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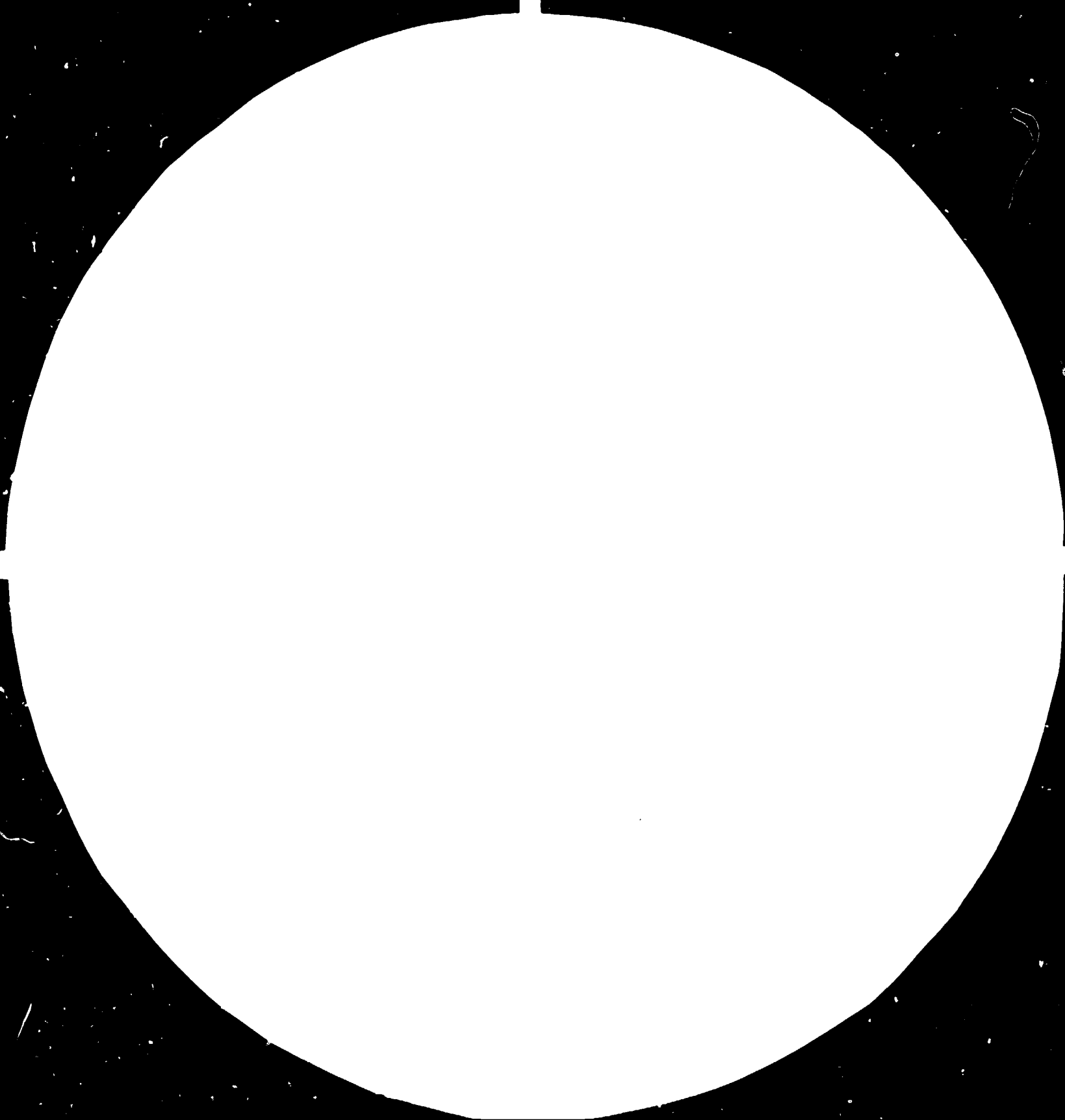

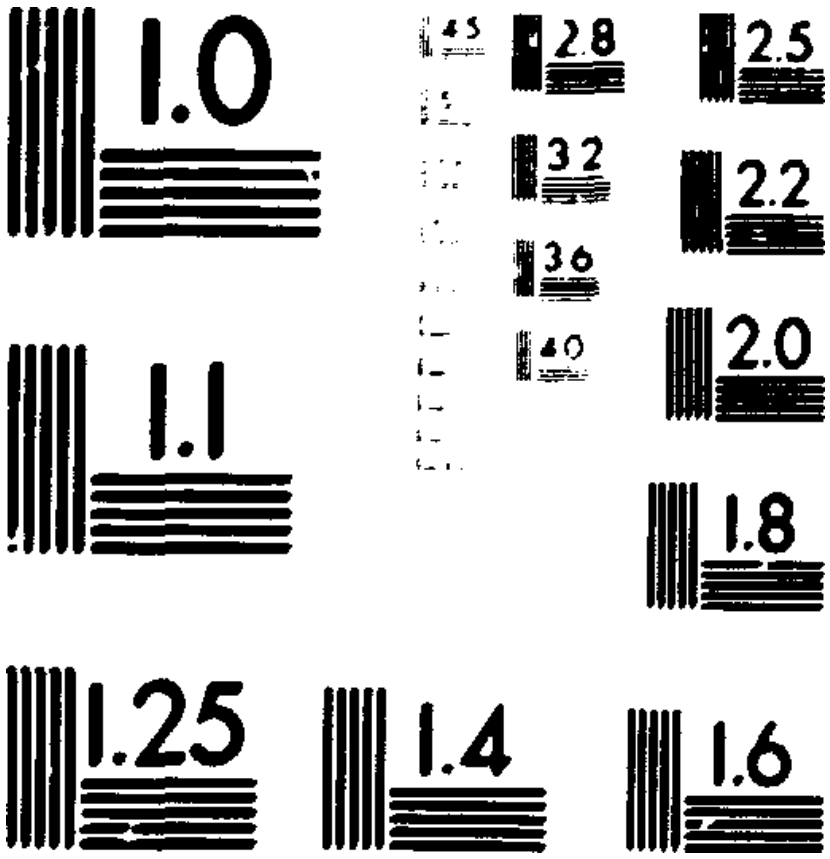

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THE MINERAL TRADE POTENTIAL OF THE LEAST DEVELOPED AFRICAN COUNTRIES*

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TABLE OF CONTENTS

MINERAL TRADE POTENTIAL OF THE LEAST DEVELOPED AFRICAN COUNTRIES

Walter C. Labys*

1. INTRODUCTION

This study attempts to provide insights into the industrialization process by focussing on the mineral industry as a vehicle for increasing the trade and development prospects of those least developed (LDC) African nations which possess the potential for increased mineral production and exports.** This pursuit can be seen as important for industrialization in two ways. First, basic mining as well as smelting and mineral processing all constitute forms of industrial development. Second, other industrial sectors in a country can be stimulated by foreign exchange earned from exports from the mineral industries by using these earnings to invest in a broader industrial base.

While it is obvious that a wide background exists for explaining mineral investment and mineral trade potential, this study concentrates only on the benefits, costs, policies, and problmles likely to occur in the LDC context. The study also limits itself to the minerals that are mined and of essential interest to this group of countries. The particular focus is on the metals which provide a ready base for industrialization. The fuel minerals are thus omitted, except for uranium, which

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** 15 of the 26 African LDCs are selected for the study.

is abundant in several of the LDCs under study here and could provide a source of export earnings.

In establishing this focus, the present study attempts to answer several questions which may be of interest to policy-makers. What are the mineral endowment, production and trade patterns of these countries? What crucial factors cause the expansion of mineral investment in them? How can a favorable investment climate be established in this regard? What are the likely impacts of such mineral investments on the patterns and extent of economic development in these countries? And what are the main policy incentives required to achieve success in this area?

The methodological approach taken to answer these questions draws upon the experience of the successful mineral exporting developing countries and then generalizes from this experience to provide practical insights and guidelines useful for decision making in this area. At the same time, it recognizes that the mineral investments under consideration relate to small countries in which one or several investment projects provide one of the few opportunities for substantial economic growth. The insights obtained are intended to isolate those principles and policies which might permit each country's mineral trade potential to be best realized. Altogether, this study consists of the following parts: (2) The Countries and Their Minerals (3) Mineral Resource Endowment, (4) Mineral Investment Potential, (5) Mineral Investment Climate, (6) Economic Impact of Mineral Exports, and (7) Conclusions for Policy.

2. THE COUNTRIES AND THEIR MINERALS

The least developed countries of Africa constitute a special group because their abundant mineral potential represents a possible vehicle for helping them to surmount some of the economic problems faced by developing countries in general. These problems have included declining primary commodity prices, overvalued currencies and shortages of foreign exchange, import difficulties such as rising energy and manufacturing costs which have prohibited the purchase of new and replacement equipment, shortages of foreign investment, lack of domestic generated capital, and an inability to borrow in financial markets. Many of the countries falling into this group possess little industrial base beyond limited mineral production, few developed indigenous energy resources, and often a land-locked configuration inhibiting transportation to ports. The countries selected for the present study have already had some success with mineral sector development such as Guinea, Niger and Togo, or else they have been the subject of recent geological studies which have revealed that they have a resource endowment that reflects mineral potential. Altogether the following countries have been selected out of the 26 African LDC's: Burundi, Central African Republic, Chad, Ethiopia, Guinea, Malawi, Mali, Niger, Rwanda, Sierra Leone. Sudan, Togo, Uganda, United Republic of Tanzania, and Upper Volta.

An overview of the economic characteristics of these countries can be obtained from Table 1 where the latter have been classified according to their position as major or minor mineral exporters. The major mineral exporters can be seen to have per capita incomes in the region of $400 per capita annually or more, excepting Sudan. Per Capita incomes in the other minor mineral exporting countries are well below this. Also of

Table 1

ECONOMIC INDICATORS OF THE LEAST DEVELOPED AFRICAN NATIONS[a]
(U.S. & Millions except where indicated)

Country	GDP		Population		Total Exports	Total Imports	Trade Balance	Balance of Payments	Terms of Trade[b]
	Actual	Per Capita ($per person)	Level (millions)	Annual Growth (%1970 - 80)					
Major Mineral Exporters:									
Guniea	1,926	384	5.0	2.5	390	270	+ 120	11.2(1974)	--
Niger	2,513	474	5.3	2.9	566	594	- 28	36.1(1976)	78
Togo	1,104	409	2.7	2.9	335	550	- 215	30.1(1979)	71
Minor Mineral Exporters:									
Burundi	889	197	4.5	2.2	65	168	- 103	--	--
C.A. Republic	796	358	2.2	2.2	116	81	+ 35	+18.0	115
Chad	920	203	4.5	2.2	65	160	- 95	- 3.6(1977)	96
Ethiopia	4,088	125	32.6	2.5	425	722	- 297	-93.4	97
Malawi	1,529	248	6.2	3.2	295	440	- 145	-22.4	77
Mali	1,337	201	6.2	2.6	206	439	- 233	- 6.4	94
Rwanda	1,163	242	4.8	3.0	76	243	- 167	+29.7	155
Sierra Leone	1,298	374	3.5	2.6	181	425	- 244	-10.7	85
Sudan	9,053	493	18.4	2.7	543	1,576	-1,033	-172.2	86
Uganda	3,750	284	13.2	3.0	345	293	+ 61	-40.1	138
U.R. Tanzania	4,933	275	17.9	3.0	508	1,226	- 718	-66.0	104
Upper Volta	1,372	199	6.9	2.5	90	358	- 268	+20.8	92

[a]All data are for 1981 except where indicated. [b]1975 = 100.

Source: UNCTAD, Handbook of International Trade and Development Statistics, New York: United Nations, 1983.

importance is that most of the countries report negative trade balances and balance of payments for 1981. Past cyclical export problems as well as an inability to increase processed and manufactured exports have caused most of the countries to experience falling terms of trade since 1975.

The present importance of the mineral sector in this group of countries can be assessed from Table 2. Typically the greatest percentage of the labor force is in agriculture with little in the mineral or manufacturing sector. The percent contribution of the mineral sector to GDP is generally higher for the major than for the minor mineral exporters. This also follows for the share of mineral exports in GDP. There are few opportunities for mineral processing and for linkages with other sectors in these countries; most mineral production is thus exported. Mineral imports reported typically are those that do embody processing and fabrication (see appendix Table A.1). Although they are shown to be only a small portion of GDP, they could be the subject of domestic import-substitution should local processing expand where feasible.

Regarding the composition of present mineral exports from these countries, Table 3 includes only the nonfuel minerals except for uranium. This choice was made because the basic metals and minerals have received much less attention than energy in recent studies of mineral investment potential. Uranium was included because it is not only mined but represents a commodity of clear export value to these countries. The final minerals selected include: alumina and bauxite, chromite, cobalt, copper, diamonds, gold, iron ore, lead, manganese, molybdenum, nickel, phosphates, platinum metals, tin, titanium minerals, tungsten, zinc, the minor metals (columbium, niobium, tantalum, zinc and uranium). The major mineral exporters are shown already to be important in terms of world production and exports. Guinea's share of world bauxite production is 14.6 percent;

Table 2

IMPORTANCE OF THE MINERAL SECTOR IN THE LEAST DEVELOPED AFRICAN NATIONS[a]
(U.S. $ Millions except where indicated)

Country	Percentage of Labor Force		Mineral Production		Mineral Imports		Mineral Exports	
	Agriculture	Mineral	Value	% of GDP	Value	% of GDP	Value	% of GDP
Major Mineral Exporters:								
Guinea	80	0.1	298	27.1	16.7	0.9	298[b]	27.1
Niger	87	0.1	250	11.4	11.4	0.5	250	11.4
Togo	78	0.1	128	15.0	66.3	6.0	105.5	9.6
Minor Mineral Exporters:								
Burundi	83	----	----	----	14.2	1.6	1.2	0.1
C. A. Republic	87	----	30	4.0	5.9	0.7	28.9	3.6
Chad	83	----	----	----	7.0	0.8	----	----
Ethiopia	79	0.03	44	1.1	52.1	1.3	----	----
Malawi	83	1.0	7	0.8	46.7	3.1	0.5	0.04
Mali	86	1.04	----	----	10.1	0.8	----	----
Rwanda	89	0.2	11	0.8	15.1	1.3	----	----
Sierra Leone	64	----	165	12.7	11.0	0.8	165	12.7
Sudan	76	----	10	0.2	110.8	1.2	2.9	0.03
Uganda	80	0.03	----	----	11.5	0.3	----	----
U. R. Tanzania	90	0.03	----	----	95.4	1.9	42.2	0.9
Upper Volta	81	----	----	----	29.6	2.2	0.8	0.06

[a]Labor Force and production values given for 1981; trade values are given for 1980, except for Togo, which is 1979.

[b]Estimated.

Source: Appendix Table A.1 and United States Bureau of Mines, Mineral Industries of Africa, Washington, D.C.: Government Printing Office, 1984.

Table 3

MINERAL PRODUCTION AND EXPORTS OF THE LEAST DEVELOPED AFRICAN COUNTRIES[a]
(Mostly primary, unprocessed products)

Country/ Mineral	Reserves 1981	Production 1978	Production 1982	Production % of World 1982	Exports 1978	Exports 1982	Exports % of World 1982
Burundi							
Gold (troy oz)	NA	321	96	*			----
Central African Republic							
Diamond Gem (ct)	NA	198,953	193,900	*		320,000	*
Industrial	NA	85,266	83,100	*			
Gold (troy oz)	NA	964	1,607	*		NA	*
Ethiopia							
Copper							
Gold (troy oz)	2,500	7,716	12,860	*		0[b]	----
Platinum (troy oz)	NA	129	129	*		NA	*
Guinea							
Alumina (000mt)		622	578	2	400	150	*
Bauxite (000mt dry)	15,900,000	11,468	11,479	14.6	9,200	10,200	41
Diamonds (000 ct)							
Gem		25	10	*	NA	NA	*
Industrial	NA	55	23	*	NA	NA	*
Mali							
Phosphate Rock (mt)	NA	2,000	10,000	*		NA	*
Gold (troy oz)	1,000,000	965	1,447	*		Small[b]	*
Niger							
Molybdenum	NA	NA	42	*	NA	NA	*
Phosphate Rock	NA	NA	1,000	*		NA	*
Tin (mt metal)	NA	89	70	*	72	77[b]	*
Uranium (U_3O_8 mt)		2,693	5,014	10		5,000	NA
Rwanda							
Beryllium	NA	80	90	8		41[c]	1.2
Columbium and Tantalum (mt gross)	NA	54	62	*	28	60[c]	*
Tin Ore (mt)	NA	1,400	1,189	*	2,137[e]	300	*
Tungsten (mt metal)	NA	339	322	1	665[e]	640[e]	1.8
Gold (troy oz)	NA	1,125	1,286	*		820[c]	*
Sierra Leone							
Bauxite (000 mt)	130,000	550	600	*	550	680[d]	2.7
Diamonds Gem (000 ct)	3,000	353	198	*	281	310[d]	*
Industrial (000 ct)	23,000	426	92	*		270[d]	*
Gold (troy oz)	NA	NA	8,713	*		1,920[d]	*
Titanium (mt)	1,600,000	---	46,576	1.5		36,000[d]	2.3
Sudan							
Chromite (mt gross weight)	NA	23,680	19,260	*		14,000[b]	*
Gold (troy oz metal)	NA	300	400	*		50	*
Manganese Ore (mt)	NA	450	400	*		---	
Togo							
Iron and Steel							
Crude (000 mt)	------	NA	5	*	NA	NA	
Semi-manufactures	------	NA	10	*	NA	NA	
Phosphate Rock (000 mt)	60,000	2,827	2,035	1.6	2,802	2,055	5
Uganda							
Iron and Steel (mt)	------	15,000	NA		NA	NA	
Tin (mt metal)	NA	239	30	*	NA	NA	
Tungsten (metal)	NA	110	20	*	200	NA	
United Republic of Tanzania							
Diamond (ct)	3,600,000	295,177	220,000	*	293,310	260,000[b]	*
Gold (troy oz)	NA	129	289	*	NA	NA	
Tin (metal mt)	NA	9	NA		24[e]	NA	

[a] Minerals included in this table are only nonfuel metal minerals, diamonds and phosphate. Countries included in Table 1 but not producing metal are omitted.
[b] Average exports (1978-1980)
[c] Average exports (1975-1977)
[d] Average exports (1979-1981)
[e] Concentrates
NA = not available, * = less than one percent.

SOURCES: U.S. Bureau of Mines, Mineral Yearbook, 1982, and Mineral Industries of Africa, U.S. Government Printing Office, Washington, D.C., 1984; British Geological Survey, World Mineral Statistics 1978-1982, Her Majesty's Stationery Office, London, 1984.

Niger represents 10.0 percent of world uranium production; Rwanda supports 8.0 percent of world beryllium production; Sierra Leone supplies 1.5 percent of the world's titanium production; and Togo accounts for 1.6 percent of world phosphate production. For the remaining countries, present mineral production constitutes only a small portion of world production. Exports also are small or in most cases negligible.

The relatively low mineral production and export figures reported suggest that the African LDC's have not taken full advantage of their likely resource endowment in terms of increased investment in mineral exploration, production and trade. This view has been strongly exphasized in the recent Brandt (1980) report. We thus begin this analysis of mineral trade potential by attempting to assess the likely resource endowment of these countries.

3. MINERAL RESOURCE ENDOWMENT

Any assessment of the mineral trade potential of the African LDC's should begin with an examination of the extent of the quality of their underlying resource base. This endowment typically described in the form of the mineral resource classification diagram shown in Figure 1 relates resource levels and their certainty to the quality of the resource in economic terms. The uncertainty surrounding reserves is reflected in the fact that the right-hand boundary of identified resources can be shifted tc the right, depending on the extent to which more extensive exploration is conducted. Similarly, the right-hand boundary of unidentified resources can be shifted to the right by obtaining better knowledge of mineral occurrences and geology. The lower boundary or economic dimension fluctuates with the relationship between prices and costs, as they are influenced by extraction and processing conditions or even tax systems. Certain kinds of technological improvements can increase reserves, such as process improvements that decrease costs. Other technological improvements can decrease reserves, such as a decline in the demand for a mineral (such as substitutes for lead) or an increase in the supply of scrap (such as lead battery reclamation). Significant changes in factor costs, such as energy and labor can also cause reserves to diminish.

Attempts to define the resource base in these countries have not always been successful. Many of these countries have found it difficult to justify exploration expenditures, whether they have pursued exploration independently or through joint ventures; they also have not made geologic information available to potential investors. We would be incorrect to assert that extensive geologic mapping in a country is a necessary prerequisite to economic growth, but the increased avail-

Quality of the Resource (economic dimension)	Degrees of Certainty about the Resource (geologic dimension)				
	Identified Resources			Undiscovered Resources	
	Proved	Probable	Possible	In Known Districts	In Undiscovered Districts
Recoverable under market and technological conditions	Reserves			Hypothetical resources	Speculative resources
Recoverable at prices up to 2 times those prevailing now or with comparable advance in technology	Paramarginal resources				
Recoverable at prices 2 to 10 times those prevailing now or with comparable advance in technology	Submarginal resources				

Totals: Potential resources = paramarginal + submarginal + hypothetical + speculative
Total resources = reserves + potential resources
Resource base = total resources + other mineral raw materials

Figure 1

GEOLOGIC AND ECONOMIC RESOURCE CLASSIFICATION SYSTEM

ability of geologic knowledge is more likely to result in successful exploration, discovery and investment. Botswana, for example, has managed to raise per capita incomes substantially because of its successful exploration and mineral development activities. Nickel, diamonds and cobalt account for 65 percent of the annual export earnings from that country.

The approach taken to assess the resource endowment of the group of LDC's is first to concentrate on the discovered or "identified reserve" levels as described in Figure 1.[1] These figures appear from sources such as The Mineral Industries of Africa, published by the U.S. Bureau of Mines, and The Mining Annual Review, published by the Mining Journal Ltd. Later in this section we will discuss the potential resource endowment of these countries or the promise to find further mineral reserves based on the existing geologic configuration of these countries. We begin with four of the countries in this group who have been active in discovering and exploiting their resource base, namely Burundi, Guinea, Niger and Togo. Exploration activity is then examined to the extent it has been carried out in the remaining countries.

Burundi has recently received assistance from the World Bank and foreign mineral firms in delineating commercial deposits which it hopes to exploit in the next decade. Phosphate and limestone deposits suitable for developing fertilizer and cement industries have been found north of the capital city of Bujumbura where close proximity exists to water

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[1] The resource endowment potential examined here is based on each country's geologic configuration and does not include an attempt to define that potential in an economic value sense, such as that suggested by Johnson and Dorian (1984). Should more adequate data be availabe, those authors would base mineral resource assessment on the economic concept of unit regional production value.

supplies and adequate highways. The British Sulphur Corp. also has completed a phosphate mining pre-feasibility study under a World Bank contract which will further classify this deposit and permit exploration. Although in a remote location, discovered nickel laterite deposits have been estimated to contain 75 million tons of reserves with an average grade of 1.6 percent nickel. High-grade vanadium deposits amounting to 10 million tons with a grade of 1.5 percent V_2O_5 have also been discovered within a 100 km north-south belt running through the center of the country. Burundi would appear to have sufficient energy potential to support several mineral industries.

Guinea possesses 15.9 million tons of bauxite reserves which amount to approximately 25 percent of the world's total; Guinea also was the second largest producer in the world in 1981. Diamond deposits which include several delineated areas and the Aredor diamond project near Banankoro are expected to enter production this year at an annual rate of 0.4 million carats (with an increase to 1.0 million carats by 1987). Attempts also have been made to further explore and to develop the Mifergui deposits which contain some 350 million tons of 60.0 percent iron ore. Accordingly, the government has reached an agreement with the United States Steel Corporation to manage, operate and engineer the Mifergui-Nimba project within this area.

The economic development of Niger has been stimulated by discoveries of uranium which took place in the late 1960's and now amount to some 350 thousand tons. More than 35 percent of the total government revenue and 85 percent of the total export revenue were derived from uranium in 1981. However, recent declines in the price and demand for uranium have caused related revenues to fall and hence investment in uranium exploration has declined. Exploration in the future will thus

shift to ore, phosphate and cassiterite.

Togo also has explored extensively for phosphate and several other minerals. Its phosphate deposits now amount to some 60 million tons. Phosphate exports historically have constituted nearly 50 percent of all of the country's export earnings. These earnings, however, have recently fallen because of a decline in the price and demand for phosphate. Future exploration and development in Togo is likely to depend on other mineral resources including a 95 million ton deposit of iron ore near Baseri, a 10 million ton deposit of manganese ore near Bayega, and deposits of copper, chromite and marble. The main problems with the development of these resources is the lack of infrastructure within Togo and a lack of funds to cover the large investment that would consequently be required. The National Bureau of Mines and Mineral Resources has recently announced a five-year plan to develop the country's mineral resources. The first stage, expected to cost $500,000 will involve the preparation of a national minerals inventory.

The next countries of interest within the group possess reserve positions which demonstrate potential for development; however, they have not been able to complete the mapping of these reserves or to foster extensive mining development. Mali, for example, has depended on foreign investors, principally France's Bureau de Recherches Geologiques et Mineres (BRGM) and Soharem, to investigate its phosphate, bauxite, iron ore and uranium deposits. Other significant exploration has included prospecting for thorium, zirconium, chromium, copper, gold and phosphate in the Tadhala area by a UNDP supported team. At Bougouni, in the Sikasso region the BRGM has discovered lithium deposits, which have been the subject of a study of the possible production of lithium carbonate.

Rwanda has discovered deposits of gold, cassiterite and wolframite of which the first two have recently contributed to export earnings. While producing small amounts of tin, tungsten, niobo-tantalate, beryl and gold, the country also has deposits of lithium, monazite, bismuthinite, uranium and thorium in the granite western part of the country as well as copper, lead, zinc, gemstones, carbonate rocks, kaolin, pozzolan, and talc elsewhere. Although geological mapping and prospecting by France's BRGM and the UNDP is continuing, planned developments exist only for the extraction of methane gas from Lake Kiviu and for cement production in the south of the country.

Although Sudan actively produces both chromite and gold, it has increased regional mapping along the Sudan-Chad border as well as joint prospecting projects with foreign agencies. Through its Geological and Mineral Resources Development (GMRD) board, some recent finds resulting from these joint prospecting projects include the following: (1) the Sudanese-West German team has found chromite, magnesite and iron ore deposits in the north-east Nuba mountains of central Sudan; (2) the University of Berlin team working in the little known north-west of Sudan has reported wide-spread occurrences of palaeozoic-mesozoic marine and continental sediments; (3) the BRGM-GMRD teams have almost completed drilling campaigns for evaluation of two gold deposits in the Central Red Sea Hills area; and (4) Minex has carried out successful explorations of extensions to the ancient Gabeit gold mine. Encouraging results have also been announced after examining gold prospects further to the south of Gabeit. Prospecting in the Northern Province of the Sudan has resulted in several deposits of mineralized quartz.

Malawi in 1982 conducted an aeromagnetic survey over Lake Malawi

and part of the Shire Valley with the help of Shell Exploration BV. The results of the study point to the existence of a sedimentary basin under Lake Malawi, and thus the possible presence of oil and gas. Foreign firms also have helped in defining Malawi's resource base. British Bypsum Ltd. has extracted limited amounts of kynite and vermiculite. United Carbide has found tungsten deposits in the Lake Malawi region and niobium-uranium mineralization in the Ilomba Hill region has been confirmed. Marble deposits, limestone and glass sands provide the basis for domestic mineral development.

Tanzania has concentrated its efforts on cement, diamond and gold production, although the Government has also shown an interest in exploring for nickel, uranium, niobium, apatite, and coal.

The remaining countries generally have not attempted to assess their mineral potential on an extensive or wide geographic basis; rather their resource base must be viewed in terms of a number of single deposit explorations and investments. Among these countries, the Central African Republic possesses a diamond industry which contributed roughly 4 percent of GDP in 1981, but it has not pursued exploration in other potential ores such as gold and uranium. Chad has not pursued mineral exploitation except for local building materials. Ethiopia similarly has concentrated on developing local building materials with only a slight interest in further exploration for copper and potash. Sierra Leone's export earnings have grown mostly from increased production of bauxite, diamonds, gold, titanium and rutile. Uganda has enjoyed the production of tungsten and cement but presently does not view the mineral sector as a source of development. And Upper Volta which possesses manganese, tungsten and limestone deposits has devoted only limited attention to the development of the latter two.

As mentioned at the outset, the existing reserve and production data do not provide us with a thorough view as to the extent of the mineral trade potential of these countries in the future. Such a view requires also examining estimates of their undiscovered resources. We thus turn our attention to such a set of estimates as prepared by Torries (1983). His data are based on a geologic quantification of each country's likely deposits which are subsequently interpreted according to a probablistic analysis of their likely commercial value. Although these estimates are rough and subject to a wide margin of error, they do provide a systematic basis for assessing future mineral trade potential.

Table 4 presents the results of this estimation and valuation process, based on the information reported later in Table 6. The ranking of the importance of the various mineral deposits pertains to mineral potential only and not to existing mining operations or to known deposits under development. Among the results presented for some 16 countries, all of the latter show at least some potential to have economic mineral resources. For most countries we find that a high mineral potential exists for a number of important metallic minerals. Most of this potential would appear to be in countries possessing sulfides such as copper, nickel, lead and zinc. Less development potential is suggested for countries possessing ultramifics such as chromite and cobalt.

Gold development appears to have at least medium potential in as many as 13 countries. These results would suggest, at least at first glance, that a potential exists for significantly improving mineral production and trade in most of the countries under study. More will be said about the meaning and implications of this potential in the next section.

Let us now conclude this section by focusing on the exploration

Table 4

MINERAL RESOURCE POTENTIAL OF THE LEAST DEVELOPED AFRICAN COUNTRIES

Country	Mineral Potential[a]		
	Low	Medium	High
Burundi	Au, Nb, Ta	Sn, W, RE	Ni, V, P
Central African Republic		Ni, Cr, Co, Dm*	Au*, Cu, Zn, U, Fe
Chad	U, Al, Cu, Sn, Pb, Ni, Au		Tro*
Ethiopia	Ti, W, Mo, Mg	Cr, Co, Pt, Mn	Au*, U, Fe, Cu, Ni, Pb, Zn
Guinea	Zr, Ti	Cu, Ni, Pb, Zn, Cr, Co	Al*, Dm*, U, Au, Ag, Fe*
Malawi	Ni, Cr	U, Al, RE	Zr, Au, Nb, P
Mali	Sn, W, RE	Ni, Cr, Co, Mn, P, Dm	Au*, Cu, Zn, U, Pb, Fe, Al
Niger	Nb	Sn*	U*, Fe, P
Rwanda		Ni	Nb-Ta*, Sn*, W*, Au*
Sierra Leone	Sn, RE	Cu, Ni, Pb, Zn, Co, Pt	U, Au*, Fe*, Zr, Ti*, Al*, Dm*, Cr
Sudan	Pt, Asb	U, Sn, W, Mn, Dm, Ag	Au*, Fe, Cu, Co, Ni, Pb, Zn, Cr*
Togo		Ni, Cr, Co, U	Au, Fe, P*
Uganda	Cr, Pt	U, Ni, Fe, Pb, RE, P	Cu*, Co*, Au, Sn, W*, Nb-Ta
United Republic of Tanzania	P, Sn*	Ni, Co, Cu, U, Zn, Nb, RE, Fe	Dm*, Au*
Upper Volta	U	Mn, V, Ti, P, Fe, Al, Cu, Ni, Zn	Au

[a]Probability ranges given in percent indicates the likelihood of a country having economic resources of the mineral:

Low	>0 - 25%
Medium	25 - 75%
High	74 -100%

*Indicates mineral is in production.

Table symbols

Ag . . . Silver	Fe . . . Iron Ore	Sn . . . Tin
Al . . . Bauxite	Mg . . . Mercury	Ta . . . Tantalum
Asb. . . Asbestos	Mn . . . Manganese	Ti . . . Titanium
Au . . . Gold	Nb . . . Niobium	Tro. . . Trona(soda ash)
Co . . . Cobalt	Ni . . . Nickel	U . . . Uranium
Cr . . . Chromite	P . . . Phosphate	V . . . Vanadium
Cu . . . Copper	Pb . . . Lead	W . . . Tungsten
Dm . . . Diamonds	Pt . . . Platinum Group	Zn . . . Zinc
F . . . Fluorspar	RE . . . Rare Earths	Zr . . . Zirconium

Source: Mineral Industries of Africa, U.S. Bureau of Mines (Mineral Perspectives), U.S. Department of the Interior, Washington, D.C., March 1984. T.F. Torries, Economic Justification for a Comprehensive Mineral Resourse Program for " ". A series of unpublished reports, College of Mineral and Energy Resources, West Virginia University, Morgantown, 1983.

initiatives necessary to transform the possible resource endowments given in Table 4 into a useful set of reserve estimates, i.e. a move to the left of the identified resource boundary in Figure 1. Most evidence suggests that those countries which have accomplished this task have utilized exploration assistance from international agencies such as the United Nations and more recently the World Bank, from cooperation of private firms, or from overseas donor countries through technical cooperation arrangements. For example, Burundi has increased its reserve base through exploration aided by the World Bank and the British Sulfur Corp. Chad has sought the assistance of the UNDP as well as the Continental Oil Company. Kenya has entered cooperative arrangements with Great Britian and Finland. Mali has called upon the Esso Oil Co., and Elf-Aquitane. Niger has improved its uranium exploration through equity participation with several European firms. And foreign airborne geological surveys have been carried out by foreign firms in both Tanzania and Malawi. It would thus appear that channels are open for these and other African LDC's to better define their mineral endowments.

4. MINERAL INVESTMENT POTENTIAL

Among the African LDC's, mineral investment has been most noticeable in Guinea for bauxite, in Niger for uranium, and in Togo for phosphate. Such investments generally have had favorable consequences, particularly on increasing export revenues and GDP. The purpose of this section is to examine basic issues required to bring the mineral reserves of these and other African LDC's to their fullest trade potential. This requires first examining past patterns of mineral investment so as to establish the base in each country from which further mineral investment can be evaluated. Emphasis then shifts to the resource estimates prepared by Torries (1983) and introduced above which point to the investment possibilities of specific minerals in each country. These possibilities, of course, are limited by a number of investment constraints which also are discussed. The section closes with a set of guidelines which can be generally offered to help expand mineral investment. Throughout this section, emphasis is placed on the existing and potential levels of investment and their determinants rather than on the underlying investment agreements, a subject taken up in the next section.

Investment Background

Analyzing the pattern of past mineral investments in the African LDC's is difficult because of the lack of detailed information on the determinants of those investments. Table 5 based on Appendix Table A2 provides an overview of investments that have been planned or undertaken, several of which will be discussed here. The general guidelines followed in discussing these investments are based on Mikesell (1983) and Radetzki and Zorn (1979). Let us begin with the example of the more successful case of Botswana.

Botswana's mineral sector has prospered largely through the encourag-

Table 5

SUMMARY OF PAST NEW MINING INVESTMENTS AND EXPANSIONS IN THE LEAST DEVELOPED AFRICAN COUNTRIES (1979-1984)

Country	Mineral and Design Production[a]	Total Capital
Burundi	Iron/Nickel (30Kt) Nickel/Copper (2MT), Phosphate	$500M
Central African Republic	U_3O_8 (500-700t), Diamonds	$311M
Guinea	Bauxite (9Mt), Iron (15 Mt), Al_2O_3 (1.4 Mt), Diamonds (250ct), Alumina (2.2 Mt)	$5,685M
Mali	Phosphate (240 Kt), Gold (1.8t), Silver (.5t), Iron, Bauxite	$1,170M
Niger	Uranium (2.6 Kt), U_3O_8 (7.8 Kt), Iron, Phosphate	
Rwanda	Tin metal	$5 M
Sierra Leone	Bauxite (1Mt), Rutile/Ilmenite (100Kt), Beach Sands, Iron (1Mt), Diamonds	$541M
Sudan	Chromite (500Kt), Iron, Asbestos (100Kt), Ferric Chrome Plant, Lead, Zinc, Tungsten	$175M
Togo	Phosphate (3.75Mt.), Gold, Iron	--
Uganda	Phosphate, Copper, Cobalt	--
United Republic of Tanzania	Gold (0.3t), Phosphate	--
Upper Volta	Gold (2.5t), Phosphate, Manganese (500Kt)	$220M

[a]Production in tons per year, K=thousand, M=million.

Source: Appendix Table A2 as derived from "Major New Projects and Expansion Programs," Reported Annually, Mining Magazine, 1979 - 1984.

ing of private investment and the training of able advisors and government administrators. This has been the result of establishing viable policy guidelines in the form of the Mineral Policy Act (30) of 1976, i.e. see U.S. BOM (1984) and Johnson (1981). Additional and amended legislation to improve this act have been passed in each subsequent year. In addition to exploration, this act was designed to promote foreign investment in nonfuel as well as fuel projects. Existing mineral industries in this country consequently are a mixture of private, foreign, and government investments. Some examples of foreign ownership shares are 50 percent in diamonds, 51 percent in nickel-copper-cobalt and 100 percent in coal. Comparative advantage in the minerals sector has been achieved not only through low production costs, but also through improvements in and government control of the transportation sector. Although most energy requirements for the mining industry are met by electricity generated from imported oil, much of this generation is expected to be coal-fired from domestic sources by the end of the decade.

Botswana is clearly a country with major economic dependence on its mineral industries. Its mineral exports in 1981 amounted to some $260 million compared to a GDP of $950 million. Among these exports, diamonds accounted for 65-70 percent of the total and nickel-copper-cobalt for the remainder. Some examples of recent levels of mineral investment have been $250 million for the Jwaneng Diamond Mining Complex and $141 million for the Selebi nickel-copper-cobalt mining complex. Because this economic dependency is based on only two mineral commodity groups, about 65 percent of the country's export revenues are subject to the instability of corresponding mineral market price fluctuations. Thus, the decline in diamond prices between 1980-81 has moved the country from an overall balance of payment surplus of $81 million at the end of 1980 to a deficit of

about $68 million in 1981. Since then, the deficit has lessened.

Successful mineral investment has also taken place among the three African LDC's defined in Table 1 as major mineral exporters. The mining sector of Guinea has benefited from the production of bauxite and alumina as well as diamonds, the former providing about 95 percent of total mineral exports. Mineral production in 1981 has been valued at $300 million compared to a GDP of $1,926 million. Guinea's largely state-run economy has followed Botswana's lead in encouraging private investment through its newly organized Foreign Investment Code of 1981. The code offers potential foreign investors relief from customs duties, import and export taxes; it also tailors land use and mineral rights to the needs of a particular investor. Of the three major bauxite companies, the government has a 49 percent interest in two of them and full interest in the third.

The government's latest planned investment has involved the United States Steel Co., which will be responsible for the management, operations, and engineering of the Mifergui-Nimba iron ore project near the border with Liberia, as described in Table A2. The Mifergui deposit contains 350 million tons of 60.0% iron ore. A $1.1 billion investment is planned to produce 15 million tons per year of 66.5% natural sinter feed, which will be exported through Liberia (on the Liberia-American-Swedish Minerals Co. railway) to the port of Buchanon. Although Guinea has a viable rail network, the government has had to negotiate World Bank-African Development Bank loans to improve port handling facilities. The country has hydroelectric generating potential, but presently imports all of its fuels.

The economy of Niger has prospered from mineral investments not only in uranium but also in tin, cement and coal. Uranium accounted for 40 percent of its mineral exports valued at $298 million in 1981, while its GDP equaled $2.5 billion. Because of the decline in uranium prices and

exports, both export earnings and GDP declined in both 1981 and 1982. The government which owns all mineral rights has vested control in its Office National des Resources Miniere (ONAREM). Foreign investment has been encouraged by an Investment Code in effect since 1974, which provides business and export tax relief, tariff protection and profit and salary expatriation.

Both private companies and ONAREM have equity positions in the two Nigerian uranium producing companies, the Societe des Mines de l'Air (SOMAIR) and Compagnie Miniere d'Akouta (COMINAK). Ownership of SOMAIR is 33% ONAREM, 27% Compagnie General des Matieres Nucleaires, 11.8% Compagnie Francaise des Minerals d'Uranium, 7.6% Pechiney Mokta, 7.6% Minatome S.A., 6.5% Urangesellschaft mbH, and 6.5% Agip Nuclaire. Ownership of COMINAK is 31% ONAREM, 35% Comagnie General des Matieres Nucleaires, 25% Overseas Uranium Resources Development Co. of Japan, and 10% Empresa Nacional del Uranio S.A. As shown in Table 5, production capacities for SOMAIR and COMINAK are both about 2,600 tons per year U_3O_8. A third and fourth uranium company were formed with foreign investors, but due to the slump in the uranium market, only the former has moved towards completion. The government has depended on these companies for some infrastructure developments. While most energy derives from petroleum imports, coal-fired generation is on the increase.

Investment in Togo has been primarily in phosphate and to a lesser extent in cement and iron ore and steel. Mineral exports were $106 million in 1981 of which phosphate represented about 40 percent, while its GDP reached $1.1 billion. Similar to the above countries, falling commodity (phosphate) prices and exports have resulted in recent declines in export earnings and GDP. The government has regulated the mining industry beginning with the first mining decree of 1972. Since 1978, the

decree has been liberalized with an Investment Code which provides preferential tariff and tax treatment. However, the phosphate sector was nationalized in 1974 with full indemnification. The Office Togolaise des Phosphate at Lome now operates the phosphate mine and the processing plant at Kpeme with an input capacity of 3.4 million tons per year. Cement de l'Afrique de l'Quest (CIMAO) formerly operated the cement clinger plant which was jointly owned by Togo, Ghana, and the Ivory Coast. Because of management difficulties, the operation now is being restructured and is the only major mineral investment activity in Togo. The World Bank recently has approved $15 million of a total of $394.9 million of investment funds slated for the project. The remainder is from Caisse Centrale de Economique of France at $12.9 million and from the European Investment Bank at $7 million. The Societe Nationale de L'Sidurgie has recently commenced operations of a single steel electric furnace and a rolling mill.

Among the other African LDC's mineral investment projects of any significance have been fewer. Sierra Leone has increased its export earnings through investments in the bauxite, diamond, gold, titanium and rutile industries. Diamond exports amounted to $170 million or 58 percent of total export earnings in 1981, while GDP equalled $1,298 million. The country's mining laws are based on British precendent. Although it seeks 51 percent interest in all mining operations, this intent has not been executed in many instances. Each mining company has been required to reduce the proportion of its expatriate staff and to increase the pace at which Sierra Leoneans were trained for and placed in managerial, technical and processional positions. Upon approval of the Bank of Sierra Leone, the transfer of dividends, principal and interest payments are permitted under current legislation. Investment in the mineral industry has

the spectrum from companies fully owned by the government to entirely private firms. Sierra Leone has suffered recent balance of payments problems because of the drop in the prices and quantities of diamonds and its other mineral exports. Prior to the recent change in world economic climate, the government benefited from several major investments. As reported in Table A2, these include mine expansion projects in Port Loko amounting to $500 million for bauxite, in Bangama with $41 million for rutile, and in Tonkolili with $700 million for iron ore. Infrastructure has presented problems in the development process and all electricity production depends on oil imports which feed diesel-fired generators.

The mineral industries of Sudan play no major role in its economy, although cement, chromite, gold and salt are produced. Chromite exports constituted only $2.5 million in 1981 compared to a GDP of $9.1 billion. The government owns the Sudanese Mining Co. (SMC) which produces most of the country's chromite from four mines. A smaller quantity is produced privately. As shown in Table A2, recent investments include feasibility studies for further chromite expansion at $60 million and asbestos production at $115 million. Infrastructure is a problem with most deposits occurring outside of existing transportation networks. Although the country depends on oil imports, it appears to have considerable potential for indigenous oil development and energy self-sufficiency.

Prospects for major mineral investments are beginning to emerge in Malawi. This country has been able to pursue industrial development successfully and is now looking at the above mentioned mineral deposits of kyanite, tungsten, niobium-uranium, and coal. Thus far its mineral activities have been related to domestic industries such as glass, cement and brick making, i.e. see UNIDO/IS.389 (1983).

The remaining African LDC's have experienced little mineral investment outside of exploration activities. The economic growth of their mineral sector thus depends on their prospects for increasing potential investments in mineral exploration as well as extraction.

Potential Investments

Mention was made earlier of the mineral resource potential of the African LDC's. While this potential was examined from the viewpoint of mineral endowment, our present focus is on the range of possible investments required to develop this endowment such that mining production and sales could lead to increases in export earnings and GDP. The basis for assessing this potential are the estimates prepared by Torries (1983) for a selected group of the above African LDC's. Featured in Table 6 are the important minerals that might be found in these countries, the probability of the discovered deposits having commercial value, the range of possible direct investments foreseen, and the range of possible export sales per year. These estimates are based on the geology and indications of mineralization in each country, ore occurrence models, and comparisons to what has been found in other geologically similar areas of the world. The particular assumptions and data used to derive the reported investment and sales values are given in Appendix 3. These results pertain to mineral potential only and not to existing mining operations or to known deposits under development. While Table 6 is concerned mostly with metals, it also includes other minerals which can be mined including uranium but not coal.

The ranges of investment and annual sales reported are reasonable for the corresponding country areas and deposits, considering their geological conditions and mineral potential. The estimates reflect not only

Table 6

POSSIBLE VALUES OF MINERALS INVESTMENT AND SALES IN
LEAST DEVELOPED AFRICAN COUNTRIES
(U.S. $ Millions)

Country/ Mineral	Probability of Commercial Discovery	Range of Possible Investment Values	Range of Possible Yearly Sales Values	Level of GDP 1981
Central African Republic				
Gold	High - Med.	15 - 150	30 - 300	796
Massive Sulfides (Cu, Zn)	High - Med.	200 - 800	200 - 800	796
Ultramafics (Ni, Cr, Co)	Medium	200 - 550	200 - 550	796
Diamonds	Low - Med.	25 - 125	15 - 100	796
Uranium	Low - Med.	40 - 160	45 - 170	796
Ethiopia				
Iron Ore	Med. - High	100 - 750	110 - 825	4,088
Sulfides (Cu, Ni, Pb, Zn)	High	100 - 500	75 - 375	4,088
Ultramafics (Ni, Cr, Co)	Medium	100 - 250	75 - 300	4,088
Gold	High	15 - 150	15 - 150	4,088
Platinum	Med. - High	4 - 40	4 - 40	4,088
Uranium	High	120 - 160	200 - 225	4,088
Guinea				
Iron Ore	High	500 - 1500	550 - 1700	1,926
Sulfides (Cu, Ni, Pb, Zn)	Medium	100 - 500	75 - 375	1,926
Ultramafics	Medium	100 - 250	75 - 300	1,926
Gold, Silver	High	15 - 150	15 - 150	1,926
Diamonds	Medium	25 - 125	15 - 100	1,926
Sands (Zr, Ti)	Low	5 - 40	5 - 30	1,926
Uranium	Med. - High	40 - 310	60 - 350	1,926
Mali				
Gold	High - Med.	25 - 125	30 - 150	1,337
Massive Sulfides (Cu, Zn)	High - Med.	200 - 800	200 - 800	1,337
Ultramafics (Ni, Cr, Co)	Med. - High	200 - 550	200 - 550	1,337
Diamonds	Low	25 - 125	15 - 100	1,337
Uranium	Med. - High	150 - 600	90 - 350	1,337
Sierra Leone				
Sulfides (Cu, Ni, Pb, Zn)	Medium	100 - 250	75 - 300	1,298
Ultramafics (Ni, Cr, Co)	Medium	100 - 200	75 - 150	1,298
Gold	High	15 - 75	15 - 100	1,298
Diamonds	Med. - High	25 - 125	15 - 100	1,298
Iron Ore	Med. - High	100 - 250	110 - 275	1,298
Heavy Sands (Zr, Ti)	High	5 - 40	5 - 30	1,298
Uranium	Med. - High	40 - 120	60 - 183	1,298

Table 6 (continued)

Country/ Mineral	Probability of Commercial Discovery[a]	Range of Possible Investment Values	Range of Possible Yearly Sales Values	Level of GDP 1981
Sudan - North				
Sulfides (Cu, Ni, Pb, Zn)	Med. - High	100 - 500	75 - 375	9,053
Ultramafics (Ni, Cr, Co)	Med. - High	100 - 300	75 - 250	9,053
Gold	High	25 - 75	15 - 150	9,053
Other Metals (Sn, W, Mn)	Med. - High	25 - 75	20 - 60	9,053
Iron Ore	Med. - High	100 - 750	110 - 825	9,053
Sudan - South				
Sulfides (Cu, Ni, Pb, Zn)	High	100 - 500	75 - 375	9,053
Ultramafics (Ni, Cr, Pt)	Low - Med.	100 - 300	75 - 250	9,053
Gold	High	15 - 150	15 - 150	9,053
Diamonds	Medium	25 - 125	15 - 100	9,053
Other Metals (Sn, W)	Low	25 - 75	20 - 60	9,053
Iron Ore	Med. - High	100 - 750	110 - 825	9,053
Uranium	Medium	40 - 200	60 - 305	9,053
Tanzania				
Diamonds	Medium	30 - 40	15 - 25	4,933
Uranium	Med. - High	85 - 100	60 - 70	4,933
Gold	Med. - High	20 - 40	35 - 45	4,933
Nickel	Medium	180 - 200	150 - 180	4,933
Togo				
Gold	Med. - High	15 - 75	30 - 150	1,104
Massive Sulfides (Cu, Zn, Au, Ag)	Medium	200 - 400	200 - 400	1,104
Ultramafics (Ni, Cr, Co)	Med. - High	250 - 750	300 - 900	1,104
Iron Ore	Med. - High	250 - 750	300 - 900	1,104
Uranium	Medium	40 - 120	45 - 130	1,104
Uganda				
Gold	Medium	25 - 75	30 - 90	3,750
Massive Sulfides (Cu, Zn, Au, Ag)	Med. - Low	200 - 800	200 - 800	3,750
Ultramafics (Ni, Cr, Co)	Med. - Low	200 - 550	200 - 550	3,750
Kilembe Type (Cr, Co)	Med. - High	125 - 250	55 - 110	3,750
Uranium	Med. - Low	150 - 600	90 - 350	3,750

Table 6 (continued)

Country/ Mineral	Probability of Commercial Discovery[a]	Range of Possible Investment Values	Range of Possible Yearly Sales Values	Level of GDP 1981
Upper Volta				
Gold	High	15 - 150	30 - 300	1,372
Massive Sulfides (Cu, Zn)	High	200 - 800	200 - 800	1,372
Ultramafics (Ni, Cr, Co)	Medium	200 - 550	200 - 550	1,372
Uranium	Low - Med.	40 - 160	45 - 170	1,372
Diamonds	Low - Med.	25 - 125	15 - 100	1,372

[a]Probability ranges given in percent likelihood of discovery:
Low 0 - 25%
Medium 25 - 75%
High 75 - 100%

Source: I. F. Torries, Economic Justification for a Comprehensive Mineral Resource Program for " ". A series of unpublished reports, College of Mineral and Energy Resources, West Virginia University, Morgantown, 1983

the number of deposits that might be present in a country, but also how many are likely to be developed, if found, in the next 30 year period. The investment and sales values accordingly reflect world market prices and a production level corresponding to an efficient scale of mine capacity, given the type of deposit likely to be found. We wish to emphasize that the reported figures are best possible estimates but they should be interpreted as subject to further confirmation. The range of possible investments could vary, depending on site specific conditions and inflation rates. The range of sales requires that the projected market prices should not be subject to the supply pressures that would result if all of the projects were undertaken simultaneously for a particular mineral. While such forecasts are obviously tentative and subject to uncertainty, they are based on an organized methodology and accepted here at least as a vehicle for comparing country potential.

Table 6 indicates that a considerable potential for investment and export sales exists in each of the African LDC's. Furthermore, the export sales foreseen for each country would be large relative to the GDP reached by each country in 1981. This would also be the case for most of the countries if we take the realistic view that only one or two projects could be adopted in each country. Export revenues are likely to increase for many of the countries with investments in copper, nickel, cobalt, chrome, lead and zinc. Investments in gold and diamonds are also likely to be beneficial. Iron ore projects, although reported to have large sales potential, probably cannot be pursued beyond the scale of planned domestic steel consumption.

An appropriate question to ask is whether any of the countries have moved toward further investment in exploration and production of any of these minerals since these estimates were prepared. Recent experience

has shown that indeed a substantial number of mineral investments have taken place. However, documentation on many of these investments is limited. We can consequently refer to the more recent of the larger investments, as have been reported in Table A2. That table shows that Guinea has moved to develop its gold deposits and its Mifergui iron ore deposit. The government of Mali is undertaking feasibility studies for iron ore with the Soviet Union, for bauxite with Pechiney, and for phosphate with BRGM. High grade poly-sulfide mineralization is being examined in the Central African Republic. Sudan also seems to be pursuing development with investment in wolframite, lead and zinc mining projects. And Upper Volta is seeking funding to conduct development studies of its manganese deposits.

Investment Constraints

The above review of past and potential investments has only hinted at the constraints which may have prevented countries in this group from developing their mineral potential. The first constraint of importance has been the reported shift of foreign investors away from mineral projects in developing countries, as emphasized by Crowson (1982), Mikesell (1979), and Radetzki and Zorn (1979). Crowson would base this shift on changes in ore grades among countries, on outright or creeping expropriations of the past decade, on sudden and possible arbitrary changes in taxation and other conditions, and on perceived political risks. These constraints can be said to have recently been made more severe by excess capacity, weakened demand and profit prospects, and rapid rising capital costs in the metal industries.

Crowson, nonetheless, believes that this shift can be offset because of the interests of a variety of investors. Among such potential investors, he suggests the following (1980, p. 8):

1. Existing mining companies, which expand in order to keep down or reduce their unit costs. The pressures for such expansion often intensify in recession when profit squeezes are most acute. Such expansions usually require less capital than greenfield projects. Their potential contributions to total supply can be considerable; in copper, for example, nearly two-fifths of the projected 0.8 million ton increase in capacity in the 1980-84 period was from expansion.
2. Mining companies which produce more than one metal, and which are usually unable to carry significantly, the proportions of different products. Their output of by-products may crucially affect their profitability, regardless of their influence on supply/demand balances.
3. Smelting/refining companies, or merchants anxious to obtain ores and concentrates to supply their existing processing plants, or consumers wanting to safeguard their supplies. Their established sources of supply may be threatened by exhaustion or diversion, thus forcing them to seek alternatives.
4. Governments wishing to establish new industries in order to diversify their economies, or to exploit previously undeveloped resources in order to expand income and employment. Oman is an example in copper.
5. Countries anxious to reduce imports and become more self-sufficient for employment, foreign exchange, or strategic reasons. Brazil is a good example, but even the United States is sometimes influenced by such pressures.
6. Companies trying to diversify into mining from their established businesses, which may accept lower returns or take a longer view than traditional mining companies. The major oil companies are the most frequently cited in this respect, but there are many other examples.
7. Traditional mining companies that have widely differing managerial objectives and required rates of return. There will always be more adventurous companies who are prepared to take greater risks for higher prospective rewards than the industry average.

Our conclusion must be that a sufficient number of prospective investors exist to provide financing for mineral projects of the size suggested in Table 6. According to Crowson, the sizeable excess capacity margins of the mid to late 1970's are being eroded, and the mineral markets could experience possible disruptions. The supplies of many minerals could thus become tight, if there is a strong concerted boom in the industrial countries in the mid-1980's. While this might provide an opportunity for new mineral investments in the African LDC's, any realization of this opportunity in specific countries will depend on the successful establishment of appropriate mining policies.

A second important constraint affecting mineral investment is the frequent lack of adequate infrastructure. Mineral investment simply will not take place without adequate infrastructure or the means to establish it through effective mineral agreements. Infrastructure can include a variety of services such as transportation networks, water supplies, power supplies, storage facilities, communications, and social, medical and educational facilities. Transport, however, is most critical as it relates to mineral exports. Here landing strips, ports, and rail access to the sea (land-locked countries) are vital. Examples can be drawn of the effect of this constraint on African LDC's where mineral investment has been low. Upper Volta needs a 360 km rail link to develop its manganese deposits at Tamboa and then it must ship exports across the Ivory Coast. Mali suffers from the impassibility of most of its roads during the rainy season and rail links are essential to move exports through Senegal. Most of Uganda's rail system is badly in need of rehabilitation, and most of Sudan's known mineral deposits lie in areas having little or no infrastructure.

One way that countries have attempted to overcome the infrastructure problem, at least on a domestic scale, has been to foster small scale mining in different regions. Malawi has made good progress in this respect, i.e., see UNIDO/IS.389 (1983). One of a number of its valuable small-scale industrial activities is traditional lime-burning. One small company and half-a-dozen cooperative or village groups are involved in the industry. These operate in a labor-intensive way with simple kilns, and reduce costs further by operating on a seasonal basis. They are thus able to supply lime from dispersed sites at competitive prices. Another possibility would be for Malawi to develop its recently discovered glass sand deposits. The country could produce ordinary flint glass but not sheet

and plate glass, where the minimum viable-sized plant is many times greater than total Malawian demand. Since sheet and plate constitute no more than 10 percent of glass imports, it is thought possible to import-substitute for about 85 percent of all imports, for which the most important supplier is the Republic of South Africa. Furthermore, the glass could be melted hydroelectrically, avoiding the presently extensive use of imported oil.

A third constraint is whether or not the combined production and transportation costs of exporting a mineral will permit a country to have comparative advantage in a specific mineral relative to that of other countries. Production costs will be lower for those countries which have ore grades generally of higher quality than deposits of other countries. Since the developing countries tend to have higher ore grades for a particular mineral than do the developed countries, there would appear to be an opportunity for the African LDC's to export certain minerals on world markets. As long as infrastructure is in place, higher grade ores steming from efficient mines are likely to have greater future sales potential, given reasonable demand prospects.

A fourth constraint may be the lack of plentiful low-cost energy as might be required to mine or to process a particular mineral. Table 7 provides some of the fuel and gross energy requirements of smelting minerals either directly or ultimately from crude ore. The smelting of minerals such as bauxite and aluminum as well as magnesium and titanium could only take place in countries with abundant, low-cost energy. The smelting of iron, zinc and lead would be more suitable for countries with lesser energy resources.

A final but less tangible constraint on mineral investment is the

Table 7

DIRECT FUEL AND GROSS
ENERGY REQUIREMENTS OF PRODUCING METAL FROM ORE[a]

	Direct Fuel Requirements (MJ/kg)	Gross Energy Requirements	
		Smelting only (MJ/kg)	Metals from Ore (GJ/tn)
Aluminum	54	228	270
Magnesium	50	393	400
Titanium	177	430	430
Iron	15.1	25	30
Tin	10.7	19.6	180
Zinc	25.3	55	70
Nickel	35	103	170
Copper	7.6	47	115
Lead	8.1	19	30

[a]Energy Units: MJ/kg = mega joules per kilogram, GL/tn = giga joules per ton.

Sources: P.F. Chapman and F. Roberts, Metal Resources and Energy, London: Butterworths, 1983.

possible lack of perceived future demand for a mineral. Given the uncertainty of long run mineral demand or price projections, this constraint may not be perceived as severe if the deposit to be developed is of sufficient high quality and low cost. There have been a number of recent attempts to project world demand for selected major nonfuel minerals, including Leontief et al. (1982), Malenbaum (1977), Mikesell (1979), Ridker and Watson (1980), Wolff (1984), and the World Bank (1982). A summary of these demand projections appears in Table 8, at least for those studies that have attempted to project demand for a wide-range of minerals. There are differences in the rates of growth reported and these are obviously the result of differences in underlying assumptions among the studies. The demand projections, nonetheless, provide a basis for assessing the potential of different mineral projects. Metals with the highest potential of demand growth (above 4.47 percent) are molybdenum, tungsten, manganese, chromite, lead, aluminum, vanadium, platinum, silicon, potash, soda ash (trona), borate, and phosphate. Determining factors which are likely to sustain these rates of growth are a foreseen world population increase of about 2.0 percent per year and likely income increases in developing countries. Factors which may diminish these rates are a shift in economic activities, resource-saving technological innovations that affect processing and manufacturing, and substitution among raw materials inputs in references in relative prices.

Mineral price projections are also important for investment decision-making. Overall Dobozi (1983) believes that mineral prices will become firmer to the year 2000 because of a continuation of world inflation, use of lower grade deposits, rapid growth of environmental protection costs, and firm energy prices. Such a projection also confirms Crowson's (1982)

Table 8

COMPARISON OF PROJECTED RATES OF GROWTH
IN WORLD DEMAND FOR SELECTED MINERALS, 1970 - 2000

(Percent per year[a])

Mineral	Bureau of Mines	W. Malenbaum[b]	Ridker and Watson[c]	Leontief et. al.	Range
Iron Ore	2.6	2.95	2.05	4.03	2.05-4.03
Molybdenum	4.5	--	2.40	4.15	2.40-4.50
Nickel	4.3	2.94	3.21	2.70	2.70-4.30
Tungsten	3.5	3.26	2.09	4.47	2.09-4.47
Manganese	2.7	3.36	0.55	4.90	0.55-4.90
Chromium	3.3	3.27	-0.49	4.60	-0.49-4.60
Copper	3.9	2.94	2.70	4.35	2.70-4.35
Lead	3.5	--	3.34	4.47[c]	3.34-4.47
Zinc	2.1	3.05	2.60	3.53	2.10-3.53
Gold	1.5	--	--	4.48	1.50-4.48
Silver	2.3	--	--	4.30	2.30-3.30
Aluminum	5.4	4.29	5.10	3.67	3.67-5.40
Mercury	2.3	--	--	1.76	1.76-2.30
Vanadium	3.6	--	4.26	4.70	3.60-4.70
Platinum	2.6	3.75	--	4.60	2.60-4.60
Titanium	3.8	--	2.12	3.50	2.12-3.80
Tin	0.9	2.05	2.93	4.00	0.90-4.00
Silicon	3.7	--	--	4.50	3.70-4.50
Potash	3.6	--	2.57	4.70	2.57-4.70
Soda ash	2.4	--	--	4.80	2.40-4.80
Borate	3.5	--	--	4.80	3.50-4.80
Phosphate	5.0	--	3.61	4.60	3.01-5.00
Sulphur	4.6	--	1.95	3.76	1.95-4.60
Magnesium	2.1	--	--	3.90	2.10-3.90

[a]Rates of growth computed on the basis of physical units.

[b]1975 - 2000

[c]Indicates primary as well as secondary demand.

Sources: U.S. Bureau of Mines, Preprints from Bulletin 671, 1980 Edition; W. Malenbaum, The Global 2000 Report to the President, Vol. II, 1980, pp. 206-207; R.G. Ridker and W.D. Watson, To Choose a Future, Resources for the Future and John Hopkins University Press, 1980, p. 153, and W. Leontief et. al. The Production and Consumption of Nonfuel Minerals to the Year 2030, Institute for Economic Analysis, New York University, 1982, p. 260.

belief that world mineral productive capacity will have to increase by the end of this decade to prevent shortages of certain minerals. However, there are also influences at work which could place downward pressure on prices until the year 2000. Higher grade deposits are constantly being discovered because of our increasing knowledge of geology and ore occurrence and the spread of exploration to more remote areas. We also find increasing production of minerals from state-owned mineral companies who are willing to accept lower direct returns on capital invested than are private companies. Improved technology also allows for lower grade or difficult ores previously discovered to be economically processed as well as for increased secondary recovery and for decreased amounts of mineral use per unit of final product. In some cases, mineral demand itself may be declining or growing at a slower rate than previously. Any investment decision, therefore, must make use of the latest and of the potentially most accurate mineral price forecasts.

Investment Expansions

Based on the above and other mineral investment patterns, potentials and constraints, let us attempt to generalize how governments can best pursue new mineral investment. At a basic level a government can stimulate mineral investment by doing the following:

1. Encourage private industry by providing geologic data and economic incentives,
2. Initiate government agencies with skilled personnel which instigate and implement mineral policies such that foreign investors will be able to work efficiently and will be able to receive a reasonable return on their investment,
3. Investigate direct government development of the mineral industry through internal funding,

4. Seek foreign aid or external funding in addition, particularly for cases where the donor country or the foreign investor wants to obtain a constant source of raw materials, and
5. Pursue a combination of the above; where necessary more complex financial arrangements and consortium funding must be sought.

The first of these guidelines relates to the discussion of resource endowment and stresses the importance of geologic data. In order to discover new mineral occurrences and to enable governments to have the type of information needed to make decisions, data must be gathered in as comprehehsive manner as possible. Ideally, a complete mineral inventory of each country should be made. The inventory would identify the minerals present, their location and their quantity. With this information, a government could determine the correct priority among its various mineral deposits and other non-mining projects important to the country. Although such a complete inventory is seldom available, exploration methods and data gathering and interpreting procedures have improved. Greater knowledge of deposits has occurred because of increased understanding of the mineral forming geologic processes and of increased surveying and prospecting. More sophisticated exploration techniques are now employed on a routine basis such as airborne geophysical surveys backed up by ground follow-up work.

The second guideline recognizes that an investor must be able to deal effectively with a government not only in negotiating economic incentives but also in implementing exploration and development activities. Before inviting a foreign firm to begin extensive and costly exploration, the government should guarantee certain development rights if discovery occurs and expedite any import processes regarding exploration equipment

and personnel. The closer a project is to the development stage, the higher the costs involved and the greater the need for final guarantees. Once discovery occurs, the returns anticipated from developing a known deposit depend on the quality of the deposit as well as the related costs of extraction and transportation. We have learned that a country has comparative advantage in a particular mineral where the latter's costs of extraction and transportation are low relative to that of other countries. Here costs are influenced not only by the quality of the resource endowment, but also by mining and processing technology, labor costs and quality, economies of scale, energy costs, availability of infrastructure and mineral royalties, taxes and laws.

The third guideline suggests that the government attempt to develop a mineral industry itself. However, this possibility is limited by a number of factors ranging from a lack of know how and access to marketing channels to a scarcity of funds. Internal or domestic financing of larger projects is difficult, because as Table 6 has shown, their cost may be a sizeable fraction or several times that of the GDP for a small country. Given that the rate of return from mining projects is often in the vicinity of 12-15 percent, it is difficult for country governments to rank mineral projects ahead of those in other sectors with more favorable returns. In the past, internal financing has depended on government mining enterprises, private capital, national mineral development banks, and direct budgetary appropriations. But for smaller countries such as the African LDC's internal financing is rarely possible and external funding must be sought.

The fourth guideline asserts that the government seek foreign aid or more practically that it obtain external funding. Radetzki and Zorn (1979)

have shown that large project needs can be met by extending private investment through an external matching of several rather than a single source of funds. In this manner, risks are shared, by syndicating the project loan on as wide a basis as possible. This brings us to the fifth guideline which would confirm the necessity of seeking more complex financial arrangements. More recently the establishing of such arrangements has required the involvement of the World Bank, The United Nations Development Program, or the United Nations Revolving Fund for Natural Resource Exploitation. There is also room for South-South development in which one developing country might invest in another in order to obtain the minerals the former needs for its processing facilities or simply to expand direct mineral investment. As an example of the former, Jamaica and Columbia have signed a preliminary agreement to build a joint aluminum smelter at a cost of $400-500 million, which would use Jamaican bauxite and Colombian coal. The refinery to be built in Colombia will provide part of its output to Colombian industry and the rest to other Latin American countries and the United States. The agreement also covers the shipment of Colombian coal to supply part of Jamaican energy needs. As an example of direct investment, the Islamic Development Bank together with Coframines have recently invested $100 million to help Upper Volta reopen its Poura gold mine operation.

5. MINERAL INVESTMENT CLIMATE

The climate or environment necessary to attract foreign investment to African LDC's is discussed here in terms of the bargaining situation that surrounds the formation of mineral contracts or agreements. Partnership in the ownership and control of a mining project by a foreign investing firm and a host government can constitute constructive relationships in which the two parties cooperate in achieving certain common objectives; these typically include maximizing the net earnings of the project and creating a social and economic environment in the mining company conducive to co-operation and productivity. When an adversary relationship exists between the government and the foreign investor and neither party is willing to understand the problems of the other, then such partnerships are not likely to succeed. It is well known that this relationship has not always been a favorable one; mining companies historically have been accused of exploitation through concessionary agreements and host governments have demanded controlling equity positions as well as outright nationalizations. However, there recently has been evidence of growing co-operation between these two parties.

In this section we draw from a number of sources to demonstrate the major issues involved in establishing successful mining agreements taking into account the complex economic and social objectives of the host government and the financial and managerial concerns of private investors, e.g., see Labys (1980), Mikesell (1980, 1983), Radetzki (1982), Smith and Wells (1975) and the United Nations Center on Transnational Corporations (1983). Our starting point is with the overall mineral market structure and how this structure can influence the bargaining position that either party can possess in negotiating a mineral contract.

A series of examples of recent mineral agreements reached by Sierra Leone, Sudan and Niger are then reviewed to provide insights into actual contractual terms. The section then closes by using these case studies to illustrate what can be considered the most essential issues in contract negotiation and in establishing a suitable investment climate.

Role of Market Structure and Bargaining Power

The terms of agreement that a host government can acquire depend on several broad concepts. First, they depend on the amount of economic rent that is available for collection in any given mineral project. Here rents are defined as the profits which are in excess of those necessary to allow current and future projects to be undertaken. (Hence available rents exclude returns due to exploration and technical advantage). The amount of the rent available varies with the quality of the deposit of interest. Second, the terms depend on the relative strength or the bargaining power of the government and other rent seekers to collect these rents. Other rent seekers include the mineral investor(s), financers, labor, other governments, and suppliers of equipment, raw materials, and energy. A third broad influence is the structure and performance of the related international mineral market. Both Labys (1980) and Maizels (1984) have specified a number of underlying factors which are important in this regard. The more important of these factors are briefly reviewed below (Labys, 1980, pp. 49-52).

Government Alternatives. The host government will have greater or fewer alternatives depending on its range of potential mineral projects. This choice of alternatives is reflected in the extent of the mineral export dependence of a country and in the magnitude of the investment required to bring any mineral project to fruition. Mineral export dependence

implies that a country relies on one of at most several mineral exports for the majority of its foreign exchange earnings and export income. Several criteria can be empirically judged for a host government that reflect this dependence. Among these are: (1) the commodity concentration of a country's trade, (2) the growth in export earnings from primary commodities, (3) the change in the terms of trade taken on a single commodity basis, and (4) the instability in earnings resulting from price and quantity fluctuations of the mineral at the export level.

The magnitude of the fixed investment in mineral mining and processing projects has grown immensely. In judging the magnitude of such investment relative to a country's ability to finance it, the investment value can be compared to the value of the country's gross domestic product, the mining sector's share in that product, and the gross domestic investment. To some extent, such a comparison can be derived from Table 6. Depending on whether the project investment is relatively large or small, the position of the foreign investor vis-a'-vis the host government will be stronger or weaker. In the case of a large project, the foreign investor is in a strong position initially, but his position deteriorates once his capital has been transformed into a mineral facility. More will be explained about this situation in discussing the obsolescing bargain.

Nature of Technology. When the technology of mining or processing is complex and changeable, it is less easy for a host government to develop its domestic cadre and to share in mineral production and ownership. The foreign firm occupies a dominant position. For the case where the technology is simple and stable, the host government has a better possibility of expanding its share of rents. When technology is also simple at the processing stage, the country can attempt to integrate forward.

Control over Reserves and Production. The benefit that either party can derive from a mineral depends ultimately on its control over reserves and production. The patterns of ownership and control in a mineral market are fairly straightforward. The foreign firms may own the land they have explored and are exploiting or they may acquire mineral rights through leasing. A firm obviously has difficulties in mineral development where exploration rights are limited. This is increasingly the case in developing countries where there is a determination to bring companies under control. Host governments also have other devices for extending mineral control. They can expand their shareholding in a firm, they can organize state-owned mining firms, or they can establish a state-trading enterprise to coordinate domestic production and sales with external purchases.

Opportunties for Increased Processing. Processing offers the possibility for increased value-added as well as foreign exchange earnings. At present semi-processed and fully processed mineral commodities account for only 10 percent of the exports being shipped from developing to developed countries. Among the factors affecting the ability of a country to increase processing, a most important one is the complexity of the technology involved. Others include the tightness of industry integration, tariff and nontarrif barriers facing them, and restrictive business practices.

Of course, there are a number of possibilities for a host government to enter into the investors' processing network. (1) The parties can agree when signing a contract that processing facilities are to be built by a certain date. (2) The government may require the firm to undertake feasibility studies on processing facilities. (3) The government may offer tax or other fiscal incentives, such as refunding some or all of the taxes collected in the first years of a concession, if the firm will use the

money to build processing facilities. (4) The government can offer tax holidays to profits acquired from processing. (5) The government may levy tariffs or quotas on raw materials leaving the country and erect positive tariffs on imports. (6) The government may require the investor to offer output to any local processor, at a price not higher than that sold to other buyers. Although there are other methods of encouraging processing, these are probably the most common.

Material Share in Product Prices. The host government will be able to increase prices or demand more concessions when the raw material is a relatively unimportant cost item in relation to the sales price of a final product. The share of the raw material cost in final product price depends on two factors. First, it will tend to be higher, as more processing is undertaken before the material is sold. Second, it will be lower as the value-added created by the buyer increases. The higher the value-added per unit of sales, the less important will be the raw material cost to the buyer. Buyers with far-reaching forward integration, therefore, will ordinarily be less affected by the price changes of raw materials bought and will find it easier to absorb such changes in their total costs.

Project Timing. The host government will be able to prolong its demand for concessions where immediate revenue seeking and the cyclical instability of the related mineral market do not present serious problems. The extent to which project delays can affect cash flows can best be viewed by a simple example. Assume that a four year delay can increase rents by as much as 50 percent; project revenues in this case will have a net present value of $ 150 million per year rather than $ 100 million per year (real values assuming no inflation). The change or difference in the net present value resulting from the four year delay in start-up has been calculated below (based on a 25 year cash-flow, and a discount rate of 10 percent).

Year to Start-Up	Cash Flow Over 25 Years NPV of $100 m/yr.	NPV of $150 m/yr.	Change in NPV Given 4 year lag
0	907.7	1,361.6	----
2	750.2	1,125.3	----
4	620.0	930.0	22.3
6	512.4	768.6	18.4
8	423.5	635.2	15.2
10	350.0	525.0	12.6
12	289.2	433.9	10.4

As can be seen, a government would be better off to negotiate for the higher cash flow as long as more intensive negotiations do not cause project initiation to be postponed more than four years. However, in addition to the declining value of money over time, a government must be concerned about changing economic and suitable mineral market conditions. If a project is delayed, the risk of not having the project initiation at all is increased. Mineral market instability can be high, and if a project is not developed in a timely fashion, it may not be developed at all.

Obsolescing Bargain. This factor as well as the two remaining ones concentrate on the evolution of bargaining power over time. In order for a project to be initially undertaken, there must be an assurance of return on the total project investment. Once a project is underway, initial capital costs become sunk costs and the firm's decision to stay in operation depends on current operating costs. There is a temptation on the part of governments to try to capture the profits due to capital investments, once a project is undertaken. Indeed, these profits can be taken by the government without disrupting the existing operation, but such action discourages

future investment and may be counterproductive. While payment to capital and quai-rents due to exploration can be collected by a government from an ongoing operation, such a policy will, in the long run, prevent future investment in that country. Vernon (1971) has termed this an "obsolescing bargain." There has been a regular and predictable effort mady by host governments to increase their control over a foreign firm. Such governments have scrutinized the profitability of the resource extraction and export operation, and have attempted subsequently to increase their share of profits as a means of satisfying national goals.

Nature of Competition. The competitiveness of a market indicates the extent to which new entrants can appear and lessen any oligopolistic or monopolistic power that a major firm may have had in a market. In such a case, the position of the host government relative to the investing firm becomes stronger. Most of the major mineral markets have experienced an increase in the number of competitors over the 1960's and 1970's. Japanese and European firms particularly have entered the market to assure supplies of minerals to meet their needs. The developing countries can now more easily enter the market as well; they can also more readily choose among alternatives in selecting sources of investment as well as buyers for their raw materials.

The nature of competition in the market where the raw materials buyer sells his product also is important. It is likely that a buyer will negotiate more stubbornly against increases in his raw materials costs where he has had to absorb these himself, and that he will be more amenable to accept the seller's demands in situations where the cost increase can be passed on by way of higher prices on his sales. The rationality of this argument is obvious. In the former case his profits will be directly affected by the increase in costs. In the latter they will not. From

this point of view, it would be an advantage to the sellers of the mineral to trade with processors who have a strong monopoly or oligopoly in the final product market. For example, the petroleum companies know that they can pass on most of their cost increases to the final consumers. This probably has contributed to their ready acceptance of the raised tax demands of the oil-producing countries.

Government Learning Process. Often a host country reaches its obsolescing bargain by attracting new investments and then tightening its terms; it slowly advances along a learning curve. The learning process includes improved understanding of the cost structure and operating techniques of the industry as well as increased negotiating skills. The historic case has been that of host countries first observing mineral industry operations with little understanding of them. Gradually the governments began to understand the operations, to demand hiring of nationals in supervisory positions and to require participation in expansion and marketing. Mutual accomodation on its part now becomes more demanding.

There can be two observable effects as a result of the learning process. First, Erb (1975) finds that learning leads to tighter and more equitable contracts, replacing traditional concessions with more complex, modern ones. Cited are an increase in government participation in the ownership of mining operations (equity sharing) and an expansion of the government's management role. Secondly, Moran (1977) suggests that because of this learning, some foreign investors now begin to face a tax rate ranging from 60 to 90 percent plus demands for local ownership, local control over marketing, and local regulation of profit remittances, irrespective of the original contract. This seems to be particularly true for the "mature" minerals such as copper, tin, and bauxite. Whether this second effect is stable or not depends on whether rents or

quasi-rents are being collected by the governments.

Recent Mineral Agreements

The typical mineral agreement is negotiated by representatives of the mineral investing firm and of host government officials who are supported by a team familiar with the particular mining industry. This team may be composed entirely of government officials but frequently includes consultants. The issues negotiated as summarized in the cases discussed below deal with the division of economic rents between the two parties as well as with control over the investment program and the government's role in this control. There are many mineral contracts that could be presented as an example, but the three presented below illustrate many of the features commonly found in modern mineral agreements between LDC governments and mineral producing companies. Because mineral contracts are typically 50-100 pages in length, only the most essential aspects of these three contracts have been summarized below. Interested readers can consult the more complete description found in the document published by the UN Centre on Transnational Corporations (1983) from which the summaries have been extracted.

Sierra Leone and Bauxite. In August 1972, the Sierra Leone Ore and Metal Company Limited (SIEROMCO), a subsidiary of Schweizerische Aluminum AG (Alusuisse), was granted exclusive rights to prospect for bauxite in the Port Loko region of Sierra Leone. Exploration of the area was completed in June 1977, by which time SIEROMCO had proved the existence of 100 million tons of bauxite. With both parties sharing a mutual interest in exploiting the Port Loko deposits, the agreement states that effective exploitation would most likely be contingent upon the construction of a local alumina plant at Pepel. The Pepel Alumina Company, a wholly-owned subsidiary of Alusuisse, was established to finance and execute a pre-

liminary feasibility study. Alusuisse was then to form a consortium to construct and operate the Pepel Alumina Company plant. The plant which was to be operated independently of mining operations, would have an estimated annual capacity of 500,000 tons of alumina, with a provision for doubling the capacity should market conditions permit.

The government of Sierra Leone and Alusuisse each with a 50 percent share formed a joint venture, the Sierra Leone Bauxite Mining Company Limited (referred to hereinafter as the company), for the purpose of developing and exploiting the Port Loko reserves in a fashion that would provide an inviting environment for prospective investors in the Pepel alumina plant. The authorized share capital was 10 million Leones represented by 10 million equal shares; the issued share capital was to be divided into two equal shares.[1] In return for its right to assume SIEROMCO responsibilities and priviliges for the Port Loko bauxite deposits, the company was to issue new shares to Alusuisse in an amount equal to the costs incurred by SIEROMCO with respect to its prospecting of the deposits. A like number of shares would be issued to the government in return for which it paid the company their full nominal value in cash.

Aluisse agreed to manage the company in turn for which it would receive the following:

1. Full reimbursement for all Aluisse employees working in Sierra Leone, including direct and indirect costs.
2. For its technical know-how granted in the construction phase and the performance of duties as engineer, a fixed annual fee of 10 percent of the actual total investment costs of the company, plus 10 percent of the total investment costs of any

[1]One Leones or Le = U.S. $1.80 in 1982.

expansion.

3. For its know-how and technical assistance in operations and its services as the managing partner, a fixed fee of 2.5 percent per annum of the net invoice amount of all sales made by the company under the terms of Alusuisse management.

Aluisse was not subject to any taxation in Sierra Leone on any income earned under the terms of the agreement, except for the following:

4. Ten percent of the fee actually received for its performance of duties as engineer (engineering fee) should be deemed the chargeable income on which tax is to be paid at the applicable standard rate.
5. Thirty percent of the fee actually received for its services as the managing partner (management fee) should be considered as chargeable income on which tax is to be paid at the applicable rate.
6. Any interest payable to Alusuisse in Sierra Leone based on estates or property located, or contracts entered into, in Sierra Leone should be taxed at the applicable standard rate.

Alusuisse was not taxed on any dividends from its share in the company except for those taxes to be levied on the company's chargeable income.

In addition, the Company was responsible for the payment of the following:

1. A special exclusive prospecting license rent of Le 50 percent per annum for each square mile as of the date it was granted.
2. A mining lease of Le 960 per annum for each square mile in the mining area, to be reduced to Le 640 on 31 December following

production day.

3. A surface charge at the rate of Le 10 per year per acre.

The company was subject to the regular customs duties and tariffs with the following exceptions:

1. For an initial period of five years commencing on the date of its first duty-free import, the company could import all mining machinery and equipment, construction materials and tools, hospital and sanitary equipment, spare parts and other items needed for construction of the project and related facilities free of all duties and fees.
2. For a similar period of time, the company could import or purchase locally all fuels (other than petrol and kerosene) needed soley for the operations of the company free of all duties, excise taxes and fees.
3. The company could export, pursuant to the terms of the agreement, all the products of its mining operations - in either its crude or refined state - free of all taxes, duties and customs.

The company was exempt from the payment and deduction of any withholding tax on payments to foreign creditors or recipients of interest on indebtedness and on service fees. During the five-year tax-free period the company was exempt from the foreign travel tax and payroll tax for employees who are not citizens of Sierra Leone. This not only gave the company an economic incentive to make the investment but allowed contractors to bring in specialized labor for construction.

Exchange losses or profits resulting from currency fluctuations were allowed as deductible expenses or treated as taxable income for the purpose of computing taxes.

The company was to purchase products and services in Sierra Leone,

whenever such goods and services are of comparable quality and at prices competitive with those obtained abroad. All services that are not directly related to mining, processing, transportation and other industrial activities, and that are obtainable at costs which do not exceed the costs to the company of its providing such services at the same standards, were to be procured from local enterprenuers. The company would also "encourage" its major contractors to purchase domestic products and services.

The company agreed to employ "its best endeavors" to transport its products in ships in which the government has an interest or which fly the flag of Sierra Leone, on the conditions of competitiveness and suitability.

Although the company, Alusuisse and the government were subject to the laws of Sierra Leone, "only those provisions of....The Mineral Act which are consistent with the Agreement shall apply hereto". Disputes regarding the master agreement were to be submitted to the jurisdiction of the International Centre for Settlement of Investment Disputes. Irreconcilable problems arising under the management and technical assistance agreement were to be resolved in accordance with the Rules of Conciliation and Arbitration of the International Chamber of Commerce. Following an early amendment, the entire agreement was to be governed by the laws of Sierra Leone "and such rules of international law as may be applicable."

Niger and Uranium. Le Commissariat a'L'Energie Atomique (CEA) has been involved in the exploration of uranium in the Niger since 1959. The Continental Oil Company of the Niger (Conoco) sought to co-operate with CEA in the discovery of uranium ore deposits in economically exploitable reserves of approximately 5 million tons of uranium, at a grade of 0.55 percent U_3O_8. Together with the government of Niger, the three parties entered into an agreement in April, 19.4. The State was given a 30 percent share, CEA a 35 percent share and Conoco a 35 percent share in the undivided interests. The agreement was to remain in effect "until the termination of all exploratory and/or exploitation activities hereunder".

The accompanying long-term agreement between Conoco and the state was for a term of 20 years from the start of commercial production. Should economically exploitable reserves remain, the parties would negotiate for the continuance of operations.

The project is under the control of the Representative Committee, a body "charged with making the decisions and programs necessary to the realization of the activities delegated to the Operator" which was to protect the interests of the parties. The committee bears the responsibility for all economic, financial, budgetary and primary technical decisions with respect to all aspects of the project. Control was centered in the operator who was to implement the decisions of the Representative Committee and to act as its agent "for the purpose of arranging the services and of all other activities necessary to accomplish the tasks and work intended by the Agreement". Conoco was designated to bear the total cost of the minimum work obligations under phase one. Conoco was also responsible for the expenses of phase two and three until either the conclusion of the feasibility study or the completion of work representing the amount of maximum expenses agreed upon for phases one,two and three (35 million French francs). Upon completion of phase one, the parties can (by a two-thirds majority) obtain an exploitation license. Any non-consenting party may withdraw from the agreement. The government agreed to pay all exploitation costs for its share of production on the terms that apply to the other parties.

Conoco was to hold its petroleum operations separate from uranium. Each was subject to its own accounting, legal and tax regime. Under the relevant tax law (1968), Conoco was requested to pay an income tax of 40.5 percent of net profits. Conoco was entitled to a depletion allowance that was not to exceed 10 percent of total shares, or 33 percent of

net taxable income. Such allowances, however, were to be reinvested within three years or they were considered as taxable income.

Equipment, materials and products imported for the purpose of the project were exempt from import taxes and duties. The depreciation and amortization schedule allows for the deduction of contributions in kind at a rate of 10 percent and of pre-production expenses at a rate of 25 percent. Conoco also was subject to certain fixed charges and surface royalties. Pursuant to a law under revision at the time that the agreement was concluded, royalties were to be considered a deductible expense rather than a tax credit (as was then provided) upon the enactment of that law.

The Government agreed not to impose obstacles on the free conversion and repatriation of funds for the repayment of capital loaned plus interest, the recovery of capital invested or loaned and returns (interest or dividends) on such sums, the payment of expenses incurred in sales transactions and the satisfaction of financial oblications to suppliers. The Government also agreed not to restrict the free movement and conversion of funds belonging to Conoco and not to limit its access to the foreign exchange proceeds earned from exports that were needed to maintain operations and to fulfill its obligations abroad. Conoco was to provide preferential employment to personnel of the Niger and to "contribute as promptly as possible to the occupational and technical training" of nationals.

Conoco was under no restrictions with respect to its choice of suppliers and contractors. It was, however, to give preference to local businessmen, producers and contractors in the provision of services, equipment and products for the project, provided these are available on comparable conditions and schedules and at competitive prices.

Unresolved disputes were to be settled by arbitration. Cases will be

heard by the International Centre for Settlement of Investment Disputes or, if the Centre lacks jurisdiction, in accordance with the procedures established by the Rules of Conciliation and Arbitration of the International Chamber of Commerce.

The Government guaranteed Conoco, for the term of the agreement, the "stability of the general legal, economic, financial, and tax conditions" under which it entered the agreement and agreed to do business. The mining laws in force at the time of execution of the agreement were to remain applicable to Conoco's operations and mining claims for the duration of the agreement. To afford further protection, it was stated in the agreement that:

> "...in the event of a fundamental change in the conditions which were material to the making of this Agreement, or to the accomplishment of its stated goals, and if the circumstances create for one or all of the Representative Parties, difficulties of performance manifestly outside their initial anticipations, the Representative Parties shall meet for the purpose of modifying the terms and conditions of this Agreement and, if appropriate, the Complementary Documents, in order to alleviate the charges or costs inequitably imposed".

If resolution could be obtained, the injured party could request arbitration. In addition, if any other firms exploiting uranium deposits in the Niger received more favorable terms than those granted to Conoco under the agreement, the more favorable terms would become part of the agreement.

Sudan and Chrome. The mining laws of Sudan are in The Mines and Quarriers Act of 1972, and the Encouragement of Investment Act of 1980. The laws are administered through the Ministry of Energy and Mining and its Geological and Mineral Resources Department. The 1980 law provides

concessions for both local and foreign investors, including exemption from the Business Profits Tax for the first 5 years of mineral production, exemption from custom duties on imported machinery and related minerals, land necessary for minerals development projects, discount rates for electrical power and transportation, protection of mineral development projects from importation of similar products. Also, the Ministry has the right to exempt a project from any other duties, either totally or partially. As an incentive to foreign investment, the Sudanese Government offers a variety of ownership arrangements, which include joint venture agreements with governments, joint ventures with the local private sector, and independent enterprises.

In May 1975, the Ingessana Hills Mines Corporation (IHM), a unit of the Grouped Industries Corporation, and the Marubeni Corporation entered into an agreement under which Marubeni was to provide technical assistance to IHM "for the exploration, development and production of chrome ore deposits in Ingessana Hills and any other areas in Sudan".

Periodically, Marubeni is to send geologists and mining engineers to the chrome mines owned by IHM. The experts were to provide general technical advice and proposals with respect to:

1. Effective and safe mining operations,
2. Exploration and development of new deposits,
3. Quality control of chrome ore, and
4. Technical training of mining engineers.

Marubeni also was to provide some survey and prospecting aid to IHM. Marubeni was to receive no renumeration in return for provision of the above-mentioned services and tools.

Marubeni was to lend $1 million to IHM in order to finance the expansion of IHM chrome ore production. IHM was to repay the loan over a five-year

period, with the first installment to be paid one year after the date of the loan. The interest on the loan was set by mutual agreement.

Marubeni was to purchase between 15,000 and 25,000 tons of chrome ore during the period of July 1975 to June 1980. These sales were subject to the availability of transport of these ores to Port Sudan and to agreement on the purchase price.

Marubeni was to complete, at its own expense, a feasibility study for the establishment of a ferro-chrome plant in the Sudan. "Both sides are convinced that such a plant, once established, will add a sizeable new added-value to the Sudanese chrome, in addition to solving a number of problems facing its transport to international markets". Subject to the economic viability of such a project, IHM and Marubeni negotiated the creation of a joint venture for the operation of facilities and the production and sales of ferro-chrome.

Essential Issues in Contract Negotiation

The provisions of the above mineral contracts can now be combined with the results of studies previously mentioned to present what can be considered the most essential issues to African LDC's in negotiating mineral contracts. For the sake of convenience, the issues have been grouped into the following categories: (1) profits and fiscal policy, (2) ownership and management, (3) economic development and infrastructure provisions, (4) negotiating team and agency coordination, and (5) pricing, marketing and foreign exchange. More detailed information on these various issues can be found in the UN Centre on Transnational Corporations (1983), in Lewis (1980) and in Mikesell (1980).

Profits and Fiscal Policy. The basic motive to both the host government and the foreign mining company is the generation of income and profits. Some of the mineral profits are designated as economic rents and

the purpose of royalties and taxes is to capture all of the rents associated with a mineral project. The most important provisions with respect to rents and profits are those relating to royalties, profit sharing, various fiscal devices, surface rentals, tax incentives, production sharing, etc. The mining company desires to earn and repatriate the value of its investment, while the government wants to add certain development objectives to its basic revenue gains. Recent approaches taken (Mikesell, 1980) to harmonize these interests have been to establish a tax formula in the contract which assures full repatriation of initial capital before any corporate tax is levied on earnings. This formula may provide that no more than the normal tax rate be levied until the investor has earned an agreed minimum discounted cash flow on his investment, after which an excess profits tax rate would apply. There is also the need to provide stability in the taxing agreement. The foreign investor could very well be exempt from any new taxes, such as production taxes, export taxes, import duties, etc., for a period of years following the initiation of commercial operations.

The importance of stable tax agreements cannot be overstressed, because we have recently viewed a period in which foreign investors moved operations away from countries where excess and unwarranted tax increases occurred. In addition, companies have faced the "obsolescing bargain" mentioned above in which governments obtained company control through steps leading from increased taxation and increased equity share demands to actual or final expropriation. Such action either taken alone or coupled with a history of political instability in a country obviously deters future mineral investments.

Referring to the above example of the uranium agreement reached by the government of Niger, Conoco must hold its uranium and petroleum interests separate, each governed by its own tax regime. Income taxes

were levied on profitability, and Conoco, which provided for one half of the carried equity interest of the Government of the Niger, was subject to an income tax of 40.5 percent. Amounts paid in royalties are usually counted as tax deductions rather than tax credits. At the time of the agreement between Conoco and the Government of Niger, royalty payments in the country were deemed as credits against income taxes. In the agreement it was acknowledged that the Government was changing the accounting procedures and that royalties were to be considered tax deductions in the future. Conoco was to be subjected to these changes when enacted by the Government.

Ownership and Management. Related to the royalty and tax provisions are the terms of ownership, control and management that are required at the various stages of mineral project development. The government at the outset should attempt to establish a clear legal framework for the related mineral rights. Agreement also is needed within the various government departments on prospecting and exploration rights, extraction rights following discovery, the timing and rate of extraction, specific royalty and tax schemes, and ancillary engineering, safety, environmental and regional considerations. The government can then move to negotiate ownership and tax levels if required. The division of ownership of a mineral project between government and private companies is often the case of considerable negotiation. However, ownership is not always correlated with control or collection of rents. It is possible for a government to have a minority interest and still exercise control of an operation and to obtain rents. Conversely, it is possible for a government to own the majority interest in an operation and still not have control of production and sales policies and not collect all rents available.

A variety of ownership patterns are possible. In some cases the government may not have ownership at the outset. For example, a government might have a fixed equity share with the option to acquire all or a greater portion of the equity share after a certain period of commercial operations such as 20 years, with the terms of payment fully specified. The equity share can also be equal to that of the foreign partner as was the agreement between the Government of Sierra Leone and Alusuisse in exploiting a bauxite deposit. In other cases the governmeny may have dominant ownership and delegate management control by means of a long term contract with the lesser or foreign investor, the latter of whom would only have minority voting rights. In joint ownership the government might be expected to share in high risk exploration outlays in addition to ownership share outlays.

Economic Development and Infrastructure Provisions. The above provisions have often been interwined with country economic development provisions concerning mineral processing, local purchasing, infrastructure services, local research and the employment and training of nationals. However, any LDC attempting to use a project as a partial national development plan should be careful not to overburden it with overly ambitious development objectives. Mining companies can only provide limited infrastructure in this regard. And mineral processing, as will be explained in the next section, can only be successful when the related conditions pertaining to domestic markets, tariff structures and intra-regional trade are favorable ones.

The development of infrastructure is an essential prerequisite for the exploitation of mineral reserves and the effective development of a mining project.[1] Investments in infrastructure and programs to further

[1] This discussion as well as that of pricing, marketing and foreign exchange are based on the UNCTC (1983), pp. 79-80.

the social goals of the government are important for the intergration of the mining project into the local economy and the promotion of regional and national socio-economic development. The contractural provisions with respect to these issues are the means by which the host government can maximize the positive and minimize the negative social and economic impacts of foreign investment.

The enclave and dual economy problems resulting from the lack of integration of the foreign mining company's activities are characteristics of the traditional concession arrangement. The promotion of forward and backward linkages is also important as witnessed by recent attempts to increase mineral processing in these countries. Efforts made by the governments of developing countries to have foreign mining companies utilize local input as much as possible have been most successful in the extraction sectors. However, the requirements of a mining project such as technological expertise, advanced skills, capital-and technology-intensive equipment, manufactured goods and specialized services cannot always be met from domestic sources.

In most agreements it is required to the extent possible and depending upon competitive costs, availability and comparable quality, that the mining company utilize local input (goods and services) at all stages of project development. This stipulation was specified in the Sierra Leone-Alusuisse agreements and in the Niger-Conoco agreement. In the latter case, however, Conoco was exempt from any restrictions in its selection of suppliers.

The Negotiating Team and Agency Coordination. Before proceeding further, one should realize that a requirement for any government to negotiate the above or any other provisions successfully is that it develop or acquire the capability to do so. A team of appropriate mining,

engineering, economic and legal experts should be assembled who properly understand all phases of project negotiation and development as well as the mining company's interests and objectives. For example, the team should comprehend the technical aspects of the mining process, the cost accounting and product pricing procedures, the company's discounted cash-flow analysis, the impact various financial device have upon such analysis (particularly taking into account home country tax rules), and should seek a financial package which maximizes benefits for the country. An additional advantage of such a team is that its multi-disciplinary qualifications would enable it to serve the government internally as a board for coordinating interagency interests. A large mineral project in a small country would generate considerable interests and the board could serve to reduce rivalries and to avoid conflicting policies. In short, it could influence the government to clarify its objectives in forming an overall policy on mining development.

There is also a need for the composition of the team to remain fairly permanent, so that it can gain experience as the project proceeds to the commercial extraction phase. As confirmed by Waelde (1977), mining contracts are not ultimate legal documents but a vehicle for facilitating the process of bargaining which typically occurs throughout the life of the agreement. That is why the legal, social and economic framework of the document should be such that it eases renegotiation and dispute settlements. This is usually done by including renegotiation clauses, fade-out provisions, progressive reduction of the concessions areas, and most-favored country provisions. The government is thus in a better position to avoid changes in contract provisions that would significantly impair the profitability of the investment. Renegotiation clauses were shown to be included in the Sierra Leone-Alusuisse and the Niger-Conoco agree-

ments.

Pricing, Marketing and Foreign Exchange. Beyond understanding these basic aspects of establishing a favorable investment climate, the government should also determine how it can bargain in areas of mineral marketing and pricing and how it can appropriately set exchange rates. In attempting to control marketing, the government must have information on how the foreign mining company markets its products internationally. The extent to which product prices can be influenced depends on three factors in particular. The first of these is the nature of the marketing arrangements which the company has entered into or foresees in the future. The second of these is the market structure and the third is the mineral share in the final product sold. All of these factors have been discussed above.

A related issue is that of transfer pricing. Simply stated, the traditional concession arrangement allowed the mining companies to sell mineral products to affiliate enterprises at arbitrary prices. As a result, the firm could show a minimum of net profits on which it could be taxed. Royalties and other taxes and duties calculated on arbitrarily low values of minerals extracted, transported, processed or exported yielded very small amounts of revenue for the governments. In an attempt to avoid the potential abuses associated with transfer pricing, it is mandated in virtually all agreements that sales should be negotiated on arm's-length terms which are comparable to the conditions prevailing in the international marketplace between unassociated third parties.

Finally, the government should review its bargaining objectives in the area of foreign exchange and trade policies. The failure to establish sound policies in this area could make it difficult for any foreign investor to operate profitably and with a minimum of legal harrassments. To begin with, the company needs a clear dividend and capital repatria-

tion policy. According to Mikesell (1980), foreign exchange arrangements should permit the company to hold sufficient export proceeds abroad to meet all external obligations, including those arising from current foreign purchases, and to remit dividends and authorized capital repatriation. This can include depositing foreign exchange earnings in a special account of the host's central bank at a foreign commercial bank under an escrow or trustee arrangement whereby debt service and other agreed obligations must be paid from this account before funds become available to the government. In most agreements, the foreign investor can hold abroad an amount of foreign currency equal to the amount needed to satisfy approved foreign debt obligations for 60 days. For example, Alusuisse had the option of holding abroad those amounts necessary for the proper operations in Sierra Leone, and in the agreement between the Government of the Niger and Conoco there were no restrictions on the company's freedom to hold such proceeds abroad.

Accordingly, the company should have freedom to make payments to its parent or to other foreign firms for technical services and the use of patented processes, and to import equipment and materials from any source according to the conditions mentioned earlier. This is best accompanied by an exemption from import duties on equipment and materials employed in exploration, construction and operations. And expatriate personnel should have an ease of visa requirements and of required imports and exports of a personal nature.

6.0 ECONOMIC IMPACT OF MINERAL EXPORTS

Increased mineral investment, production and exports could have profound effects on the economic growth of an LDC. While many of these effects are positive, some may be negative. In this section we briefly consider some of the effects which are more commonly associated with mineral development. These include: (1) Growth in GDP and related multiplier effects, (2) an increase in industrial linkages through purchases and sales by mining companies and purchases by those employed in the mining and supporting industries, (3) an increase in export earnings, balance of payments surplus and money balances, (4) an increase in wages and employment in related mining and support industries, (5) inflation and exchange rate adjustments, (6) regional and local impacts, and (7) social impacts.

The most notable impact of increased mineral exports should be growth in GDP. As shown in Tables 1 and 2, developing economies with few other sources of productive wealth who have a mineral sector that contributes substantially to GDP will tend to experience strong GDP growth as mineral exports expand. However, the dependence of the economy on one or two mineral exports can also cause a decline in GDP when a downturn occurs in the corresponding world mineral markets. For example, we earlier discussed the declines that recently occurred in GDP in Botswana because of a decline in diamond revenues, in Niger because of a decline in uranium revenues, and in Togo because of a decline in phosphate revenues.

A more elaborate approach for measuring the impact of mineral exports on GDP employs multipliers which in the first instance assume a positive growth impact. The GDP multiplier measures the value-added generated by

each dollar of mineral production. The value-added or payment to primary factors is based on the gross value of the commodity. Because developing countries typically export all of the minerals they produce, mineral exports are assumed equal to mineral production. In Appendix 4, some estimates have been presented as to how mineral exports might impact on those African LDC's whose mineral investment and export potential have been the subject of Table 6. Although the GDP multipliers shown in Table A4a are based on Canadian experience and certain caveats are in order, metal ore and concentrate exports can be assumed to increase GDP by approximately 1.5 per every equivalent unit value of metal production. The African LDC's can thus expect a more than unitary impact on GDP from increased investment in mineral production.

Minerals exports can also result in an increase in the linkages between this sector and other sectors in the economy, leading to a further increase in overall economic growth, e.g., see Bulmer-Thomas (1978) and Hewings (1983). While no information is available regarding mineral export linkages in the African LDC's, one normally considers these effects in terms of forward and backward linkages. Forward linkages increase the extent to which other industries such as those engaged in processing would make purchases from the primary minerals industry. Backward linkages measure the extent to which the primary metal industry purchases factor inputs from other industries. The accepted view is that the forward and backward linkages of the mining industry are low and thus consideration of these linkages is only of minor importance in the case of the present group of countries, i.e. see Yotopoulos and Nugent (1973).

The argument that an economy can increase its value-added gains through further primary metal processing to the semi-fabricated metals stages as well as related industrialization is based on the concept of

linkages. Unfortunately, the gains which could result from the processing of primary minerals in the African LDC's are low because of the difficulties of achieving economies of scale in processed goods, particularly those designated for domestic rather than export demand. Roemer (1978) also discusses other processing constraints which these countries might face, such as barriers to processed market entry including market structure, freight rates and tariff protection as well as problems of distribution and only limited employment creation.

The economic effects of increased exchange earnings, balance of payments, government revenues and money balances can best be explained based on what Lewis (1982) has termed the "automatic adjustment mechanism". The result of a mining project reaching the production stage is an increase in foreign exchange revenues which in turn are likely to create a balance of payments surplus and increased government liquidity, the consequence of which is an increase in the money balance within the banking system. While some of these mining rents or funds may go directly to the government, their more immediate impact is on a country's central bank where the government holds its deposits. This is often the case in spite of sometimes large repatriation payments. The national banks of a country under certain conditions may seek to convert their non-interest bearing assets in the form of reserves with the central bank into interest bearing loans and advances leading to an increase in the money supply. Lending may occur to support development projects, as well as to purchase consumer durables and to increase business and commercial inventories. Should this spending be substantial in a small country, the likely result would be a sudden jump in imports and inflation.

The mentioned increase in government liquidity places a country's ministry of finance in a position to spend on new projects. The choice

of projects is crucial at this stage. However, the decision process is often hampered because of difficulties in evaluating projects, of political pressures to spend quickly, and of neglect of the correct sequencing of projects. The most suitable choice would be to adopt those projects which would diversify and industrialize the economy. The least favorable choice would be only to choose large projects such as public works whose long-term payoff is not favorable.

This pressure to spend and to instigate projects may in some cases lead to waste. That is, the projects finally selected may have less efficiency or fewer benefits than what could be considered optimal from the country's point of view. The sudden economic progress which takes place can be sweltering and congestive. Breakdowns, delays and similar incidents can cause the country to spend more resources for a given level of benefits than it would have if development had been planned and synchronized over time. This can be particularly true in the case of shortage problems whose solution results in an increase in imports not only of goods and equipment but also of services such as consultants. Any mining boom could thus possibly lead to more bottlenecks than it eliminates.

Economic effects can also be disfavorable where wages paid in mining operations are higher than that justified on average by the productivity of labor in alternative activities. This problem and its repercussions as well as related employment and distribution phenomena are among the most severe posed by mining development. There is first of all the tendency for the wage increases to spread to a major part of the economy, particularly among higher skilled labor. Not only do mining firms have revenues to increase wages but so does the government. Mining operations must sometimes raise wages to attract quality personnel, a practice which the government often encourages to increase the retained value from mining.

The effect of these wage differentials is often unfavorable "wage dualism" which in the case of the mining industry is also accompanied by "technological dualism." The effect of increased government wages is that the former can reduce the resources available for investment in government projects and in private diversification efforts. The combined labor effect is usually that of increasing migration first to the rural mining areas and then to the urban areas, the latter of which usually raises unemployment. By this time, income distribution in the country may also deteriorate.

One economic effect sometimes observed in larger mineral developing countries is that such a round of wage increases may result in general price inflation. While this constitutes a form of "cost-push" inflation, "demand-pull" inflation can occur if import demand persists during periods of falling or low international mineral prices. Internationally transmitted inflation can also occur, if the growth of productivity in the "non-tradeables" sector is lower than that in the "tradeables" sector. Among the consequences of inflation in small countries, there is a tendency to pay more attention to coping with inflation than to improving efficiency in the consumption and production of real goods.

The other critical price decision besides the wage rate facing the African LDC's is that of the exchange rate. We have mentioned the importance of mineral rents as a source of government liquidity. This occurs not only because taxes on the mining sector are easier to levy but also because (unlike agricultural products) the export products of this sector have relatively high income elasticities of demand. As domestic prices and money wages rise, there is likely to be an impact on a country's exchange rate. Gillis (1978, 1980) has suggested that any resulting appreciation of the exchange rate would tend to affect the country by being equivalent

to an import subsidy, a tax on exports, and a tax on import-competing industries.

Some of these effects can be countered by diversifying the nature of the commodities or products exported. However, the commodity industries selected for development are usually those which depend most on capital inputs and on imports and least on domestic materials and labor. The government's initial liquidity increase is thus absorbed before a more favorable diversification pattern can be established. There is no easy way to counter this exchange rate problem. As emphasized by Nankani (1979), the choice is often between adopting a short term "dual" exchange rate mechanism and a controlled medium or long term "equilibrium" exchange rate.

Commodity diversification can also be seen as a policy that will reduce the dependence of a small developing country on just one or two primary mineral commodities. Since mining capacity cannot be easily adjusted in the short run, any fluctuations in the international demand for a mineral will cause corresponding fluctuations in international mineral prices. When mineral prices consequently are falling or are low, mining operations in any given country will thus not necessarily be curtailed because of the high costs of reopening capacity that has been shut down. At the same time the real income of mine operators will decline and the foreign exchange position of the government will deteriorate. The result is after the government infrastructure projects will experience troublesome "stop-go" effects.

Thus far not much has been said as to how mineral development affects other productive sectors of a developing country. At the start, it may drain skilled workers from other industries or it may discourage projects in industries that would utilize substantial amounts of domestic materials

and labor. Particularly small-scale industries may not find the support they need to become a base for increased industrialization. Agricultural production units may also encounter stagnation if yield-increasing innovations are also not encouraged. Rural to urban migration can take place and the likely increase in incomes throughout the country can lead to greater food imports. Agricultural production can also suffer the bias of the mentioned exchange rate effect. The energy sector may expand, but this sometimes means an outflow of scarce foreign exchange for petroleum imports. Where greater domestic energy sources are developed, the other industries may gain from decreased energy costs.

Mining development also varies in the nature of its regional impact, as recently emphasized by Radetzki (1982). Among such impacts, increased wage income is probably the greatest. Less important are regional backward and forward linkages. Because potential local suppliers are normally less competitive internationally, the mining operation will purchase its inputs elsewhere. Forward linkages may also be weak; since beyond the first stages of mineral processing, relatively high transportation costs relative to those of other countries may give the latter an advantage in developing processing industries. Regional governments may also not be able to obtain sufficient fiscal revenues to cover local expenses or to foster regional development. Such revenues would be justified to compensate for "boom-town" development impacts or to offset possible environmental damages caused by the mining project. Thus, any additional benefits of mining projects must be examined in terms of externalties such as increased skill levels or improved infrastructure. The latter is often important in providing economic feasibility for industrial or agricultural activities completely unrelated to the mineral project.

Finally, mineral development will have a variety of social effects

both on the region and throughout the country. The capital-intensive nature of mineral production makes its direct employment impact low, although its indirect impact can be higher, i.e., the employment required for building and operating infrastructure. We have mentioned some of the problems created by the higher wage structure of the mining sector and related migration problems. Local impacts may be negative as in the case of increased alcoholism or they may be positive as in the case of education and training. Not only may schools be established in a region but most mining ventures conduct various training programs on a continuous basis. The extension of such skills to other industries that require similar skills such as manufacturing and construction can be beneficial, but the degree to which these skills can be transferred depends on the nature of activities required to operate specific types of mines and mineral processing operations. Since mining is a hazardous operation, workers can suffer problems ranging from injuries and fatalities to lung-related occupational diseases. As a consequence, mining companies often provide a comprehensive safety program and operate hospitals and clinics. The resulting external benefits of these programs can be substantial, although they must be evaluated relative to the mentioned safety and health problems.

7.0 CONCLUSIONS FOR POLICY

This study has revealed a number of policy options which would appear to be useful for African LDC's seeking to expand their mineral trade potential. Our major focus is on policies which could be of assistance in a country where mineral exploration and development activity needs to be expanded and where a sizeable mineral project would have substantial impacts. Considered most important are policies relating to the basic mining code, geologic information gathering and distribution, profits and taxes, infrastructure, mineral processing, and economic impacts.

The starting point would appear to be for a government to clarify its existing mining code or to establish a new mining code which would simplify contractual arrangements with foreign investors. Such a code would include: (1) the definition of ownership rights of the country's minerals, (2) a listing of required permits and licenses, (3) a description of the procedures for obtaining exploration concessions and properties for production, (4) requirements for disclosure of exploration results, (5) a listing of concessions that might be made by the government to allow and facilitate importation of specialized equipment and labor required during exploration, and (6) a description of how the government desires to participate in profits and operation of the various types of mining operations.

The ownership rights of the country's minerals must be determined not only indigenously but also in terms of exploration and exploitation following discovery. These rights should differ for larger and richer deposits compared to smaller deposits. In the case of Botswana the mining code has strongly aided development by placing tribal mineral rights as well as private lands with mineral potential under government control. Revisions of the code also clarified issues of exploitation rights after exploration

and encouraged private investment.

Policies dealing with information gathering and distribution are important in the development of a mineral industry but are frequently neglected. Such policy considerations should include the amount of geologic information available and the amount that could be reasonably provided by governments to entice investor interest. The existence of extensive geological mapping of a country has been cited as an important although not an absolute prerequisite to mineral development. A policy of requiring exploring companies to provide all obtained results to the government is not uncommon.

Countries might also enact special policies, for example, that would foster airborne geophysical surveying as an aid to deposit location. In the case of Tanzania, this has led to further exploration for diamonds, nickel, uranium, niobium, gold and coal. In the case of Botswana, private mineral exploration has been encouraged through modern legislation, a very efficient licensing system that takes approximately one month for most licenses, and a policy of releasing all geologic information to potential investors.

Policies needed to capture profits relate to the collection of rents and related fiscal measures. The collection of rents must first be preceded by identifying the amount of rents available, which is a formidable information gathering problem. Competition for rents is intense and involves not only the government and the private companies, but also equipment and materials suppliers, financial sources such as banks, labor, companies involved in transportation and ancilliary services, and buyers and consumers of the final products.

There are two extreme policy approaches available to a government in dealing with profits and taxes. The first is to have a policy incorporat-

ing identified royalties, taxes, and ownership provisions such that all a potential investor needs to know to evaluate a project is already defined. The second is to have a policy of negotiating every item at every stage from exploration to production.

The first approach requires little government expertise and effort but does not assure the collection of all rents by the government and may not allow the development of marginally economic deposits. However, provided the policy provisions are not overly restrictive, this type of policy allows rapid development of mineral projects.

The second approach, which can be defined as an ad hoc policy, does extract the maximum amount of rents, but requires considerable expertise and effort on the part of the government. This approach also takes more time since negotiation is required as a matter of policy. Botswana has shown recent success in using this approach by tailoring agreements to fit the characteristics of different mineral deposits and by offering a "reasonable" or "fair" return on investment. Administation of these agreements can be aided by placing qualified nationals on the board of directors of the major mining companies.

Regardless of which approach is used to capture rents, consistency in fiscal policy over time is highly desirable. In the case of the Zambian government, the frequent changes in fiscal policy which it has enacted have led to a deterioration over time of the mining industry's contribution to government revenue.

Earlier mention was made of the importance of establishing a competent negotiating team and using the team to coordinate related institutions. By not placing knowledgeable officials in different agencies and facilitating their interaction, the government could easily weaken policies directed towards mineral rights and exploitation, taxation, macroeconomic activity

and processing. Establishing such a team is a difficult task involving training at home, abroad, and obtaining real world experience. However, formation of such a team is a necessary step to increase mineral trade potential and to optimize the benefits of mineral development.

Such competance could also be used to devise ways of increasing mineral project financing. Above mention has been made of the recent tendency to extend private investment through a matching of several sources of funds and of sharing the risks involved. While this normally has involved international agencies with a North-South funding axis, the increased use of South-South funding is suggested. As an example, the Islamic Development Bank has been cited as having invested $ 100 million to help Upper Volta reopen its Poura Gold Mine operations.

Infrastructure developments also are essential to the successful completion of investment and the operation of mining projects. Government policies in this area can range from complete control of the infrastructure to letting its development occur independently or in relation to mining projects. Frequently governments can provide certain portions of the required infrastructure, such as ports, roads, and railroads, with financial aid obtained with favorable conditions from outside sources such as international banks or development authorities. In this manner, infrastructure for a project may be provided at lower overall costs than if provided by the mineral project financing per se. Problems regarding transportation links, are typically more acute in land-locked developing countries but are by no means limited to such countries. Mention has been in this regard of the needs of Chad, Central African Republic, Mali Niger, and Upper Volta. Policies must be directed to developing an integrated transportation planning approach with neighboring countries. Such activities have recently been encouraged under several UNDP-financed

transit projects.

Policies designed to promote mineral processing can take several forms. In the case of a government owned mineral sector, the government can instigate processing with foreign or national financing. The latter is possibly more effective where the minerals will be used primarily as inputs to domestic industries. In the case of a private mining sector, the government can still invest, but it must induce the mine operators to have their output processed in that facility. In the case of a foreign mining investor, the government can negotiate at the outset to include some processing as part of the initial mineral agreement. Where this is not feasible, the government might seek an equity share in a foreign processing plant by supplying some of the raw material. An example of including processing in a mineral agreement can be drawn from the above case of Sudan which required Marubeni to complete at its own expense a feasibility study for the establishment of a local ferro-chrome plant.

Finally, the economic impacts imposed by mineral projects can be improved through policies regarding wage rates, exchange rates, macroeconomic management, interest rates, taxes, etc. While the implementation of such policies in poor countries with limited government expertise has been difficult, there would appear to be some scope for successful actions. For example, Papau New Guinea has attempted to establish a reserve fund which would stabilize government revenues and Zambia has also shown interest in such a fund, e.g. see Bell (1983). As the countries discussed hope to expand further their mineral production and trade, considerable opportunities would appear to exist for policy choices that would permit them to pursue their goal in an efficient manner.

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Page 2

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APPENDICES 1, 2 and 3

Appendix 1

Appendix 1 features Table A.1 which provides a disaggregation of the mineral exports and imports of the African LDC's according to data availability. The exports are mostly those of a primary nature while the imports are mostly of processed or semi-fabricated nature.

Appendix 2

Appendix 2 features Table A.2 which provides more detailed information on past new mining investments and expansions in the African LDC's for which such data are available. Caution is necessary in reading the Table. Some investments are just at the feasibility or planning stages, while others have actually been undertaken. In some cases, a potential investment has been revised and some duplication of a single deposit description may occur.

Appendix 3

Appendix 3 features Table A.3 which provides the ranges of the deposit sizes, sales and production assumptions together with the price forecasts underlying Table 6. The information provides the background to the investment and export sales forecasts which define the mineral potential of most of the African LDC's under consideration.

Table A1

MINERAL IMPORTS AND EXPORTS OF THE LEAST DEVELOPED AFRICAN COUNTRIES[a]
(U.S. $ Thousands)

SITC	Country/ Commodity	Year/Trade Values			
	Burundi	1977	1978	1979	1980
IMPORTS					
68	Non-ferrous Metals	222	373	490	762
684	Aluminum	222	373	490	762
69	Metal Manufactures NES	5919	7949	11578	13420
	Total	6241	8322	12068	14182
EXPORTS					
28	Metalliferous ores, scrap	107	183	29	433
6618	Asbestos-, fibre-cmnt prd	-	420	398	734
	Total	107	603	427	1167
	Central African Republic	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	1291	1243	670	1187
673	Iron, Steel Shapes, Etc.	610	685	224	537
6732	Iron, Steel Bars, Etc.	529	566	106	304
674	Irn, Stl Univ, Plate, Sheet	309	239	171	370
6744	Irn, Stl Hvy Plate, Rolled	306	239	164	360
678	Iron, Stl Tubes, Pipes, Etc.	282	277	220	227
6783	Iron, Stl Tubes, Pipes, NES	221	232	177	180
69	Metal Manufactures NES	6056	3081	3902	4764
691	Structures and Parts NES	3696	188	1176	170
6911	Structures, Parts, Irn, Stl	3685	175	1009	123
693	Wire Products Non Electr	194	221	278	244
694	Stl, Coppr Nails, Nuts, Etc.	177	220	263	732
	Total	7347	4315	4572	5951
EXPORTS					
667	Pearl prec-, semi-P stone	18772	26860	35019	28898
6672	Diamonds Nonindust, Unset	18772	26860	35019	28898
	Total	18772	26860	35019	28898
	Chad	1979	1978	1979	1980
IMPORTS					
67	Iron and Steel	1376	2686	2372	3505
673	Iron and Steel Shapes	736	957	1131	1315
6732	Iron, Steel Bars, Etc.	330	382	499	874
67321	Irn, Simple Stl Bars, Etc.	330	382	499	
6735	Irn, S'l Small Sectns, Etc.	395	523	605	441
67351	Irn, Smpl Stl Small Sectn	395	523	605	
674	Irn, Stl Univ, Plate, Sheet	365	756	370	635
6743	Irn, Stl Thin Uncoated	97	243	156	350
6748	Irn, Stl Thin Coated NES	265	508	205	285
67481	Irn, Smp Stl Thin Ctd NES	265	508	205	
678	Iron, Stl Tubes, Pipes, Etc.	256	949	906	1492
6782	Irn, Stl Tube Seamles NES	161	895	477	1396
68	Non-Ferrous Metals	202	282	147	209
684	Aluminum	182	257	115	180
6842	Aluminum Alloys Worked	178	252	114	172
69	Metal Manufactures NES	2182	2806	2857	3306
691	Structures and Parts NES	366	519	205	320
6911	Structures, Parts Irn, Stl	231	459	139	97
	Total	3760	5774	5376	7020

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
EXPORTS		1977	1978	1979	1980
27	Crude Fertilizer, minrls NES.	179	184	98	329
276	Othe Crude Mineral	179	184	98	329
27699	Mineral substances NES.	179	184	98	328
	Total	179	184	98	329
	Ethiopia	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	14251	15027	21327	23371
672	Iron, Steel Primary Forms	681	1717	2690	1303
673	Iron, Steel Shapes, Etc.	1576	1480	2712	4395
6731	Iron, Steel Wire Rod	591	418	1800	1824
63711	Iron, Simple Stl Wire Rod	591	418	1800	1824
674	Irn, Stl Univ, Plate, Sheet	10203	9188	13446	12659
6741	Iron or Steel Universals	4851	6707	10096	6246
67414	Irn, Smpl Stl Universals	4851	6707	10096	6246
6747	Tinned Plates, Sheets	652	1689	794	3066
6749	Oth Irn, Stl Plates, Sheet	4700	791	2556	3347
678	Iron, Stl Tubes, Pipes, Etc.	1167	1997	1770	2889
68	Non-ferrous Metals	1190	1534	2647	2977
69	Metal Manufactures NES	8765	14843	22940	25738
691	Structures and Parts NES	371	597	2001	2472
6911	Structures, Parts Irn, Stl	365	588	2001	2458
	Total	24206	31404	46914	52086
NO MINERAL EXPORTS					
	Guinea	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	2740	4729	3479	4784
673	Iron, Steel Shapes, Etc.	750	1193	1251	1846
6732	Iron, Steel Bars, Etc.	556	983	1122	1388
67326	Irn, Oth Stel Bars Hotrold	510	965	1034	1205
674	Irn, Stl Univ Plate, Sheet	808	1183	1143	1135
6749	Oth Irn, Stl Plates, Sheet	727	1076	1047	1049
67491	--Of Iron or Simple Stl	4	1067	1007	1003
678	Iron, Stl Tubes, Pipes, Etc.	1073	2219	907	1700
6783	Iron, Stl Tubes, Pipes NES	332	1376	423	741
6785	Iron, Steel Tube Fittings	674	481	297	458
68	Non-ferrous Metals	407	565	1008	1034
684	Aluminum	324	471	797	880
6842	Aluminum, Alloys Worked	324	471	797	880
69	Metal Manufactures NES	6532	12324	13820	10886
691	Structures and Parts NES	1614	1679	1896	3808
6911	Structure, Parts Irn, Stl	1312	1402	1353	3281
	Total	9679	17618	18307	16704
No Data on mineral exports					

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
	Malawi	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	12490	20486	22976	25615
673	Iron, Steel Shapes Etc.	2305	3402	5954	4572
6732	Iron, Steel Bars Etc.	1256	2419	4321	2822
6733	Iron, Steel Profiles Etc.	1027	981	1633	1750
674	Irn, Stl Univ Plate, Sheet	5477	7139	9906	13047
6746	Irn, Stl Thin Plate, Rolld	2290	5076	6899	9385
6749	Oth Irn, Stl Plates, Sheet	3074	1634	2713	3262
676	Railwy Rails Etc Irn, Stl	912	3669	2082	360
677	Irn, Stl Wire (Excl W Rod)	1108	1122	2184	1439
67701	Iron, Simple Steel Wire	1108			
678	Iron, Stl Tubes, Pipes, Etc.	2490	4613	3760	5659
6782	Iron, Stl Seamless Tubes	1683	3508	2522	3711
6785	Iron, Steel Tube Fittings	800	808	992	1594
68	Non-Ferrous Metals	1043	1127	1203	1402
684	Aluminum	717	781	744	950
69	Metal Manufactures NES	11850	16925	18065	19701
691	Structures and Parts NES	590	2409	2064	2757
6911	Structures, Parts Irn, Stl	539	2369	1849	2283
	Totals	25383	38538	42244	46718
EXPORTS					
67	Iron and Steel	1022	567	730	483
	Total	1022	567	730	483
	Mali	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	4389	9249	6729	5411
673	Iron and Steel Shapes	1501	6933	1903	2007
6732	Iron, Steel Bars Etc.			1080	1455
67321	Irn, Simple Stl Bars Etc.			1078	1439
6734	Irn, Stl Big Sections Etc.			798	209
67341	Irn, Smpl Stl Big Sectns			798	209
674	Irn, Stl Univ, Plate, Sheet	1717	4	2231	1520
6747	Tinned Plates, Sheets			878	47
6748	Irn, Stl Thin Coated NES			920	967
67481	Irn, Smp Stl Thin Ctd NES			920	
676	Railwy Rails Etc Irn, Stl	134	1046	224	44
678	Iron, Stl Tubes, Pipes, Etc.	657	858	1941	1469
6781	Cast Iron Tubes, Pipes		333	1832	298
6783	Iron, Stl Tube Pipe NES				957
69	Metal Manufactures NES	2219	6012	3862	4737
691	Structures and Parts NES	101	465	683	905
6911	Structure Parts Irn, Stl	81	460	629	685
	Total	6608	15259	10591	10148
EXPORTS					
28	Metalliferous ores, scrap	449	60	36	--
282	Iron and steel scrap	449	60	36	--
	Total	449	60	36	--

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
	Niger	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	2479	3268	3115	6232
673	Iron and Steel Shapes	1122	1682	1477	2558
6732	Iron, Steel Bars Etc.				1207
67321	Irn, Simple Stl Bars Etc				1204
6734	Irn, Stl Big Sections Etc				1330
67341	Irn, Smpl Stl Big Sectns				1328
674	Irn, Stl Univ Plate Sheet	426	443	434	1216
677	Irn, Stl Wire Excl W Rod	93	59	52	408
67701	Irn, Smp Stl Wire Exc Rod				406
678	Iron, Stl Tubes, Pipes, Etc	446	840	750	2003
6781	Cast Iron Tuves, Pipes				1246
6785	Iron, Steel Tube Fittings				555
679	Irn, Stl Castings Unworkd	378	236	383	7
68	Non-ferrous Metals	312	334	350	757
684	Aluminum	284	306	331	703
6842	Aluminum Alloys Worked	258	306	331	702
68422	Aluminum Plate Sheet, Strip	207	266	319	646
69	Metal Manufactures NES	3144	3217	3379	4383
691	Structures and Parts NES	1063	926	1139	449
6911	Structures, Parts Irn, Stl	933	904	1127	424
	Total	5935	6819	6844	11372
EXPORTS					
28	Metalliferous ores, scrap	24720	26334	55445	85973
286	Uranium, thorium ore, conc	24760	26332	55431	85944
	Total	24720	26334	55445	85973
	Rwanda	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	4239	4246	4664	6068
673	Iron and Steel Shapes	239	963	877	815
674	Irn, Stl Univ, Plate Sheet	2621	1596	2802	4244
677	Irn, Stl Wire Excl W Rod	257	917	275	
67701	Irn, Smp Stl Wire Exc Rod	257	917		
678	Iron, Stl Tubes, Pipes, Etc	658	748	711	880
679	Irn, Stl Castings Unworkd	461			
68	Non-ferrous Metals	15	100	490	88
684	Aluminum	9	79	421	75
69	Metal Manufactures NES	4186	8003	7663	8960
691	Structures and Parts NES	1168	1327	1758	1087
6911	Structures, Parts Irn, Stl	1150	954		650
6912	Structures, Parts Aluminum	18	372		437
	Total	8440	12349	12817	15116
EXPORTS					
28	Metalliferous ores, scrap	5829	7611	7091	7391
2836	Tin Ores, concentrates	4281	5392	5276	5137
2839	Nonfer ores, concentrate Nes.	1548	2219	1812	2254
28392	Tungsten ore, concentrate	1487	1970	1812	1910
28393	Vanadium, molybd etc. ores	--	49	--	341
28399	Oth monfer ore. conc. Nes.	5829	200	--	2
	Total	5829	7611	7091	7391

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
	Sierra Leone	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	4817	6565	4328	4379
673	Iron and Steel Shapes	1115	1390	1590	1025
6732	Iron, Steel Bars, Etc.	804	1064	1295	773
674	Irn, Stl Univ, Plate, Sheet	1819	3407	1333	2209
6742	Irn, Stl Thin Coated NES	1621	3132	1017	2115
678	Iron, Stl Tubes, Pipes, Etc	1603	1555	998	932
68	Non-ferrous Metals	371	520	834	790
684	Aluminum	302	415	745	718
6841	Aluminum, Alloys Worked	302	415	745	718
68422	Aluminum Plate, Sheet, Strip		261	689	585
69	Metal Manufactures NES	6099	8500	5302	5875
691	Structures and Parts NES	1201	347	666	1129
6911	Structures, Parts Irn, Stl	1175	318	494	870
	Total	11287	15585	10482	11044
EXPORTS					
27	Crude fertlzr, Minrls nes	--	--	--	1860
2751	Industrial diamonds	--	--	--	1860
28	Metalliferous ores, scrap	18370	20175	19868	4990
281	Iron Ore concentrates	13776	14788	14751	--
282	Iron and stell scrap	277	467	284	594
283	Nonfer base mtl ore conc.	4316	4847	4833	4396
2833	Bauxite, etc.	4316	4847	4833	4396
667	Pearl prec-, seml-P stone	80036	88632	75685	65039
6672	Diamonds nonindust. Unset	80036	88632	75685	65039
	Total	98406	108807	95553	71889
	Sudan	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	35280	22077	30316	54701
672	Iron, Stl Primary Forms	1715	2202	3156	2662
673	Iron and Steel Shapes	12935	6312	6766	26153
6732	Iron, Steel Bars Etc	5188	3177	4324	18205
6734	Irn, Stl Big Sections Etc	6937	2752	2377	7331
674	Irn, Stl Univ, Plate Sheet	12172	8924	8696	18431
6741	Irn, Stl Heavy Plate Etc	10131	7269	6203	12585
675	Iron, Steel Hoop, Strip	2294	2071	3264	1588
678	Iron, Stl Tubes, Pipes, Etc	4531	1284	6831	3625
68	Non-ferrous Metals	5497	6236	5767	7025
684	Aluminum	2736	2580	3565	4329
6842	Aluminum, Alloys Worked	2736	2580	3565	4322
69	Metal Manufactures NES	41324	38235	49522	49101
691	Structures and Parts NES	18309	17948	28856	20167
6911	Structures, Parts Irn, Stl	14330	17422	28793	18969
6912	Structures, Parts Alumnm	3979	526	63	1198
	Total	82083	66548	85605	110827
EXPORTS					
28	Metalliferous ores, scrap	--	904	3830	2944
283	Nonfer base mtl ore, conc	--	804	2716	1541
	Total	--	904	3830	2944

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
	Togo	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	10094	14299	52636	13209
673	Iron and Steel Shapes	3359	3285	8203	4291
6732	Iron, Steel Bars Etc	2842	2564	6096	2873
67321	Irn, Simple Stl Bars Etc				2873
67323	Alloy Steel Bars Etc	2842	2564		
674	Irn, Stl Univ, Plate Sheet	2938	2818		2944
6742	Irn, Stl Medium Plate Etc				2908
67421	Irn, Simple Stl Med Plate				2908
678	Iron, Stl Tubes, Pipes, Etc	2529	6677		3870
6781	Cast Iron Tubes, Pipes	1020	4376		858
6783	Iron, Stl Tube, Pipe NES				2358
679	Irn, Stl Castings Unworkd	986	1261		132
69	Metal Manufactures NES	7088	18395	4542	53096
691	Structures and Parts NES	3233	12613		40705
6911	Structures, Parts Irn, Stl	2449	11680		35760
6912	Structures, Parts Alumnm	784	933		4945
	Total	10943	12949	14592	11520
EXPORTS					
27	Crude fertlzr. Minrls nex.	78316	--	102043	55650
2713	Natural Phosphates Nes.	77585	94337	101979	55070
273	Stones, sand and gravel	42	--	22	386
2731	Bldg. dimension stone	39	--	17	385
27312	Marble etc. bldg. stone	39	--	11	384
661	Cement etc. building prod.	889	--	3517	14
6612	Cement	887	--	3497	11
	Total	79205	94337	105540	55672
	Uganda	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	4905	4808	6015	2779
673	Iron and Steel Shapes	314	753	637	665
6732	Iron, Steel Bars Etc	67	569	264	198
674	Irn, Stl Univ, Plate, Sheet	1154	2252	1747	1087
6743	Irn, Stl Thin Uncoated				566
676	Railwy Rails Etc Irn, Stl	286	163	445	172
6762	Ry Track Equ NES Irn, Stl	36	111	434	172
677	Irn, Stl Wire Excl W Rod	337	422	205	331
678	Iron, Stl Tubes, Pipes, Etc	2431	1042	2938	349
6782	Irn, Stl Tube Seamles NES	643	39	265	28
6783	Iron, Stl Tube Pipe NES	788	641	2331	183
6785	Iron, Steel Tube Fittings	960	299	226	113
68	Non-ferrous Metals	1291	2243	1026	769
682	Copper	395	616	65	99
6822	Copper, Alloys Worked	395	615	65	99
68221	Copper Bars, Wire, Etc	387	504	47	57
684	Aluminum	681	1089	675	535
6842	Aluminum, Alloys Worked	681	1089	674	535
68422	Aluminum Plate, Sheet, Strip	187	450	385	253
68423	Aluminum Foil	356	431	148	252
686	Zinc	189	441	135	94
69	Metal Manufactures NES	4747	5898	7551	7972
691	Structures and Parts NES	939	504	601	2072
6911	Structures, Parts Irn, Stl	816	504	599	2065
	Total	10943	12949	14592	11520

Table A.1 (continued)

SITC	Country/ Commodity	Year/Trade Values			
EXPORTS					
28	Metalliferous ores, scrap	628	2026	831	557
283	Nonfer base mtl ore conc.	627	1168	780	550
	Total	628	2026	831	557
	United Republic of Tanzania	1977	1978	1979	1980
IMPORTS					
6672	Diamonds Nonindust, Unset	2307	85	1350	
67	Iron and Steel	32706	45704	47954	42095
672	Iron, Stl Primary Forms	2649	5514	9688	10680
6725	Irn, Stl Blooms, Slabs, Etc	1180	2894	3577	2280
6727	Irn, Stl Coil Fr Rerolling	1296	2507	5956	8243
673	Iron and Steel Shapes	3210	9040	8055	7316
6732	Iron, Steel Bars Etc	1300	5436	3270	4348
674	Irn, Stl Univ, Plate, Sheet	12353	16721	12941	9854
6743	Irn, Stl, Thin Uncoated	4615	10094	7237	1687
6747	Tinned Plates, Sheets	2504	2140	2974	5222
6748	Irn, Stl Thin Coated NES	5081	3861	2275	2207
675	Iron, Steel Hoop, Strip	3297	1915	1072	1426
676	Railwy Rails Etc Irn, Stl	2431	1590	6598	1486
6761	Railway Rals Irn, Stl	2359	550	1084	19
6762	Ry Track Equ NES Irn, Stl	72	1040	5514	1467
677	Irn, Stl Wire Excl W. Rod	2101	3560	1961	1735
678	Iron, Stl Tubes, Pipes, Etc	5458	6657	6210	8569
68	Non-ferrous Metals	10839	13189	11529	14800
684	Aluminum	6458	7366	4478	8541
6841	Aluminum, Alloys, Unwrght	4867	5783	3105	6495
686	Zinc	2998	3570	5054	3146
6861	Zinc Alloys Unwrought	2980	3561	5025	2809
69	Metal Manufactures NES	28778	65281	48567	38552
691	Structures and Parts, NES	2085	12901	10405	8682
6911	Structures, Parts Irn, Stl	1812	12624	10304	8309
	Total	74630	124259	109400	95447
EXPORTS					
27	Crude fertlzr minrls nes.	1274	1345	1735	26865
275	Natural abrasives	16	27	--	24403
2751	Industrial Diamonds	--	3	--	24403
276	Other crude mineral	1137	839	1705	2451
2763	Salts	1113	778	1634	2376
667	Pearl prec-, Semi-P stone	16708	29971	30564	15314
6672	Diamonds Nonindust, unset	16578	29734	30309	15037
	Total	17982	31316	32299	42179
	Upper Volta	1977	1978	1979	1980
IMPORTS					
67	Iron and Steel	11901	6540	11885	15742
673	Iron, Steel Shapes Etc	2601	2596	2880	4049
6732	Iron, Steel Bars Etc	1510	1287	1722	2491
67326	Irn, Oth Stl Bars Hotrold	1508	72	146	218
67327	Irn, Oth Stl Bars Forged		1260	1643	2273

B-731

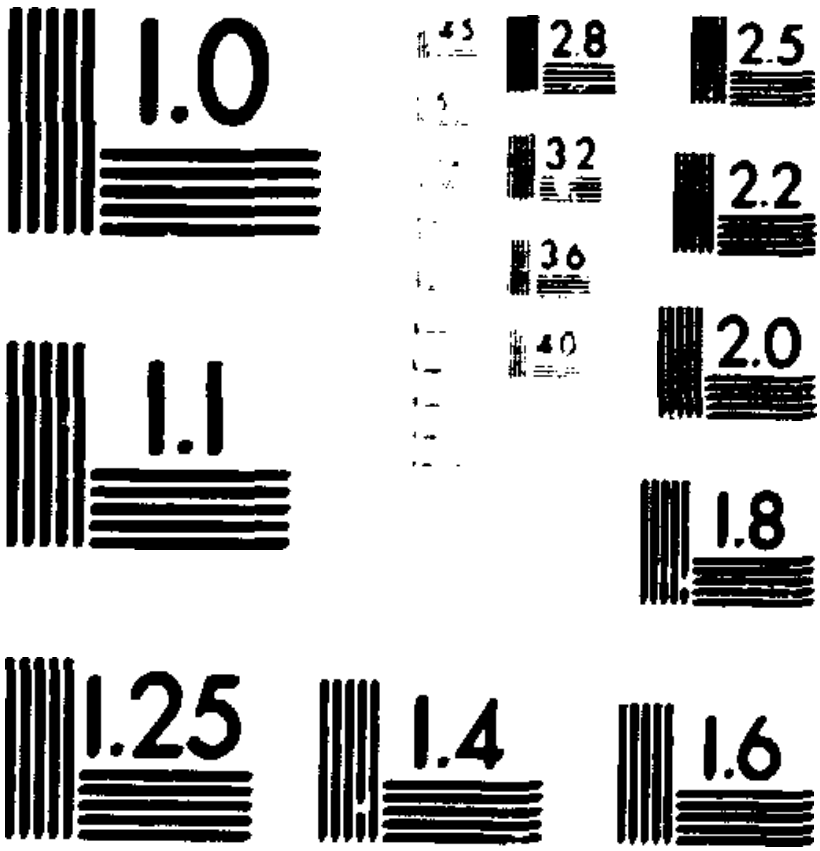

Table A.1 (continued)

SITC	Country/ Commodity		Year/Trade Values		
6733	Iron, Steel Profiles Etc	1085	1297	1151	1558
674	Irn, Stl Univ, Plate, Sheet	4257	2633	5804	8844
6746	Irn, Stl Thin Plate, Rolld	730	590	1825	2032
67461	--Of Iron or Simple Stl		590	1825	2032
6747	Tinned Plates, Sheets	2151	1	1	1
6749	Oth Irn, Stl Plates, Sheet	869	1771	3760	6248
67491	--Of 'ron or Simple Stl	869	1771	3760	6248
676	Railwy Rails Etc Irn, Stl	129	1	1067	475
67602	Ry Track Equ NES Irn, Stl			1067	475
678	Iron, Stl Tubes, Pipes, Etc	4488	950	1428	1648
6781	Cast Iron Tubes, Pipes	3193	6	58	196
6782	Iron, Stl Seamless Tubes	1009	382	527	553
68	Non-ferrous Metals	1220	1590	2363	1487
684	Aluminum	623	1042	1486	1230
6842	Aluminum, Alloys Worked	623	1035	1486	1228
68422	Alumm Plate, Sheet, Strip	595	764	1335	1158
69	Metal Manufactures NES	6915	7154	9464	12355
691	Structures and Parts NES	782	1287	528	853
6911	Structures, Parts Irn, Stl	769	1038	478	829
694	Stl Coppr Nails, Nuts, Etc	944	889	946	1594
	Total	20036	15284	23712	29584
EXPORTS					
67	Iron and steel	117	17	338	754
	Total	117	17	338	754

[a]These products have been selected by using an approximate cut-off point based on SITC numbers which represents the difference between semi-processed (included) and processed or manufactured (excluded) commodities.

Source: United Nations, International Trade Statistics, Vol. 1, By Country, 1981, United Nations, New York.

Table A.2

PAST NEW MINING INVESTMENTS AND EXPANSIONS IN THE LEAST DEVELOPED AFRICAN COUNTRIES[a]
(1979-1984)

Country and Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital	Type of Operation[b]	Remarks
BURUNDI						
Govt.	Buhinda	30,000 tonne/year Fe/hi	1985	$500m	P/Rf	Finance, partners sought for development.
Govt.	Musongati Plateau	2 Mt/y Ni, Cu			P	Feasibility studies underway with World Bank grant but infrastructure problems.
Govt.	Musongati Plateau	2 Mt/y Ni,			P	2nd phase drilling and exploratory shaft scheduled for 1984. Foraky (Drilling)& Exploration Bergbau undertaking the work.
Govt.	Matonga-Bandaga	Phosphate				British Sulphur Corp. contracted for $1.2m pre-feasibility study.
Govt.	Matonga-Bandaga	Phosphate				British Sulphur Corp. pre-feasibility study for World Bank completed end-1983.
CENTRAL AFRICAN REPUBLIC						
Soc. de l'Uranium Centrafricin	Bakouma	500-700 tonne/year U_3O_8 concs; Phosphate by-product.	1980's	$300m	P	Mine development considered by government/CEA/ Cie. Francaise de Minerais de l'uranium
Consortium	unspecified	Diamonds		$11m		Israeli-Iranian-Swiss group has 30,000km^2 concession.
GUINEA						
Alugui	Ayekoe, Boke	9m tonne/year Bauxite 2m tonne/year Alumina	1980's	$1,000m	P/Rf	Arab financed mine/refinery development to go ahead. Alusuisse contract for feasibility studies and prelim design
Alugui	AyeKoye, Sangaredi	9Mt/y Bauxite, 1.2Mt/y Alumina	1980's	$3,000	P/Rf	Possibly also 150,000 t/y Sm but power supplies not yet secured. Development decision still awaited.
Cie, Bauxite de Guinee	Boke	9m tonne/year Bauxite	1980	$385m	P	Sangaredi mine expansion from 7million; costs include mine ($180m) rail/port development.
Miferguí-Nimba	Mt. Nimba	8m tonne/year Fe		$200m	P	Feasibility studies complete; financing under consideration. Possible 15m + later.
Miferguí-Nimba	Mt. Nimba	15m tonne/year Fe		$200m	P	Feasibility study for sinter feed/pellet operation, transport and shipping facilities underway (updates 1978 study).
Miferguí-Nimba	Mt. Nimba	15 Mt/y Fe	1980's	$600m	P	U.S. Steel manager for potential sinter feed/pellet operation; plus $200m for transport link to existing Liberian facilities.
Miferguí-Nimba	Mt. Nimba	15 Mt/y Fe sinter fines	1980's	$1,100m	P/Cn	Includes transport link to Liberian port facilities; U.S. Steel subsidiaries to manage engineering contract for mine and pellet project.

Table A.2 continued

Page 2

Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital	Type of Operation[b]	Remarks
GUINEA						
Friguia	Fria-Kimbo	1.4 Mt/y Al_2O_3 plus Al metal			Rf/Sm	Refinery output may be doubled; dam construction at Konkoure will allow smelter construction.
Friguia	Fria	700,000 t/y Alumina		$33m	Rf	Plant expansion
Govt.	Dabola	2 Mt/y Bauxite, 1 Mt/y Alumina			P/Rf	Development involves Govt. with Reynolds, Yugoslav, Algerian and Nigerian partners; refinery possibly in cooperation with Somiga.
Aredor Services	Kissidougou	250,000ct/y diamonds	1984	$80m	A	500,000 ct later. Development underway.
Offices des Bauxites de Kindia (OBK)	Fria	1.3 Mt/y Alumina			P/Rf	Expansion from present 700,000 t/y capacity.
Somiga (Govt./ Alusuisse)	Tougue	8 Mt/y Bauxite	1990's		P/Rf	Possibly later 13 Mt; considering 1 Mt/y Rf
Aredor Guinea SA	Kerouane	250,000ct/y diamond	1984	$85m	A/Cn	Development underway with commissioning due in April, 1984. To treat 400,000 m^3/y gravel. Possible doubling of capacity at later date.
MALI						
Sonarem	Tilemsi Valley	240,000 t/y Phosphate				Considering expansion from 10,000.
Sonarem	Kalana	1,800 kg/y Au, 500 kg/y Ag	1984			Initial output from USSR aided new mine at 400 kg au in 1984.
Sonarem	Bafing-Makana	Fe			P	USSR assisted feasibility studies continuing.
Govt.	Kenieba-Bamako	Bauxite			P	Pechiney has undertaken initial studies. Project unlikely to be developed in short term.
Govt./ BRGM	Tilemsi Valley	240,000 t/y Phosphate	1980's		P	Feasibility study involving initial production of 20,000 t from Tamaguilelt section prepared.
NIGER						
Cie. Miniere d'Akouta	Akouta	2,600 tonnes U in concs.	1980	$70m	U/Cn	Production commenced in 1978 with output of 600 tonnes U in concs. Will build up to full rate in 1980.
Soc. Miniere Tassa N'Taghalgue (Onarem/Cogema)	Arlit, Air	2,300 t/y U_3O_8	1982		P	Mine expansion from 1,900 t, double mill output is 3,000 t/d.
Govt.	Say	Fe				UNDP evaluating reserves.
Govt.	Say	Fe			P	KHD Humboldt Wedag Ag under contract to UNDP conducting metallurgical studies and reserve evaluation.

Table A.2 continued

Page 3

Company	Location	Design production (Ore, unless otherwise stated)	Completion Date	Capital	Type of Operation[b]	Remarks
NIGER						
Cogema/ Onarem/ OURD	Afasto-ouest, Air				U	Pre-feasibility study to be prepared
Onarem/ Japanese	Abkorun-Azelik	1,500 t/y U_3O_8	1990's		P/U	Preliminary feasibility studies complete.
Onarem/ Cogema/ Conoco	Imouraren	3,000 t/y U_3O_8	1990's	$1,000m+	U/Cn	Feasibility study being undertaken by Fluor and Creps (France) but development to be deferred.
Soc. Miniere Tassa Na Taghalgue' (SMTT)	Arni	1,000 t/y U_3O_8	1980's		P.	Feasibility studies of Arni deposits complete; rising later to 1,800t/y.
Govt.	Tapoa, Say	Phosphate				Feasibility studies continuing on possible j.v. with Nigeria.
RWANDA						
Somirwa	Kigali	Sn metal	1980's	$5m	Sm/Rf	Tin smelter and refinery designed to handle all local tin concentrates is under construction.
Somirwa		Sn metal	1980's		Sm/Rf	New Sm complete; 5 yr expansion double capacity planned.
Somirwa	Kururuma	Sn metal	1980's		Sm	Plans to double smelter capacity over the next five years.
SIERRA LEONE						
SL Ore and Metal (Alusuisse)	Port Loko	1 Mt/y Bauxite		$500m	P	Mine expansion from 760,000 tonnes planned.
Govt./ Sierra Rutile (Bethlehem)	Bangbama	100,000 t/y Rutile, Ilmenite	1979	$41m	A	Facilities to exploit former Sherbo Minerals property substantially complete and commissioning in progress.
Bayer-Preussag	Rotifunk	Beach Sands			A	Evaluating reserves; pilot programme underway.
Govt.	Marampa	Fe			P/Cr	LKAB International is studying feasibility of reopening mine closed in 1975.
Govt.	Marampa	1 Mt/y Fe		Le 12.6m	P/Cn	Austromineral contract to reopen Delco leases.
Diminco/ Selection Trust	Kono	Diamond	1985		U	New mine development.
Govt.	Tonkolili	Fe				Austromineral evaluating; 200 Mt. Reserves.
Diminco/ Selection Trust	Yengema	Diamond				Negotiations underway for an agreement on kimberlite mining.
SUDAN						
Govt./ Japanese	Ingessana	Cr; 500,000t/y FeCr	1980	$60m	P	Feasibility studies for mines expansion and establishing plant.

Table A.2 continued

Page 4

Company	Location	Design Production (Ore, unless otherwise stated)	Completion Date	Capital	Type of Operation[b]	Remarks
SUDAN						
Govt.	Karora; Port Sudan	Fe				Fe reserves evaluation; finance sought.
Johns-Manville/ Gulf Intl.	Qala En Nahl	100,000s ton/year Asbestos products		$115m		Pilot plant testing.
Mitsubishi	Ingessana Hills	FeCr				Feasibility studies underway for 20,000 t/y FeCr plant.
Minex	Gabeit	Au				Planning reopening of former Red region mine.
BRGM/GMRD	Red Sea Hills	W, Pb, Zn				Feasibility studies continuing.
Johns-Manville/ Gulf	Qala en Nahl, Inghessana	100,000 t/y Asbestos		$115m		Pilot plant testing.
Greenwich Resources	Gebeit, Red Sea Hills	Au			U	Rehabilitation of Gebeit Mine. Heap leaching of tailings in progress.
GMRD/BRGM	Jebel Gash Amir, Red Sea Hills	W, Pb, Zn				Pilot plant testing in progress. Commercial scale production expected to commence soon.
TOGO						
Govt.	Bafilo/ Buem Basin	Fe			P	Development planned to feed iron and steel works at Lome.
Cotomib	Kpeme	3.75 Mt/y Phosphate rock	1980's		Cn	A fifth line is to be added to the beneficiation plant - which treats ore from Hahoetoe and Kpogame - increasing capacity from present level of 3Mt/y; possible further addition later.
Sodemi	Ity	Au		Fr15,000m		BRGM studies consider project viable but no co. formed.
UGANDA						
Kilembe Copper		Cu, Co		ShU100m		Mine rehabilitation, contract tender called.
Govt.	Tororo, Sulukwe Hills	Phosphate				Engineering study for development of fertiliser projects based on domestic phosphate.
Kilembe Mines	Kilembe	Cu,Co			U/Cn/Sm	Seltrust Engineering completed feasibility studies for rehabilitation of operations. Sherritt Gordon cobalt halted pending Govt. decision.
Toroto Industrial Chemicals & Fertiliser Co. (Tiicaf)	Sukulu, Sulukwe Hills	Phosphate				Detailed engineering study being undertaken by Beardon Potter/SEMA (France) on development of phosphate project.
TANZANIA						
Govt.	Chungu Valley	300 kg/year Au				New mine development with Russian help.
State Mining Corp.	Minjingu, Arusha	Phosphates				Evaluating reserves as feed for 60,000 t/y Tanga fertiliser plant.

Table A.2 continued

Page 5

Company	Location	Design Production (Ore, unless otherwise stated)	Completion Date	Capital	Type of Operation[b]	Remarks
UPPER VOLTA						
Soc. de Recherche Miniere	Poura	2,000 kg/y Au	1984	$20m		Mine reopening planned.
Bovogui/CDF Engenierei	Abobo Djouna	Phosphate				Feasibility studies and trial mining under way.
Soremi	Poura	2,500 kg/y contained Au	1984	$100m		Mine reopening planned. Coframines providing technical assistance. Plans are underway to open other gold mines at Guiro Bavildiaga and Diouga
Somitam	Tambao	500,000 t/t Mn		$100m	P	Needs finance, and associated 360 km rail link ($200m) to enable development. Studies continuing with French technical assistance.

[a] This listing is tentative and depends only on projects reported to the source.

[b] U, underground mine; P, open pit; A, alluvial; S, solution mining; Cn, concentrator; Sm, smelter; Rf, refinery; R, tailings retreatment.

Source: "Major New Projects and Expansion Programs." Reported Annually, Mining Magazine, 1979 - 1984.

Table A.3

POSSIBLE MINERAL POTENTIAL OF SELECTED LEAST DEVELOPED AFRICAN COUNTRIES
(U. S. Millions)

Country/ Mineral	Range of Size of Deposit and Production and Sales Assumptions	Range of Possible Investment	Range of Possible Annual Sales
Central African Republic			
Pegmatite or Carbonatite Minerals (Tin, Niobium, Rare Earths, Phosphate)	1 to 3 deposits or equivalent	25 - 75	20 - 60
Massive Sulfide (Copper, Zinc, Gold, Silver)	1 to 4 deposits or equivalent containing 1.8% copper and 3.2% zinc per deposit: 50,000 tpy recoverable copper in conc. 89,000 tpy recoverable zinc in conc.	200 - 800	200 - 800
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	200 - 550	200 - 550
Gold	1 to 10 deposits or equivalent, 500 tpy ore operation per operation or grade 20 g/t ore	15 - 150	30 - 300
Diamonds	1 moderate to several smaller deposits or equivalent to produce 10 million tons ore for a moderate deposit .75 to .25 carats per ton ore	25 - 125	15 - 100
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 12 year life	40 - 160	43 - 170
Ethiopia			
Massive Sulfide (Nickel, Copper)	1 to 5 deposits or equivalent, ore grade per deposit: 2.0 % copper and .5% nickel 22 million tons of ore 400,000 tons recoverable copper 100,000 tons recoverable nickel 20 year life per deposit	100 - 500	75 - 375
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfides	100 - 250	75 - 300
Gold	1 to 10 deposits or equivalent	15 - 150	15 - 150
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 5 million ton deposits or equivalent 12 year life		
Platinum	10,000 to 100,000 troy ounces per year 20 year life	4 - 40	4 - 40
Tungsten, Titanium	.3 to 1.5 million tons per year ilmenite 20,000 to 200,000 pounds per year tungsten	15 - 80	15 - 90
Iron Ore	2 million to 15 million tons per year operation	100 - 750	110 - 825
Guinea			
Massive Sulfide (Nickel, Copper)	1 to 5 deposits or equivalent ore grade per deposit: 2.0 % copper and .5% nickel 22 million tons of ore 400,000 tons recoverable copper 100,000 tons recoverable nickel 20 year life per deposit	100 - 500	75 - 375
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	100 - 250	75 - 300
Gold-Silver	1 to 10 deposits or equivalent	15 - 150	15 - 150

Table A.3 (continued)

Country/ Mineral	Range of Size of Deposit and Production and Sales Assumptions	Range of Possible Investment	Range of Possible Yearly Sales
Diamonds	1 moderate to several smaller deposits or equivalent 10 million tons ore for a moderate deposit .7 to .25 carats per ton ore 20 year life	25 - 125	15 - 100
Heavy Sands (Zircon, Titanium)	1 moderate to 1 large deposit or equivalent. The large deposit is the size and grade of Sierra Leone deposit. Large deposit, 187 million tons alluvium containing 3.0 million tons rutite. 30 year plant life Note: Resulting 100,000 tpy rutite for the large production equalt 25% of current world production.	5 - 40	5 - 30
Iron Ore	10 million to 15 million tons per year operation 200 million tons for 10 million ton mine. Assumes must be large operation or will not be opened at all.	500 -1500	550 -1650
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 30 million tons ore at .17% U_3O_8 100 million pounds recoverable U_3O_8 12 year life	40 - 310	61 - 350
Mali			
Pegmatite or Carbonatite Minerals (Tin, Niobium, Rare Earths, Phosphate)	1 to 3 deposits or equivalent	25 - 75	20 - 60
Massive Sulfide (Copper, Zinc, Gold, Silver)	1 to 4 deposits or equivalent containing 1.8 % copper and 3.2% zinc per deposit: 50,000 tpy recoverable copper in conc. 89,000 tpy recoverable zinc in conc.	200 - 800	200 - 800
Uranium	5 million tons ore at .18 U_3O_8 33 million pounds recoverable U_3O_8 2.5 million pounds U_3O_8 per year produced. Four $5 million ton deposits or equivalent. 12 year life.	150 - 600	90 - 350
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide.	200 - 550	200 - 550
Gold	1 to 3 deposits or equivalent, 500 tpy ore operation per operation ore grade 20 g/t ore.	25 - 125	30 - 150
Diamonds	1 moderate to several smaller deposits or equivalent to produce 10 million tons ore for a moderate deposit .75 to .25 carats per ton ore.	25 - 125	15 - 100
Sierra Leone			
Massive Sulfides (Nickel, Copper)	1 to 3 deposits or equivalent. Ore grade per deposit: 22 million tons ore 400,000 tons recoverable copper 100,000 tons recoverable nickel 20 year life per deposit	100 - 250	75 - 300
Ultramafics (Nickel, Chrome, Cobalt)	1 to 2 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	100 - 200	75 - 150

Table A.3 (continued)

Country/ Mineral	Range of Size of Deposit and Production and Sales Assumptions	Range of Possible Investment	Range of Possible Yearly Sales
Gold	1 to 5 deposits or equivalent	15 - 75	15 - 75
Diamonds	1 moderate to several smaller deposits or equivalent 10 million tons ore for a moderate deposit, .75 to .25 carats per ton ore 20 year life	25 - 125	15 - 100
Iron Ore	2 to 5 million tons per year operation 40 to 100 million tons of ore 20 year life	100 - 250	110 - 275
Heavy Sands (Zircon, Titanium)	1 moderate to 1 large deposit or equivalent. The large deposit is the size and grade of Sierra Leone deposit. Large deposit, 187 million tons alluvium containing 3.0 million tons rutite. 30 year plant life. Note: Resulting 100,000 tpy rutite for the large production equals 25% of current world production.	5 - 40	5 - 40
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 5 million tons ore at .17% U_3O_8 12 year life	40 - 120	61 - 183
Sudan-North			
Massive Sulfide (Nickel, Copper)	1 to 5 deposits or equivalent Ore grade per deposit: 2.0% copper and .5% nickel 22 million tons ore 400,000 tons recoverable copper 100,000 tons recoverable nickel 20 year life per deposit	100 - 500	75 - 375
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	100 - 300	75 - 250
Gold	1 to 10 deposits or equivalent	15 - 150	15 - 150
Other Metals (Manganese, Tin, Tungsten)	1 to 3 deposits or equivalent	25 - 75	20 - 60
Iron Ore	2 million tons per year to 15 million tons per year operation. 40 to 300 million tons of ore. 20 year life.	100 - 750	110 - 825
Sudan-South			
Massive Sulfide (Nickel, Copper)	1 to 5 deposits or equivalent, Ore grade per deposit: 2.0% copper and .5% nickel 22 million tons ore 400,000 tons recoverable copper 100,000 tons recoverable nickel 20 year life per deposit	100 - 500	75 - 375
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide.	100 - 300	75 - 250
Gold	1 to 10 deposits or equivalent	15 - 150	15 - 150
Other Metals (Tin, Tungsten)	1 to 3 deposits or equivalent	25 - 75	20 - 60
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 5 million tons ore at .17% U_3O_8 12 year life	40 - 200	61 - 305

Table A.3 (continued)

Country/ Mineral	Range of Size of Deposit and Production and Sales Assumptions	Range of Possible Investment	Range of Possible Yearly Sales
Iron Ore	2 million tons per year to 15 million tons per year operation. 40 to 300 million tons of ore. 20 year life.	100 - 750	110 - 825
Diamonds	1 moderate to several smaller deposits or equivalent 10 million tons ore for a moderate deposit .75 to .25 carats per ton ore. 20 year life.	25 - 125	15 - 100
Tanzania			
Diamonds	1 deposit to produce 1.0 million tons per year .20 carats per ton ore	30 - 40	15 - 20
Gold	1 deposit to produce 300,000 tons ore per year, Ore grade .25 oz. per ton	85 - 100	60 - 70
Nickel	1 deposit to produce 59 million pounds ore per year.	20 - 40	35 - 45
Uranium	1 deposit to produce 22.5 million tons ore per year at .17% U_3O_8	180 - 200	150 - 180
Togo			
Iron Ore	5 million tons to 15 million tons per year operation, 100 to 300 million tons of ore 20 year life	250 - 750	300 - 900
Ultramafics (Nickel, Copper, Cobalt, Chrome)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	200 - 400	200 - 400
Gold	1 to 5 deposits or equivalent, 500 tpy ore per operation, ore grade 20 g/t ore	15 - 75	30 - 150
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recovrecoverable U_3O_8 5 million tons ore at .17% U_3O_8 12 year life	40 - 120	45 - 130
Uganda			
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	200 - 590	200 - 550
Gold	1 to 3 deposits or equivalent, 500 tpy ore per operation, ore grade 20 g/t ore	25 - 75	30 - 90
Kilembe Type (Cobalt, Copper)	20 to 40 million tons ore at 2.3% Cu, .18% Co. Produce 40 to 80 billion lb. Cu, 2.6 to 5.2 million lb. Co per year as matter.	125 - 250	55 - 110
Uranium	5 million tons ore at .20% U_3O_8 1.84 million lb. U_3O_8 produced for 12 years 5 million tons ore at .17% U_3O_8 12 year life	65 - 195	55 - 165
Other Pegmatite or Carbonatite Minerals (Tin, Niobium, Rare Earths, Phosphate)	1 to 5 deposits or equivalent	25 - 125	20 - 100
Massive Sulfide (Copper, Zinc, Gold, Silver)	1 to 4 deposits or equivalent, containing 1.8% Copper and 3.2% zinc per deposit: 50,000 tpy recoverable copper in conc. 89,000 tpy recoverable zinc in conc.	200 - 800	200 - 800

Table A.3 (continued)

Country/ Mineral	Range of Size of Deposit and Production and Sales Assumptions	Range of Possible Investment	Range of Possible Yearly Sales
Upper Volta			
Uranium	5 million tons ore at .18% U_3O_8 17 million pounds recoverable U_3O_8 four 5 million ton deposits or equivalent 12 year life.	40 - 160	43 - 170
Other Pegamite or Carbonatite Minerals (Tin, Niobium, Rare Earths, Phosphate)	1 to 3 deposits or equivalent	25 - 75	20 - 60
Massive Sulfide (Copper, Zinc, Gold, Silver)	1 to 4 deposits or equivalent containing 1.8% copper and 3.2% zinc. 50,000 tpy recoverable copper in conc., 89,00 tpy recoverable zinc in conc.	200 - 800	200 - 800
Ultramafics (Nickel, Chrome, Cobalt)	1 to 3 deposits or equivalent of approximately same level of investment of sales and investment as massive sulfide	200 - 550	200 - 550
Gold	1 to 10 deposits or equivalent, 500tpy ore operation, ore grade 20 g/t ore. Prices U.S. $350/oz.	15 - 150	30 - 300
Diamonds	1 deposit or equivalent to produce 10 million tons ore .75 to .25 carats per ton ore 20 year life	25 - 125	15 - 100

Source: T.F. Torries, Economic Justification for a Comprehensive Mineral Resource Program for "_____". A series of unpublished reports, College of Mineral and Energy Resources, West Virginia University, Morgantown, 1983.

Prices (U.S. dollars per unit) for valuing sales from production.

Refined Metals		Ore in Concentrate	
Copper	$1.25/lb. metal	Copper in concentrate	$.63/lb. Cu
Nickel	$3.00/lb. metal	Zinc in conecntrate	$.25/lb. Zn
Cobalt	$10.00/lb. metal	Precious metals in concentrate	$23/ton ore
Gold	$350/oz.	Ilemite	$55/ton
Platinum	$400/oz.	Rutite	$350/ton
		Tungsten in concentrate	$8.00/lb. W
Matte Refining Charges		Iron Ore, 63% Fe	$55/ton
Copper	$.04/lb. Cu	Diamonds	$30-$70/carat
Cobalt	$4.00/lb. Co	Uranium	$30/lb.

Appendix 4

MINERAL IMPACT MULTIPLIERS

Multipliers have been developed to measure the impact of industrialization in the form of macroeconomic or aggregate terms. Since the empirical estimation of these multipliers in the context of mineral production and exports has taken place only infrequently, we are limited to observing multiplier values only for certain industrialized countries. Table A.4a summarizes a set of mineral industry multipliers developed by McCulla and Stahl (1977) for the Canadian economy and based on the Canada 1966 Input-Output tables. The estimation of such multipliers is obviously complex and the interested reader should examine the original text. The three principal sectors of the mineral industry provide the basis for the computations and represent weighted averages of values taken from more disaggregated sectors. The sectors include: ores and concentrates, primary metals, and semi-fabricated metals. Due to the level of aggregation, slight differences may be present in the sectoral averages, particularly at the semi-fabricated stage. The multipliers also are presented only for a small group of metals: aluminum, nickel, copper, zinc, and iron and steel.

The definition of the multipliers is as follows. The gross production multiplier measures the total value of goods and services generated by the production of one dollar worth of the commodity. The GDP multiplier measures the value added generated by each dollar of commodity production. The value added or payment to primary factors is based on the gross values of the commodity. The employment multiplier is the ratio of the total employment generated in the economy by one million

Table A.4a

MINERAL INDUSTRY ECONOMIC IMPACT MULTIPLIERS[a]

Mineral Commodity	Metal Ores & Concentrates	Primary Metals	Semi-Fabricated Metals
	Gross Production Multipliers		
Alumina	2.11[b]	2.13	3.00
Nickel	2.13	3.26	3.23
Copper	2.13	3.25	3.64
Zinc	2.13	3.26	3.88
Iron and Steel	2.61	1.58	2.57
Aggregate	2.23	2.28	2.76
	GDP Multipliers		
Alumina	1.15[b]	1.16	1.37
Nickel	1.50	1.45	1.47
Copper	1.50	1.44	1.46
Zinc	1.50	1.45	1.38
Iron and Steel	1.45	1.36	1.43
	Employment Multipliers		
Alumina	1.97[b]	1.96	4.49
Nickel	2.64	5.14	2.58
Copper	2.64	5.15	7.60
Zinc	2.64	5.14	4.12
Iron and Steel	3.28	6.07	7.93
Aggregate	2.67	4.64	7.02

[a]Mining defined as ores and concentrates. Primary Metals represents smelted and refined output and in the case of the ferrous system it includes pig iron and steel in primary forms. Semifabricated metals represents the cast, rolled, and extruded stage for the nonferrous system, and iron and steel mill products.

[b]Alumina production from imported ore.

Source: D. J. McCulla and J.E. Stahl, Quantitative Impact of Minerals on Canadian Economic Development: A Partial Analysis, Energy, Mines and Resources, Ottawa, Canada, 1977.

dollars of commodity production; the latter is the employment directly required in the production of one million dollars worth of the commodity.

In interpreting these figures, one must realize that these multipliers are probably different in Canada than they would be in the African LDC's because of differences between the economies. They are thus accepted as a guide in the absence of better data. The macroeconomic importance of mining in Canada also is diluted by the development of other major industries. Torries (1983) thus suggests that the dynamic GDP multipliers for the African LDC's might be higher than the static multipliers in Table A4a by a factor of one, e.g., the GDP multiplier for copper at the metal ore and concentrate stage is 2.5. He confirms that the other multipliers are approximately representative. Referring again to copper, one can say that $100 million of ore and concentrate production would lead to $213 million of value added and to an increase in GDP of $250 million. And total jobs created would be roughly 2.6 in total for each job in the mining industry.

An example of how the GDP multiplier can be applied to measure the incremental effects of new mineral investment in several of the African LDC's can be derived from Torries (1983). Table A4b features the impact of the estimated cumulative value of mineral investment and sales that could take place based on each country's respective mineral endowment, as reported in Tables 6 and A3. The reported present value of the cumulative investment and sales is based on a 20 year period with an interest rate of 6 percent and figures in constant 1983 dollars. The GDP shown is computed to 2000 based on a "business as usual" growth rate. The GDP multiplier increment represents the increase in GDP that would result from the estimated investment and sales as well as the investigation of geological (airborne) surveys in each country. Table A4b, therefore,

shows as an example that the incremental increase in GDP for Togo due to geological survey as well as the multiplier reported in Table A4a would amount to some $1,432 million by the year 2000.

Table A4b

IMPACT OF MINERAL DEVELOPMENT ON GDP[a]
($ Million)

Country	GDP 1980	Cumulative Investment	Annual Sales	Total Sales & Investment	GDP Year 2,000	GDP Multiplier Increment
Central African Republic	500	379	356	735	1,327	1,282
Ethiopia	3,100	452	453	885	8,225	1,394
Guinea	1,130	512	435	947	2,998	1,614
Mali[b]	885	478	362	840	2,348	1,496
Sierra Leone	630	303	216	519	1,672	868
North Sudan	2,300	410	260	670	6,103	1,140
South Sudan	2,300	218	163	381	6,103	682
Togo[c]	853	439	503	942	2,255	1,432
Uganda[b]	2,800	272	222	494	7,429	798

[a]Based on the undertaking of necessary geological surveys.

[b]1982 - 2000

[c]1983 - 2003

Source: T.F. Torries, Economic Justification for a Comprehensive Mineral Resource Program for" ". A series of reports, Department of Mineral and Energy Resource Economics, West Virginia University, Morgantown, 1983.