

MINERAL RESOURCE CIRCULARS
No. 15

ADDITIONAL NOTES ON GRAPHITE IN TEXAS
by V. E. Barnes

This circular is supplementary to Mineral Resource Circular No. 1, Graphite in Texas, 1930. During 1936 in connection with a Works Progress Administration Mineral Resource Survey of Burnet County, sponsored by the Bureau of Economic Geology, some additional information was obtained about the graphite deposits of Burnet County. It was hoped that the mapping of this area could be completed so that the information released would be more complete. However, the project terminated before mapping had been completed. Since there is a likelihood of graphite imports being curtailed resulting in a need of domestic production to replace imports, a statement will be made of the results obtained.

Graphite is very common in the Packsaddle schist of Llano and Burnet counties. This schist series was originally a sedimentary series composed mostly of argillaceous, calcareous, arenaceous, and carbonaceous sediment mixtures. This series before metamorphism took place probably was very similar to the Pennsylvanian rocks of north-central Texas. The carbonaceous material changed into graphite during the metamorphism to which these pre-Cambrian rocks were subjected. The graphite content of these rocks varies in amount, as did the carbonaceous material in the original sediments. Many of the graphite schists of this area contain insufficient graphite to be commercial while others contain abundant graphite.

Sidney Paige, in U.S. Geological Survey Bulletin 45, pages 77-82, describes a graphite property 800 feet north of the Houston and Texas Central Railroad due south of Lone Grove in Llano County. An average sample taken from a 70-foot open cut on this property yielded 11.45 per cent carbon (graphite). He also cites average analyses of material from underground workings from a report made in 1902 by William Young Westervelt. These analyses ranged from 10.36 to 19.30 per cent carbon (graphite).

Paige also states: "About two miles south of Llano graphite schists trending in a northwest-southeast direction toward Sharp Mountain may be observed. This vicinity is, perhaps, with the exception of the property just described, the most favorable locality to prospect, though graphite schists do occur at many other localities throughout the region." A mill to produce graphite from this graphitic schist has recently been constructed about one mile south of Llano. A sample from this graphite schist chosen because of a white mineral which it contained was analyzed by Mr. A. W. Paessler for carbon (graphite). He found 13 per cent to be present. This is not an average sample of this schist and considering the amount of white mineral present may be below average. The graphite in this schist is in very small flakes.

"The Southwestern Consolidated Graphite Company established a mill on Clear Creek nine miles west of Burnet in 1916 or 1917 to concentrate graphite schist. This mill burned in 1927 and was replaced by a modern plant equipped with oil-froth flotation machinery and an electrostatic separator."¹ In 1936 the plant was idle, but most of the machinery remained. Since that time some of the machinery has been removed. This property is now owned by Miller and Clemson, Los Angeles, California.

A mill was temporarily operated in 1928 by the Burnet-Texas Company at a distance of 2¼ miles to the northeast. "The Texas Graphite Company, Llano, Texas, was reorganized in 1936, began operations in 1937 and shipped a small amount of crystalline graphite for foundry facings in that year."² This graphite was probably obtained from the Debo property in Burnet County.

A detailed review of mining conditions, concentration processes, and other relative material about the Texas graphite production is contained in an article entitled Preparation of Crucible Graphite, by G. D. Dub, U.S. Bureau of Mines War Mineral Investigation, Series 3, December, 1918. Extracts from this article are contained in Minerals Yearbook 1919.

Burnet County

During the Burnet County mineral resource investigation especial attention was given to tracing out the graphite schist bands of the area. In places where they were concealed by surficial materials test pitting was resorted to in order to trace the continuity of these bands. The results of this investigation are shown on the accompanying map, figure 1.

The original mapping was done by pace-compass methods. Three-lens aerial photographs made by the United States Army became available after the pace-compass mapping was finished. The base for the present map is taken from the aerial photographs, and the pace-compass data are adjusted to it. Some formation boundaries are visible on the aerial photographs which were not traced in the field. These boundaries are shown in dashed lines and may in places be slightly out of position.

Dr. H. B. Stenzel in 1926 investigated the Midway sill shown on the northern part of this map and in addition made several traverses across the gneiss-schist area to the south. He obtained a wealth of structural data along these traverses which are in part incorporated in this map.

The graphite schist is entirely within an area of Packsaddle schist as defined and mapped by Paige.³ The Packsaddle schist of this area is predominantly hornblende schist or amphibolite. Some of the schist is rich in mica, some contains tourmaline, and a small amount of garnet-rich schist has been reported but not seen. A few thin marble bands are present in the northern part of the area. The Packsaddle schist is the oldest rock exposed in the area.

¹Univ. Texas Bull. 3401, pp. 260-261, 1934 (1935).

²Minerals Yearbook 1939, Review of 1938, p. 1400, U.S. Bur. Mines, 1939.

³Paige, Sidney, Description of the Llano and Burnet quadrangle, U.S. Geol. Survey, Geol. Atlas, Llano-Burnet folio (No. 183), 103 pp., 1912.

The Packsaddle schist was intruded by a series of granites now gneissoid and termed the Valley Spring gneiss. This gneiss may be of two periods. The more gneissic portion of the Valley Spring in the southern part of the area appears to be separated from the Packsaddle schist in the vicinity of the Miller and Clemson property by a much less gneissic, less micaceous, and more massive pink gneiss. This gneiss is well exposed in large rounded domes which are rougher in contour than most granite domes. This gneiss is of value as a building stone. The gneissic area containing stone suitable for building has been indicated on the map.

Much later this gneiss-schist series was extensively intruded by granite. The chief intrusion in this area is the Midway sill which intruded the series along the northern gneiss-schist boundary. Many other smaller sills and dikes of granite and pegmatite are present in the Packsaddle schist.

A small area of dark gray granite is shown in the south-central portion of the map. A quarry known as the "Shannon quarry" produced stone from this intrusive many years ago. This granite is younger than the schist-gneiss series, but its age relative to the other granites of the area is unknown.

Following a long period of erosion the Cambrian sandstones and limestones were deposited over this area. The Cambrian outcrop areas are shown at both the western and eastern edge of the map. In the eastern area the Cambrian overlaps the older rocks, and in the western area the Cambrian is downfaulted against them.

Debo property. — This graphite schist is the most eastern occurrence within the map area. During 1936 additional exploration was being conducted, and experiments upon concentrating the graphite were being made. The property is now idle. Previous to this exploration a cut 125 feet long and about 20 feet deep at the uphill end had been made across the graphite schist. Two hundred feet to the northeast a smaller cut had been made across part of the graphite schist. The 1936 exploration consisted mostly of test pits and one 25-foot shaft entirely within graphite schist.

This graphite schist is exposed at the edge of the Cambrian Hickory sandstone and only that now covered by sandstone has been prospected. The area underlain by graphite schist is roughly 100 by 300 feet in size.

The graphite is in a gneissic-appearing feldspathic schist. The feldspar is highly kaolinized, and individuals may be up to a quarter of an inch across. Mica is abundant, quartz is plentiful, and graphite may equal 8 per cent of the mass. The graphite schist in the shaft and in the north side of the cut is regularly banded. On the south side of the cut it is highly contorted.

Weathering has penetrated the graphite schist deeply. The shaft in 1936 was 25 feet deep, and the feldspars for the entire distance are entirely altered to kaolin. It is quite possible that this weathering is related to the old pre-Cambrian erosion surface.

The graphite is distributed rather uniformly within the graphite schist, even though individual bands may be much richer than those adjacent. The graphite tends to be concentrated as laminae along the schistosity, and as much as a quarter of an inch of graphite may be so situated. The graphite is crystalline in flakes and is almost entirely caught on a 200-mesh screen. The upper limit of the flake size is about one-eighth of an inch. A screen test shows approximately the following range in size:

	Per cent
Through 40 mesh on 60 mesh	25
Through 60 mesh on 100 mesh	50
Minus 100 mesh	25

To the southwest, a few hundred feet, low-grade, fine-grained, well-bedded graphite schist without a gneissic structure is exposed along a drain. This graphite schist is folded but not contorted. The folds are normal with flank dips ranging from 10 to 45 degrees.

The rocks above and below the graphite schist are amphibolites mostly with poorly defined bedding. The predominating feldspar mineral is hornblende. Feldspar is common, but very little mica is present. A tourmaline-bearing amphibolite outcrops about 200 feet south of the open cut. This rock is studded with very small bright black tourmaline crystals. The tourmaline crystals contained in the soil from this rock glitter in the sunlight. Some of this soil was panned and a few small colors of gold were found. The rest of the heavy mineral content is tourmaline and magnetite.

Pegmatites are scarce in the vicinity of the graphite schist. Euhedral garnets up to one inch in diameter were found about one-quarter of a mile to the southwest in a pegmatite. The garnets were mostly in quartz and a few were in feldspar. The feldspar is also euhedral with quartz filling the remaining space. Many granitic dikes are located immediately to the south of this outcrop.

Directly above the pre-Cambrian is a Cambrian basal conglomerate composed essentially of quartz pebbles. This conglomerate contains an occasional water-clear flawless quartz pebble. These have been used to cut sets. The conglomerate grades upward into Hickory sandstone somewhat limonite stained and containing limonitic concretions. Large cross-beddings in the Hickory sandstone strike north-south and dip to the east. Not enough observations were taken to determine if this was the prevailing direction of sand movement.

Watson property. — This graphite is on the next ranch to the west of the Debo ranch and is in the vicinity of the Watson house. The maximum thickness of graphite schist seen is 20 feet. The surface exposure is about 200 feet long, and test pitting made known another 350 feet of graphite schist to the east. This graphite schist band may continue eastward beneath a cultivated field. To the west it is cut off by a granitic intrusive.

Garrett property. — The graphite schist on this property is west of the Watson graphite schist and is south of the road. The Burnet-Texas company produced a small amount of graphite from this property in 1928. This graphite schist band is traceable for 1¼ miles across the Garrett ranch. The average thickness throughout this distance is about 6 feet. However, the graphite schist is much thicker in the vicinity of the open cuts, where it has apparently been squeezed into masses during the folding of the Packsaddle schist. The graphite schist in both open cuts is highly contorted and is about 40 feet thick.

The relationship of granitic intrusives to the Packsaddle schist is well shown on this property. Many of the intrusives are sill-like masses not strictly parallel to the bedding, as shown by one mass which roughly parallels the graphite schist band, cutting across it three times. The graphite schist is not offset along the sill but is spread apart so that the ends of the broken graphite schist band are directly opposite each other across the sill. The graphite schist in contact with these intrusives has become indurated with the development of large graphite flakes. The graphite schist is usually better exposed because of this along granitic contacts. These sills are unusually free of inclusions suggesting that they were rather viscous at the time of intrusion.

A schist containing garnets has been reported from this property and is supposedly located south of the old graphite workings near the Valley Spring gneiss contact.

Dorbant property. — The northernmost Dorbant graphite schist is a westward continuation of the Garrett graphite schist. This schist band extends across the Dorbant property for 1¼ miles where it abuts Cambrian rocks downdropped by faulting. This band of graphite schist is rather thin throughout and is also of low grade.

One-half mile to the south is another zone of graphite schist also abutting Cambrian rocks at the west. This zone extends east-southeast for a distance of about one mile. Several prospect holes have been dug at the eastern end of this belt in some of the more favorable-appearing areas. Much of this graphite zone is cut by numerous pegmatites.

The third band of graphite schist on the Dorbant ranch trends southward from near the eastern end of the band just mentioned. This band of graphite schist has been rather thoroughly prospected and has many prospect holes along it. It becomes thicker toward the south where it continues on property originally a part of the Dorbant ranch but now owned by Miller and Clemson, Los Angeles, California.

Miller and Clemson property (formerly Southwestern Consolidated Graphite Company). — A map of this property made in 1923, contained in the Bureau files, is reproduced as figure 2. The writer visited but did not critically examine this property. The map appears to outline the graphite-bearing area correctly, and a penciled note states: "This plan is based on a stadia survey. Property line from tie to northeast corner only. No other corners were found. Date July 10, 1923. Scale 1 inch = 80 feet. Assumed elevations." A fire destroyed the buildings shown on this map in March, 1927. The new mill was built in a different location, the pit to the northeast has been enlarged, and a large pit southwest of the granite dike has been opened.

Baker⁴ makes the following statement about this property: "The schist strata at this locality dip at a high angle approaching vertical, and mining was carried on from the surface exposure downward. The uppermost few feet of the schist at the surface are decomposed and discolored by oxidation. However, the surface as well as the deeper ore was milled, no overburden being removed. Working was by the open pit method from the surface downward. The pits are nearly dry, comparatively little water other than rainfall coming in. The more abundant minerals of the schist are quartz, flake graphite, a limited amount of mica, and, in the unoxidized schist, pyrite, and perhaps other sulphides. The ore varies in richness but will probably average 5 or 6 per cent graphite."

Analyses of this graphite were not made during the investigation of this area, but from unofficial sources the probable average mentioned by Baker is substantiated.

Guthrie property. — This graphite schist band is not within the map area. It is 4 miles west of Burnet along Spring Creek and is a short distance south of the Burnet-Llano highway. It is in an area of Packsaddle schist about 2 miles long bounded by Valley Spring gneiss on the north and overlapped by Paleozoic rocks to the south. The schist has a rather uniform dip of about 30 degrees to the south and conforms to the structure of the Valley Spring gneiss.

The graphite schist band is not well exposed except in gullies. It was traced for less than half a mile. In one place it is 14 feet thick. The grade of this graphite was not determined. Spring Creek has a sufficient flow of water to meet the requirements of a small mill. Other graphite deposits of the county are situated away from water which necessitates the installation of pipe lines to carry water to the mills.

Structure

The mapping of this area, as mentioned before, was not completed, and much more structural data are needed in order to arrive at a correct structural interpretation. The northern graphite schist band dips southward possibly with an average dip of 30 degrees. The middle graphite schist band in general dips northward at a steep angle. This suggests a synclinal condition for this area but far from proves it. This area is complicated by stringers of Valley spring gneiss, and also little is known about the smaller structural features of the pre-Cambrian of the Llano-Burnet area. It seems likely, however, that these three bands of graphite schist represent the same bed. The southernmost band of graphite schist dips steeply to the west and may be a limb of an overturned fold.

Graphite schist tends to be mobile during deformation and is apt to be thinned in compressional areas of folds and concentrated in tensional areas. The graphite schist on the Miller and Clemson holdings and adjacent thereto is thicker than in most of the area. This thickening may in part have been caused by folding. It is also possible that part of this thickness may be attributed to a greater thickness of the original carbonaceous sediments.

Graphite Statistics

In Table I and on the accompanying chart some statistics have been compiled on the graphite situation as affecting the United States. There are insufficient data on United States production and the manufacture of artificial graphite to allow trends to be detected after 1928. However, some significant facts can be seen. The production of crystalline graphite in the United States up to 1928 tended to decrease, whereas the production of amorphous and artificial graphite increased. The 1935 Minerals Yearbook contains the following statement: "On the basis of three-year averages the apparent consumption of crystalline graphite dropped from 18,995 short tons yearly in 1912 to 1914 to 12,642 tons in 1927 to 1929, whereas the use of amorphous and manufactured graphite rose meanwhile from 14,760 to 24,000 tons annually." Since 1931 production of graphite in the United States has been practically nil. Texas produced graphite from 1916 to 1928 and was the leading producer in the United States during 1922, ranked second in 1921, and third in 1920. The Texas production has been crystalline graphite.

Artificial graphite is in direct competition with natural graphite, and figures for artificial graphite are not available since 1927. It is very well possible that the use of artificial graphite has increased during this time and will continue to increase.

The Minerals Yearbook 1939, Review of 1938, shows that activity in national graphite production is increasing in various parts of the United States. The question immediately arises as to the desirability of Texas again entering graphite production and whether it is justified in doing so. At present world conditions are such that predictions cannot be made as to the amount of imports that will be arriving in the future. If these imports are stopped, then Texas would have ample reason to enter the field in competition with other

⁴Baker, C. L., Univ. Texas Bull. 3401, p. 261, 1934 (1935).

areas of the United States already producing graphite. The Texas production has been crystalline graphite mostly from Burnet County. The use of crystalline graphite has been decreasing and it may continue the same trend. The deposit of graphite south of Llano, however, is very finely crystalline and may be usable for many of the same purposes as amorphous graphite. In any event the situation should be thoroughly investigated before an attempt to produce graphite is made. Furthermore a small number of well managed plants can produce sufficient graphite to satisfy the graphite requirements of the United States. A mushroom growth of producers, such as happened in 1918 at which time forty-two plants were in operation, will be fatal to the graphite industry if repeated.

Buchanan Dam of the Lower Colorado River Authority is located only 3 miles from the Miller and Clemson mill. Cheap power is now available near to all of the important graphite deposits of the Llano-Burnet area. This should be an important factor in helping to establish a graphite industry in this area.

Uses

There is a great demand for graphite from many branches of industry. Crystalline graphite because of its inert and heat-resisting nature is particularly valuable for crucibles. This use, however, is decreasing. Graphite is extensively used as a lubricant with oil. The artificial mineral is especially useful for this purpose. Graphite is also used extensively for pencils, foundry facings, polishing powder, paint, electrodes, batteries, and as an adulterant for fertilizers. Graphite electrodes are produced chiefly from artificial graphite.

The Minerals Yearbook 1936, page 1058, states: "Domestic consumption of natural graphite, which probably parallels world conditions, is roughly twenty per cent in crucibles, forty per cent for general foundry work, fifteen per cent in pencils and crayons, fifteen per cent in lubricants, and ten per cent in paints, stove polishes, and miscellaneous uses."

The Burnet County graphite is of value for crucible manufacture and foundry facings. The fine-grained graphite of Llano is apparently of value for everything except crucibles. It appears to be especially suited for pencils, foundry work, and lubricants.

Use of this graphite for lubricants in connection with the oil industry of the State should be one of the first aims. Introduction of Texas graphite into the foundry industry should parallel the above use. The use of graphite for pencils might be carried a step forward and the manufacture of pencils inaugurated in Texas, thus utilizing a native resource to produce a finished product.

TABLE I

	UNITED STATES Natural Graphite				Artificial graphite Production	Texas Rank	Number of Producers in U.S.	World Production	United States Production Of Natural Graphite By Kinds	
	Production	Imports	Exports	Consumption					Amorphous Graphite	Crystalline Graphite
1910	4,202	25,235	—	—	6,575	c	—		1,407	2,795
1911	3,618	20,702	—	—	5,072	c	—	Ave.	1,223	2,395
1912	3,835	25,643	2,320	27,158	6,448	c	—	109,867	2,063	1,772
1913	4,775	28,879	2,692	30,962	6,817	c	—		2,243	2,532
1914	4,336	21,990	1,960	24,366	5,228	c	10		1,725	2,610
1915	4,718	23,075	529	27,264	2,542	c	13	112,831	1,181	3,537
1916	8,088	42,930	798	50,220	4,199	d	23	183,509	2,622	5,466
1917	13,593	42,577	2,573	53,597	5,237	d	33	216,591	8,301	5,292
1918	12,991	19,498	954	31,525	4,591	d	42	205,791	6,560	6,431
1919	7,422	26,626	629	33,419	4,082	d	20	126,701	3,379	4,043
1920	9,510	21,095	607	29,998	3,700	3rd	17	115,089	4,694	4,816
1921	2,437	8,183	921	9,699	2,944	2nd	8	87,167	1,842	595
1922	3,130	12,488	569	15,049	6,516	1st	7	110,000	2,200	930
1923	6,038	19,817	908	24,947	13,380	d	7	—	4,056	1,982
1924	4,971	16,375	1,022	21,346	5,493	d	5	—	4,071	900
1925	4,665	17,768	945	21,488	6,068	d	6		3,536	1,129
1926	5,470	16,166	405	21,231	10,582	d	6	Ave.	2,975	2,495
1927	5,207	17,429	1,819a	20,817	6,129	d	9	139,334	2,595	2,612
1928	5,611	17,843	2,203	21,251	b	d	9		2,994	2,617
1929	b	24,072	1,613	—	b		8		3,555	b
1930	b	16,726	1,556	—	b	c	5		1,941	b
1931	b	9,090	1,188	7,902	b	c	—	Ave.	b	b
1932	b	7,015	790	6,225	b	c	—	121,416	b	b
1933	b	8,053	914	7,139	b	c	—		b	b
1934	b	14,121	1,245	12,876	b	c	—		b	b
1935	b	18,361	1,480	16,881	b	c	—	212,172	b	b
1936	b	24,171	816	23,355	b	c	—	133,594	b	b
1937	b	29,593	1,514	28,079	b	d	—	137,842	b	b
1938	b	17,005	983	16,022	b	c	—	—	b	b

(a) 1927-1938 included manufactures, except crucibles. Prior to 1927 all manufactures are excluded.

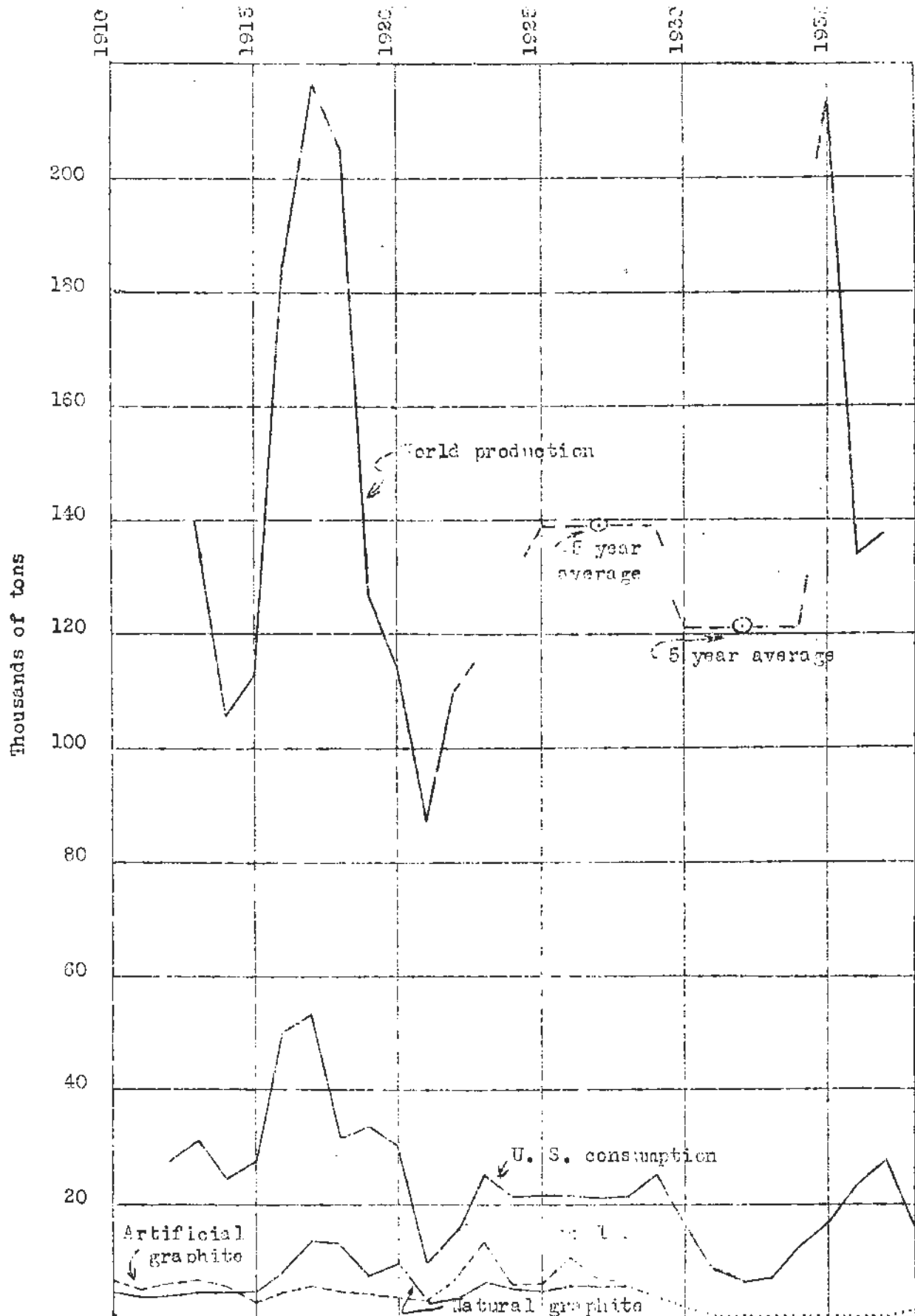
(b) Figures not available for distribution.

(c) No production.

(d) Rank not given.

These data are compiled from U.S. Government Mineral Yearbooks from 1910 to 1938. The material under "United States production is listed in the Yearbooks as graphite sold. The figures for United States consumption have been derived from the difference between exports and production plus imports. These consumption figures are not strictly accurate since the "Export Column" is reported in two manners as noted, and U.S. production is not given after 1938.

Chart showing world production of graphite, United States consumption of graphite, and United States production of natural and of artificial graphite.



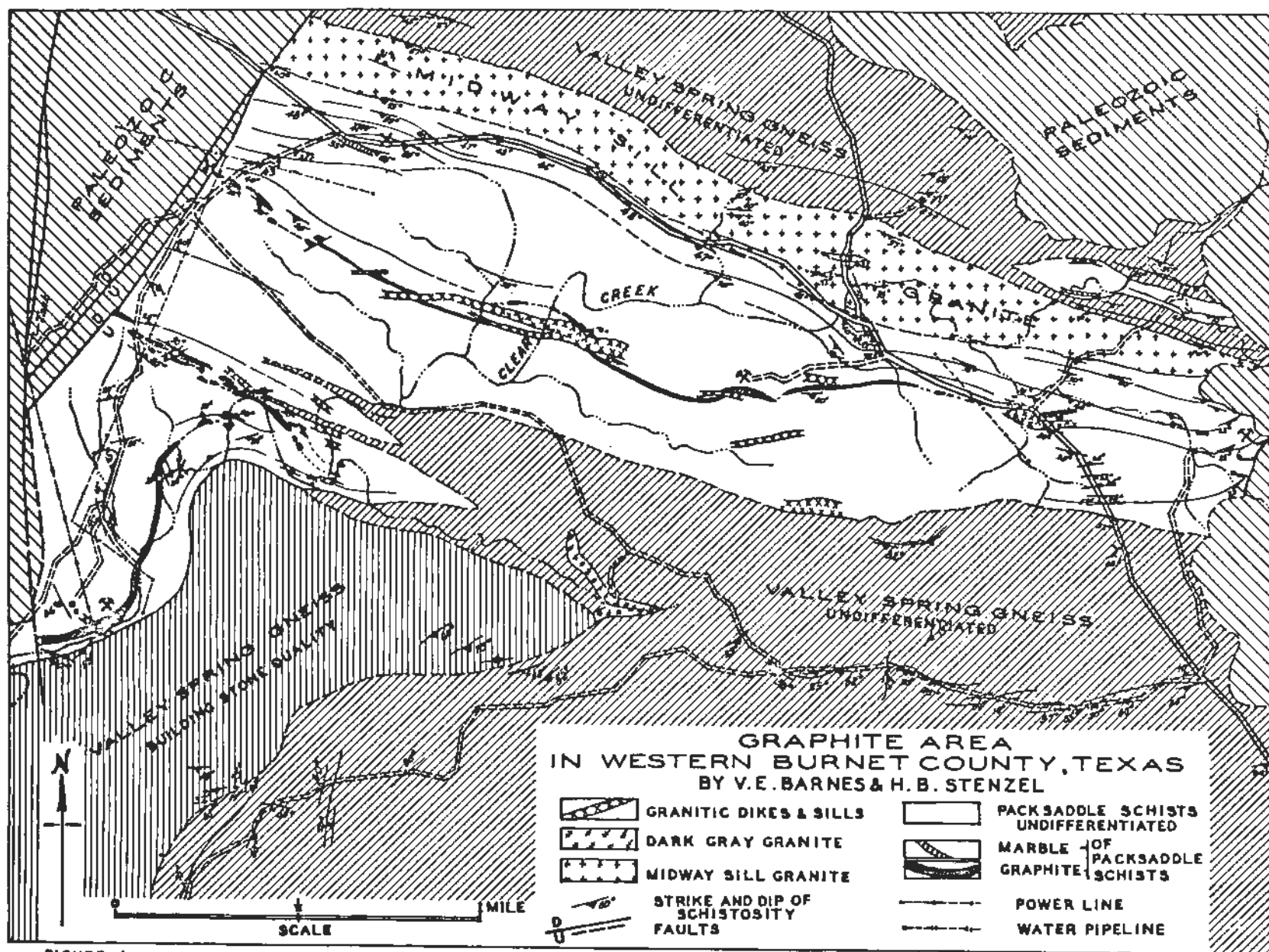
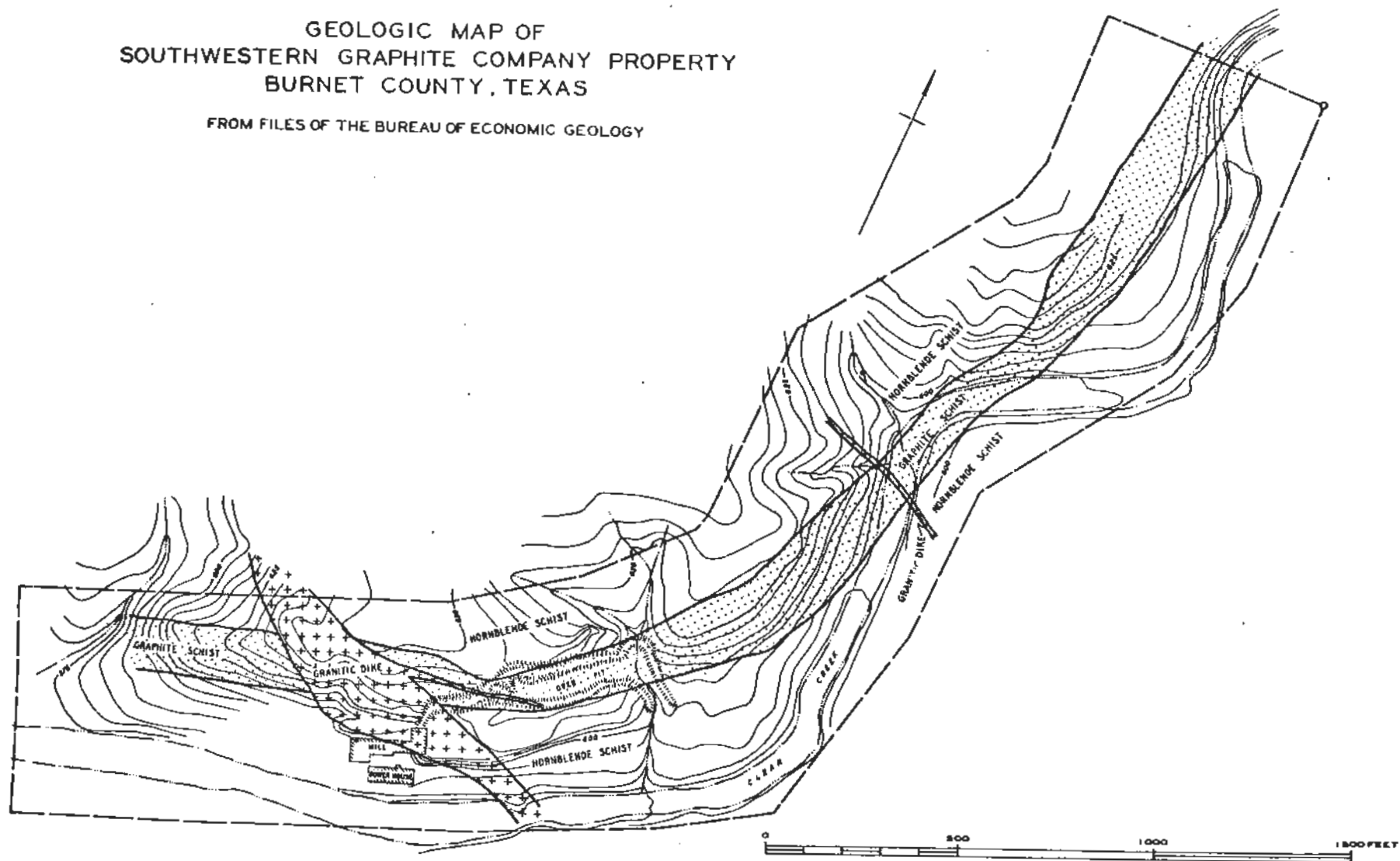


FIGURE 1

GEOLOGIC MAP OF
SOUTHWESTERN GRAPHITE COMPANY PROPERTY
BURNET COUNTY, TEXAS

FROM FILES OF THE BUREAU OF ECONOMIC GEOLOGY



CONTOUR INTERVAL 5 FEET

DATUM IS ASSUMED

DATE, JULY 10, 1923