Talc Resources of the United States

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By A. H. CHIDESTER, A. E. J. ENGEL, *and* L. A. WRIGHT

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TALC RESOURCES OF THE UNITED STATES

By A. H. Chidester, A. E. J. Engel, and L. A. Wright

ABSTRACT

The United States is self sufficient in most varieties of talc and depends upon imports only for small tonnages of critical block steatite and for some varieties, such as cosmetic grades, where demand is based upon consumer preference. The United States yields about one-third of the world's total talc production and is the principal talc-producing nation. World production of talc was about 1.5 million tons in 1956.

Quantitative appraisal of domestic resources of talc in terms of the various types and grades is complicated by wide variations in properties, complex geologic features of deposits, and industrial factors that preclude precise specifications for many grades, particularly the higher ones.

The uses of talc are many and varied. Relatively small quantities of lump talc are required for special uses such as crayons and block steatite. Ground talc is used in a wide range of industrial applications. Classified as talc in the industrial sense are materials that range in composition from virtually the pure mineral to gross admixtures of talc, carbonate, tremolite, serpentine, and other minerals.

Deposits of industrial talc are associated principally with sedimentary rocks and with ultramafic and mafic igneous rocks. Most of these deposits are confined to regions in which the rocks have been folded and metamorphosed. Carbonate rock, chiefly dolomite, is the most common parent rock of talc deposits associated with sedimentary rocks; serpentinite is the most common parent rock of deposits associated with ultramafic and mafic igneous rocks. The deposits show a wide range of genetic relations. Some were formed by contact metamorphism, others by regional metamorphism. Relationships to stratigraphy and structural features vary widely in nature and in relative importance. Deposits in sedimentary carbonate rock and quartzite commonly consist of relatively pure talc. Steatite, an especially pure variety of commercial talc, is associated almost exclusively with sedimentary carbonate rock. Deposits in argillaceous sedimentary rocks and in ultramafic rocks generally contain minerals that limit either the value or use of the talc.

Block steatite has been produced, though sporadically and in small quantities, only in Montana and, probably, in California; none is currently produced in the United States. Steatite is produced chiefly in Montana and California. The chief producers of other grades of talc are California, New York, Vermont, Maryland, North Carolina, Georgia, Texas, and Nevada. Washington, New Mexico, and Arkansas are, or have been, minor and sporadic producers.

The United States has no known reserves of block steatite, but small potential resources are known in Montana and California. Reserves of steatite total more than 2 million tons, and the total resources of steatite are probably several times

that. Crayon-talc resources, though poorly known, are probably ample for several decades. Reserves of other grades of talc are adequate for any foreseeable requirements.

INTRODUCTION

PURPOSE AND SCOPE OF THE REPORT

This report is a summary of the available information on the talc resources of the United States. It concerns all varieties of commercial talc,[1] but the main emphasis is on grades and types that are essential to our industrial needs and that are most likely to be strategic or critical. These are the varieties composed essentially of talc and include chiefly block steatite, steatite (ground), and crayon talc. Less pure varieties may eventually serve for these uses when advances in technology permit the upgrading of impure material and the forming of ground talc into blocks that are adequate substitutes for the natural massive varieties.

Geologic factors of the talc deposits are stressed because genetic features determine to a large extent the physical and chemical characteristics of the talc. However, the geologic discussion is limited to features that are essential for evaluation of talc resources. For details of geologic theory and descriptions of individual deposits and districts, the reader is referred to publications cited in the bibliography.

SOURCES OF INFORMATION

This report is based on several kinds of information. Three of the principal talc-bearing regions, in whole or in part, have been studied in detail by the authors—Engel, the Gouverneur district, New York; Chidester, Vermont; Wright, California. Engel and Chidester visited the Inyo Range–Northern Panamint Range district in California, the Dillon–Ennis district in Montana, and the Murphy district in North Carolina in 1950; Chidester visited the Chatsworth district in Georgia in 1950; Wright, Engel, and Chidester examined the Southern Death Valley–Kingston Range district in California in 1952; Wright visited the Hembrillo Canyon–San Andres Mountains district in New Mexico and the Palmetto–Oasis district in Nevada in 1942; and Wright and Chidester reexamined the principal deposits of the Dillon–Ennis district in Montana in 1957. The literature was thoroughly searched. Most of the statistical data were obtained from publications of the U.S. Bureau of Mines, particularly the Minerals Yearbook and the annual Mineral Market Reports on "Talc, Soapstone, and Pyrophyllite." Because of the time interval between visits to mines and other factors inherent in a project of this kind, the information on some

[1] Pyrophyllite, the production data for which are commonly lumped with those of talc in statistical compilations, is not included in this report.

districts is more recent than that on others, but the data are believed to be comparable.

ACKNOWLEDGMENTS

Many of the data for this report were obtained through the generous help of many officials and employees of talc companies throughout the United States. Individuals who gave freely of their time and help are too numerous to mention specifically, but particular thanks are due to officials and employees of the Sierra Talc and Clay Co., Grantham Mines, Kennedy Minerals Co., Pomona Tile Manufacturing Co., Western Talc Co., Industrial Minerals and Chemical Co., and Pacific Mineral Products Co. in California; the Southern California Minerals Co. in California and Montana; the International Talc Co., Loomis Talc Co. (now merged with International Talc Co.), and Gouverneur Talc Co. in New York; the Eastern Magnesia Talc Co. and Vermont Talc Co. in Vermont; the Hitchcock Corp. in North Carolina; and the Georgia Talc Co. and Cohutta Talc Co. in Georgia. Peter T. Flawn generously furnished a manuscript copy, in advance of publication, of his report on the talc deposits of the Allamoore district of Texas.

GENERAL STATEMENT

The United States is almost self sufficient in talc. The domestic supply of block steatite [2] is deficient, and the small but as yet essential requirements are met entirely by import. A large proportion of such varieties of talc as French chalk and fine cosmetic talc is imported also. All the other principal varieties are adequately supplied by domestic sources, which currently yield about half a million tons annually.

Discoveries and technological developments since about 1950 have greatly improved our domestic position. The major production of ground steatite has shifted from California to Montana, where several deposits have been brought into production, with reserves apparently assured for many years. Improvement in the manufacture of synthetic block steatite has yielded material suitable for all but the most exacting uses, and investigations now under way promise to yield synthetic block steatite that is a complete substitute for the natural material (Irving, 1956, p. 867). Production and resources of crayon talc seem to be adequate at present; and synthetic pressed and bonded crayons, though not as yet generally economically competitive, are probably suitable for all uses of crayon talc. The domestic supply of other industrial grades of talc is adequate for all foreseeable needs. Moreover, with the possible exception of steatite, crayon, cosmetic and pharmaceutical grades of talc, a wide range of substitution is possible,

[2] For definitions of this and other terms, see p. 6-10.

either by other grades of talc or by other readily available industrial minerals.

Quantitative appraisal of talc resources is complicated by a general lack of adequate quantitative information on reserves and by arbitrary, vague, and conflicting specifications for many grades and uses. Nevertheless, the considerable flexibility in specifications for most industrial grades makes it possible to evaluate reserves and resources in terms of broad grade classifications with fair satisfaction. Quantitative evaluation of resources is least satisfactory for grades composed essentially of the mineral talc, for which specifications are generally rather strict (though in some cases conflicting) and for which substitutes are not generally acceptable.

PRODUCTION, CONSUMPTION, AND FOREIGN TRADE

World production of talc, soapstone, and pyrophyllite for 1947–56 ranged from about 1 million tons to about 1,830,000 tons annually. No breakdown by grade and type of talc is possible, nor is it possible to separate the pyrophyllite production; but if it is true for the world, as it is for the United States, that pyrophyllite constituted about one-fifth of the total, world production of talc ranged from about 800,000 tons to about 1,500,000 tons annually.

The United States is the world's principal source and consumer of talc. Approximately 250,000 to 600,000 tons of talc have been mined, processed, and utilized yearly in the United States since 1940; annual production and consumption since 1950 have been close to, or in excess of, 500,000 tons. Annual imports of unground talc total only a few tens of thousands of tons, chiefly for such uses as French chalk, cosmetics, and block steatite. Exports of unmanufactured talc are about equal to imports (table 1). The salient statistics of the talc industry in the United States are given as nearly as possible in table 1 by the more important grades. Statistical data of the talc industry are almost inextricably involved with those of pyrophyllite and other miscellaneous mineral products, and it has not been possible to free table 1 entirely of such extraneous data.

Annual production, by States, of talc, soapstone, and pyrophyllite combined, and total annual production for the United States of talc and pyrophyllite separately, for 1942 and 1952–56, are given in table 2. California, New York, Vermont, Georgia, North Carolina (though the major part of the production recorded for North Carolina in table 2 was pyrophyllite), Maryland, and Virginia have long been major producers of talc. Table 2 shows that Montana and Texas have become large producers in the last several years. Montana and California are the only significant producers of steatite; Georgia, North Carolina, and Vermont produce practically all the domestic crayon

TABLE 1.—*Salient statistics, in short tons, of the talc and ground soapstone industry in the United States, 1940 55*

[Does not include soapstone in sawed and shaped slabs. Data partly from U.S. Bureau of Mines Minerals Yearbooks]

Year	Sold by producers				Imports				Exports [5]	Apparent consumption			
	Block steatite	Crayons	Other [1]	Total	Crude and unground [2]	Cut and sawed [3]	Ground [4]	Total		Block talc [6]	Crayons	Other [1]	Total [7]
1940	0	1,829	249,546	251,375	93	125	28,145	28,363	9,402	218	1,829	268,289	270,336
1941	0	3,186	373,183	376,369	341	71	18,225	18,637	10,889	412	3,186	380,519	384,117
1942	[8] 14	1,474	332,790	334,264	286	<1	8,492	8,778	9,246	300	1,474	332,052	333,826
1943	[8] 16	1,446	349,280	350,726	408	1	6,201	6,610	10,693	425	1,446	344,772	346,643
1944	0	1,358	331,262	332,620	696	132	7,650	8,478	10,709	828	1,358	328,203	330,389
1945	0	336	320,454	320,790	385	122	6,192	6,699	11,141	507	336	315,505	316,348
1946	0	306	360,209	360,515	8	34	18,407	18,449	16,373	42	306	362,243	362,591
1947	0	603	411,751	412,354	48	27	17,629	17,704	17,557	75	603	411,823	412,501
1948	0	400	411,019	411,419	85	98	18,194	18,377	16,327	183	400	412,886	413,469
1949	0	560	372,475	373,035	58	110	18,648	18,816	15,841	168	560	375,282	376,010
1950	0	600	----------	502,941	177	156	23,054	23,387	20,644	333	600	----------	505,684
1951	0	738	----------	517,224	109	127	20,404	20,640	23,009	236	738	----------	514,855
1952	0	703	----------	468,660	284	64	19,954	20,302	23,223	348	703	----------	465,739
1953	0	660	----------	487,337	198	127	22,478	22,803	23,230	325	660	----------	486,910
1954	0	612	----------	481,985	36	45	22,076	22,157	23,607	81	612	----------	480,535
1955	0	766	----------	564,040	125	72	28,882	29,079	35,365	197	766	----------	557,754

[1] Includes crude talc, ground talc other than steatite, and small amounts of sawed and manufactured. Figures for 1940-49 also include ground steatite.
[2] Probably chiefly block steatite; may include some French chalk.
[3] Probably chiefly French chalk and similar grades; may include appreciable amounts of block steatite.
[4] Probably chiefly cosmetic grade, but may include some steatite.
[5] Undivided. Includes some pyrophyllite; does not include packaged toilet preparations.
[6] Total of all crude and cut and sawed. Includes block steatite, French chalk, and similar grades (but not crayons). This figure represents the upper limit for consumption of block steatite, for which more accurate data are not available.
[7] Total apparent consumption equals sales plus imports minus exports.
[8] Estimated.

TABLE 2.—*Crude talc, soapstone, and pyrophyllite, in short tons, produced in the United States, 1942 and 1952–56, by States*

[Data from U.S. Bureau of Mines Minerals Yearbooks and Mineral Industry Surveys]

State	1942 [1]	1952	1953	1954	1955	1956
Alabama	0	0	0	0	1,500	2,200
California [2]	51,649	123,793	126,442	133,474	166,551	153,710
Georgia	29,930	58,411	57,891	50,536	53,828	57,916
Maryland and Virginia	[3] 15,294	36,963	37,358	37,611	36,603	26,574
Montana	0	(4)	(4)	(4)	(4)	22,197
Nevada	[5] 12,239	7,580	10,906	5,866	10,732	10,540
New York	136,752	150,138	156,299	(4)	(4)	(4)
North Carolina [6]	56,909	116,722	119,341	112,704	125,206	125,487
Pennsylvania [7]	0	0	2,463	1,898	(4)	(4)
Texas	0	17,495	16,210	19,362	35,064	41,332
Vermont	58,695	72,533	80,209	66,195	(4)	(4)
Washington	7	(4)	5,351	(4)	(4)	(4)
Other States [8]	26,388	17,273	19,048	191,348	296,224	299,083
Total	387,963	600,908	631,518	618,994	725,708	739,039
Pyrophyllite	53,669	125,496	123,457	126,702	158,460	167,756
Talc and soapstone	334,294	475,412	508,061	492,292	567,248	571,283

[1] Sold by producers.
[2] Includes as much as 15,000–20,000 tons of pyrophyllite annually.
[3] Maryland only.
[4] Included under "Other States."
[5] Includes pinite.
[6] Largely pyrophyllite—53,669 tons in 1942 and as much as 100,000 tons or more annually thereafter.
[7] Sericite schist.
[8] Includes States indicated by footnote 4, Arkansas (1955), and Virginia (1942).

talc; California, Nevada, North Carolina, Texas and Montana are the leading producers of relatively pure talc rock used largely in ceramics, cosmetics, and pharmaceuticals, although Vermont contributes a significant amount of flotation-beneficiated talc to those uses.

Prices for ground talc usually are quoted on the short-ton basis, f.o.b. at the mill, and vary according to type of talc, purity, and fineness of grind. Crayons are sold by the gross, and special varieties of block talc may be sold by the pound or by the piece. Prices quoted in trade journals are nominal, and actual selling prices are the result of direct negotiation between seller and buyer. The range in price from the lowest to the highest grades is wide—from $10 a ton or less for the lowest grades to several hundred dollars a ton for particular grades specifying special properties and purity.

DEFINITIONS AND TERMINOLOGY

Industrial talc includes mineral products of widely different chemical and mineral composition. Specifications of physical and chemical properties vary widely, depending upon use. Consequently, there have been developed within the talc industry a number of special terms. Moreover, each mining district has evolved terms that are purely local in their application and may not be understood generally throughout the industry. As a further complicating factor, some industrial terms are used by geologists in very different senses. It is desirable, therefore, to define at the outset a number of terms used in this report.

TERMS IN GENERAL USE

Talc.—Mineralogically, talc is a hydrous magnesium silicate whose simple basic formula is $(Mg,Fe^{+2})_3Si_4O_{10}(OH)_2$. Theoretical weight percentages of oxides in the pure magnesian end member are MgO, 31.89; SiO_2, 63.36; and H_2O, 4.75 (atomic weights for 1955). Fe^{+2} may substitute for as much as 10 percent of the atoms of Mg (that is, to a maximum formula value for Fe^{+2} of about 0.3, or a weight percentage of FeO of about 4) but is commonly less, particularly in talc derived from dolomitic marble and quartzite. Very small, generally negligible, amounts of aluminum may substitute for silicon and magnesium.

Industrially, the term "talc" is applied to a variety of rocks and rock products in which the mineral talc may be only a minor constituent. Commonly, however, talc is the predominant, or at least an abundant, mineral; and many talcs, particularly those of steatite, cosmetic, and crayon grade in California, Montana, and North Carolina, are composed almost entirely of the mineral talc and closely approach the theoretical composition of the mineral.

In a report of this kind, "talc" must repeatedly be used in both the mineralogical and the industrial senses. The particular usage intended, if not clear from context alone, is indicated by a suitable modifier or qualifying phrase.

Particular varieties of industrial talc, or particular forms in which talc products are marketed, are designated by prefixing suitable modifiers to "talc." Many such compound terms have come to be recognized in a specific sense throughout the industry. Thus, in "fibrous talc" the particles are fibrous or acicular; much material so designated is composed largely or entirely of anthophyllite. Talc composed largely of tremolite is generally designated "tremolitic talc," but locally it is called fibrous talc. "Block talc" is massive talc rock that can be machined and fired but is too impure for block steatite (see below). "Ground talc" applies to all industrial talc products that are utilized in ground form. "Crude and unground talc" is a category, used in the U.S. Bureau of Mines Minerals Yearbook, that includes many grades of talc; probably the major part of the material imported under this category is cosmetic-grade talc and block steatite. "Crude talc" sold by producers in the United States includes many grades and types in undeterminable amounts. "Sawed and manufactured talc" in the Minerals Yearbook includes crayons, sawed slabs, and some block steatite and cannot be broken down usefully. "Crayon (or 'pencil') talc" is massive or schistose material that can be sawed or shaped into crayons or pencils for such a use as marking structural steel.

Steatite and talc rock.—The term "steatite" is used differently—principally with different emphasis—in the talc mining industry and by geologists. Geologically, steatite is a rock composed essentially of talc and with only minor proportions of other minerals, such as chlorite. Industrially, steatite denotes a relatively pure talc rock that meets certain specifications for ceramic insulator bodies. To avoid confusion, in this report "steatite," with suitable modifiers, is used only in the industrial sense. The term "talc rock" is substituted for "steatite" in the geologic sense.

Steatite logically includes both material used in lump form and that which is ground. In general usage, however, material used in lump form is designated specifically as "block steatite" (also lava steatite and lava grade talc); "steatite" by itself refers to ground steatite or to material that will ultimately be utilized in ground form. This general usage is followed in this report. "Synthetic block steatite" (also called artificial block steatite and artificial lava talc) is formed from bonded ground steatite that is pressed into blocks for use as a substitute for the natural block material. Specifications for the various kinds of steatite are discussed in the section "Uses and specifications," pages 10–13.

Soapstone.—Industrially, soapstone is a talcose rock that is marketed in sawed and shaped slabs; it falls in the category of dimension stone. Most soapstone in the United States is quarried at Schuyler, Va., and is an amphibole-chlorite-carbonate-talc rock, but the term also includes talc-carbonate rock and talc rock. Waste soapstone is commonly marketed as a ground talc product and is sometimes distinguished as "ground soapstone" in statistical compilations such as the Bureau of Mines Minerals Yearbook.

TERMS OF LOCAL USAGE

VERMONT

'Grit'.—The term 'grit' (enclosed in single quotation marks here to distinguish it from a variety of sandstone) applies to rock that consists of talc and carbonate in roughly equal proportions. Locally, 'grit' may contain considerable relict serpentine. The word is a miner's term and presumably refers to the harsh, gritty feel imparted by the carbonate.

GEORGIA

White-grinding talc.—The better, lighter-colored grades of talc that are suitable chiefly for grinding are distinguished locally as "white-grinding talc." They are composed essentially of the minerals talc and dolomite in about equal proportions. At the mines, a distinction is made between "hard white-grinding talc" and "soft white-grinding talc," but the distinction is subtle and is not based on readily apparent mineralogical differences.

Dark-grinding talc.—Talc that contains abundant dark impurities and therefore does not qualify as white-grinding talc is called dark-grinding talc. It is further divided into hard and soft varieties, which exhibit significant mineralogical differences. "Soft dark-grinding talc" is composed predominantly of talc, chlorite, and dolomite, in that order of abundance; talc and chlorite commonly form about two-thirds of the rock, and dolomite forms nearly one-third. "Hard dark-grinding talc" commonly contains only a relatively small amount of the mineral talc. Talc and chlorite combined form 25 percent or less of the rock, and the balance consists of quartz, orthoclase, albite, sericite, and limonite.

CALIFORNIA

Soft talc.—Friable white schistose rock composed mostly of the mineral talc and subordinate proportions of serpentine, calcite, and dolomite is commonly termed "soft talc."

Hard talc.—Massive or thinly laminated rock composed mostly of tremolite, generally with subordinate calcite, dolomite, and serpentine but with little or no talc, is termed "hard talc." It is ordinarily white or very pale green or brown.

Blue talc.—The name "blue talc" is commonly applied to a dark-green chlorite rock that is locally associated with talc deposits in southeastern California. "Sierralite" is a trade name applied to a fine-grained massive variety of chlorite rock.

TECHNOLOGICAL TERMS

Manufacturers, retailers, and consumers have adopted a system of terminology that enables them to describe talc products more or less quantitatively. The terms have evolved from various sources over a period of years; consequently, some terms employ metric units, and others use units of the English system.

Bulking values.—The apparent densities of a powder when lightly fluffed and when tightly packed are termed "bulking values." They are determined in accordance with government-specified methods and are designated "tapped bulk" and "loose bulk." Each is commonly stated in terms of both pounds per cubic foot and cubic centimeters per 20 grams of powder. The value designated in pounds per cubic foot is commonly called the apparent density.

Color.—The color of talc products is described in terms of various shades and tints of gray and white, such as white, off-white, gray, and greenish gray. A product that has high reflectance (see below) commonly is said to have "good color." "Fired color" refers to the color of material that has been held at a specified high temperature for a specified length of time.

Oil absorption.—Oil absorption, as the term implies, is a measure of the amount of oil that a given amount of talc will absorb. The value is determined by a standard procedure called the Gardner-Coleman spatula method and is based upon the pounds of oil absorbed per 100 pounds of powder; the value is commonly stated as percentage.

Particle shape.—The particles of ground commercial talcs have shapes to which such terms as acicular, fibrous, platy, micaceous, and granular can be applied. Such terms, or symbols that represent them, are used to indicate which shapes predominate in a given ground talc.

Particle size.—Several methods of measuring particle size are in general use. "Sieve fineness" is most commonly used and is generally stated in terms of percentage of material that passes through 200- and 325-mesh screens. Sieve fineness is determined by screening the material, wet, through appropriate U.S. Standard sieves.

Particle-size distribution.—The particle-size population of talc powder is measured according to conventional methods. The result is commonly presented as a cumulative size distribution, or "percent-less-than" curve and is designated the "particle size distribution."

pH.—The pH has the usual meaning of hydrogen-ion concentration. It is measured by glass electrode in a 10-percent dispersion of talc in water.

Reflectance (or brightness).—Reflectance is an approximate quantitative measure of color that is determined by a photovolt reflectometer adapted for use with powders. The reflectometer measures the percentage of light reflected by a given powder as compared with a standard powder sample (usually MgO).

Slip.—Slip is a property not susceptible to strict definition or objective determination. It expresses the smoothness, slipperiness, or "feel" of a powder and depends principally on the talc (mineral) content and the particle shape. Slip is expressed in terms of poor, fair, good, or excellent.

Specific gravity.—The specific gravity of ground talc is measured in the conventional manner on powdered material.

True density.—The term "true density" is applied to the values obtained by converting specific gravity into terms of pounds per gallon and gallons per pound.

USES AND SPECIFICATIONS

The uses of talc are many and varied. The principal uses of ground talc are in ceramics, paint, insecticides, roofing, rubber, paper, asphalt filler, textiles, toilet preparations, foundry facings, and food processing. Lump talc is used for crayons, block steatite, and carvings. Soapstone is used for sawed and shaped slabs (dimension stone) for sinks, electrical base plates, and similar uses. Table 3 shows the an-

TABLE 3.—*Talc and ground soapstone sold by producers in the United States, by uses, 1950–55*

[Data from U.S. Bur. Mines Minerals Yearbooks]

Use	1950		1951		1952		1953		1954		1955	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Ceramics	125,781	25	119,938	23	120,404	26	120,794	25	125,179	26	174,700	31
Paint	140,166	28	142,852	28	117,046	25	113,406	23	118,353	25	118,908	21
Rubber	42,377	8	53,781	10	52,280	11	32,137	7	32,536	7	33,272	6
Roofing	54,204	11	63,568	12	48,721	10	53,858	11	52,431	11	60,537	11
Insecticides	42,260	8	46,334	9	33,305	6	57,762	12	48,262	10	63,472	11
Paper	29,566	6	27,884	5	26,327	6	25,018	5	20,699	4	17,339	3
Asphalt filler	6,931	1	11,229	2	23,005	5	21,305	4	19,651	4	22,608	4
Textiles	13,311	3	11,414	2	12,029	3	9,811	2	9,315	2	8,286	1
Toilet preparations	11,168	2	7,916	2	8,361	2	8,126	2	9,718	2	9,912	2
Foundry facings	7,800	2	7,986	2	7,279	1	7,502	<2	6,332	1	9,131	2
Rice polish	2,845	<1	1,944	<1	1,438	<1	2,624	<1	1,060	<1	1,125	<1
Crayons	600	<1	738	<1	703	<1	660	<1	612	<1	766	<1
Other	25,932	5	21,640	4	17,762	4	34,334	7	37,837	8	43,994	8
Total	502,941	100	517,224	100	468,660	100	487,337	100	481,985	100	564,050	100

nual sales by producers of talc and ground soapstone in the United States, by use, for 1950–55.

The essential features and the chief uses of the principal industrial types of talc are given in table 4. Properties and specifications cannot be rigidly defined for any given type and may vary appreciably. Thus, block steatite for ultrahigh-frequency insulators must meet more strict specifications of purity than that for less demanding uses. Variations for ground steatite, within the general limits shown in the table, are restricted chiefly by the die settings of individual manufacturers. For other types of talc, different consumers emphasize particular specifications of mineralogy, physical or chemical properties, or milling procedure, according to individual needs. For example, cosmetic and pharmaceutical talcs must be of uniform light color, high purity, and pleasant feel; talc for paint must have good color and, commonly, a specified particle shape and particle-size distribution; talc for such ceramic uses as wall tile and dinnerware must be of good firing color and generally is required to be tremolitic (so as to contain about 6 percent CaO), but textural and physical properties are relatively unimportant. Many of the industrial uses of talc have shown a distinct trend in recent years toward ultrafine and very fine grinds and toward more uniform particle size.

Critical or near-critical uses of talc, from a national resource point of view, are confined to those uses, such as block and ground steatite and crayons, which require relatively pure talcs with particular physical characteristics. For these types, the last three columns of table 4 list critical uses, competitive uses, and additional uses, respectively, to indicate how noncritical uses may compete for talc of critical grade.

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TABLE 4.—*Properties, specifications, and uses of different grades and types of talc*

Industrial classification	Requisite properties of raw material				Uses of raw material		
	General physical properties and mineral composition	Approximate chemical composition (weight percent)	Preparation	General physical requirements	Critical	Competitive	Additional
Block steatite	In lumps composed of microcrystalline relatively equant grains of talc.	Close to $Mg_3Si_4O_{10}(OH)_2$; or, in weight percent: MgO, 31.89; SiO_2, 63.36; H_2O, 4.75.	Lump talc machined or carved, then fired.	Small uniform shrinkage during firing, low dielectric loss, light fired color, and resistance to thermal shock.	High frequency insulation.	Cosmetics, food processing, pharmaceuticals, ceramic bodies, paint, specialties, crayons.	Paint, ceramic bodies, plastics, rubber, textiles.
Ground steatite	Nearly or quite massive talc, composed of microcrystalline grains.	Approximately the same as for block steatite. Impurities not to exceed: CaO, 1.5; $FeO+Fe_2O_3$, 1.5; Al_2O_3, 4.0.	Talc is ground, pressed or bonded, extruded, and fired.	Same as for block steatite, except that properties of lump material not a factor.	do	do	Do.
Crayon talc	Massive or foliated talc.	Nearly pure talc, but purity not required, and a relatively high iron content is common.	Lump talc is sawed or shaped into crayons or pencils.	Softness, freedom from gritty minerals, and specified minimum breaking strength.	Crayons	Cosmetics and food processing.	Similar to those for steatite.
Other relatively pure talcs.	do	Relatively pure talc, but no rigid specifications.	Fine grinding	Softness and freedom from gritty minerals.		Cosmetics, pharmaceuticals, food processing, and others.	Do.
Tremolitic talc (locally called fibrous talc).	Aggregate of microcrystalline to coarsely crystalline tremolite.	About as follows: SiO_2, 58; MgO, 28; CaO, 7; $(Al_2O_3+Fe_2O_3+FeO+MnO)$, 1.5; loss on ignition, 5.	Ground to about −200 mesh or finer, added to ceramic body, and fired.	Limitations as to effect on shrinkage and mobility during firing, color, and crazing in ceramic body.			Whiteware and other ceramic bodies.
Fibrous talc	Aggregate of highly fibrous anthophyllite.	About as follows: SiO_2, 65.5; MgO, 27.0; CaO, 2; $(Al_2O_3+Fe_2O_3+FeO+MnO)$, 2; loss on ignition, 4.	Fine grinding	Highly fibrous, teased form, and refractory or relatively inert properties.			Foundry facings, insulation, ceramic bodies, and paint.
Other talc	Wide variations in physical properties; mixtures of talc, tremolite, carbonate, anthophyllite, and serpentine.	Wide variations	Coarse to very fine grinding.	Wide variations			Whiteware and other ceramic bodies, paint plastics, rubber, paper, roofing, insecticides, foundry facings, and other uses

Competitive uses generally can command prices equal to or higher than those of the critical uses. Uses listed under "Additional" can compete generally only under exceptional geographic or economic conditions.

CLASSIFICATION AND GEOLOGY OF TALC DEPOSITS

Talc occurs in many parts of the United States in association with metamorphosed sedimentary[3] and volcanic rocks and with the ultramafic and mafic igneous rocks serpentinite, dunite, peridotite, and gabbro. In both types of deposit the country rock adjacent to the characteristic host rock also may be altered to talcose rock, and locally the proportion of altered country rock may be relatively large. Both types of deposits are confined to areas of folding, faulting, and metamorphism in the eastern, western, and south-central United States. All appear to have formed by selective replacement under somewhat similar conditions of metamorphic intensity. Plate 1 shows the distribution of the principal deposits in the United States.

DEPOSITS ASSOCIATED WITH SEDIMENTARY ROCKS

Talc deposits associated with sedimentary rocks vary widely in size and range in form from lenticular to highly irregular. In the United States, sedimentary host rocks range in age from Precambrian to Silurian.

In many places, diabase or granitic rocks are associated with the deposits, and a direct genetic relationship is generally inferred. However, many deposits isolated from igneous rocks appear to have formed under conditions of regional metamorphism and may be unrelated to igneous activity insofar as regional metamorphism may itself be unrelated.

Most talc deposits associated with sedimentary rocks are in dolomite, but many replace adjacent silicate rocks (quartzite, schist, gneiss, argillite, granite, and so on) to some extent. Some deposits, though adjacent to units of carbonate rock, appear to have been derived largely or wholly from silicate rocks. Other deposits appear to be associated exclusively with silicate rocks such as argillite, phyllite, schist, and mafic volcanic rocks. Geologic relationships in individual districts are generally fairly constant, but vary widely among deposits in different areas. Stratigraphy, structural features, and metamorphic environment are probably the principal ore controls, and the nature and relative importance of one or another are the most useful distinctions to be made.

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[3] For brevity, the term "sedimentary rocks" will be used throughout the report in referring to metamorphic rocks of sedimentary parentage. In all instances, it should be understood that the rocks referred to are metamorphic and range from argillite and crystalline carbonate rocks to schist and lime silicate rocks.

Stratigraphic control serves to localize talc deposits with respect to stratigraphic position in sedimentary rocks. The talc deposits may be restricted to particular formations, to particular zones within a formation, or to particular horizons such as contacts between contrasting types of rock. Talc may occur, within the same district, in formations of different age and of contrasting rock type. Stratigraphic control probably operates both chemically, through the chemical and mineral composition of the favorable zone, and physically, through the structural reaction of different rock types to particular structural environments.

Structural control commonly serves to localize talc deposits at particular sites within favorable stratigraphic zones. Some structural controls, such as conspicuous folds, shear zones or faults, and fracture zones at the intersection of joint systems, are readily apparent. Others are subtle and elusive, such as that implied by parallelism between lineation in the country rock and the axes of spindle-shaped masses of talc in almost uniformly dipping strata. In some deposits or groups of deposits, several structural controls seem to have operated in varying degree in different places.

The talc may have been formed by either contact or regional metamorphism. Where diabase dikes (or sills) or granitic plutons are nearby, a contact-metamorphic origin is generally assumed, and the control due to the juxtaposition of the igneous rock body and a favorable stratigraphic unit is fairly obvious. Deposits not associated with igneous rocks appear to have been formed by regional metamorphism. In such deposits the causes for localization are commonly subtle and elusive. Structural controls probably were largely responsible for most. Such controls may have acted by the channeling of solution or by causing critical variations locally in physical conditions such as partial pressure of water and carbon dioxide.

The interrelations of these genetically important factors vary greatly throughout the United States. Stratigraphic control is predominant in a few deposits in carbonate rock—for example, those of the Murphy district in North Carolina—and seems to be predominant in many or most deposits in phyllite, schist, or other noncarbonate sedimentary rocks, such as those of the Allamoore district in Texas. Structural features in those deposits probably have exerted significant control, but their role appears to have been subordinate. Both structural features and stratigraphic relations appear to have played major roles in many, perhaps in most, deposits in carbonate rock and in silicate rock (quartzite, granite) adjacent to carbonate rock. The deposits of the Inyo Range–Northern Panamint Range district of southeastern California are excellent examples: they occur in sheared and fractured zones of several dolomite and quartzite strata, along major contacts between dolomite and quartzite, and in granitic rocks adjacent to deposits in dolomite and quartzite. Structural controls such as faults, fracture zones, and major folds, appear to have been dominant in many deposits; both a suitable rock type and a favorable structural environment were necessary, but the structural factor was predominant. The deposits of the Palmetto–Oasis district in Nevada are along a major thrust fault, though the latest movement on the thrust postdates the talc; those in the Gouverneur district in New York are along major shear zones in dolomite strata and are commonly localized in the crests of large folds; and at least some of the deposits in the Dillon–Ennis district of Montana are localized in dolomite strata along fracture zones formed by a joint system. The spatial relationship to associated igneous rocks is a dominant feature in most contact-metamorphic deposits, which appear to be confined essentially to dolomite host rocks. The Southern Death Valley–Kingston Range district contains excellent examples of deposits at or near contacts with diabase dikes or sills; the Silver Lake–Yucca Grove district contains fine examples of deposits near genetically associated granitic plutons.

Figure 1 illustrates a variety of deposits associated with sedimentary rocks.

All these talc deposits were formed by low-grade metamorphism. Some contact-metamorphic deposits and many regional metamorphic deposits were formed by simple progressive metamorphism; they generally are mineralogically simple. Other deposits of both types, particularly some of those in dolomite, have had a relatively complex metamorphic history marked by nearly complete alteration to tremolite or anthophyllite followed by widely variable retrogressive alteration to talc and serpentine; such deposits are commonly of correspondingly complex mineralogy.

The alteration to talc probably was carried out by simple aqueous solutions. Host rocks of relatively pure dolomite required the introduction of SiO_2 and, possibly, MgO; quartzite and granite required large quantities of MgO; siliceous dolomite may have required little other than water; phyllite and schist probably required complex interchange of chemical constituents, but the altering solutions may have been relatively simple in composition. Diabase sills or granitic plutons may have furnished the solutions for contact metamorphism, at least in part. The solutions in regional metamorphism may have been unrelated to igneous activity. An understanding and evaluation of these factors is necessary in assessing the relative importance of such features as stratigraphic and structural controls and proximity to igneous rocks, knowledge of which may be critical to successful exploration.

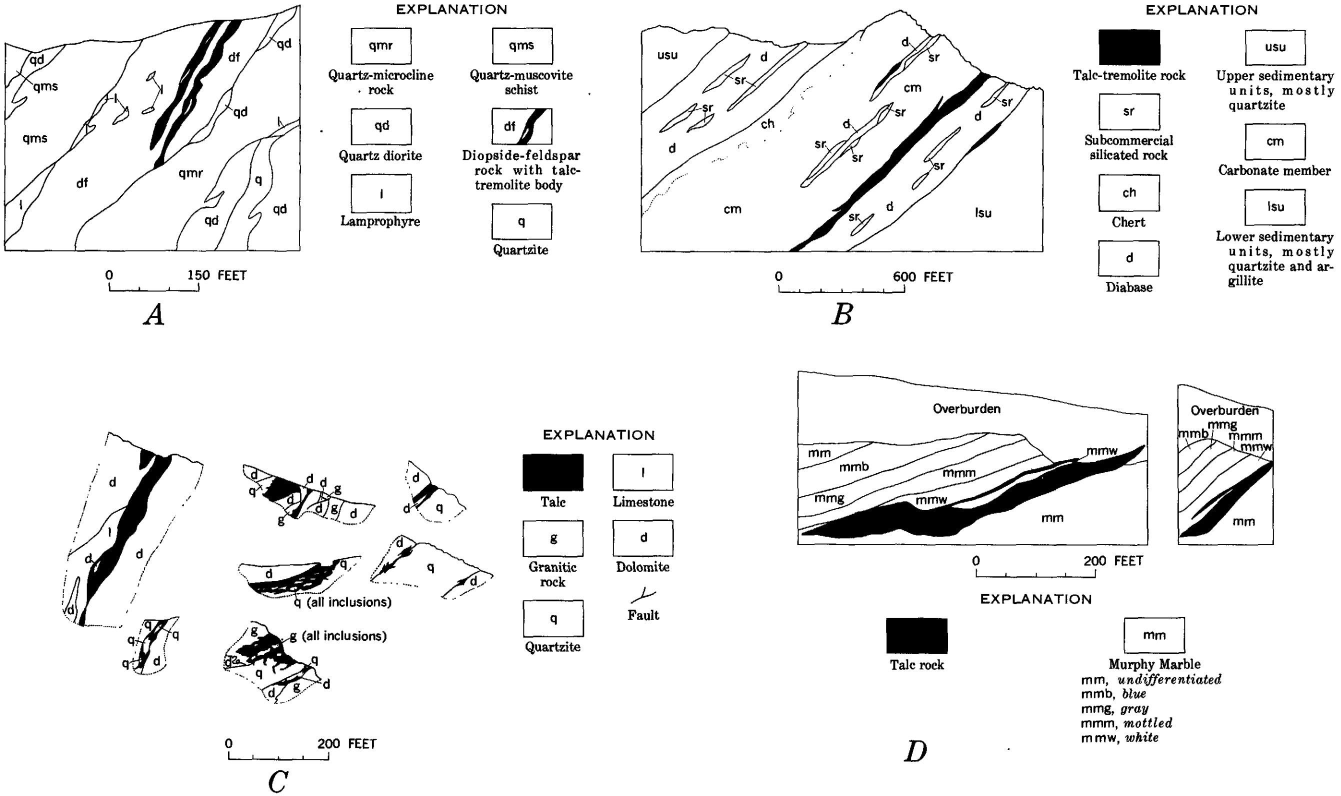

FIGURE 1.—Diagrammatic sections of talc deposits associated with sedimentary carbonate rocks. *A*, Idealized cross section of talc deposit in the Silver Lake–Yucca Grove district, California. Modified from Wright (1957, fig. 9). *B*, Idealized cross section of talc deposits in the southern Death Valley–Kingston Range district, California. Modified from Wright (1957, fig. 3). *C*, Idealized cross sections of talc deposits in the Inyo Range–Northern Panamint Range district, California. Modified from Wright (1957, fig. 5). *D*, Vertical longitudinal and cross sections of talc deposit in the Murphy district, North Carolina. Modified from Van Horn (1948, pl. 5).

Commercial talcs in deposits associated with sedimentary rocks differ widely in mineralogy, chemical composition, and fabric. The differences depend chiefly upon differences in the host rock and in the metamorphic and tectonic history of the deposits. Material in deposits having a simple progressive metamorphic history and derived from host rocks of simple composition (such as quartzites or dolomites) ranges from virtually pure talc rock with only minor chlorite to impure material with varying amounts of unaltered host rock and contaminating minerals such as chlorite, carbonate, graphite, and quartz. Material in deposits derived from dolomite but having a more complicated metamorphic history ending in retrograde alteration to talc ranges in composition from almost pure tremolite rock to almost pure talc rock; these grade into impure types with varying amounts of unaltered inclusions and intermixed serpentine, chlorite, carbonate, and quartz. Material derived from host rocks such as granite, phyllite, and schist shows similar variations in composition but commonly is less pure than material derived from dolomite, and the talc mineral commonly contains appreciable iron. In some deposits probably derived from such parent rocks most of the commercial talc is talc-carbonate rock, and the talc rock contains abundant contaminating minerals.

Fabrics range from dense or fine grained to coarse and from massive to schistose. The component particles of talc range in shape from shredded to equant grained to platy; tremolitic and anthophyllitic varieties are fibrous or acicular. Equant-grained material is generally massive; other material may be massive or schistose. Some talc rock seems to vary slightly in porosity, with resultant small but noteworthy variations in critical properties such as shrinkage upon firing; such variations may be associated with differences in particle shape and may be accompanied by outward manifestations such as dendritic veining.

DEPOSITS ASSOCIATED WITH ULTRAMAFIC IGNEOUS ROCKS

Talc deposits associated with serpentinite and related ultramafic igneous rocks such as dunite, peridotite, and pyroxenite occur characteristically in belts of folded and regionally metamorphosed sedimentary and volcanic rocks typical of mountain chains. The bodies of igneous rock range in size from small pods to masses several miles or tens of miles in extent; they are predominantly concordant with the bedding and foliation of the enclosing rocks, though crosscutting relations are locally common. The parent igneous rocks display appreciable differences in original (primary) characteristics and vary widely in degree and nature of alteration to serpentinite and varieties of talcose rock. The talc deposits range in form from thin shells to irregular masses, and some occupy the entire parent-rock body.

Two principal genetic types of deposit may be distinguished: one, related to the intrusion of acid igneous rocks younger than the serpentinite, occurs at the contacts of sodium-rich pegmatites that intrude serpentinite; the second is genetically related to regional metamorphism. Figure 2 illustrates types of talc deposits in ultramafic rocks.

Talc deposits associated with serpentinite and genetically related to regional metamorphism, of which the talc deposits in Vermont are typical (Chidester, 1962), characteristically consist of a serpentinite core surrounded successively by a shell of talc-carbonate rock ranging from less than 1 foot to as much as 100 ft in thickness and a shell of talc rock a few inches to several feet thick. The adjacent country rock is altered for a width of several inches to chlorite rock or to concentric shells of chlorite rock and biotite rock, commonly referred to as the blackwall. In some deposits the distribution of talc rock and talc-carbonate rock relative to serpentinite is irregular, and some have a very small core of serpentinite or none at all. In areas of low-grade metamorphism the talc-rock and talc-carbonate-rock zones are generally distinct, the talc particles fine grained, the talc rock and talc-carbonate rock massive to schistose, and the blackwall composed almost entirely of chlorite. In areas of slightly higher grade metamorphism, actinolite commonly forms a thin zone at the outer margin of the talc rock, adjacent to the blackwall. At higher grades of metamorphism, such as in the amphibolite facies, the talc-rock and talc-carbonate-rock zones are less distinct and are broadly intergradational, the talc particles coarsely flaky, the talcose rocks schistose to gneissic in fabric, and the blackwall is composed of successive shells of chlorite rock and biotite rock. Ultramafic rock bodies that contain considerable amounts of fresh dunite and peridotite appear to be more irregularly, and generally less extensively, steatitized than those composed of serpentinite. The talc commonly occurs in irregular tabular zones within the ultramafic mass, but in some places talc occurs marginally to the ultramafic body as well. The talc deposits range from a few feet in width and less than 100 ft in length to several hundred feet in width and thousands of feet in length. The deposits vary greatly in shape and attitude. Most are pod shaped or lenticular, pinch and swell markedly both in plan and section, and are steeply dipping or vertical; some tabular bodies are folded, and a few very irregular ones are branched, folded, and faulted.

Talc rock and talc-carbonate rock associated with serpentinite are generally rather uniform in composition but vary appreciably in fabric and color; the rocks range from massive to schistose and gneissic and from dark greenish gray to light gray or cream colored. Both types of rock are high in iron, which occurs as grains and disseminated dustlike particles of magnetite, in ferriferous carbonate and accessory

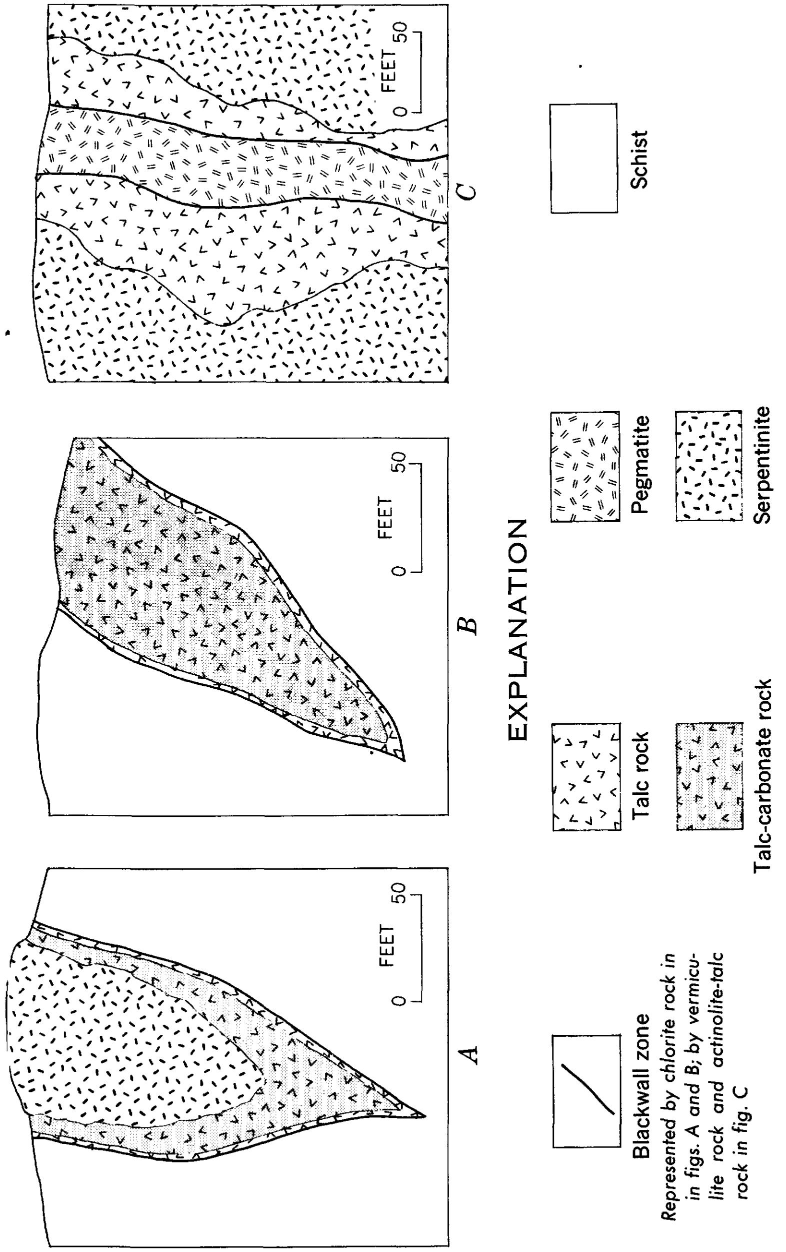

FIGURE 2.—Diagrammatic sections of talc deposits associated with ultramafic igneous rocks. *A*, Partial replacement of serpentinite at margins of ultramafic body; *B*, complete replacement of serpentinite; *C*, replacement of serpentinite along contacts of pegmatite dike.

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silicate minerals, and in substitution for magnesium in the talc lattice. The talc rock is commonly 95 percent or more talc, with minor chlorite, magnetite, and carbonate. The talc-carbonate rock is composed of roughly equal proportions of talc and carbonate, with minor proportions of magnetite; serpentine is locally abundant. Some of the talc-carbonate rock that forms irregular or tubular masses in peridotite varies greatly in the proportion of talc and carbonate and locally grades into almost pure magnesite rock. In areas of low-grade metamorphism the talc particles are fine and irregular or shredded; carbonate in the talc-carbonate rock is coarse and somewhat irregularly distributed. In areas of higher-grade metamorphism the talc particles are coarser, and commonly are platy or micaceous; the carbonate commonly also forms coarse elongate aggregates. The fabric of both talc rock and talc-carbonate rock ranges from massive to weakly or moderately well foliated in areas of low-grade metamorphism, and from weakly schistose to strongly schistose or gneissic in areas of higher grade metamorphism.

Steatitization in regionally metamorphosed deposits was accomplished by reaction between serpentinite and introduced CO_2 to form talc-carbonate rock, and by reaction between serpentinite and siliceous country rock (metamorphic differentiation) to form talc rock. The two processes operated in concert but were fundamentally independent, and their roles varied at different places. Where CO_2 metasomatism dominated, the volume of talc-carbonate rock is proportionately large; where metamorphic differentiation prevailed, the proportion of talc rock is large. The observation that talc rock with physical characteristics suitable for crayons seemingly occurs in deposits in which the proportion of talc rock relative to talc-carbonate rock is large suggests that an understanding of the genetic relationships may be useful in evaluating a deposit.

Talc deposits related to sodium-rich pegmatites that intrude serpentinite, typified by those near Dublin, Md., are very irregular and range in width from less than an inch to many feet. A vermiculite zone is commonly developed adjacent to the pegmatite, and a zone of actinolite commonly separates the vermiculite and the talc rock. The deposits consist principally of white to greenish-blue talc rock that ranges from massive to foliated or granular and contains various proportions of serpentine, carbonate, and magnetite as impurities. (See Pearre and Heyl, 1960.)

Such deposits appear clearly to be genetically related to pegmatite intrusions, and the pegmatites were presumably the source both for the material introduced into the serpentinite (chiefly silica) and for much of the heat. The talc rock, actinolite, and vermiculite appear to have formed by reaction between the serpentinite and the minerals or solutions of the pegmatite.

DEPOSITS ASSOCIATED WITH MAFIC IGNEOUS ROCKS

Talc deposits associated with hypersthene gabbro and related mafic igneous rocks occur at a few places in belts of ultramafic rocks. The deposits near Schuyler, Va., are typical. The deposits are characteristically tabular to lenticular and as much as several hundred feet thick and more than a thousand feet long. The material from such deposits is suitable chiefly for soapstone and furnishes most of that quarried in the United States.

The soapstone is generally dark greenish gray but varies appreciably in mineral composition and physical properties. It consists essentially of various proportions of amphibole, chlorite, carbonate, talc, and magnetite. Two principal varieties, hard and soft, may be distinguished. They differ principally in degree of steatitization or in the proportion of relict hornblende and other earlier minerals. The interlocking and felted habit of the minerals imparts a toughness to the soapstone that is very desirable.

Soapstone is associated with relatively fresh gabbroic rocks in some places and probably was derived from hypersthene gabbro (Edward Chao, oral communication, May 1958). Steatitization has pervasively altered much of or all the igneous rock mass in most places; there was no prior or accompanying episode of serpentinization. The alteration was accomplished by dilute hydrothermal solutions whose source, as well as the source of the heat, may have been nearby subjacent magmas or which may have originated in regional metamorphic processes unrelated to igneous activity. (See Hess, 1933a, p. 405–408.)

TALC DEPOSITS IN THE UNITED STATES

Talc is widely distributed in several parts of the United States. (See pl. 1.) The principal occurrences are in the Appalachian region of the east; in the Coast Ranges, Sierra Nevada, Basin and Range, and western Rocky Mountain regions of the west; and in areas of Precambrian rock in southwestern and central Texas. Scattered minor occurrences are known elsewhere in the western and southern United States.

Talc deposits in sedimentary strata are associated with rock units that commonly are of considerable size and may extend over as much as tens or even hundreds of miles. Within such units the talc deposits are localized in one or more districts. The principal deposits associated with carbonate sedimentary rock are in southeastern California, southwestern Montana, western Nevada, northern New York, and southwestern North Carolina. A few minor occurrences in carbonate rock are reported elsewhere in New York, and in Georgia, Idaho, New Jersey, Pennsylvania, and Wyoming. The principal deposits of talc in noncarbonate sedimentary rock are in northern Georgia (parent rock actually doubtful) and southwestern Texas. Minor occurrences in noncarbonate sedimentary rocks are known in New Mexico, and deposits of unknown or doubtful mode of origin are reported in Arkansas and Wyoming.

Ultramafic rocks and associated talc deposits occur chiefly in elongate belts in the Appalachian region of the eastern United States and in the Pacific Coast mountain region of the western United States. The ultramafic rocks in these belts are of Paleozoic and Mesozoic age. There are scattered occurrences of ultramafic rock of probable Precambrian age in western and north-central United States. The degree of steatitization of different ultramafic bodies within a region is highly variable, and some of the ultramafic bodies contain little or no talc.

The Appalachian belt extends from Alabama to Newfoundland. South of the latitude of New York City, the belt of ultramafic rocks is rather narrow and fairly well defined. North of that latitude the main belt of ultramafic rocks trends about north in a well-defined zone approximately through central Vermont, but a few scattered bodies of ultramafic rock are found to the east in a broad poorly defined belt that extends through eastern Connecticut, Rhode Island, eastern Massachusetts, New Hampshire, and Maine.

Soapstone deposits in gabbroic rocks are known only in the southeastern Appalachian region. The deposits near Schuyler, Va., are the only soapstone deposits in such rocks now exploited in the United States. Similar deposits probably occur elsewhere in Virginia and perhaps in adjacent States.

The Pacific Coast region contains areas of ultramafic rock in California, Oregon, and Washington. Those in California and southwestern Oregon form two rather well defined belts; one extends the length of the Sierra Nevada along its west flank, the other extends through the Coast Ranges from southwestern Oregon almost to Los Angeles. The occurrences in central and northeastern Oregon and in Washington form no distinct belt but appear to be distributed sporadically; the irregular pattern is probably due in part to burial under volcanic rocks.

The principal mines that exploit talc in ultramafic rock are in Vermont. A few deposits in California and Washington are worked steadily on a small scale, and sporadic small production is reported from a few other States. Many other bodies of talc are known in the belts of ultramafic rock, and it is probable that an appreciable number of the bodies of ultramafic rock in each region contain talc deposits of potential commercial value.

Texas contains a cluster of ultramafic-rock bodies in the central part of the State; Idaho, Montana, and Wyoming have scattered occurrences.

The geologic and commercial features of deposits in the principal talc districts of the United States are summarized in table 5.

ALABAMA

A few bodies of serpentinite occur in east-central Alabama from Coosa County to Randolph County at the east border of the State. Most known occurrences of talc in Alabama are in this region and are probably associated with serpentinite, although their geologic relations are not adequately known. Block talc of "lava grade" reportedly was produced near Talladega many years ago, and interest in the area is revived intermittently, but no significant sustained production has ever been attained. (See Ladoo, 1923, p. 9; McMurray and Bowles, 1941.)

ARKANSAS

Ladoo (1923, p. 9) reports "* * * large deposits of soapstone near Benton, Saline County, Arkansas." Nothing is known of the geologic relations. Small sporadic production reported from Arkansas at Benton and Bryant is probably partly from these deposits.

CALIFORNIA

California has many talc deposits in association with both sedimentary rocks (chiefly carbonate rock) and ultramafic rocks. (See Page, 1951; Wright, 1950, 1951,[4] 1954, 1957; Wright and others, 1953.) The deposits in sedimentary rock have been by far the more actively exploited. Talc associated with ultramafic rocks is little used, and the distribution, size, and quality of the deposits are inadequately known.

DEPOSITS IN SEDIMENTARY ROCK

The talc deposits in sedimentary rock occur in the southeastern part of the State and form a belt about 30 miles in average width that stretches northwestward from the Silver Lake area near Baker for about 200 miles through the Panamint and southern Inyo Mountains to the vicinity of Big Pine. Plate 2 shows the distribution of the deposits in the belt. Almost 100 deposits of commercial interest are known in the area. These deposits can be grouped in three distinct geographical districts. Within each district the deposits have similar

[4] Wright, J.A., 1951, Geology and origin of talc deposits of eastern California: Pasadena, Calif., California Institute of Technology Ph. D. Thesis.

TABLE 6.—*Geologic and commercial data for mines and prospects in the Silver Lake–Yucca Grove district, California*

Mine or prospect	Form and size of talc deposits	Kinds and grades of talc rock mined	Use	Production	Remarks
Calmasil mine	Lens about 200 ft long and 6 ft wide mined to depth of more than 250 ft downdip.	Blocky tremolite rock and talc schist.	Wall tile and pottery	18,000 tons through 1955.	
Gladding McBean prospect	Lenses of undetermined size	None mined	Suitable for wall tile?	None	An extension of the Yucca Grove deposit.
Halloran Spring (Calmasil Extension, Great Wanamingo) prospect.	Two parallel lenses, each 5–15 ft in average width and about 250 ft long. Enclosed in calc-hornfels.	None produced	do	do	
Silver Lake mine	Several bodies in belt 2 miles long; principal bodies 180–800 ft long, 10–25 ft wide. Most have bottomed at 300 ft or less. Deposit ordinarily consists of two parallel bodies 10–20 ft apart.	Mixture of massive tremolite rock, massive tremolite-forsterite-serpentine rock, and foliated talc-tremolite rock.	Tile, pottery, rubber, insecticides, and commercial talcs.	224,000 tons through 1955.	See Wright (1954).
Yucca Grove (Desert Talc and Clay, Pomona) mine.	Zone 700 ft long; two parallel bodies 8 ft wide apparently bottom at 250–300 ft.	Similar to Silver Lake	Wall tile	80,000 tons estimated through 1955.	
Yucca mine	Lenses of undetermined size	do	Wall tile?		

geological settings; marked differences in setting distinguish each district from the other two.

SILVER LAKE-YUCCA GROVE DISTRICT

The deposits of the Silver Lake–Yucca Grove district form a belt 12 miles long that extends eastward from the vicinity of the Silver Lake playa to the settlement of Yucca Grove in northeastern San Bernardino County. (See pl. 2.) These deposits occur as lenses in a terrane composed mainly of early Precambrian(?) metasedimentary and intrusive rocks and contrast markedly with those in the districts to the north. They appear to have selectively replaced dolomitic strata, and they show a complex metamorphism that involved an early and nearly complete tremolitization concurrent with the emplacement of nearby large bodies of granitic rock. Tremolitization was followed by retrograde alteration to talc, mostly in the form of schistose masses along the margins of the tremolite bodies. Most of the talc schist and tremolitic rock is snowy white and medium to coarse grained. Forsterite grains and serpentine veinlets are abundant in darker phases of the tremolitic rock. Geologic and commercial data and analyses of crude talc rock from the district are given in tables 6 and 7.

TABLE 7.—*Chemical analyses of tremolite-talc rock from mines in the Silver Lake–Yucca Grove district, California*

	1	2
SiO_2	58.06	56.29
Al_2O_3	.98	1.07
Fe_2O_3	.60	.43
CaO	4.28	9.26
MgO	28.65	28.31
K_2O+Na_2O	--------	1.06
Less on ignition	6.93	4.02
Total	99.50	100.44

1. Calmasil mine. Analysis by Southern California Minerals Co.
2. Silver Lake mine. Analysis by Sierra Talc and Clay Co.

Most of the talc mined in the Silver Lake–Yucca Grove area has been obtained from a group of workings, known collectively as the Silver Lake mine (Wright, 1954, p. 19–23), scattered along a zone 2 miles long. Within this zone the minable talc bodies are, on the average, about 10 feet thick and as much as 800 feet long. The deposits (fig. 1*A*) are enclosed in feldspar-diopside-quartz-calcite hornfels but have border zones from a few inches to several feet wide of phlogopite-feldspar-tremolite schist. Deposits similar to those at the Silver Lake mine occur near Yucca Grove, but these have been less extensively worked.

The talc rock mined consists chiefly of tremolite; talc commonly is abundant, forsterite and serpentine each may make up as much as 10 percent, and carbonate ranges from about 0.5 to 6 percent. Iron oxide is kept less than 1 percent in the talc as shipped. Although formerly mined selectively, the talc rock is now mined in bulk.

SOUTHERN DEATH VALLEY-KINGSTON RANGE DISTRICT

About two-thirds of the talc produced in California is obtained from the region that extends from the southern part of Death Valley eastward to the Kingston Range, in Inyo and San Bernardino Counties. (See pl. 2.) The talc deposits are confined to the Crystal Spring Formation, the lowest of the three formations that from the Pahrump Series of Precambrian age. This formation typically is about 4,000 feet thick and consists of mildly metamorphosed sedimentary rocks intruded by diabase sills.

The lower 1,000 feet of the Crystal Spring Formation is composed of interbedded quartzite and argillite. In the middle of the formation is a massive member of carbonate rock several hundred feet thick that consists mostly of dolomite and commonly is cherty. The massive carbonate member is overlain by several hundred feet of interbedded argillite, quartzite and dolomite. The diabase is confined chiefly to sills immediately above and below the massive carbonate member. The lower sill is nearly continuous throughout the district and is associated with all the talc bodies of proved commercial interest.

The talc occurs as replacement bodies in the lower part of the carbonate member. Most of the bodies are in contact with and above the diabase sill, but some form septa within the sill, others lie below the sill, and still others lie above the sill but are separated from it by noncarbonate strata. Figure 1*B* illustrates talc deposits typical of this district.

Silication is apparent nearly everywhere at the contacts between the lower sill and the lower parts of the carbonate rock member, but bodies of commercial talc that can be easily mined are less widespread. In some places the silication is too weak to be of economic value, and in other places the talc bodies are too thoroughly faulted. At numerous localities, however, active mining operations have developed bodies of commercial talc that are virtually unfaulted and that range from 500 to 5,000 feet in length and from 10 to about 100 feet in width. Such deposits occur in the Warm Spring Canyon–Galena Canyon area of the southeastern Panamint Range, in the Saratoga and Ibex Hills, low on the north flank of the Avawatz Mountains, in the Alexander Hills, and in the Kingston Range. Inactive talc mines and prospects occur in the northern Owlshead Mountains, in the Silurian Hills, and in the southern Amargosa Valley. Table 8 summarizes geologic and commercial data for mines and properties in the district.

Although the mineralogic composition of the commercial talc differs from one deposit to another and within individual deposits, all the deposits contain unusually white fine-grained material whose iron-oxide content is consistently less than 1 percent and whose carbonate content (dolomite and calcite) ordinarily lies in the range of 3 to 10 percent. The magnesian silicate minerals consist of talc, tremolite, and subordinate serpentine, mixed in various proportions. Commonly, either talc or tremolite predominates to the virtual exclusion of the others. A thinly laminated talc- or tremolite-rich rock occupies the lower half of many of the deposits above the diabase. Elsewhere, the commercial talc ranges from schistose and friable to blocky and tough.

INYO RANGE-NORTHERN PANAMINT RANGE DISTRICT

Nearly all the talc of steatite grade and much of the nonsteatite talc that has been produced in California has been obtained from a region in central Inyo County that embraces the Inyo Range and the northern part of the Panamint Range (Page, 1951; pl. 2). The talc deposits of this district are replacement bodies chiefly in Paleozoic sedimentary rocks and locally in Mesozoic granitic rocks. These deposits, which generally are smaller and more irregular than those of the southern Death Valley–Kingston Range district, are mainly along fractured and sheared zones in dolomite of the Lower and Middle(?) Ordovician Pogonip Group, the Middle to Upper(?) Ordovician Eureka Quartzite, the Upper Ordovician Ely Springs Dolomite, and dolomite and quartzite of Silurian age.

Talcose zones are most abundant as replacements along major contacts, especially between quartzite and dolomite. The deposits that have replaced granitic rock are adjacent to quartzite and dolomite, and most are closely associated with bodies of punky calcareous rock. This rock appears to have been dolomite originally, and most or all of the magnesium in the talc probably was derived from it. Figure 1*C* illustrates deposits typical of the district.

The mined material ranges from dark gray through pale green to white, is fine grained, and consists predominantly of the mineral talc; the chemical composition of much selectively mined and sorted material approaches that of the pure mineral. The principal impurities are carbonates, mainly as fracture fillings, and iron oxides, which are abundant enough to cause much of the mined talc to be of substeatite grade. Much of the darker-colored talc from this region fires nearly white. Table 9 summarizes geologic and commercial data for deposits in the district.

In this district many deposits contain two or more varieties of talc. The varieties are generally distinguished by color differences but not by significant differences in mineralogy, and they intergrade irregularly. In many deposits the color of the talc seems to be inherited from the parent rock. Talc derived from quartzite is consistently white or very pale gray or green. Most dark-gray talc has replaced dark-gray dolomite. Near some of the talc deposits, silicic dikes have been altered to chlorite. Bodies of nearly pure chlorite are mined, and the product is sold under the trade name "Sierralite."

The commercial talcs of the district are made by blending material from several mines. The final color is a paler tint of the color of the original talc rock, except that the dark-gray talcs burn white. The talc grinds to nearly equant particles termed "granular" by the operators. The particle-size distribution is controlled by the grinding process rather than original textures.

The largest and most continuously active talc-mining operation in this region is the Talc City mine, in low hills at the southern end of the Inyo Mountains; two bodies, each about 500 ft long and as much as 50 ft wide, are enclosed in carbonate strata, mainly dolomitic limestone, of Ordovician age. The second most productive talc mine in the area has been the Bonham (White Mountain) mine, whose deposits are largely or wholly replacements of Silurian dolomite and quartzite (C. W. Merriam, oral communication, 1951). The White Eagle deposit of this district is the only deposit in California to have yielded large tonnages of talc that has altered from granitic rock.

DEPOSITS ASSOCIATED WITH ULTRAMAFIC ROCKS

The ultramafic rocks of California occur in two main belts. One extends along the west flank of the Sierra Nevada from southwestern Tulare County about to Lake Almanor in northern Plumas County; the other extends along the Coast Ranges and Klamath Mountains from Santa Barbara to the Oregon border.

Although many of the ultramafic bodies in both belts are extensively serpentinized and steatitized, the geologic settings of the productive talc deposits have not been studied in detail. Few deposits, however, have been mined to any extent, and most of those are in the western foothills of the Sierra Navada. The product is high in iron and is marketed principally as low-grade talc.

Since 1895, talc production has been recorded from 17 properties in 7 counties in the Sierra foothills region. Before 1895, soapstone had been mined for dimension stone, but specific information is not available on this early phase of the mining activity. Most operations were small, and few continued for periods greater than 10 years. Talc has also been produced from several ultramafic deposits outside the

Sierra foothills. Talc deposits on Santa Catalina Island that were worked in the 1890's are among the first for which there is recorded production.

CONNECTICUT

The talc deposits in Connecticut are associated with ultramafic rocks, whose distribution is inadequately known. Rice and Gregory (1906, p. 100, 112–113) note the occurrence of soapstone in Torrington and New Hartford and of verde antique serpentine at Maltby Lakes near New Haven.

GEORGIA

The known talc deposits in Georgia are probably all derived from sedimentary rocks. The principal deposits are in the Chatsworth district in Murray County. A few occurrences are known near Canton, in northern Georgia, on the southern continuation of the Murphy district of North Carolina. Several bodies of ultramafic rock occur in Georgia, but none is known to contain talc.

CHATSWORTH DISTRICT, MURRAY COUNTY

The talc deposits of the Chatsworth district are in an area of less than 10 square miles, centered about 3 miles east of Chatsworth. The country rock of the talc deposits is a moderately to strongly folded Precambrian sequence consisting of the Cohutta Schist of Furcron and others (1946), the Fort Mountain Gneiss of Furcron and others (1946), and the Corbin Granite of Hayes (1901), unconformably overlain by a conformable sequence of Precambrian(?) (King and others, 1958, p. 965) and Paleozoic slate, sandstone, and dolomite. The talc is associated with lenticular bodies of Cohutta Schist that occur as remnants in the Fort Mountain Gneiss and as isolated thrust slices in the Lower Cambrian Wilhite Slate (Furcron and others, 1947, p. 7, 25). Although deposits are most numerous in the Fort Mountain Gneiss, the largest producers are in the Wilhite. Plate 3 shows the distribution of deposits and the general geology of the district.

The talc deposits form irregularly pinching and swelling tabular bodies a few feet or tens of feet thick, as much as several thousand feet long, and several hundred feet downdip. The major part of each deposit is talc-dolomite-chlorite rock suitable chiefly for ground talc. White-grinding and dark-grinding talc (see definitions, p. 8–9) occur together in large masses separated by irregular gradational boundaries, but it is commonly possible to block out and mine the two grades separately and to predict their downward extensions. Massive crayon talc occurs in distinct lenticular or spindle-shaped masses that lie in echelon and plunge at moderate to low angles in the talc-carbonate-chlorite rock. The lenses range in size from less than 1 foot in thickness and a few tens of feet in length to a few tens of feet in thickness and 100 feet or more in length. The lenses of crayon talc constitute a small proportion of each deposit but are economically very important. The crayon talc is translucent, medium to light green, fine grained, and is composed almost wholly of talc; fine magnetite (and probably other opaque minerals) commonly forms streaks and cloudy patches in the rock. Table 10 contains several chemical analyses; table 11 summarizes characteristics of the principal varieties of talc

TABLE 10.—*Chemical analyses of talcs from the Chatsworth district, Murray County, Ga.*

[From Furcron and others (1947). Analyses by L. H. Turner, Georgia Dept. of Mines]

	M-1	M-2	M-3	M-4	M-5	M-6
SiO_2	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	20. 50	27. 93	28. 60	30. 41	26. 00	26. 00
CaO	3. 69	. 90	4. 76	5. 94	4. 76	4. 14
Na_2O	. 00	. 00	. 00	. 00	. 00	. 00
K_2O	. 00	. 00	. 00	. 00	. 00	. 00
MnO	. 12	. 00	. 00	Trace	Trace	. 00
P_2O_5	. 06	. 00	. 00	Trace	. 02	. 00
TiO_2	. 15	. 00	. 00	. 00	Trace	. 15
S	. 13	. 08	. 21	. 22	. 07	. 09
H_2O-	. 05	. 00	. 00	. 01	. 05	. 05
Ignition loss	11. 37	3. 19	15. 51	27. 28	8. 37	7. 51
Total	99. 18	100. 08	100. 18	100. 16	99. 95	100. 03

M-1. Air-floated talc (−325 mesh) from Southern Talc Co. mill.
M-2. Dust from crayon saws, Georgia Talc Co. mill.
M-3. "A-white" talc powder, 98 percent through 200-mesh screen.
M-4. Roofing granules (−35 mesh), Southern Talc Co. mill.
M-5. Gray talc (80 percent through 200-mesh screen), Cohutta Talc Co. mill.
M-6. Roofing granules (−32 mesh), Cohutta Talc Co. mill.

TABLE 11.—*Varieties of talc rock mined in the Chatsworth district, Georgia, and principal uses of milled talcs*

[Information principally from Furcron and others (1947)]

Kind	Mineral composition	Physical characteristics	Uses
Massive talc (crayon stock).	Talc, 98 percent; impurities are magnetite, pyrite, chlorite, dolomite, and quartz.	Massive, fine grained, dark green, translucent. Schistose in places.	Crayons; scrap and rejects ground for low-grade cosmetic talc.
White-grinding talc.	Talc and dolomite about equal; impurities magnetite, pyrite, and actinolite total about 2 percent.	Massive to schistose, light gray. Medium-grained dolomite in matrix of fine-grained talc.	Probably chiefly paint and rubber.
Dark-grinding talc:			
Soft	Talc and chlorite 65–70 percent; dolomite, 25–30 percent; albite, apatite(?), zircon(?) about 4 percent.	Similar to white-grinding talc, but chlorite more abundant.	Paint, rubber, roofing, insecticides, foundry facings, lubricants, and dusting agents.
Hard	Talc and chlorite, as much as 25 percent; quartz, feldspar, sericite and limonite total about 75 percent.	Schistose, dark gray.	Do.

from the Chatsworth district, and table 12 summarizes information on the size and form of the principal deposits.

TABLE 12.—*Form and size of the principal talc deposits in the Chatsworth district, Georgia, and kinds of talc rock mined*

[Information principally from Furcron and others (1947)]

Mine	Form and size of talc deposit	Types of talc rock mined
Georgia	Moderately dipping lens nearly 1 mile long, as much as 150 ft thick, and probably extending at least 250 ft downdip; mined more than 125 ft deep.	Massive (crayon stock); white-grinding; and dark-grinding, soft and hard.
Southern	Gently to moderately dipping lens more than 400 ft long, as much as 85 ft thick, and mined to depth of more than 150 ft.	Chiefly white-grinding; crayon; some dark-grinding.
Fort Mountain	Two moderately to gently dipping lenses, size unknown; mined on adit level only.	Crayon, dark-grinding, white-grinding.
Cohutta	Moderately to gently dipping lens more than 600 ft long, as much as 50 ft thick, and extending more than 300 ft downdip; mined more than 100 ft deep.	Crayon, white-grinding, hard, dark-grinding.

Furcron and others (1947, p. 41–43) conclude that the deposits were formed by alteration of dolomitic parts of the Cohutta Schist, but they may have been derived from peridotite, as some earlier investigators believed. In either event, the original rock is believed to have been replaced by serpentine or chlorite, which in turn was replaced by talc.

The Georgia, Southern, Cohutta, and Fort Mountain mines have been the principal producing mines in the Chatsworth district. The Georgia mine alone has accounted for nearly half the total past production; in 1949 it produced about 60 percent of the district total of 49,338 tons. Recently, the Earnest and Lindsey mines also have become leading producers.

OTHER DEPOSITS

The talc belt of the Murphy district in North Carolina (see below under "North Carolina," p. 42–44) extends southward into Georgia to near Ellijay in Gilmer County. Twelve occurrences of talc are known (Furcron and others, 1947, p. 29), but none has been mined for many years.

Several bodies of ultramafic rock in Georgia are in a poorly defined belt that extends northeastward through Carroll County from the Alabama border to Towns County on the North Carolina border. No reliable information is available, but none of the deposits is actively mined nor appears to have been exploited much in the past.

IDAHO

A talc deposit potentially of economic interest occurs in west-central Idaho near Riggins, "* * * on the ridge south of the confluence of the Rapid and Little Salmon Rivers" (H. F. Albee, written communication, November 1950). The deposit may be as large as several million tons, but no detailed information is available. Although much of the material is rather dark talc-carbonate-chlorite(?) rock, an appreciable part of it appears to be light-colored talc rock. Serpentinite derived from ultramafic igneous rocks is associated with the deposits, but some of the talc grades into sedimentary carbonate rock.

MAINE

Ultramafic rocks occur in Hancock County in the Deer Isle area east of Penobscot Bay (Smith and others, 1907) and in a poorly known belt in northwestern Maine that extends northeastward from near Parmacheene Lake to near Moosehead Lake in Somerset County (Hurley and Thompson, 1950; Wing and Dawson, 1949; Wing, 1951). Some ultramafic bodies in the Spencer area of Somerset County are extensively serpentinized and steatitized. Some talc zones are more than 100 feet wide, but none has been mined.

MARYLAND

Numerous talc deposits are associated with ultramafic rocks in Maryland. They lie in a belt about 10 miles wide that extends from the Potomac River about 20 miles northwest of Washington, D.C., northeastward to the Pennsylvania State line at the Susquehanna River. The deposits include both the type associated with pegmatites and the type associated with regional metamorphism; a few, of soapstone type, may be associated with gabbroic rocks. Talc has been mined in the area since the early 1800's. At present only two localities are actively mined: one near Dublin and one near Marriottsville.

The Dublin quarries exploit several irregular talc deposits associated with pegmatite dikes that intrude serpentinite. Both ground talc and block talc are produced. The block talc has long been used for "lava grade" material suitable for many electrical uses, but owing to a high iron content it does not qualify for block steatite. A chemical analysis of block talc from Dublin is given in table 13.

The Marriottsville quarries are now exploiting deposits that appear to have been formed by alteration of serpentinite during regional metamorphism. The product is used entirely for lower grades of ground talc. Several nearby abandoned quarries were once worked for soapstone.

Pearre and Heyl (1960) describe the talc deposits of the region and discuss the history of talc mining.

TABLE 13.—*Chemical analysis of talc suitable for gas-burner tips from the Dublin area, Maryland*

[Diller and others, 1920, p. 671]

SiO_2	58.68
Al_2O_3	3.75
Fe_2O_3	Nil
FeO	5.52
MgO	26.80
CaO	Nil
H_2O	5.33
Total	100.08

MASSACHUSETTS

Ultramafic rocks occur in western Massachusetts in three areas (Emerson, 1917, p. 41–42, 85, 214–217, pl. 10): (1) in a narrow belt, continuous with that in Vermont, that extends from near Rowe at the north to near Granville at the south, where it presumably plunges beneath Triassic rocks; (2) in the central part of the State within a roughly circular area about 25 miles in diameter centered approximately at Enfield in southeastern Hampshire County; and (3) in the northeast near Newburyport. The ultramafic bodies in central Massachusetts are predominantly fresh peridotite and saxonite; elsewhere, they are extensively serpentinized and steatitized. Several deposits in the northwestern part of the State, particularly at Dalton in Berkshire County (Herz, 1958) and at Zoar and Rowe in Franklin County, have been mined for talc in the past, but all have been inactive for many years.

MONTANA

The talc deposits of Montana are in the Dillon–Ennis district, within an area of about 800 square miles that embraces parts of the Gravelly and Ruby Ranges between Dillon and the Madison River south of Ennis. Although talc has been known in this region for many years, the extent and commercial value of the deposits were not fully realized until the early 1950's. By 1957, exploration had disclosed large resources of talc of steatite or near-steatite grade, and the deposits in this district now constitute the principal domestic reserves of steatite.

The talc deposits occur in the Cherry Creek Series of early Precambrian age (Perry, 1948, p. 1–11) (pl. 4). The series consists of highly metamorphosed schist, quartzite, gneiss, and dolomitic marble. The talc deposits are derived from the marble, and deposits of commercial interest are clustered in belts in which the marble is especially abundant. The wallrock of most of the talc deposits consists of dolomitic marble and subordinate schist, gneiss, or quartzite. Some bodies are between marble and noncarbonate rock.

Bedding in the carbonate rock strikes generally northeast and is about vertical, though numerous local deviations occur; and in places, tight folds are evident. The talc occurs in lenticular masses that range in size from small stringers to masses several hundred feet in length, several tens of feet in thickness, and several hundred feet in vertical extent. The lenses are about vertical and commonly are parallel to bedding. In many places, however, the contacts are crosscutting in detail; and in some places, particularly at the Yellowstone mine, the lenses follow a joint system that trends northwestward, crossing the bedding at a marked angle.

The commercial talc of the district ranges from nearly white through various shades of gray, green, and brown, but it is mostly pale to medium green. Most of the talc is very fine grained and blocky, but some is flaky and moderately friable. Except for a minor proportion of chlorite (R. S. Lamar, oral communication, 1957), no magnesium silicate minerals other than talc have been observed. Iron oxides occur as stains on talc fragments and in the form of minute grains of very thinly disseminated limonite. Graphite is widespread but ordinarily constitutes a minor impurity. In general, the talc in individual bodies is quite uniform from wall to wall, but some bodies contain subordinate masses of material that is subcommercial because it contains excessive amounts of incompletely altered dolomite, earthy iron oxide, or talc that is excessively iron stained or graphitic.

Massive talc rock said to be suitable for block steatite, known chiefly at the Yellowstone mine, is associated principally with oxidized zones, but some occurrences are below the oxidized zones in fresh dolomite. H. L. James (U.S. Geological Survey, written communication, 1943) notes that siderite and ankerite are leached to a soft but compact mass of iron and manganese oxides to a depth of at least 30 feet; block steatite occurs as lumps that weigh as much as 200 pounds and that are dispersed throughout the weathered mass. In the fresh dolomite, the block steatite appears to be confined chiefly to the smaller lenses and stringers. A distinctive feature of the material considered to be suitable for block steatite is the prevalence of dendrites of manganese oxides. The significance of this feature is not certainly understood, but uniform distribution and moderate concentration of dendrites is considered to be indicative of optimum porosity for block steatite (Donald B. Kempfer, Sierra Talc and Clay Co., oral communication, 1957).

Table 14 lists geologic and commercial data for the Dillon-Ennis district. Some chemical analyses are given in table 15.

TABLE 15—*Chemical analyses of talc ore from the Dillon-Ennis district, Montana*

	Bozo Group mine [1]	Keystone mine [2]	Smith-Dillon mine					Sweetwater mine [1]	Treasure mine [2]	Yellowstone mine	
			Steatite [2]	SD-1 [3]	SD-2 [4]	SD-3 [5]	SD-S [6]			Steatite [7]	Y-1 [8]
SiO_2	58.2	57.72	58.46	62.25	62.06	61.78	62.37	61.0	60.40	62.65	62.73
Al_2O_3	1.50	1.13	1.90	.27	.50	.57	.50	.90	1.91	.31	.10
Fe_2O_3	.51	.48	.84	.71	.67	.75	.63	.10	.27	1.51	1.45
CaO	.20	1.34	.30	<.05	<.05	<.05	<.05	.20	.80	Trace	<.05
MgO	31.0	30.72	31.78	31.13	31.12	31.06	31.32	31.7	30.81	30.23	30.32
K_2O	-------	Trace	Trace	.02	.01	.02	.01	-------	.14	.05	.01
Na_2O	-------	Trace	Trace	.06	.07	.08	.07	-------	.20	.15	.03
H_2O-				.14	.18	.17	.10			.08	.27
H_2O+	5.8	5.94	6.22	5.03	5.09	5.17	4.90	5.6	5.15	4.87	5.14
CO_2				Nil	Nil	Nil	Nil			.27	Nil

[1] Analyst unknown. Data from S. W. Stockdale, American Chemet Corp.
[2] Analysis by Raymond G. Osborne Laboratories, Inc.
[3] Massive white to pale-green opaque to translucent fine-grained to dense talc rock with intermixed splotches and veinlets of gray and darker green talc. Contains scattered tiny flakes of graphite and a few dendrites of manganese oxide. Analysis by Leonard Shapiro, U.S. Geological Survey.
[4] White to pale-green or cream-colored massive talc rock, predominantly fine grained but with variable proportion of disseminated medium-sized folia or plates of talc. Analysis by Leonard Shapiro.
[5] Fine-scale intermixture of types SD-1 and SD-2. Analysis by Leonard Shapiro.
[6] Material representative of whiter and denser parts of sample SD-1. Analysis by Leonard Shapiro.
[7] Analysis by A. J. MacArthur, Sierra Talc and Clay Co.
[8] Dense pale-green talc. Analysis by Leonard Shapiro.

The principal deposits are grouped in the Johnny Gulch area on the east slope of the Gravelly Range and in the Stone Creek and Sweetwater Creek areas on the west slope of the Ruby Mountains. By far the most productive operations have been the Yellowstone mine at Johnny Gulch, the Smith-Dillon mine on Sweetwater Creek, and the Stone Creek mine on Stone Creek. Through 1956, these mines had a total output of about 200,000 tons, obtained mainly since 1949.

Development work in the Dillon-Ennis district has disclosed 10 talc bodies that range from 200 to 500 ft in exposed length and 30 to 70 ft in exposed width, but the actual surface extent of most of them is incompletely known. Smaller bodies, mostly undeveloped, are numerous. Most of the bodies are lenticular and are commonly cigar shaped in plan.

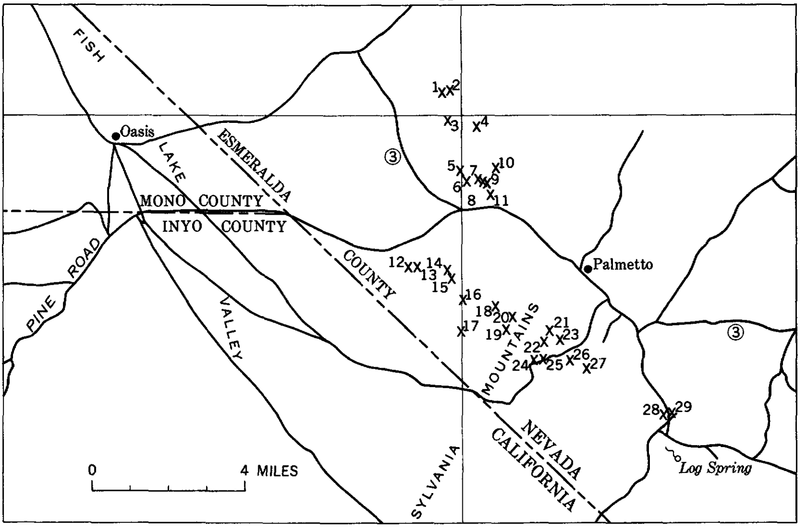
The talc is mined principally by opencut, and reserves of hundreds of thousands of tons remain.

NEVADA [5]

Talc mining in Nevada has been confined almost wholly to an area of about 16 square miles in the Palmetto-Oasis district in Esmeralda County near the west border of the State. Although the geological features of the district are not well known, the deposits and the rocks associated with them are broadly similar to those of the Inyo Range–Northern Panamint Range district of California, and they probably represent the northeastward extension of the Inyo Range talc district.

[5] Most of the data contained in this section were condensed from an unpublished report by Ben M. Page, U.S. Geological Survey, in 1943. Additional and more recent information has been kindly supplied by Donald B. Kempfer, Sierra Talc and Clay Co., and by Wright Huntley, Huntley Industrial Minerals, Inc.

Figure 3 shows the location of the principal talc deposits in the district, and table 16 summarizes geologic and commercial data.



LIST OF MINES AND PROSPECTS

1 Nevada Talc prospect
2 Nevada No. 1 mine
3 Mae Talc prospect
4 High Ridge mine
5 Shaw (Blue Star, Sundown) mine
6 White Eagle No. 1 and No. 2 prospects
7 Erma prospect
8 Laura Bell prospect
9 Campview prospect
10 Crystal White mine
11 Curley's Talc mine
12 Oasis mine
13 Roseamelia mine
14 Reed mine
15 White Eagle mine
16 White Swan prospect
17 Oversight and Crystal Butte No. 1 claims
18 White Cloud No. 1 mine
19 Hideout and Cowhide claims
20 MacBoyle Blue mine
21 White King mine
22 Sunnyside prospect
23 Paramount mine
24 Alta prospect
25 Lone Springs mine
26 Belle prospect
27 White Bird prospect
28 Tamarack mine
29 Log Spring mine

FIGURE 3.—Map of the Palmetto-Oasis district, Nevada, showing location of the principal talc mines and prospects.

Most of the commercial material is talc rock altered from Paleozoic(?) dolomite. The district also contains deposits of chloritic material altered largely from granitic rock but partly from hornfels. The two types of deposits appear to be genetically associated and commonly occur near each other. The miners refer to light-colored talc rock as "white talc" and to both chloritic material and dark-colored talc rock as "blue talc."

The deposits of talc rock in the district are podlike to very irregular. Some are as much as 250 feet in exposed length, but most are much smaller. Most of the mines are along or near a major thrust fault that has brought Mesozoic(?) granite porphyry to rest upon Paleozoic(?) dolomitic marble. The fault trends northwestward and dips gently to very steeply northeastward. Talc deposits are scattered along the fault for a distance of at least 3 miles. Although the general distribution of talc has been determined largely by the fault, much of it lies wholly within the dolomitic marble 50 to 200 feet from the fault. Posttalc movement has disturbed much of the talc that formed close to the fault, so that the contact between dolomite and granitic porphyry commonly is marked by gouge and breccia of mixed talc and chlorite rock 10 to 20 feet thick. For most of its exposed length, however, the fault is barren of talc rock in minable quantities.

The talc rock ranges from virtually pure talc to material with an appreciable amount of impurities, chiefly chlorite, carbonate, and iron oxide. The color ranges from almost white through various shades of green to dark gray. Most of the talc rock is fine grained and blocky, but some shows a crude schistosity. The whiter and purer varieties of talc rock are characteristically derived from white quartzite, the darker and impurer varieties from dark dolomite. Most lighter and purer material qualifies for steatite, and it can commonly be mined selectively. The chloritic "blue talc" is essentially a massive chlorite rock and ranges from medium to dark green in color.

NEW HAMPSHIRE

Talc occurs at several places in New Hampshire (Hitchcock, 1878). Most of the occurrences scattered throughout southern and central New Hampshire are described only as "beds of steatite" and are of doubtful quality and unknown mode of origin. A few of the "beds of steatite" were worked in the past, but all have been inactive for many years—probably since the early 1800's. The only known serpentinite body (Billings, 1956, p. 46, 106) is in the northeasternmost part of the State.

NEW JERSEY

Talc deposits associated with Precambrian marble crop out in the vicinity of Phillipsburg, N.J., and extend to Easton, Pa. The talc appears to replace the marble and forms small lenses and pods of abruptly varying grade. Small production has been reported in the past, but none of the deposits has been active for many years.

NEW MEXICO

Talc is exposed on the north and south slopes of Hembrillo Canyon in the San Andres Mountains of Doña Ana and Socorro Counties, N. Mex. The country rock is moderately metamorphosed argillite and diabase sills of Precambrian age. Talc deposits are enclosed in the argillite and are lenticular masses 200 to 300 feet long and as much as 20 feet wide. Locally, masses of carbonate rock and silica-carbonate rock border the talc. Unmetamorphosed Cambrian quartzite rests unconformably upon one of the lenses of talc and was unaffected by the talc mineralization, indicating that the talc deposits were formed in Precambrian time. The talc appears to have been derived almost entirely from argillite.

The commercial talc varies widely in composition; it ranges from nearly white virtually pure talc rock through all intermediate stages to dark-gray talcose argillite. Much of the material is fine grained, but some is made up of flaky particles of talc. Table 17 contains chemical analyses of talc from the district.

TABLE 17.—*Chemical analyses of talc rock from Red Rock mine, Hembrillo Canyon–San Andres Mountains district, New Mexico*

[Analyses by Sierra Talc and Clay Co.]

	Mine run	*Hand-picked steatite- grade*
SiO_2	61. 18	61. 67
Al_2O_3	1. 72	. 68
Fe_2O_3[1]	. 30	. 34
MgO	30. 60	32. 33
CaO	. 52	. 01
Na_2O+K_2O	. 15	. 07
Loss on ignition	5. 40	4. 83
H_2O-	. 23	. 04
Total	100. 10	99. 97

[1] Total iron calculated as Fe_2O_3.

Two mines—the Hembrillo and the Red Rock—have been operated in the district. The Hembrillo mine is believed to have been in operation in the late 1920's or early 1930's and probably yielded less than 10,000 tons of talc. The mine exploited two lenses about 300 feet long and 25 feet wide to depths of about 50 feet. The talc was white, with much red stain, and was used in cosmetics.

The Red Rock mine comprised two lenses, only the larger of which, 120 feet long by 20 feet wide at the surface, was mined. The mine was closed down after the land was purchased by the Government for the White Sands Proving Ground. Although some of the material from the mine accepted for steatite during World War II probably would not be acceptable today, steatite-grade material probably is present.

NEW YORK

GOUVERNEUR DISTRICT

The talc deposits of the Gouverneur district, St. Lawrence County, N.Y., occur in elongate zones within a northeast-trending belt of impure marble of the Precambrian Grenville series. The marble appears to be part of a highly deformed and metamorphosed succession of strata in the southeast flank of northeast-trending anticlinorium. North- to northwest-plunging cross folds, foliations, shears, and lineations are the chief structural features of the talc zones. Plate 5 shows the general geologic features of the two principal belts of talc deposits in the Gouverneur district.

The zones of commercial talc pinch and swell and curve in sinuous to complexly folded patterns but are rudely conformable with adjoining marble layers. The talc zones have a composite strike length of more than 5 miles, a probable extent down dip of more than 2,000 feet, and widths as great as 400 feet. Dips of the talc lenses are variable and range from horizontal to vertical but average about 45° NW.

Changes in thickness of the talc zones and of individual layers within the zones may be either abrupt or gradual. (See pl. 5.) The zone near Talcville, which contains two producing mines, is 300 feet or more in maximum thickness and averages perhaps 150 feet thick in the mines. Much of this thickness is commercial talc. A talc zone north of Balmat Corners and southeast of Fowler, along which are four active mines, is at least 425 feet in maximum thickness and averages possibly 125 feet thick. This zone consists of several layers of commercial talc as much as 100 feet thick separated by impure or discolored noncommercial layers.

The talc deposits of the Gouverneur district are complexly silicated; they do not contain minable amounts of essentially monominerallic talc rock. Indeed, the mineral talc commonly is subordinate in amount to tremolite in the milled-talc products. Approximate modes of various types of commercial talc of the district are shown in table 18. A wide variation in proportion of tremolite, anthophyl-

TABLE 18.—*Approximate mode and oil absorption of varieties of commercial talc in New York*

[Leaders (----) mean not determined]

	1	2	3	4	5	6	7	8	9	10
Tremolite	68	98	17	----	78	38	29	15	88	46
Anthopyllite	----	----	20	----	----	----	45	78	4	39
Talc, fibrous	----	1	63	----	----	----	----	5	----	----
foliated	----	----	----	----	} 4	----	----	1	----	5
shredded aggregate	----	----	----	----		----	----	1	1	} 4
Serpentine, massive	----	1	----	80	18	54	21	----	4	
fibrous	----	----	----	----	----	----	5	----	----	----
Quartz	31	Trace	----	----	----	----	----	----	2	4
Carbonates	1	----	----	2	Trace	4	----	----	----	1
Hexagonite, iron and manganese oxides, mica, and other impurities.	Trace	----	----	Trace	----	----	----	----	----	1
Diopside	----	----	----	18	----	4	----	----	1	----
Oil absorption of size grade, 97.5 percent through 325-mesh screen.	29	33	58	56	45	50	55	52	35	48

1. Pale-pink tremolite schist, hanging-wall side of Talc belt, Talcville, N.Y. A siliceous A-1 type talc.
2. Lustrous white stubby-bladed tremolite rock interlayered with specimen No. 1 type. An A-1 type talc.
3. Pale-gray to white fibrous talc, Talcville, N.Y. An A-4 type talc.
4. Watery-green serpentinized diopside rock along footwall talc belt, Talcville, N.Y. Uncommon in occurrence, with properties of A-3 type of talc.
5. Serpentinous tremolite, "10A ore," Talcville, N.Y. Typical A-2 type talc, relatively common in Talcville region.
6. Streaked buff to chalky-tan serpentinous tremolite, "regular ore," Talcville, N.Y. Talc somewhat transitional between A-2 and A-3 types.
7. Watery-gray fibrous to bladed tremolitic talc, Ontario mine, Fowler, N.Y. An A-4 type talc, but slightly higher in tremolite than the average.
7. "Arnold fiber," Arnold mine, Fowler, N.Y. Another common talc, somewhat transitional between A-2 and A-4 types.
9. Splotchy medium-grained serpentinous tremolite "Arnold heavy stock," Arnold mine, Fowler, N.Y. Typical A-1 talc, and the dominant commercial talc in the Arnold mine.
10. Pale buff highly schistose talc, hanging-wall zone, Woodcock mine, Balmat, N.Y. Transitional between A-2 and A-3 types.

lite, serpentine, and talc is apparent. Other minerals occurring in and along the talc belts include quartz, calcite, dolomite, hexagonite (a manganese-bearing tremolite), iron and manganese oxides, diopside, chlorite, pyrite, mica, feldspars, sphene, magnesian and manganiferous tourmaline, and apatite. Most of these last-named minerals constitute obvious adulterants or impurities and are avoided in mining.

Chemical analyses of some of the principal commercial types of talc are given in table 19. Iron and manganese oxides, SO_3, and CO_2,

TABLE 19.—*Chemical analyses of commercial talcs mined in New York*

[Leaders (----) mean not determined]

	1	2	3	4	5	6	7	8
SiO_2	59.80	66.23	67.00	56.50	59.40	57.26	65.74	74.00
Al_2O_3	.57	1.05		1.00	.74	1.14	.78	1.71
Fe_2O_3	.05	.13	1.40	.10	.02	.24	.10	----
FeO	.15	.22		----	.12	.05	.31	----
MnO	.39	.16	.80	----	.20	.51	.32	----
CaO	6.80	2.26	2.30	6.20	4.94	6.50	1.96	6.61
MgO	27.45	25.71	24.80	30.40	30.09	29.08	27.16	33.50
TiO_2	----	----	----	----	----	.04	----	----
SO_3	.07	.01	.07	----	.01	.14	.02	----
Ignition loss	4.75	3.86	3.10	4.80	4.09	3.98	3.71	7.74
Water (105°C)	.45	.25	.30	.77	.47	.34	.29	1.96
CO_2	1.18	.56	1.30	.20	.31	.29	.71	2.61
Total	101.66	100.44	101.07	99.97	100.39	99.57	101.10	101.13

1. Average sample of mined talc zone, Talcville, Gouverneur district, New York; an A-1 type talc. Analysis by Glen Edgington, U.S. Dept. of Agriculture.
2. Average sample of footwall talc zone, Fowler, Gouverneur district, New York; an A-3 type talc. Analysis by Glen Edgington, U.S. Dept. of Agriculture.
3. Hanging-wall talc zone, Woodcock mine, Balmat, N.Y.; an A-3 type talc with about 8 percent free SiO_2. Analysis by Orton Smalley, courtesy of Loomis Talc Corp.
4. Footwall zone, American mine, Balmat, N.Y.; an A-2 type talc. Courtesy of St. Joseph Lead Co.
5. Middle zone, Woodcock mine, Balmat, N.Y.; an A-2 type talc. Analysis by Charles O'Brien, courtesy of Loomis Talc Corp.
6. Average sample across commercial talc zone, Balmat, N.Y.; consists of more than 80 percent A-1, 15 percent A-2, and less than 5 percent A-3 and A-4 type talcs. Analysis by F. A. Gonyer, Harvard Univ.; courtesy of R. T. Vanderbilt Co.
7. "Fiber Vein," Talcville, N.Y.; an A-4 type talc.
8. "Micro Velva Talc," Natural Bridge, New York. Courtesy of Carbola Chemical Co.

when present in excess of the amounts shown, constitute serious impurities for some markets. In general, the companies in the Gouverneur district attempt to keep the CaO content between 3 and 7 percent and the MgO content between 25 and 30 percent. The relatively high CaO content is largely a reflection of the calcium present in tremolite and anthophyllite.

Much of the tremolite probably formed by reactions between, and replacement of, favorable beds of quartzite and dolomite. This initial stratigraphic control of talc distribution was partly obscured, and to some extent superseded, by dominant secondary structures, especially shear zones that developed during metamorphism. Although the talc-forming constituents were derived largely from the quartzite and dolomite beds, water, silica, and other minor elements were introduced into the present talc belts, and calcite was removed by the talc-forming fluids.

Table 20 summarizes the chief characteristics and reserves of the principal types of commercial talc produced in New York.

TABLE 20.—*Mineral composition, reserves, and physical properties of talc, by commercial grades, in the Gouverneur district, New York*

Grade and type	Mineral composition	Reserves, in thousands of tons, to depth of 1,800 ft			
		Measured	Indicated	Inferred	Total
A-1 Heavy stock	Nonfibrous, relatively pure tremolite.	350	650	750	1,750
A-2 Intermediate type	Slightly fibrous; contains as much as 20 percent serpentine, talc, and anthophyllite combined.	1,125	2,000	2,500	5,625
A-3 Light talc	Slightly fibrous, moderately tremolitic.	225	615	785	1,625
A-4 do	Highly fibrous; largely talc, serpentine, and anthophyllite, in various proportions.	8	12	15	35
Total reserves, A grades.		1,708	3,277	4,050	9,035
B-1	(Similar to corresponding A grades but off color and containing as much as 15 percent impurities.)	2,000	3,500	5,000	10,500
B-2		3,500	5,200	8,000	16,700
B-3		2,200	2,875	4,000	9,075
B-4		75	100	1,260	2,335
Total reserves, B grades.		7,775	11,675	18,260	38,610
Grand total, all grades (in round figures).		9,500	15,000	22,000	47,600

Physical properties of processed talcs:

Particle shape.—Shapes range from moderately inequant (some of A-1, A-2, and A-3) through bladelike (much A-1 and A-2) and mixtures of equant, bladelike, and fibrous (A-2 and A-3 especially) to highly foliate (some A-3) and fibrous (A-4 and A-5).

Color.—Talcs are very white. Most exceed 88 on the scale of absolute whiteness, and some are as high as 96.

Oil absorption.—For talcs having 98 percent of particles $<$325 mesh, and not more than 20 percent $<$400 mesh, oil absorption is about as follows: A-1, 30-35; A-2, 40-45; A-3 and A-4, 50-55. Finer grinding tends to increase oil absorption.

Density.—The more tremolitic grades are heavier for a given volume than the more fibrous and foliate types.

NATURAL BRIDGE

Talc occurs at Natural Bridge, N.Y., and is mined by the Carbola Chemical Co. The commercial talc actually consists of the minerals talc and serpentine, with various amounts of admixed diopside, chlorite, and carbonates. The talc and serpentine occur as a network of irregular veinlets enveloping and cutting a complex breccia of marble. The brecciated marble has the form of a very irregular vertical pipe as much as 1,200 feet across locally and averaging about 600 feet in diameter. Local nodes and bumplike protrusions extend into the enveloping country rock, which is a complex of granitic and syenitic gneiss, migmatite, and metagabbro.

Stopes and sublevels in the mine follow the talc-serpentine veinlets. The mine has considerable mineralogical interest because of the presence of subsidiary veinlets of prehnite and celestite.

NORTH CAROLINA

Talc in sedimentary rocks and associated with ultramafic rocks occurs extensively in North Carolina. Only deposits in sedimentary rock in the Murphy district are currently of commercial interest.

MURPHY DISTRICT

The Murphy talc district is a narrow belt about 85 miles long that extends northeastward from near Canton in northern Georgia through Cherokee and Swain Counties in southwestern North Carolina to near Wasser. The talc deposits occur in the Murphy Marble, which is in the overturned northwest limb of a large anticline. (See Van Horn, 1948, p. 18–20.) In the southwestern half of the district the Murphy Marble crops out in a regular belt of rather uniform width, but in the northeastern half appreciable folding is revealed by numerous loops in the outcrop pattern and a large variation in outcrop width. The rocks of the belt are considered to be of Precambrian(?) and early Paleozoic(?) age. (See King and others, 1958, p. 964.) The distribution of the Murphy Marble and the location of the principal talc deposits are shown in plate 6.

The commercially important talc deposits in the Murphy district appear to be confined to a zone of white fine-grained dolomitic marble, locally somewhat quartzose, at about the center of the Murphy Marble. In the vicinity of the Nancy Jordan No. 1 mine (No. 5, pl. 6), this central talc-bearing zone (the "white or talc zone," Van Horn, 1948, p. 12) appears to be more than 100 feet thick, and the entire Murphy Marble appears to be about 350 feet thick. In the vicinity of other talc deposits, Van Horn (1948, p. 8–13) reports thicknesses of as much as 400 feet for the Murphy Marble and probable thicknesses of 25 feet or more for the central talc zone. There are few data on the thickness of the talc-bearing zone elsewhere, largely because much of the marble is obscured by alluvial cover.

The talc deposits of commercial size in the Murphy district are roughly lens or spindle shaped. The long axes of the lenses lie in the plane of bedding and range in dip from horizontal to 35° NE or SW; the plunges of the long axes appear to conform with those of nearby folds in the country rock and with lineations in both the talc and the country rock. The lenses range in size from small pods to bodies almost 700 feet in length and 140 feet in width. In several of the better known deposits, lenses or septa of marble within the talc partition it into smaller lenses and zones. Boundaries between the varieties of talc are irregular and gradational, but they conform roughly to the gross pattern of the deposit.

Most of the talc is flaky to slightly fibrous, but much is massive and fine grained. The talc varies from white through greenish white to green, blue, and gray. Virtually pure talc rock forms an appreciable part of most deposits, and a relatively small but significant proportion is crayon grade. Carbonate, quartz, and pyrite are the principal impurities. Talc from the Murphy district is suitable for many uses, particularly those requiring exceptional purity and whiteness. Several samples of talc rock that the U.S. Geological Survey tested in 1951 proved to be of steatite quality, and one sample was possibly of block steatite grade; however, little or none has been used as steatite. Chemical analyses of varieties of talc from the Murphy district are listed in table 21.

The talc was formed by replacement of carbonate, quartz, and minor amounts of other minerals such as mica and tremolite. Talc derived from tremolite constitutes only a very minor part of most of the deposits. The deposits appear to have been formed by relatively simple metasomatic processes. (See Van Horn, 1948, p. 27–29.)

Information on the principal talc deposits in the Murphy district is summarized as follows (numbers in parentheses refer to mines shown on pl. 6).

Biltmore mine (11).—Although the Biltmore mine yielded several hundred tons of high-grade talc, it has been inactive a long time, and the size and shape of the talc body are unknown.

Carolina (Bailey, Kinsey, Notley) mine (2).—The Carolina deposit is similar in form and size to the Nancy Jordan No. 1 and was mined to a depth of 155 ft. From 1930 to 1937 about 11,750 tons of off-white to light-gray talc, including 562 tons of crayons, was sold for nonsteatite uses; total production is not known. Although reserves are appreciable, the deposit is worked only intermittently because the

TABLE 21.—*Chemical analyses of commercial talcs from the Murphy district, North Carolina*

[Leaders (----) mean not reported]

	1	2	3	4
SiO_2	61.60	63.07	61.35	58.54
Al_2O_3	[1] 2.10	1.56	4.42	[1] 3.60
Fe_2O_3		----	----	
FeO	----	.67	1.68	----
MgO	31.24	28.76	26.03	31.04
CaO	.24	.30	.82	.22
H_2O+	----	4.36	5.10	5.15
Loss on ignition	4.88	----	----	----
Total	100.06	98.72	99.40	98.55

[1] Al_2O_3+total iron calculated as Fe_2O_3.

1. Maltby, N.C. (From Van Horn, 1948, p. 27, table 1, sample 1.)
2. Kinsey, N.C. (From Spence, 1940, p. 118, analysis 44.)
3. Hewitt, N.C. (From Spence, 1940, p. 118, analysis 45.)
4. Murphy, N.C. (From Van Horn, 1948, p. 27, table 1, sample 6.)

workings are flooded by the waters behind Hiwassee dam most of the year.

Cold Springs mine (6).—The Cold Springs mine was mined to a depth of about 65 feet and produced about 1,000 tons before it was abandoned.

Hayes mine (9).—An abandoned opencut 60 feet long by 40 feet wide and 30 feet deep yielded about 1,000 tons of talc, and the deposit is now mined out.

Kinsey mine (1).—The Kinsey mine is believed to have produced several thousand tons from two flat lenses of unknown size.

Maltby mine (10).—The Maltby mine, now abandoned, probably yielded more than 1,000 tons.

Mineral and Metals (Mulberry Gap) mine (3).—Several thousand tons of crayon and nonsteatite-grade ground talc was obtained through 1949 from a warped lens about 300 feet long and 10 feet wide that was mined to a depth of 60 feet. Some of the material probably is of steatite grade.

Moore mine (7).—The Moore mine yielded a small amount of talc of unknown quality and is now abandoned.

Nancy Jordan No. 1 mine (5).—Probably more than 20,000 tons of high-grade ground talc and crayons has been obtained from a lens 700 feet long, 50 feet wide, and worked to a depth of 250 feet.

Nancy Jordan Nos. 2 and 3 mines (4).—The Nancy Jordan Nos. 2 and 3 mines yielded material similar in quality to the Nancy Jordan No. 1; although sold for nonsteatite uses, some material probably was of steatite grade. Production is believed to have totaled several thousand tons from ore bodies of unknown form and size.

Nantahala mine (12).—The Nantahala mine comprised several lenses apparently of considerable size and probably yielded many thousands of tons; the readily accessible talc has been mined out. Much of the product is believed to have been of steatite grade, and massive material was used for gas-burner tips.

Regal mine (8).—The Regal mine workings include an 80-foot shaft and about 25 other pits, shafts, and adits that appear to be in float material, some of which may have moved several hundred feet. Much of the talc is badly stained; total production is not known.

Other prospects.—More than 25 other unnumbered small prospects and occurrences are shown on the map of the belt of Murphy Marble (pl. 6).

DEPOSITS IN ULTRAMAFIC ROCKS

Ultramafic rocks are abundant in North Carolina (Pratt and Lewis, 1905) in a belt as much as 30 miles wide that extends northeastward immediately west of the Blue Ridge Mountains from Georgia to Virginia. Many of the bodies are little altered and contain large amounts of dunite, peridotite, pyroxenite, and amphibolite, but throughout the belt a high proportion of the ultramafic bodies are extensively serpentinized and steatitized. No talc deposits in ultramafic rocks appear to have been worked for many years.

OREGON

The extent of ultramafic rocks in Oregon is not adequately known. They occur in southwestern Oregon, near Grants Pass (Wells, 1955), where they are continuous with the large Coast Ranges belt of California, and in northeastern Oregon in the John Day area. The intervening area is covered by Tertiary volcanic rocks. Some of the ultramafic rocks in both areas are known to have associated talc, but none of the deposits is known to be of commercial quality.

PENNSYLVANIA

Ultramafic rocks in southeastern Pennsylvania extend from the south State boundary near the Susquehanna River to beyond the Schuylkill River near Springfield, where the belt of ultramafic rocks appears to plunge beneath Mesozoic rocks. Talc was produced near Philadelphia before 1800, and many deposits were exploited in the early 19th century; but production was small, and none has been recorded for many years. (See Pearre and Heyl, 1960.)

Deposits near Easton, Pa., are in sedimentary rock, and are similar to those near Phillipsburg, N.J. (see p. 37). Total past production from these deposits is probably about 200,000 tons.

"Talc" production from Pennsylvania currently listed in the Minerals Yearbook is actually of sericite schist.

RHODE ISLAND

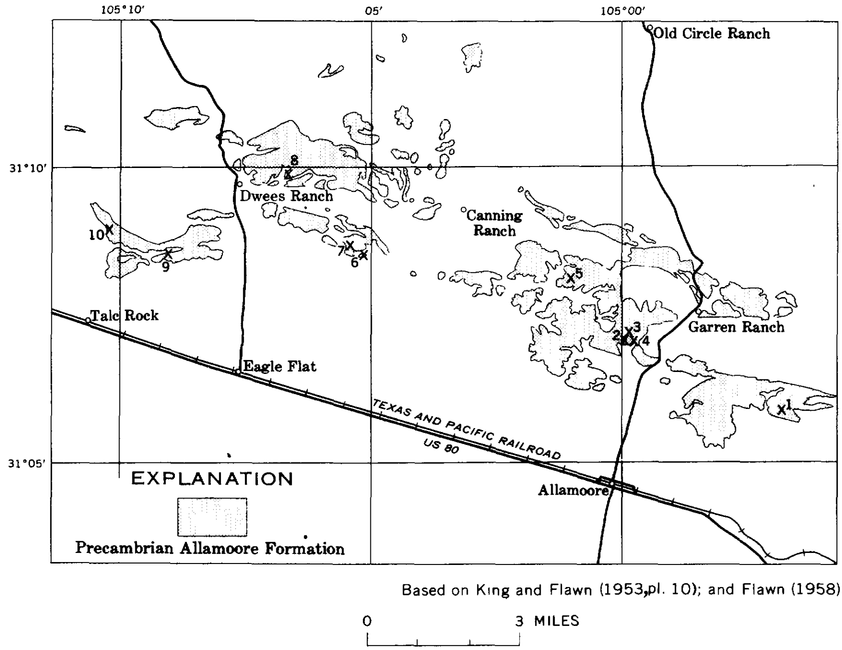
Several small bodies of talc, some of them associated with small pods of serpentinite, occur in a belt of greenstone northwest of Pawtucket (Quinn and others, 1949). A small body of peridotite crops out near Woonsocket in northeastern Rhode Island, but no associated talc is known.

TEXAS

Talc deposits in Texas are associated both with ultramafic igneous rocks and with metamorphosed sedimentary and volcanic rocks. There are two principal districts: the Allamoore district in western Texas, and the Llano district in central Texas.

ALLAMOORE DISTRICT

The talc deposits of the Allamoore district (King and Flawn, 1953, p. 170–172; Flawn, 1958) are about 100 miles southeast of El Paso in an area about 20 miles long from east to west and about 5 miles wide. The deposits are in the Precambrian Allamoore Formation, which consists of interbedded highly deformed and variably metamorphosed limestone, volcanic rocks, and thin beds of phyllite. The talc is associated chiefly with the phyllite, with which it intergrades. The talc deposits are tabular masses as much as several thousand feet long; they pinch and swell from a few feet to as much as 200 feet in thickness. They trend about east and are nearly vertical. Only locally are igneous rocks such as diabase associated. In some places the talc deposits are in fault contact with the adjacent country rock. Figure 4, a generalized geologic map of the area, shows the location of the principal talc deposits.



LIST OF MINES AND PROSPECTS

1 Buck Spring prospect
2 Lone Star Mining Co. mine
3 Texas Talc Co. mine
4 Southern Clay Products Co. mine
5 Section 18 mine
6 Milwhite Co. mine
7 Escondido prospect
8 Glen Rey Corp. mine
9 Southwestern No. 4 mine
10 Rossman mine

FIGURE 4.—Map of the Allamoore district, Hudspeth County, Tex., showing outcrop areas of the Allamoore Formation and location of the principal talc mines and prospects. Based on King and Flawn (1953, pl. 10) and Flawn (1958).

The upper parts of the talc bodies at and near the surface are of light-gray soft talc rock, commonly veined by caliche and containing fractures and cracks penetrated by earth and vegetable matter. At greater depths the talc rock is darker and harder, and beds and lenses of chert and carbonate rock are the principal contaminants.

Genetic features of the talc deposits are imperfectly known. Available information suggests that the deposits were formed by alteration of interbeds of dolomitic marl or magnesium-rich volcanic tuff in the Allamoore Formation.

Occurrences of talc potentially of commercial interest are known at 10 scattered localities; 6 operators were active in the area in 1957. The talc is mined in open pits. Selective mining and handsorting are generally necessary. Production in the district dates from 1952; through 1957, about 120,000 tons had been produced, and approximately 85 percent of that was from the west end of the district. About 90 percent of the product is sold as ceramic talc for the manufacture of walltile; 10 percent is sold for insecticides. The talc is said to be of superior ceramic grade, with excellent pressing qualities, early strength, and good firing characteristics.

LLANO DISTRICT

The talc deposits of the Llano district (Dietrich and Lonsdale, 1953, p. 70–71; table 8) are chiefly in Llano, Gillespie, and Blanco Counties within a radius of about 15 miles of the common corner of the three counties. A few small deposits are scattered as far as northwestern Mason County.

Many of the talc deposits are pods and lenses along the margins of serpentinite masses, which range in size from a few hundred feet in length to as much as 4 miles in length and 1 mile in width. A genetic relationship to serpentinite is clearly indicated for such deposits, but details of the mode of origin are not known. Numerous deposits are isolated from bodies of serpentinite. Some of these may be genetically related more or less directly to bodies of serpentine; others appear to be unrelated and have altered entirely from schist, gneiss, or carbonate rock, or from mafic volcanic rocks interbedded with the schist. Most of the pods and lenses are relatively small. In several areas, as at the Big Branch, Cedar Mountain, and Coal Creek mines, closely spaced groups of lenses and pods aggregate several hundred thousand tons.

The minable rock consists chiefly of talc, talc and tremolite, talc and anthophyllite, and anthophyllite; in many deposits it also contains various proportions of quartz, magnetite, chlorite, and a few other minerals. The talc rock is suitable chiefly for low-grade ground talc, but small quantities of material suitable for sawing or carving occur in a few deposits.

Deposits in the Llano district have been exploited only since the early 1950's. A few deposits are currently mined on a small scale.

VERMONT

The main belt of ultramafic rocks in Vermont follows approximately the central meridian of the State from Massachusetts to Canada. Several of the bodies of ultramafic rock in the northern part of the State and a few near Dover and Ludlow in the southern part of the State contain large proportions of fairly fresh dunite and relatively little talc. The rest are extensively serpentinized and have appreciable amounts of talc associated with them. (See Chidester and others, 1951; Chidester, 1962.) Most of the talc deposits form concentric shells of talc-carbonate rock and talc rock around central cores of serpentinite; the cores of serpentinite vary greatly in size and are absent in a few deposits. Some deposits are irregular or tabular bodies within dunite, peridotite, and serpentinite; they are composed of talc-carbonate rock that locally grades into carbonate (magnesite) rock. Plate 7 shows the distribution of ultramafic rocks and talc localities in Vermont.

The talc-carbonate rock and talc rock range from medium or light gray to dark gray and from massive or faintly schistose to gneissic. In most deposits the component particles of talc in both talc rock and talc-carbonate rock are fine and shredded; in a few deposits near Chester, where the setting is one of somewhat higher grade regional metamorphism, the particles are flaky or micaceous in habit, and the rock fabric is coarsely schistose or gneissic. Talc rock is minor in all the deposits, and only in a few is it suitable for crayons. All the talc is high in iron, and most of the commercial product contains appreciable carbonate. Flotation beneficiation practiced at Johnson yields a product that contains 95 percent talc and is of increased whiteness. Table 22 contains chemical analyses of a variety of talcs from several localities in Vermont.

Talc has been mined at many localities in the past, but only four mines have been active within recent years. The Johnson mine, in the town of Johnson, and the Waterbury mine, in Moretown, have long been the largest producers in the State. The Waterbury mine is the sole producer of talc crayons in Vermont and has long occupied a leading position in that field. The Hammondsville and Windham quarries near Chester are relatively small producers. The Johnson and Waterbury mines employ underground mining methods, and the Windham quarry has converted to underground methods; the Hammondsville deposit is mined by open-pit methods. Table 23 summarizes geologic and commercial data for the principal mines and prospects in Vermont.

TABLE 22.—*Chemical analyses of varieties of talc in Vermont*

[Leaders (----) mean not determined]

	W-23	36 [1]	37 [1]	38 [1]	J-103	39 [1]	VT	40a [1]	40b [1]	40c [1]	CA-9
SiO_2	60.48	56.33	42.73	59.15	62.24	54.14	42.52	59.30	45 95	58.96	35.98
Al_2O_3	.82	3.19	1.17	.26	------	1.66	2.32	1.81	1.70	3.43	.43
Fe_2O_3	.10	[2] 5.39	[2] 5.93	[2] 3.36	.10	1.33	[2] 6.88	.64	[2] 4.70	3.78	.65
FeO	4.59				4.22	3.59		4.42			5.96
MgO	28.52	27.89	33.16	31.34	28.57	30.16	33.42	29.42	32.39	28.54	32.95
CaO	.02	.41	.10	.15	.00	.46	.80	.20	1.59	1.43	.00
Na_2O	.00	------	------	------	------	------	2.12	------	------	------	.00
K_2O	.03	------	------	------	------	------	Trace	------	------	------	.00
TiO_2	.01	------	------	------	------	------	.00	------	------	------	.02
CO_2	.00	.36	4.74	1.76	.04	2.90	[3]	.18	------	------	20.45
P_2O_5	.02	------	------	------	------	------	------	------	------	------	.01
Cr_2O_3	.26	------	------	------	------	------	------	------	------	------	.18
NiO	.20	------	------	------	.18	------	------	------	------	------	.21
MnO	.09	------	------	------	------	------	------	------	------	------	.41
CoO	.01	------	------	------	------	------	------	------	------	------	.01
As_2O_3	.00	------	------	------	------	------	------	------	------	------	.00
S	.01	------	------	------	.00	------	------	------	------	------	.06
H_2O-	.00	------	------	------	.00	------	[3] 19.84	------	------	------	.00
H_2O+	4.94	5.68	12.95	4.30	4.47	5.25		4.67	12.19	2.15	2.73
Less O for S	.00	------	------	------	.00	------	------	------	------	------	.05
Total	100.10	99.25	99.78	100.32	99.82	99.49	107.90	100.64	98.52	98.29	100.00

[1] From Spence (1940).
[2] Presumably total iron calculated as Fe_2O_3.
[3] Reported as loss on ignition.

W-23. Crayon talc from Waterbury mine, Moretown, Vt. R. N. Eccher, U.S. Geol. Survey, analyst.
36. Gray talc from Waterbury mine, Moretown, Vt. Eastern Magnesia Talc Co. analysis.
37. Gray talc, standard mine-run product, Johnson mine, Johnson, Vt. Eastern Magnesia Talc Co. analysis.
38. Flotation talc, Johnson mine, Johnson, Vt. Eastern Magnesia Talc Co. analysis.
J-103. Pale-green massive fine-grained talc; occurs as irregular, branching masses in 'grit' and talc rock, Johnson mine, Johnson, Vt. W. J. Blake, U.S. Geol. Survey, analyst.
39. Crude, mill-run talc, Vermont Talc Co., Chester, Vt. Company's analysis.
VT. Fine-ground mill-product talc, Vermont Talc Co., Chester, Vt.; from Windham quarry. Company analysis.
40a. Crude, mill-run talc, Vermont Mineral Products Co., Chester, Vt.; from Hammondsville quarry. Company analysis.
40b. Fine mill-product, Vermont Mineral Products Company, Chester, Vt.; from Hammondsville quarry. Company analysis.
40c. Flake mill-product, roofing grade, same source as 40b.
CA-9. Computed analysis of average talc-carbonate rock for deposits similar to the Johnson and Waterbury mines, Johnson and Moretown, Vt. (See Chidester, 1962, p. 203.)

VIRGINIA

A belt of ultramafic rocks in Virginia extends northeastward from about the center of Grayson County on the North Carolina border through Fairfax County to the Potomac River a few miles west of Washington, D.C. Talc has been produced at scattered localities in Fairfax County in the past, but for long the only active operations have been the soapstone quarries in Nelson and Albemarle Counties, centered near Schuyler.

The soapstone deposits at Schuyler are tabular bodies that dip southeastward at 45°. The deposits are as much as 180 ft. thick. The length of deposits is undetermined, but some have been exposed in quarrying operations for distances of as much as 1,500 ft. The soapstone consists of varying proportions of talc, chlorite, carbonate, magnetite, and amphibole. Two principal types of material are quarried, and they are designated as "soft" and "hard." They seem to differ mainly in degree of steatitization or in the proportion of relict hornblende and other earlier minerals. Table 24 gives chemical analyses of soapstone from the Schuyler district.

TABLE 24.—*Chemical analyses of soapstone in the Schuyler district, Virginia*

[Leaders (----) mean not reported]

	1	2		1	2
SiO_2	39.54	41.75	H_2O+	5.04	10.22
Al_2O_3	3.72	4.80	CO_2	9.50	
Fe_2O_3	3.62	[1] 14.04	TiO_2	.27	----
FeO	7.12		P_2O_5	.29	----
MgO	24.84	25.56	MnO	.16	----
CaO	5.93	4.19			
Na_2O	.08	----	Total	100.13	100.56
K_2O	.00	----			
H_2O-	.02	----			

[1] Total iron calculated as Fe_2O_3.

1. Soapstone from Schuyler, Va. Analysis by R. B. Ellestead. (From Hess, 1933a, p. 398, table 6, sample Va 15.)
2. Soapstone (Alberene Stone), Alberene Stone Corp., Schuyler, Va. Company analysis. (From Spence, 1940, p. 118, sample 46.)

The soapstone is sawed and shaped for sinks, insulators, electrical base plates, and similar uses. Scrap and waste "soft" soapstone are ground and used in roofing, rubber, and insecticides.

WASHINGTON

Ultramafic rocks are scattered throughout the northern half of Washington from Puget Sound to Idaho. Many are extensively serpentinized and steatitized, but only a few deposits have been mined, and those on a small scale (Valentine, 1949). In general, specific information about the geologic character of individual deposits is lacking. However, most or all the known talc occurs in areas of ultramafic rocks and is presumed to be of ultramafic derivation. The Skagit mine on the Skagit River in the northern part of the State has been the most active mine in recent times. Table 25 contains a chemical analysis of "soapstone" from Washington.

WYOMING

Talc occurrences are known at several places in Wyoming (Osterwald and others, 1959), but none appears to be of commercial quality. Most deposits seem to be associated with amphibolite or hornblende schist and granite, and a few with ultramafic igneous rocks. All are in areas of rock designated as Precambrian and are presumed to be of Precambrian age.

TABLE 25.—*Chemical analysis of soapstone, Washington*

[Skagit Talc Co.; from Spence (1940, p. 118, analysis 47)]

SiO_2	44.10
Al_2O_3	.50
Fe_2O_3 [1]	6.96
MgO	30.60
CaO	2.00
CO_2+H_2O	15.10
Total	99.26

[1] Total iron calculated as Fe_2O_3.

RESERVES

Reserves of talc for the United States, by State and district, genetic association, reserve classification, and type and grade of material, are given in table 26. The classification of reserves adopted by the U.S. Geological Survey and the U.S. Bureau of Mines (Lasky, 1945, 1950, p. 12–16), with the modifications recommended by Blondel and Lasky (1956, p. 695), is followed. For many districts it is not possible to give reserve figures that are precise within the usual specified limits, both because the operators of many mines do not attempt to estimate reserves on such a basis and because the data for many localities are not available. The difficulty in estimating reserves for some types of talc is further increased by variations in specifications among consumers and by lack of detailed information on individual deposits. The estimates are based on published reports, unpublished data in the files of the Geological Survey and State surveys, firsthand knowledge, past records of individual mines and districts, and experience gained in detailed studies of several of the major talc districts in the United States.

Because of the great differences in kind and amount of information available, reserve data for the different districts vary widely in accuracy. For districts that have been studied in detail, the accuracy is about that specified in the usual classification of the Geological Survey and the Bureau of Mines. For other districts conservative estimates have been attempted. Consequently, we believe that for nearly all those other districts the reserves—particularly of the "demonstrated" class—are probably considerably larger than estimated.

Reserves of the principal grades and types of talc are considered individually in the following sections and discussed in relation to the methods of calculating reserves, specific problems of different districts, and the reliability of the estimates. Genetic associations, geologic relationships, and general properties that are significant in the evaluation of talc resources are summarized for each grade and type of talc.

TABLE 26.—*Reserves of talc in the United States, by State and district, genetic association, and grade or type of material, in 1958*

[Totals, except for crayon talc, are rounded to the nearest thousand or to three significant figures. Parent rock: C, carbonate rock, chiefly dolomite; G, granitic rock; M, mafic igneous rocks, chiefly gabbro; Q, quartzite; S, miscellaneous sedimentary rocks, including principally argillite, phyllite, and shist; U, ultramafic rocks, chiefly serpentinite; V, volcanic rocks; ( ), indicates relatively minor types. Reserve classification: D, demonstrated—measured+indicated; I, inferred. * Includes talc not now accepted as steatite but which probably could be used in the manufacture of electrical insulators in an emergency]

State and district	Parent rock	Reserve classification	Reserves (short tons)							Discovery possibilities
			Talc rock [1]					Other [5]	Total	
			Block steatite	Steatite [2]	Crayon talc	Block talc [3]	Other [4]			
California:										
Silver Lake–Yucca Grove	C	D	0	0	0	0	0	50,000	50,000	Fair.
		I	0	0	0	0	0	150,000	150,000	
Southern Death Valley–Kingston Range	C	D	0	0	0	0	900,000	100,000	1,000,000	Excellent.
		I	0	0	0	0	>2,700,000	300,000	>3,000,000	
Inyo Range–Northern Panamint Range	C, Q, (G)	D	0	*40,000	0	0	20,000	0	60,000	Fair.
		I	500	*60,000	0	0	55,000	0	116,000	
Other	U	D	0	0	0	0	0	0	0	Excellent.
		I	0	0	Possibly large	0	0	Probably large	Probably large	
Georgia:										
Chatsworth	S?, V?, U?	D	0	0	1,650	0	0	900,000	902,000	Good.
		I	0	0	5,300	0	0	2,250,000	2,255,000	
Murphy marble	C	D	0	0	0	0	0	0	0	Fair.
		I	0	Probably small	Probably small	0	Probably small	Probably small	Probably small	
Maryland	U	D	0	0	0	No data	0	No data	No data	Fair to good.
		I	0	0	0	Moderate	0	Possibly large	Possibly large	
Montana, Dillon-Ennis	C	D	0	>600,000	0	0	0	0	600,000	Excellent.
		I	>500	>900,000	Possibly small	0	>100,000	0	>1,000,000	
Nevada, Palmetto-Oasis	C, (S), (G)	D	0	*10,000	0	0	----------	>300,000	>300,000	Good.
		I	0	*20,000	0	0	----------	>1,000,000	>1,000,000	
New York	C, (G)	D	0	0	0	0	0	24,500,000	24,500,000	
		I	0	0	0	0	0	22,000,000	22,000,000	
North Carolina:										
Murphy	C	D	0	120,000	10,000	0	120,000	0	250,000	Good.
		I	0	500,000	10,000	0	500,000	0	1,010,000	
Other	U	D	0	0	0	0	0	0	0	Very good.
		I	0	0	Possibly large	0	0	Probably large	Probably large	

Texas:										
Allamoore	S	D	0	0	0	0	Large	Large	Large	Very good.
		I	0	0	0	0	Very large	Very large	Very large	
Llano	U, V, S	D	0	0	0	0	0	1, 650, 000	1, 650, 000	Good.
		I	0	0	Probably small	0	0	Probably large	Probably large	
Vermont	U, (S)	D	0	0	600	0	0	4, 000, 000	4, 000, 000	Excellent.
		I	0	0	900	0	0	>25, 000, 000	>25, 000, 000	
Virginia:										
Schuyler	M	D	0	0	0	0	0	No data	No data	Very good.
		I	0	0	0	0	0	Probably large	Probably large	
Other	U, (M)	D	0	0	0	0	0	0	0	Very good.
		I	0	0	Possibly large	0	0	Possibly large	Possibly large	
Washington	U	D	0	0	No data	0	0	No data	No data	Very good.
		I	0	0	Possibly large	0	0	Probably large	Probably large	
Other [6]	U, (S?)	D	0	0	0	0	0	0	0	Very good.
		I	0	0	Possibly large	0	0	Probably large	Probably large	
Total		D	0	>770, 000	12, 250	No data	>1, 040, 000	>31, 500, 000	>33, 300, 000	
		I	>1, 000	>1, 480, 000	>16, 200	Moderate	>3, 355, 000	>50, 700, 000	>55, 500, 000	

[1] Commercial ore consisting essentially of the mineral talc.
[2] Material suitable for marketing as ground steatite.
[3] Impure (principally high-iron) material not suitable for block steatite.
[4] Chiefly varieties of relatively pure talc rock used principally for ground talc but not suitable for steatite.
[5] Varieties of commercial talc containing appreciable quantities of minerals other than talc, such as carbonate, tremolite, anthophyllite, chlorite, and serpentine. The following rock types are predominant: tremolite rock, talc-carbonate rock, and anthophyllite rock.
[6] Principally Idaho, Maine, and Pennsylvania. Small to moderate resources of talc are also known in Alabama, Arkansas, Connecticut, Massachusetts, New Hampshire, New Jersey, Oregon, Rhode Island, and Wyoming.

BLOCK STEATITE

Known occurrence of material potentially of block-steatite grade are exclusively in talc deposits associated with sedimentary rocks. Most or all such material is derived from relatively pure dolomite or quartzite. The talc rock is fine grained, massive, very pure, and is composed of subequant particles of talc. In the Dillon-Ennis district of Montana much of the possible block steatite is associated with deeply oxidized zones, but some occurs also in small veins and lenses in fresh dolomite; the material has a rather chalky appearance and generally is moderately veined with uniformly distributed dendrites of manganese oxide. In other districts the possible block steatite is distributed irregularly, and no useful associations have been noted.

None of the potential block steatite is considered to be economic at present, and there is considerable doubt as to the acceptability of the material for the most exacting uses and as to the rate of production that could be achieved under optimum conditions. Most block talc produced in the past was used in low-frequency insulation, but this was before development of high-frequency insulation led to the exacting requirements now demanded of block steatite; consequently, the suitability of the talc for block steatite according to present standards has never been determined.

The Yellowstone (Johnny Gulch) mine in the Dillon-Ennis district of Montana is the only domestic source of talc rock known to have been accepted for block steatite. On the basis of observed geologic relations and the production of 30 tons of block steatite in 1942–43, it is inferred that probably considerably more than 500 tons of block steatite could be recovered under optimum conditions.

Several occurrences of talc in California offer promise as possible sources of block steatite. Block talc for gas-burner tips and for insulator cores in electric stoves was produced at the Talc City mine in the Inyo Range–Northern Panamint Range district in 1915–25. The talc rock is soft, pale gray green, can be recovered in lumps several inches in diameter, and seems to meet the requirements for block steatite. Similar material might be obtained from several other properties, including the White Mountain, Alberta, Gray Eagle, and Eureka mines. If commercial tests should prove the material to be acceptable for block steatite, it seems reasonable on geologic grounds to infer that as much as 500 tons or more of block steatite could be recovered in the Inyo Range–Northern Panamint Range district.

The Murphy district in North Carolina might yield some block steatite. One of several samples of talc from deposits near Murphy submitted to the American Lava Corp., the U.S. Bureau of Mines, and Kirchberger and Co., Inc., for testing was described by R. T.

Church of Kirchberger and Co. (written communication, March 20, 1951) as having some possibilities as block steatite. Lumps of the talc were cured for 6 months in a cool, damp place—a practice employed by early producers in the area to obtain block talc for gas-burner tips. Officials of the Hitchcock Corp. expressed the belief that the curing may relieve internal stresses that cause cracking and distortion of the material in firing, and so make it usable as block steatite.

STEATITE

Steatite, like block steatite, is associated almost exclusively with sedimentary rocks, chiefly with fairly pure carbonate rock and quartzite. The estimated reserves of steatite include, in addition to material known to be acceptable, material that meets or closely approaches the general specifications. Total reserves shown in table 26 are adequate for many years at present rates of consumption; very probably, however, much of the material included in this reserve figure will be diverted into other uses than steatite.

The Dillion-Ennis district in Montana contains the largest reserves and resources of steatite in the United States. The Yellowstone, Smith-Dillon, and Stone Creek mines are the largest current producers and contain the largest developed reserves. Discovery possibilities at each of these localities are good to excellent, and most of the other occurrences shown on plate 4 are potentially of steatite grade. Furthermore, the district is inadequately explored, and the possibilities for discovery of additional deposits are good. Potential resources of the district, therefore, are probably several times the present reserves.

Many talc deposits in the Inyo Range–Northern Panamint Range district of California are proved or potential sources of steatite; prior to development of the deposits of the Dillon-Ennis district in the early 1950's, the California deposits contained the principal reserves of steatite in the United States. About four-fifths of the estimated reserves are at four mines—the Talc City, Alberta, Gray Eagle, and Eureka (Nikolaus). The Gray Eagle mine (including the Hilderman) contains the largest reserves in California known to be acceptable as steatite. The talc from the Eureka mine is probably satisfactory for steatite, but it is more difficult to mold and extrude than that from many other deposits, and it is now used largely for cosmetics, pharmaceuticals, and similar uses. The balance of the reserves of steatite is in numerous small deposits, including the Ubehebe, Alliance, Frisco, Trinity, East End, Irish, Victory, Viking, Smith, and White Swan; the Gold Belt and Pencil Talc claims in the Gold Belt Spring area of the northern Panamint Range are potential sources of steatite.

The potential resources of the district may be twice as large as the estimated reserves.

In the Palmetto-Oasis district in Nevada, the Oasis, Reed, Shaw, (Blue Star, Sundown), and Roseamelia mines contain material that meets the compositional specifications for steatite, but only a small fraction of the output of more than 100,000 tons has been used in the manufacture of electrical insulators; most has been used in paints, cosmetics, pharmaceutical preparations, and paper. However, in 1942–43, material from the Palmetto-Oasis district was used for steatite by order of the War Production Board. The general lack of acceptance of talc from the Palmetto-Oasis district for steatite is attributed by mine operators to the fact that insulator manufacturers had generally adjusted their techniques to the use of steatite from the Inyo Mountains and, since 1951, from Montana. The material is doubtless suitable for steatite.

Reserves of steatite in the Murphy district of North Carolina and Georgia should all be classed as "near steatite," because none of the material is currently used for commercial steatite. The classification as steatite is based upon tests conducted by the U.S. Geological Survey and the U.S. Bureau of Mines. The reserve figure is based upon the estimate that about half the total reserves of talc would qualify for steatite. The possibility for discovery of additional resources of talc and steatite in the district is good. It is questionable, however, whether much of the reserves classed as steatite will be used for that purpose.

BLOCK TALC

Block talc that can be fired satisfactorily but that is not of the high purity required for block steatite occurs both in talc deposits associated with ultramafic rocks and in those associated with sedimentary rocks. The principal—and only sustained—production in the United States has been from the Dublin deposits in Maryland, and those deposits constitute the only known resources. Additional resources of block talc may exist in similar deposits in the Maryland area and possibly elsewhere in association with ultramafic rocks in the Appalachian and Pacific Coast regions. It is possible, also, that the Inyo Range–northern Panamint Range district of California, the Dillon–Ennis district of Montana, and the Murphy district of North Carolina may contain small resources of block talc.

CRAYON TALC

Rock composed almost entirely of talc occurs in all genetic types of talc deposit, and in each genetic type a relatively small proportion of such talc rock has the requisite physical properties for crayon talc. Current production and known resources are divided rather evenly among Vermont, the Murphy district of North Carolina, and the Chatsworth district of Georgia. No direct quantitative information is available on reserves of crayon talc in those districts. The tonnages in table 26 were computed from reserve estimates of all types of talc on the basis of past production records. Thus the reserve tonnages indicate the tons of finished crayons that may be expected to be recovered from the total reserves of deposits currently producing talc crayons. Though relatively small on a tonnage basis, the reserves are adequate for many years at current rates of production.

Potential resources of crayon talc in the United States are probably many times as large as the estimated reserves. Unexploited deposits in Vermont, North Carolina, and Georgia may contain considerable additional resources. Probably many talc deposits in southeastern California and in the Dillon–Ennis district of Montana contain material suitable for crayon talc that could be recovered if there were sufficient incentive. Talc crayons have been produced sporadically in Washington and California, probably from deposits of ultramafic origin, and it is likely that many deposits associated with ultramafic rocks, both in the Appalachian and Pacific Coast regions, may contain potential resources of crayon talc.

OTHER GRADES AND TYPES OF TALC

Included under "Other grades and types of talc" are many varieties of talc suitable for a wide range of ground-talc products. Soapstone is properly a dimension stone, but the waste material is used for ground talc and constitutes a significant resource. The categories of talc included herein range from relatively pure talc rock that, because of physical characteristics or minor impurities, is not of steatite grade, through tremolitic talc, to varieties of talc-carbonate rock and talcs with abundant impurities such as quartz, carbonate, serpentine, feldspar, and oxide stains. The whiter and purer grades of talc rock are associated predominantly with sedimentary rocks—chiefly dolomite and quartzite—but a talc product of good whiteness and purity (95 percent or more talc), though with an appreciable content of iron, can be produced by flotation from deposits of ultramafic origin. Fibrous, tremolitic, and anthophyllitic varieties of industrial talc are associated chiefly with deposits in sedimentary carbonate rocks. Impure talc suitable for a variety of ground-talc products forms an appreciable proportion of all these deposits and forms the bulk of most talc deposits of ultramafic origin and of other genetic associations.

Fairly pure nonsteatitic talc rock occurs extensively in southeastern California, the Dillon–Ennis district of Montana, the Murphy district of North Carolina, and the Allamoore district of Texas. Reserves are adequate for many years under any foreseeable conditions. Tremolitic and fibrous talcs occur extensively in New York and California;

reserves are adequate for at least 100 years at present rates of production. Talc of coarsely flaky or micaceous habit occurs in deposits of ultramafic origin in areas of middle-grade metamorphism near Chester, Vt., and forms minor layers and lenses in some deposits in carbonate rock in the Dillon–Ennis area in Montana; known resources of such material are small to moderate.

Other, rather impure, varieties of talc are associated with most of the talc deposits in the United States. Reserves are very large and are adequate for hundreds of years under any foreseeable conditions. Most of the reserves are in areas that have been studied in considerable detail (New York, California, and Vermont), and the reserve estimates for these districts are believed to be conservative. For other districts, an equally conservative estimate has been attempted. Estimates for undeveloped localities are probably far less than the actual reserves. Potential discoverable resources in the Appalachian and Pacific Coast belts of ultramafic rocks alone may be several times as large as the total reserve estimate.

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