WESTERN WAR MINERALS

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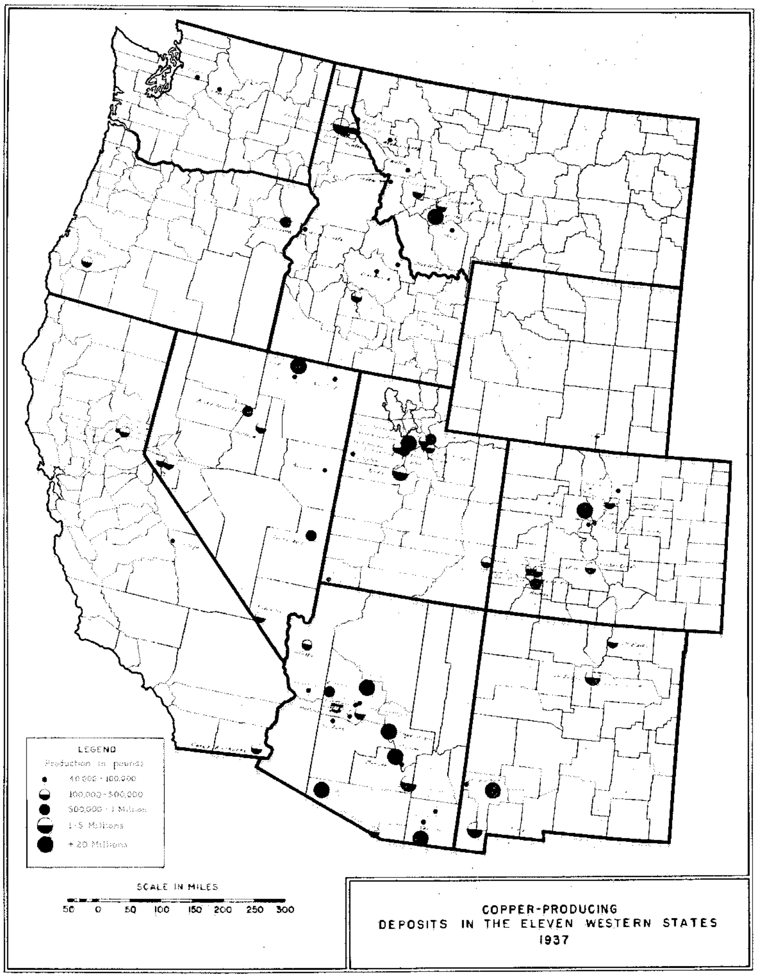
All of us are becoming increasingly conscious these days of the part many raw materials play in our daily lives. As the priorities system becomes more widespread, and more raw materials are totally withdrawn from civilian use and increasingly restricted in their military uses, there inevitably will be some very marked changes in both the technology, economics, and sources of our raw material supplies. Although the problem of supplying our essential needs is national, its effects will vary regionally. Its influence in the Southwest will be of particular interest because of the normal productivity of this area and the many rapid changes there taking place as a result of war activities. War stimulated industries leave their mark on peacetime industrial development. The tremendous expansion now going on around us will have many permanent effects, some of which are discussed in the following pages.

In 1940 the Army and Navy Munitions Board defined fourteen materials as strategic in the sense that dependence in war time must be placed in whole or in substantial part on sources outside the continental limits of the United States and strict conservation and distribution control measures must of necessity be enforced. This list of strategic materials included nine mineral products, namely antimony, chromium, manganese, mercury, mica, nickel, quartz crystals, tin and tungsten, together with five other materials: manila fiber, quinine, rubber, silk and cocoanut shell char. The same board also defined fifteen other materials as of critical importance, either because they had a lesser degree of essentiality or because they were obtainable in more adequate quantities from domestic sources. Some control over the use of critical materials was anticipated. These materials included five mineral products: aluminum, asbestos, iodine, platinum and vanadium, together with ten other materials: cork, graphite, hides, kapok, opium, optical glass, phenol, tanning materials, toluol and wood. Other mineral products regarded as essential to the national war effort and for which the supply was considered adequate if not abundant included bauxite, copper, 100-octane gasoline, industrial diamonds, iridium, zinc, fluorspar, lead, beryl, bismuth, cadmium, cobalt, rutile, zirconium, molybdenum and magnesium.

Since 1940 our foreign sources of supply and trade routes in many of these materials have been drastically altered. Great effort has been made to stimulate domestic production, particularly through governmental reconnaissance and wider dissemination of information concerning our resources, the drilling of many deposits of marginal or unknown value by the United States Bureau of Mines, and through Federal loans to finance development, exploration, and production of many mineral deposits. At the same time strenuous efforts have been made to control the price of various mineral products. For some metals, such as mercury, the price advance prior to its restriction reached a level such as to stimulate mining activity. In other cases the price restrictions were applied at levels such that additional production could be encouraged only through a bonus paid for new metal. In general, metal prices have not advanced in any degree comparable to the increased demand while at the same time labor, supplies and all the other costs of mining have increased tremendously. Thus we are demanding that our mining industry increase production and utilize lower grade, higher cost ores, while its costs and taxes are steadily increasing and its profits disappearing. This has resulted in many very real problems for the producing mineral companies.

WESTERN RESOURCES

From both an economic and a geological standpoint the Rocky Mountain and Western States must be regarded as a unit in the domestic mining picture. This block includes the states of Montana, Wyoming, Colorado and New Mexico along the eastern edge, with the central states of Arizona, Nevada, Utah and Idaho, and the western states of Washington, Oregon and California. These eleven western states together constitute the major domestic source for many essential metals. Virtually all of our domestically produced chromite, molybdenum, tungsten, vanadium and uranium is obtained from these states; about 90 per cent of our copper, mercury and silver, 60 per cent of the gold, about 50 per cent of the lead,



COPPER-PRODUCING DEPOSITS IN THE ELEVEN WESTERN STATES 1937 and 35 per cent of the zinc. Only iron is conspicuously low among metals produced by the western states. This is due not to a shortage of iron ore, but to the unfavorable locations and unsatisfactory quality of coke and coal necessary in the reduction of iron ore to pig iron and steel.

The importance of the western states as a source of metals is not the result of accidental development or exploration, but is the inevitable consequence of the geological character of the area. Most metals are obtained from deposits found only in relatively close association with igneous rocks and then only where structural conditions have been favorable for the accumulation of ore. In the western states, large areas have been subjected to intensive intrusions of igneous rocks at successive geologic periods and usually under conditions favorable to the development of a variety of mineral deposits. Since mineralization, the prevailing conditions such as climate, vegetation, weathering and erosion, have aided the exposure of metalliferous deposits. As a result the western states not only contain numerous deposits with a very diverse metal content, but these deposits are so situated with respect to the earth's surface that they can be found and exploited. It is most probable that the western states will continue to be the main domestic source for many metals in the future.

CURRENT DEMAND FOR MINERALS

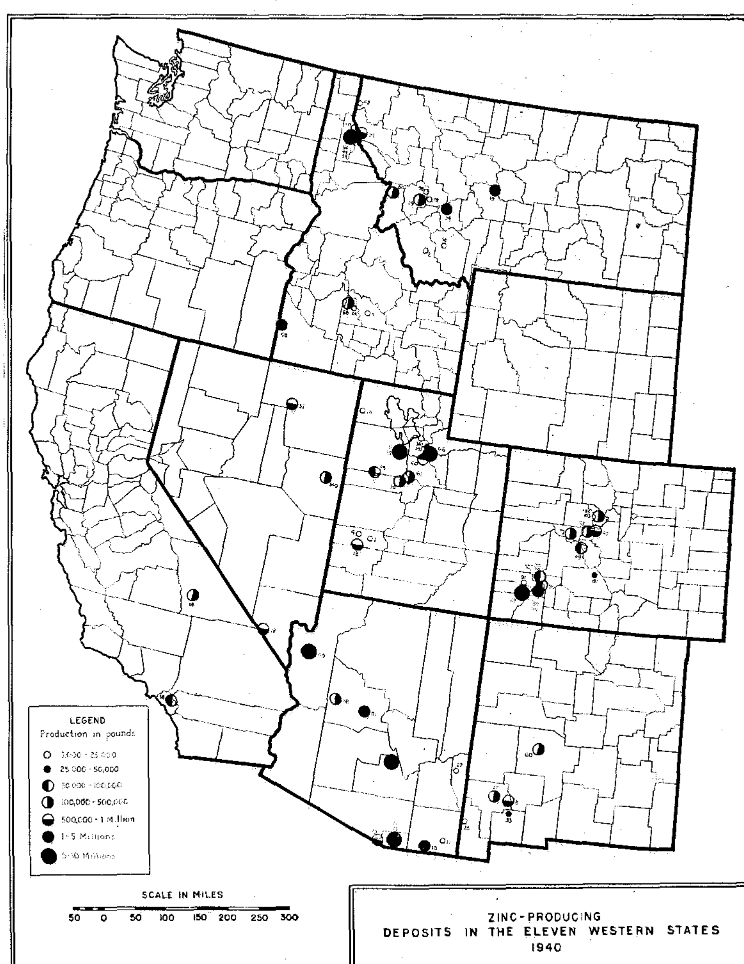
Let us briefly review the current situation with respect to strategic and critical mineral products insofar as it affects the western area. Production and consumption figures will be those of 1940, unless otherwise stated. Current figures although not generally available, do not materially change the 1940 picture for most metals.

The demand for aluminum has expanded tremendously since 1940 because of its consumption in aircraft of all types. Aluminum is produced exclusively from the mineral bauxite which forms by long continued weathering under tropical conditions of aluminum rich rocks. Commercial bauxite deposits in the United States are restricted to Arkansas, Georgia, Alabama, Tennessee and Mississippi. It is most probable that materials other than bauxite will soon be used as a source of aluminum. Then, some of the alunite or aluminous clay deposits of the west may be utilized. However, until such time as these processes may be perfected, any aluminum produced in our western refineries will be obtained from bauxite either mined domestically or imported from abroad, mainly from the Guianas. The existence of these western plants, situated near cheap power but far from sources of bauxite will unquestionably greatly stimulate efforts to utilize other available new materials.

Antimony is widely used in peacetime as a hardener in lead. We normally consume about 18,000 tons of primary antimony and produce less than 1,000 tons. Its wartime uses include hardening of lead for bullets and shrapnel, use of the sulphide in priming caps of shells and explosives, and also in shells to produce a white cloud of smoke marking the position of the exploding shell. Normally our supplies of antimony are imported from China and Mexico. With loss of the Chinese supply we have been forced to expand domestic production from the many small antimony deposits scattered throughout the western states. Moreover, we at last are recovering substantial amounts of by-product antimony from lead-silver ores, particularly those in the vicinity of Kellogg, Idaho. Domestic deposits containing only antimony probably cannot continue producing under ordinary economic conditions, but the by-production may well continue after this emergency period is over.

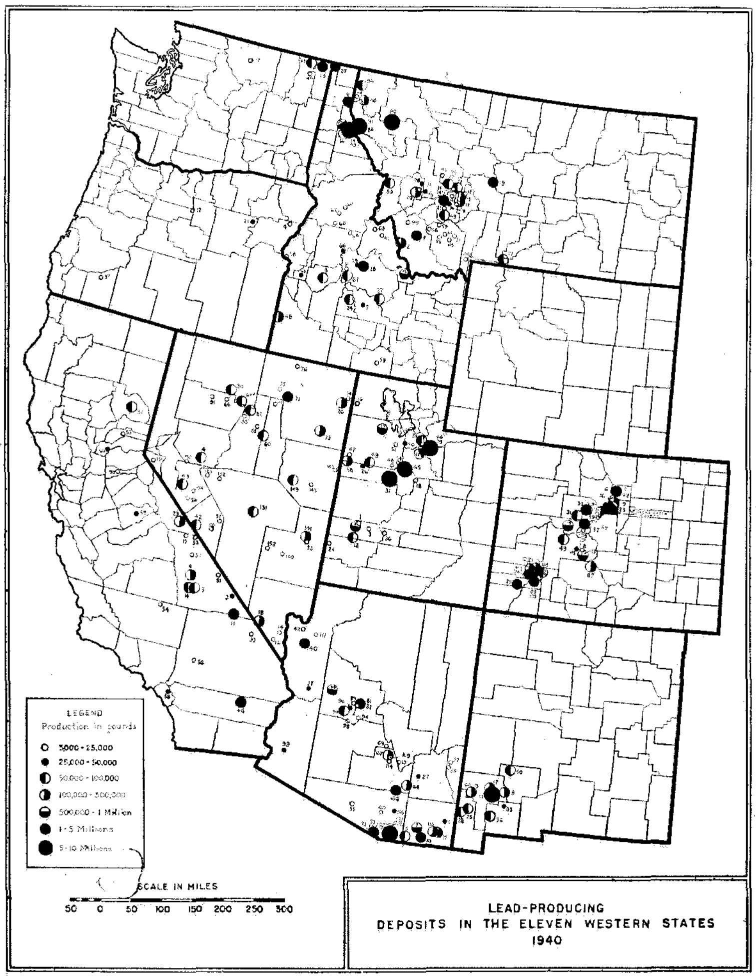
For the 25-year period prior to 1938 we consumed on the average 49 per cent of the world's production of chromite, and produced less than 1 per cent of our needs. We used about 45 per cent of this chromite as a ferro alloy to produce hard, tough and chemically resistant steels. Another 40 per cent went into refractories, particularly for furnace linings and 15 per cent was used in various chemical fields, such as dyeing, tanning, and chrome plating. Our known chromite reserves are almost entirely in the west, particularly in California, Oregon and Montana. The California and Oregon deposits were extensively worked during the last war; the Montana deposits are a comparatively recent discovery and are now undergoing extensive development. The survival of a chromite industry after this war will depend entirely on price, since it has been clearly established that our domestic deposits cannot compete with foreign deposits under prices prevailing up to the present. The development of the Montana district and the attempt to work chromite beach sands in Oregon are current results of our need for chromite.

Iodine is essential in medicine and photography and we normally consume about 500 tons. Most iodine is recovered as a by-product from refining Chilian nitrate ore, but our domestic



ZINC-PRODUCING DEPOSITS IN THE ELEVEN WESTERN STATES 1940 production of iodine is normally obtained (by two companies in southern California) from treatment of natural brines. During periods of emergency additional supplies of iodine can be recovered from kelp and other sea-weed.

Manganese is consumed almost entirely by the steel industry, where about twelve pounds of manganese are used in the production of each ton of iron. This is added mainly as a manganese-iron alloy rich in manganese. Ores used in the preparation of this alloy must contain a high manganese and a low iron content. The ratio of manganese to iron should be 8 to 1 or better. Recently we have been consuming 900,000 tons or more of such manganese ore and have been producing from 25,000 to 40,000 tons of high grade ore. Our supplies normally have come about one quarter from the Gold Coast, one quarter from Soviet Russia, one sixth each from Cuba and India, and the balance from various other countries, of which Brazil is the most important. Now we are calling for increased domestic production. The western states contain practically all our known high grade domestic deposits. They also contain large reserves of low-grade deposits and others are found in Dakota, Minnesota and elsewhere. Most domestic high-grade deposits are small and the standard grade of ore can be obtained only by selective mining. In order to stimulate present production, the Metals Reserve Corporation has dropped its specifications from 48 to 30 per cent manganese. Our low grade reserves have not been previously mined because no facilities were available for concentrating low-grade ores, but several plants are now being built with Federal funds and we probably can anticipate continued production from this source after the war, particularly if the industry is protected by increased tariffs or a higher price.



LEAD-PRODUCING DEPOSITS IN THE ELEVEN WESTERN STATES 1940

During peace times mercury has a wide range of uses in the drug and chemical field. In war times mercury fulminate becomes of great importance as a detonator in all types of explosives. We normally consume about 750 tons of mercury a year and produce about three quarters of our needs. California, Nevada and Oregon have supplied most of our domestic production and imports have been obtained mainly from Spain and Italy. The rapid increase in the price of mercury from less than $75 to more than $190 a flask during the period 1939-1940 resulted in a tremendous expansion in mercury mining and a consequent increase in production. Old mines and old dumps have been reworked and many new prospects developed. The maintenance of our current production is problematical and will depend on further price increases since our reserves are being rapidly depleted. During the last year and a half or more we have produced substantially in excess of our needs and have been able to supply our neighbors with much needed mercury.

The demand in mica is mainly for large flakes and sheets of quality usable for condensers and insulators. We have adequate supplies of ground and ordinary mica but our better grades were imported mostly from Madagascar and India. During recent years our imports of all types of mica have ranged between 5,000 and 11,000 tons. Considerable success has been met in the eastern states in producing from high grade pegmatites and granite, but in the western states there is little if any increased production.

Our consumption of nickel has averaged somewhat more than 50,000 tons a year during recent years. The distribution of this nickel is about 60 per cent in ferrous alloys, non-ferrous alloys 28 per cent, electro-deposition 10 per cent, and the balance in miscellaneous uses. Nickel, like chromite, imparts strength and resistance, (particularly to acids), to steels in which it is alloyed. It finds a very wide range of use in many types of military and industrial equipment. Our supply of primary nickel is obtained almost entirely from the Sudbury district in Canada. We have a few small scattered deposits, but none appear to be of more than minor commercial importance.

Platinum is on the critical minerals list largely because of its utility as a chemical utensil and the part it plays in many chemical reactions. In 1939 we used about 100,000 ounces, of which roughly one half was consumed by jewelry, one fifth in the chemical industry, somewhat more than a tenth in the dental and electrical industries and the balance in various other fields. The entire domestic primary production of platinum minerals comes from Alaska, California, Oregon and Montana. Ordinarily California is the leading producer from gold washing operations, but during the last two or three years there has been a very large production from the Good News Bay district in Alaska, where platinum is found as a placer deposit. This production is now declining and probably the deposit will soon be worked out. We normally produce less than 10 per cent of our consumption of new platinum but quantities adequate

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The Chemists' War on Disease

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In this way antibodies to several simple antigens and, we believe, to various proteins like egg albumin have been prepared. They behave much like the natural antibodies in many respects. Since one of our goals is the preparation of synthetic antisera, Dr. Dan Campbell has started a series of experiments on synthetic antibodies to various bacteria. He has chosen to start on the pneumococci, which are relatively easy to work with and are at the same time very important in medicine. The synthetic antibody produced will be tested for its ability to actually protect mice against pneumonia in the same way that the natural pneumonia antiserum now in common use is tested before being distributed for use.

The possibility of making synthetic antisera for treatment of disease is something to stir one's imagination, especially under the urgent needs of war-time conditions. Making them naturally has always been a slow and involved process. It may be that we can make them quickly and in large quantities in the vats of a chemical works. Also the synthetic antibodies should be relatively free from the foreign substances that occasionally cause serum sickness when the use of present day antisera is not carefully controlled. It is not unlikely that certain infectious diseases which cannot be handled by the classical methods will succumb to the synthetic treatment.

There has been some question as to whether the particular type of antibodies with which we have been working, namely precipitins, which precipitates antigens in solution, are the same as the agglutinins which cause bacteria and other cells to clump, tbus helping to render them harmless. Dr. David Pressman has performed some interesting experiments to add strength to evidence obtained in other laboratories that there is no essential difference between them. First he tested Pauling's postulate that an antibody or other molecule capable of combining with two bacterial cells could cause agglutination. Using diazotized benzidine which can link with two protein molecules, he simulated the agglutination of red blood cells. Then he caused the precipitin for egg albumin to agglutinate red cells simply by first coating the cells with albumin. Other workers have performed the converse experiment, showing that the antibody which agglutinates pneumococci will also precipitate the material which coats the organisms.

Reference was made in the introduction to a study of the kinectics of immunological reactions at The Institute. Ordinarily the first step in such a study would be to get pure materials and select a clean cut reaction that gives products of known and constant composition. That is not possible in immunology. Antiserum contains the normal components of blood as well as the antibodies of interest. Probably the antibody molecules to a particular antigen are quite inhomogeneous. Some have only one complementary combining region and others two or more. The resulting precipitate has a variable composition. In spite of these difficulties Dr. Pauling has derived rather complicated expressions relating the composition and amount of precipitate with the concentrations of antibody and antigen, the equilibrium constant for their combination, and the effects of inhibiting agents. Dr. Pressman and assistants have been testing these expressions in a series of experiments involving thousands of analyses. A great simplification was introduced when it was discovered that relatively simple organic dyes of known structure and high purity could be used for the antigen. Experiments of this type add greatly to our knowledge of the manner in which antibodies combine with various antigens.

A still more direct attack on the structure of antibodies is to be made this winter with the use of a new electrophoresis apparatus which I constructed last year. It is still a matter of conjecture as to how many places on an antibody can combine with the antigen molecules. In these new experiments the antibody will be allowed to form soluble complexes with very simple antigens. When an electric current is passed through the mixture the antibody molecules will separate into distinct layers. With the new apparatus it will be possible to measure the amount of antibody in each layer and also to test the uniformity of any particular layer. The material in each layer can be collected for further experiments.

It should be mentioned that these experiments on antibodies probably have a much broader significance than just their relationship to immunity. In all living matter there is a great variety of highly specific reactions. Enzyme action, the fertilization of eggs, certain steps in cell division, allergy, and the synthesis of proteins are but a few examples. It seems likely that the type of bonds involving complementary structure which have been discussed in this paper play a leading role in many of these life processes. In view of the excellent progress in immunochemistry made at the Institute last year and the increasing interest being shown, important results should appear during the next year.

Western War Minerals

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for all our needs are readily obtained as a by-product from nickel mining in Ontario.

The demand for radio-sending and detection devices of all types in this war has increased tremendously the need for quartz crystals, which are a vital part of many such units either as a frequency control, a crystal detector, or because of the piezoelectrical properties. Miscellaneous uses of strategic interest include range-finders, instruments measuring pressures or detonation in gun barrels or airplane engines, in depth sounding and direction finding apparatus, and for sundry precision instruments such as chronometers, seismographs, periscopes, gun-sights and polariscopes. These quartz crystals must be free from flaws of all types, twinning, impurities, intergrowths and fractures. Most of it occurs in igneous rocks or veins from which it only can be separated by explosives which fracture the quartz. Our supplies normally are obtained almost entirely from Brazil, where the quartz crystals are found in clays resulting from the long-continued weathering of igneous rocks. By this process the matrix around the quartz is decomposed and the quartz liberated.

Our imports increased from about 10 tons in 1936 to 63 tons in 1940. There are one or two deposits in California where optical quartz can be mined. Weathering conditions throughout the west however, have not favored the liberation of optical quartz from our existing deposits.

Tin finds its greatest use in the ever-present tin can, which consumes about 40 per cent of our normal consumption. Another 20 per cent goes into solder and the balance of the tin consumed is spread through a very wide range of uses, of which babbitt, bronze, collapsible tubes, tinning, chemicals, type metals, tin oxide, and so on, are all important uses. We normally consume about 75,000 tons of tin a year, or equivalent to somewhat more than 40 per cent of the world's production. Our normal production of tin from primary sources is 25 tons, or less, a year. There are no known tin deposits of economic importance within the United States.

Tungsten is one of the ferroalloy materials which, although we consume only about 7,000 tons a year, is absolutely vital to both peace and war activity. Tungsten is added to ferroalloys to improve their resistance to heat, fatigue, abrasion and corrosion; the largest and most important use is in the manufacture of high-speed tool steels which retain their hardness at red heat. Self-hardening steels are another important use and the recent development of tungsten carbide and powdered tungsten in cutting tools makes them a potential substitute in many uses for industrial diamonds. Although the use of tungsten filaments in electric lights is very widespread, it accounts for only about 1½ per cent of the annual consumption of tungsten. Our domestic tungsten production, all from the western States, has increased from about 2,500 tons in 1939 to over 5,000 tons in 1940, and the rate of increase is still accelating. The exploration of scheelite deposits has been greatly aided by the fluorescent lamp. With the recent development of two or three new and potentially large western producers, we may become self-sufficient in tungsten and continue so after the war.

Vanadium is another important ferro alloy metal of which we normally produce less than half of our consumption. In 1939 the apparent consumption of vanadium was somewhat over 2,000 tons, mainly in steel alloys of special types. In part, vanadium is used in high-speed tool steels, in carbon vanadium steel and similar special steels which are noted for their hardness, tensile strength and unusual toughness. Our domestic production is all obtained from Colorado and Utah and our imports come mainly from Peru.

Among the metals not on the strategic or critical list but which at the present time appear of great importance in the war activity and which are becoming increasingly scarce, one should mention copper, zinc, lead and magnesium. In all all of these it is not so much a case of a shortage in our raw materials but a bottleneck in our productive capacity coupled with the fact that our proposed uses are far in excess of anything within our past experience. The accompanying figures show the distribution of the western production of the first three of these vital metals. The production there portrayed accounts for about 90 per cent of our domestic copper, 50 per cent of our lead, and 35 per cent of our zinc.

FUTURE TRENDS

During the past few years exploration and development of our mineral deposits has been more active than at any period since tbe last war and possibly even more active than then. Despite this activity, aided by recent technological improvements, it must be realized that the discoveries of new deposits have been disappointingly few in number and in importance. Practically all of our production, both from current producers and from new deposits now being brought to production, is from deposits known during the last war.

It must be realized that the surface of our western states has been rather thoroughly examined during the past fifty years of mining activity. There are very few districts in which a mineralized deposit of substantial size could be located and which had not been examined by one or more competent mining men. We no longer have great geologically unexplored and unexploited areas. Future discoveries will mostly be made either as extensions of known ore bodies or will be discovered by use of sub-surface methods, either geological or geophysical.

Our consumption of metals is on such a large scale that discoveries of new reserves must be made frequently and ore bodies of substantial size must be developed if we are going to maintain our present rate of consumption. It is evident that we have not done this during the past 25 years and during this emergency every effort is being made to stimulate production at the expense of exploration. Our rich deposits are rapidly being depleted and only the low grade ores left to compete with foreign producers. We must look elsewhere for an increasing proportion of our mineral supplies and also expect to pay more for those produced domestically. The effects of this trend will become increasingly apparent and important to the Southwest when the present emergency is past.

Maps reproduced from "Metalliferous Deposits of the Eleven Western States", written by Horace J. Fraser, and published by the Industrial West Foundation.