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STATE DIVISION OF CONSERVATION

DEPARTMENT OF MINES, MINING AND GEOLOGY

GARLAND PEYTON, Director

THE GEOLOGICAL SURVEY

Bulletin Number 53

TALC DEPOSITS OF MURRAY COUNTY, GEORGIA

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MINERALOGY OF TALC DEPOSITS

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Published in Cooperation with the Tennessee Valley Authority

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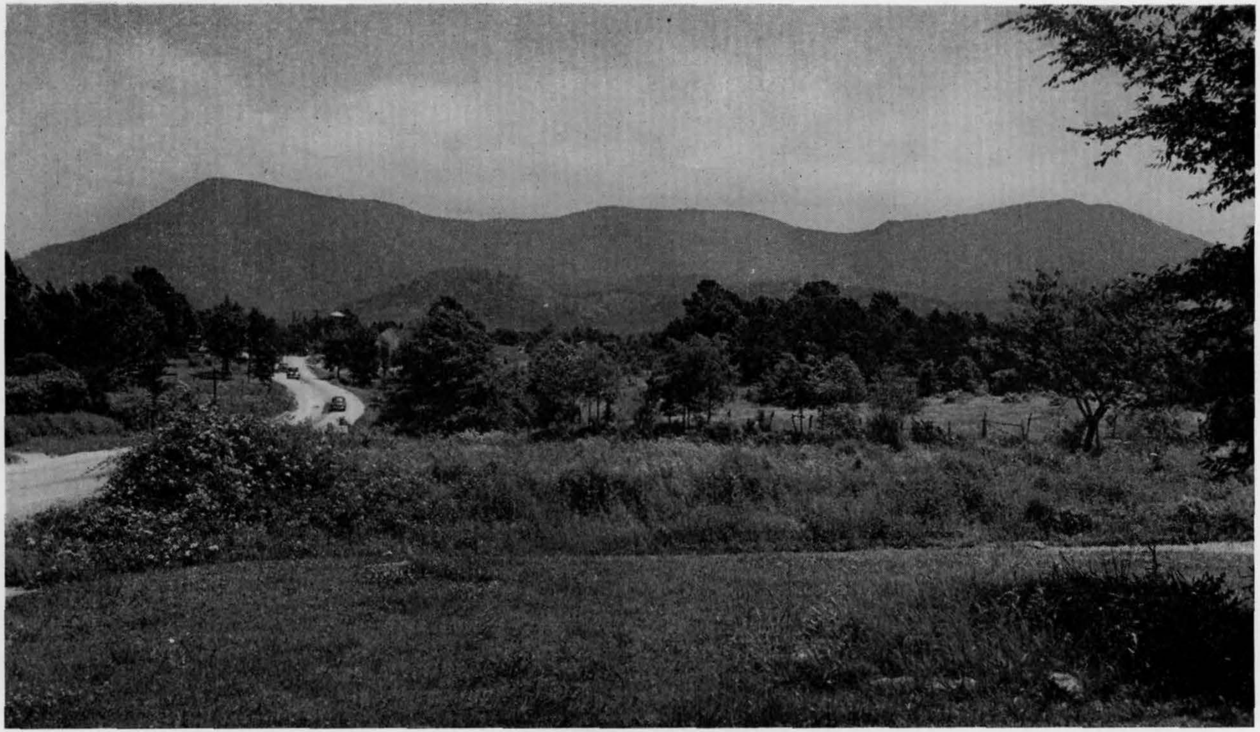

Southwestern end of the Cohutta Mountains in Georgia, looking east from a point at the western edge of Chatsworth; Fort Mountain on left; Cohutta Mountain on right. Talc is mined from a series of deposits which occur along the western side of these mountains.

LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

Atlanta, April 3, 1947

To His Excellency, M. E. Thompson, Governor

Commissioner Ex-Officio, State Division of Conservation

Sir:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 53, "Talc Deposits of Murray County, Georgia," by Dr. A. S. Furcron, Assistant State Geologist, Kefton H. Teague, and Dr. James L. Calver, Associate Geologists of the Tennessee Valley Authority. This report has been prepared and published in cooperation with the Tennessee Valley Authority.

This bulletin is a detailed report upon a long established mineral industry. It presents a complete review of structural, stratigraphic and petrologic problems of the districts which are involved in the economics of the talc. Detailed mine maps have been correlated with surface and subsurface structure. The results of this work indicate that our talc deposits are the most extensive in the Southeastern states. The report offers numerous suggestions on improvement of mining methods which would lead to increased production; also it shows that many prospects of the district may be developed into mines. A geologic map is submitted which shows distribution of Fort Mountain gneiss which contains the talc deposits. It is believed that this map will prove quite helpful to those who may prospect for new deposits in the future.

It is desired, too, to point out the value of cooperation such as the Tennessee Valley Authority has contributed in this instance. Undoubtedly it would not have been practicable for this department of the State Government to have undertaken this project alone. The cooperation of the Regional Products Research Division, Commerce Department, Tennessee Valley Authority, has provided the technical personnel considered necessary to supplement our own staff in conducting a special field project and the publication of this report, thus enabling us to present a publication which, in itself, is in this instance an accomplishment which would not ordinarily have been considered a part of our regular routine.

Very respectfully yours,

GARLAND PEYTON

Director.

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ABSTRACT

Talc has been produced from the talc deposits of Murray County, Georgia, since 1872, and this investigation indicates that large reserves of talc suitable for grinding and for crayons remain in this district. A large production may be expected in the future from present mines; many prospects of the area may be developed into mines. These deposits occur in Fort and Cohutta Mountains near the southern end of the Great Smoky range in crystalline rocks which crop out a short distance east of the Cartersville overthrust.

The talc deposits occur in dolomitic portions of an ancient pre-Cambrian formation (Cohutta schist) which was intruded by and included in a coarse-grained biotite granite (Fort Mountain gneiss) of pre-Cambrian age. Both Cohutta schist and Fort Mountain gneiss have been intruded by the later pre-Cambrian Corbin granite.

These pre-Cambrian rocks have been brought up east of the Cartersville fault by secondary overthrusts which extend from Hassler Mill southward to the vicinity of Ramhurst. These crystalline rocks have been thrust over the Ocoee sandstone with its dark slates and the Wilhite slate. In this district the Ocoee series rest in normal position unconformably upon pre-Cambrian crystalline rocks discussed above; thus, although no fossils have been found in it, the writers believe that this evidence indicates that the Ocoee series as described in this report is of Lower Cambrian age and that it corresponds generally to the Great Smoky formation of Keith. The Ocoee rocks of this district have been traced continuously eastward to the Murphy marble belt. A geologic map of the area is included with this report.

Planimetric and geologic maps of the four active mines of the district are included in the report. Talc has been mined extensively in the Georgia, Southern, Fort, and Old and New Cohutta mines, where large amounts of talc still remain. The report offers suggestions on mining methods where improvements on mode of extraction would produce considerably more talc.

FIELD WORK AND ACKNOWLEDGMENTS

This report presents results of a cooperative project between the Georgia Department of Mines, Mining and Geology and the Tennessee Valley Authority. About three months of field work was done by the writers in mapping and collecting data for the report between the summers of 1945 and 1946. The work was about equally distributed between field and area geology, and the study and mapping of active mines.

The writers wish to express their appreciation for the encouragement and assistance of Captain Garland Peyton, Director, Georgia Department of Mines, Mining and Geology, and Mr. H. S. Rankin, Senior Mining Engineer, Commerce Department, Tennessee Valley Authority; also to Mr. Paul Morris, Regional Engineer, Maps and Surveys Division, Tennessee Valley Authority, under whose direction base maps of the active mines were prepared. Dr. James L. Calver, Geologist, Tennessee Valley Authority, spent several days in the field and mines examining the talc formation and collecting samples for his study of the mineralogy of the talc deposits. In several cases certain special contributions to the geology and mineralogy of the area by other geologists have been acknowledged in the text of the report. A special study of the ceramic qualities of the microcline dikes was undertaken by the Department of Ceramic Engineering at the Georgia School of Technology under the direction of its head, Dr. Lane Mitchell. A report by Professor Charles F. Wysong established economic value for the feldspar. Also, Dr. W. M. Spicer of the Department of Chemistry, Georgia School of Technology, who made a detailed spectroscopic examination of the material, has supplied a report upon the rare elements in this peculiar rock.

The writers wish to express here their appreciation for the cordial cooperation and assistance of Mr. Floyd F. Farrar of the Cohutta Talc Company and Messrs. M. Woodward Glenn and Francis Glenn of the Southern and Georgia Talc Companies; also the foremen of the various mines and the mill superintendents have supplied cordial assistance to the writers at all times. Many photographs included in the report were taken by Mr. Edgar Orr of Atlanta, Georgia.

PREVIOUS GEOLOGIC WORK

The geology of the Dalton quadrangle was mapped between 1889 and 1896, and a manuscript and geologic map were prepared by C. W. Hayes[9]* of the U. S. Geological Survey. This folio was not published. In this manuscript, Hayes described a gneiss in the Fort Mountain area which seems to the writers to correspond in general with the ancient biotite gneiss described in this report. For that reason, and to avoid confusion, the term Fort Mountain gneiss used by Hayes is retained in this report for that formation although it is better exposed in the Cohuttas. The writers find that the talc is associated with another older pre-Cambrian formation, to which the term Cohutta schist is here applied. A conglomerate occurs locally in the Ocoee series of this district which may represent the "Cohutta conglomerate" mentioned in Hayes' report.[8] The only conglomerates of any importance noted in the course of this work are local fanglomerates occurring in the Ocoee. In this report the term "Cohutta schist" is applied to the old pre-Cambrian schist which contains the talc deposits.

In 1914 the Georgia Geological Survey published Bulletin 29, a report on the "Asbestos, Talc and Soapstone Deposits of Georgia," by Oliver B. Hopkins.[12] At that time, most of the talc mining was confined to outcrops. Hopkins' report discusses the talc deposits of Murray County on pages 243-267. Upon the State geologic map of Georgia (1939)[7] Dr. Geoffrey W. Crickmay has mapped in this area Lower Cambrian Ocoee rocks and rocks which he defines as of late pre-Cambrian Talladega age. The rocks he mapped as of Talladega age in the talc district are believed by the writers to belong to the Ocoee series and to be of Lower Cambrian age.

INTRODUCTION

Location and Accessibility

The entire talc producing area is situated a few miles east of Chatsworth, the county seat of Murray County. This town, with a population of 1,001 in 1940, is located on the main line of the Louisville and Nashville Railroad. United States

* References are listed at the end of the report.

Highway 411 connects Chatsworth with Cartersville and Atlanta to the south and Etowah, Tennessee, and Knoxville, Tennessee, to the north. This highway is intersected at Chatsworth by State Highway No. 2 which connects Chatsworth to the west with Dalton, and to the east with Ellijay. The road leading east from Chatsworth crosses the talc producing area where roads to the mines connect with it.

Recently the Georgia Highway Department, with the aid of federal funds, improved existing roads and built new access roads to all of the operating mines. The new road to the Cohutta mine has been extended northward to the Fort Mountain mine. These new roads represent a total distance of about four miles, and, since they are built along the talc bearing formation, should bring into production additional talc properties.

Physiography

The talc area lies along the western boundary of the Older Applachian Mountain province,[16] where the rough mountainous topography of the province contrasts abruptly with the gently rolling hills and valleys of the Valley and Ridge province to the west. Chatsworth is on the eastern edge of the Valley and Ridge province, just west of the mountainous region. The boundary between these provinces is generally a north-south trending line; however, at the point where Holly Creek emerges from the mountainous region, a large reentrant has been made into it by stream erosion. In general, the valley floor of the western foothills of the mountains is only about 800 feet above sea level. That part of the Older Appalachian Mountain province covered by this report includes the three southernmost peaks of the Cohutta range of mountains. Fort and Cohutta Mountains attain an elevation of 2832 and 2716 feet respectively. Cold Spring Mountain, southeast of Cohutta Mountain, reaches an elevation of 2700 feet.

An old land surface developed at about the 2600-foot level marks the crest of Fort and Cohutta Mountains. Its broad and uniform summits are trenched by shallow hanging valleys prominent in this area. The State of Georgia has recognized this relatively flat surface as a desirable location for recreation and has established the Fort Mountain State Park on the crest of these mountains.

The region lies within the drainage area of Holly Creek which flows into Conasauga River between Tilton and Spring Place. The northern portion of the area is drained by Holly Creek proper and its tributaries, Mill Creek, Emery Branch, and Leadmine Branch. The western portion of the region is drained by Rock Creek and Goldmine Branch which flows into Holly Creek and the southern portion by Chicken and Rock Creeks. These streams have rather constant flow, thus, except during periods of heavy rainfall, are seldom flooded.

STRATIGRAPHY AND PETROLOGY

INTRODUCTION

The rocks of the district east of the Cartersville fault consist of igneous and meta-sedimentary rocks of pre-Cambrian age, unconformably overlain by unfossiliferous arkoses and dark slates of early Cambrian age, the latter here classified as Ocoee. West of the fault and the base of the mountain, the rocks of the Great Valley contain Lower Cambrian fossils.

Much has been written of the age of the rocks east of the Cartersville overthrust (see section on Ocoee). General disagreement centers about the rocks definitely unconformable over the gneisses. The writers regard these rocks as of Lower Cambrian age. They do not grade upward into established Lower Cambrian sediments as in Virginia because they are separated from such rocks by the Cartersville overthrust.

In New England Palezoic fossils have been discovered in metamorphic rocks which rocks have been traced into highly metamorphosed sediments. Metamorphic rocks in the southern Appalachians have been referred to as pre-Cambrian by most students because these rocks contrast with almost unaltered sediments of the Great Valley. The Ocoee rocks of this district are out of place, and all agree that they have been thrust westward to their present position. Lower Paleozoic rocks have been much more metamorphosed during the Permian in more eastern positions, where it is reasonable to assume that they would represent a higher degree of metamorphism. In this area the Ocoee series, unconformable upon

Fort Mountain gneiss and Corbin granite, is composed of unaltered sandstone and slate. Certainly Permian movement which thrust it and its floor rocks westward, changed it almost not at all. It is reasonable to classify the Ocoee series of this district as Paleozoic. Thus, there is in Georgia an extensive series of unaltered arkoses and slates correlative with similar rocks classified as of Lower Cambrian age along the eastern side of the Great Valley from Virginia to Georgia. It is reasonable, in the present stage of knowledge, to regard these rocks as basal Cambrian sediments; however, the argument may continue indefinitely or until someone finds a fossil.

PRE-CAMBRIAN ROCKS

Cohutta Schist

The Cohutta schist is believed to be the oldest formation of this area. It represents remnants of a meta-sedimentary formation which is included in the Fort Mountain gneiss. It is here named from Cohutta Mountain, one of the southernmost conspicuous elevations of the Great Smoky Mountains. This formation contains the talc deposits of Fort and Cohutta Mountain districts.

Distribution

Portions of this old formation may be found widely distributed throughout the area occupied by Fort Mountain gneiss and Corbin granite. Lack of outcrops and limitations of time for field work make it necessary to indicate the presence of the schist on the geologic map only where known talc deposits occur. Facies of the schist in which talc is absent or not known to occur have not been mapped. The schist is best observed in valleys or on the walls of valleys. Between the valleys, where outcrops of Fort Mountain gneiss are covered by talus from the mountain escarpment, the Cohutta schist and its talc zones are concealed. The schist remnants occupy no special position in the enclosing gneiss although there is a tendency for talc-bearing schist to be confined to certain areas of the gneiss if one is to judge by the distribution of talc mines and prospects. About sixty per cent of the potential talc producing area is concealed by fans, a condition which must modify any attempt to localize the distribution of talc deposits. Commercial talc deposits may occur anywhere within the area mapped as Fort Mountain gneiss. (Plate 1).

Lithologic Character

Outcrops of the Cohutta schist consist generally of chlorite schist which may contain beds of stained micaceous talc. An examination of the schist in the mines and more developed prospects reveals soluble minerals absent in surface occurrences. Serpentine, a resistant mineral to weathering, is not noted generally at the surface, probably because it is so thoroughly mixed with dolomite that it disintegrates in the zone of weathering by solution of the soluble carbonate. The amphiboles, rare and unimportant, are noted almost entirely in surface outcrops. A thick band of chlorite schist may occur between the enclosing Fort Mountain gneiss and the talc serpentine-dolomite portions of the formation. This material may be ground for roofing talc. The South Entry to the Fort Mountain mine, main entry to the Cohutta mine, and the Bramlett prospect represent such occurrences. In general, a minable inclusion of Cohutta schist at the surface will consist of chlorite schist and talc. At depths other mineral combinations may be expected. Carbonates appear beneath the zone of oxidation; at greater depth, large bodies of coarsely crystallized secondary dolomite occur with the talc. Serpentine-carbonate lenses are found, and all white-grinding talc (talc with dolomite) occurs only after the prospect has been developed to considerable depth into a mine. Since weathering has left only chlorite and talc at the surface, it is likely that many talc prospects in this district could be developed into mines.

Origin and Geologic Age

The Cohutta schist occurs as inclusions in Fort Mountain gneiss. It is a metamorphic rock, which consists essentially of talc, chlorite, serpentine, and dolomite. It represents a pre-Cambrian sediment which was engulfed, intruded and partially assimilated by the magma of the Fort Mountain gneiss. Many dismembered portions of the formation occur as remnants in the old igneous gneiss, where the dolomitic

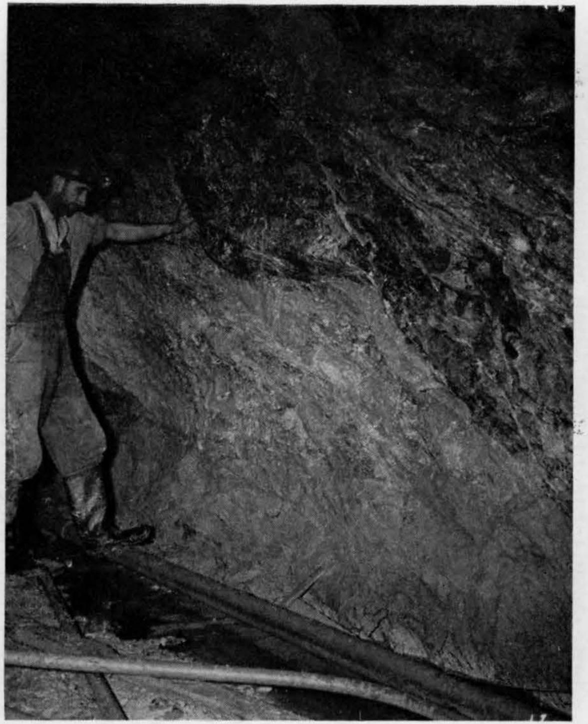

Figure 1. Brecciated serpentine (dark) in white grinding talc, Georgia Mine; similar boulders occur throughout most of the developed deposits in this district where they are usually large enough to be the controlling factor in layout of mine development.

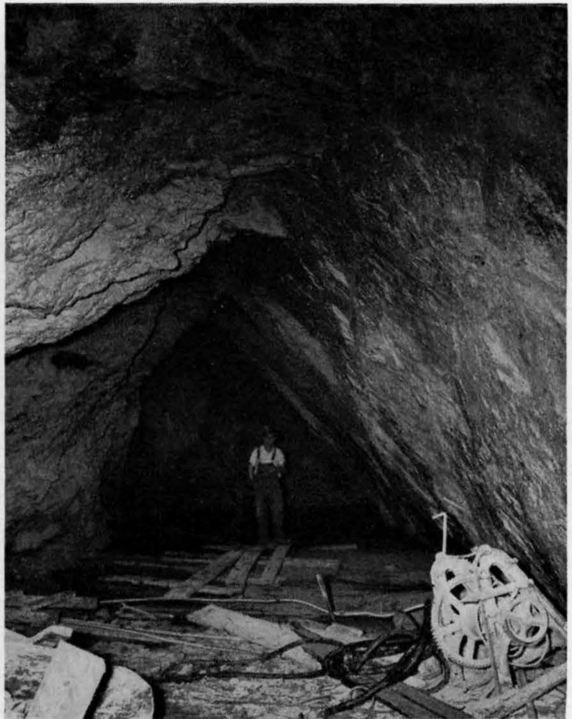

Figure 2. Normal fault on fourth level at Southern Mine; on right hanging wall of hard dark grinding talc, four to six feet of crayon talc on footwall adjacent to fault, and remainder white grinding talc.

portions of the formation have been partly altered to talc and serpentine. This formation, and the enclosing gneiss, are unconformable beneath the Ocoee series.

Fort Mountain Gneiss

The Fort Mountain gneiss is named from Fort Mountain, Murray County, where it occurs unconformably beneath the Ocoee series. This gneiss (as mapped) is a complex of igneous and metamorphic rocks which contains numerous bodies of Corbin granite, and Cohutta schist.

Hayes[9] described briefly a metamorphosed igneous rock, the Fort Mountain gneiss, "which occupies a narrow belt about a mile broad, and four or five miles in length along the western slope of Fort Mountain." He states that it is older than the sedimentary formation surrounding it. It is probable that it is the rock here described, thus this name is retained to avoid confusion.

Distribution

Two distinct belts of Fort Mountain gneiss crop out in the Fort and Cohutta mountain district east of Chatsworth (Plate 1). The longest and widest belt extends from the vicinity of the abandoned CCC Camp on Holly Creek to a point about three-fourths of a mile north of Dennis, northeast of Ramhurst. The belt is ten and one-half miles long with an average width of about one-half mile. Its greatest thickness is in the general vicinity of Emery Branch, Mill Creek, and Cohutta Mountain where the belt is about one mile wide. Chicken Creek has cut a deep valley through Ocoee sandstone between Chestnut Knob and Cohutta Mountain exposing this underlying gneiss. This belt is bounded on its western side by a thrust fault. On its eastern side the Ocoee rests unconformly upon it.

The second belt of gneiss occurs about one-half mile west of the area described above and 300 to 600 feet below it on the western slopes of Cohutta Mountain. It extends from Goldmine Branch southward to a point just beyond the Georgia Talc Mine. The belt is three and one-half miles long, with a maximum width of about one-half mile. It is separated from Ocoee sandstone on both east and west sides by thrust faults and is terminated to the south by the Cartersville overthrust. A narrow strip of gneiss about one and one-half miles long, just south of the Ellijay Highway, is also similarly bounded by overthrusts but merges into the belt. It contains the Georgia, Southern, and Old Cohutta talc mines.

Lithologic Character

The Fort Mountain gneiss is a biotite augen gneiss of granitic and granodioritic character, massive to schistose. The prevailing type is a dark gray rock, coarse grained and gneissic in appearance. Large and small grains of blue quartz and large feldspars, locally smeared out into knotty strings, are conspicuous. These minerals occur between wisps of very finely crystallized biotite which exhibits a silky appearance on all cleavage surfaces. The proportions of the minerals composing the gneiss vary greatly. Biotite is much more abundant in the schistose facies; the proportion of blue quartz to feldspar is variable. Massive ledges of the gneiss exposed on the Ellijay Highway east of Chatsworth contain a high percentage of quartz.

In thin section the rock exhibits a granitic texture and a banded structure. Plagioclase (albite) is the dominant feldspar. Potash feldspars, orthoclase and microcline, occur but are not abundant. The feldspar grains are granulated and exhibit wavy extinction. Feldspar may be crowded with minute inclusions, especially dust-like particles.

Quartz is secondary in abundance to feldspar; locally it is nearly absent but may be more abundant. It is more broken and granulated than the feldspars and always shows wavy extinction.

Brown biotite is the third most abundant mineral. It is irregularly distributed in small flakes, aggregates of flakes and patches, and in bands (interwoven) with feldspar and quartz grains. Some magnetite is associated with the biotite.

Garnet is common as small, round colorless grains. Some pink poikilitic garnet metacrysts with ragged outlines also occur. Apatite and long rutile needles occur.

Sericite, a mineral produced through alteration of feldspar, is abundant. All the feldspar is more or less sericitized, especially along fractures. Secondary calcite occurs in larger quantities than would be expected. Some of it is obviously derived from feldspar; interlocking calcite grains are also common and fill interstices between larger mineral grains. Biotite locally is altered to chlorite.

The following analyses of Fort Mountain gneiss exposed on the Chatsworth-Ellijay Road were made in the laboratory of the Tennessee Valley Authority at Muscle Shoals, Alabama:

Table 1

Analysis of Fort Mountain Gneiss *

Lab. No.	Moist. at 105°	Ign. Loss	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O	Na_2O
177627	None	2.40	63.25	14.58	4.63	3.57	1.01	0.92	4.47	4.06
			63.18	14.51	4.63	3.59	1.00	0.92	4.51	4.11

* Analysis by Department of Chemical Engineering,
Tennessee Valley Authority

The following petrographic description of the rock sample analyzed above was made by Dr. W. A. Rice of the Tennessee Valley Authority:

"Petrographic examination shows albite and microcline feldspars, quartz, and biotite as the dominant minerals. There are infrequent examples of parallel growth (not perthite) of the two feldspars, and of myrmekite inter-growth with quartz. Minor and accessory minerals are apatite, muscovite, rhombic carbonate, (probably calcite), sphene, pyrite, one or more of the black iron ores, and possibly some epidote, of which all except part of the apatite are secondary. The bulk of the biotite occurs in masses of books, containing the sphene and iron 'ores,' much of the calcite, and some of the apatite. These masses are probably relics of original titaniferous pyrobole, but do not show original form. Shattering and granulation of the quartz, bending of albite twinning lamellae, and rounding of grains and fragments of grains of feldspars and quartz indicate strong deformation. Interstitial spaces are filled with irregular stringers of micas, granulated quartz, and calcite in varying proportions. Texture, mineralogy, and chemical analysis suggest a much sheared and somewhat altered granodioritic rock. If so, the plagioclase has probably been albitized from an original more calcic composition."

Relation to Cohutta Schist

The Cohutta schist represents numerous bodies of metasediments which are included in the Fort Mountain gneiss. It is probable that a considerable amount of the original schist was assimilated, which may explain the unusually high carbonate content of the gneiss.

A thin section from a 150-foot core in the hanging wall of the Southern Talc Mine (position in core not determined) contains a large amount of calcite second only to feldspar in quantity. In all thin sections made of the gneiss near included bodies of Cohutta schist, biotite shows some alteration to chlorite.

Origin and Geologic Age

The Fort Mountain gneiss, the oldest igneous rock of the area, is pre-Cambrian in age and represents the dominant type of basement rock. It is unconformably overlaid by unaltered Ocoee sandstones which are composed of quartz and feldspar fragments derived from the gneiss. The gneiss closely resembles the pre-Cambrian biotite quartz monzonite gneiss (later called Lovingston gneiss) described by Watson[22] from the Blue Ridge province of Virginia.

Corbin Granite

The term Corbin granite was first applied by Hayes[11] to granite from the vicinity of the former post office of Corbin in Bartow County. Several facies of this granite have rather widespread occurrence at the southern end of the Great Smokies in Georgia. It appears best to retain the term for the granite of this district because the granite in Murray County resembles facies of Corbin granite.*

Distribution

Numerous patches of this granite occur within Fort Mountain gneiss. It is difficult, locally impossible, to map the contacts which in many places are covered by detritus. The best outcrops are seen in valleys. The most conspicuous of these are in the valley of Emery Branch, near the fault contact north of the Cohutta talc mine, and just south of Cohutta Mountain on and north of the Chatsworth-Ellijay Highway at the fault contact. At the latter locality the granite, considerably broken, follows generally the cleavage directions of the old gneiss. Small, narrow intrusions are medium-

* Work by the writers since this report went to press shows that the porphyritic granite of the Cartersville area is of different, and probably later age than granite discussed in this report.

grained. Large bodies, as in the case of the granite north of the Cohutta talc mine, are coarse grained containing large crystals of feldspar (Plate 1).

Lithologic Character

This rock is light gray, medium to coarse-grained granite. In hand specimens feldspar and blue quartz are the only noticeable minerals. The granite lacks biotite, a feature that distinguishes it from Fort Mountain gneiss. It is generally massive in appearance. Most of the granite occurs in narrow dike-like injections parallel to the structure of the enclosing Fort Mountain gneiss; in such cases, the rock is medium-fine grained with a uniform texture. The larger bodies of rock are coarse-grained.

The quartz usually is blue to smoky-blue in color, a characteristic feature of the pre-Cambrian granites of the region. It is distributed irregularly and occurs in patches and stringers. Feldspar is gray, white to flesh colored, locally pink.

Thin sections show the rock to be composed of quartz and microcline, the latter generally clouded by inclusions. Locally, the feldspar contains long rutile needles. The feldspar is microperthitic, containing minute rods of an acid plagioclase near albite in composition. Feldspars are locally granulated. Quartz is more fractured and strained than is the feldspar and generally exhibits wavy extinction. In many cases, although the rock appears to be quite massive in hand specimens, thin sections reveal the presence of considerable cataclasis.

Small amounts of biotite are noted in some thin sections; garnet is generally absent; magnetite is scarce and calcite was not observed. Feldspars are usually more or less sericitized. Alteration may be distributed through the feldspar grains but is conspicuous along fracture lines.

Relation to Enclosing Rocks

The Corbin granite intrudes Cohutta Schist and Fort Mountain gneiss. It seems to have a preference for Cohutta schist where the solutions encountered easier access upward than in the more massive gneiss.

Origin and Geologic Age

This rock possesses all the features of the typical pre-Cambrian granites of the Blue Ridge region, such as irregular texture, presence of blue quartz, and scarcity of primary muscovite mica. It is unconformable beneath the Ocoee series, thus pebbles of Corbin granite are common in the conglomerate facies of the Ocoee. In texture and mineral composition it resembles Old Rag granite described by Furcron from the Blue Ridge in Virginia.[3,4]

Microcline Dikes

Distribution

Several microcline dikes were found to intrude Corbin granite, Cohutta schist, and Fort Mountain gneiss. The rock ranges from small narrow bands of microcline and quartz in Corbin granite to dikes 80-feet or more thick in the other rocks. They tend to follow original structural trends of the enclosing rocks. They are too narrow and scant to plot upon the geologic map. Further search should locate other occurrences. It is peculiar that the known occurrences are near the Cartersville overthrust. The most conspicuous dike crosses the Chatsworth-Ellijay Highway about three-fourths of a mile above the Ocoee fault contact between the Ocoee series and the granite. It is about 75 feet thick and strikes about N. 60° W. The enclosing rock, a weathered green schist, is probably a facies of Cohutta schist. The dike is generally conformable with strike and dip of the schist and contains some schist inclusions. It may be traced in both directions for a total distance of about 1,500 feet where it is covered by talus.

A second dike, enclosed in granite, occurs near the fault contact with black slate about one-half mile up the branch, north of the Chicken Creek Talc Mine. The dike strikes northwest; it is about 20 feet thick and 100 feet long.

Lithologic Character

The rock is massive, dark blue-gray in color, and weathers to a dark red soil. It is cut by veins of blue quartz. The dikes are shattered and thoroughly and uniformly replaced by small veinlets and stringers of secondary quartz. The following microscopic description of a sample taken from the Ellijay Highway was made by Dr. W. A. Rice of the Tennessee Valley Authority:

"**Perthite** (lenses of sodium feldspar in potassium feldspar) makes the bulk of the rock.

"**Albite** or a plagioclase near albite is present as free grains in excess of the perthite.

"**Quartz** occurs in three ways: irregular masses against which the feldspars show their form, veinlets of granular quartz, and veinlets of cherty intergrowth. These are, probably respectively, the bluish, clear, and white masses.

"**Mica** of sericite type (fine aggregate) makes a few veinlets and is scattered through the feldspars. Some clay mineral is included here.

"An estimate analysis, by minerals: quartz, 20 or 30%; potash feldspar, 35 or 40%; and soda feldspar, 35 or 40%. This is by inspection of one slide, without any planimetric measure. The estimate of 20% quartz, 40% of each feldspar, is, on the basis of pure minerals: 73.4% SiO_2, 15.2% Al_2O_3, 6.8% K_2O, and 4.7% Na_2O.

"The rock is granitic, with two generations of later quartz veins, and alteration of the feldspars. The color is unusual, in that the potash feldspar would more commonly be pink (finely divided Fe_2O_3). It is very possible that the iron has been sulfided to pyrite. The quartz shows lamellae, shattering, wavy extinction, and biaxiality, all indicative of shear. Some of the twin lamellae of the plagioclase are bent."

TABLE 2

Analyses of Microcline Dike Rock From Ellijay Road East of Chatsworth.

	A	B
Moisture	0.09%	------
Loss on ignition	0.43	0.73
Soda (Na_2O)	3.57	3.16
Potash (K_2O)	2.81	5.15
Lime (CaO)	0.40	0.16
Magnesia (MgO)	0.25	0.16
Alumina (Al_2O_3)	15.85	15.46
Ferric oxide (Fe_2O_3)	0.47	0.10
Silica (SiO_2)	76.24	73.99
Total	100.11	98.91
HCl Insoluble	97.2	

(A) Analysis by L. H. Turner, Georgia Geological Survey

(B) Analysis by Department of Chemical Engineering, Tennessee Valley Authority

A qualitative spectrographic analysis of this rock made by Dr. W. M. Spicer* indicates the presence of much silicon, aluminum and potassium, less sodium, a little iron, magnesium, calcium and traces of manganese, titanium, lead, silver, tin, and gallium.

Origin and Geologic Age

These dikes represent the final stage of pre-Cambrian intrusive feldspar-bearing rock in this district. In location and in mineral composition they are closely related to Corbin granite; thus, may represent the mica-free pegmatite of that rock.

PALEOZOIC ROCKS

Ocoee Series

Definition and Past Interpretation

The economic scope of this report and the limited area involved in the study make it impractical here to attempt a stratigraphic classification of the "Ocoee Series." Its mode of deposition that resulted in frequent repetition of beds of similar composition, general lack of definite stratigraphic horizons, and lack of fossils make such a study difficult. It can be done only through a detailed investigation of structural and stratigraphic features which extend over considerable territory.

Safford defined the "Ocoee group" in 1869, page 192.[19] Over his "Metamorphic group" of "Eozoic" rocks he places the "Ocoee Conglomerate and Slates." Above the Ocoee he places the Chilhowee sandstone, and overlying it the Knox group of shales, dolomites, and limestones. He states on page 182, "The group corresponds to Dana's Potsdam Period .... It is not easy to separate, lithologically, the Ocoee sub-group from the Chilhowee, as they often run into each other .... Perhaps the better arrangement would have been to throw the Ocoee and Chilhowee together as the Potsdam, the Knox remaining as an individual group." Rocks mapped as Ocoee

* Personal communication, May 7, 1946.

by Safford extend into Georgia where they would include rocks of this area lying east of the Cartersville overthrust.

C. W. Hayes in 1895 divided the Ocoee series of the Cleveland sheet[10] from oldest to youngest into five formations, viz., Wilhite slate, Citico conglomerate, Pigeon slate, Thunderhead slate, and Thunderhead conglomerate. In the legend these rocks are placed beneath the Chilhowee series but as of unknown age. However, in the text of the report, he points out that they are separated by a great fault from rocks of known age, and that it "is best to consider them Algonkian until satisfactory evidence to the contrary is found." In the unpublished Dalton folio,[9] immediately south of the above, these rocks east of the Cartersville fault also are classified as Algonkian by Hayes.

Arthur Keith did not publish upon this particular district in Georgia; however, on the Loudon folio, 1889-90,[15] he maps the Ocoee formation as of unknown age. The Murphy folio by Keith was not published, but LaForge, who followed Keith's classification, mapped basal arkoses and slates (Great Smoky formation) unconformable over the granites and gneiss, as early Cambrian on the Ellijay sheet.[17] Since this folio adjoins the Dalton sheet, it may be seen that a shift in point of view had developed, and that these Ocoee rocks were then regarded by Keith and LaForge as Lower Cambrian in age. In 1925, Keith[16] wrote of these rocks in northwest Georgia which he regarded as of early Cambrian age: "Nearly all of them are concentrated in a belt from 1 to 3 miles wide near the Murphy marble, except the Great Smoky formation. The latter occupies a belt 20 miles wide and underlies most of the western group of mountains." It seems necessary to infer from the above that, at that time, Keith would have mapped the Ocoee series as of Lower Cambrian age.

On the State Geologic Map of 1939[7] that part of western Fannin County and northern Murray County north of the Holly Creek re-entrant is mapped by Crickmay as Ocoee of Lower Cambrian age. However, east of that area and including the formations of the Murphy marble belt, Keith's classification is not retained and the rocks are regarded as belonging to the Talladega series of late pre-Cambrian age.[7] The writers fail to find in this district valid distinctions which separate the Ocoee series as indicated on the map from the Great Smoky formation and, for reasons stated later, believe it is best to regard both Ocoee and Great Smoky there portrayed as the same series and to be of early Cambrian age, thus agreeing with Keith and LaForge in that respect. The writers[6] have expressed previously views upon the classification of the rocks of the Murphy marble belt which differ with those of some other writers.

The Stoses[20] in a recent extensive review of the Ocoee problem state that the Ocoee series is not Cambrian but is of late pre-Cambrian age.

Distribution

In this region the Ocoee series is the most abundant rock exposed (Plate 1). Zones of Ocoee rocks in fault position occur immediately east of the Cartersville fault underneath the main zone of Fort Mountain gneiss. The westernmost zone of the Ocoee series is about three miles long and up to three-fourths of a mile wide. Its western border is the Cartersville fault. Another belt occurs east of Hassler Mill.

The most extensive area of the Ocoee series occurs east of the Fort Mountain gneiss belt and unconformably on it. It underlies all of the eastern half of the area mapped and extends eastward from the Cartersville fault in the southern, the Fort Mountain gneiss in the middle, and the Cartersville fault in the northern portions of the talc district.

Lithologic Character

The Ocoee series of this district consist of coarse, thick-bedded feldspathic sandstone with interbedded dark, locally gray, slates. Slaty beds are abundant but erratic in their distribution. No true conglomerates are observed, but local conglomeratic zones occur where rounded pebbles or cobbles are imbedded in sand; also, fanglomerates occur.

Basal Ocoee beds are well exposed on the Chatsworth-Ellijay road 5.5 miles east of Chatsworth where they rest unconformably on Fort Mountain gneiss. They are composed of blue quartz and feldspar derived from that rock. Dark slates begin to appear several hundred feet above the base. No conglomerates have been observed at this locality.

The dark slates with a graphitic carbon content of one or two per cent occur generally throughout the series in this district. The zones range in thickness from several feet to several hundred feet.

A short distance east of the Wilhite slate zone east of the Cartersville fault, conglomerate beds are exposed in the Ocoee series on the road just west of the abandoned CCC Camp on Holly Creek. Pebbles and cobbles are scattered through a zone 100 feet or less in thickness. Most of the pebbles are of a hard, dense, coarse-grained quartzite composed of interlocking grains of feldspar and quartz.

In a somewhat similar position just above black slates in Mill Creek valley above Hassler Mill, cobbles occur imbedded in arkose. Some of these fragments are amphibolite, others represent a typical flaser gneiss, composed of quartz, microcline, plagioclase and sericite. The pebbles examined were so sheared that it was not possible to determine if originally they were granite or arkose. Boulders of Corbin granite also occur here. They appear massive in hand specimen, but a thin section indicates that the quartz and microcline are badly strained and granulated. The same conglomerate is well exposed in the valley of Emery Branch. This conglomerate is a fanglomerate or channel conglomerate which represents rapid deposition by streams from the granite area to the east into the subsiding geosynclinal basin.

It is possible that several zones of pebbles and cobbles occur. They are unusual, thus represent an inconspicuous part of the series. They occur in unmetamorphosed arkose. A perusal of Hayes' unpublished report indicates that these local conglomerates represents his "Cohutta conglomerate,"[9] but it is questionable if they have sufficient stratigraphic continuity to deserve formational recognition.

Origin and Geologic Age

Statements made here are based entirely upon observations made in north Georgia[5, 6] and adjacent parts of Tennessee and North Carolina, thus there is no attempt to define Ocoee rocks in other states. The Ocoee series is regarded here as a series of arkoses and slates which lie unconformably upon gneisses, schists, and granites, and which are derived from the weathering of these old crystalline rocks. Rocks of this type may be observed east of the Murphy marble belt where they were mapped as Great Smoky formation by LaForge.[17] West of that belt to the Cartersville fault, similar rocks occur but their relation to basement crystallines is obscure. However, the writers find that the crystalline basement has been brought up east of the Cartersville fault in this area by overthrusts, and this discovery justifies a re-examination of the entire problem so far as Georgia is concerned.

East of Chatsworth, Ocoee rocks rest unconformably upon Fort Mountain gneiss and Corbin granite. They are unmetamorphosed, and consist of feldspar and blue quartz grains derived from the underlying crystalline rocks. Although essentially undeformed, the mineral constituents exhibit effects of metamorphism, produced prior to their deposition. Pebbles and boulders which occur in some zones consist of typical Corbin granite and of schists and gneisses.

Also, as this series is traced eastward to the Murphy marble belt, there is an increase in metamorphism toward the east, but this change, which is to be expected, would not appear to justify any change in age classification because the formations remain similar to those of the west, except for local metamorphism. Thus, the Ocoee series would appear to be identified with the Great Smoky formation of Keith.

For example, the section of the Ocoee series as exposed along Ocoee River in Tennessee appears to represent essentially the same type of rocks as the section of Ocoee above the unconformity between Chatsworth and Ellijay. Also, a section of the rock between Fairmont and Jasper, Georgia, differs very little from other sections mentioned. The Ocoee series, where exposed outside the regions of high relief, appears to be less massive and generally more metamorphized. In such localities, outcrops are scarce, and weathering has taken place to considerable depth.

The lithologic character, mineral composition, etc., of the series, as described above, indicate conditions of rapid deposition on the borders of the Appalachian Geosyncline in early Cambrian times. This view is in agreement with other writers upon the subject, thus needs no further elaboration in this article.

The general lack of intrusive rocks in the Ocoee series deserves mention. Dike-like bodies of hornblende meta-gabbro occur locally in the arkoses and slates. LaForge has described several from the Ellijay quadrangle[17]; however, they are rare or absent in this district. Dikes of this character have been described by Furcron[4] from Lower Cambrian sediments, in similar positions, in Virginia.

Wilhite Slate

An extensive formation of dark slates occurs beneath Ocoee rocks in this district immediately east of the Cartersville overthrust. This slate formation was considered by Hayes[9] to be the Wilhite slate, although he regarded it as of "Algonkian" age. The Wilhite slate, named by Keith from exposures on Wilhite Creek, Sevier County, Tennessee, is described in the Knoxville [14] and Loudon[15] folios.

The slate of this area does not seem to correspond entirely to the description of the Wilhite slate to the north; thus, its age is open to question. It should be mapped separately from Ocoee rocks because it does not appear to belong to that series lithologically. Basal Ocoee rocks exposed in Cohutta Mountain are sandstones; also, there is no extensive and thick formation of dark slates which do not contain sandstone beds to be found within the Ocoee formation. Also, Hayes[9] states that these dark slates in this area contain limestone beds, and no limestone has thus far been discovered in the Ocoee series. Thus, the Wilhite should represent Paleozoic rocks younger than the Ocoee series.

Later and more detailed studies may establish the age of this slate. It is classified by necessity in the legend as Lower Cambrian, but it may be of later age. Lithologically, it bears resemblance to the Rockmart slate which Butts[2, 7] has shown to be of Mississippian age and which occurs on the Cartersville fault in very similar position a short distance to the South of this area. The term "Wilhite slate" is here tentatively accepted pending later studies which may lead to its definite correlation. The Rockmart slate was, until recently, regarded as old.[7] Thus, discovery of fossils in slates and limestones which peep out from under the Cartersville overthrust may ultimately serve to classify them.

Rome Formation

Distribution

The Rome formation crops out along three belts in northwest Georgia. The northwesternmost belt extends from near Villanow, Walker County, northward to the Tennessee-Georgia State line. The middle belt extends from Cave Springs northward through Rome to a point east of Dalton, thence northeastward into Tennessee. The eastern belt extends from Cartersville northward through Chatsworth, and disappears under the Ocoee series along the Cartersville fault a few miles northeast of Crandall. The eastern belt is the one which occurs in the area mapped in this report (Plate 1.)

Lithologic Character

The following description of the Rome formation is abstracted from the work of Dr. Charles Butts.[2] The Rome is almost entirely composed of sandstone and shale, but in places there are thin layers of limestone. The sandstone is fine-grained and green or red. Much of the shale is gray, pinkish, or yellowish as weathered, but probably where unweathered is greenish. In the most eastern belts of Rome, next west of Cohutta Mountain, only pinkish shale and a rather rough gray shale, more or less dark stained as with manganese oxide, occur. A large body of quartzitic sandstone which makes a conspicuous ridge three miles long, Camp Ground Ridge, occurs between Chatsworth and Eton.

Geologic Age

Dr. Butts[2] states that the Rome formation in Georgia has yielded but few fossils so far as certainly known, but through its lithology and lateral continuity it is known to be the same as the Rome in Alabama, Tennessee and Virginia. In those states, *Olenellus, Wanneria,* and other fossils of accepted Lower Cambrian age occur.

Conasauga Formation

Distribution

The Conasauga formation is rather widely distributed in northwest Georgia. The largest area occurs north and south of Coosa River in Floyd County. Another belt crosses the northwest part of the State between Graysville and Menlo and a short belt lies along Chattooga River. The formation southeast of Rome and Dalton crops out in numerous belts. In the vicinity of Fort and Cohutta mountains the formation has been over-ridden by older rocks from the east along the Cartersville overthrust, thus crops out in this district west of the foot of the mountains (Plate 1).

Lithologic Character

The following description of the Conasauga formation was written by Dr. Charles Butts:[2] "The Conasauga is composed mainly of shale which weathers to a pale yellowish-gray or pinkish color. The unweathered rock is greenish. In its western belt the weathered shale is fissile, soft and fragile. In the easternmost belt, as at the west base of Cohutta Mountains, the weathered shale is commonly pinkish and firmer. Interbedded in the shale is much blue limestone, exposures of which are common throughout all the Conasauga belts. The presence of the limestone, and the absence of red shale or sandstone are two criteria upon which the boundaries between the Rome and Conasauga are approximately determined. As a general rule, if red rock is present, the formation is Rome; if limestone is present, the formation is Canasauga."

Geologic Age

Butts[2] states that most of the fossils found in the Conasauga formation are referred to the Middle Cambrian, but that certain species characteristic of Upper Cambrian age (Nolichucky horizon of the Conasauga) occur in the limestones of the formation near the Cartersville fault.

Knox Dolomite

Distribution

Knox dolomite crops out over a large area in northwest Georgia; however, in the area covered by this map only one belt of Knox dolomite is present. This belt occurs northwest of Chatsworth, extending beyond the margins of the map (Plate 1).

Lithologic Character

As described by Dr. Charles Butts, [2] "so far as exposed, the Knox is prevailingly a thick-bedded, gray dolomite which yields on weathering a great amount of gray chert which is universally distributed over the surface as boulders and chunks of smaller size. Such chert marks the outcrop of the Knox even where there are no exposures of underlying strata of the formation."

Geologic Age

According to Dr. Butts,[2] the Knox dolomite includes the Longview limestone at the top, the Chepultepec dolomite next below, and the Copper Ridge dolomite for that portion of the strata between the Chepultepec dolomite and the Conasauga formation. According to the present usage of the U. S. Geological Survey, the Knox dolomite is Cambrian-Ordovician in age.

STRUCTURE

Both igneous and Ocoee rocks dip southeastward at angles usually between 25 and 40 degrees. The rocks are much folded, but details of folding can be observed only locally.

The dominating structural features of this area are a series of overthrust faults, the westernmost of which is known as the Cartersville fault. Along this fault, Ocoee rocks and Wilhite slate are overthrust upon later, fossiliferous formations of the Great Valley. The former westward extent of this overthrust block is not known but must have been considerable because the fault line owes its present position to erosion. The fault plane dips southeastward at a low angle, thus re-entrances occur where its emergence is intersected by large stream valleys. The most prominent example is the valley of Holly Creek, where Upper Cambrian limestones are exposed beneath overthrust Ocoee rocks. The mountain province is terminated abruptly at the fault line where hard Ocoee slates and arkoses overlie the soft Conasauga formation.

Several overthrusts east of the Cartersville fault have been identified in the mountain region, where the pre-Cambrian basement is thrust upon the Ocoee series and Wilhite slate. These secondary overthrusts are of great economic importance because they bring up the pre-Cambrian formations which contain the talc deposits. The effects of thrusting upon the extent and character of talc in the principal mines is discussed in later pages.

The principal belt of Fort Mountain gneiss and Corbin granite is thrust over Ocoee rocks and Wilhite slate from a point in Holly Creek valley west of Hassler Mill southward to the vicinity of Rock Creek valley. The Ocoee series is unconformable upon these rocks at their eastern boundary between these points.

METAMORPHISM

The pre-Cambrian formations were metamorphosed before the Ocoee series was deposited. This is true, especially of the Fort Mountain gneiss and its included bodies of Cohutta schist. The latter may have been partly schistose before it was included in Fort Mountain gneiss, but certainly it was profoundly changed by that event. All of its minerals are secondary except, perhaps, some primary dolomite and other accessory minerals.

Ocoee rocks of this district are practically unaffected by regional metamorphism. They are composed of minerals and rock fragments from the underlying igneous and metamorphic formations, the massive arkose beds interlayered with slates, where unweathered, are hard and firm. The beds are very little deformed. Original bedding is preserved in the slates.

In passing eastward from the Fort and Cohutta Mountain area, the Ocoee rocks exhibit progressive metamorphic changes. These dynamo-thermal alterations do not affect all of the beds even as far eastward as the Murphy Marble Belt. On the present State Geologic map[7] a thrust fault has been indicated as extending from the head of the Holly Creek re-entrant into Tennessee in the vicinity of Copperhill, where it separates Ocoee rocks on the west from rocks mapped as of Talladega age on the east. The writers believe that the burden of evidence indicates that this fault is not necessary in Georgia because this increased metamorphism to the east is a progressive one which involves the same Ocoee rocks.

Muscovite, developed at the expense of feldspar, was produced under minimum stress conditions; thus, depending upon a number of factors including geographic position, localization of stress, and relative resistance of the beds, all stages of metamorphism from unaltered slate and arkose to quartz-mica schist occur between this district and the Murphy Marble Belt. Small muscovite flakes develop in the dark slates to produce a finely-spangled effect, and locally, eastward, very fine flaky graphite appears.

Pseudo-diorite which contains varying amounts of hornblende develops in certain more massive beds; also, garnet may appear locally. Beds of finer-grained arkose become greywackes containing more or less secondary muscovite and biotite. The alterations described above may be studied locally in the same outcrop, where they are interlayed with unaltered beds of massive arkose. Some of the fresh rock layers towards the east are cut by narrow stringers of mica pegmatite.

This entire metamorphic problem deserves detailed study because it involves questions of geologic age and structure. The development of porphyroblasts and poikioloblasts of biotite, garnet, and staurolite in certain beds is also of special interest. These beds of garnet, staurolite, and biotite schist which occur in the Great Smoky formation are interlayered with beds which are unaltered and which are typical of the Ocoee from Fort Mountain to the Murphy Valley.

Cataclastic metamorphism is common to the pre-Cambrian rocks, and affects also the Ocoee rocks in the vicinity of shear zones. In such cases, the principal minerals are smeared out to produce a banded rock. No true mylonites have been observed in the Fort and Cohutta mountain areas. Typical flaser structure is locally observed in both Fort Mountain gneiss and Corbin granite, where eyes of shattered and sheared quartz are enclosed in iron-stained wisps of sericite and quartz.

The formation of ribbon gneiss and the shearing out of quartz veins and pebble beds into beds of greatly elongated "stretched" pebbles on the borders of shear zones have been described previously by the writer[6] from Ocoee rocks near (west of) the sheared Murphy Marble Belt.

TALC DEPOSITS

GENERAL PROPERTIES OF TALC

Talc is a rock forming mineral found widely distributed in metamorphic rocks, but commercial quantities of it are found only in a relatively few localities. The mineral has the theoretical chemical composition of $H_2 Mg_3 Si_4 O_{12}$ which broken down to standard oxides is magnesia, 31.7 per cent; silica, 63.5 per cent; and water, 4.8 per cent. Talc occurs generally as a fibrous or foliated mineral with a pearly luster. It has the hardness of 1 in Mohs' scale and specific gravity of about 2.7. When pure, talc varies in color from apple green or light yellow to white or silvery white. It has a greasy feel referred to in the talc industry as slip. In thin scales talc is translucent to semi-transparent. Talc is acid resistant and heat resistant; however, it loses its combined water at white heat and becomes hard. Several varieties of talc are recognized among which the following may be mentioned.

Massive or Steatite Talc—This is a dense, relatively hard, compact variety of talc used principally in ceramic products. Massive talc is generally derived from the alteration of magnesian limestones and marbles.

Foliated Talc—This is the phanerocrystalline variety which occurs as flakes somewhat similar to mica. Its color is characteristically light green, and the thin foliae may be almost transparent. Foliated talc is commonly referred to as micaceous talc. The Murray County talc to a large extent is of the micaceous or foliated variety, although the crayon talc represents a peculiar compact variety.

Pseudomorphic Talc—As the name implies, this variety of talc assumes the crystal outline of the mineral from which it was derived. Some of the more common minerals from which the pseudomorphs are formed are tremolite, actinolite, and asbestos. New York and North Carolina have talc of this variety, but this type is not known from Murray County.

WORLD DISTRIBUTION OF TALC

Deposits of talc are known in nearly every country, but production on a commercial scale is confined to those countries which have industrial development. Countries which have no talc-consuming industries generally produce only the highest grade of talc for export. Talc is a relatively low cost commodity, this, in general, must be utilized near the producing area.

Of the total world production in 1920, the United States produced about 66 per cent, France 14 per cent, Italy 7 per cent, Germany and Austria 5 per cent, and Canada 5 per cent. Since that date three additional countries have become important in world talc production; listed in the order of their importance they are Manchuria, Norway, and India. India and Manchuria, even though not highly industrialized, have attained their importance in talc production mainly by producing a high-grade steatite talc for export. In 1940 about 30 countries reported talc production, the United States producing about 42 per cent of the total.

In this country commercial or semi-commercial deposits of talc are known in 18 states; five states are outstanding talc producers. The leading states listed in order of tonnages produced are: New York, California, Vermont, North Carolina, and Georgia. A short discussion as to the quality and variety of talc produced in the United States by state follows:

New York—All of the talc produced here comes from a small area in the extreme northwestern part of the state. The talc occurs in pre-Cambrian marble associated with gneisses and schists. It has resulted from the alteration of tremolite, thus is of the fibrous variety. Most of it is used as a filler in paper.

California—The largest talc deposits occur in the eastern central part of the state. It has been formed from a dolomitic limestone which has been intruded by diorite. Talc from this state is generally high grade and demands a high price on the eastern market.

Vermont—Deposits of talc are found in the northern and southern parts of the state. A greater part of this talc has been formed from the alterations of peridotites. Foliated or micaceous talc is the variety produced and finds a market as a filler in cloth and rubber.

North Carolina—Two talc producing areas are important. In the Marshall area, located about 20 miles northwest of Asheville, talc has apparently been formed from the alteration of ultrabasic rocks. Some metal workers' crayons are cut from the sounder blocks of talc, but the largest production is in the form of powder for the filler trade. The Murphy area contains the only important deposits of white talc known in the state. This talc occurs as lenses in a dolomitic marble along a belt about 25 miles long from Culberson to Hewitts. Production from this belt has been more or less sporadic. This talc is of the fibrous variety principally; however, some steatite talc also occurs. It is used for crayons and for powder in the filler industry. A limited amount has been produced of cosmetic grade.

Georgia—Two well-known talc producing areas occur in this state. The Murphy belt, described as occurring in North Carolina, extends southward into Georgia across Fannin County and to Ellijay, Gilmer County. Twelve occurrences have been described from this belt*; however, at no place has there been extensive mining. No talc is produced from this belt in Georgia at present. This report contains a discussion of the talc in Murray County.

Other States—In addition to the above states, Maryland produces a limited amount of steatite talc, and some talc of industrial grade from an altered marble. Washington produces a small amount of high-grade steatite talc. Pennsylvania and New Jersey produce a small amount of industrial talc from an altered impure limestone. Alabama[18] contains at least one deposit of massive talc which has resulted from the alteration of a limestone or dolomite.

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* Unpublished manuscript by A. S. Furcron and Kefton H. Teague on "Talc Deposits of the Murphy Marble Belt, Georgia" in files of Georgia Geological Survey.

TALC DEPOSITS OF MURRAY COUNTY

Distribution of Deposits

All the known occurrences of talc in Murray County are limited to the 26th District and the 2nd Section. These occurrences, as shown on the geologic map (Plate 1) are all located on the northern, western, or southern slopes of Fort and Cohutta mountains (Frontispiece). Two of the three belts of Fort Mountain gneiss have inclusions of Cohutta schist which contain deposits of talc. The western or lower belt contains the Southern, Georgia and Old Cohutta mines. The eastern belt contains the remainder of the known deposits. This eastern belt or zone of rock has an outcrop length of about eight miles and contains the Chicken Creek mine, Bramlet prospect, Cohutta mine, Latch prospect, Fort Mountain mine, and Mill Creek prospect. More than half of the area underlain by Fort Mountain gneiss is covered by talus which may conceal undiscovered deposits of talc.

Varieties of Talc in Murray County

The talc in this region is the massive variety and has a more or less schistose structure. The talc veins associated with the secondary dolomite is always foliated, apple green or silvery white in color, and in thin plates semi-transparent to translucent. This variety occurs in very limited volume. The talc that makes the bulk of the deposits is generally light to dark green in color, dense, and schistose in structure. Commercial talc contains a large variety of impurities in varying amounts. Several grades, depending upon the kind and amount of impurities present, are recognized by the miners. These grades with the more characteristic minerals are listed below:

"Crayon talc or saw rock"—Consists principally of straight grained or schistose talc with minor amounts of chlorite, magnetite, and pyrite.

"Blue John"—A term used to describe a material having the appearance of crayon talc but too hard to saw because of the presence of chlorite, carbonate, quartz, pyrite, and magnetite.

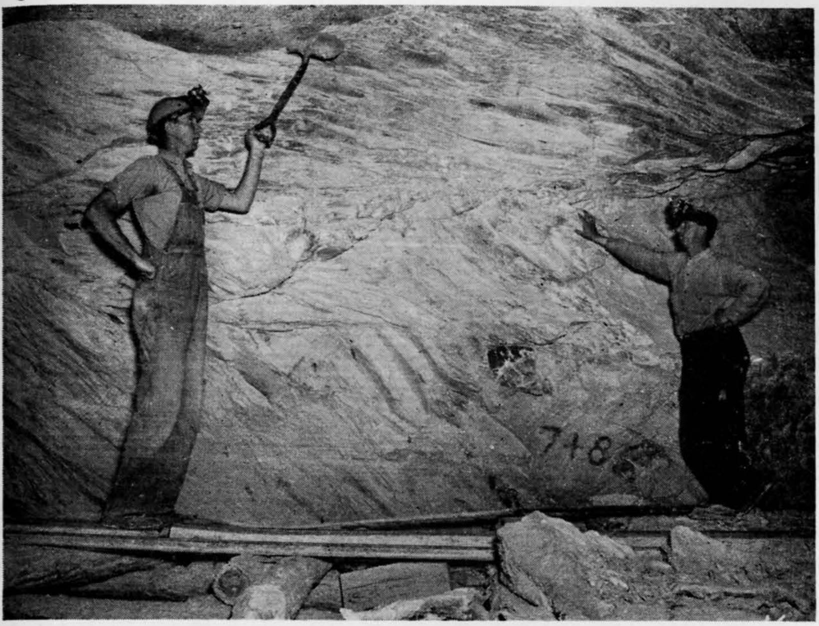

Figure 3. Four-foot zone of crayon talc enclosed by hard white grinding talc at the Fort Mountain Mine. Note sharp contacts, and straight schistosity of crayon talc.

Figure 4. Serpentine (dark) and secondary dolomite (white) South Entry of Fort Mountain Mine; upper left corner, part of a large mass of coarsely crystalline secondary dolomite; beneath this is sheeted and brecciated serpentine and dolomite, visible due to deposition of secondary dolomite.

"White grinding"—a mixture consisting essentially of minerals which, when ground, produce a white powder. This grade usually contains talc and dolomite with minor amounts of the other common impurities.

"Dark grinding"—A rock containing a mixture of light and dark-colored minerals which, when ground, produces a gray powder. It is composed essentially of talc, chlorite, serpentine, and carbonate with minor amounts of magnetite, pyrite, chromite, etc.

Uses

Talc has had a wide variety of uses, depending upon its purity, color, and structure. During the early years of the industry in Murray County efforts were directed towards the production of crayons, with little attention given to that talc ore suitable only for grinding. As new uses for ground talc have been developed, the talc industry has gradually changed its emphasis from production of crayons to powder. This utilization of both crayon and grinding grade talc has led to a more efficient and systematic mining of the ore.

Industries which consume the largest tonnage of ground talc are the paint, ceramic, rubber, roofing, paper, and insecticide. Of these major talc consuming industries, talc from Murray County is suitable for the paint, rubber, roofing, and insecticide trades. In paint talc serves as an extender, and in some types of paints may be the principal pigment. The rubber industry utilizes talc as a filler because of its softness and insulating properties. Also, talc is used to coat rubber molds to prevent sticking. In the roofing industry coarsely ground talc, mixed with petroleum by-products, is used in the maunfacture of asphalt roofing; it is also used for dusting the finished product to prevent the layers from sticking together when rolled for shipment.

As a result of the insecticide development during the war years, large tonnages of ground talc are now consumed as a carrier. Talc is adaptable for this use because of its spreading and cohesive characteristics.

In addition to the uses described above, ground talc from this district is used as a coating for foundry facings by the iron and steel industries, as special lubricants, and in various types of dusting agents.

The more pure form of talc is sawed into crayons. Talc suitable for crayons must be relatively soft, of uniform quality, free of cracks and fractures, and have a straight grain. The Chatsworth talc district, for a number of years, has been the leading area in the production of metal workers' crayons. Rejects and scraps from the saw lines are ground and sold as a low grade cosmetic talc.

Chemical Analyses

In the Georgia talc report by Hopkins[12] numerous analyses of various types of talc are given. During the preparation of the present report samples of several commercial grades of talc were collected and analyzed. These analyses are given below:

TABLE 3

*Chemical Analyses of Murray County Talc**

	M-O	M-1	M-2	M-3	M-4	M-5	M-6
SiO_2 . .	63.50	40.75	59.72	41.02	22.80	46.24	47.92
Al_2O_3. .		12.77	3.04	4.23	4.79	7.29	7.35
Fe_2O_3 . .		9.59	5.22	5.85	8.71	7.15	6.82
MgO . . .	31.70	20.50	27.93	28.60	30.41	26.00	26.00
CaO . . .	.	3.69	0.90	4.76	5.94	4.76	4.14
Na_2O . . .	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K_2O. . . .	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO . .		0.12	0.00	0.00	Trace	Trace	0.00
P_2O_5 . .		0.06	0.00	0.00	Trace	0.02	0.00
TiO_2. . .		0.15	0.00	0.00	0.00	Trace	0.15
S		0.13	0.08	0.21	0.22	0.07	0.09
H_2O . . .		0.05	0.00	0.00	0.01	0.05	0.05
Ign. loss	4.80	11.37	3.19	15.51	27.28	8.37	7.51
Totals	100.00	99.18	100.08	100.18	100.11	99.95	100.03

M-O Theoretical talc

M-1 Air floated talc (-325 mesh) from Southern Talc Mill, Murray County.

M-2 Dust from crayon saws, Georgia Talc Mill, Murray County.

M-3 A-white talc powder (98% through 200), Murray County.

M-4 Roofing granules (-35 mesh), Southern Talc Mill, Murray County.

M-5 Gray talc (80% through 200 mesh), Cohutta Talc Mill, Murray County.

M-6 Roofing granules (-32 mesh), Cohutta Mill, Murray County.

* Analyses by Dr. L. H. Turner, Chemist, Georgia Department of Mines, Mining and Geology.

Production

Talc was first discovered in Murray County about 1872. Small scale mining began shortly after that date. The talc produced during the early period of mining was, as a rule, from the outcrops; it was stained by surface weathering and of inferior grade. Production prior to 1898 was small, and no figures as to the amount produced are available; however, it is known that this industry has been active continuously since 1898. The Georgia Talc Company was organized in 1905 in North Carolina and has been a continuous producer in this district since 1907. The Cohutta Talc Company was organized in 1903; however, this company, under another name, had produced talc prior to 1900. It, too, has been a continuous producer since the date of organization.

Production figures which follow are incomplete, and those figures given for the years prior to 1907 represent the total talc produced in Georgia and include talc produced from the Murphy belt in Fannin and Gilmer counties.

Total talc produced in Murray County to date exceeds 300,000 tons. As noted from the production and values given, there has been a wide fluctuation in yearly production and in the average price per ton received. This has been caused by marketing conditions and to some extent by mining and milling facilities. Of the eight leading talc producing states, Georgia now ranks fifth in quantity produced, also in value. Production figures given below were obtained from the files of the Georgia Department of Mines, Mining and Geology.

TABLE 4

Talc Production in Georgia

YEAR	TONS	VALUE
1898	639	$ 4,054
1899	1062	42,085
1900	6477	77,217
1901	693	4,717
1903	1012	9,042
1907	739	11,473
1908	455	7,261
1909	400*	6,800*
1910	1150	15,000*
1911	1191	18,883
1912	1020	15,124
1913	990	25,916
1914	670*	14,000*
1915	498	12,050
1916	3080	88,364
1917	3819	94,314
1918	4000*	100,000*
1919	3000*	60,000*
1920	1174	48,248
1921	1025	15,000
1922	1506	40,042
1923	796	16,568
1924	1885	30,548
1925	5022	76,028
1926	4220	89,000
1927	3110	42,370
1928	4888	85,265
1929	5041	146,025
1930	3439	89,690
1931	3672	65,873
1932	2510	26,487
1933	3408	40,045
1934	6095	61,086
1935	7315	81,373
1936	11473	114,545
1937	11984	148,177
1938	15117	130,595
1939	20090	177,881
1940	20104	219,959
1941	28511	364,560
1942	29930	464,160
1943	35210	396,031
1944	30425	363,342
1945	32433	296,162
Total	349094	$4,235,360

* Estimated

Structural Features of the Talc Deposits

The talc deposits and their associated rocks are included in the pre-Cambrian Fort Mountain gneiss which reached its present position from below by thrust faulting. The general or over-all structure of the principal producing mines is determined by thrust faults which may come into actual contact with the ore. In the case of the Cohutta mine (Plate 5), however, the talc body is entirely enclosed in the old gneiss so that, to any reasonable workable depth, a thrust fault contact is not to be expected adjacent to the ore body. In the Southern mine faulting limits the ore body on the hanging wall side. The heading at Station 9+00 (Plate 4) is in black slate on a thrust, and pencil talc, granite and slate, occur at this position. In general, the foot wall side of the deposits is not affected by fault problems. The entrances to the talc formation are driven through Fort Mountain gneiss or Corbin granite to intersect the talc upon the foot wall. Both of these rocks may be encountered before the talc is cut. Also it may be necessary to cross-cut a considerable thickness of chloritic slate of the Cohutta schist in which the talc occurs before talc is encountered.

The interior structure of the talc-bearing zone is also dominated by slipping and movement. Evidently, stresses which did not especially affect the massive enclosing rocks were released in movement because of the "lubricating" features of talc. This fact makes it difficult to predict geology ahead of mining. Serpentine-dolomite boulders of all sizes dominate the interior structure, and thus determine the plan of the mine. Crayon talc, a sort of "talc mylonite," locally enwraps them. Pencil talc and "Blue John" seem to be related to the more sheared zones, thus are common to the walls of the talc deposits and also tend to enclose the serpentine-dolomite boulders. "Blue John", however, contains other minerals in addition to the talc, thus may be too hard to saw. The serpentine masses are smooth, round, and frequently slickensided on their exterior; schistose talc ends abruptly against them locally. The masses of serpentine show all indications of having been moved and smeared about in the deposit. Although apparently quite massive, they are slickensided interiorly. They do not have a constant alignment in the deposit. Slickensiding is especially notable in the deposits near the "boulders."

These serpentine-dolomite lenses are not to be confused with the hanging wall, although locally they compose the "roof".

Lenses of Corbin granite and Fort Mountain gneiss occur locally in the talc deposits. In all cases they parallel the schistocity, thus have not been seen to cut the talc. They generally occur near the walls and show every evidence of having been sheared into the deposits.

Normal faults occur. They may be traced along the strike for distances of several hundred feet, but it is difficult to determine the throw.

Mineral Composition of Talc Deposits

Of the minerals associated with the talc deposits chlorite, dolomite, serpentine, and talc are the most abundant. A number of minerals, however, occur in relatively minor quantities in rocks that are composed of varying amounts of the four dominant minerals. The mineral species and varieties that have been identified by their optical properties include; talc (a) foliated, (b) massive; dolomite; serpentine (a) antigorite, (b) chrysolite, (c) picrolite; chlorite material including penninite; amphibole (a) actinolite, (b) anthophyllite; magnetite; pyrite; limonite; picotite or chrome-spinel; chromite; quartz; zircon; apatite; sericite; felspar (a) orthoclase, (b) microcline; plagioclase: albite; and vermiculite.

The Cohutta schist, in which the talc bodies occur, is composed of at least four rock types: quartz-biotite-chlorite schist, chloritic slate, serpentine schist, and "blue-john." A microscopic study of these rocks has been made, and a listing of the mineral constituents of each is given here. (1) The quartz-biotite-chlorite schist also contains considerable amounts of albite and lesser amounts of orthoclase and microcline that have suffered alteration to sericite. Minor quantities of apatite, zircon, magnetite and limonite occur as accessory minerals. (2) The chloritic slate usually contains grains of albite and orthoclase that are altering to sericite and quartz. Portions of this rock may be almost entirely chlorite; however, other portions may include considerable amounts of dolomite and talc. Apatite, zircon, magnetite, pyrite, and limonite are present as accessory minerals. Vermiculite is locally developed from the chlorite along a contact between the schist and granite. (3) On the southwest side of Cohutta Mountain a serpentine schist phase of the talc formation is found to crop out. This rock consists almost entirely of serpentine. In thin section this mineral appears to be altering to chlorite and talc. Biotite, which contains small crystals of zircon, is altering to chlorite. Minor quantities of magnetite, limonite and chromite are also present. (4) "Blue-john" is a term applied by talc miners to a dense, green schistose rock that cannot be distinguished by appearances from some varieties of talc. In part, at least, the material called "blue-john" is a dense talc-chlorite schist in which the following minerals have been identified: quartz, orthoclase, albite, sericite, zircon, magnetite, pyrite, and limonite. The quartz, albite, and orthoclase all occur as rounded grains or fragments of grains that are surrounded by chlorite and talc. Some of the "blue-john" may contain considerable amounts of serpentine and dolomite; however, these minerals were not present in the "blue-john" studied in thin section.

There are at least three stages of dolomite development in the talc deposits. Two of these are very clearly illustrated in a number of the thin sections that were studied, while the third stage was observed in only one section. The oldest dolomite is composed of fine-grained interlocking crystals, which contain minute inclusions of magnetite and pyrite. This dolomite is here designated as the original dolomite of the talc formation. In one thin section this dolomite contained a fracture which had been filled with extremely fine interlocking grains of dolomite. Both the original dolomite and the dolomite that filled the fracture were being replaced by younger, or secondary, dolomite and chlorite. The secondary dolomite usually contains twinning; it is coarse-grained; and it is associated with secondary quartz and talc. Optical properties of several specimens of both the primary and secondary dolomite were determined and found to be within the range of dolomite.

Original dolomite occurs in nearly pure form as well as in mixtures of talc, chlorite, and serpentine. The secondary dolomite also occurs in pure masses as well as in mixtures with original dolomite. It is usually associated with secondary quartz and apple green talc.

Serpentine is found in nearly pure masses, in schist, and in rock composed of a mixture of varying quantities of dolomite, chlorite and talc. It makes up the "roof" in many of the mines. Ordinary massive or common serpentine (antigorite), is the most plentiful variety. It is found in light to very dark green masses that have granular, schistose, or massive texture. Some of the serpentine occurs in rather pure form; however, it is commonly found with varying amounts of dolomite. In thin section, dolomite apparently is being replaced by serpentine. Irregular grains of dolomite are found surrounded by serpentine. Serpentine pseudomorphs after several minerals are common. The original minerals that have been replaced include: feldspar, actinolite and dolomite. In addition to dolomite, minor accessory minerals identified in the serpentine include: magnetite, pyrite, limonite, zircon, apatite, chlorite, secondary quartz, chromite, and actinolite.

Relatively small amounts of two varieties of fibrous serpentine have been identified. Chrysotile, composed of delicate flexible fibers that have a silky luster, is found in thin seams in massive serpentine. Picrolite, columnar to fibrous serpentine having a splintery fracture, occurs associated with dolomite in the Cohutta Mine.

Crayon Talc

Fine granular or cryptocrystalline steatite occurs in nearly pure masses of talc which can be sawed into pencils or crayons. In color, crayon talc varies from greenish gray to dark green; in texture, it may be laminated schistose or foliated massive. Thin flakes of steatite are subtransparent to translucent. Crystals of pyrite and magnetite are found scattered throughout the talc; also, in thin sections small quantities of serpentine, chlorite, dolomite and quartz were identified. The impurities in good crayon grade talc make up less than one per cent of the material.

White Grinding Talc

White grinding talc is composed essentially of a mixture of white to very light green steatite and light gray dolomite. The amount of dolomite in white grinding talc may be in excess of 50 per cent of the total mineral content of the rock. At the mines, a distinction is made between soft grinding and hard grinding varieties; however, there appears to be no mineralogical evidence to account for this classification. Thin sections of both varieties contained approximately the same quantity of dolomite. By mineral count, hard grinding talc contained an average of 53.5 per cent talc, 45 per cent dolomite and 1.5 per cent impurity, while in the soft grinding variety dolomite comprised from 40 to 53 per cent of the rock. No differences in texture or grain size were noted. In some cases it is believed that the hard grinding varieties contain a greater proportion of dolomite; nevertheless, one specimen of soft grinding talc contained more dolomite than was found in hard grinding specimens. Dolomite usually occurs in individual rhombs or crystals that are less than 0.5 mm. across. A few crystals, however, measured 2 mm. in their greatest dimension.

Impurities, other than dolomite, generally constitute less than 2 per cent of white grinding talc. Of these accessory minerals, magnetite and pyrite are more abundant than actinolite, zircon, and chromite. Both talc and dolomite were found to fill fractures in magnetite. Dolomite is being replaced by talc, and magnetite is being replaced by pyrite.

Dark Grinding Talc

Dark grinding talc is also classified at the mines into hard grinding and soft grinding varieties. Both varieties are dark gray in color and schistose in texture. The difference in hardness reflects the mineral composition of the two varieties. In thin section, the hard grinding talc was found to contain up to 25 per cent chlorite and talc. It is a chlorite schist containing quartz, orthoclase, albite, sericite, zircon, and limonite. The soft grinding variety, by mineral count in thin section, is composed of 68 per cent talc and chlorite with talc predominating, 28 percent dolomite, and 4 per cent accessory minerals. The latter minerals include albite, apatite, zircon, and limonite. Both the dolomite and the chlorite show alteration to talc. Limonite appears along cleavage planes in dolomite as well as in pseudomorphs after magnetite or pyrite.

Genesis of Murray County Talc Deposits

There is disagreement upon the genesis of these deposits because previous writers have ascribed an igneous origin to them. In his unpublished folio on the Dalton quadrangle, Hayes[9] states that the talc and serpentine of this area were produced from basic intrusive bodies.

Hopkins[12] believed that the talc deposits represent altered basic intrusions and that they occur in the Ocoee series. He pointed out that extreme metamorphism has obliterated the original character of the rock (Page 213), yet the Ocoee rocks of this district are almost unmetamorphosed. He believed that these supposed igneous rocks were originally dikes or sills which, although generally accordant, actually cut the Ocoee beds at small angles. On Page 215 he states that limestones, a possible source of talcose material, are generally absent from rocks of the Ocoee series; thus, he writes "in brief, the postulation of an igneous origin in the form of dikes and sheets seems to satisfy the conditions better than any other theory." He points out, however, that there is definite absence of intrusive character to the talc rocks, but concludes "that as a whole a theory of igneous origin is more tenable, although the condition of sedimentary origin would more easily explain the conditions at certain localities." He found no evidence of igneous structure in thin sections. Mines were not extensively developed at that time and, not having the opportunity to work out the general geology of the area, it is obvious that Hopkins was undecided upon the origin of the deposits.

The writers believe that an investigation of the structure and stratigraphy of the area affords important clues to the genesis and to the extent of the deposits. These deposits do not occur in the Ocoee series but in an old up-faulted granite gneiss of pre-Cambrian age (Fort Mountain gneiss). They are found in a highly-altered pre-Cambrian dolomite which was part of a meta-sedimentary formation (Cohutta schist) included in and intruded by the Fort Mountain gneiss. Both of these formations are intruded by the later Corbin granite which also is pre-Cambrian. Certainly, there was sufficient igneous activity, as well as shearing, to produce the mineral assemblage which composes the deposits. No evidence has been discovered in the field to indicate that the talc formation is an intrusive one. No igneous rocks have been discovered which represent a part of the talc formation. The formation does not occupy any special level in the Fort Mountain gneiss.

Deposits are repeated locally at different levels, and this accounts for disagreement in observations made by the miners who, in their several localities, recognize different numbers of "talc zones" on the mountainside.

The talc formation is quite variable in composition, but the dolomitic marble facies produces the talc. Some of the talc zones are but a few feet in thickness; others, where good mines are located, are 100 or more feet thick.

Neither Hopkins nor Calver have discovered mineral evidence of an igneous origin for the deposits. Dr. James L. Calver, who examined numerous thin sections of the talc and associated minerals, writes the following statement upon the genesis of the deposits:

"The petrographic study of talc bodies in the talc formation of the Chatsworth, Georgia, area presents no evidence other than the rare occurrence of chromite or picotite to suggest an igneous origin for the talc formation. These chromium minerals probably represent detrital minerals in an old sediment rather than indicating that the original rock of the talc formation had a basic igneous character. Both chromite and picotite occur in small amounts locally, and are not found distributed throughout the talc bodies.

"The mineral sequence is fairly well indicated. Talc was formed after the process of serpentinization was complete. Talc replaces both serpentine and dolomite. Accompanying the formation of talc, a portion of the dolomite recrystallized to form secondary dolomite. Talc replaced serpentine both directly and with the intermediate state of chlorite formation. Talc is always associated with dolomite. The order in which the most abundant minerals in the talc deposits appear, from oldest to youngest, is: actinolite, albite, quartz, magnetite, dolomite, pyrite, serpentine, chlorite, secondary dolomite, talc, quartz, pyrite, anthophyllite and limonite."

In conclusion, the chemical composition of the deposits, their mineralogy, structural and stratigraphic position, geologic age, and relation to enclosing igneous rocks point to a sedimentary origin for the talc deposits of Murray County.

Descriptions of Mines and Prospects

Georgia Mine

The Georgia mine is located on the western side of a low strike ridge 3.5 miles southeast of Chatsworth in lot 271 (Map location 5, Plate 1). It is accessible via county road (formally calley Federal Road) which turns south from Georgia Highway No. 2 one-half mile east of Chatsworth. This mine is owned and operated by the Georgia Talc Company.

About 1872 the late W. C. Tilton discovered talc on lot 271. This lot has the distinction of being the first lot on which talc was mined, also it has been most extensively developed. The Georgia Talc Company began mining talc from this lot in 1907 and has produced talc from this property continuously since that date. Many of the old openings made along or near the talc outcrop have been abandoned and are at present caved. Mining is now confined to the northern half of the property. The openings on the southern part of the lot are filled with water, thus inaccessible; however, the mine operator plans to reopen this part of the mine in the future. The writers have not had an opportunity to examine these openings, thus the description of the talc body which follows is limited to those openings which are accessible at present. The mine map (Plate 2 and 3) is incomplete in that it covers only that portion of the mine now being worked. Mr. Glenn reports that the flooded portion of the mine to the south is as extensive as that portion mapped.

The talc body in which the Georgia mine is located is the most extensive body known in this talc producing district. It extends from the old Cohutta mine (south of the Georgia mine, but now abandoned) northwestward to the Gordon Pit at the north end of the Georgia mine, a distance of almost one mile. It attains a thickness as great as 150 feet in the Shop Tunnel opening, and has been opened down the dip for at least 250 feet. As might be expected from the size of the talc body, not all of the material is suitable for powder or crayons because numerous lenses of Fort Mountain gneiss occur in the talc body. The gneiss was probably worked into the talc body by faulting, since slicken-siding is present throughout the mine; however, no definite major displacements can be recognized. Locally, movement was sufficiently extensive to produce brecciation in the resistant serpentine bodies of the talc formation (Figure 1). Wall rock structure in this mine is similar to that found at the Southern mine. The same two faults which brought up the talc bearing rock at the Southern mine are present here (see areal geologic map, Plate 1).

From south to north in that portion of the mine mapped, the character of the talc-bearing zone changes considerably. In the southern part, the talc body is characterized by a large amount of white grinding material as well as some crayon talc. A large amount of crayon grade talc has been mined from the second level east of station 29-92 in the Hollow Pit entrance. The long axis of this crayon talc lens parallels the strike of the talc body. In the extreme northern portion of the mine, a large amount of crayon talc has been taken from the lower and upper Gordon Pits. The crayon talc here occurs as a sort of talc mylonite between large bodies of serpentine (called boulders by the miners). In those portions of the mine where serpentine boulders are abundant, extreme care in mining is necessary since they are invariably surrounded and cut throughout by slickenside surfaces, thus may fall from roof or walls of the openings without warning even though they appear sound when the roof is scaled after shooting. These serpentine boulders when mined and milled produce a dark powder suited only for the roofing trade. The general strike of the talc body here is north, with dips ranging from 30° to 40° E.

Reserves of talc suitable for grinding and blocked out in the openings here are great; however, talc of crayon grade encountered in mine development has, to a large extent, been mined. Numerous thin zones of crayon talc exposed in the walls of drifts can be recovered along with the grinding talc when it is mined. At the present rate of mining, reserves are adequate for a long period.

Southern Mine

This mine, formerly called the Piedmont Mine, is located on the western slopes of the first north-south striking ridge east of the Great Valley, three miles southeast of Chatsworth

(Map location 6, Plate 1). It is reached by a dirt road which extends south from Georgia Highway No. 2 at the old prison camp, two miles east of Chatsworth. The distance from the mine to this highway is approximately one mile. The mine is in the northwestern corner of lot 270, which is owned by the heirs of Samuel Fields and is leased by the Georgia Talc Company which operates the mine.

Initial work at this mine was done prior to 1900; however, little talc was produced until about 1917. The mine was operated from 1917 until 1921, when it was abandoned. The Southern Talc Company, formed in 1935, leased the mine and began production of talc at that time. In 1941, the Southern Talc Company was sold to the Georgia Talc Company.

Talc at this place occurs enclosed in granite gneiss, which in turn is surrounded by black slate (Wilhite slate). The position, as seen on the areal geologic map (Plate 1), is due to a double thrust fault which has thrust the granite gneiss and included talc into the Wilhite slate. This talc body has a pronounced lens-like shape, especially parallel to the strike, and the decrease in thickness down the dip suggests that the two faults merge at depth, thus cutting the talc body off on the dip. In the center of the lens, near the top of the haulage incline (Plate 4), the talc body has a thickness normal to the dip of about 85 feet; however, this thickness appears to decrease along both dip and strike. The rocks strike here about N. 15° W., with dips ranging from 25° to 35° NE.

In general, talc ore from this mine is of more uniform grade than from other mines now active in the district. The ore is invariably high in dolomite, and generally contains minor amounts of pyrite and chlorite. Serpentine occurs only in minor quantities or not at all. The majority of the grinding talc produced from this mine is of the white grinding grade. Crayon grade talc is confined to the foot and hanging walls, with minor amounts occuring in the zones of movement between the soft and hard grinding material; also on the foot wall sides of two normal faults which are exposed on the fourth level (Figure 2).

Most of the talc which can be removed safely from the upper levels has been mined, thus future mining will be from

Figure 5. Talc mills at Chatsworth, viewed from the east; Georgia, Cohutta, and Southern Mills from left to right.

Figure 6. General surface layout at Cohutta Mine. Ore bin has 60-ton capacity. Dump on left contains talc ore suitable, when dry, for grinding.

developments at greater depths or from extensions of the mine along the strike. In the planning of new openings, levels should be far enough apart to permit efficient stoping.

It is difficult to predict the reserves of talc to be expected here; however, present indications are that the reserves are not great. This conclusion is based upon the structure as seen at present and the character of the talc body in the deepest openings; however, future drilling may prove that this conclusion is incorrect.

Cohutta Mine

This mine, located 3.5 miles east of Chatsworth on the northwestern slope of Cohutta Mountain, is in lot 294, known as the Cohutta lot (Map location 10, Plate 1). It is reached from Chatsworth by the mine road which turns north at the abandoned prison camp from Georgia Highway No. 2, two miles east of Chatsworth.

Several old abandoned and caved prospect pits and drifts occur on this lot; however, mining at present is confined to one area on the south side of Goldmine Branch. Mining here was begun about 15 years ago, and has been continuous to the present. This mine has three openings to the surface (Figure 6). The lower adit serves as a haulage and man-way. The upper two openings, which follow the talc body up the dip to the outcrop, serve as air courses.

Talc at this place occurs enclosed in Corbin granite and Fort Mountain gneiss. No evidence that the position of the talc is related to faulting is observed, although abundant zones of local movement are evidenced in the mine by slicken-siding. In those portions of the mine where the talc is in direct contact with granite, good quality pencil talc is found (Plate 5). This is especially true in that area between station 21+00 and 19+50, also a similar condition exists near the head of the main haulage incline.

In the development of this mine to date, three large bodies of good talc have been found. These bodies are shown on the mine map and may be identified upon it by the position of large stopes in them. As a rule, the talc encountered in these large open stopes consists of a mixture of white grinding and crayon grade material. Other than the material described above, this mine is characterized by extensive bodies of hard dolomitic serpentine which when ground produces a gray or dark powder. Areas of the mine where this type of material is abundant can be recognized by the long drifts with no stopes from them.

Dips and strikes of the talc body vary greatly; however, the general strike is to the northeast, with dips to the southeast.

Future life of this mine is dependent upon the type of ore desired. There is a large reserve of materials suitable for the roofing industry, although no large deposit of good grade talc suitable for white grinding powder or crayons is exposed at present. Perhaps future development here should be directed from those areas where good talc has been mined in the past. It is suggested that future prospecting is warranted from the second level northeastward from Station 9+96 and on the first level southwestward from Station 7+65.

Fort Mountain Mine

The Fort Mountain Mine is located in lot 297 on the northwest slope of Fort Mountain at an elevation of about 1900 feet (Map location 13, Plate 1). Access to the mine is by soil road from Chatsworth, a distance of 5.2 miles. A new road has recently been completed which will eliminate some of the very steep grades encountered on the haulage road formerly used. This new road turns north from Georgia Highway No. 2 two miles east of Chatsworth at the old prison camp and continued with gentle grade around the western slopes of Cohutta Mountain to the Cohutta Mine; from there it extends northward around Fort Mountain to the Fort Mountain Mine. This mine is owned and operated by the Cohutta Talc Company.

Talc was first discovered on this lot by the late W. C. Tilton prior to 1900. Early mining was confined to outcrops, thus it consisted of digging small pits and taking out only material which could be reached with ease. Talc produced from this type of mining was always stained by surface weathering and was of inferior grade. Evidence of this early mining may now be seen as caved pits along the talc outcrop. Mining during this early period was not extensive. Two openings, North Entry and South Entry, are accessible at present; however, the South Entry was last mined about two years ago. These openings are about one-eight of a mile apart.

In the northern entry two lenses of talc (Plate 6), separated by granite gneiss, are present. The lower lens is from 6 inches to 10 feet in thickness, strikes about N. 30° E. dipping about 40° SE. Little or no crayon grade talc occurs in this lens. Associated with the talc here is a large amount of chlorite and serpentine with minor amounts of pyrite and secondary dolomite. Foot and hanging wall contacts are sharp; both walls are of granite gneiss. When ground, talc from this lens produces a dark product because of the impurities contained. Due to the inferior grade of talc, mining of this lens has been discontinued.

Some 15 to 20 feet above this lens another talc lens occurs. At present, the entire production of talc from the mine is obtained from this lens. Three general types of talc are produced here: hard dark grinding talc composed mainly of serpentine, dolomite, chlorite and talc; white grinding talc composed of talc and chlorite; and crayon talc composed principally of talc. The location and distribution of these various grades of talc are shown on the mine map and structure sections. This talc body is the most important producer of crayon grade talc in the district (Figure 3).

Zones of movement are evident at numerous places in the talc body. In general, dislocation cannot be followed for any great distance; however, in that part of the mine east of station 5+93 the top or roof of the openings is a fault surface. On the footwall side of this fracture a large body of crayon grade talc occurs (Figure 3). As a general rule in this mine, the grades of talc are separated by conspicuous zones of movement. Strike and dip of the upper talc lens are variable, with a general strike to the northeast and a low dip to the southeast.

The South Entry exposes only one talc body. It is not known if this lens is connected to either of those opened by the North Entry. Rock types present here include granite, chloritic schist, serpentine, talc, and secondary dolomite. The entrance adit is driven through granite (Corbin granite). Between the granite and talc, there is a 50-foot zone of chloritic schist of the Cohutta schist formation in which the talc occurs. The talc body strikes about N. 20° E., dipping 25° SE. No strong evidence of extensive movement is present in this mine. A two-foot zone of crayon talc is exposed on the footwall side of the body, and a large lens has been mined from the bottom of an incline near the center of the mine. Adjacent to this crayon talc a pseudo-bedding effect has been produced by deposition of secondary dolomite in the serpentine (Figure 4). The headings last worked are in a mixture of serpentine, dolomite and talc which is hard, thus causing probably the abandonment of the mine. Total length of openings in the mine at present accessible, are about 350 feet.

No drilling has been done on this lot, either from the surface or underground; however, the thickness of the talc bodies as exposed in the underground openings as well as the character of the bodies, indicate that talc reserves here are adequate for a long period of mining with the present schedule.

Other Mines and Prospects

In addition to the four active mines described more or less in detail, several inactive mines and prospects occur in this district. Many of these old openings were active talc producers at the time the previous talc report[12] was published; thus, the writers here abstract information on these old abandoned mines presented in that report which is now out of print. Such information as is available from local residents and miners of the abandoned prospects discovered and opened since the previous talc report was published also is given. Descriptions which follow are arranged in the order that the talc properties occur from south to north. Numbers given with the name of the mine or prospect refer to the map location of the talc occurrence on Plate 1.

1. **Pickering Mine**—This mine is located 4.5 miles (airline) and 5 miles by road southeast of Chatsworth. The land is owned by Lofton Reed; V. C. Pickering owns the mineral

rights. This mine was opened in 1937 by Mr. Pickering for the Southern Talc Company.

Talc at this place occurs enclosed by Fort Mountain gneiss. The entrance adit is driven through black slate identified as Wilhite slate in this report. It is now completely flooded. Talc found in the dump is of inferior grade. Local miners report that production from this property has been small. Nothing is known of the size or extent of this talc deposit; however, it is not believed to be large.

2. **Rock Creek Road Prospect**—A few pits in talcose material have been dug on the north side of a small branch 200 yards north of the road up Rock Creek 4.5 miles (airline) and 5.5 miles by road southeast of Chatsworth. This property is owned by the Cohutta Talc Company.

Talc here occurs enclosed by Fort Mountain gneiss; however, the openings are not sufficient to indicate the extent of the talc body. It is believed that talc of grinding grade can be produced from the deposit and that it warrants further prospecting.

3. **Chicken Creek Mine**—This mine, owned by the Cohutta Talc Company, was first opened about 1937. It is located very near (east of) the Cartersville fault along a tributary of Chicken Creek 3.7 miles (airline) and 4.2 miles by road southeast of Chatsworth. Recently the owners of the mine have prepared to begin production from this property.

The talc occurs here in Fort Mountain gneiss very near the Cartersville fault. The talc body, as exposed in the two openings made to date, is from 10 to 12 feet thick, consisting of a good grade of white grinding talc and crayon talc. The openings are at present flooded; therefore, the underground workings were not examined. Reports from local residents and size of the spoil material indicate that little talc has been removed from the property. It is believed that this property can be developed into a steady producer of high quality talc.

4. **Old Cohutta Mine**—This abandoned mine, owned by the Cohutta Talc Company, is located 4 miles (airline) and 4.5 miles by road southeast of Chatsworth. This property is joined on the north by the Georgia Mine and the talc body

mined here apparently represents the southern continuation of the talc body in which the Georgia Mine is located. The mine was opened prior to 1912 and was last operated about 1932. It is understood from the mine owner that considerable good talc was in sight when the mine was abandoned. Reports from local miners suggest that abandonment of the mine was due to heavy ground, and not to the absence of talc. Any attempts to reopen this mine in the future should consider the possibility that talc remaining here can be perhaps more easily recovered by mining entirely from new openings since dangerous ground conditions probably exist in the old workings.

Hopkins[12] in 1914 described this mine as follows: "A tunnel has been driven in an almost easternly course for a distance of 165 feet. The hanging wall at this mine is graywacke* the foot wall is not exposed. The thickness of the talc-bearing formation is not known, but in the tunnel from six to eight feet of it are exposed without showing either wall. There is no hard massive serpentine rock at this locality; all that is exposed is either talc or 'blue john.' Here the talc has been stained and rendered useless as saw-rock by the percolation of surface waters to a greater depth than at most places in the district. At the back end of the tunnel, a distance of 165 feet from the entrance, considerable yellow talc is present, although the indications point to the fact that green talc will soon entirely replace it. The workable talc varies from one foot to three or four feet, but a great deal of otherwise good talc is found too hard to saw."

The mine was operated approximately 20 years after the above was written; therefore, a great change in character of talc and size of openings is to be expected. Local reports indicate that underground openings here are quite extensive, also that the talc body worked was similar in thickness and mineral composition as that worked at the Georgia Mine.

7. **Bramlet Mine and Prospect**—These openings, on lot 292, are located on the southwestern slope of Cohutta Moun-

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* Probably Fort Mountain gneiss.

tain 3.1 miles (airline) and 3.9 miles by road S. 65° E. of Chatsworth near Georgia Highway No. 2. This lot is owned by the Cohutta Talc Company. Two openings have been made on the property. The lower opening is just above and on the northeast side of the highway. At this place some four or five pits have been made in the talc outcrop. One of the pits was extended into an incline down the talc body; however, this opening is now caved, thus inaccessible. Size of the dump indicates that the underground opening here is not extensive.

The talc body where exposed is from four to five feet thick, enclosed by Fort Mountain gneiss. It strikes about due north, dipping 35° E. and is conformable both in strike and dip with the enclosing gneiss. The outcrop talc is of low grade, thus suggesting that perhaps abandonment was due to a thin body of inferior grade material.

About one-eighth of a mile northeast and some 600 to 700 feet above this occurrence another talc deposit occurs. This place is reached by a very steep truck road from Highway No. 2 just west of the lower talc occurrence on this lot. A four to five foot talc body is exposed here enclosed in Fort Mountain gneiss and Corbin granite. A vermiculite zone up to six inches in thickness separates the talc body on the hanging wall side from the rocks which enclose it. The talc body strikes approximately due north, dipping about 40° to the east. Several small pits and trenches have been dug along the talc outcrop for a distance of about 200 feet. Dumps from all the pits show talc. The principal opening has been an incline down the talc body. From a point down the slope from the talc outcrop, a crosscutting drift has been driven which intersects the incline at about the 40-foot level.

The talc is light green, foliated, and exceptionally free from iron. The deposit has been mined intermittently since about 1910. It was last worked about three years ago. Since the opening is very inaccessible, only crayon grade talc has been mined here. It is believed that a sizable deposit of high grade talc remains at this place.

8. **Fields Prospect**—This prospect, on lot 293 (known as the Fields or Goldmine lot), about 3.4 miles east of Chats-

worth on the west slope of Cohutta Mountain, is owned by Samuel Nix of Chatsworth. Little work has been done on this property. The last work was done about 1904; since that time it has been abandoned. Little can be concluded from this caved prospect; however, its location between lots on which good talc has been mined suggests that good quality talc may also occur here.

9. **Hammock Prospect**—This prospect, on lot 319, is 2.6 miles (airline) and 3.1 miles by road due east of Chatsworth. It is on the west side of the road from Georgia Highway No. 2 to the Cohutta Mine. The prospect is owned by the Cohutta Talc Company. Two openings have been made on this property in a talc deposit reported to be about four feet thick. At present both openings are caved and no talc is exposed. Work here has not been extensive.

11. **Russell Prospect**—These prospects, on lot 295, are located on the western slope of Fort Ridge at the head of the south tributary of Rock Creek, 3 miles (airline) and about 3.1 miles by road east of Chatsworth. They are reached by a new road which extends north from the Cohutta Mine to the Fort Mountain Mine. The property is owned by the Cohutta Talc Company.

Here the talc occurs in association with massive serpentine, all of which is enclosed by Fort Mountain gneiss. Associated with the serpentine is both actinolite and chrysotile. Talc is present not only at the contact with the enclosing rocks but also as irregular fracture fillings in the serpentine. This talcose zone is perhaps 50 feet thick where prospected.

Numerous old openings have been made here, some from which considerable talc was produced; however, at present no talc is mined here. It is believed that a large portion of this talc body is suitable for grinding.

12. **Latch Prospects**—These prospects, on lot 296, are located at the headwaters of the north tributary of Rock Creek, 3.5 miles (airline) and 4.6 miles by road northeast of Chatsworth. They are on or near the new access road about one mile north of the Cohutta Mine. The lot has been cut into three parts by east west lines; the Cohutta Talc Company

owns the northern and southern parts, and M. Woodward Glenn owns the central part. This lot was prospected and a limited amount of talc mined about 1904 by W. Z. Latch, former owner; however, since that time no talc has been mined.

The thickness of the talc-bearing rock here appears to be as much as 100 feet. The greater part of the exposure is hard, somewhat massive serpentine rock, with good quality talc developed most extensively along the upper and lower contacts with the Fort Mountain gneiss, although a lesser quantity is to be found in serpentine rocks along joint planes and other openings which by movement favored the formation of talc. There are three small openings on this lot, each above the other. Little can be written about this interesting property because the old openings are inaccessible, and surface outcrops are generally covered.

14. **Mill Creek Prospect**—These pits and shafts, on lots 260, 261, and 245, are located on the eastern slope of Fort Mountain, near the headwaters of Mill Creek 4.5 miles (airline) and 7 miles by road N. 50° E. of Chatsworth. The property was first mined about 1890, and was last worked about 1915. Total production from this property probably has not exceeded 1000 tons of talc. The Fort Mountain Talc Company of New York owns the property.

Extensive prospecting has been done along the creek and up the western side near an abandoned homesite. Considerable talc was encountered here in boulder form in the soil; however, no extensive deposits were found. Another body of talc about 400 feet stratigraphically above the one found near the homesite was also prospected. Here good quality talc was found; however, the deposit was too thin to work. Little can be said about the reserves of talc remaining here since the old openings are now filled or caved; however, considerable talc should still remain.

15. **Warren Earnest Prospect**—This property, on lot 244, is located 4.7 miles (airline) and 7 miles by road N. 50° E. of Chatsworth on the east side of Mill Creek northeast of the Mill Creek property. The property is owned by Warren Earnest. Talc has been prospected along the strike for about one-eighth of a mile. Here the pits have exposed a talc body

which apears to be at least 20 feet thick. Little talc has been removed from the property; however, that remaining around the old openings is of rather good grade, indicating that at least part of the deposit is suitable for crayons. Most of the talc exposed is suitable for grinding. It is believed that a considerable deposit of talc may occur on this property.

Mining

Earliest mining was confined to working the talc outcrop, thus talc obtained was stained by surface weathering. Mines are now opened by driving an adit into the footwall of the talc lens so that the talc body is encountered well below the zone of stained material. The adits have enough slope (1 per cent) so that mine cars will roll from them by gravity. These entries are generally made in granite (Corbin granite) or in granite gneiss (Fort Mountain gneiss), and thus require little timber. The mines have only one haulage way, using a 16- to 24-inch gauge steel track. From the main entry, after the talc body has been encountered, inclines are put down in the talc body from which levels for stoping are turned off on either side of the incline.

Locally, the plan of the mine levels is somewhat confusing since the quest is generally for talc of crayon grade thus little attention is given to systematic mining development.

In general, the method employed in mining the talc is overhead stoping with a minor amount of underhand stoping. The miners usually select the location of upstopes from a level by the presence of crayon grade talc. The practice is to mine the more impure talc used to make powder from underneath the crayon grade and then break that material down so as to get the minimum amount of shattering. The most sought-after or crayon grade talc usually makes up less than 5 per cent of the ore produced.

Generally, the roof of the deposits stands well, thus little timber is required for support. Only in those areas of extreme faulting is timber used. Except during periods of unusual rainfall, little water is encountered. One small air driven pump is generally sufficient to keep the mines free of water. As a matter of fact, little or no water is encountered in the lower levels. Light is obtained underground from carbide lamps carried by the miners.

Exterior equipment at the mines consists of gasoline or Diesel driven compressors which can deliver air at 200-pound pressure, storage room, magazine for explosives, and ore bins with capacities varying from 20 to 80 tons. The bins are so located as to permit loading by gravity into the trucks used in hauling talc to the mills. One man is generally employed at the surface.

Underground, two men are employed hoisting and tramming ore cars from the head of the incline to the ore bins. Two or three men are employed in drilling working headings or stopes. They use light (40-pound) jack hammers, held by hand, or, as at the Georgia and Southern Mines, the drill is held in a saddle. Holes are usually drilled six to eight feet deep and are loaded with varying amounts of black powder. Black powder is used in blasting because it produces less fines, and a minimum amount of shattered ore. Fuses and caps are used in blasting the holes. The arrangement of holes and order of blasting are such as to use the "V" cut for breaking. At the Georgia and Southern Mines broken ore is loaded by an air operated Sullivan mechanical loader where possible. At the other mines hand mucking is practiced. When mining is from stopes a mucking platform is generally built at the bottom of the stope from which broken ore is shoveled into the mine cars. Crayon grade talc is separated from the mine-run ore underground. Two men tram loaded cars from working headings to the foot of the haulage incline.

Gasoline or air-driven hoists are used underground in those mines which afford good ventilation; air hoists underground or hoists operated from the surface are used at those mines where ventilation is poor. The use of gasoline motors underground always involves a certain amount of risk.

Crude talc is hauled in company-owned 6-ton dump trucks from mine to mill. These trucks, when in continuous service, have a life of from two to three years. Cost of hauling ore is dependent upon the condition of access roads and condition of trucks; however, in general, the hauling cost varies from $0.50 to $0.75 per ton of ore.

Milling

Talc ore, depending upon its purity and structure, is converted into two types of products—ground dust and sawed or manufactured shapes. Talc suitable for crayons must be straight grained (straight schistosity), have strength and softness, and be relatively free of hard or gritty impurities. Talc too hard to saw, even though it may have the appearance of crayon material, is called "blue john" by the miners. Talc ore unsuitable for sawing is ground into powder.

All the talc companies operating in the Chatsworth district have their ore processing plants located in Chatsworth adjacent to the Louisville and Nashville Railroad (Figure 5). Each talc mill is generally divided into two departments—grinding and sawing. Recently the saw line at the Southern Mill was combined with the Georgia saw line. This action was prompted by the lack of sufficient crayon grade talc to operate both lines at full capacity. The Cohutta Mill operates a sawing department along with the grinding department. Grinding and sawing procedure at the three mills and the two saw lines are similar. The following discussion describes in a general way the grinding and sawing operations as practiced in this district.

Sawing: The Cohutta and Georgia saw lines will be described together since the operations are very similar. The Cohutta saw line is housed in the same building as the Cohutta grinding department. It is operated by the Cohutta Talc Company and secures talc for sawing from the Cohutta and Fort Mountain Mines. The Georgia saw line is housed in a separate building near the Georgia Mill. It is operated by the Georgia and Southern Talc Companies. Talc for sawing is obtained from the Georgia and Southern Mines.

The saw rock is delivered to the receiving floor at the saw lines from dump trucks. The saw lines consists of one 24-inch facing saw, 14- to 18-inch cutoff saw, 14- to 16-inch stock saws, and a variable number of 8- to 9-inch pencil or crayon saws. These saws, placed on tables about 44 inches above the floor, are each powered by separate motors with push-button control. The motors range in power from 2 to 10 horsepower, with the large facing saws using the 10

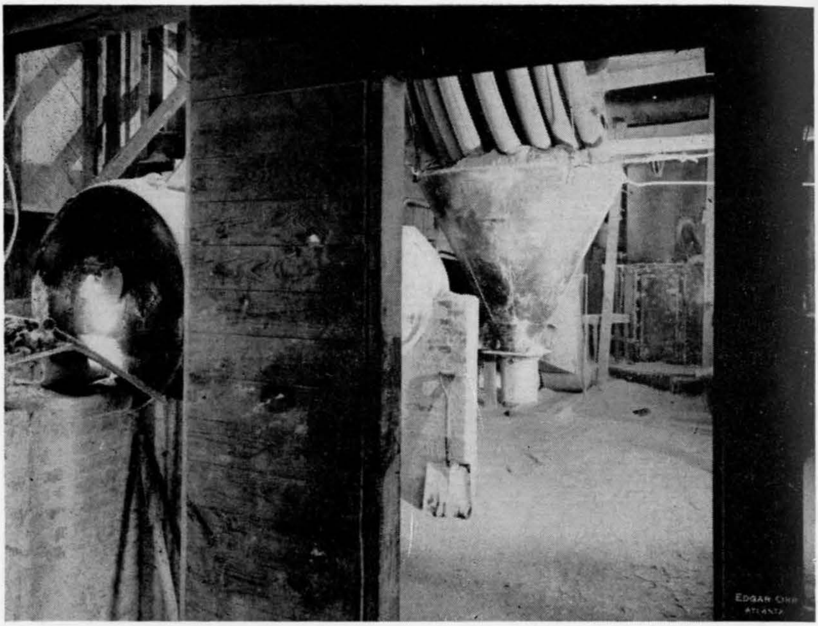


Figure 7. Flash dryer at Southern Mill used to dry damp talc; stocking collector used to trap air floated talc in right center, and Williams roll mill in background.

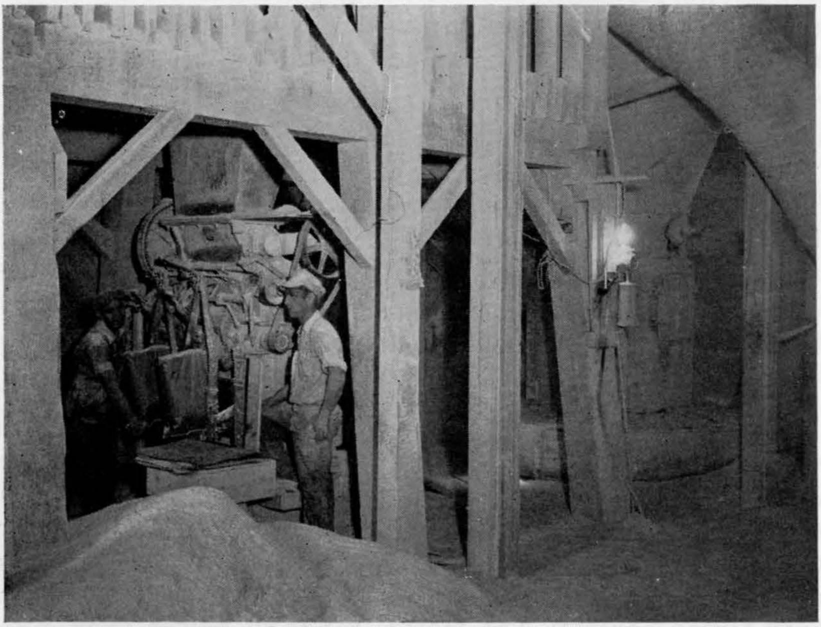


Figure 8. Bagging ground talc in 50-pound self-sealing paper bags at Cohutta Mills; roll mill for fine grinding in right background.

horsepower motor. Motors are dust-proof and are housed underneath the tables; they drive the saws with V-belts. Saws used are manufactured especially for the trade. Life of the saws is dependent upon the hardness and grit in the talc.

The facing saw splits the large talc masses into more or less square blocks. Next, the cut-off saw cuts the blocks into 5-inch lengths or the length of the finished crayon. The stock saws split the blocks from the cut-off saw into proper widths. The width is variable depending upon the type of finished product desired. The crayon saws split the talc into the desired thickness. These tables are also adjustable to permit various thicknesses.

Each saw is provided with a dust collector which is located either over the saw or underneath the saw (Figure 9). A suction provided by an exhaust fan removes the dust caused by the saw. This dust, along with the scraps from the saws, is ground into powder which finds use as a low grade cosmetic material.

From the saw line the crayons go to a separate room for grading and packing (Figure 10). Here the crayons are divided into three classes or grades (Clear, Regular, and Economy). The clear grade is from the highest grade talc and contains less sawing imperfection than the other grades. In general the following standard sizes are produced:

3/16 x 1/2 x 5	1/8 x 1/2 x 4
1/4 x 1/4 x 5	1/4 x 1/2 x 5
3/16 x 1/2 x 4	3/16 x 1-1/4 x 5
1/4 x 1/4 x 4	1/2 x 1/2 x 5
1/16 x 1/2 x 5	1/4 x 5 (round)

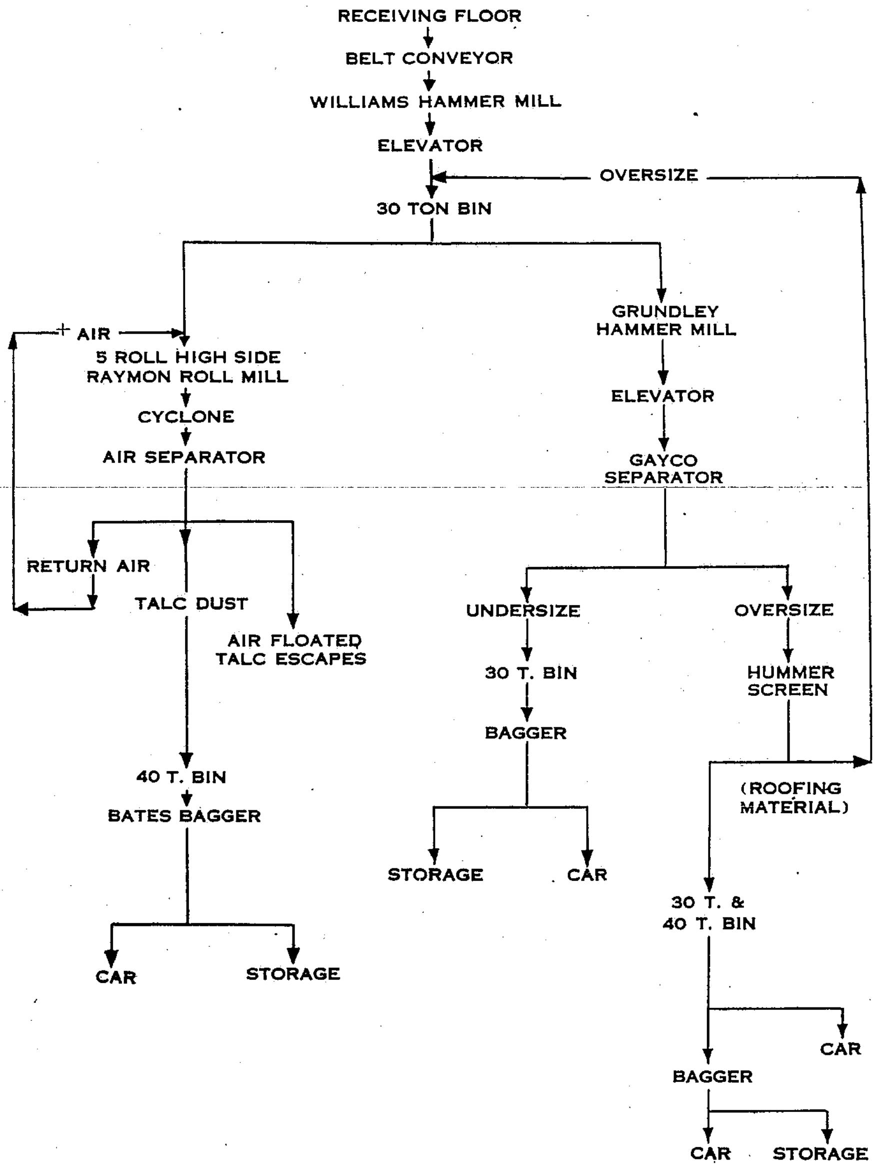
Note: All of the above sizes are in inches.

The ¼-inch round is produced from the ¼ x ¼ by forcing it through a turning machine similar to a pencil sharpener.

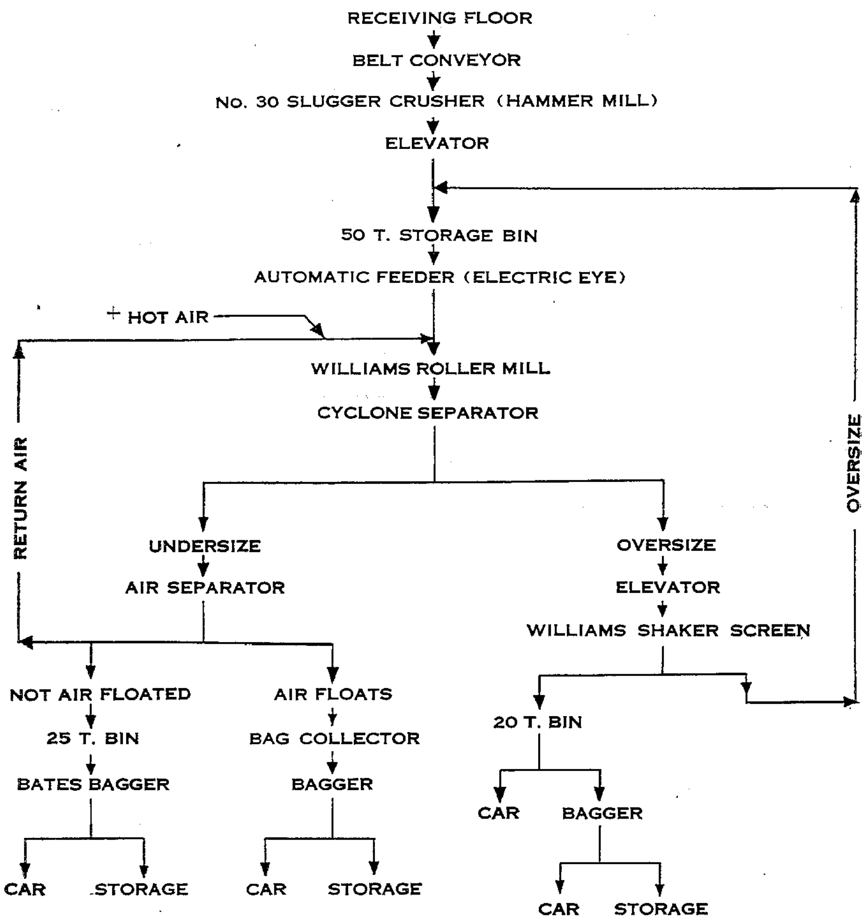
Crayons are packed in paper boxes with one gross per box. The boxes are in turn packed in wooden crates with 24 gross to the case. Sawdust is used in packing the gross boxes to prevent the crayons from being broken in shipment.

The Georgia and Southern saw lines employ on an average of twelve workers for the sawing, grading and packing of

FLOWSHEET 1
COHUTTA MILL

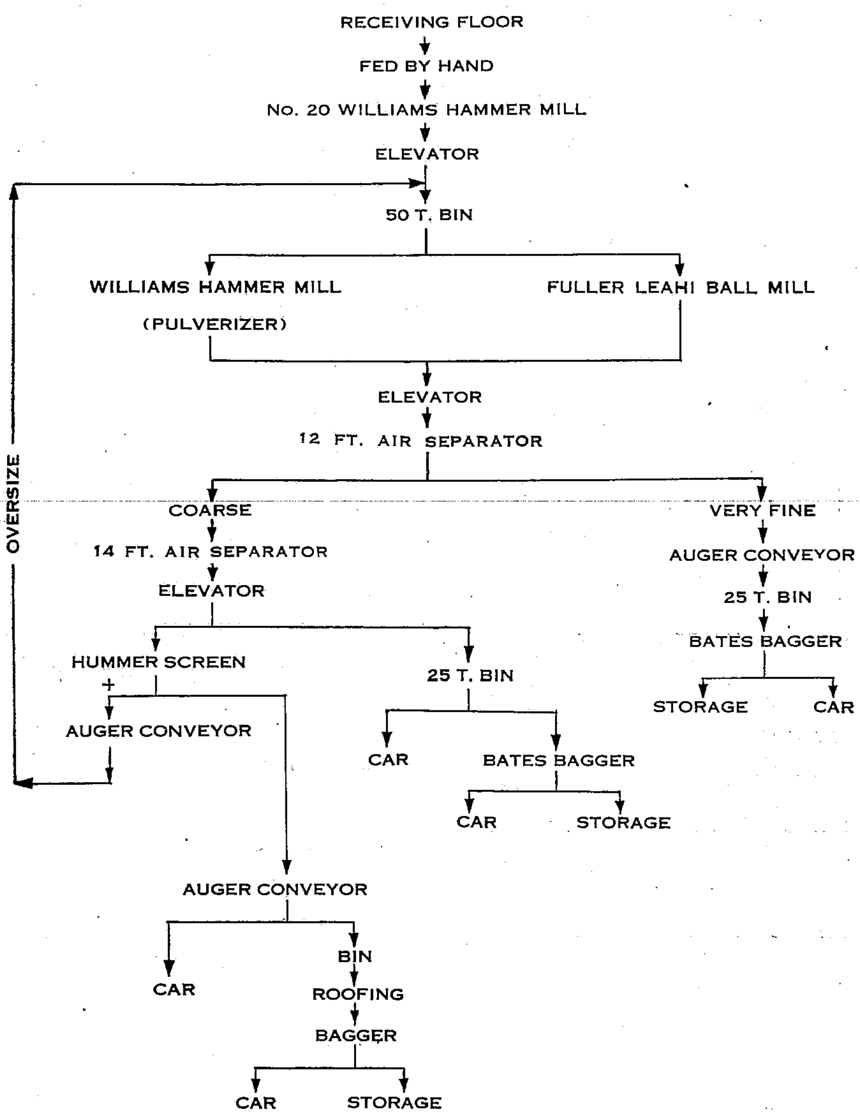


FLOWSHEET 2
SOUTHERN MILL



FLOWSHEET 3

GEORGIA MILL



FLOWSHEET 4
CRAYON SAW LINE

RECEIVING FLOOR
↓
24 IN. FACING SAW
↓
18 IN. CUTOFF SAW
↓
2-16 IN. STOCK SAWS
↓
4-8 IN. PENCIL SAWS
↓
PENCIL GRADERS
↓
PENCIL PACKERS
↓
SHIPPED OR STORED

crayons. A similar number are employed at the Cohutta saw line.

Grinding: Grinding procedures practiced at all of the mills are similar, especially the major operations. This similarity may be noted by a comparison of the flowsheets. Talc ore is delivered onto the receiving floor (also may be considered storage and drying bin) at the mills by dump trucks. These receiving floors have facilities for storing about 100 tons of crude talc ore. The ore is then fed either by hand shovel (Georgia Mill) or belt conveyor to the primary crusher. The primary crushers are set to crush the ore to about -¾ inch. From the crusher, ore is elevated to storage bins. The crushed ore feeds by gravity from the bins to the secondary grinding mills. Rate of feed from the bins is determined by the pressure within the mill. With the exception of one unit at the Georgia Mill where a Fuller Leahi ball mill is used and at the Cohutta Mill where a Grundley hammer mill is used, all secondary grinding is obtained by use of various makes of roll mills. Air is forced through the mills at a controlled velocity, removing the finely ground talc. All

Figure 9. Crayon saw line; stock saw in foreground, with crayon saws in background. Note dust collectors above each saw. Facing and cut-off saws not shown.

Figure 10. Grading and packing talc crayons. A gross is packed in each box.

secondary grinding is in closed circuit. Air forced through the mill removes and elevates the fine talc powder to air separators, where the talc and air are separated with the air returned through the mill and the talc dust going to bins for baggage and shipment.

In addition to the above generalized flowsheets, certain minor modifications are used to produce special products. At the Southern Mill the Williams roll mill is equipped to produce both fine dust and roofing granules at the same time. The Southern Mill is also equipped with stocking collectors which trap the extremely fine talc which escapes from the breathers at the other two mills. Recently, a flash dryer (Figure 7) was installed at the Southern Mill for grinding ore heretofore too wet to grind. Not only does the dryer permit grinding ore which previously went to the dump when wet, but it increases the rate of grinding of all the ore.

The mills are so designed to permit production of a large variety of products at various size and color specifications as required by the buyers. The better grades of talc are bagged in 50-pound self-sealing paper bags (Figure 8). Material used by the roofing trade is shipped in either 100-pound paper or burlap bags or loose in box cars. As a rule, roofing granules are produced at -35 to -50 mesh. The more pure talc is produced at either -200 or -325 mesh.

Mill design allows loading loose material directly from the bins into box cars. Also, the bagged material can be loaded from the various baggers directly to the cars, or it may be put in storage. It is estimated that each mill has space for storing approximately 250 tons of bagged talc. In addition, the various dust bins give even greater storage capacity. As a matter of interest, it is noted that all the dust bins are of wood. In the past some bins were lined with metal; however, the metal tended to sweat, thus causing the ground talc to bank up in the bins. Production capacities are dependent upon the product made. The Southern Mill can produce from 20 to 50 tons of ground material in eight hours; the Georgia Mill has a capacity of from 100 to 130 tons per eight hours; and the Cohutta Mill can produce from 50 to 80 tons in eight hours. From five to ten men are employed in the grinding and shipping department of each mill.

Future of the Industry

Structural and stratigraphic evidence presented in this report indicates that present mines will be worked for many years, and that new mines can be developed from the known prospects. The talc-bearing rock occurs included in Fort Mountain gneiss, thus talc prospecting in the future should be restricted to those areas of Fort Mountain gneiss shown on the geologic map of the area (Plate 1). Presence of talc deposits is indicated at the surface by talcose and chloritic schist which often is locally marked by ocherish spots caused from the weathering of pyrite. From the study of this area it would appear that the better areas for future prospecting include the Chicken Creek area, the area between the Cohutta and Fort Mountain mines, and in the valley of Mill Creek.

Present active mines are by no means exhausted. Of the total ore body exposed in the mine workings to date, at no mine has more than 45 per cent of the ore body been removed, and at the Fort Mountain mine probably less than 20 per cent of the exposed ore has been mined. It seems reasonable that from 60 to 70 per cent of the total orebody can safely be taken out. Some previous writers have suggested that the talc may be confined to the near surface portions of the deposits. An inspection of the mines shows that this cannot be the case; also, the origin of the deposits as described in this report is opposed to such a view.

In addition to the 300,000 tons of processed talc produced from the area, perhaps as much as 75,000 tons of ore have been mined and placed in dumps at various mines. Much of this dump material, if properly ground, is suitable for roofing talc. The Georgia mine, with extensive underground developments, has probably produced in the past between 150,000 and 200,000 tons of talc ore. At least an amount equal to and probably larger than the previous production can be removed safely from the now developed portion of the mine. In the undeveloped portions of the mine it would appear that perhaps as much as 500,000 to 1,000,000 tons of talc ore remain. The known reserves at the other active mines are less than this estimate for the Georgia mine; however, they are adequate, with the present rate of mining, for at least a 30-year operation. Total talc reserves in the district are unknown; however, they amount to millions of tons.

The return of talc-consuming industries to peacetime conditions will bring about keener competition among talc producers, necessitating efficient mining and milling procedure. Talc producers in this area are steadily modernizing both mines and mills. Efforts are being made to secure electricity for power at the mines. Also, more efficient and systematic mining methods are being installed. Where possible, mechanical equipment should replace hand operations. As a rule, grinding mills are modern; however, because of the mineral composition of the original ore, the talc powder is not suitable for the more specialized uses. It would be advisable to experiment with methods whereby the talc grade could be improved enough to compete with more pure talcs. Preliminary froth flotation test on some of the talc ore from this district gave encouraging results; however, the research in beneficiation has not progressed far enough to permit predictions as to the outcome.

Other Mineral Resources

Gold

Gold was mined on Lot 257, 26th District near the crest of Cohutta Mountain around the year 1900. Mineralization occurs in the Fort Mountain gneiss. Previous to that time, gold had been discovered in a small placer on a branch a mile west of the mine. Several goldbearing veins were located, several shafts were sunk, several open-cuts made, and a stamp mill was erected. Jones[13] visited the property at this time where he examined several auriferous quartz veins. He describes one, known as the "Little Mildred", which had been exposed for a distance of about 90 feet in a shallow open cut. The exposed portions showed a thickness of 4 to 10 inches, and some of the ore examined contained free gold. Gold was seen also in quartz from veins found 200 yards east of this vein.

Garland Peyton and A. S. Furcron collected samples in July 1938, from a 2-inch vein, and from a mineralized zone of quartz and schist exposed in a caved open cut, which ran $1.75 and $9.10 per ton respectively.

Placer deposits are reported from Chicken Creek, and on Lots 256 and 285, and some prospecting was done formerly on Lot 229.

Lead and Silver

There are many persistent rumors of the discovery of lead and silver in Fort and Cohutta mountain areas. Stories of such discoveries have been handed down for generations. According to some reports these metals were mined by the Indians, and according to others, lead was mined locally and made into bullets by settlers of the district prior to the War Between the States. There are, however, no known deposits on record to this date. In the course of this work the writers have discovered no evidence of the presence of these metals. It is recorded by some that the ore of lead was discovered long ago on Mill Creek, east of Crandall, and on Leadmine Branch east of Hassler Mill. Several years ago the tenant who lived in a dwelling which was on the west side of Mill Creek about one-half mile east of the crest of Fort Mountain exhibited a sample of galena to Furcron, stating that it was discovered locally. Those who are interested in prospecting for silver, lead and other ores should give special attention to the crystalline rocks of pre-Cambrian age (see geologic map, Plate 1).

Feldspar

The Corbin granite of this district is essentially free of mica, thus a potential source of feldspar if outcrops sufficiently unweathered and accessible can be discovered. One of the most extensive occurrences is in the valley of Emery Branch.

Microcline dikes, described on previous pages, also represent a possible source of feldspar. Their most peculiar feature is their conversion to a light pumice-like rock when heated to approximately 2000° F. Dr. W. M. Spicer* suggests that its low melting point may be due to the fact that the feldspar mixture is near the eutectic composition.

A hundred pound sample of these microcline perthite lumps was submitted to Professor Charles F. Wysong of the School of Ceramic Engineering, Georgia School of Technology. His report, submitted August 30, 1946, is as follows:

1. Cone Fusion Test

"Cone fusion was determined by the standard procedure and found to be equivalent to Orton Standard Cone No. 15. It was observed that the powdered material maintained its gray color up to approximately Cone 12 and bloating developed at Cone 13.

2. Ceramic Uses

"It is doubted that sufficient iron can be removed from this material to make acceptable whiteware or glass flux where whiteness is a necessary quality. However, for ceramic wares and glasses which will permit discoloration, it would probably make a very good flux to be substituted for its chemical equivalent in feldspar and flint.

3. Light Weight Aggregate Tests

"The one hundred pound sample was placed in a gas furnace and fired to Cone 13 down. Bloating took place at this temperature and the lumps became quite white but retained a certain amount of iron specking. The average density of the fired lumps was 1.17 grams per cc. The entire lot was reduced to one inch lumps in a jaw crusher and separated into three groups, namely one inch on three mesh, three mesh on 20 mesh and through 20 mesh to dust. The normal packing density of these groups was, respectively, 43, 44, and 86 pounds per cubic foot.

"Concrete cylinders were made up using four parts coarse material, one part intermediate material, one part fine material, and one part Portland

* Personal Communication May 7, 1946.

cement. Due to the angularity of the aggregate, a very poor working mixture was obtained and the test cylinders (six inch diameter, one foot length, were very badly honeycombed. The cause of this was deficiency of fine aggregate. The density of these cylinders was about 86 pounds per cubic foot and the strength was 960 pounds per square inch.

"Two inch cubes were made up out of various proportions of the material through three on 20 mesh and through 20 mesh aggregate in the ratio of three parts total aggregate to one part cement by volume as shown in the table below. Number 1 was re-run for additional samples and for gravity determinations. This mixture yields a concrete weighing sixty-five pounds per cubic foot and a strength of 3150 per square inch.

Table 5

Composition of Two Inch Tubes

Batch No.	Through 3 Mesh on 20	Through 20 to Dust	Average Strength In Pounds per Square Inch
1.	25%	75%	3150
2.	30%	70%	1967
3.	40%	60%	1750
4.	50%	50%	1358

"CONCLUSIONS: The test herein was not extensive enough to give very definite conclusions, but it is the writer's opinion, substantiated by Professor James H. Lucas, that the bloated feldspar would be superior to Birmingham light weight slag, known as 'Superock.' However, the cost of calcination would exceed the cost of transporting 'Superock' to this area. It is estimated that calcination costs would be in the neighborhood of $4.00 per ton. A rotary furnace temperature of not less than 2500° F. would be required to properly expand the feldspar. At this temperature it is believed that powdered coal or oil would be superior to natural gas."

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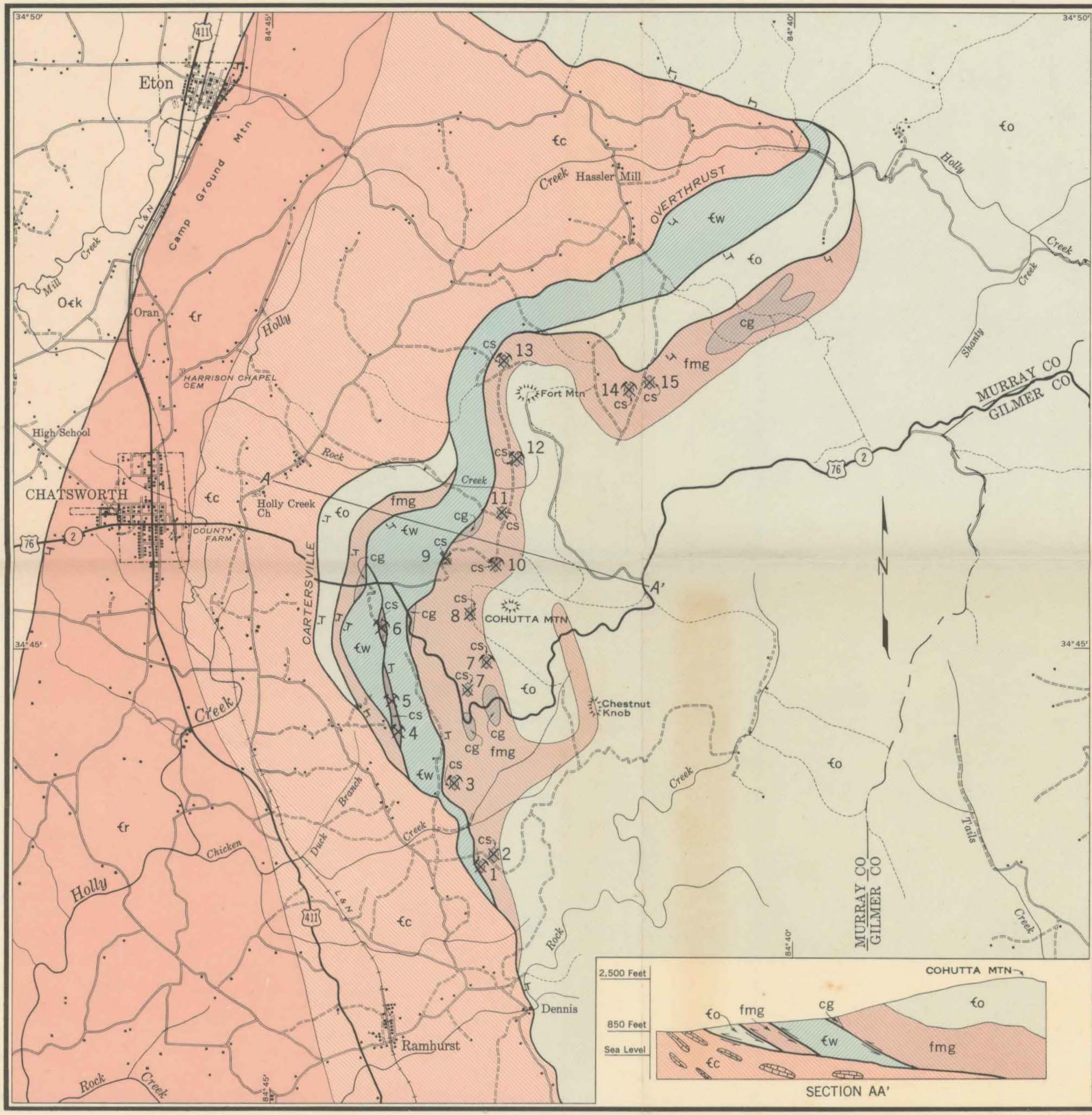

TALC MINES AND PROSPECTS

1. Pickering Mine
2. Rock Creek Road Prospect
3. Chicken Creek Mine
4. Old Cohutta Mine
5. Georgia Mine
6. Southern Mine
7. Bramlet Mine and Prospect
8. Fields Prospect
9. Hammock Prospect
10. Cohutta Mine
11. Russell Prospect
12. Latch Mine
13. Fort Mountain Mine
14. Mill Creek Mine
15. Earnest Prospect

GEOLOGY LEGEND

PALEOZOIC

Cambro-Ordovician
- Knox Dolomite — *Cherty dolomite* — O€k

Upper and Middle Cambrian
- Conasauga Shale — *Clay shale with beds of limestone* — €c

Lower Cambrian
- Rome Formation — *Brown or purplish clay shale* — €r
- Wilhite Slate — *Dark blue slate; stratigraphic position uncertain* — €w
- Ocoee Series — *Sandstones, conglomerates and dark slates; unconformable upon pre-Cambrian formations* — €o

PRE-CAMBRIAN
- Corbin Granite — *Coarse blue quartz granite; intrudes formations below* — cg
- Fort Mountain Gneiss — *Granite gneiss; includes and intrudes Cohutta schist* — fmg
- Cohutta Schist — *Quartz-biotite-chlorite schist, with beds of dolomite altered in part to talc and serpentine* — cs

GEOLOGY MAPPED BY A. S. FURCRON AND K. H. TEAGUE

GEOLOGIC MAP OF

CHATSWORTH TALC DISTRICT

MURRAY COUNTY, GEORGIA

GEORGIA DEPARTMENT OF MINES, MINING AND GEOLOGY
AND
COMMERCE DEPARTMENT
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS DIVISION

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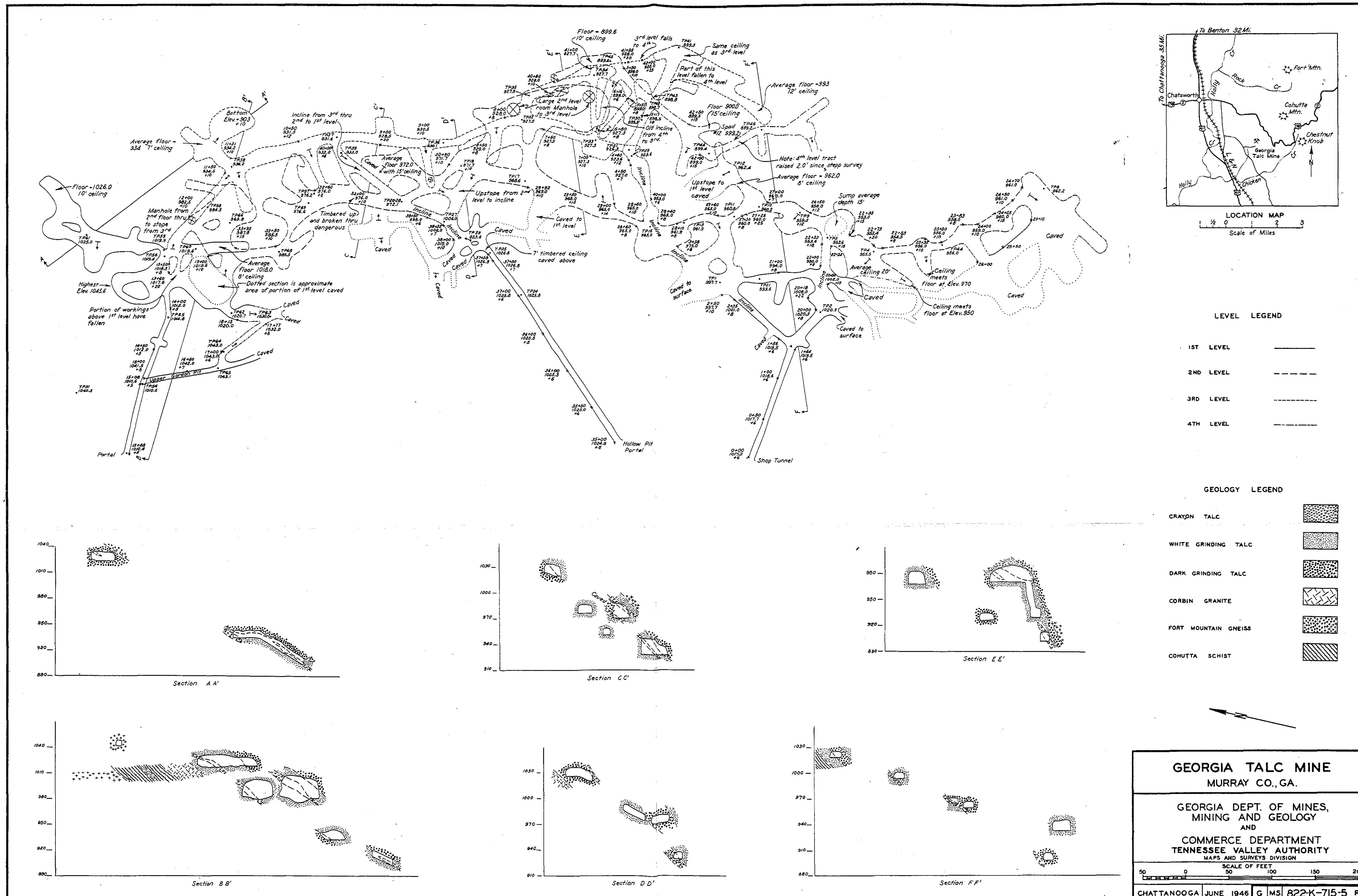

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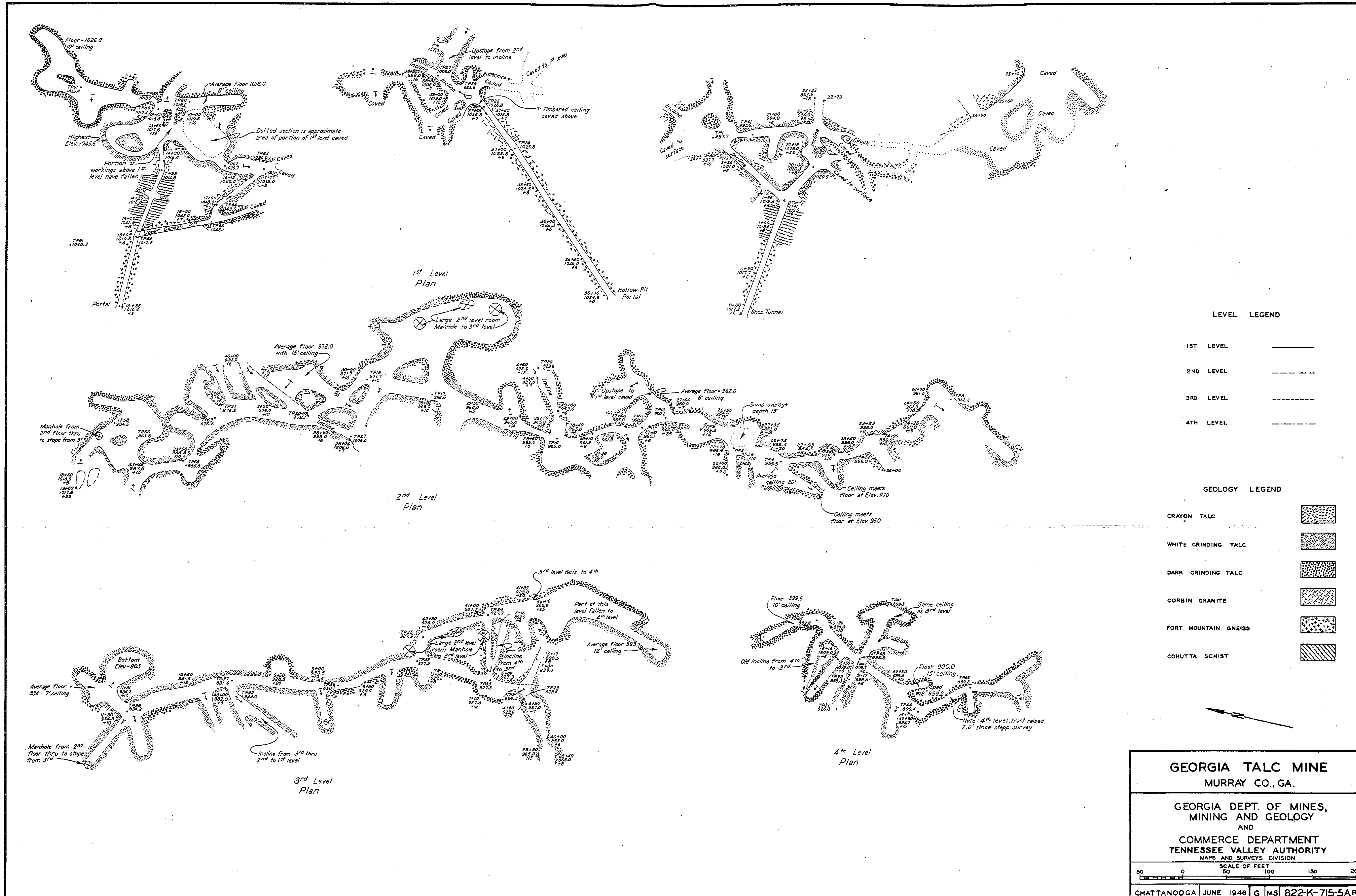

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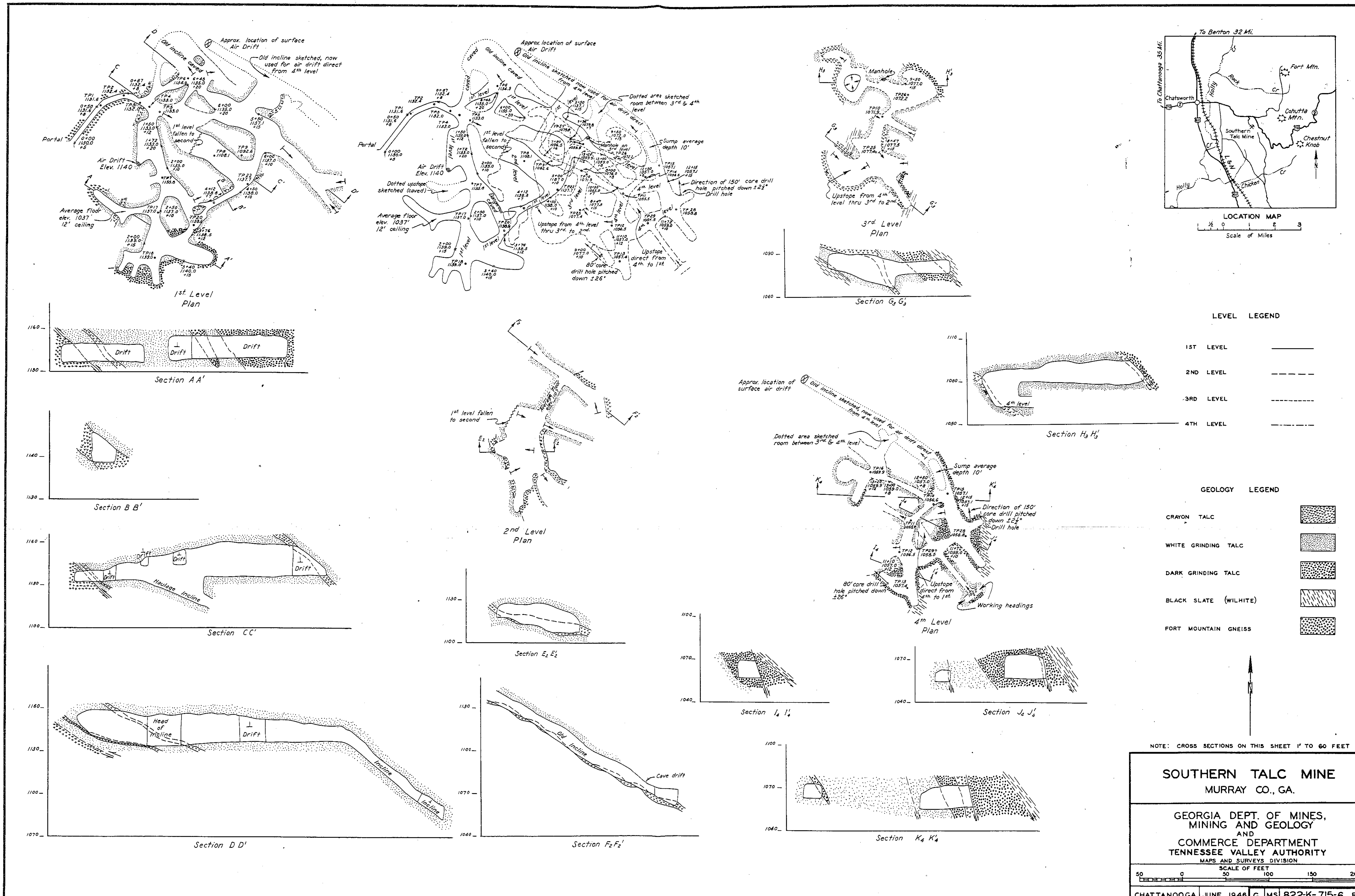

SOUTHERN TALC MINE
MURRAY CO., GA.

GEORGIA DEPT. OF MINES, MINING AND GEOLOGY
AND
COMMERCE DEPARTMENT
TENNESSEE VALLEY AUTHORITY
MAPS AND SURVEYS DIVISION

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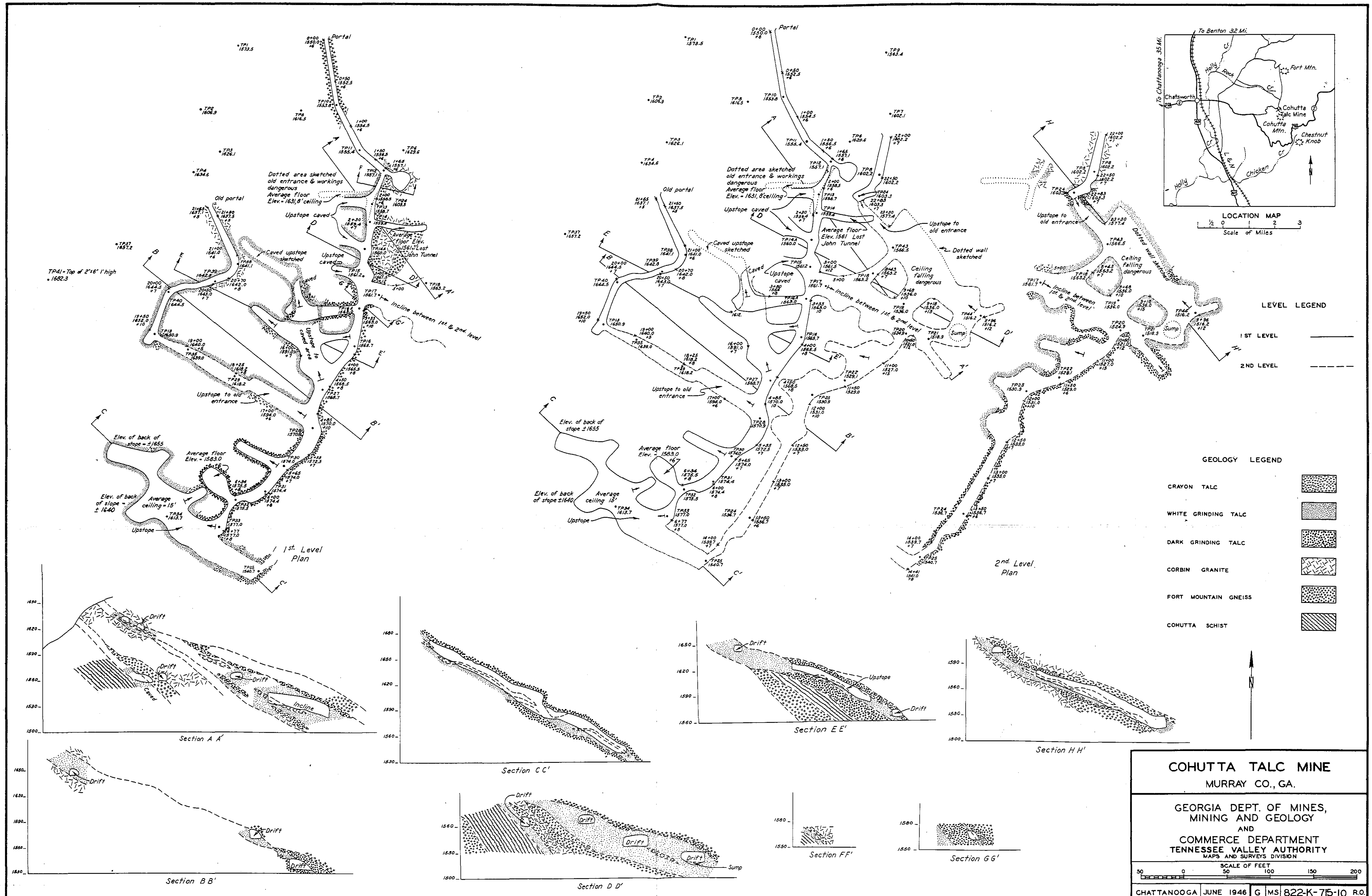

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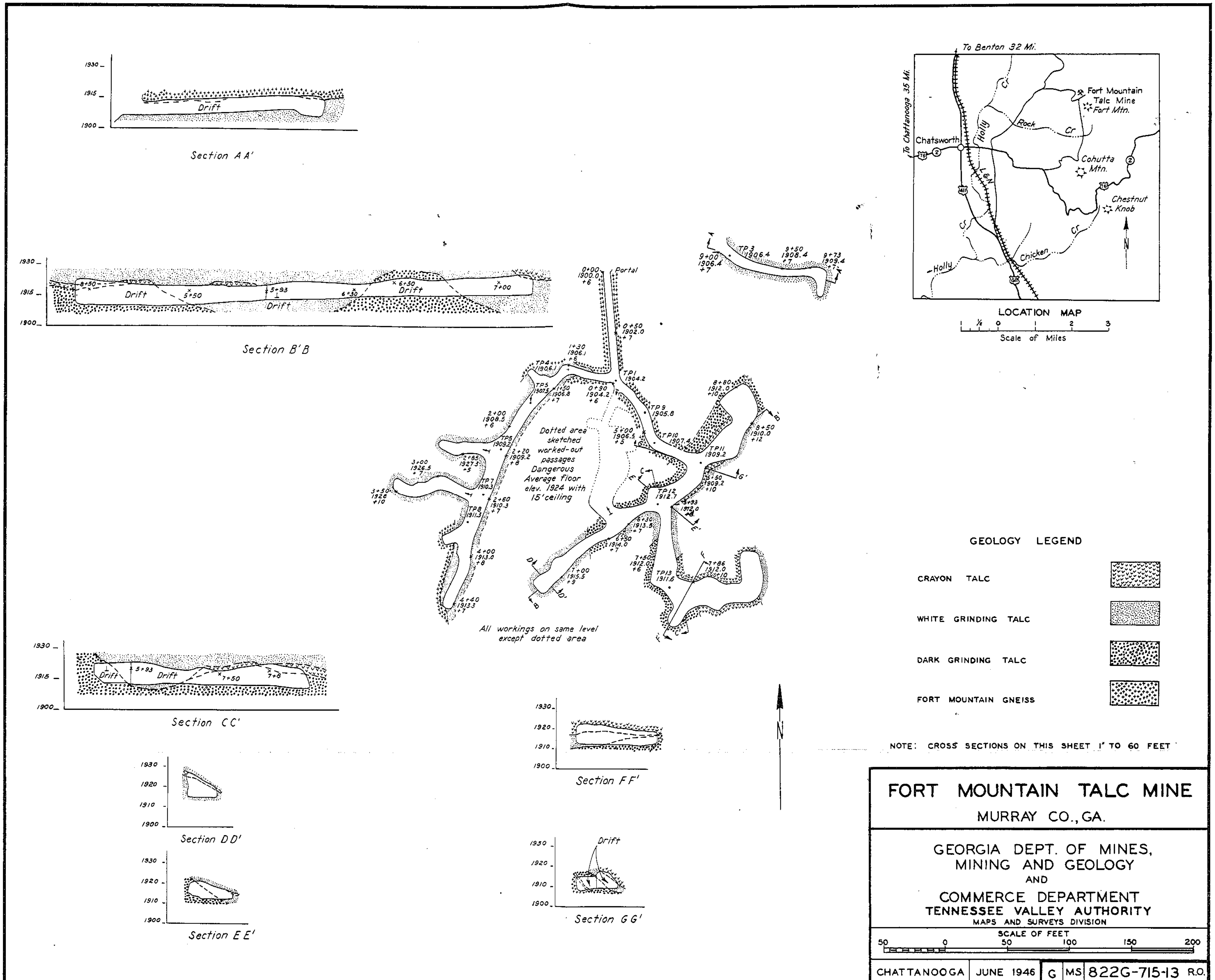

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