TALC AND ANTHOPHYLLITE DEPOSITS IN TALLAPOOSA AND CHAMBERS COUNTIES ALABAMA

By Thornton L. Neathery

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BULLETIN 90

TALC AND ANTHOPHYLLITE ASBESTOS DEPOSITS IN TALLAPOOSA AND CHAMBERS COUNTIES, ALABAMA

By Thornton L. Neathery

UNIVERSITY, ALABAMA

1968

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University, Alabama
June 3, 1968

Honorable Albert P. Brewer
Governor of Alabama
Montgomery, Alabama

Dear Governor Brewer:

I have the honor to transmit herewith the report "Talc and Anthophyllite Asbestos Deposits in Tallapoosa and Chambers Counties, Alabama," by Thornton L. Neathery, which has been published as Bulletin 90 of the Geological Survey of Alabama.

Anthophyllite asbestos is an important industrial mineral for which there are few substitutes. The demand for this acid resistant material has been increasing for many years and should increase more rapidly in the future. In view of the expanding market and anticipated growth of the asbestos industry, an appraisal of Alabama's anthophyllite and talc resources was considered necessary. The present report indicates that significant quantities of talc and asbestos are available for economic development.

Respectfully,

Philip E. LaMoreaux

Philip E. LaMoreaux
State Geologist

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TALC AND ANTHOPHYLLITE ASBESTOS DEPOSITS IN TALLAPOOSA AND CHAMBERS COUNTIES, ALABAMA

By Thornton L. Neathery

ABSTRACT

Talc and anthophyllite asbestos deposits in Tallapoosa and Chambers Counties, Alabama, are associated with a complex group of calcic-magnesium mafic and ultramafic rocks. These rocks are a part of a discontinuous belt of mafic and ultramafic rocks which occur within the crystalline gneiss and schist of eastern North America and extend from east-central Alabama to western Newfoundland. In Tallapoosa County, these rocks crop out in narrow, arcuate bands which extend from the vicinity east of Dudleyville westward to the southwestern part of the county, a distance of approximately 20 miles.

The mafic rocks consist chiefly of amphibolite, gabbro diorite, and hornblende gneiss. The ultramafic rocks are predominantly pyroxenites composed of heterogeneous aggregates of enstatite, hypersthene, olivine, and bronzite.

The enclosing paraschist and gneiss are moderately folded and have a well developed foliation usually parallel to their compositional layering. The rock sequence strikes northeasterly concordant with regional trends. An occasional divergence in strike suggests minor cross folding. Field mapping indicates that the regional structure is a broad synform trending northeastward from south of Dadeville to a prominent granite outcrop in Chambers County.

Amphibolite zones are extensive and numerous. Their outcrop area tends to be elongate with the regional strike, and often exceeds 6 miles in length. The outcrops vary in width from 100 feet to over a mile. Exposures of amphibolite are few, and outcrop boundaries are difficult to map.

The mafic and ultramafic rocks represent a wide variety of distinct but related rock types which have been involved in one or more periods of regional metamorphism. Four processes of alteration are recognized in the amphibolites and pyroxenites. These are (1) serpentinization, (2) steatitization, (3) amphibolization, and (4) chloritization; steatitization and amphibolization predominate.

Most occurrences of asbestos are found in the eastern part of the mafic-ultramafic belt. Three types of anthophyllite asbestos are recognized on the basis of fiber orientation: cross-fiber, slip-fiber, and mass-fiber.

The talc is predominantly a "talc-rich" soapstone which occurs as shell-like entities in the saprolite overlying the mafic-ultramafic rock complex. Talc appears to be far more abundant than anthophyllite. Calculations, based on evaluation of three talc samples and five significant talc-bearing properties,

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indicate the potential availability of approximately 8 million tons of talc. Considerable tonnages of anthophyllite asbestos could conceivably be derived as a primary product or as a secondary product from talc mining.

INTRODUCTION

LOCATION AND DISTRIBUTION

Talc and anthophyllite asbestos deposits in Alabama are associated with a complex group of mafic and ultramafic calcic-magnesian rocks. They are considered to be part of the discontinuous belt of mafic and ultramafic rocks that extends from east-central Alabama to western Newfoundland, a distance of more than 2,000 miles (Pratt and Lewis, 1905, p. 34). The belt is well developed in the Piedmont region of Alabama, especially in Tallapoosa County. Isolated mafic and ultramafic rock occurs in other divisions of the Alabama Piedmont, especially in Coosa, Chilton, Clay, and Cleburne Counties.

Various types and quantities of asbestos and talc are found in the area of mafic and ultramafic rock. The significant deposits of asbestos occur in the eastern part of the county near Dudleyville. The talc deposits are less restricted in distribution and crop out more or less continuously from Dadeville to Dudleyville (fig. 1).

The area of the present study is bounded on the east by the Pleasant Grove granite outcrop in Chambers County; on the north and west by the Brevard zone; and on the south by an arbitrary line 10 to 12 miles south of and parallel to the strike of the Brevard zone.

PURPOSE AND SCOPE

Anthophyllite asbestos is an important industrial mineral for which there are few substitutes. The demand for anthophyllite asbestos has increased for many years and is expected to increase more rapidly in the future. Research continues to develop new uses for all varieties of asbestos, especially the acid resistant variety, anthophyllite. Anthophyllite is presently used for acid resistant filter material, asbestos cement, and insulating material. In view of the expanding market and anticipated growth of the

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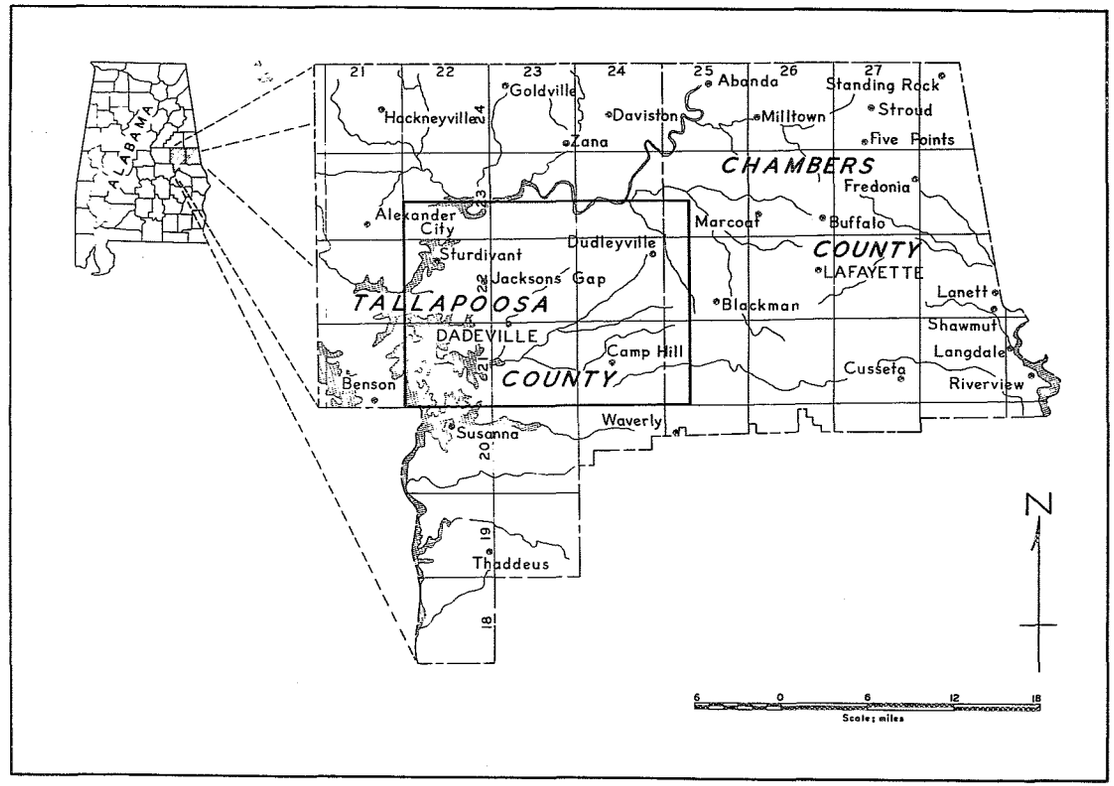


Figure 1.—Index map of study area.

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asbestos industry, an appraisal of Alabama's anthophyllite resources was considered necessary. The associated talc deposits, although somewhat inferior in grade to other talc deposits of the eastern United States, occur in significant quantities to be considered a primary resource.

The purpose of this report is to present the basic geology, and an appraisal of the talc and anthophyllite asbestos resources in Tallapoosa and Chambers Counties. It is hoped that the data in this report will be the basis for future investigation and development of these resources.

PREVIOUS WORK

The occurrence of talc and anthophyllite asbestos in the Dadeville area of Tallapoosa County was noted by Eugene A. Smith in 1873 at several prospects opened in search of corundum.

It is reported that from 1939 to 1940 extensive prospecting for chromite took place in the Easton and Buttson communities of the central Dadeville ultramafic rock outcrop area. Numerous shallow cuts and pits were excavated in the pyroxenite, many of which are still open for examination.

In 1953, the Red Hawk Mining Co., Montgomery, Ala., conducted exploration activities in the western end of the Dadeville area. They opened 7 or 8 large bulldozer trenches and possibly several smaller ones. It is not known if the company removed any sample material for testing.

In 1963, the American Talc Co., Alpine, Ala., leased several hundred acres of land in the east-central part of the district along the Dadeville-Dudleyville road. Twelve diamond core holes were completed during their investigation. The Geological Survey of Alabama furnished technical assistance in interpreting the drill hole data.

Also, in 1963, the Tallapoosa Mining Co., Camp Hill, Ala., was organized and acquired the mineral rights to several thousand acres of land. The company opened several small bulldozer pits and one large pit in the eastern end of the area, and recovered 20 to 25 tons of material which was subsequently used for product testing in 1965. In 1965, the Tallapoosa Mining Co. lands were conveyed to the Black Warrior Petroleum Co.

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In 1965, the Powhattan Mining Co., Baltimore, Md., obtained a mineral lease on 140 acres of land in the Oziah Church area, and began sampling for anthophyllite. They conducted extensive exploration activities on the property, excavating numerous pits and trenches. Sampling continued during 1966-67, and several carloads of crude material were shipped from Dadeville for test purposes.

PRESENT INVESTIGATION

The present geologic study of the talc and anthophyllite asbestos deposits was begun in the spring of 1965. The original purpose of the investigation was to obtain as much information as possible on the distribution, character, origin and potential reserves of anthophyllite asbestos in Alabama. As the investigation continued it became apparent that the associated talc was of sufficient quantity to warrant expanding the original scope of the project. As the project progressed and additional deposits were located, regional reconnaissance studies were incorporated into the program. Although the outcrop area of the mafic and ultramafic rocks is extensive, the area containing talc and anthophyllite was found to be largely restricted to the original area of study.

The area of mafic and ultramafic rock between Dadeville and Dudleyville was mapped in detail. Attempts were made to locate, examine, and delineate all of the previously prospected asbestos deposits and establish the general limits of the talc-bearing rock. Particular attention was given to several deposits that were currently being prospected. A geologic rock-type map of the talc-anthophyllite area was prepared.

ACKNOWLEDGMENTS

Many persons contributed to this investigation, and without their assistance many phases of the study would not have been completed. Particularly helpful were W. H. Barnes, Probate Judge, Tallapoosa County; J. C. Pritchard, Road Commissioner, District 3, Tallapoosa County; L. A. Abrams, Mayor, Dadeville; Mrs. Marian Tucker, Dadeville; Claude T. Bartlette, Camp Hill; and Donald G. Ferrell, President, Black Warrior Petroleum Co., Mobile, Ala.

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Acknowledgment is also made to Mr. Fred A. Mett, President, and Mr. Frank Burleson, Mine Foreman, Powhattan Mining Co., for their courtesies and suggestions. Local residents and land owners in the principal area of study were most helpful in supplying background data and directions to outcrops.

Mr. James F. O'Neill, Supervising Mining Engineer, U.S. Bureau of Mines, visited the area and made helpful suggestions as to how to sample the talc and asbestos outcrops for mineral dressing studies (Neathery and others, 1967). The cooperation and advice of other personnel of the U.S. Bureau of Mines is also appreciated.

GEOGRAPHY

The Dadeville area is located in east-central Alabama in parts of Tallapoosa and Chambers Counties (fig. 1). The area lies within the Piedmont region of Alabama which coincides with the Opelika Plateau physiographic division of Adams (1926, p. 26) and is equivalent to the Greenville Plateau in Georgia (LaForge and others, 1925, p. 77-80). The Opelika Plateau is considered to be an ancient peneplaned upland surface. Elevations range from 800 to 900 feet above mean sea level with occasional hills rising above the general surface.

The Dadeville area is underlain by an alternating sequence of resistant and nonresistant weathered metamorphic rock; the strike and dip of this rock influences the topography. Streams generally follow the trend of softer rocks. Near the Tallapoosa River valley the topography becomes irregular.

Most of the land has been under cultivation in previous years. Now, however, most of the land has been given over to pulpwood and dairy farming. Some acreage is still natural forest; it is in these areas that most of the ultramafic rock outcrops are found.

The area is readily accessible by numerous State and County roads, both hard surfaced and graded. Numerous logging roads have been constructed into many of the larger timber tracts. Most of the roads can be traveled by car or truck; a few are passable only with 4-wheel drive vehicles.

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Dadeville, the county seat of Tallapoosa County, is the principal railroad loading and serviceing facility for the area. The Central of Georgia Railroad operates north from Dadeville to Birmingham and connecting railroads, and southeast to Opelika, Ala., and Columbus, Ga. Another branch of the Central of Georgia Railroad passes through the eastern end of the area of Lafayette, county seat of Chambers County.

GEOLOGY

GENERAL

The rocks of the Dadeville area consist of a series of paraschists and paragneisses, all of high metamorphic rank, extrusive and intrusive mafic and ultramafic rock, and plutons of granite and granodiorite. Diabase dikes, tentatively dated as being of Triassic age, cut across the area in Chambers County. Adams (1933, p. 168), in a report on reconnaissance mapping of the Alabama Piedmont, tentatively designated this series as the Dadeville Belt. The belt extends from southeastern Tallapoosa County, across Chambers County and parts of Lee and Randolph Counties northwestward through Georgia (Crickmay, 1952, p. 6-22). The rocks of the Dadeville Belt are correlative with those of the Inner Piedmont Belt of North Carolina (King, 1955, p. 352-356) and South Carolina (Overstreet and Bell, 1965, p. 43-70).

Paraschists and paragneisses are the principal rock types underlying the Dadeville area. These rocks vary considerably in bulk composition and include many rock types of the amphibolite facies of regional metamorphism, including: muscovite-biotite gneiss, biotite gneiss, biotite schist, mica schist, quartz-mica schist, quartzite, and garnet-kyanite mica gneiss and schist. The biotite gneiss and schist are folded and contorted and enclose pegmatite veinlets and lenses. The quartzite is usually white to dark gray, and grades from a massive quartzite to a quartz-mica schist. It is usually present as thin layers associated with the muscovite-biotite gneiss and mica schist, although quartzite is not restricted to this group. The garnet-kyanite mica gneiss and schist have been found only on the southeastern side of the Dadeville mafic zone.

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Many observed contacts between the gneiss and schist are gradational. The gneiss grades into mica schist with an increase in the quartz and mica, and possibly a decrease in feldspar content. Originally, these rocks may have been sedimentary rocks of eugeosynclinal affinity—graywacke, shale, siltstone, etc.

The mafic rocks consist of hornblende schist or gneiss of variable thickness and are interlayered with the more felsic or micaceous rocks. The hornblende gneiss and schist are commonly dark gray, dark green, or black, fine to coarse grained, gneissic, schistose, or massive. The various rock types include garnet-bearing and garnet-free hornblende gneiss and schist, diopside-hornblende gneiss and schist, diopside-biotite-hornblende gneiss and schist, diopside-labradorite-hornblende gneiss and schist, hornblende-biotite-oligoclase gneiss and schist, actinolite schist, and chlorite schist. The diopside-labradorite-hornblende-bearing rocks are the most common calcic-magnesian rocks in the Tallapoosa County mafic-ultramafic area. Included in the mafic rock series are small masses of hornblende gabbro, pyroxenite, and soapstone. Many of the mafic rocks probably originated either as intrusive or extrusive volcanic flows of intermediate to basic composition. Some may have been impure calcareous sediments interbedded with the original sedimentary material.

Within the area of study, three large areas are underlain by granitic rocks of varying textural and structural composition. A granite exposed at Rock Mill, Randolph County, is a medium- to coarse-grained gneiss containing porphyritic phases composed essentially of biotite, plagioclase, orthoclase, and quartz, with garnet, zircon, and rutile as accessory minerals.

At the Pleasant Grove community, northwestern Chambers County (T. 23 N., R. 25 E.), granitic gneiss crops out over an area of several square miles. The granite is medium to coarse grained and displays banding of the mafic constituents. The granite weathers to retilinear exfoliated blocks which are used locally as building stone. The essential minerals are biotite, orthoclase and plagioclase feldspar, and quartz, with rutile and zircon as accessory minerals.

The third prominent granite area is located in southeastern

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Tallapoosa County and parts of Lee and Elmore Counties. A badly weathered biotite granite is exposed throughout several townships. The granite consists of biotite, orthoclase and plagioclase feldspar, and quartz, with apatite, garnet, zircon, and rutile as minor accessory minerals. Gneissic banding of the major constituents is visible near the perimeter of the granite mass.

In the Dadeville area a number of pegmatites strike generally N. 30° W., across the regional strike. These pegmatites are for the most part mica-bearing, although several are only quartz-feldspar in composition. They show no evidence of metamorphism, and are interpreted as products of the last period of metamorphism. Several pegmatites, which have been mapped in detail, are complete entities with no off-shoots or leader veins; most are less than 150 feet in length, although two are known that are more than 300 feet long. The pegmatites are zoned elipsoid-shaped entities with a quartz core, feldspar zone, feldspar-mica zone, and selvage zone. Most of the pegmatites lie south of and adjacent to the eastern mafic and ultramafic zones. Several small thin pegmatites appear to cut across the mafic and ultramafic zones. On the southeastern border of the Dadeville Belt, several scattered pegmatites are known but they are small and may represent large segregations in a granite complex.

The Inner Piedmont of Alabama is cut by at least four prominent diabase dikes, presumably of Triassic age, which strike N. 8°-15° W. The largest dike, the Auburn Dike (Adams, 1933, p. 172), extends from south of Auburn, Lee County, to the valley of the Tallapoosa River in northwestern Chambers County. This dike has been traced for approximately 33 miles from near the Upper Cretaceous overlap to the valley of the Tallapoosa River. Its width averages about 50 feet.

A second dike, designated the Marcott by Adams (1933, p. 172), lies approximately 3.5 miles east of the Auburn Dike. It has been traced for approximately 26 miles, its width averaging less than 20 feet. Two smaller dikes, the Snapper and Danway (Adams, 1933, p. 173), lie east of the Marcott. These are 3 and 6 miles long; they average 8 to 10 feet in width. R. W. Deininger (personal communication, 1965, Memphis State University) states that the

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dikes may be easily traced and that the two largest dikes, Auburn and Marcott, may be dike systems in which several dikes are spaced closely *en echelon* along strike.

STRUCTURE AND METAMORPHISM

Except for diabase dikes of Triassic age in the southwestern part of Chambers County and the mica-bearing pegmatites, the rocks of the Inner Piedmont of Alabama have been subjected to several successive cycles of deformation and metamorphism. Resulting structural and metamorphic features are complex and only a general outline as related to the ultramafic occurrence is given here.

The metamorphic rocks of the Inner Piedmont of Alabama have a northeast regional strike, are moderately folded, and have a well developed foliation that is usually parallel to the compositional layering of the gneiss and schist. Local divergences from regional strike are attributed to minor cross folding, possibly reflecting strike-slip movement along the Brevard zone (fig. 2). Reconnaissance mapping in the Dadeville area indicates that the local structure is a synform, possibly complicated on the northwestern flank by isoclinal or overturned asymmetrical folding of high amplitude and short wave length.

The synform is bounded on the north and south by thrust faults. Strike and dip measurements show that on the northwestern flank, dips are to the southeast, and on the southeast, the dips are to the northwest. The axis of the synform trends northeastward from south of Dadeville, Tallapoosa County, to at least as far as the granite outcrops in Chambers County.

The Inner Piedmont of Alabama is bounded on the north by the projection of the Brevard zone. This zone is a narrow belt of low-grade metamorphic rocks (Reed and Bryant, 1964), which includes phyllonite, phyllonite schist with lenses of blasto-mylonite, etc. The rocks of the Brevard were classified by Adams (1926, p. 36) as altered Wedowee Formation. To the southeast, the Dadeville Belt of the Inner Piedmont is mapped separately from its companion, the Opelika Belt, because of the absence of hornblende gneiss in the Opelika Belt (Adams, 1933, p. 169). Crickmay (1952, p. 6-22), however, did not recognize the Opelika Belt as a separate

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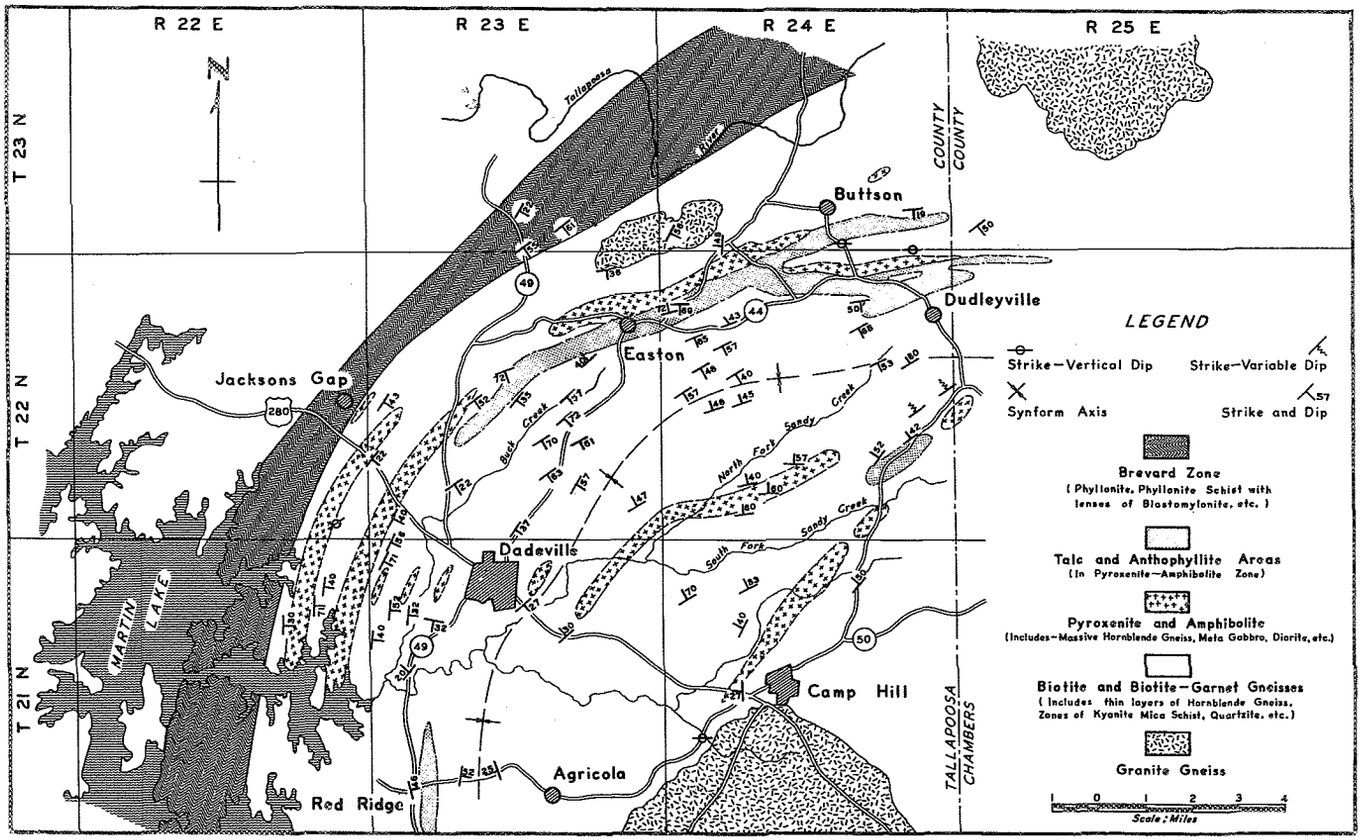


Figure 2.—Geologic rock-type map of the Dadeville area.

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identity and grouped it with the Dadeville. The present reconnaissance study concurs with Crickmay; no separation of the Dadeville and Opelika Belts appears justified. Comparisons of rock units within the Inner Piedmont do not support separation of the Opelika from the Dadeville. Berquist (1960) described many of the rocks of the Opelika Belt as being intensely shattered. This suggests the possibility that the zone may represent the sole of an overthrust, supporting Clarke's (1952, p. 78-80) hypothesis of tectonic emplacement.

Structural interpretations by Clarke (1952, p. 78) on the relationships of the three principal faults of the Inner Piedmont, the Brevard, Towaliga, and Goat Rock, suggest that they may be tectonically related. He proposed that all three faults may represent a plane of a large overthrust fault upon which is superimposed contemporaneous or later folding.

The degree of metamorphism varies considerably within the area. Metamorphic grade increases from northeast to southwest and from northwest to southeast. Outcrops of higher grade metamorphic rocks are scattered throughout the area, representing either residual thermal centers or retrograde resistant areas.

Detailed study of the various rock units was not within the scope of the present investigation. Cursory examination of composite mineral assemblages of the various rock types suggests that the metamorphic grade may be represented by the cordierite-amphibolite facies of Abukuma-type regional metamorphism; for example, products of high temperatures and moderate to low pressures, or the almandine-amphibolite facies of Barrovian-type regional metamorphism (Winkler, 1965, p. 69-107).

PYROXENITE AND RELATED MAFIC ROCKS

The talc and anthophyllite deposits in the Dadeville area are associated with a complex group of calcic-magnesian mafic and ultramafic rocks which range in composition from hornblende gneiss and enstatite-pyroxenite to soapstone. These rocks crop out in two prominent narrow arcuate rock-unit bands which extend from the vicinity of Dudleyville westward to the southwestern part of Tallapoosa County, a distance of approximately 20 miles (fig. 2).

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In the following discussion the term "amphibolite" is used to describe all schistose mafic rocks which are composed essentially of amphibolite minerals (hornblende, actinolite, tremolite, etc.). Those rocks which are designated as mafic rocks are composed of 50 percent or more ferromagnesian minerals (hornblende, pyroxene, and olivine). With an increase in the dark mineral content the mafic rocks may grade into ultramafic rocks. The pyroxenites are ultramafic rocks composed of heterogeneous aggregates of enstatite, hypersthene, and bronzite.

DISTRIBUTION

Amphibolite, mafic and ultramafic rock outcrops are extensive and numerous. Outcrop areas tend to be elongate with regional trends, generally exceeding 6 miles in length and ranging from 100 feet to over 1 mile in width. Exposures are few and outcrop boundaries of the individual zones cannot be mapped accurately.

An extensive amphibolite zone has been traced from Georgia into Alabama north of the granite outcrop at Rock Mills, Ala. This zone is cut off before it reaches the town of Roanoke in Randolph County. Between Roanoke and the Pleasant Grove community, Chambers County, only thin bands of hornblende gneiss occur. West of Pleasant Grove an amphibolite-mafic-ultramafic complex crops out and is exposed more or less continuously along the regional strike for 15 miles. Near Jacksons Gap, two distinct amphibolite zones, spaced approximately 0.5 mile apart, crop out and extend southward for an additional 5 miles.

For the purpose of description, the district is divided into four parts: (1) the area west of Alabama Highway 49 and west of U.S. Highway 280; (2) the area in the vicinity of Red Ridge and Agricola; (3) the area south of the North Fork of Sandy Creek and east of U.S. Highway 280; and (4) the area east of Alabama Highway 49 and north of the North Fork of Sandy Creek.

(1) West of Alabama Highway 49, amphibolite rock crops out as two large, distinct, and separate rock units. Several small amphibolite outcrops, which have not been delineated, are also present. They are essentially greenstones containing small masses of meta-ultramafic rock and zones of soapstone. The greenstones

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are composed chiefly of green hornblende (possibly edenite), epidote, actinolite, chlorite, and talc. The meta-ultramafic rocks appear as massive aggregates of epidote, diopside, and hornblende.

(2) Near Red Ridge west of Agricola, a zone of soapstone crops out. Rocks of hornblende gabbro composition have also been found in this area.

(3) In the vicinity of the North Fork of Sandy Creek, north and east of Camp Hill, a major zone of ultramafic rock crops out. Its longitudinal limits are concealed by saprolite and dense vegetation. Most of the ultramafic rock is essentially enstatite with disseminated talc and anthophyllite, although one pyroxenite body does have a high percentage of talc and anthophyllite. Contacts are not visible and continuity between outcrops have not been established. Additional mafic and ultramafic bodies may occur within the area.

(4) East of Alabama Highway 49, a prominent zone of mafic and ultramafic rock has been mapped. The two bands of amphibolite which occur west of Alabama Highway 49 (see item 1) appear to converge into a single irregular mass east of the highway. This mass is a complex assemblage of various mafic and ultramafic rock composed predominantly of pyroxenite-bearing amphibolites, pyroxenite bodies, serpentine zones, and hornblende gneiss. Included within this assemblage are scattered occurrences of hornblende, actinolite, chlorite schist, hornblende gabbro, and hornblende diorite. The talc and anthophyllite deposits are associated with the pyroxenite and pyroxenite-bearing amphibolite rock. In the central part of the zone, near Easton, outcrops suggest overfolds.

A striking feature of the eastern ultramafic complex is hornblende gneiss enclosing lenticular masses of ultramafic rock (fig. 3). These ultramafic rocks are essentially pyroxenite composed of massive crystalline aggregates of enstatite and hypersthene with olivine and bronzite as occasional accessory minerals. The amphibolite matrix is a prominently banded hornblende gneiss composed of green hornblende, albite-bytownite feldspar, quartz, chlorite, talc, and magnetite.

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Figure 3.—Pyroxenite inclusions in well banded hornblende gneiss; W. B. Railey property, NE¼ sec. 15, T. 22 N., R. 23 E.

CHARACTER

Pyroxenite outcrops exhibit distinct and easily distinguished characteristics unrelated to the enclosing gneiss and schist. The contact between the mafic and ultramafic zone and the surrounding gneiss and schist is usually sharp. Often the pyroxenite masses form prominent knobs and peaks (fig. 4) and near streams may form moderate cliffs or spurs. The pyroxenite is massive and more resistant to weathering than the foliated gneiss and schist and stands above the surface as rounded, solution-pitted, boulderlike masses.

The pyroxenite outcrops are barren or have a thin soil zone covered by sparse vegetation. The soil contains abundant small boulders, cobbles, and nodules of greenish-gray to yellowish-green weathered pyroxenite. Such soil is known locally as "buckshot

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Figure 4.—A typical outcrop of pyroxenite; W. B. Railey property, NE¼ sec. 15, T. 22 N., R. 23 E.

soil" (fig. 5). The fragments of weathered pyroxenite often have an ocherous crust which grades into yellowish-green centers of coarsely crystalline pyroxenite. Some fragments may have a hard oxide shell enclosing talc, with or without anthophyllite. Several outcrops consist of massive boulders displaying thin anthophyllite veins in raised relief against a matrix of pyroxene (fig. 6).

ORIGIN

The mode of origin, emplacement, and alteration of ultramafic rock and volcanic amphibolite has been of interest to geologists for many years. Considerable controversy has existed regarding the formation and emplacement of ultramafic rock and it was not until the early part of the 1900's that they were generally accepted as being of igneous origin. Most geologists now consider ultramafic

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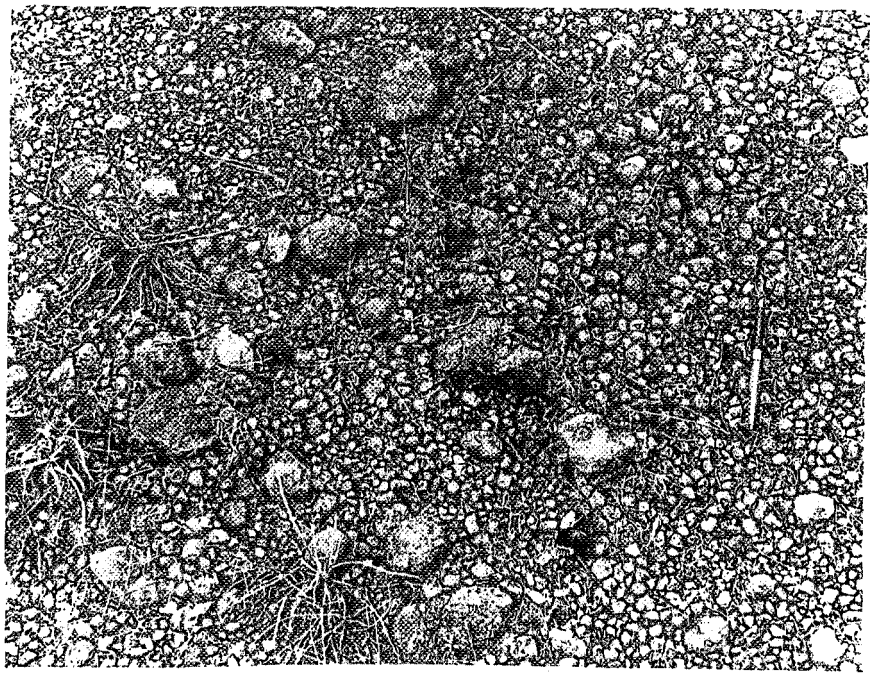


Figure 5.—Typical "buckshot" soil derived from the decomposition of pyroxenite-amphibolite rock.

rock to be the result of direct crystallization from primary magmas of their composition. The mechanics of emplacement, however, remains conjectural. In recent years experimental work supported by field observation has suggested that certain forms of ultramafic rocks can be produced by metamorphic processes acting upon less basic rocks.

Field observations suggest that the mafic and ultramafic rocks of the Inner Piedmont of Alabama may be products of one or more of the following modes of origin: (1) metamorphosed equivalents of lava flows or sills associated with tuffs and volcanic detrital material; (2) ultramafic segregation in a basalt flow; (3) gabbro intrusions with partially crystalline xenoliths of pyroxenite; or (4) an alpine-type peridotite-pyroxenite intrusion associated with earlier deformation. The uniqueness of the Dadeville mafic

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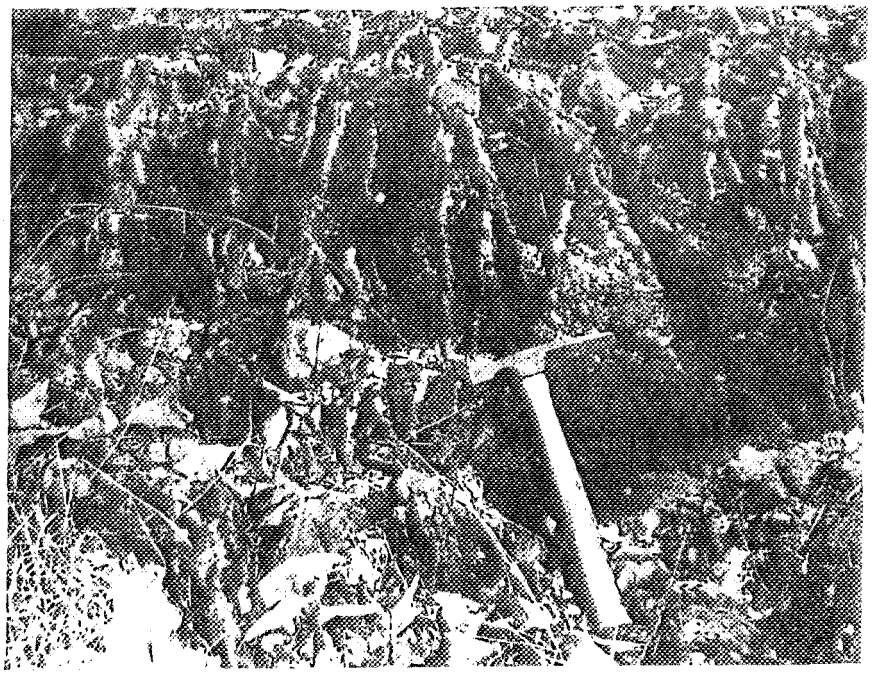


Figure 6.—Anthophyllite veins crisscrossing the face of a pyroxenite boulder.

and ultramafic rocks lies in the areal distribution of the amphibolites and the unusual relationship of the pyroxenites to the amphibolites. It is difficult to account for all the variations in texture and mineralogy of the ultramafic-mafic rock complex with a single hypothesis of origin.

The following section discusses briefly the concepts of origin and mechanism of emplacement for various occurrences of ultramafic rock. The discussion is presented as an aid in understanding the rock relationship within the Dadeville area.

Early proponents of igneous origin of the ultramafic rock proposed that the material making up the ultramafic mass was injected as a liquid into the enclosing rock from magmatic chambers below the outer crust.

In 1915, Bowen (p. 79-80) suggested that an ultramafic magma consisting almost entirely of olivine (a peridotite) could not exist in a liquid state below the melting point of olivine (1800° C). The lack of evidence to support emplacement of peridotite at this high temperature led him to conclude that olivine peridotites were

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formed by accumulation of early crystallizing olivine from a complex magma. He then suggested (Bowen, 1917, p. 237) that if the mass of olivine crystals was subjected to stress forces, the mass could then be intruded into other rocks as a solid or near solid mass with little or no liquid addition.

Later, Hess (1938, p. 326-341) postulated that ultramafic magmas of peridotite composition were the result of partial fusion of a peridotite substratum, injected synkinematically into the overlying rock. These magmas would have approximately the composition of serpentine, and the presence of as little as 5 percent water would sufficiently lower the temperature of the mass, facilitating migration and further assimilation. Hess further contended that the water necessary for melting and migration would be taken up by the cooling mass to form serpentine.

Hess (1938, p. 329) suggested also that basaltic magmas were products of partial fusion of mafic norite, or equivalent, from a zone above the peridotite substratum. He reasoned that the mafic rock would become more Ca-rich upon rising above the peridotite substratum, producing norite, olivine basalts, gabbros, etc. In comparing serpentine and other ultramafic occurrences, Hess (1938, p. 331) observed that ultramafics intruded at shallow depths into water-bearing sediments suffered a much greater degree of serpentinization than did ultramafics intruded at great depths into relatively anhydrous gneiss. Two processes were postulated for this association: (1) magmatic differentiation of the ultramafic magma, and (2) the acquisition of additional water by the ultramafic magma from the wall rock.

Bowen and Tuttle (1949) studied the ternary system MgO-SiO_2-H_2O at temperatures up to 1000° C, and pressures as great as 40,000 pounds per square inch. The results of their investigation supported Bowen's earlier work and indicated that peridotite magmas could exist only at temperatures well above 1000° C, even if the water content was in excess of 10 percent. Thus they concluded (Bowen and Tuttle, 1949, p. 455) that the formation of peridotite from a liquid magma intruded at low temperatures was not feasible. Bowen and Tuttle (1949, p. 355-456) postulated, however, that under certain conditions of crustal deformation,

They (Engel and Engel, 1962) concluded that the Adirondack amphibolites are metamorphic in origin and indicative of reduction, dehydration, and incipient basification of a basaltic system at temperatures between 550° C to 625° C and at pressures near those that occur at a minimum depth of 7 miles.

Petrographic studies have led some workers to postulate amphibolite origin as the result of basification of magnesium-rich sedimentary rock. Sørenson (1953), reporting on the distribution of ultramafic bands in an amphibolite in west Greenland, considered the association to be a product of metamorphic processes acting upon impure calcareous sediments. He argued that the ultramafic rock could not be considered a magmatic secretion in the amphibolite, nor could the amphibolites be considered as being derived from an original ultramafic rock. He (Sørenson, 1953, p. 33) suggested that the ultramafic pyroxenite had been formed as a band of ultramafic schlieren in the amphibolite by metamorphic differentiation combined with metasomatic processes. The ultramafic schlieren were localized along internal zones of potential shear. The kinetic energy required for the creation of the potential shear zone was assumed to have been converted into some other form of energy inasmuch as shearing apparently did not take place. Sørenson (1953, p. 35) concluded that this energy transformation was responsible for the formation of the ultramafic bands, provided that a state of tension was maintained over a sufficient duration to permit equilibration under the imposed physicochemical conditions.

Amphibolites of like bulk composition may thus be derived from rocks of diverse parentage by different metamorphic processes. The true origin of most amphibolites, therefore, remains conjectural, largely because there are few, if any, relict textures, minerals, or field relations clearly indicative of the parent rock.

Areal relationships of structure and distribution of ultramafic and mafic rock types in the Dadeville area follow closely the described occurrences of Benson (1926, p. 68-76). The association of alpine peridotites with geosynclinal sediments is nearly universal. The location of the Brevard fault zone, elongate amphibolite zones on one side of a regional synform structure, and random ultramafic bodies on the other, indicate this mode of origin. The

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emplacement of the ultramafic bodies is considered to have occurred during the early stages of deformation and the ultramafic rocks may become completely altered to magnesium schist if deformation is severe. However, the wide occurrence of rocks of gabbro composition and the pyroxenite boulders which are seen enclosed within the amphibolite matrix at many localities in the Dadeville area could represent ultramafic differentiates of gabbroic intrusives, preserved or accentuated by polymetamorphism.

The rocks of the Inner Piedmont of Alabama are similar to the metamorphic facies of the Abukuma-type series of regional metamorphism. It is assumed that the intercalated volcanics would also be products of high temperature, low pressure metamorphic environment. The experimental work reported by Holmes and Harwood (1932), Bowen (1915-1917), Bowen and Tuttle (1949), and data obtained on the formation boundaries of enstatite-forsterite equilibrium, suggest that the ultramafic rocks of the southeastern Piedmont may reflect material of common origin differentiated under different environmental conditions.

Most of the associated hornblende gneiss and gabbroic rocks weather rapidly, forming clayey soils. These soils are generally reddish black to greenish black, often containing irregular fragments of quartz. Some of the more massive hornblende gneiss and metagabbro bodies are resistant to weathering and form blocky outcrops with large fragments scattered throughout the soil cover (fig. 7). The soil derived from these rocks is generally light greenish gray to greenish yellow.

ALTERATION PROCESSES

The mafic and ultramafic rocks represent a wide variety of distinct but related rock types which have been involved in one or more cycles of regional metamorphism, structural dislocation, and pervasion by emanations mobilized from the country rock. Four processes of alteration are recognized in the Alabama mafic and ultramafic rocks: (1) serpentinization; (2) steatitization; (3) amphibolization; and (4) chloritization.

All these processes occurred more or less concurrently throughout the mafic-ultramafic belt; however, one mode of alteration generally predominated over the other three at a given locality

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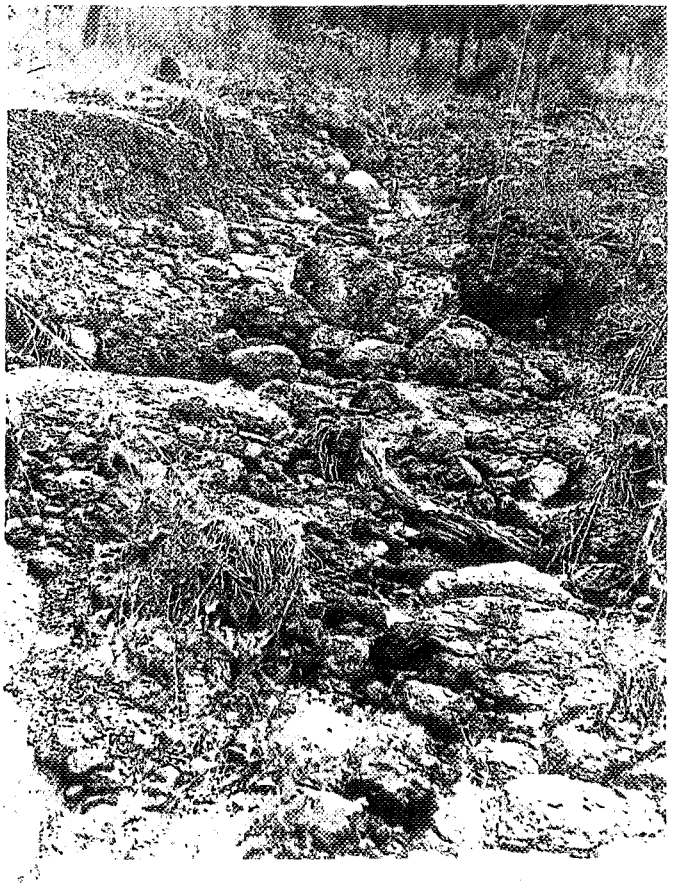


Figure 7.—Pyroxenite boulders released by the weathering of hornblende gneiss (see also figure 3).

(fig. 8). The processes of amphibolization and steatitization were most widespread. Serpentinization and chloritization were more localized.

SERPENTINIZATION

Serpentinization is the process of alteration by which the ferromagnesian minerals, or rocks, are converted to serpentine minerals or serpentinite rock. The process is best illustrated by

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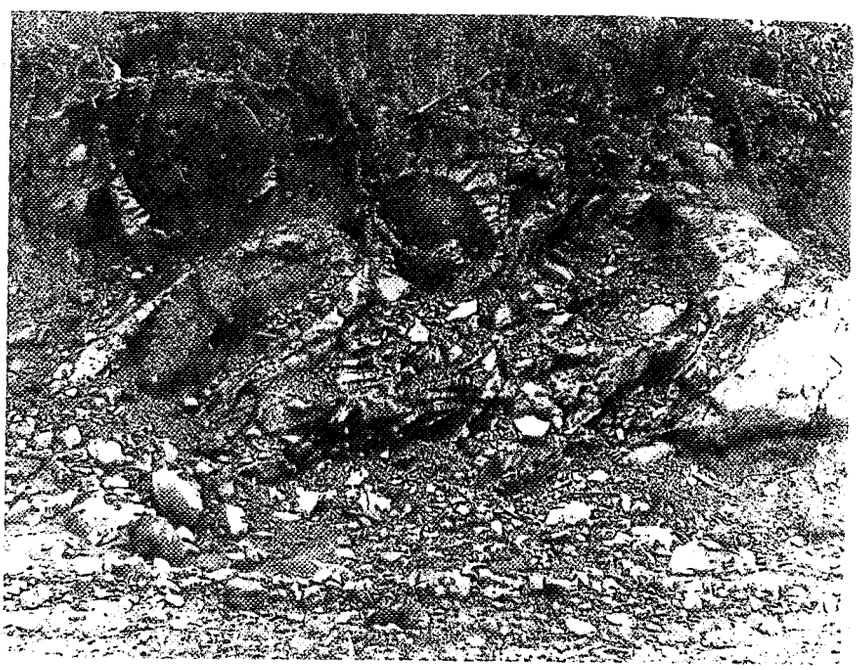


Figure 8.—Road cut exposure showing shell-like rims of talcose-pyroxenite surrounding decomposed pyroxenite. Thin veinlets of anthophyllite may be seen in the lower center of the cut.

the alteration of olivine, a constituent of many mafic and ultramafic rocks.

The alteration of olivine to serpentine involves essentially the process of hydration. If the olivine is iron rich, magnetite may form as a secondary product. A typical reaction is:

(1) $6\ (Mg_3Fe)(SiO_4)_2 + 12\ H_2O + O_2 = 3\ Mg_6Si_4O_{10}(OH)_8 + 2\ Fe_3O_4$
Olivine — Serpentine — Magnetite

Serpentinization begins along the periphery of the olivine grain and progresses toward the center. In many cases the serpentinization is so complete that only a small remnant or skeleton of the original olivine crystal may be observed under the microscope. Many large olivine bodies contain a core of unaltered olivine surrounded by a sheath of serpentine olivine.

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The following mechanisms of serpentinization have been postulated: (1) deuteric alteration of peridotites during crystallization, by hydrous components of the original magma; (2) direct crystallization of the serpentine from hydrous ultramafic magma; (3) alteration of peridotites by hydrothermal solutions derived from the surrounding country rock during later metamorphism; and (4) serpentinization of the ultramafic rock during tectonic transport, with water supplied from the enclosing rocks.

Recent experimental work by Bowen and Tuttle (1949) on the system MgO-SiO_2-H_2O seems to preclude the acceptance of the first two theories. Serpentinization by tectonic transport is particularly advocated by Bowen and Tuttle (1949, p. 454-457).

STEATITIZATION

Steatitization is the alteration of mafic and ultramafic rocks resulting in the formation of talc. Talc is a common-to-major constituent of the Dadeville deposits. It appears to have been derived by the alteration of olivine, pyroxene, and amphibole in the presence of water, carbon dioxide, and silica. Chidester (1962, p. 94) concluded from a detailed study of some selected talc-bearing ultramafic rocks in Vermont that ". . . steatitization took place contemporaneously with and at essentially the same temperature as regional metamorphism." He further suggested that the additive components were derived mainly from adjacent rocks of sedimentary origin during progressive metamorphism. Field observations and microscopic studies made during the investigation for this report favor this mode of alteration.

Steatitization of hornblende rock derived from gabbros produced massive, often schistose rocks, referred to as soapstone. Metasomatism of aluminous hornblende usually produces chlorite; however, under certain conditions of temperature and pressure the aluminum is mobilized and removed from the system and talc is formed.

$$(2)\ 3\ \underset{\text{Hornblende}}{Ca_2(Mg, Fe)_4Al(OH)_2(Al, Si_7O_{22})} + H_2O + 6\ O_2 =$$

$$4\ \underset{\text{Talc}}{Mg_3(Si_4O_{10})(OH)_2} + 6\ CaO + 12\ FeO + 3\ Al_2O_3 + 5\ SiO_2$$

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The alteration of olivine to talc involves the addition of water and the loss of iron and magnesium.

(3) $4\ (Mg, Fe)_2SiO_4 + H_2O = Mg_3(Si_4O_{10})(OH)_2 + 5\ (Mg, Fe)O$
Olivine Talc

The iron and magnesium may be deposited as magnetite or magnesite or removed by solution. Iron is often deposited as limonite.

The alteration of enstatite is very common, and involves the addition of water and silica.

(4) $3\ MgSiO_3 + H_2O + SiO_2 = Mg_3(Si_4O_{10})(OH)_2$
Enstatite Talc

Talc may develop on olivine or enstatite along cleavage cracks or within the mineral grain. The talc growth may develop until the original host mineral is totally replaced. Anthophyllite may also alter to talc, which usually develops parallel to the cleavage of the anthophyllite crystal.

At many localities, steatitization has progressed to the stage where the amphibolite, mafic, or ultramafic body is more or less a talcose rock, or soapstone. Faint lineations of schistosity are often observed in the replaced rock. Generally, the texture is of randomly oriented and interlocking talc laminae. In some talc occurrences, thin flakes and layers of pure, apple-green talc have been developed along what may be cleavage planes or shear planes. Several anthophyllite occurrences show talc, anthophyllite, and enstatite in apparent equilibrium.

AMPHIBOLIZATION

Amphibolization is the alteration of pyroxenes (enstatite, hypersthene, olivine, etc.) to amphibole minerals (anthophyllite, hornblende, actinolite, tremolite, etc.). Alteration of pyroxene to an amphibole takes place with a decrease in specific gravity and an increase in volume. The reverse is true in the alteration of olivine.

The formation of hornblende from augite and basic plagioclase in gabbro or diorite is a common metamorphic alteration process. By the introduction of magnesium and iron, the basic plagioclase may reform to various ferromagnesian silicates, but more commonly

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to hornblende of the actinolite series. Other silicates often associated with this reconstitution are zoisite, epidote, and chlorite.

The alteration of olivine to amphibole in Appalachian amphiboles is commonly observed and reported. The needles of amphibole penetrate the olivine crystals without regard to boundaries, cleavages, or cracks. The needles are usually straight, oriented in all directions, and may penetrate several individual olivine crystals. Continued formation of amphibole needles leads to the conversion of a pyroxenite or peridotite to an amphibolite composed of a mass of crossed and interlocking amphibole minerals.

The amphibole thus formed, especially in the Dadeville area, is the orthorhombic variety, anthophyllite. The monoclinic variety, cummingtonite, which is difficult to distinguish from tremolite and actinolite, has not been identified in Alabama. The alteration of olivine to anthophyllite involves the elimination of a part of the magnesium and iron or an addition of silica.

(5) $7\ (Mg, Fe)_2SiO_4 + 9\ SiO_2 + 2\ H_2O = 2\ (Mg, Fe)_7(Si_8O_{22})(OH)_2$
Olivine — Anthophyllite

(6) $8\ (Mg, Fe)_2SiO_4 + H_2O = (Mg, Fe)_7(Si_8O_{22})(OH)_2 + 9\ FeMgO$
Olivine — Anthophyllite

The alteration of olivine to tremolite or actinolite is not as simple; it involves the addition of both silica and lime.

(7) $5\ (Mg, Fe)_2SiO_4 + 11\ SiO_2 + 4\ CaO + 2\ H_2O =$
Olivine

$2\ Ca_2(Mg, Fe)_5(Si_8O_{22})(OH)_2$
Tremolite

The alteration of enstatite to anthophyllite involves the addition of silica and water and often the secondary anthophyllite may take the form of the original enstatite grain. This type of alteration evidently results in the formation of the mass-fiber asbestos boulders often observed scattered in the surface of the amphibolite rock. The amphibole needles may penetrate the enstatite in all

(8) $7\ MgSiO_3 + SiO_2 + H_2O = Mg_7Si_8O_{22}(OH)_2$
Enstatite — Anthophyllite

directions or they may develop parallel to the long dimension of the enstatite crystal.

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CHLORITIZATION

Chloritization of basic igneous rock involves hydration, carbonation, and oxidation; processes characteristic of dynamic metamorphism. The formation of chlorite from augite or hornblende requires only the addition of water and a reconstitution of the components. Chlorite formed from olivine or enstatite requires the addition of aluminum and water, and the loss of magnesium and iron. The formation of chlorite from enstatite involves the loss of silica.

Chloritization of rocks of hornblende composition, such as gabbros, requires the addition of water and the separation of lime, iron, and silica. The following reaction represents a possible alteration:

$$(9)\ 5\ Ca_2(Mg,\ Fe)_4Al(OH)_2(Al,\ Si_7O_{22}) + 7\ O_2 + 11\ H_2O =$$
Hornblende

$$4\ Mg_5Al(OH)_8AlSi_3O_{10} + 23\ SiO_2 + 10\ CaO + 20\ FeO + Al_2O_3$$
Chlorite (typical)

The reaction favors the formation of chlorite rather than talc because of the presence of the more immobile aluminum ion and the absence of sufficient magnesium. If the composition of the original rock was typical of gabbro, the basic plagioclase may also alter to chlorite. The resulting rock derived from a gabbro may assume the texture of the original material or if stress was a catalytic parameter, the resulting chloritic rock may assume a schistose structure.

The alteration of olivine to chlorite requires the addition of alumina and water. A typical chemical reaction is represented by equation 10:

$$(10)\ 3\ (Mg,\ Fe)_2SiO_4 + Al_2O_3 + 4\ H_2O =$$
Olivine Alumina

$$(Mg,\ Fe)_5Al(OH)_8AlSi_3O_{10} + (Mg,\ Fe)O$$
Chlorite

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The alteration of enstatite to chlorite is similar:

$$(11)\ 5\ (Mg,\ Fe)SiO_3 + Al_2O_3 + 4\ H_2O =$$
Enstatite Alumina
$$(Mg,\ Fe)_5Al(OH)_8AlSi_3O_{10} + 2\ SiO_2$$
Chlorite

The chlorite generally develops as flakes or laminae enclosing the olivine or enstatite grain, and as narrow veinlets penetrating the grains in all directions. The alteration of olivine often produces magnitite which is disseminated in the chlorite mass.

PHYSICOCHEMICAL CONDITIONS OF ALTERATION

The physicochemical conditions involved in the formation and alteration of the talc and anthophyllite are discussed in the following pages. This discussion should aid in understanding the occurrence of talc and anthophyllite in the ultramafic rocks.

The physicochemical relationships of enstatite, talc, anthophyllite, and various other members of the ternary system MgO-SiO_2-H_2O (fig. 9), have been studied by Bowen and Tuttle (1949),

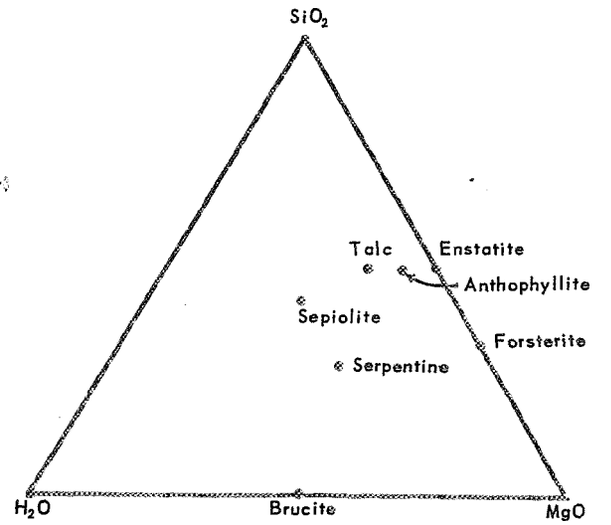


Figure 9.—Compositional diagram showing several phases in the system MgO-SiO_2-H_2O.

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Yoder (1952), Roy and Roy (1955), Fyfe (1962), Greenwood (1963), and Kitahara and others (1966). The binary system MgO-SiO_2 was studied by Bowen and Anderson (1914).

Based on the results of a series of experiments performed at temperatures up to 1,000° C and pressures up to 40,000 psi (pounds per square inch), Bowen and Tuttle (1949, p. 447) constructed a series of pressure-temperature curves for univariant equilibrium between four phases of the system MgO-SiO_2-H_2O. These curves define the boundaries of divariant regions where three of the various phases are in equilibrium.

A significant part of Bowen and Tuttle's studies (1949) dealt with the interrelations of the phases talc, anthophyllite, and enstatite. Stable phase relationships of anthophyllite with other members of the MgO-SiO_2-H_2O system could not be determined in the presence of excess water; however, Bowen and Tuttle reported that small amounts of anthophyllite were obtained together with the other equilibrated phases under a wide variety of conditions. A hydration-dehydration sequence illustrating the basic relationship of talc-anthophyllite-enstatite is given below:

$$(12)\ 7\ MgSiO_3 + SiO_2 + H_2O = Mg_7Si_8O_{22}(OH)_2$$
Enstatite — Anthophyllite

and

$$(13)\ 3\ Mg_7Si_8O_{22}(OH)_2 + 4\ SiO_2 + 4\ H_2O = 7\ Mg_3Si_4O_7(OH)_2$$
Anthophyllite — Talc

Bowen and Tuttle (1949) were able to produce anthophyllite in the presence of water vapor only as a metastable phase by heating talc at 800° C at 15,000 psi for an hour; continued heating produced enstatite and silica. They concluded that anthophyllite formed only a transient phase in the presence of water vapor in the alteration of enstatite to talc.

Talc was found to form readily below 800° C at water pressures between 6,000 and 30,000 psi. At temperatures above 800° C talc appeared as a metastable product with forsterite (magnesium olivine) and enstatite. Below 800° C in water deficient systems where talc is a stable product, anthophyllite occurred but was found to be always partially altered to talc.

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Bowen and Tuttle (1949, p. 450) concluded that anthophyllite will develop as an intermediate phase in the formation of talc from anhydrous material. They surmised that a stable field of existence for anthophyllite could be found under the physicochemical parameters bounded by the field to the left of curve I (fig. 10). Above curve II, enstatite, talc, and water vapor are in equilibrium with each other. Anthophyllite cannot exist as a stable phase in this region since it is a simple binary compound between enstatite and talc. Anthophyllite might exist, however, as a stable phase immediately above curve I for its region of divariant stability would then be bounded by the univariant curve II. Curve II would represent the binary equilibrium

enstatite + talc = anthophyllite

Bowen and Tuttle (1949) speculated that anthophyllite would form under conditions where total composition of the rock mass and the parameters of the induced components was such that there would be sufficient water to convert the mineral assemblage to talc and (or) serpentine. A stable equilibrium between anthophyllite and serpentine is not possible because of the more hydrous character of the serpentine.

Yoder (1952) and Roy and Roy (1955) also concluded that anthophyllite was a stable phase of the system MgO-SiO_2-H_2O only in water deficient regions. Yoder (1952, p. 599) concluded, on the basis of experimental data, that the upper limit of talc stability

enstatite + quartz + vapor = talc

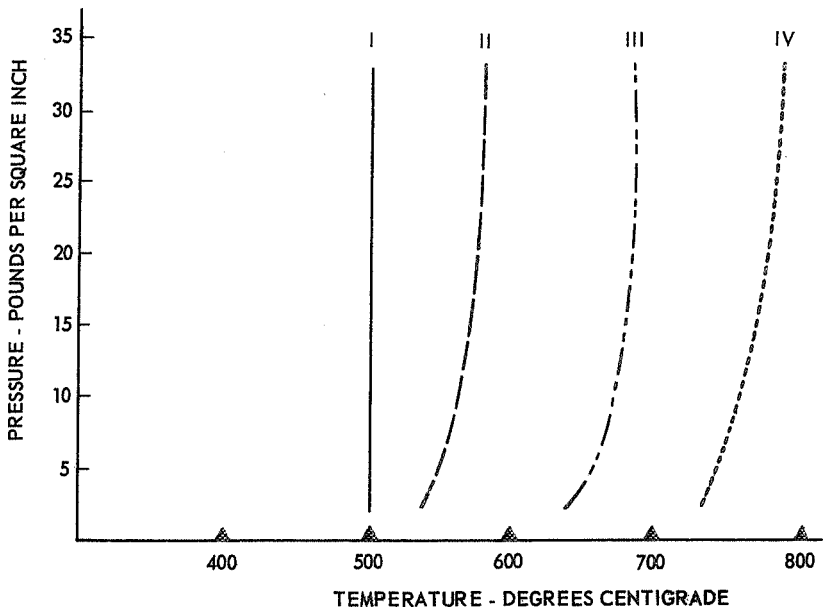
lies near an invariant point at 795° C. He also determined that the equilibrium reaction

talc + forsterite = enstatite + vapor

takes place at approximately 660° C at 15,000 psi. Above 660° C enstatite is stable in the presence of excess water. Yoder (1952, p. 612) surmised that anthophyllite would remain stable at temperatures below 660° C in water deficient systems.

Fyfe (1962), in a study of the relative stability of talc, anthophyllite, and enstatite, experimentally showed that anthophyllite was not a transient phase but that the reactions involving the formation and dehydration of anthophyllite were "sluggish." He experimented over a limited range of conditions between 670° C at

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CURVE I - Maximum limit of existence of serpentine in systems containing excess H_2O (Bowen and Tuttle, 1949)

CURVE II - Maximum limit of anthophyllite stability in systems having a deficiency in H_2O. (Inferred from Bowen and Tuttle, 1949)

CURVE III - Maximum limit of existence of talc in systems containing excess H_2O. Also, lower limit of region of stability of anthophyllite under conditions of excess H_2O (Greenwood, 1963)

CURVE IV - Maximum limit of stability of anthophyllite in systems containing excess H_2O (Greenwood, 1963)

Figure 10.—Pressure-temperature curves of univariant equilibrium for several phases in the system MgO-SiO_2-H_2O.

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2,000 bars [1] pressure and found it possible to convert talc to anthophyllite + quartz in the presence of water and enstatite + quartz to anthophyllite in the presence of water. Complete conversion of talc to anthophyllite and enstatite to anthophyllite was achieved at temperatures near 760° C in the presence of excess water. Enstatite and quartz heated to 775° ± 5° C at 2,000 bars pressure yielded only a small amount of anthophyllite. Enstatite and quartz heated to 755° ± 5° C at 2,000 bars pressure formed only anthophyllite.

Greenwood (1963) experimentally determined the stability limit of anthophyllite at low water pressures and concluded that the curve for the reaction

talc + enstatite = anthophyllite

should pass through 727° C at 22.5 kilobars [2] water pressure with a slope of 12.5 bars per degree. He further showed that the reactions

forsterite + talc = 5 enstatite + H_2O; and

enstatite + quartz + H_2O = talc

were transient reactions up to nearly 30 kilobars pressure and 900° C. The stable reactions were

4 forsterite + 9 talc = 5 anthophyllite + 4 H_2O; and

7 enstatite + quartz + H_2O = anthophyllite

at approximately 690° C at 10 kilobars pressure.

Kitahara and others (1966) studied the phase relations of the system MgO-SiO_2-H_2O at high temperatures and pressures and agreed generally with the results of Greenwood (1963). They found that the reaction

forsterite + talc = anthophyllite

was a transient phase to temperatures of approximately 730° C before enstatite appeared. They further supported conclusions of Bowen and Tuttle (1949) that primary serpentine magmas cannot exist at low temperatures and high water pressures. The results

[1] 1 bar equals approximately 14.5 lbs/in^2; 2,000 bars equal approximately 29,000 lbs/in^2.

[2] 1 kilobar equals 1,000 bars.

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of their work showed that the water pressure could be increased to at least 30 kilobars without the formation of serpentine liquid.

The preceding experimental data indicated that the relationship between talc-anthophyllite and talc-anthophyllite-enstatite (pyroxene) is dependent upon the nature of the hydrothermal components. It has been shown that in order to maintain equilibrium between talc and anthophyllite, the hydrothermal emanations must be low temperature and water deficient, or high temperature with excess water. In addition, the hydrothermal alterations must begin at sufficiently high temperatures to produce talc-anthophyllite-enstatite instead of talc-enstatite.

Based on the above discussion the significant parameter of metamorphic alteration is considered to have been water deficient environment. Field evidence indicates that the ultramafic bodies in the Dadeville area have a mineral zonation typical of that shown in figure 11.

A thin discontinuous zone of serpentine (zone I) forms the periphery of the ultramafic body. Stable mineral phases existing in zone I are shown in figure 11. Zone I may grade gradually or sharply into zone II, which is composed primarily of talc, talcose-anthophyllite, talcose-enstatite, and enstatite. Veins of anthophyllite are common in zone II and vary in width from microveinlets to as much as 18 inches. Stable phases which are common to zone II are shown in figure 11. Zone II grades gradually into zone III, the central core. In some of the ultramafic bodies the central core appears to be missing or is represented by an abundance of enstatite crystals having incipient talc and anthophyllite alteration. Anthophyllite veins are common in zone III, but they are usually less than 2 inches in width. The stable mineral phases indicative of zone III are shown in figure 11. The ultramafic mass is commonly surrounded or enclosed by a hornblende gneiss, gabbro, or diorite, although biotite gneiss has been recovered from core samples.

The existence of a low water vapor parameter is supported by the configuration of the mineral zones, their mineral composition, and a scarcity of serpentine. The gradual transition from a hydrous border zone assemblage to a relatively anhydrous internal mineral assemblage indicates one of two basic variations in the metamorphic history of these deposits. Replacement of the enstatite by

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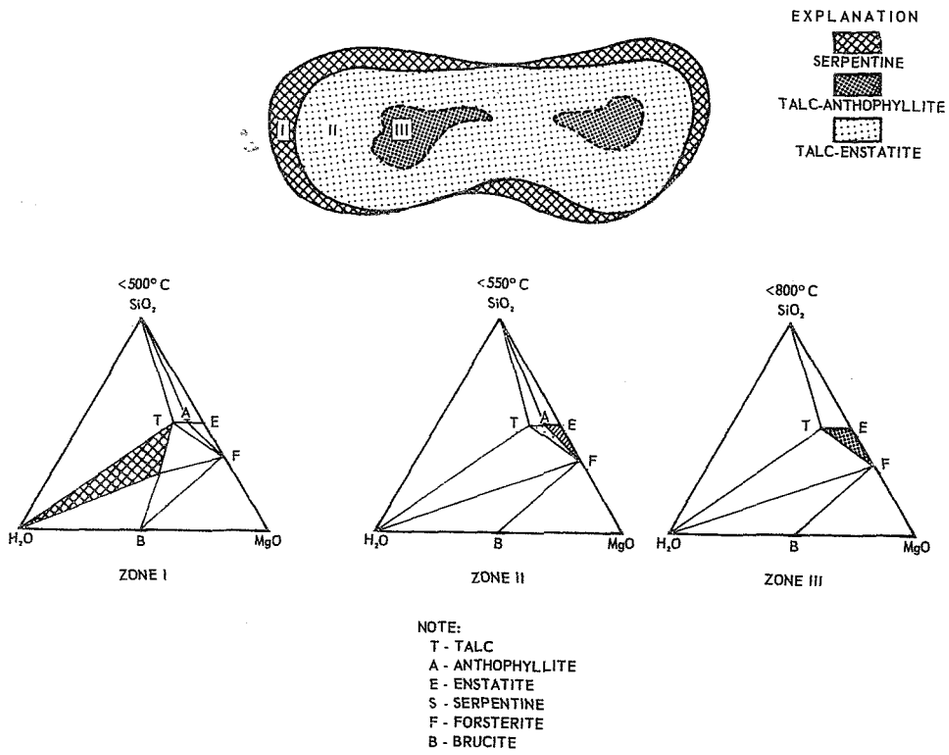


Figure 11.—Principal zones of a typical talc-anthophyllite-bearing ultramafic body, and diagrams of stable mineral phases in the principal zones. (Modified from Bowen and Tuttle, 1949, p. 447.)

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anthophyllite indicates either high temperature metamorphism under conditions of sufficient water vapor or low temperature metamorphism under conditions of insufficient water. Replacement of anthophyllite by talc indicates either a decrease in temperature while the equilibrium pressure of the H_2O remained equal to the total pressure, or that of the activity of H_2O increased while the temperature remained constant. A combination of both conditions would produce the same resultant effect.

The amount of anthophyllite present in a given mineral assemblage must vary inversely with the amount of serpentine because of the equilibrium conditions (fig. 10). A water deficient system would restrict the formation of the more hydrous phases such as serpentine and tend to redistribute the available water to form more partial hydrated minerals such as talc or anthophyllite. The lack of serpentine in the Dadeville area suggests that the excess water was not available to hydrate the ultramafic masses. The incipient alteration observed in the interior part of the ultramafic bodies reflects the decrease in the amount of water vapor permeating to the central part of the mass.

The influence of internal stress forces has not been considered. It is assumed that under the influence of high internal stress, the parameters of alteration would be affected, resulting in a lowering of the kinetic energy necessary to activate alteration processes.

In summation, it is postulated that the last metamorphic parameters affecting the ultramafic bodies were most probably low temperature (500° to 550° C), low pressure (less than 2,000 bars), with a deficiency in the available water. The divariant field lying between curve I and II in figure 10 would reflect the most probable general compositional variation in the ultramafic assemblage in the Dadeville area.

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ASBESTOS

MINERALOGY

Asbestos is a commercial term applied to a family of fibrous minerals that are resistant to heat and acid. The fibrous nature of some of the asbestos minerals allows them to be woven into fabric. Chrysotile asbestos, a variety of serpentine, is the most important commercial variety of asbestos and constitutes about 95 percent of the total world's asbestos production. Two divisions of the asbestos family are recognized: chrysotile asbestos and amphibole asbestos. Chrysotile asbestos has been reported at several localities in the Dadeville area, but the presence of this mineral could not be confirmed. Amphibole asbestos includes the fibrous varieties of anthophyllite, actinolite, tremolite, crocidolite, and amosite. These minerals vary in chemical and physical properties. Anthophyllite is the principal mineral in the Dadeville area. Small amounts of nonfibrous tremolite and actinolite occur with the anthophyllite and mafic and ultramafic rocks.

CHRYSOTILE ASBESTOS

Chrysotile asbestos is a fibrous form of the mineral serpentine, a hydrous magnesium silicate, $Mg_3(Si_2O_5)(OH)_4$. It has fine, silky, flexible fibers that range in color from light green to shades of brown. Often trace quantities of iron, nickel, manganese, or aluminum may substitute for the magnesium and modify the physical properties. Chrysotile generally occurs as cross-fiber veins ranging in width from a fraction of an inch to over 6 inches. Most of the commercially valuable deposits occur as crosscutting discontinuous veins in massive serpentine bodies, which have been derived by the alteration of peridotites. Chrysotile may also occur in thin alteration zones in dolomite or dolomitic limestone which has been intruded by basic igneous rock.

Approximately half of the world's annual production of chrysotile comes from a relatively small district in the province of Quebec, Canada. This district contains numerous rich chrysotile deposits associated with a northeastward-trending belt of serpentine peridotite bodies. A small amount of high-grade chrysotile has been produced in Arizona from dolomitic limestone which has

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been altered by diabase igneous intrusion (Stewart, 1955, p. 5-12).

AMPHIBOLE ASBESTOS

The amphibole asbestiform minerals are a series of complex silicates characterized by perfect prismatic cleavage. Tremolite, actinolite, crocidolite, amosite, and anthophyllite are the only amphibole minerals which occur in asbestiform masses.

All the asbestiform amphiboles contain iron, and, with the exception of crocidolite, magnesium. Anthophyllite is distinguished from tremolite and actinolite by the absence of calcium. Crocidolite is distinguished from the other amphibole minerals by the presence of sodium, and amosite is distinguished by its high iron content (up to 40 percent). Actinolite and tremolite form a continuous Fe-Mg molecular substitution series, with tremolite containing little or no iron.

The replacement of one element by another is a common characteristic in amphibole asbestos minerals. This substitution of elements and the resulting change in the physical properties of the amphibole asbestos produces erratic and unpredictable physical characteristics in some deposits.

TREMOLITE-ACTINOLITE

Tremolite and actinolite are commonly associated with the ultramafic rocks in the Dadeville area. These amphibole minerals often occur in asbestiform. They form a continuous Fe-Mg molecular substitution series; tremolite, $Ca_2Mg_5(Si_8O_{22})(OH)_2$, being the low iron (less than 2 percent) or iron free member, and actinolite, $Ca_2(Mg, Fe)_5(Si_8O_{22})(OH)_2$, being the iron-bearing member. Large crystals of each have been found along the periphery of the ultramafic-mafic rock complex in the Dadeville area.

These minerals may appear white or grayish green to green, and occur in slender prismatic crystals often arranged in a radial pattern. Tremolite fibers are generally coarser and weaker than chrysotile, but fibers of exceptional strength and flexibility occur. Tremolite asbestos most commonly occurs as slip-fiber veins in shear zones. It has been found in metamorphosed dolomite and dolomitic limestone, but more often in metaultramafic rocks.

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Actinolite asbestos is commonly green to grayish green. It is of poor quality and has limited use in industry because the fibers are weak and brittle. Actinolite asbestos is commonly found in slip-fiber veins in metaultramafic rocks of the southeastern Piedmont as alteration products of pyroxene minerals. It has been tentatively identified from several samples collected in the Dadeville area; however, it does not occur in significant amounts to be considered a potential asbestos mineral.

ANTHOPHYLLITE

Anthophyllite asbestos, $(Mg, Fe)_7Si_8O_{22}(OH)_2$, is the fibrous form of the orthorhombic amphibole, anthophyllite. It is greenish gray to gray in fresh unweathered specimens, but weathers to a characteristic clove brown. The fibers are generally short, slightly flexible, and have a low tensile strength, unsuited for spinning purposes.

Members of the anthophyllite series have been shown to be three component minerals of limited substitution involving chiefly magnesium, iron, and aluminum; calcium, sodium, and potassium may also occur in small amounts (Rabbitt, 1948). Chemical analyses of three samples of anthophyllite taken from various prospects in the Dadeville area are given in table 1.

The identification of anthophyllite, especially the asbestiform varieties, is dependent on X ray. An electron micrograph (fig. 12) shows the fibrous characteristics of anthophyllite from the Dadeville area. The sample was treated with a dilute solution of sulfuric acid prior to electron analysis to remove any surface contamination.

Anthophyllite asbestos occurs in magnesium-rich medium-grade metamorphic rock. Commercial deposits of anthophyllite asbestos occur as mass-fiber aggregates associated with altered mafic and ultramafic rock and in lesser quantities of cross-fiber and slip-fiber veins.

CROSS-FIBER VEINS

Cross-fiber anthophyllite occurs in veins, with the fibers arranged parallel to each other and perpendicular to the walls of the vein. The veins may vary from a fraction of an inch up to 12

Table 1.—*Chemical analyses of anthophyllite samples, Dadeville, Alabama*
(in percent)

	Assay 1	Assay 2	Assay 3
Magnesian oxide, MgO	31.12	34.09	26.16
Iron oxide, FeO	10.58	11.31	10.75
Silica, SiO_2	54.22	48.73	57.84
Calcium oxide, CaO	.26	N.D.	.72
Sodium and potassium oxide, $Na_2O + K_2O$	.87	.93	.43
Alumina, Al_2O_3	.19	.34	1.21
Loss on ignition, L.O.I.	1.89	N.D.	2.89

N.D. - Not determined.
Assays 1 and 2 by L. B. Adams Co., Birmingham, Ala.
Assay 3 by Black Warrior Petroleum Co., Mobile, Ala.

to 14 inches in width, but average 1 to 4 inches. They cut through the enclosing rock in all directions, often intersecting one another at various angles. Vein length is erratic, extending from several inches to several tens of feet with many cross-fiber veins fading into mass-fiber anthophyllite bodies (fig. 13). Many cross-fiber veins are composed of practically pure anthophyllite with lesser quantities of talc, quartz, and enstatite. In the more altered ultramafic rocks, talc is commonly associated with the anthophyllite and often has almost completely replaced the anthophyllite.

Contacts between the vein material and the enclosing rock are usually quite sharp. Veins stand out in both saprolite material and in partially decomposed pyroxenite. Often the wall rock material is removed by weathering leaving the anthophyllite veins in positive relief (fig. 6).

The cross-fiber material probably represents products of early hydrothermal solutions reacting on the wall surfaces of tension fractures produced by dislocation forces accompanying metamorphism. Many of the cross-fiber veins fade into mass-fiber asbestos, suggesting that the processes of hydrothermal alteration continued after cessation of early dislocation.

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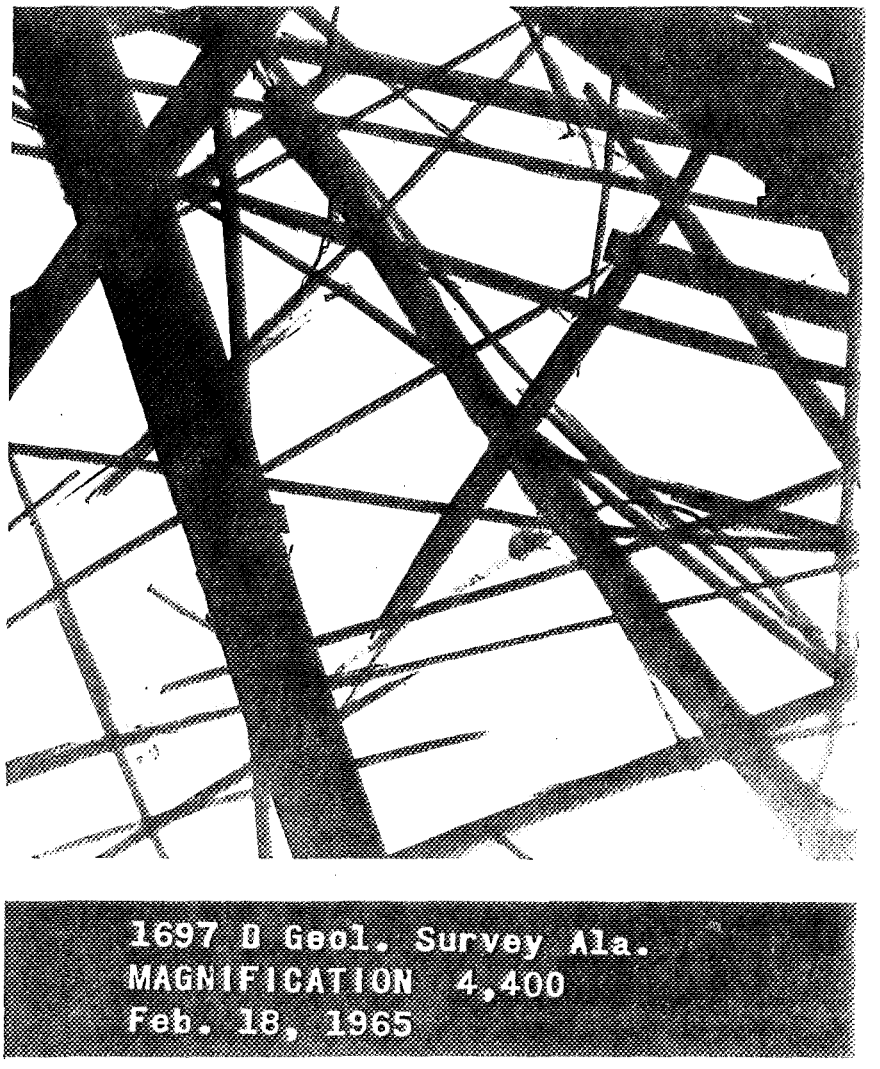


Figure 12.—Electron micrograph of randomly oriented anthophyllite fibers, magnification 4,400.
(Photograph by U.S. Bureau of Mines, 1965.)

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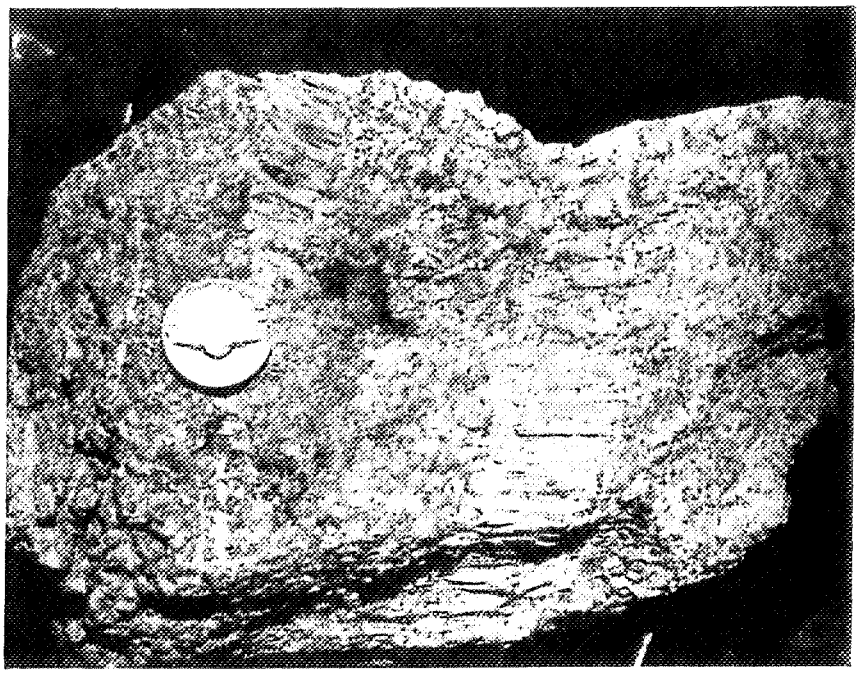


Figure 13.—Specimen of mass-fiber anthophyllite containing small veins of cross-fiber anthophyllite.

SLIP-FIBER VEINS

When the asbestos fibers are arranged parallel to the enclosing wall rock, it is designated slip-fiber asbestos. There are all gradations in orientation of fiber arrangement between cross-fiber and slip-fiber veins. Generally, it is interpreted that slip-fiber asbestos is derived from cross-fiber by movement of the wall rock with respect to the vein material. Except for the orientation of the fibers, slip-fiber anthophyllite is similar to cross-fiber in character and chemical composition. Slip-fiber veins are not as common as cross-fiber veins. In the Dadeville area most of the slip-fiber anthophyllite is short, rarely exceeding 2 inches in length, and generally averaging less than an inch.

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MASS-FIBER DEPOSITS

Mass-fiber asbestos differs from cross- and slip-fiber asbestos in that it forms the body of the rock mass. Much of the mass-fiber anthophyllite is very coarsely crystalline, composed of interlocking bundles of fibers. Other mass-fiber anthophyllite is less coarsely crystalline and often the fibers are arranged in a distinct radial form around a central core of anthophyllite-enstatite. Two types of mass-fiber anthophyllite asbestos have been recognized in the Dadeville area: (1) peripheral zone anthophyllite; and (2), massive individual bodies composed almost entirely of anthophyllite.

A peripheral zone of schistose rock is characteristic of many of the ultramafic rocks; the well developed zone of mass-fiber anthophyllite is much less common. Where present, the zone of mass-fiber anthophyllite lies adjacent to the ultramafic rock mass and is separated from the country rock by a thin layer of schistose talc and vermiculite. The peripheral zone of asbestos is generally uniform in width, although the zone may vary rapidly in width along the strike or with depth.

The peripheral zone mass-fiber asbestos ranges in color from grayish white to various shades of mottled buff and light brown. Anthophyllite, which lies on or near the surface, is usually stained by iron oxide and is often quite soft. The unweathered asbestos is more compact, but the fibers can be easily separated. The peripheral zone of mass-fiber asbestos is usually composed of 75 to 85 percent anthophyllite and 15 to 25 percent talc. Trace amounts of chlorite, magnesium oxide, and magnetite are often present.

Altered ultramafic rock may occur as irregular masses composed predominantly of varying percentages of anthophyllite, talc, and enstatite. The enstatite usually occurs as large, bladed, interlocking crystals oriented in all directions in respect to each other. In some outcrops 50 percent or more of the rock is composed of partially altered enstatite. Generally, the enstatite has undergone extensive alteration, and consists chiefly of anthophyllite with lesser amounts of talc and traces of chlorite. It is the completely altered enstatite pyroxenite rock that contains the greatest

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percentage of anthophyllite. The degree of alteration of the enstatite varies considerably within each rock and from one rock to another. Significant interpretation cannot be placed upon the variation in alteration or completeness of alteration in one rock and the adjacent rock.

The most common form of anthophyllite in the massive asbestos is that in which the anthophyllite fiber has developed parallel to the long direction of the enstatite crystal and is pseudomorphic after the original crystalline structure of the rock. Thus, the anthophyllite fiber occurs as wide flat interlocking bundles having diverse orientation. Fresh unweathered anthophyllite is bluish gray to greenish gray, massive, and hard. In unweathered exposures, the fibrous character of mass-fiber anthophyllite is not readily apparent; however, if crushed the fibrous character is observed.

A less common form not readily observed in Alabama is the variety of mass-fiber anthophyllite in which the fibers occur as a mass of interlocking cones. Conrad and others (1963, p. 19) described a typical occurrence "... the fibers radiate from a common center and vary from a ¼ inch up to about 1 inch in length. In some cases, the apex of an individual cone is as much as ¼ inch higher than the perimeter, and in others the cones are almost flat. Individual well shaped cones are not common because of mutual interference during development, but the tendency toward radial and cone structure is quite evident . . ."

Massive anthophyllite varies from light bluish or greenish gray to mottled buff to grayish yellow. It is massive, compact, and tough. The individual fibers are generally short; the individual bundles splintering on impact. Talc is the most common accessory mineral, often occurring as apple-green flakes between the anthophyllite bundles and as interstitial filling material around and between the radial cones. A pseudobanding of talc and anthophyllite was observed in several rock specimens found in the vicinity of Oziah Church. (See section "Description of Properties," Clem Vines property, north area.)

OCCURRENCE OF ANTHOPHYLLITE

The alteration of pyroxene to anthophyllite is a common process in rocks composed of olivine and (or) enstatite. Thin sections prepared from the Dadeville pyroxenite-anthophyllite rock show slender needles of anthophyllite scattered throughout the groundmass of pyroxene. The anthophyllite needles are usually straight, show no preferred orientation, and often may penetrate several pyroxene grains. Anthophyllite forming from enstatite often takes the crystal form of the enstatite crystal with needles lying parallel to the major axes of the enstatite crystal. As alteration increases and the ratio of anthophyllite to pyroxene becomes greater, large areas of the rock may be composed of crossed and interlocking anthophyllite crystals enclosing small remnant pyroxene grains.

Cross- and slip-fiber anthophyllite veins are products of secondary mineralization. Rarely do they show any evidence of having been derived from the wall rock as is so often shown by the mass-fiber varieties. Many theories have been proposed and discarded in an effort to explain the origin, character, and relation of vein asbestos.

The theory most generally accepted today and the one which appears to be most applicable to the Dadeville area is aptly illustrated by Cooke (1936, p. 362) and summarized by Paige (1937, p. 109): "In my opinion, all important phenomena of asbestos veins, . . . are explainable on the hypothesis that gradual opening of fissures in response to tensional strain was accompanied by contemporaneous deposition of asbestos."

In explaining his hypothesis Paige cited the following:

(a) The gradual opening of the vein was an adjustment to tensional strain carried out beyond the elastic limit of the peridotite mass.

(b) If the expansion was induced by hydration of the rock mass (serpentinization), the increase would have been taken up in the increased volume of the affected block.

(c) The relatively constant ratio of width to wall rock alteration to width of vein would be a natural accompanying process.

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(d) The narrow width veins meet the requirement for a gradual widespread structural adjustment throughout the area.

(e) The attitude of the crystal fiber to the walls would reflect differential movement of the walls during formation.

(f) Where no asbestos veins exist, the absence could reflect the absence of suitable host openings during permeations.

The fact that anthophyllite is present in various forms in rocks which range from peridotite to soapstone in composition and occur in a similar manner throughout the entire length of the Appalachian peridotite belt, indicates a probable metamorphic derivation.

The development of fibrous asbestiform anthophyllite has been considered to be partly related to physical phenomena directly related to weathering. The softest and most fibrous anthophyllite in the Dadeville area occurs generally near the weathered surface of the deposit, and, with increasing depth, the anthophyllite fiber is harder, more brittle, and less easily worked.

Chalcedony quartz occurs with surface and near surface fibrous anthophyllite as boxwork, irregular nodules, and massive fragments (fig. 14). Such secondary quartz may be a product of

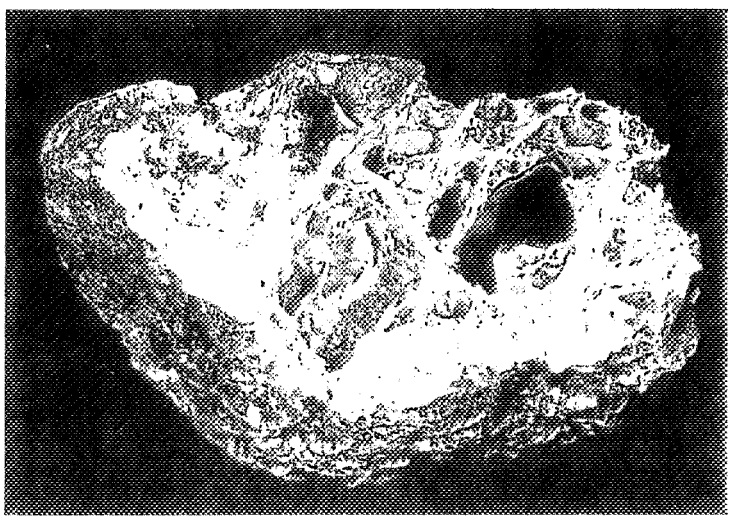


Figure 14.—Fragment of chalcedony boxwork.

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leaching from the anthophyllite. It is common practice to allow anthophyllite ore, especially mass-fiber varieties, to remain in a stockpile exposed to the weather for a year or more prior to milling.

TALC

MINERALOGY

Talc is an inclusive term used to describe: (1) the pure mineral in the form of aggregates of flakes or fibers; (2) steatite, the compact cryptocrystalline variety; and (3) soapstone, a soft impure talcose rock (Wells, 1965).

The mineral talc, $Mg_3Si_4O_{10}(OH)_2$, is a hydrous magnesium silicate. The theoretical formula corresponds to 63.5 percent SiO_2, 31.7 percent MgO, and 4.8 percent H_2O. Experimental work has shown that these components may vary within wide limits—the magnesium to silica ratio ranges from 1.1 to 4.3 and the water content ranges from 3 to 7 percent (Spence, 1940). Most talc (Chidester, 1962, p. 48) contains small amounts of Fe^{+2} (generally about 0.x percent) and lesser amounts of Al (generally about 0.0x percent). The Fe^{+2} substitutes directly for the Mg^{+2}, whereas the Al^{+3} may substitute for both the Mg^{+2} and Si^{+4}. A few other elements may occur in trace amounts.

CHARACTER AND CLASSIFICATION

Three varieties of talc or talc rock are recognized, based on the purity of the talc-bearing rock. In the Dadeville area all varieties may be observed but soapstone is the most common.

TALC

Talc commonly occurs as a foliated or micaceous mineral which can be easily scratched with a fingernail. It has a greasy feel, pearly luster, and when pure, ranges in color from light green to white. The color is dependent on the processes by which it has been formed and the nature of the original magnesium rock. Talc derived from dolomite rock is generally pure white to cream colored, whereas talc derived from magnesium and ferromagnesian silicate minerals is commonly pale greenish gray. Talc pseudomorphs after diopside, enstatite, and tremolite are often buff to

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brown, depending upon the iron content of the original mineral and the degree of iron oxidation. On weathering, talc becomes white and lusterless.

Thin light-green leaves of talc are often observed dispersed throughout anthophyllite masses. The leaves are generally oriented parallel to the long axis of the asbestos fiber and may represent alteration of the asbestos to talc.

STEATITE

Steatite is a massive compact cryptocrystalline variety of talc which has no visible grain and is usually pale cream to off white in color. It is most often a metasomatic alteration product of carbonate rock, such as dolomite. Some steatite, however, may be produced by hydrothermal alteration of low iron magnesium rocks and pyroxene (diopside and enstatite), amphibole, and often mica.

SOAPSTONE

Soapstone is generally defined as massive talc mixed with varying proportions of chlorite, amphibole, pyroxene, and mica, as well as lesser amounts of quartz, carbonate minerals, and sulfide minerals. Soapstone is frequently found as bands or lenses either bordering or enclosed in bodies of altered ultramafic rock, such as peridotites and pyroxenites, or mafic rocks, such as a gabbro, which have been transformed wholly or in part into soapstone. In such occurrences, the formation of talc constitutes a high degree of alteration of the original rock. If the alteration has proceeded to the point where 75 to 95 percent of the rock is composed of talc, this material is often designated talc instead of soapstone.

OCCURRENCE

Talc is a secondary mineral, usually formed by hydrothermal alteration of original magnesium-rich carbonate or silicate rocks or minerals, such as dolomite, pyroxene, amphibole, or chlorite. Pseudomorphs of talc after a variety of minerals are known, particularly in zones of intense metamorphism. Transient phases are

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common and the paragenetic sequence is often difficult to decipher.

The formation of talc on a major scale is considered to take place under one or more of the following conditions:

(1) Intense dynamic metamorphism, where the magnesian host rock has been subjected to severe deformation together with accompanying differential changes in heat and pressure.

(2) Contact metamorphism, where the magnesian-rich host rock has been intruded by igneous rock.

(3) Hydrothermal alteration contemporaneous with regional metamorphism where the magnesian host rock has been subjected to pervasive emanations mobilized from the adjacent country rock.

Where the host rock is an ultramafic ferromagnesian rock, as found in the Dadeville area, the first stage in the alteration sequence from the pyroxenite, peridotite, or serpentine is usually to a chlorite, which in turn alters to talc. If the alteration is only partially complete, the soft talcose-chlorite rock, soapstone, is formed. However, if the conditions of alteration lie above the stability limits of the chlorite mineral, intermediate compounds and minerals may form instead. In the Dadeville area, talc is observed as a secondary alteration product after anthophyllite rather than chlorite.

Talc occurs as solid massive blocks and as irregular shell-like bodies in the saprolite overlying the mafic and ultramafic rock. These bodies are known to exist in the saprolite cover to depths of at least 30 feet. Material exposed in road cuts shows a characteristic oblate to circular peripheral shell of talc similar to that observed around mass-fiber anthophyllite, and identical in shape to the outline of the ultramafic inclusions in the hornblende gneiss (fig. 3). It is probable that the talc rings represent an alteration product from the anthophyllite, which in turn formed from the pyroxene minerals of the ultramafic component. Many of the talc boulders have solid centers. Residual accumulations in several areas completely cover the ground surface with talc boulders and cobbles (fig. 15).

The most abundant form of talc appears to be the soapstone variety. Zones of soapstone and several large bodies of soapstone

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Figure 15.—Surface accumulation of talc along access road on the Clem Vines property, north area.

are found in the Dadeville area. Bands of soapstone occur as lenses or irregular shaped bodies in and along the margins of the ultramafic and mafic rock, and often grade into these rocks. Large massive bodies of soapstone occur along the strike of the Dadeville ultramafic belt. They average 2 miles in length and half a mile in width. The limits of these original bodies are poorly defined and may grade into partially altered gabbroic rock.

DESCRIPTION OF PROPERTIES

Many occurrences of talc and anthophyllite have been noted in the Dadeville area. This report describes all the deposits and occurrences that were investigated by the Geological Survey of Alabama (fig. 16). Included with the following descriptions (Neathery and others, 1967) are eight deposits that were jointly investi-

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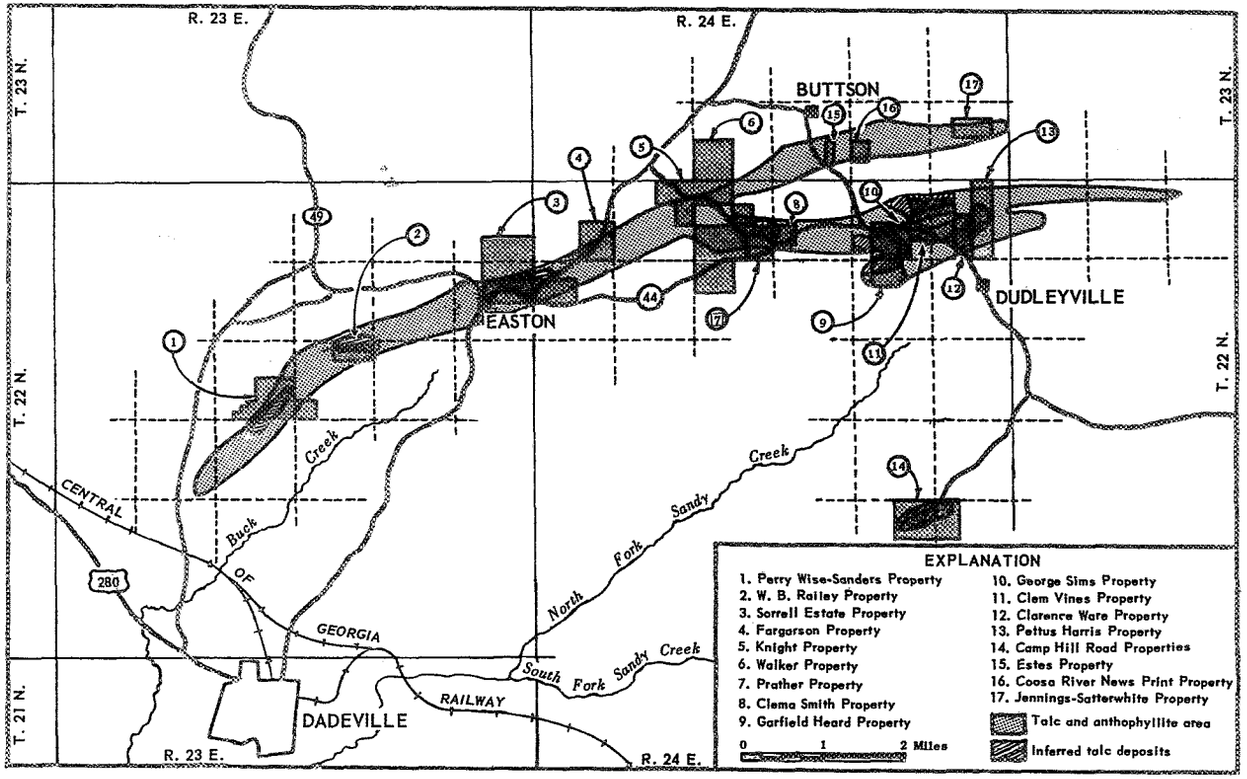


Figure 16.—Index map of talc and anthophyllite properties in the Dadeville area.

gated by the U.S. Bureau of Mines and the Geological Survey (fig. 17). None of the deposits have been mined commercially.

In 1963-66, more than 175 tons of anthophyllite material were taken from two of the properties for sampling and testing purposes. Talc has not been produced from the area, although research samples have been collected from many localities.

To obtain information on the quantity and quality of the talc and anthophyllite material, the Survey excavated six prospect trenches on five significant properties distributed along the strike of the talc-anthophyllite zone. The trench sites were chosen on the basis of exposures or outcrops of talc or anthophyllite and earlier favorable prospecting sites.

The trench sites were first cleaned or denuded of any forest or field cover. The soil and saprolite clay was either scraped off or excavated until the remnant structure of the pyroxenite-amphibolite could be seen in the walls or floor of the trench. At three locations the depth of weathering was extremely variable and only a partial removal of the overburden could be made using a bulldozer. At these locations auger holes were used to supplement the information obtained by trenching methods.

Representative samples were obtained from the cleared trench sites by the use of a small gasoline-powered trenching machine. This machine cut a ditch approximately 8 inches wide to a depth of between 16 and 18 inches (fig. 18). Material excavated from the ditch was passed through a sample splitter with 4-inch splitter slots until approximately 800 pounds of material remained (fig. 19). This material was stored in airtight and watertight drums and delivered to the U.S. Bureau of Mines, Tuscaloosa Metallurgy Research Center, for testing (Neathery and others, 1967).

Trench logs were recorded for each trench excavated. These logs accompany the description of the prospect on which the exploration was performed. Table 9 is a summary of the trenching activity.

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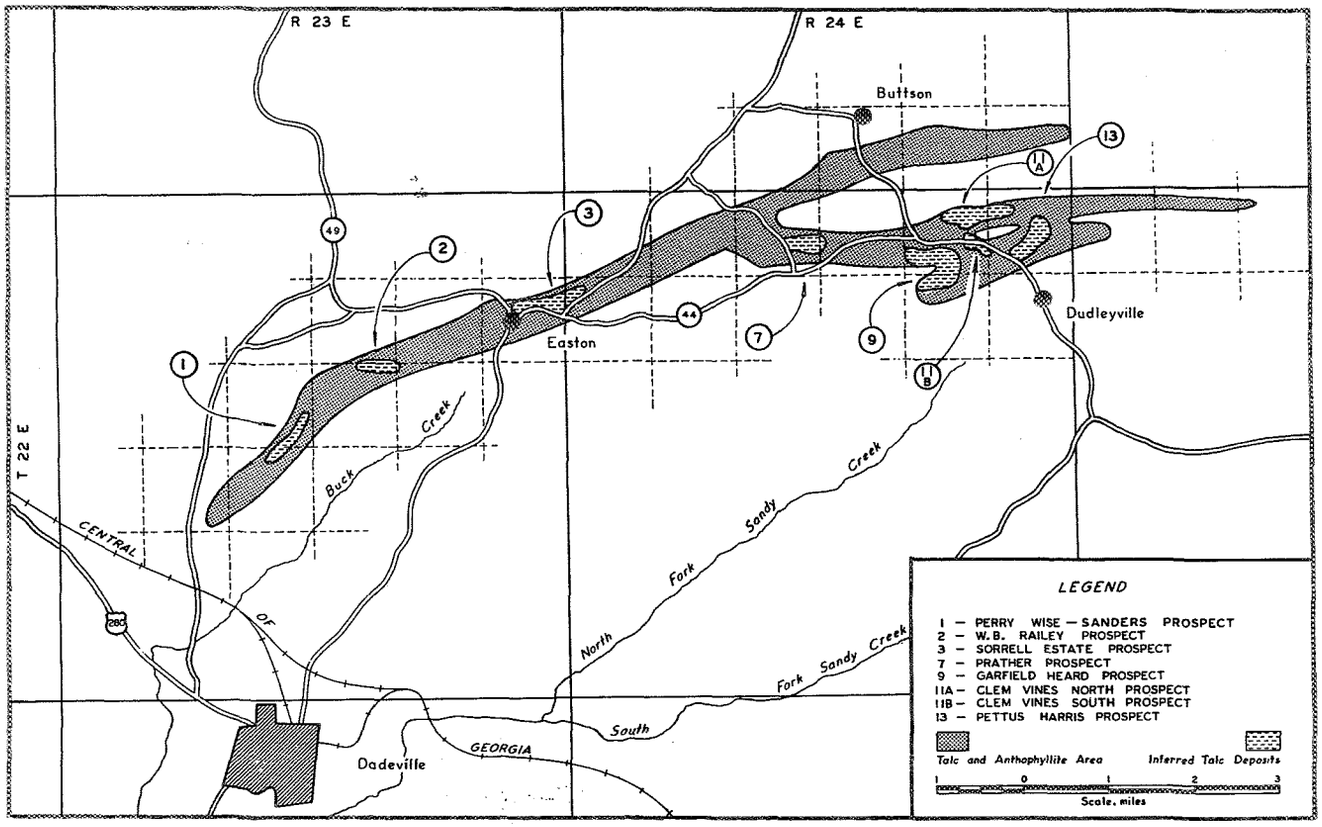


Figure 17.—Index map of talc and anthophyllite deposits investigated by the Geological Survey of Alabama and the U.S. Bureau of Mines. (From Neathery and others, 1967.)

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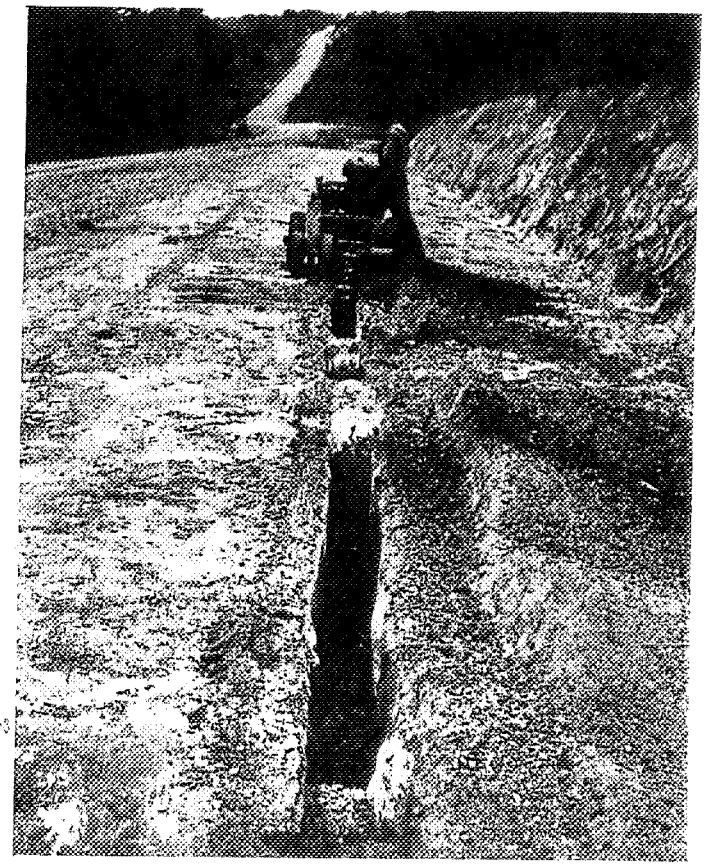


Figure 18.—Trenching machine cutting typical sample trench.

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Figure 19.—Sample material being quartered prior to final recovery.

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PERRY WISE-SANDERS PROPERTY

The Perry Wise-Sanders property (No. 1, fig. 16) is 4 miles north of Dadeville, in parts of secs. 15 and 16, T. 22 N., R. 23 E. (fig. 20). This prospect includes the Perry Wise and Sanders properties and those adjacent to them, and represents the westernmost part of the Dadeville mafic-ultramafic belt.

The mafic and ultramafic rocks occur as isolated outcrops of amphibolite, serpentinite, and pyroxenite. Serpentinite is exposed in three shallow trenches approximately 700 yards northeast of the Wise house and in a road cut in front of the Sanders house. Pyroxenite float is scattered over the land surface, especially in the wooded areas, on and surrounding the Wise property. The rock is an interlocking aggregate of enstatite crystals with minor amounts of hypersthene. Both of these minerals show alteration to talc and commonly to anthophyllite.

Near the mafic rock boundaries the talcose material becomes hard and has a texture similar to the enstatite rock or radial mass-fiber anthophyllite. Veins of talcose-anthophyllite, ⅛ to 1 inch wide, crisscross the face of several of the pyroxenite outcrops. Thick zones of chlorite and vermiculite suggest internal shearing within the ultramafic mass. Hard anthophyllite, talcose-anthophyllite, talcose-enstatite, and massive talc boulders are scattered over much of the surface. This land has been under cultivation for many years and much of the larger float material has been removed. The largest exposures of talc are visible in the road cuts along the section-line road east of the Sanders house. Peripheral shell-like structures of talc ranging from ½ to 10 inches in thickness and up to 3 feet in diameter are distributed through the saprolite for approximately 400 feet along the road right-of-way (fig. 21).

In 1953, the Red Hawk Mining Co., in an effort to develop an anthophyllite deposit, excavated three large trenches on the Perry Wise property and two on the adjacent Scroggins property. Two trenches across the road from the Perry Wise house are reported to have uncovered considerable talc, probably similar to that visible along the section-line road. The remaining three trenches exposed serpentinite and enstatite rock containing small veins of anthophyllite and talcose-anthophyllite.

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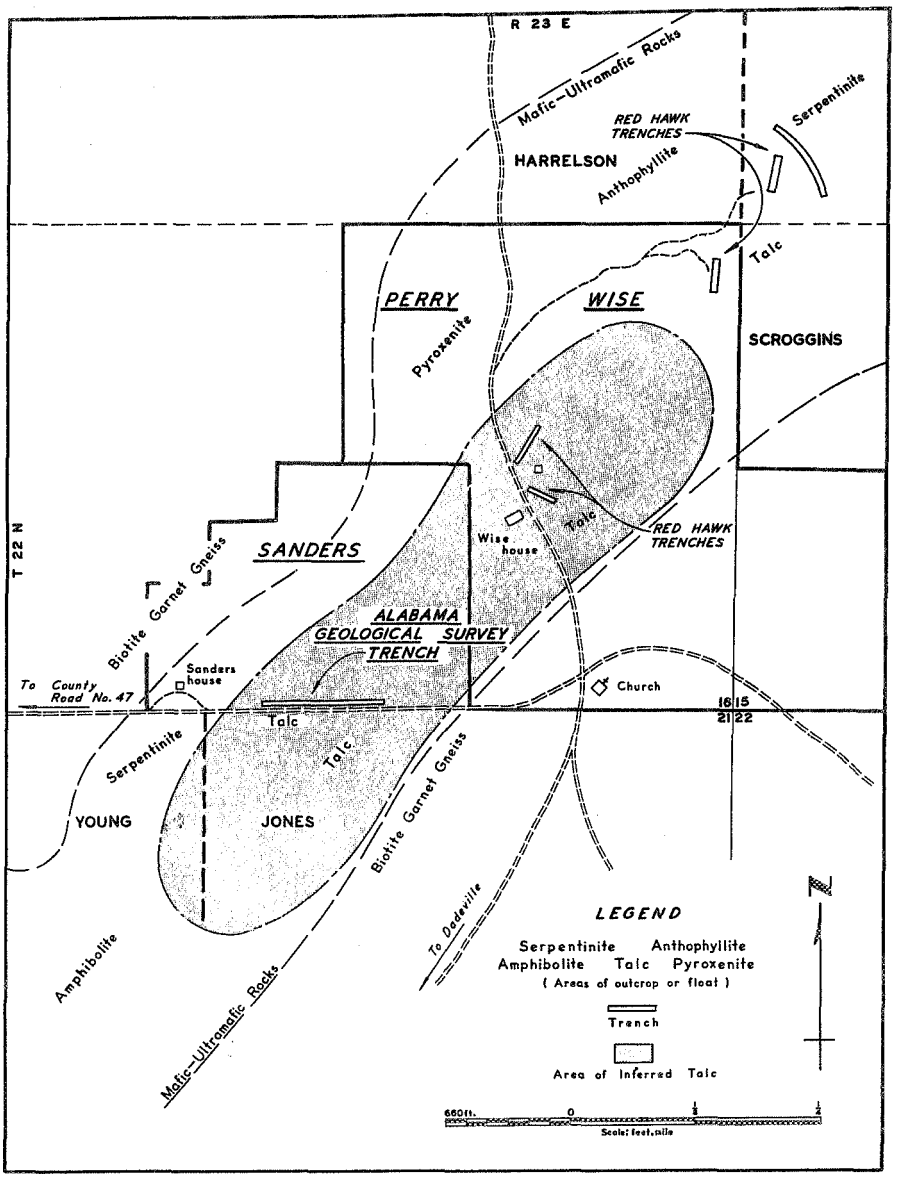


Figure 20.—Sketch map of Perry Wise-Sanders and adjoining properties.
(From Neathery and others, 1967)

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Figure 21.—Road cut in the NE¼ sec. 21, T. 22 N., R. 23 E. showing peripheral shell talc boulders in saprolite.

The talc zone exposed along the road right-of-way east of the Sanders house (fig. 22) was bulk sampled by the Survey (table 2). A narrow trench 16 inches deep was cut parallel to the road on the shoulder after removal of superficial material. Talc, talcose-anthophyllite and several small veins of anthophyllite were cut. Two thin small quartz mica pegmatites were cut, one at the eastern end of the trench and one at the western edge.

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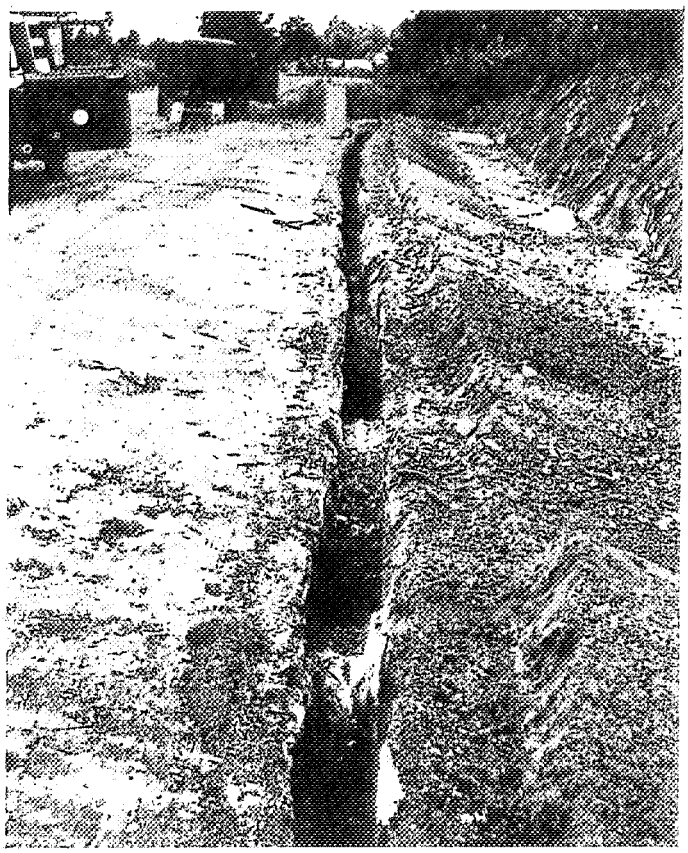


Figure 22.—Typical sampling trench cut by the Geological Survey of Alabama on the Perry Wise-Scroggins properties. Humps in trench are massive talc boulders later removed by pick and axe.

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Table 2.—*Trench log, Perry Wise-Sanders properties*

Location: Perry Wise-Sanders properties, in road cut on north side of road in the SE¼ sec. 16, T. 22 N., R. 23 E. Top 6 inches of road base removed. Azimuth, 270°.

Sample: Beginning at east end of trench, 8 inches wide x 16 inches deep x 340 feet long.

Interval (in feet)	Description
0-3	Yellowish-tan clay saprolite.
3-12	Yellowish-buff saprolite.
12-30	Reddish-gray to maroon saprolite.
30-212	Buff-tan saprolite with hard greenish-gray talc boulders at 34, 37, 41, 48, 54, 59, 72, 76, 81, and 84 feet; at 95 feet, hard green talc; hard greenish-gray talc boulders at 100, 112, 121, 133-140, 145, 176, 184, and 200-212 feet; scattered anthophyllite fibers between 125-212 feet.
212-225	Pink-tan saprolite with occasional talc boulders.
225-229	Hard gray-white talc.
229-239	Brown saprolite.
239-242	Hard, partly altered talcose hornblendite, tremolite crystals.
242-251	Orange-brown to pink saprolite, few talc boulders.
251-255	Hard gray-white talc.
255-259	Black hornblende, talcose, limonite crusts.
259-267	Brownish-tan to pink saprolite with occasional talc boulders, mostly feldspar pegmatite.
267-283	Yellow-tan saprolite, talc saprolite with thin stringers of pegmatite; at 280 feet, large talc boulders.
283-285	Pegmatite, injected between talc seams; strike N. 33° W., dip 33° NE; not sampled.
285-340	Brown to tan saprolite and soil; not sampled.

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W. B. RAILEY PROPERTY

The Railey property (No. 2, fig. 16) is in the N½NE¼ sec. 15, T. 21 N., R. 23 E., about half a mile northeast of the Perry Wise property (fig. 23). The soil zone has been removed by bulldozer stripping from a number of acres of previously cultivated land, and subsequent erosion has exposed the underlying bedrock at many localities.

The bedrock is a well banded hornblende-gneiss-amphibolite, which encloses irregularly shaped and random sized inclusions of ultramafic rock (fig. 3). Occasional fragments of hornblende gabbro and hornblende diorite are found scattered over the extreme eastern part of the property. The soil is a typical example of "buckshot" soil. It contains numerous pyroxenite fragments and has a buff-green to yellow-green color. The pyroxenite fragments range from ⅛ inch to 24 inches in diameter and comprise over 50 percent of the upper level of the exposed saprolite zone.

In 1953, the Red Hawk Mining Co. cut two large trenches, one normal to the strike and one parallel to the strike of the ultramafic belt. The trench nearest the Railey house cut through several thin veins of anthophyllite and scattered masses of apple-green talc. Mr. Railey reported that during the sinking of a well adjacent to the house, a thick zone of material which resembled anthophyllite was penetrated at a depth of approximately 100 feet.

During this investigation, one small trench was cut approximately normal to the strike in a field 250 feet south of the Railey house. The material exposed consisted of saprolite, chlorite, vermiculite, thin-vein anthophyllite, apple-green talc, and alluvium (table 3).

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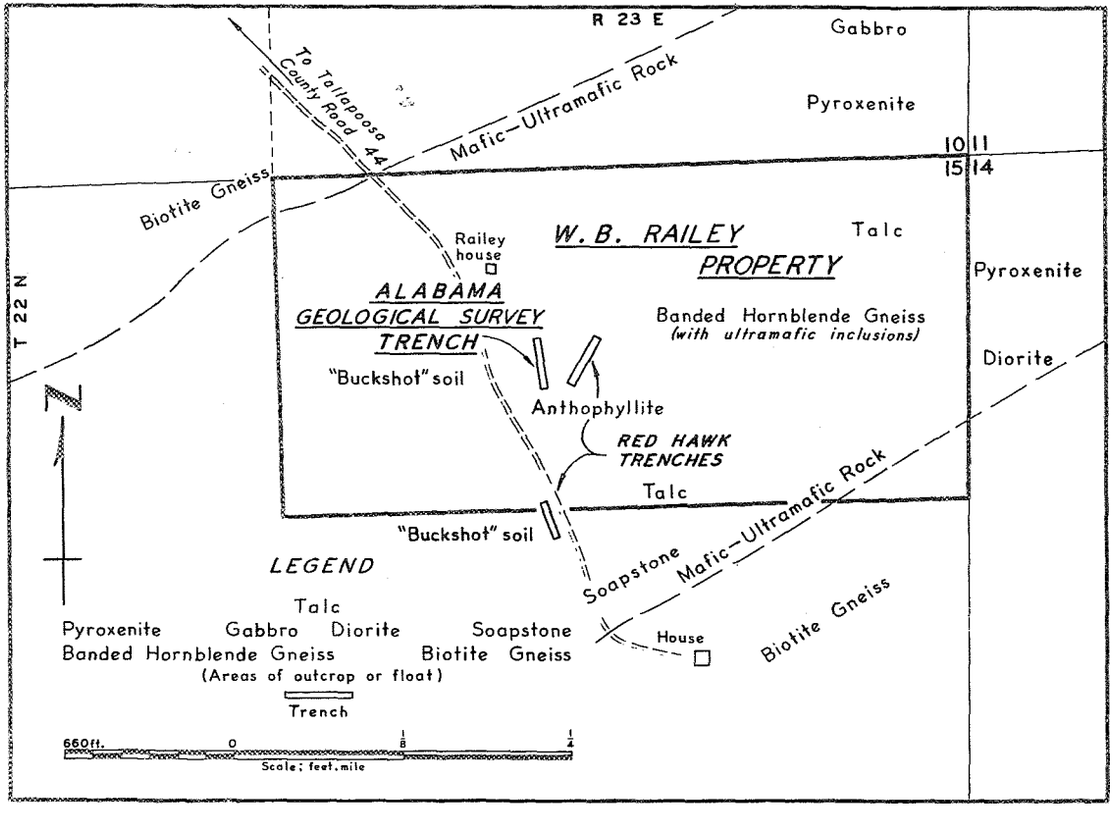


Figure 23.—Sketch map of W. B. Railey property.
(From Neathery and others, 1967)

Table 3.—*Trench log, W. B. Railey property*

Location: W. B. Railey property; trench 300 feet long and 2 to 4 feet deep cut using bulldozer. Azimuth, 165°.
Sample: Beginning at north end of trench, 8 inches wide x 16 inches deep x 270 feet long.

Interval (in feet)	Description
0-29	Reddish-brown saprolite; at 0 feet, talc boulders; at 9 feet, talc boulders; at 10 feet, dark weathered hornblendite fragments; at 25 feet, talc boulders.
29-33	Large talc boulders, dark-gray-green talc, greasy, some iron stain inclusions.
33-42	Reddish-brown saprolite, occasional talc boulders.
42-68	Greenish-black to green-brown saprolite, occasional talc fragments at 47, 52, and 56 feet.
68-110	Green-brown saprolite, occasional fragments of hard hornblendite; at 77 feet, firm to hard rock with thin seams of talc; at 90 feet, talcose hornblendite cobbles; at 96 feet, hard hornblendite; at 100-105 feet, hard rock; at 106 feet, seam of talc 1 foot thick.
110-132	Buff- to grayish-tan saprolite, talc cobbles, iron-manganese nodules in top 3 inches of cut.
132-150	Buff-tan saprolite, very talcose, no boulders; at 139-143 feet, zone of silver-gray vermiculite mixed with chlorite.
150-175	Buff-tan to whitish-tan talc and anthophyllite, soft to hard; hard boulders at 155 to 160-164 feet.
175-192	Gray saprolite; fragments of talc, anthophyllite, actinolite-schist, hornblendite, quartz, mica, and chlorite.
192-200	Reddish-brown top soil saprolite, few fragments of talc.
200-270	Reddish-brown alluvium containing talc and anthophyllite fragments, nodules of weathered pyroxenite, and hornblende gneiss.

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SORRELL ESTATE PROPERTY

The Sorrell Estate property (No. 3, fig. 16) is on a large tract of timberland in parts of secs. 1 and 12, T. 22 N., R. 24 E., in the vicinity of Easton (fig. 24).

Numerous outcrops of mafic and ultramafic rock occur throughout the property. Mafic rock types include hornblende gabbro, hornblende gneiss, and hornblende diorite. Actinolite schist was found as surface rock at several places. The ultramafic rock is a pyroxenite composed of stubby interlocking crystals of enstatite and hypersthene with traces of bronzite. Black magnesium-oxide stains are common along cleavage faces. Altered material retains the crystalline structure of the pyroxenite, but includes talc and anthophyllite as transformation products. Corundum crystals were found on this property during the latter part of the 19th century.

Talc, talcose-anthophyllite, and talcose-pyroxenite occur mostly as surface material and a talcose mass-fiber anthophyllite was found in an outcrop. Along the Germany Ferry Road, beginning at its junction with Tallapoosa County Road 44 and extending northeasterly for approximately 1,000 yards, massive peripheral shell-like talc bodies, chalcedony boxwork, anthophyllite veinlets, and hornblende gneiss with ultramafic inclusions are exposed along the right-of-way. The rocks are weathered to variable depths and display continuous alteration from amphibolite-pyroxenite to talc-anthophyllite.

A 20-foot shaft on the west side of the road, approximately 300 yards from the road junction, exposed spheroidal boulders of talc and talcose enstatite throughout its depth. A large pit is located approximately 550 yards north of the shaft. There is mass-fiber anthophyllite and talcose mass-fiber anthophyllite on the dump. The original depth of this pit is unknown. Several other prospect trenches are in the area south of the pit; each has material similar to that found in the large pit.

A narrow trench, approximately 650 feet in length, was cut along the Germany Ferry Road right-of-way, beginning at the junction of the Germany Ferry Road and County Road 44. The trench-cut material is shown in the trench log (table 4).

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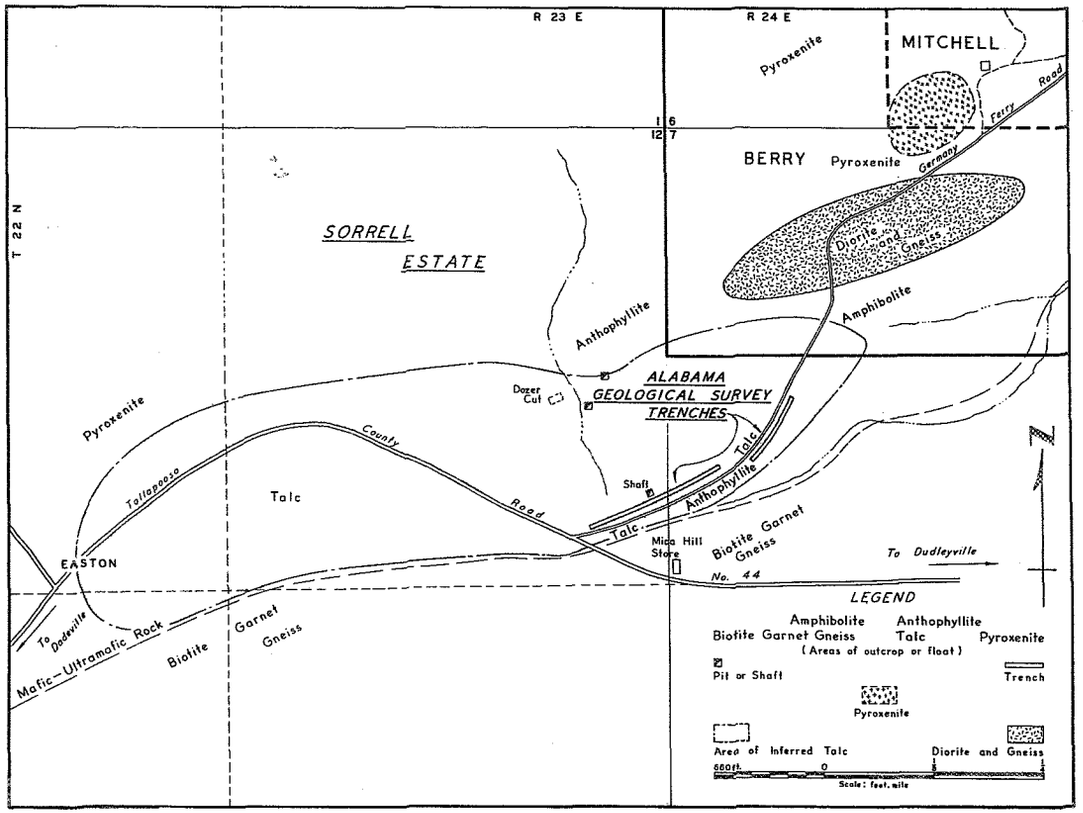


Figure 24.—Sketch map of Sorrell Estate and adjoining properties.
(From Neathery and others, 1967)

Table 4.—*Trench log, Sorrell Estate property*

Location: Sorrell Estate property, Germany Ferry Road right-of-way; trench cut 1200 feet long and 1 foot deep using bulldozer. Azimuth, 65° at 0-815 feet, 56° at 815-900 feet, 50° at 900-1000 feet, and 45° at 1000-1100 feet.
Sample: Beginning at southwest end of trench, 8 inches wide x 16 inches deep x 650 feet long.

Interval (in feet)	Description
0-8	Large talc boulders, hard, fractured, filled with clay seams, partly altered pyroxenite fragments.
8-220	Tan saprolite containing boulders and cobbles of talc of variable sizes, very firm, some hard zones; large talc boulders at 42-52, 57, 97, 118, and 139 feet.
220-231	Dark-brown saprolite, iron-manganese rich nodules.
231-383	Tan saprolite, talc boulders increasing in number and size; at 276 feet, large hard talc boulders; hard talc at 322-324, 334-338, and 378-383 feet.
383-420	Soil and talc, saprolite, soil, black loam saprolite, with boulders of talc.
420-432	Tan to reddish-tan saprolite, abundant talc blebs, cobbles, and boulders.
432-452	Black loam, little saprolite, large cobbles and boulders of hard talc.
452-479	Red-brown to gray saprolite, some talc, high-iron nodules; hard silica gossan at 450, 455, and 461 feet.
479-483	Green to silver-gray talc zone, chlorite, vermiculite, talc, tremolite, boulders of silica gossan and limonite.
483-650	Red-tan saprolite, talcose, few blebs of talc, talc cobbles, and silica gossan; hard talc boulders at 508, 512, 521-526, 531-533, 550-553, 569-571, and 650 feet.
650-716	Black loam overlying talc and talc saprolite exposed in lower 4 inches of trench; scattered boulders of hard white talc; not sampled.
716-815	Reddish-tan talcose, saprolite; talc boulders at 747, 767, 803, and 856 feet; not sampled.
815-900	Reddish-tan saprolite; talc boulders at 837, 845-851, and 855-861 feet; at 874 feet, anthophyllite seam; not sampled.
900-1140	Reddish-brown saprolite, talc cobbles, some anthophyllite at 974 feet, high iron, very clayey; not sampled.

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FARGARSON PROPERTY

The Fargarson property (No. 4, fig. 16) is in the SE¼ sec. 6, T. 22 N., R. 24 E., approximately half a mile north of the Sorrell Estate property on the Germany Ferry Road.

Pyroxenite, amphibolite, and hornblende gabbro occur as surface float material and in isolated outcrops. Pyroxenite crops out to form low bluffs along the banks of a small stream which passes through the property. Vegetation and soil cover conceal the rock-type boundaries. The residual soil type is the typical "buckshot" variety found throughout the district. On the Germany Ferry Road, north of the old Fargarson house, a road cut exposed talcose pyroxenite and chloritic amphibolite. Irregular shaped lenses of talcose-chloritic amphibolite are encased in zones of green-black chlorite and thin sheaths of talc. Physically, the lenses are similar to those observed in the area of the Perry Wise-Sanders property.

Cross-fiber and mass-fiber anthophyllite, talcose-anthophyllite, and chalcedonic anthophyllite are found as surface material in the wooded area in the eastern part of the property. In a road cut on the Germany Ferry Road just south of the old Fargarson house, cross-fiber anthophyllite, talcose-pyroxenite, and chalcedony boxwork occurs scattered throughout dark-red saprolite.

Evidence of former prospecting was not found during a cursory examination of the property.

KNIGHT PROPERTY

The Knight property (No. 5, fig. 16) is in the N½NW¼ sec. 5; N½NE¼ and SE¼NE¼ sec. 5, T. 22 N., R. 24 E. (fig. 25).

A large body of pyroxenite crops out 100 yards northeast of the Knight house. It is an ellipsoidal-shaped exposure, approximately 1,000 feet long, the major axis of which trends east-west. The pyroxenite body is composed chiefly of large interlocking crystals of enstatite and hypersthene with minor olivine. Incipient talc alteration along crystal boundaries can be observed in thin sections. To the south, amphibolite, hornblende gneiss, and hornblende gabbro are present as scattered surface rock. A large area is littered with quartz fragments and may represent the location of

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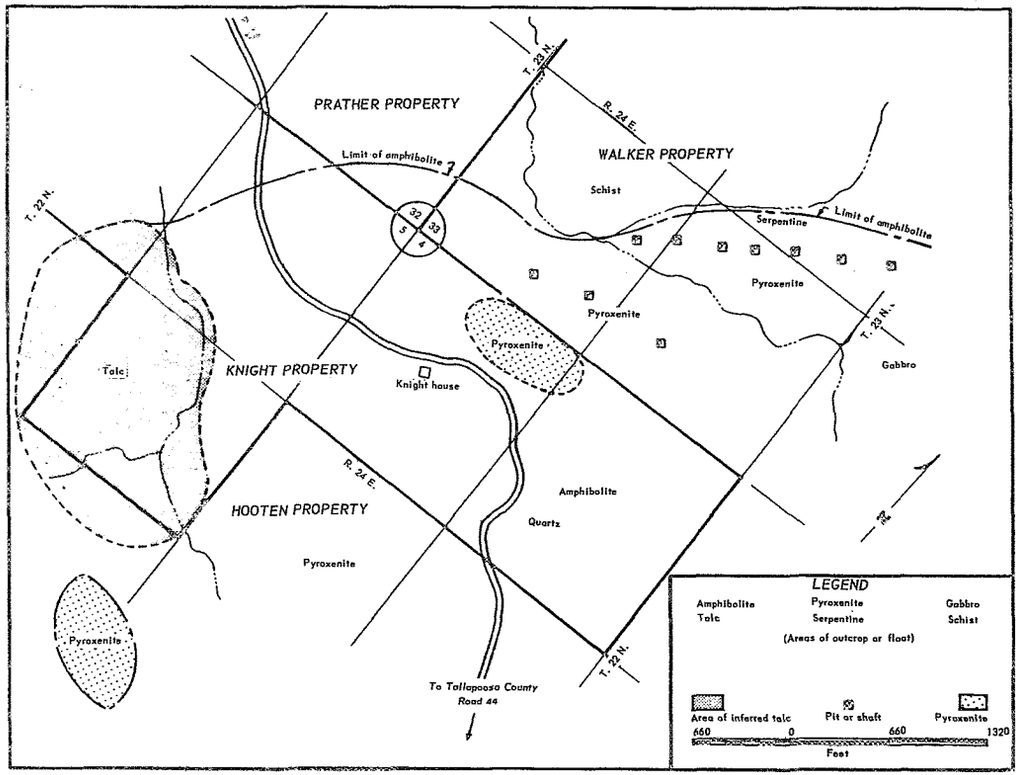


Figure 25.—Sketch map of Knight-Walker properties.

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a quartz body. The boundary limits between the mafic and ultramafic rocks and surrounding gneiss are obscured by dense undergrowth but changes in soil color and the presence of the surface rock tend to follow the contacts.

Talc and talcose anthophyllite are exposed as surface accumulations in the stream southwest of the Knight house and in the fields to the west of the stream. Several thin veins of soapstone crop out in the roadbed near the northern boundary of the property. Major prospecting has not been done on the property.

WALKER PROPERTY

The Walker property (No. 6, fig. 16) is in the SW¼ sec. 33, T. 23 N., R. 24 E. The principal prospects are located on a narrow northeastward-trending ridge, approximately 650 yards N. 22° E. from the Knight house. These workings can be reached only by foot (fig. 25).

From the pyroxenite outcrop on the Knight property, northward to the creek, ultramafic rock occurs as surface material. Beyond the creek, a narrow ridge rises to the northeast. The rock exposed along the crest of the ridge is predominantly a pyroxenite but scattered boulders of serpentinite are present. Hornblende gneiss and hornblende gabbro occur as surface rock material on the eastern part of the property.

A series of shallow prospect pits and trenches have been excavated along the crest of the ridge for a distance of approximately 550 yards. Material exposed in the dumps consists of minor amounts of green flaky talc, talcose-anthophyllite, and talcose-pyroxenite. On the southwest nose of the ridge, a large prospect trench, cut in the form of a "T", exposes talcose-pyroxenite, pyroxenite, and serpentinite.

Just north of the fence line between the Knight and Walker properties several smaller prospect pits have been excavated along the northern face of the hill. Dump material is a talcose pyroxenite similar to that found on the Knight property.

The date of the prospecting work is uncertain. It is reported that most of the work was done during 1939-40. It was also reported that the excavations were done searching for corundum and chromite. No recent work has been done.

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PRATHER PROPERTY

The Prather property (No. 7, fig. 16) is in the SE¼ sec. 4, T. 22 N., R. 23 E., north of Tallapoosa County Road 44 (fig. 26). Pyroxenite and amphibolite constitute the country rock over most of this property. Biotite gneiss crops out along the southern part of the property, and scattered masses of hornblende-diorite occur north of the property. The pyroxenite is a mixture of enstatite and hypersthene, showing incipient talc alteration along many crystal faces. Some pyroxenite material may be bronzite. Small talcose pyroxenite cobbles and quartz fragments occur as surface material over much of the cultivated area.

Anthophyllite-bearing zones are indicated in the pyroxenite-amphibolite zones by sharp changes in soil color. The soil derived from the amphibolite is usually gray to greenish gray, whereas the soil derived from the pyroxenite and anthophyllite is yellow to ocher in color. At a tenant house in the NE¼SE¼ sec. 4, an excavation for a storm cellar uncovered a thick vein of cross-fiber anthophyllite in one of the lighter-colored soil areas. Talc, soapstone, and talcose-chalcedonic anthophyllite occur scattered as surface accumulations through the cotton field (fig. 27). Several corundum crystals have been found on the property. In 1963, the American Talc Co. explored parts of the property. Twelve drill holes were completed to an average depth of 65 feet. Three bottomed in talc and the remainder penetrated the mafic-ultramafic rock complex and bottomed in a biotite gneiss or diorite. A typical core log is given in table 5.

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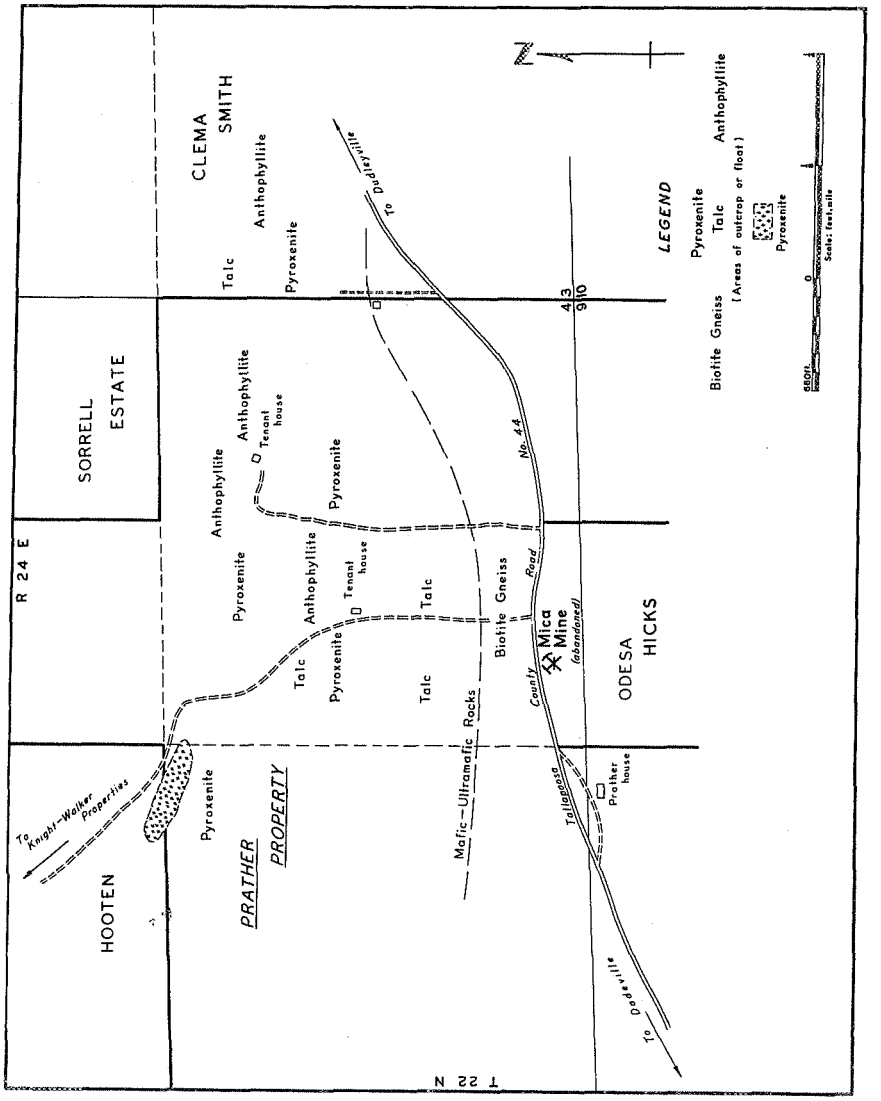


Figure 26.—Sketch map of Prather and adjoining properties.
(From Neathery and others, 1967)

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Figure 27.—Surface accumulation of talc and anthophyllite in cotton field on the Prather property.

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Table 5.—*Typical core log, Prather property*

Depth (in feet)	Interval	Core recovered	Description
0.0 to 5.0	5.0	No core	Overburden.
5.0 to 11.6	6.6	2.0	Gray soft saprolite, granitic texture; top contact dip 80°; schist planes dip 40°.
		.5	Brown mud (core ground up).
		.4	Talc fragments, light-gray (original thickness unknown).
		.4	Gray granitic saprolite.
11.6 to 18.8	7.2	.9	Gray granitic saprolite.
		1.5	Gray granitic rock altered to talc.
		1.1	Talc, light-gray.
18.8 to 25.5	6.7	1.6	Talc.
25.5 to 35.7	10.2	.4	Talc, containing mica fragments.
		.1	Mica-schist saprolite, dip 30°.
		1.7	Talc.
		1.0	Mica-schist saprolite.
		.7	Fragments, mica-schist and talc.
		1.7	Talc.
35.7 to 37.9	2.2	2.2	Talc.
37.9 to 45.7	7.8	.3	Mica-schist and talc fragments.
		1.0	Talc vein, dip 30°.
		.6	Mica-schist saprolite.
		.7	Talc, soft.
		.2	Mica-schist saprolite.
		.3	Talc.
		.2	Mica schist.
		.7	Talc.
45.7 to 60.4	14.7	No core	Unknown.
60.4 to 65.8	5.4	.2	Weathered mica schist.
		5.2	Biotite schist to gneiss, hard; dip at top of unweathered gneiss, 35°.
65.8 to 75.5	9.7	9.3	Banded biotite gneiss, dip 35°.
	Bottom of hole 75.5 feet		

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CLEMA SMITH PROPERTY

The Clema Smith property (No. 8, fig. 16) is in the NW¼SW¼ sec. 3, T. 22 N., R. 24 E., adjacent to the Prather property (fig. 26).

Pyroxenite float and hornblende gneiss are scattered over much of the property. Fragments of soapstone, talc, and talcose-anthophyllite were found as surface float in a small cotton field. Prospecting has not been done on the property but its location relative to the Prather property suggests that material similar to that found on the Prather property should occur on this property.

GARFIELD HEARD PROPERTY

The Garfield Heard property (No. 9, fig. 16) is in the E½SW¼ sec. 2, and in the NE¼NW¼ sec. 10, T. 22 N., R. 24 E., south of Tallapoosa County Road 44, approximately half a mile west of Oziah Church (fig. 28).

The mafic-ultramafic rock forms an irregular outcrop pattern, the limits of which are difficult to map because of the saprolite cover. The rock type is predominantly pyroxenite with minor occurrences of actinolite-hornblende amphibolite. Irregular zones of chlorite and vermiculite cut the mafic rock body. Two small northwestward-trending quartz-mica pegmatites have been located adjacent to the mafic body, but evidence is not available to indicate whether they cut the mafic rock complex.

The anthophyllite occurs as veins, in widths up to 14 inches and as mass-fiber bodies. Cross-fiber veins are exposed in the ditches along the timber road near the Heard house. Talc and talcose enstatite boulders were found along the southern and southwestern limits of the mafic body.

The anthophyllite occurrence is irregular and varied. Pockets ranging in weight from 1 ton to over 8 tons have been extracted. Veins vary widely in width and often terminate abruptly at a small nonmineralized cross joint. The anthophyllite is buff tan to cream color, but individual fibers are generally light cream to white when separated from the mass. Small flakes of chlorite and talc have developed parallel to some of the anthophyllite fibers and often constitute more than 50 percent of the rock.

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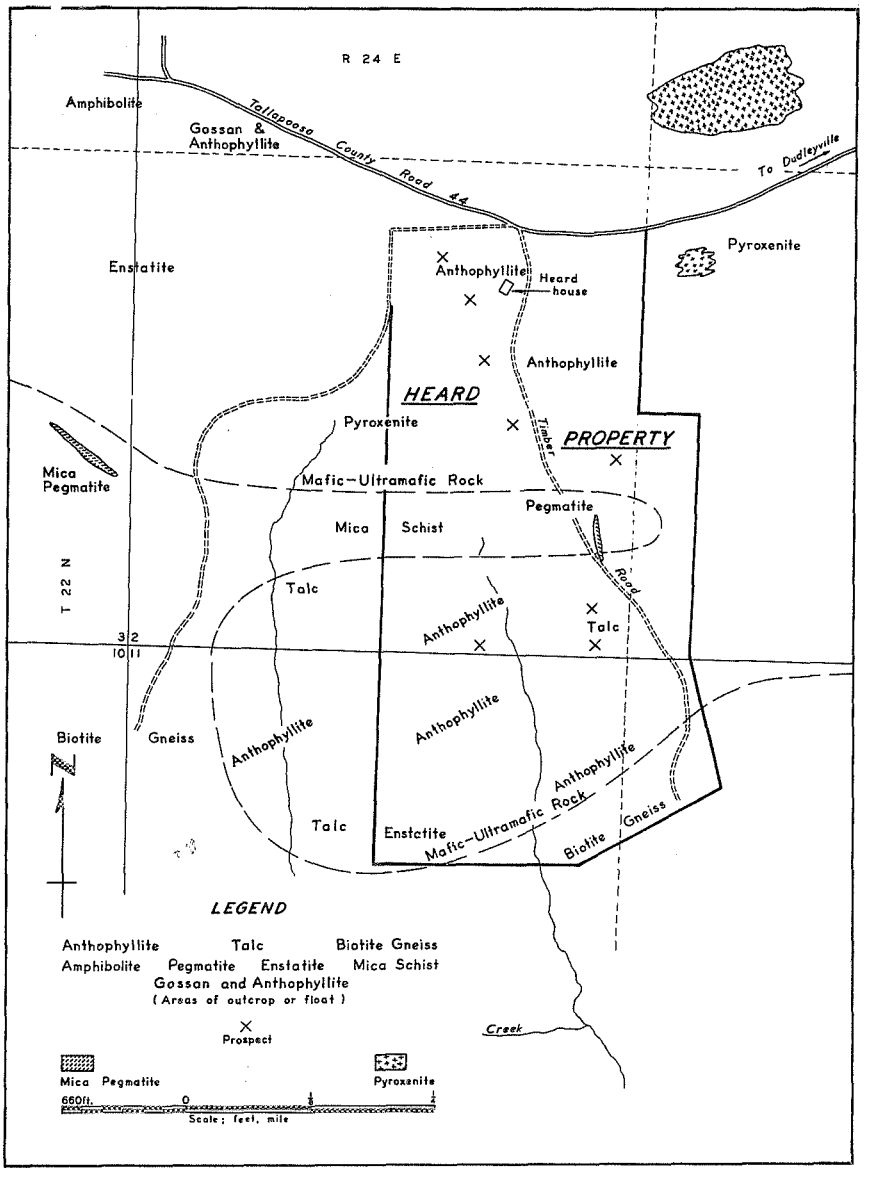


Figure 28.—Sketch map of Garfield Heard property.
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Prior to 1964, several individuals, including Mr. Heard, opened small prospect pits at several places on the property. In 1965, the Powhattan Mining Co. prospected the property and it is reported that approximately 100 tons of anthophyllite were shipped to their Baltimore processing plant. Most of the excavations were refilled by contract agreement after termination of prospecting activities and little evidence remains to indicate the subsurface conditions.

GEORGE SIMS PROPERTY

The George Sims property (No. 10, fig. 16) is in the NW¼SW¼ sec. 2, T. 22 N., R. 24 E., between the Garfield Heard and the Clem Vines properties, south of Tallapoosa County Road 44 (fig. 29). Pyroxenite and some actinolite-hornblende schist crop out on a small hill south of the road, adjacent to the east boundary of the Heard property. The pyroxenite is a composite mixture of interlocking crystals of enstatite and hypersthene with talc and anthophyllite alteration rims. Thin veinlets of cross-fiber anthophyllite, ⅛ to ½ inch wide, crisscross the surface of many of the outcrop boulders. The boulders are often composed of talcose mass-fiber anthophyllite which may have a chalcedonic zone or rim.

The soil is the characteristic "buckshot" type, containing pyroxenite nodules and irregular fragments of talc. Several large boulders of talc were found embedded in the saprolite.

Prospecting work has been limited to a small pit located 100 yards south of the road, adjacent to an old field. Fragments of cross-fiber anthophyllite are found on the dumps as residual material. Tallapoosa Mining Co. opened this pit during exploration activities on adjacent properties. South of the pit, scattered fragments of talc and hard talcose anthophyllite occur as surface float. Several large boulders of black hornblende gneiss were found on the field-rock dump.

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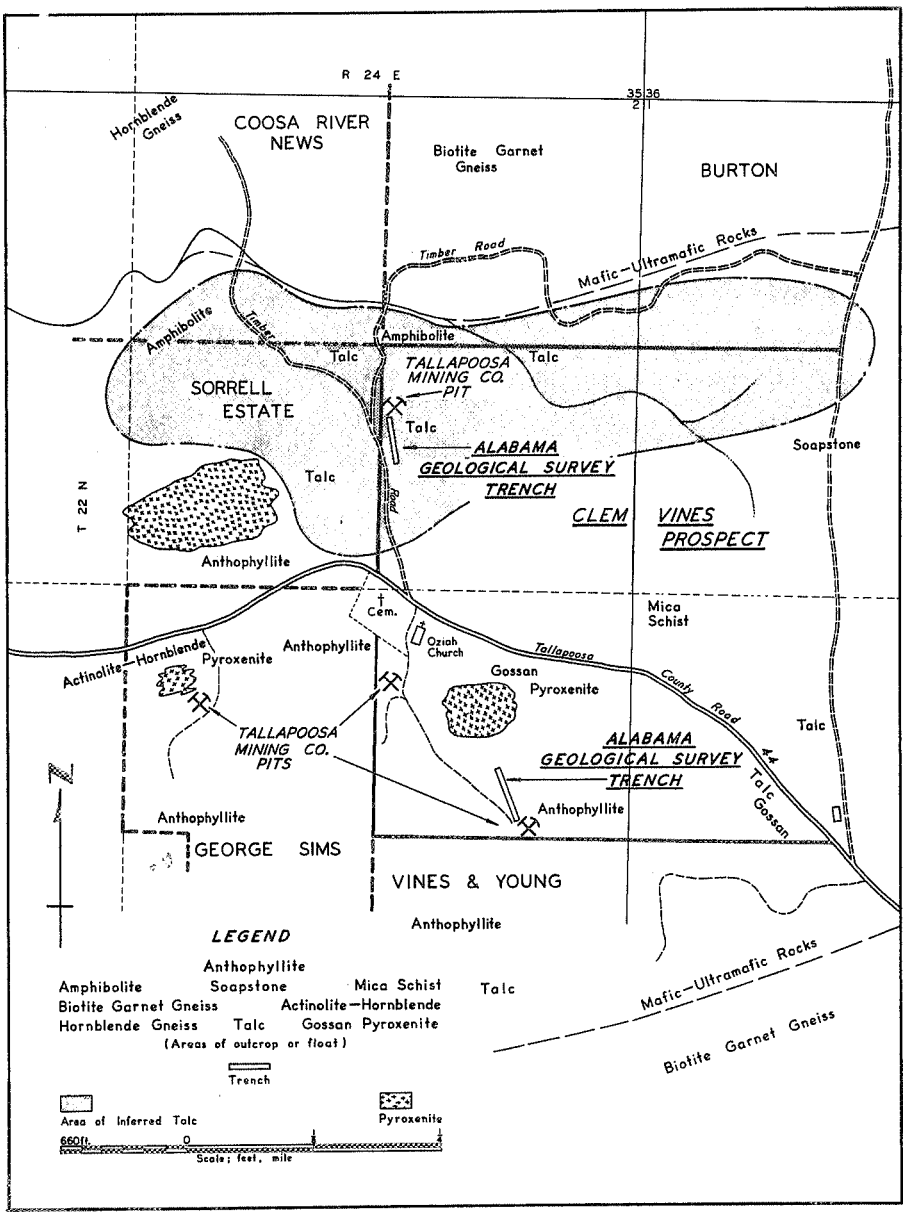


Figure 29.—Sketch map of Clem Vines and adjoining properties.
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CLEM VINES PROPERTY

The Clem Vines property (No. 11, fig. 16) is in the E½ sec. 2, T. 22 N., R. 24 E., north and south of Tallapoosa County Road 44 (fig. 29). For purposes of description the property has been divided into the north and south areas.

CLEM VINES PROPERTY, NORTH AREA

The north area (No. 11A, fig. 16) is accessible by a well graded timber road which leaves the county road directly across from Oziah Church. Approximately 300 yards north of the church, the timber road junctions; the left fork veers to the northwest and the right fork continues north for a short distance and then turns east. Both roads cross a small stream about 150 yards north of their junction. This stream exposes black to green-black amphibolite along much of its course and represents the northern boundary of the mafic-ultramafic complex in this area. North of the stream, mica schist, biotite gneiss, and quartz bodies crop out and separate this mafic-ultramafic area from another about 0.5 mile to the north. To the west of the timber road, on a parcel of land belonging to the Sorrell Estate, a large mass of altered pyroxenite is exposed. The material grades from talcose pyroxenite to talcose-chalcedonic mass-fiber anthophyllite. Talcose pyroxenite also occurs in a few scattered outcrops and surface float.

In the vicinity of the timber road junction, surface accumulations of talc and talcose anthophyllite are common (fig. 15). Numerous boulders, cobbles, and fragments of peripheral shell talc are found along the stream course south of the black amphibolite zone. A 300-foot north-south oriented trench excavated during this investigation exposed massive boulders and peripheral shell-like bodies of talc embedded in the saprolite (table 6).

For completeness in sampling and to avoid the necessity of excavating the entire trench to fresh rock material, three 4-inch diameter auger holes were drilled into the floor of the trench on 100-foot centers. Each hole bottomed at a depth of 15 feet in fresh unweathered talcose material. Two of the holes contain cross-fiber anthophyllite in the auger cuttings. A smaller prospect pit had been opened earlier near the northern end of the large trench. It

Table 6.—*Trench log, Clem Vines property, north area*

Location: Clem Vines property, north area; trench cut 300 feet long and 4 feet deep using bulldozer. Azimuth, 340°.
Sample: Beginning at south end of trench, 8 inches wide x 1 foot deep x 267 feet long.

Interval (in feet)	Description
General	Reddish-tan saprolite with abundant boulders of talc.
0-30	Reddish-tan saprolite with many talc boulders.
30-40	White to gray-white talc; 1.1 foot of clay at 53 feet; thin seam of anthophyllite.
40-79	Reddish-tan saprolite with many talc boulders.
79-96	White to gray-white talc, some staining, little clay, talc massive, hard.
96-109	Reddish-tan saprolite with occasional talc boulders.
109-111	Talc boulder zone; talc, white to gray-white, hard, massive.
111-123	Reddish-tan saprolite with talc boulders.
123-145	Talc zone, gray to gray-white talc, seam of reddish-tan saprolite, talc stained, gritty, hard.
145-156	Reddish-tan saprolite, talcose.
156-169	Talc zone, numerous zones of massive talc interspersed with thin seams of reddish-tan saprolite; talc, hard, gritty, white to gray-white to greenish-white.
169-179	Reddish-tan saprolite, talc boulders.
179-186	Talc boulders, massive hard talc, gray to gray-greenish-white; 1.5 foot seam of saprolite.
186-199	Reddish-tan saprolite, few small talc pebbles.
199-209	Talc zone, massive talc boulder, hard, white to gray-greenish-white, some grit; reddish-tan saprolite seam, some iron staining.
209-226	Reddish-tan saprolite, few cobbles and pebbles of white to gray-white talc, iron stained.
226-257	Talc zone, white to greenish-white, hard, massive, some grit, iron staining erratic; reddish-brown saprolite seams.
257-267	Reddish-brown saprolite, high percentage of talcose cobbles and pebbles.

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was excavated by the Tallapoosa Mining Co. during their prospecting activities in 1964. Some cross-fiber material was obtained. The pit site is now covered by material removed from the larger trench.

CLEM VINES PROPERTY, SOUTH AREA

The south area (No. 11B, fig. 16) is accessible by a field service road, beginning immediately behind Oziah Church. Included with the south area are the road cut exposures along Tallapoosa County Road 44.

An outcrop of pyroxenite is exposed on a small hill approximately 125 yards southeast of the church. It is composed of large stubby interlocking crystals of enstatite and hypersthene which have been altered to talc and mass-fiber anthophyllite. The pyroxenite body grades southward into more highly altered material. Throughout the area the soil is of the "buckshot" variety and often contains large boulders of pyroxenite.

In a road cut on Tallapoosa County Road 44 (100 to 200 yards east of the church), cross-fiber anthophyllite, talc, and chalcedony boxwork may be seen in the deep-red saprolite. The anthophyllite veins are badly weathered and stained. The asbestos fiber is soft and ranges from 4 to 6 inches in length. A pyroxenite intrusion is suggested by the presence of a discordant zone of weathered biotite gneiss separating two zones of weathered mafic rock. Above the road cut in the adjoining woods, pyroxenite and gneiss are found as float material. Boundaries between the two rock types are covered by vegetation and soil.

A small pit, approximately 100 yards southeast of the church and adjacent to the field service road, was opened by the Tallapoosa Mining Co. in 1963. A small quantity of anthophyllite was recovered prior to its being backfilled. Short cross-fiber anthophyllite remains scattered about the rim, a residual product from the leaching of the excavated material. A cemetery adjacent to the churchyard and immediately north of the pit described above, is situated on several large pockets of mass-fiber anthophyllite. Many of the grave sites were excavated in the mass-fiber and cross-fiber anthophyllite, which was dumped along the southern fence line.

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Table 7.—*Trench log, Clem Vines property, south area*

Location: Clem Vines property, south area; trench 325 feet long and 6 to 10 feet deep cut using bulldozer. Azimuth, 160°.
Sample: Beginning at south end of trench, 8 inches wide x 18 inches deep x 296 feet long.

Interval (in feet)	Description
General	Reddish-brown saprolite with stringers of anthophyllite; talc boulders; vermiculite zones; and partially altered pyroxenite.
0-32	Reddish-brown saprolite, talc cobbles; 6- to 8-inch wide anthophyllite vein at 23 feet.
32-74	Gray to buff-tan altered pyroxenite; abundant vermiculite; gray to gray-green talc cobbles and boulders; thin veins of anthophyllite; reddish-brown saprolite seams and iron stains.
74-220	Reddish-brown saprolite containing boulders of gray talc; vein and shells of anthophyllite; few seams of vermiculite and chlorite at 153 feet.
220-235	Massive anthophyllite vein with clay seams. Fiber, buff-tan to reddish-brown; some 2½ to 3 inches long, most short, cross-fiber, little mass-fiber.
235-255	Reddish-brown saprolite with random anthophyllite blebs and small veinlets.
255-258	Thick vein of cross-fiber anthophyllite, buff-tan, 4 to 6 inches long.
258-296	Reddish-brown saprolite; thin veinlets of short cross-fiber anthophyllite, little talc, some vermiculite and chlorite.

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CLARENCE WARE PROPERTY

The Clarence Ware property (No. 12, fig. 16) is in the NE¼SW¼ and part of the SE¼SW¼ sec. 1, T. 22 N., R. 24 E., east of the Clem Vines property and west of the Pettus Harris property (fig. 31). The property is accessible by a number of logging and field roads.

Ultramafic and mafic rocks occur in badly weathered and altered pyroxenite and amphibolite outcrops and some altered pyroxenite and amphibolite occur as occasional scattered surface float. The soil is green to greenish black and contains abundant small nodular concretions of pyroxenite.

The pyroxenite is essentially a composite mixture of interlocking bundles of short stubby enstatite crystals with incipient talc alteration. Anthophyllite and chalcedonic-anthophyllite occur in cross-fiber veins and mass-fiber bodies. Soapstone is common; it is found in outcrop and as surface accumulations, particularly in the fields adjacent to the Ware house. Prospecting has not been attempted on the property.

PETTUS HARRIS PROPERTY

The Pettus Harris property (No. 13, fig. 16) is in the SW¼NE¼ sec. 1, T. 22 N., R. 24 E., approximately half a mile north of the Dudleyville community (fig. 31). Outcrops of mafic and ultramafic rock are scarce and few were found during a cursory examination of the property. Some amphibolite and pyroxenite were found as occasional surface material along the western property boundary. Mica schist and quartz occur as float and in rock dumps in the eastern part of the property. Faint shadows and coarse textured zones in the saprolite on a wall of a 10-foot deep trench suggest that the country rock is a hornblende gneiss (with pyroxenite inclusions) similar to that seen on the Railey property and the Sorrell estate. Well-banded gneiss and schist are exposed in the floor of a large trench. Talcose and chalcedonic mass-fiber anthophyllite and talcose-pyroxenite occur as surface material in the area of exploration activity. Chalcedony boxwork fragments occur also as surface material in the immediate area of the prospect.

Exploration consists of two trenches; one cut by the Tallapoosa Mining Co. parallel to the regional strike of the country

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CAMP HILL ROAD PROPERTIES

These properties (No. 14, fig. 16) are located along the right-of-way of the Dudleyville-Camp Hill Road, in the NE¼ sec. 26, T. 22 N., R. 24 E. (fig. 32) on the Ragsdell, Vines, and Burnett properties. The pyroxenite occurs as a lens-shaped mass approximately 600 yards long and 200 yards wide. Tallapoosa County Road 87 dissects the mass for approximately 0.8 mile, parallel to a northeastward-trending major axis. Road cut exposures show irregularly shaped pyroxenite boulders enclosed in a matrix of amphibolite and chlorite. The pyroxenite is an aggregate of interlocking talcose enstatite crystals. All the material is badly weathered and identification is often difficult. The exact dimensions of the material is not defined because of soil and vegetation cover, and the deposit may be larger or smaller than indicated.

Cross-fiber veins, 2 to 3 inches wide, peripheral shell, and mass-fiber anthophyllite were found in the altered part of the ultramafic body. Chalcedony boxwork and concretions are scattered over the surface. Soapstone fragments were found in the drainage ditches bordering the road, but the property has not been prospected.

ESTES PROPERTY

The Estes property (No. 15, fig. 16) is in the E½NW¼SE¼ sec. 34, T. 23 N., R. 24 E., about half a mile south of the Buttson community. Large isolated boulders of pyroxenite are scattered through the wooded sections of the property. The pyroxenite is an enstatite-hypersthene assemblage typical of the district. All the specimens examined show alteration along the crystal boundaries to talc and anthophyllite.

Mass-fiber anthophyllite occurs as surface accumulations in an abandoned field. Soapstone fragments were found along the northern flank of the ridge which crosses through the property. Several excellent specimens of actinolite and chlorite were collected from boulders in a field-rock dump, but exploration work was not carried out on this property.

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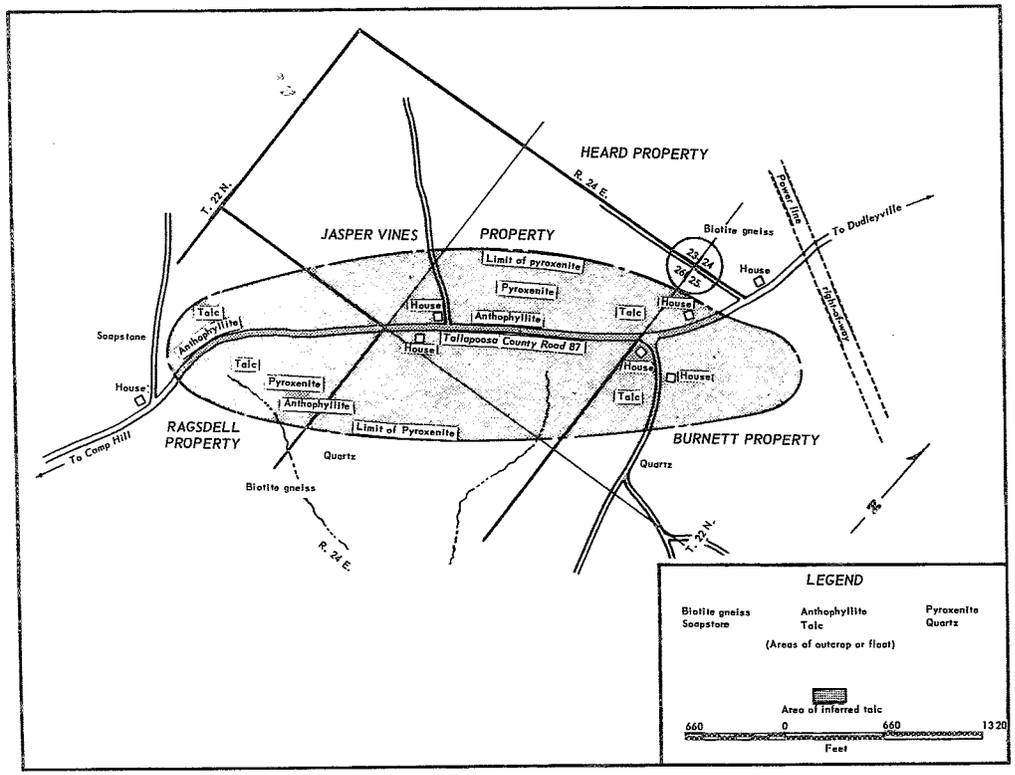


Figure 32.—Sketch map of Camp Hill Road properties.

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COOSA RIVER NEWS PRINT PROPERTY

The Coosa River News Print property (No. 16, fig. 16) lies to the east along the strike from the Estes property and is in the NW¼ and part of the S½ sec. 35, T. 23 N., R. 24 E. Pyroxenite crops out along the northern flank of the eastward-trending ridge and forms small prominent bluffs along an adjacent stream. The bluffs mark the approximate northern boundary of the mafic-ultramafic rock complex in this area. To the north, mica schist and gneiss occur as surface material. Along the crest of the ridge and to the south, abundant pyroxenite and altered pyroxenite occur as scattered float. In several areas abundant surface accumulations of pyroxenite occur. The pyroxenite is a mixture of enstatite and hypersthene with traces of bronzite. Incipient alterations of the pyroxene minerals have formed talc and anthophyllite. Some serpentine occurs at several localities.

An old abandoned road trace crosses the property. Just before it crosses a small stream, the first of a series of small pyroxenite bluffs crop out. Extending eastward from the trace, a series of shallow pits, trenches, and cuts have been opened. The material exposed from these excavations is a talcose pyroxenite. Tourmaline occurs with the pyroxenite approximately half a mile east of the road in an area of dense surface accumulations of pyroxenite. To the east of the Coosa River News Print property, an outcrop of soapstone occurs. To the south of the ridge, amphibolite, pyroxenite, and talcose pyroxenite make up the larger part of the surface material. Dense vegetation and heavy soil cover mask the limits of the various rock units.

Several boulders of mass-fiber talcose-anthophyllite occur near the site of an old home on the prospect. The prospecting work along the northern bluffs is tentatively dated as 1939-40.

JENNINGS-SATTERWHITE PROPERTIES

The Jennings-Satterwhite properties (No. 17, fig. 16) are in the SE¼NW¼ and the SW¼NE¼ sec. 36, T. 23 N., R. 24 E., approximately a quarter of a mile east along the strike from the Coosa River News Print property, and approximately a mile north of the Pettus Harris property.

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Serpentine and pyroxenite are exposed in a road cut just north of the Jennings house. Thin veins of asbestos ⅛ inch to 3 inches in width crisscross the outcrop surface. Boulders and fragments of pyroxenite occur near the upper part of the cut. The boundary of the mafic-ultramafic rock complex is represented by a narrow northeastward-trending ridge which passes through both properties. To the north and south, biotite schist and gneiss crop out. The southern boundary is also marked by an outcrop of black hornblende gneiss.

In a cotton field, along the crest of the ridge, boulders and fragments of talc, talcose-anthophyllite, and talcose-pyroxenite occur scattered across the surface. Chalcedonic anthophyllite is present toward the center of the field. The surface material extends from the vicinity of the Jennings house northeastward to the Satterwhite house, a distance of about 2,000 yards. There are several shallow overgrown depressions in the woods west of the Jennings house, but it is not known if they represent old prospect pits.

Table 9.—*Summary of trenching activity*

	Property name and number [1]	Length of cut (feet)	Depth of overburden (feet)	Length of sample trench (feet)	Length of sample (feet)
(1)	Perry Wise-Sanders	340	.....	340	283
(2)	W. B. Railey	300	2-4	270	200
(3)	Sorrell Estate	1200	1-10	1140	650
(11A)	Clem Vines, north area	300	0-4 [2]	267	267
(11B)	Clem Vines, south area	325	6-10 [2]	296	296
(13)	Pettus Harris	300	6-10 [2]	274	202

[1] Property number given by the Geological Survey of Alabama (fig. 16).
[2] Supplemental auger holes used for verification of material and overburden estimate.

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HISTORY OF MINING AND PRODUCTION

Since 1873, a number of mining companies and individuals have taken small to moderate amounts of anthophyllite asbestos from the Dadeville area. Most of the early prospecting efforts were for evaluation tests. Several tons of material would be removed from a surface or near-surface occurrence and either stockpiled in hopes of attracting larger mining interest or shipped to laboratories and producers for evaluation studies.

In 1965, the Powhattan Mining Co. began small-scale mining activities on the Garfield Heard property, near the eastern end of the anthophyllite district (fig. 33). The property was worked intermittently during the following year and several carloads of anthophyllite were shipped to a Baltimore processing plant. At present no other mining company is active.

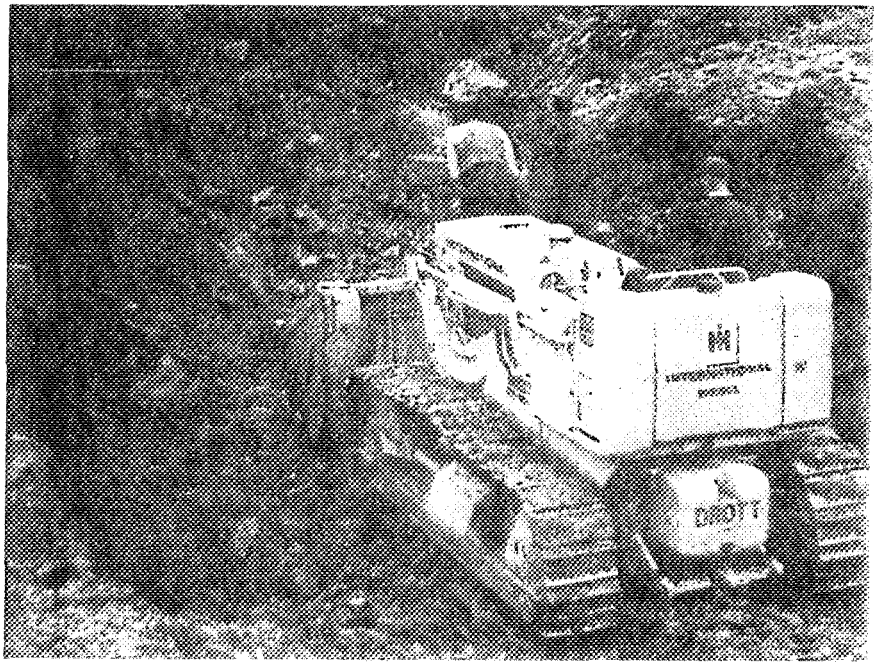


Figure 33.—Excavation of small open pit on the Garfield Heard property, 1965.

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In 1963, the American Talc Co. did preliminary exploration drilling for talc on the Prather property. The results of their work were inconclusive. Over the years several attempts have been made to interest various talc producers to develop the material but without success.

MINING METHODS

Simple mining methods are employed in the extracting and recovery of anthophyllite asbestos because of the size, shape, and occurrence of the deposits. Open-cut methods are generally used. In many instances, the ore is recovered entirely by hand labor using picks, shovels, and wheelbarrows. Auxiliary equipment may include bulldozers, front-end loaders, draglines, and pneumatic drilling equipment (fig. 34).

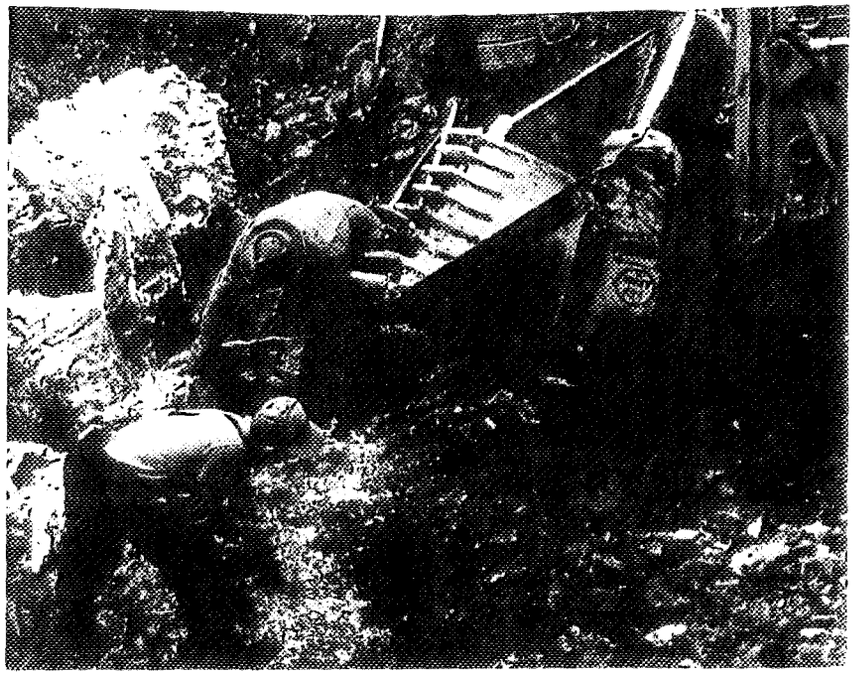


Figure 34.—Hand loading of anthophyllite material after excavation.

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Most of the anthophyllite mined to date in Alabama has been from shallow deposits. Both vein and mass-fiber material have been recovered. Ore near the surface is usually quite soft and can be removed by hand methods. With depth, the anthophyllite becomes harder and more compact and hammers and dynamite are employed to break up the larger masses.

Open cuts are limited in depth by hard rock but often groundwater seepage makes continued excavation difficult. Also, the saprolite wall rock tends to become unstable when wet making deep excavation hazardous. It should be noted that many of the early prospect shafts and trenches, which are entirely within the amphibolite-pyroxenite boundaries, have stood open without shoring for several decades.

The recovery of talc has not been attempted in the Dadeville area. Mining methods would by necessity take the form of large-scale open-pit operations. Primary recovery would consist principally of the separation of the large nodules and boulders of massive talc and talcose-anthophyllite from the associated saprolite by a log washer operation. Bulldozers, scraper pans, front-end loaders, and draglines would constitute the principal items of earth-moving equipment required. Mining depth would be limited by depth to hard rock, but observations indicate that depths to 30 feet are feasible.

RESERVES

The nature and occurrence of the anthophyllite and talc deposits makes it difficult to formulate an estimate of the potential total reserves of these materials in the Dadeville area. The occurrence of talc appears to be far greater than the available anthophyllite but insufficient exploration, a saprolite zone of varying depth, and limited outcrop information foreshadow any estimate.

Market requirements for lower grade mass-fiber asbestos would dictate the quantity of anthophyllite that might be minable. Reserve estimates of the vein-type asbestos cannot be computed. Based on past exploration and observations during this study, it is possible that a considerable tonnage of anthophyllite asbestos of all varieties may be derived as a primary product, or as an indirect secondary recovery product from talc production.

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The total potential talc-anthophyllite-bearing zone of the Dadeville amphibolite belt may encompass as much as 6,800 acres of timberland and farmland. Based on field observations, it is possible that 25 percent or 1,700 acres of the land could contain talc or talcose material.

Prospect pits and road cuts indicate that the talc occurs to depths of at least 30 feet. The crude talc is mixed with varying parts of saprolite clay, thin seams of anthophyllite, pyroxene alteration products, and unaltered pyroxene. The amount of talc in the crude ore ranges from 3 to 26 percent. In preparing tonnage estimates for this report only material yielding more than 15 percent talc was considered. A large-scale recovery test would more accurately establish a finite recovery and percentage figure.

Ore estimate data for five properties are given in table 10. Although little data are available to substantiate the tonnage estimates, it is believed that the results are within the limits of error for the investigation. A tonnage factor of 3,700 tons per acre-foot was used to estimate the potential talc ore in the Dadeville area. Tonnage factor calculations are as follows:

	43,560	sq ft/acre
	1	ft thickness
	43,560	ft^3/acre-foot
Estimated wt. 1 ft^3	170	lbs/ft^3
	7,405,200	lbs/acre
@ 2,000 lb/ton	3,700	tons/acre-foot

Table 10.—*Ore reserve estimates*

	Property name and number	Area (acres)	Expected depth (feet)	Tonnage factor (tons/acre-foot)	Crude material (tons)[1]	Talc (percent)[2]	Talc (tons)[1]
(1)	Perry Wise-Sanders	80	30	3,700	8,900,000	16.1	1,400,000
(3)	Sorrell Estate	108	30	3,700	12,000,000	17.4	2,100,000
(5)	Knight	50	30	3,700	5,550,000	[3](19.7)	1,090,000
(11A)	Clem Vines, north area	86	30	3,700	9,950,000	25.9	2,580,000
(12)	Clarence Ware	36	30	3,700	4,000,000	[3](19.7)	790,000
Total acres represented		360					
Average grade						19.7	
Total tons of talc							7,960,000
Total talc-anthophyllite area (acres)		6,800					
Potential talc-bearing acres		1,700	[4]15	3,700	94,500,000	19.7	18,620,000

[1] All numbers rounded.
[2] Based on beneficiation studies.
[3] Not included in calculations for average grade.
[4] Minimum average depth.

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