STATE OF TENNESSEE
DEPARTMENT OF CONSERVATION
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THE ZINC INDUSTRY OF TENNESSEE

By
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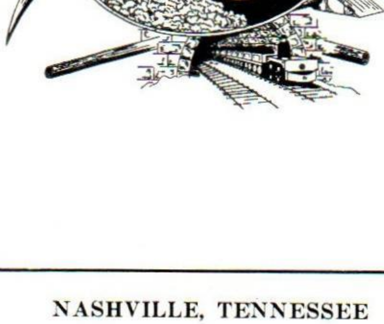

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STATE OF TENNESSEE

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DEPARTMENT OF CONSERVATION

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PREFACE AND ACKNOWLEDGMENTS

This report is an effort to acquaint the general reader with one of Tennessee's major industries. The State has a significant minerals industry producing a diversity of products from all three Grand Divisions, and now making a gross product valued in excess of $100,000,000 annually. The zinc industry is a large contributor to this total, and is of national as well as local significance.

Zinc mining in Tennessee has a long history, a large present establishment, and a promising outlook for future growth in an expanding economy. The industry is faced with economic problems which remain unresolved as this report is written. The writer hopes this study will provide background data for a better understanding of the industry's problems.

This report was prepared under the supervision and at the suggestion of W. D. Hardeman, State Geologist, whose able assistance is gratefully acknowledged.

Representatives of the American Zinc Company of Tennessee, especially H. A. Coy and C. R. L. Oder; of The New Jersey Zinc Company, especially Johnson Crawford; and of the Tennessee Coal and Iron Division, U. S. Steel Corporation, especially R. T. Wilson, generously assisted the writer. These gentlemen and their companies supplied data, suggested improvements, and contributed much in discussing the report and the history and development of the zinc industry. However, the report is essentially the responsibility of the writer, and its limitations reflect his knowledge and effort.

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THE ZINC INDUSTRY OF TENNESSEE

By

Stuart W. Maher [1]

HISTORY AND PRODUCTION

Early Industry

The date of the discovery of zinc ores in Tennessee and the name of the discoverer are unknown. Pre-Revolutionary War operators of lead and iron furnaces knew that zinc oxides accumulated as dust in the furnace flues and formed a scum on the molten metal. To these people zinc was a nuisance contaminator. The occurrence of zinc ores in Tennessee was first described in the Seventh Geological Report by Gerard Troost in 1844.

The first mine opened for zinc was at Mossy Creek (now Jefferson City). In 1854, A. W. Daby leased 400 acres from B. M. Branner and began open-pit mining of zinc silicates and carbonate to be used for making zinc oxide pigment. Daby's operations ceased in 1858, and the mine remained idle throughout the War Between the States. After the war, Daby's lease was nullified by litigation, and B. M. and J. R. Branner leased the tract to East Tennessee Zinc Company (of New York) on September 7, 1867 (Seymour, 1930).

The East Tennessee Zinc Company erected a smelter at Jefferson City in 1867 to manufacture zinc oxide (presumably the mill referred to by Safford, 1869, p. 488). After a few months of operation the company became involved in litigation that extended for 13 years, during which time mining ceased.

The Mossy Creek mine was sold in 1882 by the U. S. court to T. H. Heald who organized the Eades, Mixter, and Heald Zinc Company. This company did the first substantial zinc mining in Tennessee and was the first to mine significant amounts of sulfide ore. They operated the Mossy Creek mine intermittently until 1894, when Eades, Mixter, and Heald ceased operations in Tennessee. No production records are available, but several thousand tons of concentrates were shipped by the company to a smelter in Clinton; an 80-ton concentrator was operated at the mine.

The American Metals Company mined a small amount of zinc at Mossy Creek in 1901 after which the property was idle until 1911, when the Osgood Exploration Company prospected it (Seymour, 1930). The

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last work at Mossy Creek was done by American Zinc Company between 1916 and 1919.

Deposits of lead and zinc in Claiborne and Union Counties near the Powell River were known to early settlers. In 1883 commercial mining at the Stiner, or Lead Mine Bend, property (New Prospect mine) was begun; however, only the lead was recovered. In 1889, Eades, Mixter, and Heald Zinc Company acquired the property. They erected a mill in 1890 and mined intermittently until 1897 (Seymour, 1930, and Purdue, 1912). The lead ore was hand picked, bagged, and shipped to New Jersey. The zinc concentrate was shipped down the Powell and Clinch Rivers to the smelter at Clinton. Seymour (1930) states that 50 tons of concentrates a week were shipped to Clinton. J. W. Love (1911) quotes company records which showed that the greatest activity was between 1890 and 1892, during which time 195,500 tons of ore was mined. However, Purdue (1912) quotes unknown sources that Eades, Mixter, and Heald shipped 1,000 barges of 65 tons capacity.

In 1899 American Metals Company acquired the property and shipped a small tonnage of concentrates to Marion, Ohio. Their operations ended in 1901. In 1914 Union Zinc Company began some prospecting which extended to 1918, but no shipments resulted. In World War II the heirs of the Union Zinc Company's owners robbed enough pillars in the stope to ship a small amount of 40-percent combined zinc and lead ore.

The third of these early zinc mines is the Straight Creek mine in Claiborne County. This mine was opened about 1880 as an open-pit mine from which carbonates were shipped to Clinton via the Clinch River. Later a shaft was sunk and sulfides and carbonate ores were shipped to Clinton by several operators, including Eades, Mixter, and Heald who built a mill at the mine. This company ceased mining in 1894.

Between 1906 and 1908 the Tennessee Zinc Company (of Cincinnati) did some prospecting and a little mining at Straight Creek.

The early mines on the Powell River and at Straight Creek, as well as the Mossy Creek mine, shipped concentrates and ore to a smelter built in Clinton about 1880 by a Mr. Richburg. As first established this smelter consisted of 76 retorts operated by Belgian laborers imported by Richburg. In 1883 Eades, Mixter, and Heald bought the smelter, and in 1888 had it enlarged to 2 blocks each containing 127 retorts with a daily capacity of 3,220 pounds of metal. Smelting permanently ceased in 1894 (Seymour, 1930).

The Mossy Creek mine, described above, and some mines near Mascot and New Market which were opened from about 1892 to 1910, were the predecessors of today's Mascot-Jefferson City district, Tennessee's largest zinc district. Zinc was discovered at Mascot about 1858 on the J. M. Carter property, which later became the Mascot No. 3 mine of American Zinc Company. The earliest mining here was done by small open pits; but in 1902 a 187-foot shaft was sunk by the Roseberry Zinc Company, which also mined from larger open cuts on the west bank of Roseberry Creek, Knox County.

In 1903 the Holston Zinc Company began mining both zinc carbonates and sulfides near the present Mascot No. 1 mine of American Zinc Company. In 1905 the company sank a 150-foot shaft.

As early as 1892 zinc carbonate was mined near New Market, Jefferson County, and shipped to the Bertha Smelter at Pulaski, Va. This mine became the Grasselli mine, and was first developed by shaft about 1925.

In 1894 John G. Long mined and shipped some carbonates from a mine on Lost Creek near New Market. In 1898 a mill was built and various companies operated the property until 1911. The property was actively mined during World War I, but no work was done after 1918.

The Hardwick mine in Bradley County was opened in 1892 and was worked intermittently until 1906. During these years it is reported to have yielded $120,000 worth of lead and zinc ores (Secrist, 1924, p. 138-139).

Modern Industry

The modern zinc industry of Tennessee is considered to have been founded in 1908, after the meeting between Walter G. Swart, a mining engineer who was associated with the American Zinc, Lead & Smelting Company, and Samuel W. Osgood.

Osgood was associated with the Chicago firm of Osgood, Carter, and Company. He was engaged in exploration work in the Mascot-Jefferson City area and was managing the Holston Zinc Company at Mascot at the time he asked Mr. Swart to come to Mascot to see their operation and examine the zinc exposures in that area. By 1913 this company had developed the Mascot No. 1 ore body and had built a 1,000-ton per day concentrating plant. Additional land purchases were made and the Mascot No. 2 mine was developed and brought into production in 1914-15.

In 1916 American Zinc purchased the Roseberry property, built a 600-ton mill, and operated the mine until 1918. In 1916 the company also bought the Mossy Creek mine, which was closed at the end of World War I.

During this same period, 1913-19, the major mining of zinc at Embreeville in the Bumpass Cove area of Washington and Unicoi Counties took place. Lead and iron had been mined in the district since the 18th Century, but the associated zinc had been discarded. In 1913 the Embree Iron Company, in receivership, through C. A. Morris who had been active in Bertha, Va., began extensive exploration for zinc. Churn drilling established fairly large bodies of zinc silicate ores and mining began at the Fowler, No. 13 and 14, and Peach Orchard mines. A mill was erected in 1915.

The Tennessee Zinc and Lead Company, which was organized in 1913, explored and mined in Bumpass Cove until 1917, with indifferent success (Rodgers, 1948, p. 44).

By 1926 mining had virtually ceased; however, some small ore bodies were mined between 1931 and 1935, and hand mining was done from 1942 to 1949.

Rodgers (1948, p. 46) estimates that 213,286 short tons of 40-percent zinc concentrates were produced in the period 1913-46; this does not include shipments aggregating possibly 2,000 tons prior to 1913 or flue-dust shipments prior to 1910.

The Universal Exploration Company, a subsidiary of the United States Steel Corporation, and now the Tennessee Coal and Iron Division, entered Tennessee in 1926. After a period of exploration this company established and developed the Davis mine just south of Jefferson City and built an 800-ton concentrating plant.

In 1927 the American Zinc Company leased 450 acres and, after two years of exploration, developed the Jarnigan mine in 1929. This property is immediately northeast of Jefferson City.

The economic depression of 1929 halted new development in Tennessee, although production levels held at pre-1929 rates until 1932. With the expanding economy of World War II production increased, and new mines were sought. American Zinc Company added to the mill capacity at Mascot, reopened the Jarnigan mine in 1941 after it had been idle since 1937, and opened the Athletic (Mossy Creek) mine in 1943.

Universal (now The Zinc Mines and Works of U. S. Steel's Tennessee Coal and Iron Division) explored the Straight Creek mine, and other much smaller companies operated mines in Embreeville, the Powell River district, and in Central Tennessee, as well as in the Jefferson City-New Market area.

After the war the continued expansion of the U. S. economy led to the major prospecting effort by operators already in Tennessee, and by

The New Jersey Zinc Company. This effort has resulted in adding greatly to the known reserves of zinc in the State; to the development of the Jefferson City and Flat Gap mines by New Jersey Zinc, and the North Friends Station, Young, and Coy mines by American Zinc; and to the expansion of milling facilities by Tennessee Coal and Iron. The effect of this postwar expansion is to make Tennessee potentially the leading zinc producer in the United States.

In addition to the production from the companies' mines reviewed above, a substantial tonnage of zinc concentrates is produced from the Tennessee Copper Company's mines in Polk County. The ores mined are complex iron, sulfur, copper, and zinc ores which contain approximately a half of 1 percent zinc. Zinc concentrates have been recovered since 1927.

PRESENT MINES AND MILLS

Zinc mines and mills presently or recently active in Tennessee are operated by the American Zinc Company, The New Jersey Zinc Company, and The Zinc Mines and Works of U. S. Steel's Tennessee Coal and Iron Division.

American Zinc Company's mines include Mascot No. 2, Coy, Grasselli, Athletic, North Friends Station, Jarnigan, and Young. The Company's mill at Mascot has a rated capacity of 5,000 tons of ore daily.

The New Jersey Zinc Company operates the Jefferson City mine and mill; and the Flat Gap mine and mill, the latter near Treadway, Hancock County. Both of these mills will have 2,000 tons daily capacities.

The Tennessee Coal and Iron Division operates the Davis-Bible mine at Jefferson City and a mill rated at 1,500 tons per day.

The Tennessee Copper Company at Ducktown, Polk County, recovers and ships zinc concentrates as by-products of mining for copper and sulfuric-acid-producing ores. Since this mill is not primarily a zinc plant, it is not included in the total zinc milling capacity figures.

Periods of high price usually lead to some small production, chiefly of secondary ore concentrates, by independent operators.

The zinc production of Tennessee from 1907 to 1956 is given in the table below:[1]

1907	109
1908	344
1909	596
1910	966

[1] U. S. Bureau of Mines; short tons of recoverable zinc.

1911	1,117
1912	2,191
1913	5,583
1914	10,425
1915	16,461
1916	26,428
1917	28,498
1918	21,071
1919	23,247
1920	19,217
1921	9,692
1922	15,568
1923	15,900
1924	14,376
1925	16,256
1926	12,098
1927	10,400
1928	14,597
1929	19,805
1930	22,606
1931	25,320
1932	12,841
1933	21,442
1934	25,972
1935	23,102
1936	23,830
1937	29,335
1938	29,810
1939	32,375
1940	34,796
1941	36,170
1942	43,971
1943	41,766
1944	40,831
1945	33,824
1946	24,614
1947	31,212
1948	29,524
1949	29,788
1950	35,326
1951	38,639
1952	38,020
1953	38,465
1954	30,282
1955	40,216
1956	46,023
1957	58,063
Total	[1]1,204,108

[1] The U. S. Bureau of Mines (1957, p. 974) estimates that between 1850 and 1954 Tennessee produced 1.1 million tons of recoverable zinc.

In 1956 Tennessee produced 8.40 percent of the Nation's zinc; only New York east of the Mississippi, and Montana and Idaho west of the Mississippi produced more (10.9 percent; 13.37 percent; and 8.64 percent, respectively). U. S. production is summarized below:

DOMESTIC MINING [1]

(Zinc content in tons of 2,000 lbs.)

State	*Average 1935-1939*	*Percentage of 1935-1939*	*Total 1956*	*Percentage of 1956 total* [2]
Western States				
Arizona	4,895		25,150	4.68
California	39	(3)	8,100	1.51
Colorado	2,601	(3)	41,000	7.62
Idaho	45,186	8.0	46,483	8.64
Montana	37,462	6.6	71,865	13.37
Nevada	11,684	2.1	6,900	1.28
New Mexico	24,863	4.4	35,200	6.55
Utah	36,697	6.5	40,600	7.55
Washington	6,011	1.1	25,955	4.83
	169,438	30.0	301,253	56.03
West Central States				
Tri-State District				
Kansas	71,084	12.6	27,200	5.06
Missouri	14,379	2.5	3,920	.73
Oklahoma	129,587	23.0	29,960	5.57
	215,050	38.2	61,080	11.36
States East of the Mississippi				
Kentucky	364	(3)		
Illinois	67	(3)	23,985	4.46
Wisconsin	6,393	1.1	24,065	4.48
New Jersey	90,311	16.0	4,415	.82
New York	29,852	5.3	58,589	10.90
Tennessee } [4]	52,399	9.3	45,188	8.40
Virginia }			19,068	3.55
	179,386	31.8	175,310	32.61
TOTAL	563,896	100.0	537,643	100.00

[1] Data from U. S. Bureau of Mines and American Zinc Institute.
[2] Preliminary.
[3] Less than 1 percent.
[4] Figures for individual states not available.

OCCURRENCE AND LOCATION [1]

Zinc minerals have been observed in 20 counties in East Tennessee and in 9 counties in Central Tennessee. The major known deposits are in Knox and Jefferson Counties (the Mascot-Jefferson City district); Polk County (Ducktown district); and Grainger, Hawkins, and Hancock Counties (the Copper Ridge district). Past mining has been conducted in Union and Claiborne Counties (Powell River district); Washington and Unicoi Counties (Bumpass Cove district); Bradley County (Hardwick mine); and in Cannon County (Hoover Mine). See figure 1.

GEOLOGY

The deposits are nearly all in limestone or dolomite host rocks of Cambrian and Ordovician age. Zinc mineralization has been observed in dolomites (or limestones) of the Shady, Rome, Rutledge, Maynardville, and Copper Ridge formations of Cambrian age; and the Chepultepec, Longview, Kingsport, Mascot, Lebanon, Carters, Lenoir, and Catheys formations of Ordovician age. The deposits in the Shady, Rome, Maynardville, and Copper Ridge formations of East Tennessee generally contain lead and zinc, as do those in the Lebanon, Carters, and Catheys formations of Central Tennessee.

The most important deposits are in the Mascot-Jefferson City and Copper Ridge districts, and these occur in the Kingsport formation (upper Knox dolomite). These deposits are lead-free, low in iron, and consist of the zinc sulfide, sphalerite. The straw-yellow sphalerite of the Kingsport formation occurs as small veins and disseminated grains in a gangue of white crystalline dolomite filling shattered and broken gray to brown host rocks. Only traces of other minerals are found with the zinc and dolomite in these deposits.

The early mines were open cuts in the clay produced by the weathering of mineralized limestones and dolomites. Zinc silicate, calamine, and zinc carbonate, smithsonite, were formed from sphalerite and accumulated in these clays. Such deposits were easily mined and milled, and they supported the early small zinc industry. Limited size of the surficial secondary deposits led to the development of the large underground bodies of primary sphalerite.

Prospecting guides consist of suitable host rocks which have been broken and shattered. Thus, geologic maps which locate areas underlain by faulted and disturbed beds of the formations listed above are very helpful to the prospector. Insofar as most of the zinc produced in Tennessee has come from the Kingsport formation, maps showing the distribution of this formation are especially valuable.

[1] For detailed locations, see Appendix.

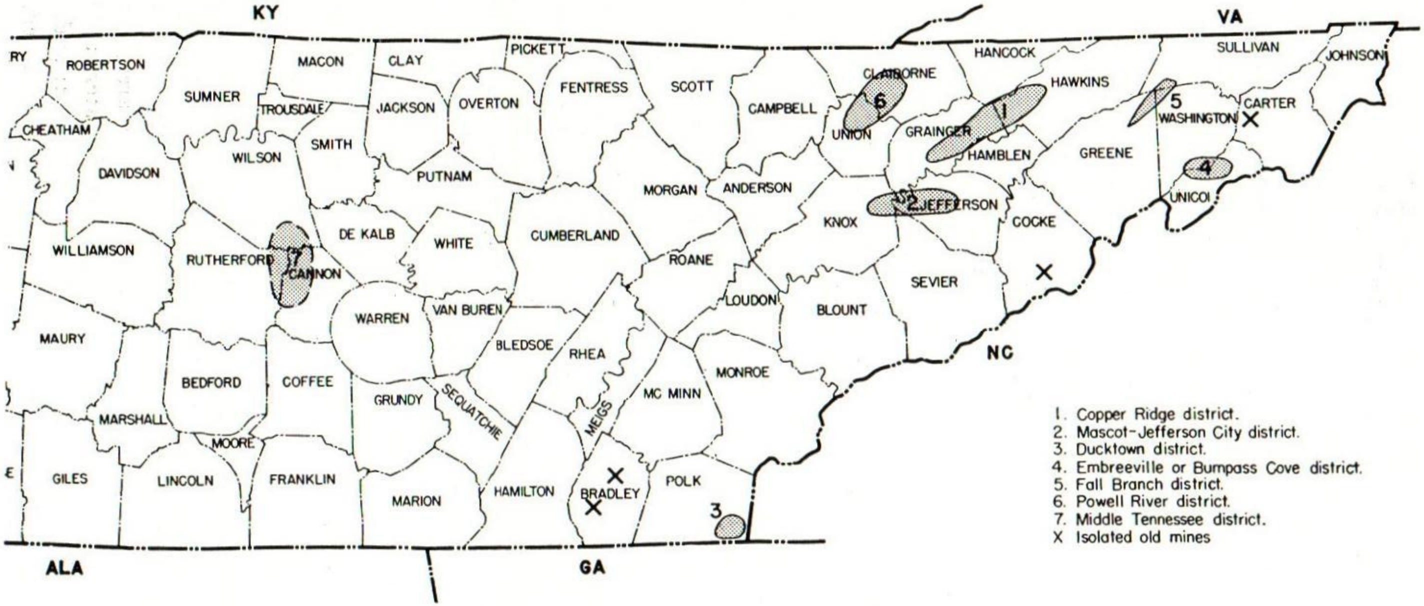


FIGURE 1.—Index map showing location of zinc-mining areas in Tennessee.

The next guide sought after is broken country rock resealed by white crystalline gangue dolomite, called recrystalline by the miners. Such dolomite invariably accompanies zinc ore in East Tennessee, but not all recrystalline contains zinc.

Finally, zinc minerals themselves are sought—yellow to brown resinous sphalerite or crusts and masses of white to colorless bladed crystals of calamine on weathered rock faces.

MINE DEVELOPMENT

The development of a modern underground zinc mine is both expensive and time-consuming. Initially the company desirous of establishing a mine must select a region considered geologically favorable. They then must evaluate smaller areas within the selected region, eliminating the unfavorable parts and prospecting the areas that show the most promise.

Once the areas have been decided upon, and to an extent prior to this phase, detailed geologic maps are made. Such maps reveal the location and extent of suitable host rocks, the depth of such rocks where they are buried beneath the surface, and the configuration of the potential host rock (which is generally folded and broken by faults). From these maps drill holes can be so located and bored to proper depths on predetermined angles, that a given area can be tested adequately. Drilling without such geologic control is in effect random, without known targets, and serves neither to prove nor condemn the area.

The drilling may be preceded or accompanied by soil testing (geochemistry), trenching, or other exploration techniques. Obviously, the most concentrated efforts are directed toward areas having surface shows of zinc minerals. All such occurrences are carefully studied for clues as to extent and mode of occurrence, and for indications of possible concealed deposits.

If the data established by this preliminary prospecting are favorable and the best property can be acquired, detailed drilling is done to establish the size, shape, depth, and grade of the deposits. Several such programs may be required to establish one ore body of commercial magnitude and quality. Factors other than size and grade enter into the evaluation of a prospect's potential. These factors include distance to the mill (or in areas of no mills the feasibility of erecting one to serve the deposit); transportation facilities and costs in the area; land values; engineering problems presented by underground water; ability of the rock to stand unsupported or to require reinforcement; and, of course, demand and favorable outlook for the metal to be produced.

After the above problems are resolved actual sinking of the shaft, erection of necessary surface facilities, and development of the ore body begins. By this time geologic mapping and study of drill cores have provided the engineer with a map of the ore body itself, and of conditions in the rocks around it. Thus armed, he plans the shaft and drifts, ore hoist openings and haulageways, and ventilation facilities to permit the best development of the mine. In this planning sound walls for shafts, strong backs (roofs) for drifts, minimum drainage of underground water, minimum loss of ore left in pillars, and minimum removal of barren rock are desired. But always, sound engineering and safety practice must be followed.

In operating practice, exploration by drilling in the mine itself, mapping of new exposures, and study of the now-revealed ore zones accompany and aid the development and future exploitation of the ore.

Thus, it can be seen that large expenditures, some on uneconomic deposits, and an appreciable period of years are generally required to develop and bring a new mine into production.

MILLING OF THE ORE

Zinc ores from the mines contain rather small amounts of metal, perhaps 2 to 5 percent zinc in Tennessee deposits. The first step in milling is to remove waste rock and thus concentrate the ore. This is done by crushing and grinding to liberate ore grains from the enclosing rock, followed by either flotation or gravity separation.

Flotation recovery is used only for small particles (less than .04 inch in diameter). This process is based on the fact that metallic mineral particles cling to air bubbles in agitated mixes of oils and water. The rock fraction sinks to the bottom of the tank; the mineral-air bubbles float and are skimmed off. This concentrate is then filtered and dried.

Gravity concentration in the form of the heavy-media separation process is used in separating zinc-bearing sphalerite from the gangue dolomite in the coarse sizes ranging from 5/16 to 2 inches. The medium employed is finely ground ferrosilicon suspended in water, the specific gravities of the medium being between that of the zinc-bearing rock and the barren rock. The heavy mineral fractions sink; the light fractions float and are discarded as tailing.

Separation is usually carried out to produce a 60-percent minimum zinc concentrate, which is dried and shipped to the smelter.

To make zinc metal the concentrate is roasted to drive off the sulfur and make zinc oxide. The oxide is then converted to zinc metal either by reduction with carbon or electrolytically.

A modified roasting procedure is followed when zinc oxide is to be the final product. Zinc ore concentrates and coal briquettes are fed through a furnace, over a slowly moving grate carrying burning coal, as a stream of air is passed through the furnace. This forced draft combustion produces zinc vapor which is burned under controlled conditions to make the proper shapes and sizes of zinc oxide particles. An older zinc oxide process uses zinc metal slabs which are melted and vaporized. The zinc vapor reacts with air to form zinc oxide. This method thus requires two steps, ore to metal and metal to oxide; whereas the method previously described is a one-step procedure.

Zinc oxide is a white powder of smaller particle size than any other common white pigment. It is unaffected by light or weather. Much Tennessee ore is used to make zinc oxide.

No zinc smelters or zinc oxide plants are now operated in Tennessee.

MARKETING

Prices

Zinc ores are concentrated, as outlined in the section on milling, and are shipped to the smelter as concentrates. Ores from the Western United States usually are complexes of zinc with lead, copper, and precious metals. The zinc values make it possible to mill out the other metals profitably. However, concentrates from these western ores range from 48 to 60 percent zinc, whereas Tri-State and Tennessee concentrates consistently average 60 percent or more zinc.

U. S. zinc metal prices are based on the price of Prime Western grade zinc metal, per pound, f.o.b. East St. Louis, Ill. Freight allowances and grade premiums (or penalties) vary so that the net cost for delivery to a consumer's plant normally increases by grade from Prime Western to Special High (American Zinc Institute, 1958).

Foreign zinc prices are established by the daily price bid on the London Metal Exchange.

Prices quoted for concentrates are based on the price of zinc metal and on recoverable zinc content of the concentrate; the quotation is based on a 60-percent concentrate, Prime Western grade, Joplin, Mo., per ton.

As of May 1, 1958, Prime Western zinc metal, f.o.b. East St. Louis, was quoted at 10 cents a pound. The producers absorbed the freight in excess of ½ cent a pound. The price of 60-percent zinc concentrates at Joplin was $56 a ton in mill bins. To this should be added the cost of truck loading and freight to smelter.

GRADES

Zinc metal is normally marketed in six grades which are established by the American Society for Testing Materials. These standards are subject to revision, and the most recent version should be consulted. In 1958 the grades and standards were:

	Lead	*Iron*	*Cadmium*	*Aluminum*	*Total of Lead, Iron, and Cadmium*
Special High Grade	0.006	0.005	0.004	None	0.010
High Grade	0.070	0.02	0.070	do.	0.100
Intermediate	0.200	0.03	0.500	do.	0.500
Brass Special	0.600	0.03	0.500	do.	1.000
Selected	0.800	0.04	0.750	do.	1.250
Prime Western	1.600	0.08	....	....	....

Note: Values given are maximum allowable percentages.

PRICE AND GRADE RELATIONS

The value of zinc depends to a degree upon its quality based on the American Society for Testing Materials grade standards. These prices, however, are subject to change. In May 1958 Engineering and Mining Journal reported that Special High Grade commanded a 1.25-cent premium and High Grade a 1.0-cent premium over Prime Western grade zinc.

PRICE HISTORY

Zinc prices are subject to marked fluctuations which reflect general economic conditions, tariff rates, and Federal stockpiling and barter programs, as well as concentrates or metal offered by foreign producers.

The price history of zinc metal, based on Engineering and Mining Journal data, is shown graphically in figure 2. These data, summarized in tabular form below, are average zinc metal prices in cents per pound, f.o.b. East St. Louis. [1]

1911-1920	8.29
1921-1930	6.18
1931-1940	4.65
1941-1950	9.93
1951-1956	13.59
Highest price (1915)	27.00
Lowest price (1932)	2.30
Ceiling price, World War II	8.25

The price history graph shows that the price of zinc fluctuates markedly. These fluctuations reflect general economic conditions, especially steel and auto production, and the price of zinc offered by foreign

[1] American Zinc Institute, 1958, p. 82.

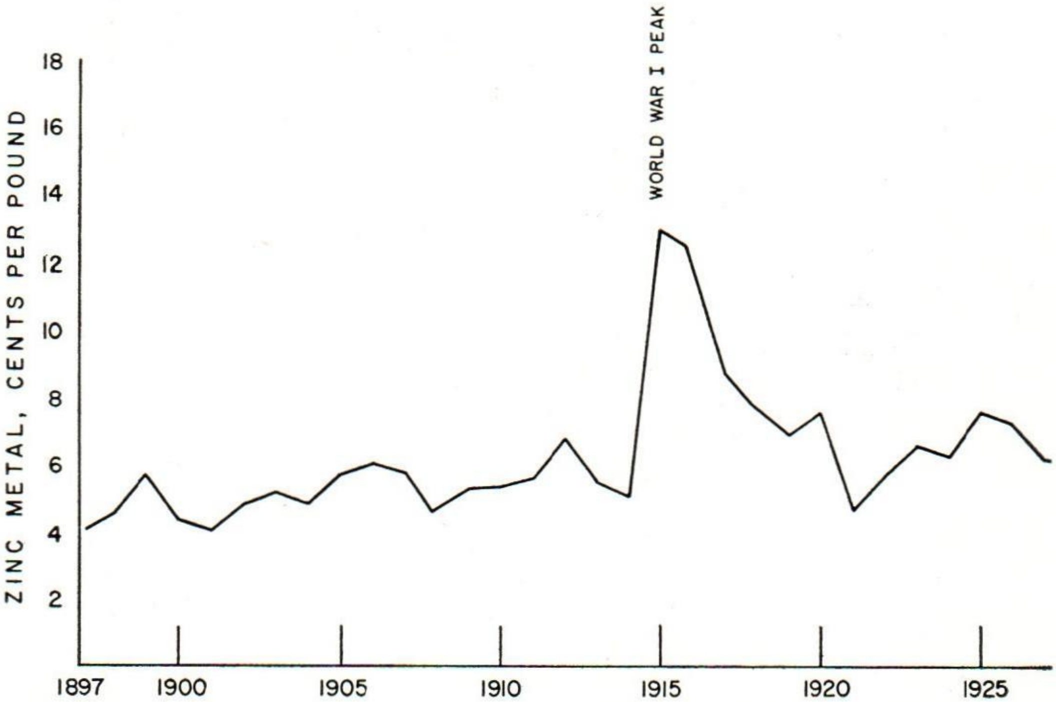


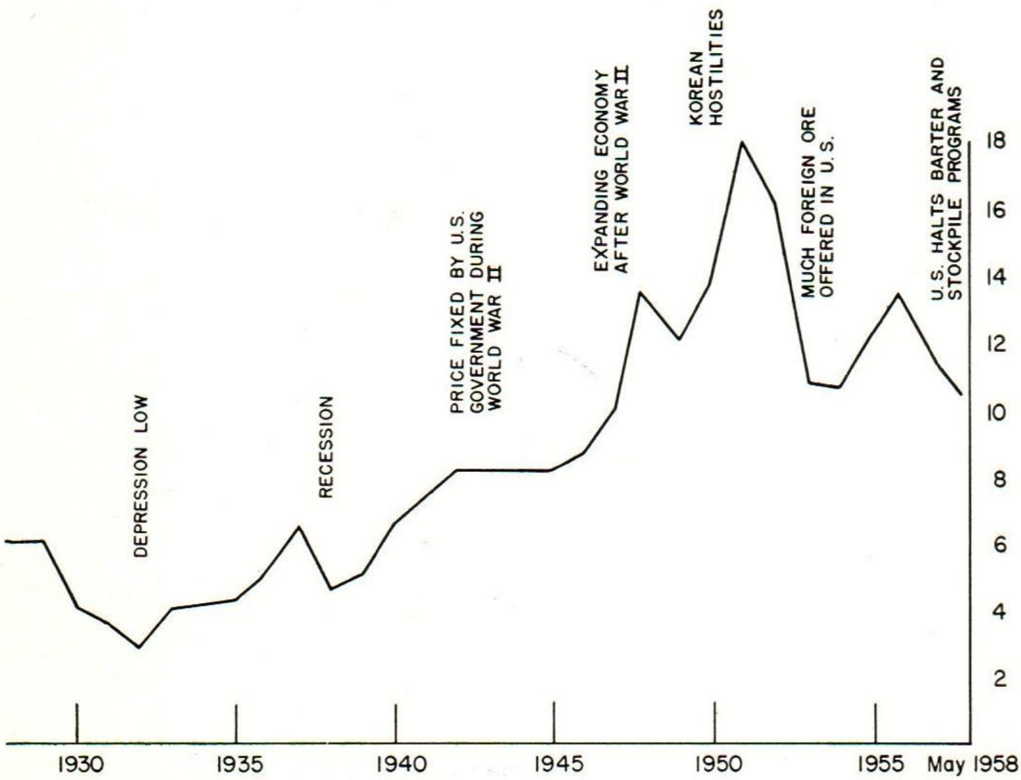
FIGURE 2.—Graph showing the price per pound of zinc metal, f.o.b. East St. Louis, Ill., 1897-1958.

producers. Tennessee producers are particularly affected by these factors, owing to the relatively low zinc content of Tennessee ore bodies. These large low grade, but high quality, ore bodies require the most efficient mining practices in order to be operated economically. These same factors require large mills and major capital outlays for development. Thus a decline of a few cents per pound for zinc may well represent the difference between profit and loss for Tennessee miners. The situation is further complicated by the impracticability of re-entering large underground mines in East Tennessee if they have been closed for any length of time.

ECONOMIC SIGNIFICANCE

Uses of Zinc

Zinc is fourth in rank, by tonnage, of all metals mined and manufactured. In 1957 the United States produced 113,000,000 tons of steel, 1,649,000 tons of aluminum, 1,614,000 tons of refined copper, 1,057,000



(From Engineering and Mining Journal)

tons of zinc metal, and 825,000 tons of lead (Engineering and Mining Journal).

Zinc is indispensable in both the wartime and peacetime economy of the Nation (fig. 3). Wartime uses include brass for ammunition, copper-alloy castings in shipyards, plates for the protection of steel ship hulls, zinc oxide for rubber tires and gas masks, and galvanized equipment of all sorts. Similar uses apply to civilian products, as well as paint pigments, galvanized metal, and die-castings. In wartime zinc is used chiefly for making brass, but in peacetime it has been used principally for galvanizing. However, since about 1935 the amount of zinc used in die-castings has rapidly increased, surpassing that used for making brass after World War II, and exceeding zinc used for galvanizing in 1957.

Engineering and Mining Journal statistics for 1957 give the following consumption of zinc (in short tons):

Die-casting	375,000
Galvanizing	363,000

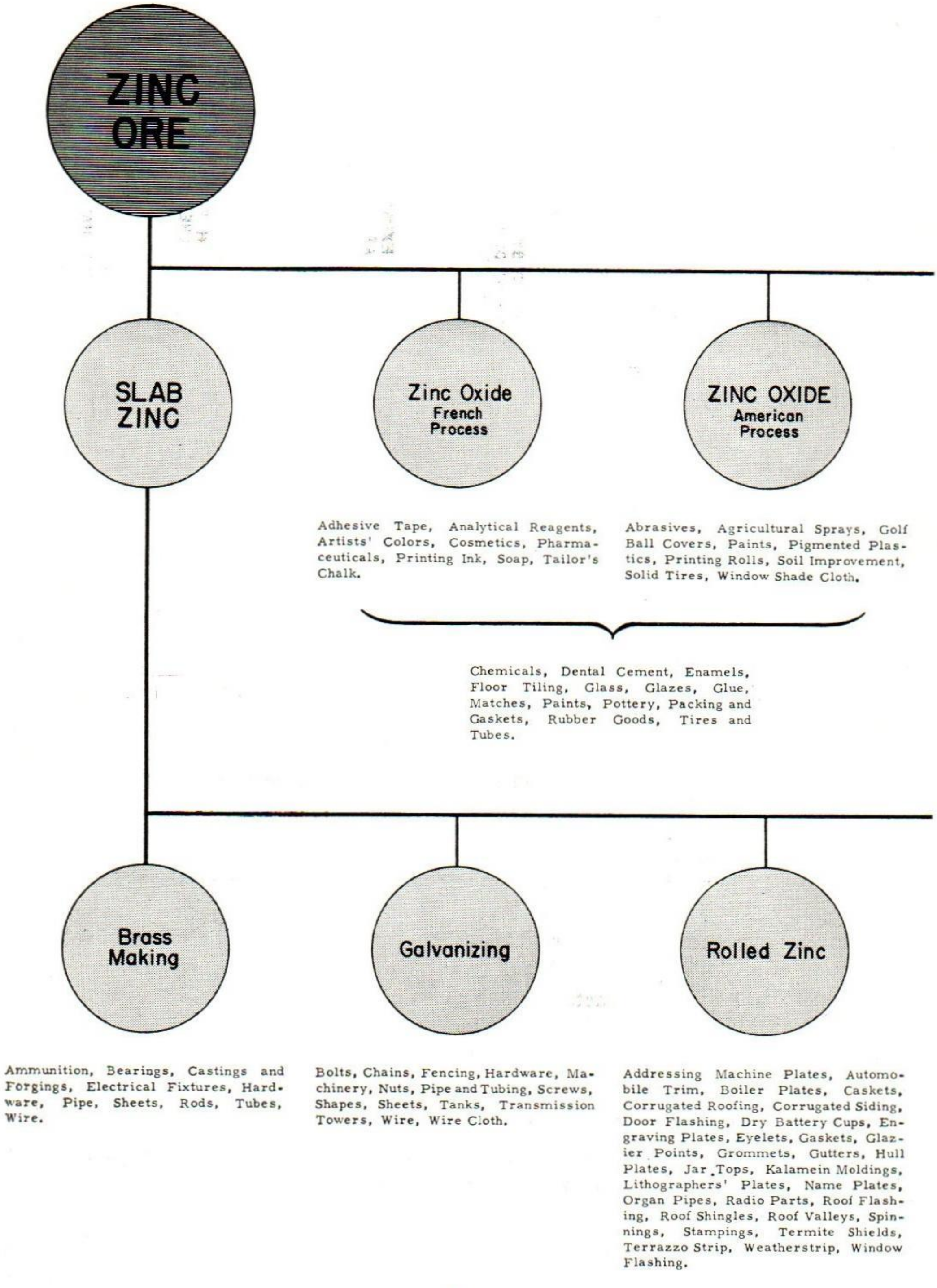
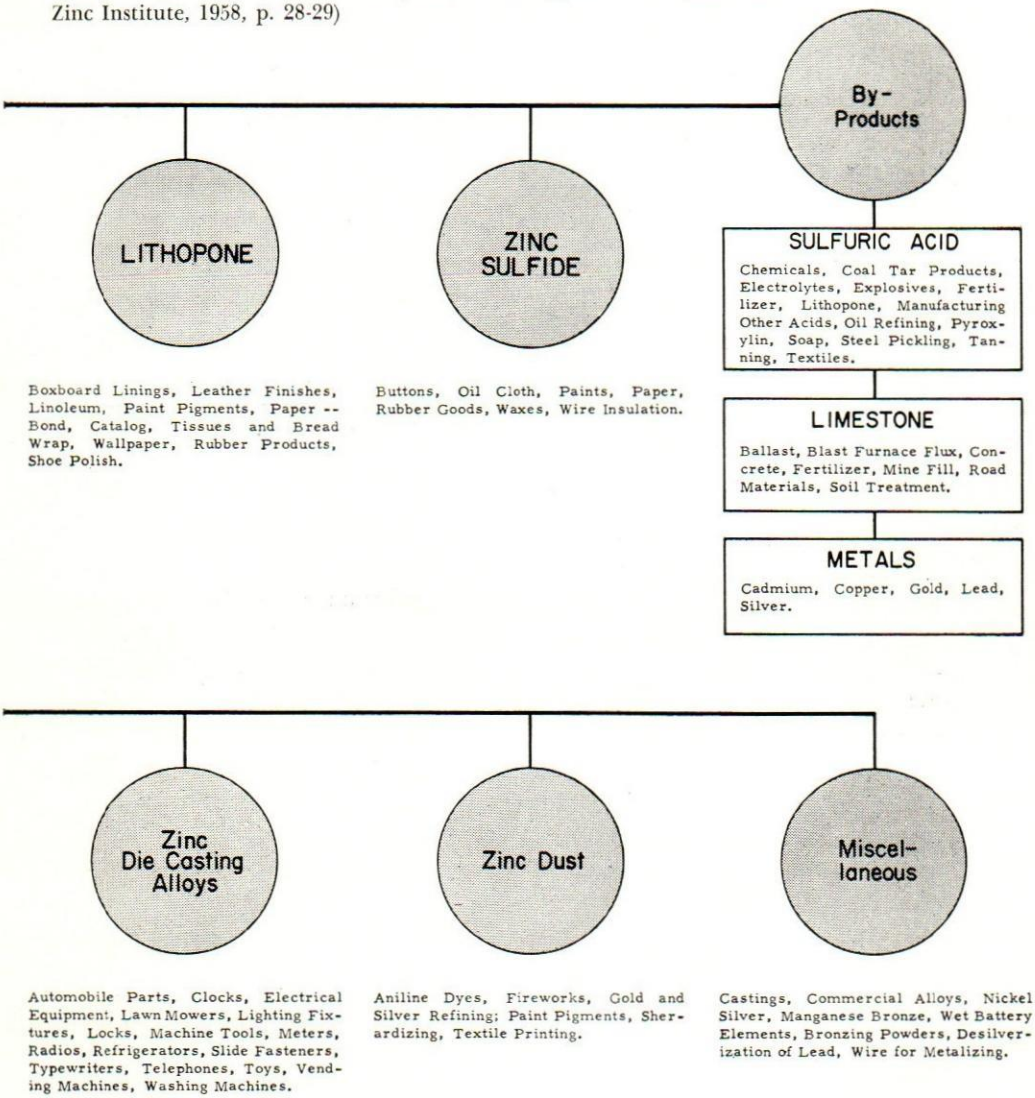

ZINC ORE
SLAB ZINC
Zinc Oxide French Process
ZINC OXIDE American Process
Adhesive Tape, Analytical Reagents, Artists' Colors, Cosmetics, Pharmaceuticals, Printing Ink, Soap, Tailor's Chalk.
Abrasives, Agricultural Sprays, Golf Ball Covers, Paints, Pigmented Plastics, Printing Rolls, Soil Improvement, Solid Tires, Window Shade Cloth.
Chemicals, Dental Cement, Enamels, Floor Tiling, Glass, Glazes, Glue, Matches, Paints, Pottery, Packing and Gaskets, Rubber Goods, Tires and Tubes.
Brass Making
Galvanizing
Rolled Zinc
Ammunition, Bearings, Castings and Forgings, Electrical Fixtures, Hardware, Pipe, Sheets, Rods, Tubes, Wire.
Bolts, Chains, Fencing, Hardware, Machinery, Nuts, Pipe and Tubing, Screws, Shapes, Sheets, Tanks, Transmission Towers, Wire, Wire Cloth.
Addressing Machine Plates, Automobile Trim, Boiler Plates, Caskets, Corrugated Roofing, Corrugated Siding, Door Flashing, Dry Battery Cups, Engraving Plates, Eyelets, Gaskets, Glazier Points, Grommets, Gutters, Hull Plates, Jar Tops, Kalamein Moldings, Lithographers' Plates, Name Plates, Organ Pipes, Radio Parts, Roof Flashing, Roof Shingles, Roof Valleys, Spinnings, Stampings, Termite Shields, Terrazzo Strip, Weatherstrip, Window Flashing.

FIGURE 3.—The flow of zinc from mine to market. In this diagram are shown the primary derivatives and by-products of the reduction of zinc ore, and a partial list of their many and varied applications. (American Zinc Institute, 1958, p. 28-29)



Brass	110,000
Rolled zinc	41,000
Zinc oxide	21,000
Other uses	25,000

Most zinc used in die-casting is consumed by the auto industry and household appliances industry. However, industries that manufacture electrical equipment, cameras, office machines, toys, and other products also use zinc for dies. This use requires and consumes most of the Special High Grade (99.99-percent pure) zinc produced. A modern auto contains an average of 77 pounds of zinc (Engineering and Mining Journal).

Zinc's corrosion resistance and its electrochemical behavior make it highly desirable for protecting iron and steel from the rusting and corroding effects of water. Rolled zinc is used for roof flashings, jar lids, and batteries; and in photoengraving, ship hulls, and steam boilers.

Zinc oxide is used chiefly in the rubber, paint, and ceramic industries; but some is used in making coated textiles, inks, dental cements, soap, glue, matches, lithopone, and as a polishing agent.

The Bureau of Mines (1951, p. 1-17) states that in wartime suitable substitutes for zinc are few and most are in short supply. This is particularly true of galvanizers and pigments.

High Quality of Tennessee Concentrates

Impurities in zinc ores and concentrates produce undesirable properties and result in price penalties and poor performance. Much Tennessee ore, especially that of the Mascot-Jefferson City district, is notably free from contaminants. As a consequence most Tennessee concentrates are used to make pigments, since purity is most important in the paint industry.

Iron renders zinc brittle and hard; lead produces a brass which cracks under stress; and high cadmium causes warping and lowers corrosion resistance. Mascot-Jefferson City ores are lead-free and unusually low in iron. An analysis of Tennessee concentrates is compared with an analysis of Tri-State concentrates below:[1]

	Zinc	*Lead*	*Iron*	*Copper*	*Cadmium*
Tennessee	62.00	Tr.	0.26	Tr.	...
Tri-State (Mo., Okla., Kan.)	58.95	0.56	1.25	...	0.39

Mill Capacity

The capacity for producing zinc concentrates in Tennessee has shown a long period of growth. Early mills consisted of crushers and jigs, and in most cases involved hand-picking. Today's mill contains crushers, jigs, and flotation cells, and one Tennessee mill has a heavy-media separator.

[1] From Purdue, 1912, and Ammon, 1930.

Installed capacity, and expansion in progress, permits the milling of 10,500 tons of ore daily in Tennessee. Of this total, 8,500 tons is installed in the Mascot-Jefferson City district and 2,000 tons in the Copper Ridge district. Industry spokesmen state that under favorable economic conditions this capacity would be expanded.

No smelting is done in Tennessee. The ores are concentrated and shipped to smelters in other states for processing to metallic zinc and for the removal and recovery of cadmium.

BY-PRODUCTS

Limestone, cadmium, and sulfuric acid are recovered from the milling and smelting of zinc ores. Only limestone is recovered in Tennessee, since the acid and cadmium are products of the zinc smelters.

The limestone recovery is large and is an economically significant aspect of zinc mining in Tennessee. Exact production records of by-product stone are not available, but the amount produced annually is well in excess of 1,000,000 tons valued at more than $1,000,000. The stone sold is used for railroad ballast, highway surfacing, aggregate, rip-rap, agricultural limestone, and similar construction purposes.

Considerable amounts of limestone for agricultural use are sold to consumers in the vicinity of the zinc mills. Many sales are made to the farmer in his truck at the mill, thus saving the local user freight and handling charges.

EXPENDITURES BY THE INDUSTRY

The zinc industry has made a very large capital investment in Tennessee since the beginning of substantial mining. Exact figures are not available, but the investment in mills, surface facilities, land, equipment, and other capital investments are valued currently at more than $20,000-000 (exclusive of mines and underground works).

The industry, when in full operation, gives employment to 1,175 people who earn more than $4,660,000 annually. Taxes (exclusive of personal income taxes, but including Federal old-age insurance, unemployment taxes, and sales taxes) paid by the industry at full production amount to $355,000 annually.

The zinc industry makes extensive purchases of goods and services in local markets. Equipment, supplies, maintenance, and expenditures for utilities, etc., in the local market amount to approximately $4,700,000 annually (assuming full-scale operation).

Expenditures by the zinc industry for the items cited above and for exploration, development, additions to mill capacity, land acquisition and miscellaneous costs averaged more than $11,600,000 per year from 1948 to 1957, inclusive.

Specific figures for given mines and mills cannot be disclosed, but at prices prevailing in the last decade it is estimated that the total cost of proving, developing, and acquiring a modern zinc mine and mill in Tennessee will not be less than $5,000,000.

Value of Zinc Recovered

The value of mine output varies with the price of zinc on the market. Value is reported in terms of tons of recoverable zinc metal. In applying these figures to the costs outlined in the preceding section it should be borne in mind that the zinc leaves Tennessee as a zinc concentrate, that smelting costs must be added to mining and milling costs, and that values of by-products are not shown.

The value of recoverable zinc mined in Tennessee is shown below:

Year	*Tons*	*Value*[1]
1947-51 (average)	32,898	$ 9,378,258
1952	38,020	12,622,640
1953	38,465	8,846,950
1954	30,326	6,550,345
1955	40,216	9,893,136
1956	46,023	12,610,302

POTENTIAL OF THE INDUSTRY

Tennessee's future as a zinc producer is impressive. The industry has had a long history of large production and of rather continuous growth. The observer is also impressed by the long life of individual ore bodies; for example, the Mascot mine has been operated continuously from 1912 to the present and is now the eighth largest producer in the United States (U. S. Bureau of Mines, 1958, p. 1334).

Another impressive fact is the widespread occurrence of zinc in Tennessee. Only a few counties in East Tennessee are not known to contain prospects, at least; another district is composed of the Central Tennessee mines and prospects, which are spread over 9 counties. Altogether, more than 35 mines with greater than 100 tons of zinc production are operated or have been operated in East Tennessee, and more than 135 prospects are recorded. The Central Tennessee district consists of 2 small inoperative mines and 14 prospects. The area favorable for zinc minerali-

[1] U. S. Bureau of Mines data. This figure is net value of the refined zinc metal and must cover all costs of mining and milling of the crude ore, freight on zinc concentrates from Tennessee to the smelter, and smelting costs for converting concentrates to zinc metal.

zation is thus large, and the known deposits occupy a number of various limestone and dolomite rock formations. Although the most favorable areas for prospecting are those analogous to the districts described above, the writer believes that the mountain areas along the North Carolina border in East Tennessee may contain additional Ducktown-type complex ore deposits.

Exploration for new deposits must be guided by a competent geologic staff which should utilize all available techniques. As such it is a major undertaking. In retrospect, however, the post-World War II period indicates what this type exploration can do. Under the stimulus of a favorable market and the Federal Defense Minerals Exploration Administration program, very large scale exploration was carried on by several companies. This resulted in tremendous new ore reserve discoveries in the Mascot-Jefferson City area, the establishment of the Copper Ridge district as a major mining district, and the development of 4 new mines and 2 new mills in Tennessee. Existing facilities have also been expanded. Tennessee is potentially the leading zinc producer in the Nation. Such developments as these are important to the entire United States, as well as to Tennessee, because they assure adequate zinc supplies for many years ahead. Indeed, known reserves in Tennessee greatly exceed all past production, and a hundred-year reserve is probably established.

Those familiar with the area think that continued exploration of the proper type can be confidently expected to add to the known reserves.

OUTLOOK FOR THE INDUSTRY

Further development of the industry, and indeed maximum utilization of its present capacity, depends upon the general course of the economy and national trade policies. Zinc prices and production levels constitute a sensitive barometer of the economic climate (see Price History). Tennessee production is particularly affected because the ores are derived from large low-grade ore bodies, because large amounts of water must be pumped from many mines, and because zinc substitutes create intense competition in the oxide and die-casting industries. Hence, a decline in steel or auto output or low tariffs on imported zinc concentrates is promptly reflected by curtailed operations in Tennessee. Most recently the closing of Federal stockpile purchases and the ending of a program of barter exchange of agricultural goods for foreign zinc has depressed the U. S. price.

Much of the industry feels that a stable market can best be established by a tariff schedule based on a sliding scale determined by the price bid for zinc. This program is opposed by those favoring reciprocal trade, and a counterproposal of a subsidy nature is suggested. Existing tariffs are 0.7 cents a pound for zinc metal and 0.6 cents a pound on zinc contained in ores or concentrates. The Tariff Commission recommended 50-percent increases, but these have not been imposed. It is noteworthy that lead and copper prices are also affected by foreign mine production. The situation is illustrated by conditions at the beginning of 1958; zinc on the London Metal Exchange was offered at 7.67 cents a pound, or 2.83 cents a pound less than the 10.5 cent price at New York. Even with tariffs, freight, and insurance added, foreign zinc could be bought in London and delivered to New York for about 1.25 cents a pound less than the U. S. price (Wall Street Journal). The zinc industry asked for a tariff increase from 0.7 cents to 2.1 cents a pound in the face of this situation, but no change in duty has been made (as of June 1958).

The Secretary of the Interior has proposed a stabilization plan to Congress which involves a support price guaranteed by the Federal Government. This plan applies to several mineral commodities, zinc included. In the instance of zinc, the Government would pay U. S. miners the difference between the market price and 12¾ cents a pound on the first 550,000 tons mined; the program would last for 5 years. The industry generally opposes this plan on grounds of its temporary nature, "hand-out" character, and difficulty of administration.

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APPENDIX

The following information is from a forthcoming Division of Geology report entitled, *Mining Districts and Mineral Occurrences in Tennessee,* by Stuart W. Maher.

The locations are made by reference to the 7½-minute topographic quadrangle series of the U. S. Geological Survey and Tennessee Valley Authority,[1] and to the Tennessee 10,000-foot grid. The first number refers to the U. S. G. S.-T. V. A. map; for example, 163-SW. The numbers following refer to the location in the 10,000-foot Tennessee coordinate system; for example, 639,000N., 2,742,500E. The grid coordinates are shown along the margins of the quadrangles.

DISTRICTS

MASCOT-JEFFERSON CITY: Knox and Jefferson Counties; 136-SE, 155-NE, 155-SE, 155-SW, 163-SW, 163-SE, 163-NW (Bridge, 1945; Oder, 1945; Hook, 1950; Secrist, 1924).

Mines

Athletic:[2] Jefferson County; 163-SW; 639,000N., 2,742,500E.
Coy:[2] Jefferson County; 163-SW; 639,200N., 2,746,000E.
Davis:[2] Jefferson County; 163-SW; 634,600N., 2,740,000E.
East Tennessee: Jefferson County; 155-SE; 625,000N., 2,731,200E.
Grasselli:[2] Jefferson County; 155-SE; 630,000N., 2,727,300E.
Jarnigan:[2] Jefferson County; 163-NW; 643,000N., 2,744,000E.
Mascot:[2] Knox County; 155-SW; 616,000N., 2,665,000E.
Mossy Creek: Jefferson County; 163-NW; 640,500N., 2,742,500E.
New Jersey Zinc Company:[2] Jefferson County; 163-SW; 631,400N., 2,744,-700E.
North Friends Station:[2] Jefferson County; 155-SE; 624,000N., 2,711,000E.
Young:[2] Jefferson County; 155-SE; 621,700N., 2,705,400E.

Prospects

Loves Creek: Knox County; 146-SE; 600,000N., 2,632,500E.
McMillan: Knox County; 146-SE; East, 610,000N., 2,651,000E.;
West, 608,700N., 2,648,500E.
Woods Creek: Knox County; 146-SE; 604,000N., 2,639,500E.

WHITE PINE: Jefferson County; 163-SE. Ore is found in the upper Knox, in this and the foregoing district, as replacement deposits of sphalerite. The ore bodies are localized in breccia zones and are controlled by minor structures.

Mine

Felknor:[3] Jefferson County; 163-SE; 620,600N., 2,799,300E.

BUMPASS COVE (EMBREEVILLE): Unicoi and Washington Counties; 190-NE and 199-NW. As of 1950, this district is estimated to have produced 213,200 tons of 40% zinc concentrates (Rodgers, 1948). The district is now (1956) inactive.

[1] In some instances, final 7½-minute maps were not available at the time of compilation. In such cases, the base maps were either 15-minute topographic quadrangles or county highway maps, as indicated in the text.

[2] Active.

[3] Lead also present.

Mines

Big Moccasin: Unicoi County; 190-NE; 654,000N., 3,028,600E.

Dry Branch:[1] Unicoi County; 190-NE; 657,000N., 3,033,000E.

Fowler:[1] Unicoi County; 199-NW; 659,300N., 3,037,000E.

Frog: Unicoi County; 190-NE; 654,700N., 3,030,000E.

Jackson:[1,2] Washington County; 199-NW; 661,000N., 3,038,300E.

Lick Log:[1] Unicoi County; 190-NE; 654,000N., 3,028,000E.

Little Polly Hollow: Washington County; 199-NW; 660,400N., 3,034,300E.

Number 5: Unicoi County; 199-NW; 661,000N., 3,033,200E.

Number 13: Unicoi County; 199-NW; 658,600N., 3,035,000E.

Number 14: Unicoi County; 199-NW; 657,300N., 3,034,500E.

Peach Orchard:[1] Unicoi County; 190-NE; 654,500N., 3,028,000E.

Rock Quarry Hollow: Washington County; 199-NW; 660,000N., 3,034,500E.

Simmons Branch: Unicoi County; 190-NE; 655,000N., 3,031,000E.

Sugar Hollow:[2] Washington County; 199-NW; 662,700N., 3,040,000E.

Tucker:[2] Washington County; 199-NW; 662,100N., 3,039,500E.

GREENEVILLE: Greene County; 181-NW, 181-NE, 181-SW (Kent, Laurence, and Rodgers, 1945; Secrist, 1924; Warner, 1950). No mines have been developed in this district. The prospects are associated with anticlines and minor faults. Mineralization is of the sulfide type with the Honaker limestone, Copper Ridge dolomite, and Kingsport formation being mineralized.

Prospects

Brown-Tipton: Greene County; 181-NW; 682,400N., 2,900,000E. Copper Ridge-Chepultepec formation.

R. P. Johnson: Greene County; 181-NE; 673,500N., 2,931,400E.

Roberta Johnson: Greene County; 181-NE; 675,000N., 2,933,000E.

Naff (Rader): Greene County; 181-NW; 650,300N., 2,896,300E.

Neas: Greene County; 181-SW; 620,800N., 2,912,300E.

WATAUGA: Carter Conuty; 198-SE (King, Ferguson, Craig, and Rodgers, 1944; Secrist, 1924). No mines have ever existed in this area. The prospects on the Watauga River near Elizabethton are sphalerite and galena in the Honaker formation, associated with an anticline and minor shears.

Prospects

Watauga Point: Carter County; 198-SE; 728,500N., 3,099,000E.

Carden (Lyons): Carter County; 198-SE; 733,200N., 3,101,500E.

BUTLER: Johnson County; 214-SW (King, Ferguson, Craig, and Rodgers, 1944). This district consists of several minor occurrences of red sphalerite in the Shady dolomite.

Prospects

Daugherty: Johnson County; 214-SW; 730,000N., 3,196,300E.

Dugger: Johnson County; 214-SW; 721,500N., 3,193,000E.[3]

Wagner: Johnson County; 214-SW; 727,400N., 3,195,000E.

FALL BRANCH: Greene and Sullivan Counties; 189-NE, 189-SW, 188-SE. Mineralization in this district consists of sphalerite and barite in the upper Knox dolomite. Although a shaft was sunk at Fall Branch, no ore was ever produced (Secrist, 1924).

[1] Lead also present.
[2] Chiefly iron; showings of zinc.
[3] Approximate.

Mines

Fall Branch: Sullivan County; 189-NE; 762,500N., 2,995,800E.

Prospects

Horse Creek: Sullivan and Greene Counties; 189-NW, 189-NE; 770,000N., 2,985,000E.[1]

Dobbins: Greene County; 189-SW; 726,200N., 2,964,200E.

Jearoldstown: Greene County; 189-SW; 735,000N., 2,971,500E.[1]

Bowman: Sullivan County; 188-SE; 816,000N., 3,026,500E.[1]

POWELL RIVER: Claiborne and Union Counties; 145-SW, 145-SE, 145-NE, 153-SW, 154-NW, 154-NE. Mineralization in this district is sphalerite, galena, and pyrite. Formations mineralized include the Maynardville, and all of the Knox, but chiefly the Copper Ridge dolomite. The Kings Bend and Bunch Hollow mines operated briefly in the late 1930's and early 1940's and are estimated to have produced a total of 800 tons of zinc-lead concentrates (Kent, Rodgers, and Laurence, 1946). However, the largest mine in the district, the New Prospect mine, is in the Maynardville limestone; it is estimated to have produced 60,000 tons of concentrates (Kent and Rogers, 1945; Safford, 1869; Secrist, 1924; Nason, 1915a, 1915b, 1917). In addition to these 3 mines, 91 prospects are known. Of these, 8 contain only pyrite or limonite, and 6 only galena.

Mines

Kings Bend: Claiborne County; 153-SW; 775,500N., 2,690,500E.

New Prospect: Union County; 145-NE; 737,300N., 2,635,800E.

Bunch Hollow: Claiborne County; 154-NW; 754,000N., 2, 665,100E.

Prospects

The 91 prospects referred to above are located along the strike of the Powell anticline from Tennessee coordinates 783,000N., 2,630,000E. to 720,000N., 2,710,000E., an area of approximately 11 miles by 15 miles. (For details, see Kent and Rodgers, 1945.)

COPPER RIDGE: Hawkins, Hancock, and Grainger Counties; 154-SE, 162-NW, 162-SW, 162-NE, 171-NW, 171-NE.

Mines

Flat Gap: Hancock County; 171-NW; 752,900N., 2,811,600E. (Under development, 1956.)

Prospects

Washburn: Grainger County; 154-SE; 703,800N., 2,708,500E.

W. S. Mallicoat: Grainger County; 154-SE; 718,300N., 2,735,000E.

Thorn Hill: Grainger County; 162-SW; 727,100N., 2,756,800E.

Idol (Comstock): Grainger County; 162-NW; 732,500N., 2,764,500E.

Dalton: Grainger County; 162-NW; 736,100N., 2,771,500E.

L. L. Mallicoat: Grainger County; 162-NE; 741,500N., 2,781,200E.

Davis: Hancock County; 162-NE; 746,500N., 2,800,500E.

Lee Valley: Hawkins County; 171-NW; 767,200N., 2,838,500E.

Shiloh: Hawkins County; 171-NE; 775,350N., 2,852,600E.

E. J. Lee: Hawkins County; 171-NE; 780,100N., 2,860,700E.

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[1] Location generalized.

EVANSTON: Hancock County; 161-SE, 162-NE. Sphalerite occurs as replacement veinlets and disseminated flakes in dolomites of the Rome formation. A mill was constructed in 1917 and an unsuccessful attempt made to mine zinc from these deposits. Low tonnage and grade resulted in failure. (Secrist, 1924, p. 53)

Prospects

Keaton: Hancock County; 161-SE; 782,100N., 2,787,600E.
Brewer: Hancock County; 161-SE; 784,100N., 2,794,000E.
Livesay: Hancock County; 161-SE; 784,000N., 2,796,200E.
Purkey: Hancock County; 161-SE; 784,600N., 2,796,800E.
Givens: Hancock County; 161-SE; 784,700N., 2,800,000E.
Dodson: Hancock County; 162-NE; 770,000N., 2,787,300E.
Lamb: Hancock County; 162-NE; 770,500N., 2,790,500E.
Green: Hancock County; 171-NW. Location uncertain.

STRAIGHT CREEK: Claiborne County; 154-NW, 164-NE. Sphalerite and minor amounts of galena occur as veinlets and replacement masses in the Maynardville limestone. The Wallen Valley Fault seems to have controlled the mineralization.

Mines

Straight Creek: Claiborne County; 154-NW; 735,500N., 2,693,800E. The Straight Creek mine was opened in the 1880's and was worked intermittently. No production records are available. (Secrist, 1924)

Prospects

G. L. Phelps: Claiborne County; 154-NW; 736,700N., 2,696,300E.
Jones: Claiborne County; 154-NE; 740,200N., 2,699,400E.[1]
Jennings: Claiborne County; 154-NE; 749,200N., 2,707,500E.[1]
Bunch: Claiborne County; 154-NW; 730,500N., 2,685,200E.[1]

CENTRAL BASIN

Mines

Holt: Williamson County; 70-NW; 568,400N., 1,791,000E. Lead, barite, fluorite, and zinc. Shipped 10 tons of lead in World War I. Shafts: early mine.

Hoover: Cannon County; 319 (15-minute quadrangle); 533,000N., 1,955,-800E. Zinc, barite, and lead. Mill; 1,350 tons of zinc by 1945.

Prospects[2]

Bell-Orren: Rutherford County; 315 (15-minute quadrangle); 560,000N., 1,916,400E. Fluorite, barite, lead, and zinc.

Carter: Cannon County; 319 (15-minute quadrangle); 531,000N., 1,955,500E. Zinc and barite.

Paschal: Cannon County; 319 (15-minute quadrangle); 515,000N., 1,957,-800E. Zinc.

Wilder Hollow: DeKalb County; 319 (15-minute quadrangle); 656,000N., 2,015,200E. Fluorite, barite, lead, zinc, and pyrite.

Terry: Smith County; 322 (15-minute quadrangle); 640,500N., 1,991,200E. Fluorite, barite, lead, and zinc.

[1] Approximate.
[2] No production. Minerals arranged in order of abundance.

Brown: Wilson County; 313-SE; 690,800N., 1,929,200E. Barite, fluorite, lead, and zinc.

Dillard: Wilson County; county highway map; 688,300N., 1,931,000E. Fluorite, barite, lead, and zinc.

Medling: Wilson County; 319 (15-minute quadrangle); 570,500N., 1,945,-000E. Barite, fluorite, and zinc.

Knight: Wilson County; 319 (15-minute quadrangle); 577,200N., 1,938,-000E. Zinc and lead.

Robinson: Wilson County; 319 (15-minute quadrangle); 581,500N., 1,941,-500E. Zinc.

Seven Mile Bluff: Trousdale County; 313-SE; 712,200N., 1,920,500E. Fluorite, barite, lead, dark zinc, and pyrite.

Beasley Bend: Trousdale County; county highway map; 714,800N., 1,936,-200E. Fluorite, calcite, barite, lead, and zinc.

Heard: Pickett County; 329 (15-minute quadrangle); 787,250N., 2,927,-000E. Barite and zinc.

Hagan: Pickett County; 333 (15-minute quadrangle); 782,500N., 2,925,-000E. Chalcopyrite, zinc, and pyrite.

Baker: Davidson County; 307-SE; 713,000N., 1,774,300E. Lead, fluorite, and zinc.

ISOLATED PROSPECTS AND OCCURRENCES[1]

Friendsville: Blount County; 138-SW; 512,000N., 2,553,500E.[2]
Lost Creek (Rhodelia): Union County; 145-SW; 701,900N, 2,606,200E.
Fairgarden: Sevier County; 164-NW; (a) 553,000N., 2,764,700E.
(b) 552,200N., 2,770,000E.
Fairgarden: Sevier County; 164-NW; 552,200N., 2,770,000E.
Hambright: Bradley County; 120-NE; 309,500N., 2,372,200E.
Hardwick: Bradley County; 120-SW; 260,000N., 2,325,500E.
Eve Mills: Monroe County; 131-NE; 459,500N., 2,500,300E.
Willis: Cocke County; 173-NE; 559,000N., 2,875,700E.
Maryville: Blount County; 148-NW; 497,700N., 2,601,400E.
Moore: Anderson County; 137-NE; 637,500N., 2,576,000E.
......: Union County; 146-NW; 663,200N., 2,621,000E.[1]
Nuns Cove: Sevier County; 164-NW; 550,000N., 2,769,300E.
Little Mountain: Sevier County; 164-NW; 552,000N., 2,770,000E.
Owl Hole Gap: Grainger County; 155-NE; 679,000N., 2,712,500E.[1]
Beech Grove: Grainger County; 162-SW; 728,200N., 2,744,800E.[1]

REFERENCES[3]

Bridge (1945); Hook (1950); Kent and Rodgers (1945); Kent, Laurence, and Rodgers (1945); Kent, Rodgers, and Laurence (1946); King, Ferguson, Craig, and Rodgers (1944); Nason (1915a, 1915b, 1917); Oder (1945); Rodgers (1948); Safford (1856, 1869); Secrist (1924).

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[1] Occurrences are indicated by this footnote; all others are classified as prospects.
[2] Approximate.
[3] For complete citations, see Tennessee Division of Geology Bulletin 59.