DP/UN/JAM-82-008/1

UNITED NATIONS

DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

INDUSTRIAL MINERALS DEVELOPMENT

JAMAICA

Project findings and recommendations

Prepared for the Government of Jamaica
by the United Nations
Department of Technical Co-operation for Development
acting as executing agency for the
United Nations Development Programme

New York, 1988

NOTES

The designations employed and the presentation of the material in this report do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The monetary unit in Jamaica is the dollar ($J). During the period covered by the report, the value of the Jamaican dollar in relation to the United States dollar ranged from $US 1 = $J 4.76 in July 1984 to $J 5.50 in December 1986.

Abbreviations used

DTCD	-	Department of Technical Co-operation for Development
EDP	-	electronic data processing
GSD	-	Geological Survey Division
JNIP	-	Jamaica National Investment Promotion Company
UNDP	-	United Nations Development Programme
USAID	-	United States Agency for International Development

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ABSTRACT

Under the auspices of the Government of Jamaica and the United Nations Development Programme, the Jamaican Geological Survey Division (GSD) and the United Nations Department of Technical Co-operation for Development embarked on a joint project for the exploration and development of non-metallic minerals throughout the island country of 10,900 square kilometres during the period June 1984 through December 1986.

Deposits of high purity limestone and dolomite and attractive marble were discovered. Silica sand, gypsum, clay and aggregate materials were evaluated for economic potential.

Investors, both local and foreign, were attracted. Other non-metallic deposits were found, including igneous ceramic raw materials and special aggregate minerals.

A sample preparation facility, chemical laboratory and electronic data processing facility were established to provide support for field work during the course of the project. Field vehicles, geologic and laboratory equipment and computers were obtained. Training was provided on-the-job and through visiting consultants and study tours.

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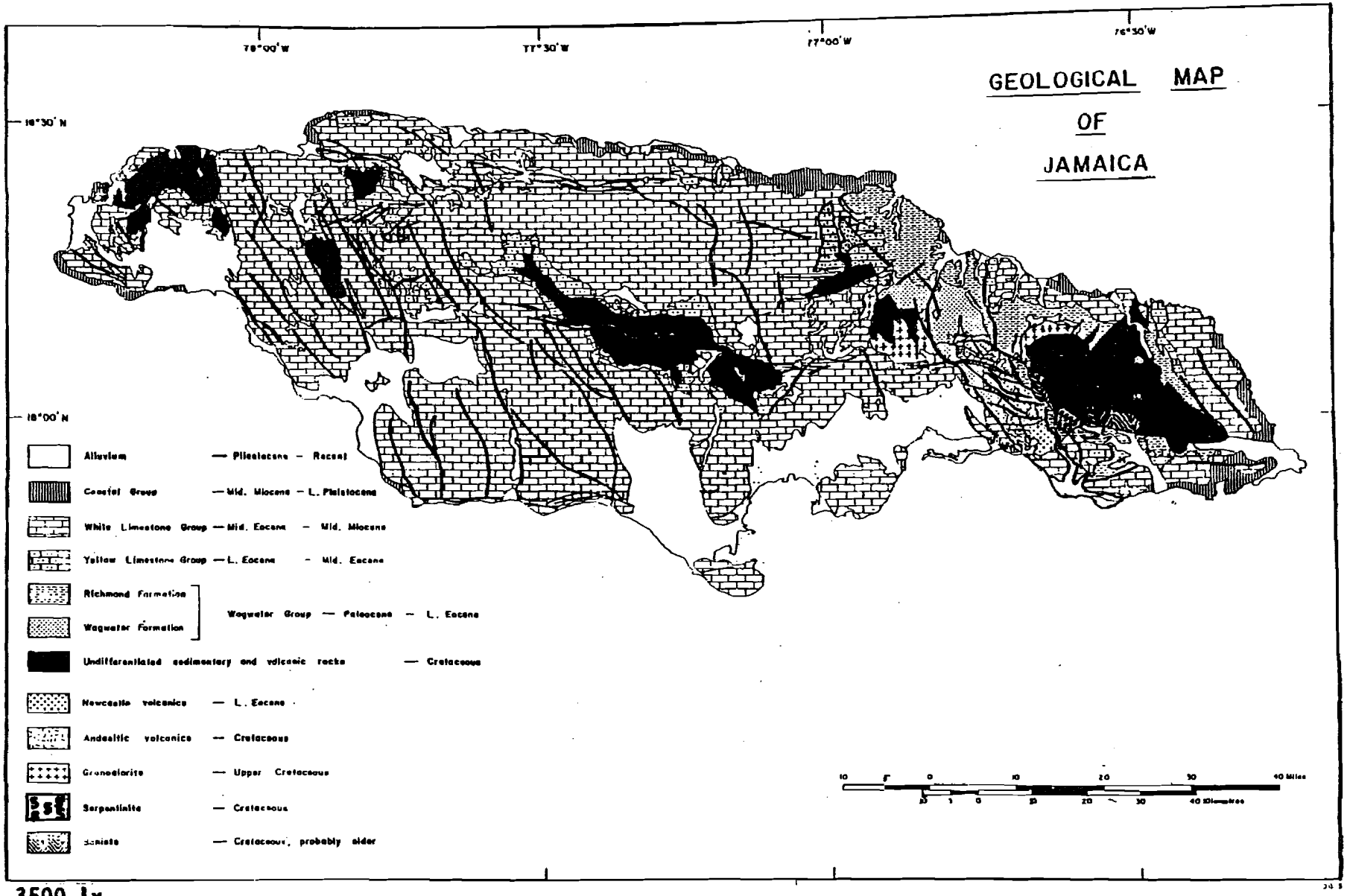
GEOLOGICAL MAP
OF
JAMAICA
78°00'W
77°30'W
77°00'W
76°30'W
18°30'N
18°00'N
Alluvium — Pliestocene – Recent
Coastal Group — Mid. Miocene – L. Pleistocene
White Limestone Group — Mid. Eocene – Mid. Miocene
Yellow Limestone Group — L. Eocene – Mid. Eocene
Richmond Formation
Wagwater Formation
Wagwater Group — Paleocene – L. Eocene
Undifferentiated sedimentary and volcanic rocks — Cretaceous
Newcastle volcanics — L. Eocene
Andesitic volcanics — Cretaceous
Granodiorite — Upper Cretaceous
Serpentinite — Cretaceous
Schists — Cretaceous, probably older
10 5 0 10 20 30 40 Miles
40 30 20 10 0 10 20 30 40 Kilometres

3500.1x

FIG. 1

INTRODUCTION

The Government of Jamaica, through its Ministry of Mining, Energy and Tourism and the Geological Survey Division (GSD), in conjunction with the United Nations Development Programme and its executing agency, the Department of Technical Co-operation for Development (DTCD) undertook a joint project, Industrial Minerals Development (UNDP project JAM-82-008) which ran from June 1984 through December 1986, including a one-year extension.

The Government's primary development objective was to accelerate the evaluation and development of the country's non-metallic (industrial minerals) resources, so as to strengthen and diversify the national economy by providing employment, developing infrastructure, forming capital and earning foreign exchange and to provide basic raw materials for expanding the national industrial capacity.

The Jamaican Government's goal was to concentrate on exploration and evaluation programmes on those non-metallic minerals targets which offered the best prospects for early development, and to attract national and external investment and enhance the capacity of the Ministry of Mining and Energy in all aspects of non-metallic mineral sector planning and development.

The project commenced on 1 June 1984 and was initially scheduled for 18 months. An additional one-year extension was requested by the Government through 1986, in view of accomplishments made and the recognised potential of the project. During 1986 project findings attracted potential investors resulting in several ventures and promises of more to follow.

Support for the project was provided by UNDP, the United States Agency for International Development (USAID) and by the Government of Jamaica. The funding details are given in table 1.

Table 1. Funding history, project JAM-82-008

Source	Original term (1/6/84-31/12/85)	Extension term (1/1/85-31/12/86)	Total (30 Months)
Jamaican Government	$J 1,826,000	$J 775,000	$J 2,601,000
(Converted to $US)	332,000	140,909	472,909
UNDP ($US)	463,549	200,500	664,049
USAID ($US)	---	79,500	79,500
Total ($US)	795,549	420,909	1,216,458

I. OBJECTIVES AND BACKGROUND

The Jamaican Government's overall development objective and strategy for the non-metallic mineral sector has been to accelerate the evaluation and rational development of the country's mineral resources, so as to strengthen and diversify the national economy by providing employment, developing infrastructure, forming capital, earning foreign exchange and by providing the raw materials for expanding the national industrial capacity. In this context three immediate objectives covered the key provisions within the Government's overall development objective as follows:

1. To identify promising non-metallic mineral deposits warranting priority for detailed exploration and evaluation, with particular reference to gypsum, anhydrite, limestone, dolomite, marble, silica sand and clay; and to prepare detailed programmes for further investigation;

2. To provide the technical data base for the attraction of national or external investment for non-metallic mineral development; and

3. To strengthen the capacity of the Ministry of Mining and Energy, especially the Geological Survey Division, to explore and evaluate non-metallic mineral deposits and to support their development in all its aspects.

The project was planned and carried out within the context of a minerals industry that has been dominated by bauxite alumina for more than a third of a century so that other non-metallic minerals have been exploited to a much lesser extent. These include limestone, dolomite, sand, gravel, gypsum, shale, silica sand, clay and dimension stone.

Because carbonate raw materials (limestone and dolomite) occur in great abundance in Jamaica (figures 1 and 2) their use historically

JAMAICA
LOCATION OF NON-METALLIC RESOURCES

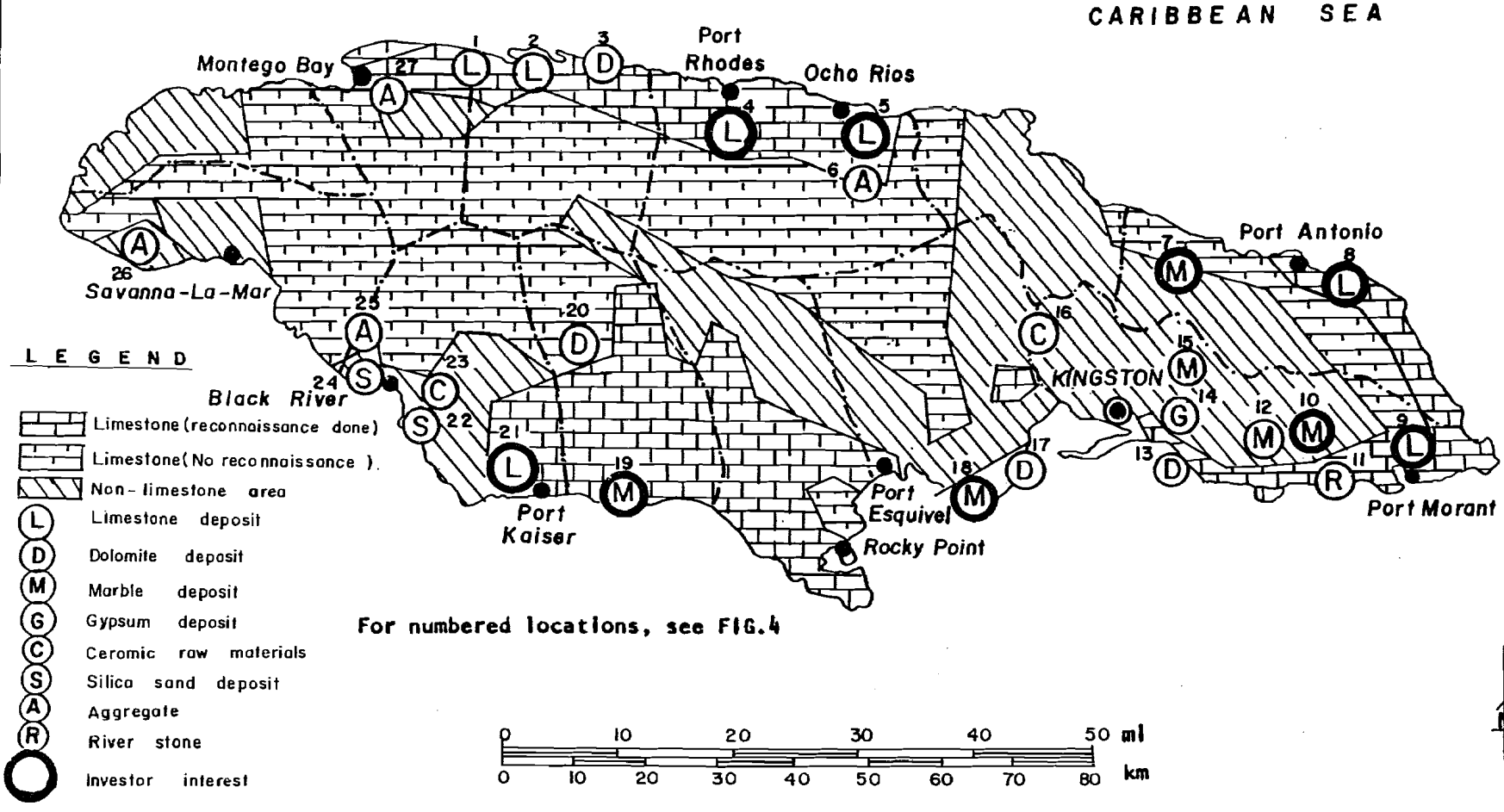

FIG. 2

3500.2x

has been confined to certain special small-scale applications. Limestone has been and still is calcined for the alumina production industry. Also, a rising demand for carbonate construction aggregate to replace sand and gravel has resulted in the evolution of a limestone-dolomite crushed stone industry which is finding significant overseas markets.

For many years an easily exploited soft limestone called marl, has been used extensively for a variety of local purposes, especially road base and maintenance applications, but it is currently being replaced by hard crushed stone from carbonate and igneous sources. Marl, however, is still a major aggregate constituent in concrete blocks which are widely used as building components.

Dolomite has been confined to aggregate production in one location. One inland producer has developed local markets, but high transportation costs have blocked its consideration for export.

Limestone and dolomite have dozens of applications other than as aggregate, depending on such physical properties as colour, particle size and shape, purity and hardness. Likewise, the chemical composition and relative ratios of impurities in carbonate minerals determine their potential application for many industrial uses including chemical, glass, refractory and pollution control.

Historically, few investigations have been made by foreign mineral companies into the higher value uses of carbonate raw materials in Jamaica, with little of substance ever developing until the project provided new information of interest to investors.

Sand and gravel production in Jamaica has until recent years been adequate to meet local needs, however, supplies have been significantly depleted in many parts of the country. This transportation-sensitive, low-unit-value commodity is being replaced by processed crushed stone from abundant limestone and dolomite rocks throughout the island. Because of the rapid evolution of a crushed stone

industry and the entry of new producers, considerable assistance has been provided by the Geological Survey Division and the Mines and Quarries Department in support of this growing industry.

Gypsum was originally mined for export but today it is primarily used for making cement. Sales to the local cement plant should increase and the need to ensure adequate reserves of gypsum are a high priority.

Shale has been quarried locally for the cement plant. Abundant reserves can be found throughout the country.

Silica sand has been mined from one location in southwestern Jamaica (Black River basin) for more than 20 years for the West Indies Glass Company. There had been concern about long-range reserves, but finds by the project have added 30 years of proven reserves to the company's inventory.

Clay of various composition and type has long been extracted to meet the modest needs of numerous small ceramics producers. Because of the relatively minor tonnages required by any one producer, supplies have been unreliable and the quality variable resulting in costly processing problems. There is a strong need for proven reserves of ceramics-quality clay to support this rapidly growing Jamaican industry. In addition, a planned structural clay products industry has been so far blocked because sufficient economically viable reserves have not been proven.

Dimension stone, especially marble, was briefly exploited in the 1960s, in the Serge Island area of eastern Jamaica. Operational problems with the stone's physical properties resulted in a decline in market acceptance which closed the operation. Marble chips have been, and still are, produced for terrazo tile production. A small craft work marble industry was developed at Hellshire Bay, near Kingston, that has potential for growth. It has been assisted by the Geological Survey Division, including assessment of reserves and means of extraction.

Two major types of marble are found in Jamaica: (1) a metamorphic variety in the eastern Blue Mountains tectonic zone, and (2) re-crystallized limestone along the south coast which, for all intents and purposes, may be called marble in that it takes a fine polish and is durable. Considerable work is needed to attract investors to this industry, including detailed geologic mapping, drilling and proven quarrying techniques. Other varieties of dimension stone have been used in Jamaica since colonial times, often being the main construction material used in the great houses and structures of former days. The stone was usually taken from quarries near the structure being built and included various types of igneous and volcanoclastic rocks as well as bedded limestone, sandstone and marble.

In summary, the objectives were consistent with the Government's development objective. Sufficient latitude was provided to adjust priorities as circumstances changed during the project. The time was ripe to attract investors in Jamaica's non-metallic resources. The general geologic background of the country had been defined by a competent Geological Survey Division and the general potential for industrial minerals was evident. Further, Jamaica is favourably located to serve major international markets, especially those of North America.

II. PLANNED ACTIVITIES AND OUTPUT

The project work plan called for achieving three principal objectives. The following review of activities and goals is organized on the basis of those objectives.

A. Summary and analysis of targets for investment

There was to be as a first objective a detailed data review and evaluation, identification of targets for project investigation, preparation of data summaries and reports with recommendations. There would be a summary of available data on occurrences of gypsum, anhydrite, limestone, marble, dolomite, silica sand and clay in Jamaica.

The project began on the arrival of the Chief Technical Adviser with a detailed review of the available data on raw material commodities. The Geological Survey Division library provided many publications on all aspects of Jamaican geology. The Geological Survey Division was established in 1859 and had prepared many maps and publications covering non-metallic minerals. Recent correspondence and inquiries from persons, companies and organizations interested in non-metallics also proved useful.

The analysis of available data in relation to current economic factors enabled the setting of priorities so that minerals with the highest unit value of importance would be evaluated first. Considerable input from foreign sources was required to establish current export values and probable needs. Accordingly, the following priorities were established for project exploration guidelines.

Priority	Mineral
I	High-grade limestone, marble and silica sand
II	Dolomite, gypsum and anhydrite
III	Aggregate
IV	Clay, raw material for ceramics, other minerals

The priority I minerals were chosen because market studies indicated that (1) high-grade limestone (99 per cent pure) with high brightness, could be a high-unit-value commodity of interest in certain export markets; (2) marble markets were found both inside Jamaica and overseas if interesting and economically viable varieties could be found; and (3) additional reserves of silica sand had to be proven for the local West Indies Glass Company to formulate expansion plans involving export possibilities.

Priority II minerals concerned (1) dolomite, which has fewer potential markets than limestone, and (2) gypsum which has less geologic potential for finding new reserves but which would be important if sufficient reserves could be found.

Priority III minerals concentrated on low-unit-value aggregate, especially the lower grades of limestone or dolomite which, although plentiful throughout the country, are generally geologically complex.

Priority IV minerals included (1) clay with little export potential but necessary for the local market, (2) ceramic resources (igneous), and (3) other economic minerals including non-skid aggregate, volcanoclastic dimension stone, sized river stones and brines from evaporite lagoons, all of which required more exploration, research and development.

The above priorities were established as a general guide and several were changed as unexpected outside investor interests appeared.

Detailed exploration and evaluation programmes or invitations were provided to private investors. Some specific studies were made as follows:

Limestone reserves were identified throughout the country transportation zone of approximately 16 km (10 miles) from the sea and 8 km (5 miles) on either side of the national railroad line

(figures 3 and 4). The economic objective was to find limestone of high brightness and high purity by collecting representative channel samples for chemical analysis in the project laboratory.

Specific locations of marble in Jamaica, of which some were already partially identified, required additional geologic mapping, sampling and strategic core drilling to outline attractive deposits. The economic objective was to find the best quality marble to interest investors.

The shore line zone of the Black River basin in Jamaica was searched for the most likely sources of additional silica sand. The economic objective was to prove adequate reserves for the West Indies Glass Company. Close-spaced grid drilling, using auger and drive tube, were employed. The sand beds were shallow and many interfingered with clay beds.

Some dolomite deposits previously identified, e.g., Port Henderson and Dunsinane, required channel sampling and chemical analysis. An especially attractive deposit was found at Stewart Bay warranting a drilling programme to delimit reserves. The economic objective was to find high-purity deposits for special dolomite markets.

Gypsum and anhydrite were found in only one general area known as the Bull Bay District, 10 miles (16 km) east of Kingston. The best surface deposits had already been identified and only subsurface deposits, if any, remained to be discovered. The economic objective was to find significant reserves for export and new applications in Jamaica. Four target areas were identified by consultants for future detailed mapping and possible core drilling.

No exploration programme was planned for limestone or dolomite aggregate owing to the significant number of local investors who had already entered or were planning to enter this business sector. However, considerable evaluation and consulting assistance was made

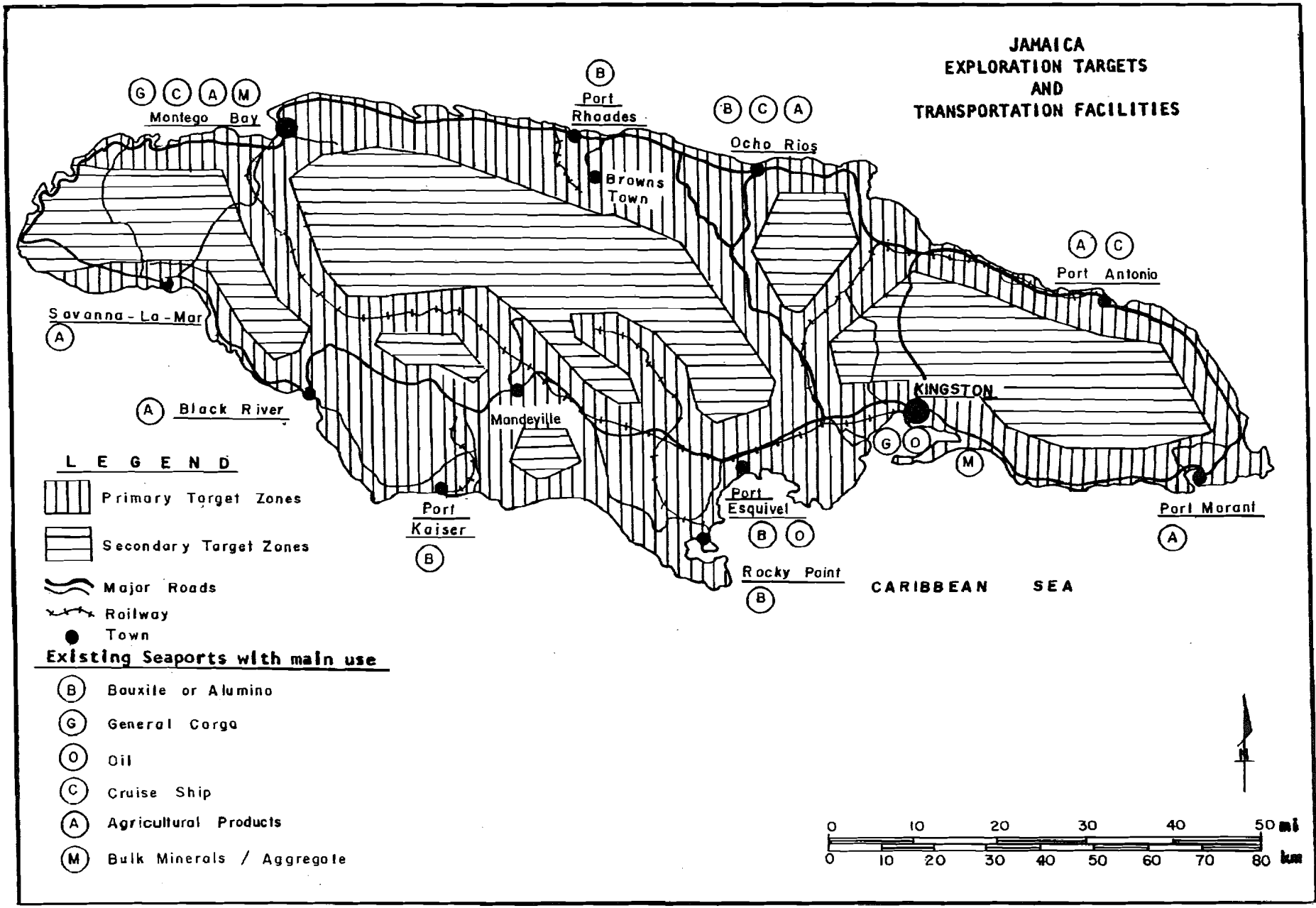
JAMAICA
EXPLORATION TARGETS
AND
TRANSPORTATION FACILITIES
G C A M
Montego Bay
B
Port Rhoades
B C A
Ocho Rios
Browns Town
A C
Port Antonio
Savanna-La-Mar
A
A Black River
Mandeville
KINGSTON
G O
M
Port Esquivel
B O
Port Kaiser
B
Port Morant
A
Rocky Point
B
CARIBBEAN SEA
LEGEND
Primary Target Zones
Secondary Target Zones
Major Roads
Railway
Town
Existing Seaports with main use
B Bauxite or Alumina
G General Cargo
O Oil
C Cruise Ship
A Agricultural Products
M Bulk Minerals / Aggregate
N
0 10 20 30 40 50 mi
0 10 20 30 40 50 60 70 80 km

FIG. 3

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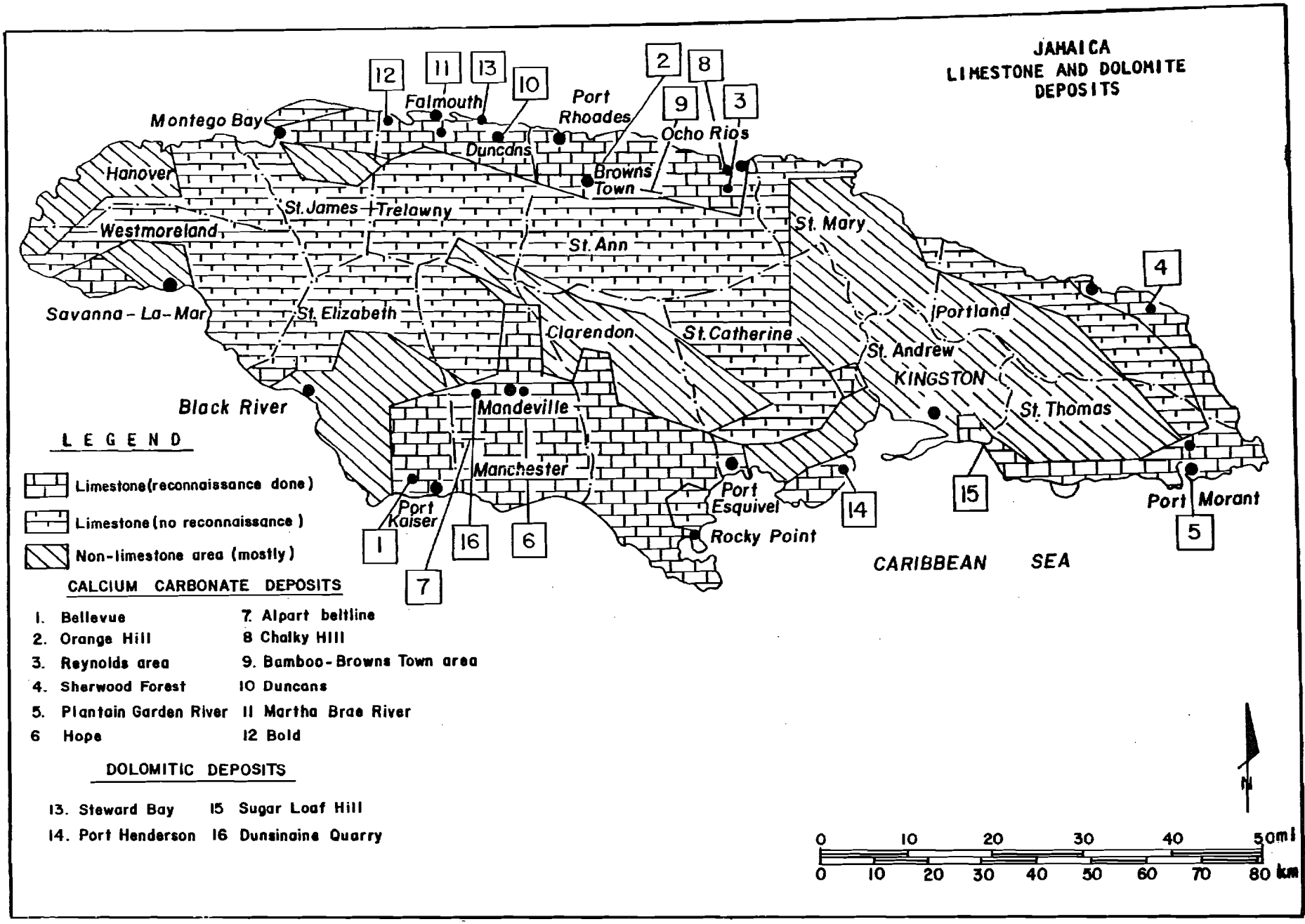

JAMAICA
LIMESTONE AND DOLOMITE
DEPOSITS
Montego Bay
Falmouth
Port
Rhoades
Ocho Rios
Duncans
Browns
Town
Hanover
St. James
Trelawny
Westmoreland
St. Ann
St. Mary
Savanna - La - Mar
St. Elizabeth
Clarendon
St. Catherine
Portland
St. Andrew
KINGSTON
St. Thomas
Black River
Mandeville
Manchester
Port
Kaiser
Port
Esquivel
Rocky Point
Port Morant
CARIBBEAN SEA
LEGEND
Limestone(reconnaissance done)
Limestone(no reconnaissance)
Non-limestone area (mostly)
CALCIUM CARBONATE DEPOSITS
1. Bellevue
2. Orange Hill
3. Reynolds area
4. Sherwood Forest
5. Plantain Garden River
6 Hope
7. Alpart beltline
8 Chalky Hill
9. Bamboo-Browns Town area
10 Duncans
11 Martha Brae River
12 Bold
DOLOMITIC DEPOSITS
13. Steward Bay
14. Port Henderson
15 Sugar Loaf Hill
16 Dunsinaine Quarry
N
0 10 20 30 40 50 mi
0 10 20 30 40 50 60 70 80 km

FIG. 4

3500.4x

available to them. The economic objective was to aid the development of this export-oriented business to the extent possible.

Studies of all the available data indicated many deposits of clay and ceramic resources occur throughout Jamaica but most require sampling and core drilling to outline viable deposits. The economic objective was to find small deposits of interest to local investors.

Occasional investor inquiries regarding such other mineral commodities as non-skid aggregate were investigated on an ad hoc basis throughout the project.

Various approaches were used to solicit investors including direct phone calls, letters, consultants' contacts, brokers, advertisements in technical journals and personal contacts by the CTA and GSD Director. Potentially interested investors were brought to the attention of GSD by the Jamaica National Investment Promotion Company (JNIP). To speed up investor participation, project data was usually provided as generated, rather than waiting for full data accumulation for particular mineral deposits. This concept resulted in bringing investors to Jamaica fairly rapidly, consequently they often picked up the remaining development efforts on specific deposits allowing concentration of project staff in other areas.

B. Reports and prospectuses for investment promotion

A second immediate objective was to be the preparation of reports and prospectuses on mineral deposits warranting investment, after detailed review and/or after detailed exploration and evaluation of prospects by the project. Because of the large size of the exploration area, literally the whole country, 10,900 km^2 (4,208 mi^2), and the many commodities to be evaluated, it was decided early in the programme that carbonate rocks would be the first exploration priority and that submission of prospectuses to investors would be done concurrent with the accumulation of data. This was to attract investors as early as possible so as to encourage them to spend some of their time and money on "parallel development" of the necessary detailed information required for an investment decision.

Accordingly, typical prospectuses submitted to investors were confined to technical data packages including brief field geological reports, infrastructure facts and detailed analytical data on surface and bore hole samples, and invitations to visit Jamaica for personal data reviews and guided tours of selected mineral deposits.

The areas of Jamaica selected for exploration were chosen on the basis of favourable geologic environment and transportation viability. Consequently the exploration zones selected for initial evaluation included a 16 km (10 miles) band encompassing Jamaica's coastal areas and similar exploration corridors paralleling the one major railroad and several first-class roads (figure 3).

This programme focused on gathering hundreds of channel samples which were prepared for chemical analysis by drying, crushing, pulverizing and splitting. Analysis was by atomic absorption spectrophotometer as well as photo light meter reflectance tests for whiteness (brightness) values. The data so obtained was published as generated on analysis sheets which were given to potential investors.

Although high-grade carbonate resources, especially limestone, represented the most attractive non-metallic mineral commodity for new investors, other industrial minerals were evaluated to assist local companies and to aid in quarry planning and development.

Ten aggregate companies either use, or were planning to use, carbonate raw materials for crushed stone. They were provided with geologic maps, samples, laboratory analyses, drilling, and limited marketing assistance.

One activity was dedicated to assisting Jamaica's single glass producer, the West Indies Glass Company, in expanding silica sand reserves. Detailed geologic mapping and an extensive drilling programme proved significant additional resources.

Three producers of ceramics and one brick producer were assisted with raw material problems associated with quantitative and qualitative reserves evaluations. Also, field exploration for ceramic glaze and clay identified several potential resource locations.

Two local companies and one foreign broker were assisted in a search for non-skid aggregate and sized river stones. Whereas some raw materials were found, reserves are not sufficient for economic development; however, further search is warranted.

Jamaica's only small-scale marble producer, Hellshire Bay Marble Co., was given assistance in exploration and definition of reserves and implementation of a quarry development plan. A Canadian marble investor (Commonwealth Marble Co.) received aid from exploration drilling to and including marble block extraction for testing overseas.

C. Training, laboratory support, documentation and advisory services

Diverse activities were implemented to achieve the third immediate objective, i.e., strengthening the capacity of the Ministry of Mining and Energy to explore, evaluate and support the development of Jamaica's non-metallic minerals. The project provided on-the-job training, workshops, seminars and study tours. It undertook to establish a GSD chemical laboratory and provide laboratory support to field operations and other Ministry divisions. It also undertook to establish a data storage and retrieval system, and it provided consultant support and advisory services to the Ministry and para-statal organizations.

It was intended that at least two national geologists and up to four geologist assistants be trained in exploration for, and evaluation of, non-metallic minerals. The difficulties of training staff were minor but included the teaching and instilling of good field-work habits in new staff members. Most had only limited experience in mapping, core logging and technical report writing.

Effective training was hampered by the need to meet rigid deadlines which left little time for personal attention. There was, further, a high turnover of both field and laboratory staff. Nevertheless, five national geologists were trained.

A workshop in electronic data processing was held in November 1985. Twelve staff members were provided two weeks of computer instruction from a visiting consultant. Another workshop on marble quarrying was given at the Hellshire Bay Marble Company deposit. This provided hands-on experience under the guidance of a skilled Jamaican technician and project experts. The GSD now has a wire-saw crew capable of cutting marble dimension stone. Training was continuing at project's end with focus on line drilling extraction techniques.

Prior to the project, no analytical facilities existed at the GSD and the goal of a chemical laboratory with one trained chemist and at least four assistants had to begin from the ground up. (See report by Y. Goscinny, Dec. 1986).

The project Chemical Analyst guided the laboratory programme from its beginning to a fully functional basis. Again, heavy staff turnover posed severe problems and there were delays in receiving supplies and equipment. Nevertheless, since its start-up in July 1985, the laboratory has provided competent analytical services on a reliable scheduled basis. It also offers services to outside users in addition to normal GSD work and has established the following system to handle the increased demand: routine service provides results in one or two weeks, high priority needs are handled in two or three days, and urgent demands bring results within 24 hours. The laboratory can provide almost any type of wet chemical analysis and atomic absorption spectrophotometry. Laboratory services planned for the future include "soundness" tests for aggregates, basic thermal tests on ceramic raw materials, and physical strength tests for marble.

The major problem facing the laboratory, at project's end, was the high staff turnover reflecting low salary levels not competitive with those in the private sector. This problem must be addressed if the laboratory is to continue providing the services needed.

Parallel with the establishment of the chemical laboratory was the strengthening of the sample preparation laboratory. Equipment was added, allowing it to prepare hundreds of samples per week for chemical analysis in the laboratory.

The project was to establish a geoscience and mineral resource data storage and retrieval system for published Ministry technical reports, with one GSD member trained in the system adopted. Pending full operation of the newly installed electronic data processing system, a traditional manual office filing system was established.

Basic microcomputer equipment was acquired, consisting of an IBM PC-XT and associated hardware and software. The EDP programme was hampered by delays in receipt of equipment, faulty equipment, and fluctuations in the power supply. Three EDP consultancies concentrated on basic training, systems analyses and applications to departmental requirements. A computerized inventory control system for chemical supplies was developed, but progress was slow and a fully functional EDP department was still some time away by the project's end.

The project was to provide expert and consultant reports and otherwise advise the Ministry (e.g., Mines and Quarries Division). Seven consultancies were fielded. In June 1985, Drs. Robert Speed and Rudolph Torrini from Northwestern University, Evanston, Illinois, USA, mapped the structural geology of a complex gypsum/anhydrite area. In August 1985, November 1985 and October 1986, Miss Nellie Guernsey, Mineral Systems Inc., New Haven, Connecticut, USA, assisted in the installation of computer hardware, training in software use and a third visit one year later was requested for additional applications. In January 1984 and November 1985, Dr. Roberto Pisani,

International Technical Services, Carerra, Italy, evaluated the commercial potential of various Jamaican marble deposits during two consultancy missions. Finally, in June 1986, Mr. Peter Harbin, Ossining, New York, USA, provided assistance in advertising and bringing to investor attention the several high-grade calcium carbonate deposits identified during the project. The reports of all seven missions are listed in Annex II, by consultant's name.

Other project activities supported the Government of Jamaica divisions and para-statal agencies. Advice was given to the Jamaica National Investment Promotion Co. in the shipping of bulk minerals and responding to investor inquiries in minerals and mining matters. The project provided the Planning Institute of Jamaica with detailed marble investment studies. It assisted the Jamaica Gypsum and Quarries Company in developing reserves data. Finally, the project provided the Petroleum Corporation of Jamaica with geologic data on selected mineral properties.

III. RESULTS

A. Deposits identified

1. Limestone

Approximately 70 per cent of the limestone area within the economic transportation zone, i.e., 10-mile (16 km) band around the island's coast and partially along the national railroad, were evaluated by geologic reconnaissance (figure 2). Large reserves of limestone occur with carbonate purities in range of 98 per cent which is suitable for aggregate, pollution control and calcined lime production. However, only a limited number of very high-grade deposits (carbonate purities in the range of 99 per cent) were discovered. These are at: (1) Bellevue, St. Elizabeth; (2) Orange Hill, St. Ann; (3) Reynolds Belt, St. Ann; (4) Sherwood Forest, Portland; and (5) Plantain Gardens, St. Thomas. The following deposit descriptions are from the report of Associate Expert, K. Paakkonen, Preliminary Evaluation of Jamaican Limestones, Nov. 1986. All numbered map locations can be found in figures 2 and 4.

(a) Bellevue, St. Elizabeth (map loc. 21). The deposit occurs on the south coast of Jamaica approximately 10 miles (16 km) from Port Kaiser, a former bauxite shipping facility. Possible reserves are in the range of 10 million tons. $CaCO_3$ purity averages 98.9 per cent with a brightness of 92. A Canadian company (Commonwealth Limestone Co.) holds a prospecting license and plans development work if suitable shipping facilities can be found. Port Kaiser is apparently unavailable for shipping non-bauxite minerals for the immediate future.

(b) Orange Hill, St. Ann (map loc. 4). The deposit is located near Brown's Town 6 miles (10 km) and Ocho Rios, 20 miles (32 km) distant. Reserves may be more than 10 million tons. $CaCO_3$ purity averages 99 per cent and average brightness is 92. Local investors and a Canadian company are planning development.

(c) Reynolds Belt, St. Ann (map loc. 5). The deposit is located near Ocho Rios on the north coast, about 3 miles (5 km) inland along a former bauxite conveyor belt line. Reserves are greater than 10 million tons although quality is slightly less, averaging 98.8 per cent $CaCO_3$ purity with a brightness range of 89.5. A local investor is interested.

(d) Sherwood Forest, Portland (map loc. 8). The deposit occurs approximately 7 miles (11 km) from Port Antonio, the nearest shipping port. It had the highest purity and the highest brightness found during the project, averaging 99.2 per cent $CaCO_3$ with a brightness of around 94. Reserves are about 5 million tons. A major U.S. industrial minerals company is currently (1986) evaluating the deposit (Pfizer Minerals and Pigments Co.).

(e) Plantain Garden, St. Thomas (map loc. 9). The deposit occurs about 4.5 miles (7 km) north of Port Morant on Jamaica's southeast coast. Reserves are apparently large but need more definition. The limestone quality is good, averaging 99.2 per cent $CaCO_3$. Dry brightness averages around 92. There is current investor attention from two companies in the USA. Other limestone deposits identified during the project with slightly less economic potential are described in the report of K. Paakkonen, Nov. 1986.

2. Dolomite

Dolomite is less common in Jamaica than limestone, nevertheless, a few deposits with good economic potential exist. While no theoretically pure dolomites (21.7% MgO) were found, one excellent deposit was found with an overall MgO content in the range of 17 to 18 per cent and very low impurities of iron and silica averaging 0.05 and 0.12 per cent respectively. Other less pure deposits are

scattered throughout the island. Impurities of Fe_2O_3 and S_1O_2 and variations in MgO content render some of the deposits unsuitable for glass, refractory and chemical industry uses. However, the dolomites in general are harder than many of the limestones making them suitable for aggregate. The most promising dolomite deposits were: (1) Stewart Bay, Trelawny (figure 2, loc. 3); and (2) Port Henderson, St. Catherine (figure 2, loc. 13). Others with less promising economic potential included Dunsinane, Manchester (figure 2, loc. 20) and Sugar Loaf, St. Thomas (figure 2, loc. 13) and are detailed in the report of K. Paakkonen, Preliminary Evaluation of Jamaican Limestones, Nov. 1986.

(a) Stewart Bay, Trelawny (map loc. 3). The deposit is located on Jamaica's north coast, outcropping in high cliffs facing the sea. Reserves appear to be in the millions of tons, based on preliminary drilling from three widely spaced core holes. More importantly, impurities of S_1O_2 and Fe_2O_3 are very low, averaging only 0.11 and 0.05 per cent respectively. The MgO content averages about 17.9 per cent or about 4 per cent less than pure dolomite, only a minor drawback for most applications. The consistently high purity and massive nature of the deposit make it highly suitable for dimension stone and such industrial uses as glass, refractories metallurgical, chemical and aggregate. Road transportation to the nearest shipping port at Discovery Bay is 13 miles (21 km). Promotion to investors was planned as soon as representative bulk samples could be provided for investor evaluation.

(b) Port Henderson, St. Catherine (map loc. 17). Located as a capping formation of the Port Henderson hills, on the western side of Kingston Harbour, this deposit is attractive from a transportation and shipping standpoint. Reserves are in the millions of tons based on drilling data and geologic mapping. The MgO content is around 13 per cent whereas S_1O_2 and Fe_2O_3 average around 0.34 and 0.07 per cent respectively.

Probable highest and best use would be as aggregate. Proximity to Kingston is a transportation advantage, but, possibly an environmental disadvantage, requiring mining operations to be carefully planned and executed.

3. Marble

Certain marble deposits have been recognized for many years in Jamaica, one of which (Serge Island) was briefly under development in the 1960s but terminated after a few years of inefficient operation. Essentially two geologically different types of carbonate rock occur in the country that may be classified as marble and that fit the commercial definition of a stone which takes a polish and meets certain standards of dimensional and physical integrity. The first is a metamorphic marble occurring in several distinct tectonic zones in the Blue Mountains area of eastern Jamaica, a few of which were evaluated for economic potential. The second type occurs within highly faulted carbonate zones along the south Jamaican coast, and are actually recrystallized limestones. Most have recemented brecciated patterns with varigated colours of pink and beige. One such deposit in the Hellshire area near Kingston has been under modest development for three years, primarily for craft work items and small-sized marble products. Project objectives focused on the identification of new deposits, the extension of reserves for development and quarry planning.

Specific locations evaluated during the program, as shown in figure 2 by resource map number, included: (15) Garbrand Hall; (10) Bath; (7) Portland-Chepstowe; (19) Cuckold Point; and (18) Hellshire.

(a) Garbrand Hall, St. Thomas (map loc. 15). The deposit is located on the flanks of the Blue Mountains at an elevation of 2,000 feet (609 meters). Immediate access to the deposit is difficult and road transportation to the nearest port is approximately 20 miles (32 km). Marble colours are predominantly green and black. Reserves are likely more than

1 million tons, however, additional core drilling is needed to confirm and determine the best quarrying area. Three widely spaced, strategically located, core holes were drilled that indicated large reserves, but there were also some indications of local quality problems evidenced by jointing, fracturing and thin schistose bedding related to the Miocene uplift tectonics contemporaneous with the formation of the Blue Mountains. The Commonwealth Marble Co. (Canadian) has taken out a prospecting license covering the whole area and has indicated intentions to explore the deposit in more detail. See the report Garbrand Hall (Island Head) marble deposits by L. Henry, Jan. 1985.

(b) Bath, St. Thomas (map loc. 10). Deposits of metamorphic marble occur in the coastal foothills near the town of Bath in eastern Jamaica. Distance to the nearest shipping location at Port Morant is 5 miles (8 km). The deposits are unusually attractive with mottled brown, white and green patterns; however, mapping and core drilling determined that the marble had a highly brittle nature with no large monolithic masses being detected during exploration, very likely eliminating its consideration for commercial quarrying of large blocks. There is currently some production of about 1,000 tons per year for terrazo tile chips and random-sized floor tiles by a local Kingston company (Gore Brothers). Reserves of fractured material are apparently large, in the range of millions of tons. Investment potential is good for craft work and tile markets. See the report Economic assessment of the Bath limestone (marble) by F. Gillings, July 1986.

(c) Portland-Chepstowe, Portland (map loc. 7). These deposits occur in nine separate areas within a 12-square-mile (30 km^2) zone, however, only a few are feasible for development either because of unfavourable geologic conditions or urban restrictions. Where exploitable, the

marble is a fairly hard, dense, dark grey, massive variety that should have architectural attraction where conservative colours are desired. Reserves were not estimated but are probably large. Distance from deposits to nearest shipping point at Port Antonio is approximately 10 miles (16 km). The Commonwealth Marble Co. (Canadian) has taken out a prospecting license on the area with the intention of doing further development work. See the report Portland-Chepstowe marble deposits by F. Gillings, Nov. 1985.

(d) Cuckold Point, Manchester (map loc. 19). Exposures of attractively brecciated and recrystallized beige and pink marble occur along a 6-mile (10 km) outcropping of Newport Limestone along Jamaica's southern coast. Discovered early in the project, the deposits were mapped, sampled and then drilled with three widely-spaced core holes. Preliminary data suggests reserves to be extremely large. The material occurs as a capping, or top zone, between 50 and 75 feet thick. Preliminary tests showed good marble qualities. The nearest shipping point is at Port Kaiser (figure 2) approximately 8 miles (13 km) from the deposits. The Commonwealth Marble Co. (Canadian) has taken out a prospecting license to develop the deposits and also has extracted sample blocks for physical tests abroad which have proven the acceptable quality of the material. See the report Dimension stone (marble) evaluation at Cuckold Point by H. Elliston, Nov. 1984.

(e) Hellshire, St. Catherine (map loc. 18). Very large exposures of brecciated, recrystallized cream, beige and rusty marble occur in this area which is only 6 miles (10 km) from Kingston. Development of the deposit commenced in 1983 by the Urban Development Corporation, Hellshire Marble Co. Division. Development objectives have been modest, focusing only on the cutting of surface boulders for craft work and random-sized tiles. The GSD had been providing certain

technical assistance which was increased during the project with the objective of assessing reserves and quality, locating a feasible quarry site and determining viable extraction techniques. Core drilling and geologic mapping indicated the existence of the marble over a 4-square-mile area (10 km2), occurring as a surface capping material 50-75 feet (15-23 m) thick. A trial quarry face was established using wire saw from an earlier project. GSD personnel are now trained and successfully operating the machine and providing raw blocks to the Hellshire Marble Plant. In addition, the project acquired a line drill (quarry bar) for extracting blocks by line drilling holes and splitting out with wedges for the break-out step.

4. Gypsum and anhydrite, St. Thomas (map loc. 17).

The objective of identifying additional reserves of gypsum and anhydrite proved to be unusually difficult owing to the geologic complexity of the district targeted for evaluation. Two consultants in structural geology were called in to assess the geology and recommend follow-up. It was hoped that hidden reserves of gypsum and anhydrite might be found either as subsurface faulted blocks or as thinly covered surface deposits. The consultants identified four target areas of variable size for detailed field mapping. By the project's conclusion, one of the recommended areas had been field mapped by GSD staff with disappointing results. Continued mapping was planned. See the report Sulfate in the Southern Wagwater Belt by R. Torrini and R. Speed, Aug. 1985.

5. Silica sand, St. Elizabeth (map locs. 22 and 24).

Acting on a request for a silica raw materials reserves study by the West Indies Glass Co. of Jamaica, the project investigated the only known major Jamaican source of silica sand. A grid drilling programme was implemented on those tracts considered to have best potential, i.e., Luana and Punches. Drilling was done on a 200-foot

(61 m) grid interval and included a center hole. Auger drilling was employed because the deposits are shallow, usually 4-8 feet (1-2 m) thick. Some strategically placed drive tube holes were also drilled to test the deeper lying clay. The overall results were good and reserves of more than 500,000 tons were proved, sufficient to last the company about 25 years at current usage. Although some areas remain undrilled, additional reserves are probably small. While the silica reserves are sufficient for the glass company, there is not enough for export. See the reports, Silica sand evaluation, Luana, by H. Elliston, Mar. 1987 and Silica sand evaluation, Punches by Y. Drakapoulos, April 1987.

6. Clay, St. Elizabeth and Clarendon - (map locs. 23 and 16).

The clay resources of Jamaica have been evaluated by many researchers in the past and their data indicate many occurrences islandwide. Many questions remained, however, regarding reserves and quality. The project evaluated by wildcat drilling a few select locations. Wide spaced drive-tube sampling was carried out during the silica sand evaluation in the Luana Frenchman and Punches area of the Black River basin (map loc. 23). It was found that clay beds usually occur beneath the silica sand beds or are interfingered with them. Possible reserves appear to be in the range of hundreds of thousands of tons. However, precise quality definition for ceramic use was not determined, owing to the large number of samples and lack of laboratory equipment, i.e., a laboratory ceramic testing kiln (which is planned for future acquisition). Other potential clay areas were investigated at Harker Hall (map loc. 16) but reserves are small, around 50,000 tons, based on surface mapping and drive-tube sampling. Some interesting weathered and primary acidic aplite dikes were examined in the Above Rocks area (near map loc. 16) and in the Mavis Bank region (near map loc. 15). A few outcrop samples were tested by a local ceramics production company, Things Jamaican, who reported results warranting further investigation of the material for use as a body flux or glaze raw material. A thorough evaluation of Jamaican

clay resources was not possible during the project but the continuing growth of the ceramics industry in Jamaica warrants further attention to this aspect.

Further detailed investigations are recommended:

1. Carbonate resources should be explored, especially high grade plus 99 per cent pure limestone in the remaining third of Jamaica.

2. Gypsum and anhydrite resources should continue to be sought in the Bull Bay district of St. Thomas.

3. Clay and other resources should be methodically evaluated throughout the island.

4. Marble resources, especially new varieties, should be identified and evaluated by extracting large test blocks and slabs.

5. Aggregate raw material from known occurrences of hard igneous sources for special purposes should be evaluated.

6. Fertilizer raw material, i.e., bat guano, should be estimated in various large caves, because of its potentially high unit value.

7. Semi-precious stones and their potential for the tourist craft industry should be evaluated.

8. Shale, clay and igneous raw materials should be investigated for lightweight aggregate.

B. Data base records

A second objective focused on creating an adequate technical data base for the attraction of national and foreign investment for non-metallic minerals development.

Once priorities were established as to which resources would be evaluated, the type and quality of information to be gathered was outlined and then implemented by project personnel. Accordingly, the following basic records were established to create the necessary data base.

Topic	Generated records
Field geology	Field maps and final maps.
Outcrop sampling	Field sample record books, retained samples (1 yr.), Master record book for outcrop samples taken by field personnel or brought in by outside sources.
Boreholes	Borehole logs, retained drill core and sludge samples, Master borehole logbook for holes, chemical analyses of cores and sludge.
Chemical analysis	Chemical analyses record book, retained 50 gram samples in permanent storage for laboratory samples analysed.
Physical analysis	Physical testing records, including screen analysis and abrasion testing.
Geologic reports	Field exploration reports, final project reports.
Topographic maps	Contracted aerial surveys at 1:1,200 for areas of major investor interest.

Topic	Generated records
Consulting	Consultants' reports, special subjects.
Electronic data processing	Chemistry laboratory inventory records, personnel records.

C. Investment promotion

Contacts with potential foreign investors who would be interested in non-metallic minerals were established by solicitation letters, advertisements, telephone discussions, minerals brokerage services and consulting services. Also, numerous contacts were established with investors through the efforts of the Jamaica National Investment Promotion Co. (JNIP), the National Project Director and the Chief Technical Adviser.

National investment interest was established through local personal and professional contacts, agencies and organizations such as JNIP, the Jamaica Geological Society, the University of the West Indies and even the local inhabitants in the areas of exploration activity. Consequently, numerous local potential investors requested and received strategic information and assistance on various mineral commodities. An important contribution to this end was made by Geological Survey personnel who assisted local Jamaican investors in the evaluation of non-metallic mineral opportunities.

The encouragement of national investors entailed substantive assistance by project personnel including field work, exploratory drilling, surface sampling, sample preparation, physical testing and chemical analysis. National investors displayed particular interest in carbonate resources, marble and silica sand. Also, interest in clay resources and requests for assistance came from: Things Jamaican, the Jamaica School of Art, and the Hodges Ceramics Products Co. Ltd. Many small ceramics producers throughout the country were

provided raw materials assistance in the form of property evaluations with follow-up geologic and mining advice. A summary of investors still displaying investment interest at 1986 year end is shown in table 2.

In some instances the actual investment commitment to the establishment of mines, quarries or production plants was not yet made by the end of 1986. The lead times necessary for data gathering, evaluation, negotiation, and financial decision making exceeded the project term. However, in view of the optimistic positions displayed by the investors listed in table 2, it was reasonable to assume that probable final commitments would be made in early 1987 subject to respective investment guidelines and industry economics.

Economic factors other than satisfactory raw material deposits have to be factored into investment decisions. These include development costs, transportation criteria (mine to port, to market), transport mode (truck, rail, ship), port shipping infrastructure, market evaluation, laws and regulations regarding taxes and incentives, profit margins, and status of competition. For the most part these subjects, other than transportation, went beyond the scope of the project.

Table 2. INVESTOR LIST AND SUMMARY OF ECONOMIC POTENTIAL

Includes investors actively pursuing investment interest as of December 1986

Investor/Company	Country	Commodity	Location (Parish)	Possible annual export tonnage	Average sales price $US per ton	Possible annual sales ($US 000s)
Pfizer Minerals Company	U.S.A.	Limestone	Portland	200,000	100	20,000
Commonwealth Limestone Company	Canada	Limestone	St. Ann	150,000	60	9,000
Genstar Corp.	U.S.A.	Limestone	St. Ann	45,000	12	540
Stacote Finishes Ltd	Jamaica	Limestone	St. Ann	5,000	100	1,000
Hellshire Marble Company	Jamaica	Marble	St. Catherine	2,000	500	1,000
Smith's Engineering & Construction Co.	Jamaica	Limestone	St. Elizabeth	50,000	4	1,000
Jamaican Minerals Export Ltd	Jamaica	Limestone	St. Ann	1,000,000	3.50	3,500
John's Hall Quarry	Jamaica	Limestone	Hanover	1,000,000	3.50	3,500
West Indies Glass Co.	Jamaica	Silica	St. Elizabeth	20,000	11	220
Hodges Ceramic Products Inc.	Jamaica	Clay	St. Elizabeth	2,000	100	200

INACTIVE OR PENDING INVESTORS WITH REGISTERED INTEREST

J.C. Huber Co.	U.S.A.	Limestone
Marblehead Lime Co.	U.S.A.	Limestone
Business Brokerage Group	U.S.A.	Limestone
Commonwealth Marble Co.	Canada	Marble
Lewis Quarries	Jamaica	Limestone
Norton Quarries	Jamaica	Limestone
Cane River Quarries	Jamaica	Limestone
St. Thomas Aggregates Co.	Jamaica	River stone

D. Institution-building

The objective of strengthening the capacity of the Ministry of Mining and Energy, especially the Geological Survey Division, to explore and evaluate non-metallic mineral deposits and to support their development was achieved. Some aspects were more successful than others, as the following review shows.

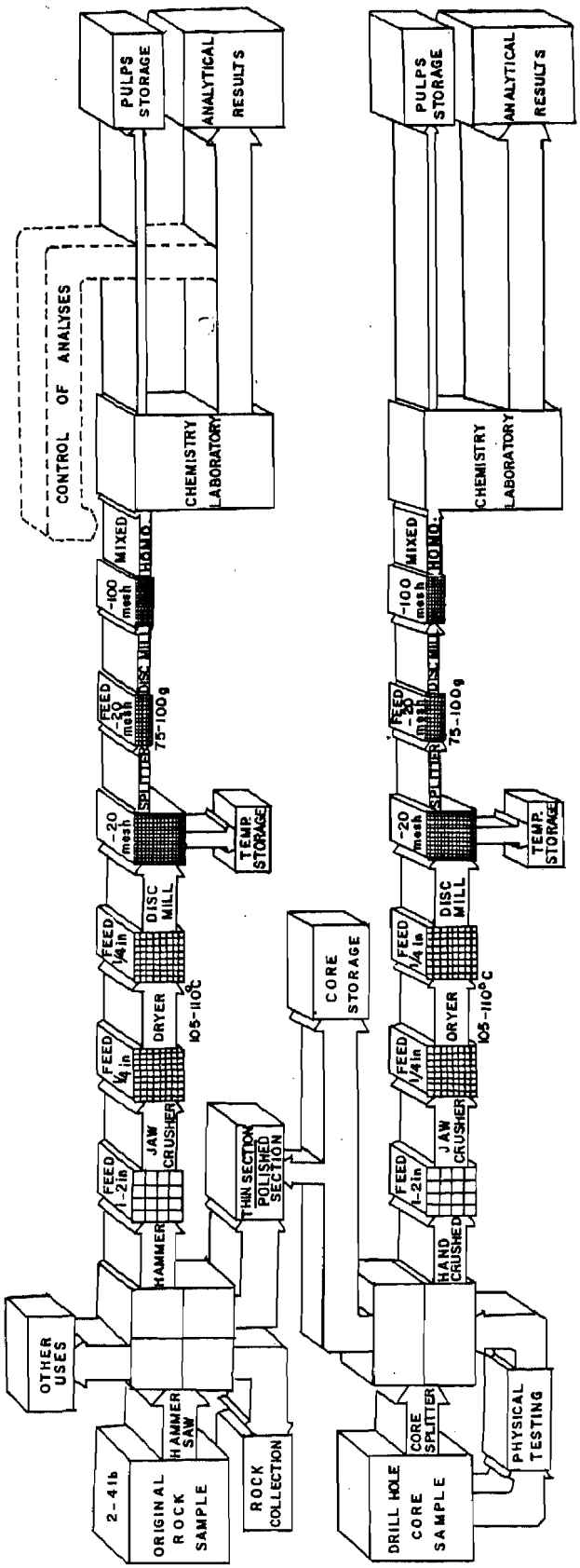
Instruction and training was considered to be the most important strengthening objective. Five national staff geologists, six laboratory personnel, six sample preparation staff and six office staff were fully trained. Expertise was acquired in field geology, exploration drilling (instruction on geologist's role), economic geology, mining production and extraction, investor promotion, sample and core preparation, chemical analysis, electronic data processing, technical reporting and project administration.

Consultants provided staff instruction and training in electronic data processing, structural geology, marble deposit evaluation and carbonates marketing and promotion.

A complete chemical laboratory facility was established in remodeled building space to perform chemical analysis using either wet methods or atomic absorption spectrophotometry. Complete electronic data processing facilities were established with the acquisition of hardware and software and provision of an air-conditioned room for this purpose. Sample preparation facilities were improved with the addition of special equipment including a jaw crusher, core splitter, diamond saw and mineral pulverizer; their places in the flow of work are shown in figure 5. The petrographic laboratory was improved by adding a thin section machine, polarizing viewer, microscope accessories and slide preparation equipment. Additionally, the Geological Survey Division was provided with several major items of equipment (annex III).

FIG. 5

WORK FLOW, SAMPLE PREPARATION FACILITY



The project faced two continuing problems in its strengthening efforts: high turnover of personnel and delays in receiving equipment and supplies. In addition, the occasional suspension of Government funds caused short unexpected delays. Personnel turnover was a serious problem throughout, especially in the laboratory where the turnover was complete. The second most critical area of personnel turnover occurred with the field geologic staff where approximately half left.

The basic problem stems from low salaries in the Geological Survey Division and the corresponding inducement to move on to better paying jobs in the private sector or other Government agencies.

The problem could be partially alleviated by raising salary levels to at least par with other Government agencies and also by keeping a larger cadre of trainees from which to draw replacements. As the importance of industrial minerals development in Jamaica is more widely perceived by Government leaders and the public, young professionals serving with the GSD might be more motivated to stay.

Delays in obtaining equipment and supplies plagued the project for all its 2 1/2 years. The chemical laboratory was not operational for nearly a year owing to lack of equipment and supplies. Field vehicles were not available until eight months after the start of the project. Even after the basic items arrived, there were continuing delays in delivery of supplies and spare parts.

The problems stemmed from three root causes: (a) slow servicing of purchase orders by certain major chemical suppliers, (b) slow customs clearance by the local Government which, surprisingly, worsened with time, and (c) slow processing of field requisitions at DTCD headquarters in New York early in the project.

E. Summary of results

1. Training

Trained personnel are available to explore for and develop investor interest in non-metallic minerals vital to the Jamaican economy. Staff can provide instruction, counselling and advice on field geologic evaluation, sampling, drilling, mapping, sample preparation, laboratory, laboratory analysis, mining practice and electronic data processing. Thus the GSD is better able to assist the development of Jamaica's non-metallic mineral resources and locate new non-metallic resources with corresponding investor interest.

2. Discoveries

Important new non-metallic mineral deposits were located (figure 2). These discoveries generated interest by prospective investors and the development of viable economic enterprises has begun. There are, however, serious shortcomings in port facilities for export. Basic improvements for marine shipping of non-metallic minerals must be made if significant industrial mineral export markets are to attract investors either domestic or foreign.

3. Data management

The generation of project data within the GSD and its effective management was an important result. Because the Geological Survey Division has a mandate for providing data on the country's mineral resources, this was a fundamental project task. One of the first objectives was the establishment of useful manual data systems concerning samples, drilling data, laboratory analyses, exploration reports and maps. Such data has been the means by which investors are attracted and has added significantly to the archives of Jamaican geology. Another early objective was the establishment of an electronic data processing (EDP) capability. This was begun with the acquisition of selected computer hardware and later introducing

specialized training. It will continue to be a GSD objective that EDP become an effective tool in the management of administrative and technical data.

4. Investor assistance

Investor assistance was a primary development goal of the Government of Jamaica in the project's original concept. The effectiveness of this aspect may be seen in table 2 and further returns are expected. One factor in successful investment promotion has been the assistance given investors in evaluating their interests. This included geologic mapping, sampling, drilling, negotiation with land-owners, and interfacing with shippers and other Government agencies. Jamaica is fortunate in having high quality industrial minerals resources, and the project helped provide the critical linkage of exploration, discovery, technical evaluation, direct assistance and promotion to investors. The Government's main objective of exploring for and developing non-metallic minerals was well served.

IV. CONCLUSIONS AND RECOMMENDATIONS

The project clearly established that investors are interested in the non-metallic minerals of Jamaica. The design of the project was sound and should stand as a model for future programmes dedicated to non-metallic minerals development. The most useful approach is to contact potential investors early, even as the data is collected from attractive mineral locations. The provision of direct technical assistance to investors sustains their interest and improves the likelihood of positive decisions.

Adequate geologic training is a continuing process which should include mineral economics and technical applications of all the industrial minerals found in Jamaica if there is to be staff capable of providing complete investor assistance.

There are continuing, apparently unavoidable, delays of equipment delivery, lapses in Government funding, and high personnel turnover. Although ultimate solutions are sought, the recognition of the realities of these problems and finding ways to work around them is essential if future programmes are to proceed in a timely manner.

The project established that some of the major barriers to non-metallic minerals development by investors occur in the transportation and shipping sectors. Many parts of the country have poor roads, and lack of suitable port facilities hinder otherwise feasible development of highly attractive non-metallics deposits.

Present Jamaican mining regulations permit an investor to acquire control of more than one favourable mineral deposit location. This can be counterproductive to the country's best interests if not carefully regulated or controlled, and it is recommended that this issue be included in any further review of the country's mining codes and regulations.

The project identified high grade and high brightness limestones having a potentially good market value which the Ministry of Mining and Energy has designated as Crown minerals warranting a higher royalty rate than for common limestone. The new royalty rate is needed as soon as possible so that potential investors may complete their economic evaluations.

The following recommendations on further development of non-metallic minerals in Jamaica are given in descending order of priority:

1. A Phase II continuation of the project is recommended to concentrate on development-oriented investor assistance. This would maintain present investor momentum and complete the unfinished plans and activities of this project.

2. Provide better incentives, either money or peripheral benefits, to retain national staff and reduce personnel turnover in the GSD.

3. Jamaican mining regulations and laws should be reviewed and revised to promote orderly mineral development and encourage potential investors.

4. Improve and continue staff training in:

   (a) Field work, including mapping, sampling, drill hole logging and data recording,
   (b) Quality control during mining and shipping,
   (c) Quarrying of dimension stone,
   (d) Technical report writing with emphasis on the economics of mineral development,
   (e) Providing direct investor assistance by appropriate GSD staff, and
   (f) Electronic data processing.

5. The Geological Survey Division should acquire the following major items of equipment:

   (a) A vehicle, preferably a station wagon, to assist investors in evaluating deposits in the field,
   (b) A marble-polishing machine,
   (c) A marble block saw,
   (d) A laboratory furnace for testing clay and ceramics raw material, and
   (e) A computer terminal for the library.

6. The GSD manual filing systems for maps and publications should be improved.

7. Sample and core storage facilities within the GSD should be enlarged and improved.

Annex I

PROJECT STAFF

A. International experts

H. Busby (USA)	Chief Technical Adviser, Economic Geologist
Y. Goscinny (Belgium)	Chemical Analyst, Laboratory Analyst
K. Paakkonen (Finland)	Associate Expert, Geologist

B. National staff

A.J. Geddes	Director, Geological Survey (National Project Coordinator)
L. Henry	Deputy Director (Senior Geologist, Industrial Minerals)
G. Perkins	Commissioner of Mines
C. Roache	Deputy Commissioner of Mines
H. Elliston	Geologist
F. Gillings	Geologist
Y. Drakopoulos	Geologist
M. Allison	Geologist
D. Green	Geologist
J. Thompson	Laboratory Manager
F. James	Sample Preparation Manager
R. Crooks	EDP Manager
C. Spencer	Project Administrator
C. Bassaragh	Administrator, Geological Survey Division
P. Bennett	Secretary
V. Millwood	Secretary

C. Consultants

Miss Nellie Guernsey (electronic data processing -- Aug., Nov. 1985, Oct. 1986) Mineral Systems Inc., New Haven, Connecticut, USA.

Mr. Peter Harbin (minerals marketing -- June 1986)
Peter Harbin Inc., Ossining, New York, USA.

Dr. Roberto Pisani (marble -- Jan. 1984, Oct. 1985)
International Technical Services Co., Carerra, Italy.

Drs. Robert Speed and Rudolph Torrini (structural geology -- June 1985)
Northwestern University, Evanston, Illinois, USA.

Annex II

TECHNICAL REPORTS BY PROJECT STAFF AND CONSULTANTS

Allison, M.	Field work carried out in Garbrand Hall (marble), St. Thomas, Oct. 1984.
Allison, M.	Mining potential of the Newport formation (marble) limestone (NE Hellshire Hills), St. Catherine, March 1985.
Busby, H.	Local limestone and marble reserves, Nov. 1985.
Drakapoulos, Y.	Silica sand evaluation, Punches, St. Elizabeth, Apr. 1987.
Elliston, H.	Dimension stone (marble) evaluation at Cuckold Point, Manchester, Nov. 1984.
Elliston, H.	Preliminary evaluation of dimension stone (marble) at Cuckold Point, Manchester, Mar. 1985.
Elliston, H.	Silica sand evaluation, Luana, St. Elizabeth, Mar. 1987.
Gillings, F.	Dolomite evaluation, Port Henderson, Sugar Loaf and Dunsinane, Nov. 1986.
Gillings, F.	Economic assessment of the Bath limestone (marble), St. Thomas, July 1986.
Gillings, F.	Portland-Chepstowe marble deposits, May 1986.
Goscinny, Y.	Final report on (chemical) laboratory, Dec. 1986.
Goscinny, Y.	Sample preparation, June 1985.
Guernsey, Nellie	Mission reports (3) Electronic data processing, 11 July 1985, 11 Dec. 1985, 14 Nov. 1986.
Harbin, Peter	Market potential of calcium carbonate (marble) from Jamaica, 1 June 1986.
Henry, L.	Garbrand Hall (Island Head) marble deposits, St. Thomas, Jan. 1985.
Henry, L.	Jamaican limestones, July 1986.
Paakkonen, K.	Preliminary evaluation of Jamaican limestones, Nov. 1986.
Paakkonen, K.	Progress report (fieldwork and analytical results-carbonates) Sept. 1986.

Paakkonen, K. Proposal for borehole code system (drilling records), May 1985.

Paakkonen, K. Prospecting of calcium carbonate in Jamaica, preliminary study, Nov. 1985.

Pisani, Roberto Project exploration of non-metallic minerals (marble), Dec. 1985.

Torrini, Rudolph and Robert Speed Sulfate in the southern Wagwater belt, structure and exploration strategy (gypsum, anhydrite), Aug. 1985.

Annex III

EQUIPMENT SUPPLIED BY UNDP

Vehicles

2 Land Cruisers
1 pick-up truck

Laboratory equipment

1 Perkin-Elmer atomic absorption spectrophotometer
1 Coleman flame photometer
2 drying ovens
1 water still
1 fumehood with fan
1 refrigerator
3 air-conditioners
1 Seragen brightness testing instrument

Sample Preparation Laboratory

1 jaw crusher
1 core splitter
1 shatter box (Micronizing) containers
1 marble-polishing machine
1 air sampler

Computer equipment

1 IBM PC
1 Epson printer
1 Tallgrass hard disk drive
1 Elgar uninterruptable power supply

Petrographic laboratory

1 Buehler thin-section machine
1 polarizing viewer
1 thin-section slide preparation kit

Field equipment

1 Cobra rock drill
1 Pellegrini quarry bar (line drill)