carbonate veins have been encountered. Each may have small open spaces where crystals may exist. Other sources of crystal specimens in are fault zones, in joints, rarely in matrix, and in miarolitic cavities within the syenite. Unfortunately, many times there are very few or no cavities exposed. Each type of rock has its own suite of microminerals including the carbonate-rich layers in the Stanley Shale. Table 5 gives a brief description of these minerals and their occurrences.

Table 5: MINERALS OF THE MARTIN MARIETTA JONES MILL QUARRY (AKA MIDSTATE / HIGHWAY 51 QUARRY)

Mineral	Rock Source	Description	Reference
Aegirine	Syenite, altered shale, qtz veins	Black, brown, green needles	Smith (2001)
Albite	Syenite, quartz veins	White to pale pink thick tabular crystals	Estes (1998)
Ancylite-(Ce)	Syenite	Pale groups of micro prisms	Stephano (2016)
Allanite-(Ce)	Altered shale	Black laths to tabular micro crystals	Estes (1998)

Allanite-(La)	Altered shale	Minute brown laths	Smith (1998a)
Analcime	Altered shale	White rounded crystals to 4 cm	EDS-SEM
Anatase	Quartz veins	Black to deep blue typical crystals	Estes (1999), Howard (1999)
Anatase	Carbonates	Sparse, tiny complex lustrous black xls	AES observation (2005)
Andradite	Altered shale	Yellow to dark brown dodecahedral xls	Estes (1998)
Ankerite	Veins in shale	Pale tan veins with rhombohedral xls	Smith (1998)
Arfvedsonite	Altered shale	Brown 5 mm prismatic crystals	EDS-SEM
Astrophyllite (Mg)	Altered shale	White sprays of elongated crystals	EDS-SEM
Barite	Syenite	Bright colorless tabular & prismatic xls	EDS-SEM
Bastnâsite-(La)	Altered shale	White to brown flakes in rosettes	EDS-SEM
Biotite	Altered shale	Micro pseudohex. green to brown books	EDS-SEM
Brookite	Quartz veins	Tiny black crystals with anatase and qtz	Howard (1999)
Burbankite	Carbonates	White elongate prismatic micro crystals	EDS-SEM
Cacoxenite	Altered shale	Minute yellow spheres and bow ties	K. Estes specimen
Calcite	Carbonates	Colorless, pastel rhombs & discoids	Estes (1998)
Calcite (Mn)	Syenite	White to pink fluorescent micro crystals	AES specimen
Carb.-fluorapatite	Quartz veins	White prisms	Barwood
Catapleiite	Altered shale	Colorless pseudohexagonal microplates	Estes (1998)
Chabazite-Ca	Altered shale	Minute pale tan crystals and aggregates	EDS-SEM
Chalcopyrite	Altered shale	Trace amounts	Reported
Chamosite	Altered shale	Green to black spheres and coatings	EDS-SEM
Diopside (Cr)	Lamprophyre dikes	Micro crystals	Barwood, p.c.(1999)
Dolomite	Veins	White to gray, slightly ferroan	EDS-SEM
Epidote	Quartz veins, altered shale	Green crystals to 4 mm	EDS-SEM
Fluorapatite	Feldspar veins, altered shale	Pink, yellow, blue crystals	Howard (1999)
Fluorapophyllite	Syenite	Pale brown, transparent elongate xls	EDS-SEM
Fluorite	Syenite, quartz veins	Purple, blue, white, crystals rare	Estes (1998)
Galena	Quartz & carbonate veins	Cubic crystals rare	EDS-SEM
Goethite	Quartz veins	Lustrous cubes after pyrite	EDS-SEM
Gypsum	Altered shale seams, syenite	Dendritic, thin crystals, masses	AES observation (2004)
Hedenbergite	Quartz veins	Pale tan micro crystals	EDS-SEM
Hematite	Loose in soil	Small cubic crystals	Smith (1998a)
Hematite	Quartz veins, altered shale	Small bladed crystals, some rosettes	Smith (1999b)
Ilmenite	Syenite matrix	Small gray black masses	EDS-SEM
Ilmenorutile	Altered shale	Aggr. of minute black striated, stubby xls	EDS-SEM
Jarosite	Quartz veins	Tiny yellow-brown xls on qtz & hematite	EDS-SEM
Kaolinite	Veins	Micro beads coating other minerals	Howard (1999)
Kolbeckite	Altered shale	Minute lime-green crystals in fractures	Barwood (1998)
Labuntsovite	Syenite	Minute pale brown tabular crystals	EDS-SEM
Leucosphenite	Syenite	Minute yellow crystals	EDS-SEM
Mg-arfvedsonite	Syenite	Green laths to tabular crystals	EDS-SEM
Magnetite	Altered shale	Tiny bright octahedral crystals	EDS-SEM
Malachite	Altered shale	Thin green coatings and minute spheres	EDS-SEM
Marcasite	Altered shale	Crystals perched on pyrite, also masses	Howard (1999)
Microcline	Syenite	White to colorless blocky crystals	Reported
Molybdenite	Syenite	Minute blebs and flakes on orthoclase	EDS-SEM
Narsarsukite	Syenite	Yellow transparent microxls in cavities	Barwood, p.c. (2005)
Natrolite	Carbonates	White, pale pink to orange elong. prisms	EDS-SEM
Nenadkevichite	Syenite	Minute pale orange pseudohex. crystals	EDS-SEM
Orthoclase	Syenite	Tan, gray, white, blocky to lath-like xls	EDS-SEM
Pectolite	Syenite, altered shale	Silky white strands in cavities	Estes (1989)
Phlogopite	Altered shale, quartz veins	Pseudohex. yellow to brown crystals	EDS-SEM
Polylithionite?	Altered shale	May be tainiolite	Estes (1989)
pseudoleucite	Syenite	Phenocrysts (albite + nepheline)	Williams (1891)
Pyrite	Veins, altered shale, syenite	Common as crystals and small masses	Barwood (1998)
Pyrochlore	Syenite	Brown micro octahedrons	EDS-SEM
Quartz	Veins	Gray, colorless, smoky xls, few large	Smith (1996)
Quartz	Syenite	Clear, colorless masses with no xl form	EDS-SEM

Rhabdophane-Ce	Altered shale	Minute white discoidal crystals & rosettes	EDS-SEM
Rhodochrosite	Altered shale	Discoidal, pale yellow to tan with siderite	Barwood XRD
Rutile	Altered shale, syenite	Black to reddish, elongate, reticulated	EDS-SEM
Sanidine	Quartz veins	Clear crystals with quartz and anatase	Howard (1999)
Siderite	Altered shale	Stalac., discoids, rhombs, grn, yell-ambr	Smith (1999)
Siderophyllite?	Altered shale	Probably chamosite, EDS	Estes (1999)
Sphalerite	Altered shale, syenite	Green, red complex micro tetrahedra	Estes (1999)
Struverite	Carbonate vein	Black rod-like micro xls with branches	Smith (1998a)
Tainiolite	Altered shale, quartz veins	Micro plates forming rosettes, spheres	Howard (1999)
Tetraferriannite	Xenolith in syenite	Deep red-brown pseudohexagonal	EDS-SEM
Yofortierite	Syenite	Pale pinkish tan fiber clusters	Barwood XRD
Zircon	Syenite	Bright yellow micro crystals in cavities	Smith (1994a)
Ca-Na silicate	Syenite	White, tiny thin laths with barite	EDS-SEM

Note: As this quarry advances into the syenite complex of Magnet Cove, minerals like those at the Diamond Jo quarry are becoming more common.

Good specimens larger than thumbnail size have been very rare. In October, 1996 during a Coon Creek Association field trip, a vein of gray smoky quartz crystals was discovered, but probably less than 20 specimens were collected. The crystals ranged up to about 18 cm long and were fairly interesting, mainly because the crystals had multiple small prism faces instead of single smooth faces. None have been found since. During this same trip some minute yellow green kolbeckite crystals were collected. They are very similar to those found at the Christy mine, but some are associated with pyrite.

The Arkansas Novaculite in the upper level of the western part of the quarry in late 1998 had abundant hematite. Crystal discoids up to 4 mm across were abundant in open spaces. However, the crystals were so fragile and so closely packed that it was almost impossible to get good specimens without many broken crystals. Rarely these discoids formed small, widely spaced, hematite roses up to 5 mm across.

The largest volume find of any collectible mineral at this quarry was in 1997, along with a similar find in 1998, when quartz veins in the metamorphosed Stanley Shale containing very deep blue, appearing black, anatase crystals were discovered (Howard 1999). Estes (1999) describes the similarities and differences of the two finds. The anatase crystals were small, mostly less than 5 mm, but specimens having multiple anatase crystals are up to 10 cm across when trimmed. According to Howard (1999) anatase was deposited on mattes of drusy, etched, pale smoky quartz crystals or colorless sanadine crystals. Tiny black equant brookite crystals with alternating “m” faces, typical of crystals from the brookite deposits, are scattered inconspicuously among the anatase. Rutile occurs as inclusions in the quartz. Other minerals observed were pyrite, marcasite, tainiolite, colorless to pale pink, stubby fluorapatite crystals and white, granular, kaolinitic clay (Howard 1999). When the discovery of the anatase was first made by three local collectors, one being Jimmy Matlock, they loaded up all of the about 25 flats they had with them with specimens. Then they took them to Clyde Hardin in Malvern. He showed a strong interest in them and purchased several flats. They knew that they had only taken a small quantity of what had been blasted down. So they got some additional flats and headed back to the quarry the next weekend, only to find that everything in the area had been sent to the crusher and not a single anatase crystal specimen was to be seen.

Recently lustrous black, at times skeletal, microscopic crystals of anatase have been observed in matrix with intergrown natrolite crystals from some of the carbonate-rich layers. Brookite is generally fairly rare except as noted above. Rutile is common in the contact metamorphic rocks, but some of the best reticulated, geniculated, and untwinned, reddish to black, microscopic crystals were found in syenite dikes before the main body of the syenite was reached.

A visit to the quarry in April 2003 yielded very few microscopic crystals in any type of rock. Possibly because the only rock blasted down recently was still covered with dust; so it was impossible to see anything. All the igneous rocks had been pushed into irregular windrows in the center of the quarry and had been washed clean by rain. Although we located only one or two cavities, much of the rock contained very large white crystals of pseudoleucite "frozen" in matrix. Most of these pseudomorphs were rounded and showed very little evidence of crystal form. However, their large size, with some over 10 cm in diameter, was impressive.

All the other minerals, except rarely pyrite crystals or hematite that might be large enough to be considered thumbnail specimens, are microscopic specimens and are summarized in Table 5. As the rock operation proceeds further into the syenite, there is no doubt that many additional mineral species will be added to the list of occurrences from this location.

The Martin Marietta quarry is a large and active operation, often operating 7 days a week. Casual collectors are generally not welcome. Visiting geologists who have made prior arrangements may get in, but even if they do their visit may be restricted to a limited area that may not be worth the time searching or to try to collect minerals. Two hour visits on some occasions have resulted in nothing of interest, even though on one of these visits, a complete run of the quarry was available.

PART 4. PSEUDOLEUCITE CRYSTALS AND LOCATIONS

Pseudoleucite as a mineral name is a misnomer and as such will not be found in any recent mineralogy textbook. However, late 19th century mineral texts use the term pseudoleucite to describe the intimate solid state exsolved phases of orthoclase and nepheline in the original crystal form of leucite from Magnet Cove. This term remains in the AGI Glossary and is defined as a "pseudomorph after leucite" and gives Magnet Cove, Arkansas as one of the notable locations. So when we use the term pseudoleucite, it is with this understanding because, although it is not a valid mineral species, it is commonly used in the literature about Magnet Cove.

Garnet pseudoleucite nepheline syenite is the most abundant rock type making up 21% of the exposed Magnet Cove igneous rocks and forms almost a complete outer ring that is particularly well developed on the south rim of the complex (Erickson & Blade 1963). Williams (1891) describes and illustrates well-formed crystals, both in the host syenite and loose in the soil, however he describes the pseudoleucite syenite as a dike rock instead of an integral component of the intrusive. Pseudoleucite is frequently noted as only as white to cream spots in many boulders and outcrops. The pseudoleucite pseudomorphs range from 6 mm to 5 cm in diameter and make up from 0 to 60% of the mapped rock unit. It is rarely present in the coarse-grained or pegmatitic portions of the garnet pseudoleucite nepheline syenite (Erickson and Blade, 1963). Williams (1891) writes that in some pseudoleucite, the nepheline may have formed large short prismatic crystals and much of the nepheline may be altered to cancrinite.

George Frederick Kunz (1886) was the first to write about the pseudoleucite. He obtained one half of a trapezohedral crystal in about 1881 and he sent it to F. A. Genth to analyze, but before Kunz's own examination was complete, the specimen was lost. However, in 1886 he received over 100 crystals, probably from either W. J. Kimzey or Hodge Kimzey. According to Williams (1891) these crystals likely came from the southeast portion of Magnet Cove on a flat area where the rock is exposed high above Stone Quarry creek on the west side, just before the creek exits the igneous rocks. This area is in the NE ¼, Section 29, T. 3 S, R.17 W. Other pseudomorphs were found on the east side of the creek and in a lower area where garnet pseudoleucite syenite is also present. The illustrated specimen in Williams (1891) is from the latter area.

Two sites are known for yielding good crystals during the past few years. One location is on the east flank of Cook Mountain, east of the center of section 24 where the county road crosses an outcrop of the garnet pseudoleucite nepheline syenite (N 34.55592^{o}, W 92.884172^{o}) as mapped by Erickson and Blade (1963). For years the road was a well maintained dirt two-lane and after any rain, in both the road bed and its adjacent ditches, loose rounded crystals and the occasional matrix specimen were readily recovered. But in the early 1990s, the county paved the road with oil and pea gravel and later recoated it with macadam. Specimens, after some significant effort, may still be recovered from the west road ditch, but not in the former abundance or quality since paving. Crystals to 5 cm in diameter have been recovered, but most range from 1.8 to 3 cm. Matrix specimens with trapezohedral crystals in bold relief are the scarcest because the crystals tend to release from the weathered matrix during collecting. Attractive material for book ends has been obtained from this outcrop, with the cream colored pseudoleucites contrasting with the darker fine-grained matrix.

The second site is a field in Section 21 to the southeast of the junction of the previously mentioned road and Arkansas Highway 51 that trends east across Magnet Cove (N 34.458164^{o}, W 92.880538^{o}). Here clearing for a subdivision resulted in a small exposure of soil, that soil being the weathering product of the garnet pseudoleucite nepheline syenite. After rains, sparse loose specimens were recovered, some still having distinct trapezohedral crystal faces typical of leucite.

Another area where pseudoleucite pseudomorphs were observed is on the western flank of Magnet Cove where garnet pseudoleucite nepheline syenite is exposed north of Arkansas Highway 51 in what became Cove Creek Estates. Houses were built on this area in the 1970s. These pseudomorphs, though very abundant, were mostly rounded masses.

One unusual specimen was recovered by the junior author from south of the Kimzey calcite pit in the small unnamed drainage that empties east into Cove Creek. It consists of tannish cream albite crystals and is about 10 cm across. When the specimen was collected, nothing unusual about it was noticed. Later, the piece was accidentally dropped and when broken there were exposed 4 large faces of a trapezohedron identical to the form of pseudoleucite. The specimen is the largest known single pseudomorph of leucite known from Magnet Cove, weighing nearly 1 kilogram and is about 30% complete.

RUTILE LOCATIONS AND MINERALS

INTRODUCTION

There are several areas in Magnet Cove where rutile can be collected and it occurs in a variety of forms. Some of the earlier collected specimens, particularly those that consist of aggregates of crude elongated crystals, are labeled as the variety nigrine. Nigrine is the iron-rich black variety of rutile that contains 2 to 3 percent iron. However, spectrographic analyses of 23 rutile paramorphs by Erickson and Blade (1963) all showed less than 2% iron and analyses of an additional 45 specimens had only 2 specimens over 2% and they were both just 2.2%. So the Magnet Cove rutile variety nigrine label does not fit most specimens. The black color of rutile from Magnet Cove has been shown to be due to the presence of niobium (Erickson and Blade 1963), not iron.

The illustrations of a rutile sixling and an eightling that are given without credit in Williams (1891) actually illustrate Graves Mountain, Georgia specimens (Howard 1999). They are from Gustav Rose (1862) and no rutile crystals like them have been reported from Magnet Cove. Much of Williams (1891) manuscript was dictated from his death bed to his brother. He died at age 29 of malaria in 1890, contracted during field work while in Arkansas. His brother then submitted the manuscript for publication in 1891, so it is not surprising to find some inconsistencies in his remarkable work.

PART 1: THE TITANIUM CORP OF AMERICA PIT / MAGNET COVE RUTILE COMPANY DEPOSIT N 34.468294°, W 92.867897°, TCAP, MCRCD

The Magnet Cove Rutile Company deposit is also known as the Magnet Cove Titanium mine and Titanium Corporation of America pit. It is located in the center of the east half of section 18, T. 3 S., R. 17 W. in the northern half of the intrusion.

Exploration was as early as 1913 by the Titanium Alloy Company of Maine. The area was prospected with an auger drill and one 60-foot shaft was sunk, which is probably within the confines of the pits dug by later operations. In 1931, the Titanium Corporation of American was formed and it began immediate commercial development of the deposit. A 30-40 ton per hour mill was shipped to the site in 1932 and the first railcar load of concentrates was shipped that year. The first ore shipped consisted of alluvial and residual rutile recovered by working the soils to the south of the later mined area. In 1933 concentrates were produced from both weathered and unweathered *insitu* ores from the pit operation. Operations were continued to 1942, but were intermittent during the summers, due to shortages of water for the mill. During this period 200 to 600 tons of concentrates were reported to be produced annually, the bulk of which were shipped to Europe (Fryklund and Holbrook, 1950). In 1942 the Titanium Alloy Manufacturing Company of Maine, through a local subsidiary, acquired the property and facilities. Additional milling equipment was installed and approximately 10 cars of rutile concentrates were produced during 1943. However, there was insufficient demand for rutile from this site for the production of alloys when it was discovered that welding rod coatings made with this rutile resulted in brittle welds; not a good thing for welds on warships. The operation was abandoned and sold to Magnet Cove Rutile Company in December. Production in 1944 was sporadic and ceased in the fall. In 1945 the U.S. Bureau of Mines undertook an exploration project and increased reserves significantly. A more extensive core drilling project was done in 1948. Altered host rock with ore-grade rutile mineralization is known to extend to at least 200 feet in depth.

Rutile occurs in veins and pods to as much as 28.8 cm in thickness but typically 6 to 12 mm throughout altered phonolitic host rock. Several types of veins carrying variable amounts of rutile crosscut the host rock, including sucrosic albite-dolomite veins, microcline-calcite veins, coarse-grained albite-perthite-carbonate veins, albite-ankerite veins, and calcite-rutile veins. Notable also is the development of a significant amount of pyrite during the alteration of the host and emplacement of the veins. At one time, up to the late 1960s, there was a small area thickly covered by loose, small, pyrite crystals adjacent to the old mill site.

The rutile from Magnet Cove is black due to the presence of niobium and at this site may occur as blebs, reticulated needle masses, black veins with metallic luster crosscutting the weathered host rock, and as paramorphs after early formed brookite. Paramorphs to 3.6 cm across have been recovered from this site as well as pyrite crystals to 1 cm in diameter. Rutile sixlings from this location are rare but still are occasionally recovered. The problem can be differentiating rutile paramorphs from sixlings. Generally, the paramorphs have smoother faces while the sixlings have rough faces (Howard 1999). Most specimens of rutile from this site consist of black metallic masses of interlocking rutile crystals. One single rutile specimen in the State collection of this type weighs over 20 pounds. Some of the older matrix specimens from this location, probably obtained during mining consist of small rutile paramorphs on and imbedded in 2 to 4 cm thick slabs of an off white feldspar-carbonate vein material. Evidently the vein material once exposed has been highly altered by the acid waters present in the mine area because none has been found in recent years. Table 6 gives a summary of other minerals occurring at this location.

Table 6: MINERALS OF THE TITANIUM CORPORATION OF AMERICA PIT (AKA MAGNET COVE RUTILE COMPANY AREA)

Mineral	Occurrence	Description	Reference
Albite	veins, encrustations	masses of white crystals to over 1 cm	Shockley (1948)
Allophane	veins	alteration of albite	Fryklund & Holbrook (1950)
Anatase	veins	minute black flat crystals	Estes, p.c. (2004)
Anatase	rutile alteration	white portion of acicular crystals	Fryklund & Holbrook (1950)
Ankerite	carbonate dikes	white to brown crystals	Flohr (1994)
Augite	dike rock	black	Welch (1968)
Beidellite	alteration	clay mineral	Fryklund & Holbrook (1950)
Biotite	syenite	black plates to 2.4 cm	Fryklund & Holbrook (1950)
Cacoxenite	coatings	minute yellow hemispheres	Barwood & Delinde (1989)
Calcite	veins	white, cleavable masses	Smith (1996)
Chalcopyrite	hybrid rocks	trace amounts	Flohr (1994)
Epidote	phonolite	green alteration product	Fryklund & Holbrook (1950)
Fluorapatite	hybrid rocks	accessory mineral	Flohr (1994)
Fluorite	veinlets	rare, very small	Fryklund & Holbrook (1950)
Galena	loose masses	uncommon, crystalline mass	JMH collected specimen
Goethite	feldspar veins	pseudomorphs after pyrite forms	Smith (1988)
Hematite	loose in soil	small pseudohexagonal crystals	Smith (1996)
Ilmenite	dike rock	small, irregular, black to purple masses	Erickson & Blade (1963)
Marcasite	dike rock	masses with internal radiating structure	Shockley (1948)
Melanterite	on marcasite	white powdery alteration product	This study
Molybdenite	dolomite-albite veins	small fine-grained gray masses	Erickson & Blade (1963)
Natrolite	seams in dike rock	orange to white, assoc. with ilmenite	EDS –SEM
Olivine	dike rock	matrix component	Shockley (1948)
Pyrite	veins	crystals to over 1 cm common	Shockley (1948)
Rutile	veins, loose in soil	acicular, reticulated, paramorphs, sixlings	Howard (1999)
Sphalerite	veins	black to reddish brown, arborescent, masses	Shockley (1948)
Titanite	dike rocks	crystals partlally altered to anatase	Shockley (1948)
Wavellite	veins	white, radiating spheres, on rutile	Howard (2001)
Wollastonite	calcite veins	white needles	Fryklund & Holbrook (1950)

A small specimen of galena from this locality collected by the junior author was used in the isotopic determination of the source of lead, which was found to be strongly mantle in affinity with little crustal mixing. Two specimens of sphalerite from the deposit are known to exist, one in the collection of the State of Arkansas, and the other in Howard's collection. The State's specimen consists of arborescent veinlets of brown sphalerite to 3 mm thick within a coarsely crystalline albite vein. The junior author's specimen consists of 6 mm brown sphalerite crystals exposed with rutile and pyrite on the face of a carbonate vein that was etched with dilute HCl to expose the mineralization.

At present, part of this property has a housing development that was built on it during the past 25 years, called Beaver Lake Estates. The southernmost pit has been converted to a small lake – Beaver Lake. The larger northern pit, due to the continued deterioration of the abundant pyrite, continues to have significant exposures of bare ground some 65 years after mining. On these exposures are found numerous small microscopic specimens of black rutile and fresh to corroded pyrite crystals. The land is private property at this time but has not been posted. It is strongly recommended that visitors contact local land owners for permission to collect.

COLLECTING RUTILE PARAMORPHS

by J. Michael Howard

This is my recollection of guiding a trip to Magnet Cove with a company geologist, accompanied by Wm. (Bill) Prior, while working for the Arkansas Geological Commission (AGC) during 1982.

Having acted as a guide for over 150 trips to Magnet Cove during my 39 years with the AGC/AGS, only a couple stand out from a significant mineral collecting standpoint. One of these was a trip to take a company geologist around to various mineral collecting sites at the Cove in May of 1982. It was a Friday and the weather was sunny with mild temperatures as we made our rounds to many of the standard stops I had access to. One of these locations was to the Beaver Lake Estates area to collect black rutile and pyrite at the long abandoned Titanium Corporation of America pit. The land was not yet subdivided and sold off, and this was the last stop of the day. Collecting of bare ground exposures of the bottom of the pit gave up many small black rutile specimens and pyrite, for once your eyes were adjusted to what you were looking for, the ground was littered with these average specimens.

One drainage caught our eyes as there was a recent excavation by rockhounds; a pit some 4 feet wide by 5 to 6 feet long. It was filled with water from recent rains, and a small drainage was next to it with flowing water. Since the water was cloudy, Bill and I decided to scoop out a couple of shovelfuls of material. We sampled the bottom and washed that in the small drainage. There was the typical small rutile pieces and pyrite, so then we tried the south wall. On the first shovel, we recovered a nice larger than average rutile paramorph after brookite. Encouraged, we washed a second shovel and there were 2 more, also nice with high luster and recognizably not transported. We both recognized we may have discovered a pocket of them, or a vein filled with them. As it was fast getting to be time to leave, we muddied the water a bit, and then drove the visitor back to his car. He had not noticed what we were doing, as he sat in one spot and collected all he wanted off the bare ground.

On the way back to the office, we excitedly discussed what to do and quickly agreed a trip the next day on our own time was justified. We arrived early the next morning well outfitted with a hand screen, a 5-gallon plastic bucket, some collecting sacks, and a pick and shovel, along with a short pry bar. After bailing out about half the water from the hole so that we had the sidewall well exposed, we began first to shovel all the loose material away from that wall. We took turns, Bill shoveling and I screening, and after a few minutes, we swapped places. Every shovel or two we turned up another rutile paramorph after brookite. Each got packed in a collecting sack as we had previously determined we would pool our efforts and resources, and would split the bounty later. We finally had that end of the hole cleaned out of loose detritus, and began the harder work of ripping down sections of the high wall with the pick. The rock was moderately rotten, so the efforts went fairly quickly, again shovels of loose material being screened and sometimes a yield of 2 or 3 paramorphs being recovered. After about 3 hours of concentrated digging, screening, washing, and sorting, our efforts began to fail, and finally we gave up, assuming we had run through the nest or vein lode of paramorphs. We agreed that I would take them home to do the finish cleaning, and later we would get together and split up our finds. After cleaning, we had two beer flats of 54 samples each….over 100 specimens! The smaller ones ranged from 0.5 to 0.75 inches, while several were nearly 2 inches across. They all had brilliant luster and sharp edges, not like the many worn ones normally surface collected. We decided that one of us should divide the two flats up as equally as possible and the other would get the first pick.

Later I showed my flat to Gene Newsom and he purchased a couple of medium-sized ones for his collection. I think he became fascinated with my collecting story because when the property changed hands a few years later, he met with the new owner who was a construction contractor and had a backhoe stored on the property. Gene told the author that finding paramorphs was expensive and difficult, and explained that he contracted with the owner for $1000 to dig several trenches on the site, so that Gene could look for paramorphs. From Gene's comments, he never found a good one on the site. When Gene told me that, I soon made a run down to the location on a Saturday to see what had been done. Sure enough there were two deep trenches and two holes dug, but nowhere near where Bill and I dug our specimens. In fact, the land owner had cut numerous small pine trees and using the back hoe had pushed them into the small drainage we collected from, ruining the site for any further collecting. A couple of years later, while leading a college field trip to the location, a nice paramorph of better than average size was recovered by one of the students while surface hunting from dirt turned out of one of Gene's trenches. The problem with disturbed ground is that everything is covered with soil and mud and it is only after very heavy rains that specimens are washed off and exposed well enough to recognize them. Gene may well have had a pocket of paramorphs dug, but no one could see them and during the earth removal they would have been scattered everywhere, rather than concentrated where they formed. Such is collecting at Magnet Cove!

PART 2: RICHARDSON PROSPECT

This property is located north of Cove Creek and about ½ mile east of the Magnet Cove Rutile mine. It is in the northwest ¼ of section 17, T. 3 S., R. 17 W. It was also known as being near the D. R Rutherford number 2 house (Williams, 1891). The shaft of the Civil War pyrite mine is located on this property (Fryklund and Holbrook, 1950).

The prospect has several small exposures of fine-grained feldspar veins in syenite with fine-grained rutile. However, a plowed field about 400-feet south southwest of the Richardson farm buildings was the source of many fine specimens after the field was plowed (Fryklund and Holbrook, 1950). Most of the better specimens are the large (over 4 cm across) well-formed rutile paramorphs after brookite that are part of what made Magnet Cove a premier collecting locality in the middle to late 1800s. Evidently this source of good specimens was exhausted before 1900. Although these large paramorphs could be found anywhere in the Cove, they were evidently concentrated more in this area and finding them now anywhere is extremely rare. The senior author recovered a nearly complete, almost 4 cm long, prismatic paramorph after brookite in the brook in front of the Magnet Cove Missionary Baptist Church in May of 1975 after workers had constructed a new bridge into the church parking lot.

PART 3: THE YORK RUTILE PROSPECT

The York rutile prospect, more recently called the Heath farm, is located near the center of Section 20, Township 3 South, Range 17 West, immediately south of Arkansas Highway 51 (Fryklund and Holbrook, 1950). This is just south of where the highway turns west after descending from the east rim southwest into the Cove's interior. Williams (1891) mentions this location as the R. C. Preston no. 1 house. Rutile, magnetite**,** and black garnet occur in the soil. In recent years the plowed field west of the farmhouse along the highway has been a source of rutile eightlings for those getting permission to search it. However, in 2001 a house was built in the field so this collecting location is no more. The rutile evidently had a very limited distribution because the author, along with several others, had an opportunity to dig and screen in some dirt piles scraped off the surface of the adjacent field to the southwest. After a discouraging morning only one piece of rutile was found but a fair number of 2 to 3 cm across vermiculite books, quite a number of black garnet pieces (probably schorlomite and andradite) up to several centimeters across and generally with no faces, plus a lesser amount of small rounded magnetite masses up to 5 cm across were recovered. The junior author did collect several high quality rutile eightlings from the Heath garden site adjacent to the house during one of his visits.

Most of the eightlings the authors have seen from here are in the 1 cm plus size range. This location and Perovskite Hill are the only specific sources of rutile eightling specimens in Magnet Cove. None have been reported with matrix but it is assumed that they probably formed in feldspar veins like much of the rutile in the Magnet Cove Rutile mine.

PART 4: THE NICHOLS AND CAMPBELL PROSPECT

The Nichols and Campbell prospect was located in the SW ¼ of Section 18, Township 3 South, Range 17 West in the western part of the interior of Magnet Cove. A small amount of alluvial rutile was mined from this prospect in 1935 and 1936 but the operation was not economically successful. A long trench trending northwest to southeast and other shallow pits did have some bed rock exposed in them with small amounts of fine-grained rutile (Fryklund and Holbrook, 1950), but they have been obliterated by the subdivision and development of the Cove Creek Estates in the early 1970s. The authors have seen no rutile specimens attributed specifically to this location.

BROOKITE DEPOSITS AND LOCATIONS

INTRODUCTION

Brookite was first described from Magnet Cove by Shepard (1846) as a new mineral that he named arkansite. He thought it was a "niobate of yttria and thoria". Eventually there were a series of articles that recognized the true composition and crystal form as that of brookite (Teschemacher, 1849, Rammelsberg, 1849b, Whitney, 1849 among others). Additional studies on the crystallography of brookite followed by G. vom Rath (1876), E. S. Dana (1886), and S. L. Penfield (1886). Although Fryklund and Holbrook (1950) think that all of the described crystals came from the Magnet area road cut, in fact brookite crystals can be found scattered throughout the Cove's interior where they were washed from their source in the altered novaculite on higher elevations (Williams, 1891). Though some crystal forms of brookite seem to be more dominant from any given deposit, probably most crystal forms could come from any of the deposits or locations. In the part of the Rutherford deposit where most of the digging has been done, the thick tabular form of Rath (1876) dominates the larger crystals (over 8 mm) and is very characteristic of this deposit. However, the smaller crystals have a greater variety of forms and none are particularly characteristic of this deposit. The brookite illustrated by E. S. Dana (1886) numbers 17 and 19 seem to be more common at the Christy deposit but most are under 0.5 mm. The crystal form number 1 is rare except as the large rutile paramorphs. Large rutile paramorphs of the form of number 17 are less common, but smaller paramorphs, 1 cm or less, are very common as are small brookite crystals. Rarely some of the brookite crystals have a bluish, greenish, yellowish or reddish iridescence that does not seem to be affected by oxalic acid or other types of cleaning.

Brookite crystals occur with quartz crystals, slightly embedded in quartz crystals, and contrary to what Williams (1891) states, they do rarely occur completely included in quartz crystals. Most of these included crystals are small, 3 mm or less. Much of the quartz crystals that occur where brookite is abundant or attached to them are pitted and corroded. Williams (1891) states that the quartz crystals are seldom doubly terminated except for the milky crystals which are predominant and often doubly terminated. This may be true for the Magnet road outcrop but not the other areas where milky quartz is rare. In the other deposits most of the quartz is gray or a mottled white and gray with lesser amounts of milky, colorless, black and smoky. Williams (1891) writes that the only forms present on the quartz crystals are the primary prism and pyramid faces. Although the terminating faces often appear to be almost equal and similar to pyramid faces. We believe that they are not pyramid faces but the positive and negative rhombohedrons which are the common forms of most Arkansas Ouachita quartz.

The white elongated inclusions in quartz have been called anatase**,** variety leucoxene. However, analyses of these inclusions show no titanium but iron and clay. They may have once been an included amphibole that has been altered. Some minute elongated inclusions of rutile**,** some altered to white leucoxene have been described by Fryklund and Holbrook (1950). The anatase crystals associated with the brookite deposits are not mentioned by Williams (1891) except the similarity of a brookite drawing to octahedrite (anatase) in quotes of Dana (1886). It is not known if this data was inadvertently left out, or he never wrote about it before he died, or the anatase was not known, probably the latter. Penfield (1894) was the first to describe anatase as octahedrite with a crystal drawing. The anatase crystal drawing, number 24 by Dana (1886), does resemble an octahedron. Just like the brookite crystals in the quartz-anatase veins in the Jones Mill quarry are smaller, lesser in number, and inconspicuous, so are the anatase crystals in the brookite deposits. Work by the U. S. Geological survey in the late 1980’s showed that as much as 50% of what collectors considered brookite from the Christy pit is actually anatase. This may be why the early investigators had so much trouble correlating specific gravity of many crystals to the crystal form of brookite (Williams 1891). However, no paramorphs of brookite after anatase or anatase after brookite have ever been described.

EAST RIM BROOKITE DEPOSITS AND LOCATIONS

The major brookite deposits and other brookite occurrences are in the altered Arkansas Novaculite that crops out on the east rim of Magnet Cove. From north to south the deposits are: Hardy-Walsh, Christy, Highway outcrops south of where the old Magnet Post Office was located, Rutherford (AKA Moses Hill), the Harver Hills subdivision and the Magnet Cove High School.

PART 1: HARDY-WALSH DEPOSIT N 34.467173°, W 92.848445° (Google Earth image, 2016)

The Hardy-Walsh or Adams and Kilpatrick deposit is on two adjoining 40 acre tracts in Sections 16 and 17, T.3S, R.17W (Fryklund and Holbrook 1950). They give a good description and geology of the deposit. Lawton Kimzey did some exploration by sinking a 50-foot shaft and digging several pits on the Adams property for the Titanium & Alloy Company in 1936 (Miser and Stevens 1938). Exploration by trenching, coring and hand-auger drill holes began by McCombs Hardy in the fall of 1941 and continued into 1942. The U. S. Bureau of Mines examined and sampled the property in the same year.

Subsequent exploration may have occurred but there is no published record. Union Carbide leased this area during the 1960's and drilled it during vanadium exploration during the 1970s. Only spotty vanadium values were recovered. There has never been any mining attempted. This deposit was open to collecting for many years, but it was more of a bust than a collecting boom. Much hard work was required and few pockets were found. The brookite crystals are generally small, 2 mm or less so quartz was the main mineral sought after by collectors. Most of the quartz from this location is black and opaque but some is a mottled black and white. The pockets containing smoky quartz crystals are not abundant, but could be quite large and the crystals in them very large. After many years of digging and getting nothing, Clyde Hardin hit such a pocket in the late 1970s and felt all his efforts had been worthwhile (Smith 2003). The brookite crystals are bright and lustrous, but small and seldom occur on the quartz crystals except near their attachment, and most are found loose in the pocket clay. Some smoky quartz crystals from that pocket were over 36 cm long. However, Hardin's subsequent attempts at finding another pocket were unsuccessful. In recent years an occupied trailer blocks the entrance to the location. Tainiolite was discovered on the prospect by Lawton Kimzey in 1936 (Miser and Stevenson 1938). It occurs as lustrous, silvery white, fine-grained micaceous aggregates. One of the Union Carbide cores in the 1970s contained a 30-foot interval of tainiolite probably from drilling directly down a vertical vein containing it. Collections from the late 1930's and 1940's often have a small jar or vial with small aggregates of tainiolite flakes inside. It has been observed at the Christy and Rutherford deposits as minute mica flakes sparsely dispersed on quartz or brookite. Some tainiolite aggregates may be stained reddish brown by iron-oxide rich clay.

PART 2: CHRISTY BROOKITE DEPOSIT (UNION CARBIDE VANADIUM MINE, CP)
N 34.952871°, W 92.845490° (Google Earth image, 2016)

The Christy brookite deposit, later to become the Union Carbide Christy vanadium mine or pit, was first explored in 1913 by the Titanium Alloy Company. The company drove an adit 200 feet under the deposit from the Chamberlain Creek gorge. In 1941 Wynn O. Christy made many pits and trenches and built a house and a small plant to process some developed titanium ore but it was not economically successful. He also re-entered the adit but found it caved in and abandoned the attempt.

The Reconstructive Finance Corporation explored from 1942 until 1948 making additional trenches and pits. This was followed by core drilling by the U. S. Bureau of Mines. From 1970 to 1977 Union Carbide explored the deposit by core drilling. A commercial vanadium deposit was delineated and open pit mining started in 1981, continuing until 1986. The ore was trucked west to their mine and mill at Wilson Springs, adjacent to the Potash Sulphur Springs intrusion, in Garland County. The pit was reclaimed in the mid-1990s. With permission, collecting was allowed in the pit in the 1980s and early 1990s. However, the collecting for brookite crystals was better before mining particularly during exploration when the pads for drill rigs were made in 1970. The floor of the pit was often littered with millions of 1 to 2 mm brookite crystals, but only a very few were perfect or showed little attachment damage. Close examination of these crystals revealed that some are anatase**.** No large anatase crystals were noted. Recovery of larger crystals of brookite or quartz crystals was somewhat limited to scattered scarce finds associated with some very large quartz masses. Much of this material was often heavily coated with goethite or manganese oxide, hiding any specimen potential. A very few outstanding brookite and quartz crystal specimens were recovered from the Christy pit during mining. It is notable that some of these larger brookite crystals were skeletal crystals, indicating rapid growth without infilling of crystal faces. These crystals have brilliant luster, very different than most specimens.

Generally, collecting brookite crystals and quartz crystals was disappointing due to heavy goethite deposits, making it difficult to recognize the potential of any given specimen. Many collectors searched the pit for other, often unusual, microscopic minerals (See Table 7). Goethite seemed to cover everything. It was the main carrier of vanadium, but the brookite/anatase crystals also contain ~1 % vanadium pentaoxide. The vanadium minerals montroseite and paramontroseite have been reported from the deposit as acicular crystals up to a centimeter long. However, XRD indicates many, if not all of these specimens, may actually be goethite crystals with a thin coating of vanadium pentaoxide.

Amber to greenish, rounded, often striated siderite crystals to 2 cm are one of the few other minerals that were collected in larger than microscopic size. They generally occur in pockets in vuggy masses of gray quartz and are up to 1 cm across. Of particular interest from the Christy pit were the 1 to 3 mm yellow green micro crystals of kolbeckite. They are sparingly dispersed through the porous matrix of small gray quartz crystals and minute brookite crystals and are difficult to spot without magnification. The normal cleaning of this material in oxalic acid destroys the kolbeckite. Wavellite has been reported from Magnet Cove for many years. However, until white microcrystals were found from the Magnet Cove Rutile Company mine by the junior author and later larger specimens were found in the Christy pit, it was never verified. Actually most of the early finds were described as pale green crystals and spheres which probably have the classic Dug Hill locality near Avant north of Lake Ouachita in Garland County as their source. The wavellite from the Christy pit consists of white radiating crystal sprays up to about 1 cm in diameter within drusy quartz-lined vugs in a dark Arkansas Novaculite matrix.

A single example, weighing slightly over 1 pound, of late common opal, orange yellow with black spiderweb veining, was discovered by the junior author in the mid-1990s. It was not discovered in place but on one of the waste dumps before the reclamation of the site was completed. The specimen has yet to be cut into cabochons, but appears to be lapidary quality.

Table 7: MINERALS OF THE EAST RIM BROOKITE DEPOSITS INCLUDING THE CHRISTY VANADIUM MINE

Mineral	**Location**	**Description**	**Reference**
Actinolite	Christy	reported in thin sections	Flohr (1994)

Aegirine	Hardy-Walsh	reported in thin sections	Flohr (1994)
Anatase	Christy, Hardy-Walsh	tiny crystals and inclusions in quartz	Fryklund & Holbrook (1950)
Ankerite	Christy	minor amounts	Flohr (1994)
Arfvedsonite	Christy	orange-brown veinlets in fractured novaculite	Howard (2001)
Arsenopyrite	All	veinlets and veins	Flohr (1994)
Beidellite	All	clay mineral	Fryklund & Holbrook (1950)
Brookite	All	black lustrous crystals to over 1 cm	Williams (1891)
Cacoxenite	Christy	yellow spheres and acicular crystals on quartz	Smith (1996)
Churchite-(Y)	Christy	white radiating spheres look like sea urchins	Howard (2001)
Clinoptilolite	Christy water treatment pit	blocky colorless microcrystals on altered rock	Howard (1987)
Cryptomelane	Christy	black acicular, some barium rich	Flohr (1994)
Dickite	All	with tainiolite	Miser & Stevenson (1938)
Fervanite	Christy	in quartz-brookite aggregates	Flohr (1994)
Fluorapatite	Christy, Hardy-Walsh	in pyrite and thin hexagonal crystals in dike rock	Flohr (1994)
Galena	Christy water treatment pit	minute crystals in quartz-feldspar dike	Smith (1996)
Goethite	Christy	radiating groups of microcrystals, coatings	EDS-SEM
Goethite	Moses Hill	cubic pseudomorphs after pyrite to 1 cm, films	Smith (1996)
Hewettite	Christy	minute reddish acicular crystals	Howard (2001)
Ilmenite	Hardy-Walsh, Christy	accessory mineral in dikes and blades in veins	Howard (2001)
Kaolinite	All	iron oxide-stained masses of clay	Fryklund & Holbrook (1950)
Kolbeckite	Christy	bright yellowish green micro pseudorhombic xls	Barwood (1987)
Lenoblite	Christy	bluish lavender mass of acicular crystals	Howard (2001)
Lorenzenite	Hardy-Walsh	accessory mineral in dikes and veinlets	Flohr (1994)
Magnetite	All	pseudo. after brookite, never seen by authors	Frondell (1932-35)
Marcasite	Christy water treatment pit	bladed crystals to 3 mm	Howard (2001)
Metahewettite	Christy	minute reddish acicular crystals	Howard (2001)
Montroseite?	Christy	tested samples - vanadium pentoxide on goethite	EDS-SEM
Nontronite	Christy	blocks of light yellow-green clay in test pit	Howard (2001)
Opal-common	Christy	orange yellow vein filling with black webbing	Howard observ. (2016)
Paramontroseite	Christy	minute black acicular crystals	Barwood, p.c. (1989)
Pectolite	Christy	white fibers	Barwood, p.c. (1989)
Planerite?	Christy	microxls tested are probably variscite	EDS-SEM
Pyrite	All	cubic crystals present but not abundant	Smith (1996)
Pyrrhotite	All	dikes and veinlets	Flohr (1994)
Quartz	All	white, gray, black, smoky, and some clear	Williams (1891)
Rhodochrosite	Christy	micro pink epimorphs	Barwood, p.c. (1989)
Rutile	All	minute needles in quartz	Fryklund & Holbrook (1950)
Rutile	Christy	as microneedles encrusting quartz	Barwood, p.c. (1989)
Siderite	Christy	Mn- to Mg-rich, variety of forms and colors	Flohr (1994)
Smithsonite	Christy water treatment pit	white frosted rice grains	Smith (1996)
Sphalerite	Christy water treatment pit	micro crystals In quartz-feldspar dike	Smith (1996)
Tainiolite	All	groups of silky yellow to white plates	Miser & Stevenson (1938)
Variscite	Christy	colorless to pale green spheres	EDS-SEM
Wavellite	Christy	white acicular, radiating spheres	Barwood & de Linde (1989)

PART 3: OLD HIGHWAY OUTCROPS

Brookite and quartz were collected from a series of poor outcrops that are probably altered novaculite along the south side of Arkansas Highway 51 where the town of Magnet and Magnet Post Office were formerly located. It is now just south of the highway and a little west of the Magnet Cove Cemetery. (Fryklund & Holbrook 1950) These were the source of many, if not most, of the early specimens. There is so much dirt and clay mixed with the rock that early investigators had little idea of the source rock. Some outstanding specimens of small lustrous brookite crystals on slender white milky to clear quartz crystals up to 5 cm long and 0.5 cm in diameter were collected in the late 1960s or early 1970s. In recent years there has been little digging in this area though it is not generally posted. However such digging would probably result it the filling of the highway drainage ditch with dirt and not looked on favorably.

PART 4: RUTHERFORD PROPERTY (aka MOSES HILL, MH) N 34.52871°, W 92.843129°

Further southeast from the road outcrop is the Rutherford or Moses Hill brookite location. Union Carbide had leases and drilled this property in the 1970s for vanadium and eventually dropped their leases with the reclamation of the Christy pit. The location for years had a house on the top of the hill but the area was not posted. Collectors took full advantage of the situation particularly in the 1970s and 1980s and dug north of the house which is now gone. During that time Union Carbide allowed collectors access to this site to take collecting pressure off the then active Christy pit. The brookite crystals occur loose or are embedded on porous masses of rough, dull, gray quartz crystals. The brookite crystals range in size from microscopic to rarely over two centimeters in maximum dimension. The large ones are typically thick tabular crystals. To collect the loose crystals in the clay and dirt, you must screen them or probably less that 10 percent of those in the soil will be recovered (Smith 2003). Although many of the quartz crystals with brookite are rough and a dull gray in color and not attractive, some mottled white and gray, plus black smooth well-formed crystals 5 cm or more across and 10 cm long have been collected. Some of the black quartz is transparent and facetable though it has numerous minute inclusions which makes getting good larger stones difficult. The crystals generally are broken and unattached in collapsed, weathered, pockets. Rarely cubic goethite pseudomorphs after pyrite up to 2 cm across occur with the quartz. No doubt deeper in the deposit they actually would be pyrite. In recent years since there have been no mineral leases on the property, it has been posted by the property owners.

COLLECTING AT MOSES HILL, RUTHERFORD PROPERTY

by J. M. Howard

In the fall of 1991, while on a trip to visit Potash Sulphur Springs, I was asked by the Chief Engineer at Stratcor if I would give the company an appraisal of the Moses Hill site for mineral specimen recovery. Stratcor had been approached by a collector, Gene Newsom of Little Rock, to sublease the property for the purpose of mining the mineral specimens brookite and smoky quartz. I was well aware that the property was leased by Union Carbide years before and had been examined for vanadium potential, and was left open to collectors to relieve the collecting pressure on the Christy pit during the years it was actively being operated. I proposed to dig some test pits, at least 2, during the evaluation, and to use the removed material to fill in several of the large older hand dug pits on the site. Company personnel agreed and left it to me to locate a back hoe.

I approached Charles Steuart, one of the Coon Creek Association collecting group, with the idea to provide this opportunity for group collecting at the same time as the evaluation. Primarily the excavations were to determine if the concentration of minerals extended some significant depth or if it was only shallow in extent, and the general concentration of specimens in the underlying host rock.

On November 2, 1991, a Saturday, Charles and other members of the CCA collector group, which included Art Smith, Jr., Henry de Linde, Meredith York, and myself, as well as others, visited Moses Hill. I instructed the machine operator what I wanted done. We started with a pit immediately on the west side of the center of the hill, and material was excavated to a depth of 3.5 feet, the final excavation measuring about 12 X 12 feet. The upper portion of the removed material was used to fill an adjacent hole, and the rest of the material removed was placed on the downhill edge of the new hole. Few specimens were seen at that time due to the wet nature of the heavy reddish sandy clay matrix, but it was obvious that a lot of the excavated material consisted of altered recrystallized Arkansas Novaculite fragments. A couple of specimens were recovered, enough to be encouraging for a visit at a later date. Bedrock at 3.5 feet showed little mineralization and no quartz veins. No pockets were seen *in situ* nor in the reddish clay soil as it was being removed.

The second excavation was made on the east side of the crest of the hill, near a trench where it was rumored Joe Kimzey had removed many large smoky quartz crystals, the so-called source of many of the specimens he had sold through the years from his home business. As that excavation proceeded, several large, but broken, smoky quartz crystals were noted in the bucket and we stopped the work, long enough to dig several from a rotten pocket in the shallow highwall. Meredith York did most of the extraction by hand, and many of the collecting group got decent specimens. After York finished, excavation continued, the resultant pit being 2.5 feet deep by 10 feet by 12 feet. Bedrock was encountered at that depth.

I reported this information to Stratcor and also reported that the bulk of the mineral concentration on the site was within the residual soil and was present within the host rock at greater depth, but at a much smaller concentration. Over the eons of weathering and erosion, the brookite and quartz crystal fragments from the veins within the host rock were concentrated in that thin soil zone from an unknown thickness of eroded rock. The company declined the lease proposal, viewing it as too much paperwork and hassle for the small amount of royalty expected for such a thin deposit.

In the summer of 1993, some two years after these explorations, I revisited the site, with some unusual collecting equipment: a small Honda generator and a hand operated spray gun. Everything was coated with a heavy layer of clay and some samples had iron oxide over the quartz crystals and brookite, especially on matrix specimens. I spent 6 hours cleaning samples on site to determine if they had collectible potential…those that did not were tossed out into the woods, while those that did went into 5 gallon buckets. Three 5-gallon buckets resulted from this effort. These specimens were later washed, cleaned, and graded into flats, which were taken to Tucson and sold by the flat. The best specimens were kept for my personal collection. Eventually the unrelenting growth of Arkansas honeysuckle and rip briars overtook the bare ground and collecting potential, without heavy digging, was insignificant. The site remained open for collectors so long as the company held the lease, but when the lease was dropped, the heirs to the property posted the location and have prosecuted several people for trespassing since then.

PART 5: HARVER HILLS SUBDIVISION

Further southeast along the east rim, Clyde Hardin collected small, up to 4 mm, brookite crystals in the Harver Hills subdivision and the Magnet Cove school areas. It was developed in the 1970s and 1980s (Smith 2003). The area is closed to collecting presently.

PART 6: WEST RIM BROOKITE LOCATION

There is only one noteworthy brookite location on the west rim. Williams (1891) describes it as being south of Thomas Holt's house near the road leading south along the ridge. This description is rather vague even with William's geologic map. However, it is obviously located in the extreme NE ¼, Section 24, T. 3 S., R. 18 W. Erickson and Blade's (1963) geologic map of the area shows it to be garnet pseudoleucite syenite with an area of metamorphic rock. Williams (1891) reports beautiful red, semi-transparent crystals implanted on the surface of sandstone, which is probably altered Arkansas Novaculite. W. J. Kimzey sent Williams an approximately 7 mm long perfect crystal from the locality.

Upon examination the surface of the “sandstone” it had a network of minute plagioclase feldspar crystals, possibly albite. Several people have tried to locate this occurrence, but if they found it, they did not report finding any of the red brookite crystals.

MISCELLANEOUS MINERAL-BEARING LOCALITIES

MOLYBDENUM-TITANIUM PROSPECT, Mo-Ti prospect (Mo-Ti) N 34.468581°, W 92.852308°

The Molybdenum-Titanium prospect or Mo-Ti Corporation prospect pit is situated in Section 17, Township 3 South, Range 17 West or just south of Cove Creek in the northeast corner of the Cove. The prospect is on what originally was the Cotton Golden farm. It was churn drilled by the Southern Acid and Sulphur Company for pyrite in 1929-1930. First thought to be graphite, molybdenite was recognized in 1939 and exploration for it by W. W. Sheldon occurred in 1942. It was investigated by the U.S. Bureau of Mines in 1944. In 1945 to 1947 the Mo-Ti Corporation drilled, trenched, and dug a small open pit but there has never been any production (Fryklund & Holbrook, 1950).

The country rock is jacupirangite (magnetite and pyroxene), which is cut by feldspar veins mineralized in places by abundant pyrite and lesser amounts brookite, fluorapatite, rutile, titanite and later by molybdenite. The feldspar veins are primarily perthitic microcline with lesser amounts of albite. The microcline is partly altered to allophane and small amounts of halloysite (Fryklund & Holbrook, 1950). Thin veinlets of dolomite, oligoclase, and pyrite also cut the jacupirangite.

The senior author first visited the prospect in April, 1958 and even by that time the pit walls had slumped covering any bedrock or vein material. Most of the dumps and other areas had few exposed rocks of interest but creek bed cobbles seemed prominent. Most of the more recent specimens, including our own are actually from nearby diggings in the adjacent Cove Creek which is also on a pyrite-feldspar vein. When these diggings were first worked by collectors is uncertain but specimens that were collected in the early 1970s were common.

The primary collectible mineral from this locality is pyrite. It is in cubic crystals from 0.5 cm to crystals with faces 3 or 4 cm across. These crystals may have a thin silvery coating of molybdenite, giving some of the cubic forms a similar appearance to bright lustered galena to the inexperienced eye. The pyrite may be in single cubes or groups of intergrown crystal groups. Some of the larger groups have what appears to be corroded areas where inter grown microcline vein material has been altered and then dissolved. Some of the larger pyrite crystals may have tabular albite crystals or albite rosettes on their surface. The brookite crystals, though small, are bright and well formed. Rutile occurs in a variety of forms but is mostly as small elongate striated crystals, but also very rarely may occur as paramorphs after brookite, usually under 5 mm across. When Clyde Hardin found some of these paramorphs he was excited because they matched the size of the brookite crystals he had collected. He found it difficult to believe that there were once brookite crystals as large as the giant rutile paramorphs from the Richardson or other prospects. Molybdenite also occurs as sooty gray masses over 2 cm across in the vein and according to Fryklund and Holbrook (1950) as pseudomorphs after pyrite and brookite. Other minerals occurring in this area are given in Table 8.

Collecting in Cove Creek adjacent to the Mo-Ti prospect can still be done in warm weather if you do not mind getting wet. A box screen, shovel, pick, and large pry-bar are useful tools.

Table 8: MINERALS OF THE MO-TI PROSPECT AND ADJACENT COVE CREEK DIGGINGS

Mineral	Occurrence	Description	Reference
Albite	veins	white, massive, crystals, rosettes	Shockley (1948)
Allophane	veins	alteration of albite	Fryklund & Holbrook (1950)
Anatase	veins	as leucoxene, white encrustations on rutile	Fryklund & Holbrook (1950)
Aragonite	vein cavities	rare, white fibrous, fluor. & phosphor.	Howard (2001)
Barite ?	veins	rare, minute cream colored crystals	Estes, p.c. (2004)
Brookite	veins	equant lustrous black crystals to 1 cm	Fryklund & Holbrook (1950)
Calcite	in jacupirangite	white veinlets crosscutting host rock	Erickson and Blade (1963)
Cheralite-(Ce)?	veins	with pyrite, pale tan aggregates, thin xls	EDS-SEM
Diopside	contact zone	reported with jacupirangite	Erickson and Blade (1963)
Ferberite	drill core	doubtful identification	Fryklund & Holbrook (1950)
Ferrimolybdite?	veins	yellow coatings, see plumbojarosite	Smith (1996)
Fluorapatite	veins	inclusions in orthoclase	Fryklund & Holbrook (1950)
Fluorapophyllite	vein cavities	crystals assoc. with pyrite, molybdenite	Sleight (1941)
Galena	veins	small blobs and masses	Smith (1996)
Gonnardite	jacupirangite	white acicular crystals in cavities	Milton XRD, Howard (2002)
Gypsum	vein cavities	colorless divergent microcrystals	Smith observation, this study
Halloysite	veins	a clay mineral	Fryklund & Holbrook (1950)
Marcasite	veins	irregular nodular radiating masses	Shockley (1948)
Molybdenite	veins	thin coatings on pyrite, soft fine-grained masses	Howard (2001)
Orthoclase	veins	white masses and blocky crystals	Holbrook (1947)
Plumbojarosite	veins	sparse yellow coatings,see ferrimolybdite	EDS-SEM
Pyrite	veins	large crystals and masses	Howard (2001)
Pyrrhotite	on pyrite	micro rosettes of hexagonal crystals	Smith (1996)
Quartz	vein cavities	small, dull, dark smoky, doubly terminated xls	Howard (2001)
Rhabdophane-(Ce)?	veins	similar to, if not the same as, Cheralite-(Ce)	EDS-SEM

THE KIMZEY MAGNETITE PIT (KMP) AND THE SURROUNDING AREA

The Kimzey magnetite mine or pit, in the past also called the “magnetite bed” or “lodestone hill”, is located just north of Arkansas Highway 51 in the east half of the interior of Magnet Cove just north of the Arkansas Centennial Commission historical sign. It is situated in the west ½ of section 20, T.3S, R.17W around N 34.452639^{o}, W 92.859944^{o} (Google Earth image, 2016).

The magnetic anomaly in this area had an effect on travelers’ compasses and so what was originally just called the “Cove” had its name changed to Magnet Cove. There were several small attempts to mine the magnetite, the last in the early 1950s but all the operations were small and most of the magnetite mined was residual in the soil. Lodestone Hill that was mentioned in early articles has probably been obliterated by the pit. In the mid-1970s a portion of the area was chain-link fenced and called the “garnet mine” and was supposed to become a “collect your own” mineral location, but evidently it only operated that way once, during a Hot Springs Gem and Mineral Show. After that time the owner’s husband became ill and she was unable to keep it available to collectors.

Rock types in the area are ijolite and those rocks termed lime-silicates composed primarily of vesuvianite and white diopside. Magnetite occurs in both. Exposures are well covered by alluvium and there are very few surface rocks *in situ*. The ijolite is best found as erosion resistant masses and pieces in the soil. The lime silicate rocks are exposed in an excavation in the magnetite pit plus a smaller area in a pit to the northeast. The magnetite in the coarse ijolite commonly occurs in irregular rounded pieces up to 9.6 cm across. Similar, but larger pieces up to 29 cm across occur in the lime-silicate rock. Some are aligned like beads in a string in vesuvianite-diopside matrix (Erickson and Blade, 1963). The typical magnetite is smooth and rounded and seldom has any other minerals attached or a crystal form. However, Henry Barwood (per. comm.) says that when he analyzed it, he found that much of the magnetite is mixed with a black spinel. "Blisters" or botryoidal magnetite can be found protruding from the rounded magnetite masses (Williams 1891). Williams also mentioned possible pseudomorphs of magnetite after pyrite and after hornblende. Magnetite (lodestone) showing polarity is less abundant than magnetite that does not. Williams (1891) mentions that lodestone piled with magnetite that does not show polarity will eventually make all of the magnetite become lodestone. Newhouse (1929) notes, the lodestone mentioned by Williams, is an example of it becoming lodestone by oxidation of magnetite. Recent studies of lodestone by A.A. Mills (2004) indicate that lodestone forms from intense lightning strikes on the ground and high magnetic fields generated from said lightning. He states that measurements of the magnetic intensity of lodestone from Magnet Cove give an age of formation of about 3500 years ago.

Concerning the commercial collecting of lodestone by the Kimzeys, Wheeler (1944a) relates the following:

> …"The Kimzey boys would often receive orders for this perennially popular mineral in quantities of 50, 100, or even 500 pound lots. Such orders specified that the material should be graded by its ability to support 4-penny, 6-penny, 10-penny, 20-penny nails and rail road spikes. The boys learned that these "grades" could be almost as accurately determined by the fuzziness of the lodestones raked over the ground with an ordinary garden rake. And so they could dispense with the nail test and save time. The more strongly polarized pieces naturally brought a fancier price, but not many "spike grade" specimens were ever found".

ROMANCE IN ROCKS

by H. E. Wheeler

What follows has been excerpted from an article on Magnet Cove in the *Arkansas Gazette*, Sunday Magazine section, July 2, 1944. Most of the article has no significance to this work. However, the few parts that do are reprinted below.

My first visit to the Cove was more than 40 years ago. I was then on crutches and my business in Arkansas was to test the efficacy of the baths at Hot Springs for inflammatory rheumatism. The project was so successful that all the years since I have not had the slightest symptoms of that inconvenient malady. The initial acquaintance with the romantic character of the Cove was made on the back of a mule, my guide [W. J. Kimzey. Ed.] being the father of the present state geologist [Joe W. Kimzey. Ed.] We measured the width and breadth of that storehouse of mineralogical wonders and at sunset my collecting kit was full of fine specimens to which collection many others have been added during the passing years. On one occasion I received through the mail a lovely crystal of limpid quartz on which were embedded several brilliant crystals of brookite, this specimen reaching me uninjured though it had no suggestion of protective wrapping……

The Cove has offered to anyone who would take the time and have the patience to look for them, treasures of both economic and scientific significance. Years ago a distinguished German mineralogist spent some eight months at the Cove and shipped from there a carload of specimens to Germany where they repose, or did, in a special room devoted to Magnet Cove in one of their large museums.

You must go to Magnet Cove to get some minerals that contain very rare elements. One of them is eudialyte occurring in a pegmatite dike. It is of a beautiful peach blossom color and if you are fortunate enough to extricate a well-faceted crystal it will be your red letter day as a collector. A huge boulder of this pegmatite was salvaged from near Cove Creek bridge when the present highway was under construction and in addition to splendid examples of eudialyte it contained some 15 others. This one specimen has been accorded a special case in the Alabama Museum of Natural History at Tuscaloosa, Alabama.

The present state geologist was a son of that versatile native genius who was Professor [J. Francis. Ed.] Williams' first hand assistant and who then lived in the old Conway house. Is it any wonder that the bright-eyed boy who grew up with these rocks under masterful tuition and had actual contact with erudite authorities should later qualify as a most competent director of the Geological Survey of the State?

Andradite is common but there are two garnets from this area that can be visibly difficult to differentiate. The andradite varies in color from black to reddish brown to brown and yellowish and many specimens are color zoned. Most of the crystals are dodecahedral but some pieces show few if any faces. Masses of black garnet from the soil or stream bed may show a face 3 cm or more across. White fluorapatite crystals may be associated with or penetrate this black andradite but this mineral association seems to be more common with the schorlomite. Andradite crystals associated directly with the lime-silicate rocks are usually smaller. Complete crystals are more common plus they tend to be more brownish and color zoned. Some pale orange crystals from the lime-silicate rocks were analyzed by EDS-SEM and found to be grossular-andradite**.** Clyde Hardin (Smith 2003) wrote and talked with glee about finding a large "nest" of what is a brown andradite adjacent to the fenced garnet mine along the highway right of way. Most of these garnets are fairly well formed, and are up to 2 cm in diameter. Most of these specimens have fluorapatite veinlets included within them. Biotite occurs as large black books in the ijolite that may be up to 18 cm across and rarely more than a centimeter thick. It is also common in the soil where it alters to a silvery, pale greenish vermiculite (protovermiculite of Williams 1891), also in very large books. Nepheline can be a major constituent (10 to 95%) of the ijolite. The coarse ijolite will have poor crystals of nepheline to over 10 cm across. In color it ranges from greasy grayish white to brown to deep pink (Erickson & Blade, 1963). The more attractive brownish to pink pieces were called "sun stones" and cut and polished into cabochons. This type of material is very rare to collect today. The nepheline commonly has a white coating or rind on it that is a replacement of the nepheline by a zeolite (Erickson & Blade, 1963). There is no feldspar in the ijolite so anything that looks like feldspar is probably nepheline**.** Schorlomite is generally found as rounded to irregular bluish black masses loose in the soil. It seldom has any crystal faces though Shepard (1846) reported some small crystals and a few euhedral crystals have been found since. The ijolite is its source because some specimens have been recovered that were embedded in nepheline. White elongated hexagonal prisms of fluorapatite up to several centimeters long and 3 mm in diameter may penetrate the schorlomite making a nice contrast.

The lime-silicate rock has abundant cavities usually lined with crystals. The rock primarily is massive vesuvianite and diopside. Crystals lining the cavities are vesuvianite, diopside, fluorapatite. Large (45 cm) melilite crystals are partly replaced by a mixture of vesuvianite, diopside, tremolite, biotite, and garnet (Erickson and Blade, 1963). A similar lime-silicate rock with cavities is also exposed in a small cut northeast of the magnetite pit. Though fairly attractive, specimens of this rock or microscopic crystals from this location are uncommon and absent, even in many Magnet Cove collections. See Table 9 for a list of minerals occurring in the Kimzey magnetite mine area.

Table 9: MINERALS OF THE KIMZEY MAGNETITE PIT AND SURROUNDING AREA INCLUDING THE MAGNET COVE BAPTIST CHURCH AND YORK FARM

Mineral	Occurrence	Description	Reference
Aegirine	syenite	acicular black crystals	Stone et al. (1982)
Albite	loose in soil	white bow ties, rosettes, blocky	Stone et al (1982)
Andradite	loose in soil	brown to black, color zoned, 3 cm crystals	Williams (1891)
Augite	loose in soil	large green intergrown prismatic crystals	Smith (1988)
Biotite	loose, carbonatite	large green to dark brown plates	Smith (1988, 1996)
Brookite	loose, carbonatite	small black equant crystals	Nizamoff et al. (1998)
Calcite	loose in soil	small lenses between vermiculite plates	Williams (1891)
Cancrinite	syenite	alteration of nepheline	Williams (1891)
Carbonate-fluorapatite	loose in soil	replacements of fluorapatite	McConnell & Garner (1940)
Chabazite	dark dike rock	with natrolite and calcite	Howard (2001)
Corrensite?	lime-silicate	a clay mineral	EDS-SEM
Clinochlore	magnetite masses	greenish gray	EDS-SEM
Diopside	lime-silicate	white to pale green crystals in cavities	Banion (1959)
Fluorapatite	veins, lime-silicate, ijolite	white elongated hexagonal crystals	Stone et al. (1982)
Grossular-andradite	lime-silicate	pale orange microcrystals	EDS – SEM
Maghemite	magnetite	minute irregular veinlets in lodestone	Nagata (1961)
Magnetite	loose in soil, lime-silicate	smooth rounded masses, lodestone	Williams (1891)
Melilite	lime-silicate	large crystals, partially replaced	Erickson & Blade (1963)
Natrolite	lime-silicate	white, prismatic crystals	Smith (1996)
Nepheline	loose in soil, lime-silicate	brown to reddish masses	Erickson & Blade (1963)
Perovskite	magnetite	black, yellow, orange, and brown crystals	Smith (1999a)
Quartz	loose in soil	pale smoky to pale amethystine	Smith (1996)
Rutile	loose in soil	paramorphs after brookite and eightlings	Smith (1996)
Schorlomite	loose in soil, ijolite	black, rare crystal faces, with fluorapatite	Smith (1996)
Spinel	with magnetite	black intergrowths with magnetite	Barwood, p.c. (1996)
Tremolite	lime-silicate	bladed white, greenish, reddish crystals	Erickson & Blade (1963)
Vermiculite	loose in soil	platy sheets with a silvery sheen	Stone et al. (1982)
Vesuvianite	lime-silicate	yellow to green masses and tiny crystals	Stone et al. (1982)

CHAMBERLAIN CREEK BARITE MINE N 34.472364°, W 92.815918° (Google Earth image, 2016)

Although located about 3 miles northeast of Magnet Cove at the meeting of sections 10, 11, 14, 15, T. 3 S, R. 17 W, the deposit is often considered as part of the Magnet Cove complex.

The deposit is a barite replacement of shale at the base of the Stanley Shale in a faulted syncline. The barite replacement averages 60 feet thick and is now considered subeconomic. Although barite was known from the area in 1900, it was not until much later that there was extensive exploration and mining started in 1940. Two companies mined the deposit, National Lead Company's Bariod Division and Magnet Cove Barium Corporation. The limbs of the syncline were mined by open pit method and the base of the syncline by shafts and underground workings. Mining ceased in 1977 when mining the deposit became uneconomic due to high costs of mining and the importation of foreign barite.

Most of the barite looks like a gray heavy micritic limestone, but no carbonate is present. Cavities with white, intergrown and subparallel, thin, tabular barite crystals, transparent elongate crystals, and discoidal crystals have yielded some nice hand specimens, up to large cabinet size specimens. Most of the crystalline barite specimens are in the 5 to 10 cm across size range. Rarely, distinct, thin but well-formed, thin, tabular crystals about 1 cm across have been recovered. Most of these specimens were recovered by miners during the underground operations late in the mine operational history.

This is the type locality for the mineral benstonite but no crystals have been recovered from the site. Its occurrence is limited to white or ivory cleavable masses with slightly curved faces associated with milky quartz, barite, and calcite. Although calcite and benstonite both react in hydrochloric acid, its identity can be confirmed by its red fluorescence under long wave ultraviolet light, plus it has a distinct odor of hydrogen sulfide when crushed (Lippman, 1962)

Other collectable minerals from the location are clear quartz crystals some with white elongate orthoclase**,** variety adularia, small crusts of calcite crystals and comby honey colored thicker calcite crusts, pyrite as coatings with crystal faces and small crystalline masses, and large stalactitic masses of marcasite to 24 cm. Most of these larger masses deteriorated from “pyrite disease” within 2 years of removal from the ground, though the alteration can be slow acting in some specimens. A list of other minerals occurring in the deposit is given in Table 10.

Table 10: MINERALS OF THE CHAMBERLAIN CREEK BARITE MINES (NL BARIOD DIVISION OF NATIONAL LEAD COMPANY AND MAGNET COVE BARIUM CORPORATION)

Mineral	Description	Reference
Arsenopyrite	veins and small masses with pyrite	Parks (1932)
Barite	replacement of shale, rarely crystalline, nodular	Shockley (1948)
Benstonite	white veins cutting barite, curved rhombs, fl. pink	Lippmann (1962)
Calcite	crusts of orange scalenohedrons to 5 cm thick, fl.	Howard (2004)
Celestine	white massive with barite, could be benstonite?	Parks (1932)
Gypsum	white veins and beds	Scull (1985)
Marcasite	large stalag. & stalac. masses, altering to melanterite	Howard, this study
Melanterite	white efflorescent powdery alteration of marcasite	Smith, this study
Molybdenite	rarely as gray masses in sedimentary rocks	Parks (1932)
Orthoclase	white adularia crystals in quartz veins	Howard, this study
Pickeringite	white efflorescence in old underground mine workings	Marshall (1954)
Pyrite	common in dark shales as masses and crystals	Parks (1932)
Quartz	colorless crystal in Paleozoic veins, cutting barite ore	Howard, this study
Sphalerite	reported from dark shales	Parks (1932)

The large open pit is now filled with over 600 feet of water. A hunting club controlled some of the land at one time, and small dumps around the edge of the pit were available for collecting, though they generally were only productive for microscopic minerals. The property recently sold and significant efforts are being made by Halliburton Company, the present owner, to keep unauthorized people off this location due to liability issues.

ADDITIONAL MAGNET COVE MINERAL OCCURRENCES

There are other occurrences both general and specific that have produced specimens in Magnet Cove. Some have produced only one or a limited number of specimens but others have yielded numerous specimens and some of the occurrences do not produce collectable minerals. These are summarized in Table 11.

The authors also have minerals in their collections that have Magnet Cove labels on them. However their source cannot be verified and similar mineral occurrences have not been recognized from Magnet Cove, but are briefly be mentioned here: Betafite as a typical 1 cm crystal with no matrix; monazite as an elongated, red brown, 2 cm crystal with no matrix; and 3mm dark brown, crude octahedrons with no matrix of what are probably spinel that were in a packet with brookite and bearing a Wards label.

Table 11: MINERALS FROM UNSPECIFIED MAGNET COVE LOCALITIES

Mineral	Location	Description	Reference
Albite	Cove Creek west of iron bridge	white, thick tabular crystal clusters, rosettes	Smith (1996)
Analcime	not specified	crystal in cavity	Erickson & Blade (1963)
Anatase	Stone Quarry Creek area	blue crystals reported as diaspore	Howard (1987)
Barite	Parker property	pale yellow tabular crystals	EDS-SEM
Brookite	Runyan quartz mine	microscopic black crystals on smoky quartz	Howard (1999)
Cancrinite	along Cove Creek	in jacupirangite	Howard (2001)
Diaspore	Stone Quarry Creek area	see anatase	Scull (1959)
Goethite	Cove Creek Estates	pseudomorphs after pyrite to over 2 cm	Smith (1988)
Gonnardite	Cove Creek jacupirangite	white fibers and sprays in cavities	Milton XRD, Howard (1987)
Magnetite	Cove Creek N of iron bridge	masses with vermiculite	Williams (1891)
Monazite-(Ce)	Cove rim rocks	clusters of poorly formed crystals	Tice et al (1999)
Olivine	Central Cove area	monchiquitic dike rocks, species undeter.	Shockley (1948)
Orthoclase	Teager Creek	large tabular crystals in dike rock	Williams (1891)
Pyrite	Cove Mtn and Runyan mine	in altered novaculite	Williams (1891)
Serpentine	Central Cove	alteration of large biotite masses	Williams (1891)
Sodalite	South and north outer flanks	blue films and white hackmanite variety	Miser & Glass (1941)
Thorite	Cove rims	minute crystals in quartz, novaculite	Tice et al (1999)
Titanite	Cook Mtn outcrops on Hwy 51	pale pinkish microcrystals, typical disphenoids	Howard (2001)
Wohlerite?	Unspecified locality	?????	Anthony et al (1995)

Part 2 – THE MINERALS OF MAGNET COVE, HOT SPRING COUNTY, ARKANSAS AND VICINITY

An alphabetical listing and descriptions of both the minerals and localities of occurrence, including details on chemical analyses.

ACTINOLITE $\{Ca_2\}\{Mg_{4.5-2.5}\ Fe_{0.5-2.5}\}(Si_8O_{22})(OH)_2$

General. Actinolite was first reported from Magnet Cove by Comstock (1888) and probably was aegirine (Howard 1987).

Christy mine (CM) Actinolite, aegirine, sodic amphiboles and tainiolite are among the earliest minerals formed during novaculite replacement. Actinolite contains little or no vanadium (Flohr 1994).

ACTINOLITE ANALYSIS

Loc & descr.	SiO_2	FeO	MgO	CaO	Al_2O_3	source
CM	55.57	11.50	17.08	12.65	1.25	Flohr (1994)

AEGIRINE (ACMITE) $NaFe^{3+}Si_2O_6$

Brookite deposits on the east rim (BD). Aegirine occurs in mineralized quartz-rich rock at the Hardy-Walsh deposit (Flohr 1994).

Cove Creek bridge (CCB) and the Branch pegmatites (BP). Aegirine is common and abundant in the pegmatites. The long, large black crystals with a greenish tint are the best known crystal and occur as prisms over 30 cm long and 3 cm thick. These prisms are terminated by long, steep pyramids. The prisms have indistinct crystal faces but some are rounded. Aegirine crystals range from 30 cm down to microscopic size (Williams 1891, 248-250) and occur in both the pegmatite and the contact metamorphic rock. Radiating sprays of pale brown acicular crystals are scattered among the larger black crystals (Smith 1994). The green felted masses of tiny crystals have been misidentified as epidote (Shockley 1948). The aegirine crystals are strikingly zoned from opaque forest green through gemmy mauve and apple-green and its composition ranges from aegirine to augite with molar proportions of titanaugite, johannsenite, and petedunnite components (Tice, Falster & Simmons 1999).

Diamond Jo quarry (DJQ). In the miarolitic cavities aegirine occurs as green needles (Erickson & Blade 1963, 11). Its color also occurs as black, green, yellow, orange, and brown crystals. The crystals range up to 2 mm long and occur as elongate prismatic crystals and laths that may be seen as groups of divergent crystals, randomly oriented crystals, or single crystals. Most of the terminations are pointed. Some terminations are blunt being modified by crystal faces. The variation in color probably indicates that aegirine is not the only pyroxene in the cavities. Quite a variation in composition is shown by Ross (1984) in quartz syenite (Smith 1989). An orange aegirine crystal was analyzed by Henry Barwood and its composition was not significantly different from green or black aegirine crystals.

Kimzey calcite quarry (KCP). Black aegirine occurs in the contact metamorphic rocks (Smith 1996).

Kimzey magnetite mine (KMP). Aegirine crystals occur in cavities in vesuvianite with andradite, vesuvianite and diopside (Stone et al. 1982).

Martin Marietta Jones Mill quarry (JMQ, MMQ). Aegirine and possibly other pyroxenes are common in the syenite dikes that cut altered and fenitized shales. It occurs in the matrix and in cavities. The color ranges from black to brown and include all shades of green, some a very bright green. In the cavities the crystals vary from acicular to stubby prismatic with the typical blade-like terminations. There are also nests of minute pale green acicular crystals that appear to have replaced an earlier formed mineral that may also be aegirine (Smith 2001). Aegirine and amphibole crystals found in cavities of a light-colored altered rock may be covered with a coating of translucent brownish to green siderite (Smith 1999). Nests of brown slightly elongated tabular crystals associated with an altered xenolith in syenite were thorium rich by analysis (see below). A less than .5 mm well-formed dark terminated crystal in a cavity in syenite was determined to be aegirine by analysis (see below).

Titanium Corporation of America. Altered hybrid rocks have accessory aegirine, some vanadium bearing (Flohr 1994).

AEGIRINE ANALYSES

Location, Descr.	SiO_2	Fe_2O_3	Na_2O	MgO	ThO_2	TiO_2	CaO	Al_2O_3	MnO	FeO	SOURCE
JMQ, BR, TAB	53.50	29.11	13.67	0.00	0.00	1.31	0.00	0.00	1.41	0.00	EXCALIBUR
JMQ, YELLOW	48.91	32.29	12.64	1.10	0.00	1.69	1.33	2.15	0.00	0.00	EXCALIBUR
JMQ, BROWN	58.03	19.63	10.74	0.00	6.26	2.26	0.34	2.39	0.00	0.00	EXCALBUR
JMQ, PL GR	51.38	31.10	12.86	0.00	0.00	1.14	0.00	2.50	1.04	0.00	EXCALIBUR
JMQ, NEEDLES	51.84	34.64	11.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	EXCALIBUR, ESTES
JMQ, DX XL	52.82	31.51	09.23	0.67	0.00	0.00	3.96	1.79	0.00	0.00	EXCALIBUR
DJQ, ORANGE	52.73	29.50	12.67	1.40	0.00	0.76	1.16	0.45	0.00	0.82	BARWOOD
CCB XL	51.41	23.30	11.86	0.13	0.00	0.13	2.03	1.82	0.00	9.45	SMITH 1875
BD, ALT. ROCK	59.16	15.33	13.25	0.43	0.00	1.09	0.02	0.33	0.09	0.38	FLOHR 1994
BP	51.20	25.11	12.03	0.69	0.00	0.82	4.93	1.07	0.71	4.97	E & B 1963
JMQ, BRN, matrix	51.33	26.80	13.03	2.84	0.00	1.31	2.10	1.57	1.10	-	EXCALIBUR
JMQ, BROWN	52.84	-	9.23	0.67	0.00	0.00	3.96	1.79	0.00	31.50	EXCALIBUR

ALBITE $Na(AlSi_3O_8)$

Albite pocket. A short distance west of the iron bridge across Cove Creek in the south bank a large pocket of white albite crystals was discovered in the 1990s. The albite occurs in thick tabular crystals up to 2 cm across. J. M. Howard obtained about 20 Baveno twinned crystals by looking through a lot the diggers took to Tucson. Many large and small groups of albite were recovered and sold. Some albite formed particularly attractive crystal nodules/rosettes. The only associated mineral was a small amount of pyrite. The albite may have a pink or deep red fluorescence under short-wave radiation. Specimens with long exposure to sunlight seem to have diminished fluorescent response.

Central Cove area. Pale yellow-brown stained to white albite crystal groups, up to several centimeters across, have been found in the soil. The crystals are prismatic and in the 1 cm range (Smith 1996).

Cove Creek and Branch pegmatites. Albite is inconspicuous but present in the pegmatites (Smith 1996).

Diamond Jo quarry (DJQ). Typically albite occurs as clear overgrowths on white orthoclase crystals. Thin tabular clear or white albite crystals are not common (Smith 1989).

Kimzey magnetite mine. Albite forms white bowties similar to stilbite (Stone et al. 1982). It is also seen as rosettes and blocky masses (Smith 1996). Albite may coat and replace “pseudoleucite” a mixture of nepheline and orthoclase.

Martin Marietta Jones Mill quarry. Albite is common as white and opaque to translucent, thick tabular crystals in miarolitic cavities. It also forms white coatings and overgrowths on orthoclase crystals. It is usually whiter than the orthoclase (Smith 2001). Estes (1998) also reports albite as transparent, pink to colorless crystals associated with green calcite, amphibole, and polylithionite. White, thin plates oriented perpendicular to the matrix in veins and cavities in the baked and altered shale have been identified as albite by EDS analysis (Smith 2004, not published).

Mo-Ti prospect. Larger crystals than at the titanium mine are present. It also occurs as drusy coatings (Welch 1968). It is a major consitutent of the white vein material dug in adjacent Cove Creek. White albite crystals may form large white rosettes over 3 cm across on some of the larger pyrite crystals. Downstream from the iron bridge, white albite rosettes were recovered from a large cavity and formed masses to several pounds. Scarce Baveno twins were noted as well as minor pyrite on the albite.

Titanium Corp of America pit, Magnet Cove Rutile mine. Gray to white well-formed crystals of albite to over 1 cm and botryoidal masses showing crystals faces occur in dolomite-albite veins. Encrusting masses of a gray or white color and nearly botryoidal in form are also albite. It has a faint pink fluorescence under short wave ultraviolet radiation (Shockley 1948).

ALLANITE $\{La,Ce,Ca\}(Al_2Fe^{2+})(Si_2O_7)(SiO_4)O(OH)$

Martin Marietta Jones Mill quarry. Black, short, lath-like to tabular crystals, under 0.5 mm have been identified by EDS as the lanthanum variety of allanite that has not been given separate species status. It occurs in quartz veins in silicified shales and in the nepheline syenite in cavities (Smith 1998a). See analysis below. Not determined which Group member is present.

ALLANITE-(Ce) $\{CaCe\}\{Al_2Fe^{2+}\}(Si_2O_7)(SiO_4)O(OH)$

Martin Marietta Jones Mill quarry. Allanite-(Ce) was identified by EDS analysis. On a Karl Estes specimen this mineral occurs as groups of dark brown to black, short, lath-like to tabular crystals that are under 1 mm long (see analysis below).

ALLANITE & ALLANITE-(Ce) ANALYSES

LOCATION/ DES .	SiO_2	Al_2O_3	Fe_2O_3	CaO	La_2O_3	Ce_2O_3	MnO	MgO	SOURCE
JMQ, BLACK	38.83	15.38	18.66	9.02	11.22	9.36	0.53	0.00	EXCALIBUR
JMQ, BROWN	48.17	22.39	8.01	10.46	3.57	3.67	6.42	0.98	EXCALIBUR, ESTES

ALLOPHANE amorphous hydrous aluminum silicate

Mo-Ti prospect and Titanium Corp of America pit. Allophane is an alteration product of albite (Fryklund & Holbrook 1950).

ANALCIME $Na(AlSi_2O_6)\cdot H_2O$

General. Analcime occurs in the groundmass of the analcime olivine metagabbro and as an alteration product of nepheline (Erickson & Blade 1963, 70). Analcime has been reported by Shockley (1948) as a white transparent crystal in a vug of coarse-grained syenite with fluorescent sodalite (hackmanite) from an undisclosed location.

Martin Marietta Jones Mill quarry. White opaque rounded crystals up to 4 mm across were collected by Karl Estes in the late 1990s.

ANATASE TiO_2

Brookite deposits on the east rim. The elongate white, centimeters long inclusions in smoky quartz crystals from these deposits have been called leucoxene, which is the mineral anatase and considered a paramorph after rutile. All of this material that has been analyzed is an iron oxide and probably an alteration of amphibole (Howard 1999). The minute acicular crystals of rutile included in quartz in these deposits are usually partly altered to anatase (Fryklund & Holbrook 1950).

Christy mine. About twenty percent of the “brookite” is actually anatase (Flohr 1994). The anatase crystals are usually slightly smaller than the brookite crystals and can be identified by their crystal habit and striations.

Cove Creek bridge pegmatite (CCBP). Anatase occurs in cavities in the pegmatite as black, lustrous, flat crystals. The crystals are typical anatase and are 1 mm or less. Associated with this anatase are some crystals less than 0.5 mm across that are tan, thick platy, with a crude hexagonal outline. They are probably also anatase. They may be a pseudomorph of another mineral (Smith 1999a). Their composition is some what variable (see analysis below).

Diamond Jo quarry. Striking deep blue and blue-black truncated, pyramidal crystals occur with drusy quartz, orthoclase, and aegirine. They are less than 1 mm tall and occur in cavities associated with sandstone xenoliths in the quartz syenite above the western side of the quarry face (Smith 1989).

Kimzey Calcite quarry. Pale brown to tan cubo octahedrons of anatase after perovskite in carbonatite are found in the quarry, adjacent to Cove Creek, and the bridge area. They range in size from 2 mm to almost 5 mm and are a pseudomorph of perovskite (Smith 1994, Howard 1999).

Titanium Corp of America pit. Minute (less than 0.5 mm) black lustrous flat to octahedral anatase crystals embedded on feldspar were observed in a specimen owned by Karl Estes. They are evidently rare from this locality.

Martin Marietta Jones Mill quarry. The first find of abundant anatase in 1997 was as black equant, prismatic, and tabular striated crystals with pinacoidal truncations. Some are corroded and all are implanted on drusy rutilated smoky quartz associated with orthoclase, opaque white prismatic fluorapatite, and groups of unidentified shiny yellow crystals. The second find in 1997 had more equant crystals than the first discovery. Associated with the anatase was a colorless, transparent, micaceous mineral in thin crystals and books; green rhombohedral calcite; drusy colorless albite and larger pink crystals; pale brown siderite rhombs; yellow to golden, transparent, highly modified fluorite crystals; and dull gray to white well-formed orthoclase crystals (Estes 1999). The 1998 anatase find had deep blue, generally seen as black, lustrous crystals, from 2 mm to 6 mm, on tiny white quartz crystals with brookite and cubic pyrite (Smith 1998). Other associated minerals are tabular marcasite, green transparent and tetrahedrons of sphalerite (Estes 1999). Howard (1999) also reports tainiolite and fluorapatite. The anatase faces may be smooth or finely striated. Some crystals have irregular angular to diamond-shaped cavities from where another mineral has been removed (Smith 1998). Unfortunately when the collectors of these specimens went back for more, they found that the pile from which they came had been crushed and no similar occurrences have been found since.

Mo-Ti prospect. Anatase reported as leucoxene occurs at this prospect (Fryklund & Holbrook 1950). It is usually an alteration of rutile.

Perovskite Hill (PH). Anatase, called hydrotitanite, is a yellowish brown alteration of perovskite that also occurs in the carbonatite in Cove Creek. Crystals occur alone or implanted on magnetite octahedrons (Williams 1891, 184, 334-335). Numerous anatase pseudomorphs after perovskite were collected by Clyde Hardin during the 1980s and 1990s (Smith 2003). The crystals are cubes, octahedrons and combinations of both. They range is size up to slightly over 1 cm across. Some are perovskite only partly replaced by anatase. Some clusters with octahedral magnetite have both perovskite and anatase after perovskite crystals attached (Smith 1996).

Stone Quarry Creek. In a quartzite bed 80 feet above the creek a blue mineral was identified as diaspore (Scull 1959), but is probably blue anatase similar to that found at the Diamond Jo quarry (Howard, 1987).

Titanium Corp of America pit. Acicular, 0.5 mm crystals of rutile may be in part or completely altered to leucoxene (anatase) (Fryklund and Holbrook 1950).

ANATASE ANALYSES

LOCATION/ DESC.	**TiO_2**	**SiO_2**	**Fe_2O_3**	**Nb_2O_5**	**CaO**	**MgO**	**H_2O**	**SOURCE**
CCBP, XL	**83.38**	**7.78**	**3.60**	**3.21**	**2.03**	**0.00**	**-**	**EXCALIBUR**
per pseudo	**82.82**	**0.00**	**7.76**	**0.00**	**0.80**	**2.72**	**5.50**	**Koenig 1876**

ANCYLITE – (Ce) $SrCe(CO_3)_2(OH) \cdot H_2O$

A scarce micromineral that occurs as pale groups of prisms on orthoclase at the Martin Marietta Jones Mill Quarry. Reported by Chris Stefano from EDS data in a personal communication with Henry Barwood.

ANDRADITE $Ca_3Fe^{3+}_2(SiO_4)_3$

General. Andradite is common and ranges from light-colored red, orange or yellow to dark-colored melanite varity (titanium garnet) (Erickson & Blade 1963, 74).
Central Cove area. Andradite, variety melanite, occurs in well-formed crystals. They are generally black, but under the petrographic microscope they are composed of reddish brown centers and light yellow exteriors. Fluorapatite and biotite occur as inclusions (Williams 1891, 213). Black masses, often showing some crystal faces, occur in the Brook in front of the Magnet Cove Baptist Church (Smith 1996). They are also present in the soil of the Heath Farm or York Place area. Pieces can be several centimeters across and show some dodecahedral faces. Rutile eightlings, vermiculite, and magnetite fragments are also found (Smith 2003).
Cove Creek Bridge, south 800 feet. An altered phonolite has amygdules rimmed with pale brown to colorless andradite. The centers contain calcite, colorless diopside, pyrite, wollastonite, garnet, and a zeolite (Erickson & Blade 1963, 25-26).
Cove Creek Bridge and Branch pegmatites. Andradite is rare in the pegmatite and seldom occurs as small dark distinct crystals (Williams 1891, 251).
Diamond Jo quarry. Black rounded crystals of andradite to over 0.5 cm across are common in the matrix of the pseudoleucite syenite. However, andradite in the miarolitic cavities is very rare. Only one dodecahedral, black crystal, about 0.5 mm across was found attached to the wall of a cavity (Smith 1989).
Kimzey calcite quarry. Andradite occurs as usually dull black dodecahedral crystals in carbonatite. The crystals seldom reach 4 mm across, but are larger than the kimzeyite crystals with which they are often confused (Smith 1994).
Kimzey magnetite mine. Andradite occurs as small crystals and masses. Most andradite is black, but it may also be internally zoned yellow or red in color. Small crystals occur in cavities in vesuvianite. Clyde Hardin dug a nest of brown crystals, 1 to 2 cm in diameter, intergrown with fluorapatite in the highway right-of-way that more than filled a gallon jar (Smith 2003).
Lime-silicate area. Andradite crystals line miarolitic cavities in the vesuvianite-diopside rock (Erickson & Blade 1963, 39).
Martin Marietta Jones Mill quarry. Andradite occurs in pale yellow to dark brown crystals with striated faces. The crystals are usually simple dodecahedrons, but some have been modified by trapezohedrons.

Most crystals occur as groups in altered shale and are less than 1 mm across (Estes 1998). Brown to yellow crystals in syenite, associated with altered xenoliths, were collected in November 2002. An analysis is given below.

Perovskite Hill. Small black dodecahedral crystals up to 4 mm in diameter have been collected (Smith 1996). Clyde Hardin dug what is probably an andradite crystal fragment with a bright red center (Smith 2003).

ANDRADITE ANALYSIS

LOCATION/ DESC.	SiO_2	Al_2O_3	CaO	Fe_2O_3	V_2O_5	SOURCE
JMQ, BRN-YEL	34.07	0.00	32.20	30.42	0.26	EXCALIBUR

ANHYDRITE $CaSO_4$

Kimzey calcite quarry. Microscopic clear crystals of anhydrite occur as inclusions in kimzeyite garnets (Milton, Ingram & Blade 1961).

ANKERITE $Ca(Fe^{2+},Mg)(CO_3)_2$

Christy mine. Ankerite is reported in minor amounts (Flohr 1994).

Kimzey calcite quarry. Howard (1987) reports that ankerite is rare in the carbonatite as a primary mineral.

Martin Marietta Jones Mill quarry. Veins of pale tan ankerite(?) with crystals under 5 mm occur in altered shales. The corroded areas of the ankerite contain minute rod-like struverite crystals (Smith 1998a).

Titanium Corp of America pit. The carbonate dikes contain ankerite (Flohr 1994). Small white to brown crystals occur in cavities in the veins (Smith 1996).

ANORTHITE $Ca(Al_2Si_2O_8)$

General. Sodium anorthite (andesine) forms the groundmass of trachyte dike rock. It is associated with sanidine and biotite (Erickson & Blade 1963).

ANORTHOCLASE $(Na,K)AlSi_3O_8$

General. Anorthoclase was observed in petrographic thin sections of trachyte (Erickson & Blade 1963).

APATITE – See Fluorapatite, Carbonate-fluorapatite

APOPHYLLITE - See fluorapophyllite

ARAGONITE $CaCO_3$

Kimzey calcite mine. Aragonite in the form of "cave coral" was found in small amounts during mining in the 1940s. It occurs in white, tufted, acicular crystals that have a pale yellow fluorescence and phosphorescence under short wave ultraviolet radiation (Shockley 1945). Another occurrence of aragonite was as minute white tufts in a rock composed primarily of small vesuvianite crystals. Howard purchased a thick mass of secondary aragonite from an older mineral dealer's stock that showed stalactitic formation, apparently having formed in an open cavity within the carbonatite at the Kimzey

calcite pit. The mass had small magnetite crystals embedded within it. The specimen is fluorescent bluish white and highly phosphorescent (JMH personal observation).
Mo-Ti prospect area. Rarely, white fibrous, late-formed aragonite occurs in cavities dug in Cove Creek (Howard 2001).

ARFVEDSONITE $[Na][Na_2][Fe^{2+}_4Fe^{3+}]Si_8O_{22}(OH)_2$

Christy mine. Veinlets of orange-brown arfvedsonite occur in the novaculite (Howard 2001). This mineral was identified by Ross and Flohr of the USGS.
Diamond Jo quarry. Lustrous opaque poorly formed prismatic crystals of arfvedsonite with indistinct terminations have been identified by J.M. Howard (1977, personal communication). Similar material at Granite Mountain, Pulaski County has been confirmed as arvedsonite. Charles Milton (1977, personal communication) reported other unspecified amphiboles from the miarolitic cavities.
Martin Marietta Jones Mill Quarry (JMQ, MMQ). Aggregates of brownish microscopic crystals up to 5 mm long were observed by Karl Estes in 1999 and may be arfvedsonite.

ARFVEDSONITE ANALYSIS

LOCATION/ DESC.	SiO_2	Fe_2O_3	Na_2O	MgO	CaO	TiO_2	Al_2O_3	SOURCE
JMQ, Brown	55.01	23.61	16.05	2.02	1.05	0.41	1.85	EXCALIBUR - ESTES

ARSENOPYRITE FeAsS

Brookite deposits on east rim. Arsenopyrite is reported to be an accessory mineral in dikelets and veins by Flohr (1994).
Chamberlain Creek barite mines. Arsenopyrite is reported from these mines (Parks & Branner 1932). It occurs as veins and small masses with pyrite and other sulfides.

ASTROPHYLLITE $K_2NaFe^{2+}_7Ti_2Si_8O_{24}(OH)_4F$

Cove Creek bridge & the Branch pegmatites. Astrophyllite is very rare in the pegmatites. It occurs as 5 mm to 10 mm poorly developed crystals. The crystals are composed of thin brittle plates crowded together as irregular masses. It has a brownish yellow color and shows a brilliant luster on cleavage surfaces (Williams 1891, 247-248). More recently, 1 mm yellowish blebs (Smith 1999a) and lath-like crystals have been analyzed and found to be lamprophyllite. The material described by Williams has not been observed and confirmed in recent years.
Martin Marietta Jones Mill quarry (JMQ). Magnesioastrophyllite occurs as white sprays of prismatic crystals in seams in the baked shale.

ASTROPHYLLITE ANALYSIS

LOCATION/ DESC.	SiO_2	Fe_2O_3	Na_2O	MgO	CaO	TiO_2	Al_2O_3	SOURCE
JMQ white	51.19	11.53	6.86	9.18	0.93	13.61	4.48	EXCALIBUR

AUGITE $(Ca,Na)(Mg,Fe^{2+},Al,Fe^{3+},Ti)[(Si,Al)_2O_6]$

General. Augite is found only in the late analcime olivine metagabbro (Erickson & Blade 1963, 70). It is reported in monochiquitic dike rock in the north central portion of the Cove (Shockley 1945). The large green crystals found in the 1960s while digging the pipline crossing to Cove Creek are not diopside, but augite by EDS analysis.

Cove Creek Bridge pegmatite. Some of the aegirine crystals in the pegmatite are actually augite in composition, but they can not be distinguished visually from most of the aegirine (Tice, Falster, and Simmons 2001).

Cove Creek gas pipeline crossing (CCGPC). Located in the central part of the Cove and made in the 1960s, this area produced many intergrown dark to light green prismatic, seldom terminated augite crystals up to 10 by 4 cm.

Diamond Jo quarry. Charles Milton (1977, personal communication) indicates that augite is one of the pyroxenes present in the miarolitic cavities.

Titanium Corp of America pit. Augite is reported to be in a dike rock in the titanium mine and along the road entering the mine (Welch 1968).

AUGITE ANALYSIS

LOCATION/ DESC.	Na_2O	MgO	Al_2O_3	SiO_2	CaO	MnO	FeO	SOURCE
CCGPC, light green	54.76	18.62	14.36	2.92	0.73	6.86	1.76	EXCALIBUR

BADDELEYITE ZrO_2

Cove Creek bridge pegmatite. Eudialyte alters to baddelyite, catapleiite, låvenite, paraumbite, and barytolamprophyllite (Nizamoff, Falster, Simmons & Webber 1998).

Kimzey calcite quarry. Small round grains of baddeleyite are associated with residual magnetite and perovskite (Howard 2001).

Perovskite Hill. Earthy, dull, brown crude crystals, up 1 cm across, collected by Clyde Hardin were identified as baddeleyite pseudomorphs after kimzeyite by Henry Barwood in 1996. All of Clyde's specimens (over 100 of them) came from one small area (Smith 2003).

BARITE $BaSO_4$

Chamberlain Creek Barite mines. These mines are located in a syncline adacent to the northeast flank of Magnet Cove. Most of the barite from this deposit is dark gray, earthy, and compact. In some places it is banded red and pale gray. Small well-formed, white to colorless, transparent crystals occur in vugs, but they are not common. Some of the crystals have a thin coating of sulfides on them. The clear and white barite has a pale yellow fluorescence and phosphorescence under short wave radiation. The earthy material is only phosphorescent (Shockley 1945). Crystalline barite rosettes to 2 cm diameter are present in shale at this site (Howard, personal observation).

Cove Creek bridge pegmatite. A minor amount of barite is present as a late-stage component of the pegmatite (Tice, Falster & Simmons 2001).

Diamond Jo quarry. Barite occurs in the miarolitic cavities as thin, transparent, colorless tabular crystals, often in a subparallel stacked arrangement. It also occurs as elongate prismatic crystals that are lightly frosted. It is associated with aegirine, pectolite, orthoclase, and rarely kassite (Smith 1989). It has a bright blue fluorescence under short-wave radiation.

Kimzey calcite quarry. A dense green and black rock had a vug lined with small, clear calcite crystals with barite crystals growing on the calcite. The crystals were clear, tabular and about 4 mm in size (Shockley 1948).

Martin Marietta Jones Mill quarry. Microscopic bright, clear, tabular crystals of barite, along with complex prismatic habit, were not common with altered carbonate beds near syenite found in November 2002. No strontium was detected by EDS analysis.

Mo-Ti Corporation prospect. Barite occurs as minute cream-colored rosettes on feldspar on a specimen owned by Karl Estes. They are not common at the location.

Parker property. Pale yellow tabular crystals of barite were collected on the Parker property by Karl Estes and their identification was verified by EDS analysis. It occurs with goethite.

Rayburn prospect. This prospect is located about 4 miles east of Magnet Cove. Twelve feet of massive barite is present on the north limb of the Rayburn syncline in Stanley Shale (Stroud et al. 1969).

BARYTOCALCITE $BaCa(CO_3)_2$

Diamond Jo quarry (DJQ). Barytocalcite occurs mostly as pseudorhombohedral crystals up to 2 mm across. They dominate some cavities and may be crude and somewhat skeletal. Most are clear and colorless. They are most common in cavities with cotton-like pectolite, but also occur in cavities with labuntsovite and associated minerals (Smith 1989). Analysis made by Henry Barwood in 1995.

BARYTOCALCITE ANALYSIS

LOCATION/ DESC.	CaO	SrO	BaO	FeO	SOURCE
DJQ, WI, PRISM	18.46	0.14	56.12	TR	BARWOOD

BARYTOLAMPROPHYLLITE $(Ba,Na)_2(Na,Ti,Fe^{3+})_4Ti_2(Si_2O_7)_2O(OH,F)$

Cove Creek bridge pegmatite. A small pink grain associated with eudialyte was identified as barytolamprophyllite (Nizamoff, Falster, Simmons, and Webber 1998).

BASALUMINITE (name now discredited, accepted name Feslobanyaite) $Al_4(SO_4)(OH)_{10} \cdot 4H_2O$

Rayburn prospect. Located about 4 miles east of Magnet Cove, this barite prospect is on the north limb of the Rayburn syncline. Basaluminite occurs as white, internally radiating spheres under 1 cm in diameter in seams of the Stanley Shale. Barite is also present (Smith 1987).

BASTNÂSITE – (Ce) $Ce(CO_3)F$

Kimzey calcite quarry (KCQ). Tabular intergrown platelets of bastnâsite-Ce and synchesite-Ce occur as veins in the carbonatite. The tabular crystals are less than 1 mm across and bright yellow, and consist of an intergrowth of the two minerals (Barwood & Howard 1990). They form as a weathering product from carbonate fluorapatite (Howard 2001). In 1995 Barwood found that the light areas of the crystals are essentially bastnâsite-(Ce) and the dark areas are synchesite-(Ce). Pale gray to tan aggregates of platy crystals in calcite have also been identified as bastnâsite-(Ce).

BASTNÂSITE – (La) $La(CO_3)F$

Martin Marietta Jones Mill quarry (JMQ). White to brownish rosettes of micaceous flakes were obtained from Jimmy Matlock. An SEM/EDS and XRD confirmed the identification of bastnâsite – (La). Karl Estes collected similar material. Analyses of both are given below.

BASTNÂSITE ANALYSES

LOCATION/DESC .	La_2O_3	Ce_2O_3	Nd_2O_3	CaO	Fe_2O_3	CO_2	F	SOURCE
KCQ, Plates	26.38	30.88	4.82	9.07	00.00	21.88	6.96	BARWOOD
KCQ, Plates	20.47	25.37	5.26	11.89	00.00	32.58	4.42	EXCALIBUR, ESTES
KCQ, Tan	13.22	14.81	3.63	-	13.86	54.47	0.00	EXCALIBUR
JMQ, Rosettes	20.05	10.28	1.06	10.28	5.89	48.84	0.00	EXCALIBUR
JMQ, MICROS	28.42	22.89	11.29	6.18	1.75	29.47	0.00	EXCALIBUR, ESTES

BEIDELLITE $(Na,Ca_{0.5})_{0.3}Al_2((Si,Al)_4O_{10})(OH)_2 \cdot nH_2O$

Brookite deposits on east rim. Beidellite is reported to be one of the clay minerals present (Fryklund & Holbrook 1950). It is interesting to note that later workers have not identified this mineral. (Howard 2004)

Titanium Corp of America pit. Beidellite is one of the clay minerals present (Fryklund & Holbrook 1950). It cannot be identified visually (Welch 1968).

BENITOITE $BaTi(Si_3O_9)$

Diamond Jo quarry (DJQ). Three grains of sky-blue benitoite were originally found embedded in pectolite in miarolitic cavities in pseudoleucite pegmatite. Its identity was confirmed by EDS and XRD analyses (Barwood 1995). Subsequently, pink grains in solidly filled cavities and colorless crystals in pectolite were also found to also be benitoite. The crystals are triangular and connected by the prism face. It is fluorescent bright blue under short wave radiation and quite rare. Analyses show that the three colors of benitoite have essentially the same composition.

BENITOITE ANALYSIS

LOCATION/DESC.	SiO_2	TiO_2	ZrO_2	Al_2O_3	BaO	Others	SOURCE
DJQ, blue	42.72	18.65	0.33	0.19	35.35	0.77	BARWOOD

BENSTONITE $Ba_6Ca_6 Mg (CO_3)_{13}$

Chamberlain Creek barite mines (CCBM). This is the type locality for benstonite. It occurs in irregular white veins cutting the fine-grained gray barite. It is associated with milky quartz, barite, and calcite. The benstonite occurs as white, cleavable masses, with cleavage faces up to 1 cm. The cleavage faces are slightly curved. Benstonite fluoresces red under long wave or short wave radiation (Lippmann 1962).

BENSTONITE ANALYSIS

LOCATION/DESC.	BaO	SrO	CaO	MgO	MnO	CO_2	SOURCE
CCMB, CLEAVAGE	43.05	4.02	19.52	1.69	0.35	31.35	LIPPMANN 1962

"BIOTITE" $KFe_3^{2+}AlSi_3O_{10}(OH)_2$ Name discredited by IMA, still useful as a field term.

Central Cove area. (CCA). This area includes the Kimzey magnetite mine where biotite occurs in blackish green books (Smith 1996). Biotite is common in the soil on both sides of State Highway 51, where it occurs as large books to over 10 cm across. Much of this biotite is partly or completely atered to vermiculite.

Kimzey calcite quarry. Biotite forms pseudohexagonal prismatic crystals and plates of a pistachio green color in the calcite (Williams 1891, 335-336). Most of the crystals are small and under 5 cm across. It may be intimately associated with hercynite and often is associated with kimzeyite.

Magnet Cove Baptist Church. This location is in the Central Cove area. A coarse-grained crystalline carbonatite contains green biotite usually scattered through it, but also in veins exposed in the Branch in front of the Church (Smith 1988, 1996). Plates of biotite, up to 4 cm across, may be color zoned .

Martin Marietta Jones Mill quarry. Small dark brown pseudohexagonal crystals on and in clear, colorless quartz crystals were obtained from Jimmy Matlock in 1998. A SEM/EDS confirmed their identity as biotite. Karl Estes found slightly larger reddish brown, flattened aggregates of pseudohexagonal biotite crystals with a small percentage of vanadium. See analyses below.

Perovskite Hill. Some greenish biotite has been observed in small flakes loose in the soil (Smith 1988).

Titanium Corp of America pit. Phenocrysts of biotite up to 2.4 cm in diameter were observed in syenite (Fryklund & Holbrook 1950).

DARK MICA ANALYSES

LOC & DESCR	SiO_2	Fe_2O_3	Al_2O_3	MnO	MgO	K_2O	TiO_2	V_2O_5	SOURCE
JMQ,TFA	39.19	25.59	25.63	2.83	6.82	8.05	1.88	0.00	EXCALIBUR, GAMBLE
JMQ, BIOTITE	45.35	13.25	16.70	0.00	14.24	7.44	0.76	3.23	EXCALIBUR, ESTES
JMQ, BIOTITE	61.02	6.13	14.40	0.00	9.10	6.03	1.78	0.00	EXCALIBUR
JMQ, PHLOGOP	45.08	18.89	7.02	0.00	22.99	4.75	0.00	0.00	EXCALIBUR
PROTOVERMIC	33.28	6.36	14.88	0.00	21.52	0.00	0.00	0.00	KOENIG 1877
CCA, PHLOGOP	38.67	8.16	14.11	0.45	21.81	9.76	1.40	0.00	ERICKSON & BLADE 1963

BRITHOLITE Group name synonym.

Diamond Jo quarry. Matted masses of pale pink needles were originally thought to be pectolite. It occurs in larger than normal cavities found in a quartz-rich xenolith. They were identified as probable britholite by Henry Barwood using XRD. They have a fairly bright green fluorescence and occur with barite, quartz, albite, and aegirine. Barwood also noted a rose red britholite crystal in a miarolitic cavity.

BROOKITE TiO_2

Brookite deposits on east rim. Brookite crystals from these deposits were originally called “arkansite”. They are usually a brilliant black and occur as equant to thick tabular crystals, ranging from 1 mm to 5 mm and rarely over 2 cm. Most of the crystals are attached to quartz or have become detached from the quartz (Williams 1891, 304-310). The brookite may be included in quartz. However, most of the crystals are loose or attached to quartz. The brookite crystals may also have minute inclusions of acicular rutile (Fryklund & Holbrook 1950). The larger brookite crystals from the Christy deposit often have a skeletal interior. This possibly accounts for the lower specific gravity reported by most early writers (Howard 1999). The Harver Hills subdivision and Magnet Cove school areas produced small bright crystals of brookite loose in the soil during construction. Some were elongated and were up to 5 mm long. A few had a tinge of red in them (Smith 2003). At the Hardy-Walsh deposit, numerous small brilliant crystals mostly under 5 mm were collected by Clyde Hardin in a large pocket of smoky quartz in 1979-1980 (Smith 1988, Smith 2003). Moses Hill or the Rutherford property is just south and across the highway from the Magnet Cove Cemetery. It was the favorite digging place for brookite crystals and gray smoky quartz for over 30 years. The larger brookite crystals from here tend to be more tabular and less bright than those from the other localities of the east rim. Clyde Hardin had much success digging here in the 1970s and 1980s (Smith 2003).

Brookite deposits, west rim. Brilliant red, semi-transparent crystals to 7 mm occur on sandstone south of Thomas Holt house near the road leading south along the ridge (Williams 1891, 322).

Brookite deposits, south rim. Brookite occurs scattered among the decomposition products for the syenite (Williams 1891, 323).

Central Cove area. Some brookite has been found (Williams 1891, 181).

Cove Creek Bridge pegmatite. Black, lustrous, brookite crystals to 6 mm were found adhering to aegirine crystals in 1985. The brookite has the same crystal form as the brookite in the altered novaculite (Howard 1999).

Diamond Jo quarry. Brookite occurs as tiny equant, black crystals up to 0.5 mm across. It was common in the quartz syenite found on top of the quarry, but very rare in the miarolitic cavities in the quarry. It is associated with aegirine and quartz crystals (Smith 1989).

Kimzey calcite quarry. Brookite occurs in the carbonatite (Nizamoff, Falster, Simmons & Webber 1998).

Kimzey magnetite mine. Brookite occurs at this location and is reported by Nizamoff, Falster, Simmons, and Webber (1998).

Martin Marietta Jones Mill quarry. Brookite occurs with the anatase on beds on tiny white quartz crystals in a 1998 find. The lustrous black crystals are up to 2 mm across and are flat with grooves and ridges on the large faces. The smaller faces are smooth and may reflect a blue iridescence under strong light. Many of the brookites are inconspicuous because they are implanted on their thin edge and the characteristic large face does not show (Smith 1998).

Mo-Ti prospect. Brookite crystals up to 1 cm across occur in the feldspar veins at this prospect (Fryklund & Holbrook 1950). These crystals have a different morphology than the crystals from the brookite deposits in the novaculite (Howard 1999). However, most of the crystals are less than half that size. They are usually well-formed bright bipyramids (Howard 2001). The brookite occurs on altered white orthoclase or scattered on pyrite or rutile, all in turn may be coated with molybdenite (Howard 1999). Clyde Hardin found that small brookites may occur on the rutile paramorphs after brookite. Some of the other brookites are the same size and crystal form as the paramorphs (Smith 2004).

Perovskite Hill. Brookite reported by Williams (1891, 184). No brookite was seen in the material collected by Clyde Hardin in the 1970s to 1990s (Smith 2004), but the crystals may have been too small to be collected in the screens he used.

Runyan quartz deposit. Small crystals occur with and on quartz crystals (Williams 1979).
The deposit is located 1 mile north and 25 degrees west of the Mo-Ti prospect. The tiny black crystals rarely coat quartz crystals and may be intergrown with kaolin (Howard 1999).

BROOKITE ANALYSES

LOC & DESCR	TiO_2	Fe_2O_3	SiO_2	Nb_2O_5	V_2O_5	SOURCE
UN SPEC. XL	99.36	1.36	0.75	-	-	DAMOUR & DES CLOIZEAUX 1849
UN SPEC. XL	96.50	1.00	2.00	-	-	HERMANN 1851
CHRISTY XLS	95.93	0.81	0.06	2.86	0.70	FLOHR 1994 (AVERAGE)

BRUCITE $Mg(OH)_2$

Cove Creek bridge and the Branch pegmatites. Brucite occurs in white transparent or partly transparent hexagonal plates up to 2 mm across, but many are much smaller and show a laminated surface (Williams

1891, 253). Although no specific locality is given for his material, Foshag (1923) suggests that catapleiite is the brucite of Williams (1891).

BURBANKITE $(Na,Ca)_3(Sr,Ba,Ce)_3(CO_3)_5$

Martin Marietta Jones Mill quarry. White to yellow prismatic crystals of burbankite occur in altered carbonate layers. The crystals are up to 1 mm long and vary from opaque to translucent. They have been identified by EDS analysis (see below).

BURBANKITE ANALYSIS

LOCATION/ DESC.	CO_2	Na_2O	SrO	CaO	BaO	SOURCE
JMQ, PRISM. XL	44.28	13.03	34.14	5.79	2.75	EXCALIBUR

CACOXENITE $Fe^{3+}_{24}Al(PO_4)_{17}O_6(OH)_{12}\cdot17H_2O$

Christy mine. Small amounts are reported (Barwood & de Linde 1989). It occurs as small orange spheres up to 3 mm across that have a radiating internal structure. It is associated with goethite and may coat crusts of smoky quartz crystals (Howard 2004).

Martin Marietta Jones Mill quarry. Minute golden yellow spheres, hemispheres, and bow ties, composed of minute acicular crystals, occurred with goethite-rich baked and altered rocks collected by Karl Estes.

Titanium Corp of America pit. Reported in minute amounts (Barwood & de Linde 1989). J.M. Howard (2004) observed microscopic spherical crystal clusters coating rutile.

CALCITE $CaCO_3$

Central Cove area. Calcite is abundant in the area. It was noted as occurring in thin lens-shaped masses between vermiculite books (Williams 1891, 225).

Chamberlain Creek Barite mines. Crusts of orangish scalenohedral crystals, 5 cm thick, were collected from the underground workings of the Macobar (Magnet Cove Barium Corporation) mine. They are fluorescent red under short wave ultraviolet light (Howard 2004).

Diamond Jo quarry. Clear calcite crystals have been found in some cavities, but are rare (Smith 1989).

Kimzey calcite quarry (KCP). Calcite is the major component of the carbonatite found at this quarry and elsewhere in the cove. It is a white to pale gray and readily breaks into rhomobhedral cleavages, usually under 2 cm in size. Distinct well-formed crystals are not common in the carbonatite. Secondary calcite crystals are found in vugs in a fine-grained dark rock. The crystals are cream-colored rhombohedrons. The calcite may have a yellow thermoluminescence and some has a pink fluorescence under short wave ultraviolet light (Shockley 1948).

Martin Marietta Jones Mill quarry. Calcite occurs as white to green rhombohedral crystals in cavities and veins in altered shale with acicular amphibole, fluorite, and aegirine. Pale yellow scalenohedrons of calcite have been noted. Pale brown scalenohedrons may have tainiolite crystals on them (Estes 1998). Clear, bright, well-formed discoidal microcrystals with many faces were collected in small cavities in the syenite in 2002. It may be associated with pale tan garnets and magnetite octahedrons in tiny cavities well under 1 cm across. In 2004, some individual, very pale pink to white, frosted, 1 to 2 mm equant, manganoan calcite was found in cavities in syenite. They fluoresce a bright hot pink under short wave ultraviolet light.

Mo-Ti prospect. Calcite has only been observed in small veins in the jacupirangite (Holbrook 1948).
South border of the Cove. Calcite associated with sodalite and fluorite is thermoluminescent. It glows a brilliant yellow, almost flame-color as does all the Magnet Cove calcite tested (Miser & Glass 1941).
Titanium Corporation of America pit. Calcite is reported as occurring in cleavable masses in carbonate veins (Smith 1996).

CALCITE (CARBONATITE)

LOCATION/ DES.	SiO_2	CaO	CO_2	P_2O_5	MgO	SOURCE
KCQ, CLEAV.	1.90	53.37	39.41	2.00	1.05	ERICKSON & BLADE 1963
KCQ BULK	0.15	55.30	39.28	0.12	0.38	BROOKINS 1967

CANCRINITE $(Na,Ca,{}_{,}\square)_8(Al_6Si_6O_{24})(CO_{3,}SO4)_2\cdot 2H_2O$

Central Cove area. Cancrinite forms along the surface of and within cracks in nepheline. It is observed in petrographic thin sections (Williams 1891, 225).
Diamond Jo quarry. Cancrinite occurs as white veinlets in garnet pseudolucite syenite and is an alteration of nepheline.
Jacupirangite locality. An outcrop of jacupirangite occurs in Cove Creek northeast of the Mo-Ti prospect. Cancrinite occurs as an alteration of nepheline in this rock (Howard 2002).

CARBONATE-FLUORAPATITE $Ca_5(PO_4,CO_3)_3(F,O)$

Central Cove area (CCA). Carbonate-fluorapatite occurs as porcelaneous replacements and over growths, partly filling cavities within fluorapatite crystals (McConnell & Gruner 1940).
Kimzey calcite quarry. Carbonate-fluorapatite occurs as inclusions and replacements in fluorapatite crystals in the carbonatite. Pale yellow to white and brown crystals of fluorapatite that contain the carbonate-fluorapatite may reach a length of 5 cm or more. It is impossible to visually determine the carbonate-fluorapatite from the fluorapatite in the crystals, except with a petrographic microscope (McConnel & Gruner 1940).
Magnet Cove Baptist Church (MCC). J.M. Howard reports in the March 1997 edition of the *Hot Springs Geology Club News* that a carbonatite dike exposed in the Branch in front of the church contains green biotite and fine-grained carbonate-fluorapatite.
Martin Marietta Jones Mill quarry (JMQ, MMQ). Henry Barwood in 1996 collected some corroded drusy quartz veins that had some, white, simple hexagonal prisms of relatively pure carbonate-fluorapatite by analysis. The crystals were up to 6 mm in length.

CARBONATE FLUORAPATITE ANALYSES

LOC. & DESCR	Ca	P	F	Al	Fe	Sr	Ba	La	Ce	S	SOURCE
MCC, PRIS. XL	54.65	45.28	1.62	0.01	0.04	0.57	0.06	0.10	0.20	0.05	BARWOOD, MP
JMQ, PRIS. XL	53.71	44.74	4.03	0.03	0.51	1.20	0.09	0.02	0.09	0.06	BARWOOD, MP
CCA, PRIS. XL	54.55	42.00	4.16	-	0.16	-	-	-	-	-	WILLIAMS 1891

CATAPLEIITE $Na_2Zr(Si_3O_9)\cdot 2H_2O$

Cove Creek bridge pegmatite. Foshag (1923) identified catapleiite, probably from this location, as translucent ivory yellow to faint pink aggregates of hexagonal crystals up to 3mm and suggests that this is the "brucite" of Williams (1891). The brown alteration that may form rims around eudialyte are catapleiite, baddeleyite, låvenite, paraumbite, and barytolamprophyllite (Nizamoff, Falster, Simmons and Webber 1998).

Diamond Jo quarry. Groups of clear to tan hexagonal crystals under 1 mm across occur with pectolite, orthoclase, and aegirine (Smith 1998).

Martin Marietta Jones Mill quarry. Estes (1998) observed plates of colorless pseudohexagonal catapleiite associated with epidote.

CELESTINE $SrSO_4$

Chamberlain Creek barite mines. Celestine is reported with the barite at these mines (Parks & Branner 1932).

CHABAZITE – (?) $(Ca, K_2, Na_2)_2[Al_4Si_8O_{12}]_2 \cdot 12H_2O$ undiffentiated as to species.

General. Chabazite occurs with natrolite and calcite in mafic igneous rocks (Howard 1977).

Martin Marietta Jones Mill quarry (JMQ). Minute light brown crystals and aggregates of crystals in altered shale were identified as chabazite-Ca.

CHABAZITE ANALYSIS

LOCATION/DESC.	MgO	Al_2O_3	SiO_2	K_2O	CaO	BaO	Fe_2O_3	SOURCE
JMQ, brown	2.22	16.71	70.54	1.72	3.98	2.75	2.08	EXCALIBUR

CHALCOPYRITE $CuFeS_2$

Christy mine. Trace amounts of chalcopyrite occur with amphibole and tainiolite (Flohr 1994).

Martin Marietta Jones Mill quarry. Green coatings and spheres associated with some pyrite looking masses indicate that some of it is chalcopyrite. No distinct crystals have been reported.

Titanium Corp of America pit. Small amounts of chalcopyrite occur as an accessory mineral in hybrid rocks (Flohr 1994).

CHAMOSITE $(Fe^{2+},Mg,Al, Fe^{3+})_6(SiAl)_4O_{10}(OH,O)_8$

Martin Marietta Jones Mill quarry (JMQ). Microscopic black to dark green discs associated with green calcite, acicular amphibole, rutile and other minerals were identified as chamosite by EDS analysis and not siderophyllite as originally thought (Estes 1998). See analyses below. Microscopic gray spheres of platy crystrals are also chamosite (see below).

CHAMOSITE ANALYSES

LOC & DESC.	Fe_2O_3	SiO_2	MgO	Al_2O_3	K_2O	TiO_2	Cl_2O	SO_3	MnO	SOURCE
JMQ, GREEN	46.16	25.84	9.61	18.39	0.00	0.00	0.00	-	-	EXCALIBUR, ESTES
JMQ, BLACK	34.16	34.55	9.16	17.41	1.60	0.41	0.63	-	-	EXCALIBUR
JMQ, GRAY	49.65	26.90	3.27	10.59	1.76	0.00	0.00	3.23	2.83	EXCALIBUR

CHERALITE-(Ce) $(Ce,La)(PO_4) \cdot H_2O$ Discredited species, actually is Rhabdophane-(Ce).

Mo-Ti prospect. Cheralite-(Ce) is reported from this prospect as microscopic light tan aggregates of thin crystals. What appears to be the same mineral has been identified as rhabdophane-(Ce). The EDS analysis of each is different. The cheralite-(Ce) analysis has the Si that the rhabdophane-(Ce) does not have. The rhabdophane-(Ce) occurs in thin tan hexagonal crystals and has Nd that is not reported from the cheralite-(Ce). This mineral name was discredited by the IMA in favor of the name Rhabdophane – (Ce), but since it was in the literature it was included here. See Rhabdophane – (Ce) below.

Chlorite group minerals undifferentiated

Cove Creek bridge pegmatite. Chlorite occurs as green to brown spheres and hemispheres up to 1 mm in diameter in the syenite pegmatite (Smith 1999a).

Kimzey calcite quarry. Chlorite is an alteration of monticellite. It forms green radiating or earthy masses. Tremolite appears to be an intermediate weathering product between chlorite and monticellite (Shockley 1948).

Martin Marietta Jones Mill quarry. Brown and green spheres and hemispheres of chlorite are common in altered rocks where they are perched on tainiolite crystals and associated with colorless quartz crystals. Dark green spheres are present in cavities within the syenite. Probably most are chamosite but this has not been confirmed.

CHRYSOTILE – see CLINOCHRYSOTILE

CHURCHITE-(Y) $Y(PO_4)\cdot 2H_2O$

Christy mine. White radiating microscopic spheres that look like tiny sea urchins are rare in recrystallized novaculite at this locality (Howard 2001), identification by Ross and Flohr of the USGS.

Clay minerals – undifferentiated and mixtures

Kimzey Magnetite mine (KMM). A soft white clay mineral was found in seams of massive magnetite collected along the gas pipeline right-of-way not far from the lime-silicate pits by Gene Bearss in the late 1960s. EDS indicates it is probably a mixture, possibly similar to “corrensite”.

“CORRENSITE” ANALYSIS

LOCATION/DESC.	MgO	Al_2O_3	SiO_2	Fe_2O_3	SOURCE
KMM, Clay	23.68	27.49	43.91	4.19	EXCALIBUR

CLINOCHRYSOTILE $Mg_3Si_2O_5(OH)_4$

General. Clinochrysotile is an alteration mineral reported as chrysotile and occurs with amphiboles and pyroxenes (Erickson & Blade 1963)

CLINOCHLORE $Mg_5Al(AlSi_3O_{10})(OH)_8$

Kimzey Magnetite mine area. Gene Bearss collected some magnetite from the gas pipeline where it crossed this area in the late 1960s. Small amounts of a greenish-gray micaceous mineral occur with magnetite and a white clay mineral mixture. It lines tiny cavities and is flat to bubbly in habit. An EDS indicates that it probably clinochlore.

CLINOCHLORE ANALYSIS

LOCATION/DESC.	MgO	Al_2O_3	SiO_2	Fe_2O_3	SOURCE
KMM, GR-GR	36.63	25.57	36.71	1.09	EXCALIBUR

CORDIERITE $(Mg,Fe)_2Al_3(AlSi_5O_{18})$

General. Cordierite was reported by Comstock (1888), but its presence has not been confirmed by subsequent collecting and analytical work.

CRANDALLITE $CaAl_3(PO_4)(PO_3OH)(OH)_6$

Diamond Jo quarry. Crandallite (pseudowavellite) was reported as colorless needles in miarolitic cavities (Erickson & Blade 1963, 11). Charles Milton (1977 personal communication) reports that this mineral is probably pectolite.

CRYPTOMELANE $K(Mn^{4+}{}_7Mn^{3+})O_{16}$

Christy mine. (CM) Microscopic black acicular crystals have been identified as cryptomelane. They are very similar to paramontroseite (Henry de Linde 1990, personal communication). Cryptomelane commonly contains minor amounts of phosphorous and barium though barium-rich cryptomelane with up to 4.57 weight percent BaO is rare (Flohr 1994). Also occurs as black sooty coatings on quartz (Howard, personal observations).

CRYPTOMELANE ANALYSIS

LOC & SOURCE	MnO_2	MnO	K_2O	Al_2O_3	BaO	SOURCE
CP	83.28	5.02	5.06	0.56	0.33	Flohr 1994

DELINDEITE $(Na,K)_2(Ba,Ca)_2(Ti,Fe,Al)_3(Si_2O_7)_2O_2(OH)_2 \cdot 2H_2O$

Diamond Jo quarry. This is the type location for delindeite. It occurs in pale pink, gray, or brownish compact spherical aggregates, rarely reaching 1 mm in diameter (Appleman et al 1987). Rarely the aggregates have a distinct bow tie form. The individual crystals are micron-size laths or flakes. It is associated with the labuntsovite suite of minerals and is common in these cavities (Smith 1989).

DIASPORE AlO(OH)

Stone Quarry Creek. Scull (1959) reported deep blue crystals with quartz crystals and goethite from a quartzite bed about 80 feet above the creek in the SE1/4, section 29. His description fits the description of anatase from the Diamond Jo quarry (Howard 1977).

DICKITE $Al_2(Si_2O_5)(OH)_4$

Brookite deposits on east rim. Dickite is one of the clay minerals reported in these deposits and is associated with tainiolite (Miser and Stevenson 1938). It is generally white, but may be stained red-brown with iron oxide.

DIOPSIDE $CaMgSi_2O_6$

General. Diopside occurs chiefly in the ijolite group rocks and as diopside-hedenbergite in the syenite, phonolite, and jacupirangite. Aegirine-diopside occurs chiefly in the syenite and phonolites as rims around a diopside-hedenbergite core (Erickson & Blade 1963, 70). The large cleavable green crystals several centimeters long that were recoverd from the natural gas pipeline crossing of Cove Creek in the late 1960s have been labeled diopside, but analysis shows them to be augite.

Central Cove area. (CCA). Pale green diopside was observed in petrographic sections (Williams 1891, 217). Green diopside is usually less than 2.4 cm in the ijolite (Erickson & Blade 1963, 28). It was reported that large (15 cm long) crude diopside prisms were collected from the gas pipeline crossing of Cove Creek in the late 1960s. However, these are augite, not diopside.

Cove Creek bridge, south 800 feet. An altered phonolite has andradite-lined amygdules with colorless diopside in the center with calcite, pyrite, garnet, wollastonite, and a zeolite (Erickson & Blade 1963, 25-26).

Lime-silicate area. (LSA). The rock is composed of fine- to medium-grained anhedral vesuvianite and colorless diopside. A mixture of diopside and other minerals partly replace melilite crystals. Well-formed diopside crystals line miarolitic cavities (Erickson & Blade 1963, 39). The diopside crystals range from clear to white and prismatic to lath-like.

Kimzey magnetite pit. Banion (1959) reports that a large mass of syenite in the center of the mine contained large masses of hypersthene (possibly diopside) that had a pleasing chatoyancy when polished with the grain. Small crystals of diopside occur in cavities of vesuvianite (Stone et al. 1982).

Martin Marietta Jones Mill quarry. Microscopic chrome diopside crystals are reported by Henry Barwood (1997 personal communication). They come from a lamprophyre dike with chlorite and a blue fibrous amphibole.

Mo-Ti prospect. Diopside has been reported by some collectors. It probably occurs from near the jacupirangite.

Titanium Corp of America pit. Large green cleavages of diopside have been reported (Smith 1996).

DIOPSIDE ANALYSIS

LOC & DESC	CaO	SiO_2	MgO	Al_2O_3	Fe_2O_3	FeO	SOURCE
LSA, CLEAR	30.18	52.98	16.96	-	-	-	EXCALIBUR
LSA, WHITE	14.30	58.54	18.35	7.21	1.69	-	EXCALIBUR
CCA, GREEN	22.94	53.17	15.06	-	1.65	2.24	ERICKSON & BLADE 1963
CCA, GREEN	24.63	53.50	15.51	-	1.64	2.52	ERICKSON & BLADE 1963

DOLOMITE $CaMg(CO_3)_2$

Martin Marietta Jones Mill quarry (JMQ). White to pale gray, transparent to opaque, microscopic rhombs from Karl Estes are by analysis a slightly ferroan dolomite.

Titanium Corp of America pit. Euhedral dolomite crystals, averaging about 0.5 mm across, are one of the primary constituents of the dolomite-albite veins (Fryklund & Holbrook 1950). A specimen is on display in the Arkansas State collection at the Arkansas Geological Survey.

DOLOMITE ANALYSIS

LOCATION/ DESC.	CO_2	MgO	CaO	Fe_2O_3	SOURCE
JMQ, WHITE	59.54	19.26	18.16	3.06	EXCALIBUR

ELPIDITE $Na_2ZrSi_6O_{15}\cdot 3H_2O$

Diamond Jo quarry. Microscopic opaque, white, thin prismatic crystals of elpidite with pinacoidal terminations occurred in the quartz syenite above the quarry (Smith 1989).

Martin Marietta Jones Mill quarry (JMQ). Transparent lustrous acicular crystals are reported by Barwood (2016, personal communication).

EPIDOTE $\{Ca_2\}\{Al_2Fe^{+2}\}(Si_2O_7)(SiO_4)O(OH)$

Cove Creek bridge and the Branch pegmatites. The green felted masses identified as epidote by Landes (1931) are actually aegirine as suspected by Shockley (1945).

Martin Marietta Jones Mill quarry. Epidote occurs as green transparent crystals up to 4 mm long in open spaces in quartz veins with quartz crystals, fluorite, and pyrite. It is common but not abundant. Karl Estes has confirmed it by EDS analysis: Al_2O_3 – 27.37, SiO_2 – 45.32, CaO – 17.53, Fe_2O_3 – 9.78.

Titanium Corp of America pit. Epidote was observed microscopically as an alteration product in phonolite (Fryklund & Holbrook 1950, 20).

EUDIALYTE $Na_{15}Ca_6(Fe^{2+},Mn^{2+})_3Zr_3[Si_{25}O_{73}](O,OH,H_2O)_3(OH,Cl)_2$

Cove Creek Bridge (CCB) & Branch pegmatites. Eudialyte is conspicuous as transparent to translucent, crimson red to rose red to yellow crystals and crystal masses, ranging from 3 mm to 18 mm in diameter. The crystals are generally thick, tabular parallel to the base. Crystals with the positive rhombohedron dominant are larger than crystals with the negative rhombohedron dominant. The smaller crystals, less than 4 mm, generally have better form (Williams 1891, 241-247, 257-258). Yellow eudialyte (eucolite) forms rims around the eudialyte. Good specimens were collected during excavation of the Kimzey calcite quarry (Shockley 1948). The yellow alteration of eudialyte called eucolite has the same chemical composition and is recognized to also be eudialyte. The eudialyte crystals are often fractured and brittle so they are difficult to expose when embedded in the matrix (Smith 1994). A glassy pink crystal from the bridge area gave the EDS weight percent analysis shown below. Niobium oxide amounts vary from 0 to 0.30 % and titanium oxide may be up to 1 %.

Diamond Jo quarry (DJQ). Pink to red 1 to 2 mm eudialyte in crude crystals occur near, but generally not in miarolitic cavities. They are extemely rare and the senior author has only seen 3 or 4. In 1995 Henry Barwood ran a EDS on one of these matrix crystals (see below). Small, 1 mm or less, pale brown, pink or colorless, transparent equant prismatic crystals occur in cavities. They are probably within the Eudialyte Group. An EDS analysis by weight percent was run by Excalibur Minerals and is given below. Obviously the eudialyte in the matrix and that in the cavities are different. The cavity mineral may represent a new species for the Eudialyte Group.

EUDIALYTE ANALYSES

LOCATION/DESC.	SiO_2	ZrO_2	Na_2O	CaO	FeO	MnO	K_2O	Nb_2O_5	Al_2O_3	SrO	BaO	RE_2O_3	SOURCE
DJQ, Cavity	30.58	9.16	3.10	19.35	4.17	11.86	2.19	5.37	1.85	0.00	0.00	11.26	EXCALIBUR
DJQ, Matrix	47.75	12.49	6.75	11.76	3.09	2.15	0.00	0.00	0.00	6.78	0.00	0.00	EXCALIBUR
CCB, PINK	54.27	19.66	19.66	7.83	2.24	0.89	1.36	0.00	0.00	0.00	2.22	0.00	EXCALIBUR
CCB, PINK	51.83	11.45	13.25	14.77	4.37	0.37	0.43	0.00	0.00	0.00	0.00	0.00	GENTH 1891

FERBERITE $Fe^{2+}WO_4$

Mo-Ti prospect. Ferberite was reported by the Mo-Ti Corporation in a core, based on chemical analysis (Holbrook 1948). Its identification is considered doubtful (Smith 1996).

FERRIMOLYBDITE $Fe_2(MoO_4)_3 \cdot 8H_2O$

Mo-Ti prospect. The yellow coatings with molybdenite thought to be ferrimolybdite (Smith 1996) were found to be plumbojarosite on EDS analysis. See plumbojarosite.

FERRO-HORNBLENDE $\square\{Ca_2\}\{Fe^{2+}_4Al\}(AlSi_7AlO_{22})(OH)_2$

Diamond Jo quarry. Thick lustrous black crystals of ferro-hornblende occur with aegirine and pectolite. Multicolored and multiterminated prismatic amphibole crystals in the quartz syenite from above the quarry may also be in part ferro-hornblende (Smith 1989).

FERVANITE $Fe^{3+}_4V^{5+}_4O_{16} \cdot 5H_2O$

Christy mine. Fervanite occurs in quartz-brookite aggregates (Flohr 1994).

FLUORAPATITE $Ca_5(PO_4)_3F$

Apatite veins in NW1/4 section 20. Fine- to medium-grained subhedral apatite with some biotite and garnet make up the veins (Erickson & Blade 1963, 54).
Brookite deposits on the east rim. Fluorapatite occurs in mineralized quartz-rich rock at the Hardy-Walsh deposit (Flohr 1994).
Central Cove area. Fluorapatite occurs as large, hexagonal prisms up to 15 cm long and 2.5 cm in diameter, only a few show terminations. These crystals usually penetrate schorlomite or magnetite. It also is present as radiating masses of small needles embedded in schorlomite and nepheline. The color is white or pale yellow (Williams 1891, 181, 220-221). The white porcelaneous material in the crystals is carbonate-fluorapatite (McConnell & Gruner 1940). Most of the recent fluorapatite that has been found is less than 4 mm in diameter.
Christy mine. Apatite, possibly fluorapatite, occurs as inclusions in pyrite (Flohr 1994). In the early stages of mining, white, thin hexagonal crystals of apatite were encountered in a smoky quartz-feldspar dike with sulfides and other minerals.
Diamond Jo quarry. Tiny crystals of fluorapatite are inconspicuous on aegirine and orthoclase. They are cathodoluminescent and were detected by Henry Barwood (1986, personal communication). Larger, 0.5 mm, white stubby hexagonal prisms are rare (Smith 1989).
Kimzey calcite quarry. Fluorapatite occurs as needle-like crystals that are seldom more than 1 mm in diameter. These needles form radiating and parallel masses of crystals that are embedded in the calcite. They are usually pale green, yellowish brown, or white in color (Williams, 1891, 335). Portions of these crystals are carbonate-fluorapatite and may readily be delineated with a petrographic microscope (McConnell & Gruner 1950).
Kimzey magnetite mine. Veins of fluorapatite intergrown with andradite and vermiculite cut the lime-silicate rock and the ijolite country rock (Stone et al. 1982). Apatite, probably fluorapatite, occurs as crystals in the vesuvianite-diopside rock and line miarolitic cavities in the lime silicate rocks (Erickson & Blade 1963, 39).
Martin Marietta Jones Mill quarry. Stubby, colorless to pale pink fluorapatite occurs in simple to complex prisms in the anatase-brookite vein discovered in 1998. They are easiest seen when they are perched on anatase or brookite (Howard 1999). Clusters of pale yellow prismatic hexagonal crystals of fluorapatite with anatase were collected by Karl Estes and verified by EDS analysis. Pale blue microscopic prisms of fluorapatite to 0.5 mm occur with hematite in quartz veins.
Middle Tufa Hill. Fluorapatite, perovskite, and magnetite occur in the soil on the flat south of the hill (Fryklund, Harner & Kaiser 1954).

Mo-Ti prospect. Apatite, probably fluorapatite, occurs as minute inclusions in orthoclase (Holbrook 1948).

Titanium Corp of America pit. Fluorapatite is an accessory mineral in hybrid rocks (Flohr 1994) and has also been observed in the groundmass of weathered phonolite (Howard 2004).

FLUORAPATITE ANALYSIS

LOCATION/DESC.	F_2O	P_2O_5	CaO	SOURCE
JMQ, XLS	8.60	36.80	54.90	EXCALIBUR, ESTES

FLUORAPOPHYLLITE $KCa_4(Si_8O_{20})(F,OH) \cdot 8H_2O$

Cove Creek bridge pegmatite. Typical colorless to white prismatic crystals of fluorapophyllite occur in cavities in the pegmatite (Smith 1996).

Diamond Jo quarry. Fluorapophyllite occurs in miarolitic cavities as short prisms (Erickson & Blade 1963) and thick tabular crystals up to about 1 mm across. The crystals are clear, colorless and occur with pectolite, natrolite, orthoclase, and aegirine in the white orthoclase-rimmed cavities. It is common in these cavities, but not abundant (Smith 1989).

Kimzey calcite quarry. Veinlets that cross-cut the carbonatite contain fluorapophyllite. Crystals from these veinlets exhibit complex combinations of crystal forms. They typically show faces associated with first- and second-order tetragonal prisms, a tetragonal dipyramid, and a pinacoid (Tice, Falster & Simmons 1998).

Mo-Ti Corporation prospect. Crystals of fluorapophyllite occur in vugs with molybdenite and pyrite (Sleight 1941).

Martin Marietta Jones Mill quarry (JMQ). Pale brown, transparent, elongated prismatic crystals up to 8 mm long, intergrown and as small radiating sprays were collected from a ping pong ball-size miarolitic cavity in syenite in April 2004. The crystals are terminated by a dipyramid and a pinacoid. They occur with and are included in calcite of the same color and can be easily overlooked. See analysis below.

FLUORAPOPHYLLITE ANALYSES

LOCATION/DESC.	SiO_2	CaO	Fe_2O	K_2O	MgO	FeO	Al_2O_3	SOURCE
JMQ, pale tan	63.51	20.24	5.29	4.47	2.83	2.35	1.13	Excalibur

FLUORITE CaF_2

General. Fluorite forms small purple crystals embedded in nepheline syenite and as larger vein fillings along seams in masses 3 to 5 cm in diameter and usually less than 2 mm thick. It has a yellowish green thermoluminescence. It also occurs as yellow or colorless transparent crystals (Williams 1891, 238). Fluorite occurs as purple grains in a fine-grained, gray syenite. It is also reported from the south central portion of the Cove (Shockley 1948).

Diamond Jo quarry. Fluorite and sodalite coat joints of pegmatite (Erickson & Blade 1963, 54). Irregular masses of colorless to pale purple fluorite are rare in some cavities (Smith 1989).

Kimzey calcite quarry. Purple fluorite is intimately associated with calcite in the carbonatite (Meurer et al. 1989).

Martin Marietta Jones Mill quarry. Fluorite is common and abundant, estimated up to 3% in small syenite dikes in altered and fenitized shale. It occurs in grains less than 2 mm across embedded in the matrix. Faces are rare but it can form incomplete cubic crystals in the matrix or in cavities. It is usually pink or pale peach color, but rose, pale purple and colorless fluorite have also been observed (Smith

2001). Colorless, blue, pale yellow, and purple fluorite occurs in fractures and quartz veins in the altered shale. Crystals are cubes, dodecahedrons, and combinations of these forms. Incomplete and broken crystals up to 4 cm have been found, but most are much smaller (Estes 1998). Colorful seams of intermixed purple fluorite, orange calcite (now known to be siderite JMH), and pyrite were observed in in syenite from the lowest quarry level (Smith 2004).

South border of the Cove. Purple fluorite rims sodalite masses in a fine-grained dark greenish dike rock. The fluorite and associated calcite are thermoluminescent. The fluorite glows a yellow-green color and the calcite a brilliant yellow, almost flame color (Miser & Glass 1941).

Titanium Corp of America pit. Fryklund & Holbrook (1950, 26) noted a veinlet of fluorite in the mine.

FORSTERITE Mg_2SiO_4

Kimzey Calcite quarry. Forsterite occurs as small inclusions in fluorapatite (Nesbitt and Kelly 1977).

GALENA PbS

Christy mine. Small, less than 5 mm, cubooctahedral crystals were found in cavities in feldspar-quartz veins exposed when a water treatment pit was dug prior to mining in 1980. The galena is associated with pyrite, fluorapatite, sphalerite, and smithsonite.

Cove Creek Bridge and the Branch pegmatites. Shockley (1945) reported one small cubic crystal of galena from the Branch pegmatite. Sulfide mineralization in the form of galena, pyrrhotite, pyrite, and sphalerite occurs in the pegmatite (Tice, Falster, & Simmons 1999). Small amounts of galena have also been found in the contact metamorphic rocks (Smith 1996).

Perovskite Hill. The junior author identified very scarce octahedral galena in concentrates from this site.

Martin Marietta Jones Mill quarry. Galena is rare as dull silvery cubic crystals 1 mm across or smaller and is associated with sphalerite. It occurs in both quartz and carbonate veins.

Mo-Ti prospect. Microscopic blobs and masses of galena are in albite veins (Smith 1996).

Titanium Corp of America pit. Galena was rarely encountered during processing of the titanium ores. The junior author recovered a single 0.5 inch cubic galena crystal loose in soil residuum in the area.

GOETHITE $\alpha\text{-}Fe^{3+}O(OH)$

Brookite deposits on east rim. Cubic pseudomorphs of goethite after pyrite up to 2 cm across occur with brookite and gray porous quartz at the Rutherford deposit (Moses Hill) (Smith 1988). See also Christy mine.

Central part of the Cove. Goethite octahedrons up to 1.2 cm across are pseudomorphs after pyrite or magnetite (Bettencourt, Smith, and Howard 1994).

Chamberlain Creek barite mine. Botryoidal and stalactitic goethite specimens were found on the dumps with massive barite (Welch 1968).

Christy mine. Vanadium was recovered from goethite-rich clay and brookite in the 1980s (Stone, Howard, and Holbrook 1982). Goethite contains significant amounts of cations other than iron, most notably vanadium, phosphorous, aluminum and silica (Flohr 1994). Microscopic needle-like crystals purchased as montroseite were subjected to SEM/EDS and XRD. Although the specimens contained titanium and vanadium, they are goethite, perhaps pseudomorphs after rutile (Tony Nickisher 1999, personal communication). Bright black blades forming crystalline surfaces on the veins and nodules of massive granular material intergrown with quartz and iridescent brookite were collected from the lower part of the pit. These masses and crystals give a XRD pattern for goethite but EDAX analysis shows they are a vanadium iron oxide. The powdered material is dark green (Henry Barwood 1995 Coon Creek Assoc. communication).

GOETHITE, ANALYSES OF MATERIAL THOUGHT TO BE MONTROSEITE.

LOCATION/DESC.	Fe_2O_3	SiO_2	TiO_2	V_2O_5	Al_2O_3	SOURCE
CHRISTY	68.84	9.56	3.89	17.72	0.00	EXCALIBUR
CHRISTY	61.31	3.08	7.68	27.19	0.93	EXCALIBUR
CHRISTY	80.82	1.37	0.09	0.39	1.64	FLOHR 1994
CHRISTY	72.22	0.90	0.62	6.04	1.26	FLOHR 1994
CHRISTY	56.83	22.98	-	19.85	0.35	EXCALIBUR

Cove Creek Estates are located in the west and north northwest portions of the cove. Altered feldspar dikes contain goethite cubes and striated cube-pyritohedrons to 5 cm in maximum dimension. They are pseudomorphic after pyrite (Smith 1988).

Diamond Jo quarry. The miarolitic cavities contain several brown to pumpkin colored goethite pseudomorphs after unknown minerals. Some are possibly after an amphibole, others may be after pyroxene (Smith 1988).

Harver Hills subdivision. Clyde Hardin collected in this area in 1976 when construction was on going. Cubic goethite crystals were collected during screening for brookite crystals, and are attracted to a magnet or are magnetic (Smith 2003). Smith thought these crystals might have a core of magnetite, but on close examination of broken crystals, he could find none.

Martin Marietta Jones Mill quarry. Tiny bright octahedrons in heavily oxidized quartz veins in the upper level of the west part of the quarry were thought to be magnetite. However, an SEM-EDS analysis shows the crystals to be goethite. They are probably a pseudomorph after magnetite. Small magnetic cubes similar to those that Clyde Hardin found at the Harver Hills subdivision were found loose in some sand during the early collecting at what was then known as the Highway 51 quarry. Goethite also occurs as small black botryoids and short bronze acicular crystals.

Perovskite Hill. Cubic goethite after pyrite has been found in the soil. They range up to just over 1 cm across (Smith 1996).

Ross property located south of Perovskite Hill along Cove Creek has yielded small, brown, goethite rhombohedrons probably pseudomorphs after siderite.

Titanium Corp of America pit area. Cubes and striated cubo-pyritohedrons to over 3 cm of goethite are pseudomorphs after pyrite. They occur loose in the soil and in feldspar dike rock (Smith 1988).

GONNARDITE $(Na,Ca)_2(Si,Al)_5O_{10} \cdot 3H_2O$

Diamond Jo quarry. Large, to 5 cm, blocky gonnardite pseudomorphing earlier formed nepheline crystals occur in ijolite xenoliths (Howard 2004).

Jacupirangite locality. A jacupirangite outcrop in Cove Creek is located northeast of the Mo-Ti prospect. Microscopic gonnardite occurs as white fibrous crystals and sprays in tiny cavities formed from the alteration of nepheline (Howard 2001), identified by XRD (C. Milton personal comm.).

GROSSULAR $Ca_3Al_2(SiO_4)_3$

Cove Creek bridge and the Branch pegmatites. A group of minute, pale yellow, dodecahedral crystals found in one specimen of pegmatite with pyrophanite, aegirine, and albite may be grossular. It has not been verified by analysis (Smith 1994).

Lime-silicate area. (LSA), Kimzey magnetite mine. Pale orange brown crystals, most less than 2 mm across occur with white diopside. Analysis shows them to actually be grossular-andradite in composition.

GROSSULAR ANALYSIS

LOCATION/DESC.	SiO_2	Al_2O_3	CaO	Fe_2O_3	SOURCE
LSA, ORANGE	49.79	16.44	24.31	9.47	EXCALIBUR, GROSSULAR-ANDRADITE

GYPSUM $CaSO_4 \cdot 2H_2O$

Chamberlain Creek barite mines. Gypsum occurs in veins and beds associated with barite and celestine.

Cove Creek bridge pegmatite. Clear crystals and masses up to 1 mm of gypsum occur in small cavities of the syenite pegmatite (Smith 1999a). A small amount of finely crystalline white gypsum has been reported by Shockley (1945). It comes from the contact rocks between the pegmatite and the carbonatite.

Diamond Jo quarry. Clear, colorless gypsum crystals to 3 mm tall dominate some of the small miarolitic cavities. It is associated with a cotton-like pectolite or the labuntsovite suite of minerals (Smith 1989).

Kimzey calcite quarry. Small amounts of white crystalline gypsum have been found in solution cavities in the carbonatite (Smith 1996).

Martin Marietta Jones Mill quarry. Gypsum occurs as small branching or radiating sprays of transparent colorless crystals. It occurs in cavities and in thin seams of the silicified shale, and appears almost dendritic. Small masses of crystallized colorless gypsum almost completely fill some cavities in the syenite associated with altered xenoliths.

Mo-Ti Prospect. Gypsum occurs as microscopic groups of thin colorless divergent crystals in cavities of albite with pyrite. They are obviously secondary and some may have formed after the specimens were collected.

HALLOYSITE $Al_2(Si_2O_5)(OH)_4$

Mo-Ti prospect. The clay mineral halloysite is reported in small amounts by Fryklund & Holbrook (1950).

HEDENBERGITE $CaFe^{2+}Si_2O_6$

Cove Creek Bridge and the Branch pegmatites. The pyroxene hedenbergite occurs as phenocrysts in the groundmass, but aegirine is present in the cavities (Tice, Falster, & Simons 2001).

HEMATITE Fe_2O_3

General. Minute inclusions of vanadian hematite occur as minute rosettes in smoky quartz within altered novaculite surrounding Magnet Cove (Tice, Falster, & Simmons 1999).

Brookite deposits on east rim. Landes (1931) reports hematite from these deposits.

Central Cove area. Hematite octahedral pseudomorphs after magnetite up to 6mm across have been reported (Bettencourt, Smith and Howard 1994). Flat, brown to black, pseudohexagonal crystals are rare in the soil. They are up to 2.4 cm across.

Diamond Jo quarry. Brown to reddish, opaque, non-metallic, acicular to narrow, thin bladed crystals that may be recticulated, but also occur as subparallel crystals and in jackstraw arrangement are mostly iron oxide by EDS analysis. Henry Barwood suggests that they may be hematite after pyrite. No such form of pyrite has been found elsewhere in the Magnet Cove area.

Harver Hills-Magnet Cove School. Striated cubo-pyritohedrons of hematite after pyrite that are attracted to a magnet were found in 1976 while screening for brookites on the pipeline right of way just south of the school (Smith 1998). One crystal is actually magnetic and pulls the others toward it (Smith personal observation).

Martin Marietta Jones Mill quarry. Cubic hematite crystals after pyrite with a thin coating of goethite were found loose in sand on the surface. The crystals range in size from 3 to 5 mm, are lightly striated, occur as singles or intergrown crystals, and are attracted to a magnet (Smith 1998). Hematite is abundant in cavities in altered shale in the upper level of the quarry. It occurs as thin-bladed black crystals. It is difficult to collect undamaged specimens. Rarely, the hematite occurs as lustrous and at times, iridescent roses up to 3 mm across. Associated minerals are goethite, jarosite, opal, orthoclase, phlogopite, pyrite, and quartz (Smith 1999).

Middle Tufa hill. Hematite occurs in a layered massive deposit with interspersed radiating spherules of yellow quartz crystals up to 2 mm in diameter (Shockley 1948).

Perovskite Hill area. West of the hill in a small stream bed between it and the main ridge, hematite occurs as large flat plates, 2 to 2.5 cm in diameter bounded by the basal pinacoid, a positive rhombohedron and possibly other faces. Rutile occurs on the hematite. Hematite also occurs as “iron roses” that are usually less than 8 mm in diameter. They consist of numerous very thin plates arranged in rosettes. The hematite occurs loose in the soil or is embedded on the sandstone (Williams 1891, 330).

Titanium Corp of America pit. Small pseudohexagonal, flat, brown to black crystals of hematite have been found loose in the soil (Smith 1996).

HERCYNITE $Fe^{2+}Al_2O_4$

Kimzey calcite quarry. Hercynite occurs in the carbonatite in black octahedrons that were not differentiated from perovskite until recognized during microprobe analysis by Henry Barwood. The crystals generally range from 2 to 4 mm. Crystal edges are slightly beveled, and the tips are never truncated. It may be associated with green biotite and, in some areas, it is as abundant as perovskite and may be intergrown with it. (Smith & Henderson 1992)

HEULANDITE $(Ca,Na,K)_5(Si_{27}Al_9)O_{72} \cdot 26H_2O$

Christy mine. Microscopic clear crystals of heulandite were found on novaculite during stripping operations in 1981 (Smith 1996). The crystals are well-formed and range from 0.5 to 1 mm. These crystals have not been checked by analytical methods.

HEWETTITE/METAHEWETTITE $CaV_6O_{16}\cdot 9H_2O$ / $CaV_6O_{16}\cdot 3H_2O$

Christy mine. Hewettite/metahewettite occurs as microscopic reddish crystals on brookite (Howard 2001).

ILMENITE $Fe^{2+}TiO_3$

Brookite deposits on east rim. Ilmenite occurs as an accessory mineral in dikes at the Hardy-Walsh prospect (Flohr 1994).
Central Cove area. Large jagged pieces of ilmenite showing a purplish color were observed (Williams 1891, 218).
Christy mine. During the construction of one of the waste pads, altered Stanley Shale was exposed. Veins of quartz and feldspar crosscutting the altered rock rarely contained black bladed ilmenite, It was identified by the U.S. Geological Survey (Howard 2004).
Martin Marietta Jones Mill quarry (JMQ). Ilmenite is common and abundant in the matrix of the small syenite dikes that cut the altered shale. It occurs in gray to black, rarely silvery black, small rounded masses up to 3 mm across. In some instances, flat plates of ilmenite extend out from the wall rock (JMH observation). Partly formed crystals with some faces have been seen. It was thought to be magnetite, but is nonmagnetic. EDS analysis confirmed its identity. Ilmenite in cavity walls appears to be altered to tiny brown acicular rutile (Smith 2001) or possibly ilmenorutile.
Titanium Corp of America pit. Ilmenite occurs as an accessory mineral in altered hybrid rocks (Flohr 1994). Small irregular, black to brown or purplish, small irregular masses in a dike rock are reported to be ilmenite.

ILMENITE ANALYSIS

LOCATION/DESC.	TiO_2	Fe_2O_3	SOURCE
JMQ, GRAY	27.2	72.80	EXCALIBUR

ILMENORUTILE $Fex(Nb,Ta)_{2x}\cdot 4Ti_{1-x}O_2$ A variety of rutile.

Martin Marietta Jones Mill quarry (JMQ). Ilmenorutile forms a series with struverite, which also occurs in the quarry. Karl Estes found it as microscopic aggregates of minute, black, stubby striated crystals and starbursts of black acicular crystals in 1999. Crystals are about 0.5 mm and clusters about 1.3 mm across.

ILMENORUTILE ANALYSIS (SEE ALSO STRUVERITE)

LOCATION/DESC.	TiO_2	Fe_2O_3	Nb_2O_5	SOURCE
JMQ, ACIC.	61.11	5.59	33.31	EXCALIBUR - ESTES

JAROSITE $KFe^{3+}_3(SO_4)_2(OH)_{16}$

Martin Marietta Jones Mill quarry (JMQ). Minute yellow to pale brown crystals in rounded irregular aggregates a few millimeters across are jarosite by SEM/EDS analysis. It occurs in small veins between quartz crystals (Smith 1998). Minute crystals of jarosite also occur on hematite roses (Smith 1999).

JAROSITE ANALYSIS

LOCATION/ DESC.	Fe_2O_3	K_2O	SO_4	SOURCE
JMQ YELLOW	41.54	10.76	47.70	EXCALIBUR

JOAQUINITE-(Ce) $NaBa_2Ce_2FeTi_2(Si_4O_{12})(OH,F)\cdot H_2O$

Diamond Jo quarry. Pale yellow-brown crystals, less than 5 mm across, are often corroded and overgrow kassite in miarolitic cavities in pseudoleucite syenite (Barwood 1995).

JOAQUINITE-(Ce) ANALYSIS

LOCATION/DESC	SiO_2	TiO_2	Ce_2O_3	La_2O_3	Nd_2O_3	BaO	Na_2O	F	SOURCE
DJQ, XL	32.44	10.18	15.99	7.81	1.96	20.76	1.77	0.85	BARWOOD

JOHANNSENITE $CaMn^{2+}Si_2O_6$

Cove Creek bridge pegmatite. Johannsenite is a molar consituent of the aegirine-augite crystals in the pegmatite (Tice, Falster & Simmons 2001).

KAOLINITE $Al_2(Si_2O_5)(OH)_4$

Brookite deposits on east rim. Kaolin is generally stained red but rarely small white masses can be found. At the Christy deposit it is associated with nontronite (Fryklund & Holbrook 1950).

Central Cove area. Beds and masses of impure kaolin clay have vermiculite, schorlomite, andradite, fluorapatite and nepheline imbedded in it (Williams 1891, 181).

Martin Marietta Jones Mill quarry. Kaolinite was the last mineral formed in the veins with anatase and coats other minerals as white granules (Howard 1999).

Titanium Corp of America pit. Some of the abundant white clay is kaolinite (Smith 1941).

KASSITE $CaTi_2O_4(OH)_2$

Diamond Jo quarry (DJQ). Kassite was first reported as pinkish to brown, clear to translucent, less than 1 mm groups of thin crystals with curved terminations forming tiny rosettes. It is associated with aegirine and cottonlike pectolite (Evans et al. 1986). Tiny yellow, white, or tan spheres are the same mineral and have the same occurrence. They occur with the labuntsovite suite of minerals and often with thin bladed colorless barite (Smith 1989).

KASSITE ANALYSIS

LOCATION/DESC.	CaO	TiO_2	SOURCE
DJQ, brn rosette	24.57	75.49	Excalibur, York

KIMZEYITE $Ca_3(Zr,Ti)_2((Si,Al,Fe^{3+})O_4)_3$

Kimzey calcite quarry/pit (KCP). This is the type locality for kimzeyite (Milton, Blade, & Ingram 1961). Dark brown crystals, less than 1 mm in diameter occur in the carbonatite. The crystals are composed of equally developed dodecahedral and trapezohedral faces. This gives them a rounded appearance and helps distinguish them from andradite. Associated minerals are fluorapatite, magnetite, perovskite, green biotite, vesuvianite, and andradite. Colorless anhydrite crystals occur as inclusions in the kimzeyite (Milton, Ingram & Blade 1961). Larger crystals up to 2 mm in diameter were reported by Falster, Hanson & Simmons (1992). They also report phlogopite and pyrite as associated minerals.

Middle Tufa Hill (MTH). Clyde Hardin collected small brown crystals and masses of kimzeyite with spinel in the spring area in 1977. Their identity was confirmed by EDS analysis (see below).

Perovskite Hill (PH). Minute dark brown crystals like those at the Kimzey calcite quarry have been found in carbonatite near Perovskite Hill. Dull black or dark brown crude crystals up to 1 cm across were found by Clyde Hardin and identified as kimzeyite by Henry Barwood in 1996. Some are partly or completely altered to baddelyite (see analysis below).

KIMZEYITE ANALYSES

LOCATION/DESC.	ZrO_2	SiO_2	Al_2O_3	TiO_2	CaO	Fe_2O_3	Nb_2O_3	SOURCE
MTH, XL	26.99	14.46	14.46	5.56	16.33	16.79	0.00	EXCALIBUR
PH, XL	34.35	9.18	7.70	3.71	26.90	14.68	1.93	BARWOOD
KCP, XL	29.90	9.60	11.00	5.60	29.80	13.60	1.00	MILTON, ET AL. 1961

KOLBECKITE $ScPO_4 \cdot 2H_2O$

Christy mine. Bright apple-green to white, stout prismatic to pseudo-rhombohedral twinned crystals of kolbeckite from 0.1 – 0.4 mm in size occur in pockets of quartz-brookite aggregates. Some crystals may be stained by iron oxide. The crystals vary from transparent to opaque and generally are loosely attached to brookite or corroded quartz matrix. Their identity was confirmed by X-ray powder diffraction and EDS (Barwood 1987). Kolbeckite crystals from this location are considered by many collectors as the finest examples discovered anywhere.

Martin Marietta Jones Mill quarry. Kolbeckite occurs as minute lime-green crystals within fracture fillings in the altered shale (Barwood 1998).

KUPLETSKITE $(K,Na)_3(Mn,Fe)_7Ti_2Si_8O_{26}(OH)_4F$

Diamond Jo quarry (DJQ). Transparent amber to brown kupletskite forms monoclinic elongate prismatic crystals. It is rare in the miarolitic cavities of the Diamond Jo quarry (Howard Evans, Smith 1989). Sheet-like crystals previously thought to be kupletskite by Barwood have a composition of zircophyllite.

KUPLETSKITE ANALYSIS

LOCATION/DESC.	SiO_2	MnO	Fe_2O_3	MgO	Al_2O_3	ZrO_2	K_2O	CaO	TiO_2	SOURCE
DJQ, brown	51.26	12.79	9.33	3.61	2.45	2.01	3.60	2.80	4.47	Excalibur, York

LABUNTSOVITE $(K,Ba,Na)(Ti,Nb)(Si,Al)_2(O,OH)_7 \cdot H_2O$ Formula as given by Milton.

Diamond Jo quarry. Clear bright-orange, thin prismatic monoclinic crystals are abundant in some cavities associated with altered xenoliths. The crystals are rarely over 1 mm long and occur in groups with aegirine, pectolite, orthoclase, delindeite, and lourenswalsite (Smith 1989). J.M. Howard (2004) noted some blocky equant, orange crystals in his original discovery of this mineral. XRD identification of this mineral was by C. Milton (JMH personal comm.) Not distinguished from labunstovite-Mn.

Martin Marietta Jones Mill quarry (JMQ). Minute pale brown tabular crystals of labuntsovite were identified from the syenite in 2004. Noted by Barwood as labuntsovite-Mn.

LABUNTSOVITE ANALYSIS

LOCATION/DESC.	Na_2O	SiO_2	Al_2O_3	K_2O	TiO_2	BaO	Nd_2O_3	MnO	Fe_2O_3	SOURCE
JMQ, brown	3.70	38.96	3.61	11.01	35.64	unk*	1.96	1.88	3.25	Excalibur

***peak overlain by Ba peak**

LAMPROPHYLLITE $(Na,Mn^{2+})_3(Sr,Na)_2(Ti,Fe^{3+})_3(Si_2O_7)_2O_2(OH,O,F)_2$

Cove Creek Bridge at State Road 51(CCB). Small yellow to yellow brown blebs and lath-like crystals from 1 to 3 mm long in contact metamorphic rock were thought to be astrophyllite, but on analysis were found to be lamprophyllite.

LAMPROPHYLLITE ANALYSES

LOCATION/DESC.	SiO_2	Na_2O	TiO_2	SrO	CaO	MnO	K_2O	BaO	Fe_2O_3	SOURCE
CCB, YELLOW	33.64	20.99	21.27	20.48	1.05	1.40	1.18	0.00	0.00	EXCALIBUR
CCB, BRN-YELLOW	35.29	17.69	26.85	9.48	0.41	1.59	1.77	4.75	1.62	EXCALIBUR

LARNITE Ca_2SiO_4

Kimzey Calcite Quarry. Calcite inclusions in monticellite are crosscut by larnite (Nesbitt and Kelly 1977). Larnite has not been reported by other workers.

LÅVENITE $(Na,Ca)_2(Mn^{2+},Fe^{2+})(Zr,Ti)(Si_2O_7)(O,OH,F)_2$

Cove Creek bridge pegmatite. Eudialyte alteration minerals include catapleiite, baddelyite, låvenite, paraumbite, and barytolamprophyllite (Nizamoff, Falster, Simmons & Webber 1999).

LENOBLITE $V^{4+}{}_2O_4 \cdot 2H_2O$

Christy mine. A bluish lavender viscous fluid that solidified into a mat of minute acicular crystals that changed to a yellow-green color around the outer edges was collected by Henry de Linde in September, 1989. The material was identified by H. Barwood as lenoblite and later confirmed by Howard Evans. It occurred in a large boulder with brown, somewhat botryoidal, lustrous siderite crystals (de Linde 1990, personal communication).

LEUCOSPHENITE $BaNa_4Ti_2B_2Si_{10}O_{30}$

Martin Marietta Jones Mill Quarry. Minute yellow inconspicuous crystals in cavities in syenite with dark aegirine are shown by EDS analysis to possibly be leucosphenite.

LOCATION/DESC.	SiO_2	TiO_2	BaO	Na_2O	MgO	K_2O	FeO	SOURCE
JMQ, Yellow	55.43	18.39	15.87	6.24	1.85	1.02	1.20	EXCALIBUR

LOPARITE-(Ce) $(Na,Ce,Ca,Sr,Th)(Ti,Nb,Fe)O_3$

General. Loparite-(Ce) is reported from Magnet Cove (Tice, Falster & Simmons 1999).

LORENZENITE $Na_2Ti_2(Si_2O_6)O_3$

Brookite deposits on east rim. Lorenzenite is reported as an accessory mineral in dikes and veinlets at the Hardy-Walsh prospect (Flohr 1994).

Diamond Jo quarry (DJQ). Lorenzenite was found in the quartz syenite outcrop above the quarry. It occurs as elongate prisms. The mineral is transparent and pale pinkish tan. Crystal terminations are flat, but rare because the crystals are usually attached to both sides of the cavity (Smith 1989).

LORENZENITE ANALYSIS

LOCATION/DESC.	SiO_2	TiO_2	Nb_2O_3	Na_2O	SOURCE
DJQ	34.96	42.44	3.62	14.93	BARWOOD

LOURENSWALSITE $(K,Ba)_2(Ti,Mg,Ca,Fe)_4(Si,Al,Fe)_6O_{14}(OH)_{12}$

Diamond Jo quarry. This is the type locality for lourenswalsite. It occurs in silvery brownish gray rosette-like clusters or spheres composed of very thin hexagonal plates. The groups are rarely up to 1 mm across. Individual crystals have a pearly luster. It occurs in cavities with the labuntsovite suite of minerals and is common in some cavities (Appleman et al. 1987).

MAGHEMITE $Fe^{3+}{}_2O_3$

Kimzey magnetite mine. Maghemite occurs as minute irregular veinlets penetrating masses of lodestone (Nagata 1961).

MAGNESIO-ARFVEDSONITE $\{Na\}\{Na_2\}\{Mg_4Fe^{3+}\}(Si_8O_{22})(OH)_2$

Martin Marietta Jones Mill quarry (JMQ). Thin, lath-like to tabular, color-zoned green crystals in miarolitic cavities in a small syenite dike that cuts altered and fenitized shales are suspected to be an amphibole. They are usually separate from the aegirine (Smith 1990). Tufts of a green amphibole occur in cavities in altered light colored rock and may be covered by siderite (Smith 1999). Fibrous tremolite-actinolite, formerly termed byssolite, composed of minute acicular crystals occur as white mattes covering other minerals, and is associated with epidote, rutile, and pyrite (Estes 1998). An acicular pale green to brown amphibole is often mistaken for rutile, but analysis by Henry Barwood confirms that it is an amphibole.

Diamond Jo quarry (DJQ). Unspecified amphiboles were reported by Charles Milton (1977, personal communication) in the miarolitic cavities. Henry Barwood's analyses confirm this (see below).

MAGNESIO-ARVEDSONITE, MICROPROBE & EDS ANALYSES

LOCATION/DESC	SiO_2	TiO_2	Al_2O_3	MgO	CaO	MnO	FeO	Na_2O	K_2O	F	H_2O	SOURCE
DJQ, BROWN	53.23	1.48	3.38	22.06	9.84	0.37	1.33	4.38	1.60	3.02	0.72	BARWOOD
DJQ, BLUE	57.00	0.23	0.08	18.97	6.19	0.61	6.39	6.34	1.63	3.56	0.43	BARWOOD
JMQ, BYSSOL	60.85	0.00	1.57	9.10	0.00	2.88	10.33	10.33	1.80	0.00	-	EXCALIBUR
JMQ ,Prsm, GR	59.21	0.00	-	10.18	0.30	5.47	10.51	10.51	2.23	0.00	-	EXCALIBUR

MAGNESIOFERRITE $MgFe^{3+}{}_2O_4$

General. Spectrographic analysis of two magnetites from jacupirangite and one from the carbonatite contain more than 10% MgO and so are magnesioferrite (Erickson & Blade 1963, 74). Nesbit and Kelly (1977) refer to the magnetite at the Kimzey Calcite pit as magnesioferrite, but this is not confirmed by published analysis (see magnetite analyses).

MAGNETITE $Fe^{2+}Fe^{3+}{}_2O_4$

Brookite deposits on east rim. Magnetite pseudomorphs after brookite have been reported (Frondel 1933-35, 414). Grains of magnetite occur in the soil and residual deposits at the Hardy-Walsh deposit (Fryklund & Holbrook 1950). Magnetite is an accessory mineral in dikes and veinlets at the Hardy-Walsh prospect (Flohr 1994).

Central Cove area. Magnetite and lodestone occur in black to brown, smooth, rounded masses that are usually free of other minerals. Some magnetite has the appearance of being pseudomorphic after pyrite but this has not been substantiated. A columnar, 4 cm pseudomorph of magnetite, with crude, but distinct terminations, is a pseudomorph after an amphibole. Rarely, vermiculite or fluorapatite may be associated with magnetite. The masses are usually small, but some masses over 15 cm in diameter have been found (Williams 1891, 180-181, 219-220).

Cove Creek bridge at State Route 51. After heavy flow volume, placer deposits of magnetite fragments and crystals can be found downstream of tree roots and boulders in the creek north of the bridge.

Cove Creek at the iron bridge. About 1000 feet due north and just to the northeast of Dr. Rutherford's house is a body of magnetite and vermiculite (Williams 1891).

Kimzey calcite pit. Magnetite octahedrons are usually the largest and dullest of the black octahedral crystals that occur in the carbonatite. They may form single crystals up to 2 cm or groups of intergrown crystals that may be 8 cm across. Magnetite is usually less bright than the perovskite or hercynite, and usually form simple octahedral crystals. Although they are attracted to a magnet, they are seldom magnetic themselves.

Kimzey magnetite mine. Masses of magnetite with rounded edges litter the ground and also occur in the soil. Only a small percentage of the magnetite is lodestone (Smith 1996).

Lime-silicate area. Magnetite in irregular, but rounded masses up to 29 cm across, are present in the vesuvianite-diopside matrix. Some magnetite is aligned in the host matrix like beads on a string (Erickson & Blade 1963, 39).

Martin Marietta Jones Mill quarry (JMQ). Estes (1998) reports magnetite crystals that occur as bladed crystals and twinned spears. Lustrous black, minute (less than 0.5 mm), octahedra occur in seams in altered shale and in miarolitic cavities in syenite. In the miarolitic cavities, it occurs with a brown garnet as bright, thin discoidal, multifaced crystals up to 2 mm across.

Middle Tufa Hill. In the flat south of the hill, the residual soil contains magnetite, perovskite, and apatite (Fryklund, Harner & Kaiser 1954). Botryoidal magnetite occurs near the spring.

Perovskite Hill. Magnetite occurs as octahedral crystals up to 2 cm across. Faces observed, other than octahedral, are rhombic dodecahedron and the ikositetrahedron. It may be intergrown with perovskite (Williams 1891, 184, 335). Magnetite crystals occur with anatase, perovskite, kimzeyite, and baddelyite crystals attached (Smith 1996).

MAGNETITE ANALYSES

LOCATION/DESC.	Fe_2O_3	FeO	Al_2O_3	MnO	TiO_2	Ca-Mg	H_2O	SOURCE
UK, MAGNETIC	67.20	24.46	0.46	0.30	1.20	2.19	1.0	OWEN 1860
JMQ, OCT. XL	100.00	-	0.00	0.00	0.00	0.00	0.0	EXCALIBUR
KCP, OCT XL	95.23	00.00	0.00	4.77	0.00	0.00	0.0	EXCALIBUR

MALACHITE $Cu_2(CO_3)(OH)_2$

Martin Marietta Jones Mill quarry. Malachite occurs as thin, green coatings and minute spheres, up to about 0.5 mm across. It is widespread, but not abundant in the quarry. Its identity has been confimed by an Excalibur EDS on a Karl Estes specimen. Malachite forms from the alteration of chalcopyrite.

MARCASITE FeS_2

Christy mine. The excavation of the water pond exposed some vuggy quartz veins with bright, 1 to 3 mm blades of marcasite (Howard 2004).

Martin Marietta Jones Mill quarry. Henry Barwood has identified masses of radially fibrous pyrite and marcasite collected in 1996. When marcasite and pyrite occur together in the veins with anatase, the marcasite is often perched on the pyrite (Howard 1999).

Magcobar mine. Large masses of stalactitic iridescent marcasite were recovered, but within a year had turned to melanterite due to pyrite "disease" (Howard personal observation).
Mo-Ti prospect. Marcasite is composed of irregular masses, composed of nodules with an internal radiating structure. It is associated with rutile, sphalerite, and molybdenite (Shockley 1945).
Titanium Corp of America pit. Marcasite similar to that found at the Mo-Ti prospect also occurs at this mine (Shockley 1945).

MELANTERITE $FeSO_4 \cdot 7H_2O$
General. White to grayish pulverent masses and coatings of melanterite occur in Magnet Cove and the Chamberlain Creek barite mines whenever pyrite, marcasite, or pyrrhotite are exposed to oxidation.

MELILITE group $Ca_2M(XSiO_7)$
Lime-silicate pits. Melilite occurs as crystals in the vesuvianite-diopside rock. Large crystals up to 43 cm may be partly replaced by a fine- to coarse-grained mixture of vesuvianite, diopside, tremolite, biotite, perovskite, aegirine, andradite, calcite and a zeolite (Erickson & Blade 1963, 39). Some small, equant, greenish yellow crystals were collected in the 1950s (Smith 1996).

MICROCLINE $K(AlSi_3O_8)$
Cove Creek. A dark dike rock, just north of the Cove Creek canyon through the south rim of Magnet Cove, contains phenocrysts of white microcline crystals up to 6.5 cm across.
Cove Creek Bridge at SR 51 (CCB) & Branch pegmatite. Microcline occurs as large tabular crystals to over 15 cm in diameter and 2 cm thick. Its color varies from white to pale green (Williams 1891, 239-240). These crystals do not exhibit the usual twinning (Landes 1931). Crystals and cleavable masses of microcline are still found in Cove Creek at the bridge (Smith 1996).
Martin Marietta Jones Mill quarry. Microcline has been identified as clear colorless well-formed prismatic crystals with hematite and calcite in quartz veins in altered sediments. It has also been identified as pseudo-rhombohedral crystals with sphalerite, natrolite, aegirine, and brownish yellow labuntsovite (Barwood 2004 from results by Al Falster).

MICROCLINE ANALYSIS

LOCATION/DESC.	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	SOURCE
CCB, LG XL	64.30	19.70	0.74	18.60	0.48	PISDANI IN DES CLOIZEAUX 1876

MISERITE $K_{1.5-x}(Ca,Y,REE)_5(Si_6O_{15})(Si_2O_7)(OH,F)_2 \cdot yH_2O$
Cove Creek bridge contact metamorphic rocks. There have been several unconfirmed reports of miserite occurring with wollastonite at this location, but none have been verified. Pink thomsonite or natrolite may have been mistaken for miserite.

MOLYBDENITE MoS_2

General. Molybdenite occurs at the Mo-Ti prospect, the floor of the Kimzey calcite quarry, in a stock pond on the western side of section 20 and with rutile veins about 500 feet south of the Mo-Ti prospect (Erickson & Blade 1963, 90).

Chamberlain Creek barite mines. Molybdenite is rare at the barite mines (Branner & Parks 1932).

Cove Creek bridge pegmatite. Small masses and grains of molybdenite occur in the contact metamorphic rock associated with the pegmatite (Smith 1996).

Diamond Jo quarry. Thin flattened or crumpled single brilliant plates of molybdenite, some with a crude hexagonal outline occur in the miarolitic cavities. It is widespread, but not abundant (Smith 1989).

Martin Marietta Jones Mill quarry (JMQ). Minute silver blebs and flakes on white orthoclase and other minerals are molybdenite by EDS analysis. It is not common, but some specimens will contain numerous flakes in a small area.

Mo-Ti prospect. Molybdenite was identified in the northwest bank of Cove Creek disseminated throughout a siliceous material and coating pyrite (Sleight 1941), having previously been misidentified as graphite. The area was later prospected for molybdenite. It coats and replaces pyrite and brookite and occurs in feldspar veins and in jacupirangite (Fryklund & Holbrook 1950). The molybdenite is steel-blue in color and very fine-grained. It occurs as thin, elongated seams and small pods scattered through the veins (Holbrook 1948). Sooty metallic albite veins are coated with fine-grained molybdenite (Howard 2002)

Titanium Corp of America pit. Molybdenite occurs in dolomite-albite veins (Fryklund & Holbrook 1950).

MONAZITE-(Ce) $Ce(PO_4)$

General. Monazite-(Ce), thorite, and a rare earth carbonate occur as irregular clusters of poorly formed crystals less than 1 mm across in early formed smoky quartz in altered novaculite outside of the Magnet Cove intrusive contact (Tice, Falster, & Simmons 1999).

MONAZITE-(La) $La(PO_4)$

East Tufa Hill. A very irregular vein, 5 to 20 cm wide, of earthy, very fine-grained, pale greenish yellow material composed of monazite and plumbogummite occurs in the extremely weathered part of the apatite-pyrite vein (Rose, Blade & Ross 1958, Erickson & Blade 1963, 54-55).

MONTICELLITE $CaMgSiO_4$

Kimzey calcite quarry. Monticellite occurs in grains, large nodular masses, and well-formed crystals from 1 mm to 2 cm across in the calcite (Williams 1891, 338-341). Most of the monticellite in the carbonatite exhibits poor crystal form. Rarely, there are pale brown glassy crystals with distinct faces. However, the crystal faces are difficult to expose from the carbonatite without damaging their surfaces (Smith 1994).

MONTICELLITE ANALYSES

LOCATION/DESC.	SiO_2	Al_2O_3	FeO	CaO	MnO	MgO	SOURCE
CARBONATITE	35.06	0.17	5.33	34.16	1.16	21.71	GENTH ET AL. 1891, incl. in apatite
CARBONATITE	35.19	0.20	5.18	34.26	1.19	21.58	GENTH ET AL 1891, “ “ “

MONTROSEITE $(V^{3+}, Fe^{3+})O(OH)$

Christy mine. Montroseite was reported by Henry Barwood in 1995, and recently reconfirmed by Tony Kampf. It occurs as black acicular crystals with coatings of vanadium oxysalts and black smectite clay. Two specimens of "montroseite" purchased in Tucson in 1999 were actually goethite with a coating of vanadium oxide from SEM-EDS analysis. This was confirmed by an XRD analysis of one of the crystals. Those specimens may be pseudomorphs after rutile.

MORDENITE $(Na_2,Ca,K_2)Al_2Si_{410}O_{24} \cdot 7H_2O$

Kimzey calcite quarry. Mordenite was reported as "ptilolite" by Shockley 1948. It was found in a vug in contact metamorphic rock as white, silky masses with vesuvianite and garnet.

MUSCOVITE $KAl_2(AlSi_3O_{10})(OH)_2$

Cove Creek bridge pegmatite. Muscovite is present, but is not conspicuous in the syenite pegmatite (Smith 1996). It occurs as small transparent colorless flakes.

Kimzey calcite quarry. Muscovite is intimately intergrown with phlogopite in alternating layers in the carbonatite (Meurer et al. 1989).

Kimzey magnetite mine. The sericite variety of fine-grained muscovite is reported (Smith 1996).

NARSARSUKITE $Na_4(Ti,Fe)_2[Si_8O_{20}](O,OH,F)_2$

Diamond Jo quarry. Yellow equant crystals of narsarsukite are rare. They occur with similarly colored yellow sphalerite tetrahedrons, pectolite, and aegirine in miarolitic cavities in syenite (Smith 1989).

Martin Marietta Jones Mill quarry (JMQ). In syenite cavities, yellow transparent micro-crystals were identified by Barwood (personal comm., 2005).

NATROLITE $Na_2Al_2Si_3O_{10} \cdot 2H_2O$

Cove Creek bridge (CCB) and the Branch pegmatites. Natrolite forms thick prisms to over 2 cm in diameter, and may form large masses of jumbled white crystals. Some terminations can be observed in the cavities between crystals (Williams 1891, 252-253). It is also observed as white radiating masses up to 15 cm across and smaller crystals of white or colorless natrolite. Some natrolite has a silky texture and a pinkish tinge. It may be intermixed with black aegirine and thomsonite. Natrolite may have what appears to be colorless thomsonite crystals perched on it. The white to pink massive material with a faint radiating structure from the syenite pegmatite that was thought to be manganopectolite, is also natrolite based on XRD (Charles Milton USGS). Typically terminated crystals of natrolite, some with aegirine inclusions, were also observed. (Smith 1994, 1999a).

Central Cove area. At the natural gas pipeline crossing of Cove Creek, white natrolite was exposed with green diopside when the crossing was dug in the late 1960s.

Diamond Jo quarry. Terminated, transparent to translucent, elongated crystals of natrolite up to 3 mm long dominate some cavities. It is commonly associated with apophyllite and pyrite in cavities near shale xenoliths (Smith 1989).

Kimzey calcite quarry. Natrolite occurs as clear to white crystals and pink masses in the contact metamorphic rock adjacent to the carbonatite (Smith 1996).

Kimzey magnetite mine. White crystals and masses have been found in the magnetite mine (Smith 1996).

Lime-silicate area. Pieces of an unknown zeolite found on the dumps of these pits contain cavities with crystals of natrolite (Erickson & Blade 1963, 39).

Martin Marietta Jones Mill quarry (JMQ). Natrolite occurs as distinct terminated elongated prismatic crystals up to 0.5 cm long. The crystals are white and opaque on the outside, but have a glassy colorless interior. It also occurs as subparallel masses of colorless to pale pink, glassy, elongated crystals. The natrolite is associated with altered carbonate layers near syenite.

NATOLITE ANALYSES

LOCATION/DESC.	Na_2O	Al_2O_3	MgO	CaO	SiO_2	SOURCE
JMQ, CLEAR	9.57	26.60	5.10	0.00	58.73	EXCALIBUR
JMQ, PINK	8.60	36.01	0.00	5.55	49.94	EXCALIBUR
CCB ?	15.40	26.82	0.09	0.13	47.56	MELVILLE 1892

NENADKEVICHITE $(Na,\square)_8Nb_4(Si_4O_{12})(O,OH)_4 \cdot 8H_2O$

Martin Marietta Jones Mill quarry (JMQ). Small, less than 0.5mm, transparent pale orange to almost white, pseudohexagonal crystals are rare in some cavities in the syenite that is associated with altered xenoliths.

NENADKEVICHITE ANALYSIS

LOCATION/DESC.	SiO_2	TiO_2	Nb_2O_5	K_2O	Al_2O_3	MgO	Ce_2O_3	MnO	SOURCE
JMQ, XL	42.65	22.99	14.94	10.05	2.04	0.79	3.86	2.68	EXCALIBUR

NEPHELINE $(Na,K)AlSiO_4$

General. Nepheline phenocrysts, over 5 mm in size, occur in nepheline porphyry in several places in Magnet Cove. The phenocrysts are pink or yellowish and hexagonal in outline (Williams 1891, 258-259).

Central Cove area (CCA). Nepheline occurs in rounded masses, several centimeters in diameter, usually without any distinct crystal faces. It varies in color from pink to red to yellow and brown or gray with an oily luster. Translucent to semi-transparent pieces have been cut by lapidaries and have been termed “sun-stones”. Nepheline often occurs with thomsonite (Williams 1891, 181, 209). Shockley (1945) writes that the “sun stones” form by the weathering of nepheline. The surface of these pebbles becomes covered with spangles that show a sparkling display of reds, greens, and yellow. Attempts to cut and polish nepheline were not successful. In the middle 1970s, when work was being done on the concrete bridge into the Magnet Cove Baptist Church, brown residual masses of nepheline with a white rind several centimeters across were exposed. Residual masses of nepheline originate from the garnet nepheline ijolite, which forms the principal rock underlying the interior of Magnet Cove.

Cove Creek bridge pegmatite & Branch. Nepheline is not conspicuous in the syenite pegmatites, perhaps because it weathers so easily. In recent years much of the pegmatite has been exposed. Under a petrographic microscope, it usually does not display distinct crystals. However, short prismatic crystals were observed by Williams (1891, 209). Landes (1931) writes that it is irregular greenish masses.

Diamond Jo quarry. Blocky nepheline crystals in garnet nepheline ijolite xenoliths have been replaced by gonnardite (Howard 2004).

Kimzey magnetite mine. Brown masses of nepheline with a white rind were found in the soil (Smith 1996).

NEPHELINE ANALYSES

LOCATION/DESC.	SiO_2	Al_2O_3	Fe_2O_3- FeO	CaO	K_2O	Na_2O	IGN	SOURCE
CCA	44.46	30.97	2.09	0.66	5.91	15.61	0.95	SMITH & BRUSH 1853b
CCA	40.90	33.37	1.12	1.15	6.82	14.57	-	ERICKSON & BLADE 1963

NONTRONITE $Na_{0.3}Fe_2((Si,Al)_4O_{10})(OH)_2 \cdot nH_2O$

Christy mine. Nontronite, a clay mineral, occurs with kaolinite at the Christy brookite deposit (Fryklund & Holbrook 1950). Nontronite also was observed as large blocks of light yellow-green clay in the early vanadium exploration pit (Howard 2004).

NOSEAN $Na_8(Al_6Si_6O_{24})(SO_4) \cdot H_2O$

General. Nosean is a constituent of some of the syenites and related rocks in Magnet Cove (Fryklund & Holbrook 1950). It has only been reported in thin-sections.

Olivine group mineral

General. Olivine occurs in monochiquitic dike rocks in the north central part of Magnet Cove (Shockley 1948) and at the titanium mine. Little analytical work has been done on Magnet Cove olivine.

OPAL $SiO_2 \cdot nH_2O$

General. A gray siliceous material at the Mo-Ti prospect and Tufa Hills, known as “geyserite”, is opal.

Diamond Jo quarry. Hemispheres and coatings of clear hyaline opal are common in the cavities of the quartz syenite above the quarry as late secondary formation (Smith 1989).

Christy pit. While searching for minerals on the dumps of the Christy pit before the land was reclaimed, the junior author recovered a single specimen of common opal. It is a late fracture filling, some 1.75 inches thick, and consists of yellowish orange opal with a black spider webbing pattern. The specimen weighs just over 1 pound.

ORTHOCLASE $K(AlSi_3O_8)$

Diamond Jo quarry. In the miarolitic cavities, white blocky crystals project from the cavity walls. They rarely reach a length of 5 mm and may be covered with a clear coating of albite (Smith 1989). Tabular sodic orthoclase up to 1 cm long is conspicuous in the matrix of the pseudoleucite syenite (Erickson & Blade 1963, 11). Barian sodic orthoclase occurs as very pale gray crystals up to 3 cm long and makes up from 70 to 80% of the nepheline syenite pegmatite in the quarry (Erickson & Blade 1963, 44).

Martin Marietta Jones Mill quarry. Orthoclase is gray, pale tan or off-white in color. Tan laths of orthoclase with open spaces between them are over 1 cm long and 7 mm wide in small syenite dikes cutting altered and fenitized shale. Blocky off-white crystals with clear albite overgrowths occur in miarolitic cavities. In some cavities, these orthoclase crystals are very thin empty shells. The matrix contains anhedral gray to off white orthoclase (Smith 2001). An EDS analysis of a blocky white opaque crystal in a cavity showed it to be pure with no unusual trace elements.

Mo-Ti prospect. Orthoclase occurs as white veins with small blocky white crystals in the cavities (Smith 1996). Orthoclase is the chief feldspar in the pyrite-feldspar veins. It occurs as fine-grained masses, coarse individual crystals up to 3 mm, and aggregates of crystals (Holbrook 1948).
Teager Creek, 300 feet west of railroad bridge. Large flat crystals in a greenish dike rock (Williams 1891, 202).

ORTHOCLASE ANALYSES

LOCATION/ DESC.	SiO_2	Al_SO_3	Na_2O	K_2O	BaO	SOURCE	
SYENITE	57.9	23.1	9.0*	7.0	0.4*	ERICKSON & BLADE 1963	*sodium contamination
DJQ, PEGMATITE	60.0	21.6	3.4	11.7	2.4	ERICKSON & BLADE 1963	

PARAMONTROSEITE $V^{4+}O_2$

Christy mine. Paramontroseite was identified by Henry Barwood as minute black acicular crystals. It occurs in quartz-brookite aggregates imbedded in clay, and is very similar in appearance to cryptomelane from this locality.

PARAUMBITE $K_3Zr_2H(Si_30_9)_2 \cdot nH_20$

Cove Creek bridge pegmatite. The alteration minerals of eudialyte are baddelyite, catapleiite, låvenite, paraumbite, and barytolamprophyllite (Nizamoff, Falster, Simmons & Webber 1998).

PECTOLITE $NaCa_2Si_3O_8(OH)$

Cove Creek Bridge pegmatite (CCB). Manganpectolite occurs as thick tabular crystals up to 10 cm long. A brown coating of manganese oxide occurs on weathered crystals. It is transparent to translucent and gray in color on fresh samples (Williams 1891, 253-257). Shockley (1948) reports that manganpectolite is probably a form of thomsonite. Whisps of pectolite were identified by EDS analysis. It occurs as microscopic, thin, white, circular and divergent sprays of acicular elongate crystals, up to 2 mm in diameter, on black aegirine (Smith 1999a).
Christy mine. White fibers were identified by Barwood in 1989 as pectolite. It occurs with rhodochrosite, siderite, rutile, quartz and kolbeckite.
Diamond Jo quarry (DJQ). Pectolite occurs in the miarolitic cavities as silky white elongate and acicular crystals, tufts, and cotton-like masses and “nests” of colorless crystals. It is common and found in many of the cavities in one form or another (Smith 1989). Erickson & Blade (1963) identify a similar mineral as pseudowavellite (crandallite). Charles Milton identified it by XRD as pectolite. Pectolite also occurs as white prismatic crystals. Barwood (1997 personal communication) identified some as manganese-rich.
Martin Marietta Jones Mill quarry. Pectolite is reported as long silky strands in cavities with tainiolite (Estes 1998). It also occurs as lustrous microscopic fans of acicular crystals.

PECTOLITE ANALYSES

LOCATION/DESC.	SiO_2	Na_2O	CaO	Al_2O_3	MnO	SOURCE
CCB, FIBERS	58.80	7.89	35.31	0.00	0.00	EXCALIBUR
CCB, Mn-pectolite	53.03	8.99	30.20	0.00	4.26	WILLIAMS 1891
DJQ, CLEAR	53.06	11.78	30.07	1.92	3.17	EXCALIBUR

PEROVSKITE $CaTiO_3$

Kimzey calcite quarry. Perovskite, variety dysanalyte or niobium perovskite, occurs in the carbonatite as shiny black octahedrons usually with subordinate cubic trucations. They range in size from less than 1 mm to over 5 mm. It is one of the most common black minerals found at the quarry, the other being magnetite. Loose crystals from this source are also found in the adjacent Cove Creek. They can be distinguished from magnetite by their lack of magnetism, and from magnetite and hercynite by the cubic truncations (Shockley 1945). Cubic perovskite crystals are rare. Some combinations of cubes and octahedrons have equally developed faces. The niobium content of the crystals varied from 5.3 to 5.9% (Frykland et al. 1954).

Lime-silicate area (LSA). Near these pits, on the natural gas pipeline crossing, cavities in massive magnetite collected by Gene Bearss in the late 1960s contained black pseudooctahedral perovskite crystals with beveled edges, less than 2 mm across (see analysis below). Other crystals are yellow, orange, and brown with variable colors present in the same crystal. These pseudocubic crystals usually resemble octahedrons or cubes, and are also less than 2 mm. They occur as single crystals and groups of crystals. The other minerals present were clinochlore and a white clay mixture with a composition similar to “corrensite” by EDS analysis (Smith 1999a).

PEROVSKITE ANALYSES FROM LSA

LOCATION/DESC.	CaO	TiO_2	SOURCE
LSA, BLACK	41.08	58.92	EXCALIBUR
LSA, ORANGE	40.66	59.34	EXCALIBUR

Middle Tufa Hill. On the flat, south of the hill, the soil contains magnetite, apatite, and perovskite (Fryklund, Harner & Kaiser 1954).

Perovskite Hill. Perovskite, variety dysanalyte, occurs as black cubes, octahedrons and combinations of both (Williams 1891, 184, 331-334). The crystals occur with magnetite, kimzeyite, and anatase, and range up to 1.5 cm in maximum dimension (Smith 1996). Some of the crystals may be partly or completely altered to pale brownish yellow anatase. Clyde Hardin found a large perovskite on a garnet and a perovskite with small cubic truncations that has small magnetite crystals on each of the four cubic faces displayed. Cubic crystals are more common than at the Kimzey quarry. The niobium content of the perovskite crystals varies from 5.6 to 8.8 % (Fryklund et al. 1954).

PEROVSKITE ANALYSES

LOCATION/DESC.	TiO_2	SiO_2	Nb_2O_5	Ta_2O_5	REE	Fe_2O_3	FeO	CaO	MgO	H_2O	SOURCE
CARBONATITE? XL	41.12	0.08	4.36	5.08	0.10	6.16	0.23	33.22	0.74	0.00	MAR 1899
ANATASE PSEUDO.	82.82	0.00	0.00	0.00	0.00	7.76	0.00	0.80	2.72	5.50	KOENIG 1876

PETEDUNNITE $Ca(Zn,Mn^{2+},Mg,Fe^{2+})Si_2O_6$

Cove Creek bridge pegmatite. Petedunnite is a molar constituent of the aegirine/augite occurring in the pegmatite (Tice, Falster & Simmons 2001).

PHLOGOPITE $KMg_3(AlSi_3O_{10})(OH)_2$

Cove Creek Bridge pegmatite. Phlogopite is reported to occur as small flakes in the contact metamorphic rock between the carbonatite and syenite pegmatite (Shockley 1945). Small brownish books are also present (Smith 1996).

Diamond Jo quarry (DJQ). Hexagonal brown, transparent plates and prisms, less than 1 mm across, of phlogopite are uncommon in the white rimmed cavities (Smith 1989). The phlogopite is a lithium phlogopite (Charles Milton 1976 personal communication). Light orange to brownish, clear to translucent, elongate prismatic crystals about 0.5 mm long are reported to be phlogopite-3T (Howard Evans 1985, personal communication).

Kimzey calcite quarry. Plates of pseudohexagonal phlogopite up to over 250 microns across are intimately intergrown with muscovite in alternating layers in the carbonatite (Meurer et al. 1989).

Martin Marietta Jones Mill quarry (JMQ). Phlogopite occurs as pseudohexagonal, yellow to brownish crystals with hematite that appears somewhat altered. It occurs as tiny flakes and crystals averaging 1.5 mm across.

PHLOGOPITE ANALYSES

LOCATION/DESC.	SiO_2	Fe_2O_3	MgO	K_2O	Al_2O_3	Na_2O	SOURCE
JMQ, XL	59.25	10.29	22.02	8.44	0.00	0.00	EXCALIBUR, ESTES
JMQ, COR. XL	45.08	18.89	22.99	4.74	7.02	1.27	EXCALIBUR

PICKERINGITE $MgAl_2(SO_4)_4 \cdot 22H_2O$

Chamberlain Creek barite mine. Pickeringite occurred in the old tunnels as a silky white fibrous material (Marshall, 1954). The pit and underground workings are now abandoned and flooded.

PLANERITE $Al_6(PO_4)_2(HPO_4)_2(OH)_8 \cdot 4H_2O$

Christy mine. Clear to translucent microscopic spheres originally thought to be planerite are variscite. They are associated with churchite-(Y), white wavellite, and cacoxenite (Howard 2004). See analysis under variscite.

PLUMBOGUMMITE $PbAl_3(PO_4)(PO_3OH)(OH)_6$

East Tufa Hill. A very irregular vein of very fine-grained, pale greenish-yellow material composed of a mixture of monazite and plumbogummite occurs in the weathered part of the apatite-pyrite vein (Erickson & Blade 1963, 54-55).

PLUMBOJAROSITE $Pb_{0.5}Fe^{3+}_6(SO_4)_2(OH)_6$

Mo-Ti prospect. Scarce yellow coatings and minute masses with minute grains of molybdenite were reported as ferrimolybdite (Smith 1996), but it is actually plumbojarosite as identified by EDS analysis.

POLYLITHIONITE $KLi_2Al(Si_4O_{10})(F,OH)_2$

Martin Marietta Jones Mill quarry. Colorless, transparent rounded mica-like hexagonal crystals occur as isolated crystals and small rosettes (Estes 1998). Their identity has not been confirmed by analysis. It may possibly be either tainiolite or muscovite.

PSEUDOLEUCITE – Discredited as a valid mineral species, it is a pseudomorphic mixture of nepheline and orthoclase after leucite. The term is used because it is entrenched in the literature concerning Magnet Cove.

General. Leucite is unstable at surface temperatures and pressures so it becomes an intimate 2 phase mixture of nepheline and orthoclase at lower temperature, but retains the leucite crystal form. Pseudoleucite forms crystals up to 5 cm in garnet pseudoleucite nepheline syenite. The crystals are trapezohedrons, and in some areas may remain as complete crystals after the matrix has weathered away. The crystals are white to yellowish in color. Small crystals of magnetite, pyroxene, and nepheline may be included in them (Williams 1891, 268-273).

Highway 51, 1000 feet south in section 21. Pseudoleucite phenocrysts up to 2.4 cm across are abundant in a fine-grained green matrix of pseudoleucite tinguaite porphyry. They show a hexagonal outline in the matrix (Erickson & Blade 1963, 40). On a road leading south, rounded crystals up to several centimeters in diameter, rarely showing some faces, can be dug in the road ditch (Shockley 1945).

Johnson, J.N., no. 1 house, just southwest. A green leucite rock has pseudoleucite crystals over 7.6 cm across. They weather the same rate as the matrix and appear as large white usually hexagonal spots on the dark bluish green stone (Williams 1891, 196).

Jones Mill quarry. In April 2004 the lower level of the quarry contained blocks of dark syenite with abundant white irregular to circular crystals of pseudoleucite up to 5 cm across “frozen” in matrix (Smith 2004).

Orr, R.F., house, in front. Large crystals of pseudoleucite in leucite syenite dike (Williams 1891, 200).

Stone Quarry Creek, top of bluff to the west where it leaves the igneous rocks. Trapezohedral crystals accumulate from weathering. It is probably the location of the crystals described by Kunz (1886) (Williams 1891, 194).

PSEUDOLEUCITE AFTER LEUCITE

LOCATION/DESC.	SiO_2	Fe_2O_3	Al_2O_3	CaO	SrO	MgO	K_2O	Na_2O	Li_2O	H_2O	SOURCE
LARGE XL	55.06	>26.26	<0.69	TR	0.28	10.34	7.69	TR	1.78	-	WILLIAMS 1891
LARGE XLS*	66.77	0.44	22.13	0.00	0.00	0.05	13.91	0.36	0.00	2.95	GENTH IN KUNZ 1886

*AVERAGE OF 2 XLS

PYRITE FeS_2

Central Cove area. Pyrite was noted to be quite abundant in the rocks of the area (Williams 1891, 320).

Chamberlain Creek barite mines. Pyrite is fairly common in the dark shales of these mines.

Cove Creek Bridge pegmatite. Sulfide mineralization in the pegmatite is in the form of galena, pyrrhotite, pyrite, and sphalerite (Tice, Falster, & Simmons 1999). Pyrite is common but not abundant in the contact metamorphic rocks (Smith 1996).

Cove Mountain. On the crest of the northern part of the hill, on sandstone are partly altered pyrite crystals 12 to 20 mm across (Williams 1891, 191).

Diamond Jo quarry. Pyrite is present in small amounts as simple and modified cubes, up to 4 mm across, in cavities with natrolite and fluorapophyllite associated with dark shale xenoliths (Smith 1989).

Gully west of Neasch’s house. Pyrite crystals up to 13 mm in diameter occur in a pink rock (Williams 1891, 175).

Kimzey calcite quarry. Skeletal octahedrons of pyrite in the carbonatite may be pseudomorphs after magnetite (Bettencourt, Smith, and Howard 1974). Pyrite also occurs as pyritohedral crystals (Meurer et al. 1989) and combinations of pyritohedrons and cubes up to 2.5 cm across (Smith 1996).

Martin Marietta Jones Mill quarry. Pyrite is common in cavities and matrix of small syenite dikes that cut the altered and silicified shale. The crystals of pyrite in the cavities are bright, somewhat rounded,

and have distinct faces. Some are skeletal. Similar crystals occur in the matrix, but are usually intergrown with other pyrite crystals. The crystals range up to 6 mm, but most are less than half that size (Smith 2001). The crystals formed as cubes, octahedrons, pyritohedrons and combinations of all three. Pyrite as fracture fillings occurs in octahedrons up to 1 cm (Barwood 1998). When pyrite and marcasite occur in a vein the marcasite is often perched on the pyrite. Both pyrite and marcasite may be iridescent. (Howard 1999). Crystals up 2 cm across occur embedded in fenitized rock (Howard 2004).
Mo-Ti prospect. Pyrite crystals may reach 20 cm on an edge, but most are less that 2.4 cm. Massive pyrite is a host rock for albite. It may have a silvery gray coating of molybdenite on crystal faces (Howard 2001). The small crystals form perfect or modified cubes, and larger crystals may appear corroded where they have been partly intergrown with feldspar and the feldspar has been removed.
Runyan quartz deposit. Pyrite is reported in several places at this location (Williams 1979).
Titanium Corp of America pit. Cubes of pyrite with rounded edges and deeply striated faces occur as single crystals, aggregates of crystals, and irregular masses at this location. They are common and abundant (Shockley 1945). The crystals are 5 mm to 2 cm on an edge and occur in carbonate-microcline veins (Fryklund & Holbrook 1950). Small pyrite crystals up to 1 cm are still very common in the soil with little or no matrix.

PYROCHLORE group $(Ca,Na)_2Nb_2O_6(OH,F)$ Species not identified.

Martin Marietta Jones Mill quarry (JMQ). Microscopic brown octahedrons in syenite veins in silicified shale are pyrochlore, identified by SEM/EDS analysis in 2001,

PYROCHLORE ANALYSIS

LOCATION/DESC.	Na_2O	Al_2O_3	SiO_2	SrO	Nb_2O_5	K_2O	CaO	TiO_2	Fe_2O_3	SOURCE
JMQ, XLS	2.16	2.78	9.70	8.40	61.66	1.40	4.04	6.58	2.83	EXCALIBUR

PYROPHANITE $Mn^{2+}TiO_3$

Cove Creek Bridge and the Branch pegmatites. Pyrophanite was collected in 1985 by Bill Prior from the Arkansas Geological Commission. It was found in pegmatite after bridge reconstruction, and was abundant as discoidal crystals and lustrous black rosettes in the 2 to 3 mm size range. Their identity was confirmed by analysis by Henry Barwood (Smith 1994).
Diamond Jo quarry. Transparent, brown, tabular rhombohedral crystals of pyrophanite were noted by Howard Evans. They are microscopic, uncommon, and associated with fluorapophyllite (Smith 1989).

PYRRHOTITE Fe_7S_8

Brookite deposits on east rim. Pyrrhotite is an accessory mineral in dikes and veinlets at the Hardy-Walsh prospect (Flohr 1994).
Christy mine. Pyrrhotite is reported from the Christy vanadium mine by Flohr (1994).
Cove Creek Bridge pegmatite. Sulfide mineralization is in the form of galena, pyrrhotite, pyrite, and sphalerite (Tice, Falster, and Simmons 1999).
Jacupirangite locality. An outcrop of jacupirangite in Cove Creek is northeast of the Mo-Ti prospect. Pyrrhotite can be seen in this rock with a hand lens (Howard 2002).
Kimzey calcite quarry. Pyrrhotite is associated with magnetite at the contacts between the carbonatite and syenite (Fryklund, Harner & Kaiser 1954).

Mo-Ti prospect. Microscopic crystals of pyrrhotite may form rosettes up to 3 mm across on pyrite (Smith 1996).

QUARTZ SiO_2

Brookite deposits on east rim. The brookite deposits with quartz crystals occur in altered novaculite. The quartz crystals range from transparent and colorless to milky, gray, black, and opaque. Luster may be from vitreous to waxy to dull, depending upon the degree of etching or chemical reaction with late fluids. Smoky or black quartz crystals can be quite large and weigh up to 11 pounds. The smoky or milky crystals are more likely to be doubly terminated than the clear crystals. The crystals are usually fairly simple, but many have a corroded appearance where brookite crystals were attached. They may have some brookite crystals attached. Completely included brookite crystals are rare (Williams 1891, 303-304). Typically many crystals exhibit a white mottled appearance (Shockley 1945). At the Hardy-Walsh deposit, brookite, rutile needles, altered tainiolite and anatase may include quartz. Cube-shaped cavities, partly filled with goethite were also noted (Fryklund & Holbrook 1950, 46). In 1979-1980, Clyde Hardin hit a pocket with black quartz crystals and small brookites at the Hardy-Walsh deposit. The quartz crystals were up to 25 cm long and about 10 cm in diameter. Most of these crystals did not have any brookite attached to them, but a few brookites were found in corroded areas near their point of attachment or as inclusions (Smith 2003). Hardin also found a scepter quartz crystal when digging at Moses Hill in 1986. It was 17 cm long and about 4 cm in diameter (Smith 2003).

Central Cove area. Shockley (1945) reported clear quartz crystals with a rough exterior and irregular vuggy interior, but with excellent terminations. Some specimens had a faint amethystine color. They occur in masses from 18 cm to more than 36 cm across. Some small pieces of amethystine quartz were found when a gas pipeline was put through the area in the late 1960s. Recent house construction, east of the Kimzey Calcite quarry across Cove Creek, exposed masses of comby doubly terminated quartz. The dull-lustered quartz was gray to amethystine (Howard 2004).

Christy mine. Large masses of interlocking gray to black smoky quartz were common on the south bench level of the mine. It is now covered by reclamation (Howard 2004). A white quartz pseudomorph after a twinned titanite crystal was collected by Karl Estes. Bluish chalcedony coats the interior of some quartz vugs (D. McAlester, personal comm.).

Diamond Jo quarry. Typical prismatic, clear and colorless, quartz crystals, many doubly terminated, up to 5 mm long, were abundant in the quartz syenite. Tiny clear drusy quartz crystals line cavities associated with deep blue anatase near sandstone xenoliths (Smith 1989).

Kimzey magnetite mine. Rarely, some light smoky, clear faceting quality crystals have been found. Some of these crystals may have a pale amethystine color.

Martin Marietta Jones Mill quarry. Quartz is common as milky veins in the altered dark shale. These veins may contain cavities with crystals. The crystals are clear and colorless, milky white, smoky, opaque gray, and black. They range in size from less than 1 mm to rarely over 16 cm long. Inclusions in the quartz are chlorite, amphibole, and shale particles. Gray quartz crystals to over 12 cm long were collected in the 1990s from quartz veins. Barwood (1997 personal communication) noted beautiful tabular anatase, albite, fluorapatite, galena, and green sphalerite in the quartz veins. Estes (1998) reported the discovery of a Japan-law twin. Several other similar microscopic twins have been found. Smoky quartz crystals, up to 6 cm, in iron-stained albite are usually transparent, but have etched surfaces (Barwood 1998). Microscopic Japan-law twins were observed by Meredith York. Some bright clear microscopic anhedral crystalline quartz occurs in cavities with fluorite associated with xenoliths in syenite. The junior author recovered a hand specimen of quartz crystals coated by coarsely crystalline calcite. Removal of the calcite by HCl soak exposed brilliant lustered water-clear quartz crystals with inclusions of chlorite.

Middle Tufa Hill. The hill is composed of a porous siliceous sinter that contains large quartz crystals (Williams 1891, 182). A massive layered hematite deposit contains yellow quartz spherules up to 2 mm across (Shockley 1948).

Mo-Ti prospect. Well terminated quartz crystals have been found in vugs (Holbrook 1948).
Dull black quartz as small crystals, often double terminated, occurs with pyrite, rutile, brookite, molybdenite and albite in the creek diggings (Howard 2001). The crystals are usually less than 1 cm long. A few groups of 1 to 2 cm dull gray crystals have been recovered by digging in the creek.

Runyan Quartz deposit. Also known as Clark Runyan quartz mine is located north of the north rim of Magnet Cove in altered novaculite. It was a fee collecting area in the 1970s. Dark smoky, black, and white (coon-tail) quartz crystals occur as clusters and individual crystals in smoky quartz veins. The crystals are generally less than 8 cm long and formed in altered novaculite (Williams 1979). When the coontail crystals are cut perpendicular to the c axis, a series of light and dark zoning bands is evident.

RHABDOPHANE-(Ce) $(Ce,La)(PO_4)\cdot H_2O$

Martin Marietta Jones Mill quarry (JMQ). Rhabdophane-(Ce) was observed as white, minute discoidal crystals that often form rosettes less than 0.5 mm across on aegirine and feldspar. These rosettes may form compact groups with some single crystals or occur alone. Some of the crystals appear to be altered. It occurs in small syenite dikes in altered and fenitized shales (Smith 2001). Small brown crystal groups were seen in altered syenite xenoliths by B. Gamble and M. York in December of 2002. Its identity was confirmed by EDS analysis (see below).

Mo-Ti prospect. Possible rhabdophane-Ce was identified by SEM-EDS. It occurs as minute pale tan rosettes with albite and pyrite. Rhabdophane-(Ce) from this locality was identified as Cheralite-(Ce), but that name is now discredited.

RHABDOPHANE-(Ce) ANALYSES

LOCATION/ DESC.	P_2O_5	Ce_2O_3	La_2O_3	CaO	Nd_2O_3	ThO_2	Fe_2O_3	SOURCE
JMQ, DISC.	33.69	34.04	20.09	8.90	3.23	0.00	0.00	EXCALIBUR
MO-TI	28.85	23.84	15.61	4.89	8.66	3.63	4.98	EXCALIBUR

RHODOCHROSITE $MnCO_3$

Christy mine. Rhodochrosite occurs in cavities in fenitized rocks as microscopic pink, hollow, epimorphs with siderite, quartz, pectolite, rutile, kolbeckite, and corroded masses of pyroxene that were collected by Henry Barwood in 1989.

Martin Marietta Jones Mill quarry. Minute pale yellow to pale tan spheres in cavities and veins in altered shale are a mixture of siderite and rhodochrosite by XRD analysis. An EDS analysis was unreliable.

RIEBECKITE ☐ $[Na_2][Fe^{2+}_3Fe^{3+}_2]Si_8O_{22}(OH)_2$

Kimzey calcite quarry. Riebeckite as fine-grained masses occurs intimately intergrown with fluorapatite (Meurer et al. 1989).

RUTILE TiO_2

General. Rutile and brookite both contain traces to a few percent of niobium, which gives the mineral the black color common in the TiO_2 minerals of Magnet Cove. Many analyses are given by Erickson and Blade (1963).

Brookite deposits on the east rim. Minute (0.1 mm) needles of rutile are included in quartz in these deposits. This type of rutile may also occur as inclusions in brookite crystals. Some of this rutile is altered to leucoxene (anatase) (Fryklund & Holbrook 1950).

Central Cove area. Rutile paramorphs after brookite occur loose in the soil. They were particularly abundant near the Rutherford no. 2 house north of Cove Creek and west of where it enters the Cove (Williams 1891, 322). In the southeast corner near R. C. Preston house (later York farm), rutile eightlings are not uncommon (Williams 1891, 324). Howard (1999) expands this area to both sides of Highway 51. A single rutile paramorph after brookite was found in the brook in front of the Magnet Cove Baptist Church in May 1975. It is a 4.5 cm long prism with dipyramid terminations (Howard 1999). Similar smaller crystals have been recovered to the west in the brook at the Branch pegmatite area (Smith 2003).

Christy pit. Microscopic quartz crystals encrusted by needles of rutile were seen in 1989 by Henry Barwood. Associated minerals are siderite, rhodochrosite, pectolite, kolbeckite and altered pyroxene.

Kimzey calcite quarry. Needles of rutile occur in the carbonatite (Meurer et al. 1989). Microscopic thin plates of barely distinct acicular rutile crystals occur in the carbonatite with rhombohedral calcite crystals. Black granular rutile intergrowths in carbonatite are rarely recovered (Howard, Personal Obs.).

Kimzey magnetite quarry. Rutile paramorphs after brookite and eightlings have been found in the soil (Smith 1996).

Martin Marietta Jones Mill quarry. Black rutile encapsulated in quartz is a component of the quartz veining with anatase (Howard 1999). Rutile occurs as divergent groups, up to 1 mm, of tiny prismatic, lustrous black to red smooth crystals. The smaller crystals tend to occur in sprays and rounded flat masses of intergrown, often reticulated, crystals and are red to brown in color. The larger crystals tend to be black and occur as single crystals. They may show branching and rarely are genticulated twins. Some minute acicular brown rutile in cavities is associated with altered ilmenite on the wall of the cavities. These crystals were found in small syenite dikes in altered and silicified shale (Smith 2001). Acicular gray, yellowish to brown amphiboles, at times appearing reticulated, often are mistaken for rutile (Barwood personal communication).

Mo-Ti prospect. Small black striated crystals of rutile occur in the feldspar veins (Smith 1996). Small rutile paramorphs after brookite occur on pyrite with smaller brookites formed on the paramorph (Smith, personal observation).

Perovskite Hill. Rosettes or eightlings of rutile are still quite common (Williams 1891, 184, 324). Rutile also is present on hematite plates occurring to the west of the hill in a small stream between it and the main ridge of Magnet Cove (Williams 1891, 330). Clyde Hardin made several finds of rutile eightlings in the Perovskite Hill area. Most are about 1 cm across or less, though larger incomplete crystals have been recovered (Smith 2003). The rutile eightlings have never been found on matrix and it is uncertain if they actually originated from the carbonatite or from feldspar-carbonate veins in the area.

Richardson farm. This location in the NW1/4 of section 17 is thought to be the origin of most of the large paramorphs collected in the middle 1800s (Fryklund & Holbrook 1950). The crystals occurred loose in the soil in a plowed field. The location was quickly collected out. Examples of these specimens are preserved in many museum collections dating from the 19th century, including the Bement Collection (American Museum Natural History) in this country and several in Europe (Howard 1999).

Strahan property. Microscopic acicular black rutile occurs on white albite.

Titanium Corp of America pit. Rutile was the primary ore mineral at this mine. It occurs as single, 0.5 mm, acicular crystals, nests of acicular crystals, blebs, veinlets, and veins of rutile in feldspar carbonate veins. The acicular crystals may be completely or in part altered to leucoxene (anatase) (Fryklund & Holbrook 1950). Numerous rutile sixlings that mimic pseudohexagonal dipyramids have been collected. They range up to 2 cm across, but most are under 1 cm (Howard 1999). Also as black, small, elongated and striated crystals, some are genticulated twins. Smooth-faced dull, dark gray, rutile paramorphs after brookite, up to 4 mm across, occurred on thick feldspar plates during mining, but none have been recovered recently. Nests of minute needles with a purplish tinge are also rutile, confirmed by SEM-EDS analysis.

SANIDINE $K(AlSi_3O_8)$

General. Sanidine occurs as phenocrysts in nepheline tinguaite in several places in the Magnet Cove. Thin tabular crystals reach a length of 2 cm in a dark matrix (Williams 1891, 264-265).

Martin Marietta Jones Mill quarry. Microscopic colorless sanidine, reported as overgrowths on albite crystals, are a component of the quartz veins with anatase crystals discovered in 1998 (Howard 1999).

SCHORLOMITE $Ca_3(Ti,Fe^{3+})((Si,Fe^{3+})O_4)_3$

Central Cove area (CCA). Schorlomite is the younger of the two garnets and shows no crystal faces. The large opaque rounded masses are bluish black and may show iridescence. Fluorapatite prisms and biotite may penetrate it and vermiculite and magnetite are associated (Williams 1891, 212-217). Schorlomite may be recovered in the church area in the brook, the York farm area across the highway, and in the Kimzey magnetite mine area, all loose in the soil. Magnet Cove is the type location for schorlomite (Smith 1996).

Kimzey calcite quarry. Schorlomite occurs in a greenish contact metamorphic rock that is composed mostly of minute vesuvianite crystals (Shockley 1948).

SCHORLOMITE ANALYSES

LOCATION/DESC.	SiO_2	TiO_2	FeO	CaO	MgO	Al_2O_3	SOURCE
CCA	27.85	15.32	23.75	32.01	1.52	-	RAMMELSBURG 1849
CCA	26.09	17.36	22.83	31.15	1.56	-	RAMMELSBURG 1849
CCA	27.89	20.43	21.90	30.05	0.00	-	WHITNEY & CROSSLEY IN WHITE 1849
CCA	25.66	22.10	2.58	29.78	0.00	-	WHITNEY & CROSSLEY IN WHITE 1849
CCA	26.36	21.56	22.00	30.78	1.26	-	CROSSLEY IN DANA 1950
CCA	25.24	22.39	21.68	29.38	1.36	-	RAMMELSBERG 1849
CCA	26.10	20.52	21.95	29.35	1.47	-	KOPF IN PHILLIPS 1872
CCA	27.89	15.51	21.23	31.79	1.22	2.12	ERICKSON & BLADE 1963

SEIDITE-(Ce) $Na_4(Ce,Sr)_2Ti[(O,OH,F)_5|Si_8O_{18}(OH)] \cdot 5H_2O$

Diamond Jo quarry (DJQ). Seidite-(Ce) is rare in miarolitic cavities. It occurs as pinkish yellow dense aggregates that form microscopic equant crystals. It has been identified by EDS.

SEIDITE-(Ce) analysis

LOCATION/DESC.	Si_2O	SrO	TiO_2	Ce_2O_3	Na_2O	Al_2O_3	ZrO_2	K_2O	CaO	Fe_2O_3	P_2O_5	SOURCE
DJQ agg. of xls	33.93	10.10	13.63	14.63	2.25	2.75	3.05	0.97	7.21	2.81	2.81	Excalibur,York

Serpentine Group minerals – undifferentiated

Cove Creek, northeast of Cove limits. Large biotite crystals are completely altered to serpentine from dark brown coarse-grained syenite (Williams 1891, 226-227).

SIDERITE $FeCO_3$

Christy mine. Siderite compositions range from magnesian siderite to manganese-rich siderite (Flohr 1994). Spheres and crystals of bright brown siderite up to 8 mm across were found emplanted on gray to white drusy quartz in cavities in 1989 (Smith 2003). Siderite is widespread, but not abundant at the Christy mine, where it occurs in a variety of forms from botryoidal coatings to rhombohedral, acicular, and equant prismatic crystals. Most of crystals are less than 3 mm in size. The color varies from all shades of brown to red, orange, yellow, gray and gray-green.

Martin Marietta Jones Mill quarry (JMQ). Siderite forms mattes of greenish and yellow-brown to brown, translucent, microscopic, discoidal crystals to over 1 mm diameter in cavities of altered light-colored rock. It coats greenish amphibole tufts and aegirine crystals (Smith 1999) and may also form brown to greenish crusts on sphalerite (see analysis). It also occurs as rhombohedrons that alter to pale yellowish and greenish gray stalactitic masses. Small groups of minute spheres and discoidal manganese-rich siderite crystals occur in carbonate-rich rocks. They are bright yellow-brown to brown in color. Minute pale yellow to pale tan opaque spheres in altered shale are a mixture of siderite and rhodochrosite by XRD analysis. The results from an EDS analysis were unreliable. Amber, thin, discoidal crystals, 1 to 3 mm, occur with white calcite.

SIDERITE (MANGANESE RICH) ANALYSES

LOCATION/DESC.	CO_2	CaO	MnO	Fe_2O_3	SOURCE
JMQ BROWN	49.54	2.30	13.50	34.66	EXCALIBUR
JMQ OR-BROWN	38.97	1.96	12.16	48.91	EXCALIBUR
JMQ, CRUSTS	51.61	2.37	9.24	36.79	EXCALIBUR, ESTES

SIDEROPHYLLITE $KFe^{2+}{}_2Al(Al_2Si_2O_{10})(OH)_2$

Diamond Jo quarry. Charles Milton identified black micaceous siderophyllite in the miarolitic cavities, but it is uncommon (Smith 1989).

Martin Marietta Jones Mill quarry. Estes (1998) reports siderophyllite as occurring as dark green crystals with the color fading toward the interior. However, the EDS analysis contains magnesium and has a composition very similar to the EDS of similar material that has been identified as chamosite.

SMITHSONITE $ZnCO_3$

Christy mine. Microscopic, white, frosted “rice-grains” of smithsonite were observed in quartz-feldspar veins exposed at the water treatment pit in 1980. It occurs with galena, sphalerite, and fluorapatite.

SODALITE $Na_8(Al_6Si_6O_{24})Cl_2$

Diamond Jo quarry. Blue sodalite coats joints in pegmatite (Erickson & Blade 1963, 54).
Sodalite also occurs in the matrix, but none has been found in the miarolitic cavities (Smith 1989).
Kimzey calcite quarry. A small amount of colorless sodalite (hackmanite) has been found in a coarse-grained syenite. It fluoresces a golden yellow under long wave ultraviolet radiation and rose under short wave radiation. Some specimens show a faint pink evanescence that fades on exposure to artifical light or sunlight (Shockley 1948).
South border Magnet Cove (SBMC) between Cove Creek and Stone Quarry Creek. Some prospecting pits dug by the Kimzeys contain a fine-grained dark greenish-gray dike rock (tinguaite) with sodalite. Blue sodalite and the colorless variety of sodalite called hackmanite occur in widely spaced masses and veins. The masses range in size from specks to masses up to almost 10 cm across. The blue sodalite occurs alone or intimately associated with the hackmanite. Blue sodalite contains pyrite, calcite, black biotite, and purple fluorite that, at times, form a rim around the edges. Thomsonite is an alteration product of the fluorite. Both sodalite and hackmanite are fluorescent, but the hackmanite is spectacular with fluorescence that varies from golden yellow to deep rose to reddish-orange. It is also evanescent being white translucent to colorless in daylight, but turns a lilac-rose color when kept in darkness. Analyses of the two types of sodalite are nearly identical (Miser & Glass 1941).
North side of the Cove. A similar occurrence of purple sodalite and hackmanite is reported (Miser & Glass 1941).

SODALITE ANALYSES

LOCATION/DESC.	$Si0_2$	Al_20_3	Fe_20_3	Mn0	Na_20	Cl	$CaCO_3$	SOURCE
SBMC, BLUE	36.36	32.09	0.07	0.06	24.73	6.79	0.50	MISER & GLASS 1941
SBMC, HACK.	36.70	32.01	0.00	0.00	24.79	7.00	0.29	MISER & GLASS 1941

SPHALERITE ZnS

General. A 4 mm crystal of green sphalerite was found in a cavity in syenite emplanted on a mass of felted brown aegirine (Miser & Glass 1941). No specific locality was given.
Chamberlain Creek barite mines. Sphalerite has been reported from these mines (Parks & Branner 1932).
Cove Creek Bridge pegmatite. Sulfide mineralization in the pegmatite consists of galena, pyrrhotite, pyrite, and sphalerite (Tice, Falster, & Simmons 1999). Emerald green crystals up to 4 mm across occur on a mass of felted dark brown aegirine. Sphalerite is fairly common as small brown resinous masses in the contact metamorphic rocks (Smith 1996).
Christy mine. Small crystals and masses of sphalerite occur in cavities in quartz-feldspar veins exposed during construction of the water treatment plant. It occurs with fluorapatite, galena, and smithsonite.
Diamond Jo quarry. Simple or modified single yellow sphalerite tetrahedra, less than 0.5 mm across, occur in miarolitic cavities. They are readily recognised, but not abundant. (Smith 1989).

Martin Marietta Jones Mill quarry (JMQ). Green, transparent sphalerite occurs as masses, complex crystals and simple tetrahedra in quartz and carbonate veins with pyrite and other sulfides. The crystals range up to 2 mm, but most are smaller. Raspberry colored sphalerite occurs on pyrite in 1 mm crystals in syenite. It also occurs in syenite cavities as waxy yellow distorted crystals.

Mo-Ti prospect. Small dark microscopic crystals of sphalerite occur on albite. They are not common (Smith 1996).

Titanium Corp of America pit. Sphalerite is found sparingly in light-colored, feldspar dike rock. It occurs as shiny, nearly black, stringers. Small red-brown crystals occur in marcasite (Shockley 1945). An arborescent mass of sphalerite formed within K-feldspar, now in the Arkansas State collection, was recovered during active mining (Howard 2004). A crude black tetrahedron of sphalerite over 1.2 cm was collected by Clyde Hardin (Smith 2003). A rutile vein intergrown with calcite was recovered by the junior author and, after acidizing to remove the calcite, two dull brown crude sphalerite crystals were noted attached to the feldspar wallrock.

SPHALERITE ANALYSES

LOCATION/DESC.	Zn	S	FeO	SOURCE
JMQ, RED-BROWN	75.84	23.35	0.82	EXCALIBUR, ESTES
JMQ, YELLOW	61.67	38.33	0.00	EXCALIBUR

SPINEL $MgAl_2O_4$

Central Cove area. Massive black spinel is a constituent on the rounded magnetite pieces found in this area (Barwood 1996 personal communication).

Kimzey calcite quarry. Minute crystals of spinel, some displaying spectacular twins, are included in fluorapatite crystals (Meurer et al. 1989).

Middle Tufa Hill – Spring area (MTH-SA). In 1977, while tending his beehives in this area, Clyde Hardin picked up some black crystals up to 4 mm diameter (Smith 2003). EDS analysis showed them to be iron-rich spinel, similar to the pleonaste variety. They may have a slight attraction to a magnet.

SPINEL ANALYSIS

LOCATION/DESC.	Al_2O_3	MgO	Fe_2O_3	SOURCE
MTH-SA XL	59.00	24.11	14.85	EXCALIBUR

STRONTIANITE $SrCO_3$

Cove Creek Bridge area (CCB). White sprays of divergent acicular crystals form hemispheric groups up to 2 mm across in small cavities of pegmatite. The mineral is not common and was identified by EDS analysis. Some of the flattened hemispheric groups were thought to be a form of wollastonite.

Martin Marietta Jones Mill quarry (JMQ). Clear to white, elongated thin, rounded crystals, extending across and into vugs, have been identified as calcium-barium-rich strontianite by EDS. The cavities contain natrolite and are associated with carbonate-rich layers.

STRONIANITE ANALYSES

LOCATION/DESC.	CO_2	SrO	CaO	BaO	SOURCE
CCB, SPRAYS	37.62	50.57	11.82	00.00	EXCALIBUR
JMQ, ACICULAR	10.39	54.37	24.64	10.60	EXCALIBUR

STRUVERITE (Ti,Ta,Fe)O_2 a variety of rutile.

Martin Marietta Jones Mill quarry. Struverite was identified by EDS analysis. It occurs as aggregates of minute rod-like black crystals that form groups of crystals extending from a central pole in a corroded ankerite or siderite vein (Smith 1998a). To the author's knowledge, the specimens collected in 1997 are the only ones preserved.

STRUVERITE ANALYSIS

LOCATION/DESC.	TiO_2	TaO	SnO_2	Fe_2O_3	SOURCE
JMQ RODS	47.16	46.99	2.11	3.74	EXCALIBUR

SYNCHYSITE-(Ce) $CaCe(CO_3)_2F$

Kimzey calcite quarry. Synchysite-(Ce) occurs intergrown with bastnâsite-(Ce) in veinlets in the carbonatite and consist of bright yellow thin tabular crystals. The crystals are less than 1 mm across (Barwood and Howard 1990). An analysis of the dark areas of the crystals by Henry Barwood in 1995 showed the following percentages: La_2O_3: 21.64, Ce_2O_3: 22.26, Nd_2O_3: 7.90, CaO: 16.80, F: 5.00.

TAINIOLITE (TAENIOLITE) $KLiMg_2(Si_4O_{10})F_2$

Brookite deposits on the east rim (BD). Aggregates of silky, yellow to white flakes of tainiolite occur with the brookite deposits. It was discovered in 1936 by Joe and Lawton Kimzey. Tainiolite occurs in irregular veins and pockets up to 30 cm wide in a red and yellow clay and altered novaculite. The tainiolite occurs as loose friable masses associated with crude quartz crystals and dickite. It is in the form of plates that vary from 0.04 mm to 0.2 mm thick, averaging about 0.15 mm in diameter. Rarely these plates show a crude hexagonal outline. Most have an irregular or lobate outline (Miser & Stevens 1938). At the Hardy-Walsh deposit it occurs as small masses in kaolinite. Altered tainiolite occurs as inclusions in quartz (Fryklund & Holbrook 1950). Veinlets of tainiolite in novaculite were seen during vanadium mining at the Christy mine (Howard 2001). In the Christy mine, Henry Barwood, recovered green fibrous veinlets and masses interspersed with greenish flakes before the mine was reclaimed. The greenish flakes are pure tainiolite and the green fibrous material is a mixture of tainiolite and smectite clay (1995, Coon Creek Assoc. communication).

Diamond Jo quarry. Charles Milton identified tainiolite in the miarolitic cavities as 0.1 mm tan to silvery lustered, micaceous flakes (Smith 1989).

Kimzey calcite quarry. Tainiolite occurs in the contact zone between the carbonatite and syenite (Estes 1998). It is associated with small pyrite and magnetite crystals, occurring as clear microscopic crystals that form small masses and rosettes.

Martin Marietta Jones Mill quarry. Tainiolite occurs as brown to silver-gray mica-like plates forming rosettes and spheres. Associated minerals are well-formed pale tan calcite, pyrite, pectolite, rutile, and smoky quartz. Tainiolite spheres may be scattered on the pectolite (Estes 1998). In the anatase veins tainiolite occurs as colorless leafy aggregates with a rosette-like structure sticking out from the earlier formed quartz crystals (Howard 1999). Smaller, pearly, clay-like masses obtained from Karl Estes were analyzed and proved to probably also be tainiolite, as was a small, pale blue, foliated mass.

Mo-Ti prospect. Small pale gray flakes of tainiolite are inconspicuous at this prospect (Smith 1996).

TAINIOLITE (TAENIOLITE) ANALYSIS

LOCATION/DESC.	SiO_2	K_2O	MgO	Al_2O_3	Fe_2O_3	Na_2O	Li_2O	F	SO_3	SOURCE
JMQ, CLAY-L	63.39	10.64	21.61	1.94	1.25	1.27	-	-	-	EXCALIBUR
BD, FLAKES	58.82	10.44	19.18	1.29	0.60	0.64	3.10	8.56	-	MISER & STEVENS 1938
JMQ, BLUISH	63.25	7.50	23.93	2.25	1.37	0.00	-	-	-	EXCALIBUR
CHRISTY	59.16	11.06	19.39	0.91	0.95	0.08	-	-	-	FLOHR 1994

TALC $Mg_3Si_4O_{10}(OH)_2$

Kimzey calcite quarry. Talc is found in small foliated, pinkish plates in the contact metamorphic rock between the carbonatite and syenite pegmatite (Shockley 1945). It has been suggested by some that this material may be miserite. An X-ray diffraction of a small pink mass was identified it as natrolite (Charles Milton, personal communication).

TETRAFERRIANNITE $KFe^{2+}_3((Fe^{3+},Al)Si_3O_{10})(OH)_2$

Martin Marietta Jones Mill quarry. Deep red brown, transparent, pseudohexagonal tapered prisms were seen in altered xenoliths in syenite in December 2002. The crystals are less than 1 mm long and occur alone or in subparallel groups. They are associated with a tan garnet and lustrous magnetite octahedrons. An analysis by Excalibur Minerals was completed in Jan. 2003 on a specimen submitted by Bob Gamble (see analysis under biotite).

THAUMASITE $Ca_3(SO_4)[Si(OH)_6](CO_3)\cdot 12H_2O$

Kimzey calcite quarry. Massive white thaumasite has been reported, but not verified from the contact metamorphic rocks (Shockley 1948).

THOMSONITE $NaCa_2[Al_5Si_5O_{20}]\cdot 6H_2O$

Central Cove area (CCA). Thomsonite reported as “Ozarkite” was listed by early writers from this area, but it was not observed by Williams (1891, 221-224). Thomsonite is abundant as an alteration product of nepheline particularly around the periphery of the Kimzey magnetite pit and on Cove Creek where the ijolite is in contact with the carbonatite (Erickson & Blade 1963, 28). Thomsonite in the ijolite has an analysis, specific gravity, and refractive indices of thomsonite, but the X-ray diffraction pattern fits natrolite (Erickson & Blade 1963). Thomsonite varies in color from white to reddish and rarely green. Usually opaque and rarely translucent, it occurs in veins as minute radiating greenish fibers and rounded masses up to 8 cm in diameter.

Cove Creek bridge and the Branch pegmatites. Small quantities of thomsonite are present (Williams 1891, 253). Thomsonite occurs as greenish to brown masses in the contact metamorphic rock (Shockley 1945). White crystalline masses of thomsonite that may show a concentric or radiating structure have been found in the pegmatite (Smith 1996).

THOMSONITE (OZARKITE) ANALYSES

LOCATION/DESC.	SiO_2	Al_2O_3	CaO	Na_2O	H_2O	SOURCE
CCA, OZARKITE	40.91	15.75	8.42	0.00	15.10	SHEPARD IN DANA 1851
CCA, OZARKITE	36.85	30.97	13.95	3.19	13.80	SMITH & BRUSH 1853
CCA, OZARKITE	37.08	31.13	13.97	3.91	13.80	SMITH & BRUSH 1853
CCA, IJOLITE	38.70	30.21	6.99	10.57	12.60	ERICKSON & BLADE 1963

THORITE Th(SiO_4)

General. Thorite, monazite-(Ce), and a rare earth carbonate occur as irregular clusters of poorly formed crystals, less than 1 mm across, in smoky quartz crystals in altered novaculite outside of the igneous rocks of Magnet Cove (Tice, Falster, and Simmons 1999).

Martin Marietta Jones Mill Quarry. Thorite occurs as a granular dusting on fibrous acmite collected from a large cavity in altered Stanley Shale in the upper west area of the quarry. (Howard, personal comm.).

TITANITE CaTi(SiO_4)O

Central Cove area. Titanite occurs as brilliant, sharp, yellow crystals up to 3 mm in diameter (Williams 1891, 217-218).

Christy Vanadium mine. An 8 mm long, white pseudomorph of quartz after twinned titanite crystals is in the collection of Karl Estes.

Cove Creek Bridge (CCBP) and the Branch pegmatites. Well-formed crystals of titanite from the pegmatite are 1 to 5 mm long and are often a brilliant sulfur yellow color, but may also be a more subdued bronze color. They occur embedded in the matrix or protrude into cavities as wall rock extensions (Williams 1891, 252-253). Dark brown crystals of titanite up to 2.4 cm with dull exteriors, but glassy interiors, have been reported (Shockley 1948). These are probably from the contact metamorphic rocks and also occur as pale brown, pink, and peach colored microcrystals. They are of the typical flattened prismatic form and rarely reach 0.5 cm in size (Smith 1994). Splendid euhedral straw-yellow crystals, averaging 0.5 mm in their greatest dimension, were reported by Tice, Falster & Simmons (1999). Minute bright yellow crystals from a contact metamorphic rock are slightly niobium-rich as determined by EDS analysis.

Diamond Jo quarry. Brown to pale yellow flat crystals of titanite with a rounded or sharp euhedral form are common in the matrix of some of the pseudoleucite syenite, but they are rare in the miarolitic cavities. Brown crystals in the cavities are up to 2 mm long and appear to be extensions of matrix crystals. The rare yellow crystals are sharper and are perpendicular to the cavity walls (Smith 1989).

Martin Marietta Jones Mill quarry (JMQ). Titanite occurs as 1 mm dark red-brown groups of typical crystals. Karl Estes confirmed their identity by EDS analysis (see below). He also observed titanite as black 1 mm crystals. Yellow opaque, waxy appearing titanite in poorly formed crystals was observed in cavities in quartz veins crosscutting altered shale. Thin, white to colorless crystals occur in subparallel groups and as singles in quartz-orthoclase veins with hematite in baked shale.

Mo-Ti prospect. Titanite has been reported from this area probably from the jacupirangite (Smith 1996).

Titanium mines. Shockley (1945) reports that titanite partly altered to leucoxene (anatase) occurs in dike rocks.

West rim of Magnet Cove. Notable outcrops of titanite nepheline syenite were reported (Erickson & Blade 1963). Typical pale pinkish tan disphenoid crystals are dispersed in exposures of this rock on the highway right-of-way on Cook Mountain (Howard 2004).

TITANITE ANALYSES

LOCATION/DESC.	SiO_2	CaO	TiO_2	Al_2O_3	Nb_2O_5	Na_2O	FeO	MgO	SOURCE
CCBP YELLOW	45.72	18.92	24.42	4.16	3.60	3.18	0.00	0.00	EXCALIBUR
CCBP	30.84	28.26	39.36	0.00	0.00	0.00	0.73	TR	GENTH 1891
JMQ, RED-BR	40.81	26.06	22.56	7.79	0.00	0.00	2.60	0.00	EXCALIBUR, ESTES

JMQ, YELLOW	**20.42**	**19.41**	**51.53**	**3.80**	**0.00**	**0.00**	**4.95**	**0.00**	**EXCALIBUR**
JMQ, WHITE	**36.96**	**29.21**	**26.35**	**6.54**	**0.00**	**0.00**	**0.93**	**0.00**	**EXCALIBUR**

TOBERMORITE $[Ca_4Si_6O_{17} \cdot 2H_2O] \cdot (Ca \cdot 3H_2O)$

Cove Creek bridge and the Branch pegmatites. A chert-like material in the pegmatite was identified by X-ray analysis as tobermorite (Erickson & Blade 1963, 48).

TREMOLITE $\square\{Ca_2\}\{Mg_5\}(Si_8O_{22})(OH)_2$

Kimzey calcite quarry. Tremolite is reported as an alteration of monticellite. It occurs as radiating green and reddish colored crystalline aggregates in a band of about 6 mm surrounding monticellite crystals (Shockley 1945).

Kimzey magnetite mine. Tremolite occurs as bladed crystals and radiating aggregates over 5 cm long. It is associated with vesuvianite, biotite, and melilite and varies in color from white to pale green to reddish.

VARISCITE $AlPO_4 \cdot 2H_2O$

Christy mine (CM). Variscite is reported to occur at the Christy vanadium mine by Flohr (1994). It occurs as microscopic pale green spheres with goethite and is not common. Microscopic colorless to white spheres that were thought to possibly be planerite are likely variscite (see analysis).

VARISCITE ANALYSIS

LOCATION/DESC.	**P_2O_5**	**Al_2O_3**	**SiO_2**	**SOURCE**
CM, WHITE	**63.71**	**38.14**	**6.43**	**EXCALIBUR**

.

VERMICULITE $Mg_{0.7}(Mg,Fe,Al)_6(Si,Al)_8O_{20}(OH)_4 \cdot 8H_2O$

Central Cove area. Vermiculite occurs in plates up to 30 cm or more in diameter and books. It is grayish green to silvery green to pale tan in color. Thin lens-shaped crystals of calcite may occur between the plates (Williams 1891, 181, 224-225). The plates of vermiculite altered from biotite and occur loose in the soil. Partially altered biotite has been called protovermiculite in the older literature (Smith 1996).

Iron Bridge across Cove Creek. About 1000 feet due north, and just northeast of Dr. Rutherford's house, is another magnetite body with vermiculite (Williams 1891, 187).

Kimzey magnetite mine. Silvery colored vermiculite is reported as an alteration of biotite (Stone et al. 1982).

VESUVIANITE $(Ca,Na,\square)_{19}(Al, Mg, Fe^{3+})_{13}(\square,B,Al,Fe^{3+})_5(Si_2O_7)_4(SiO_4)_{10}(OH,F,O)_{10}$

Cove Creek bridge and the Branch pegmatites. Imperfect crystals of vesuvianite can be up to 8 cm long, but most well-formed crystals are smaller. The crystals are usually well terminated. Pyramidal faces dominate with prism faces being very small or absent. Clyde Hardin found this type of crystal in an area along Cove Creek 150 to 200 yards north of the bridge. The crystals from the Branch pegmatites are generally prismatic (Smith 2003). The color varies from an oily, yellowish green to an olive-green and rarely yellowish or reddish brown (Williams 1891, 336-338). At the Cove Creek bridge, vesuvianite occurs in contact metamorphic rock as single crystals or aggregates of intergrown crystals. Color zoning is prominent in the larger crystals and crystalline masses, but microcrystals are all yellow (Smith 1994).

It occurs as doubly terminated bipyramids, flat-topped prisms, and combinations of both forms with additional faces. In recent years, no complete or nearly complete crystals from the Cove Creek bridge area have been reported.

Kimzey calcite quarry. Metamorphic rock with a green color is composed of minute crystals of vesuvianite up to 2 mm across. This rock contains thomsonite, schorlomite, and other minerals (Shockley 1948). Vesuvanite occurs in the contact metamorphic rock as masses and crystals and as tiny microscopic yellow crystals in carbonatite (Smith 1996).

Kimzey magnetite mine. Vesuvianite occurs as yellow and green masses. Small crystals occur in cavities (Stone et al. 1982).

Lime-silicate area. The lime-silicate rock is composed of fine- to medium-grained anhedral vesuvianite (idocrase) and colorless diopside. Vesuvianite and other minerals partially replace melilite. Well formed vesuvianite crystals line miarolitic cavities (Erickson & Blade 1963, 39). These crystals are bright yellow and transparent to translucent. They occur with pale green diposide and a bladed mineral that is possibly scapolite.

VESUVIANITE ANALYSIS

LOCATION/DESC	**SiO_2**	**TiO_2**	**Al_2O_3**	**Fe_2O_3**	**FeO**	**CaO**	**SrO**	**MgO**	**K_2O**	**Na_2O**	**H_2O**	**SOURCE**
UNKNOWN, XL	**36.68**	**0.72**	**16.14**	**5.56**	**1.07**	**35.52**	**TR**	**0.95**	**0.19**	**0.26**	**1.83**	**WILLIAMS 1891**

WAVELLITE $Al_3(PO_4)_2(OH,F)_3 \cdot 5H_2O$

General. Wavellite has been reported from Magnet Cove for many years. However, most of this green wavellite came from Dug Hill near Avant in Garland County.

Christy mine. White wavellite occurs at this mine (Barwood & de Linde 1989). It occurs as spheres and masses consisting of white radiating blades up to 1 cm long on gray novaculite.

Titanium mine. Microscopic crystals of white wavellite perched on rutile have been observed and photographed by Howard (2004).

West Tufa Hill carbonatite. A core taken in 1954 had wavellite logged from 72 feet to 94 feet (Erickson & Blade 1963, p. 34). Howard thinks this report of wavellite is probably radially fibrous apatite (Barwood & de Linde 1989).

WOHLERITE $NaCa_2(Zr,Nb)(Si_2O_7)(O,OH,F)_2$

General. Wohlerite is listed as an occurrence in Magnet Cove (Anthony et al. 1995, Gaines et al. 1997). The authors are unaware of any additional reports of the occurrence of wohlerite in Magnet Cove.

WOLLASTONITE $CaSiO_3$

Cove Creek Bridge and the Branch pegmatites. Wollastonite has been observed in only a few cases (Williams 1891, 251). Wollastonite occurs in the contact metamorphic rock between the carbonatite and syenite pegmatite. It occurs as relatively clear, irregular crystalline masses that have pearly luster and may show terminations. This mineral may have a delicate pink fluorescence under short wave ultraviolet radiation (Shockley 1948). Dense white wollastonite is the primary light colored component of the contact metamorphic rock (Smith 1996). It occurs as white to yellowish opaque radiating masses of blades, compact masses, irregular veins, and narrow thin bladed crystals. Some have a delicate pink to dull red fluorescence under both long wave and short wave ultraviolet radiation. It may also be phosphorescent.

Cove Creek Bridge south 800 feet. An altered phonolite has andradite lined amygdules with wollastonite, diopside, calcite, garnet, and an infilling zeolite (Erickson & Blade 1963, 25-26).

Diamond Jo quarry. Wollastonite was identified by XRD and was discovered by its yellow luminescence. It occurs with benitoite, labuntsovite and other minerals in cavities in pseudoleucite syenite. It was found and identified by Barwood in 1996. Wollastonite occurs as inconspicuous microscopic colorless coarse prismatic crystals that form radiating bundles.

Kimzey calcite quarry. Wollastonite occurs in both patches of radiating yellowish white needles and irregular veins (Landes 1931). This sounds like a description of the carbonate fluorapatite. Wollastonite does not occur in the carbonatite, but in the contact metamorphic rock.

Titanium Corp of America pit. Needles of wollastonite occur in calcite veins (Fryklund & Holbrook 1963).

YOFORTIERITE $Mn_5Si_8O_{20}(OH)_2 \cdot 8\text{-}9H_2O$

Martin Marietta/Jones Mill Quarry. Pinkish tan clusters and tufts of fibrous crystals of yofortierite occur in miarolitic cavities with orthoclase. The mineral was identified by XRD by H. Barwood.

ZIRCON $Zr(SiO_4)$

Cove Creek bridge at State Route 51 (CCB). Minute, pale tan, transparent crystals of zircon occur with aegirine and orthoclase in cavities of pegmatite. It was identified by EDS analysis.

Diamond Jo quarry. Henry Barwood identified zircon as crude, 0.5 mm long, pale yellow to white, dipyramidal crystals in the quartz syenite. The crystals have rough surfaces, and implanted on those surfaces are minute, transparent colorless elongate zircon crystals (Smith 1989).

Martin Marietta/Jones Mill quarry. Zircon was identified by EDS analysis. It consists of bright pale yellow transparent, equant, crystals, less than 0.5mm across. The crystal form is difficult to recognize because of their small size, brightness, and transparency. An SEM shows some zircon to be typical short prismatic dipyramidal crystals. They occur in small rounded miarolitic cavities in the small syenite dikes that cut the altered and silicified shales (Smith 2001).

Perovskite Hill. Well-formed yellowish zircon crystals, up to 5 mm, were recovered by screening (Smith 1996). They came from a small gully south of the “hill”. A white opaque 1 cm crystal was recovered by Clyde Hardin (Smith 2004). Zircons may be more abundant at Perovskite Hill, but any crystals smaller than 6 mm probably go through the screens of the diggers.

ZIRCON ANALYSIS

LOCATION/DESC.	ZrO	SiO_2	Fe_2O_3	SOURCE
CCB, TAN XL	64.56	32.35	2.98	EXCALIBUR
JMQ, YELLOW XL	62.54	37.46	-	EXCALIBUR

ZIRCOPHYLLITE $(K,Na)_3(Mn,Fe^{2+})_7(Zr,Ti)_2Si_8O_{24}(O,OH,F)_7$

Diamond Jo quarry. Barwood (1997 personal communication) reports that the sheet-like mineral that he had tentatively identified as kupletskite in a miarolitic cavity is compositionally zircophyllite.

UNNAMED OR INCOMPLETLY IDENTIFIED MINERALS

CALCIUM VANADATE – Christy mine. Occurs in brookite-quartz aggregates, may be a member of the Straczekite family (Flohr 1994).

CALCIUM-SODIUM SILICATE – Jones Mill quarry. Tiny, thin lath-like, white crystals that occur intermixed with transparent barite crystals in cavities associated with xenoliths in syenite. Analysis: Na_2O – 15.43%, CaO – 22.25%, SiO_2 – 62.32%

MAGNESIUM ALUMINUM SILICATE – Diamond Jo quarry. A pale tabular crystal in miarolitic cavity in pseudoleucite syenite was sent for analysis by Excalibur. EDS gave the following analysis: MgO – 26.29%; Al_2O_3 – 12.54%; SiO_2 – 49.88%; K_2O – 6.84%; MnO – 1.87%; Fe_2O_3% – 2.57.

NEODYMIUM-RICH RARE EARTH SPECIES – Noted as inclusions within early formed smoky quartz in altered novaculite areas (Tice, Falster & Simmons 1999).

NIOBIUM-RICH TiO_2 polymorph – Kimzey calcite quarry. Yellow (Meurer et al. 1989).

OKANOGANITE related mineral – Diamond Jo quarry. Wine-colored flat crystals of a calcium rare earth borosilicate. The crystals are rhombohedral and closely related to okanoganite. They occur in miarolitic cavities in pseudoleucite syenite with clear calcite crystals (H. E. Evans, Jr., 1985, personal communication).

RARE EARTH MINERAL Diamond Jo quarry. Unknowns number 24 and 27 contain Ce, La, Fe, Si, and Al (Barwood, 1985, personal communication): from the quartz syenite boulder above the quarry. UK 24 – present as colorless, prismatic (elongate) crystals alone or more commonly in divergent groups. UK 27- present as pale yellow to white, crude dipyramids in masses. Both forms are under 0.5 mm.

UNKNOWN NO. 5 Diamond Jo quarry. Occur as pale orange equant microscopic crystals. An SEM shows a cubic crystal. The EDS analysis by weight percentage is: Na_2O: 6.98, Al_2O_3: 1.46, SiO_2: 45.98, NbO_2: 5.85, K_2O: 6.96, TiO_2: 16.47, BaO: 13.85, Fe_2O_3: 2.46.

Part 3 - BRIEFS OF THE IMPORTANT MINERAL LOCATIONS OF MAGNET COVE

Brookite deposits on the east rim. In the early 1970s, all of the brookite deposits were explored for vanadium by Union Carbide, but only the Christy deposit was mined (Howard 2004). The *Hardy-Walsh deposit* is located about 1 mile north of the Magnet Cove Cemetery on the high area between Chamberlain and Cove Creeks. The deposit was explored for titanium in the early 1940s, but there was no production (Fryklund & Holbrook 1950). Clyde Hardin of Malvern found a pocket of large black quartz crystals in the spring of 1980, after 9 years of relatively unsuccessful digging. The largest crystals were up to 30 cm long. Only a few of the crystals had brookite crystals attached. He also collected numerous small bright complete loose brookite crystals. The *Christy deposit* is just south of Chamberlain Creek about 0.5 miles north of the cemetery. This deposit was explored for titanium as early as 1913 and again in the 1940s. No production of titanium was reported. The deposit was explored for vanadium in the 1960s and early 1970s. A test pit was dug in 1975 and the mine produced vanadium ore that was trucked to Union Carbide's Wilson Springs operation sporadically in the 1980s and early 1990s. The open pit has now been completely reclaimed. This location has many more mineral occurrences than the others and so is listed as the Christy mine or pit under many occurrences in this article. *Road outcrops at Magnet* were the source of brookite in the area west and south of the cemetery across the road from where the post office was formerly located. The quartz veins contained vugs with imperfect quartz crystals and brookite crystals up to 5mm in diameter. The majority of the described Magnet Cove brookite crystals came from this location (Fryklund & Holbrook 1950). *Moses Hill or Rutherford deposit* is a hill south of the Magnet Road outcrops, across the highway from the Magnet Cove Cemetary. The brookite crystals can be large, some reaching over 1.5 cm (Frykland & Holbrook 1950). The characteristics of the brookite crystals from this area are that they tend to be somewhat flat and not always as bright as those from other areas, due to well defined alternating repetitions of the *m* crystal faces. The quartz crystals are gray, intergrown, and have a porous appearance. Larger black crystals are more like those from other deposits. The *Harver Hills subdivision - Magnet Cove School* is the southernmost of the brookite occurrences. During the 1970s, Clyde Hardin collected numerous small brookite crystals during and after construction in the area (Smith 2003). One location is actually ~1.5 km north of the Magnet Cove intrusive contact with the country rock: the *Runyan Quartz Mine.* This site yielded scarce samples with crusts of microscopic brilliant lustered microscopic brookite crystals on smoky quartz. "Coon tail" quartz was named from this site for the typical alternating black and gray pattern present on the terminations when viewed down the C axis.

Central Cove area. This area centers on the Magnet Cove Baptist Church. It extends westward along Arkansas Highway 51 to Cove Creek, and eastward to the Kimzey magnetite mine on the north, and the York farm on the south. There are no bedrock outcrops within this area, except some carbonatite with zoned green biotite along the brook under the bridge of the Magnet Cove Baptist Church property. The minerals are found loose in the soil and are only available during periods of construction within the area.

Diamond Jo quarry. The quarry was probably opened in the 1880s as a source of construction rock for the Hot Springs ("Diamond Jo") railroad. It has long been inactive, but it was a significant collecting site for many years. This quarry was well known for the thin films of blue sodalite on fractures within the syenite. The unusual suite of microminerals in miarolitic cavities was not discovered until the early 1970s. The quarry is under private ownership and is not open to visitation or collecting without the owner's permission.

Lime-silicate area. This area, northeast of the fenced magnetite area along Highway 51 is considered a reaction zone between the ijolite and carbonatite by Erickson & Blade (1963). It is located in the edge of the field just before it starts to rise to the east rim. In the 1950s, it was considered to be the magnetite mine and what is now the Magnetite mine was the garnet area. Some bedrock was exposed in the shallow pits, but it has been off limits to collecting for many years. The mineralogy is similar to the Kimzey magnetite mine.

Kimzey calcite quarry. Also known as Calcite Hill and the Kimzey calcite pit, the Kimzey calcite quarry is located just west of Cove Creek on the north side of Arkansas Highway 51. It was first worked for calcite in the 1940s and later worked in the middle 1960s. It has been a collecting area for many years, although it is presently posted and off limits without permission. The quarry is in the same carbonatite that underlies Perovskite Hill to the southwest across the highway. Good specimens of this carbonatite also occur in the bed of Cove Creek adjacent to the quarry and downstream from it, as well as on the highway outcrop.

Kimzey magnetite mine. Also known as the Garnet field, the Kimzey magnetite mine is located in the NW1/4 of section 20. The mine has sporadically produced magnetite from an open pit, particularly during 1950 to 1951. Large rounded masses of magnetite occur loose in the soil. Some are natural magnets or lodestones. The area was briefly operated as a collecting site for magnetite and garnets in the early 1980s, but it is now fenced, and not open for collecting (Stone et al. 1982). A very few, but large rutile paramorphs after brookite, were recovered by collectors while this site was open. Clyde Hardin dug a vein of dark garnet crystals with fluorapatite inclusions from a weathered zone on the highway right-of-way just outside the fence of this site. The fenced portion of the magnetite mine was opened by the owners as the Garnet mine for only 1 summer.

Martin Marietta Jones Mill quarry. Also known as the Midstate or Mid-state, and Highway 51 quarry. Opened in the early 1990s within the Arkansas Novaculite, this quarry expanded into the Stanley Shale since its purchase by Martin Marietta in the late 1990s. The quarry produces contact metamorphosed Stanley Shale for road construction. Recently an asphalt plant has been added to the facility. The quarry intercepted stringers of syenite in 2000 and a larger mass of fine-grained syenite on the second level in 2001. Minerals occur in quartz and feldspar veins in the altered shale and in small miarolitic cavities in the syenite and larger cavities in syenite pegmatite between feldspar laths. The most variation in mineral species is found associated with altered xenoliths, often garnet ijolite in composition.

Molybdenum-Titanium prospect. (Mo-Ti) The Mo-Ti prospect is located in the NW1/4 of section 17 and south of Cove Creek on what was the Cotton Golden Farm. It was first prospected for pyrite in 1929-30 and for molybdenum in the 1940s. It consists of feldspar-pyrite-molybdenite veins in fractured altered jacupirangite. The area is overgrown and the pits have had their exposures covered by slumping material, but similar material is encountered just to the north in the banks of Cove Creek (Holbrook 1948). The area in and on the banks of Cove Creek has been a popular collecting area for many years. Interestingly, the molybdenite was misidentified for years as graphite until a sample was analyzed by the Arkansas Geological Survey.

Perovskite Hill. Perovskite Hill is located on the south side of Arkansas Highway 51 and west of Cove Creek. The land rises from Cove Creek westward toward the west rim of the Cove. Perovskite Hill is only a break in this slope. It is underlain by carbonatite just as the Kimzey Calcite quarry north of the highway. No bedrock is exposed on the “hill”, but minerals are found loose in the soil. However, there are small exposures of carbonatite on the lower slopes. There has been only limited recent collecting in the area for many years, mostly by Clyde Hardin, Linden Davis and a few other locals. Collecting is accomplished by screening the soil in and around a shallow pit for crystals that have weathered from the carbonatite (Smith 2003).

Richardson rutile prospect. This prospect is located about 0.5 miles east of the titanium mine on the north side of Cove Creek. The plowed fields of this property were the source of many of the fine rutile specimens from the Cove in the early days of collecting. Adjacent to the mouth of a flowing spring on this property is the abandoned shaft of a pyrite mine operated during the Civil War (Fryklund & Holbrook 1950).

Titanium Corporation of America pit. The titanium mine has had several names including: Magnet Cove Rutile Company, Titanium Corporation of America, Titanium Alloy Company, and Beaver Lake Estates. Sporadic mining started by open pit in 1932 and continued until 1944. No attempt was made to remove the niobium since it was not then known as a contaminant. The rutile from this location was used for welding rod coatings on battleships. The brittle welds caused by the niobium contamination were traced back to this deposit so the mining became economically unsuccessful. A portion of the shallow open pit mine is now Beaver Lake. Some collecting is still possible in the area with permission of the land owners. Rutile and pyrite are the predominant collectable minerals.

York Farm rutile deposit. Rutile occurs loose in the soil on the York Farm that is located south of Arkansas Highway 51, just before it starts climbing up the east rim of the Cove. A house was built on one of the fields where the rutile was found in 2001. In the past few years, collecting has been very limited in this area.

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Part 4 – PHOTOGRAPHIC GALLERY OF MAGNET COVE MINERALS, ARRANGED ALPHABETICALLLY

Introduction

We have been privileged to be allowed to use photographs taken by many individuals. Below is a list of those people with name and location abbreviations used in the photograph captions. The captions have been standardized. Here is an example: Biotite zoned 0.6 inch across KCP MC DM DM TM (species name, specimen descriptors and size, location, collected by, collection of, and photographer). If only one name abbreviation is given (example – RR), either that individual listed is the collector, still has the specimen, and is the photographer or the original collector information is lost. Sometimes some of the information was not available and unfortunately could not be given.

Name abbreviations in image captions

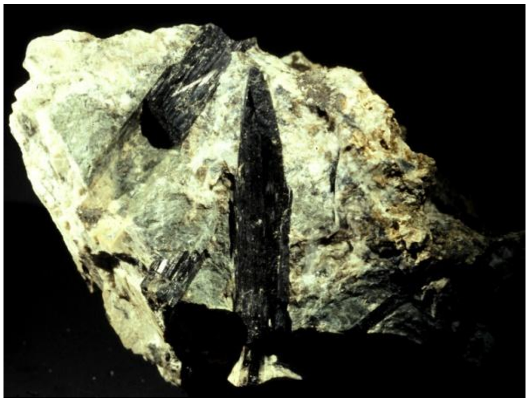
AES – Arthur E. Smith, Jr.
CH – Clyde Hardin
DM – David McAlester
EO – Ed O'Dell
GC – Glen Carlson
GN – Gene Newsom
HB – Henry Barwood
JC – Julian Cranfill
JK – Joe Kimzey
JM – Jimmy Matlock
JMH – J. Michael Howard
JS – Jim Stoops
RL – Ray Lynch
RR – Robert Rothensburg
SB – Steve Bonney
TM – Tom Miller

Location abbreviations in image captions

CCBA – Cove Creek bridge area
CP – Christy pit
DJQ – Diamond Jo quarry
HWD – Hardy-Walsh deposit
JMQ – Jones Mill quarry
KCP – Kimzey calcite pit
KMP – Kimzey magnetite pit
LSAZ – lime silicate alteration zone
MBM – Magcobar barite mine
MC – Magnet Cove
MH – Moses Hill
Mo-Ti – Mo-Ti prospect
NLBM – NL Baroid mine
PH – Perovskite Hill
RF – Richardson farm
RQM – Runyan quartz mine
TCAP – Titanium Corp of America pit

Adularia 0.4 in. with quartz
MBM MC JMH

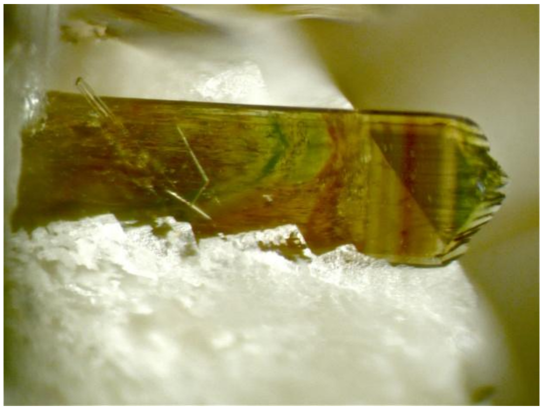
Adularia cluster 0.75 in. across w quartz
MBM MC JMH



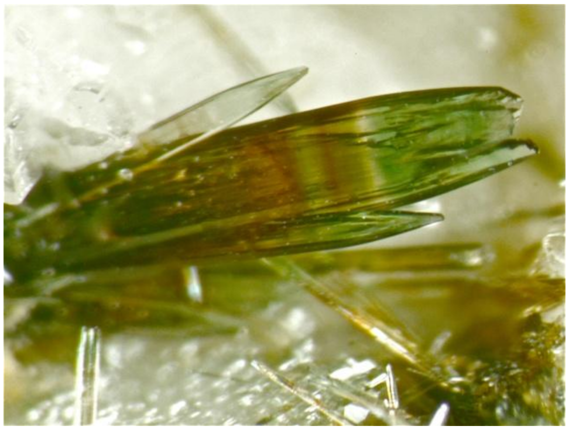
Aegirine 3 in. terminated in pegmatite
CCBA MC CH JMH JMH

Aegirine 6 in. in pegmatite matrix
CCBA MC GC

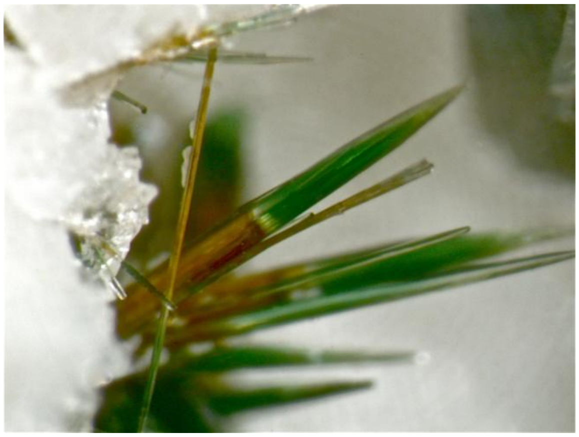
Aegirine 4 in. terminated crystal
CCBA MC GC



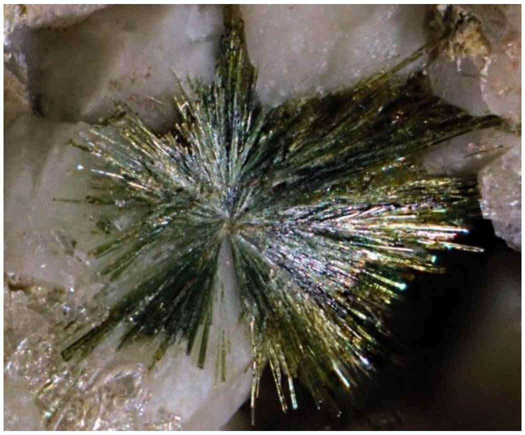
Aegirine zoned micro-crystal
JMQ MC RR



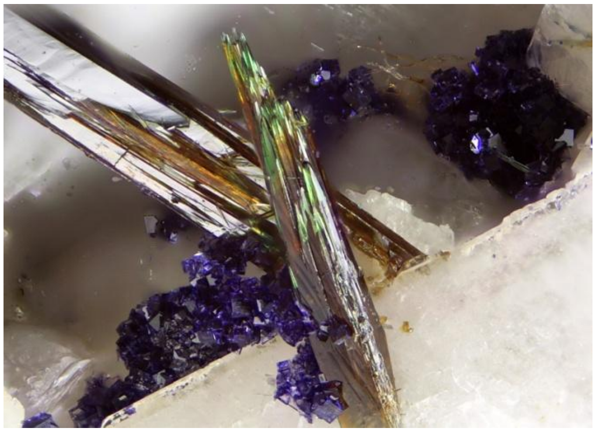
Aegirine zoned micro-crystal cluster
JMQ MC RR



Aegirine zoned micro-crystal cluster
JMQ MC RR



Aegirine spray of micro-crystals
JMQ MC GC



Aegirine with fluorite micro-crystals
JMQ MC RR

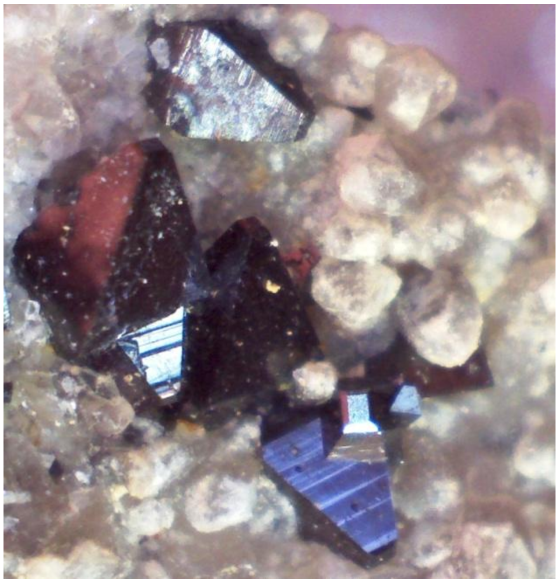
Albite crystal cluster, location unknown
Joe Kimzey collection, MC JK, JMH

Albite rosette cluster, 25 cm long
Cove Creek, MC JMH

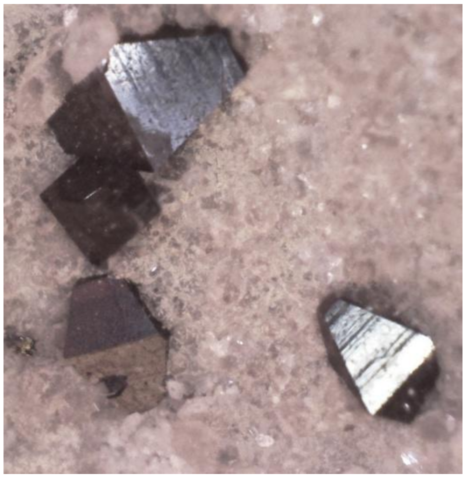
Albite rosette cluster 2 in. tall
Cove Creek MC JMH

Amphibole unidentified species on reticulated
rutile JMQ MC HLB

Amphibole species unidentified
JMQ MC HLB

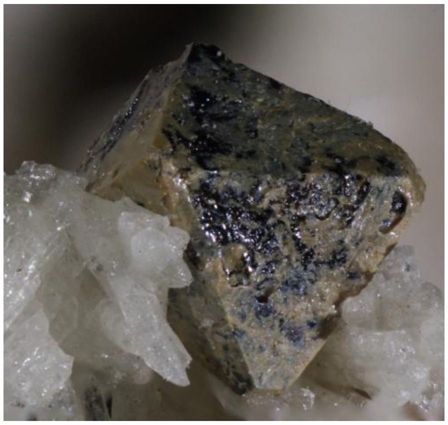


Anatase 0.8 mm on drusy quartz
JMQ MC JM JMH JMH



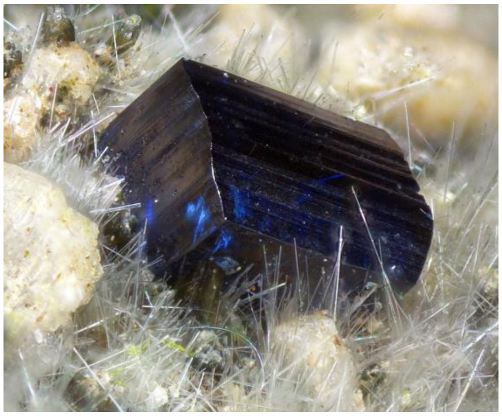
Anatase 1.0 mm crystals on drusy quartz JMQ MC JM JMH JMH

Anatase 1.5 mm blue crystals in quartz syenite DJQ MC JMH



Anatase after perovskite 2 mm with fluorapatite CCBA MC GC

Anatase pseudomorphs after perovskite in matrix 0.6 X 1.1 in. PH MC CH DM TM

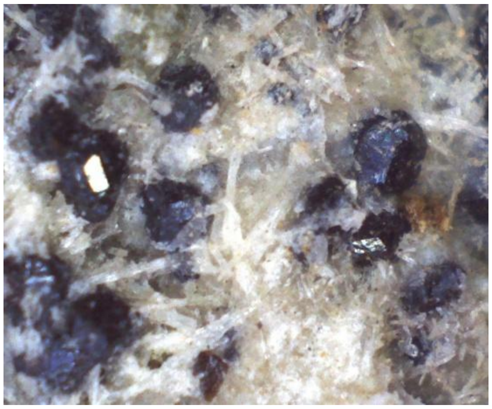


Anatase blue microcrystal with lorenzenite Fibers JMQ MC HLB

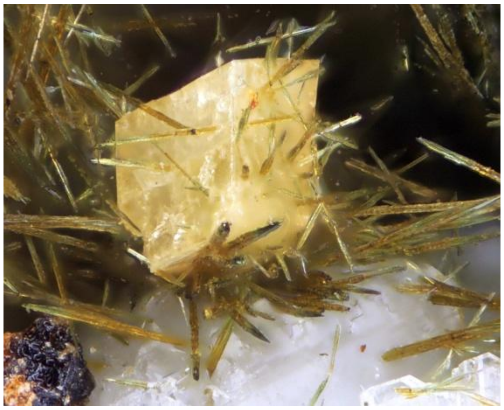
Anatase pseudomorph after perovskite 1.0 in. on magnetite PH MC CH DM TM

Ancylite – (Ce) 0.25 mm crystals on aegirine on orthoclase JMQ MC GC

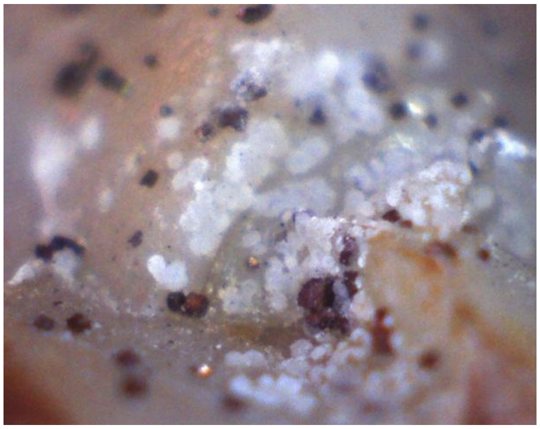
Andradite 0.5 in. crystal MC JMH



Andradite 0.7 mm diameter with fluorapatite MC JMH

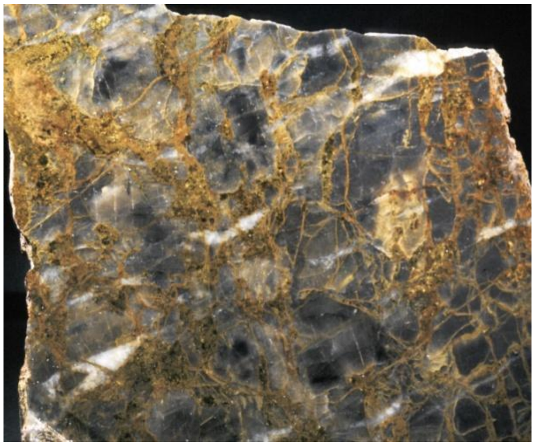


Ankerite with zoned aegirine JMQ MC HLB



Aragonite micro-crystal aggregates on dolomite with pyrite TCAP MC AES

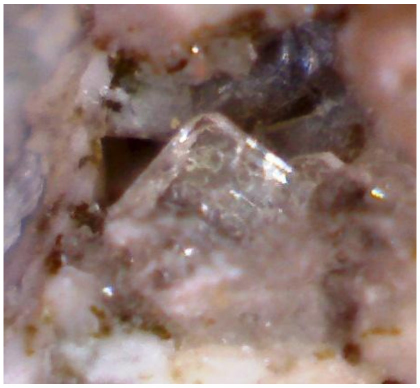
Aragonite 2 in. thick fibrous plate KCP MC JMH



Arfvedsonite brown veining in novaculite
with quartz veins CP MC JMH

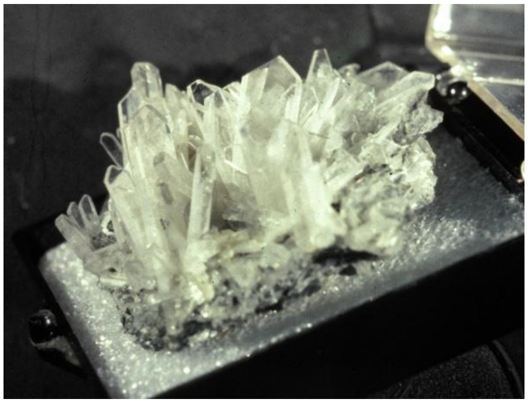
Augite 1.8 X 3.1 in. CC MC
DM DM TM

Baddellyite whitish pseudomorphs
after kimzeyite on magnetite xls
1.6 X 2.6 in. PH DM DM TM



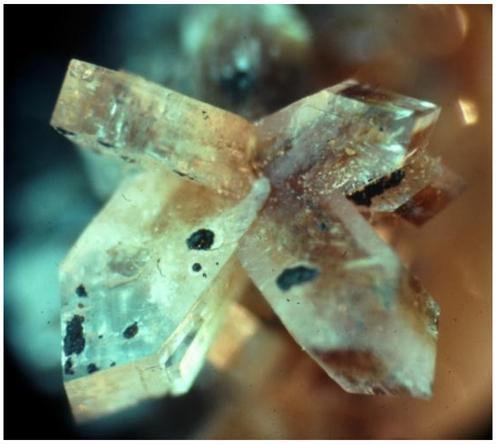
Barite 1.0 mm crystal DJQ MC
Hdel JMH JMH

Barite bladed crystals 4.0 in. across
MBM MC JMH



Barite bladed crystals 0.75 in. across
NLBM MC JC JMH JMH

Barite jackstraw crystals to 1.0 in. long
NLBM MC JC JMH JMH



Barite micro-crystal cluster
MBM MC JMH

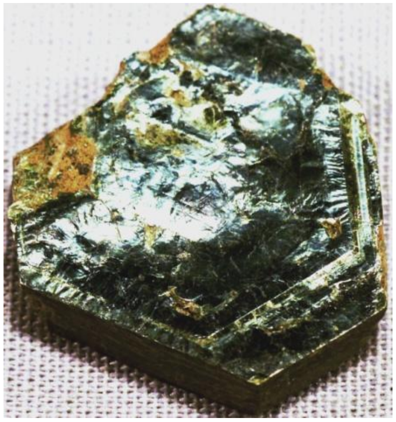
Barite colorless platy micro-crystal
DJQ MC AES

Barytocalcite micro-cluster with
lorenzenite JMQ MC HLB

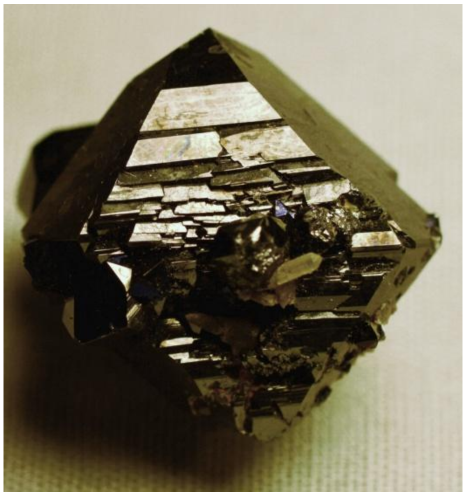
Benitoite white platy micro-crystal
DJQ MC HLB

Benitoite micro-crystals on aegirine
DJQ MC HLB

Benstonite massive white 0.7 in.
NLBM MC RW JMH JMH

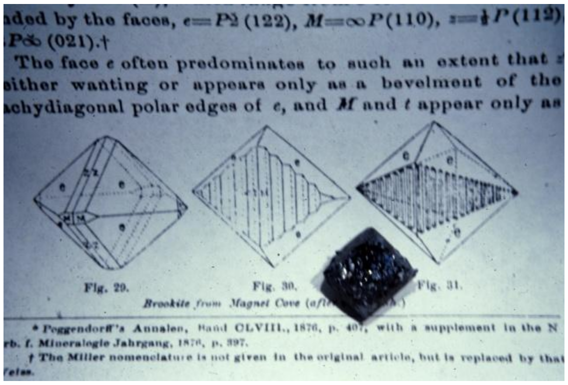


Biotite zoned 0.6 in. across
KCP MC DM DM TM



Brookite 0.8 inch across with
tiny quartz CP MC DM DM TM

Brookite crystal cluster < 1.0 in. across
probably MH MC mindat.org



ded by the faces, $e = P\breve{2}$ (122), $M = \infty P$ (110), $z = \frac{1}{2}P$ (112)
$P\breve{\infty}$ (021).†

The face e often predominates to such an extent that
either wanting or appears only as a bevelment of the
achydiagonal polar edges of e, and M and t appear only as

Fig. 29. Fig. 30. Fig. 31.

Brookite from Magnet Cove (af

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* Poggendorff's Annalen, Band CLVIII., 1876, p. 40, with a supplement in the N
rb. f. Mineralogie Jahrgang, 1876, p. 397.

† The Miller nomenclature is not given in the original article, but is replaced by that
eiss.

Brookite crystal with J.F. Williams drawings
MH MC JMH

Brookite 0.5 in. crystal on smoky
quartz CP MC JMH

Brookite on 1.4 X 0.6 in. smoky quartz MH MC RL

Brookite 1.0 X 0.8 in. crystal on smoky quartz MH MC DM DM TM

Brookite on 3.25 X 2.0 in. smoky quartz cluster MH MC DM DM TM

Brookite red crystals MH MC CH JMH JMH

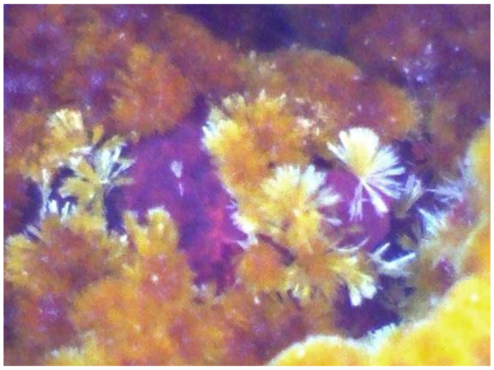
Brookite with etched quartz MH(?) MC Mindat.org image

Brookite on mottled 3 in. smoky quartz crystal CP MC JMH

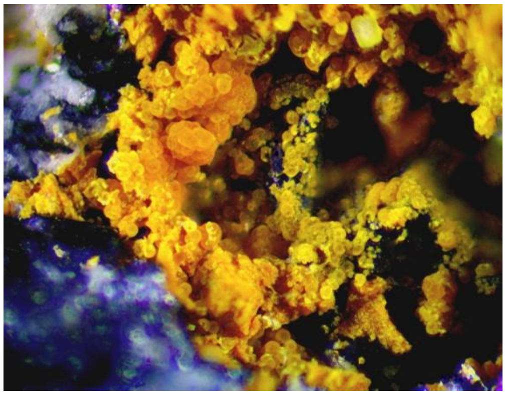
Burbankite micro-crystal JMQ MC HLB

Burbankite terminated micro-crystal JMQ MC RR

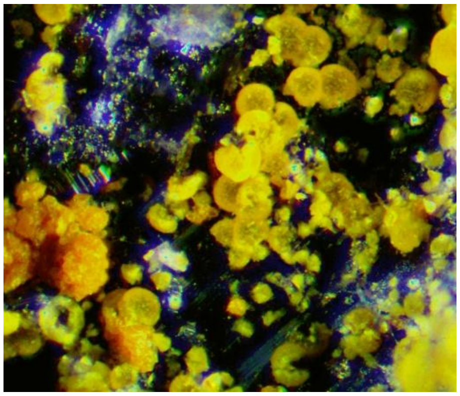
Burbankite 0.3 mm long with iridescent pyrite JMQ MC EO



Cacoxenite micro-spherical aggregates CP MC JMH



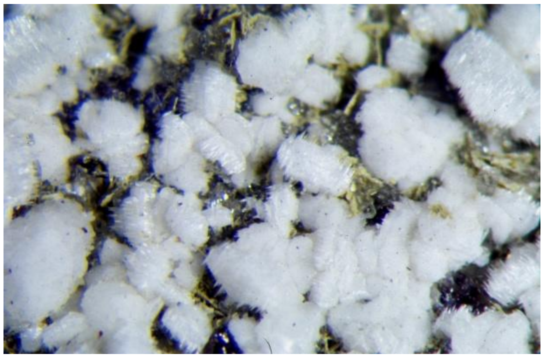
Cacoxenite micro-spheres on rutile TCAP MC JMH EO EO



Cacoxenite spheres to 0.5 mm on rutile TCAP MC JMH EO EO

Calcite 3 in. cluster MBM MC JMH

Calcite on 2.5 in. matrix CP MC DM DM TM



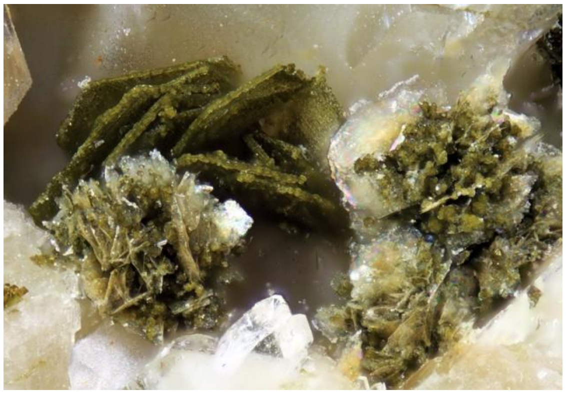
Calcite epitaxial habit JMQ MC HLB

Calcite micro-crystal on aegirine and orthoclase JMQ MC HLB

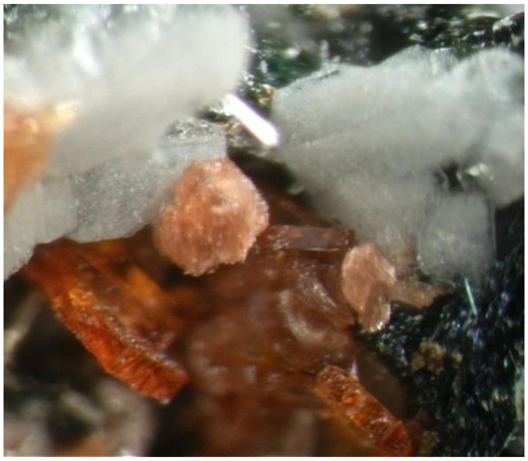
Calcite crystal 4 in. cluster MBM MC JMH

Carbonate-fluorapatite crystal mass KCP MC JMH

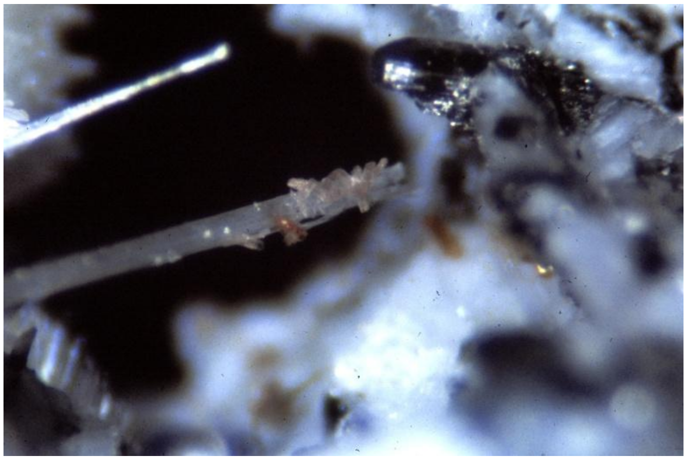
Carbonate fluorapatite 3 in. long residual mass KCP MC JMH



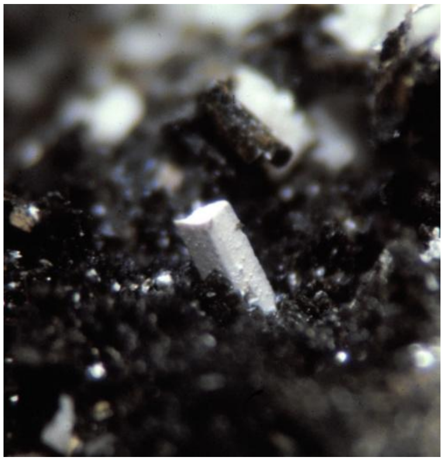
Chlorite on tainiolite(?) micro-crystals JMQ MC HLB



Delindeite micro-crystalline spheres with labuntsovite and orthoclase DJQ MC RR

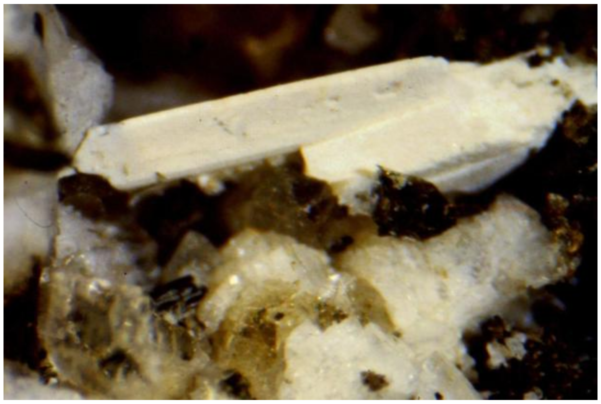


Delindeite micro-crystals on pectolite DJQ MC JMH



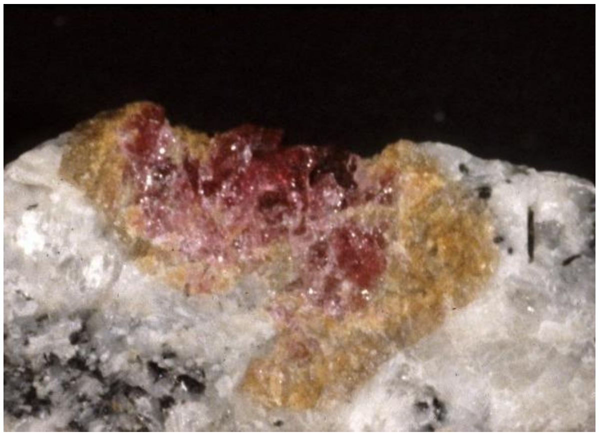
Elpidite white micro-crystal on aegirine DJQ MC JMH

Elpidite micro-crystals JMQ MC HLB



Elpidite white microcrystal DJQ MC AES

Eudialyte pink crystals in pegmatite CCBA MC DM DM TM



Eudialyte bicolor 1 in. mass CCBA(?) MC Troost Coll. Louisville Kentucky Museum JMH

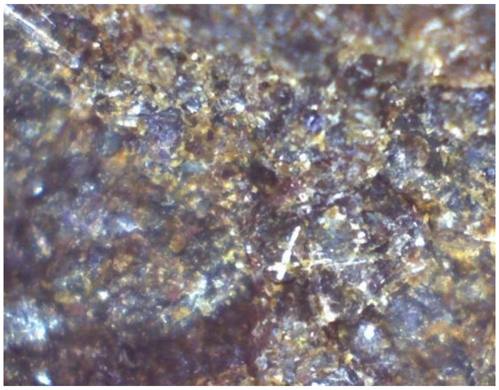
Eudialyte micro-crystal with aegirine DJQ MC HLB

Eudialyte 0.4 in. crystals in pegmatite CCBA MC JMH

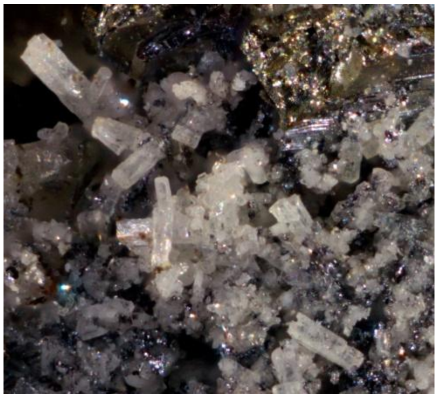
Eudialyte micro-crystals with natrolite DJQ MC HLB

Fluorapatite 0.15 X 5.5 in. crystal sections KCP MC DM DM TM

Fluorapatite inclusions in 1 in. schorlomite mass KMP MC JMH



Fluorapatite micro-needles in matrix TCAP MC MC JMH

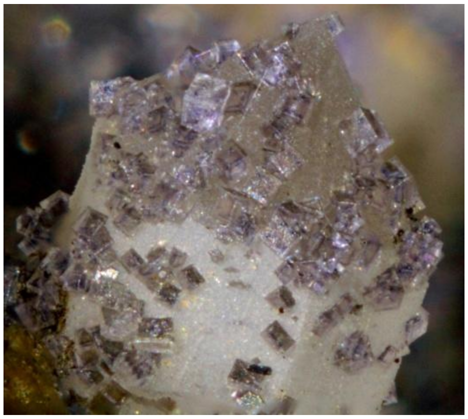


Fluorapatite 0.25 mm long prisms JMQ MC GC

Fluorapophyllite with red pyrophanite DJQ MC AES

Fluorite 1.0 mm crystal with siderite JMQ MC GC

Fluorite joint filling DJQ MC JMH

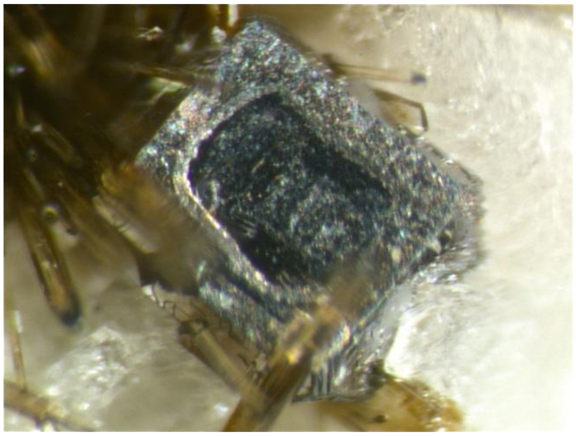


Fluorite crystals on 2 mm quartz crystal JMQ MC GC

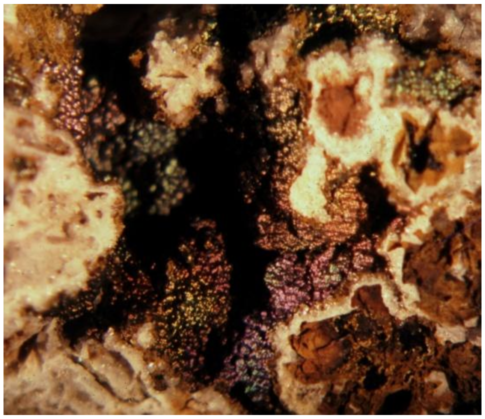
Fluorite on siderite JMQ MC GC

Galena 0.5 in. cleaved crystal TCAP MC JMH

Galena 0.35 in. octahedral crystal PH MC CH JMH JMH



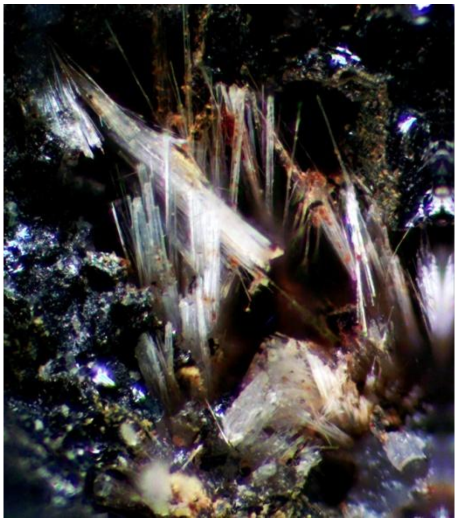
Galena 0.67 mm skeletal crystal JMQ MC RR



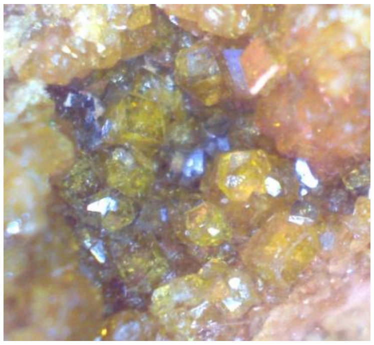
Goethite iridescent coating on drusy quartz CP MC AES

Goethite 2.8 X 1.8 in. mamillary mass MH MC DM DM TM

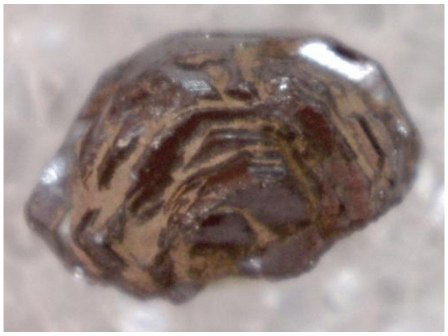
Gonnardite micro-fibers in jacupirangite CC MC SB SB EO



Gonnardite micro-fibers in jacupirangite CC MC SB SB EO



Grossular 0.5 mm crystals LSAZ MC JMH

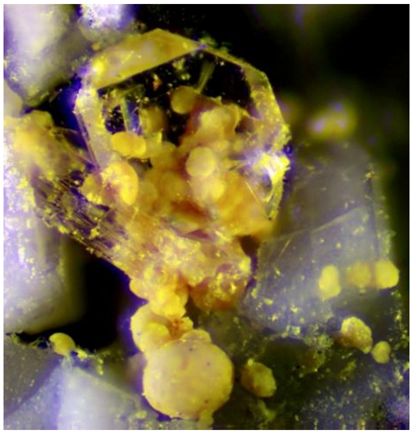


Hematite 0.35 in diameter rose from residuum KMP MC JMH

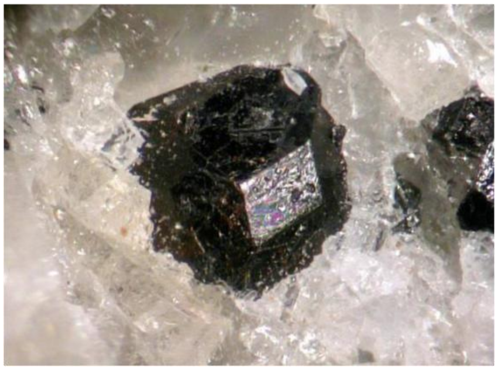
Goethite 0.75 in thick Troost Collection Louisville Kentucky Museum MC JMH

Hercynite 5 X 8 mm crystal cluster CCBA MC GC

Ilmenite black 0.5 in long blades on altered Stanley Shale JMQ MC JMH

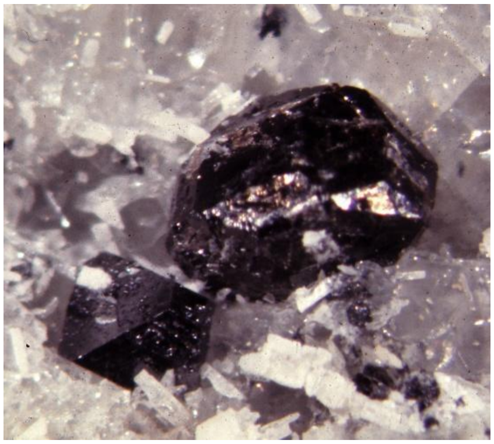


Kassite 0.1 mm spheres in and with barite on orthoclase DJQ MY JMH EO



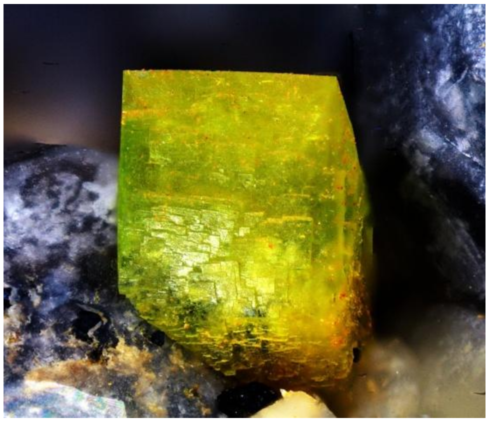
Kimzeyite 0.5 mm crystal in calcite KCP MC RR

Kimzeyite 0.8 mm crystal in calcite KCP MC Mindat.org Image

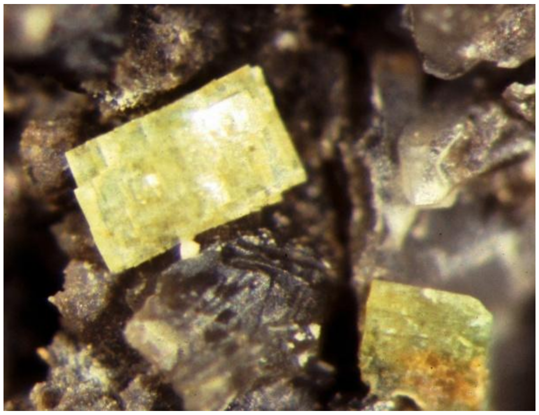


Kimzeyite 1.0 mm crystal with perovskite KCP MC JMH

Kolbeckite micro-crystal on smoky quartz CP MC HLB

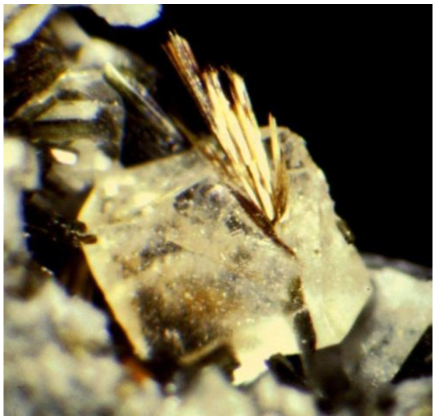


Kolbeckite micro-crystal on smoky quartz CP MC HLB

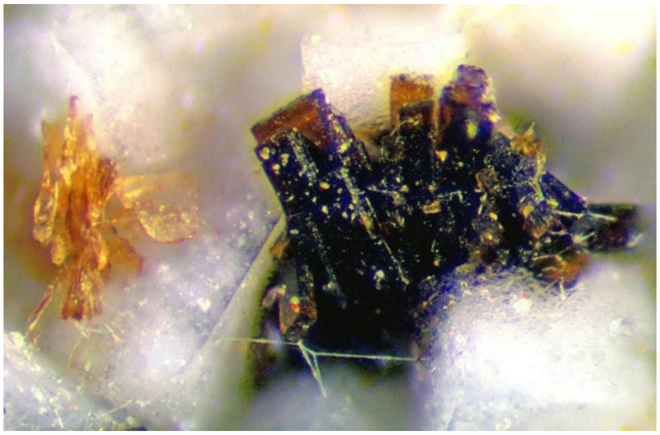


Kolbeckite micro-crystals on smoky quartz CP MC JMH

Kupletskite 0.3 mm crystal cluster On orthoclase DJQ Hdel JMH EO



Kupletskite micro-crystals with barite DJQ MC AES



Kupletskite zoned micro-crystal cluster with labuntsovite DJQ MC Hdel JMH EO

Labuntsovite micro-crystal cluster DJQ MC RR

Labuntsovite crystals with aegirine on orthoclase DJQ MC JMH

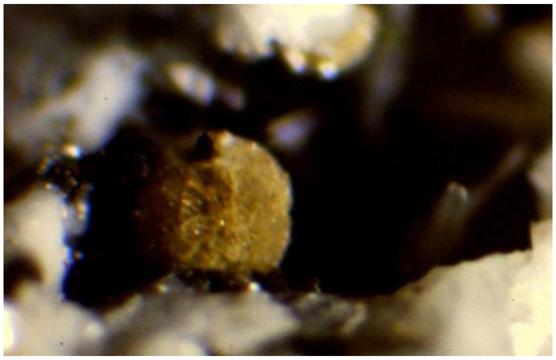
Labuntsovite – Mn micro-crystal on orthoclase JMQ MC HLB

Labuntsovite – Mn on orthoclase JMQ MC HLB

Lorenzenite micro-crystal spray JMQ MC HLB

Lorenzenite acicular crystal DJQ MC AES

Lorenzenite micro-spray JMQ MC RR



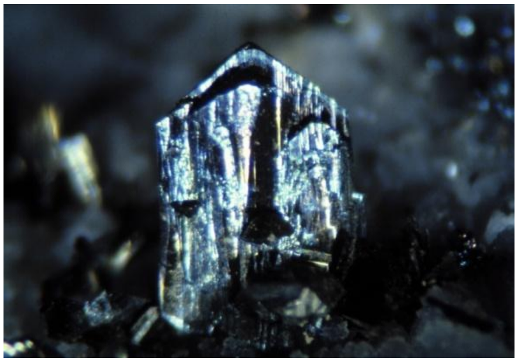
Lourenswalsite crystalline sphere DJQ MC AES

Lourenswalsite crystalline sphere DJQ MC RR

Magnetite crystal cluster 2.6 X 1.9 in. PH MC CH DM TM

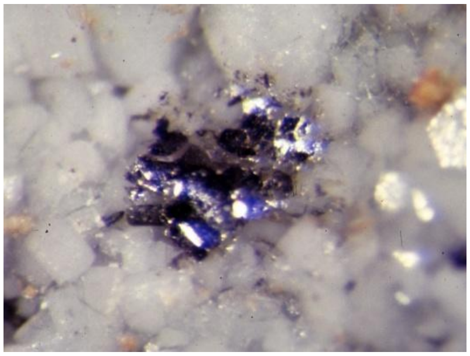
Magnetite massive lodestone 6 pounds KMP MC JK JMH JMH

Magnetite 1 in. lodestone
KMP MC JMH



Marcasite bladed micro-crystal CP MC
JMH

Molybdenite massive 3.0 in. Mo-Ti
MC JMH

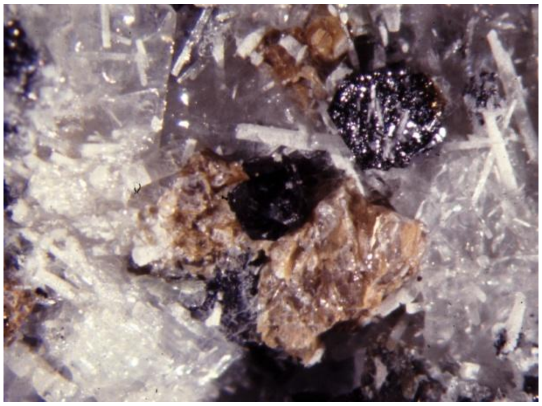


Molybdenite micro-crystals DJQ
MC HLB

Molybdenite coating pyrite 3 in.
Mo-Ti MC JMH DM TM

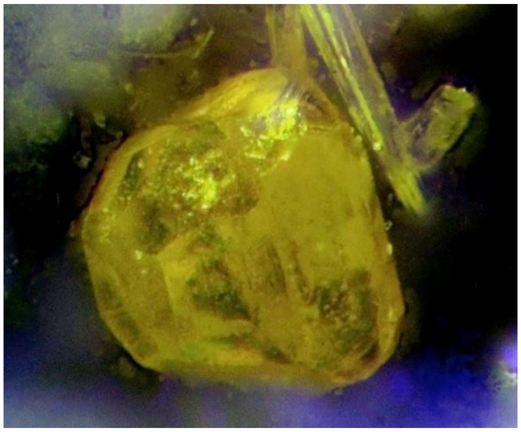
Molybdenite micro-scales on
orthoclase with aegirine JMQ
HLB

Molybdenite micro-crystal cluster on aegirine JMQ MC HLB



Monticellite brown masses with perovskite and carbonate-fluorapatite KCP MC JMH

Monticellite 0.5 in crystal KCP MC JMH



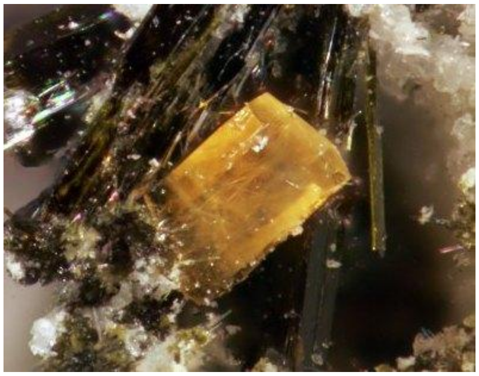
Narsarsukite 0.25 mm diameter crystal DJQ MC Hdel JMH EO

Narsarsukite micro-crystal JMQ MC HLB

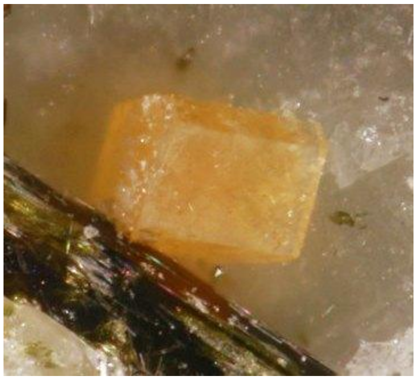
Narsarsukite micro-crystals JMQ MC HLB

Natrolite micro-crystals with eudialyte DJQ MC HLB

Natrolite micro-crystals MC JS



Nenadkevichite micro-crystal on aegirine JMQ MC HLB



Nenadkevichite micro-crystal on orthoclase with aegirine JMQ MC HLB

Opal spiderweb 1.75 in thick vein CP MC JMH

Orthoclase Baveno twin CC MC JMH

Orthoclase microcrystals DJQ MC AES

Orthoclase twinned JMQ MC HLB

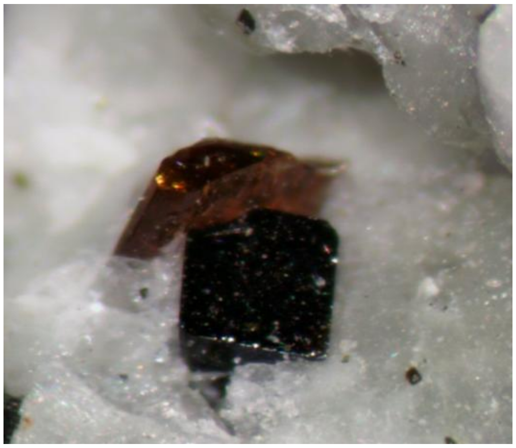
Paramontroseite 0.5 mm crystal with micro pyrite crystals CP MC JMH

Pectolite micro-fibers DJQ MC AES

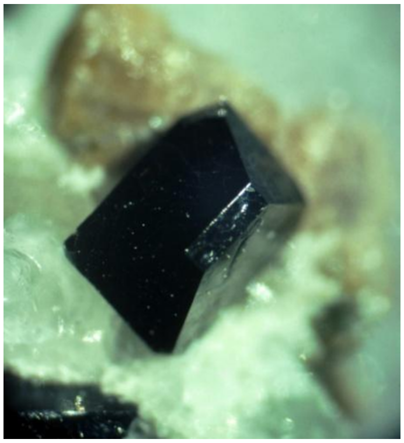
Pectolite nest of fibers DJQ MC RR

Pectolite spray DJQ MC RR

Pectolite with aegirine 3.0 X 3.5 in KCP MC DM DM TM



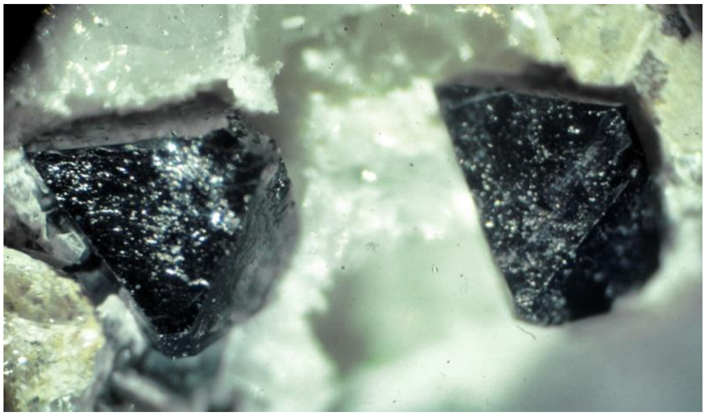
Perovskite 0.45 mm crystal with titanite JMQ MC EO



Perovskite 2.5 mm cubooctahedron on calcite KCP MC JMH

Perovskite on 0.6 in magnetite crystal PH MC DM DM TM

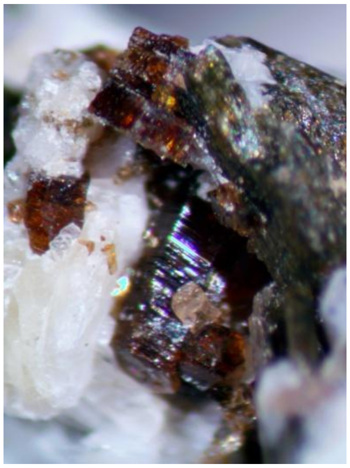
Perovskite partially altered to anatase PH MC CH DM TM



Perovskite 3 mm crystals in calcite KCP MC JMH

Phlogopite altered micro-crystals JMQ MC HLB

Phlogopite micro-crystal DJQ MC RR



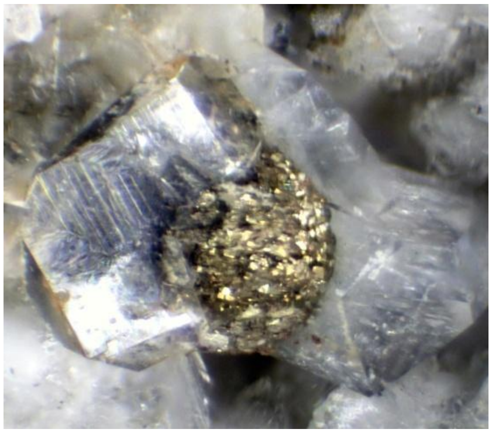
Phlogopite 0.65 mm crystal JMQ MC EO

Phlogopite zoned micro-crystal cluster JMQ MC RR

Pseudoleucite 1.5 in diameter MC JK Arkansas Geological Survey Collection JMH

Pseudoleucite 4.0 in diameter CCBA MC JMH

Pseudoleucite ~0.6 in diameter crystal
CCBA MC RL

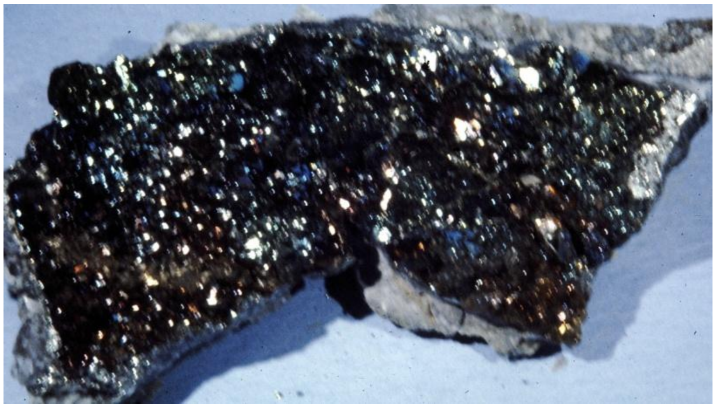


Pyrite 0.5 mm sphere with calcite
JMQ MC GC

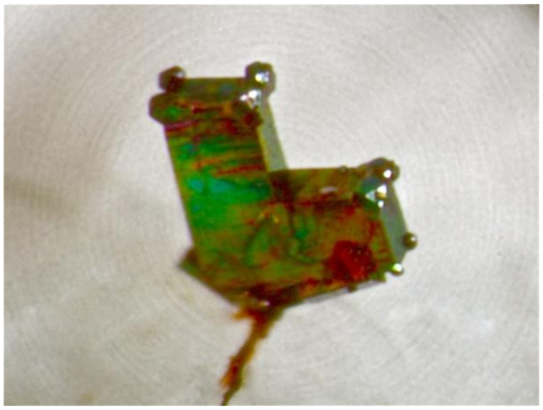
Pyrite 0.62 mm cluster with siderite CP
MC JMH EO EO

Pyrite cubes in 2.5 X 1.5 in. feldspar matrix
TCAP MC DM DM TM

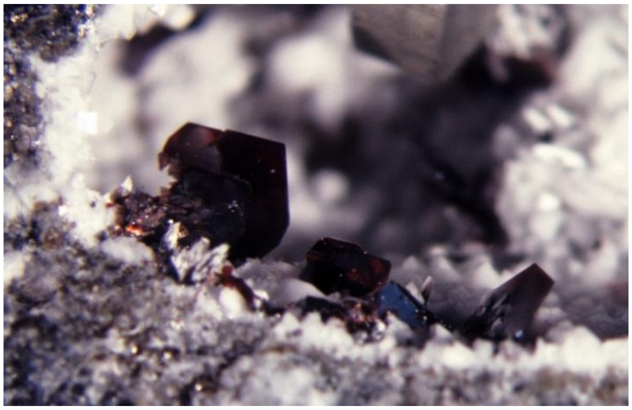
Pyrite intergrown crystals in
1.4 X 2.1 in. feldspar matrix
TCAP MC DM DM TM



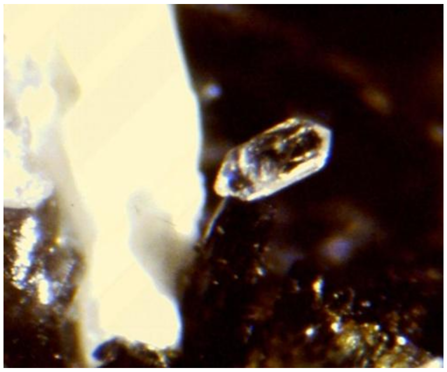
Pyrite iridescent 4 in. crystal crust CP MC JMH



Pyrite iridescent with oriented pyrite crystals on its corners 0.67 mm across JMQ MC RR



Pyrophanite micro-crystals DJQ MC AES



Quartz 1.0 mm double terminated crystal on aegerine DJQ MC AES

Quartz coontail variety 4.0 in. cluster RQM MC JMH

Quartz coontail variety 8 X 3.8 in. cluster RQM MC DM DM TM

Quartz double terminated crystals on orthoclase DJQ MC JMH

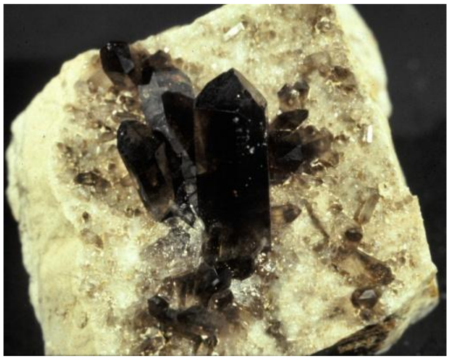
Quartz smoky 2.5 X 3.5 in. cluster HW MC DM DM TM

Quartz iron-oxide stained smoky cluster 5 X 2.5 in. CP MC DM DM TM

Quartz double terminated smoky crystal 2 X 1 in. CP MC DM DM TM

Quartz smoky crystal 1.6 X 2.9 in. HW MC DM DM TM

Quartz smoky crystal 9 in. tall HW MC RR



Quartz 0.5 in. smoky crystal RQM MC JMH

Quartz 2.6 in. long crystal cluster HW MC DM DM TM

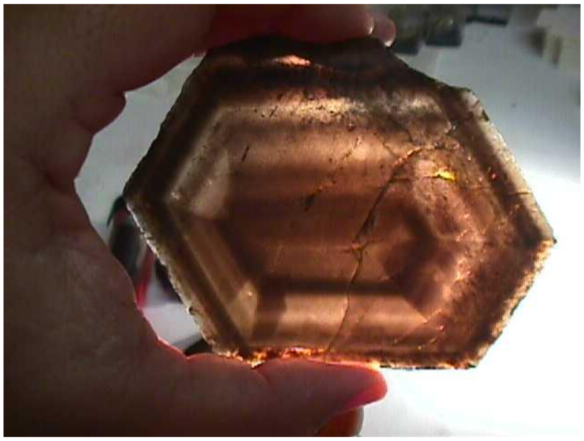
Quartz smoky crystal with brookite 1.5 in. long MH MC JMH

Quartz smoky crystal cluster 9 in. long MH MC JMH DM TM

Quartz smoky crystal cluster 0.75 in. tall RQM MC JMH

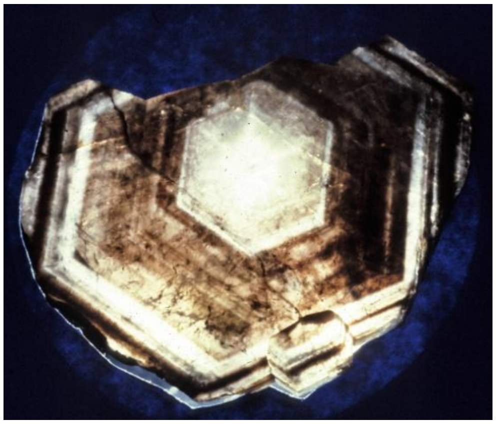
Quartz cluster 0.75 in. tall MBM MC JMH

Quartz variety chalcedony on drusy quartz CP MC DM DM TM



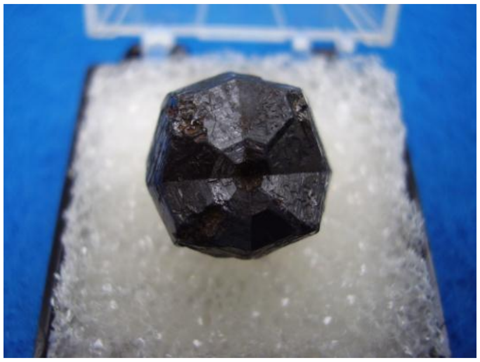
Quartz zoned smoky slice HW MC CH JMH

Quartz smoky crystal 6.0 X 3.5 in. crystal probably MH MC JK RR RR

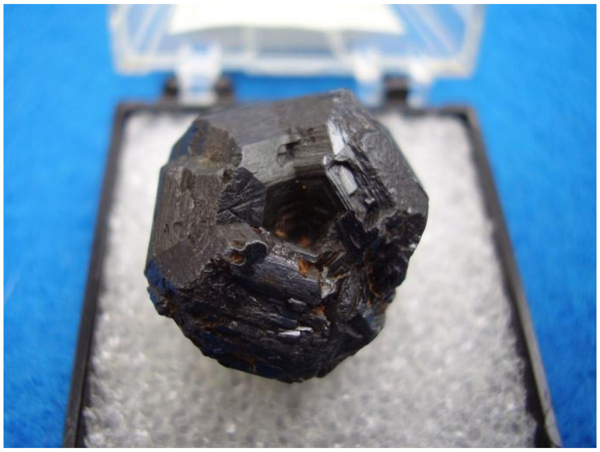


Quartz zoned smoky crystal section 5.5 in. diameter HW MC CH JMH JMH

Rutile eightling twins 0.4 and 0.6 in. diameter KMP MC DM DM TM



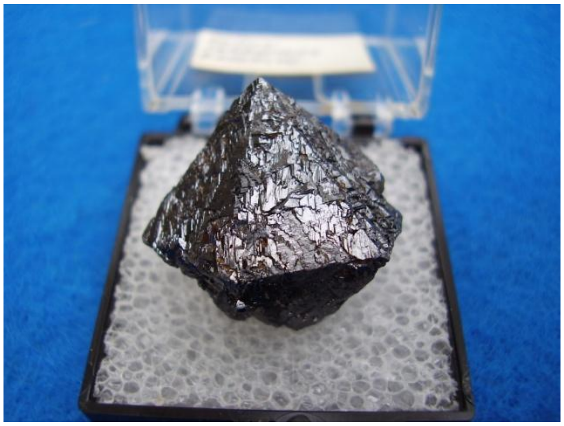
Rutile eightling twin 0.6 in. diameter MC JMH GN RL



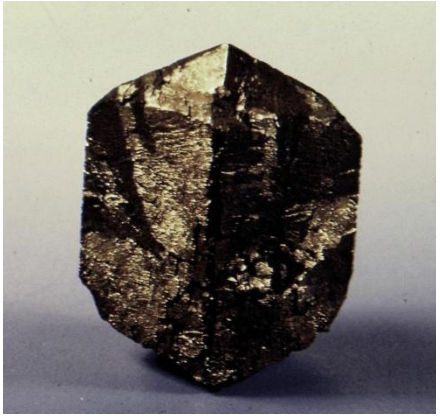
Rutile eightling twin 0.8 in. diameter MC JMH GN RL

Rutile eightling twin MC Mindat.org

Rutile micro-crystals with siderite JMQ MC HLB

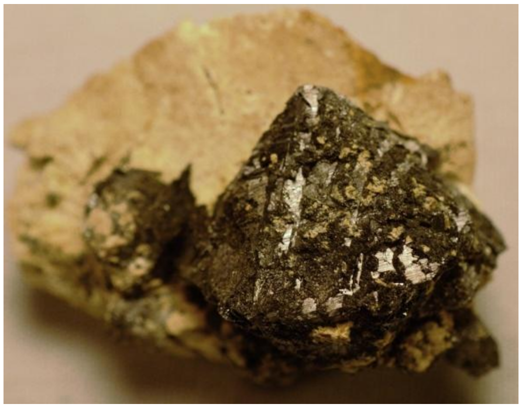


Rutile paramorph after brookite 1 in. diameter JMH GN RL



Rutile paramorph after brookite 1.25 in. long MC AES

Rutile paramorph after brookite cluster 2.4 X 1.5 in. crystals RF MC JMH



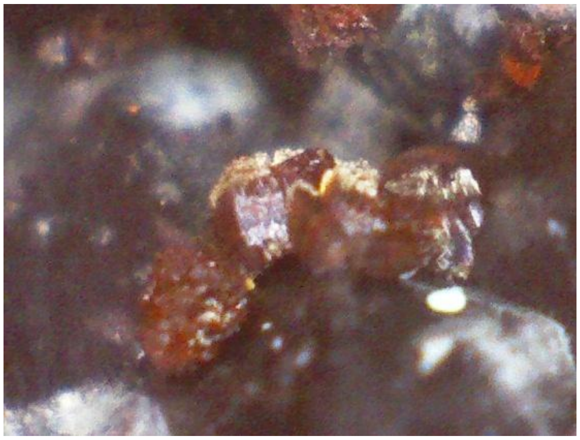
Rutile eightling on feldspar matrix 1.5 X 1.25 in. TCAP MC DM DM TM

Rutile reticulated micro-crystals JMQ MC HLB

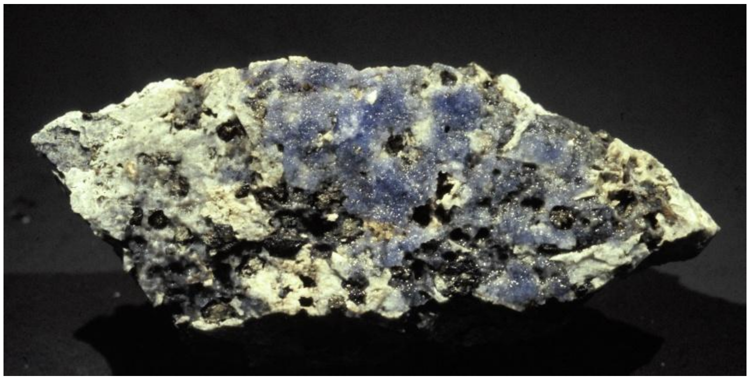
Schorlomite 1.5 in. diameter crystal MC JMH

Schorlomite 2.5 in. mass MC Troost Collection Louisville Kentucky Museum JMH

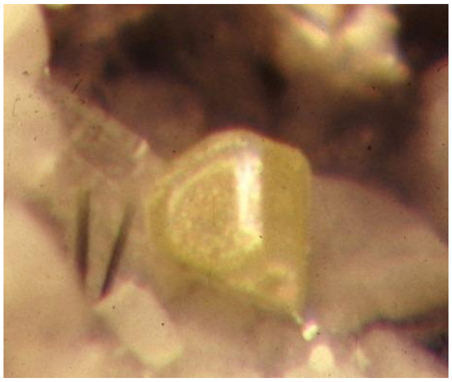
Siderite 5 mm crystalline mass on quartz CP MC JMH



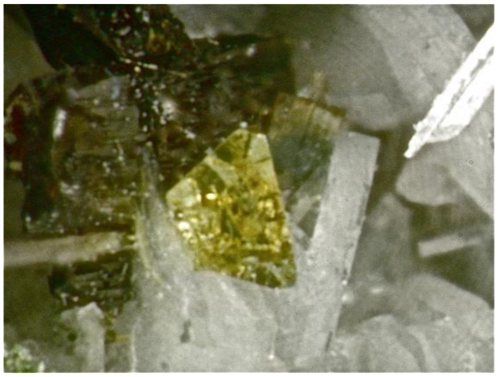
Siderite micro crystals on smoky quartz CP MC AES JMH JMH



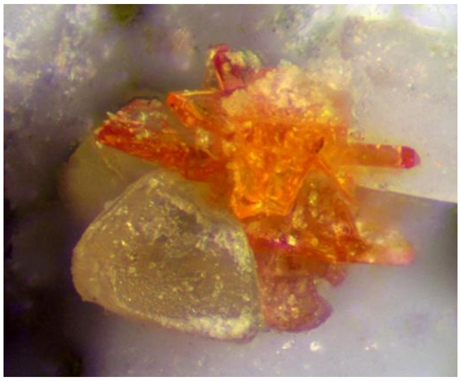
Sodalite joint filling 4 in. DJQ MC JMH



Sphalerite micro-crystal DJQ MC JMH

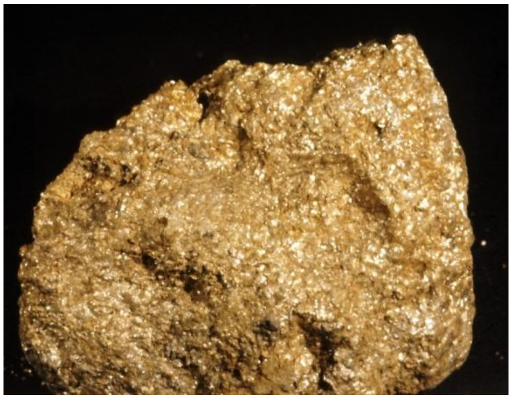


Sphalerite micro-crystal JMQ MC HLB

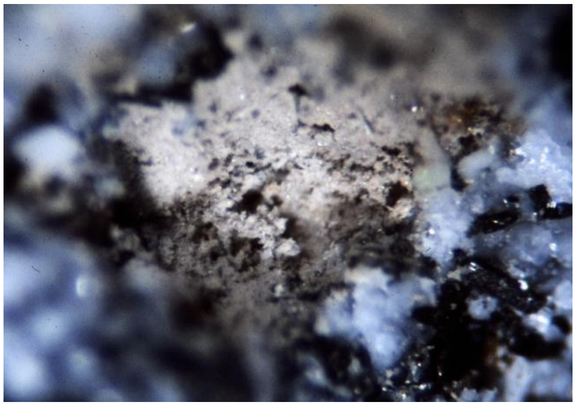


Sphalerite micro-crystals with labuntsovite DJQ MC Hdel JMH EO

Strontianite micro-fibers on orthoclase DJQ MC Hdel JMH JMH



Tainiolite 2 in. aggregate MC Troost Collection Louisville Kentucky Collection JMH

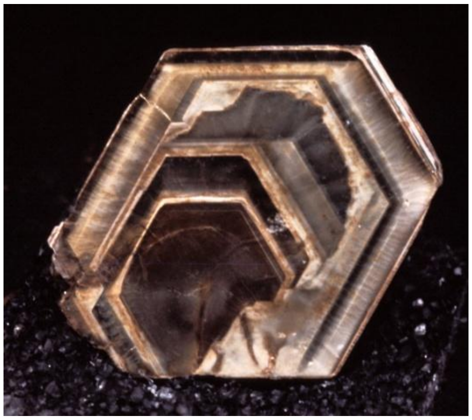


Tainiolite micro-crystalline aggregate DJQ MC JMH

Thorite dusting on aegirine JMQ MC JMH

Titanite micro-crystal JMQ MC HLB

Titanite micro-crystal cluster JMQ MC RR



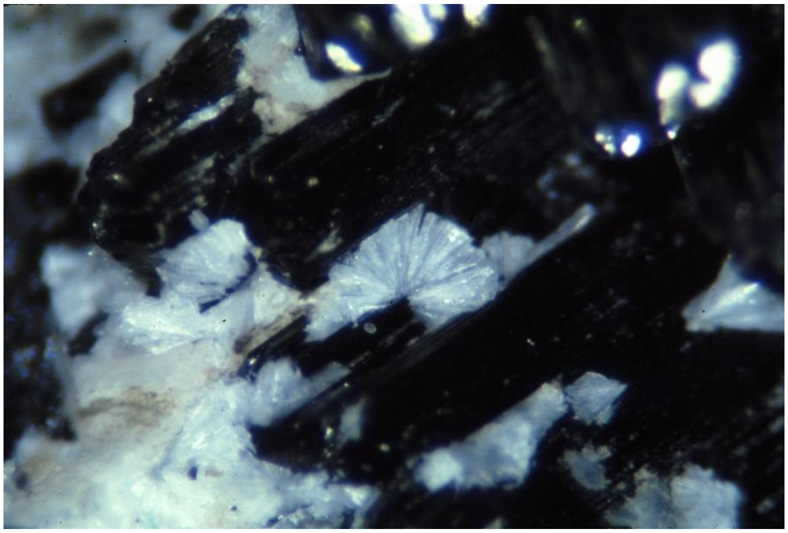
Vermiculite zoned 1 in. crystal after biotite MC JMH

Vesuvianite 2 mm crystalline grains in calcite KCP MC JMH

Vesuvianite 0.5 in. crystal in contact rock CCBA MC JMH

Vesuvianite crystal MC Mindat.org

Vesuvianite crystal cluster MC Mindat.org



Wavellite white micro-radiating crystals on rutile TCAP MC JMH

Yofortierite micro-fiber mass JMQ MC HLB

Yofortierite micro-fiber tufts 0.97 mm long JMQ MC EO