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Norman F. Williams, Geologist-Director

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QUARTZ, RECTORITE, AND COOKEITE FROM THE JEFFREY QUARRY, NEAR NORTH LITTLE ROCK, PULASKI COUNTY, ARKANSAS

By

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U. S. Geological Survey

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STATE OF ARKANSAS

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By

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ABSTRACT

Spectacular quartz crystals, with abundant rectorite and cookeite, also pyrite, sphalerite, galena, rutile, apatite, ankerite, and chlorite, occur at the Jeffrey Stone Company's quarry near North Little Rock, Arkansas. These minerals form veins in the Mississippian Jackfork Sandstone, but they are also suspended in semiliquid fissure fillings; on drying, the semiliquid becomes rectorite. Three thin basaltic dikes, now changed to clay, cut the sandstone sequence, but have no evident relation to the mineralization. Analyses and x-ray powder data are given of the cookeite and rectorite. The occurrence of quartz crystals in Arkansas is discussed.

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[1] Publication authorized by the Director of the U. S. Geological Survey.

Location and occurrence of mineralization

The Jeffrey quarry is situated along the south edge of Camp Joseph T. Robinson, 5 miles northwest of North Little Rock in sec. 8, T. 2 N., R. 12 W., on a west-northwest-trending ridge whose crest, 500 to 560 feet in altitude, rises 300 feet above the adjacent valley to the south (figure 1). Near the quarry in this valley are the communities of Jeffrey (population 560) and Haig (265), also U. S. Highway 65 and the Missouri Pacific Railroad. The quarry is operated by the Jeffrey Stone Company, and produces crushed sandstone from the Jackfork Sandstone of Mississippian age.* Rectorite with quartz was observed there in 1959; in 1960 the quarry workings disclosed a unique association of fine quartz crystals with rectorite and superb cookeite, the first of this rather rare mineral to be discovered in Arkansas. The cookeite was identified in 1961, after having been thought to be pyrophyllite.

We are indebted to Woodrow Bettis of the Arkansas Geological Commission for information on the early history of the Jeffrey quarry occurrence (oral communication June 11, 1962). The first printed record of the new find followed Mr. Bettis' (1961, p. 366) sending a specimen to the editor of *Rocks and Minerals,* who commented "What a specimen! It is beautiful! A 5 x 7 inch mass of bristling rock xls. Though the xls as a whole are transparent and gemmy an odd fact is that every xl has an incomplete or imperfect termination. We never saw anything like this before."

The Jeffrey quarry is the only known source of abundant "needle" quartz (i.e., elongated doubly terminated crystals) in the Ouachita Mountains of Arkansas and Oklahoma; it is likewise the only major source of rectorite (an unusual clay mineral) and the only known occurrence of cookeite in Arkansas. The location of the Jeffrey quarry and the other known occurrences of rectorite in Arkansas are shown on figure 1, a map of central Arkansas.

The main opening of the quarry, with two smaller ones, have been excavated in well-bedded massive sandstone, dipping north 33° to 37°. Locally the sandstone grades laterally into, and is overlain by, interbedded shale and sandstone.

A view of the main face of the quarry is shown in figure 2. Figure 3, a closer view of the well-bedded sandstone, shows the drusy crystalline quartz which coats joints in the massive sandstone of the quarry wall; and figure 4 shows white quartz veins that cut brecciated sandstone. When these pictures were taken in the summer of 1962 the main face, up to 106 feet high, was half a mile long.

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*Charles G. Stone of the Arkansas Geological Commission, who has mapped the geology of a large area north and west of Little Rock, presents evidence for Pennsylvanian age of the Jackfork Sandstone and of the topmost part of the underlying Stanley Shale, the rest of the Stanley being Mississippian (pages 1-4 of guide book second regional conference, Fort Smith Geological Society, southeastern Arkansas Valley and the Ouachita and frontal Ouachita Mountains, Arkansas, 1963).

Igneous rocks in the Quarry

The sandstone and shale are cut by three vertical dikes, 1½ to 3 feet wide, which have caused no discernible alteration in the wall rock, and have no evident relation to the mineralization of the sandstone. One of the dikes is shown in figure 5. The dike rock is fine grained, gray green, with spheroidal holes a millimeter or two across lined with dark-green chlorite. The rock has weathered to a clayey consistency. In thin section it has a micro-basaltic texture, with plagioclase laths embedded in a pale-brown to green chloritic (?) or nontronitic (?) devitrified glass (?). Some brown biotite is present. Minute apatite needles are fairly abundant.

Minerals in the Quarry

A variety of minerals occurs in the quarry. Quartz is the chief mineral; cookeite ($H_8LiAl_5Si_3O_8$) and rectorite ("interlayered pyrophyllite and montmorillite," Bradley, 1950) are abundant. Other minerals are pyrite, sphalerite, galena, rutile, apatite, chlorite, ankerite, and limonite. The most spectacular is the quartz. Many large quartz groups show a peculiar habit, the crystals being flattened parallel to a prism face like the specimen shown in figure 6. Liquid inclusions, with movable bubbles, are as much as several millimeters across. It will be seen that these quartz crystal aggregates show complete crystal development, that is, the group shows no point of attachment to any wall rock, a significant feature discussed further on. The drusy quartz on the quarry walls, shown in figure 3, shows crystal faces only where not in contact with the wall rock on which it has grown.

Before discussing the quartz, cookeite, and rectorite, the other minerals may be briefly described.

Pyrite, rare, occurs in masses up to several inches across.

Sphalerite, rare, occurs in complexly crystallized dark brown or black crystals as much as 3 millimeters in diameter, usually attached to large quartz crystals. Figure 7 shows this.

Galena, very rare, associated with sphalerite, well crystallized, occurs in crystals smaller than a millimeter.

Rutile, very rare, is microscopic, as hairlike acicular crystals, apparently loose in the rectorite-complex described below.

Apatite, rare, occurs similarly, as small flat sharply crystallized hexagonal plates. They are shown in figure 8.

Chlorite is microscopic and very rare.

Ankerite occurs in discoidal yellowish, brown on the weathered surface, crystals up to a centimeter or two across; usually coating quartz as shown in figure 9. It is not rare.

Limonite, possibly after pyrite, was found very sparingly as brilliant black small grains embedded on drusy white quartz.

Quartz

The quartz crystals show many unusual features. The flattened habit (see figure 6) of many larger ones has been noted; the needle crystals up to a length of five or six centimeters are sometimes bent with a continuous flexure as much as a centimeter from straightness. Many needle crystals show a cloudy longitudinal streaking, running diagonally the length of the prism. The needle crystals appear at first sight to have broken ends; these are really small multiple terminations; and less than one percent show smooth normal rhombohedral-face terminations. The microscopic crystals, shown in figure 10, are perfectly terminated in sharp rhombohedra and are thus unlike the needle crystals. Another curious feature of some of the microscopic quartz crystals is a peculiar amethyst or pale blue color. It has been suggested that this may be an optical effect caused by an extremely thin film coating the crystals. Crystallographically, the quartz crystals are simple combinations of trigonal prisms and rhombohedrons.

On the prism faces of large quartz crystals there may be observed both sharply rectangular minute shallow depressions, oriented randomly, and similarly unoriented tiny euhedral quartz crystals. These may be carefully prized out with a needle, leaving the depressions. Evidently the large crystal grew to some extent around the little ones, without any union of the two—a rather unusual phenomenon.

Cookeite

Cookeite has been found in Maine, Connecticut, Wales, Sweden, Brazil, Russia, Siberia, and Madagascar but cannot be considered a common mineral. It has not been reported previously from Arkansas. Its composition is given in table 1, and x-ray powder pattern in table 2.

Optically, it is colorless or creamy white, rarely yellow, positive with a small optic angle, α and β very nearly 1.555. Its characteristic appearance in this deposit as spheroidal aggregates is shown in figures 10 and 11.

Cookeite from Buckfield, Maine, described by Landes (1925) is pale green or pink, or yellow to cream colored; it there replaces microcline, spodumene, lepidolite, and tourmaline; none of these minerals occur in the Jeffrey quarry.

Brammall, Leech, and Bannister (1937) describe cookeite from Wales. It is creamy white in color. These authors discuss the relationship of cookeite to other layer silicate structures, it being made up of alternating muscovite-like $[Al_2Si_3AlO_{10}(OH)_2]^{-1}$ and gibbsite-like $[LiAl_2(OH)_6]^{+1}$ layers. They consider that the Welsh cookeite is primary, not an alteration product; and is low-temperature, hydrothermal (magmatic), although they note the absence of igneous rocks locally.

Cookeite from several Russian localities has been described, with analyses and powder data, in papers by Ginzburg (1953) and Zvyagin and Nefedov (1954), who also indexed their d-spacings.

The analysis of the Arkansas cookeite shows virtual absence of cations other than silicon, aluminum, lithium, and hydrogen, and thus indicates approach to ideal purity, particularly with reference to substitutions by iron, magnesium, and the alkali metals.

TABLE 1

Analyses of Cookeite

	Jeffrey Quarry, Arkansas		$Li_2O \cdot 5Al_2O_3 \cdot 8H_2O \cdot 6SiO_2$ (theoretical)	Northwest Russia [e]
SiO_2	34.7[a]		34.48	33.31
Al_2O_3	48.4[a]		48.85	44.16
Fe_2O_3		0.1[d]		1.72
FeO				1.69
MnO				0.18
CaO	0.2[a]	0.04[d]		0.00
MgO		0.05[d]		0.37
Na_2O		0.01[d]		0.70
K_2O				0.67
Li_2O	2.7[b]	2.2[d]	2.87	3.40
H_2O^+ } Penfield	13.8[c]		13.80	13.19
H_2O^- } Penfield				0.46
Loss on ignition 1100°C	(14.4)[c]			
	99.8		100.00	99.85

Specific gravity at 25°C, 2.655[c]

[a] X-ray fluorescence, H. J. Rose, Jr., U. S. Geological Survey.

[b] Wet analysis, J. I. Dinnin, U. S. Geological Survey.

[c] J. J. Fahey, U. S. Geological Survey.

[d] Microspectrography by C. L. Waring, U. S. Geological Survey; method of Waring and Worthing (1961).

[e] Zvyagin and Nefedov, 1954.

TABLE 2

X-ray Powder Data for Cookeite

Jeffrey Quarry, Arkansas		N. W. Russia, Zvyagin and Nefedov, 1954			
I	d	I	d obs.	d calc.	hkl
vs	14.03				
vs	7.095	5	6.9	7.05	002
vvs	4.72	7	4.67	4.72	003
ms	4.47	4	4.48	4.47	020, 110
		2	3.88		
vvs	3.52	9	3.52	3.54	004
		1	(3.35)	------	
		1	(3.11)	------	
w	3.01	[7]	2.81	2.83	005
vs	2.83	[9]	2.57	2.57	201, 130, 131, 202
s	2.56			2.55	200, 131
vs	2.51	8	2.51	2.52	202
				2.50	131
vw	2.35				
vvs	2.32	10	2.32	2.36	006
				2.30	202
vw	2.20		2.22	2.24	040, 133
				2.23	204
				2.22	220
		1	(2.16)		
vvw	2.085				
s	2.02	3	2.02	2.02	007, 134
vs	1.96	8	1.96	1.98	135, 135
				1.94	204
		1	1.86	1.87	206
				1.84	135
w	1.76	2	[1.80]	1.77	008
s	1.69	4	1.69	1.69	150, 240
				1.68	136
				1.67	310
vs	1.64	8*	[1.69]	1.65	137
				1.62	206
mw	1.54	4	1.538	1.57	009
				1.52	137
vs	1.49	9*	1.491	1.49	060, 331, 138
				1.48	330, 332, 207
		2	1.456	1.46	062, 333
				1.45	331
vw	1.44			1.44	209
w	1.42	4*	1.419	1.42	063
w	1.415			1.41	0010, 332
w	1.375	3	1.374	1.37	064
				1.36	208, 333
s	1.306	7	1.299	1.30	139, 334
				1.29	0011, 260

TABLE 2—(Continued)

X-ray Powder Data for Cookeite

Jeffrey Quarry, Arkansas		N. W. Russia, Zvyagin and Nefedov, 1954			
I	d	I	d obs.	d calc.	hkl
				1.28	400, 262
CuKα radiation, Ni filter ($\lambda = 1.5418$Å)		3	1.253	1.26	209, 066, 337
				1.25	335
		4	1.231	1.24	170
				1.23	350, 420
Camera diameter 114.6 mm		1	1.113	1.12	080
				1.11	440
		3	1.101	1.09	0013, 2011, 3310
Lower limit 2θ approximately 6° (14.7Å)				1.08	069
		2	1.072	1.07	338
		4	1.024	1.02	370, 280
				1.01	0014

s = strong
vs = very strong
ms = moderately strong
vvs = very very strong
w = weak
vw = very weak
mw = moderately weak
vvw = very very weak

* Diffuse lines, measured in the most intense part

( ) Beta line

[ ] Assumed superposition of beta—and alpha-lines

Rectorite

Rectorite is known from 11 localities in Arkansas (table 3 and figure 1), as well as from Calaveras County, California, (U.S.N.M. 94480). The Arkansas localities lie in a belt extending from North Little Rock west to the Hollis community, a distance of about 50 miles. Because this region is generally forested, sparsely populated, and traversed by few roads, many more discoveries of rectorite as well as quartz crystals may be expected there. The known rectorite localities generally occur along or close to the north margin of the quartz belt of Arkansas.

Rectorite is an abundant mineral, and masses several inches across are seen. It resembles "mountain leather", or paper that has been soaked and then dried. Often it is found as a thin plaster firmly adhering to quartz masses. Its color is buff or whitish gray.

In the wall of the quarry are vertical fissures, many feet long and up to a foot or so wide. These fissures, especially in the lower part of the quarry, are filled with a semiliquid substance, with the consistency of a thick grease. In it are thickly suspended, countless quartz crystals and aggregates, large and small, together with most of the other minerals found in the quarry. On drying, this material becomes rectorite. Attached to the quartz, and freely suspended in the semiliquid material, are countless spheroidal aggregates, usually less than a millimeter in diameter, of cookeite. Usually they are white, but some are yellow, rarely bluish. Figure 10 shows these minerals washed out of the enclosing rectorite.

TABLE 3.

List of known rectorite occurrences in Arkansas.

The numbers of the rectorite occurrences correspond to those shown on the accompanying map (fig. 1) of central Arkansas.

1. Jeffrey quarry, sec. 8, T. 2 N., R. 12 W., 5 mi. northwest of North Little Rock, Pulaski County. Jackfork Sandstone. Abundant rectorite and only cookeite occurrence in Arkansas.

2. Rector Hill, NE¼ NW¼, sec. 31, T. 3 N., R. 13 W., Pulaski County. Rectorite and dickite in new quarry in massive sandstone of upper part of Stanley Shale (Charles G. Stone, written communication of November 15, 1962).

3. Quarry for crushed stone, NE¼ sec. 1, T. 2 N., R. 14 W., Pulaski County. Jackfork Sandstone. Stylolites in sandstone have amplitude of half an inch. Rectorite and needle quartz crystals. Visited by Charles G. Stone and H. D. Miser in 1961 and 1962.

4. Rectorite in small quartz vein in Bigfork Chert (Ordovician), NE¼ NE¼, sec. 19, T. 1 N., R. 13 W., Pulaski County. Collected on Lake Nixon road, ⅕ mi. south of Lake Nixon (Charles G. Stone, written communication, June 26, 1962).

5. Angling Pinnacle, sec. 31, T. 2 N., R. 18 W., Saline County. Jackfork Sandstone (Engel, 1952, p. 196-197, table 10).

6. Smith Pinnacle, SE¼ NE¼ sec. 34, T. 2 N., R. 19 W., Saline County. Jackfork Sandstone. Rectorite. (Engel, 1952, table 10).

7. Sec. 27, T. 2 N., R. 19 W., Saline County. First described occurrence of rectorite (Brackett and Williams, 1891, p. 11-21; Branner, J. C., 1908, p. 25, 103-104).

8. Quartz crystal mine, reported to be 6 or 7 miles southeast of Hollis, and thus possibly in Saline County. Country rock maybe Jackfork Sandstone. Mining by Harley M. Crain. Acicular and tabular crystals obtained from owner by Charles G. Stone and H. D. Miser contain rectorite.

9. Road metal quarry in Jackfork Sandstone, east of Bear Creek in Hollis community, Perry County. Some rectorite and abundant dickite, much of which was coarse and golden yellow. Small quantity of needle quartz found and sold in 1953. Stylolites, amplitudes up to 8 inches or more, along bedding and joints in sandstone. Visited by Norman F. Williams and H. D. Miser in 1955 and by Charles G. Stone, Drew Holbrook, and Miser in 1961.

10. Deckard Mountain, NW¼ SW¼, sec. 22, T. 2 N., R. 20 W., Perry County. Jackfork Sandstone. Rectorite. (Engel, 1952, table 10).

11. Road cut on east side of Arkansas 7, about 8 miles south of Hollis and 200 yards north of Iron Springs Recreation Area, Garland County. Quartz vein in fault zone, apparently in upper part of Stanley Shale. Description of locality by Charles G. Stone (written communication). Locality visited many years earlier by H. D. Miser who collected sample (analysis in table 4 and x-ray powder pattern in table 5).

Small quantities of ground water seep from the many fissures that are occupied by the mineral-laden semiliquid material, and it is presumably this that is absorbed by rectorite to convert it to the semiliquid form.

Rectorite has not been generally considered as a valid mineral species; Bradley (1950) observes that Dana's System, 6th Edition, notes it as "of doubtful validity, and has since been omitted", but suggests that it consists of interlayered sheets of pyrophyllite and montmorillonite. It is not listed in the current (1962) Index to the X-ray Powder Data File, American Society for Testing and Materials Special Technical Publication 48L; nor indeed is there any published powder data known to us, other than Bradley's note which gives only selected lines. For this reason, measurements were made on numerous Arkansas rectorites, as well as a specimen from California labeled as rectorite (table 5). Nothing is known to the writers concerning the California specimen except that it was given to the National Museum by the late Magnus Vonsen.

Analyses of rectorite from the Jeffrey quarry and from two other localities in Arkansas are given in table 4. Analysis of the original material, U.S.N.M. 80607 from Saline County, Arkansas, (Brackett and Williams, 1891) agrees well with the two later analyses, allowing for their analysis being made of material dried at 110°C and, as Bradley (loc. cit.) notes, including a small quantity of kaolinite.

TABLE 4

Analyses of Rectorite

	Jeffrey quarry near North Little Rock, Arkansas[1] (locality 1 on fig. 1 and table 3)	Garland County 24 miles north of Hot Springs, Arkansas[2] (locality 11)	Saline County, Arkansas U.S.N.M. 80607[3] (locality 7)
SiO_2	47.03	47.10	52.72
Al_2O_3	33.71	33.97	36.60
Total Fe as Fe_2O_3	.02	0.31	.25
CaO	1.10	0.42	.45
MgO	.52	0.01	.51
Na_2O	3.5*	3.88	2.83
K_2O	.12*	0.16	.26
MnO	.01		
H_2O^+	5.83	6.27	7.76 (8.78 H_2O
H_2O^-	8.66	8.34	at 110°C)
	100.39	100.46	101.38

Jeffrey quarry analysis—

Specific gravity—2.163

*Determined by Paul Elmore, U. S. Geological Survey, using rapid methods.

Note—Loss of H_2O at 300°C = 9.55, and at 700°C = 4.83%.

[1] Analyst—Sarah Berthold, U. S. Geological Survey.
[2] Analyst—J. J. Fahey, U. S. Geological Survey (Wells, 1937, p. 110).
[3] Brackett and Williams, 1891.

TABLE 5

X-ray Powder Data for Rectorite

Calaveras County, California, U. S. Natl. Mus. 94480, F 16715		Pulaski County, Arkansas Jeffrey Quarry, (Locality 1), F 16713		Pulaski County, Arkansas, (Locality 3) F 16667		Pulaski County, Arkansas, (Locality 2), F 16743		Garland County, Arkansas, (Locality 11), F 6909		Garland County, Arkansas, (Locality 11), F 16666	
I	d	I	d	I	d	I	d	I	d	I	d
vw$_B$	13.6	s$_B$	12.63	s$_B$	12.19	s$_B$	12.36	vvs	12.63	s$_B$	12.63
vw	11.63							s	11.33		
s$_B$	10.10									w	6.281
s$_B$	4.997	w$_B$	5.07			w$_B$	4.997	w	5.039	w$_B$	5.096
vw	4.707										
vs	4.484	s	4.43	vvs	4.407	s	4.407	vvs	4.450	vs	4.429
vs	4.322							w	4.281*		
										vw	4.191
vw	4.123							w$_{BB}$	3.960		
ms	3.892	vs	3.834								
w	3.731										
w	3.500	ms	3.473								
vs	3.333*			w	3.345*			vs	3.357*	vs	3.345*
w	3.1865	w$_B$	3.175	w$_B$	3.175	w	3.175	s$_B$	3.153	w$_B$	3.175
w	2.998										
w$_B$	2.852										
s	2.592									vvw	2.679
vs	2.567	w$_B$	2.553	s$_B$	2.553	s	2.546	s$_B$	2.560	s$_B$	2.560
w	2.511									w$_B$	2.442*
w	2.458*										
ms	2.392										
w	2.259*							vvw	2.287*		
								vw	2.243*		
vw	2.206										
w	2.1365*							w$_{BB}$	2.1		

s_{BB}	1.995*							vvw	2.000*		
								vvw	1.945		
vvw	1.740					vvw_B	1.965	w	1.8275*		
vvw	1.702	vw	1.695	vw	1.681			w	1.689		
ms_B	1.653*							vvw	1.667*		
								vw	1.547*		
s	1.507	s	1.479	s	1.487	s	1.488	vvs	1.4935	s	1.488
vvw	1.425							vvw	1.383		
w_B	1.353*										
w	1.302*	vw	1.289					vvw	1.3365		
								w	1.288*		
w	1.253*	vw	1.238	w	1.283			vw	1.263*		
				vw	1.234			vw	1.240		

Footnotes on Powder Data

CuK_2 radiation, Ni filter (1 = 1.5148 Å)
Camera diameter, 114.6 mm
Lower limit 2θ approximately 6° (14.7 Å)
* Possible quartz line

s = strong
vs = very strong
ms = moderately strong
vvs = very very strong
w = weak
vw = very weak
mw = moderately weak
vvw = very very weak
$_B$ = broad
$_{BB}$ = broad band

All measurements by Charles Milton

The powder data for the three specimens from Pulaski County, Arkansas, (localities 1, 2, and 3) are reasonably concordant, the only notable exception being a very strong line, 3.834, and a moderately strong line, 3.473, in the Jeffrey quarry rectorite (locality 1) not appearing in the other two. The two from Garland County, Arkansas, from the same deposit, but collected on different occasions, are fairly concordant with each other, and also with the Pulaski County rectorites, with the exception above noted. The California rectorite apparently agrees fairly well with the Jeffrey quarry rectorite, even with respect to the two lines not appearing in the other Arkansas specimens.

From these data, it may be said that rectorite is characterized by a composition given in table 4, the physical properties cited, and a powder pattern with three strongest lines, 4.41 - 4.48, 10.1 - 12.6, 1.48 - 1.51, but whether or not rectorite constitutes a valid mineral species, or indeed, just what it is structurally, remains open.

Occurrence of crystal quartz in Arkansas

The quartz crystals and veins of the Ouachita Mountains occur in deformed Cambrian to Pennsylvanian rocks and are restricted to a belt 30 to 40 miles wide and 150 miles long extending in a west-southwesterly direction from Little Rock, Arkansas, to Broken Bow, Oklahoma. The belt coincides with the Broken Bow-Benton uplift. Also, it coincides with the belt of low-grade metamorphic rocks on that uplift. Just as the metamorphism decreases both northward and southward from the uplift, so do the quartz veins thin and disappear both to the north and south from the uplift (Miser, 1943, p. 91-118).

In the Jeffrey quarry the mineral veins, as much as one foot in width, fill openings in fractures on some of which there has been faulting. At this quarry as well as elsewhere in the Ouachita Mountains, many crystals and the vein quartz have been fractured, sheared, crushed, and recemented partly or completely by later quartz.

The quartz deposition and fracturing and also the dislocation of the rocks enclosing the crystals and veins seem to form an episode of discontinuous but recurrent quartz deposition and movement. Slickensides and the relations of the veins at the Jeffrey quarry seem to indicate movement that included a stronger horizontal component than a vertical component.

The vein quartz, the quartz crystals, and the associated minerals at the Jeffrey quarry and elsewhere in the Ouachita Mountains were formed from hydrothermal solutions. The solutions, responsible for a part or perhaps all mineral deposition at the Jeffrey quarry, were presumably associated with the nearby nepheline syenite intrusions of central Arkansas. The syenite intrusions were of early Late Cretaceous. This age is indicated by recent K-Ar age determinations on biotite in nepheline syenite from Granite Mountain near Little Rock. The sample was collected by Charles G. Stone of the Arkansas Geological Commission. An average age of 89 million years was determined from two concentrates of biotite analyzed by H. H. Thomas, R. F. Marvin, Paul Elmore, and H. Smith of the U. S. Geological Survey.

The irregular and transitional boundaries of some vein quartz with the Arkansas Novaculite at a few places near Little Rock suggest that the deposition of such quartz may have taken place in a contact-metamorphic belt close to a possible mass of syenite now concealed by Tertiary or later sediments.

The association of rectorite and roughly terminated quartz crystals at the Jeffrey quarry and at many other localities suggests a possible similar time of deposition of rectorite and this type of quartz. The quartz-rectorite occurrences lie in a 50-mile long belt that follows the north side of the quartz belt in the Ouachita Mountains in Arkansas.

The Kellogg mine, 6 miles northeast of the Jeffrey quarry, contains many minerals including those of silver, lead, and zinc which were discovered before 1840 and which have been mined on a very small scale (Smith, 1867, p. 67-69; Comstock, 1888, p. 200-202, 220, 238-249; Branner, G. C., 1927, p. 138-143). The following description of the mine is abstracted largely from unpublished data supplied January 25, 1962, by Charles G. Stone. The mine openings are scattered over a several-square-mile area centered in the northwest part of sec. 30, T. 3 N., R. 11 W. Mineralized quartz veins occur along fractures (generally east-west), and small faults in the upper part of the Stanley Shale. The minerals, whose probable time of formation Stone places in the Pennsylvanian, include quartz, dickite, pyrophyllite, siderite, sphalerite, galena, chalcopyrite, freibergite, and tennantite. Selected specimens collected by Stone from shallows pits, talus piles, and an apparent ore bin were analyzed by Troy W. Carney of the Arkansas Geological Commission. His analyses follow:

Siderite —Ag, nil; Ge, 0.010 per cent
Sphalerite —Ag, nil; Ge, 0.005 per cent; Ce, 0.3 per cent; Ga, trace
Chalcopyrite—Ag, 10 oz. per ton
Galena —Ag, 28 oz. per ton

Most of the quartz in Arkansas, including the 50-mile long belt that contains the quartz-rectorite deposits, is closely related in time of origin, to the low-grade regional metamorphism and to both the regional and local structural features (Miser, 1943; Engel, 1952, p. 243; Stone, July 26, 1963, written communication). The regional low-grade metamorphism and the intense structural deformation are generally placed in Middle and Late Pennsylvanian time. The quartz depositions in the 30- to 40-mile wide belt extending the full length of the Broken Bow-Benton uplift seems to have accompanied the regional arching of the rocks to form this uplift. This arching tock place after the major part of the intense deformation and after most of the metamorphism of the rocks.

The main period of quartz deposition in Arkansas is thus placed in Pennsylvanian time; but in the 50-mile long belt west of Little Rock, Pennsylvanian quartz deposition seems to have been followed by another period of mineralization in Cretaceous time at the Jeffrey quarry and at other quartz-rectorite localities.

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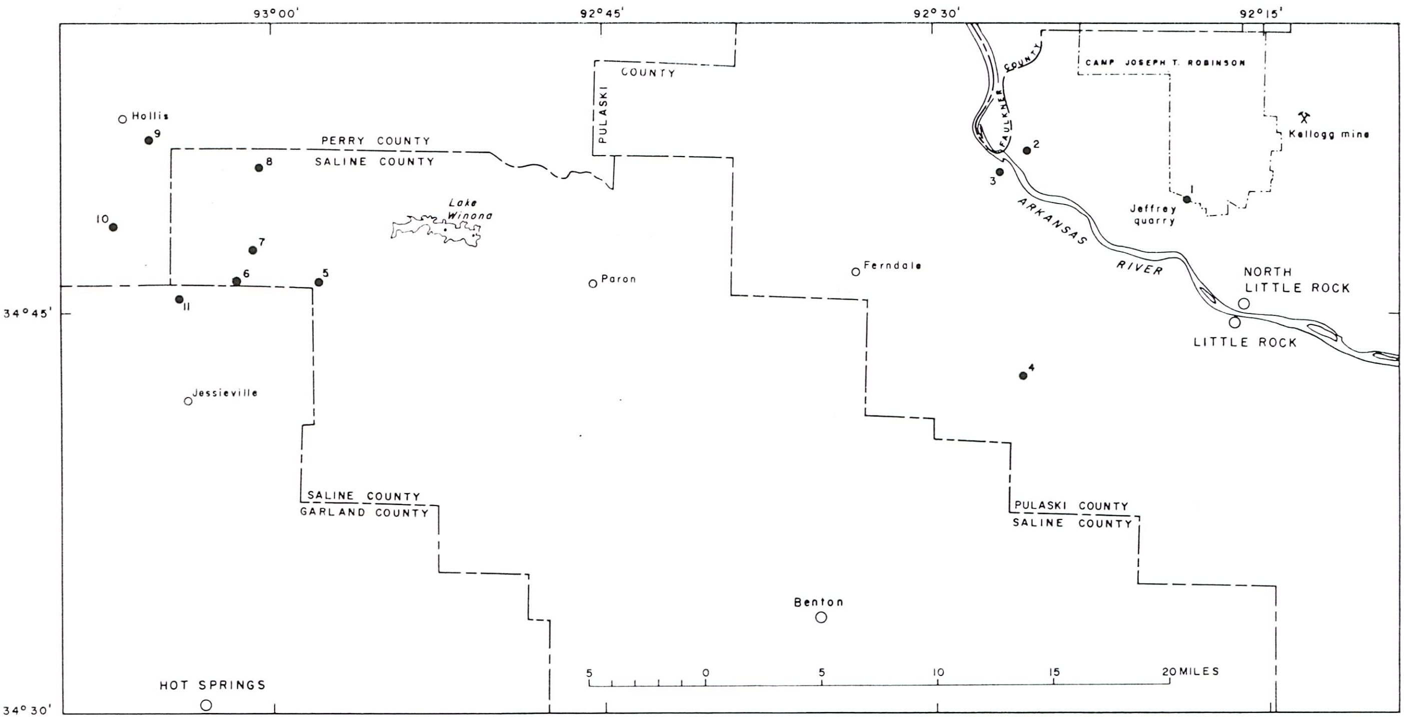

Figure 1. Map of Central Arkansas showing location of Jeffrey quarry, near North Little Rock, and other places (numbered) where rectorite occurs. The numbers correspond to those in table 3.

Figure 2. Quarry face of Jackfork Sandstone in Jeffrey quarry (June 1962). Shows well bedded sandstone and shale, and absence of strong folding.

Figure 3. Closer view of quarry face.

Figure 4. Quarry face showing drusy crystalline quartz and white quartz veins cutting brecciated Jackfork Sandstone.

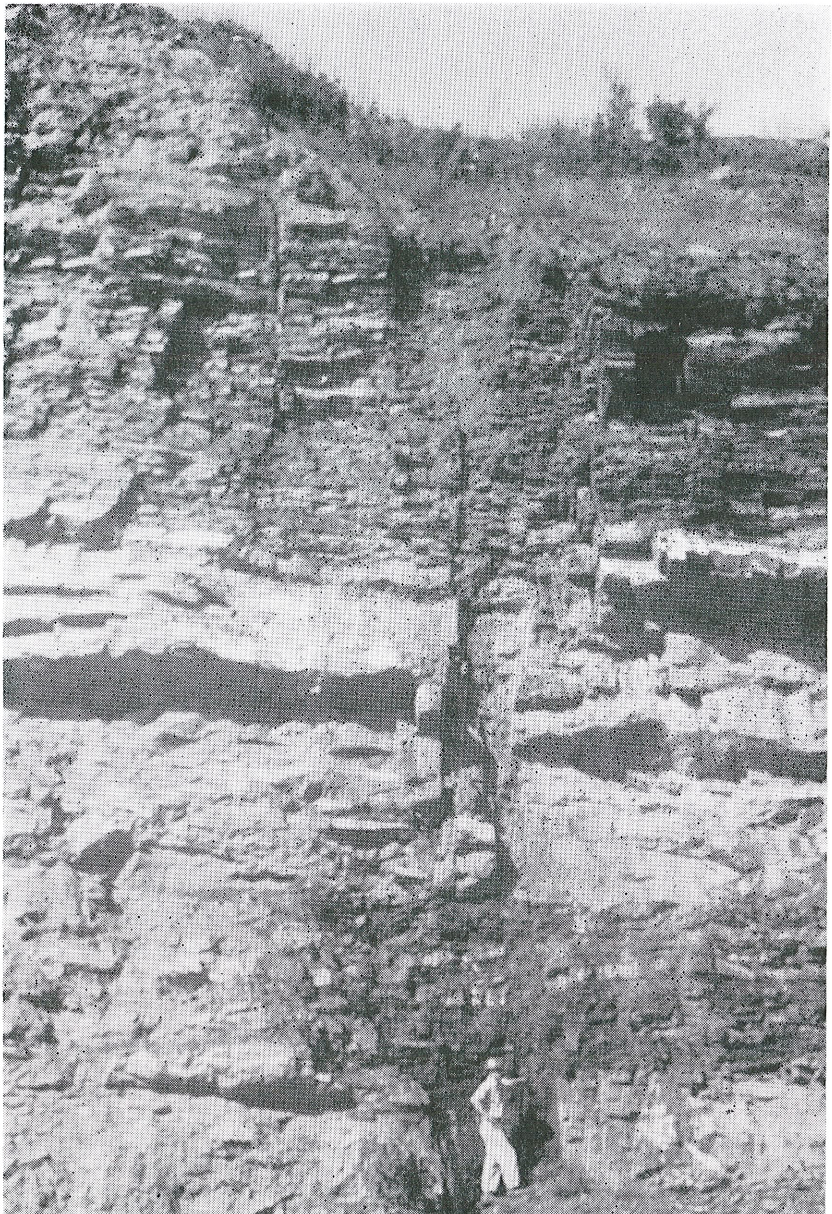

Figure 5. Vertical igneous dike in quarry face.

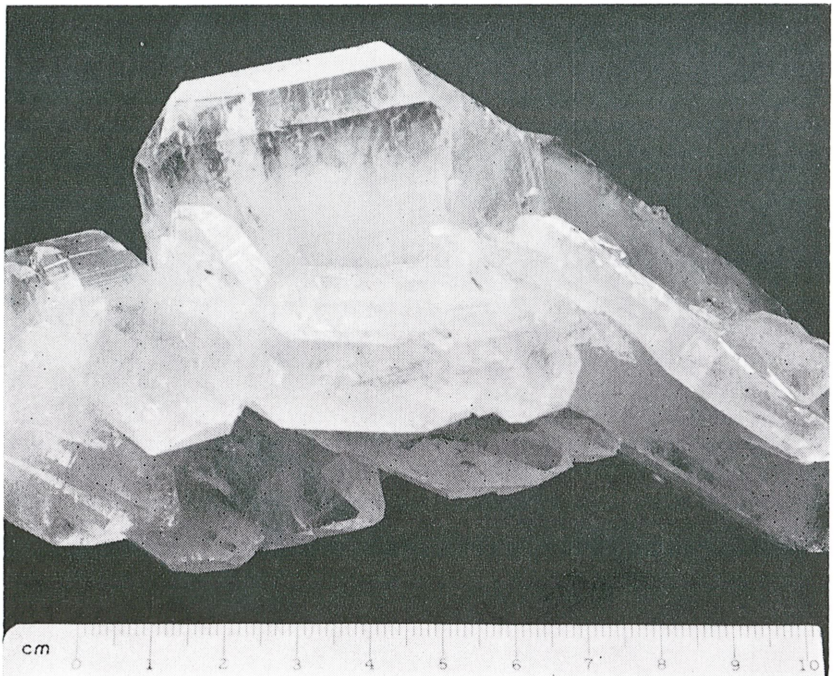

Figure 6. Quartz crystal aggregate from Jeffrey quarry, showing characteristic flattened tabular crystals.

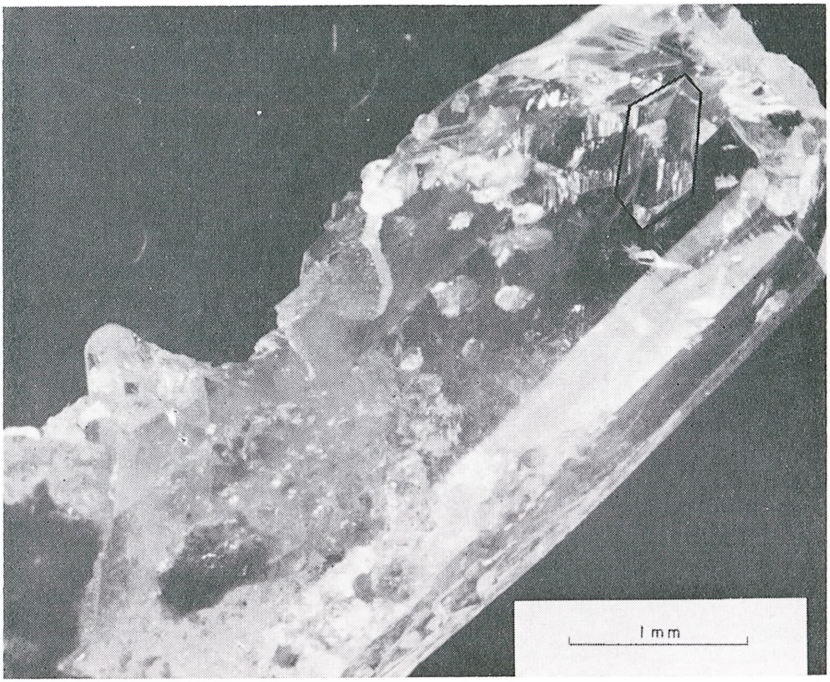

Figure 7. Quartz with cookeite and sphalerite crystal from Jeffrey quarry (crystal outlined in black).

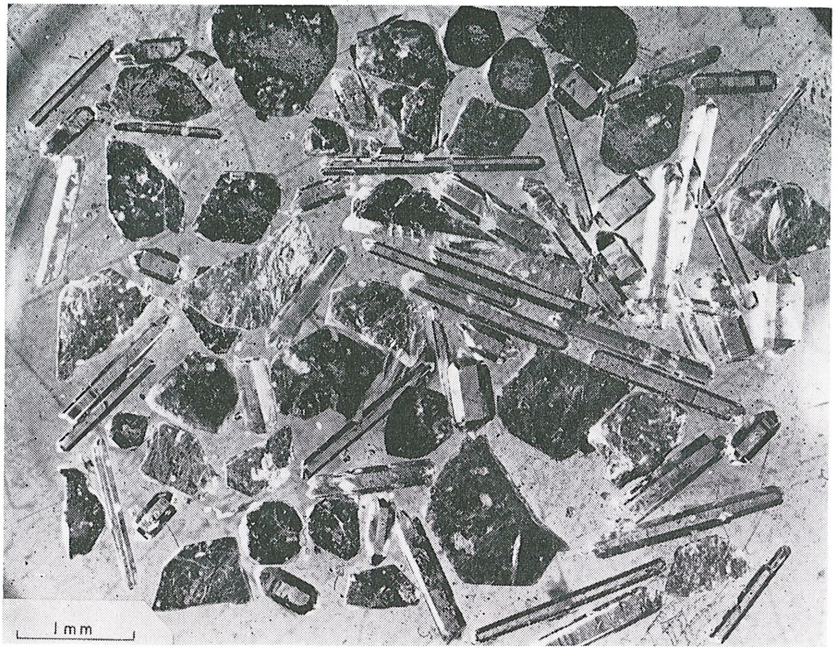

Figure 8. Small acicular crystals of quartz and platy hexagonal apatite from Jeffrey quarry.

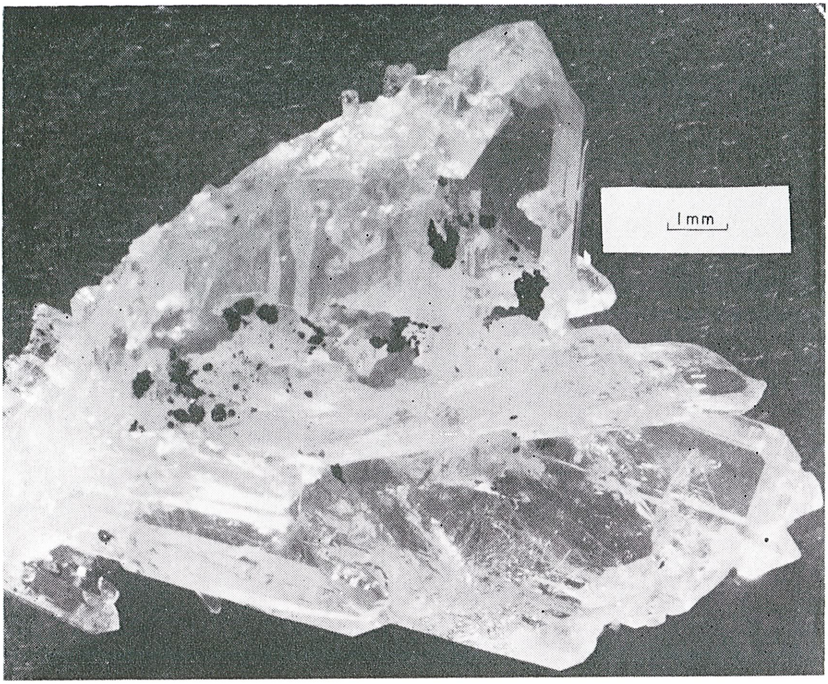

Figure 9. Quartz group with brown ankerite (dark spots) from Jeffrey quarry.

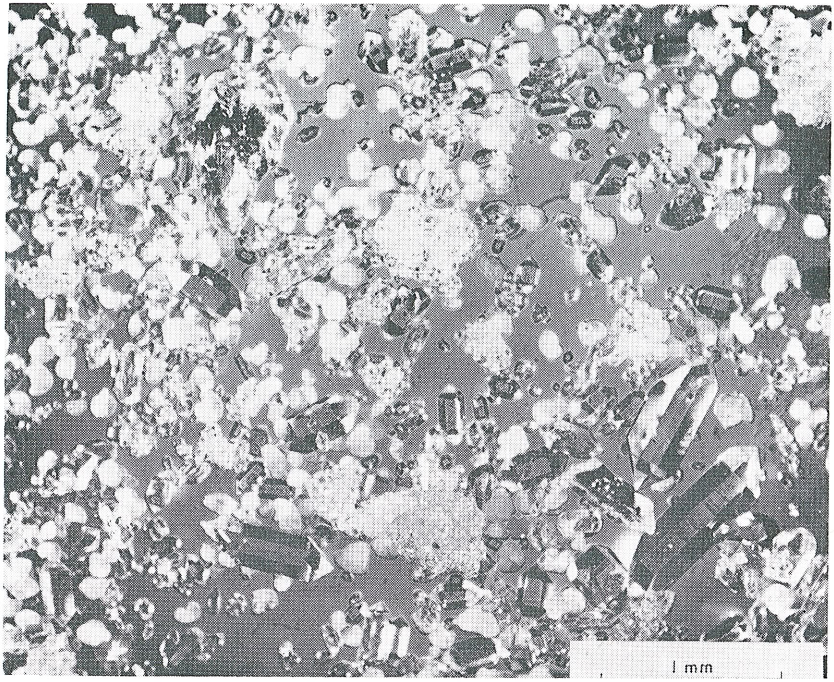

Figure 10. Microscopic doubly terminated quartz crystals, and masses of fine sugary quartz (upper and lower center, upper right, etc.). The round white spheroids are cookeite. This material, with quartz crystals to 10 or more centimeters in length, with apatite, etc., occurs suspended in a semiliquid that dries to rectorite. Specimen from Jeffrey quarry.

Figure 11. Massive very pure white cookeite aggregate without quartz, Jeffrey quarry (analyzed material).