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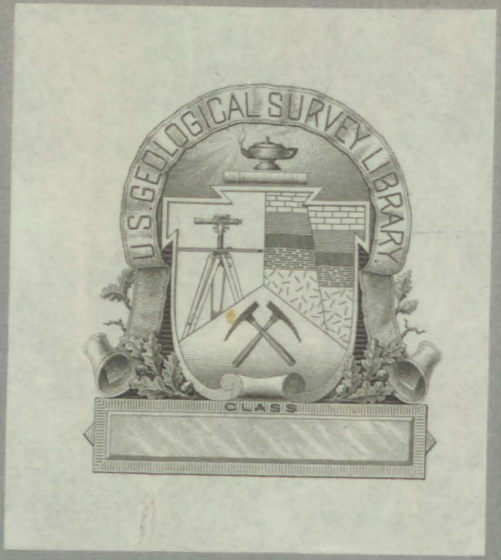
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ROLE OF MINERAL RESOURCES IN COUNTRY DEVELOPMENT

by

John Van N. Dorr II
U. S. Geological Survey

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2. Role of mineral resources in country development, by John Van N. Dorr, II. 19 p., 1 table.

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ROLE OF MINERAL RESOURCES IN COUNTRY DEVELOPMENT

By John Van N. Dorr II
U. S. Geological Survey

IMPORTANCE OF MINERAL RESOURCES TO DEVELOPED COUNTRIES

Industry, agriculture, and social development are all closely related to mineral resources. The course of civilization from the earliest days has been conditioned by the development of those resources. Note the use of the terms "stone age," "bronze age," "iron age," terms given by archeologists to the development of early cultures. Mineral commodities have been articles of trade from the beginning. Copper originating from the Michigan deposits has been found in Indian remains over much of the United States; flint was traded widely in Europe from the earliest days. The Phoenicians got their tin from Cornwall. Spanish and Greek mines were foundations of the Roman Empire. It is unnecessary to belabor this point except to emphasize that international trade in mineral commodities is even more important for our world civilization today than it was in the past.

A steady supply of mineral commodities is essential to the developed nations; the USSR is perhaps the only developed country which has the potential of supplying most of the raw materials needed for its industry from within its own borders. Our own country is for all practical purposes totally dependent on imports for a number of essential mineral commodities without which much of our industry and manufacturing would cease. Most other developed countries are in a worse position than we.

Because of unpredictably unstable political conditions, it is to the interest of all developed countries to have available alternative sources of supply, and most countries, notably Japan, have made considerable efforts to this end. Alternative sources of supply need not imply financial or political control, merely that alternative sources be known and available so that the loss of one source does not become disastrous.

This statement as to the importance of mineral resources to the developed countries may seem out of context in a paper on the importance of minerals to Developing Countries, but it is intended to show that national self-interest is deeply involved in the more altruistic approach of the rest of this presentation, and that emphasis on aiding mineral development in less developed countries is no giveaway program. As will be shown, mineral development is even more to the benefit of the Developing Countries.

IMPORTANCE OF MINERAL RESOURCES TO DEVELOPING COUNTRIES

Although mineral commodities produced in the Developing Countries are often looked at by them and by others primarily as a source of foreign exchange and governmental revenues, these are not the only benefits resulting from their development and exploitation. In the long view, they are not necessarily the most important. The minerals industry brings ancillary benefits that may be of even more importance in Developing Countries. I shall try to emphasize both aspects.

Data are readily available in various publications as to the part minerals play in the trade balance of many countries. Bolivia derives about 95 percent of its foreign exchange from the export of mineral products; Zaire, about 65 percent, Liberia about 75 percent. Table 1 lists the part that minerals play in the foreign trade of many countries. Some having considerable undeveloped potential are included in this list for contrast; in a decade their figures might well be quite different. As startling a change in export income from minerals as that experienced by Liberia over the last two decades may well take place for Ecuador. Argentina may become more comparable to Brazil, assuming that a rational political climate for development exists. Many other countries not now deriving much economic sustenance from minerals will probably show very significant increases over the next few decades.

Statistics on the importance of the minerals industries in the GNP of many countries are deceptive in that they include under categories other than minerals production such items as steel production and products made therefrom, as well as much transportation, etc., even though in many cases the railroads and the steel plants would not exist were there not a base in minerals production to support them. Such categorization is essential from the economist's viewpoint, but it radically downplays the importance of the minerals industry in terms of GNP and employment. The automobile industry of Brazil, 95 percent based on national materials, produces about 500,000 units a year; it would not exist were it not for the steel industry, which in turn would not exist without the great iron ore deposits. It has been estimated that 40 percent of America's industrial production is based on minerals.

Table 1.-- Percentage of total country exports represented by mineral exports.

(Data from USBM Minerals Yearbook except underlined figures, from K. P. Wang, Minerals and Metals in International Trade, 1970)

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Argentina			1.94		2.6				3.5	
Australia				10						25
Bolivia	88			96	95					95
Brazil			9.4							9.4
Canada	(1/3 of total exports)				26			30	28	26
Chile			89	83	83					90
Colombia			16							
Ecuador			1.0		1.0					
Gabon				44+	50-					
Indonesia										50
Iran									(oil)	90
Jamaica										55
Liberia		50-							76	75
Libya									(oil)	95
Malaysia										20
Mexico				28	26.5					
New Caledonia				95	90					95+
Nigeria			15.5						25	70(large increase due to increase in crude oil exports)
Peru										50+
Philippines										20

Table 1. Continued

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
South Africa			65	66 (41% if gold excluded)						45 (gold excluded)
Surinam										85+
Sweden										20
Thailand										20-
Turkey										10
Venezuela		95			97			95	95	90
Zaire				49	72					65
Zambia									70	95

Mining is essentially a pioneer industry; the mines are where the ore deposits are, not where the population centers are. In many cases these are located in the less accessible parts of a country and, to successfully develop the ore deposits, not only means of transportation must be built but schools, hospitals, housing, and whole communities must be provided for the people who develop the ore. Such communities and transportation facilities in turn attract satellite industry and commerce and agriculture, which in the course of years become able in many cases to stand on their own feet and may long outlive the ore deposit that was the reason for starting the development. The development of the Amapá manganese deposits in the rainforest of Brazil is an excellent example; this was carefully planned to achieve these ends. Not all are as carefully planned, unfortunately, but the trend is up.

It should perhaps be emphasized that in many Developing Countries the capital costs of developing a mine or oil field routinely include provision of housing and community development. In few of the newer mines I have visited in Africa and South America are the savage conditions of many of our own older eastern and western mining communities duplicated. These communities are instead centers of local education as to modern concepts of living.

In 1967 I had the opportunity to visit 23 African countries on a UN mission to study needs for and progress in providing education and training in the minerals industry. The training programs and policies of many mining companies were seen firsthand. Three things were impressive; the first was the amount of effort and funds devoted to training Africans

with little or no previous experience in handling modern equipment and mechanical devices in their proper use and maintenance; the company programs were usually more elaborate and better conceived and executed than the Governmental programs. A classic example from South America is that provided by the Toquepala mine in Peru, which staffed itself with illiterate Indians from the Altiplano, trained them in the use of machinery, educated their children, and moved 10,000 Peruvians into the money economy. The second was the effort and funds devoted to training and using indigenous managerial and professional talent. I know that in many cases the same is true in a number of South American countries. A third impressive thing was that a large number of the persons trained, after a period of work at the mines, left for other jobs, either self-employed, in the Government, or with other firms in urban areas. Thus mining companies mines train a much larger number of persons than their roster implies and are very significant factors in upgrading the human skills in the countries in which they operate.

Managerial skills are particularly important in Developing Countries, and a developing mining industry fosters them over a wide range of activities. The drive toward employment of nationals in industry so prominent in many countries has produced much progress indeed; the Vitória á Minas railroad in Brazil, now staffed entirely by Brazilians, and a fine ore railroad, is an example in progressive management that most U. S. railroads should strive to emulate. Engineers and technicians from all over the world visit the large iron mines at Itabira, now staffed entirely by Brazilians, to observe the innovations made there.

Contrary to some published opinion, I personally look for little if any diminution of copper production from Chile after nationalization, once the break-in problems have been solved, which will probably take a couple of years.

An important feature of mineral development activity in Developing Countries is the base it gives for introduction of other industries. The industries that process the raw materials into intermediate or finished products, such as smelters, refineries, petrochemical plants, and steel plants, are the first to come into being. Then machines or raw materials needed in the developing industry, such as barite mines and processing plants, cement plants, the manufacturing of trucks, railroad cars, machinery, and drills of various sorts, come into being because they have certain assured markets and assured raw materials. Many African countries are too undeveloped to have this phase important as yet; political adjustments and economic realism must come first. However, in some of the larger South American countries this process is well advanced and will continue; it is an essential part of the take-off process and the further advanced it is, the less closely related to mineral development the process seems. Nonmetallic minerals, such as limestone, salt, ornamental stone, gems, gypsum, and others, are particularly important in building up local industry.

Finally, I would like to emphasize how closely mineral development should be related to agricultural development. Characteristic of most Developing Countries is the low agricultural productivity, linked to low

consumption of fertilizer materials, and in many cases to the thoroughly leached nature of tropical soils. The highly publicized "green revolution" depends for success not only on special types of food plants developed in recent years, but also on a much increased input of fertilizers. Many of the fertilizers are, of course, based on mineral products: petroleum, phosphates, potassium salts, and limestone. Many of these commodities are in ample world supply, but local sources are needed if the green revolution is to be effective everywhere, for they cannot economically be transported great distances, and local sources save foreign exchange for other pressing developmental needs.

MINERAL INDUSTRY DEVELOPMENT AND THE DEVELOPING COUNTRIES

Most Developing Countries are in the tropical or subtropical zones of the world, probably because in the humid tropics human subsistence in the ecological balance was not difficult, and stimulus for development caused by uncomfortable environment was not acute, or, in the case of arid zones, little surplus for takeoff existed. With the explosion of wants and population during the past two centuries, the ring of subsistence and custom has been broken, and the tropical world is on the move, or would like to be. I have in my home an axe which I saw made in India, starting with the iron ore being fed into a tiny primitive blast furnace operated by a goatskin bellows pulled by a boy, through the stage of beating the slag out of the 10 pounds of metal produced, to the stage of shaping and hafting the axe. It is a good axe, but I doubt that many more will be made by this 4000-year old process, which produced two axes and several arrowheads in one day.

The tropical zones, both arid and humid, present many problems in development, as I do not need to emphasize. I shall not discuss the political and cultural problems which, although very important to development, are not my province, but will attempt to sketch the physical problems, different from those encountered in our temperate climate, that affect mineral development.

The most important factors in the humid tropics are those of high average annual temperature, coupled with high and often seasonal rainfall. The result of these two environmental circumstances is rapid and deep destruction of bedrock by weathering, with accelerated solution and removal of the more soluble constituents such as calcium, magnesium, potassium, sulfide minerals and a host of minor elements, and the concentration of the resistates such as oxides of aluminum and iron, and of the clay minerals. As a result of this process, tropical soils commonly are not very fertile. They need many additives to produce bountifully; they have poor structure for cultivation. From the minerals viewpoint, certain types of ore deposits form preferentially in this environment, particularly iron ores of some types, manganese ores, certain types of nickel ores, and aluminum ore. These are surficial deposits, easily found, and in fact are major sources of most of those metals.

On the other hand, many of the useful elements occur preferentially as sulfide deposits in the earth's crust. Obvious surface manisfestations of such sulfide deposits are easily and rapidly destroyed under humid tropical conditions, and many methods of prospecting that are effective

in temperate zones are much less effective or ineffective in tropical zones. Furthermore, the deep weathering and formation of clay minerals in humid tropical environments changes electrical properties of the surficial materials, and enough research to fully evaluate the effects has not yet been done. A position paper[1/] recently released discusses the state of the art and needed research in prospecting in tropical zones; those who are interested in pursuing this matter further can find much more detail in that paper. It is sufficient to emphasize here that much basic research is needed to make more effective known and still-to-be-developed prospecting techniques in the tropical areas. It should also be emphasized that deposits of industrial and fertilizer minerals are also difficult to find in the tropical environment, and even such simple construction materials as sand and gravel or rock suitable for crushing to make concrete are not easily found in many large areas. The streets of Belem, Brazil, were paved with rock imported from Europe. Crushed rock in Manaus is brought in from quarries 400 km away. I should remind you that the total value of the industrial, fertilizer, and construction minerals and materials produced in the world is considerably more than that of the metals produced.

[1/] Dorr, J.V.N. II, Hoover, D.B., Offield, T.W., and Shacklette, H.T., 1971, Application of geochemical, botanical, geophysical, and remote sensing mineral-prospecting techniques to tropical areas--State of the art and needed research: U. S. Geol. Survey open file rept. (IR) DC-20, 98 p.

Although the arid tropics in many places do not have these problems, they are most difficult of access; in many places arid tropics are covered by windblown sand which obscures rock outcrops and makes human subsistence precarious.

The primary tool in search for mineral raw materials is the geologic map, for the occurrence of useful mineral materials is governed by geologic laws. In most tropical areas, because of difficulty of access and particularly because of the deep soil cover, most such maps, if they exist at all, are commonly very generalized and inaccurate. As discussed in the paper cited above, new modes of arriving at more accurate and usable maps have been and are being developed; progress in the science and particularly in the tools available to it is now explosive. Geologic maps are useful not only in prospecting but in civil engineering, agriculture, and many other arts based on use and manipulation of the natural environment. However, to make use of these tools and to interpret the results they give demands considerable scientific and practical sophistication and experience.

In order to make use of the newer modes of geologic appraisal in the search for deposits of useful materials, Developing Countries need strong geological organizations and highly trained scientists and technicians. Many of the smaller countries obviously cannot afford to create and maintain organizations that are fully staffed and equipped to meet all the problems they may face. Because geology and mineral resources are regional and have little relation to national boundaries,

a regional rather than national approach to mineral development is the most logical, if political problems could be solved. Thus Guinea, Liberia, and the Ivory Coast all share parts of the same iron ore province which should be explored and developed as a unit rather than piecemeal. Many other countries, however, are large enough and are making efforts, some notably successful, to create such organizations. Among these are Brazil, Argentina, Mexico, Bolivia, Peru, Colombia, Venezuela, Guyana, Chile, Nigeria, the East African republics, Malagasy, Zambia, Pakistan, India, Indonesia, and others. The smaller countries usually have skeleton or poorly organized geological services, or contract most of their geological work to expatriates or foreign or international organizations. This is particularly prevalent in former French colonies.

Furthermore, there is a natural distrust in many Developing Countries of the intentions of foreign companies anxious to develop their mineral resources, a distrust rooted both in ignorance of prospecting hazards, techniques, and needs, and also, let us face it, in some rather unscrupulous historic deals and lack of political wisdom on the part of some foreign companies. If indigenous expertise can be developed in these countries, the countries will be in the position of negotiating from knowledge rather than from ignorance, and suspicion will be greatly allayed.

The needed research and the needed basic information-gathering to make productive the difficult search for mineral resources in the Developing Countries must to a large extent be carried on within the Developing Countries. For this reason the U.S. Geological Survey, financed in large part by AID, has placed prime emphasis on its bilateral programs of developing indigenous institutions and indigenous expertise. This has ranged over the whole gamut from assistance in organizing scientific libraries, through topographic mapping, cartographic techniques, analytical laboratories, geochemical and geophysical exploration, geologic mapping, computerization of geological data, engineering geology, disaster studies in cooperation with engineers and construction specialists, volcano studies, mineral-deposit evaluation, and management problems. In early years, emphasis was placed on the more immediately urgent aspects, such as geologic mapping and mineral-deposit appraisal; with the continually increasing capacity of many of our counterparts, emphasis has been shifting toward less execution ourselves and more consulting and advising on specific problems. Training programs, both in-country and in the United States, have been basic to the whole program and have paid off handsomely, both in improving host-country capacity and in insuring a continuing exchange of information between our country and the others, as well as a continuing orientation toward our country.

The Developing Countries are aware of the importance of mineral production to varying degree and of the importance of developing their own expertise and institutions to an even more widely varying degree. Here again size and history are of overriding importance, for small countries, particularly many of those in West Africa, have had little opportunity to develop sophistication in this field. I shall not soon forget the French mine I visited in the Ivory Coast, the manager of which, when asked about their training program, answered that indeed they did have a training program: young French student geologists were brought in for practical training during their vacations from France. Perhaps because of this attitude, the U.S. Geological Survey was visited recently by the Minister of Mines of that country, who expressed interest in training Ivoirians in American universities and securing help from the USGS.

Many of the newer countries, particularly in Africa, have turned to the institutions, both universities and governmental, in the original colonial powers to plan and execute the geological investigations basic to minerals development and also to such institutions and others of the European community for the actual prospecting work. United Nations organizations, whose costs have been defrayed to such a large extent by this country and whose technical personnel is largely European, are also widely used by these countries. Because of the predominantly European operative personnel, most business and development spinoffs go to European companies.

Little effort is apparently made by such organizations to build up indigenous institutional expertise, for in most cases their work is oriented toward other objectives. The average UNDP project in minerals devotes 5 percent or so of total expenditures (or less) to training of indigenous personnel. Rarely did I see or hear of any West African earth scientists in the field or actively engaged in scientific work. USGS experience in Liberia gives us keen insight into the difficulties involved in developing such expertise; it also shows that it is possible.

Many of the more developed countries, on the other hand, seem determined to expand their mineral industry to the extent possible and at the same time to develop their institutions. Turkey, Colombia, and Brazil have borrowed considerable sums from AID to defray the expenses of working with the USGS to develop their capacity; Saudi Arabia is bearing all the cost of making a wide-ranging investigation of that country; the Philippines is negotiating a loan for further mineral resource investigations using both the new and more conventional techniques. A cooperative program with Indonesia has been reactivated. Bolivia recently requested reactivation of the cooperative program with the USGS in geological mapping and minerals exploration. A long-term, broad-scale geological and geophysical program with Liberia is being wound up this fiscal year. Besides the countries mentioned above, within the last two years responsible officials in Afghanistan, Iran, Pakistan, Libya, Korea, Thailand, Yugoslavia, Greece, Zambia, Mali,

Ghana, Ivory Coast, Ethiopia, Nigeria, Mexico, Costa Rica, Guyana, Argentina, and Peru have expressed interest in bilateral assistance from the U. S. Geological Survey; because of problems of financing and political problems, few of these requests could be met. Moreover, the USGS has received a number of requests from UN agencies for assistance in our fields of competence and, wherever possible, has cooperated with these agencies in such fields as geothermal power, geochemical prospecting, cartographic work, etc. I have not mentioned the many countries in which work on water resources has been requested and carried on.

The USGS has been severely handicapped by two factors; the first is the lack of flexibility in financing, as our organization has no authority to work overseas on its appropriated funds. Among the myriad demands on AID funds, that for mineral resource development is often lost in the shuffle despite the fundamental importance of this activity. Secondly, because a number of countries are no longer on the AID list, requests for assistance cannot be funded easily, although the need for geological surveys and mineral development may be acute in order that such countries can diversify their economy. Although Iran, for example, derives a notable income from petroleum, the critical professional mass needed for diversified mineral development does not yet exist within that country, nor is it likely soon to be developed without assistance from outside.

In the course of its thirty years of experience in work in 70 different developing countries, the Geological Survey has identified a number of fundamental geological problems common to many of these countries which demand broad-scale research for solution. Solutions to these problems would benefit many countries, not just one or two. Areas of investigation involving research on these subjects would include the following:

Development and application of geophysical techniques for geothermal resources exploration;

Development and application of remote sensing techniques in the search for deposits of copper and other metals;

Laterite investigations;

Establishment and upgrading of geochemical laboratories in South America;

Application of geological and geophysical techniques to volcanologic problems in Central America;

Orthophotomapping of Zambia;

An investigation and training program in economic geology in the CENTO region;

Chromite investigations in Southwest Asia;

Regional tectonic map of SE Asia.

We would suggest that research of this type is an excellent investment for the U. S. Government to make, for results can be applied in many countries and solid economic benefits may be expected. Such benefits will be both economic and social in the Developing Countries and the work will also assist the supply problems of the more developed countries such as our own.

To summarize, the minerals industry has much greater potential of assisting the development of the Developing Countries than a simple glance at the production statistics would suggest; the multiplier effect of this pioneering industry can be great, reaching into foreign exchange balances, transportation, industry, agriculture, and education, as well as being very effective in improving the ultimate resource of any country, the skills of the people in it.

Developing Countries vary widely in their present capacity to develop their minerals industry and particularly in their realization of the potential contribution that the minerals industry can make to their progress. Although many have no concept of the importance to them of creating the knowledgeable and effective institutions which are the foundation of progress in minerals development, many others are striving to create the laboratories, field teams, geochemical and geophysical prospecting know-how, mapping and cartographic abilities, and scientific knowledge that are the sine qua non of intelligent and effective minerals development.

The U. S. Geological Survey has worked in 70 different countries during the past 31 years, and has trained or arranged training for well over a thousand men and women from these countries. It has made notable contributions to developing the minerals industry of many of these. This work could have been more effective if funding had been more regular, flexible, and had not been given on the basis of short-term objectives, but rather on the long-term effort that is needed in many specialized but interrelated fields.

The Geological Survey, which is specifically charged with responsibility for knowledge of domestic mineral resources, is keenly aware of the present and impending shortages in certain key mineral commodity resources and of the absolute necessity of having alternative foreign resources on which our country can draw for future needs. Present civilization depends on exchange of commodities, and these raw materials are as necessary to us and other developed countries as many of our products are to the Developing Countries.

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