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THE INTERNATIONAL RELATIONSHIP OF MINERALS[1]

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A FEW years ago members of this association looked forward annually to a generalized statement of the results of their president's own research work in science. The rapid specialization of science, with its consequent terminology, has, however, made it increasingly more difficult in recent years for any worker to express himself to his fellow-members.

Last year at Glasgow most of us expected that the hidden secrets of crystals would be revealed by one whose capacity for popular exposition accompanies a recognized power for extending the boundaries of science. Instead, Sir William Bragg released his store of accumulated thought on the relationship of science to craftsmanship in a way which gave each specialized worker an opportunity to adjust his sense of relativity and proportion.

If I attempted now to summarize my scattered ideas on the outstanding problems of micropetrology, I might possibly find half-a-dozen members charitably disposed to listen, and of them perhaps one might partly agree with my theoretical speculations. We have indeed to admit that the science of petrology, which vitalized geological thought at the end of the last century, has since passed into the chrysalid stage, but, we hope, only to emerge as a more perfect imago in the near future.

Coincident with the excessive degree of specialization which has developed with embarrassing rapidity within the present century, the problems of the great

[1] Address of the president of the British Association for the Advancement of Science, Cape Town, South Africa, July 31, 1929.

war drew scientific workers from their laboratories and forced them to face problems of applied science of wider human interest. And the atmosphere of this great mining field[2] stirs ideas of this wider sort—ideas concerning a field of human activity which, in recent years, has affected the course of civilized evolution more profoundly than seems to be recognized even by students of mineral economics. This must be my excuse for inviting you to consider the special ways in which the trend of mineral exploitation since the war has placed a new meaning on our international relationships.

With knowledge of the shortcomings which were felt during the war, in variety as well as quantity of metals, it was natural immediately after to review our resources with the object in view of obtaining security for the future. But events have since developed rapidly, both in international relationships and in mineral technology. The evolution of metallurgy during the present century and the developments in mining on which metallurgy depends have placed new and rigid limitations on a nation's ability to undertake and maintain a war; consequently, the control of the mineral industries may be made an insurance for peace. Let us first consider briefly how these circumstances have arisen, how each country has passed from the stage of being self-contained in variety of essential products to the most recent of all developments, the change to large-scale production that has tended to the concentration of the mineral and metal industries to certain specially favored regions which will hold the position of dominance for several generations to come.

The names of Isis, Cybele, Demeter and Ceres seem to suggest that the ancient theologians in different lands formed the same conception of those peculiar conditions in prehistoric times which made it likely that a woman—tied for long periods to the home-cave—rather than a man, was the one who first discovered the possibility of raising grain-crops by sowing seed. Whoever it was who first made this discovery was the one who diverted the evolution of man along an entirely new branch, and so laid the foundation on which our civilization was subsequently built—the beginning of what Rousseau called "Le premier et plus respectable de tous les arts."

Compared with this economic application of observational science, the later inventions, which seem so important to us—explosives, printing, the steam engine—were but minor incidents in the evolution of civilized activities. Previous uncertainty regarding the supply of the products of the chase, and the dangers which were necessarily attached to the collection of berries and edible roots in the jungle, became less important to the family-man when it was found possible to raise food-supplies nearer home. This discovery was thus not one of merely material advantage, for it necessarily led to the idea of storage and so opened up a new mental outlook for primitive man.

But then this new possession of field-crops—the acquisition of cultivated real estate—created fresh cares and new anxieties which contained the germ of future political problems. In addition to the previous dangers from nomadic hunters and predatory carnivora, new troubles arose from other enemies—herbivorous animals, birds, insects, droughts and floods.

The formation of village-groups for protection and the development later of tribal communities resulted necessarily in the radial extension of field "claims"—what our modern politicians, with careless disregard for geometrical terminology, now call "spheres of influence"—always dominated by the extending necessities of agriculture, the growing of crops for food and then, with the scarcity of skins, for textile materials.

The mineralogist and the metallurgist were perhaps before the farmer among those earliest research workers in applied science, but they were small folk, mere specialists in science. They have obtained a place of undue prominence in the minds of our modern students because of the adoption of their products for purposes of terminology in our conventional time-scale for those ages that preceded history. But this is due merely to the durability of implements as index "fossils," and is in no sense a certain indication of their political and industrial importance.

And then afterwards, long afterwards—indeed, up to historically recent times—national boundaries became extended or were fought for, but still mainly because agricultural products in some form were a necessity for the maintenance of communal life. When British traders first went to India, for instance, they extended their influence first along the navigable rivers for the trade in vegetable products which were raised on the alluvial lands around; and so British India, as we call it to-day to distinguish the administered areas from the residual native states, is now mainly agricultural. Even when the permanent settlement of Bengal was made in 1793 no one thought of reserving for the state the underlying coal which has since become so surprisingly important. It was the field, and the field only, that was considered to be of commercial and political importance.

Agricultural products, therefore, until recently dominated the political ambitions of national units. Whether, and to what extent, the possession and use of mineral resources may now modify that dominant

[2] The Witwatersrand.

spirit is the principal question to which I wish to invite your attention this evening.

In the evolution of man, as in the evolution of the animals that occupied the world before him, there are no sharply defined, world-wide period limits: the preagricultural Bushman still survives and lives the life of preagricultural man in this Union of South Africa. The recognition of agriculture as a leading inspiration for acquiring and holding territory has been modified occasionally by "gold rushes" into lands previously unoccupied, but they have generally had a temporary, often a relatively small, importance. The "gold fever" may be what our lighter species of newspaper calls "dramatic," but a fever is a short item in the life of a healthy man; heat-waves do not make climates. Possibly our school children are still told that Australia is noted for its goldfields, but the whole of the gold produced there since its discovery in 1851 is less in value than that of three years' output of Australian agriculture.

Even here in South Africa, which produces half the world's supply of gold, the value of the metal is still less than that of the pastoral and agricultural products. It is true that gold and diamonds introduced temporary diversions in the political expansion of South Africa, but the dominant interests of the Union are still determined by the *boer-plaas* and the *weiveld*.

The adventures of the Spanish *conquistadores* in the sixteenth century and of their enemies, the sea-roving Norse buccaneers, were inspired by stories of gold in El Dorado. And yet the whole of the South American output of gold, even under its modern development, is almost negligible beside the pastoral and agricultural products—wheat, maize, wool, tobacco, coffee, cocoa, sugar, meat and hides. The total production of gold for the whole continent last year was worth no more than a hundredth part of the surplus of agricultural products which the Argentine alone could spare for export. Truly there is a substantial difference between the bait and the fish, between the sprat and the mackerel.

The discovery and colonization of a continent are not the only ways in which the lure of gold has often brought results more valuable than the metal itself. The efforts of philosophers from the time of the Alexandrian Greeks in trying to transmute the base metals into gold resulted in accumulating the raw materials with which Paracelsus laid the foundations of a new chemistry.

Metals, we know, have been used since early times for simple implements and weapons, but it was not until the industrial revolution in Great Britain that the mechanization of industries led to any considerable development of our mineral resources, first slowly and with a limited range of products, then on a large scale and with an extended variety.

But to distinguish clearly cause from effect is not always simple. We were told at school of the remarkable series of inventors who laid the foundation of the textile industries in the north of England, and of the timely invention of the steam engine; its application to mine pumping; the successive construction of the steamer and the locomotive; the production of gas from coal. But the close association of ore, fuel and flux made it possible not only to improve machinery but also to increase facilities for the transport of raw materials and their products. When Josiah Wedgwood obtained his inspiration from the remains of Greek art then being unearthed from the ancient graves of Campania, he first turned to account the raw materials of his native county of Staffordshire, and then promoted canal and road construction to introduce the china clay from Cornwall.

It is obvious that the growth, if not with equal certainty the origin, of the industrial revolution was due to the close association of suitable minerals in England. It was because non-phosphoric ores were still available that, at a later stage, Bessemer was able to give that new impetus which increased the lead of the English steel maker; and so, when Thomas and Gilchrist came still later with their invention of a basic process applicable to pig-iron made from phosphoric ores, their invention fell on barren soil in Britain. The new process, however, found applications elsewhere, and, instead of adding to the stability of the English steel industry, it gave the United States the very tonic they required, whilst the industrialists of Germany—where political stability had by then been established—found the opportunity of developing the enormous phosphoric ore deposits of Alsace-Lorraine, which had been borrowed from France eight years before. And so it was through the genius of Sidney Gilchrist Thomas, and his cousin, Percy Carlyle Gilchrist, that Germany was enabled in 1914 to try the fortune of war.

For the first half century after the industrial revolution, Great Britain was able to raise its own relatively small requirements of iron as well as of the other metals that consequently came into wider use—copper, zinc, lead and tin. The rapid expansion in steel production which followed Bessemer's announcement of his invention at the Cheltenham meeting of the British Association in 1856 brought with it the necessity of going further afield for the accessory ores and for further supplies of non-phosphoric iron ores.

The next important step in metallurgical advance came in 1888, when Sir Robert Hadfield produced his special manganese-steel, for this led to the production of other ferro-alloys and so extended our requirements in commercial quantities of metals which were previously of interest mainly in the laboratory—vanadium, tungsten, molybdenum, aluminium, chro-

mium, cobalt and nickel. The adoption of alloys, especially the ferro-alloys, at the end of the last century opened up a new period in the newly established mineral era of the world's history, for, beside the increase in the quantity of the commoner base metals which were wanted for the growing industries of Great Britain, it was necessary now to look further afield for supplies of those metals that had hitherto been regarded as rare in quantity and nominal in value.

The country in which the industrial revolution originated and gathered momentum, because of the close association of a few base metals, could no longer live on its own raw materials, and never again will do so. Even in peace time Great Britain alone consumes twice as much copper and just as much lead as the whole empire produces. Meanwhile, developments had occurred elsewhere, notably in Germany, where political stability had been secured, and in the United States, where the Thomas-Gilchrist process also had stimulated expansion. Thus, by the beginning of the twentieth century, the industrial activities of the world had entered a new phase, which was characterized, if not yet dominated, by the necessity for minerals to maintain the expanding arts of peace.

From this time on no nation could be self-contained; a new era of international dependence was inaugurated, but the extent and the significance of the change was not consciously realized by our public leaders until 1914, when it was found that the developments of peace had fundamentally changed the requirements for war. Indeed, not even the German General Staff, with all its methodical thoroughness, had formed what the tacticians call a true "appreciation of the situation." Two illustrations of short-sightedness on both sides are sufficient for the present argument. Up to the outbreak of war, although the wolfram deposits of South Burma were worked almost entirely by British companies, the whole of the mineral went to Germany for the manufacture of the metal, tungsten, which was an essential constituent of high-speed tool steel. Sheffield still occupied a leading place in the production of this variety of steel, but was dependent on Germany for the metal, which the Germans obtained mainly from British ore. Under the compulsion of necessity, and without consideration of commercial cost, we succeeded before the middle of 1915 in making tungsten, whilst Germany, failing to obtain an early and favorable decision in war, used up her stocks of imported ore and turned to the Norwegian molybdenum for a substitute, until this move again was partly countered by our purchase of the Norwegian output. Germany then found that she wanted ten times more nickel than Central Europe could produce, so she imported her supplies from the Scandinavian countries, and they, being neutral, obtained nickel from another neutral country, where the Canadian ores—the world's main source—had hitherto chiefly been smelted and refined. We thus not only realized our dependence on other lands for the essential raw minerals, but we also had the mortification of finding that, through our own previous shortcomings in the metallurgical industries, we were compelled to face lethal munitions made of metal obtained from our own ores.

The political boundaries of the nations, originally delimitated on considerations dominantly agricultural in origin, have now no natural relation to the distribution of their minerals, which are nevertheless essential for the maintenance of industries in peace time as well as for the requirements of defense. This circumstance, as I hope to show in the sequel, gives a special meaning to measures recently designed on supplementary lines in Europe and America for the maintenance of international peace, measures which, as I also hope to show, can succeed only if the facts of mineral distribution become recognized as a controlling feature in future international dealings.

If minerals are essential for the maintenance of our new civilization, they are, according to the testimony of archeology and history, worth fighting for; and if, according to the bad habits which we have inherited from our Tertiary ancestors, they are worth fighting for, their effective control under our reformed ideas of civilization should be made an insurance for peace. In so attempting to correlate the facts of mineral distribution with questions of public policy, there is no danger of introducing matters controversial; every one here must agree on two things, namely, our desire and even hope for international peace, and consequently the necessity of surveying the mineral situation as developments in technological science change the configuration of the economic world.

Since the industrial revolution in Great Britain, the increase of mechanization and consequent consumption of metals has been accelerated with each decade. It is not necessary to quote the statistical returns available for estimating the rate of this acceleration, for it can be expressed in a single sentence which justifies the serious consideration of every political economist: during the first quarter of this present century alone, the world has exploited and consumed more of its mineral resources than in all its previous history, back to the time when Eolithic man first shaped a flint to increase his efficiency as a hunter.

To save you from the narcotic effect of statistical statements, I will limit myself to one illustration of this generalized statement, for this special example not only illustrates the rate of general acceleration in exploitation, but introduces an important subsidiary question, namely, the way in which activity is becom-

ing pronounced, if not substantially limited, to a group of special areas. In the year 1870 the United States produced 69,000 tons of steel; in 1880, one and one quarter million tons; in 1890, four and one quarter millions; in 1900, ten millions, and in 1928, forty-five millions.

Figures like these raise questions regarding the future which would take us beyond our present thesis. For the present we can assume with fair confidence that, taking the world as a whole, the depletion of natural stores is not yet alarming, although the rate of acceleration, by reason of its local variation, forces into prominence some international problems which will influence, and if effectively tackled will facilitate, the efforts to stabilize conditions of international relations.

I have elsewhere[3] made estimates of the quantities of metals stored in that part of the outer film of the earth's crust which may be regarded as reasonably accessible to the miner. The actual figures in billions of tons convey no precise mental impression to us and need not be quoted here, but certain of the outstanding conclusions have a bearing on our present line of argument.

The first feature of surprising interest to the man in the street is perhaps the relative abundance of those metals with which he is familiar in the arts—copper, lead, tin, zinc and nickel. Nickel, in spite of its price and limited use, is twice as abundant as copper, five times as abundant as zinc, ten times as abundant as lead and from fifty to one hundred times as abundant as tin. There are, indeed, among the so-called rare metals some which are distinctly more abundant than lead, although this is the cheapest of the lot in price and is consumed at the rate of over a million tons a year.

And so one gets at once an indication of two important features. Firstly, the miner works only those deposits in which the metal is concentrated sufficiently to make their exploitation a profitable business; and secondly, the metalliferous ores vary greatly in the completeness with which they have been concentrated in special places to form workable ore-deposits. Nickel-ore, for instance, occurs under conditions which conspicuously hinder its freedom of local concentration, and consequently the wide distribution of the metal and its relative abundance bring little comfort to those who are anxious about their supplies of a metal which jumps suddenly into importance with every rumor of war. We are safe in predicting that we shall never recover for use in the arts any fraction of our total supplies of nickel as large as we shall of most of the others which have been mentioned. Indeed, nickel stands apart from the others, for, whilst it is important in peace time and is dangerously important during war, yet, under the present state of mining and metallurgical practice, the deposits in the world worth working for nickel can be numbered on the fingers of one hand, and nine tenths of our supplies come from a single district in Canada.

Before discussing more precisely the significance of this and similar facts on the question of international relationships, let us consider for a moment the nature of our exploitation methods. Our reference to nickel shows that the metalliferous ores vary in their degrees of concentration, and, therefore, in their suitability for working, but, as the result of estimates made for a few common metals, we shall not be far from the average in assuming that we shall never recover more than about one millionth of the total that lies within workable distance from the surface of our accessible dry land. And another conclusion, based on a similar group of calculations, shows that our greatest total tonnages are not contained in the rich deposits, but in those of low grade.

It follows, therefore, that every advance in metallurgical science and in mining technology that makes it possible to work our low-grade ores adds appreciably to the actuarial value of civilization, for our mineral resources can be worked once and once only in the history of the world, and when our supplies of metalliferous ores approach exhaustion, civilization such as we have now developed during the last century must come to an end. When a miner raises a supply of ore in concentrated form for the metallurgist, he damages, and so places beyond reach forever, far larger quantities of residual ore than he makes available for use. When a metallurgist takes over the product of the miner and separates the refined metal for use in the arts, he also incurs serious losses, although not to the same extent. There are thus before both the miner and the metallurgist opportunities for extending the actuarial value of civilization; and because the cost of labor is the principal constituent in the total bill, and has recently swamped contemporaneous advances in technology, the gradual elimination of manual labor by mechanization is obviously the most profitable line of research.

But mechanization carries with it in general a tendency to limit operations to the larger deposits, with the concurrent neglect of those propositions which are widely scattered over the earth, and, though individually small, represent in the aggregate a serious section of our limited resources. And so our operations in mining, with the family of industries dependent on minerals, tend more and more to be restricted to a few special regions where work can be done on a large scale.

So now, with this thumb-nail sketch of the way in which the new mineral era is developing, we are free

[3] Presidential address, Institution of Mining and Metallurgy, *Trans.*, Vol. xxxiv, 1925, p. lvii.

to examine more closely the influence which this change in the configuration of the industrial world is likely to have on international relationships.

In the first place, it becomes obvious that no single country, not even the United States, is self-contained, whether for the requirements of peace or for the necessities of war. Not even the more scattered sections of the earth that are politically united to form the British Empire contain the full variety of those minerals that are the essential raw materials of our established activities.[4] Between them these two—the British Empire and the United States—produce over two thirds of the two thousand million tons of mineral that the world now consumes annually. Each of them has more than it wants of some minerals, but, in order to obtain its own requirements at economic rates, each finds it necessary to sell its surplus output to other nations. Each produces less than it wants of some minerals, and so must obtain supplies from other nations to keep its industries alive. Each of them is practically devoid of a few but not always the same minerals, which, though relatively small in quantity, are none the less essential links in the chain of industrial operations. Even if these two could "pool" their resources they would still be compelled to obtain from other nations the residual few. For it is important to remember that, unlike organic substance, it is not possible to make synthetic metals, and it never will be; it is not even possible to make artificial substitutes for many essential minerals that are used as such and not merely for their metallic constituents. There is no other mineral and no artificial substance, for instance, that can combine the qualities which give to the mineral mica its position of importance in the arts—its fissility in thin sheets, its transparency to light and opacity to heat rays, its stability at high temperatures, its toughness and the degree of its insulating properties. There will never be a synthetic mica.

Thus the international exchange of minerals is an inevitable consequence of our new civilization, and the cry for freedom of movement, for the "open door" and for equal opportunity for development comes into conflict with the unqualified formula of "self-determination." Whatever may have been possible before the industrial revolution, when the mineral industry merely contributed to the simple wants of agriculture, when most national units were self-contained, the formula of "self-determination" has come too late in the world's history to do good without a more than consequent amount of harm. We can not even live now without the free interchange of our minerals for those of other nations; in the name of civilization we dare not go to war.

There is one more group of fundamental data to recall before we are in a position to point the practical lessons which follow from the newly established and prospective mineral situation. I have already referred to the way in which economic considerations tend, through large-scale production, to restrict operations to a limited number of specially favored areas. There was a time within my memory when the primitive *lohar,* a survival of the aboriginal inhabitants of India, could be found in every province, nearly every district. He collected the granular mineral from the weathered outcrops of relatively lean iron-ore bodies, and, by using charcoal as a fuel, turned out blooms of malleable iron in a miniature clay furnace, using a pair of goat skins to produce the necessary blast. These primitive workers also produced small ingots of steel by the carbonization of wrought iron in clay crucibles many centuries before the same process made Sheffield famous.

But with the large-scale production of steel in western countries, attended by the opening of the Suez Canal, cheaper transport by steamers and the spread of railways from the coast of India, the *lohar* has been exterminated from all but the most remote parts of the country. His history is similar to that of other workers; the small ore-bodies that he used are of no interest to the modern ironmaster, and one result therefore of the modern movement is the neglect of a large fraction of our total resources. We are discussing, however, what is actually happening, not what we think should be a less wasteful course of evolution; natural evolution, like "trial and error" methods, is always wasteful.

Primitive workers in various lands have opened up to relatively shallow depths rich but small deposits of other ores, and in Eastern countries especially, where forms of civilization extend far back into history, the numerous and wide-spread "old workings" have given rise to travelers' impressions of great mineral wealth. But low-grade deposits that the ancient miner could not utilize are now opened up by mechanical methods on a large scale, and, on the other hand, what satisfied

[4] For purposes of reference I give a list of minerals showing how the resources of the British Empire, so far as our present information goes, can be relied on. This list has been kindly revised by Mr. T. Crook, of the Imperial Institute. (1) Those for which the world now depends mainly on the empire: asbestos, china clay, chromite, diamonds, gold, mica, monazite, nickel and strontium. (2) Those of which we have enough and to spare: arsenic, cadmium, cobalt, coal fluorspar, fuller's earth, graphite, gypsum, lead, manganese, salt, silver, tin and zinc. (3) Those in which we could be self-contained if necessary: bauxite, barium minerals, feldspar, iron ore, magnesite, molybdenum, platinum, talc, tungsten and vanadium. (4) Those for which we are now dependent on outside sources: antimony, bismuth, borates, copper, petroleum, phosphates, potash, pyrites, quicksilver, sulphur and radium. A corresponding list for the United States was prepared in 1925 by a committee under the chairmanship of Professor C. K. Leith, and published under the joint authority of the two mining and metallurgical institutions in New York.

the primitive metallurgist in abundance would be of little use to the modern furnace.

We have now to revalue the tales of travelers which have had a dangerous influence on those who have directed the course of international competition; we have to strike out of consideration the integers of the primitive worker to whom a great tonnage would form a mere decimal point in the modern unit; we have to realize that our mid-Victorian standards of metal production are gone forever, and that the comforting after-war formula of "back to normal" is merely a hypnotic drug to conceal the uncomfortable, one might say regrettable, dynamic conditions which have since developed at a speed that is not sufficiently recognized within our empire.

It is now misleading to speak of the wide distribution of minerals within a country as we could have done some fifteen years ago; we must now rule out the smaller deposits, and so form a new picture composed of those concentrations that are on a scale sufficient to support modern metallurgical units.

For this reason it is necessary to review afresh the resources of the undeveloped Far East, which has for many years been regarded as a menace to Western industrial dominance. The vague general notion that mineral deposits are evenly distributed throughout the earth's crust has fed the impression that the development of China, which is much larger than the United States, may yet shift the center of industrial gravity when her great population becomes awakened and organized by Western technical science.

It is true that the people of the East are rapidly adopting the methods and using the mechanical facilities of Western nations—railways, telegraphs, power factories, steel ships and other metal-consuming devices; but the critical investigations made by mining geologists, especially since the war, tend, with a striking degree of unanimity, towards recognizing the remarkable circumstance that China, as well as other countries of the Far East, is deficient in those essential deposits of minerals on which our mechanized form of civilization is based.[5]

When China was still an unknown land it was possible for after-dinner speakers to impress non-critical hearers by talk of the "yellow peril" and the "challenge of Asia," but these expressions have been used without thought of the circumstances that natural resources in minerals now set a rigid limit to power, whether industrial or military. We have known for some time of the natural limitations of India, of Japan and of smaller political units in the East, but until very recently we have had insufficiently precise data for estimating the quantitative value of the terms "vast" and "unlimited" which have been so often applied to China. Assuming that China may yet become a homogeneous national unit, or even assuming that her resources may become developed by Japanese energy, there is very little doubt now that, as an industrial area, the country is deficient in those minerals that form the essential basework of the modern form that civilization has definitely taken.

And the obvious limit in development, as defined by local natural resources, can be extended only to a limited degree by the importation of raw materials from other areas, for a country can buy metals only by the exchange of other products; its buying powers are limited by its selling powers. Abundant cheap labor, assisted by a semi-tropical climate, can produce an exportable surplus of foodstuffs only in limited parts of the Far East; even the so-called luxury products, which to our early navigators formed the inspiration of what we call geographical research, are now obtained elsewhere, and some are being replaced by artificial products evolved from the chemical laboratory.

Exploratory work by mining geologists tends more and more to show that the essential mineral products are far from evenly distributed over the land areas of the world. Western Europe and North America have an undue share of those deposits that can be worked on a large scale, and it is the large-scale movement that marks the specialized character of the new industrialism. Anglo-Saxon character would have found limited scope for its energy but for the fact that nine tenths of the coal, two thirds of the copper and as much as 98 per cent. of the iron-ore consumed by the world come from the countries that border the North Atlantic. Dr. Wegener might like to add this fact to the data on which he has based his theory of drifting continental fragments.

The industrial revolution, which began in Great Britain, has always been recognized as a dominant phase in Western civilization, but it is now assuming a new character. It spread first to the western countries of Europe, and developed there because of the favorable conditions of mineral resources, but the force of the movement faded out towards the Slavic East and the Latin South; the mechanical industries of Italy are based on imported scrap. When the new industries became transplanted west of the Atlantic the natural conditions which originally favored Great Britain were found to be reproduced on a larger scale.

Thus, in these two main areas, separated by the Atlantic Ocean, a family of industries based on mineral resources has arisen to dominate the world, for no similar area, so far as our geological information tends to show, seems to combine the essential features in any other part of the world. Other parts of the world will continue to supply minor accessories, and

[5] A comprehensive study of this question with bibliography has recently been published by a competent and judicial authority, H. Foster Bain, "Ores and Industry in the Far East," 1927.

the isolated basic industries associated with coal and iron will supply local needs on a relatively small scale. But political control, which follows industrial dominance, must lie with the countries that border the North Atlantic.

It is only in this region that there is any approach to the state of being self-contained. And yet since the war there has arisen, first in Europe and then by imitation in Asia, a degree of national exclusiveness more pronounced than any which marked international relations before 1914. Each small political unit has become vaguely conscious of the value of minerals, and has shown a tendency to conserve its resources for national exploitation on the assumption that they add appreciably to military security.

There is, however, no such thing now as equality of nations in mineral resources; "self-determination" and the "closed door" are misleading guides to the smaller nations. Political control may hamper, but can not stem, the current of the new industrialization; commercial and industrial integrations are stretching across political boundary-lines, and the demand for the interchange of mineral products will be satisfied in spite of fiscal barriers.

It would have been a shock to our members if, before the war, political problems were discussed from this chair, and party politics may always be inconsistent with the mental products of culture. But the results of science and technology now limit the effects of national ambitions, and therefore dominate the international political atmosphere for good or evil. One is justified always in suggesting non-controversial measures that tend to good, and this it is proposed to do very briefly as the direct suggestion of the new configuration of the mining and metallurgical world.

The League of Nations has accomplished a large measure of international understanding in questions of social value; its influence in forestalling possible causes of war has raised new hopes; but fortunately, so far, it has not been compelled to use any such instrument of force as a blockade, and any such measure that clashed with the vital economic considerations of first-class powers would probably cause stresses well beyond its elastic limits. The more recent and simpler pact of Paris associated with the name of Mr. F. B. Kellogg wants equally an ultimate instrument for its practical enforcement.

It was with this ultimate object in mind that the outline of my argument was drafted after the Glasgow meeting last year; but I am glad to find that my views have since been expressed independently. Senator Capper, of Kansas, in February last submitted a resolution to the American legislature recognizing this shortcoming of the simple treaty, and proposing to supplement its moral obligations by a corollary which, if passed, will empower the government on behalf of the United States to refuse munitions to any nation that breaks the multilateral treaty for the renunciation of war.

Senator Capper's resolution, however, still leaves unsolved a residual problem of practical importance. Those of us who had the painful duty of deciding between civil and military necessities in the great war know well that there is now but little real difference between the materials required to maintain an army on a war footing and those that are essential to the necessary activities of the civilian population; *materials* essential for one purpose can be converted to *articles* required for the other. Thus, if Senator Capper's resolution be adopted by those who have signed the Kellogg Treaty, either sympathy for the civil population would be stirred, or the armies would be still supplied with many essential munitions: the definition of "conditional contraband" would still remain as a cause for international friction.

A formula, still simpler but equally effective, is indicated by this review of the new situation arising from the essential use of minerals. It is suggested, therefore, as an amendment to Senator Capper's resolution, that the simple words "mineral products" be substituted for "arms, munitions, implements of war or other articles for use in war."

The only two nations that can fight for long on their own natural resources are the British Empire and the United States. If they agree in refusing to export mineral products to those countries that infringe the Kellogg Pact, no war can last very long. As our friends across the Atlantic have recently learned, it is easier to stop exports than to prevent imports: the customs' officer is more effective, less expensive and far less dangerous than a blockading fleet.

The confederation of American states has the advantage of forming a compact geographical unit, without interstate fiscal barriers to hamper the interchange of mineral products. The British Empire, in the words of President Nicholas Murray Butler, "has passed by natural and splendid evolution into the British Commonwealth of Nations"; it is composed of geographically scattered and independent political units, among which freedom of interchange, with due regard to local interests, can be effected safely only by more complete knowledge of our resources. Next year the Empire Congress of Mining and Metallurgy will meet in this city to discuss the proposition which I submitted to it at Montreal in 1927; and this address must be regarded, therefore, as an introduction to a movement which one hopes will supply the necessary data, and so facilitate a working agreement between the two great mineral powers that alone have the avowed desire and the ability to ensure the peace of the world.