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BLACK AFRICA: A SOURCE OF ESSENTIAL MATERIALS FOR THE UNITED ST--ETC(U)
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US ARMY WAR COLLEGE
STRATEGIC STUDIES INSTITUTE
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15 December 1977

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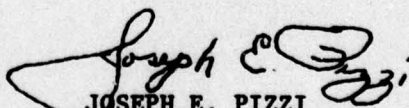
1. The accompanying report was prepared by the 432d Military Intelligence Detachment (Strategic), an Army Reserve unit based at the Fort Wadsworth USAR Center, Staten Island, New York. The 432d MID is assigned the mission of supporting the US Army War College by the preparation of studies and analyses of strategic military significance. Operational and training guidance is provided by the Strategic Studies Institute, US Army War College. Mr. James E. Trinnaman served as Project Coordinator.

2. During this training year, the 432d MID also produced two companion studies: African Development: International and Regional Paradigms and Resource Transfers in a World Market Economy: Sub-Saharan Africa and the Demands of Development.

3. Members of the 432d MID participating in the preparation of this report were: COL John J. Nash, Commanding; LTC Ihor R. Rakowsky; CPT Kevin P. Faherty; 1LT Lawrence A. Franklin; SFC Henry J. Burk; SP6 Martin A. Hyman; SP5 Jose Roman; SP5 John L. Fearey; and SP4 Carl Lankowski.

4. The findings of this study do not purport to reflect official Department of the Army positions. Distribution of the report is limited to US Government agencies only. Requests for this document must be referred to the command, US Army War College, ATTN: Strategic Studies Institute, Carlisle Barracks, PA 17013.

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REPORT: Special Report: Bank Notes of Potential Interest for the United States

See Introduction

1. The accompanying report was prepared by the WMA Military Intelligence Institute, 4800 Reservoir Road, at the Fort Belvoir, Colorado, under the direction of the WMA Chief of Staff, Major General William H. Stewart, and the assistance of the WMA Chief of Staff, Major General William H. Stewart, and the assistance of the WMA Chief of Staff, Major General William H. Stewart.

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4. The findings of this study are being reported to the WMA Chief of Staff, Major General William H. Stewart, and the assistance of the WMA Chief of Staff, Major General William H. Stewart, and the assistance of the WMA Chief of Staff, Major General William H. Stewart.

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SUMMARY

Black Africa: A Source of Essential Materials for the United States? is a study which evaluates black Africa as a potential supplier of critical materials. The paper explores what materials are found in black Africa, which materials are important to the United States and at what rates they are consumed. The paper includes a comprehensive listing of mineral resources currently known to exist in each sub-Saharan African country, the relative abundance of each mineral, the amount produced and a comparison to world production and availability.

I. Introduction.

Africa embraces nearly one fourth of the land surface of the world. Of all the populated continents, only Asia is larger than Africa. In terms of size alone, the African continent should potentially harbor a large proportion of the world's mineral reserves. In spite of the fact that the location and relative abundance of many minerals is currently well known and exploitation has been underway for some time, there are still many questions concerning the less accessible regions. With improved transportation networks other regions may still prove to be of considerable economic importance. Yet, the continent produces nearly one seventh of the world's mineral output. Its energy resources, principally coal in the south, hydropower in the center, and oil and gas in the north and west, are considerable. However, because of economic backwardness, the continent's output is considerably lower than it could be.

Owing to special characteristics of its economic development, Africa's national accounts are much lower than would be expected from its export profile. The region supplies the world market with major quantities of mineral resources such as diamonds (81 percent), tantalum and niobium ores (81 percent), cobalt (79 percent), phosphates (60-67 percent), beryllium, antimony and lead, chromium and manganese ores, gold, cadmium (40-57 percent), and copper and other minerals (24-35 percent). It has a virtual monopoly in exports of lithium ores (100 percent).¹

One of the main considerations for any of the underdeveloped countries in achieving a degree of economic development is the capability to compete in the world market. Economic development up to the standard of the

industrialized nations can only come with the investment of large sums of capital. In the case of most of Africa this can in the short term be expected to yield only a small return. Private capital from the advanced industrialized countries is unlikely to be attracted to such an area while there remain more lucrative fields of investment. Only countries with easily exploitable resources have been able to attract large quantities of private investment, particularly those that have major reserves of minerals in current or in anticipated demand.² Certainly, only some black African nations fall into this category. However, with improved transportation networks, still other regions should prove to be of considerable economic importance.

In the consideration of the potential economic gain to be realized by the black African nations, the viability of the resources must also be considered in some detail. In a continent where vast distances separate the highly productive economic "islands," and where, as a result, transportation is both costly and inefficient, it is of great importance to reduce costs and to increase efficiency. The uncoordinated development of transport in the past has contributed to the haphazard development of the continent as a whole.³ Therefore, in addition to availability, particular emphasis has to be placed on the accessibility and extractability of the resource, thus determining the capability of the nation state to make these materials available to the international market. With respect to these considerations the existence of an internal technology base versus the need for external assistance has to be taken into account.

Although the United States contains only 6 percent of the world's population and 6 percent of the land area, we consume 23 percent of the world's nonenergy resources output and even more of the world's energy output. According to Kirby and Prokopovitch,⁴ in the last 35 years the United States has consumed more minerals than all mankind from the beginning of time up to 1940. Based on its high demand for materials it would seem the United States has a vested interest in the world resource situation. In addition to simply meeting our own resource needs we are faced with the scenario of resources as a source of potential conflict throughout the world.

In order to evaluate the importance of black Africa as a potential supplier two areas must be investigated. From the resource view comes the question of what is there. Then, from the consumer point of view, comes a consideration of what materials are important and at what rates they are consumed. First, the problem of resource appraisal will be treated. Following this, an assessment of United States usage of selected key materials will be presented.

The following summary lists the mineral resources currently known to exist in each sub-Sahara African country. Figures included indicate the relative abundance of the mineral, the amount produced, and in the more important areas, a comparison to world production or availability.⁵ Again it should be noted that the mere presence of a mineral resource does not indicate its availability to the world market. Some countries have actually decreased production during the last ten years due to increased costs.

II. Mineral Resources by Country.

ANGOLA - very rich in mineral resources

1. crude oil, diamonds and iron ore account for 99 percent of investment and output of mining industry
2. diamonds - gemstones - 2,124,719 carats in 1973
3. iron ore - exports virtually all of its iron ore
4. magnetite
5. copper - estimated reserves 23 million tons, production in 1973 - 20,000 tons
6. gypsum - production in 1973 - 46,700 tons
7. asphalt - production in 1973 - 49,600 tons
8. sea salt - production in 1973 - 96,700 tons
9. manganese - production in 1973 - 4,700 tons
10. phosphates, uranium, gold

BENIN - poor in mineral resources

1. iron ore in the north - low grade
2. limestone - quarried for internal cement works

BOPHUTHATSWANA - rich in minerals

1. asbestos - production in 1972 - 60,615 tons
2. chrome - production in 1972 - 86,065 tons
3. limestone - production in 1972 - 392,183 tons
4. manganese - production in 1972 - 36,935 tons
5. vanadium - production in 1972 - 1,307 tons
6. platinum - 25 mines in 1974 among most important in non-communist world
7. gold, granite, salt, calcite, fluorspar

BOTSWANA

1. diamonds, copper, nickel, sulfur

BURUNDI - mining second in importance in economy

A. Major resources

1. cassiterite - 150 tons produced in 1975
2. bastnasite - 200 tons produced in 1975
3. kaolin

B. Also extracted

1. gold, tungsten, columbo-tantalite, beryl, amblygonite
(source of lithium)

C. Known existence

1. nickel - sizeable deposits
2. uranium, copper, molybdenum, bismuth

CAMEROON

1. bauxite - known deposits of over one billion tons
2. gold - production declining - 278 kg in 1969 to 3 kg in 1973
3. other deposits, but few commercially exploited, of diamonds, mica, columbo-tantalite, cassiterite, lignite, rutile

CENTRAL AFRICAN REPUBLIC

1. diamonds - 300,000 - 600,000 carats produced annually
2. uranium - estimated reserves 20,000 tons
3. iron - estimated reserves 500,000 tons
4. nickel, manganese, cobalt, tin, copper, china clay, limestone

CHAD

1. natron - natural form of sodium carbonate - 4,000 to 10,000 tons produced annually

2. quartz, minor deposits of gold, uranium, thorium

CONGO - mining is most important facet of economy

1. oil - estimated reserves 100 million tons in 1973
2. iron - estimated reserves 400 million tons in 1973 - one of the largest in the world
3. potash - production of 475,000 tons in 1974
4. gold - fell from 158 kg in 1967 to 16 kg in 1974
5. lead - factory being built to process 425,000 tons annually
6. zinc - factory being built to process 165,000 tons annually
7. copper - erratic production
8. bauxite, potassium, phosphate, limestone, natural gas

EQUATORIAL GUINEA - no significant exploitation

1. some offshore oil
2. some uranium
3. some iron

ETHIOPIA - little of expected mineral potential has been exploited

1. gold, silver, marine salt, eritrea, rock salt, copper, platinum, manganese, quartz, natural gas
2. various mineral surveys being conducted

GABON - richest of former French Equatorial African colonies in known mineral deposits

1. oil - estimated reserves 172 million tons in 1973
2. natural gas - estimated reserves 187 billion cubic meters in 1973
3. manganese - second most important mineral product - world's first ranking exporter - third ranking producer - estimated

reserves 300 million tons of ore with a metal content up to 53 percent - two million tons a year production - limited by transportation

4. iron - reserves estimated as high as a billion tons of ore of 60 to 65 percent iron content
5. uranium - 1772 tons produced in 1974
6. gold - reserves seem to be nearing extinction
7. potash, lead, zinc, phosphate

GAMBIA

1. ilmenite - no longer exploited - no other commercially exploitable resources

GHANA

1. gold - most valuable mineral resource export
2. manganese - 300,000 to 600,000 tons produced annually
3. diamonds - industrial variety - 2,700,000 carats produced in 1973
4. bauxite - estimated reserves 200 million tons - small production
5. beryl, tantalum-columbite, chromite

GUINEA - mining accounts for 75 percent of Guinea's foreign exchange earnings

1. bauxite - estimates vary from 8 billion tons or 2/3 of the known world reserves, to an estimate of 1/5 of the world's reserves - government projects that Guinea will be producing 25 million tons annually in 1978 - if so Guinea would become the world's largest producer

2. iron ore - reserves estimated at 300,000 to 600,000 tons - short term goal is to ship 30 million tons a year by 1980
3. diamonds - 80,000 carats in 1972

GUINEA-BISSAU

1. oil - offshore
2. bauxite - reserves estimated at 200 million tons - mining halted because of a lack of capital and transportation facilities

IVORY COAST

1. diamonds - production fluctuated greatly - 549,000 carats in 1961, 176,000 in 1967, 350,000 carats in 1973
2. manganese - estimated reserves 13 million tons - exploitation ceased
3. gold - estimated reserves of 1.4 million tons of gold ore with a content of 10.9 grams per ton
4. columbo-tantalite - small scale production
5. ilmenite - reserves 500,000 tons
6. iron, copper, titanium, chromite, bauxite, asphalt - not yet exploited

KENYA - mining declining steadily since World War II

1. soda ash - 155,997 tons produced in 1974
2. limestone, soapstone, salt, gemstones - ruby, garnet - lead, silver, zinc, fluorspar

LESOTHO - few known exploitable mineral resources

1. alluvial diamonds

LIBERIA

1. iron ore - largest producer in Africa - third largest exporter in the world
2. diamonds
3. gold - small deposits mined

MADAGASCAR

1. chromite - 65,000 tons exported in 1973
2. graphite - 13,963 tons exported in 1973
3. beryl, columbite, phosphate, gold - have been exploited
4. uranium, thorium - exploitation beginning
5. nickel - estimated reserves 70,000 - unexploited due to poor internal transportation system
6. bauxite - estimated reserves 500 million tons - unexploited
7. coal - estimated reserves 60 million tons - unexploited

MALAWI - no ore body of commercial significance has been discovered

1. limestone - only current mining activity
2. small deposits of corundum, galena, gold, kyanite, asbestos, mica

MALI - small scale exploitation - depends on better transportation

1. salt - only mining activity
2. bauxite, gold, iron, phosphate, manganese, lithium

MAURITIUS - no mineral resources

MOZAMBIQUE - rich in mineral deposits - undeveloped

1. columbite, tantalite, beryl, semiprecious stones, feldspar, kaolin, coal, copper, bauxite, fluorine, anthophyllite, bentonite, and natural gas

NIGER

1. uranium ore - substantial quantities - estimated reserves over 100,000 tons - only mineral resources to be significantly developed
2. tin - 145 tons exported in 1973
3. salt, iron, tungsten, coal, gypsum, phosphates

NIGERIA

1. oil - major resource - proven reserves in 1975 of 18.25 billion barrels: enough to last 25 years at current level of production - more exploration being conducted
2. tin - world's sixth largest producer (both ore and metal)
3. columbite - 90 percent of world supply - 1,921 tons in 1967 - 1,000 tons in 1975 (civil war)
4. coal - only west African producer - 327,000 tons in 1973
5. limestone

RHODESIA - major resources asbestos and chromium - third in world production in 1965

1. copper - 32,000 tons produced in 1973
2. gold - 15,000 kg produced in 1973
3. asbestos - 80,000 tons produced in 1973
4. chromium - 272,000 tons produced in 1973
5. coal - 3,060,000 tons produced in 1973
6. nickel - 12,000 tons produced in 1973
7. lithium - world's largest producer in 1965
8. zinc, lead, cobalt

RWANDA

1. cassiterite (tin ore) - 2,030 tons produced in 1973
2. wolframite (source of tungsten) - 688 tons produced in 1973
3. beryl and columbo-tantalite - 92 tons produced in 1973
4. amblygonite, gold, uranium - mined in smaller amounts

SENEGAL

1. phosphates - aluminum - 405,400 tons in 1974 - calcium - 1,472,000 tons in 1974
2. salt - 150,000 tons in 1974
3. iron ore - estimated reserves 1,300 million tons - transportation problems

SIERRA LEONE

1. diamonds - 1,847,000 carats in 1972
2. iron ore - 2,404,866 tons in 1973
3. bauxite - 662,899 tons in 1973
4. rutile (titanium oxide), antimony, cassiterite, columbite, corundum, fluorspar, ilmenite, titanium, lignite, magnetite, molybdenum, monazite, platinum, tantalite, tin, tungsten, lead, zinc, silver

SOMALIA

1. tin - only mineral resource commercially exploited
2. uranium, iron ore, quartz, gypsum, beryl, columbite

SOUTH AFRICA

1. diamonds - world's foremost producer of gem diamonds - third in total production behind Zaire and USSR - 7,565,374 carats in 1973

2. gold - leads world production - 855,179 kg in 1973
3. platinum - leads world production
4. manganese - second in world production to USSR
5. chrome - second in world production to USSR
6. antimony - world's leading producer
7. uranium - ranks after Canada and the United States - 2,796 tons in 1973
8. important world supplier of asbestos, beryllium, corundum, nickel, talc, titanium, copper, vanadium, tungsten, vermiculite
9. coal - 62.4 million tons in 1973
10. iron ore - 10,955,336 tons in 1973
11. all materials needed for alloying steel
12. tin, silver

SUDAN - not rich in mineral resources

1. manganese - 500 tons in 1972
2. gold 2 kg in 1970
3. salt - 55,000 tons in 1972
4. iron ore - 10,000 tons in 1972
5. copper, mica

SWAZILAND

1. iron ore - 2,147,000 tons in 1973
2. chrysolite asbestos - 39,600 tons in 1973
3. coal, kaolin, barites

TANZANIA - diamonds and salt currently of major importance

1. diamonds - 580,000 carats in 1973

2. salt - 44,000 tons in 1972
3. gold, mica, tin, tungsten, coal, iron, phosphates, lead, copper, silver

TOGO

1. lime phosphate - 2,553,000 tons in 1974 - principle mineral resource
2. marble - estimated reserves 20 million tons - 50,000 tons produced in 1971

TRANSKEI - little exploitation

1. marble - exploited the most
2. granite, sandstone, whinstone, zircon, magnetite, ilmenite, coal

UGANDA - not richly endowed with minerals

1. copper - 9,643 tons produced in 1973 - only large scale mining operation

UPPER VOLTA - virtually no commercial production - transportation

1. manganese, bauxite, limestone, cassiterite, copper, graphite, iron

ZAIRE - world's leading producer in cobalt and industrial diamonds

1. copper - 6th largest world producer - 460,697 tons in 1973
2. cobalt - 16,000 tons produced in 1975
3. industrial diamonds - 14 million carats in 1974
4. zinc - 150,000 tons in 1974
5. manganese - 334,000 tons in 1974
6. tin - 5,442 tons in 1974

7. cassiterite - 7,502 tons in 1974
8. iron ore, gold, silver, cadmium tantalum, tungsten,
uranium

ZAMBIA

1. copper - 705,800 tons in 1974
2. coal, 809,900 tons in 1974
3. zinc - 58,500 tons in 1974
4. lead - 24,500 tons in 1974
5. cobalt - 1,963 tons in 1974
6. silver, gold, selenium, cadmium vanadium, gypsum, uranium

III. US Minerals Consumption.

Following an analysis of black African mineral reserves, their significance must be assessed. A logical approach to this task is a consumer oriented consideration of these resources, focusing on the United States. Of a list of 37 strategic materials compiled by the Bureau of Mines, US Department of the Interior, at least 50 percent of the US demand for 22 of these was met by import in 1975. At least 25 percent of the demand was met by import for 31 of these 37 strategic materials. Black African nations were a major source for 5 of the 37 (Fig. 1).⁶ A description of strategic materials of which more than 25 percent of demand is met by imports is included in Appendix I. Following the elucidation of mineral reserves, 12 black African materials were selected for investigation. The criteria for inclusion were presence on the Bureau of Mines list and availability of information. Two materials, copper and uranium, were included because of their intensity of use and energy/military importance respectively.

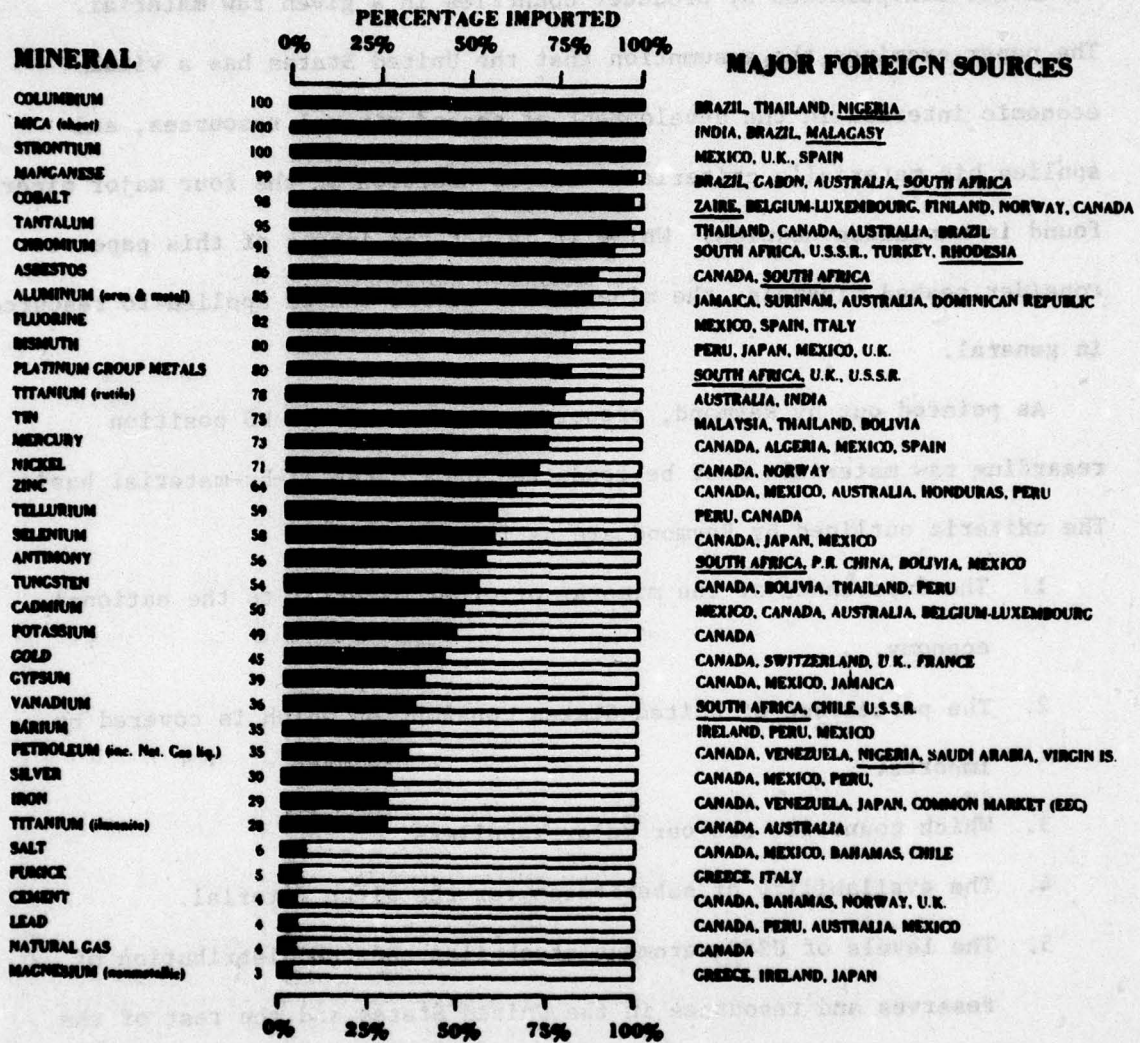


Fig. 1. Imports of strategic materials by the United States in 1975

In a recent paper in the Marine Technology Society Journal,⁷ Richard Raymond discusses various criteria for assessing economic vulnerability to market manipulation by producer countries in a given raw material. The paper examines the assumption that the United States has a vital economic interest in the development of seabed mineral resources, and applies his material's criteria to the US position in the four major minerals found in manganese nodules. While it is not the intent of this paper to consider seabed minerals, the mineral's criteria can be applied to resources in general.

As pointed out by Raymond, proper assessment of the US position regarding raw materials must be conducted on a material-by-material basis. The criteria outlined by Raymond are as follows:

1. The importance of the mineral or other material to the national economy.
2. The percentage of United States consumption which is covered by imports.
3. Which countries are our major suppliers.
4. The availability of substitutes for the given material.
5. The levels of US Government stockpiles and the distribution of reserves and resources in the United States and the rest of the world.
6. The feasibility of cartel action by producer countries.

In his analysis, Raymond looks at four materials which are found in manganese nodules: cobalt, copper, manganese, and nickel. These are also key materials in the African analysis. We propose to utilize the same

framework, looking at the materials which the United States presently imports from black Africa as well as other potentially important minerals which are present, but for various reasons are not exported to the United States. The criteria are modified in that the question of cartel action by producer countries will not be considered in this report.

In assessing economic vulnerability, Raymond utilizes as his first criteria: "importance of the material to the national economy." While this remains an important criteria, difficulty exists in assessing it any further than yes or no. In fact, Raymond points out that this is a necessary but difficult criteria to apply. He suggests two possible guidelines. The first is intensity of use. This is an objective standard which relates tons of material used to billion dollars of gross domestic product (GDP). A second guideline would be dollar value of material consumed to GDP. However, both guidelines can be misleading. With respect to platinum and iron, the two guidelines give differing levels of importance. There is no "reference" available. Quantitative statements do little to identify materials which may be limited in dollar value or in volume consumed, but which may be of some importance. Although importance is usually linked to some inflated cost this may not always be the case. Consequently, a purely quantitative measure is of questionable value.

In his paper, Raymond examines the assumption that the United States has a vital interest in rapid development of seabed minerals, and thus is forced to first determine the importance of the materials in question. For the purposes of this study, only those materials which are of importance are considered. A brief discussion of each criteria is helpful.

Percentage of consumption imported is a key indicator of potential vulnerability to producer action. The higher the ratio of imports to consumption, the more a consumer country is vulnerable to producer action. At the extreme, a country which relies totally on domestic production and has sufficient reserves is completely insulated from exogenous pressures. While it may be true that in a free market economy the flow of goods is highly correlated to price fluctuations, it still remains that any disruption of this flow will still leave a stable domestic supply available. Freedom from reliance on foreign sources is predicated on domestic reserves and resources of sufficient quality. High stockpiles provide a buffer to producer action. In addition, consumption expressed as a percentage of world reserves (i.e., years of exploitation remaining) indicate areas of latent pressure.

However, in spite of a possibly unfavorable import-consumption ratio, the nature of the major suppliers remains an important consideration. Clearly it is unreasonable to strive for economic isolation because all foreign suppliers are considered as equally unreliable sources. Long-standing alliances, as well as economically attractive situations, fault this generalization. In various cases a given material is not so unique as to its application that substitutes are not available. When considering possible substitutes clearly, cost, performance, and availability of the replacement are important, however a flexibility is introduced into the system.

8

BAUXITE

Percentage of Consumption Imported:

Imports accounted for 69 percent of US consumption in 1974. This was up 2 percent from the preceding year, however, this increase is not significant as it does not represent a trend over the last 10 years. Sales from stocks accounted for only a small fraction of consumption. Dependence on foreign bauxite and alumina is likely to continue until the use of large domestic deposits of kaolin type clays, anorthosite, alunite, or other aluminous materials becomes competitive. Consumption in 1974 amounted to 17,300,000 long tons (imports 12,000,000 long tons) or approximately 24 percent of world production (73,000,000 long tons).

Major Producers/Suppliers:

The major foreign sources of bauxite are Jamaica, Surinam, Australia, and the Dominican Republic. No African nations are considered major producers at this time although potential resource levels are high. The United States and its major suppliers account for approximately 60 percent of world production.

Substitutes:

Large scale use of domestic aluminous materials other than bauxite will depend on the cost and availability of foreign sources of bauxite and alumina. Research on processes using other materials has been accelerated in recent years.

Stockpiles, Reserves, Resources:

The total US stockpile inventory of bauxite stood at 18,878,000 long

tons as of 31 December 1973. Domestic resources of bauxite are inadequate to fulfill long term demand; however, virtually inexhaustible alternative sources of aluminum in materials other than bauxite exist in the United States as well as other major producers. Total world bauxite resources (i.e., reserves, subeconomic and undiscovered deposits) are estimated at 25 to 30 billion tons. These resources are located as follows (in millions of tons): United States - 250-300, Caribbean and Central America region - 1,500, South America - 6,000-8,000, Africa - 8,000-10,000, Asia - 2,000-3,000, Oceania - 5,000-6,000. Government stockpiles represent roughly a one year supply at present usage.

CHROMITE⁹

Percentage of Consumption Imported:

Total US consumption of chromite in 1974 amounted to 1,420,000 short tons. Of this value 88 percent was met by imports. Domestic production of chromite ceased in 1961: the United States will continue to rely on imports, with supplementation from government stockpile sales. Additional chromium demand is met from ferrochromium reserves both imported and domestic.

Major Production/Suppliers:

The major foreign sources of chromite are South Africa, the USSR, Turkey and Rhodesia. World production in 1974 amounted to 7,300,000 short tons. The above countries account for 77 percent of world production. Individually they produced: USSR - 2,100,000 short tons (29 percent),

RSA - 1,700,000 short tons (23 percent), Turkey and Rhodesia - 600,000 short tons each (8 percent).

Stockpiles, Reserves, Resources:

Total stocks of chromite as of 31 December 1974 were assessed at 700,000 short tons. This was an increase of 17 percent over 1973 figures. This is somewhat confusing in view of the fact that consumption exceeded import. However, it should be noted that the figure cited for imports was solely for consumption. Although world resources of chromite totaling nearly 9 billion short tons are ample for the foreseeable future, domestic resources are low grade and represent less than a 5 year supply. Even a world price several times its present level will not improve the outlook for the domestic resource base. The North American resource is represented by deposits in Montana in the United States, Manitoba, Canada, and large, low grade deposits in Greenland. The majority of the world's chromite is located in RSA and Southern Rhodesia.

COBALT¹⁰

Percentage of Consumption Imported:

Imports expressed as a percent of exports declined from 60 percent in 1974 to 15 percent in 1975, according to 1974 data and 1975 estimates from the Bureau of Mines. Sales from government stockpiles, however, were a large factor, and as excess stocks are drawn down, imports can be expected to increase to more traditional levels.

Major Suppliers:

The major supplier of cobalt to the United States is Zaire. From 1971-74, Zaire supplied 76 percent of US cobalt imports, either directly (47 percent) or through Belgium-Luxembourg (29 percent).

Substitutes:

Nickel may be substituted for cobalt (and vice versa), depending upon the economics of the particular application. Potential substitutes (involving higher costs and/or altered technical performance) include nickel in jet engines and catalysts, and copper, chromium and manganese in paints.

Stockpiles, Reserves, and Resources:

The total US stockpile inventory of cobalt stood at 23,448 short tons as of 30 November 1975. US reserves are virtually nonexistent. Identified resources in the United States are more than 840,000 tons, located mainly in the Midwest and Farwest. World reserves are 2,700,000 short tons, located chiefly in Zaire, New Caledonia and Australia, Zambia and Canada. World identified resources of cobalt are nearly 5,000,000 tons, mainly in tropical regions.

COPPER¹¹

Percentage of Consumption Imported:

Net imports of unmanufactured and refined copper as a percentage of consumption of refined material declined from 27.3 percent in 1974 to a net export position of 3.7 percent in 1975, according to 1974 data and 1975 estimates from the Bureau of Mines. Copper has been an extremely

volatile commodity in the past two years (consumption in the United States declined 32 percent from 1974 to 1975); thus it is probably unrealistic to expect the United States to remain a net exporter of copper. In the 1970-73 period, net imports as a percentage of consumption averaged 15 percent; this figure seems more reliable for present purposes. In addition, it is interesting to note that the United States is by far the world's largest copper producer.

Major Suppliers:

Canada, Peru, and Chile are the major suppliers of United States copper imports. From 1971-74, Canada supplied 33 percent of United States imports, Peru 22 percent, and Chile 17 percent.

Substitutes:

A number of substitutes exist for copper, depending upon application. Aluminum can be used in shell cases, and plastics can be substituted for copper in plumbing.

Stockpiles, Reserves, and Resources:

The national stockpile objective for copper is zero, and the total inventory is 489 tons of refined copper. The United States has 90 million short tons of copper reserves, located primarily in the Southwest and West Central states. In addition, the United States has some 320 million short tons of copper in identified and unidentified resources, according to Bureau of Mines estimates. World reserves are 450 million short tons of copper, with the United States, Chile, Canada and the Soviet Union (in that order) being the major holders of copper reserves. World hypothetical

resources are estimated to amount to a further 480 million short tons, generally located near known deposits.

LEAD¹²

Percentage of Consumption Imported:

In 1974 total consumption of lead amounted to 1,533,000 short tons. US mine production was 669,000 short tons (44 percent of consumption). Imports account for 46 percent of consumption. These imports were distributed in the following manner: Canada - 14 percent of consumption (211,554 short tons), Peru - 10 percent (153,300 short tons), Australia - 10 percent (153,300 short tons), and Mexico - 5 percent (76,650 short tons). The remaining 7 percent came from other sources. In 1973 US consumption (1,541,000 short tons) amounted to almost 43 percent of world production.

Major Producers/Suppliers:

Major producers of lead remain the United States, the USSR, Canada, Japan, and Australia. In 1972 (the last year for which complete figures were available) these five countries accounted for 55 percent of world production. Nine other countries with an average production of 116,900 short tons, account for an additional 28 percent of production. Following the five leaders, production is fairly evenly distributed. Import sources were Canada - 30 percent, Peru - 22 percent, Australia - 21 percent, and Mexico - 10 percent.

Stockpiles, Reserves, Resources:

Combined producer and consumer stocks were 264,100 short tons at the end of 1972. No evidence of lead on the government stockpile list was

found. Domestic demand for lead is forecast to increase at an annual rate of approximately 1.7 percent through 1980. The use of lead free gas in new automobiles has drastically reduced US demand. This use accounted for 16 percent of US consumption in 1974. The outlook for discovery of reserves and resources at a rate in excess of consumption is optimistic. Total world resources are estimated at 1.5 billion tons. This amounts to roughly 500 years at current production rates.

MANGANESE¹³

Percentage of Consumption Imported:

In 1975, net imports of manganese ore and ferromanganese amounted to 93.1 percent of US consumption of these materials. There was no mine production of manganese in the United States in 1975; the remaining share of consumption came from shipments from government stockpile excesses.

Major Suppliers:

From 1971-74, US imports of manganese ore came primarily from Brazil (35 percent), Gabon (31 percent), Australia (9 percent) and South Africa (8 percent). Imports of ferromanganese came mainly from France (39 percent), South Africa (36 percent), and India (8 percent).

Stockpiles, Reserves, Resources:

As of 30 November 1975, government stockpiles contained a total inventory of 3,608 short tons of manganese ore and 629,000 tons of ferromanganese. The United States has no reserves of manganese ore. The United States has some resources, but they can be expected to be available only at higher

prices or with considerably improved technology. World reserve countries are South Africa, Gabon, Brazil and Australia. Accurate resource figures are difficult to obtain - known landbased resources of manganese are very large and irregularly distributed throughout the world. Reserves alone are considered adequate to meet the expected growth in world demand for manganese through the year 2000.

NICKEL¹⁴

Percentage of Consumption Imported:

Preliminary figures for 1975 indicate that import of nickel accounted for 83.7 percent of total US nickel consumption. This figure is roughly equivalent to figures for the past three years, and since no exogenous factors (such as government stockpile sales) are involved in the US nickel market, the 80 percent range for import dependence can be viewed as reliable.

Major Suppliers:

Canada is the dominant supplier of nickel to the United States. From 1971-74, the United States obtained 76 percent of its nickel imports from Canada, either directly (68 percent) or via processing in Norway (8 percent). New Caledonia and the Dominican Republic supplied small amounts (6 percent and 5 percent, respectively).

Substitutes:

A number of potential substitutes exist for nickel in its major applications, but most involve increased cost of altered technical performance. Potential nickel substitutes include aluminum, coated steel and plastics

in the construction and transportation industries; nickel-free steels in power, petrochemical and petroleum industries; titanium and plastics in severe corrosion service applications; cobalt as an underplate for chromium in decorative plating; platinum, cobalt and copper in some catalytic uses.

Stockpiles, Reserves, Resources:

Nickel is not currently a government stockpile item. The United States has 200,000 short tons (0.2 percent nickel) sulfide deposits. World reserves currently total 59.5 million short tons located primarily in New Caledonia (26 million), Canada (9.6 million), and Australia (5.5 million). World resources averaging 1 percent nickel are estimated to total 70 million tons of metal.

PLATINUM GROUP METALS¹⁵ (platinum, palladium, iridium, osmium, rhenium, and ruthenium)

Percentage of Consumption Imported:

The United States imports about 99 percent of its requirements of the platinum group metals. It is unlikely that domestic production, which is largely a byproduct of copper mining, will ever satisfy much of domestic demand. Imports in 1974 amounted to 2,818,722 troy ounces with US production at 18,000 troy ounces. US imports for consumption amounted to 46 percent of world production in 1974.

Major Producers/Suppliers:

The United States demand is met by the USSR, RSA, and the UK. The material imported from the UK is refined RSA metal. The USSR and RSA account for 92 percent of world production in 1974. World production was

6,106,000 troy ounces with RSA producing 3,000,000 and the USSR producing 2,600,000 troy ounces.

Stockpiles, Reserves, Resources:

Total US stockpile of platinum group metals as of 31 December 1974 was estimated at 1,017,750 troy ounces. Estimates of world resources range from 1200 to 1900 million troy ounces. This is 2 to 3 times the estimated reserves and 5 to 8 times total estimated consumption for the period 1974-2000. Total US resources are estimated at 200 million troy ounces. World resources should last 100-200 years with moderate increases in consumption. Estimated world reserves amount to 425 million troy ounces distributed as follows: RSA and USSR - 200 million troy ounces each, Canada - 16 million, Columbia - 5 million, and the United States - 3 million troy ounces.

TIN¹⁶

Percentage of Consumption Imported:

Imports of metal and concentrate accounted for 78 percent of primary consumption for 1974. Imports accounted for 68 percent of total consumption during that year. Imports of this metal declined 17 percent from the 1973 level because sales of surplus stockpile tin lessened US demand for foreign sources. Demand is expected to increase at an annual rate of less than 1 percent through 1980. Consumption in 1974 amounted to 67,240 long tons or approximately 30 percent of world production (230,000 long tons).

Major Producers/Suppliers:

The major foreign sources for tin are Malaysia, Thailand, and Bolivia. Together these countries accounted for 51 percent of world production in

1974. Tin is mined and smelted in only small quantities in the United States. Four African nations are listed as producers of tin accounting for 6 percent of world production (Zaire - 2 percent; Nigeria - 2 percent; Rwanda - 1 percent; and south Africa - 1 percent).

Substitutes:

Increase in demand is expected to be at a low rate due to the presence of many substitutes. Substitution of aluminum, glass, paper, plastic or tin free steel for tin in cans and containers, epoxy resins for solder, aluminum alloys, other copper base alloys for plastics for bronze, and aluminum, copper-, and lead-based bearing alloys or plastics for tin containing babbitt metal would lower projected rate of growth.

Stockpiles, Reserves, Resources:

US tin stocks averaged 9,763 long tons in 1974. US tin resources, located primarily in Alaska, are insignificant compared to the rest of the world. World resources are located principally in Southeastern Asia, Bolivia, Brazil, Nigeria, People's Republic of China, the USSR, and Zaire. The known reserves are all located within established tin producing countries. Sufficient resources are available to sustain production rates well into the next century.

17
TITANIUM - (found in two forms - ilmenite and rutile. Ilmenite is the major source for titanium pigments while rutile is the principal ore from which titanium metal is extracted)

Percentage of Consumption Imported:

Dependence on foreign sources is typically more than 95 percent. Demand for titanium metal is expected to increase at an annual rate of 4 percent

through 1980. Imports of rutile accounted for 79 percent of US consumption of that material in 1974. The low figure is the result of stock sales in that year. Dependence on foreign sources is likely to continue until economic processes to extract titanium metal from low grade deposits are developed. US consumption of rutile amounted to 72 percent of world production (367,768 short tons).

Major Producers/Suppliers:

Australia has for years been the leading producer and supplier of titanium. In 1973 Australia produced 98 percent of the world rutile output. In the same year the United States, Canada, and Norway produced 66 percent of the world's ilmenite (21 percent, 21 percent, and 24 percent respectively). Australia and India were major suppliers of rutile and Canada and Australia were major suppliers of ilmenite.

Substitutes:

Various alloys can be substituted for titanium. However, redesign is usually required and lower performance characteristics usually result. Consequently, in spite of high costs of titanium over projected lifespans, titanium may be less expensive. A new factor is synthetic rutile imported from Japan, Australia, and India. However, little information on this is readily available.

Stockpiles, Reserves, Resources:

Total US stocks of rutile were 135,546 short tons. Stocks of ilmenite were 334,441 short tons, at the close of 1973. Both figures represent a decline over previous years. On the east coast of Australia 9 million tons

of rutile are present, however, only 5 million of these can be mined due to environmental pressures. This amounts to less than 14 years of production at present levels.

18
URANIUM

Percentage of Consumption Imported:

Consumption of uranium oxide amounted to 12,600 short tons in 1974. Of this, approximately 5.6 percent was imported (1,300 short tons), with 2.2 short tons being exported. US consumption amounts to almost 52 percent of free world production. US production accounts for 48 percent of free world production. Data for ore and oxide are poorly separated.

Major Producers/Suppliers:

The remaining 52 percent of 1974 free world production comes from Canada - 21 percent (5,000 short tons), France - 8 percent (1,900 short tons), Niger - 4.5 percent (1,100 short tons), Gabon - 3 percent (700 short tons), and South Africa - 15 percent (3,600 short tons).

Stockpiles, Reserves, Resources:

Stocks of uranium amounted to 27,000 short tons at the close of 1974. It is unclear as to the quality of those materials. In the United States large exploitable deposits are found chiefly in sandstone and associated rocks. The Atomic Energy Commission reports reserves of 520,000 tons of ore with estimates of \$15/pound costs and 700,000 tons with estimates of \$30/pound costs. Low cost domestic reserves are considered sufficient until the early 1980's. By this time price increases may make higher cost resources economic to exploit. Low grade high cost domestic uranium resources

in black shales and phosphorites are large, however, production from these sources would require processing of vast quantities of rock.

19

VANADIUM

Percentage of Consumption Imported:

Imports accounted for 38 percent of US consumption in 1974. This was up approximately 5 percent since 1973. Total consumption amounted to 6,393 short tons in 1973 which was 30 percent of world production (21,285 short tons). Consumption in 1974 was up only 2 percent to 6,500 short tons. Consumer stocks were augmented, however, over 35 percent from 1,291 short tons to 1,750 short tons. Exports of this material were negligible.

Major Producers/Suppliers:

The major foreign sources of vanadium are South Africa, Chile, and the USSR. Together with the United States these countries account for over 89 percent of world production (21,285 short tons). Individually, these countries contributed the following amounts and percentages of world production: South Africa - 9,870 short tons (46 percent), Chile - 1,060 short tons (5 percent), USSR - 3,700 short tons (17 percent).

Stockpiles, Reserves, Resources:

At the close of 1974 only 540 short tons of vanadium remained in the government stockpile. Consumer stocks amounted to 1,750 short tons. Congressional authority is needed before further depletion of government stocks will be allowed. Domestic reserves are large enough to meet expected demand; however, cheaper foreign material will probably account for approximately

25 percent of demand. Development of domestic reserves is impeded by costly, inefficient vanadium recovery technology. Large resources of vanadium occur in the United States in known but noncommercial deposits. Although present in large quantities, vanadium is not automatically available because much of it can only be recovered as a byproduct.

IV. Conclusions.

Is black Africa an important source of nonenergy materials for the United States? If the question is answered based on current import sources and existing producers, for the materials considered here, the answer is no. Of the twelve minerals which were analyzed, African Nations are producers of seven: chrome, cobalt, manganese, platinum group metals, tin, uranium, and vanadium. If we filter out those materials produced almost solely by the Republic of South Africa (i.e., within Africa), namely platinum group metals and vanadium, then only five of the twelve remain. Chrome is a critical, strategic material. Repeal of the Byrd Amendment prohibits further US imports of chrome from Rhodesia. Of the four remaining materials, tin and uranium are produced in only small quantities by black African states. African output of these two materials is less than 6 percent and 7.5 percent of world production respectively. Only cobalt and manganese are produced in quantity in black African countries. Zaire produces 76 percent of the world's cobalt, and Gabon produces 31 percent of the world's manganese. For cobalt, good substitutes and stockpiles exist, as well as US resources. For manganese, the United States presently has good stockpiles, stable supply channels, and US reserves. Further, both materials are found in manganese nodules, for which the collection technology is in an advanced development

stage. In spite of its alternate mission, the Glomar Explorer has demonstrated that surmounting the various technical obstacles is possible. Raymond argues that for various reasons (i.e., substitutes, stable supplies, reserves, stockpiles and lack of cartel potential) the United States has no vital economic interest in rapid development of seabed minerals.²⁰ He bases this on the conclusion that there is little threat to the United States in any of the four nodule minerals: cobalt, copper, nickel, and manganese. For the same reasons, plus the access to nodules, it can be argued that the United States has no critical resource interest in black Africa. Even when niobium, mica, tantalum and beryllium are considered, the picture is not changed appreciably. For the first three, the United States imports 14 percent from black Africa (Nigeria, Malagasy, and Zaire). The United States imports 5 percent of its beryllium from Uganda.²¹ Further, due to the time which is required to transfer technology, build roads and rail lines, and develop mines, it is not expected that this picture will change much before the year 2000. Until such time that reserves are developed, black Africa cannot play any greater role as a source of materials. Although shortages on the world market may affect the development rate, the availability of African minerals on the world market is a function of production capacity.

Yet the high rate of US mineral consumption does not permit acceptance of this conclusion. In spite of the fact that the United States is generally more self-sufficient than most industrialized nations, it has become more dependent on external sources. This is true, in spite of the prospects of seabed mining and such proposed technology as mechanical and/or biological concentration and extraction of minerals dissolved in sea water.

A brief example of resource usage should serve to emphasize the issue. Consider a reserve which is known to be viable for 1000 years at current usage rates. If consumption increases at 4 percent per annum, this reserve will last only 176 years. If the original stock were doubled due to discovery of new deposits, then the reserves would last 194 years. If the original stock were multiplied tenfold, the reserves would last 235 years. If the rate of usage increase were 5 percent annually, with the above considerations the hypothetical stock would last only 142, 156 and 189 years respectively. Although stable exponential increase in consumption is unrealistic, the results of the exercise are dramatic in demonstrating the critical nature of long term planning for meeting mineral requirements. In the above hypothetical situation, it can be seen that with a small exponential increase in consumption, doubling the available reserves of a material adds less than twenty years to the projected life of the reserves. Further, if conditions are less favorable and the initial stock would last less than 1000 years with constant consumption, or if the exponential increase were in excess of 4 percent annually, then the outcome would be even more dramatic. Some might argue that, if doubling the reserves of a particular material adds only a short time to its projected life expectancy, the return on the investment of procuring and developing these reserves might be too low. However, this would appear to be a defeatist attitude. More important, this devaluation of the projected life expectancy of world reserves will undoubtedly intensify conflict over control. While the United States may attain sufficiency in a material without black Africa, the same may not be true of less fortunate states. At the same time, being the largest consumer of raw materials it would appear to be in our best interest to look toward

potential future producers of necessary materials.

Consequently, black Africa cannot be ignored, and because of a long lead time which may be necessary before production is realized, planning must begin now. Clearly, it would appear that Africa is a logical area to focus upon due to its large untapped reserves of key materials.

A key concern of US interests in Africa's mineral resources may be the possibility of unified economic ties among black African nations. Any consideration of the possible producer cooperation among black African nations becomes an extremely complex problem. The African reality is governed at present by the existence of different trade regimes and payment systems, supplemented in most cases by specific economic ties with former colonial metropolis. Although underdevelopment is general in Africa, substantial differences in degree exist. Any integration scheme must, therefore, take into account the specific difficulties that the least developed African countries may have to face in joining such a scheme. Also, for obvious reasons, the desire for national planning in countries which only recently have acquired independence tends to be very strong. In addition, due to the poor state of intra-African communications, African countries have had little opportunity to learn about each other. While markets have to be widened, at the same time the national markets of African countries are also in need of internal integration, and in many cases, a true national market has yet to be created.²²

There are various ways an integration scheme can be visualized. As the existing precedents in different parts of the world clearly show, an integrated scheme may either be intended to solve existing specific problems and perhaps lead to increasingly intense and intimate cooperation, or else it

may aim from the beginning at the creation of an economic union where labor and capital will be free to move, as well as goods, and where the economic and social policies of member governments will be harmonized to a high degree (an example of the latter would be a cartel). Under African conditions, an integration scheme of the first type would seem especially important.²³ Certainly it seems that the economic background is not yet ripe for a full economic union, quite apart from the political obstacles.

The economic relationships formed with other countries, based on their possession of raw materials, is in most cases impractical due to cost and transportation considerations.²⁴ On-site refinement, or at least refinement within the boundaries of the supplier nation, requires more capital than many emerging countries in Africa can currently provide, especially for short term rapid industrial development. For example, at first glance Zaire could conceivably benefit from a trade agreement with a nation such as Tanzania in establishing a port to trade with the East. However, the cost of developing an adequate connection with the port would be prohibitive. In addition, the gains realized by Tanzania as a result of the agreement would be questionable.

The nations that currently seem to be striving for the greatest involvement in world affairs and economically profitable trade relationships are those that are also richest in mineral resources. Of all the black African nations, Nigeria seems to be the most likely to benefit from any form of alliances based on mineral resources.

Large reserves of iron ore are located in the Congo (Brazzaville) and Liberia, with the Congo increasing its production of lead and zinc in recent years. Also the Congo had an estimated oil reserve of one hundred million

tons in 1973. Substantial quantities of uranium ore are known to exist in Niger (estimated reserves in 1973 of one hundred thousand tons). Guinea could be the world's largest producer of bauxite. Ghana has reserves of gold, manganese and tantalum-columbite. Gabon is rich in manganese, with reserves of oil, iron and uranium. All of these nations either surround Nigeria or are located on the coast, offering transportation capabilities by water. In essence all of these nations have the kinds of mineral resources necessary to help build an industrialized society, and unquestionably if trade agreements were formed, they would be in the best interests of Nigeria. However, one must consider what advantages would be realized by the "supplier nations" from such an alliance. At this point what does Nigeria have to offer these other nations that could not be achieved more completely, efficiently, and certainly more favorable economically from the more established industrialized powers.

Other more interesting ties might be considered in conjunction with the Middle Eastern oil producing states, but the differences between the overall makeup of these areas would tend to eliminate any such activity. Also, possible alliances with South Africa strictly on a mineral resource trade basis could be interesting to consider, but stronger political ties seem extremely unlikely under present conditions. World use of African mineral resources then seems destined to continue during the next few decades as it has in the past.

The foregoing discussion tends to indicate that there is no easy way, if any, to African economic integration based on mineral resources. Formal trading arrangements cannot be divorced from the substance of promotion and planning vigorously expanding production. Production expansion requires

more money and technological capabilities than most African nations will be able to generate during the next couple of decades and might exceed short term demand in many items. On the other hand, while the coordination of development efforts may be viewed as basic to the whole integration process, it is obvious that any progress in the elimination of barriers in intra-African trade and payments in general will act as a powerful stimulus to the industrialization and economic development in general. The future possibility of strong alliances based primarily on mineral resources then, at least in the near future, appears to be only a remote possibility. Too many more fundamental internal and external economic and political problems will have to be addressed first.

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APPENDIX

DESCRIPTION OF STRATEGIC MATERIALS OF WHICH 25% OF DEMAND IS MET BY IMPORTS

(IN DECREASING ORDER OF % MET BY IMPORT)

Columbium - (new name Niobium) - A gray or white metallic element, somewhat ductile and malleable, used in chrome steels, in jet engines and rockets.

Mica - Any of a group of minerals (complex silicates) that crystalize in thin, somewhat flexible, translucent or colored, easily separated layers: resistant to heat and electricity.

Strontium - A pale yellow, metallic chemical element resembling calcium in proper ties, and found only in combination: strontium compounds burn with a red flame and are used in fireworks.

Manganese - A grayish white metallic chemical element usually hard and brittle, which rusts like iron but is non-magnetic: it is used in the manufacture of alloys of iron, aluminum and copper.

Cobalt - A hard, lustrous, steel gray, ductile metallic chemical element, found in various ores: it is used in the preparation of high temperature alloys and tool steels. Its compounds are used in the production of inks, paints and varnishes.

Tantalum - A rare, steel-blue corrosion-resisting metallic chemical element found in various minerals and used to make nuclear reactors, aircraft and missile parts, grids and plates in radio tubes, surgical instruments, etc.

Chromium - A grayish white, crystalline, very hard metallic with a high resistance to corrosion: used in chromium electroplating in alloy steel and in alloys containing nickel, copper manganese and other metals.

Asbestos - Any of several grayish amphiboles or similar minerals that separate into long thread-like fibers; because certain varieties do not burn, do not conduct heat or electricity and are often resistant to chemicals, they are used for making fireproof materials, electrical insulation, roofing, filters, etc.

Aluminum - One of the chemical elements, a silvery lightweight easily worked metal that resists corrosion and is found abundantly, but only in combination.

Fluorine - A corrosive, poisonous pale greenish-yellow gaseous chemical element, the most reactive non-metallic element known, forming fluorides with almost all the known elements.

Bismuth - A hard brittle metallic element that is grayish white with a tinge of red used chiefly in making alloys of low melting point.

Platinum - A steel gray malleable ductile metallic chemical element, highly resistant to corrosion and electrochemical attack: used as a chemical catalyst for acid proof containers, ignition fuses, jewelry and dental alloys.

Titanium - A silvery or dark gray lustrous metallic element found in rutile and other minerals and used as a cleaning and deoxidizing agent in molten steel and in the manufacture of aircraft satellites, chemical equipment, etc.

Tin - A soft-silver white crystalline, metallic chemical element, malleable at ordinary temperatures, capable of a high polish and used as an alloy in tin foils, solders utensils, type metals, and in making tin plate.

Mercury - A heavy silver-white metallic chemical element liquid at ordinary temperatures, which occasionally occurs in a free state but usually in combination with sulfurs; quicksilver: it is used in thermometers, air-pumps, dentistry, pharmacy, and electrical switches.

Nickel - A hard silver white malleable metallic chemical element, used extensively in alloys and for plating because of its resistance to oxidation.

Zinc - A bluish-white metallic chemical element usually found in combination, used as a protective coating for iron (galvanizing) as a constituent in various alloys as an electrode in electric batteries and in the form of salts in medicines.

Tellurium - A rare tin white brittle non-metallic chemical element belonging to the same family of elements as sulfur and selenium, and occurring naturally in mineral tellurite and tellurides: it is used as a glass tint as an alloying material and in thermoelectric converters.

Antimony - A silvery white brittle metallic chemical element of crystalline structure found only in combination: used in alloys with other metals with other metals to harden them and increase their resistance to chemical action; compounds of antimony are used in medicines, pigments, matches, and fireproofing.

Tungsten - A hard heavy gray white metallic chemical element, found in wolframite, scheelite, tungstite and used in steel for high speed tools, in electric contact points and lamp filaments.

Cadmium - A blue white malleable ductile metallic chemical element occurring as a sulfide or carbonate in zinc ores: it is used in some low melting alloys, electroplating, etc.

Potassium - A soft silver white waxlike metallic chemical element that oxidizes rapidly when exposed to air: it occurs abundantly in nature in the form of its salts which are used in fertilizers and making glass.

Gold - A heavy yellow inert metallic chemical element with a high degree of ductility and malleability: it is a precious metal and is used in the manufacture of coins, jewelry and alloys.

Gypsum - A hydrated sulfate of calcium occurring naturally in sedimentary rocks and used for making plaster of paris, in treating soil, etc.

Vanadium - A rare malleable ductile silver white metallic chemical element, it is alloyed with steel to which it adds tensile strength and is used in nuclear applications.

Barium - A silver white slightly malleable metallic chemical element found as a carbonate or sulfate and used in alloys.

Silver - A white metallic chemical element that is extremely ductile and malleable, capable of a high polish and is the best conductor of heat and electricity: it is a precious metal and is used in the manufacture of coins, jewelry, alloys, etc.

Iron - A white malleable ductile metallic chemical element that can be readily magnetized, rusts rapidly in moist or salty air and is vital to plant and animal life: it is the most common of all metals and its alloys (as steel) are extensively used.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The question of whether black Africa is or can be a source of essential materials is considered. In terms of size alone, the African continent could potentially harbor a large proportion of the world's mineral resources. The region supplies the world market with major quantities of various minerals such as diamonds, cobalt, phosphates, tantalum, and lithium ores, to list only a few. In order to assess Africa's mineral capabilities, a country by country analysis is performed, looking into production, reserves, resources and viability based on capacity to make these materials available to the		

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world market. While Africa does have significant production of several materials, the majority of its wealth lies in its reserves.

Twelve black African materials are selected for a consumer oriented analysis, focusing on the United States. Bauxite, chromite, copper, lead, manganese, nickel, platinum, tin, titanium, uranium, and vanadium are considered. All except copper and uranium are on the US Bureau of Mines list of strategic materials of which significant US demand is met by imports. Copper is included because of its intensity of use; uranium is considered because of its military energy significance. Based on the analysis, only Zaire and Gabon stand out, producing 76 percent of the world's cobalt, and 31 percent of the world's manganese respectively. Neither of these minerals are in critical supply at this time.

While Africa may not presently be producing and supplying the materials considered in the analysis at a high rate, the area cannot be ignored as a potential source of US mineral requirements.

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