

Document of
The World Bank

FILE COPY

FOR OFFICIAL USE ONLY

CR 1298-MAG

Report No. P-3204-MAG

REPORT AND RECOMMENDATION
OF THE
PRESIDENT OF THE
INTERNATIONAL DEVELOPMENT ASSOCIATION
TO THE
EXECUTIVE DIRECTORS
ON A
PROPOSED CREDIT
IN AN AMOUNT EQUIVALENT TO US\$11.5 MILLION
TO THE
DEMOCRATIC REPUBLIC OF MADAGASCAR
FOR THE
TSIMIRORO HEAVY OIL EXPLORATION PROJECT

October 20, 1982

This document has a restricted distribution and may be used by recipients only in the performance of their official duties. Its contents may not otherwise be disclosed without World Bank authorization.

CURRENCY EQUIVALENTS

	<u>December 1981</u>		<u>June 1982</u>	
Unit	=	Malagasy Franc (FMG)	=	Malagasy Franc (FMG)
US\$1.00	=	FMG 278	=	FMG 375
FMG 1,000	=	US\$3.59	=	US\$2.67
FMG 1,000,000	=	US\$3,590	=	US\$2,670

(The cost estimates are based on US\$1 = FMG 375)

WEIGHTS AND MEASURES

GWh	=	Gigawatt hour
kWh	=	kilowatt hour
MW	=	Megawatt
BD	=	Barrels per day

GLOSSARY OF ABBREVIATIONS

OMNIS	-	Office Militaire National pour les Industries Stratégiques
EIB	-	European Investment Bank

GOVERNMENT OF MADAGASCAR FISCAL YEAR

January 1 to December 31

- i -

MADAGASCAR

TSIMIRORO HEAVY OIL EXPLORATION PROJECT

CREDIT AND PROJECT SUMMARY

Borrower: Democratic Republic of Madagascar

Beneficiary: Office Militaire National pour les Industries
Strategiques (OMNIS)

Amount: SDR 10.7 million (US\$11.5 million equivalent)

Terms: Standard

Onlending Terms: The Government would make the proceeds of the credit
available to OMNIS as a grant.

Project

Description:

- (i) Objective: The project would support the Government's efforts to evaluate the country's hydrocarbon potential with the objective of realizing domestic oil production in the future.
- (ii) Main Project Components:
- (a) exploration of the Tsimiroro heavy oil deposit through a 10-well exploratory drilling program to determine the characteristics of the deposit;
 - (b) engineering study of a pilot plant at Tsimiroro for testing production of the heavy oil under enhanced recovery techniques, such as steam flooding (40 man-months of consultant services);
 - (c) feasibility study of upgrading the heavy oil recovered from Tsimiroro, including selection of an appropriate upgrading process (13 man-months of consultant services);
 - (d) training abroad of about 12 professionals for about six months each.

(iii) Benefits: The project would establish whether the characteristics of the Tsimiroro deposit warrant the installation of pilot facilities to test production under enhanced recovery techniques, a necessary stage before determining the commercial viability of the deposit. If such facilities are justified, the engineering and upgrading studies would provide the basis for planning the pilot stage. The training component would help OMNIS to improve further its competence in petroleum activities.

(iv) Risks: There is a risk that the results of the exploratory drilling for the Tsimiroro heavy oil would show that further work toward development of the deposit is not warranted. Given that this project is only the first step towards the potential development of the deposit, this must be considered a high risk project. However, in view of Madagascar's present dependence on oil and the existing information on these deposits, the risks are acceptable.

Foreign Local Total
------(US\$ million)-----

Estimated Project Costs:

(A) Tsimiroro Heavy Oil Component

<u>Drilling Contract</u>			
Drilling, Logging, Construction and Support Equipment	5.0	.2	5.2
Materials and Supplies	.6	.7	1.3
Shipping	2.2	.1	2.3
Management	1.5	.1	1.6
Total Drilling contract	<u>9.3</u>	<u>1.1</u>	<u>10.4</u>
Supervision	.4	-	.4
Laboratory Analysis	.5	-	.5
Sub-total	<u>10.2</u>	<u>1.1</u>	<u>11.3</u>

	<u>Foreign</u>	<u>Local</u>	<u>Total</u>
	----- (US\$ million) -----		
<u>(B) Studies</u>			
Engineering for Tsimiroro			
Pilot Operation	1.0	-	1.0
Feasibility Study of Heavy			
Oil Upgrading	<u>.2</u>	<u>-</u>	<u>.2</u>
Sub-total	<u>1.2</u>	<u>-</u>	<u>1.2</u>
<u>(C) Training</u>			
	<u>.3</u>	<u>-</u>	<u>.3</u>
Base Cost	11.7	1.1	12.8
Physical Contingencies	3.4	.3	3.7
Price Contingencies	<u>1.4</u>	<u>.1</u>	<u>1.5</u>
TOTAL PROJECT COST	<u>16.5</u>	<u>1.5</u>	<u>18.0</u>
<u>Financing Plan</u>			
Government	-	1.5	1.5
IDA	11.5	-	11.5
OPEC Fund	<u>5.0</u>	<u>-</u>	<u>5.0</u>
TOTAL	<u>16.5</u>	<u>1.5</u>	<u>18.0</u>

Estimated Disbursements:

	IDA FY	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>
		----- (US\$ '000) -----			
Annual		3,000	6,000	2,000	500
Cumulative		3,000	9,000	11,000	11,500

Rate of Return: N.A.

Staff Appraisal Report: N.A.

Maps:
 IBRD 14787R
 IBRD 16323
 IBRD 16324

INTERNATIONAL DEVELOPMENT ASSOCIATION

REPORT AND RECOMMENDATION OF THE PRESIDENT
TO THE EXECUTIVE DIRECTORS
ON A PROPOSED CREDIT
TO THE DEMOCRATIC REPUBLIC OF MADAGASCAR
FOR A TSIMIRORO HEAVY OIL EXPLORATION PROJECT

1. I submit the following report and recommendations on a proposed development credit to the Democratic Republic of Madagascar of SDR 10.7 million (US\$12.5 million equivalent) on standard IDA terms to help finance a project for the exploration of the Tsimiroro heavy oil accumulation. The proceeds of the credit would be passed on by the Government to the Office Militaire National pour les Industries Strategiques (OMNIS) as a grant. The project would be jointly financed with a US\$5 million loan from the OPEC Fund for International Development on concessionary terms still to be determined.

PART I - THE ECONOMY

2. A report entitled "Madagascar - Economic Memorandum" dated November 3, 1981 has been distributed to the Executive Directors. An economic mission visited Madagascar in March/April 1982 and an updating Economic Memorandum (MAG 82-5) was issued on June 4, 1982. Country data sheets are provided in Annex I to this report.

3. Madagascar, with a population of 8.7 million and a per capita GNP of about US\$330 in 1980, is among the poorest countries in the world. It is a sparsely populated country (about 14 persons per square kilometer) with less than 20 percent of the population living in urban areas. Although generally well endowed with natural resources and a variety of soils, there are considerable regional variations in ecology and climate. The central plateau, the most economically advanced region, has a subtropical to temperate climate, the south is the poorest region with an arid climate and infertile soils, the eastern region has a tropical climate and although rich agriculturally, crops are frequently devastated by cyclones. Agriculture accounts for about 35 percent of GDP; about 85 percent of the national labor force is engaged in agricultural activity, and agricultural products account for about 80 percent of the country's export earnings.

4. Madagascar's development over the past decade has been disappointing. With a population growth around 2.8 percent per annum, real per capita GDP has decreased by about 1.5 percent per annum; in 1980 per capita real income was probably about 20 percent below its 1970 level. Even with sluggish and erratic development, Madagascar's policies until 1978 had been characterized by cautious

and conservative public finance and balance of payments management. In 1979 and 1980 Government undertook a very large program of public investment with a marked shift to dependence on external sources for its financing. Investment outlays (in volume terms) increased by about 13 percent per annum between 1978 and 1980 and the share of investment in GDP which had been around 14 percent since the early 1970s rose to around 21 percent in 1979 and 1980. The increased investment thrust and its attendant import needs coincided with almost stagnant export earnings and a deterioration in terms of trade, so that Madagascar's balance of payments position deteriorated very sharply in 1979 and 1980. General Government and state enterprises accounted for virtually all of the increased investment expenditures so that the budget expenditures and the overall budget deficits increased dramatically in 1979 and 1980.

5. Overall output growth has continued to be very erratic over recent years. Real GDP increased by about 10 percent in 1979, increased by less than 1 percent in 1980 and decreased by about 9 per cent in 1981. The short-lived spurt of growth in 1979 was due to increased activities associated with the investment boom and to improved weather conditions benefiting agricultural production but already in 1980 agricultural and manufacturing production were adversely affected by inadequate supplies of necessary inputs and raw materials which became much more acute in 1981.

6. Agricultural output grew on average by about 1 percent between 1977 and 1980, thus continuing the very sluggish development which has characterized Madagascar's agriculture since the early 1970s. Output in 1978 was seriously affected by the prolonged drought conditions which had prevailed since 1976 and declined by about 6.5 percent. With improved weather conditions in 1979 output increased by about 7 percent but in 1980 is estimated to have grown by only about 2.5 percent and preliminary indications are that output in 1981 declined by about 1.5 percent. Production of rice, the principal staple food, has virtually stagnated over recent years; estimated production in 1981 was about 7 percent below its 1977 level. Domestic production has failed to keep pace with domestic needs, especially to satisfy the growing urban population, and imports of rice have grown rapidly from about 60,000 tons in 1975 to about 200,000 tons in 1981. Production of coffee, Madagascar's major export commodity, which had risen steadily during the first half of the 1970s, declined sharply in 1976 and 1977, mainly due to unfavorable weather, and then increased moderately from 1978 to 1980. Production in 1980, about 80,000 tons, was still somewhat below its mid-1970s level. Production of cloves, Madagascar's second most important foreign exchange earner, is subject to a four to five year production cycle; the peak production reached in 1980 was still significantly below the poor level of 1974. Vanilla production dropped sharply between 1978 and 1980 due to the combined effects of poor maintenance, unfavorable weather and competition from synthetic substitutes. Production picked up in 1981 but was still about 35 percent below the 1978 level.

7. Growth of manufacturing output has continued to be slow and erratic; real value added in the sector increased by about 13 percent in 1979, decreased by about 3 percent in 1980 and decreased by about 25 per cent in 1981. Food processing (including beverages) and textile production are the dominant

activities, accounting respectively for about 35 percent and 21 percent of the sector's value added. Output of food and beverage industries grew on average by about 2 percent per annum over the 1977-80 period. Textile production, which increased by about 9 percent in 1979, decreased by about 5 percent in 1980, in which year production was affected by reduced raw material supplies and by machinery maintenance problems. The only industries which have shown a regular growth of output over recent years were cement, tobacco, leather goods (mainly shoes) and paper products. The combined share of these industries in total manufacturing value added in 1979 was just over 15 percent. The manufacturing sector has been generally operating at a low level of capacity utilisation over recent years. With increasing scarcities of imported raw materials and spare parts in 1980 and 1981, the dislocations to production have become increasingly severe.

8. Madagascar's fiscal situation has deteriorated dramatically since 1978, due to sharply rising current expenditures and increased Government spending on capital investment. The current budget surplus, which used to be substantial, turned to a deficit as revenues failed to keep pace with the growth of expenditures. Furthermore, as Government intensified its efforts to raise investment levels and stimulate the economy, public investment expenditure rose from 16 billion FMG in 1977 to 93 billion FMG (\$440 million) in 1980. Outlays on the consumer subsidy for rice increased from about 4 billion FMG in 1975 to nearly 12 billion FMG (\$57 million) in 1980. The overall Treasury deficit increased from about 4 percent of GDP in 1978 to over 18 percent in 1980. While borrowing from external sources was greatly expanded in both 1979 and 1980, the budget deficits were financed primarily by borrowing from the Central Bank, which provided about two thirds of the financing of the 1980 deficit. Preliminary estimates for 1981 indicate that government expenditures (current and capital) were substantially cut back and that the overall deficit in 1981 was equivalent to about 15 per cent of GDP.

9. Monetary and credit developments over recent years largely reflect the Government's deficit financing needs. Domestic credit increased from about 126 billion FMG (\$536 million) at end of 1977 to about 340 billion FMG (\$1,510 million) at end 1980. Most of this expansion was accounted for by Government borrowing from the Central Bank, whose share of domestic credit rose from about 23 percent in 1977 to about 53 percent in 1980. Despite a significant reduction in net foreign assets, money supply grew by over 20 percent per annum during the 1977-1980 period. Available price information for Madagascar is fragmentary. There is a wide-ranging system of controlled prices which appears to have become inoperative with most goods selling at prices well above control levels. A price index for low income families shows an acceleration of price increases to about 18 percent in 1980 and over 30 percent in 1981 compared to about 14 percent in 1979 and an annual average increase of about 4.5 percent from 1975 to 1978.

10. Madagascar's balance of payments position deteriorated dramatically over the 1977-80 period. The current account deficit, which had averaged around FMG 8 billion (\$33 million) from 1975 to 1977, rapidly increased to about FMG

130 billion (\$613 million) in 1980, i.e., from less than 2 percent of GDP to over 18 percent of GDP. From 1977 to 1980 the import bill virtually doubled while export earnings increased by only around 3 percent. The overall balance which had been in surplus by about FMG 3 billion in 1977 was in deficit by about FMG 59 billion in 1980. Transactions with the rest of the world have been financed by a total exhaustion of reserves, an unprecedented increase in foreign borrowing and by incurring substantial arrears on external payments obligations. The increased import bill has been the most striking feature of recent balance of payments developments. Average import prices increased substantially (over 40 percent) during the 1977-80 period and import volume showed approximately the same proportionate increase. While nearly all categories of imports increased, imports of capital goods grew at a particularly rapid rate and accounted for approximately half of the increase in the import bill between 1977 and 1980. The very modest growth in export earnings between 1977 and 1980 reflected continued inertia in export volume and fairly stationary world prices for Madagascar's principal exports. Export growth continued to be sluggish in 1981 but a significant cut back in imports reduced the current account deficit to the equivalent of about 13 per cent of GDP.

11. The development of the Malagasy economy has been constrained over many years by a number of basic weaknesses, e.g. low productivity in agriculture, slow growth in major primary exports and inadequate domestic savings. The sharp deterioration in Madagascar's economic and financial situation in 1979 and 1980 reflects these continuing problems. The significant shifts in government policy through a greater openness to external finance and, also in pushing vigorously for a higher level of investment have been accompanied by continued sluggish export performance and deterioration in the terms of trade. The import bill has been swollen not only by imports of capital goods but also by a growing import of consumer goods, especially rice, for which domestic production and distribution weaknesses are a serious problem. The country is well endowed with natural resources and the administrative cadres are relatively well trained. A more effective use of these resources will depend, however, on a lasting correction of the serious imbalances which exist on both balance of payments and government budget accounts.

12. In June 1980 the Government concluded a stand-by agreement with the IMF which aimed to restore balance of payments and budgetary equilibrium. Some of the individual policy measures in this program were implemented, e.g. measures to increase government revenues, but efforts to limit government expenditures were not successful and the program was suspended. A new stand-by agreement was concluded in April 1981. This provided SDR 109 million (US\$130 million) to be drawn up to end June 1982. The stand-by agreement placed limits on public expenditure, government borrowing from the Central Bank and new external borrowing, and entailed a reduction in external payments arrears. Implementation of the stand-by proceeded successfully up to July 1981, but unanticipated shortfalls in export earnings, due in large measure to weak world coffee prices and a smaller than anticipated inflow of new capital from international commercial banks, made it impossible for Madagascar to adhere to the stand-by performance conditions in the following months. A further Stand-by Agreement was approved

by the IMF Board in July 1982. The agreement covers the period to mid 1983 and makes available SDR 51 million under the Stand-by together with SDR 22 million under the compensatory financing facility. In addition to placing limits on public expenditure, government borrowing from the Central Bank and new external borrowing, the Stand-by Agreement provided for a devaluation of the Malagasy Franc, for an increased producer price for rice and for the elimination of the consumer subsidy on rice. In June 1982 a first Aid Coordination Conference, chaired by the World Bank, was held in Paris and was successful in mobilizing new grants and credits from bilateral sources of SDR 60 million to cover the external financing gap for 1982 which was estimated to remain after taking account of IMF resources. At the June Aid Coordination Conference the formal establishment of a Consultative Group was approved and a first meeting of the group is envisaged for early 1983.

13. These stabilization measures need to be complemented by measures to enhance the long-term viability of the economy. A Plan for the period 1981-86 has been prepared. The Plan envisages a much more vigorous effort in export expansion and an action program for greater self sufficiency in food production and supply of raw materials. Administrative steps have already been taken to strengthen regional economic planning and the operations of government enterprises. Priority is to be attached to a rehabilitation and greater utilization of the existing capital stock with limited new investment largely concentrated in production sectors. Government has made substantial progress in preparing a public investment program for the 1983-85 period which would be a key element in implementing policies of economic recovery and reform. Madagascar has formally requested non-project assistance from the World Bank and discussions have been initiated to identify a program of structural adjustment and policy reform which such assistance might appropriately support.

14. With the shift in government policy to a greater reliance on foreign financing, Madagascar's external public debt has increased substantially over recent years. Total external debt (outstanding and disbursed) at end 1980 amounted to about \$1,035 million, compared to about \$245 million at end 1977. There has been a greater diversification in sources of external financing but average terms have hardened significantly. Consequently, the debt service ratio has risen from around 4 per cent in 1977 to about 12 per cent in 1980 and is likely to be around 30 per cent in 1981. Madagascar now faces a rising debt servicing burden in the next few years. A Paris Club meeting took place between April 29-30, 1981, as a result of which Madagascar obtained debt rescheduling of about \$36 million covering the period January 1, 1981 to June 30, 1982. In July 1982 the Paris Club approved a further rescheduling of maturities falling due in the period to end June 1983. Approximately \$115 million (of which \$24 million short-term) of maturities were rescheduled.

15. The World Bank group has provided about 45 percent of the concessionary assistance which Madagascar received between 1975 and 1979. Over the same period, however, around 40 percent of external public borrowing has been from non-concessionary sources. Increased external financing on a concessionary

basis will be required to support the Government's economic restructuring and development efforts and to ensure a continued capacity to service external debt. Given Madagascar's poverty and current resource constraints, IDA should continue to contribute to local cost financing.

PART II - BANK GROUP OPERATIONS IN MADAGASCAR

16. IDA credits to Madagascar amount to US\$315.95 million, and Bank loans total US\$32.58 million. Since 1975, about 50 percent of Bank Group lending has been for transport, 12 percent for electric power, 21 percent for agriculture, 10 percent for industry, technical assistance, water and petroleum, and 7 percent for education. IFC's first investment was in 1977 for the expansion of a textile mill. In 1980 IFC made a \$1.25 million loan for the Bata shoe manufacturing company in Antananarivo; other projects are under preparation. Annex II contains a summary statement of Bank loans, IDA credits and IFC investments as of September 30, 1982, as well as notes on the execution of ongoing projects.

17. Bank Group assistance to Madagascar has been concentrated on the key areas of infrastructure (including urban and social infrastructure), agriculture and energy. We have begun to lend to the industrial sector with a first US\$5 million DFC credit to the Industrial Development Bank of Madagascar (BNI). In infrastructure, four projects have been for the construction of all-weather highway links between the island's different regions and a fifth project for road maintenance and rehabilitation. There have been projects for improving Madagascar's main port of Toamasina, and to support the railway's modernization efforts. Urban infrastructure development includes a first water supply and sanitation project for the capital city of Antananarivo for which a \$20.5 million credit was signed in May 1980. In the social sectors, education has been the major recipient of Bank assistance with two credits totalling \$18.8 million. In addition, studies for urban development financed by the UNDP with the Bank as Executing Agency have led to preparation of a project for urban development. A credit of SDR 9.4 million for an accounting and audit project was signed in June 1981.

18. Bank Group lending for agriculture consists of three livestock development projects, three irrigation projects, two forestry projects and an agricultural credit project. A \$2.3 million technical assistance credit to prepare projects in the Plain of Antananarivo area was signed in January, 1981, and a \$5.7 million technical assistance for Agriculture Institutions project was signed in June 1982. We expect agriculture to continue to absorb a large share of Bank Group lending, in line with Government strategy to expand agricultural production. A project to assist the rehabilitation of rice production in the Lake Alaotra area has been appraised. Further rural development and crop production projects are being prepared.

19. Energy projects have also received growing Bank Group attention: IDA participated with several co-lenders in the financing of the cost of the large Andekaleka hydroelectric project, which was successfully completed in June 1982. A \$12.5 million credit for petroleum exploration promotion is supporting the Government's efforts to develop a domestic supply of hydrocarbons and to improve planning in the energy sector.

20. In the past, problems have arisen in the execution of several projects. The main problems encountered included delays, cost overruns, deficiencies in management and inadequate financial performance of project agencies. The Morondava irrigation project of June 1972 had to be substantially reduced, and the Government and the Association have agreed on a plan of action to deal with the management and financial problems affecting the project. The first Village Livestock project was delayed by institutional problems. The credit was renegotiated in 1977, and since then implementation has been reasonably satisfactory. The road construction component of the fourth highway project is nearly completed and the maintenance studies have been completed, although there was a delay in the start of the highway maintenance training program. The Government has agreed that training consultants be employed, and construction of the training facilities has begun. Construction under the fifth highway project has begun. Disbursements under the Second Railway Project are almost completed with a small balance of \$0.5 million. However, the railway company is facing serious financial and organizational problems which require remedial action from the Government. Disbursement of the remaining credit balance has been suspended since June 25, 1982 pending government action to correct major deficiencies affecting the railway's operations.

21. Since the start of our program in Madagascar, four projects, all of which included technical assistance, have been completed and audited by the Operations Evaluation Department. The Audit Report No 1622 of December 1976 on the Lac Alaotra project concluded that the project was generally successful. However, the Impact Evaluation Report No 3600 of August 1981 concluded that earlier assessments of project performance had been overoptimistic, and that the actual economic rate of return was probably negative. The Audit Report No 1559 of April 1977 on the Beef Cattle Development Project concluded that the Project had contributed little to Madagascar.

22. The Audit Report No 2143 of July 1978 concluded that the Third Highway project was well justified and had a good rate of return despite substantial cost overruns. Report No 2299 of December 1978 concluded that the physical objectives of the Tamatave Port Project were satisfactorily achieved but pointed out that the institutional objective was not accomplished during project implementation because of inadequacies in the staffing of the port authority. With the exception of the port project, the technical assistance components of all four projects were executed satisfactorily.

PART III - THE ENERGY SECTOR

Energy Resources, Demand and Supply

23. Madagascar's major energy resource is its forests, covering some 125,000 km², but their indiscriminate use is leading to rapid deforestation in some areas. Madagascar's other energy resources are largely undeveloped. There is considerable hydro-electric potential, estimated at about 3,500 MW, but installed capacity has only recently reached about 100 MW. No hydrocarbons are exploited at present, but during past exploration oil and gas shows were encountered in the western part of the island, and there are sizeable deposits of heavy oil and bituminous sandstones. OMNIS is currently evaluating uranium deposits in the country with the assistance of the International Atomic Energy Agency and UNDP financing, although the remote location of the deposits argues against exploitation at this time. The Government, through consultants, undertook studies in the past to evaluate the feasibility of developing domestic coal resources. However, the high infrastructure investments required, the small and distant domestic market and poor export prospects have made the outlook discouraging for any development of coal in the medium term. The country also has some geothermal resources, but preliminary investigations suggest that temperatures may not be high enough for electric power generation, and the sources are in remote areas. Renewable energy sources, such as solar and wind energy, may offer potential in the long-term, but have not yet been evaluated.

24. Energy consumption--estimated in 1979 at 2.3 million tons of oil equivalent or 270 kg per capita--is low, even compared to other developing countries. Over the past decade consumption has grown by only about one to two percent p.a., reflective particularly of low economic activity in recent years. Energy use by sector is broken down as follows: 70 percent households, 15 percent industry, 13 percent transport and 2 percent agriculture. Non-commercial energy use is dominant. Primary energy use by source is 80 percent traditional fuels (essentially wood and charcoal, mainly used by households, even in the cities), 16 percent petroleum (used in industries and transport), 2.5 percent bagasse (used in the northern part of the country for steam and power generation in sugar refineries), 0.5 percent hydropower and 1 percent imported steam coal and coke.

25. Electricity consumption (410 GWH or about 48 kWh per capita in 1979) accounts for only 2.4 percent of final energy consumption. The only extensive electric power grid is in the central plateau, the most densely populated area. Electricity is used primarily in industry. Industrial enterprises outside the central plateau normally generate their own electricity, mostly with small diesel-run generators. Household use of electricity is limited essentially to lighting in the cities. Total installed electric power capacity is now about 220 MW, of which about 44 percent is hydro-based, due to completion of the Andekaleka hydropower project in June 1982. That project doubled installed hydropower capacity and should satisfy demand in the greater Antananarivo-Antsirabe area for the next ten years. The cost of the Andekaleka project, partly financed by IDA (Credit 817-MAG), reached about US\$150 million. While hydropower represents the most economical source of electricity for Madagascar, its future development will depend on substantial growth of the country's industrial base in order to justify the high investment costs involved.

26. During the next two decades, Madagascar is expected to continue to rely heavily on traditional fuel sources, with increasing conversion of wood to charcoal, which is easier and cheaper to transport. However, increased use of charcoal should be coupled with a more efficient conversion technique (improved metal charcoal kilns) to avoid increasing pressure on wood resources. Petroleum products will remain the major commercial energy source, primarily due to their crucial use in transportation and machinery operation. Petroleum products as a percentage of final energy demand are projected to increase from 25 percent in 1981 to 32 percent by the year 2000, according to projections of the energy planning study financed under the Petroleum Exploration Promotion Credit (para. 28).

Sector Institutions

27. A number of government institutions participate in energy policy-making. The Office Militaire National pour les Industries Strategiques (OMNIS) is in charge of hydrocarbon and radioactive minerals exploration and development (para. 35). It is an autonomous institution and reports directly to the Presidency. The Ministry of Industry and Commerce has responsibility for (a) regulating exploration and development of coal, lignite and hydro resources; (b) supervising two state enterprises having energy-related responsibilities, i.e., JIRAMA (the power and water utility) and SOLIMA (in charge of petroleum imports, refining, transport and distribution); and (c) providing for overall energy planning in coordination with OMNIS. The Ministry of Finance plays a minor role in energy matters by administering fuel taxation and participating in decisions on public investment. Finally, the Ministry of Agricultural Production and Agrarian Reform has responsibility for production of traditional fuels, firewood and charcoal, and reforestation policies.

Energy Planning and Investment Priorities

28. Formal energy planning in the past has been weak because of the lack of analytical support for decision-making and reliance on informal coordination among government agencies concerned with energy matters. The Petroleum Exploration Promotion Credit (Credit 1016-MAG of May 8, 1980) provided funds to compile and analyze data on energy resources, prepare energy demand projections, review sector policies and define priorities for resource development. The study was carried out by Motor Columbus (Switzerland) and recommends that the Government give priority to (a) reforestation efforts in view of the rapid depletion of forest resources in specific areas of the country and promotion of more efficient charcoal conversion techniques; (b) the development of domestic hydrocarbons (light and heavy oil) and hydropower, as the most promising resources to meet future commercial energy needs; (c) promoting energy conservation and assuring fully economic pricing of forest products, petroleum products and electricity; and (d) establishing a formal structure for energy planning and decision-making through a ministerial level committee making policy decisions. IDA will discuss these recommendations with OMNIS, but since they also concern other departments and agencies of the Government, their implementation will also be addressed by IDA in policy discussions with the Government.

29. The Government's recent major investments in the commercial energy sector have been consistent with recommendations of the study; they include the Andekaleka hydropower project (para. 25), promotion of petroleum exploration and refinery upgrading. Total investment in petroleum exploration was about US\$4 million in 1980, but it should grow substantially over the next few years as investments by private oil companies commence (para. 44). With French assistance, SOLIMA is investing US\$30 million in upgrading and secondary processing facilities at the country's only refinery to raise its present production capacity up to its original design capacity and increase the yield of lighter products (para. 33).

Energy Prices

30. In the past, commercial energy pricing policies were determined largely by social considerations, resulting in petroleum products and electricity prices being held at inadequate levels over extended periods. This deprived state companies operating in the sector of adequate financial resources. The Government has since taken steps to correct the most glaring deficiencies of the energy price structure. During 1979-81, it raised petroleum product prices substantially in line with international petroleum price increases. Thus, retail prices for most petroleum products are now at international levels. Due to marked differentials in fuel taxation, gasoline prices are among the highest in the world, while the price of fuel oil is still lower than international prices. A comparison of Malagasy retail prices (1980/81) with average prices from a sample of 56 countries is set out below:

1980 Retail Prices (US\$/US Gallon)

<u>Product</u>	<u>Madagascar</u>	<u>International Average</u>
Premium gasoline	4.15	2.29
Kerosene	1.90	1.35
Diesel	1.85	1.45
Fuel Oil	0.90	1.06

31. The average price of electricity in Madagascar (10¢/kWh) is now in line with international levels. A comprehensive study on electricity tariffs was carried out under the Andekaleka project and recommended setting tariffs based on marginal cost, which would reduce the complexity and eliminate the inequalities of existing tariffs. The Government is presently reviewing the recommendation of the study for implementation.

32. Prices for traditional fuels are unregulated, but market distortions in the wood supply system of the country have created a situation where producers may not be making a return sufficient to encourage replanting and other necessary conservation practices. This problem was identified by the energy planning study (para. 28), and IDA will address them in the context of forestry sector policy discussions with the Government.

The Petroleum Sector

33. Supply and Demand. Madagascar's crude oil imports were close to 530,000 metric tons for the period July 1980-June 1981. Traditionally an importer of Iraqi crude, the country has been importing from Algeria and Qatar since the outbreak of the Iran-Iraq war and hopes to diversify its sources to include other Middle Eastern countries. Crude oil is processed at the refinery at Toamasina, whose capacity is 730,000 tons. In its present configuration, the refinery yields too much of heavy products and not enough of light products to match domestic demand. Therefore, the country exports heavy fuel oil (120,000 tons in 1980/81) and imports lighter products-- chiefly gas oil and, to a lesser extent, kerosene and gasoline. Product imports increased from 4,600 tons in 1975 to 70,000 tons in 1980/81. The refinery renovation and expansion planned for completion by the end of 1982 (para. 29) will enable the refinery to raise the yield of middle distillates and light ends by about 25 percent in the first year of operation, thus reducing the need for imports of oil products. Diesel and fuel oil, used primarily in power generation and rail transport, presently account for nearly 60 percent of petroleum products consumption, while gasoline accounts for about 25 percent. Jet and residential fuels (kerosene and butane) account for the remainder.

34. Oil imports represent a growing burden on Madagascar's balance of payments. During the 1973-1981 period when oil product consumption grew at some three percent p.a., net imports increased from US\$7.4 million to an

estimated US\$120 million (about 30 percent of total export earnings). While the volume of petroleum imports is expected to decline in 1982 and to stagnate through 1985, in value their share of export receipts (which are expected to decline) is projected to rise to about 40 percent of 1985 export earnings.

35. The Sector Institution: OMNIS. OMNIS was established on November 12, 1975 to take charge of Madagascar's economically strategic industries. It is an autonomous agency headed by the President of the Republic. Policymaking and general supervision is conducted by a directorate, chaired by the Minister of Economy and Commerce and including the Director General of OMNIS, department directors and representatives of the Presidency of the Republic and Ministry of Finance and Planning. The Director General of OMNIS has day-to-day responsibility for operations of the agency.

36. OMNIS is responsible for the exploration and development of petroleum, bituminous sandstones and radioactive minerals as well as the execution of other strategic projects. It also supervises two state-owned enterprises--KRAOMA, which operates the country's chromite mines, and SECREN, a ship building and repair enterprise. OMNIS receives annually budgetary contributions from the profits of these two enterprises. Its hydrocarbon division conducts all activities related to oil and gas exploration and is in charge of the implementation of the Petroleum Exploration Promotion Project.

37. OMNIS' professional staff has grown from 34 in 1978 to 101 in 1981 to cope with the increase in activities; the hydrocarbon division has 32 professionals, including 12 mining, chemical and petroleum engineers, 9 geologists and 4 geophysicists. OMNIS presently relies heavily on expatriate consultants, but it is placing strong emphasis on the training of its staff through joint work with these consultants and through training programs financed by UNDP, EIB and IDA.

38. Training financed under the Petroleum Exploration Promotion Project through January 1982 includes that of 28 trainees in such fields as geophysics, exploration geology and petroleum engineering and of four participants in other relevant seminars. This formal training, together with on-the-job training provided by the consultants, has resulted in a substantial increase of knowledge of OMNIS staff on petroleum matters during the past two years. Intensive training will continue until completion of the Petroleum Exploration Promotion Project in 1983. The proposed project would also provide specialized training in laboratory analysis and testing of heavy oil samples.

39. Of OMNIS' total capital expenditures of FMG 1,437 million (US\$7 million) in 1980, over 54 percent represented petroleum-related investment (including research on the bituminous sandstones of Bemolanga). About 45 percent was for investments in radioactive mineral research and related equipment, and another one percent of capital expenditures was related to energy planning efforts. Petroleum's share of OMNIS' capital expenditures over the next few years is expected to rise substantially. For current expenditure needs, OMNIS is financed by direct transfers from the Government's

budget; its capital expenditures are financed by allocations of the National Economic Development Fund (the financing vehicle for capital investment in public sector enterprises) and external sources. Direct Government transfers in 1980 totaled about US\$6.0 million, while transfers on account of EIB and IDA credits were US\$1.7 million.

40. Hydrocarbon-related Geology and Exploration History. Nearly three quarters of Madagascar consists of an old crystalline core. This igneous area is flanked by two sedimentary basins which are prospective for oil and gas. The largest of these is in the west, the Morondava Basin, and the other is in the north, the Mahajanga Basin. The total sedimentary land area of these basins is 170,000 km². Both basins extend offshore under the Mozambique Channel. The shelf area (0-200 m) is 80,000 km²; the deep water area (200-2,000 m), which may be found to be prospective in future years, covers another 50,000 km². Madagascar has long been known as a country with prospects for commercial oil or gas discoveries. All the elements for oil generation and accumulation exist to some degree: thick sedimentary sections, plentiful structures (mainly fault-related) and surface oil shows in the form of tar sands and heavy oil indicating the presence of hydrocarbon sourcebeds. The geology of the region is complicated, however, by the existence of impermeable igneous dykes which cut across prospective formations.

41. Most exploration in the country to date has been carried out in the Morondava Basin, where the best oil shows have been found. A feature of the basin, which has attracted oil companies since early in the century, is the occurrence of widespread and thick deposits of bitumen-saturated sandstone and heavy oil in the Bemolanga-Tsimiroro area. The reservoir for these deposits is the Isalo formation of the Karroo series, a widespread sedimentary sequence of Triassic and Lower Jurassic age and also the oldest sedimentary layer found in Madagascar. The volume of oil equivalent in place in the deposits known with certainty can be measured in the billions of barrels, which is sizeable, but extraction of these hydrocarbons from the reservoir rock is difficult. The fact that the Isalo formation is presumed to underlie the whole sediment-covered portion of western and northern Madagascar encouraged foreign oil companies in the past to move westward and northward toward the coast to explore for this formation in the subsurface in the hope of finding light oil. Seismic and drilling programs were undertaken during several periods, the most recent being the decade 1965-1974 when eight major international oil companies were active in the area. While favorable stratigraphy and hydrocarbon shows (both oil and gas) were encountered, no discoveries were made under the limited drilling which was done; moreover, many of these wells were drilled prior to the advent of modern seismic techniques (great technical progress has been made in the last ten years). Hence, only a few wells tested targeted stratigraphic traps, and some were not drilled sufficiently deep to test all possible accumulations. By 1975, however, most companies had left the country, preferring to concentrate funds and manpower on the large successful finds in the North Sea and Far East than in Madagascar, where no discoveries had yet been made, costs were high and the political climate had changed. Yet, it was clear to these explorationists that more work was

demanded before the production potential of the country could be confirmed or refuted. From 1975 to 1980, no international oil company was involved in Madagascar as the country was virtually closed to such companies.

42. Government Strategy in Petroleum. In the wake of the major oil price increase in 1979, the Government sought IDA assistance to accelerate petroleum exploration, originally by helping finance drilling by OMNIS in the Morondava Basin. In view of the high risk involved and the lack of experienced personnel within OMNIS, the Government agreed with IDA's view that a more efficient way of accelerating exploration was to attract foreign oil companies, which have the necessary technical, financial and human resources. The Government, therefore, decided to entrust exploration of conventional light oil to foreign oil companies, while having OMNIS study the heavy oil accumulation at Tsimiroro and the Bemolanga tar sands with a view to assessing their commercial potential.

Petroleum Exploration Promotion Project (Credit 1016-MAG)

43. To support this Government policy, IDA made a US\$12.5 million credit to the Government of Madagascar in May 1980 for a Petroleum Exploration Promotion Project. This was the first such project approved by IDA's Board. The project's objectives have been (a) to assist the Government in attracting foreign petroleum companies for exploration and development of petroleum resources; (b) to further study the economic feasibility of exploiting the heavy oil deposit of Tsimiroro and the Bemolanga tar sands; and (c) to lay the basis for energy planning. The project included technical and legal assistance, geophysical surveys, an energy sector study and studies related to the Tsimiroro deposit and Bemolanga tar sands. OMNIS has made substantial progress in implementing the project. Disbursements as of July 1982 were US\$4.4 million. Much of the remaining funds are committed for a reconnaissance seismic survey, LANDSAT interpretation and consultant services in respect of a second round of bidding for acreage. Progress on the various components is reviewed below.

44. Exploration Promotion. OMNIS has been successful in promoting exploration by foreign oil companies. With the assistance of legal consultants (Coudert Freres of France and Gambos of the UK) and the advice of IDA staff, it prepared a petroleum code and a fiscal framework, which was enacted in November 1980. In June 1980, OMNIS distributed widely a geological report prepared by Petroconsultants (Switzerland) and put up four blocks for exploration contracts. Industry response was good, confirming the promise of the country's geology. Ten companies made proposals. In December 1981, OMNIS signed exploration contracts with two major oil companies, Mobil (US) and Occidental Petroleum (US), covering exploration acreage of 36,000 km² offshore and 21,500 km² onshore respectively. In April 1982, OMNIS signed an exploration contract with Agip (Italy) covering acreage onshore and offshore of 22,400 km². Then, in July 1982, OMNIS signed an exploration contract with AMOCO (US) covering 22,650 km² onshore (map 14787R). Two of the companies have already commenced seismic work.

45. Meanwhile, OMNIS has contracted GSI (US) to undertake a reconnaissance seismic survey over the Morombe region, covering the southwestern part of the Morondava basin and an area not yet taken up by a private oil company. GSI started work on the 813 km survey in May 1982 and expects to complete it in October 1982. With the results of the Morombe survey and the reinterpretation of existing seismic data on both the Morondava and Mahajanga basins, all financed by IDA, OMNIS plans to launch a second round of bidding for exploration contracts covering outstanding prospective acreage. It will, of course, use the legal and fiscal framework which has evolved successfully from the previous round of negotiations with major oil companies.

46. Energy Planning. In September 1981, Motor Columbus (Switzerland) submitted a draft report on the energy sector in Madagascar (para. 28), which was reviewed and discussed between OMNIS and IDA in November 1981. A draft final report was submitted in May 1982. During negotiations for the proposed project, OMNIS and IDA discussed the recommendations of the report and further steps to be taken for their implementation.

47. Tar Sands Research. In early 1981, the Government asked IDA to join with the European Investment Bank (EIB) in financing the study of a bitumen extraction process for the Bemolanga tar sands. Considerable work financed by EIB had already been done on the geology of the region and on extraction processes. In September 1981, IDA agreed to reallocate US\$500,000 from the engineering study of Tsimiroro heavy oil (para. 51) to finance the further study of a bitumen extraction process jointly with EIB. The Board of IDA was notified accordingly. OMNIS hired INGECO (an Italian firm which had done previous work on the process) to study a modified hot water process for bitumen extraction and the necessary on-site upgrading. These consultants submitted their draft final report by September 1982. In addition, EIB was financing a study of the mining and crushing phase, which was also completed at that time. The studies showed that any development at forecast cost and price levels and with existing technology, are unlikely to be feasible, since costs are likely to exceed benefits.

Background on the Tsimiroro Heavy Oil Deposit and Origin of the Proposed Project

48. The Petroleum Exploration Promotion Project also included financing for an assessment of the Tsimiroro heavy oil deposit to investigate the economic feasibility of pilot production. This large deposit has been known since the early 1900s, and several oil companies have drilled in the area, the last one being Chevron in the early 70s. Although valuable stratigraphic and petrographic data were obtained and a number of heavy oil impregnations were found as a result of these efforts, insufficient coring and testing were undertaken to confirm with any certainty the deposit's potential to produce hydrocarbons in sufficient quantity to justify development. The geology of Tsimiroro, its exploration history and technical aspects of heavy oil exploitation are discussed in detail in Annex IV.

49. There are possibly as much as 4.8 billion barrels of oil-in-place in the Tsimiroro region, of which up to 1 billion would, theoretically, be recoverable. Heavy oil is very viscous, with a gravity of less than 20 degrees API. Thus, it must be thermically stimulated, by steam injection or in-situ combustion, to reduce the viscosity of the oil and thereby induce production; there are cases, however, where heavy oil has been produced by natural flow from the reservoir. Naturally, the characteristics of the reservoir are crucial in determining whether and by what method the heavy oil can be produced. The development of heavy oil involves three phases: (a) initial exploration drilling and subsequent testing of promising reservoirs to identify zones with the potential for production; (b) pilot production to test the responsiveness of the oil to thermal recovery methods; and (c) if justified, expansion of the pilot operation to a commercial level. Commercial production of heavy oil presently takes place in the U.S. (particularly in California, Texas and Louisiana), Canada and Venezuela.

50. Consultant Studies. Under the Petroleum Exploration Promotion Project, OMNIS hired the D&S Group of Canada (D&S) to carry out a review of existing data on the Tsimiroro deposit. They concluded in January 1981 that an extensive exploration program was necessary before considering pilot production. The program they recommended included the core drilling and testing of ten wells in potential oil-bearing formations of a sandstone and shale sequence of the Karroo located throughout the Tsimiroro area. The objective would be to identify those areas with the potential for production and to undertake a complete analysis of reservoir properties.

51. D&S was then asked to study the logistics and costs of such a ten-well exploration program. That study was completed in June 1981 on the assumption that drilling would be carried out by a drilling contractor. It concluded that the logistics of the program would be challenging, due to its special nature and the isolation of the area of operations, although not extraordinary compared to many other exploration projects in the world. All equipment and materials would be collected outside the country and shipped to Maintirano, the port closest to Tsimiroro (map 16323), where they would then be transported to the drilling site, a distance of 140 km across rugged terrain under poor road conditions. The cost of the program was estimated by D&S to be about US\$12 million (in 1982 prices). Yet, the Petroleum Exploration Promotion Project included only US\$1.5 million for the Tsimiroro component. That provision was based on a rough estimate, using the available information at the time; it underestimated the logistics involved, the number of wells, the quality of the rig and the tests required. Hence, it became evident that additional financing would be necessary to evaluate the Tsimiroro deposit. As of August 1982 about US\$1.0 million of the Tsimiroro component was committed for study of bitumen extraction (US\$500,000, para. 47) and consultants services by D & S (US\$500,000 paras. 50 to 52). The balance would be transferred to unallocated.

52. Promotion of Project to the Private Oil Industry. In view of the costs and logistics involved, OMNIS decided to try to find foreign partners with the required experience to help finance and implement the proposed

drilling program (and a potential future pilot project). With the assistance of D&S, it promoted the project to private oil companies. In September 1981, D&S, on behalf of OMNIS, advertised the project in international petroleum magazines and distributed an information package on Tsimiroro to about 90 companies in North America, Europe, Japan and some appropriate developing countries. Twenty six companies inquired about the project, and twenty-one companies were given detailed presentations by D&S. Most of these companies stated that they needed more information on the petrophysical characteristics of the reservoir, which is exactly the type of information to be collected by the proposed project. The deadline for submission of proposals was March 1982; no company made a formal proposal.

53. This lack of industry interest reflects primarily the lack of good data on the deposit from former operations, which indicated acceptable reservoir properties but also possible impediments to efficient exploitation, such as dykes, clays and low oil saturations in some places; existing data do not permit abandonment of the deposit nor do they fully endorse exploitation. Other factors were (a) the recent slowdown in exploration investment due to uncertainties concerning oil prices, an environment which is particularly discouraging for new heavy oil exploration; and (b) concern over the size of the investment and long gestation period to explore and later develop a relatively little known heavy oil deposit in an unfamiliar developing country. This industry attitude does not invalidate the project. It shows that existing data are insufficient to attract private sector interest at this stage, and further positive data must be established prior to getting a clear industry response to subsequent phases in development of the deposit.

54. The Proposed Project in View of Madagascar's Oil Development Strategy. The Tsimiroro heavy oil project has to be seen in the light of the overall strategy for development of the country's hydrocarbon potential. The Government has successfully launched exploration promotion, and as a direct result four companies have signed exploration contracts (para. 44). Therefore, the question arises whether the heavy oil project should be postponed until the search for conventional oil has been concluded, since a commercial light oil discovery would reduce the urgency to seek commercial development of the Tsimiroro deposit. It is unlikely, however, that any drilling will commence until 1984/85, and drilling could go on until 1988/90 under the agreements signed by OMNIS. Moreover, there is no assurance that any such drilling would result in commercial discoveries. If a discovery is made, it would take time to confirm reserves and then, if warranted, develop the fields. In the meantime, valuable time would be lost in establishing the potential of the Tsimiroro deposit, particularly in view of the long gestation period for development of heavy oil (7-10 years). The approach followed by OMNIS, i.e. promoting exploration by foreign oil companies and simultaneously undertaking a systematic study of the potential for exploitation of heavy oil and tar sands, is therefore both rational and prudent at this stage of knowledge of the country's hydrocarbon potential.

55. Another question is whether the project should be postponed until

industry interest increases. Given the present lack of data on Tsimiroro and other, better defined exploration prospects worldwide, it is uncertain whether any private company will be interested in undertaking this exploration project in the near future, even if the world market situation becomes strong again. Therefore, it makes sense from a national point of view for Madagascar to go ahead and complete the exploration phase now, by undertaking the minimum size drilling program considered prudent, to confirm the potential of its heavy oil deposit and, hopefully, generate sufficient data to attract needed oil company participation in a pilot production project. Indeed, OMNIS intends to compile the results of the drilling program in a report which it would sell to interested oil companies; this would serve as a basis for again promoting the Tsimiroro deposit to private industry after the initial exploration stage.

IDA's Role

56. IDA's role in the petroleum subsector would be (a) to continue to help Madagascar to accelerate the discovery of hydrocarbons and possible development of domestic supplies through active promotion of attractive acreage to foreign oil companies (for this sufficient funds are available from the Credit 1216-MAG); (b) to assist in investigating the country's known heavy oil and tar sands resources; and (c) to strengthen OMNIS as an institution capable of promoting and monitoring hydrocarbon development efficiently. The proposed project would help finance a continuation of the efforts supported in the last two years by the Petroleum Exploration Promotion Project.

PART IV - THE PROJECT

57. The project was appraised during visits of OMNIS representatives to Washington, September 28 to October 7, 1981, and of Bank staff to Madagascar, December 7 to 14, 1981. Negotiations were held in Washington on September 16 and 17, 1982; the Malagasy delegation was led by Colonel Andrianasolo. A map of Madagascar showing the project area is attached (IBRD 16324).

Project Objectives

58. The project would continue to support the Government's efforts to establish the economic feasibility of exploiting the already proven Tsimiroro heavy oil accumulation. At this stage, private sector interest in the project is low primarily because of lack of reliable data. The project would gather this data with the intention of attracting private sector interest in a subsequent pilot project and possibly eventual commercial production. The project would also continue to support the institutional upgrading of OMNIS through further training of its professional staff.

Project Description

59. The proposed project would include: (a) exploration of the Tsimiroro heavy oil deposit; (b) an engineering study for a future pilot plant at Tsimiroro; (c) a related study of the feasibility of upgrading the heavy oil, and (d) training of professionals from OMNIS.

60. Tsimiroro Exploration. The Tsimiroro heavy oil exploration program is the first phase in assessing the feasibility of heavy oil production from the extensive Tsimiroro deposit. It would consist of drilling and thoroughly testing ten wells to identify those areas, if any, which have the potential for primary production or, more likely, enhanced production through steam flooding or other stimulation techniques. The wells would be drilled to an average depth of 1,200 feet (400m); the most promising sandstone reservoir in the Isalo formation is expected to be found at depths of 1,200 feet or less (Map 3). Given the large Tsimiroro area and erratic distribution of oil concentrations, the ten well program is considered the minimum reasonable for identifying those areas with the best potential for production (i.e. where thick zones of highly impregnated reservoir sands exist). Well locations would be somewhat flexible, the location of later wells being subject to change if warranted by the results of earlier wells. IDA would approve the initial drilling program and any subsequent changes in well locations (Section 2.05(b), Draft Project Agreement). Core samples would be taken at all potential oil-bearing formations in each well, and the cores would be shipped to specialized laboratories for a complete analysis of reservoir properties and fluids. The wells would be logged using conventional electrical logging methods and equipment. If the preliminary coring and logging results indicate recovery potential, the wells would be cased and cemented. This would permit testing of the well's primary production potential and the running of injectivity and pressure transient tests which would give further information about reservoir characteristics. These same wells could then be used later for steam injection. The drilling program would be carried out in the dry season of 1983 (May to November). D & S would document the results of the drilling program in a comprehensive report, which would be sold to interested private oil companies.

61. Additional Studies and Training. Two additional studies are included in the project. If a pilot project for Tsimiroro is justified, its preparation would require an engineering study that would include plant site selection, mathematical simulations of thermal recovery techniques and preliminary facility and process designs. At the same time, the feasibility and logistics of upgrading the heavy oil under various processes would be investigated; on-site upgrading is necessary for ease in transport and to achieve a quality of oil suitable for export or as feedstock for the domestic refinery. The project, therefore, includes these two studies, but disbursement for the studies would be subject to IDA's review of the results of the exploratory drilling (Credit Agreement, Schedule 1, para. 3(b)). The results of these studies would be part of the information package sold to interested companies. The training component would finance specialised training abroad for about 12 professionals from OMNIS for about six months

each. The training program has been discussed and agreed with OMNIS, taking into account the training already carried out and planned under the Petroleum Exploration Promotion Project.

Project Implementation

62. OMNIS, which would enter into a project agreement with IDA, would hire a drilling contractor to carry out the drilling program, including the supply of supporting services (such as well services), well materials, consumables and personnel. The mobilization effort would be significant. The exploration program would require the leasing of a drilling crew, a small drilling rig capable of drilling up to 3,000 feet and ancillary equipment, such as a trailer for transporting the rig, bulldozers, trucks and camp equipment. Materials, such as drilling mud, cement, tubular goods and bits would be purchased. All equipment and materials would be collected at an optimum shipping point overseas for packing, crating and shipping to Maintirano on the island's west coast. Due to inadequate docking facilities there, a shallow draft vessel would be used to bring the shipment directly to the beach. It would then be transported by truck the 140 km to Tsimiroro. Drilling operations would begin within three months of offloading. OMNIS would supply by truck from Maintirano all fuel required during the program, estimated at some 4,000 barrels.

63. Laboratory work would be contracted to specialized firms. D&S would remain as a consultant to OMNIS during the project period to supervise the implementation of the project and to analyze and compile the petrophysical and geological data generated by the drilling program. OMNIS would probably contract D&S consultants to carry out the engineering study for the Tsimiroro pilot operation and contract a separate consultant for the feasibility study of heavy oil upgrading. Training would be conducted at appropriate petroleum institutes. During negotiations IDA would obtain assurances from OMNIS concerning the employment of consultants satisfactory to IDA (Section 2.02, draft Project Agreement). Proceeds from the sale of data collected during the project to interested oil companies (para. 60) would be kept in a special account and used for further petroleum exploration (Section 4.03, draft Project Agreement).

Project Cost

64. Total project cost, net of taxes which are not applicable, is estimated at US\$18.0 million equivalent. The cost estimates of the Tsimiroro heavy oil exploration component are based on April 1982 prices and include 30 percent physical contingencies, given that the exact extent of the drilling program will be defined as the project progresses and given the risks involved in an operation of the type proposed, which is likely to be reflected in the contract price. The consultant services for the drilling program, the

engineering study for the pilot plant and the upgrading study are estimated to require 26, 65 and 13 man-months respectively. One man-month is estimated to cost an average of US\$15,000 including travel, subsistence and overhead. This amount is reasonable, taking into account the high level of expertise required and salaries prevailing in the petroleum industry. One man-month of training is estimated to cost US\$4,200 including travel, subsistence and tuition; salaries would be paid by OMNIS. The cost estimates include price contingencies of 8.5 percent for 1982 and 7.5 percent from 1983 through 1985, for foreign and local costs.

Financing Plan

65. The proposed IDA credit of US\$11.5 million would finance 64 percent of the total project cost; it would be used for foreign exchange expenditures including indirect foreign exchange costs related to travel expenses for the project trainees. The Credit would be made to the Government which would pass on the funds to OMNIS as a grant. The OPEC Fund has agreed to make a US\$5 million loan for the project for joint financing, covering 28 percent of the total project cost. The OPEC loan proposal is expected to be submitted to its Board in November 1982. A cross effectiveness clause has not been included in the legal agreements to allow disbursement of IDA funds before effectiveness of the OPEC loan. However, signature of the OPEC loan would be a condition of effectiveness (Section 5.01 of draft Credit Agreement). The Government would finance the full local costs of US\$1.5 million, or about eight percent of the total project cost.

66. In January 1982, Petrocanada International Assistance Corporation (PCIAC), which is a newly established development aid institution for the energy field, also indicated some interest in participating in the project to an amount of US\$1-2 million. PCIAC has been unable to confirm interest because their 1983/84 budget is still under preparation. Given this uncertainty and the project's time constraints, this project was processed on the basis that no funds will be available from PCIAC. Should PCIAC still decide in 1983/84 to participate in some of the financing of the project, OMNIS would be able to accommodate PCIAC's participation, (for instance for laboratory analysis, studies), and consideration would be given to reducing the IDA credit.

Procurement and Disbursement

67. The drilling contractor would be selected following ICB procedures according to World Bank/IDA guidelines and would be responsible for providing the drilling rig, crew, camp, equipment, material and services. Consultants

for the supervision of the contractor on behalf of OMNIS, the laboratory work and studies would be selected in accordance with IDA guidelines for the use of consultants and be employed on terms and conditions satisfactory to IDA (Section 2.02, draft Project Agreement). Given D&S' past involvement with the project, it is likely and reasonable that OMNIS would select them for supervision of the project (para. 63). IDA disbursements would be for 70 percent of foreign expenditures except in the case of training where disbursements would be for 70 percent of total expenditures; OPEC disbursements would be for 30 percent of foreign and total expenditures, respectively.

Accounting, Auditing and Reporting

68. At present, OMNIS keeps separate project accounts. An external auditor acceptable to OMNIS and the Association is auditing the project's and OMNIS' accounts annually under the Petroleum Exploration Promotion Project. OMNIS agreed to submit annual reports to the Association not later than five months after the closing of its fiscal year and submitted them on time in the past. These arrangements would be maintained (Section 4.02, draft Project Agreement). OMNIS would also submit quarterly and annual reports on the implementation of the project in a format acceptable to the Association. After completion of the project, OMNIS would prepare a report on the execution of the project.

Environmental Impact

69. The proposed project comprises a small drilling program which carries little risk of an adverse environmental impact. All drilling will, of course, be conducted according to industry-accepted safety procedures.

Project Justification

70. The proposed 10-well exploration program would be only a preliminary phase in evaluating the feasibility of heavy oil production at Tsimiroro. It represents the minimum reasonable program to confirm those areas which have the potential for production and hopefully generate sufficient positive data to attract necessary private oil company participation in subsequent phases of development of the deposit.

71. Future Phases of Heavy Oil Development. By about 1985, if the results of this project warrant it, OMNIS would seek a private partner to participate with it in a second phase, which would consist of a pilot project testing enhanced production (most likely through steam flooding). This would involve an expanded drilling program, purchase of steam generating and pumping equipment, water treatment facilities, high pressure distribution systems and an oil-gathering system. Financing of a detailed study of the pilot project is included in the proposed credit if results of the exploration phase justify it (para. 61). The cost of a pilot project would be US\$20-30 million; thus, it would require the participation of a private oil company, which has the

financial resources and technical experience in heavy oil development. To finance its share, OMNIS would likely seek a possible third IDA credit.

72. By about 1987, if the pilot project determined the economic viability of steam-induced production, OMNIS, in cooperation with participating oil companies, could proceed to the third phase and expand the pilot operation to commercial levels. It is unlikely that this would occur, however, if light oil exploration has been successful or seems very promising at that point, given that Madagascar's investment budget is rather small compared to the investments required. The investment costs for commercial production would vary widely depending on the reservoir characteristics found and on the size of the project. Traditionally, heavy oil projects have been conceived on a large multi-billion dollar scale. Lately, however, research has concentrated on smaller units. The oil produced would likely be exported because its quality may not fit the configuration of the domestic refinery.

73. Economics of Potential Commercial Production. D&S has run sensitivity analyses for a 5000 BD project in Tsimiroro by adapting data from a recently completed study of a similar project in Alberta, Canada (refer to Annex IV). The presently known reservoir characteristics of the Tsimiroro deposit are slightly more favorable than those found in Alberta, but the investment and operating costs to exploit the deposit would be substantially higher in Madagascar. The production module used for the analysis included 150 wells, central and satellite facilities, full upgrading facilities and a pipeline to the coast. The cost of the module under Alberta conditions was estimated at US\$290 million in 1982 prices. A number of cases were then run using different cost factors for converting Alberta costs to Madagascar costs. Capital costs were increased by 50 percent to 150 percent and operating costs by 30 percent to 100 percent. Revenues for the upgraded crude were based on the Bank's projected price per barrel in constant 1981 dollar terms; this assumes a 2-2.5 percent p.a. real growth rate. The cost stream was also deflated to constant 1981 dollar terms for the analysis. The discounted cash flow rate of return for these cases ranged from 26 percent to 12 percent. Another variation was run assuming a constant oil price of US\$31 per barrel of upgraded crude, where the discounted cash flow rate of return ranged from 16 percent to 1 percent. In the most realistic case of a 100 percent increase in capital costs, a 30 percent increase in operating costs, and a real increase in oil prices, the DCF rate of return was a satisfactory 20 percent. Although this was necessarily a preliminary analysis, it highlights the potential for economically viable commercial production, petrophysical conditions of the deposit permitting.

74. Benefits and Risks of this Project. The primary benefit of the project would be to determine whether there is the potential for commercial exploitation of this very large heavy oil deposit (as much as 4.8 billion barrels of oil-in-place). On the basis of the existing information, the prospects of commercially tapping Tsimiroro are attractive enough to warrant the proposed exploratory drilling. This project must be considered a priority project in the overall economic framework of Madagascar. Although it is not directly productive, it enables the country to evaluate its hydrocarbon potential with the ultimate possibility of achieving some domestic oil production, thus easing the burden to the country of its annual oil imports,

currently valued at US\$120 million. Postponing the project would only delay the necessary acquisition of further data, which, if positive, could be used to develop needed private company interest in a subsequent stage of pilot production. That delay could be significant, given the long gestation period for heavy oil development, if light oil exploration is unsuccessful and the country has to rely on the production of heavy oil as its only source of domestic supplies. The risks associated with the project are that the results may be negative, i.e., that proceeding to a pilot operation and thereafter to commercial exploitation of the deposit would not be considered viable. Given that this project is only the first step towards the potential development of the deposit, this must be considered a high risk project. Given the present dependence of Madagascar on imported oil and existing information on the Tsimiroro heavy oil accumulation, however, the potential benefits outweigh such risks.

PART V - LEGAL INSTRUMENTS AND AUTHORITY

75. The draft Development Credit Agreement between the Democratic Republic of Madagascar and the Association, the draft Project Agreement between the Association and OMNIS, and the Recommendations of the Committee provided for in Article V, Section (d) of the Articles of Agreement of the Association are being distributed separately to the Executive Directors. Special conditions of the credit are listed in Section II of Annex III to this Report.

76. I am satisfied that the proposed credit would comply with the Articles of Agreement of the Association.

PART VI - RECOMMENDATION:

77. I recommend that the Executive Directors approve the proposed credit.

A. W. Clausen
President
By Ernest Stern

Attachments
October 20, 1982

TABLE 3A
MADAGASCAR - SOCIAL INDICATORS DATA SHEET

LAND AREA (THOUSAND SQ. KM.)	MADAGASCAR			REFERENCE GROUPS (WEIGHTED AVERAGES - MOST RECENT ESTIMATE) ^{/a}		
	TOTAL	MOST RECENT		LOW INCOME		MIDDLE INCOME
		1960 /b	1970	/b	ESTIMATE /b	AFRICA SOUTH OF SAHARA	AFRICA SOUTH OF SAHARA
AGRICULTURAL	587.0					
	369.3					
GNP PER CAPITA (US\$)	130.0	190.0	290.0	★	238.3	794.2
ENERGY CONSUMPTION PER CAPITA (KILOGRAMS OF COAL EQUIVALENT)	40.4	72.5	93.8		70.5	707.5
POPULATION AND VITAL STATISTICS						
POPULATION, MID-YEAR (THOUSANDS)	5474.0	6785.0	8480.0	★	.	.
URBAN POPULATION (PERCENT OF TOTAL)	10.6	14.1	17.9		17.5	27.7
POPULATION PROJECTIONS						
POPULATION IN YEAR 2000 (MILLIONS)			15.5		.	.
STATIONARY POPULATION (MILLIONS)			45.0		.	.
YEAR STATIONARY POPULATION IS REACHED			2110		.	.
POPULATION DENSITY						
PER SQ. KM.	9.3	11.6	14.4		27.7	55.0
PER SQ. KM. AGRICULTURAL LAND	15.0	18.0	22.3		73.7	130.7
POPULATION AGE STRUCTURE (PERCENT)						
0-14 YRS.	41.6	42.8	43.6		44.8	46.0
15-64 YRS.	55.2	53.9	53.1		52.4	51.2
65 YRS. AND ABOVE	3.2	3.3	3.3		2.9	2.8
POPULATION GROWTH RATE (PERCENT)						
TOTAL	1.8	2.1	2.5/e		2.6	2.8
URBAN	4.9	5.0	5.1		6.5	5.1
CRUDE BIRTH RATE (PER THOUSAND)	46.6	45.2	45.7		46.9	46.9
CRUDE DEATH RATE (PER THOUSAND)	27.0	21.7	18.0		19.3	15.8
GROSS REPRODUCTION RATE	3.0	3.0	3.2		3.1	3.2
FAMILY PLANNING						
ACCEPTORS, ANNUAL (THOUSANDS)	..	..	..		.	.
USERS (PERCENT OF MARRIED WOMEN)	..	..	..		..	..
FOOD AND NUTRITION						
INDEX OF FOOD PRODUCTION						
PER CAPITA (1969-71=100)	89.0	102.0	96.0		89.5	89.9
PER CAPITA SUPPLY OF						
CALORIES (PERCENT OF REQUIREMENTS)	106.0	108.0	115.0		90.2	92.3
PROTEINS (GRAMS PER DAY)	60.0	60.0	60.0		52.7	52.8
OF WHICH ANIMAL AND PULSE	18.0	17.0	15.0		17.8	16.1
CHILD (AGES 1-4) MORTALITY RATE	41.0	31.3	25.4		27.3	20.2
HEALTH						
LIFE EXPECTANCY AT BIRTH (YEARS)	37.2	42.5	46.9		45.8	50.8
INFANT MORTALITY RATE (PER THOUSAND)	..	177.0/c	..		..	..
ACCESS TO SAFE WATER (PERCENT OF POPULATION)						
TOTAL	..	11.0	26.0		23.9	27.4
URBAN	..	67.0	76.0		55.0	74.3
RURAL	..	1.0	16.0		18.5	12.6
ACCESS TO EXCRETA DISPOSAL (PERCENT OF POPULATION)						
TOTAL	..	..	..		26.2	..
URBAN	..	88.0	..		63.5	..
RURAL	..	..	9.0		20.3	..
POPULATION PER PHYSICIAN	8901.1	10172.4	10242.3		31911.8	13844.1
POPULATION PER NURSING PERSON	3105.0	3353.9	3470.2		3674.9	2898.6
POPULATION PER HOSPITAL BED						
TOTAL	469.0	354.4	402.3		1238.8	1028.4
URBAN	115.0	214.8	239.4		272.8	423.0
RURAL	761.0	475.3	517.9		1745.2	3543.2
ADMISSIONS PER HOSPITAL BED	..	..	..		..	..
HOUSING						
AVERAGE SIZE OF HOUSEHOLD						
TOTAL	..	5.8	4.7		..	..
URBAN	..	5.3	5.0		..	..
RURAL	..	5.9	4.7		..	..
AVERAGE NUMBER OF PERSONS PER ROOM						
TOTAL	..	..	..		..	..
URBAN	..	..	..		..	..
RURAL	..	..	..		..	..
ACCESS TO ELECTRICITY (PERCENT OF DWELLINGS)						
TOTAL	..	5.0	..		..	..
URBAN	..	..	..		..	..
RURAL	..	..	..		..	..

TABLE JA
MADAGASCAR - SOCIAL INDICATORS DATA SHEET

	MADAGASCAR			REFERENCE GROUPS (WEIGHTED AVERAGES - MOST RECENT ESTIMATE) ^{/a}		
	1960	MOST RECENT		LOW INCOME	MIDDLE INCOME	
		/b	1970			/b ESTIMATE	/b
				AFRICA SOUTH OF SAHARA	AFRICA SOUTH OF SAHARA	
EDUCATION						
ADJUSTED ENROLLMENT RATIOS						
PRIMARY:	TOTAL	52.0	88.0	94.0	56.4	73.7
	MALE	58.0	95.0	100.0	70.7	96.8
	FEMALE	45.0	81.0	87.0	50.1	79.0
SECONDARY:	TOTAL	4.0	11.0	12.0	10.0	16.2
	MALE	5.0	13.0	14.0	13.6	25.3
	FEMALE	3.0	9.0	10.0	6.6	14.8
VOCATIONAL ENROL. (% OF SECONDARY)		9.0	9.0	..	8.0	5.3
PUPIL-TEACHER RATIO						
	PRIMARY	70.0	65.0	55.0	46.5	36.2
	SECONDARY	24.0	20.0	..	25.5	23.6
ADULT LITERACY RATE (PERCENT)		..	39.0	50.0	25.5	..
CONSUMPTION						
PASSENGER CARS PER THOUSAND	POPULATION	4.0	6.8	7.1	2.9	32.3
RADIO RECEIVERS PER THOUSAND	POPULATION	15.0	79.7	127.0	32.8	69.0
TV RECEIVERS PER THOUSAND	POPULATION	..	0.5	1.5	1.9	8.0
NEWSPAPER ("DAILY GENERAL INTEREST") CIRCULATION PER THOUSAND POPULATION		8.0	7.8	9.0	2.8	20.2
CINEMA ANNUAL ATTENDANCE PER CAPITA		0.5	0.7	0.4	1.2	0.7
LABOR FORCE						
TOTAL LABOR FORCE (THOUSANDS)		3046.1	3619.9	4321.3	.	.
	FEMALE (PERCENT)	46.9	46.1	45.4	34.1	36.7
	AGRICULTURE (PERCENT)	92.8	90.0	87.4	80.0	56.6
	INDUSTRY (PERCENT)	2.0	3.0	3.9	8.6	17.5
PARTICIPATION RATE (PERCENT)						
TOTAL		55.6	53.4	51.0	41.7	37.2
	MALE	60.7	58.8	56.6	34.3	47.1
	FEMALE	50.9	48.2	45.5	29.2	27.5
ECONOMIC DEPENDENCY RATIO		0.8	0.9	0.9	1.2	1.3
INCOME DISTRIBUTION						
PERCENT OF PRIVATE INCOME RECEIVED BY						
	HIGHEST 5 PERCENT OF HOUSEHOLDS	41.0/d	..	..	..	..
	HIGHEST 20 PERCENT OF HOUSEHOLDS	60.1/d	..	..	..	..
	LOWEST 20 PERCENT OF HOUSEHOLDS	5.2/d	..	..	..	..
	LOWEST 40 PERCENT OF HOUSEHOLDS	13.0/d	..	..	..	..
POVERTY TARGET GROUPS						
ESTIMATED ABSOLUTE POVERTY INCOME LEVEL (US\$ PER CAPITA)						
	URBAN	..	..	150.0	136.0	381.2
	RURAL	..	..	86.0	84.5	156.2
ESTIMATED RELATIVE POVERTY INCOME LEVEL (US\$ PER CAPITA)						
	URBAN	..	..	135.0	99.1	334.3
	RURAL	..	..	86.0	61.2	137.6
ESTIMATED POPULATION BELOW ABSOLUTE POVERTY INCOME LEVEL (PERCENT)						
	URBAN	..	..	50.0	39.7	..
	RURAL	..	..	50.0	68.8	..

.. Not available
 . Not applicable.

NOTES

/a The group averages for each indicator are population-weighted arithmetic means. Coverage of countries among the indicators depends on availability of data and is not uniform.

/b Unless otherwise noted, data for 1960 refer to any year between 1959 and 1961; for 1970, between 1969 and 1971; and for Most Recent Estimate, between 1976 and 1979.

/c 1965-66; /d Population; /e Recent population growth estimate is 2.8% for 1975-79.

* The updated 1980 GNP per capita and population estimates to be shown in the 1981 World Bank Atlas are \$350 (at 1978-80 prices) and 8714.0 thousands.

May, 1981

DEFINITIONS OF SOCIAL INDICATORS

Notes: Although the data are drawn from sources generally judged the most authoritative and reliable, it should also be noted that they may not be internationally comparable because of the lack of standardized definitions and concepts used by different countries in collecting the data. The data are, nonetheless, useful to describe orders of magnitude, indicate trends, and characterize certain major differences between countries.

The reference groups are (1) the same country group of the subject country and (2) a country group with somewhat higher average income than the country group of the subject country (except for "Capital Surplus Oil Exporters" group where "Middle Income North Africa and Middle East" is chosen because of stronger socio-cultural affinities). In the reference group data the averages are population weighted arithmetic means for each indicator and shown only when majority of the countries in a group has data for that indicator. Since the coverage of countries among the indicators depends on the availability of data and is not uniform, caution must be exercised in relating averages of one indicator to another. These averages are only useful in comparing the value of one indicator at a time among the country and reference groups.

LAND AREA (thousand sq.km.)

Total - Total surface area comprising land area and inland waters.

Agricultural - Estimate of agricultural area used temporarily or permanently for crops, pastures, market and kitchen gardens or to lie fallow; 1978 data.

GNP PER CAPITA (US\$) - GNP per capita estimates at current market prices, calculated by same conversion method as World Bank Atlas (1977-79 basis); 1960, 1970, and 1979 data.

ENERGY CONSUMPTION PER CAPITA - Annual consumption of commercial energy (coal and lignite, petroleum, natural gas and hydro-, nuclear and geothermal electricity) in kilogramme of coal equivalent per capita; 1960, 1970, and 1979 data.

POPULATION AND VITAL STATISTICS

Total Population, Mid-Year (thousands) - As of July 1; 1960, 1970, and 1979 data.

Urban Population (percent of total) - Ratio of urban to total population; different definitions of urban areas may affect comparability of data among countries; 1960, 1970, and 1979 data.

Population Projections

Population in year 2000 - Current population projections are based on 1980 total population by age and sex and their mortality and fertility rates. Projection parameters for mortality rates comprise of three levels assuming life expectancy at birth increasing with country's per capita income level, and female life expectancy stabilizing at 77.5 years. The parameters for fertility rate also have three levels assuming decline in fertility according to income level and past family planning performance. Each country is then assigned one of these nine combinations of mortality and fertility trends for projection purposes.

Stationary population - In a stationary population there is no growth since the birth rate, and also the age structure, remains constant. This is achieved only after fertility rates decline to the replacement level of unit net reproduction rate, when each generation of women replaces itself exactly. The stationary population size was estimated on the basis of the projected characteristics of the population in the year 2000, and the rate of decline of fertility rate to replacement level.

Year stationary population is reached - The year when stationary population size has been reached.

Population Density

Per sq. km. - Mid-year population per square kilometer (100 hectares) of total area; 1960, 1970 and 1979 data.

Per sq. km. agricultural land - Computed as above for agricultural land only; 1960, 1970 and 1978 data.

Population Age Structure (percent) - Children (0-14 years), working-age (15-64 years) and retired (65 years and over) as percentages of mid-year population; 1960, 1970, and 1979 data.

Population Growth Rate (percent) - total - Annual growth rates of total mid-year populations for 1950-60, 1960-70, and 1970-79.

Population Growth Rate (percent) - urban - Annual growth rates of urban populations for 1950-60, 1960-70, and 1970-79.

Crude Birth Rate (per thousand) - Annual live births per thousand of mid-year population; 1960, 1970, and 1979 data.

Crude Death Rate (per thousand) - Annual deaths per thousands of mid-year population; 1960, 1970, and 1979 data.

Gross Reproduction Rate - Average number of daughters a woman will bear in her normal reproductive period if she experiences present age-specific fertility rates; usually five-year averages ending in 1960, 1970, and 1979.

Family Planning - Acceptors, Annual (thousands) - Annual number of acceptors of birth-control devices under auspices of national family planning program.

Family Planning Users (percent of married women) - Percentage of married women of child-bearing age (15-44 years) who use birth-control devices to all married women in same age group.

FOOD AND NUTRITION

Index of Food Production per Capita (1969-71=100) - Index of per capita annual production of all food commodities. Production excludes seed and feed and is on calendar year basis. Commodities cover primary goods (e.g. sugarcane instead of sugar) which are edible and contain nutrients (e.g. coffee and tea are excluded). Aggregate production of each country is based on national average producer price weights; 1961-65, 1970, and 1979 data.

Per capita supply of calories (percent of requirements) - Computed from energy equivalent of net food supplies available in country per capita per day. Available supplies comprise domestic production, imports less exports, and changes in stock. Net supplies exclude animal feed, seeds, quantities used in food processing, and losses in distribution. Requirements were estimated by FAO based on physiological needs for normal activity and health considering environmental temperature, body weights, age and sex distribution of population, and allowing 10 percent for waste at household level; 1961-65, 1970, and 1977 data.

Per capita supply of protein (grams per day) - Protein content of per capita net supply of food per day. Net supply of food is defined as above. Requirements for all countries established by USDA provide for minimum allowance of 60 grams of total protein per day and 20 grams of animal and pulse protein, of which 10 grams should be animal protein. These standards are lower than those of 75 grams of total protein and 23 grams of animal protein as an average for the world, proposed by FAO in the Third World Food Survey; 1961-65, 1970 and 1977 data.

Per capita protein supply from animal and pulse - Protein supply of food derived from animals and pulses in grams per day; 1961-65, 1970 and 1977 data.

Child (ages 1-4) Mortality Rate (per thousand) - Annual deaths per thousand in age group 1-4 years, to children in this age group; for most developing countries data derived from life tables; 1960, 1970 and 1979 data.

HEALTH

Life Expectancy at Birth (years) - Average number of years of life remaining at birth; 1960, 1970 and 1979 data.

Infant Mortality Rate (per thousand) - Annual deaths of infants under one year of age per thousand live births.

Access to Safe Water (percent of population) - total, urban, and rural - Number of people (total, urban, and rural) with reasonable access to safe water supply (includes treated surface waters or untreated but uncontaminated water such as that from protected boreholes, springs, and sanitary wells) as percentages of their respective populations. In an urban area a public fountain or standpost located not more than 200 meters from a house may be considered as being within reasonable access of that house. In rural areas reasonable access would imply that the housewife or members of the household do not have to spend a disproportionate part of the day in fetching the family's water needs.

Access to Excreta Disposal (percent of population) - total, urban, and rural - Number of people (total, urban, and rural) served by excreta disposal as percentages of their respective populations. Excreta disposal may include the collection and disposal, with or without treatment, of human excreta and waste-water by water-borne systems or the use of pit privies and similar installations.

Population per Physician - Population divided by number of practicing physicians qualified from a medical school at university level.

Population per Nursing Person - Population divided by number of practicing male and female graduate nurses, practical nurses, and assistant nurses.

Population per Hospital Bed - total, urban, and rural - Population (total, urban, and rural) divided by their respective number of hospital beds available in public and private general and specialized hospital and rehabilitation centers. Hospitals are establishments permanently staffed by at least one physician. Establishments providing principally custodial care are not included. Rural hospitals, however, include health and medical centers not permanently staffed by a physician (but by a medical assistant, nurse, midwife, etc.) which offer in-patient accommodation and provide a limited range of medical facilities. For statistical purposes urban hospitals include WHO's principal/general hospitals, and rural hospitals local or rural hospitals and medical and maternity centers. Specialized hospitals are included only under total.

Admissions per Hospital Bed - Total number of admissions to or discharges from hospitals divided by the number of beds.

HOUSING

Average Size of Household (persons per household) - total, urban, and rural -

A household consists of a group of individuals who share living quarters and their main meals. A boarder or lodger may or may not be included in the household for statistical purposes.

Average number of persons per room - total, urban, and rural - Average number of persons per room in all urban, and rural occupied conventional dwellings, respectively. Dwellings exclude non-permanent structures and unoccupied parts.

Access to Electricity (percent of dwellings) - total, urban, and rural - Conventional dwellings with electricity in living quarters as percentage of total, urban, and rural dwellings respectively.

EDUCATION**Adjusted Enrollment Ratios**

Primary school - total, male and female - Gross total, male and female enrollment of all ages at the primary level as percentages of respective primary school-age populations; normally includes children aged 6-11 years but adjusted for different lengths of primary education; for countries with universal education enrollment may exceed 100 percent since some pupils are below or above the official school age.

Secondary school - total, male and female - Computed as above; secondary education requires at least four years of approved primary instruction; provides general, vocational, or teacher training instructions for pupils usually of 12 to 17 years of age; correspondence courses are generally excluded.

Vocational enrollment (percent of secondary) - Vocational institutions include technical, industrial, or other programs which operate independently or as departments of secondary institutions.

Pupil-teacher ratio - primary, and secondary - Total students enrolled in primary and secondary levels divided by numbers of teachers in the corresponding levels.

Adult literacy rate (percent) - Literate adults (able to read and write) as a percentage of total adult population aged 15 years and over.

CONSUMPTION

Passenger Cars (per thousand population) - Passenger cars comprise motor cars seating less than eight persons; excludes ambulances, hearses and military vehicles.

Radio Receivers (per thousand population) - All types of receivers for radio broadcasts to general public per thousand of population; excludes unlicensed receivers in countries and in years when registration of radio sets was in effect; data for recent years may not be comparable since most countries abolished licensing.

TV Receivers (per thousand population) - TV receivers for broadcast to general public per thousand population; excludes unlicensed TV receivers in countries and in years when registration of TV sets was in effect.

Newspaper Circulation (per thousand population) - Shows the average circulation of "daily general interest newspaper", defined as a periodical publication devoted primarily to recording general news. It is considered to be "daily" if it appears at least four times a week.

Cinema Annual Attendance per Capita per Year - Based on the number of tickets sold during the year, including admissions to drive-in cinemas and mobile units.

LABOR FORCE

Total Labor Force (thousands) - Economically active persons, including armed forces and unemployed but excluding housewives, students, etc., covering population of all ages. Definitions in various countries are not comparable; 1960, 1970 and 1979 data.

Female (percent) - Female labor force as percentage of total labor force.

Agriculture (percent) - Labor force in farming, forestry, hunting and fishing as percentage of total labor force; 1960, 1970 and 1979 data.

Industry (percent) - Labor force in mining, construction, manufacturing and electricity, water and gas as percentage of total labor force; 1960, 1970 and 1979 data.

Participation Rate (percent) - total, male, and female - Participation or activity rates are computed as total, male, and female labor force as percentages of total, male and female population of all ages respectively; 1960, 1970, and 1979 data. These are based on ILO's participation rates reflecting age-sex structure of the population, and long time trend. A few estimates are from national sources.

Economic Dependency Ratio - Ratio of population under 15 and 65 and over to the total labor force.

INCOME DISTRIBUTION

Percentage of Private Income (both in cash and kind) - Received by richest 5 percent, richest 20 percent, poorest 20 percent, and poorest 40 percent of households.

POVERTY TARGET GROUPS

The following estimates are very approximate measures of poverty levels, and should be interpreted with considerable caution.

Estimated Absolute Poverty Income Level (US\$ per capita) - urban and rural - Absolute poverty income level is that income level below which a minimal nutritionally adequate diet plus essential non-food requirements is not affordable.

Estimated Relative Poverty Income Level (US\$ per capita) - urban and rural - Rural relative poverty income level is one-third of average per capita personal income of the country. Urban level is derived from the rural level with adjustment for higher cost of living in urban areas.

Estimated Population Below Absolute Poverty Income Level (percent) - urban and rural - Percent of population (urban and rural) who are "absolute poor".

MADAGASCAR - ECONOMIC INDICATORS

GROSS NATIONAL PRODUCT IN 1979

ANNUAL RATE OF GROWTH 1/

	<u>US\$ Mln.</u>	<u>%</u>	<u>1975-79</u>
GNP at Market Prices	2,768.0	100.00	1.5
Gross Domestic Investment	619.1	22.4	4.6
Gross Domestic Saving	281.6	10.2	-17.5
Current Account Balance	-434.8	-15.7	-
Exports of Goods, NFS	482.3	17.4	-7.3
Imports of Goods, NFS	819.9	29.6	5.4

OUTPUT LABOUR FORCE AND
PRODUCTIVITY IN 1979

	<u>Value added 2/</u>		<u>Labour Force 3/</u>		<u>VA Per Worker</u>	
	<u>US\$ Mln.</u>	<u>%</u>	<u>US\$ Mln</u>	<u>%</u>	<u>US\$ Mln</u>	<u>%</u>
Agriculture	961.4	34.2	3.79	88.8	253.7	38.5
Industry	551.0	19.6	0.19	4.4	2,900.0	440.2
Services	1,134.8	40.3	0.29	6.8	3,913.1	594.0
Unallocated	165.9 4/	5.9				
Total	2,813.1	100.0	4.27	100.0	658.8	100.0

GOVERNMENT FINANCE

	<u>Central Government</u>			
	<u>FMG Bln</u>		<u>% of GDP</u>	
	<u>1979</u>	<u>1980</u>	<u>1979</u>	<u>1977-79</u>
Current Receipts	114.1	126.3	19.1	20.1
Current Expenditures	131.8	148.8	21.6	20.5
Current Deficit	-17.7	-22.5	-2.5	-0.4
Capital Expenditures	55.0	105.7	9.6	6.1
Foreign financing (net)	30.9	42.3	5.2	2.8

MONEY, CREDIT and PRICES

	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
	(Million FMG Outstanding at the End of the Period)				
Money and Quasi Money	100.2	122.0	143.0	180.6	207.8
Bank Credit to public sector	19.5	29.0	49.9	100.5	186.0
Bank Credit to state enterprises and private sector	82.2	95.8	100.7	120.6	139.2

(Percentage or Index Numbers)

Money and Quasi Money as % of GDP	23.7	26.5	29.8	30.1	-
GDP Price Deflator (1978 = 100)	88.1	93.7	100.0	112.9	-
Annual percentage changes in GDP Price Deflator	11.4	6.4	6.7	12.9	-
Bank Credit to public sector	58.5	48.7	72.1	100.4	85.1
Bank Credit to State enterprises and private sector	4.8	16.5	5.1	19.8	15.4

Note: All conversions to dollars in this table are at the average exchange rate prevailing during the period covered.

1/ Based on 1978 prices series

2/ At market prices

3/ Total labour force

4/ Import duties

February 4, 1982

MADAGASCAR - TRADE PAYMENT AND CAPITAL FLOWS

BALANCE OF PAYMENTS

	1978	1979	1980 1/
	<u>(US\$ Million)</u>		
Exports of Goods, f.o.b.	405.5	411.8	420.7
Imports of Goods, f.o.b.	404.2	674.1	723.1
<u>Resource Balance</u>	<u>1.3</u>	<u>-262.3</u>	<u>302.4</u>
<u>Services (net)</u>	<u>-144.4</u>	<u>-248.2</u>	<u>-286.8</u>
Freight and insurance	-81.1	-137.7	-144.3
Others	-54.4	-87.9	-102.7
Investment income	-8.9	-22.6	-39.8
<u>Transfers (net)</u>	<u>60.7</u>	<u>70.0</u>	<u>72.9</u>
Private	8.4	7.0	7.1
Public	52.3	63.0	65.8
<u>Current account balance</u>	<u>-82.4</u>	<u>-440.5</u>	<u>-516.3</u>
<u>Direct foreign investment</u>	<u>-6.2</u>	<u>-6.6</u>	<u>-6.6</u>
<u>Net MLT borrowing:</u>	<u>22.6</u>	<u>145.2</u>	<u>199.2</u>
Disbursements	27.5	154.2	-
Amortization	-4.9	-9.0	-
Other capital (net)2/	59.0	95.9	100.3
<u>Change in reserves</u>	<u>7.1</u>	<u>206.0</u>	<u>223.4</u>
(increase = -)			
<u>MEMO ITEMS</u>			
SDR allocation	-	4.7	4.7
Foreign assets (net)3/	64.0	-	-
<u>RATE OF EXCHANGE</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
US\$1.00 = FMG	225.64	212.72	211.30
FMG 1 = US\$	0.0044	0.0047	.0047

MERCHANDISE EXPORTS (AVERAGE 1976-79)

	US\$ mln.	%
Coffee	156.1	44.8
Vanilla	27.1	7.8
Cloves	46.2	13.2
Meat and meat products	9.8	2.8
Fish and shellfish	15.6	4.5
Sugar	7.3	2.1
Petroleum products	11.2	3.2
Chromite	10.7	3.1
Other commodities	64.7	18.5
<u>Total</u>	<u>348.7</u>	<u>100.0</u>

EXTERNAL DEBT, DECEMBER 31, 1979

	US\$ Mln.
Public Debt, incl. guaranteed	1.035
Non-Guaranteed Private Debt	-
<u>Total Outstanding & Disbursed</u>	<u>1.035</u>

DEBT SERVICE RATIO FOR 1980 4/

	%
Public Debt, incl. guaranteed	12.4
Non-Guaranteed Private Debt	-
<u>Total outstanding & Disbursed</u>	<u>12.4</u>

IBRD/IDA LENDING, September 30, 1982

	US\$ million	
	IBRD	IDA
Outstanding & Disbursed	30.92	167.01.
Undisbursed		143.39.
Outstanding incl. Undisbursed	30.92	310.40

1/ Provisional estimates from the Central Bank of Madagascar.

2/ Includes SDR allocations, state and private short-term capital, and errors and omissions.

3/ Net foreign assets of the banking system.

4/ Debt service payments as % of exports of goods and services.

STATUS OF BANK GROUP OPERATIONS
IN THE DEMOCRATIC REPUBLIC OF MADAGASCAR

A. Statement of Bank Loans and IDA Credits (as of September 30, 1982) 1/

<u>Loan or Credit Number</u>	<u>Year</u>	<u>Borrower</u>	<u>Purpose</u>	<u>Bank</u>	<u>IDA</u>	<u>Undisbursed</u>
Eight Credits and Five Loans have been fully disbursed				32.58	79.55	--
CR 506-MAG	1974	Madagascar	Village Livestock		9.60	1.90
CR 641-MAG	1976	Madagascar	Highways IV		22.00	8.44
CR 663-MAG	1976	Madagascar	Education II		14.00 <u>2/</u>	4.66
CR 817-MAG	1978	Madagascar	Andekaleka Hydroelectric		43.00 <u>3/</u>	7.06
CR 881-MAG	1979	Madagascar	Mangoky - Agriculture		12.00	3.71
CR 903-MAG	1979	Madagascar	Railways II		13.00	0.94
CR 938-MAG	1979	Madagascar	Highways V		24.00	21.18
CR 977-MAG	1980	Madagascar	Industrial Bank - BNI		5.00	4.22
CR 1002-MAG	1980	Madagascar	Water/Sanitation		20.50	19.72
CR 1016-MAG	1980	Madagascar	Petroleum Exploration		12.50	7.73
CR 1064-MAG	1981	Madagascar	Agriculture Credit		9.33 <u>5/</u>	8.23
CR 1086-MAG	1981	Madagascar	Plain of Antananarivo T.A.		1.93 <u>5/</u>	1.85
CR 1155-MAG	1981	Madagascar	Accounting and Audit		10.08 <u>5/</u>	9.40
CR 1161-MAG	1981	Madagascar	Forestry II		17.48 <u>5/</u>	17.48
CR 1211-MAG	1982	Madagascar	Village Livestock II <u>4/</u>		13.72 <u>5/</u>	13.72
CR 1249-MAG	1982	Madagascar	Agriculture Institutions <u>4/</u>		5.58 <u>5/</u>	5.58
TOTAL				32.58	313.27	135.82
of which has been repaid				1.80	5.72	
TOTAL now outstanding				30.78	307.55	
Amount sold						
of which has been repaid						
TOTAL now held by Bank and IDA				30.78	307.55	
TOTAL undisbursed					135.82	135.82

B. Statement of IFC Investments (as of September 30, 1982)

		<u>Loan</u>	<u>Equity</u>	<u>Total</u>
		(US\$ Million)		
1977	Sotema - Textile Mill at Majunga	11.00	0.29	11.29
1980	Bata - Shoe Manufacturing in Antananarivo	1.25	-	1.25
				<u>12.54</u>

1/ Prior to exchange adjustments.

2/ Including a Norwegian grant participation of US\$7.0 million.

3/ Including a supplemental credit of US\$10.0 million of 1980.

4/ Not yet effective.

5/ Computed at the September 30, 1982 exchange rate.

D. STATUS OF PROJECTS IN EXECUTION AS OF SEPTEMBER 1, 1982 1/

Credit No 506-MAG: Village Livestock and Rural Development Project: US\$9.6 million credit of August 21, 1974; Date of Effectiveness: June 17, 1975; Closing date: December 31, 1982

The project encountered serious problems in the initial years and, principally because of legal and organizational difficulties, little progress was made. Following significant changes in institutional and management arrangements, the credit agreement was extensively amended; the Amended Agreement became effective September 1, 1977.

The project's main situation is much improved. FAFIFAMA, the principal project implementing agency, is well-established, fully staffed and operational. Implementation of the project's most important component - the development of veterinary and livestock services for village producers - is proceeding.

After satisfactory growth and performance from 1977-80 FAFIFAMA has been afflicted by a serious cash shortage and by management shortcomings. Part of the cash problems have arisen because Government funds intended for the project have been used to cover marketing losses. Financial management and reporting is non-existent. General and technical management has deteriorated due to a hiatus between Directors-General and the unsuitability of certain technical managers. The animal health component has reached a plateau after initial expansion and has been constrained by lack of products and equipment and by lack of an adequate training program. Initial investments, recruitment and training for expansion of the program under the follow up project are under way. The road construction and water development services suffer severe financial and management problems. Actions to solve the financial problems and strengthen management were worked out with the mission and will be implemented before the next mission. The Middle West pilot schemes continue to suffer from technical, financial and management problems and do nothing to demonstrate the replicability of such schemes. A second phase livestock project was approved by the Board in February 1982.

1/ These notes are designed to inform the Executive Directors about the progress of projects in execution, and in particular to report any problems which are being encountered and the action taken to remedy them. They should be read in this sense, and with the understanding that they do not purport to present a balanced evaluation of strengths and weaknesses in project execution.

Credit No 641-MAG: Fourth Highway Project; US\$22.0 million credit of June 23, 1976; Date of Effectiveness: August 19, 1976; Closing Date: December 31, 1982

The project assisted the Government in the construction of two major roads with a view to reducing transport costs and providing access to areas with a high agricultural potential. It also includes training and strengthening of the country's road maintenance administration. The start of the training program for personnel in the Ministry of Public Works on highway maintenance has been delayed due to lack of training facilities. Bids for construction of these facilities were received and the contract has been awarded to the lowest bidder, SARD, a local firm. Construction has begun and consultants Louis Berger have started training 39 local instructors, utilizing some of the existing facilities and equipment.

As of May 1982, about 75% of the project had been completed; it is expected to be totally completed by June 30, 1984 or four years behind schedule. This delay was induced by the then prevailing inefficiency of the project management team prior to the appointment of the new Minister in January 1982. The Minister has put in place a new management team, and the project performance has started to improve. Disbursement which was very slow has also started to improve following the shortening of administrative procedures. Despite the delay in implementation, the project is still within estimated costs and available financing.

Credit No 663-MAG: Second Education Project; US\$14.0 million of December 10, 1976; Date of Effectiveness: August 15, 1977; Closing Date: December 31, 1982

The project is designed to assist the Government in decentralizing the educational system and to improve the quality of basic education. It comprises construction, furnishing and equipping of five Regional Education Centers (RECs) including vehicles for the inspectorate, and a Teaching Materials Production Center, including related technical assistance. Norway took 50 percent participation in the project under an agreement signed on December 16, 1977.

Construction work on two of the RECs has been completed and in the remaining three is fairly advanced. The furniture and equipment for these centers is in the procurement stage. The Teaching Materials Production Center has been completed, most of the equipment is in place, and operations have begun. An expansion of the center for establishing a print shop, to be fully financed by the Government, is under way. Bids are being sought for equipment for this shop, which is part of the project. Two key technical advisors for the Center, provided under contract with the Organization for Rehabilitation through Training (ORT), started their work in the country in September 1977. In addition, several specialists under the contract have served in Madagascar in short term specific assignments. In order to ensure ORT assistance during the initial operations of the printshop, expected to take place in mid-1983, and to

complete other project components, in March 1981 the Government requested a two-year postponement of the Credit Closing Date from December 31, 1981 to December 31, 1983. In October 1981, the Bank approved a one-year postponement to December 31, 1982.

Credit No 817-MAG: Andekaleka Hydroelectric Project; US\$43.0 million credit of June 19, 1978 (including a Supplementary Credit of US\$10 million of May 8, 1980); Date of Effectiveness: May 30, 1979; Closing Date: December 31, 1983.

The project would meet the growth in electricity demand until 1992 in the Antananarivo area and provide for strengthening of JIRAMA, concrete diversion dam and an intake structure; a 4-km tunnel, underground power house, tail-race and access tunnels; two turbines and two generators; electrical and mechanical equipment; a transmission line to Antananarivo; engineering services; preliminary investigation and design for a storage reservoir; and technical assistance and training for JIRAMA staff. The project was successfully completed in June 1982.

Credit No 881-MAG: Mangoky Agricultural Development Project; US\$12.0 million credit of May 17, 1979; Date of Effectiveness: March 11, 1980; Closing Date: August 31, 1984

The project supports the development of about 3,700 ha for production of rice and cotton, to be farmed by about 3,200 families. It will complete an irrigation system serving about 10,000 ha in the Lower Mangoky Valley which has been under development since the early 1960s. These investments are based on a long-term master plan for the region which aims ultimately to bring about 100,000 ha of land into production. The project will be implemented over a five-year period and will comprise: development of irrigation and drainage networks, and road infrastructure for 3,300 ha including production of concrete canal segments; improvement of water supply for about 400 ha of traditional rice fields; consultant services for design and supervision; applied agricultural research; social infrastructure; training and project preparation for agriculture and rural development projects. IFAD is financing about 25 percent of the total project cost.

Project implementation has been seriously delayed due to problems with (i) supply of equipment and spare parts caused by foreign exchange allocations, and (ii) weak technical management of SAMANGOKY. These factors have had a negative impact on the progress of civil works, in particular, the manufacture of concrete canal elements and have resulted in slow payments for works thus affecting severely SAMANGOKY's financial situation. Completion of civil works as scheduled has become highly unlikely. To address these difficulties, the

joint IDA credit and IFAD loan agreement have been amended to permit disbursement for foreign exchange expenditures of equipment and spare parts, and technical supervision has been intensified. Agricultural production has also been low because of poor management of the irrigation scheme. This further aggravated the company's precarious financial situation.

A financial audit has been conducted under the PPF for the Agricultural Institutions Technical Assistance Project which has clarified SAMANGOKY's financial situation and resulted in the introduction of improved accounting practices; in addition a financial plan was prepared for the remainder of the implementation period. IDA staff are currently pursuing a dialogue with the Government on this plan. Technical assistance is also envisaged to provide support for improving agricultural management.

Credit No 938-MAG: Fifth Highway Project; US\$24.0 million credit of July 30, 1979; Date of Effectiveness: March 11, 1980; Closing Date: June 30, 1983.

The project is intended to arrest the deterioration of the paved highway network in order to reduce transport costs and, where possible, avoid costly reconstruction works. It also includes construction of bridges on the Antsohihy-Ambanja road and provision to increase the maintenance capacity of the Ministry of Public Works. Co-financing is provided by a European Economic Community Special Action Account credit of US\$10 million.

As of May 1982, the project was 20% completed and is scheduled to be totally completed by June 1984, or about 1 1/2 years behind schedule. The delay was induced by the then prevailing inefficiency of the project management team prior to the appointment of the new Minister in January 1982. The Minister has put in place a new management team, and the project's performance has started to improve. Disbursement also has improved following the shortening of administrative procedures. As a result of this delay and further deterioration of the paved roads, the cost of the project has increased by about 27%. The Public Works Department is reviewing the equipment list to adjust it to available financing. Since the Government lacks funds, only about 10% of budget funds for road maintenance stipulated under the Credit Agreement has been allocated in FY82.

Credit No 903-MAG: Second Railway Project; US\$13.0 million credit of June 25, 1979; Date of Effectiveness: May 7, 1980; Closing Date: June 30, 1984.

The objectives of the project are to help the Malagasy railway company renew and modernize its facilities, improve the reliability and efficiency of its operations and improve its financial management and accounting methods. The French Caisse Centrale de Coopération Economique provided US\$20.5 million in co-financing.

Following the major difficulties experienced by the Railway in early 1981 (increased derailments, maintenance, procurement and operations planning problems, resulting in a substantial decrease in carrying capacity) a recovery program was adopted in May 1981 jointly with the French CCCE that included short-term technical assistance and credit reallocation.

However, due to the critical financial situation of the railways and non-compliance with major financial covenants, and although the project was almost fully disbursed (about \$850,000 undisbursed balance), the Association suspended disbursement in June 1982. Since June a satisfactory financial recovery program has been drafted and approved by Government, the Railway has been created as a State Enterprise with financial autonomy, new statutes have been decreed and a financial director has been appointed. A new organizational chart has also been approved and is being forwarded to IDA. Remaining steps to be taken before disbursements can be resumed include agreement of foreign suppliers on the rescheduling of the railways' debt and a tariff increase, which has "in principle" been approved by Government.

Credit No 977-MAG: Bankin'ny Indostria (BNI) Project; US\$5.0 million credit of May 8, 1980; Date of Effectiveness: February 24, 1981; Closing Date: December 31, 1984.

The project supports Madagascar's industrial sector and BNI's crucial development role by providing BNI with part of its foreign exchange requirements to finance projects in the artisanal/small-scale and medium-scale enterprise sectors and by strengthening BNI itself through technical assistance. To date about US\$1.4 million of the credit has been committed for medium- and large-scale enterprises. However, the pace of commitment of funds for small scale enterprises is slower, owing to the low ceiling (US\$55,000) set for eligibility under this category.

Credit No 1002-MAG: Antananarivo Water and Sanitation Project; US\$20.5 million Credit of May 8, 1980; Date of Effectiveness: December 17, 1980; Closing Date: June 30, 1985.

The project will increase access to treated water for the Antananarivo urban population and improve sanitation conditions. Detailed designs of the water supply works has been completed and tender documents have been issued. Detailed design of the sanitation component was completed in May 1982. Construction work on the water supply component will commence as soon as bid evaluation is completed and the contract awarded.

Credit No 1016-MAG: Petroleum Exploration Promotion Project; US\$12.5 million Credit of May 8, 1980; Date of Effectiveness: August 20, 1980; Closing Date: December 31, 1983.

The project supports the Government's efforts to develop a domestic supply of hydrocarbons and improve planning of the energy sector. Implementation of the project is progressing satisfactorily. Geological and legal consul-

tants were employed to assist the Government in preparing data with a view to promoting exploration by interested oil companies. Bids from oil companies to undertake exploration have now been received and four exploration contracts have been signed with Mobil, Occidental Petroleum, Agip and Amoco. Other studies, technical assistance, and training provided in the project are proceeding satisfactorily, including a second round of bidding for exploration acreage and preparation of the project to study the feasibility of exploiting the Tsimiroro heavy oil deposits.

Credit No 1065-MAG: National Bank for Rural Development (BTM) Project;
US\$11.5 million Credit of January 7, 1981; Date of
Effectiveness: August 17, 1981; Closing Date: June 30,
1984.

The project supports the extension of seasonal, medium-term, and long-term credit to smallholders through the National Bank for Rural Development (BTM) for the purchase of improved seeds, pesticides, insecticides, fertilizers, and small farm equipment. Due to poor repayment records on many loans extended under the collective guarantee credit scheme (FMR) BTM has suspended the FMR scheme in many regions. This action has resulted in a significant drop in lending activity. Consequently, BTM has been able to use only a small amount of Project funds as it has only marginally exceeded the base period level necessary to qualify for reimbursement from the IDA Credit. In addition, due to the scarcity of foreign exchange, few inputs are available in Madagascar. To help remedy the current situation, BTM has proposed that part of the Credit be used to finance fertilizer imports destined for smallholders in selected rice growing areas. These fertilizers would provide farmers with inputs and would support lending operations directed to individuals rather than through cooperatives. The details of this proposal have been finalized and approved by the Association. Fertilizers should be ordered shortly.

Credit No 1086-MAG: Plain of Antananarivo (Technical Assistance) Project;
US\$2.3 million Credit of January 30, 1981; Date of Effec-
tiveness: October 16, 1981; Closing Date: December 31,
1983.

The project supports the Government's efforts to institute a multisectoral approach to an integrated flood control and development program for the Plain of Antananarivo area; it would also contribute to strengthening the coordinating role of the Directorate General of Planning of the Ministry of Finance in the development of the Plain of Antananarivo. This would be achieved through pre-investment studies to define options for flood control programs and to provide Government with elements for decision-making. A contract has been awarded and work began in early 1982. Measures have been taken by the Directorate of Plan to improve Project supervision and inter-Ministerial coordination of development programs in the Plain.

Credit No 1155-MAG: Audit and Accounting Project; US\$11.5 million Credit of
June 11, 1981; Date of Effectiveness: May 6, 1982;
Closing Date: March 31, 1988.

The project includes measures to develop a suitable legislative framework for the accounting and auditing sector and aims to increase the level of expertise in these professions through training. Consultants have been retained to start the design of the training programs. Government legislation providing for the creation of the training center has been enacted.

The resignation of the Accounting School (CFC) Director due to illness and his replacement by CEGIR has delayed the project by about one month. We have reviewed architectural plans to make some modifications to the rented school premises and have made suggestions about the equipment lists. It may be difficult to buy much of the furniture in Madagascar. The CEGIR team has been in place since June and has established a work program. However, it will be difficult to open the school in October as planned although it could open in early 1983. Current issues concern:

(i) the academic level of students who wish to attend the school. More information should be available from the results of the entry exams. The student level will have an impact on the first year teaching program as a year of upgrading may be necessary;

(ii) as the CFC is under the Ministry of Economy, there are no special funds for scholarships as is common in professional schools. Students will be allowed to address their needs to Government's scholarship services; and

(iii) the performance of the CEGIR team so far has been good. CEGIR (Canada) has given considerable assistance which, inter alia, allowed for the rapid replacement of the first CFC director.

Credit No 1161-MAG: Second Mangoro Forestry Project, US\$20.0 million Credit
of October 29, 1981; Date of Effectiveness: July 1,
1982; Closing Date: December 31, 1984.

The project will continue the reforestation program begun under the first project, and will assist the Government's efforts to establish a forestry industrial complex in the Mangoro Valley. Recent studies have shown that forest yields will be lower than previously estimated.

The project unit has requested consultant assistance to verify these disappointing results and determine their causes. The plantation programs have also been scaled down. Studies are currently under way to determine the most appropriate industrial development for the wood resources available. They have already shown that, due to high investment costs and the depressed world market

situation for wood products, most export oriented industrial options show poor financial and economic returns. The Malagasy are concerned that the project should generate its own foreign exchange, at least to cover the debt service for the first Mangoro Project (repayments begin in 1984) and some officials still support the idea of a large TPA pulpmill for which Mangoro's wood resources are insufficient. In a recent meeting with the Malagasy, FAO/UNDP and the consultants carrying out the industrial studies, it was agreed that further studies would examine the options of pelletizing or charcoaling the wood, which would substitute in part for oil imports, and export of wood chips, e.g., to the Japanese pulpmill industry. At the request of the Malagasy Government, consultants are preparing a prospectus for a smaller kraftmill (75,000 TPA) even though kraftmills are expensive (US\$444 million for the 75,000 TPA) and show low financial and economic rates of return.

Credit No 1211-MAG: Second Village Livestock Project; US\$15.0 million credit
of April 15, 1982; Expected Date of Effectiveness:
February 26, 1982; Closing Date: December 31, 1987

The Project would support the Government's efforts to increase beef production and to improve the productivity of the sector through animal health programs, the provision of veterinary inputs, technical assistance and research. In Mahajanga province, basic animal health programs would be continued and extended, and a pilot animal production program, supported by rural road and water supply components, would be implemented. Veterinary supplies and equipment for producing vaccines would be imported; and management assistance and training for key institutions in the livestock sector would be included. Anticipating effectiveness shortly, recruitment and training of personnel, construction, and procurement of equipment have been initiated under the ongoing project.

Credit No 1249-MAG: Agricultural Institutions Technical Assistance
Project; US\$5.7 million credit of May 28, 1982;
Expected Date of Effectiveness: February 16, 1983;
Closing Date: June 30, 1985

The project aims to assist the Government through technical assistance in identifying action programs to rehabilitate specific aspects of the agricultural sector and to foster institution building in the sector and improve investment planning and policies. To that end, a series of special studies would be undertaken covering, inter alia, the rice sector and management audits would be carried out for selected major parastatals in the sector. With funds under the PPF Government has appointed a consulting firm to initiate some of the studies and preparation is underway for the start of the remaining project activities. The credit is not yet effective.

MADAGASCAR

TSIMIRORO HEAVY OIL EXPLORATION PROMOTION PROJECT

Supplementary Project Data Sheet

Section I - Timetable of Key Events:

(a) Time taken to prepare project:	12 months
(b) Project prepared by:	Government and IDA
(c) Initial discussion with IDA:	May 1981
(d) Appraisal	September 1981
(e) Negotiations completed:	September 1982
(f) Planned date of effectiveness:	December 1982

Section II - Special IDA implementation action:

None

Section III - Special Conditions:

- (a) A condition for effectiveness of the IDA credit would be the signature of cofinancing (para. 65).
- (b) OMNIS would submit to IDA for approval the initial drilling program and any subsequent proposals for changes in well locations (para. 60).
- (c) A condition for disbursing funds for the Tsimiroro pilot plant engineering study and the upgrading study would be that the results of the drilling and testing program confirm, to the satisfaction of OMNIS and the Association, that these further studies are warranted (para. 61).
- (d) The proceeds of the sale of data on the Tsimiroro deposit collected during project implementation would be kept by OMNIS in a special account and used for further petroleum exploration (para. 63).

MADAGASCAR

TSIMIRORO HEAVY OIL EXPLORATION PROJECT

Geological and Technical Aspects

Background on Heavy Oil

1. The most important deposits of crude oil, those which furnish the bulk of the world's production, are the free-flowing light oils which are easily producible and transportable. The "light oils" have specific gravity ranges of around 30 degrees API up to 46 degrees API on the standard industry scale (developed by the American Petroleum Institute). It is this group of crudes which give the most desirable suite of refined products and hence command the highest prices. In addition there is a large number of producing operations for middle gravity crudes in the 20 degrees to 30 degrees API range. A third category of crude oil is "heavy oil" of less than 20 degrees API. Locked up in various tight reservoirs around the world are large undeveloped deposits of such low gravity, high viscosity crude oils and other bitumens. If successfully tapped, these could contribute significantly to the world's fuel supply. Some heavy oil fields have in fact been producing oil of less than 20 degrees API gravity routinely from natural flow and pumping wells, but because of technical difficulties, lower production rates per well and higher costs much of the heavy oil has remained in the ground. Also contributing to this situation are economic conditions: generally the value of crude oil on the world market decreases by something like 50 cents per barrel for each lower degree of gravity. Thus, 18 degrees API oil might bring US\$10 less per barrel than 38 degrees or 40 degrees API crude.

2. In recent years, however, new engineering techniques have been developed which, in combination with the higher prices now in force for crude oil (as compared to several years ago) permit exploiting commercially a number of heavy oil deposits which have not, heretofore, been producible by conventional methods. Among these techniques are various thermal recovery methods, such as steam injection and in-situ combustion, both of which are designed to reduce the viscosity of the oil to a movable state capable of being pumped from the reservoir.

3. Canada is a leading developer of thermal recovery methods, having several commercial production projects in operation for 15 degree to 18 degree API oil and at least two dozen pilot plants. Commercial production of heavy oil is also taking place in California, Texas, Louisiana and Arkansas. Venezuela has exceptionally large volumes of heavy crude and has six or more thermal plants in operation. Elsewhere, Romania and the USSR are producing by thermal methods.

4. A typical project can be expected to require a preliminary pilot plant to test production using thermal recovery techniques in order to demonstrate the technical and economic justification for a full-scale project. Such a pilot plant would typically cost from US\$20 to US\$30 million for the smallest practical plant and require two to three years to get into operation. If the pilot plant is successful, the full-scale production plant to follow would require three to four additional years to develop. Thus it would normally require some seven to ten years from start of initial work in the field to reach full production rates.

Tsimiroro Heavy Oil

5. Madagascar has a large known heavy oil deposit at Tsimiroro in the northeast part of the country (related geologically to the deposit at Bemolanga where the oil is at the surface in the form of bitumen, or tar sands)^{1/}. A number of wells previously drilled over the past 60 years have more or less defined the extent of the deposit, but the data from these wells are insufficient to determine the potential for commercial development. Moreover, the prospective sands are erratic and discontinuous, and the area is cut by igneous dikes. To calculate the amount of oil in place one engineering firm assumed an area of 440 sq km (less than half of the Tsimiroro horst area), an average thickness of 25 m of impregnated sand and an oil content by weight of 4 to 6 percent. This gives an order of magnitude of 1 to 1.5 billion tons (six to nine billion barrels) of heavy oil-in-place. If recovery should be no more than 10 to 15 percent, there is potential for 500 million to 1 billion barrels recoverable. Another study (by the D&S Group of Calgary) gave 4.8 billion barrels in-place over the total Tsimiroro area, or 2.8 billion in the "Southern Best" part alone. Of this 2.8 billion in the more restricted "best" part, they calculate that perhaps 840 million barrels would be recoverable (30 percent) by thermal stimulation. These two estimates are not far apart. They show that if such production could be established, 75,000 barrels per day could be produced for 30 years. A certain percentage of the oil produced (perhaps up to 30 percent) would have to be dedicated to steam generation and other operating requirements.

Geology of the Tsimiroro Area

6. The rocks of the Tsimiroro area are made up of detrital formations of the Karroo system, a series of sandstones, siltstones and shales of Permo-Carboniferous, Triassic, and Early Jurassic age. This series is very widespread across southern Africa and in Madagascar represents the oldest sedimentary formations, lying on the crystalline and metamorphic basement. Its total thickness reaches 6,000 to 8,000 m, but in the Tsimiroro area of interest its thickness ranges from about 1,200 to 2,500 m. The formations dip westward and thick sections of younger sediments overlie the Karroo between Tsimiroro and the Mozambique Channel.

^{1/} The Tsimiroro deposit is located 270 km WNW of Antananarivo and 100 km east of Maintirano the port of the west coast.

7. The Karroo is divided into a number of different formations. The main subdivisions in the Tsimiroro area are, from top to bottom:

- Clays and sandstones interbedded; discontinuous; containing poor oil shows.
- Makara shale.
- The Isalo II Formation: Amboloando sandstone; some clay and shale beds; cross-bedded; fine to medium grained; best oil shows; lignitic basal shales.
- The Isalo I Formation: Shales, sandstones, conglomerates; fluvial deposits; discontinuous beds; some oil shows in upper sands.
- Sakamena Formation: Black, hard shale.

8. The oil shows of particular interest for possible production are those of the Amboloando sand of the lower part of the Isalo II and the sands at the top of the Isalo I. The top of the Amboloando sands in this area lies at a depth ranging from about 75 to 300 m below the surface. The sands are fine to medium grained, well sorted, with high mica content and kaolin or calcareous cement. They are in part lenticular, with variegated shale layers from a few centimeters to a few meters thick. The sands show cross-bedding characteristic of fluvial deposits, likely braided streams in a widespread delta plain. The formation thins from NW to SE, showing a probable source of sediments to the northwest. Near the north end of Tsimiroro, one of the Chevron wells had nearly 140 m of the Amboloando sandstone formation, whereas wells to the south have only about 75 m. These are gross thicknesses; the net sand thickness with oil is probably less than half. Effective porosity is about 20 percent but often less because of kaolin cement. Permeability is generally low, perhaps averaging 250 millidarcys, a figure which is quite satisfactory for light oil production but is too low for heavy oil to flow out freely.

9. Below the main Amboloando sand, the basal shale is nonprospective but the underlying sands of the top Isalo I frequently have oil shows of interest and can be considered a secondary objective.

10. The source of the oil is unknown. Various analyses made for the nearby Bemolanga tar sands area show that the Isalo shales themselves are not source rocks. Tsimiroro is part of the same formation extended laterally and buried a few hundred meters. Some studies have shown that the underlying Sakamena has source rock characteristics. Even though specific sourcebeds cannot be pinpointed, the undisputed abundance of oil in place is proof enough that they exist or have existed in past geologic time.

11. Structurally, the Tsimiroro area is a long NNW-trending horst block, i.e., an uplifted zone bounded by faults. The horst is cut by numerous

crossfaults which complicate the structure and divide it into panels. There are at least two culminations, the highest of which is in the southern part of the structure. The OMNIS seismic survey of 1979 shows that the west flank dips westward fairly regularly with only minor faulting and undulation, but the east flank has a more pronounced stair-step aspect down to the east. The displacement of some faults is over 150 m. Faulting occurred early, affecting the Pre-Isalo sedimentation. These faults were rejuvenated in Isalo I time, with the Isalo II then being deposited on a peneplained surface. There was some minor faulting after Isalo II deposition.

12. The Tsimiroro horst and the surrounding country is cut by a network of igneous dikes which are impermeable and which might impede oil production. They were intruded from a subsurface source of molten rock after the sediments were lithified. The dikes range in thickness from a few centimeters to several meters and extend laterally for variable distances, from a few hundred meters to several kilometers. Some dikes appear in wells but do not reach the surface. Calculations show that in the northern part of the Tsimiroro horst area, the density of dikes is about 5 km per sq km, whereas to the south the density is only about 1.7 km per sq km. The area is thus compartmentalized by these igneous walls, which along with their metamorphosed contact zones would serve as barriers to fluid migration in any production operations. Nevertheless, individual panels are large enough to permit the testing program as proposed.

13. Wells drilled in the area range in depth from 284 to 1,200 m on the crest of the horst, with the prospective target formation lying at depths of 75 to about 400 m. On the west and east flanks, wells have been drilled to 2,529 m and 2,513 m respectively. The west flank well had no shows (apparently the only well in the whole area which did not have any shows), and the east flank well had only minor shows. Some of the best oil shows have been in structurally high wells, but not every high well has had good shows. Thus well CDT-1, the area's structurally highest, has weaker and thinner oil impregnations than BLT-3 situated 3 km west and 140 m downdip. The same observation applies to TS-1 which has good oil shows in a structurally low position as contrasted with TS-2 which is higher but with poorer shows. These variations may be caused by different cementation of the sandstone bed or by faults separating the wells. The key to the optimum accumulation of oil in the reservoirs obviously is not yet known. The ten-well program under the proposed project is designed for further testing near the best shows known so far and in the thickest Amboloando sand sections.

Tsimiroro Exploration History

14. The Tsimiroro deposit has been under lease to oil companies most of the time since 1902. Here, in an area about 70 km long, some 35 wells were drilled between 1909 and 1974. Many of these were only shallow test holes. Most of the older wells were drilled near surface oil seeps without specific reference to structural conditions. Later wells, after 1953, were based on geological and geophysical studies which showed the outlines, if not the detail, of the subsurface structural conditions.

15. The first wells were drilled at Folakara, near the center of the Tsimiroro area, from 1909 to 1913 by the British company, Madagascar Oil Development Co., Ltd., and drilling was continued until 1917 by the Betsiriry Proprietary Fields Folakara. Some of the Folakara wells initially produced as much as nine barrels per day of an oil-water mixture. From 1913 to 1917, the Sakalava Madagascar Proprietary Fields Ltd. drilled five wells at Moraboaly, at the southern end of the trend. All these wells were drilled near surface seepages.

16. Beginning in 1922 a systematic geological and structural study was undertaken, first by the Service des Mines and then by the Syndicat d'Etudes et de Recherches Pétrolières (SERP). This work led to wells Tsimiroro-1 and Tsimiroro-2 in 1936-37, which found strongly impregnated sandstone beds between 186 m and 250 m depth which gave an initial flow of 2,500 cubic meters of gas per day and 400 liters of oil (equal to 87,500 cubic feet of gas per day and about 2.5 barrels of oil per day). The well is reported to have continued to pump oil at the rate of three to four barrels per day for several years. Ten years later, tests produced oil at the rate of one-half barrel per day for nine months. In 1938 and 1939 four other structures on the trend were drilled by SERP.

17. Exploration was interrupted by World War II but resumed in 1946. During the next two years the Service des Mines in looking for road bitumen drilled T-3 and T-4, each of which produced some oil but never more than two barrels per day. In 1948 to 1951, it undertook to dig a vertical shaft 2.2 m wide on a site near the No. 1 and 2 wells. The shaft was 145 m deep and penetrated an impregnated zone between 126 m and 135 m depth. A horizontal gallery 32 m long was dug in this bed for the purpose of draining the oil by gravity flow into the central pit. In one month, only about 650 liters of oil were produced, about one tenth of a barrel per day, along with four times that much water.

18. Beginning in 1953, the Societe des Petroles de Madagascar (SPM) undertook geological and geophysical studies which led to the 1959-60 drilling of 7 wells: BLT-1, 2 and 3, CD-1, CDM-1 and 2, and MRB-1. All of these wells except BLT-1 had oil shows; some pumped a little oil but always with fresh water contamination.

19. In 1974 Chevron, as operator for a group, drilled nine appraisal wells, called coreholes although only limited coring was done, spread along the northern two thirds of the Tsimiroro trend. Valuable stratigraphic and petrographic data were obtained and a number of heavy oil impregnations were logged, but unfortunately it appears that no tests were made. Thus, the data are incomplete in terms of establishing the productive potential of the deposit.

20. Finally, in 1978 OMNIS undertook a seismic survey for which the French geophysical company CGG was operator. The grid of about 10 km spacing was sufficiently close to give a good structural picture of an elongated (N-S) horst block bounded by and cut by numerous faults, but it was insufficiently detailed to indicate stratigraphic continuity with any precision.

The Proposed Project and Future Stages of Heavy Oil Development

21. The proposed project consists of the preliminary phase in assessing the commerciality of this large heavy oil deposit. It would involve the drilling and testing of ten wells with an average depth of 1,000 feet in the potential oil-bearing sandstones throughout the Tsimiroro area. The ten-well program is the minimum reasonable to identify any thick zones of highly impregnated reservoir. Well locations would be somewhat flexible, and the location of later wells could be changed depending on results of earlier wells. All wells will be drilled through the Amboloando sandstone formation (Isalo II), which is the main horizon of interest and found at depths of 1,200 feet or less. The program calls for the coring of all potential oil-bearing formations in each well in order to have full representative samples for complete analyses of the reservoir properties and fluids. The wells would be logged using conventional electrical logging methods and equipment. If warranted, the wells would be cased and cemented with special heat resistant cement so that they could later be used for steam injection. Testing would be done through perforations in the casing over the zones of interest. Tubing would be run below the perforated interval to allow for the swabbing and pumping of the fluids. If feasible, pressure transient tests would be run to outline reservoir boundaries and obtain in situ transmissibility. The logs and test data would be sent to laboratories overseas for full analysis to determine which zones of the deposit, if any, are potentially productive--the prime objective of this project.

22. If the results of the project warrant, a subsequent pilot project, actually testing production under steam flooding, would then be considered. Again, if the pilot stage was successful, the operation could be expanded to a commercial level. If produced, the oil would probably be of 15 degree to 17 degree API gravity. Hence it would need to be upgraded for ease in transport and to achieve a higher quality product, most likely for export.

Economics of Heavy Oil Production

23. The consultants, D & S, undertook a preliminary analysis of the economics of heavy oil production in Madagascar by adapting a recent study of a similar oil project in Alberta, Canada. The analysis assumes: (a) a drilling program of 156 wells and construction of central and satellite support and oil-gathering facilities; (b) actual field production of 7500 BD, which after steam generation and utility demand would yield 5000 BD of crude for ultimate sale; (c) a 25-year project life with construction and drilling beginning in 1990; (d) investment in full upgrading facilities (using the H-oil process to upgrade oil quality); and (e) construction of a pipeline to Madagascar's west coast. D & S has made assumptions regarding the level of reserves, oil quality and production potential of Tsimiroro based on its analysis of existing data. These are outlined in the table below and compared with the characteristics of the Alberta deposit used in the base study. (In fact, the characteristics of the Tsimiroro deposit may be slightly more favorable.) The costs of the production module as adapted to the reservoir and oil characteristics of Tsimiroro are then estimated and compared with

those of the Alberta project. All cost data in the table below is in mid-1982 US dollars and assumes construction in Alberta.

Table 1

Heavy Oil Mini-Project In-situ Operations
Comparative Factors

	<u>Alberta</u>	<u>Tsimiroro*</u>
In-Place Resource, 10 ⁹ m ³	2	0.77
Depth Below Surface, m	600	300
Gravity, API	13 to 18	14
Viscosity, MPa-s	5 x 10 ² to 10 ⁴	5 x 10 ³
Pay Thickness, m	2 to 8	20
In-Place Reserves/Well, x 1,000 m ³	40 to 80	120
Well Producing Life, Years	10	8
Initial Maximum Well Rate (Thermal Recovery), m ³ /d	8 to 10	20
Recoverable Reserves per Well, x 1,000 m ³	20 to 40	60
Production Module:		
(a) No of Wells in Mini-project Field Module	50 to 100	156
(b) Mini-project Surface Facility Sustained Design Rate m ³ /d	500 to 1000	800
(c) Initial Capital, x 10 ⁶ (US\$ 1981)	48	57
(d) Unit Capital Investment, x 10 ³ US\$/m ³ /d	80	71
(e) Annual Operating and Replacement Well Costs, x 10 ⁶ (US\$ 1981)	13	15
(f) Annual Production, x 10 ³ m ³	300	290
(g) Annual Unit Operating and Well Replacement Costs, US\$/m ³	42	53
(h) Transportation & Upgrading Cost, \$/m ³	60	39
(i) Manpower No.	50 to 100	75

* Cost figures based on assumption that construction would take place in Alberta.

24. The total capital and operating cost of the production module, as designed for Tsimiroro but based on construction in Alberta, was estimated at US\$290 million (mid-1982 dollars). Revenues from the upgraded crude were calculated based on the Bank's projected oil prices in constant 1981 dollars (which assumes a 2-2.5 percent p.a. real growth rate). Then, a sensitivity analysis was run using different cost factors to convert capital and operating costs based on construction in Alberta to those based on construction in Madagascar. The total analysis was done in constant 1981 dollar terms. Nine cases were run, escalating capital costs by 50 percent, 100 percent and 150 percent and operating costs by 30 percent, 50 percent and 100 percent. The range of results are summarized below:

Table 2

<u>Case</u>	<u>Capital Cost Factor</u>	<u>Operating Cost Factor</u>	<u>DCF Rate of Return</u>
1. (Most Optimistic)	1.5	1.3	26
2. (Most Realistic)	2.0	1.3	20
3. (Variation on Most Realistic)	2.0	2.0	15
4. (Most Pessimistic)	2.5	2.0	12

25. The results of this analysis range from a DCF rate of return of 26 percent for the most optimistic case to 12 percent for the most pessimistic. Taking the most realistic case, i.e. increasing capital costs by a factor of 2 and operating costs by a factor of 1.3, the rate of return is a satisfactory 20 percent. Another sensitivity analysis was run based on a constant oil price of US\$31 per barrel. In that variation, the DCF rate of return is acceptable at 16 percent for the most optimistic case, marginal at 10 percent for the most realistic case, and unacceptably low for the two other cases (4 percent and 1 percent respectively).

26. This analysis, though hypothetical at this still early stage in the development of information on the Tsimiroro deposit, indicates that if the production potential of the Tsimiroro deposit under enhanced recovery methods could be established, then the outlook is reasonably favorable that commercial production would be economically viable.

MADAGASCAR

TSIMIRORO HEAVY OIL EXPLORATION PROJECT

Glossary of Geologic Terms

Source Rock: Those sedimentary rock formations which are either known or thought to have retained the organic debris which under conditions of burial (heat, pressure and time) are transformed into either oil or gas; usually shale (compacted clay) or fine grained carbonate (limestone).

Reservoir Rock: Those rock formations which have retained after burial sufficient porosity and permeability (pore space connections) to contain fluids; either oil, gas or water.

Trap: A barrier to the migration of fluids through a reservoir rock; may result from structural movement or lateral change in reservoir characteristics.

Reef: A build-up of carbonate rocks (limestone or dolomite) consisting of a particular assemblage of organic skeletal material formed in warm, nonturbid seas; following burial forms a unique type of reservoir and trap.

Diapir, diapiric: A flowage of plastic sedimentary rocks, usually salt or undercompacted shales (those which retain a high fraction of formation water relative to depth of burial), caused by an inversion in the specific gravity of rocks with depth (light below heavy); diapiric relates to structuring developed when diapirs are present or to the cause of the diapir, i.e., diapiric shale.

Facies: Descriptive of sedimentary rocks of a common composition deposited in a particular manner; may apply to both general and/or specific conditions of deposition.

Anticline: A term indicating a discrete positive (high) closure, usually an upward arching of sediments caused by compressional forces within the earth; often used to denote any type of positive closure which may be the result of drape over buried topography or residual structure bounded by areas of negative closure (syncline); with regional or nondiscrete positive closures, the term arch is more common.

Horst (Horst Block): A fault bounded structurally high block in which movement involved crystalline basement rock as well as overlying sedimentary rocks.

Graben (trough): A fault bounded structurally low block in which movement involves crystalline basement rock as well as overlying sedimentary rocks; grabens are normally associated with and adjacent to horsts.

Rift: Similar to graben except used on a more regional scale such as rift system when associated grabens and minor intervening horsts are included in the overall rift (system).

Unconformity: A surface of divergence in the attitude between an underlying and overlying sequence of sedimentary rocks caused by structural movement and/or a change in the character of the depositional environment of the overlying sediments or involving a hiatus in deposition and a period of erosion of the underlying sediments.

Transgression: The invasion of the sea (introducing a marine environment of deposition) over an existing sub-aerial surface caused either by subsidence or a worldwide rise in sea level; sediments deposited during transgression are called a transgressive facies and tend to be widespread in extent.

Progradation: The deposition of sediments in a seaward direction and outbuilding of shoreline, ultimately resulting in nonmarine sediments overlying marine, due to worldwide fall in sea level), rapid influx of sediments into a static sea level, or at a rate exceeding a rise in sea level.

Intrusive: A crystalline igneous rock injected in a fluid phase into preexisting rocks, either igneous, metamorphic or sedimentary.

Dike: An intrusive body of crystalline rock whose geometry is tabular with a vertical or near vertical attitude, i.e., if the preexisting rock is sedimentary, cuts across bedding planes.

Sill: An intrusive body of crystalline rock whose geometry is tabular with a horizontal or near horizontal attitude, i.e. if preexisting stock is sedimentary is parallel to bedding planes.

Play: A grouping of petroleum prospects in which the type of trap as well as age and composition of reservoir and source rocks (independently) are believed to be common; synonymous with "trend" if and when prospects become productive fields.

Show: A positive indication of the presence of oil and/or gas either in the subsurface (wells) or at the surface from seeps, notes from surface samples, drill cuttings, subsurface cores or fluid recovery; shows may vary widely both quantitatively and qualitatively.

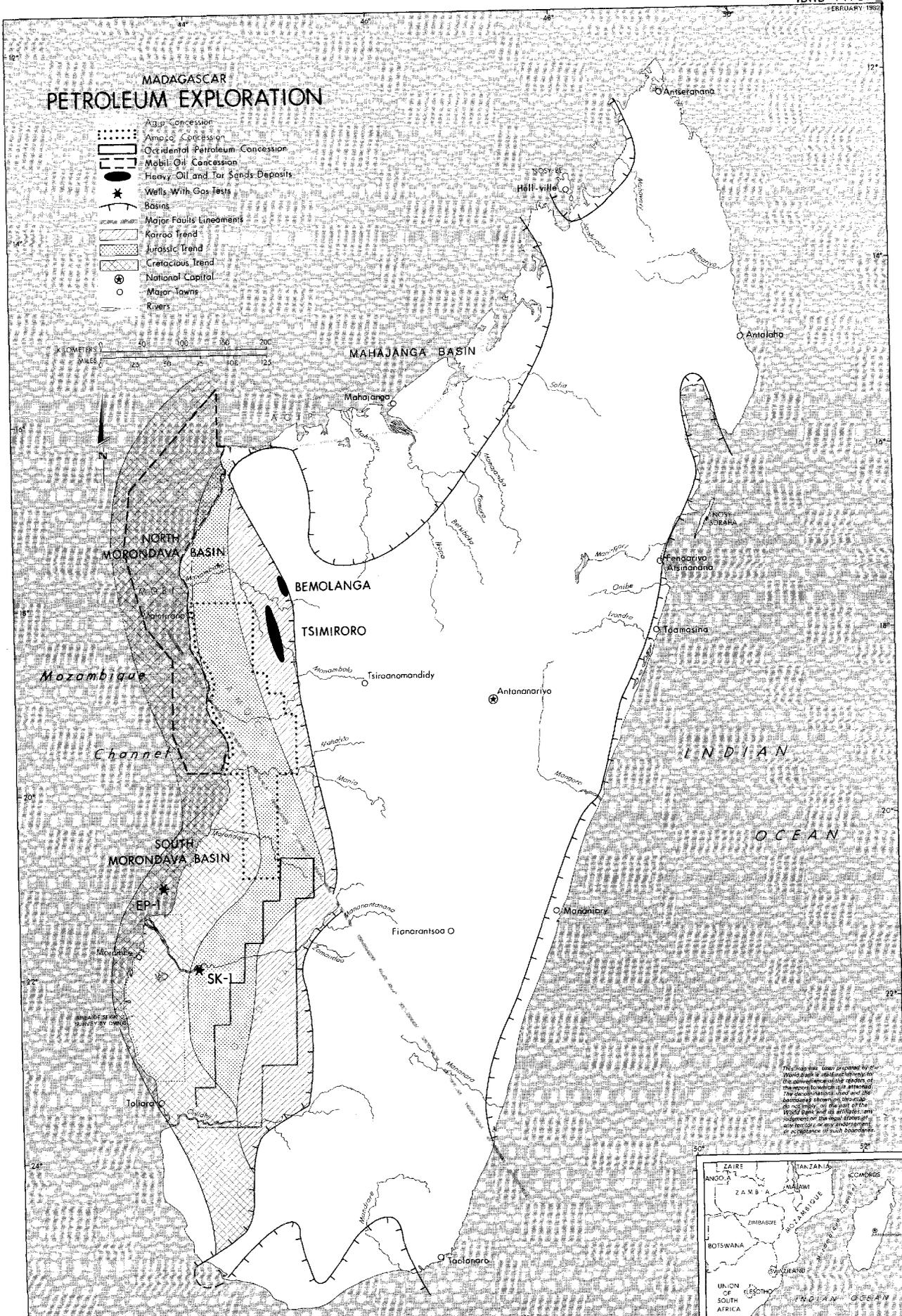
Karoo: A thick, generally nonmarine sedimentary rock sequence found in the sub-Sahara of Africa ranging in age from the Paleozoic Carboniferous through Mesozoic Triassic and into the Mesozoic Lower Jurassic; precise age determination often difficult and thus lumped into general term "Karoo".

Paleozoic: The system of sedimentary rock occupying the early ages of the geologic time scale comprising the Cambrian, Ordovician, Devonian, Silurian, Carboniferous and Permian Periods; the Paleozoic system is typified by an invertebrate fauna but witnessed the evolution of fish and near the shore primitive reptiles as well and a flora evolving through algae, ferns and primitive conifers; the pre-Cambrian system, consisting principally of nonsedimentary rocks and occasionally sedimentary rocks deficient in fossils, underlies the Paleozoic.

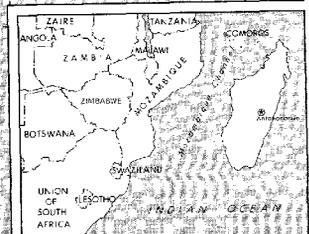
Mesozoic: The system of sedimentary rocks occupying the middle ages of the geologic time scale, comprising the Triassic, Jurassic and Cretaceous Periods; the Mesozoic system is typified by a repetition of fauna and a coniferous flora which overlies the older Paleozoic system and underlies the Cenozoic system (Tertiary, Quaternary and Recent).

MADAGASCAR PETROLEUM EXPLORATION

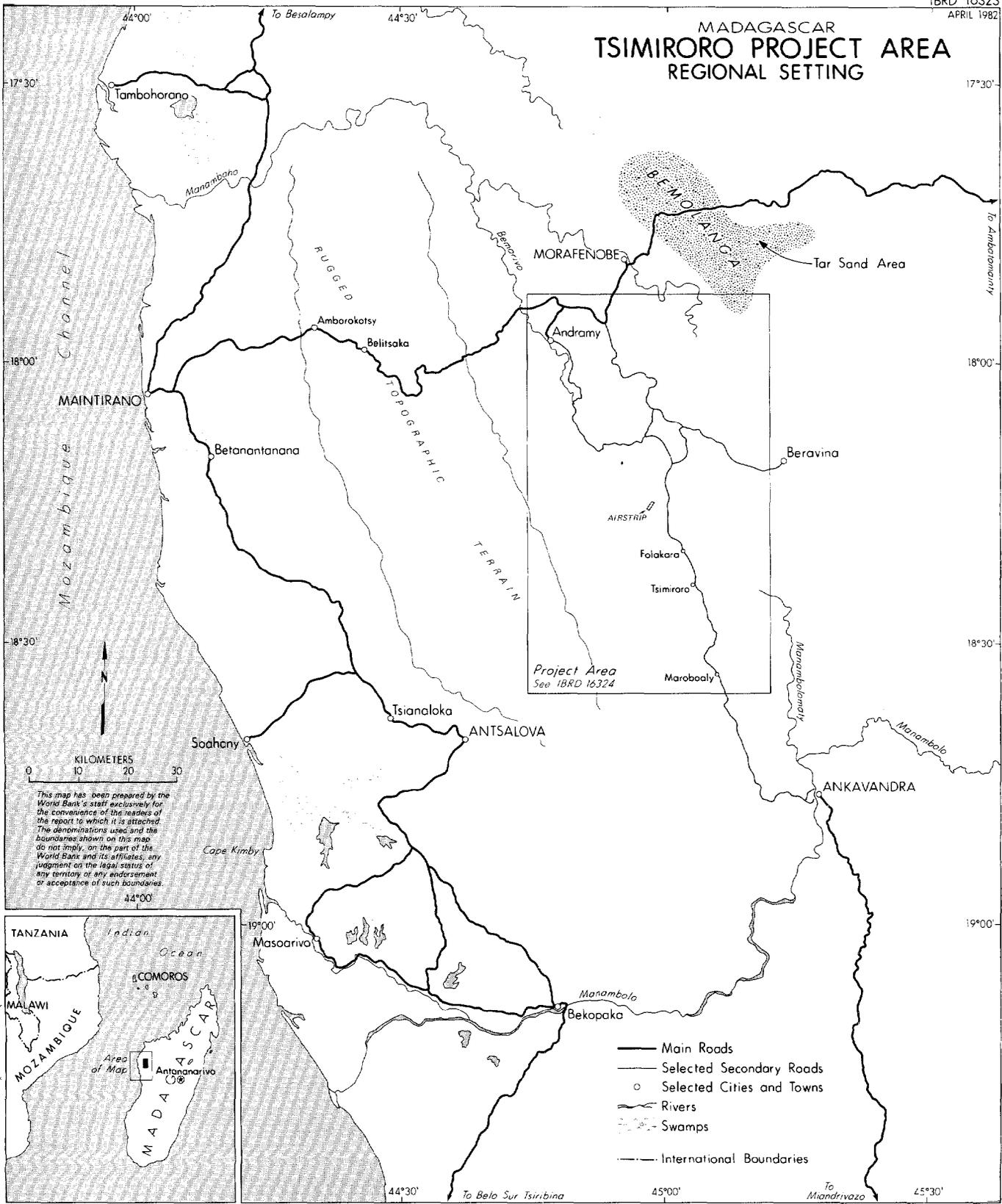
-  Agas Concession
-  Amazo Concession
-  Occidental Petroleum Concession
-  Mobil Oil Concession
-  Heavy Oil and Tar Sands Deposits
-  Wells With Gas Tests
-  Basins
-  Major Faults Lineaments
-  Korrao Trend
-  Jurassic Trend
-  Cretaceous Trend
-  National Capital
-  Major Towns
-  Rivers



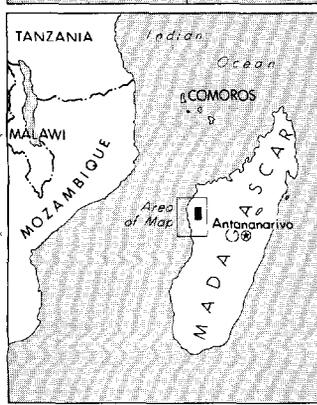
This map was prepared by the World Bank in connection with the petroleum exploration studies of the report to which it is attached. The boundaries, lines and the locations shown on this map do not imply, on the part of the World Bank, any judgment of the legal status of any territory or any endorsement or acceptance of such boundaries.



MADAGASCAR TSIMIRORO PROJECT AREA REGIONAL SETTING

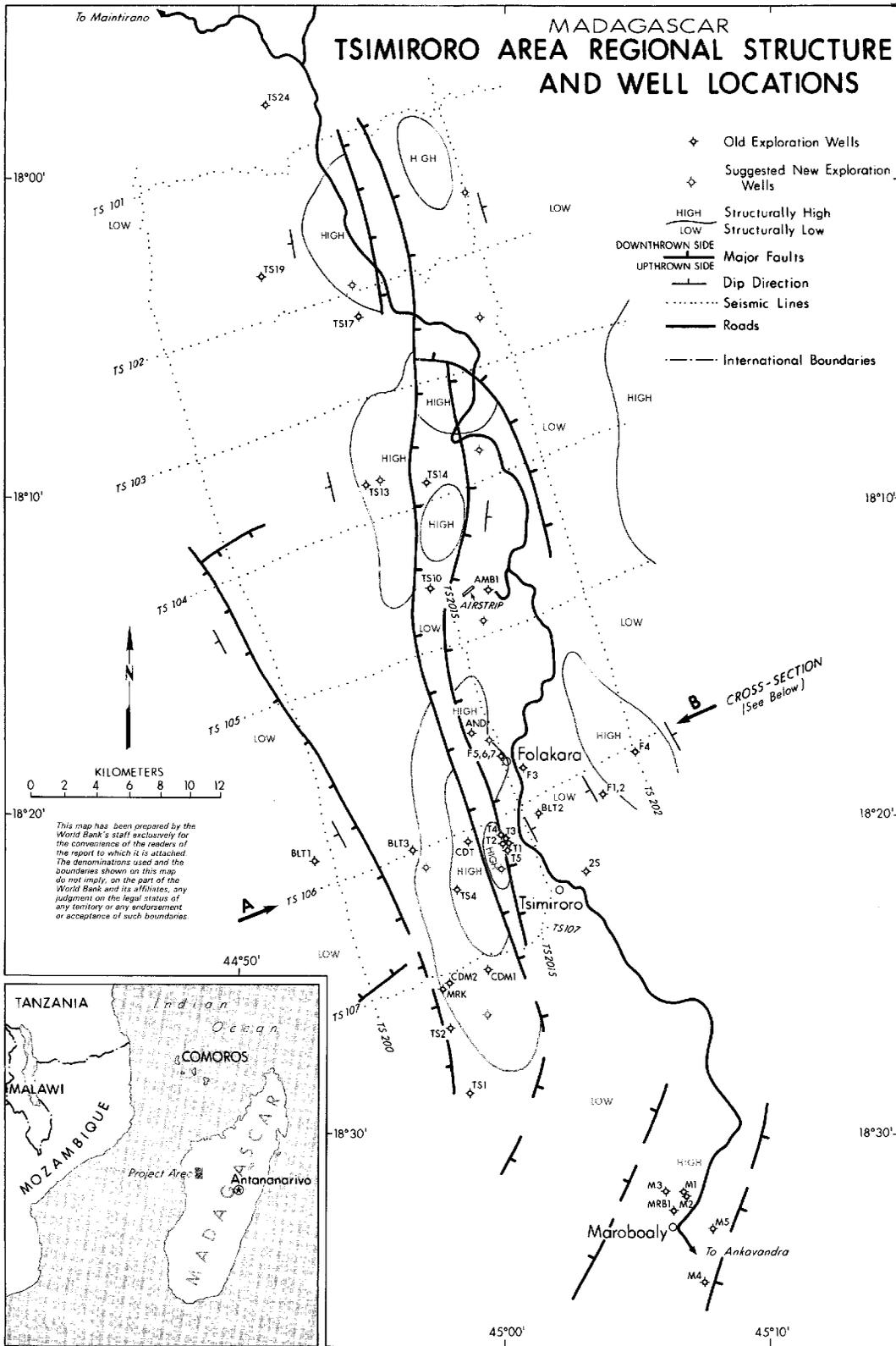


This map has been prepared by the World Bank's staff exclusively for the convenience of the readers of the report to which it is attached. The denominations used and the boundaries shown on this map do not imply, on the part of the World Bank and its affiliates, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.



- Main Roads
- Selected Secondary Roads
- Selected Cities and Towns
- Rivers
- Swamps
- International Boundaries

MADAGASCAR TSIMIRORO AREA REGIONAL STRUCTURE AND WELL LOCATIONS



DIAGRAMMATIC CROSS-SECTION ALONG SEISMIC PROFILE TS 106 THROUGH WELLS AS SHOWN

