Future Economics of Metal Production*

Rate of Discovery of Mineral Deposits is Alarming when Compared with Rate of Growth of Consumption—The Outlook for the Future

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At the meeting of the Western Division of the American Mining Congress, held in Denver last September, papers were read by F. H. Brownell, a vice-president of the American Smelting and Refining Co. and chairman of its finance committee, and by H. Foster Bain, former director of the United States Bureau of Mines and now secretary of the A. I. M. E., which dealt thoroughly with certain phases of my subject. These addresses can hardly have failed to awaken serious reflection in all who listened to them; but their implications have apparently not penetrated the consciousness of bankers, economists and statesmen, whose business it is, or should be, to prepare for the economic and social changes which must inevitably follow, if the conclusions which I shall outline hereinafter are true.

In discussing this subject I wish to disclaim any intention or desire to forecast the course of the metal markets or the immediate prospects of the mining industry. The facts adduced must inevitably influence the value of metals, the activity and profitableness of mining, and perhaps also the social status of those engaged in it. But my forecasts do not refer to this year, next year, or the year after. The nearest approach to a date on which I will venture is that the relative scarcity of gold may begin to make itself felt in something like ten years from now, but its effect will not culminate for several years thereafter.

Scarcity of new gold is likely to be offset, to some extent, by increasing use of currencies based on credit; but unless it is found possible to dispense with the gold standard altogether, this can hardly prevent a great ultimate fall in commodity prices. This fall, moreover, is likely to be more severe in manufactured goods than in what are popularly termed raw materials; and most of all in those manufactured goods which are susceptible to the greatest degree to cheapening by mass production, and which are least counter-affected by increasing metal prices; by which I mean those in which the cost of metal contained forms a relatively small element in the total cost of production.

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gold; because of cheapening of prices due to invention and mass production; because of the rise of prices due to inflation of currency, war wastage, and similar factors. In the long run, however, changes in gold supply must largely control prices, as long as we measure them in terms of gold.

I do not mean that the price-index varies directly with the price of gold. We know that it is influenced by many other factors, such as those mentioned above. The world’s total stock of gold is probably in the neighborhood of a billion ounces, of which about one-third is available for monetary purposes. Of this available stock, the present annual output is only about 5 or 6 per cent; which is doubtless the reason why changes in production are reflected but slowly and indirectly in commodity prices. I do not think, however, that economists will question the statement that a fall of one-half the world’s present gold production, sustained for a period of ten years or more, will inevitably increase the purchasing power of gold and reduce the general price-level. Such a fall in output, to my mind, is certain.

It is no doubt true that increase in the purchasing power of gold will tend to increase production; but not in the same degree that higher prices increase the output of the base metals; for, among other reasons, gold-mining is an industry which is fostered largely by the gambling spirit and by its romantic glamour. On the other hand, relative appreciation of gold does not tend to augment the stock of money from the stock hoarded or used for ornament. Indeed, experience proves the contrary to be true; as scarcity of money becomes felt, gold goes into hiding, and when gold is urgently needed by a state, forcible confiscation becomes necessary.

It is highly probable that in the United States and the British Dominions, the use of currencies based on credit will be extended; yet in view of the enormous further demands for money which may be expected to result from the development of the United States and the British Empire, it is not reasonable to expect that the amount of gold required to form a safe reserve behind their currencies will diminish. Credit currencies are possible only in highly civilized countries, where public confidence in government is complete. They can hardly be used to advantage in countries like China or India for generations to come. And even in the United States, while credit currencies function perfectly in normal times, it is backed by a 40 per cent gold reserve, and no prudent financier will consider dispensing with this metallic backing. So that, while the gold may never actually be needed, it must be provided and reserved for possible times of financial stress. Credit currency at best does not enable us to dispense with gold altogether.

2. Previous wars have always resulted in higher commodity prices, followed eventually by a fall, often to lower levels than those preceding the war.

The recent great war caused the former, but the latter has not yet followed. In my view, it has been delayed only because of the exceptional scale and the universality of the war, and because of the fact that the inflation of currencies, inevitable in great wars, still exists, and prevents commodity prices from reaching their normal level.

3. Unlike all other commodities, minerals are limited, and exhaustible. Excepting in geological time, there can be no second crop. Metals are the earliest natural resources to be developed, following discovery of new countries. Major mineral fields are readily discovered and have usually been noted by the early explorers, because (as to the metals known to the ancients) the aboriginal inhabitants knew of them, and in a limited way made use of them.

One of my earliest recollections is of being taken to a lecture by Commander Cameron, the first white man to cross Africa. At that lecture Commander Cameron vividly described the copper outcrops of the Katanga region, and prophesied that the latter would eventually become the main source of the world’s copper supply. If I remember rightly Cameron afterward became a director of one of Robert Williams’ companies, organized to develop the Katanga; and it must be thirty years or more since Williams started in earnest to exploit this region; so long does it require to bring a new mining region, in a new country, to the productive stage.

Somewhat later I remember when Claude Vautin, who had just returned from South America, described what must have been the copper deposits at Chuquicamata, and endeavored, without success, to interest European financiers in their development.

What with such instances as these, and my recollection of the accounts I used to hear concerning the discoveries at Broken Hill, Anaconda and Sudbury, the first wild rumors concerning the Bawdwin, the continual increase in tin shipments from Banca and Malaysia, the first shipments of tin from Bolivia and so forth, it seems to me that the last ten years have been relatively without important mineral discoveries. As I now see it, my early years were clouded by the expectation of progressively lower metal prices, and my whole life has been a struggle between rising costs and falling prices. My argument now is that the prospects for the future, taken as a whole, are diametrically opposite.

4. It takes a long period, averaging a generation, after an important mineral field is first known, before it attains maximum production; excepting in the case of alluvial deposits.

Cripple Creek, which reached maximum production in half that time, was an exception, due to special local conditions, among which may be mentioned its exceptional accessibility, a surplus of highly skilled labor and a great competitive smelting industry ready to treat the production at low rates.

5. Gold, tin, lead and copper were the earliest metals known to man, for obvious reasons. Gold and tin are first exhausted, because they are relatively insoluble, and form alluvial deposits, easily found, readily and rapidly worked to maximum output, and permanently exhausted. Of the gold fields known to the ancients, nearly all were completely worked out in ancient times. Commercial placers will become a thing of the past at no distant date; and the output of gold and tin must come exclusively from deposits in place. Lead is geologically a surface metal and therefore relatively soon exhausted.

The zonal theory of ore-deposition has been worked over-time of late years, and in my opinion the elaborate orders of succession claimed by W. H. Emmons and by J. E. Spurr have not been supported by sufficient evidence to constitute proof. It seems clear that the host rock has some influence on the character of the ore deposited in it. There are many cases in which the self-same fluid occasioned the deposition of silicious ores of gold and copper in silicious rocks, and of lead-zinc-pyrite in limestones and calcareous shales nearby, under conditions which preclude our attributing the differentiation solely or mainly to varying temperatures. It is, therefore, dangerous to base generalizations as to zonal distribution solely on recorded distance from a parent batholith, without allowing for differences in the containing rocks and perhaps other variable factors.
There is, however, certainly some tendency to zonal arrangement; and the successions of copper-tungsten-tin in Cornwall, and of lead-zinc-copper elsewhere, recorded by a host of observers throughout several generations, are certainly true in a general way. These theoretical considerations, together with universal experience, and the fact that the products from oxidation of lead sulphide ores are relatively insoluble, all point the same way, namely—that lead deposits are likely to show at their best near surface, and to be relatively short-lived in depth.

Outside of the United States the chief lead-producing countries, during historical times, were Spain and Great Britain. My brother, the late Henry F. Collins, one of the best authorities on both countries, considered that neither of them was likely ever to increase its production materially, or even to continue its average past output for an indefinite period.

Our own principal lead districts are Southeastern Missouri and the Cœur d'Alene. The mines of the latter district are getting very deep and presumably will have seen their best days in ten years' time, if they have not done so already. I have no personal knowledge of Southeastern Missouri, but the best information I can obtain is that the richer areas will not last ten years. The low-grade areas, I am told, are very extensive; but in order to maintain the present rate of production, higher prices will be necessary.

The same is true of the great Tri-State region, our chief source of zinc. I think there is every reason to conclude that the future lead and zinc output of the world must come mainly from the complex ore deposits, such as the Sullivan in British Columbia, the Bawein in Burma, Broken Hill in New South Wales, and Ridder in the Altai. Our Rocky Mountain States contain a host of such deposits, but mostly of relatively small size. These constitute in the aggregate a large source of lead and zinc, but most of it will not be produced until the inevitable increases in prices arrive.

It is, I think, safe to prophesy that, in the long run, the more complex ores, of greater aggregate gross metal value, will be worth more than the simpler ores which are now preferred, and are at present more profitable. There are so many chemical processes already invented, apparently based on sound principles, which lack practical application because of the absence of some minor chemical reaction, adjustment or mechanical aid that an imaginative mind can hardly avoid the conclusion that one or more of these will ultimately achieve entire success. When that time comes, the large bodies of complex ores will become the sensational bonanzas of the world.

It is obvious from my general argument that there must eventually be higher prices for all metals. Nevertheless, I look for the final rise in tin to come before that in lead; and lead in turn to advance considerably before zinc; because it seems to me that known sources of zinc will be less soon exhausted, and moreover improved metallurgy may be expected to exert a cheaper influence on zinc more than on lead.

6. There has been a relative, and rather disquieting, paucity of mineral discoveries, of the first rank, throughout the world, during the last generation; from which we might expect to supply the requirements of succeeding generations. This applies particularly to gold, tin, and lead. Moreover, the unexplored areas are becoming relatively restricted. It is hardly possible that future discoveries of these metals, if made immediately, could become productive in time to relieve the impending scarcity.

The chances of the discovery of extensive deposits, heretofore unknown, are greater in the case of some minerals than others. Iron, for instance, while easily recognized, is so widely distributed that its occurrence in quantity may have been ignored because the needs of older civilizations were supplied from small deposits, and many savage races could not use it at all. Such minerals as bauxite or chromite, on the other hand, were of no value whatever until the progress of modern metallurgy made uses for them, and they would naturally escape the observation of former generations. But this is not true of the metals which I am particularly considering in this paper—of tin, lead, copper, silver, gold, and is only partly true of zinc.

It would seem to be a corollary to the above that the world must rely for its future supply of metals on small or lean deposits, heretofore uncommercial; and that the world will have to pay for the metals prices sufficient to render their working profitable.

It is reasonably certain that the present tendency toward increasing metal consumption on the part of civilized nations will continue and increase; and probable that it will extend to those races which we term semi-civilized and uncivilized.

7. Modern material civilization is based essentially on minerals. It requires no more food or clothing; its characteristic needs are metals and power, the use of which grows in geometric ratio. All modern nations are becoming Americanized, yet if other civilized races should demand one-half as much metal, per individual, as the people of the United States, or if the awakening peoples of India or China should demand one-tenth as much metal as those of Europe now do, it would be impossible to fulfill their requirements, without enormous increases in production, at correspondingly increased prices.

Both China and India are relatively poor in metals, excepting as to iron, in the case of India. I have said above that as the individual rises in the scale of civilization he needs no more food or clothing. Indeed, as the relative importance of physical labor decreases, and as homes and working places become better warmed, it is probable that the average individual will tend to use less rather than more. Moreover, with increased knowledge of the chemistry of soils and of the possibilities of stimulation of growth by physical methods, it is to be expected that soils will become more productive.

8. The so-called "common" metals can, to some extent, replace one another, for many purposes; but taken as a group they are at once not susceptible of replacement, yet essential to civilization of the modern type. Many of their most important uses are destructive, so that there can be little or no salvage.

9. The progress of invention in mining and metallurgy, during the last two generations, was exceptionally rapid; probably more so than in most other industries. Copper mining, as we have it in the United States, is possibly the most efficient of all industries. But for several years there has been, in our field, a relative paucity of those basic discoveries which fore-run new inventions, by the aid of which we might expect to cheapen future production, to the same extent as it has been cheapened heretofore.

10. Geologically speaking, tin, lead and zinc occur in the crust of the earth in small quantities; less, in fact, than in the case of some of the "rare" metals.

11. The world's available resources of tin will be largely exhausted in ten years.

G. Temple Bridgman has shown in a recent paper before the Mining and Metallurgical Society that the world's tin
alluvials will be practically exhausted in about ten years' time, and the richer Bolivian lode deposits cannot be expected to last much if any longer. Increasing scarcity of tin must result in a greatly increased price, or compel the use of substitutes. Indeed, it seems probable that there may be a further rise in price before the ten-year period has elapsed, in anticipation of the approaching exhaustion of the major known sources of supply. Of lead and zinc the present rate of output can be maintained somewhat longer, from known deposits, but only at increased prices, to compensate for the working of leaner deposits. It is hard to see how increased demand for lead, to correspond with the output curve of the last thirty years, can be met indefinitely, at any reasonable prices. Of copper, coal and iron, in the order given, the world's known resources will last over much longer periods.

12. The Transvaal has produced approximately half of the world's gold, for the last 20 years. Its production will drop 25 per cent in about 5 years' time; 50 per cent in 10 or 12 years; 75 per cent in 15 years.

The above estimates are based mainly on Sir Robert Kotze's reports, but allow for probable new mines, especially in the Far East Rand. They do not anticipate increased production, due to lower costs or improved extraction. I do not see how the former can be expected, because the recruiting areas for native labor are becoming exhausted, and its cost, owing to saturation with those things, the desire for which induces the native to work, is more likely to increase than to fall. As to extraction, even if further metallurgical improvements succeed in squeezing out an additional 2 or 3 per cent of the gold content, its effect on output will be almost negligible.

What can take the place of the Transvaal? There is no reasonable possibility of the discovery of new gold fields, of comparable importance, in time to make up the deficiency.

13. The gold production of the United States is approximately equal to (or rather less than) its consumption in the same country for commercial purposes only, leaving no surplus for use as reserve for currency.

14. The recommendations of the Royal Commission on Indian Currency contemplate the eventual sale of the Indian stock of coined rupees (equivalent to about 700 million ounces of silver, or approximately three years' production for the entire world, at the present rate), and the purchase of an equivalent amount of gold, as a currency reserve. Opinions differ as to the immediate danger from this policy, which may be delayed or modified, because of the influence of European and American financiers, who dread the effect of dumping such huge stocks of silver on the market, and the disturbances which may follow the withdrawal of so much gold. Yet whatever plans are adopted, more or less gold will be necessary to stabilize Indian exchange for external commerce, and the commercial and industrial classes in India, backed by the Indian politicians, are determined to effect this.

15. During the last fifteen years the increasing prosperity of the peoples of India has enabled them to hoard, in addition to the silver which has been absorbed there for hundreds of years, large quantities of gold, increasing irregularly, until in 1925, the last year for which figures are available, Indian gold imports, according to the circular issued by the National City Bank of New York for September, 1926, were one-half the total production of the world.

16. In the present temper of the nations of the world, it seems more than ever before hopeless to propose an international medium of exchange, based on mutual confidence. We are compelled more than ever to regard gold as the only feasible means of paying international balances, and the principal if not the only medium by which national currencies can be stabilized.

The statement that the world's metal resources—with the exception of aluminum and possibly of iron—seem destined to become exhausted within a relatively short period, is almost a truism; yet it is one which has hardly penetrated the intelligence of the average man, who is equally unaffected by the obvious conclusion that long before exhaustion actually occurs, and when demand first begins to outstrip supply, great differences in price-levels must be expected.

It is, I believe, a principle of economics that the price of any commodity is fixed by the cost of production of the highest-cost producer, whose product is necessary to supply the demand. From this principle it would seem to be a fair deduction that when demand tends to increase rapidly, and when on the other hand it necessarily requires a long time to bring new production into existence, there is grave danger of a runaway market.

Moreover, metal prices have heretofore assumed virtually the levels corresponding to production costs of commodities, the production of which may be extended indefinitely at the same, or a decreasing cost, in which case the value tends to conform to the minimum cost of production. They have, in fact though not in theory, been produced just as if the ultimate supply had been unlimited. Hereafter, prices will tend rather to conform to monopoly values, wherein the profit which may be exacted by the owners is limited (in theory) only by the demand; which in our case is likely to increase indefinitely.

The situation of the metal-consuming industries, between the miner and the general public, might be compared to that of a speculator in stocks, who has sold "short." As a rule, there are high-cost producers, operating without profit, sufficient to ensure a surplus supply, which keeps prices down. These high-cost producers might be compared to those owners of stocks whose necessities may be depended on to ensure that there shall always be a considerable amount of the stock on the market. But if, in the case of a stock, there are no sellers who wish to sell, and if dealers have contracted to deliver the stock, there is practically no limit to the price they may have to pay. Similarly with metals, it takes a long time to get new production of consequence into existence; and if a time comes when all existing production has become completely absorbed, there is no limit to the price which the metal-consuming industries may temporarily have to pay, or themselves go out of existence. Realization of this may be one reason why we have seen so many metal-consuming concerns acquiring mines on which they depend.
Convinced as I am that world prices in general are still affected by war inflation, and that increasing pressure from limited supply of basic raw materials is sure to cause them to advance in value, even apart from the special considerations which I have advanced as to metals, I find it impossible to resist the conclusion that the spread between cost of raw materials and final prices to consumers must be reduced, and that therefore the profits of manufacturing and trading will be materially lessened.

I do not know what proportion of the world’s earnings now comes to the miner. I doubt whether any data exist which can form the basis for computation. But it is obvious that the proportion will increase very rapidly hereafter, until the non-ferrous metals become exhausted. The dependence of civilization on metal output will become increasingly apparent, and on the other hand metals will become scarcer and higher-priced, so that the mining industry will become increasingly important in the eyes of the average man, who will be compelled to realize his complete dependence on it.

The conclusion seems inevitable that ownership of ores will become of so great importance to the community, in the not distant future, that it will confer power and influence such as has heretofore attached only to ownership of land (where land is limited, as in England), or to monopoly of other great natural resources or control of combinations of capital. One can hardly think of any other way in which a man of wealth today could more easily secure wealth and leadership for his descendants, than by purchasing and laying aside for their benefit developed orebodies in mines. Nothing else seems equally sure to increase in value, to a degree altogether disproportionate to the relation between present value and ultimate yield.

Yet it seems improbable that this tendency will be curbed by nationalization or confiscation; because it will, for the next few generations, apply only to one kind of mineral deposit. Coal and iron, the minerals which to the general public seem more essential, will not share to the same degree in the increased value of non-ferrous metals for perhaps a century or more. Tin, lead, zinc and copper will develop their Rockefeller and their Fords; mining will inevitably become fashionable, and in scattered instances it will be highly profitable; and even the mining engineer will share in the rewards of an active industry, so that one may yet see the average member of our profession equal the status of a successful automobile salesman.

But as to prices of other commodities; we have all become accustomed to the fact that there has been, for hundreds of years, a prevailing tendency for prices to increase. The fact that this actually happened during historical times is so familiar that we vaguely suppose it to result from the operation of some universal law, and that it will always continue. A little consideration will indicate, I think, that the rise in prices may have been due to special causes, which are unlikely to be permanent. In ancient and medieval times, prices were low, but the stock of gold and silver available for use as money was probably lower still. Of such goods as were in general use and were actually purchased for money, the quantities used were probably as great as now, in proportion to population.

Coincidently with the awakening of commerce, came the discovery of the Indies and of the Americas; and a flood of gold and silver began, which has continued, in a succession of waves, until the present day. It is not to be wondered that prices should have shown a rising tendency, since the discovery of America. The world, however, is finite: there are no more Indies or Americas to discover; and even the minor unknown regions of Northern Australia, of Africa and New Guinea, are being ransacked for gold. Moreover, the rise in prices has been by no means universal. Meat, malt, and wheat have become far dearer than in the Middle Ages; but most manufactured articles, as might be expected from the march of invention and the use of mechanical power, have been correspondingly cheapened.

All the attempts, so far as they are known to me, that have heretofore been made, to estimate the changes which have taken place in the commodity-price index throughout past historical periods, are vitiated, to my mind, by the fact that the same commodities were often not obtainable, or were not desired, in past times, to an equal degree. The relative weight given to each element in the series should be changed for every different period; the complexity resulting being such as to render a true comparative result almost unattainable.

The tendency toward lower prices for manufactured goods, we may anticipate, will continue and even become accelerated, if what we term civilization persists. Broadly speaking, the owner of natural resources will obtain a larger relative share of wealth; and the miner, as the producer or owner of those natural resources which are most strictly limited in supply, and the relative demand for which is most certain to expand, will ultimately occupy a favored position.

In the paper already referred to, Mr. Bain expressed the belief that the world’s requirements for metals could be met from three main sources: (a) from ores which will be rendered commercially available by improvements in technology; (b) from ores to be discovered by the use of more scientific prospecting methods, and (c) by increasing salvage of metals already used. I think I would place less relative emphasis than he does on the latter; because, especially in the case of those base metals of which we shall feel the shortage first (tin, lead, quicksilver, zinc)—complete salvage is impossible, and partial salvage, in most cases, unduly expensive.

Moreover, it must be remembered that salvage, whatever the percentage possible, can apply only to that portion of the metal in question which is needed for replacements, and not at all to the portion which is required to supply the expanding demand for first use. It cannot, for instance, have any bearing on the metal requirements of the hundreds of millions of people throughout the world, who, taught by the newspaper and the moving picture, may tomorrow demand some of the comforts and conveniences which we in the United States possess. All that is needed is the growth, in the minds of these untold millions, of a desire strong enough to induce them to work for these things; it does not take generations of intellectual development to want an automobile, or to burn out the batteries after you have got it.

Nevertheless, a considerable percentage of these
metals can be re-used; it is all a question of price. Like Mr. Bain, I do not think that material civilization, as we know it, is going to stop for lack of metals; but I agree with him (but perhaps give stronger emphasis to the statement) that civilization will have to pay progressively higher prices for them. In this, together with the companion probability that most other things will eventually become cheaper, I base my hope and confidence in the ultimate future of the mining industry. Mr. Bain's final conclusion is: "If the world wants metals badly enough to pay for them the supply will be forthcoming; but that qualifying phrase is a most important one." I agree with his conclusion; but I add that there is real danger of a sudden pinch before the world makes up its mind to pay the necessary price; and the sooner the world realizes this necessity, and prepares for increased production, the better will it be for civilization, and incidentally for the miner.