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UNITED STATES DEPARTMENT OF THE INTERIOR

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TALC AND ASBESTOS AT DADEVILLE, ALA.

by

Thornton L. Neathery,[1] Herbert P. LeVan,[2]
H. William Ahrenholz,[3] and James F. O'Neill[3]

ABSTRACT

Geologic investigation of a mineralized zone in eastern Alabama indicates that large quantities of talc and soapstone are scattered over a wide area close to the surface. Laboratory experiments show that this material may be upgraded to a high-quality talc. A market survey indicates that the talc deposits may be of current and long-range interest. The anthophyllite asbestos which is associated with the talc does not appear to occur in sufficient quantities to be considered as a primary commercial source.

INTRODUCTION

A cooperative program between the Geological Survey of Alabama and the Federal Bureau of Mines was initiated to investigate the deposits of talc and asbestos at Dadeville, Tallapoosa County, Ala. This investigation was authorized under the general Appalachian program for encouraging the establishment of new industries within the Appalachian Area, under Public Law 89-301.

The work was divided as follows:

Bureau of Mines Mineral Resource and State Geological Survey personnel selected the sites to be sampled.

Survey personnel performed the geological investigation, sampled the deposit, and prepared the maps and the sections of this report on the geology and extent of the deposits.

Bureau of Mines Tuscaloosa Metallurgy Research Laboratory personnel performed analytical and beneficiation studies on the samples and prepared the section of the report covering its work.

Bureau of Mines Mineral Resource personnel also conducted a market analysis study for possible products from the deposits and prepared an economic study of the industry.

[1]Geologist, Geological Survey of Alabama, Tuscaloosa, Ala.
[2]Research chemist, Bureau of Mines, Tuscaloosa, Ala.
[3]Mining engineer, Bureau of Mines, Tuscaloosa, Ala.

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Many persons have made contributions to this investigation and their assistance is appreciated. Particularly helpful have been W. H. Barnes, Judge Probate, Tallapoosa County; J. C. Pritchard, Road Commissioner, District 3, Tallapoosa County; J. A. Abrams, Mayor of Dadeville; Mrs. Marian Tucker, Dadeville; Claude T. Bartlett, Camp Hill; and Donald G. Ferrell, President, Black Warrior Petroleum Company, Mobile.

LOCATION

The Dadeville area is in east-central Alabama in Tallapoosa and Chambers Counties (fig. 1). The area lies within the Inner Piedmont region of Alabama which coincides with the Opelika Plateau physiographic division.

The area is underlain by an alternating sequence of resistant and non-resistant weathered metamorphic rock which influences the topography by its general strike and dip. Altitudes range from 800 to 900 feet with an occasional hill rising above the general surface.

Most of the land has been under cultivation in the past, but it is now used for dairy farming or has been given over to pulp wood timber.

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

Dadeville, County Seat of Tallapoosa County, is the railhead for the area. The Central of Georgia Railroad operates north to Birmingham and to connecting railroads and southeast to Opelika, Ala., and Columbus, Ga. Another branch of the Central of Georgia Railroad also passes through the eastern end of the area at Lafayette, County Seat of Chambers County.

HISTORY

The occurrence of anthophyllite asbestos and associated talc in the Dadeville area of Tallapoosa County, Ala., was first noted by E. A. Smith in 1873 at several prospects opened in a search for corundum. Although commercial interest has been intermittent, neither systematic nor detailed geologic examination had been undertaken in the area until recently.

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

In 1953, the Red Hawk Mining Company conducted exploration activities in the western end of the Dadeville area, opening seven or eight large bulldozer trenches and possibly several smaller ones. It is not known if the company removed any material for testing.

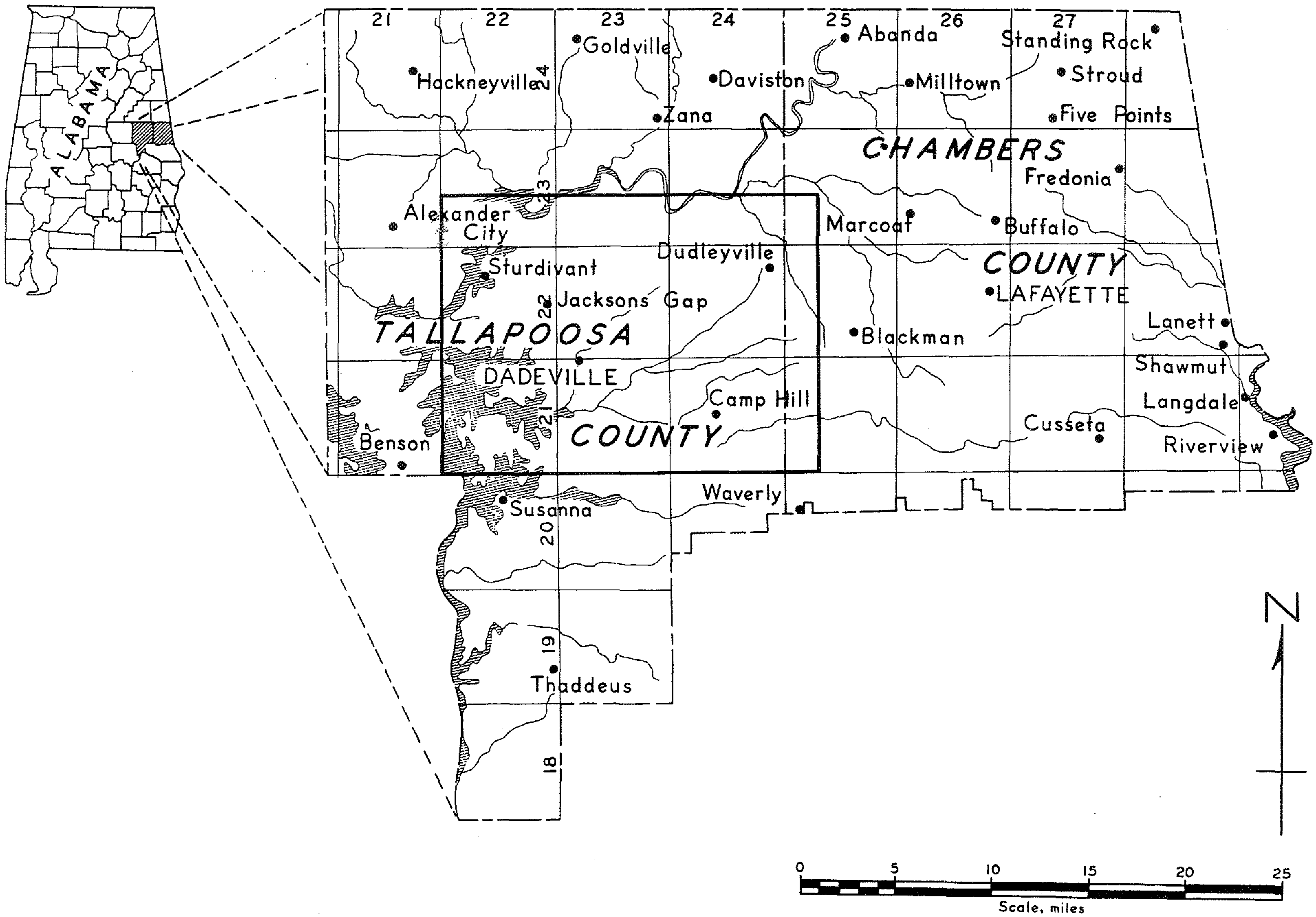

FIGURE 1. - Index Map of Study Area.

In 1963, the American Talc Company obtained options on several hundred acres of farmland in the east-central part of the area. Twelve diamond-drill holes were completed. The Geological Survey of Alabama furnished technical assistance in interpreting the drill-hole data.

Also in 1963, the Tallapoosa Mining Company 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 anthophyllite material which was subsequently used for product testing. In 1965, the company's land interest was conveyed to the Black Warrior Petroleum Company.

In 1965, the Powhatan Mining Company began sampling for anthophyllite asbestos near the eastern end of the district. Sampling continued during 1966, and several carloads of crude material were shipped from Dadeville for test purposes.

In 1965, the Alabama Geological Survey conducted a mapping and prospecting program in an effort to determine general areal limits, mineralogy, grade, and estimated tonnage of materials available. Although the purpose of this investigation was to gather information concerning the distribution, character, origin, and potential reserves of anthophyllite asbestos, it became apparent that the associated talc was of sufficient quantity to warrant expanding the scope of the project.

GEOLOGY

Talc and anthophyllite deposits occurring in the Dadeville area are associated with a complex group of calcic-magnesium mafic and ultramafic rocks which range in composition from hornblende gneiss and enstatite pyroxenite to soapstone. They form the southern part of a discontinuous belt of mafic and ultramafic rocks which occur within the crystalline gneisses and schists of eastern North America extending from east-central Alabama to western Newfoundland. In Alabama these rocks crop out in two narrow arcuate rock-unit bands extending from the vicinity east of Dudleyville westward to the southwestern part of Tallapoosa County, a distance of approximately 20 miles (fig. 2).

Because of the diverse character of the mafic and ultramafic rocks, as they occur in the Inner Piedmont of Alabama, the following terminology is used to generally describe the various rock-type groups; however, origin connotations are not inferred. The term amphibolite is used for all schistose, mafic rock types which are composed essentially of amphibole minerals (hornblende, actinolite, tremolite, etc.). Mafic rocks are composed of 50 percent or more ferromagnesian minerals (hornblende, pyroxene, and olivine) and with an increase in the dark mineral content grade into the ultramafic rocks. Often they may have faint lineations indicating a degree of metamorphism. The ultramafic rocks are composed of heterogeneous aggregates of enstatite, hypersthene, and bronzite.

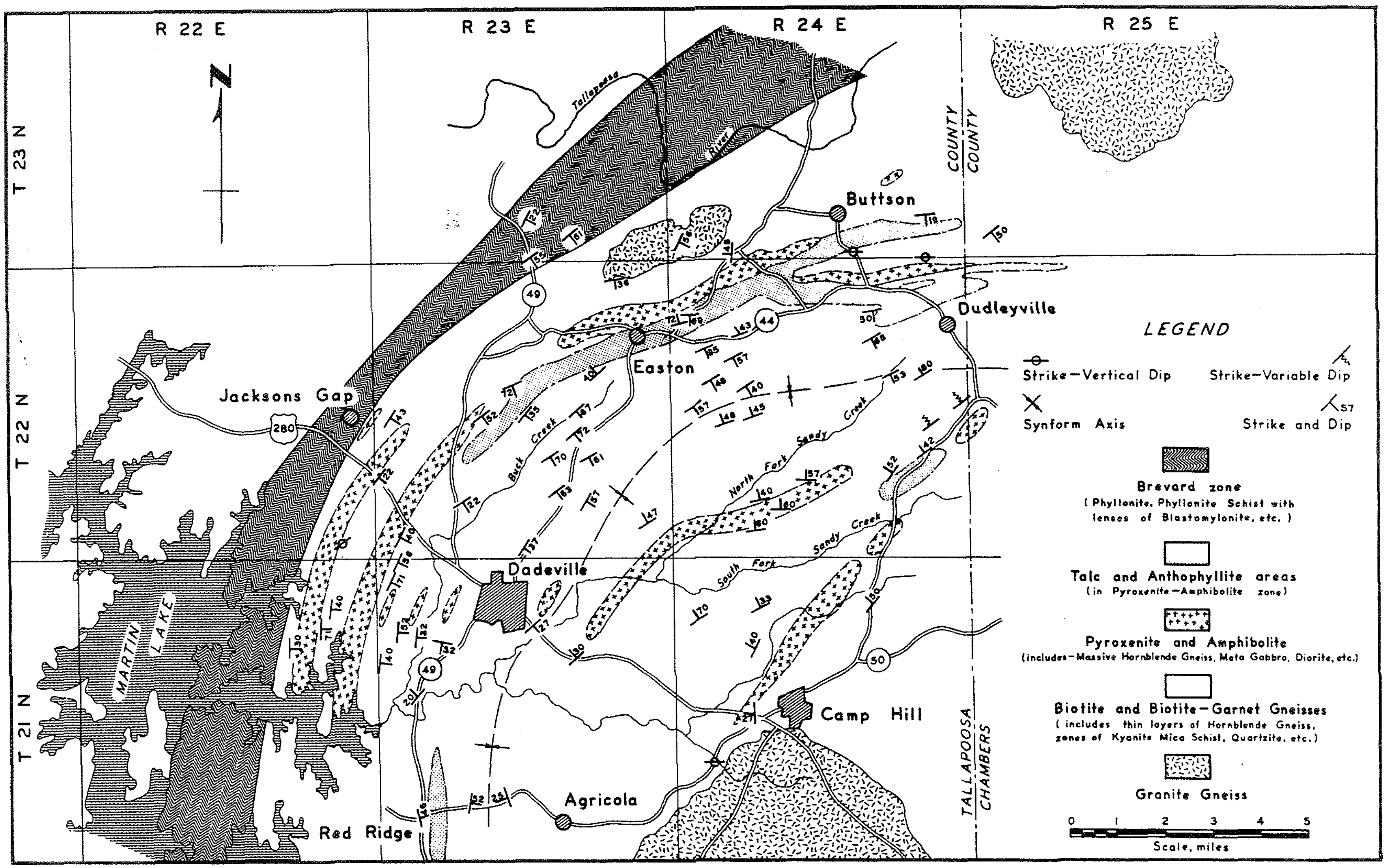

FIGURE 2. - Geologic Rock-Type Map of the Dadeville Area. (Geology by T. L. Neathery—Geological Survey of Alabama.)

The mafic and ultramafic rocks are found within a series of paraschists, paragneisses, extrusive and intrusive igneous rocks, and irregular granitic bodies, all of high metamorphic rank. Together, these rocks comprise the Dadeville Belt of the Inner Piedmont of Alabama. Biotite- and biotite-garnet gneiss and schist are the major rock types observed in the field, although hornblende gneiss, garnet-kyanite-mica schist, quartzite, and mica schist also occur. The contacts between many of the gneisses and schists are gradational. Masses of granitic rocks are scattered throughout the area. At several places, thin pegmatites cut across amphibolite zones. In Chambers County, northwesterly striking diabase dikes cut across the Dadeville Belt.

The paraschists and gneisses 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 suggests minor cross folding. Field mapping indicates that the regional structure is a broad synform trending northeastward from south of Dadeville to the granite outcrops in Chambers County and possibly beyond.

The amphibolite, mafic, and ultramafic areas are extensive in number and size. Outcrop areas tend to be elongated with the regional trend, often exceed 6 miles in length and have variable widths ranging from 100 feet to more than 1 mile. Exposures are few, and outcrop boundaries of the zones cannot be mapped accurately. Four areas are briefly described:

1. West of Alabama State Highway 49, amphibolite rock crops out in two large, distinct, separate bands and several minor ones which have not been delineated. They are essentially greenstones containing small metaultramafic bodies and zones of soapstone. The greenstones are composed predominantly of green hornblende (possibly edenite), epidote, actinolite, chlorite, and talc. The metaultramafic bodies are 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. A major zone of ultramafic rock crops out in the vicinity of the North Fork of Sandy Creek and north of Camp Hill. Its longitudinal limits are concealed by saprolite and dense vegetation. Most of the ultramafic rock is essentially enstatite with disseminated talc and anthophyllite. One pyroxenite body has a high percentage of anthophyllite and talc.

4. East of Alabama State Highway 49, a prominent zone of mafic and ultramafic rocks has been mapped. The bands of amphibolite which occur west of Highway 49 appear to converge into a singular irregular mass east of the highway. This mass is a complex assemblage of various mafic and ultramafic rocks composed predominantly of pyroxenite-bearing amphibolites, pyroxenite bodies, serpentinite zones, hornblende gneisses, and gabbros. In the central part of the zone, near Easton, outcrops suggest overfolding.

Pyroxenite outcrops exhibit distinct and easily distinguishable characteristics unrelated to the enclosing gneisses and schists. The contact between mafic-ultramafic zone and the surrounding gneisses and schists is usually sharp. The pyroxenites are massive and more resistant to weathering than the foliated gneisses and schists and generally form a barren surface, or one having a thin soil zone covered by sparse vegetation (fig. 3). The soil contains abundant small boulders, cobbles, and nodules of weathered pyroxenite, greenish-gray to yellowish-green in color, locally known as "buckshot" soil (figs. 4 and 5). These often have an ocherous crust which grades into yellowish-green centers of coarsely crystalline pyroxenite. Some have a hard iron-oxide shell enclosing talc with or without anthophyllite. Several outcrops contain massive boulders displaying thin anthophyllite veins in raised relief against a matrix of pyroxene (fig. 6).

Most of the associated hornblende gneisses and gabbroic rocks weather rapidly, forming clayey soils. These are generally reddish-black to greenish-black, often containing irregular fragments of quartz. Some of the more massive hornblende gneisses and metagabbros are resistant to weathering and form blocky outcrops with fragments scattered throughout the soil cover.

FIGURE 3. - Pyroxenite Outcrop.

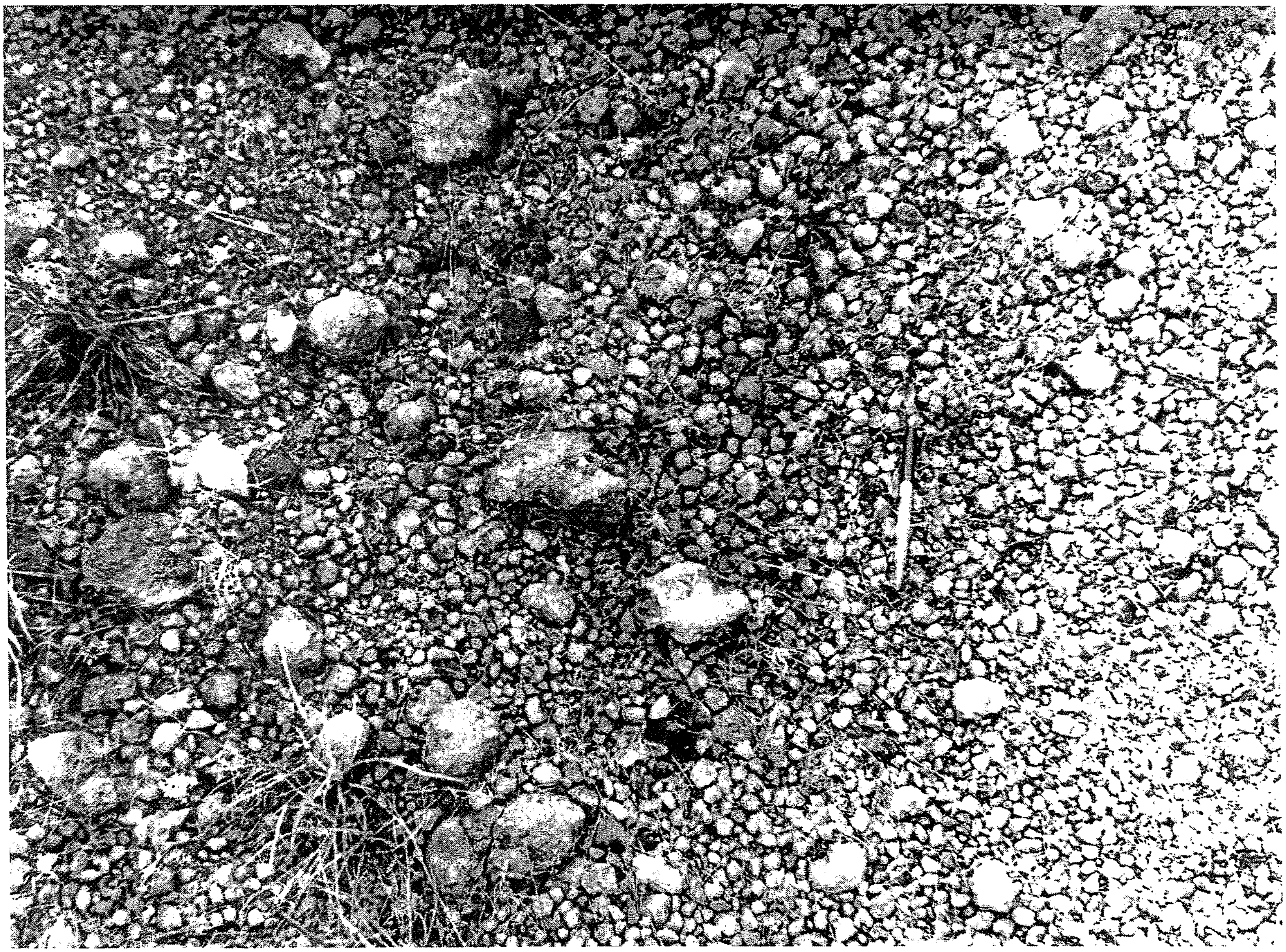

FIGURE 4. - Typical "Buckshot" Soil Derived From the Decomposition of Pyroxenite.

FIGURE 5. - Pyroxenite Boulders Weathering From Hornblende Gneiss.

FIGURE 6. - Anthophyllite Veins in Raised Relief on a Pyroxenite Boulder.

The mafic and ultramafic rocks represent a wide variety of distinct but related rock types which have been involved in one or more episodes of regional metamorphism. Four processes of alteration are recognized in the Alabama ultramafic rocks: (1) Steatitization, (2) amphibolization, (3) serpentinization, and (4) chloritization.

All these processes occurred more or less together throughout the length of the mafic-ultramafic belt and are probably physiochemically related. However, one mode of alteration generally predominated over the other three and thus one portion of the belt may be characterized by a certain alteration product, such as talc or anthophyllite.

Serpentinization and chloritization are localized and represent only minor phases of the alteration products. As such they contribute little to the economic potential of the talc-asbestos deposits.

The processes of steatitization and amphibolization are the most widespread. They are present to some extent in all the mafic and ultramafic rocks.

Since the products of steatitization and amphibolization result in the formation of talc and anthophyllite, a brief statement of their formation is given in the paragraph that follows.

Steatitization is the alteration of mafic and ultramafic rocks, resulting in the formation of talc. Talc is a common-to-major constituent in the Dadeville Belt. It appears to have been derived during regional metamorphism from the alteration of olivine, pyroxenes, and amphiboles in the presence of water, carbon dioxide, and silica at temperatures below 800° C. Talc may develop on olivine or enstatite boundaries as scales oriented either along cleavage cracks or irregularly distributed within the mineral grain, which may result in total replacement of the host mineral. Talc may also develop from anthophyllite, usually developing parallel to the cleavage of the anthophyllite crystals. Steatitization may progress to the state where the amphibolite or ultramafic body is more or less a talcose rock or soapstone.

The talc in the Dadeville area is predominantly a "talc-rich" soapstone which occurs as shell-like entities and boulders in the saprolite overlying the mafic-ultramafic rock complex. Major talc concentrations are found between Dadeville and Dudleyville (fig. 7). The accumulations occur as thick blankets overlying extensive areas and consist of clay, sand, talc, anthophyllite, soapstone, and rock fragments. The total extent of the deposits has not been determined.

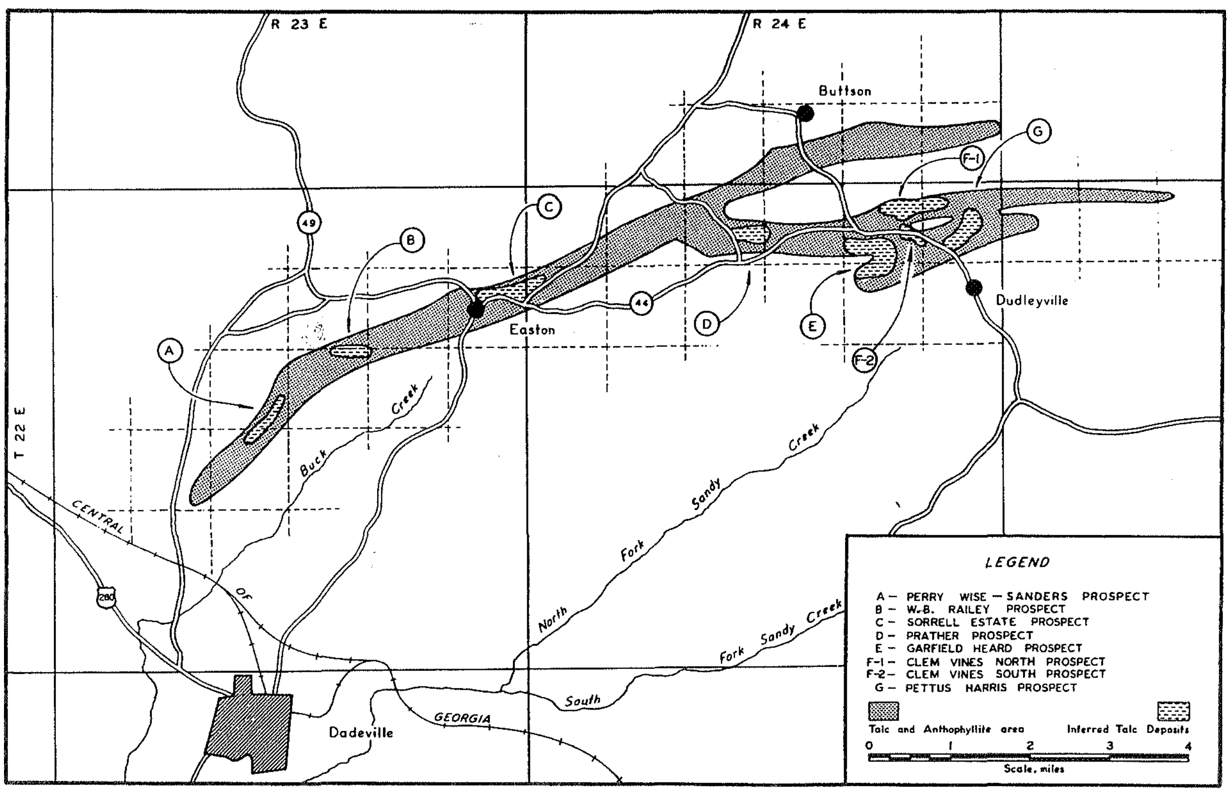

FIGURE 7. - Inferred Talc Deposits. (Geology by T. L. Neathery–Geological Survey of Alabama.)

Amphibolization is the alteration of pyroxenes (enstatite, hypersthene, olivine, etc.) to amphibole minerals (anthophyllite, hornblende, actinolite, tremolite, etc.). Such alteration of olivine and enstatite is common in Appalachian ultramafic rocks. Pyroxenite may alter to anthophyllite under water-rich conditions at temperatures between 667° C and 745° C (7);[4] under water-deficient conditions anthophyllite could form as a stable phase at temperatures below 500° C (1). Olivine alteration is not controlled by any physical property of the mineral. Amphibole needles appear to penetrate the olivine crystals without regard to boundaries, cleavages, or cracks. The alteration of enstatite to amphibole is similar. The amphibole commonly formed in the Dadeville area is the orthorhombic variety, anthophyllite.

Based on arrangement of the fibers to the wall rock and to each other, three types of anthophyllite asbestos are recognized: cross-fiber, slip-fiber, and mass-fiber. Cross-fiber and slip fiber veins are formed in tension fractures in the pyroxenite. Anthophyllite formed as interlocking bundles of fibers in massive pyroxenite is referred to as mass-fiber asbestos. Most occurrences of asbestos are found in the eastern part of the mafic-ultramafic belt where deformation appears to have been intense.

DESCRIPTIONS OF DEPOSITS

Many occurrences of talc and anthophyllite have been noted in the Dadeville area. This report describes several of the deposits which were investigated by the Geological Survey of Alabama (see fig. 7). The selection of the deposits to be sampled was made jointly by the Survey and Bureau personnel. Alphabetical letters A-G were assigned to the prospects examined. Numbers were assigned to the samples which were taken for investigation and research. None of the deposits has been operated commercially, but a large sample was shipped from one of the properties by Powhatan Mining Company for testing in 1965.

Perry Wise-Sanders Prospect (A)

The Perry Wise-Sanders prospect is 4 miles north of Dadeville, in parts of secs 16 and 21, T 22 N, R 23 E. 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 (fig. 8).

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 found scattered over the land surface, especially in wooded areas on and surrounding the Wise property. The rock is an interlocking aggregate of enstatite crystals with minor amounts of hypersthene. Both pyroxenes show alteration to talc and, commonly, anthophyllite.

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[4] Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

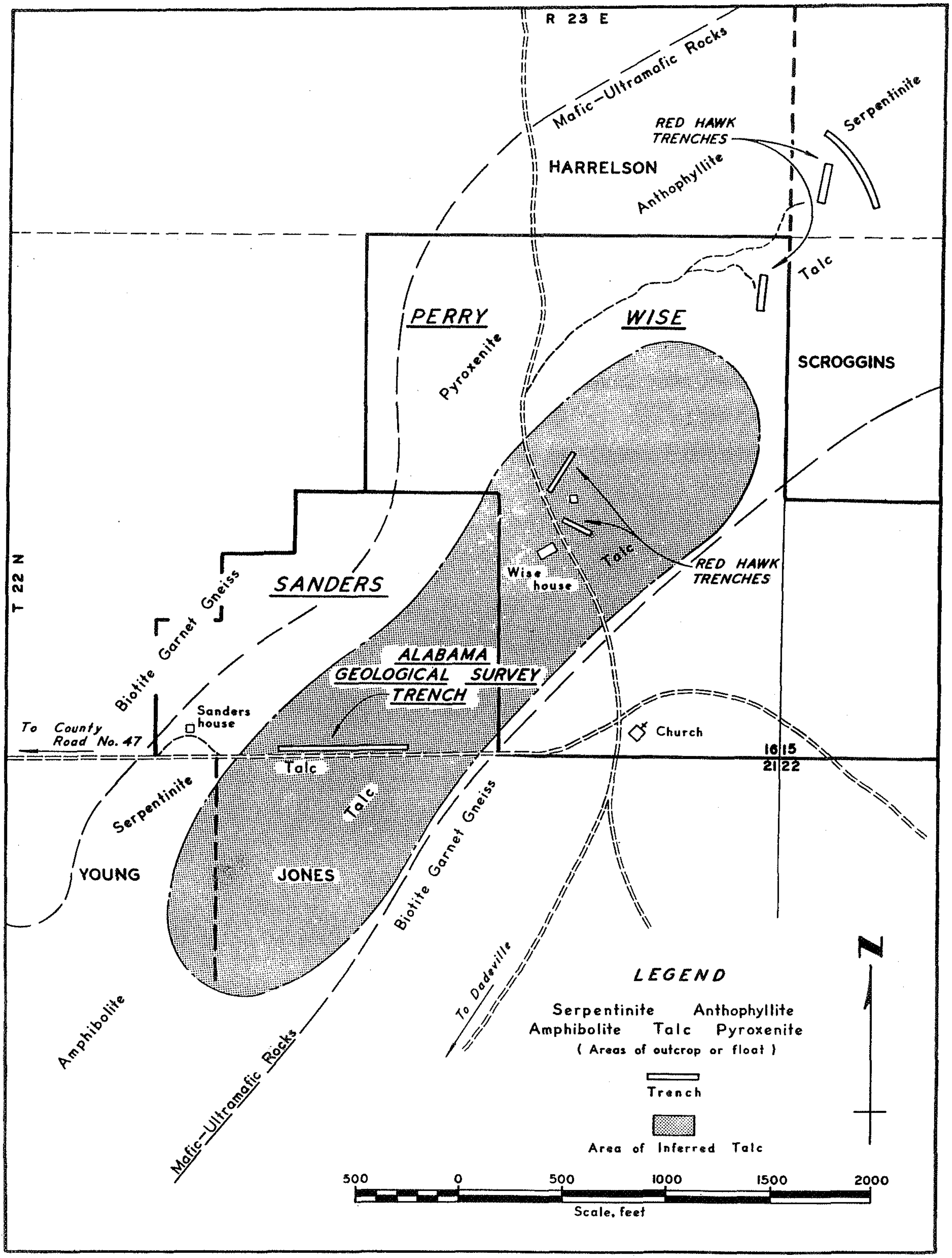

FIGURE 8. - Sketch Map–Perry Wise-Sanders Prospect. (Geology by T. L. Neathery–Geological Survey of Alabama.)

Near the mafic rock boundaries, the talcose material becomes hard and has a texture similar to the enstatite rock or mass-fiber anthophyllite. Veins of talcose-anthophyllite, one-eighth to 1 inch wide, crisscross the face of several of the pyroxenite outcrops. Thick zones of chlorite and vermiculite suggest internal shearing within the mafic-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 bodies of talc, ranging from one-half 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. 9).

In 1953, the Red Hawk Mining Company, in an effort to develop an anthophyllite deposit, excavated three large trenches on the Perry Wise property

FIGURE 9. - Road Cut East of Sanders House. Peripheral shell-like boulders exposed in saprolite.

and two large trenches 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 the talc visible along the section-line road. The remaining three trenches exposed serpentinite and enstatite rock, containing small veins of anthophyllite and talcose-anthophyllite.

The talc zone exposed along the road right-of-way east of the Sanders house was bulk sampled as part of the present project. A narrow trench, 16 inches deep, was cut parallel to the road on the shoulder after removal of superficial material (fig. 10). A log of the material in the trench is shown in table 1. Talc, talcose-anthophyllite, and several small veins of anthophyllite were cut. Two thin quartz-mica pegmatites were exposed; one at the eastern end and one at the western end of the trench.

TABLE 1. - Trench section, Perry Wise-Sanders Prospect (A)

Location: Sample 1; road cut SE¼ sec 16, T 22 N, R 23 E, north side of road; on road base; azimuth, 270°; top 6 inches of road base removed. Sample trench: 8 inches in width by 16 inches in depth by 340 feet in length.

Interval, feet:	Description
[1]0 to 3	Yellowish-tan clay saprolite.
3 to 12	Yellowish-buff saprolite.
12 to 30	Reddish-gray to maroon saprolite.
30 to 212	Buff-tan saprolite with hard, greenish-gray talc boulders at 34, 37, 41, 48, 54, 59, 72, 76, 81, and 84 feet; hard, green talc at 95 feet; hard greenish-gray talc boulders at 100, 112, and 121 feet, from 133 to 140 feet, at 145, 176, and 184 feet, and from 200 to 212 feet; anthophyllite fibers scattered from 125 to 212 feet.
212 to 225	Pink-tan saprolite with occasional talc boulders.
225 to 229	Hard, gray-white talc.
229 to 239	Brown saprolite.
239 to 242	Hard, partly altered talcose hornblendite, tremolite crystals.
242 to 251	Orange-brown to pink saprolite; few talc boulders.
251 to 255	Hard, gray-white talc.
255 to 259	Black hornblende, talcose, limonite crusts.
259 to 267	Brownish-tan to pink saprolite with occasional talc boulders; mostly feldspar pegmatite.
267 to 283	Yellow-tan saprolite, talc saprolite with thin stringers of pegmatite; large talc boulders at 280 feet.
283 to 285	Pegmatite, strike N 33° W, dip NE 33°, 1 to 2 feet thick, injected between talc seams; not sampled.
285 to 340	Brown to tan saprolite and soil; not sampled.

[1]Beginning at east end of trench.

FIGURE 10. - Sampling Trench Cut on Perry Wise-Sanders Prospect. Humps in trench are massive talc boulders, later removed by pick and axe.

W. B. Railey Prospect (B)

The Railey Prospect is in the N½NE¼ sec 15, T 22 N, R 23 E, about one-half a mile northeast of the Perry Wise property (A) (see fig. 11). The soil zone had been removed by bulldozer stripping from a number of acres of previously cultivated land, and subsequent erosion exposed the underlying bedrock in many localities.

The bedrock is a well-banded hornblende gneiss amphibolite which encloses irregularly shaped and randomly sized inclusions of ultramafic rock (fig. 12). 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 one-eighth inch to 24 inches in diameter and comprise more than 50 percent of the upper level of the exposed saprolite zone.

In 1953, the Red Hawk Mining Company cut two large trenches, one normal to the strike and one parallel to the strike of the ultramafic belt. The

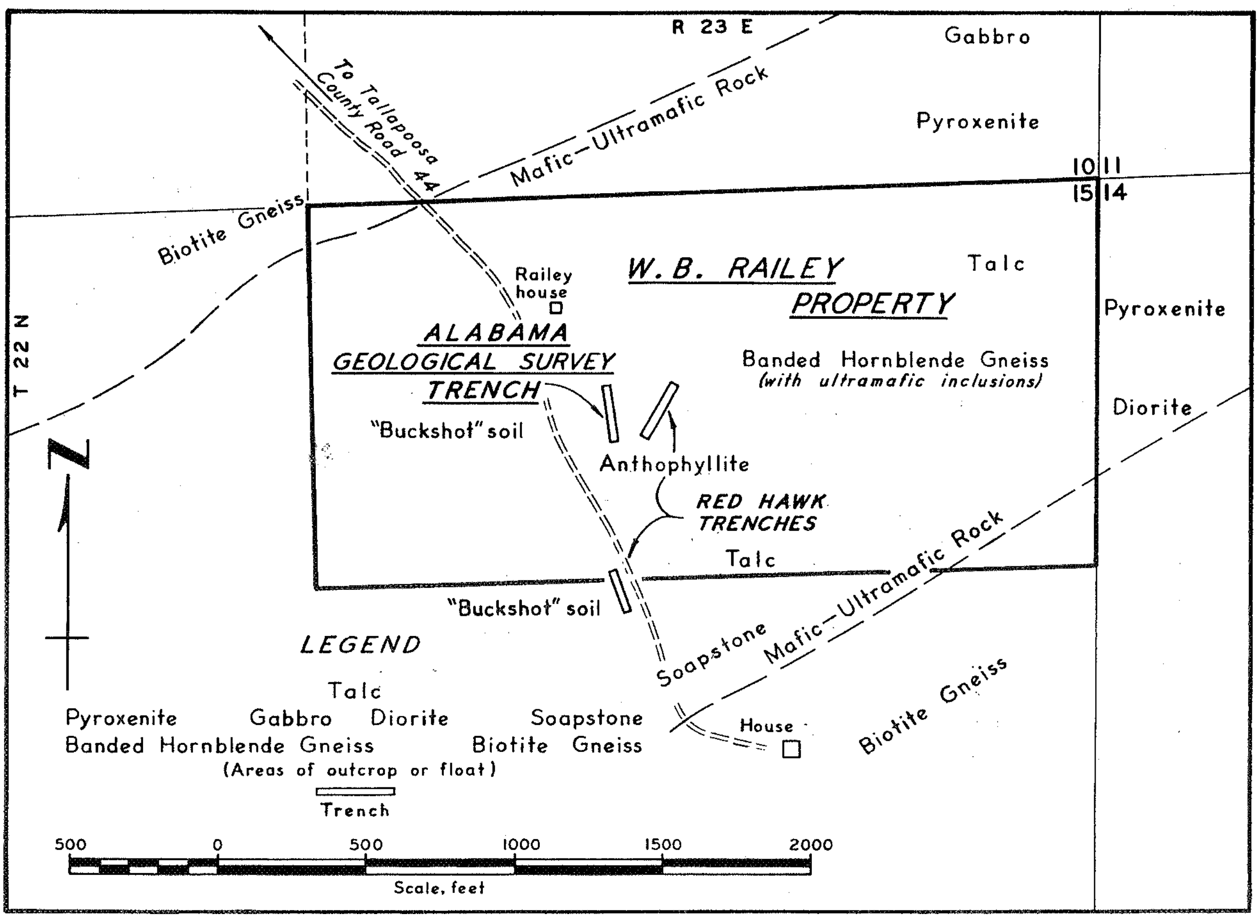

FIGURE 11. - Sketch Map—W. B. Railey Prospect. (Geology by T. L. Neathery—Geological Survey of Alabama.)

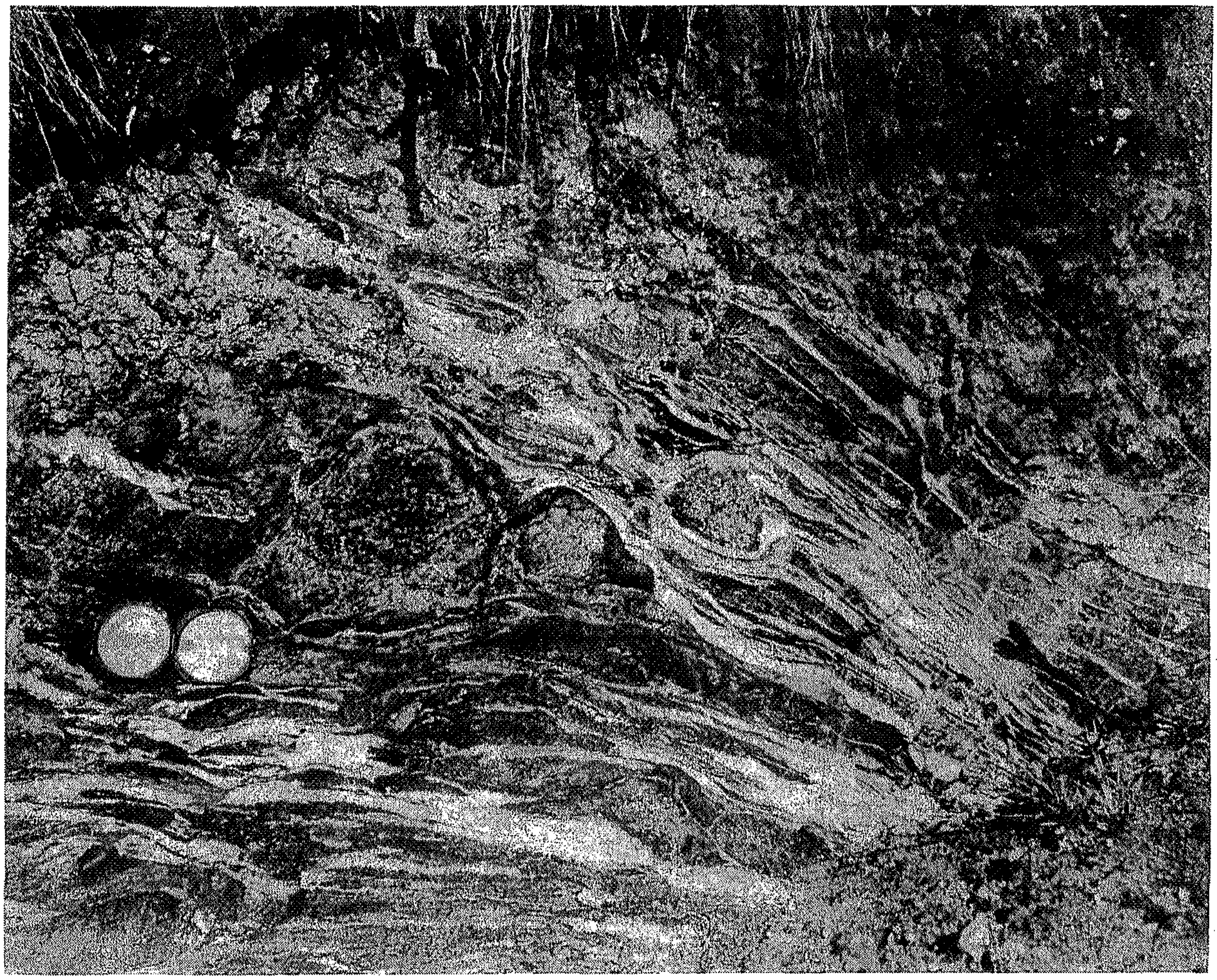

FIGURE 12. - Pyroxenite Inclusions in Banded Hornblende Gneiss.

trench nearest the 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. A log of the material in the trench is shown in table 2. The material exposed consisted of saprolite, chlorite, vermiculite, thin-vein anthophyllite, apple-green talc, and alluvium.

TABLE 2. - Trench section, W. B. Railey Prospect (B)

Location: Bulldozer cut trench 300 feet in length; azimuth, 165°; depth of cut, 2 to 4 feet. Sample trench: 8 inches in width by 16 inches in depth by 270 feet in length.

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

[1]Beginning at north end of trench.

Sorrell Estate Prospects (C)

The Sorrell Estate prospects are on a large tract of timberland in parts of secs 1 and 12, T 22 N, R 23 E, and sec 7, T 22 N, R 24 E, in the vicinity of Easton (fig. 13).

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 manganese 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.

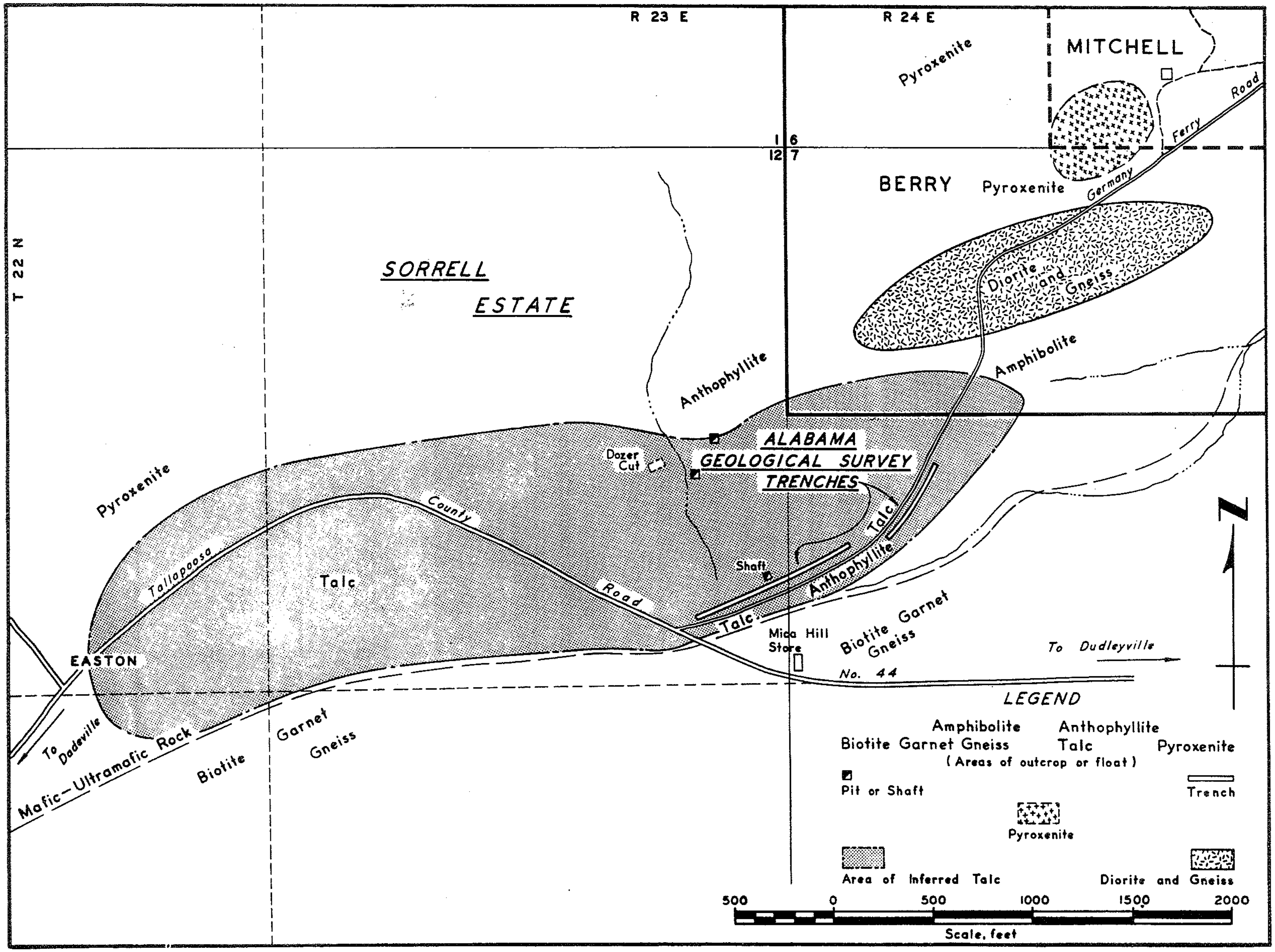

FIGURE 13. - Sketch Map–Sorrell Estate Prospect. (Geology by T. L. Neathery–Geological Survey of Alabama.)

Talc, talcose-anthophyllite, and talcose-pyroxenite occur mostly as surface materials, and 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 was cut, as part of this project, approximately 650 feet in length along the Germany Ferry Road right-of-way, beginning at the junction of the Germany Ferry Road and Tallapoosa County Road 44. A log of the material in the trench is shown in table 3.

TABLE 3. - Trench section, Sorrell Estate Prospects (C)

Location: Sample 2; right-of-way Germany Ferry Road; bulldozer cut trench 1,200 feet in length; azimuth, 65°, from 0 to 815 feet; azimuth, 56°, from 815 to 900 feet; azimuth, 50°, from 900 to 1,000 feet; azimuth, 45°, from 1,000 to 1,100 feet; depth of cut, 1 foot. Sample trench: 8 inches in width by 16 inches in depth by 650 feet in length.

Interval, feet:	Description
[1]0 to 8	Large talc boulders, hard, fractured, filled with clay seams, partly altered pyroxenite fragments.
8 to 220	Tan saprolite containing variable-sized boulders and cobbles of talc, very firm, some hard zones; large talc boulders from 42 to 52 feet, at 57, 97, 118, and 139 feet.
220 to 231	Dark brown saprolite, iron-manganese rich nodules.
231 to 383	Tan saprolite, talc boulders increasing in number and size; large hard talc boulders at 276 feet; hard talc from 322 to 324 feet, from 334 to 338 feet, and from 378 to 383 feet.
383 to 420	Soil and talc, saprolite, soil, black loam saprolite, tan with boulders of talc.
420 to 432	Tan to reddish-tan saprolite, abundant talc blebs, cobbles, and boulders.
432 to 452	Black loam, little saprolite, large cobbles and boulders of hard talc.
452 to 479	Red-brown to gray saprolite, some talc, high-iron nodules; hard silica gossan at 450, 455, and 461 feet.
479 to 483	Green to silver-gray talc zone, chlorite, vermiculite, talc, tremolite, boulders of silica gossan and limonite.
483 to 650	Red-tan saprolite, talcose, few blebs of talc, talc cobbles, and silica gossan; hard talc boulders at 508 feet and 512 feet, from 521 to 526 feet, from 531 to 533 feet, from 550 to 553 feet, from 569 to 571 feet, and at 650 feet.
650 to 716	Black loam overlying talc and talc saprolite exposed in lower 4 inches of trench; scattered boulders of hard white talc; not sampled.
716 to 815	Reddish-tan talcose, saprolite; talc boulders at 747, 767, 803, and 856 feet; not sampled.
815 to 900	Reddish-tan saprolite, talc boulders at 837 feet, from 845 to 851 feet, and from 855 to 861 feet; anthophyllite seam at 874 feet; not sampled.
900 to 1,140	Reddish-brown saprolite, talc cobbles, some anthophyllite at 974 feet, high iron, very clayey; not sampled.

[1] Beginning at southwest end of trench.

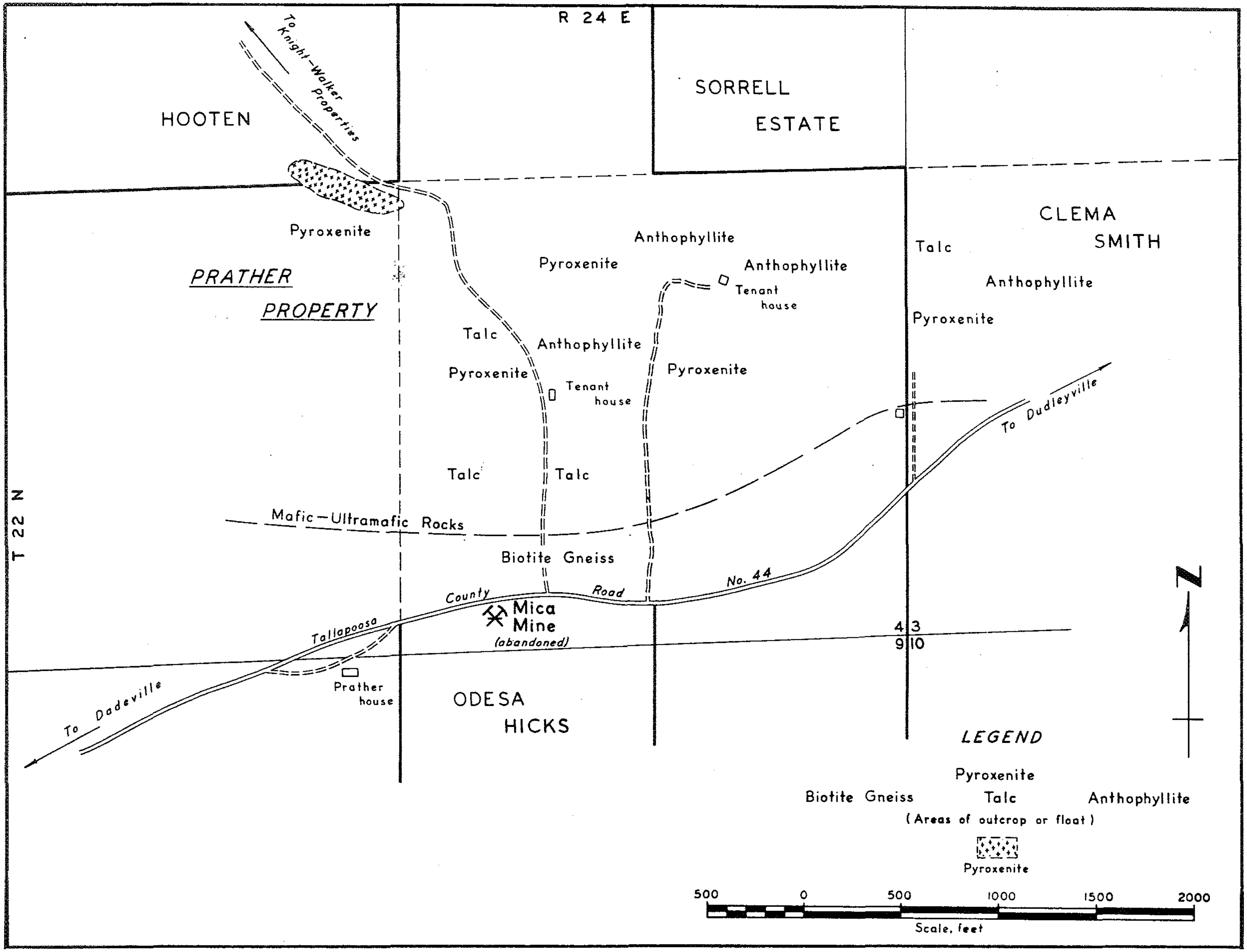

FIGURE 14. - Sketch Map—Prather Prospect. (Geology by T. L. Neathery—Geological Survey of Alabama.)

Prather Prospect (D)

The Prather prospect is in the SE¼ sec 4, T 22 N, R 24 E, north of Tallapoosa County Road 44 (fig. 14).

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 contain bronzite. Small talcose-pyroxenite cobbles and quartz fragments occur as surface material over much of the cultivated area.

Anthophyllite-bearing areas are indicated in the pyroxenite-amphibolite zones by sharp changes in soil color. The soil derived from the pyroxenite-amphibolite is generally gray to greenish-gray, whereas the soil derived from the 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 light-colored soil areas. Talc, soapstone, and talcose-chalcedonic anthophyllite occur scattered as surface accumulations throughout the cottonfield (fig. 15). Several corundum crystals have been found on the property.

In 1963, the American Talc Company explored parts of the property. Twelve drill holes were completed to an average depth of 65 feet. Three bottomed in talc, the remainder penetrated the mafic-ultramafic rock complex and bottomed in a biotite gneiss or diorite. A typical core log is given in table 4.

TABLE 4. - Typical drill-core log, Prather Prospect (D)

Depth, feet	Interval	Core recovered	Description
0 to 5.0	5.0	None	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	None	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.

FIGURE 15. - Surface Accumulation of Talc and Anthophyllite in Cottonfield on Prather Property.

Garfield Heard Prospect (E)

The Garfield Heard prospect is in the E$\frac{1}{2}$SW$\frac{1}{4}$ sec 2 and in the NE$\frac{1}{4}$NW$\frac{1}{4}$ sec 11, T 22 N, R 24 E, south of Tallapoosa County Road 44 (fig. 16), approximately one-half mile west of Oziah Church (fig. 17).

The mafic-ultramafic body 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 northwesterly trending quartz-mica pegmatites were located adjacent to the mafic body, but evidence is not available to indicate if they cut the mafic rock complex.

Anthophyllite occurs as veins in width 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 south and southwestern limits of the mafic body.

Anthophyllite occurrence is irregular and varied. Pockets ranging from one to eight 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.

Prior to 1964 several individuals, including Mr. Heard, opened small prospect pits at several places on the property. In 1965, the Powhatan Mining Company prospected the property, and it is reported that approximately 100 tons of anthophyllite was shipped to its Baltimore processing plant. Most of the excavations were refilled by contract agreement after termination of prospecting activities, and little evidence is available to indicate subsurface conditions.

Clem Vines Prospects (F)

The Clem Vines prospects are in the E$\frac{1}{2}$ sec 2, T 22 N, R 24 E, north and south of Tallapoosa County Road 44 (fig. 17). For purpose of description the property has been divided into the north and the south prospect.

Clem Vines North (F-1)

The north prospect 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, there is a junction in the timber road; the left fork veers to the northwest and the right fork continues north for a short distance 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 rock complex in this area. North of the stream, mica-schist,

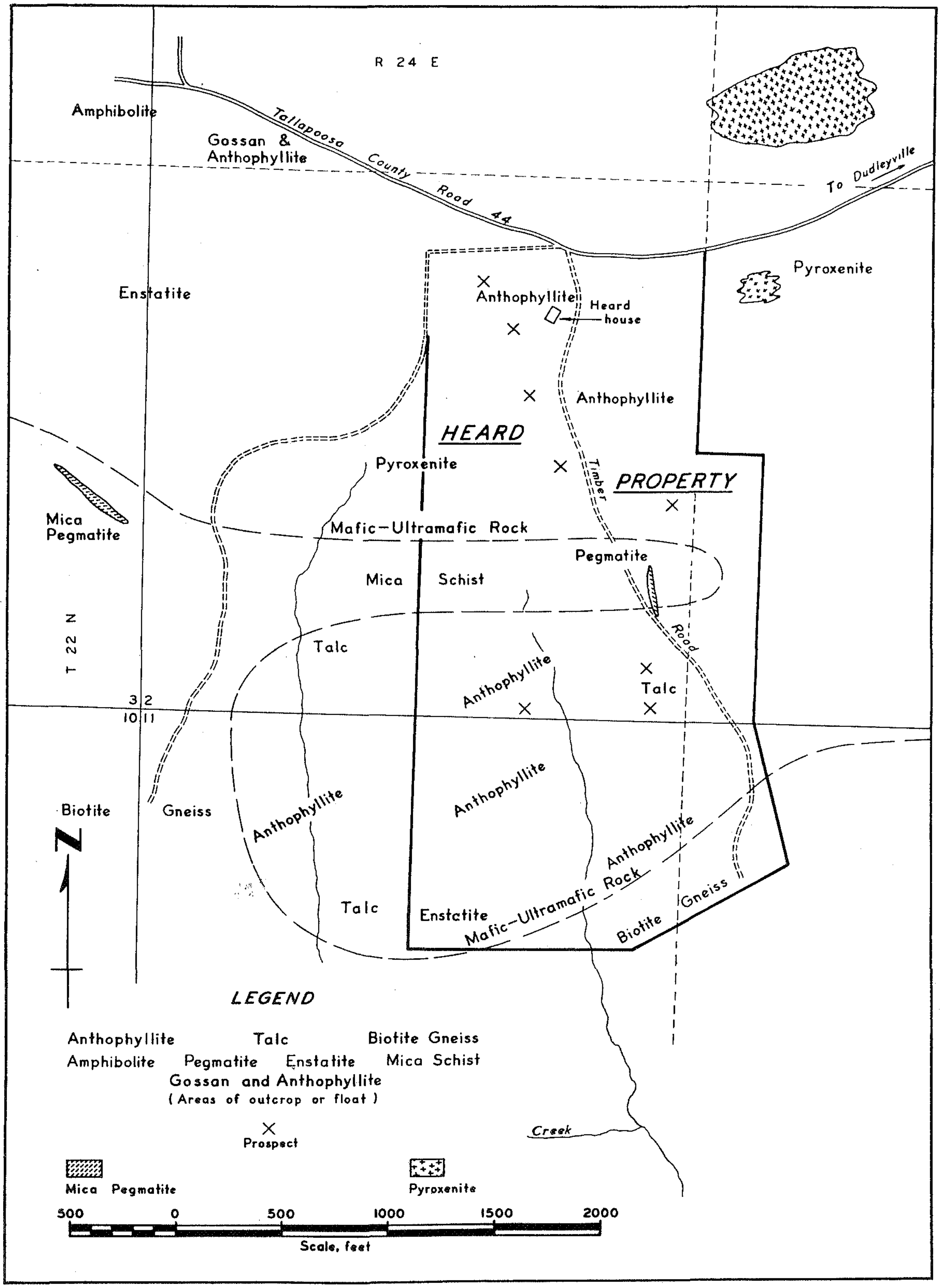

FIGURE 16. - Sketch Map–Garfield Heard Prospect. (Geology by T. L. Neathery–Geological Survey of Alabama.)

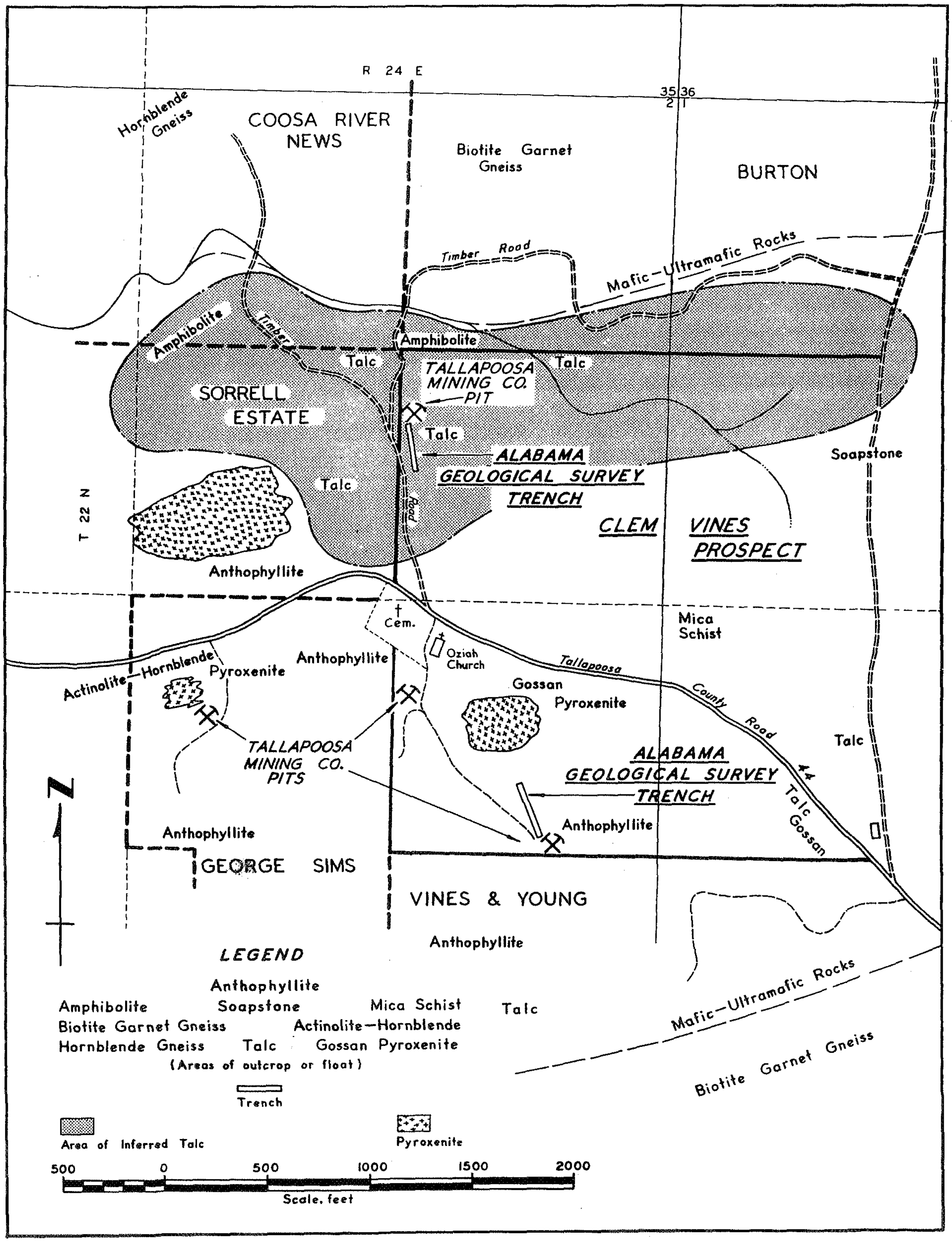

FIGURE 17. - Sketch Map–Clem Vines Prospects. (Geology by T. L. Neathery–Geological Survey of Alabama.)

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 outcrop of altered pyroxenite is exposed. The material grades from talcose-pyroxenite to talcose-chalcedonic mass-fiber anthophyllite. Talcose-pyroxenite also occurs in scattered outcrops and surface float.

In the vicinity of the timber road junction, surface accumulations of talc and talcose anthophyllite are common (fig. 18). A 300-foot north-south oriented trench, excavated during this investigation, exposed massive boulders and peripheral shell-like bodies of talc embedded in clayey saprolite. A log of the material in the trench is shown in table 5. 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 contained cross-fiber anthophyllite in the auger cuttings. A smaller prospect pit had been opened

FIGURE 18. - Accumulation of Talc Boulders Along Timber Road.

earlier near the northern end of the large trench. It was excavated by the Tallapoosa Mining Company 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.

TABLE 5. - Trench section, Clem Vines North Prospect (F-1)

Location: Sample 4; bulldozer cut trench 300 feet in length; azimuth, 340°; depth of cut, 4 feet. Sample trench: 8 inches in width by 1 foot in depth by 267 feet in length.

Interval, feet:	Description
[1]0 to 30	Reddish-tan saprolite with many talc boulders.
30 to 40	White to gray-white talc, 1.1 feet of clay at 53 feet; thin seam of anthophyllite.
40 to 79	Reddish-tan saprolite with many talc boulders.
79 to 96	White to gray-white talc, some staining, little clay, talc massive, hard.
96 to 109	Reddish-tan saprolite with occasional talc boulders.
109 to 111	Talc boulder zone, talc white to gray white, hard, massive.
111 to 123	Reddish-tan saprolite with talc boulders.
123 to 145	Talc zone, gray to gray-white talc, seam of reddish tan saprolite, talc stained, gritty, hard.
145 to 156	Reddish-tan saprolite, talcose.
156 to 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 to 179	Reddish-tan saprolite, talc boulders.
179 to 186	Talc boulders, massive hard talc, gray to gray-greenish white; 1.5-foot seam of saprolite.
186 to 199	Reddish-tan saprolite, few small talc pebbles.
199 to 209	Talc zone, massive talc boulder, hard, white to gray-greenish white, some grit, reddish-tan saprolite seam, some iron staining.
209 to 226	Reddish-tan saprolite, few cobbles and pebbles of white to gray-white talc, iron stained.
226 to 257	Talc zone, white to greenish-white; hard, massive, some grit; iron staining erratic; reddish-brown saprolite seams.
257 to 267	Reddish-brown saprolite, high percentage of talcose cobbles and pebbles.

[1]Beginning at south end of trench.

Clem Vines South (F-2)

The south prospect area is accessible by a field service road, beginning immediately behind Oziah Church. Included with the south prospect 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 but often contains large boulders of pyroxenite.

In a road cut along Tallapoosa County Road 44 (100 to 200 yards east of the church), cross-fiber anthophyllite, talc, and chalcedony box-work gossan 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 Company 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 anthophyllite, which was dumped along the southern fence line.

The site of the major prospecting work is approximately 500 yards southeast of the church, at the southeastern corner of an abandoned field. The Tallapoosa Mining Company excavated a large L-shaped pit to a depth of approximately 15 feet. The pit cut a 12-inch vein of cross-fiber anthophyllite; 15 to 20 tons of material was recovered. Many short-fibered blocks of cross-fiber anthophyllite can be found as residual material in the excavations.

During this investigation a large trench, approximately 300 feet in length, was cut starting at the backwall of the L-shaped pit of the Tallapoosa Mining Company and was oriented in such a manner as to approach the pyroxenite outcrop near the church (fig. 19). The trench was 10 to 12 feet deep and exposed massive talc, cross-fiber anthophyllite veins 1 to 6 inches wide, and several scattered zones of chlorite, vermiculite, and soapstone. A log of the material in the trench is shown in table 6. The soil and saprolite zone was too deep to be completely removed by bulldozing. Therefore, three 4-inch auger holes were drilled into the floor of the trench on 100-foot centers to depths of 15 feet. Each hole penetrated unweathered, unstained material at 10 to 12 feet below the floor of the trench. The material recovered was predominantly talcose in composition; however, the center hole produced cuttings containing anthophyllite mixed with talcose material.

Talcose-anthophyllite and talcose pyroxenite are found as surface float in the fields and woods to the south. A cursory examination revealed no evidence of prospecting in this area.

FIGURE 19. - Bulldozer Trench Excavated Prior to Cutting Sampling Trench Clem Vines South Prospect.

TABLE 6. - Trench section, Clem Vines South Prospect (F-2)

Location: Sample 3; bulldozer cut trench 325 feet in length; azimuth, 160°; depth of cut, 6 to 10 feet. Sample trench: 8 inches in width by 18 inches in depth by 296 feet in length.

Interval, feet:	Description
[1]0 to 32	Reddish-brown saprolite, talc cobbles; 6- to 8-inch-wide anthophyllite vein at 23 feet.
32 to 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 to 220	Reddish-brown saprolite, containing boulders of gray talc; vein and shells of anthophyllite; few seams of vermiculite and chlorite at 153 feet.
220 to 235	Mass-fiber anthophyllite with clay seams; short buff-tan to reddish brown fiber; some cross-fiber, 2½ to 3 inches in length, in thin veins.
235 to 255	Reddish-brown saprolite with random anthophyllite blebs and small veinlets.
255 to 258	Thick vein of cross-fiber anthophyllite, buff-tan, 4 to 6 inches in length.
258 to 296	Reddish-brown saprolite; thin veinlets of short cross-fiber, anthophyllite, little talc, some vermiculite, and chlorite.

[1]Beginning at south end of trench.

Pettus Harris Prospect (G)

The Pettus Harris prospect is in the SW¼NE¼ sec 1, T 22 N, R 24 E, approximately one-half mile north of the Dudleyville community (fig. 20).

Outcrops of mafic and ultramafic rocks are scarce, and only a 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 on 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 W. B. Railey property (B) and the Sorrell Estate (C). 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 box-work fragments also occur as surface material in the immediate area of the prospects.

Exploration consisted of two trenches: one cut by the Tallapoosa Mining Company, parallel to the regional strike of the country rock, and the other, cut as part of this project, normal to the regional strike. The former cut an anthophyllite-talc-chalcedony zone for about 200 feet to a depth of 3 feet. No usable anthophyllite was recovered from this trench. The second trench was

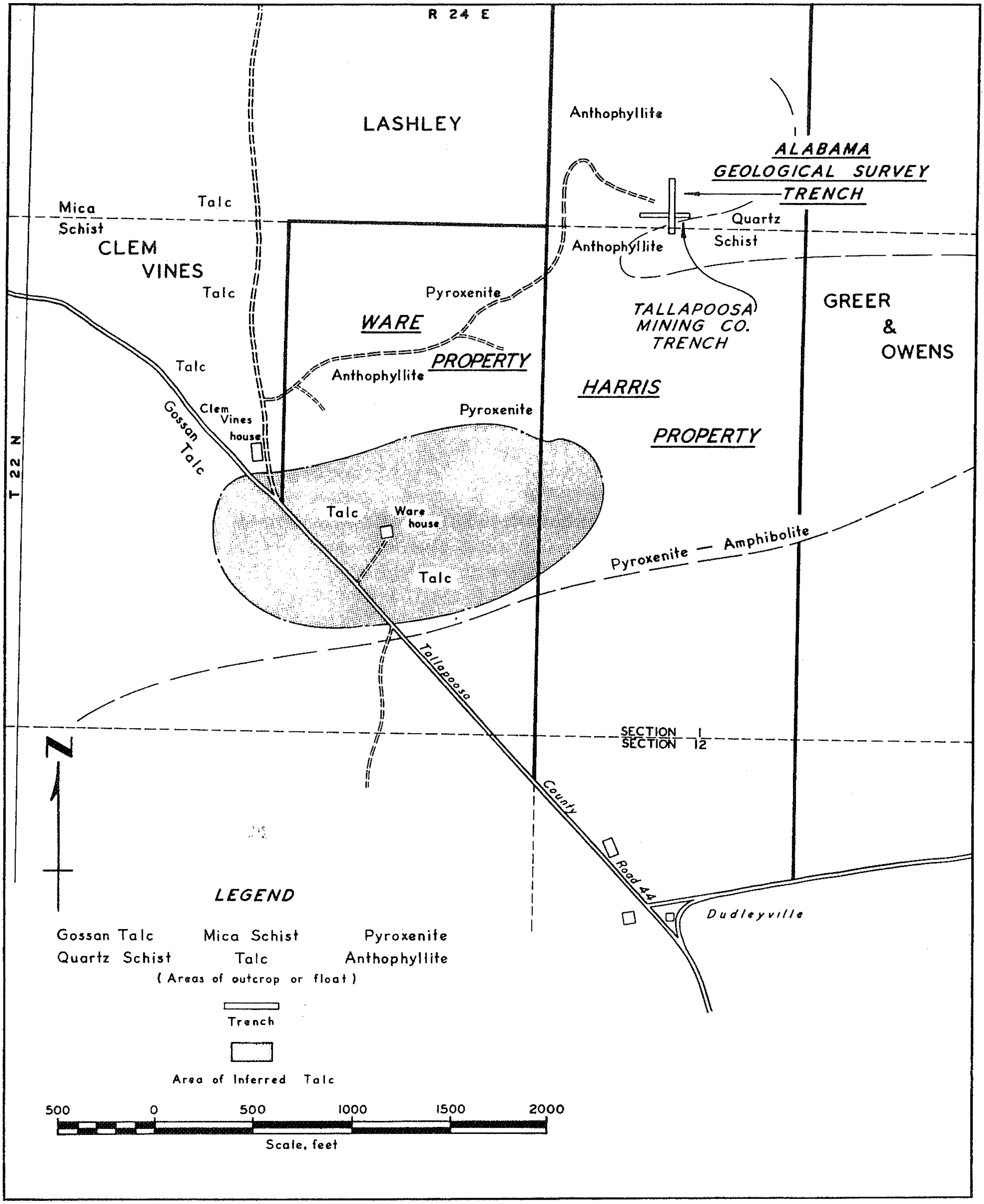

FIGURE 20. - Sketch Map–Pettus Harris Prospect. (Geology by T. L. Neathery–Geological Survey of Alabama.)

excavated to a depth of 10 feet for a distance of 300 feet across the strike of the earlier cut. A log of the material in the trench is shown in table 7. The anthophyllite zone was approximately 50 feet wide. The depth of the saprolite formation made it impractical to excavate a trench to fresh material. Therefore, three 4-inch auger holes were drilled on 100-foot centers into the floor of the trench. The two holes at the north end recovered talcose material at depths between 5 and 10 feet. The south hole bottomed in saprolite.

TABLE 7. - Trench section, Pettus Harris Prospect (G)

Location: Sample 5; bulldozer cut trench 300 feet in length; azimuth, 3°; depth of cut, 6 feet. Sample trench: 8 inches in width by 1 foot in depth by 202 feet in length.

Interval, feet:	Description
[1]0 to 27	Reddish-brown saprolite, talcose, blebs of gray-white talc, soft.
27 to 28	Gray-white talc blebs, soft.
28 to 115	Red and tan mottled saprolite; blebs and boulders of gray-white talc.
115 to 174	Tan and reddish-black anthophyllite-talc zone, hard, gritty, red saprolite seams; hard chalcedony boulders, at 117 feet; chalcedony gossan and talc, from 133 to 135 feet; chalcedony gossan and gritty talc from 141 to 145 feet.
174 to 274	Tan to reddish-brown mottled saprolite, few gritty talc boulders; no talc at 202 feet, and no sample taken from 202 to 274 feet.
274 to 300	Not sampled.

[1]Beginning at north end of the trench.

SAMPLING PROCEDURES

To obtain information on the quality and quantity of the talc and anthophyllite material, six trenches were dug on five 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/or earlier favorable prospecting.

The trench sites were first cleared or denuded of any forest or field cover. The soil 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 because of bulldozer limitations. At these locations auger-drillholes were used to supplement the information obtained by the trenching methods.

Representative samples were obtained from the cleared trench sites by use of a small gasoline-powered trenching machine. This machine cut a ditch approximately 8 inches wide to a depth between 16 and 18 inches. Material excavated from the ditch was passed through a sample splitter with 4-inch slots until approximately 1,000 pounds of material remained. This material was stored in drums and five samples were later delivered to the Tuscaloosa Metallurgical Research Laboratory for testing. A sample collected from the W. B. Railey prospect (B) was not submitted for testing.

Trench logs were recorded for each trench excavated. These logs accompany the description of the prospect on which the exploration was performed.

LABORATORY INVESTIGATIONS

Description and Analyses of Samples

About 1,000 pounds of each of the five samples collected by the Geological Survey of Alabama was submitted to the Tuscaloosa Metallurgy Research Laboratory for beneficiation. Visual inspection of the samples revealed that they were mixtures of relatively coarse lumps and finer argillaceous material. Subsequent sizing tests showed the presence of occasional 6-inch lumps and that 44 to 66 percent of the samples was finer than 325 mesh.

Representative portions of the as-received material were taken from each sample. These portions were air-dried and their moisture content determined by subsequent oven-drying at 110° C. Samples of the oven-dried material were crushed through 65 mesh for chemical and spectrographic analyses and through 28 mesh for petrographic examination.

The main constituents of the samples were silicon, aluminum, magnesium, and iron. All of the samples showed a uniform content of chromium and nickel. (See tables 8 and 9.)

TABLE 8. - Semiquantitative spectrographic analysis of talc--anthophyllite samples[1]

Analysis range, percent	Sample 1	2	3	4	5
More than 10	Si	Si	Si	Si	Si
1 to 10	Al,Fe,Mg	Al,Fe,Mg	Al,Fe,Mg	Al,Fe,Mg^+	Al,Fe,Mg
.1 to 1	Ca^-,Cr,K^-,Ti^-	Ca^-,Cr,Mn^-,Ti^-	Ca,Cr^+,Mn^-,Ti^-	Ca^-,Cr^-	Ca,Cr^-,Mn^-,Ti^-
.02 to .2	Ni	Ni^-	Ni^-	Ni^-	Ni^-
About .1	Mn	-	-	Mn	-
.01 to .1	Na,Rb^-,V	K^+Na,V	K^-,Na,V	K^-,Na,Ti^+,V	K,Na,V
.003 to .03	Co	Co	Co	-	-
.001 to .01	B,Ba,Cu,Li^+,Zr^-	B,Ba^-,Cu^-,Li,Zr	Cu,Li,Zr^-	Cu^-,Li^-,Zr^-	Ba,Cu,Li,Zr
Less than .001	-	-	-	Co	Co

[1]An element with superscript "-" indicates that the constituent is nearer the smaller end of the percentage range.
An element with superscript "+" indicates that the constituent is nearer the larger end of the percentage range.
An element without superscript is near the middle of the percentage range.

TABLE 9. - Chemical analyses of talc-anthophyllite samples

Sample	Moisture[1]	Analysis, percent[2]						
		Al_2O_3	SiO_2	MgO	CaO	Fe	Loss on ignition[3]	Insoluble[4]
1................	18.5	10.5	57.1	7.4	0.2	7.7	7.3	80.8
2................	15.0	6.2	61.4	9.4	.2	8.8	6.3	82.5
3................	12.8	10.7	45.4	13.3	.3	18.6	9.4	66.3
4................	12.8	6.6	49.7	11.5	.2	13.1	9.5	75.3
5................	15.8	10.5	51.9	3.4	.4	13.9	9.1	74.1

[1]Moisture loss by drying at 110° C.
[2]Analysis on moisture-free basis. Sample was dried at 110° C.
[3]Loss on ignition at 1,000° C for 1 hour.
[4]Hydrochloric acid insoluble.

Determination of the talc content in the different materials was complicated by the impurities present. For example, talc content calculated from chemical analysis of the magnesium oxide content was complicated by the presence of associated minerals containing magnesium oxide. Similarly, talc content determined by petrographic grain count was hindered by the presence of opaque minerals, and iron staining of mineral particles, which concealed the true identity of talc and other minerals present. Furthermore, grain counts were not reliable for the exceedingly fine size fractions, such as minus 400 mesh. In this study the petrographic analyses were based on grain counts made of the plus 400-mesh fractions. The minus 400-mesh material was not grain-counted and was assumed to contain no talc. Some investigators (6) have circumvented this difficulty by labeling all acid insoluble material in their sample as talc. This approach, however, would not be valid for the samples of this investigation because it is evident from the data that much of the sample, which is acid insoluble, is not talc.

Initially, iron staining of mineral particles caused considerable difficulty in petrographic identification of the mineral components. Leaching the samples with hydrochloric acid removed the iron stain and greatly facilitated identification of the different minerals. It is evident from the data in tables 10 and 11 that the mineral content determination made on the acid-cleaned material is more correct than that on unleached material.

TABLE 10. - Mineral analysis of sample 1 by petrographic grain count[1] of unleached material

Sample	Analysis, percent			
	Talc	Anthophyllite	Quartz	Limonite
1...............	8.9	1.2	5.6	11.1

[1]Based generally on 400 grain counts of each size fraction obtained as follows:
1. Entire sample was crushed to pass 28 mesh.
2. The minus 28-mesh material was screened and material remaining on 35-, 48-, 65-, 100-, 200-, and 325-mesh sieves was examined.

TABLE 11. - Mineral analyses of talc-anthophyllite samples by petrographic grain count[1] of leached material

Sample	Analysis, percent					
	Talc	Anthophyllite	Fibrous[2] material	Platy[3] material	Quartz	Extractable[4] iron materials
1..................	16.1	5.8	4.0	9.1	9.0	5.2
2..................	17.4	2.8	.4	1.3	11.3	5.8
3..................	3.8	16.2	.8	17.4	4.6	11.0
4..................	25.9	11.9	.1	.1	1.4	7.3
5..................	3.0	12.9	.1	20.4	12.1	6.2

[1]Based generally on 400 counts of each size fraction obtained as follows:
1. Entire sample was crushed to pass 28 mesh.
2. Iron staining of mineral particles was removed by hydrochloric acid leaching.
3. The leached residue was screened and material remaining on 35-, 48-, 65-, 100-, 200-, 325-, and 400-mesh sieves was examined.

[2]Asbestos minerals, mainly short fibers of anthophyllite.
[3]Mainly muscovite and vermiculite.
[4]Iron minerals extracted by hydrochloric acid leaching, mostly limonite.

Petrographic examination revealed that some "fibrous talc" and anthophyllite were present in each of the samples, but the fibers were very short and considered to be of negligible value as a fibrous material. Most of the talc and anthophyllite occurred as plates, or scales, and was heavily stained with limonite. Platy materials other than talc and anthophyllite were detected and were identified as muscovite, vermiculite, and green amphibole.

Although the most reliable mineral analyses are believed to have been obtained by petrographic grain count of acid leached fractions, the limited time available for the project prevented making this type of analysis for each test product obtained. Nevertheless, some simple rapid method for estimating the talc content of test products was needed for following the progress of research. Although chemical analysis alone has been shown to be unsatisfactory for establishing the quality of talc products, relative evaluations of samples and test products were made by comparing physical appearance with qualitative petrographic examination results, quantitative petrographic estimates, and occasional grain counts of unleached material. When these evaluations were combined with chemical analyses for magnesium oxide, reliable estimates of maximum beneficiation achievements could be made.

Experimental Methods

The primary objective planned for the investigation was to develop methods for beneficiating the asbestos and talc samples to yield commercially usable asbestos products. However, the shortness of the anthophyllite fibers and the relatively low anthophyllite content of the samples investigated indicated that the materials were more valuable as a source of talc. Because of this, the mineral beneficiation studies were then aimed toward recovery and concentration of the talc.

Particle size distribution of the as-received samples was determined by thoroughly agitating the material with water in a cement mixer and screening the resulting slurry. This washing action was effective for separating the argillaceous material from the coarse particles and breaking down aggregated fragments of argillaceous material. Data in tables 12 through 16 show that from 57 to 94 percent of the total MgO content could be recovered in 34 to 56 percent of the sample weight as plus 325-mesh material.

Sizing data may be used for indicating the amount of granular material that might be recovered by log washing treatment of the samples. For example, data in table 12 show that log washing of sample 1 might be used to recover a plus 200-mesh granular product that would be about 47 percent of the sample weight and would contain about 63 percent of the total available MgO.

TABLE 12. - Weight distribution and MgO content of size fractions from sample 1

Fraction	Weight, percent	Cumulative[1] weight, percent	MgO analysis		
			Percent	Distribution, percent	Cumulative[1] distribution, percent
Plus 1 inch....................	6.6	6.6	20.9	11.4	11.4
Minus 1 inch, plus 1/2 inch.....	2.8	9.4	21.9	5.1	16.5
Minus 1/2 inch, plus 3/16 inch..	4.6	14.0	20.1	7.6	24.1
Minus 3/16 inch, plus 10 mesh...	3.2	17.2	16.1	4.3	28.4
Minus 10 mesh, plus 28 mesh.....	7.8	25.0	12.8	8.3	36.7
Minus 28 mesh, plus 100 mesh....	9.2	34.2	11.9	9.0	45.7
Minus 100 mesh, plus 200 mesh...	13.2	47.4	15.9	17.4	63.1
Minus 200 mesh, plus 325 mesh...	8.8	56.2	14.8	10.8	73.9
Minus 325 mesh, plus 0 mesh.....	43.8	100.0	7.2	26.1	100.0
Composite...................	100.0	-	12.1	100.0	-

[1]Cumulative percent on the finer size indicated.

TABLE 13. - Weight distribution and MgO content of size fractions from sample 2

Fraction	Weight, percent	Cumulative[1] weight, percent	MgO analysis		
			Percent	Distribution, percent	Cumulative[1] distribution, percent
Plus 1 inch....................	8.8	8.8	22.7	14.5	14.5
Minus 1 inch, plus 1/2 inch.....	3.3	12.1	21.1	5.1	19.6
Minus 1/2 inch, plus 3/16 inch..	5.1	17.2	19.6	7.2	26.8
Minus 3/16 inch, plus 10 mesh...	4.8	22.0	18.0	6.2	33.0
Minus 10 mesh, plus 28 mesh.....	7.8	29.8	11.8	6.7	39.7
Minus 28 mesh, plus 100 mesh....	8.1	37.9	9.7	5.7	45.4
Minus 100 mesh, plus 200 mesh...	5.9	43.8	15.4	6.6	52.0
Minus 200 mesh, plus 325 mesh...	3.7	47.5	17.5	4.7	56.7
Minus 325 mesh, plus 0 mesh.....	52.5	100.0	11.4	43.3	100.0
Composite.................	100.0	-	13.8	100.0	-

[1]Cumulative percent on the finer size indicated.

TABLE 14. - Weight distribution and MgO content of size fractions from sample 3

Fraction	Weight, percent	Cumulative[1] weight, percent	MgO analysis		
			Percent	Distribution, percent	Cumulative[1] distribution, percent
Plus 1 inch....................	0.5	0.5	17.9	1.0	1.0
Minus 1 inch, plus 1/2 inch.....	1.2	1.7	17.6	2.4	3.4
Minus 1/2 inch, plus 3/16 inch..	2.8	4.5	14.1	4.4	7.8
Minus 3/16 inch, plus 10 mesh...	2.0	6.5	11.1	2.5	10.3
Minus 10 mesh, plus 28 mesh.....	4.2	10.7	17.9	8.4	18.7
Minus 28 mesh, plus 100 mesh....	14.7	25.4	23.0	37.8	56.5
Minus 100 mesh, plus 200 mesh...	5.5	30.9	20.2	12.4	68.9
Minus 200 mesh, plus 325 mesh...	3.1	34.0	17.5	6.0	74.9
Minus 325 mesh, plus 0 mesh.....	66.0	100.0	3.4	25.1	100.0
Composite...................	100.0	-	8.9	100.0	-

[1]Cumulative percent on the finer size indicated.

TABLE 15. - Weight distribution and MgO content of size fractions from sample 4

Fraction	Weight, percent	Cumulative[1] weight, percent	MgO analysis		
			Percent	Distribution, percent	Cumulative[1] distribution, percent
Plus 1 inch....................	8.0	8.0	26.2	19.9	19.9
Minus 1 inch, plus 1/2 inch.....	1.7	9.7	27.5	4.5	24.4
Minus 1/2 inch, plus 3/16 inch..	.9	10.6	23.5	2.0	26.4
Minus 3/16 inch, plus 10 mesh...	.7	11.3	18.1	1.2	27.6
Minus 10 mesh, plus 28 mesh.....	5.5	16.8	22.6	11.7	39.3
Minus 28 mesh, plus 100 mesh....	18.0	34.8	15.8	26.9	66.2
Minus 100 mesh, plus 200 mesh...	7.5	42.3	18.5	13.2	79.4
Minus 200 mesh, plus 325 mesh...	5.0	47.3	18.3	8.7	88.1
Minus 325 mesh, plus 0 mesh.....	52.7	100.0	2.4	11.9	100.0
Composite....................	100.0	-	10.5	100.0	-

[1]Cumulative percent on the finer size indicated.

TABLE 16. - Weight distribution and MgO content of size fractions from sample 5

Fraction	Weight, percent	Cumulative[1] weight, percent	MgO analysis		
			Percent	Distribution, percent	Cumulative[1] distribution, percent
Plus 1 inch....................	5.9	5.9	8.2	7.6	7.6
Minus 1 inch, plus 1/2 inch.....	1.9	7.8	6.0	1.8	9.4
Minus 1/2 inch, plus 3/16 inch..	3.3	11.1	7.7	4.0	13.4
Minus 3/16 inch, plus 10 mesh...	2.1	13.2	5.3	1.8	15.2
Minus 10 mesh, plus 28 mesh.....	7.1	20.3	10.9	12.3	27.5
Minus 28 mesh, plus 100 mesh....	20.3	40.6	13.0	42.0	69.5
Minus 100 mesh, plus 200 mesh...	10.5	51.1	10.9	18.1	87.6
Minus 200 mesh, plus 325 mesh...	4.7	55.8	8.0	6.0	93.6
Minus 325 mesh, plus 0 mesh.....	44.2	100.0	.9	6.4	100.0
Composite....................	100.0	-	6.3	100.0	-

[1]Cumulative percent on the finer size indicated.

Beneficiation by Gravity Concentration

To determine the merit of using gravity concentration methods for separating high-grade talc products from the samples, hydroclassifier and heavy liquid sink-float tests were made on the plus 3/16-inch fraction of sample 1. Gravity concentration methods were considered to have potential applicability because of the differing specific gravity of the talc, anthophyllite, quartz, and limonite, which were present in each of the samples.

The plus 3/16-inch fraction of sample 1, which represented 14 percent of the original sample and contained about 24 percent of the total MgO content, was crushed through 28 mesh. The crushed material was hydraulically classified in a batch-type classifier into three spigots and an overflow product.

Results given in table 17 indicate that by classifying the fine size material into the overflow fraction, an upgraded talc product was obtained in the classifier spigot products. For example, the composite spigot product obtained by combining spigots 1, 2, and 3 contained 68.2 percent talc, whereas the classifier feed contained 50.5 percent. Although treatment of this small fraction of sample 1 showed that hydroclassifications could be used to produce spigot products with a significant increase in grade of talc, the results showed that there was also an increase in the quartz and limonite content of the spigot product. The beneficiation of talc in the spigot products was believed to result from rejection of argillaceous material into the classifier overflow.

TABLE 17. - Summarized results from hydroclassification of plus 3/16-inch fraction (14.0 percent of total sample weight) of sample 1

Product	Spigot weight, percent	Analysis, percent					Distribution, percent				
		MgO[1]	Talc[2]	Anthophyllite[2]	Quartz[2]	Limonite[2]	MgO	Talc	Anthophyllite	Quartz	Limonite
Composite spigot product	60	19.5	68.2	0.8	7.8	7.6	59.9	81.0	53.9	78.6	83.1
Overflow product.......	40	19.6	23.9	1.1	3.2	2.3	40.1	19.0	46.1	21.4	16.9

[1] Chemical analysis.
[2] Petrographic analysis by grain count as described in table 10.

Heavy liquid separations also were made of spigot products from the hydraulic classification tests as a means of estimating the response of the material to refined heavy media and/or gravity concentration techniques. The classifier spigot fractions were separated in heavy liquids of specific gravities 2.6, 2.7, and 2.8. The products were evaluated by petrographic grain count. Data from a typical test (see table 18) indicate that some concentration of talc would be obtained by a separation made at a specific gravity of 2.7 and that nearly all of the quartz would be rejected into the float specific gravity 2.7 fraction. For example, the float specific gravity 2.7 fraction contained 7.4 percent talc and 62.4 percent quartz, whereas the sink specific gravity fraction contained 66.1 percent talc and 0.5 percent quartz. Size fractions larger than 28 mesh were also tested by heavy liquid separation, but results from these tests were very erratic and inconclusive.

TABLE 18. - Summarized results of heavy liquid sink-float separation of spigot 1 from the hydroclassification of sample 1

Product	Spigot weight, percent	Analysis by grain count, percent[1]				Distribution, percent			
		Talc	Anthophyllite	Quartz	Limonite	Talc	Anthophyllite	Quartz	Limonite
Float specific gravity 2.7.	24.4	7.4	0.2	62.4	7.6	3.5	0.1	97.9	30.0
Sink specific gravity 2.7..	75.6	66.1	.7	.5	6.2	96.5	99.9	2.1	70.0

[1] Mineral analysis by petrographic grain count as described in table 11.

Results from the gravity concentration tests showed that talc concentrate products of moderate grade could be obtained. However, good grade talc products as required for commercial use were not produced by any of the gravity concentration methods investigated.

Beneficiation by Flotation

Several flotation tests were made on each of the different samples. The tests were exploratory in nature and were not made to present a complete pattern of flotation testing but were designed to guide the investigator toward establishing conditions for producing a potentially salable talc or anthophyllite product. Flotation was found to be the most effective method for obtaining good grade talc products.

Initially, flotation tests were made to find a suitable reagent for selectively concentrating either talc or anthophyllite. Cursory tests were made with Aerofroth,[5] kerosene, sodium oleate, pine oil, tall oil, fuel oil, an organic ammonium silicate, pine oil

[5] Reference to specific brands is made for identification only and does not imply endorsement by the Bureau of Mines.

containing a refined petroleum sulfonate, and several combinations of these reagents. Results of preliminary testing indicated that pine oil alone would be a satisfactory reagent for flotation and recovery of talc. However, under the conditions tested, none of the reagents used appeared satisfactory for selectively floating the anthophyllite present in the samples.

Results of a flotation test made on the plus 28-mesh fraction of sample 3 are given in table 19. The theoretical talc content for each fraction collected was calculated on the assumption that all of the MgO is present as talc. Although the test was made on material representing only 10.7 percent of the total weight of sample 3, the results represent moderate, but not the best, concentration of talc that was obtained by flotation. This test was chosen to show that little talc is lost in intermediate fractions as a result of cleaning operations, and the effectiveness of the flotation is shown in the data by the absence of talc in the tailing. The high MgO content of the tailing was due to the presence of anthophyllite. Almost all of the talc was floated and found in the cleaner concentrate.

TABLE 19. - Flotation test results of plus 28-mesh fraction (10.7 percent of total sample weight) of sample 3[1]

Product	Weight, percent	MgO[2]		Talc,[3] percent	Qualitative petrographic evaluation
		Percent	Distribution		
Cleaner concentrate.	11.9	27.5	23.2	86.6	Relatively low-quality talc concentrate. Comparatively coarse. Some particles iron stained. Some quartz, limonite, and appreciable anthophyllite detected.
Middling 1.......	21.2	12.9	19.4	40.5	Considerable anthophyllite observed. Microcrystalline aggregates with limonite present. Very little, if any, talc found.
Middling 2.......	7.8	14.3	7.9	44.8	Anthophyllite present. Microcrystalline aggregates with limonite present. Quartz also present. Platy mineral in minor amount observed. Very little, if any, talc detected.
Middling 3.......	5.7	16.1	6.6	50.8	Iron-stained aggregates present. Considerable anthophyllite present. Minor amount of quartz found. Talc was not detected.
Middling 4.......	4.6	19.6	6.4	61.8	Contained very little talc. Iron-stained aggregates, anthophyllite and quartz present.
Total.........	51.2	-	63.5	-	
Composite rougher concentrate.	-	17.5	-	-	
Rougher tailing..	43.4	11.8	36.5	37.2	Contained abundant amount of anthophyllite. Microcrystalline material with limonite present. Quartz also present. Minor amount of platy material present. Talc was not detected.
Plus 65 mesh[4]....	5.4	24.5	-	77.1	Large plates. Muscovite and talc. Also contained chlorite and vermiculite and probably some anthophyllite.
Total.........	100.0	-	100.0	-	
Composite.......	-	15.4	-	-	

[1]Flotation reagent--0.1 pound of pine oil per ton of flotation feed added during preflotation conditioning.
[2]Chemical analysis for MgO.
[3]Theoretical talc content calculated by converting all of MgO to talc.
[4]Product screened out after grinding, not processed by flotation.

If the absence of other magnesium oxide-bearing minerals has been established by petrographic examination, the MgO content may be used to estimate the talc content of the flotation test fractions. However, it is evident from the data in table 19 that the magnesium oxide content of test fractions cannot be used alone as an index for establising the talc content because of possible contamination by anthophyllite or other magnesium-bearing minerals.

Although flotation tests were conducted under conditions of a preliminary nature and optimum parameters for flotation testing were not established, the results show that good-grade flotation concentrates can be obtained from each of the five samples (see table 20). Concentrates containing 89 percent talc or more were obtained from all five samples. Chemical analysis of two flotation concentrates, shown in table 21, indicates the high purity of the mineral products and shows that fractions were nearly all magnesia and silica.

TABLE 20. - Flotation-cleaner-concentrate products obtained from samples of talc-anthophyllite

Sample	Head[1] analysis, talc percent	Flotation feed		Flotation cleaner concentrates				Qualitative petrographic evaluation
		Fraction of total sample	Weight, percent of total sample	Weight, percent of feed	MgO analysis, percent	Talc[2] content, percent	Talc[3] recovery, percent	
1	16.1	Total....	100.0	16.08	28.3	89.3	89.4	Mainly talc. Traces of quartz and anthophyllite present. Small particles of limonite present.
1	16.1	Plus 3/16 inch.	14.0	38.28	27.4	86.4	28.6	Mainly talc. Minor amounts of anthophyllite and other minerals present.
1	16.1	Plus 28 mesh.	25.0	34.16	27.6	87.1	46.6	Good-grade talc. Minor amounts of anthophyllite and quartz present. Minor iron-staining of talc.[4]
2	17.4	Total....	100.0	18.34	28.6	90.3	95.4	Practically all talc. Minor amount of limonite present in discrete grains. Some iron-stained talc observed.
2	17.4	Plus 3/16 inch.	17.2	54.08	28.9	91.1	48.9	Good-grade talc. Minor amount of limonite present. Minor iron-staining of some particles found.
2	17.4	Plus 28 mesh.	29.8	46.87	28.7	90.6	73.0	Good talc with the exception that some iron-staining and some limonite particles were observed.
3	3.8	Total....	100.0	7.6	24.8	77.1	[5]100	Fair talc product. Considerable iron-staining of particles. Some limonite and anthophyllite present.
3	3.8	Plus 3/16 inch.	4.5	11.66	28.1	88.5	13.2	Mostly talc but some anthophyllite present. Minor amount of limonite present. Minor iron-staining of some particles observed.

See footnotes at end of table.

TABLE 20. - Flotation-cleaner-concentrate products obtained from samples of talc-anthophyllite--Continued

Sample	Head[1] analysis, talc percent	Flotation feed: Fraction of total sample	Flotation feed: Weight, percent of total sample	Flotation cleaner concentrates: Weight, percent of feed	MgO analysis, percent	Talc[2] content, percent	Talc[3] recovery, percent	Qualitative petrographic evaluation
3	3.8	Plus 28 mesh.	10.7	11.68	27.5	86.6	28.9	Poor-quality talc product, comparatively coarse. Some particles iron stained. Some quartz, limonite, and appreciable anthophyllite detected.
4	25.9	Total....	100.0	3.3	22.3	68.5	8.9	Poor-quality talc product, badly iron stained. Appreciable amount of anthophyllite present.
4	25.9	Plus 3/16 inch.	10.6	61.08	29.5	93.1	23.2	High-quality talc; rather pure.[4]
4	25.9	Plus 28 mesh.	16.8	51.51	29.7	93.7	31.3	Good talc. Trace of anthophyllite present. Very little iron staining of particles observed.
5	3.0	Total....	100.0	11.1	29.2	89.6	[5]100	Mainly talc. Particles iron stained. Traces of anthophyllite and limonite present.
5	3.0	Plus 3/16 inch.	11.1	8.09	24.6	77.6	23.3	Fair talc. Trace of anthophyllite and some limonite. Iron-stained talc and chert present.
5	3.0	Plus 28 mesh.	20.3	6.77	26.1	82.2	36.7	Contains large amount of good talc. Limonite and iron stained minerals present. Appreciable amount of anthophyllite observed.

[1]Talc analysis of head sample from table 11.
[2]Theoretical talc content was a calculated value obtained by converting MgO (by chemical analysis) to talc.
[3]Talc recovery based on talc (by theoretical talc analysis) recovered from total sample.
[4]Hydrochloric acid leached to facilitate petrographic examination.
[5]Excessive recovery of talc was probably due to the presence of anthophyllite in the flotation cleaner concentrate.

TABLE 21. - Chemical analysis of two good-grade talc flotation-cleaner-concentrate products

Sample	Fraction	Chemical analysis of flotation cleaner concentrate products: MgO	SiO_2	Al_2O_3	FeO	Fe_2O_3	TiO_2	R_2O_3	CaO	LOI	Qualitative petrographic evaluation
3	Plus 4 mesh.	28.1	62.5	0.14	0.57	2.8	0.06	2.25	(1)	4.56	Mostly talc but some anthophyllite. Minor limonite. Minor iron-staining.
5	Total...	29.2	60.4	.15	.63	2.7	.05	2.70	(1)	4.95	Mainly talc. Particles iron stained. Traces of anthophyllite and limonite present.

[1]Not detected.

Acid leach tests of several beige-colored flotation concentrates showed that the principal impurity, limonite, could be readily removed to produce a whiter product. Chemical analysis of one leach product showed that it contained 0.9 percent total Fe, 95 percent acid insoluble, and 4.5 percent loss on ignition. The loss on ignition, mostly attributable to water of crystallization, was determined by heating for 1 hour at 1,000° C.

Attrition grinding, acid leaching, and bleaching of a flotation concentrate from sample 4 was used to produce an extremely fine talc product that had excellent white color and a reflectance value of 83.5. This product was examined by personnel of a commercial talc operation and was judged to be a high-quality talc product.

ECONOMIC ANALYSIS

Asbestos

In 1964, the United States produced 101,092 short tons of asbestos, only 12.4 percent of the quantity it required. It consumed 23 percent (813,306 short tons) of the world's production (3,540,000 short tons) but produced less than 3 percent. Leading producers were Canada and the U.S.S.R. Canada and the Republic of South Africa, however, were the principal suppliers (10).

Because the United States is a have-not nation in regard to this mineral, discovery and development of new asbestos deposits have always been urgent. The discovery at Dadeville, Ala., was classified originally as one of asbestos and associated talc. Analysis of samples, however, has indicated a relatively small percentage of asbestos, and this in the form of anthophyllite, which has a very small market in the United States.

The most important variety of asbestos is chrysotile which constitutes about 95 percent of the total world production. Its fibers are generally strong and flexible and its uses great in number. By contrast, the fibers of anthophyllite are generally weak and brittle, so its use is limited. Its chemical formula is $7MgO \cdot 8SiO_2 \cdot H_2O$, but there are variations (e.g., up to 26.53 percent ferrous iron may replace magnesium). The MgO content of anthophyllite is said to range from 5 to 50 percent. The CaO content averages about 0.5 percent and rarely exceeds 2 percent. Aluminum may replace magnesium.

Market requirements for asbestos are based on fiber length, strength, flexibility, color, chemical composition, and cleanliness. Long fibers are used for manufacturing brake linings, electrical insulation, textile fabrics, etc.; intermediate length fibers, for asbestos cement products; and short fibers, for paper and millboard manufacture, heat-insulating cements, fillers, etc. Anthophyllite is used as a filler and for welding-rod coatings. It is more highly resistant to chemical reaction than chrysotile.

The Dadeville deposit appears to have little interest as a source of asbestos.

Talc

Definition

Talc is an inclusive term which covers all gradations from the pure mineral, $3MgO \cdot 4SiO_2 \cdot H_2O$ (approximately 63.4 percent SiO_2, 31.9 percent MgO, 4.7 percent H_2O), to soapstone, an impure, massive talcose rock. Its physical and chemical properties vary with its genesis, and, like all nonmetallic minerals, its use depends on its specific properties.

The whiter, purer talc is derived from sedimentary magnesium carbonate rocks; the less pure talc from ultrabasic igneous rocks; and pyrophyllite, a hydrous aluminum silicate similar to talc in properties and applications, from acidic igneous rocks.

Steatite is a term applied to any especially pure type of industrial talc that is suited to the manufacture of high-frequency electrical insulators and contains no more than 1.5 percent CaO, 1.5 percent combined FeO and Fe_2O_3, or 4 percent Al_2O_3.

Talcose rock massive enough to be machined is known as "block talc" or "lava" but is known as block steatite if it meets the specifications of the preceding paragraph.

"Fibrous Talc" may be composed principally or entirely of anthophyllite. Tremolite talc is often referred to as fibrous talc also.

Commercial talc deposits may contain impurities such as quartz, calcite, dolomite, magnetite, limonite, etc. In some markets, impurities are acceptable. Tremolite, serpentine, and anthophyllite are considered to be part of the talc, but hematite, limonite, and pyrite are objectionable.

Production and Sales

Since 1930, the value of talc, soapstone, and pyrophyllite consumed annually in the United States has increased at about 1½ times that of the gross national product (GNP) in constant dollars. Both the short- and long-term supply outlook is good, and consumption is expected to increase at a rate exceeding the GNP. In 1964 (latest figures available) domestic production attained an alltime high as did world production which has doubled in volume in less than 10 years.

In 1964, talc and soapstone were obtained from 65 mines in 14 States, and pyrophyllite was obtained from 12 mines in 3 States. States leading in production were New York, California, and North Carolina, as shown in table 22.

Figure 21 shows the annual production and sales of talc, soapstone, and pyrophyllite in the United States from 1955 to 1964. The trends of production and value of product have both been upward.

TABLE 22. - Crude talc, soapstone, and pyrophyllite produced in the United States

State	1963 Short tons	1963 Value (thousands)	1964 Short tons	1964 Value (thousands)
California....................	120,452	$1,427	132,601	$1,631
Georgia......................	42,000	93	40,400	135
Nevada.......................	4,243	50	5,322	58
North Carolina................	106,652	446	106,035	495
Texas........................	72,658	368	89,334	395
Virginia.....................	3,696	9	3,775	9
Washington....................	2,969	18	2,680	18
Other States[1]................	451,688	3,094	509,802	3,477
Total......................	804,358	5,505	889,949	6,218

[1] Includes Alabama, Arkansas, Maryland, Montana, New York, Pennsylvania, and Vermont.

Figure 22 indicates the average values per ton for both crude ore and ground product sold by producers in the United States. (Talc which is sawed for crayon stock, etc., commands a much higher price per ton.) From the 1955-59 average to the 1964 value, the trend has been downward for crude ore

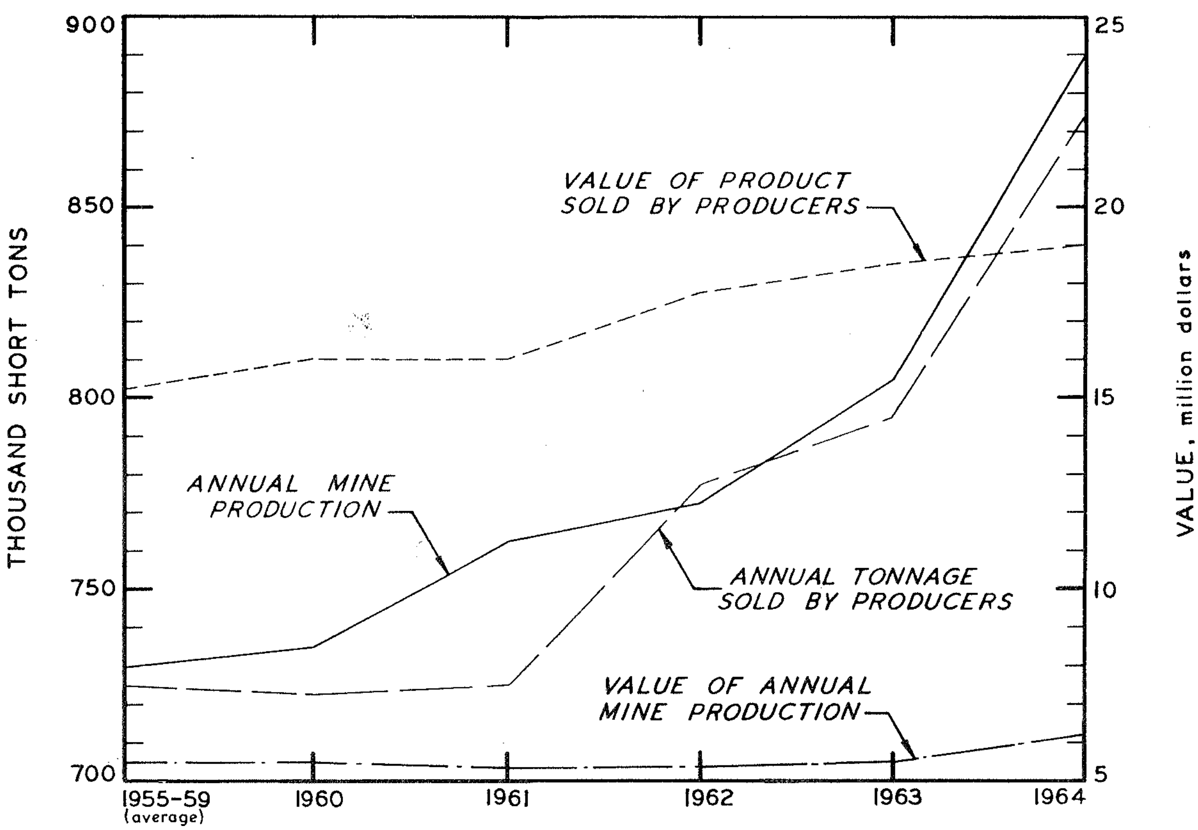

FIGURE 21. - Production and Sales of Talc, Soapstone, and Pyrophyllite in the United States.

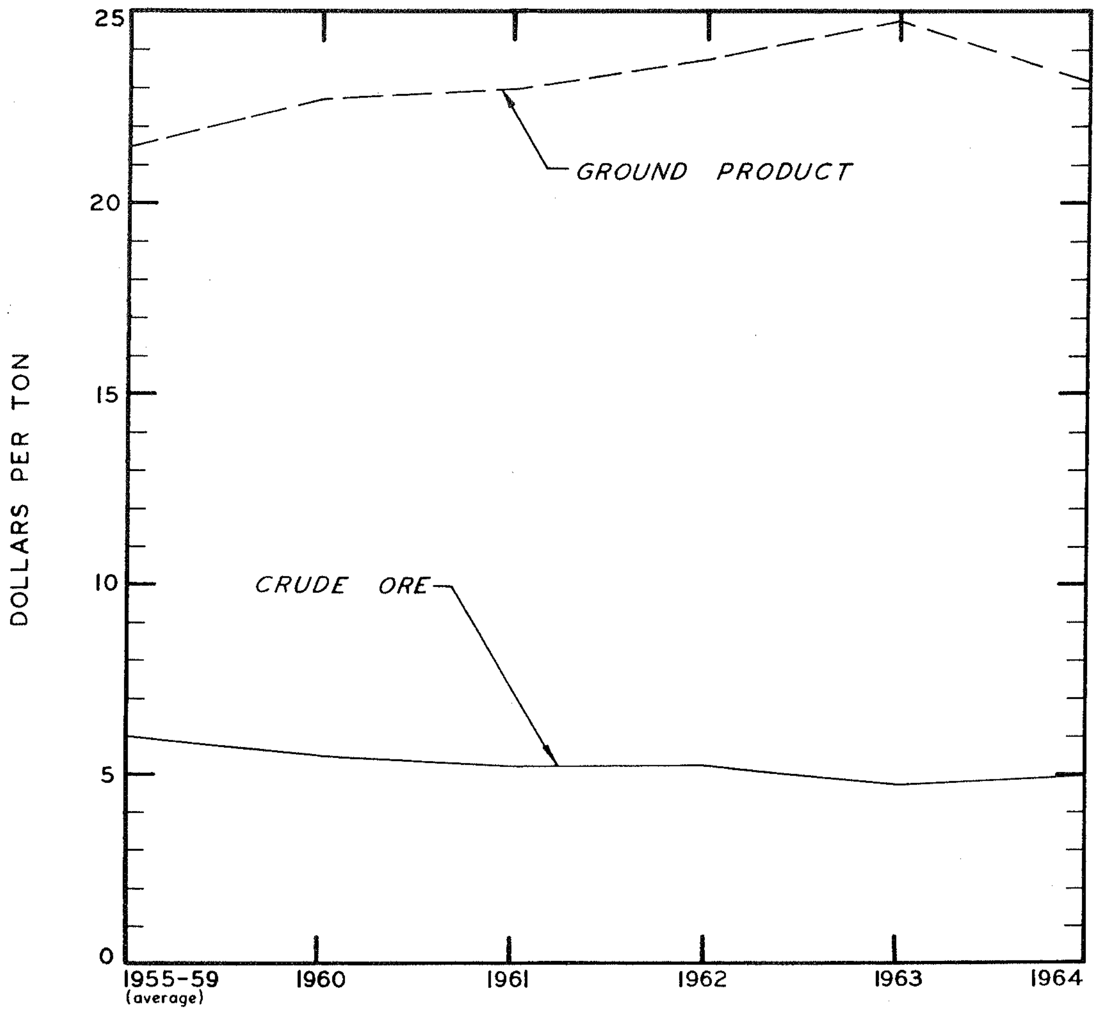

FIGURE 22. - Average Value per Ton of Crude and Ground Talc, Soapstone, and Pyrophyllite Sold by Producers in the United States.

but upward for the ground product. The significant decrease for 1964 is attributed, at least in part, to the marketing of the material in a less finely ground product than previously.

Producers of block steatite talc are granted a 23-percent depletion allowance on domestic production. Producers of all other grades of talc and all grades of soapstone and pyrophyllite are granted a depletion allowance of 15 percent.

Exports and Imports

Figure 23 indicates imports and exports for the industry. The trend for exports is on the increase; 1964 was the highest year for exports in history, Canada and Mexico being the principal recipients. Figure 24 shows the value of imports and exports.

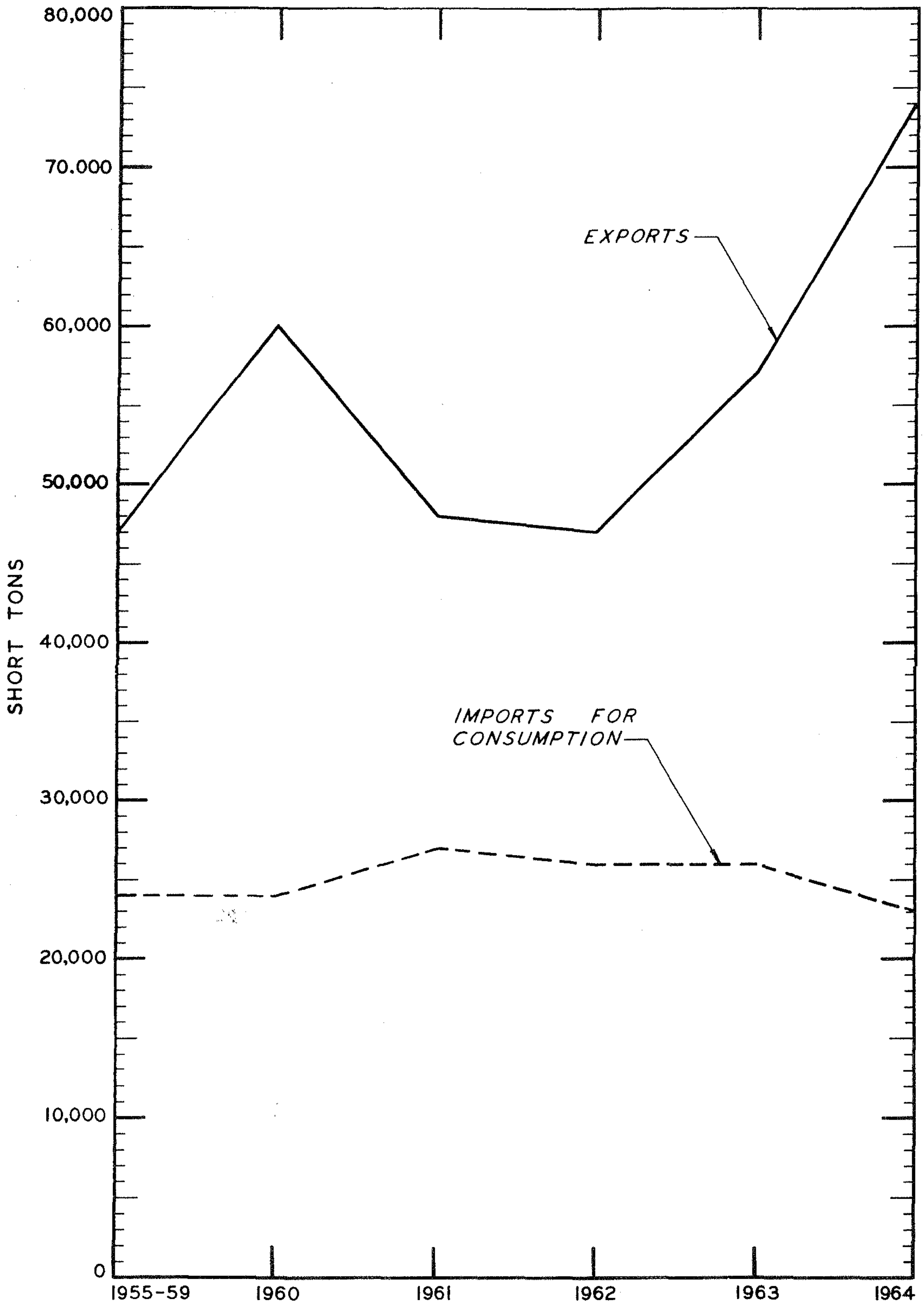

FIGURE 23. - Imports and Exports of Talc, Soapstone, and Pyrophyllite to the United States.

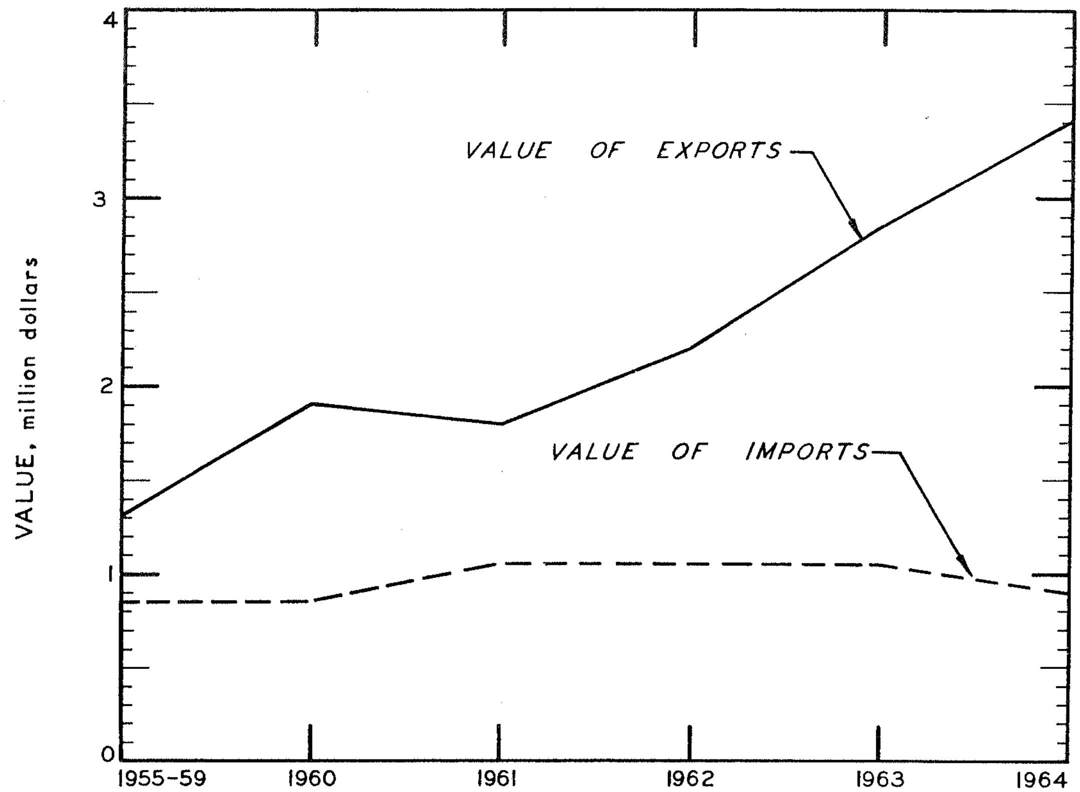

FIGURE 24. - Value of Imports of Talc, Soapstone, and Pyrophyllite.

Properties

General properties of talc which make it desirable for a wide variety of industrial uses are its softness and smoothness; whiteness and luster; high fusion point, specific heat, and dielectric strength; low electrical conductivity, heat conductivity, and shrinkage; and its chemical inertness.

When talc is heated above a pyrometric cone equivalent (PCE) of Cone 06, it is converted to clinoenstatite and cristobalite. Because the former has a very low moisture expansion and a thermal expansion equivalent to most glazes, it is ideal for use in low-temperature artware and ceramic wall tile.

Talc can be mixed with clay in the proper proportions to produce cordierite when fired to about Cone 12. Cordierite also has a very low thermal expansion.

Ground talc of steatite grade can be compounded with a binder and fluxes; then it can be extruded and fired to make refractory articles for the chemical and electrical industries.

"Fibrous talcs" serve presumably as bonding agents in paint films. Flaky talc acts as a laminal pigment. Fibrous and platy particles support heavier pigment particles thereby retarding settling and caking of paint in storage.

Talc extenders reduce the cracking and checking of paints and may reduce the tendency toward chalking.

Uses

Tables 23 and 24 indicate the many and varied uses for talc, soapstone, and pyrophyllite. Currently the ceramics and paint industries are the largest consumers of these items and in addition to the insecticide, paper, roofing, and rubber industries consumed 72.8 percent of the total sales in 1964.

TABLE 23. - Consumption patterns in the United States for 1958 and 1959-63 averages

Use	1958[1] talc, percent	1959-63 averages		
		Talc, percent	Soapstone, percent	Pyrophyllite, percent
Ceramics	34.0	38	3	27
Paints	18.5	21	2	1
Rubber	4.0	5	4	5
Insecticides	7.0	4	36	24
Paper	3.0	4	-	-
Roofing	9.5	7	23	(2)
Toilet preparations	2.0	2	-	(2)
Textiles	1.5	2	-	-
Asphalt filler	3.0	2	20	11
Foundry facings	-	(2)	4	-
Refractories	-	(2)	-	18
Rice polishing	15.0	(2)	(2)	-
Crayons		(2)	(2)	-
Other		15	8	14
Total	-	100	100	100

[1] Reference (5), p. 846. [2] Less than 1 percent.

TABLE 24. - Talc, soapstone, and pyrophyllite sold or used by producers in the United States

Use	Talc and soapstone				Pyrophyllite, tons	
	1963		1964		1963	1964
	Tons	Percent	Tons	Percent		
Ceramics	236,893	35.8	249,246	34.0	34,294	32,631
Foundry facings	4,391	.7	4,797	.7	-	(1)
Insecticides	39,826	6.0	38,927	5.3	25,408	27,661
Paint	130,596	19.7	160,653	21.9	(1)	(1)
Paper	29,159	4.4	31,585	4.3	-	-
Rice polishing	1,847	.3	(1)	-	-	-
Roofing	52,639	8.0	57,150	7.8	(1)	(1)
Rubber	31,032	4.7	32,352	4.4	(1)	(1)
Textile	8,341	1.3	7,057	1.0	-	-
Toilet preparations	10,504	1.6	16,739	2.3	-	-
Other	[2]116,064	17.5	[2]133,987	18.3	[3]73,017	[3]82,240
Total	661,292	100.0	732,493	100.0	132,719	142,532

[1] Withheld to avoid disclosing individual company confidential data.
[2] Includes adhesive, asphalt filler, composition floor and wall tile, crayons, exports, fertilizer, grease manufacture, insulated wire and cable, joint cement, patching compound, plastics, refractories, stucco, vault manufacturing, and miscellaneous products, as well as items included in footnote 1.
[3] Includes asphalt filler, battery boxes, exports, joint cement, plaster products, refractories, stucco, and related products, as well as items included in footnote 1.

Grades and Specifications

Grades of talc are usually identified with the end use such as ceramic grade, cosmetic grade, etc. (4, 5, 13).

Ceramics

Uniform chemical and physical properties are required which will insure constancy in both shrinkage and color in the ceramic body when fired.

Manganese and iron are objectionable.

The powder should be ground to minus 200 mesh.

For high-frequency insulators, more than 1.5 percent CaO, 1.5 percent iron oxides, 4 percent Al_2O_3 are objectionable.

Paints

Impurities which grind to colors other than white are highly objectionable. Therefore, a higher grade of white talc is desired which will not alter the tints of pigments.

To yield the desired smooth paint film, at least 98.5 percent must pass a 325-mesh screen. Fine grinding increases oil absorption, resulting in a low-gloss paint.

Extender pigments must have a refractive index below 1.75.

Roofing

A low-grade off-color and impure talc is acceptable. Its function is to act as a nonsticking, inert, fireproof, and weather-resistant surfacing on tar paper, asphalt shingles, and roll roofing.

Insecticides

Requirements for the mineral powder, which acts as a carrier of the toxic chemical, are high absorptive capacity, satisfactory bulk density, and low abrasive characteristics.

Rubber

Many synthetic rubbers use ground talc as fillers in their compounding formulations. Volume changes, amount of filler, and particle size all affect the stress-strain relationships of the product.

Paper

Ground talc is used as a filler to give good working qualities on the paper machine as well as to provide the desired properties in the paper sheet.

Among properties required for fillers and coating products are chemical inertness, softness, freedom from grit, satisfactory ink absorption, good adhesive suspension, brightness, dispersibility in water and rheological properties which permit ready flow and application.

Cosmetics and Pharmaceuticals

Talc must be free of grit, of fine particle size, and of excellent color.

Substitute Materials

Where talc is used as a filler or extender, other industrial minerals which may be competitive because of availability and price include barite, carbonates, clays, diatomites, fuller's earth, gypsum, mica, etc.

Marketing Analysis

Although the year-to-year consumption pattern for talc is erratic and difficult to predict, domestic per capita consumption of talc, soapstone, and pyrophyllite increased from 2.9 pounds per year in 1930 to 8.1 pounds per year in 1958 and continued at that level during the period from 1959-63.

Population for the Southeastern States--Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, and Tennessee--in 1960 was 25,822,000. By 1964 this figure had grown to 27,770,000 for an average increase of 487,000 per year. The yearly growth rate for this section of the country was approximately 1.8 percent, which exceeded the 1.5 percent rate for the country as a whole during the same period. The South Atlantic States as a group experienced a population growth of 2.0 percent per year for the same period.

Should this population growth continue in the South, it is estimated that the demand for talc could increase at the same rate. It is interesting to note that the 1965 production in Georgia increased 11 percent over that of 1964.

In comparing the yearly changes in talc uses, it will be noted that the paint industry consumed 23 percent more in 1964 than in 1963; the ceramic industry 5 percent more; the roofing and paper industries both an additional 8 percent; and toilet preparations industry 59 percent, although the latter consumed only 2.3 percent of the United States production. Consumption by the insecticide and textile industries each dropped a thousand tons.

Talc, soapstone, and pyrophyllite are not only subject of competition with each other, but are also subject to competition from other nonmetallic minerals such as diatomite, kaolin, feldspar, fuller's earth, limestone, marble, mica, etc.

The talc market, especially for the higher grades, is a customer rather than a commodity market. Ground talc prices range from ½ to 5 cents per pound, f.o.b. plant. Quotations in the trade journals are only indicative of the general price range because actual selling prices are negotiated and depend upon amounts purchased and specifications of the material.

Some producers sell their entire production directly to consuming industries through their own salesmen. Some sell exclusively through agents.

Although it is true that high-grade talc is a commodity which can be shipped considerable distances, the lower-grades must, of economic necessity, find a market close to their point of production. Furthermore, there is market stability only for the higher-grade products. Many of the lower-grade markets are seasonal.

No two deposits are identical in all characteristics (see table 25).

TABLE 25. - Chemical analyses of talc,[1] percent

Assay	Sample								
	1	2	3	4	5	6	7	8	9
SiO_2	61.06	60.21	60.59	60.20	61.51	64.53	58.70	55.18	62.17
Al_2O_3	3.63	4.23	.13	1.25	.83	29.40	5.67	3.16	.51
Fe_2O_3	-	0	-	2.50	-	-	.64	6.06	1.43
FeO	2.89	4.12	.21	0	.12	.67	-	-	-
MnO	-	.28	1.16	-	-	-	-	-	-
MgO	28.60	27.90	34.72	27.98	30.93	Trace	31.92	29.02	32.34
CaO	Trace	0	-	2.60	3.70	Trace	0	-	0
Na_2O	-	-	-	-	-	.28	-	-	-
H_2O	3.92	4.90	3.77	5.70	2.84	5.45	3.30	5.08	2.98
Total	100.10	101.64	100.58	100.23	99.93	100.33	100.23	98.50	99.43

[1]Origin of samples:
1. Waterville, Vt.--talc.
2. Moretown, Vt.--talc.
3. Gouverneur, N.Y.--fibrous talc.
4. Sheep Creek, Calif.--talc.
5. St. Gothard, Switzerland--fibrous talc.
6. Glendon, N.C.--pyrophyllite.
7. Marble, N.C.--talc.
8. Chatsworth, Ga.--talc.
9. Winterboro, Ala.--talc.

Patents recently issued include:

1. Composition for bearings requiring no lubrication made from pulverized talc and Teflon-metal base.

2. Process to make talc ore more amenable to concentration by electrostatic separation.

3. Use of talc as a mastic coating composition.

4. Use of talc as a coating and glossing agent for high-quality papers.

5. Use of talc in ditch and canal linings.

Perhaps finer grinding (micronized talc) and precise sizing will tend to develop new markets for talc in the future. Although each deposit has its own characteristics which currently make industry-wide specifications difficult to apply, the principles of mineral beneficiation will aid in quality stabilization. Then too, as higher grade deposits become depleted and industrial demands increase, there will be greater interest in upgrading submarginal resources. Development of a method for reconstituting upgraded ground talc in block form to eliminate the United States dependence on foreign sources for this strategic material may be a logical step for proposed research of the future.

Factors to be considered when contemplating production of a salable product from the Dadeville talc deposits include:

1. The potential reserves of this area are substantial.

2. The ore is at the surface; therefore, mining costs would be relatively low.

3. To produce a high-quality product, milling costs would be relatively high because of the necessity for additional beneficiation.

4. An adequate water supply must be available.

5. The anticipated demand for ground talc should be affected by the general economy of the country and region. (The population growth rate of the South has been exceeding that of the country as a whole.)

6. Talc is in keen competition with many industrial minerals in the paper, paint, rubber, and other industries where high-grade products are essential.

7. Talc is highly competitive with other industrial minerals in the insecticides, roofing, and other industries where a low-grade product is used as a filler.

8. For the higher grade product, the market is a customer, rather than commodity market; specifications are set by the customer, not the producer.

A recent modest market survey of some of the local expected users of talc revealed the following:

1. One rubber-tire manufacturer uses 100 to 120 tons per month of an approximate 20-dollar-per-ton grade. Another manufacturer formerly used 20 tons per month but has recently cut consumption to one-quarter of that amount.

2. Of five paper plants contacted, three use no talc and two use a relatively small quantity of high-grade talc as an internal additive.

3. One plant contacted in the roofing industry uses talc as a substitute for mica only when the latter is not available.

For the short-term outlook, this survey shows that the local market is limited and that its requirements are being adequately met. For the long-term outlook, however, demands may increase because of the general economy and population growth, an expected increase in paint and paper output, depletion of other talc-producing areas, and the possibility of a local source of talc being able to compete successfully with other industrial minerals currently being used in the region.

Reserves

Reserves of talc in the United States are considered adequate. The largest known ore bodies, containing more than 50 percent of the known reserves, are in New York. Vermont deposits contain 30 percent, and the remaining 20 percent is distributed in six States--California, Georgia, Montana, Nevada, North Carolina, and Texas. Of the Southern States, in 1958, Georgia was credited with 900,000 tons of indicated and 2,250,000 tons of inferred reserves with additional good discovery possibilities. North Carolina was credited with 250,000 tons of indicated and 1,000,000 tons of inferred reserves with additional good discovery possibilities. No reserve figures were given for Virginia, but the discovery possibilities for large tonnage were considered very good (3).

CONCLUSIONS

Results of the laboratory investigation show that it is technically feasible to obtain good-grade talc concentrates by flotation concentration of each of the five samples examined. Concentrates containing as much as 93 percent talc and analyzing about 28 percent MgO or more were produced by flotation of the total sample. Similar results were obtained by flotation from some of the plus 28-mesh and plus 3/16-inch fractions of the raw material as might be produced by log-washing operations. By flotation of the total sample, about 90 percent or more of the talc was recovered from four of the five samples. Pine oil was a satisfactory flotation reagent for the talc and at least four flotation cleaning stages were necessary for production of good-grade talc concentrates.

It was also demonstrated that the quality of the beige-colored flotation concentrates could be enhanced by attrition grinding, acid leaching, and bleaching to yield a high-grade talc product of fine size, white color, and a reflectance value of 83.5. The low anthophyllite content and the negligible amount of long-fiber anthophyllite in the samples indicated that it was a less valuable constituent in comparison to the talc. Under the conditions tested, anthophyllite was not recovered as a separate product.

The nature and occurrence of the anthophyllite and talc deposits makes it difficult to formulate an estimate of the potential reserves of these materials in the Dadeville area. The occurrence of talc appears to be far greater than that of anthophyllite although insufficient exploration and limited outcrop information reduce the validity of any estimate.

Market requirements for lower grade mass-fiber asbestos would dictate how much anthophyllite might be mined. Reserve estimates of the vein-type asbestos cannot be computed. Based on past exploration and fieldwork observations, it is possible that much tonnage of anthophyllite asbestos of all varieties may be derived as a primary product or as an indirect secondary recovery product from talc mining. The five samples analyzed ranged from 3 to 17 percent anthophyllite.

The potential talc reserve is also conjectural. Prospect pits and road cuts indicate that the talc occurs to depths of at least 30 feet. The crude talc is mixed with varying portions of clay, thin seams of anthophyllite, other alteration products, and unaltered pyroxene. From the samples the percentage of talc was found to range from 3 to 26 percent.

The total potential talc-anthophyllite bearing zone of the Dadeville amphibolite belt may encompass as much as 6,800 acres of land currently in timber or under cultivation. Based on field observations, it is possible that 25 percent of this area could contain talc or talcose material.

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