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Appendix B

The Classification of the Nonferrous Metal Mining Industries

THE BASIC sources, and the methods employed in the construction of our indexes of production and employment are set forth in notes to the tables in Appendix A. In some cases, however, special difficulties of measurement were encountered, and these call for more extended treatment. Accordingly we shall discuss in this appendix certain peculiarities of the more important nonferrous metal mining industries, i.e. of those industries in which gold, silver, copper, lead and zinc—singly or in combination—predominate in value.

Industrial Classification

With the exception of the decennial Censuses of mining industries, physical output data for minerals are collected on a commodity, rather than on an industry, basis. In most types of mining a single commodity rather adequately defines a mining industry, and where this is the case no difficulties of classification arise. The nonferrous metals mentioned are peculiar, however, in that it is impossible to identify total production of any one of them with the output of a single mining industry.

Let us take copper, for example. The total production of copper from domestic ores is not synonymous with the output of the copper mining industry. For copper comes from gold and silver mines (among others), while copper mines produce other minerals besides copper. It happens that the major portion of our supply of nonferrous metals originates in mines in which a combination of metals is found.

For Census purposes a mine is classified according to the metal that contributes the largest share to the value of its products. Thus a copper mine would be one in which copper is the predominant metal; and the Census statistics for the copper mining industry would include all of the products issuing from this mine, and copper employment data would include all of the men engaged in bringing forth these products. Obviously, the metal that predominates at one time may not be the chief product at another time, so that the industrial classification of a given mine may alter.[1]

Census statistics are available for a few years only, and at best are

[1] ". . . the classification of individual mines [changes] from time to time, because of price changes and because the relative proportion of metals contained in the ores of many mines is different in different parts of the mines in ores mined at different

valuable as a check or to provide auxiliary information. Our problem is to take the commodity output data collected annually by the Bureau of Mines and available in *Minerals Yearbook,* and to arrange them in a manner that will make them as comparable as possible with the employment data found in the accident bulletins which are also published by the Bureau of Mines. The latter are presented on an industry basis, the classification being made according to the metal of predominant value. As a result, employment falls into three groups: (1) copper mines; (2) lead and zinc mines in the Mississippi Valley, including fluorspar mines in Illinois and Kentucky; (3) miscellaneous metal mines, including the remaining lead and zinc mines, gold and silver mines, and mines where certain minor metals are produced. The problem of fitting production data to these categories may be considered next.

Detailed data on the distribution of nonferrous metal production among the several metal mining industries, as classified by the Census, are available only for 1929. They are presented in Tables B-1 and B-2. In 1929, in the copper industry, copper contributed 93.0 percent of the total value of products; and, what is more significant, 99.2 percent of

TABLE B-1
NONFERROUS METAL MINES
Distribution of Products, by Industry, 1929

		Copper Industry	*Lead Industry*	*Zinc Industry*	*Gold (lode) Industry*	*Gold (placer) Industry*	*Silver Industry*
Mine value of products	$ thousand	283,517	67,562	44,866	17,650	3,779	8,457
	percent	100.0	100.0	100.0	100.0	100.0	100.0
Mine value of copper, lead, zinc, gold and silver	percent	99.5	97.0	97.7	95.7	99.8	98.6
Copper	"	93.0	2.0	1.0	.7	0	2.6
Lead	"	.5	71.8	17.0	.4	0	9.6
Zinc	"	.9	11.2	77.7	b	0	8.0
Gold	"	2.4	1.7	.6	91.6	99.8	12.3
Silver	"	2.7	10.3	1.5	3.0	b	66.1
Value of other products[a]	"	0.5	3.0	2.3	4.3	0.2	1.4

Source: Fifteenth Census, "Mines and Quarries, 1929," p. 291.
[a] These include manganese, pyrites, cadmium, platinum; and custom milling.
[b] Less than 0.05.

times. Thus, certain large enterprises classified as copper mines for the year 1909 were classified as lead and zinc mines for 1919, and some mines which are essentially zinc mines were classified as silver mines for 1919 when, on account of the low price for zinc and the high price for silver, only the ores richer in silver could be profitably mined." *Fourteenth Census,* Vol. XI, "Mines and Quarries, 1919," p. 355. The quantitative effect of such shifts cannot be determined. However, the broader the classification adopted, the less is the importance of statistical migration of enterprises from one industry to another.

all copper was produced in copper mining establishments. The latter figure indicates that for comparisons of output and employment it is safe to present statistics for total copper production as representing copper produced in the copper mining industry.

TABLE B-2

NONFERROUS METALS
Distribution by Industry, 1929

		Copper	*Lead*	*Zinc*	*Gold*	*Silver*
Mine value of metal from all sources	$ thousand	265,885	58,390	45,577	29,255	21,336
	percent	100.0	100.0	100.0	100.0	100.0
From copper mines	"	99.2	2.3	5.5	23.4	35.6
From lead mines	"	0.5	83.1	16.6	4.0	32.6
From zinc mines	"	0.2	13.1	76.5	0.9	3.1
From gold mines[a]	"	[b]	0.1	[b]	68.2	2.4
From silver mines	"	0.1	1.4	1.5	3.5	26.2

Source: Fifteenth Census, "Mines and Quarries, 1929," p. 292.
[a] Both lode and placer.
[b] Less than 0.05.

Gold and silver are the next largest items in the total value of the output of copper mines; in 1929 they contributed 2.4 percent and 2.7 percent, respectively. (These amounts represented 23.4 percent of total gold production and 35.6 percent of total silver production.) In compiling annual series, we can allocate an approximately correct amount of gold and silver production to the copper mining industry with the help of a breakdown of gold and silver production by type of ore, available in the annual issues of *Minerals Yearbook.* Thus gold and silver derived from copper ores are treated as products of copper mining. Such a procedure is not entirely justifiable, however, from two points of view: (1) copper ores may be, and probably are, mined by establishments other than copper mines; (2) other ores such as lead-copper, lead-zinc-copper, lead-zinc, etc., all of which yield some copper, may be mined by copper mining establishments. The overstatement resulting from the first circumstance is in a measure offset by the understatement attributable to the second.[2] The remaining 1.9 percent of

[2] In an attempt to test the accuracy of allocating gold and silver production to copper mining establishments on the basis of amounts derived from copper ores, percentages were computed on the basis of ore figures and compared with the percentages shown for 1929 in Table B-2. Ore figures indicate that 27.2 percent of gold production was derived from copper ores, whereas in fact only 23.4 percent of gold production came from copper mines. Likewise, in silver, copper ore yielded 29.1 percent of total silver production whereas copper mines were responsible for 35.6 percent. Thus, the use of available data would yield only a rough approximation, with a bias, the direction of which cannot be determined. It is well to note, though, that relative to the total value of products of copper mining, the percentage of error would be negligible. An error of approximately 25 percent in a figure which constitutes 2.1 percent of the industry's value of products is of slight importance. (Figures by type of ore are from *Mineral Resources, 1929;* see also Table A-1 above.)

the copper industry's output in 1929 consisted mainly of lead and zinc, but there is no means of allocating the required amounts of these metals to the industry on an annual basis. Our series for the output of copper mining therefore consist of the nation's entire output of copper, plus such amounts of gold and silver as come from copper ores.

Lead and zinc mining are usually linked together. This is so because of the fact that the two metals are generally found in the same mineralized area. Table B-2 indicates that although only 83.1 percent of lead production was contributed by lead mines, and only 76.5 percent of zinc production came from zinc mines, lead and zinc mines together yielded 96.2 percent of total lead production and 93.1 percent of total zinc production. These figures refer, of course, to the continental United States and for this reason do not serve to indicate the varying relationships which obtain on a regional basis and which are particularly pertinent to this discussion.

Because of the nature of the ores worked, in the far western states the mining of lead and zinc is closely associated with the mining of gold and silver. In this area the mining of complex ores plays a large role, and this fact makes it unwise to adopt separate industry classifications for any of the four metals chiefly involved. In any case we have no way of breaking down the corresponding employment totals; indeed, as published by the Bureau of Mines, these are still more comprehensive and include the mining of mercury, molybdenum and other metals, as well as lead, zinc, gold and silver.

In the Mississippi Valley, on the other hand, the situation is quite different. Lead and zinc production in this region involves the extraction of nonargentiferous ores. The complex mixed ores of the far western states are not encountered here, and therefore the classification "lead and zinc mining" has real meaning when used with reference to this region.[8] For this region lead and zinc production are taken to represent a distinct mining industry. So as to secure comparability with employment, furthermore, fluorspar produced in these states is also included. For the far western states, on the other hand, the remaining lead and zinc is grouped with the remaining gold and silver to represent mixed mining in this area. To derive an index for comparison with employment all other nonferrous metals must also be included. This makes "mixed ore mining" so heterogeneous in character that, in presenting indexes, we have preferred to consolidate it

[8] A breakdown of the data in Table B-2 by states shows that in Kansas, Missouri, Oklahoma and Wisconsin (the only Mississippi Valley states listed separately by the Census) 1929 production of lead and zinc came almost entirely either from lead or from zinc mines. The indexes for lead and zinc mining in the Mississippi Valley are shown in Appendix Table A-6.

with lead and zinc mining in the Mississippi Valley under the rubric "other nonferrous metals": see Appendix Table A-5.

Besides the three industrial divisions already outlined—copper mining, mixed ore mining, and lead-zinc mines in the Mississippi Valley —a fourth group, placer mines producing gold (and a little silver), may conveniently be distinguished. While the output of these mines is of course included in our comprehensive indexes (Table A-7), we were not able to assemble employment data for the industry.

Copper Mining

As explained in Chapter 12 and Appendix D, we measure output in terms of metal produced. Two series are available for this purpose: (1) smelter output of copper from domestic ores, which is available back to 1845; (2) recoverable content of copper-bearing ores mined, available only since 1906. The smelter series is superior to the mines series in that the former is a measure of actual output, whereas the latter is merely an estimate of recoverable content.[4] Besides being more accurate, the smelter figure offers the more comprehensive figure of total copper production from domestic ores, for certain lead and zinc ores and siliceous ores of the precious metals contain so little copper that the mines are not paid for it and do not report it. Such amounts are included in smelter, but are omitted from mine, output.[5] Against this, it must be noted that the mines figure is superior to the smelter figure with respect to its time reference. A period of perhaps three months is consumed by transportation from mine to smelter, and by the operation of smelting; and since stocks of ore and concentrates vary from year to year, smelter output may exceed, or fall short of, mine output. Both series represent practically complete coverage, at least in the case of copper.[6] We have chosen to use the mine output series, for copper and other nonferrous metals since 1906, but have resorted to smelter figures for years prior to that date (Table A-1). Similarly, the mine output of gold and silver from copper ores is allocated to the industry for years since 1906.

All these products have to be valued in order that physical output

[4] It should be remembered that the mines figure does not refer to copper content of ore. Rather, it takes into account estimated losses in milling and smelting. These losses are calculated on the basis of past experience and the estimates are, therefore, probably quite accurate. This method of estimation is used not only in the case of copper but also for the other metals to be discussed.

[5] U. S. Bureau of Mines, *Mineral Resources, 1930,* Vol. I, pp. 701-02. However, such amounts would probably not be considered part of the product of the copper mining industry.

[6] Y. S. Leong, "Statistics on Copper in the United States," *Journal of the American Statistical Association,* Vol. 31 (Dec. 1936), p. 665.

series may be combined. The value of products shown in Table A-2 for copper mining is derived from Census sources and represents net value at the mill. This is equivalent to the smelter value of the mineral minus the cost of transporting the ores and concentrates to the smelter, and minus all smelter charges (estimated, if the smelter is owned by the mine).[7] The determination of unit mine values for individual products of the industry involves the allocation of joint costs and is difficult to carry out. However, the Bureau of the Census made such estimates for the year 1929, and these are reproduced in Table B-3.[8] Since we have to use market prices (Table A-1), which are roughly equivalent to smelter values, in combining individual products within each industrial division, it is evident that (if the relationships of Table B-3 are representative of other years) our procedure overweights silver in relation to copper and gold, and copper in relation to gold. However, in combining the output of copper mining with the output of other industries, we used the mine values shown in Table A-2.

TABLE B-3

COPPER MINING
Mine and Market Values Compared, 1929

Unit Values		*At Mine*[a]	*At Market*[b]	*Ratio of Value at Market to Value at Mine*
Copper	$ per lb.	0.136	0.176	1.29
Gold	$ per fine oz.	17.39	20.67	1.19
Silver	$ per fine oz.	0.354	0.533	1.51

[a] *Fifteenth Census,* "Mines and Quarries, 1929," p. 292.
[b] *Minerals Yearbook;* see Table A-1 above.

Lead and Zinc Mining in the Mississippi Valley

As already explained, the segregation from mixed ore mining of lead and zinc mining in the Mississippi Valley states (Arkansas, Iowa, Kansas, Kentucky, Missouri, Oklahoma, Tennessee, Wisconsin and Illinois) has for its purpose the utilization of the corresponding breakdown available in the data for employment.

As in the case of copper, so with lead and zinc we have a choice be-

[7] *Fifteenth Census,* "Mines and Quarries, 1929," pp. 288-89.

[8] The mine value of the products of any mine was computed as indicated above. In general, this total was apportioned among individual products according to percentages of total smelter value contributed by each. However, if the individual mine was able to report actual costs attributable to each metal, these figures were accepted by the Census.

tween series for mine and for smelter output.[9] Again, we have chosen the mine output series, which measures recoverable content of ore and concentrates. Mine output is in the case of these two metals a superior measure, since it includes sizable amounts of lead and zinc used directly for pigments which never find their way to the smelter. In addition, we are forced to use mine rather than smelter output in allocating production on a regional basis;[10] consequently the segregation of the output of lead and zinc mining in the Mississippi Valley from the output of the remaining nonferrous industrial division, mixed ore mining, can be achieved only for years since 1906.

As with copper mining, the mine value of products shown in Table A-2 is derived from Census sources. Moreover, for 1929 we can make a comparison of mine and smelter unit values as estimated by the Bureau of the Census. It is plain that the use of market prices to weight the two metals, which is forced upon us by lack of data on mine value in other years than 1929, overweights zinc in relation to lead (Table B-4). In combining the industry with others we are, however, able to use the mine values in Table A-2.

TABLE B-4

LEAD AND ZINC MINING (MISSISSIPPI VALLEY)
Mine and Market Values Compared, 1929

Unit Values		*At Mine*[a]	*At Market*[b]	*Ratio of Value at Market to Value at Mine*
Lead	$ per lb.	0.055	0.063	1.15
Zinc	$ per lb.	0.036	0.066	1.83

[a] *Fifteenth Census,* "Mines and Quarries, 1929," pp. 292-93. Data relate only to Kansas, Missouri, Oklahoma and Wisconsin, which are the more important Mississippi Valley states.
[b] *Minerals Yearbook;* see Table A-1 above.

The Bureau of Mines employment series (Table A-4) include workers engaged in mining fluorspar in Illinois and Kentucky. (Fluorspar is classed as a nonmetallic mineral and is used mainly as a fluxing agent in the manufacture of steel.) Consequently our production data for lead and zinc mining in the Mississippi Valley, as well as for wider indus-

[9] Although the term smelter output is used in connection with lead, the data actually refer to refinery output. Also, the data for mine output (recoverable content) allow for refining as well as for smelting losses (*Mineral Resources, 1923,* Vol. I, p. 134). In these respects the data for lead differ from the data for copper and zinc.

[10] State data for the smelter series are not available after 1931. In any case, "details of the geographic distribution of output are shown more precisely by statistics of mine production than by those of smelter and refinery production" (*Mineral Resources, 1930,* Vol. I, p. 701).

trial groupings which include this industry (Table A-5), have been computed so as to include the output of fluorspar in these two states.

Mixed Ore Mining

This division contains two distinct groups of mines: enterprises in the western states producing gold, silver, lead and zinc, mainly from argentiferous ores; and lead and zinc mines in the eastern and southeastern states that lie outside the Mississippi Valley. It is thus rather heterogeneous, and in fact indexes are not shown separately for mixed ore mining, but only for nonferrous mining other than copper—a group in which lead and zinc mining in the Mississippi Valley and mixed ore mining are combined (Tables A-3 and A-5). Mixed ore mining furnishes all gold and silver produced outside the copper industry and apart from placer operations. Together with Mississippi lead and zinc, it includes all lead and zinc production. At the same time it excludes copper entirely.[11] As in former cases, the breakdown of mine output is

TABLE B-5

MIXED ORE MINING
Mine and Market Values Compared, 1929

Unit Values		At Mine[a]	At Market[b]	Ratio of Value at Market to Value at Mine
Gold	$ per fine oz.	17.39	20.67	1.19
Silver	$ per fine oz.	0.354	0.533	1.51
Lead	$ per lb.	0.038[c]	0.063	1.66
Zinc	$ per lb.	0.028[c]	0.066	2.36

[a] *Fifteenth Census,* "Mines and Quarries, 1929," pp. 292-93.
[b] *Minerals Yearbook;* see Table A-1 above.
[c] Data relate to all states except Kansas, Missouri, Oklahoma and Wisconsin. It is not possible to exclude other Mississippi Valley states.

available only for years since 1906. Prior to 1906 it is necessary to rely on smelter output for each of the metals concerned. Once again, market values must be used to weight the various constituents of the output index for the industry, while this index can then be combined with those for other industries on the basis of the mine values given in Table A-2. It is evident from Table B-5 that this procedure overweights zinc and underweights gold; but no alternative is available.

[11] Not all copper comes from copper mines, and the copper mining industry yields sizable amounts of lead and zinc. Since it is impossible to allocate these amounts, except for 1929, we are compelled to assume that copper mines produce all of the copper and none of the lead and zinc obtained domestically. Hence mixed ore mining yields none of the copper but does supply (together with Mississippi Valley mines) all of the lead and zinc.

Placer Gold Mining

As in the other divisions of nonferrous metal mining, the two products of this industry—gold and a little silver—are combined by means of market prices; and this index is then combined with other industries with the help of the mine values in Table A-2. The output of Alaska is excluded. No satisfactory employment data are available. Thus the Census takes no account of itinerant individuals and of miners employing no help.[12] The exclusion of such individuals would be of little importance in other types of mining; but in placer mining this is not the case. It appears from a recent study that 28,022 individuals were engaged in 1935, in the continental United States, in the type of mining which the Census excludes. These individuals worked, on an average, 45 days a year and produced 57,557 fine ounces of gold.[13] Nor does the Bureau of Mines furnish employment data in this field. Since we have no measure of employment, the output of placer operations is omitted from the indexes in Table A-5, which seek to measure productivity. In the comprehensive indexes of output in Table A-7, however, placer mining is included.

[12] *Fifteenth Census*, "Mines and Quarries, 1929," p. 3.

[13] C. W. Merrill, C. W. Henderson and O. E. Kiessling, *Small-Scale Placer Mines* (National Research Project, Philadelphia, 1937), p. 4.