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Demonstration Workshop on Laboratory and
Pilot Scale Bauxite Processing

Kingston, Jamaica, 28 June - 6 July 1985

REPORT*

(Workshop on bauxite processing).

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INTRODUCTION

Jamaica is one of the world's largest producers of bauxite and alumina with an installed capacity of 15 million tons of bauxite per annum. Bauxite production commenced in the early 1950ies - over 30 years ago - and there are 4 alumina plants in the island and two companies that are engaged in the mining, drying and shipping of bauxites. The latter mine over 6 million tpy at full production capacity, for direct export. Jamaica's bauxite production 1972 - 1984 is illustrated in Annex IV.

The bauxite industry is of crucial economic importance to Jamaica accounting for over 60 % of its foreign exchange earnings. The country has estimated reserves of about 2 billion tons of bauxite.

The Jamaica Bauxite Institute (JBI) was established by the Government in 1975. The main functions of the Institute are:

(a) Monitoring the local industry so that all revenues due (under existing regulations) are promptly paid;

(b) Monitoring the movements of aluminium price so that the Government can be advised on how to set a basic rate for the levy consistent with what is most likely to be the realized price for aluminium for the financial year under consideration.

(c) Keeping abreast of all developments in the bauxite/alumina/aluminium industry so that medium and long-term analyses can be made for the use of policy-makers.

(d) Evaluate technological development in the industry as it affects the competitiveness of Jamaica's bauxite and bauxite vis-a-vis alternative raw materials.

In 1980 the Government opened discussions with the UN Financial System for Science and Technology for Development to finance a project aimed at providing modern laboratories and a pilot testing plant at the JBI. The laboratory was completed in 1983 and modern equipment which includes an electron microscope, differential thermal analyser, particle-size analyser, fusion apparatus and gamma-ray settler has been installed. The pilot plant was completed and commissioned in August 1984. The laboratory and pilot plant facilities will also function as a training centre for young scientists and engineers and give JBI capacity for sophisticated work in mineralogical analysis for bauxite and other aluminium containing ores. JBI will also be able to make its expertise available to other developing countries in line with the United Nations Development Programme's promotion of technical co-operation among developong countries (TCDC). As a first step JBI volunteered to host a Demonstration Workshop on Laboratory and Pilot Scale Bauxite Processing, mainly for Caribbean countries' representatives, to demonstrate available facilities and initiate co-operation.

ORGANIZATION OF THE WORKSHOP

The Demonstration Workshop on Laboratory and Pilot Scale Bauxite Processing was held at the Jamaica Bauxite Institute, Kingston, Jamaica, from 28 June to 6 July 1985. The Workshop was attended by 40 participants, including 13 participants from 10 developing countries (Brazil, Costa Rica, Dominican Republic, Ghana, Guinea, Haiti, Mexico, Sierra Leone, Suriname and Venezuela), and a number of guest speakers, lecturers and observers, as well as staff members from the Jamaica bauxite Institute. The list of participants is given in Annex I.

Inauguration of the alumina pilot plant

The demonstration plant for alumina production was officially inaugurated on 28 June 1985, with the inaugurating speech held by H.E. Hugh Hart, Minister of Mines, Energy and Tourism of Jamaica and with the representatives of UNDP, UNIDO, UNFSSTD and a number of institutions of Jamaica, also of specialists/representatives from Latin America and Africa, who were invited to participate in the inauguration of the pilot plant and the Workshop.

Minister Hart appreciated the pool of expertise that had been developed within the institute and the facilities that could do so much by way of training young engineers and scientists. He noted the inauguration of the JBI alumina pilot plant as an undoubted milestone in the development of the scientific and technological capability of the institute and the entire region. He said that the project holds much promise for greater efficiency in bauxite processing and hence improved cost-competitiveness, which he considered of utmost importance to the recovery of Jamaica's industry.

In his message, Mr. Lalkaka, Director, UNFSSTD, referred to the completion and commissioning of the alumina pilot plant and laboratories as a real success story. Entrusting the primary project management responsibilities to Jamaican personnel helped build the necessary national self-reliance and a plant design well suited to local conditions. He said that the JBI pilot plant provided an excellent example of international technical co-operation - German resources through UNFSSTD, Jamaican skills, Hungarian expertise and other international inputs had been brought together in an effective partnership, through the neutral independent mechanisms of the United Nations auspices.

The message sent by the Executive Director of UNIDO particularly appreciated the spontaneous readiness of the Jamaica Bauxite Institute to share their newly acquired facilities with other developing countries and he emphasized that the first step in this direction had been done - the organization, with assistance from UNIDO and the TCDC Unit, New York, of the Demonstration Workshop, in line with the United Nations Programme to promote technical co-operation among developing countries. Wishing the JBI every success, UNIDO's Executive Director looked forward to the Institute's fruitful co-operation with other countries, be it on a bilateral basis or under the auspices of UNIDO.

Opening speeches were held by Ms. B. McSweeney, Resident Representative, United Nations Development Programme and Mr. C.E. Davis, Executive Director, JBI.

The inauguration speeches and messages were followed by a tour of the pilot plant and laboratory complexes as well as a press conference.

Opening of the Workshop

On the part of UNIDO the Workshop was opened by the Head, Metallurgical Industries Section.

He referred to the mandate of the Metallurgical Industries Section of UNIDO and explained the modus operandi, referring to specific technical assistance projects in the bauxite/alumina/aluminium field that UNIDO had implemented or was still implementing in countries like Brazil, China, Colombia, Costa Rica, Egypt, Guyana, India, Jamaica, Madagascar, Mali, Mozambique and Turkey. He referred to the fact that the world bauxite processing industry was one of those few significant branches where the target of the Lima Declaration of the Second General Conference of UNIDO, held in 1975, which demanded achievement of at least 25 per cent of the world industrial production by developing countries by the year 2000, had already been surpassed by the end of the Seventieth. About 50 % of the bauxite is being mined in developing countries and the share of developing countries in world alumina production capacity also continues to increase and should expectedly surpass 3o % by the end of the 1980ies. He also pointed out that the countries represented in the Bauxite Demonstration Workshop counted for a large percentage of world mine production of bauxite. Whilst all of the represented countries had either production outputs of bauxite and/or alumina or prospects for bauxite mining and processing, they did not have their own pilot plant facilities for processing of bauxite to alumina, covering the full cycle of the Bayer technology and the Workshop was to bring about a greater and more advanced understanding of the scientific and technological principles involved in the production of alumina from bauxite by a full processing cycle demonstration on pilot-scale. UNIDO felt therefore that the Workshop provided a good opportunity for all participants to get acquainted not only with the pilot-facilities which had become available in Jamaica, but also with possibilities and conditions of future co-operation with their owner and operator, the Jamaica Bauxite Institute, on a bilateral basis or under the auspices of UNIDO.

Election of officers

The Workshop elected Mr. Conrad Douglas, National Project Director, JBI, as Chairman and Mr. Jorge Coria Cabrera (Mexico) as Rapporteur.

Programme of the Workshop

During 3 technical sessions, lecture papers were presented to the participants and speeches made related to bauxite mining and alumina production. World Bauxite Reserves and World Bauxite Production are illustrated in Figures 1 and 1, respectively.
The pilot plant was fully operational during the duration of the Workshop and various pilot plant demonstrations took place. Plant visits were undertaken to Alcan Ewarton Works (tour of alumina plant and red mud stacking operations and tour of ALCAN's agricultural operations); Another plant visit was undertaken to Alpart Mining and Bauxite Handling System, and Alpart Alumina Plant, Mandeville.
The Programme of the Workshop is contained in Annex II.

Abstracts of the technical papers presented to the workshop

A techno-economic bauxite classification scheme and its implications (ID/WG.446/1)** by V.G. Hill and S. Ostojic, International Bauxite Association, Kingston, Jamaica

A techno-economic bauxite classification scheme based on particle size distribution (lateritic versus karstic), aluminium ore minerals (gibbsite, boehmite and diaspore) and gangue minerals (iron oxides) is presented. This scheme has a direct relationship to Bayer technology and hence plant capital charges. The objectives of the paper are firstly to review the bauxite classification scheme developed, secondly to investigate its implications for the relative valuation of bauxite from different areas, and thirdly, to indicate its bearing on the prognosis for the preferred development and exploitation rates of deposits, and areas where research and develop-

** Copies of papers may be obtained from UNIDO free of charge by quoting the symbol number.

ment work on bauxite processing is needed for some developing countries. These issues are critical if the aluminium industry is to be rejuvenated through increasing its competitiveness with alternative materials such as the non-metallics and composites in particular.

Systems for the management of red mud (ID/WG.446/2)
by J.L. Chandler, Consultant, Chemical Engineering, ALCAN Jamaica Company

If red mud disposal instead of industrialization continues it is because only the heaviest industries, e.g. road and building construction can use enough red mud but they could also use other plentiful supplies of raw materials like limestone. Methods of disposal (stacking and non-stacking) are listed. ALCAN's mud disposal methods (deep thickening) are described.

Design of the Jamaica Bauxite Institute Bayer process pilot plant (ID/WG.446/3) by D.R. McGaw, Head, Department of Chemical Engg., University of the West Indies, Trinidad and Tobago

The paper describes details of the alumina pilot plant which was conceptualized as a typical Bayer process operation. Critical process operations, namely digestion, mud separation and precipitation receive special emphasis. The process flow-sheet is broken up into seven processing areas. A detailed mass balance is carried out, for a specific low grade bauxite. Heat balance calculations are determined from operation to operation. Equipment specifications are provided, as well as instrumentation, building and plant services, and plant lay out. The plant is well suited to form the basis of technical evaluations into further developing the minerals processing industry in the Caribbean and wider regions, in addition to helping to improve current Bayer process operations.

Critical parameters affecting the management and economics of alumina production (ID/WG.446/4)
by Frank A. Lopez, Works Manager, Ewarton Works, ALCAN Jamaica Company

Since most bauxites contain 40 - 50 % alumina and the alumina is extracted by the 90 year old Bayer process, one could expect that there is a typical cost for alumina production. This, however, is not the case. The cash components for alumina production differ from pant to plant. Bauxite, energy, labour, caustic soda and other costs vary widely. The wide range illustrates the contention that there is no typical cost for alumina production. It also presents some hope for reducing the costs.

Flocculation and Sedimentation of dispersed particulate systems: recent developments (ID/WG.446/5)

by R.N. Yong, Director, Geotechnical Research Centre, McGill University, Montreal, Canada

The properties and characteristics of discharged tailings material can be traced, not only to the source material variations, but also to the many complex processes brought to bear, from conditioning, digestion, and separation stages in the extraction of product material. The complex interactions established between the various constituents in the tailings material discharged, can be evaluated in terms of specific suspension volumes - which express the amount of water held by each specific constituent in the tailings. Furthermore, the subsequent dynamics of the material - settling, dehydration and crusting - can be better assessed if the mechanisms which promote interaction between the constituents are better understoood. The suspension volume concept provides the first step towards this direction.

Development trends in the alumina production (ID/WG.446/6)

by J. Zambo, Director, ALUTERV-FKI (Engineering and Development Centre of the Hungarian Aluminium Corporation) Budapest, Hungary

AIME and ICSOBA meetings provide a good survey about the newest achievements. An attempt is made to draw up the main trends of technical progress on the basis of the analysis of the present situation and the prospects of alumina production. Alterations in alumina production capacities in production and consumption figures of the past and up to the early nineties are given. Over-capacities of aluminium smelters and alumina plants seem to be lasting. The structure of production costs suffered substantial changes during the past 20 years. The increase in capital cost per unit was more rapid than the inflation rate. Plants under construction are preferably located together with smelters. There is keen competition for exploitation of existing capacities. Decisions to establish new capacities can only be expected after the reasonable utilization of existing ones. New trends in the Bayer process are optimum energy consumption, increased role of high-temperature digestion and introduction of high capacity, computerized equipment. The main plant units of the Bayer process, digestion and precipitation are surveyed.

Various lectures/speeches held by Carlton Davis, Executive Director, JBI; Conrad Douglas, Consultant and National Project Director, JBI; Dennis Morrison, Director, Projects, JBI; Parris Lyew-Ayee, Director, Bauxite Reserves; and others, centered around the historical perspective and state of the art of the Bayer process for alumina production, the bauxites of the world and the general description and capabilities of the alumina pilot plant, which is reported as follows

THE JAMAICA BAUXITE INSTITUTE'S ALUMINA PILOT PLANT

General description

The pilot plant can process a minimum of 20 tons of bauxite continuously over a one-month period. The minimum production rate is 10 kg per hour of alumina. It is a complete closed circuit Bayer process pilot plant embracing the unit operations of an industrial scale Bayer alumina plant up to the hydrate production stage. Bench scale simulations are carried out on a number of parameters in a modern well-equipped laboratory, prior to the pilot plant study stage. The plant is fully equipped with on-line slurry density gauges, magnetic flowmeters, conductivity meters for the measurement of A/C ratios, temperature and pressure recording instruments.

General capabilities

The plant has the capability of processing all types of bauxite, from e.g. Australia, Brazil, Guinea, Jamaica, Suriname, etc.

The small scale of unit operations allows for close control and monitoring of processes and the economical testing of all types and blends of bauxites, flocculants, despersants, coagulants and liquor purification agents as well as equipment including process instruments, agitators, thickeners, pumps, valves and heat exchangers. Steady state conditions are achieved in a short time, and results of tests can be quickly obtained. Process parameters can be varied rapidly and at will. The plant utilizes a single stream process, which is more energy efficient than the double stream process. The plant has adequate surge capacity for the movement of fluids from one section to another.

Summary of main uses of the alumina pilot plant of the Jamaica Bauxite Institute

1.	Materials Testing:	Bauxite, flocculants, disperants, coagulants, liquor purification agent.
2.	Equipment testing:	Pumps, valves, heat exchangers, process instruments, agitators.
3.	Training	Bayer process operations and management.
4.	Process Research and Development:	Bayer and related processes.

Characteristics and capabilities of unit operations

1. Bauxite grinding and predesilication

The plant has the capability of grinding most bauxites utilising a ball/rod mill. The balls used range from 2.5 cm to 3.75 cm (1 - 1 1/2 inches) in diameter while rods range from 1.88 cm to 3.75 cm (3/4 - 1 1/2 inches) in diameter with a length of 4 feet. The system is for wet closed circuit grinding, a maximum rate of 68.2 kg (150 lbs.) bauxite per hour. Bauxites can be ground to a very fine state allowing for the use of single stream digestion which is more energy efficient, and information on the dispersion and rheological characteristics of the slurries can be determined.

The predesilication circuit is designed to hold slurry at controlled temperatures for any period required at varying percentages of solid concentration. Under these conditions, the systematic control of phosphorous and alumina extraction can be studied by controlled analyses carried out in conjunction with the Institute's modern laboratory.

2. Digestion

The digestion system is a single stream operation, with autoclaves which have the flexibility of operating between 105 to 260 degrees C (221 - 500 F) with temperature control ± 2 degrees C. This allows for the digesting of gibbsitic, boemitic and diasporic bauxites. The digestors are equipped with mixers and can operate up to 50 atmospheres pressure (735 lb/sq. inch) and at flow-rates varying between 0 - 300 (0- 69.8 g/h) litres/hour. It is a complete heat interchange and digestion (HID) assembly and includes a retention tube which enables the study of various phase transformation under digestion conditions. The system can operate at a maximum caustic soda concentration of 250 g/l of NaO2. These conditions allow the blow-off temperature to be controlled through accurate addition of dilution.

3. Mud washing, settling and control filtration

The mud washing circuit is a continuous counter-current decantation system with two stages of washing plus a decanter. Thickeners are of small size enabling precise observation and control. The height of each thickener is 76.2 cm (30 inches) with a diameter of 0.650 sq. m (7 sq. ft.)/thickener. Each thickener is fitted with a rake, feed well and overflow well, and they are so arranged that overflow liquor is transferred by gravity. This system has the capability of handling traditional starch and/or synthetic flocculants.

Radio tracer studies can be easily and effectively done, and in combination with a Gamma Ray sedimentation apparatus yields valuable information on thickener design and operation.

The underflow mud is transferred by variable speed diaphragm pumps which can deliver up to 1,000 litre/hr. (240 gallons/hr). From the final mud washing stage the slurry is transferred to a three stage sealed mud storage pond with the capability of transferring the clarified liquor back to the plant. Control filtration can be utilised to optimise filtration conditions by the ability to closely and vary feed pressure, precoat, filter medium, and filter aid rate and qualities.

4. Precipitation

In the precipitation system, a water cooled heat exchanger is used to control the filling temperature. Precipitators are of flat bottom-design and have the capability of testing drought tube mixers. There is a special test precipitator equipped with a variable speed agitator, temperature probe and conductivity meter for measuring a/c ratios, The special test precipitator is insulated to provide closely controlled conditions enabling the simulation of an optimum cooling curve for precipitation.

5. Hydrate washing

A pan filter is used to filter hydrate slurry while it is washed with hot condensate.

6. Evaporation

The single stage flash evaporator unit has the capability of concentrating plant liquor. The system is therefore a closed circuit Bayer-process loop, which enables studies on the rate of accumulation and effect of contaminants on the process.

The pilot plant is of critical importance because the data generated from its use can be extrapolated to an industrial scale alumina plant with much greater accuracy and confidence than laboratory tests. It is of significance since it forms the basis for determining whether new technology is economically justified and should be implemented. This holds true for new processes in existing plants and for the establishment of new industrial scale plants. In fact, pilot plant testing is a pre-requisite of most financial institutions for making investment decisions in the chemical and process industries. The use of the pilot plant follows a strict logical sequence which originates with detaled physico-chemical analyses on a number of variables followed by bench scale simulation of several plant operating parameters, evaluation and optimization of these parameters for the greatest economic return and finally operation of the pilot plant under the conditions dictated by these laboratory tests which are all preformed in the JBI's well-equipped modern laboratories.

The design mode of the pilot plant enables its operation in a continuous or batchwise basis. The great flexibility of the JBI's alumina pilot plant allows it to process all types of bauxites.

The analytical laboratories of the JBI

The analytical laboratories of the JBI are well equipped with modern facilities enabling routine analytical and research tasks on a variety of inorganic based sample types for industry and agriculture such as bauxite, red mud, alumina, cement, clay, limestone shale, gypsum, quartz, sands, peat, soils, fertilizers as well as water samples and plant tissues.

Complete analytical assays can be done covering a wide range of elements whether as major or trace constituents, using classical wet chemistry methods and modern instrumental techniques such as atomic absorption spectrometry, colorimetry, flame emission spectrometry and X-ray spectrometry. Phase analyses in mineral aggregates can be determined by X-ray diffraction or using thermal methods as applicable. The scanning electron microscope is used in the investigation of micromorphological features of different materials in the alumina plant (bauxite, red mud, hydrate etc.). These features include shape, size, mutual arrangement and distribution of the mineral grams and various particles in different materials. The micromorphological features influence the processing of bauxite and the utility of hydrate.

The JBI analytical laboratories have developed techniques for the rapid and accurate elemental analysis of various sample types by X-ray spectrometry. Up-to-date procedures for sample preparation and analysis and computerization of calculations facilitate the analysis of up to 40 samples per week, with constant monitoring of the accuracy of results by concurrent analysis of internationally certified standards.

Technological Investigation of South Manchester Plateau Bauxite

During the Workshop, a bauxite sample from the South Manchester Plateau, which is being processed at the Alpart Alumina Plant, was selected for technological testing. The optimum conditions for desilication, digestion and sedimentation had to be determined as a prerequisite to a successful investigation in the pilot plant. The pilot plant liquor was used in all the experiments.

Desilication was done at 35 % solids at 95 degrees C for time intervals of 10, 20 and 45 minutes and 1, 1 1/2, 3, 5 and 16 hours. Digestion was performed at 165 degree C for 40 minutes with a lime charge of 1 % of the bauxite weight. The targeted alumina/caustic ratios were 0.55, 0.58, 0.62, 0.65, 0.68 and 0.72. Sedimentation was done using a Nalco flocculant at 90 degree C and a dosage profile drawn.

The results were as follows:

1. A desilication time of approximately 4 hours is required (see Fig. 3). The maximum silica in liquor was 0.60 g/l and was achieved after 1 hour.

2. The maximum extraction efficiency achieved during digestion was 94.2 % at an a/c ratio of 0.50 (see Fig. 4).

3. A marginal settling rate of 2.5 ft/hr was achieved for a flocculant dosage of 0.56 lb of flocculant per ton of mud. A far better settling rate of 6 ft/hr was obtained for a flocculant dosage of 0.8 lb of flocculant per ton of mud (see Fig. 5).

The experimental scheme followed in carrying out the investigation is illustrated in figures 6 and 7. The digestion temperature chosen is the digestion temperature used at Alpart.

The experiments were performed using laboratory process equipment designed to simulate the desilication, digestion, flash cooling and sedimentation operations of a Bayer process plant. Desilication studies were conducted in stainless steel bombs immersed in a water bath. The bombs were fitted into slots along a shaft which rotates to keep the contents of the bombs agitated. The bath was electrically heated and the temperature controlled by a thermostat. Digestion of bauxite was perfomed in pressure reactors manufactured by Parr Instrument Company, USA. The reactor used for the investigation consisted of a cylindrical pressure vessel,(made of type 316 stainless steel) which fits into a thermostatically controlled electric heater. It is a complete working unit with an internal agitator and accessories. The reactor operates at a maximum temperature and pressure of 400 degrees C and 2000 psig respectively. An internal control unit houses the control for the heater and motor which is used to drive the agitator. The reactor is fitted with a bottom drain valve for releasing the contents. The reactor is connected via a network of pipes to a pressure reducing flash tank which is piped to facilitate the collection of hot blow-off slurry from the conical bottom of the flash tank. The settling studies were carried out in one litre measuring cylinders held in a thermostatically controlled stainless steel tank at 90 degree C. One of the long sides of the tank was fitted with a transparent perspex window to allow monitoring of the mud/liquor interface.

Test procedures

The bauxite was analysed for alumina phosphorous and silica by wet chemical methods. The plant liquor was analysed for caustic, alumina, phosphorous and silica.

Desilication and digestion

For each desilication and digestion experiment, bauxite together with plant liquor and lime were added to the bombs and reactors for desilication and digestion. The relative amounts of bauxite and liquor were previously calculated from the desired solids concentration in desilication and target alumina to caustic ratios. After the desilication period the bomb was removed and the contents centrifuged. The liquor was analysed for silica.

After the digestion period, the bottom drain valve was opened releasing the contents of the reactor under pressure. The digester blow-off slurry flows to the flash tank where steam is flashed resulting in a drop in pressure and temperature before being collected in a plastic bucket. A small portion of the slurry was centrifuged and the liquor analysed to determine the a/c ratio achieved. The mud was analysed by X-ray to determine the extraction efficiency.

Settling test

The slurry was thoroughly mixed and quickly transferred to one litre measuring cylinders for dilution using a diluted caustic liquor. The cylinders were then quickly transferred to the thermostatically controlled settling bath. The diluted slurry was then thouroughly mixed with a repulper. Synthetic flocculant was then added and quickly distributed with another repulper having an X shaped cross-section.

The mud/liquor interface was timed as it moved down the cylinder using a Fisher Scientific Heuer stop watch. The time taken for the interface to move from the 1000 ml to the 700 ml mark on the cylinder was used to determine the settling rate. The clarity of the supernatant was estimated qualitatively by visual inspection. All muds were transferred to a Buchner funnel to be washed caustic free, dried and analysed.

Considerations of the test results and recommended follow-up

The bauxite was desilicated at 35 % solids and 95 degree C. Desilication time was approximately 4 hours. Digestion was done at 165 degree C for 40 minutes. The alumina/caustic ratio varied between 0.54 to 0.72. The maximum extraction efficiency achieved during the test was 94.24 %. This is considered low and is to be further investigated. Sedimentation was performed at 90 degree C. The settling rate increased with an increased flcculant dosage. The investigation is incomplete due to the late decision on the type of bauxite to be processed for the workshop and due to the short duration of the workshop. Despite these facts, the following processing conditions are recommended for the processing of the South Manchester Plateau Bauxite:

Desilication:	Slur y concentration:	35 % solids
	Temperatue:	95 degree C
	Desilication time:	4 hours
Digestion:	Temperature:	165 degree C (Alpart)
	Retention time:	40 minutes
	Target alumina/caustic ratio:	0.62
	Lime charge:	1 % bauxite weight
	Caustic concentration:	230 g.l equiv (Na_2CO_3)
Sedimentation:	Temperature:	90 degree C
	Flocculant dosage:	0.7 lb/metric ton of red mud

Experimental work should continue in order to establish:

Desilication:
- (a) Desilication efficiency as a function of slurry % solids
- (b) The unreacted SiO_2 in the solid phase as a function of time
- (c) The reacted SiO_2 in the solid phase as a function of time

Digestion:
- (a) Optimum a/c ratio as a function of caustic concentration
- (b) Extraction efficiency as a function of retention time
- (c) The optimum digestion temperature

Sedimentation: (a) The effect of lime charged to digestion on the settling rate of the red mud generated

(b) The effect of flocculants other than Nalco 8UD

(c) The solids flux diagram using the gamma ray settler.

CONCLUSIONS AND RECOMMENDATIONS

The discussions during the Workshop centered around the present situation of the bauxite processing industry in the world and the development trends and latest technological achievements, also in R and D work. It was realized that the present situation was not favourable for the establishment of new alumina plants; however, due account had to be taken of the fact that conceptual design and preparatory work for the establishment of new alumina production plants have a long lead time (usually 10 years or so) and therefore developing countries should not be discouraged by the present depressed market situation from their efforts for preparing the establishment of new production units, based on locally available bauxite deposits. Planning work undertaken at this stage would only show results in the mid 1990ies. The presentation of papers included suggestions for improving the productivity of the existing plants, such as through higher labour and fuel efficiency, as a means to reduce production costs.

It was unanimously agreed by the Workshop participants that the JBI with its newly established pilot and demonstration plant for alumina production represented an excellent opportunity for technical co-operation among developing countries, not only for the Caribbean but also for other developing countries in the world. The laboratory and pilot plant as now available in Jamaica are of a very high level, comparable only to those found in the industrialized world. It was considered essential to secure the supply of necessary spare parts and additional equipment in the future in order to maintain the high standard.

The participants appreciated the facilities both on laboratory and pilot plant scale that are available at the JBI and JBI's spontaneous willingness to share their experience and newly acquired facilities with other developing countries, as was demonstrated through the organization of the present Workshop. It was also proposed that the Workshop be repeated from time to time to keep participating countries abreast of latest developments in the bauxite/alumina industry. In this connexion it was suggested that the JBI should consider the organization of individual training courses or group trainings for participants from other developing countries at a self-cost training fee, for demonstrating to them the full cycle of the Bayer process for processing of bauxite to alumina. Such training opportunity should be offered not only to specialists but also to post graduates before they are entering their industrial career. It was also suggested that the acceptance of students for longer periods of training, say 1 - 2 years, should be considered.

It was recommended that full use, as appropriate and feasible, should be made of the JBI laboratory and pilot plant facilities to undertake test work with bauxite samples from other developing countries to obtain technological parameters for processing by the Bayer route; such test work could be undertaken on a bilateral basis or under the auspices of UNIDO. In this respect it was recognized that a number of less or least developed countries would have to rely on external (UN or other) assistance for financing the test work at the JBI, on a non-profit basis.

It was recommended that UNIDO, as the executing agency of the UNFSSTD project under which the pilot plant was established at the JBI should play an active role in organizing the necessary test work with bauxites from developing countries, at the request of those countries. Specifically, it was considered that the JBI could agree to undertake the following activities, as may be required by the individual country's specific needs:

(a) Test work on laboratory scale with representative bauxite samples of the order of approx. five kgs, to elaborate a first "diagnosis" on the further steps to be carried out.

(b) Where laboratory scale testing had already been carried out by the country itself or an institute abroad, pilot plant test work was recommended to be undertaken, with representatives samples of bauxite of about 15 - 20 tons, to be tested over a period of about 1 month.

(c) It was considered appropriate to allow a team of experts from the developing country that submits the sample for pilot scale testing, to observe the test work or to participate in the test work at the JBI.

(d) Provision of individual or group training programmes for trainees from other developing countries.

It was suggested that UNIDO should assist in financing of test work under individual projects with the JBI. Where feasible, the cost for collection and transportation of the bauxite sample to Kingston, as well as the expert team to observe or participate in the testing, should be borne by the requesting country, as an in-kind contribution to the project.

The importance of providing representative samples for testing was stressed. It was realized in this connexion that for a country just entering the bauxite exploration/mining industry, representative sampling of bauxites may be a difficult task and it was advised to have JBI representatives present when collecting the samples for testing.

When planning the establishment of a bauxite mining/alumina production industry the first step is usually geological prospecting work followed by an evaluation/estimation of the existing reserves. Even at this early stage it is already considered advisable to carry out technological tests, in parallel, to evaluate the bauxite from the point of view of its "technological behaviour" at the laboratory and pilot plant scale. UNIDO is assisting developing countries in a number of industrial projects, including the preparation of conceptual studies, pre-feasibility and feasibility studies. The results of technological tests with bauxite samples would serve as an important pre-requisite for the preparation of such techno-economic studies and would certainly be required before an investment decision could be taken. Whilst the participants felt that the JBI would be fully capable of undertaking all kind of test works with reliable results, the client should be free to exercise the right to include one ore more renown international consultants who could help in monitoring the implementation of the test programmes and confirm the test results, with a view to arrive at an internationally recognized technological report, which may be incorporated in a bankable techno-economic study at a later stage. The question of confidentiality of test results and patentable findings during the investigation work was also discussed. When undertaking work for clients, as was already done for Jamaican clients, such confidentiality was guaranteed and the respective Contract would contain a clause to that effect. Should, in the course of investigations, patentable findings be made, these would have to be agreed upon on a case by case basis.

Appreciating the facilities now available at the JBI a number of representatives expressed keen interest in having bauxite samples from their countries tested. A draft project concept was provided to the participants from Costa Rica, Dominican Republic, Ghana, Guinea, Mexico, Suriname and Venezuela, for possible follow-up. A sample for such a draft project concept is contained in Annex III. Interested individuals/institutes/countries should turn to UNIDO's Senior Interregional Field Adviser (SIDFA) at the local Office of the United Nations Development Programme, or to UNIDO directly, to receive information on the possibility of obtaining UNIDO's technical assistance.

With due account to environmental considerations, the Workshop also dealt with the disposal of red mud. The UNIDO Secretariat informed that, through a new process, red mud could successfully be utilized for the production of bricks, tiles, building blocks, etc. whereby, depending on the composition, the products could consist of 50 - 80 % of red mud, with the remainder being commonly available additives (e.g. clay, etc.). Substantial interest was expressed in this process and UNIDO was asked to provide more details on the subject.

Considerable interest was also expressed in the disposal of red mud by the dry stacking method which was explained in detail and demonstrated during the plant visit to ALCAN Ewarton works.

The Workshop brought about a greater and more advanced understanding of the scientific and technological principles involved in the production of alumina from bauxite and on world development trends in alumina production. With this well equipped pilot plant for alumina production, Jamaica will be in a position to launch a new era of South-South co-operation in the bauxite industry field and will be able to assist other developing countries. The Workshop was considered by all concerned an important step towards such co-operation and useful personal contacts could be established which will eventually lead to a close co-operation between Jamaica and other developing countries.

Annex I

Demonstration Workshop on Laboratory and
Pilot Scale Bauxite Processing, Kingston, Jamaica
28 June - 6 July 1985

LIST OF PARTICIPANTS

NAME, POSITION	Address
PARTICIPANTS	
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GUEST LECTURERS

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<u>IBA</u>

International Bauxite Association
Kingston, Jamaica

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S. Ostojic
Director, Technical Information

<u>JBI</u>

Carlton Davis
Executive Director

Conrad Douglas
Project Director

Parris Lyew-Ayee
Director, Bauxite Reserves

Dennis Morrison
Director, Projects

Richard Osborne
Acting Director, Pilot Plant

Andrea Blackwood
Senior Scientific Officer

Worrel Lyew-You
Chemical Engineer

George Wright
Technical Research Assistant

Urla R. Junor (Co-ordinator)
Director, Personnel and Office Management

Rosemary King
Scientific Officer

Deadre Tucker, Student

CONSULTANTS:

ALCAN:

J. Chandler
Senior Consultant - Kirvine Works

I. Porteous
Operations Manager

F. Lopez
Works Manager - Ewarton Works

I. Porteous

UNIVERSITY OF THE WEST INDIES - MONA:

Bently Thompson

Arun Wagh

Annex II

PROGRAMME OF WORKSHOP

Friday, 28 June		
10.00	Official Opening of the alumina pilot plant of the Jamaica Bauxite Institute (JBI)	H.E. Mr. Hugh Hart Minister of Mining, Energy and Tourism
		Dr. B. McSweeney, UNDP Resident Representative
		Dr. C.E. Davis, Executive Director, JBI
13.30	Tour of JBI, SRC, UWI Chemistry Department	Dr. C. Douglas, JBI
Saturday, 29 June		
08.00 - 13.00	Departure from Kingston for ALCAN, Ewarton, red mud disposals	
Monday, 1 July		
09.00 - 12.00	Formal Opening of the Workshop: Introductory Remarks; UNIDO's role	Dr. E. Balazs, Head of Metallurgical Section UNIDO
	Bayer Process for Alumina Production: Historical Perspective and State of the Art	Dr. C.E. Davis, JBI
	Bauxites of the World	Mr. P. Lyew-Ayee, JBI
13.30 - 16.40	Classification of bauxites	Dr. V.G. Hill Mr. S. Ostojic, IBA
	Systems for the Management of Red Mud	Dr. J. Chandler
	Flocculation and Sedimentation of dispersed particulate systems: Recent developments	Dr. R. Yong Director, Geotechnical Research Centre, McGill University, Canada
	Recent Developments in Alumina Production	Dr. J. Zambo, Director, ALUTERV-FKI, Hungary

Tuesday, 2 July

09.00 - 12.00	Critical Parameters affecting the Management and Economics of Alumina Production	Mr. Frank A. Lopez Works Manager ALCAN Ewarton Works
	Design Concepts of Alumina Pilot Plant	Dr. D. McGaw Head, Dept. of Chem. Engg., Univ. of the West Indies, Trinidad
	Capabilities of the JBI Alumina Pilot Plant	Dr. C. Douglas, JBI
13.30 - 17.00	Pilot Plant Demonstrations	

Wednesday, 3 July

07.00	Departure from Kingston for Tour of ALCAN Ewarton Works -Tour Alumina Plant and Mud Stacking Operation
11.00 - 12.30	Tour of Alcan's Kirkvine Plant
14.00 - 15.30	Tour of Alcan's Agricultural Operations

Thursday, 4 July

09.00 - 12.00	Pilot Plant Demonstrations (continued)
13.30 - 18.00	Laboratory Demonstrations on Bauxite Processing and Evaluation Exchange of experience among participants

Friday, 5 July

08.00	Departure from Kingston for Tour of Alpart plant, mining complex Manchester Plateau and Port Kaiser

Annex III

DRAFT PROJECT CONCEPT

Pilot scale testing of a bauxite sample at the Jamaica Bauxite Institute

1. Project objectives

(a) Development objectives

The project aims at processing local raw materials (bauxite) of the country for the local production of alumina and eventual establishment of an aluminium downstream industry.

(b) Immediate objectives

The immediate objective of the project is to establish the suitability for production of local bauxites by the Bayer route, with elaboration of optimum technological flow-sheet and main production parameters to be obtained as a result of testing a 15 ton bauxite sample on pilot plant scale.

2. Project outputs:

The project will result in a detailed project report indicating the results of testing a 15 ton bauxite sample from (name of country) at the Jamaica Bauxite Institute, with recommendations of the optimum technological flow-sheet and production parameters, that may be expected on industrial scale. Through the project, opportunity will be given to 2 - 3 experts from the country to observe the testing and discuss test results with the Jamaica Bauxite Institue, independent consultants and UNIDO representatives, to decide on the follow-up steps to be taken.

3. Project activities:

The JBI will be contracted by UNIDO to undertake technological and pilot testing of a 15 ton sample of (name of country, deposit) bauxite, by the Bayer process, including elaboration of optimum technological flow-sheet and main technological and production parameters expected on industrial scale. A report with conclusions and recommendations will be prepared.

International consultants will be invited to support JBI in programming the technological and pilot testing, on pilot plant operation and on the evaluation of the test results, with recommendations regarding the future steps to be taken. The test results will be evaluated with the participation of UNIDO's substgantive backstopping offiers during the terminal project evaluation/discussion.

4. Project inputs:

(a) UNIDO inputs:

	Estimated cost US$
Sub-contract with the JBI for pilot testing of a 15 ton sample of bauxite from (name of country, deposit) by the Bayer process 6 weeks testing (incl. all preparatory work)	40,000
International consultants on programming the technological and pilot scale testing of the sample, on monitoring the pilot plant operation and to participate in the evaluation of the test results 2 consultants, 3 weeks each (one to advise during the course of testing and one on split mission on preliminary programming and end evaluation)	12,000

Study tour of two experts from (name of requesting country) to observe the test work in Jamaica and participate in the evaluation of test results, 2 weeks ea.	10,000
Miscellaneous, including transportation of a 15 ton sample from (name of country) to Jamaica	5,000
UNIDO headquarters substantive staff participation in terminal discussion/ evaluation of test results	3,500
Total project cost	70,500

5. Evaluation and follow-up:

The project will be evaluated jointly by the JBI, the (name of country) representatives, the international consultants and UNIDO headquarters staff and any follow-up will be decided upon during that evaluation.

JAMAICA'S BAUXITE PRODUCTION - 1972-1984

(Metric Tons)

Year	Bauxite Exported	Bauxite Equivalent of Alumina Exported	Total Bauxite Disposed of	Alumina Export
1972	7,162,067	5,410,757	12,572,824	2,136,818
1973	7,390,298	6,210,169	13,600,467	2,416,917
1974	7,999,839	7,166,230	15,166,069	2,806,095
1975	5,482,680	5,897,229	11,379,909	2,374,886
1976	6,284,012	4,011,996	10,296,008	1,622,559
1977	6,355,163	5,078,502	11,433,665	2,035,993
1978	6,447,746	5,288,040	11,735,786	2,141,920
1979	6,400,047	5,105,057	11,505,104	2,074,165
1980	6,059,798	5,918,506	11,978,304	2,395,082
1981	5,294,090	6,311,930	11,606,020	2,549,855
1982	4,033,209	4,301,183	8,334,392	1,757,612
1983	3,009,724	4,673,412	7,683,136	1,907,009
1984	4,559,039	4,175,831	8,734,870	1,712,872

Jamaica Bauxite Institute
Economics Division
March 1985

Fig. 1

WORLD BAUXITE RESERVES

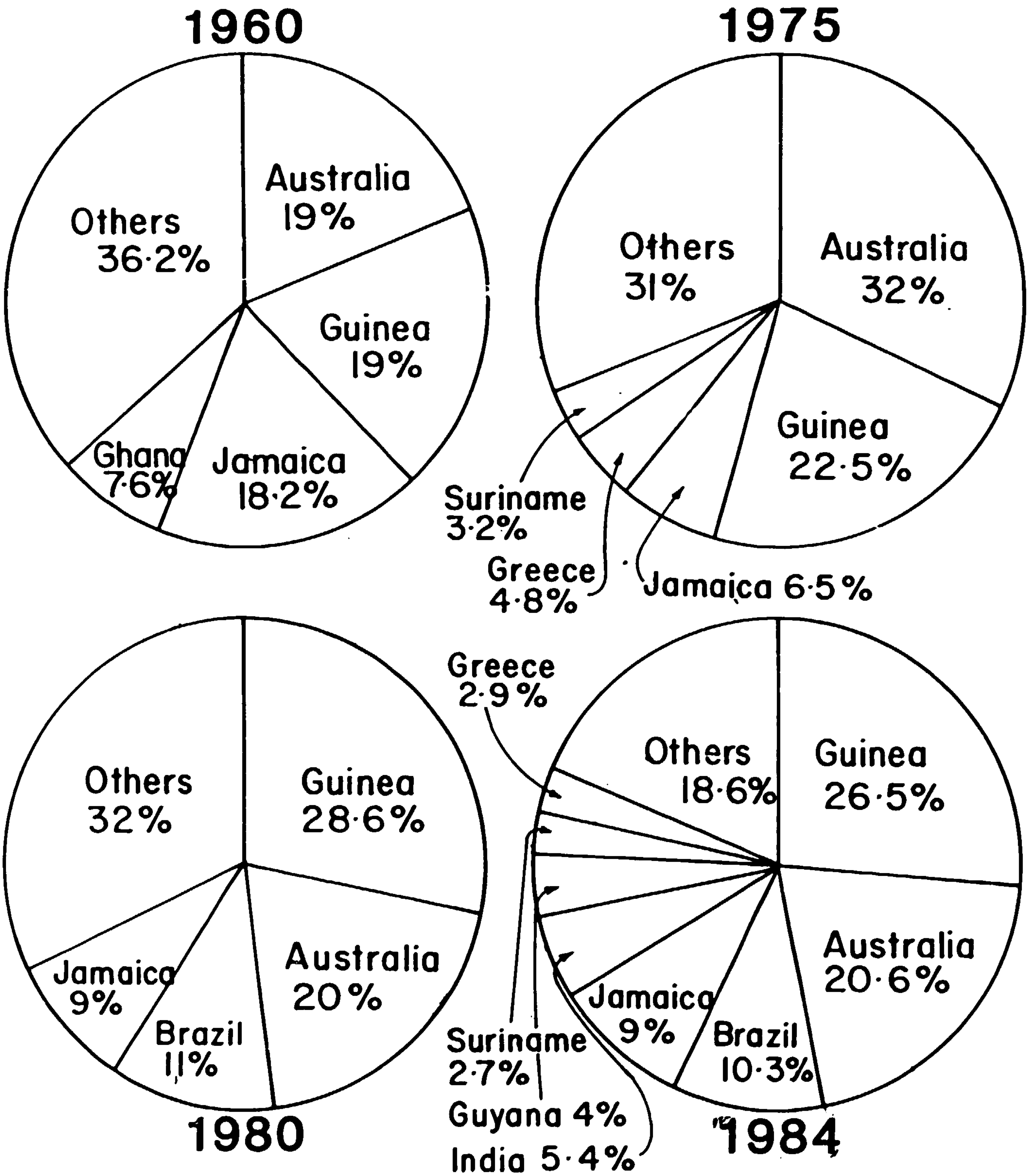

Fig. 2

WORLD BAUXITE PRODUCTION

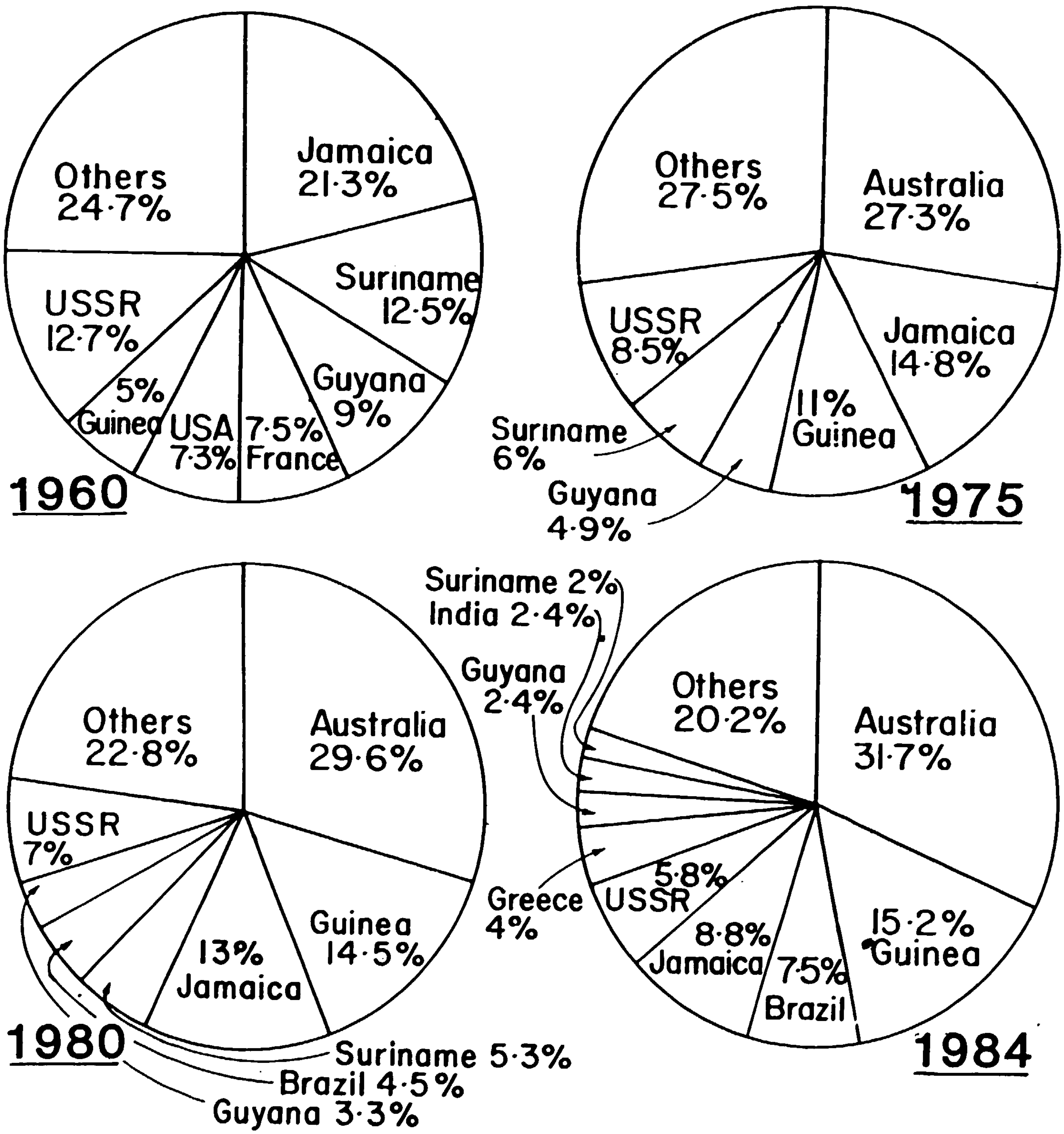

Fig. 3

TECHNOLOGICAL TESTING OF BAUXITE

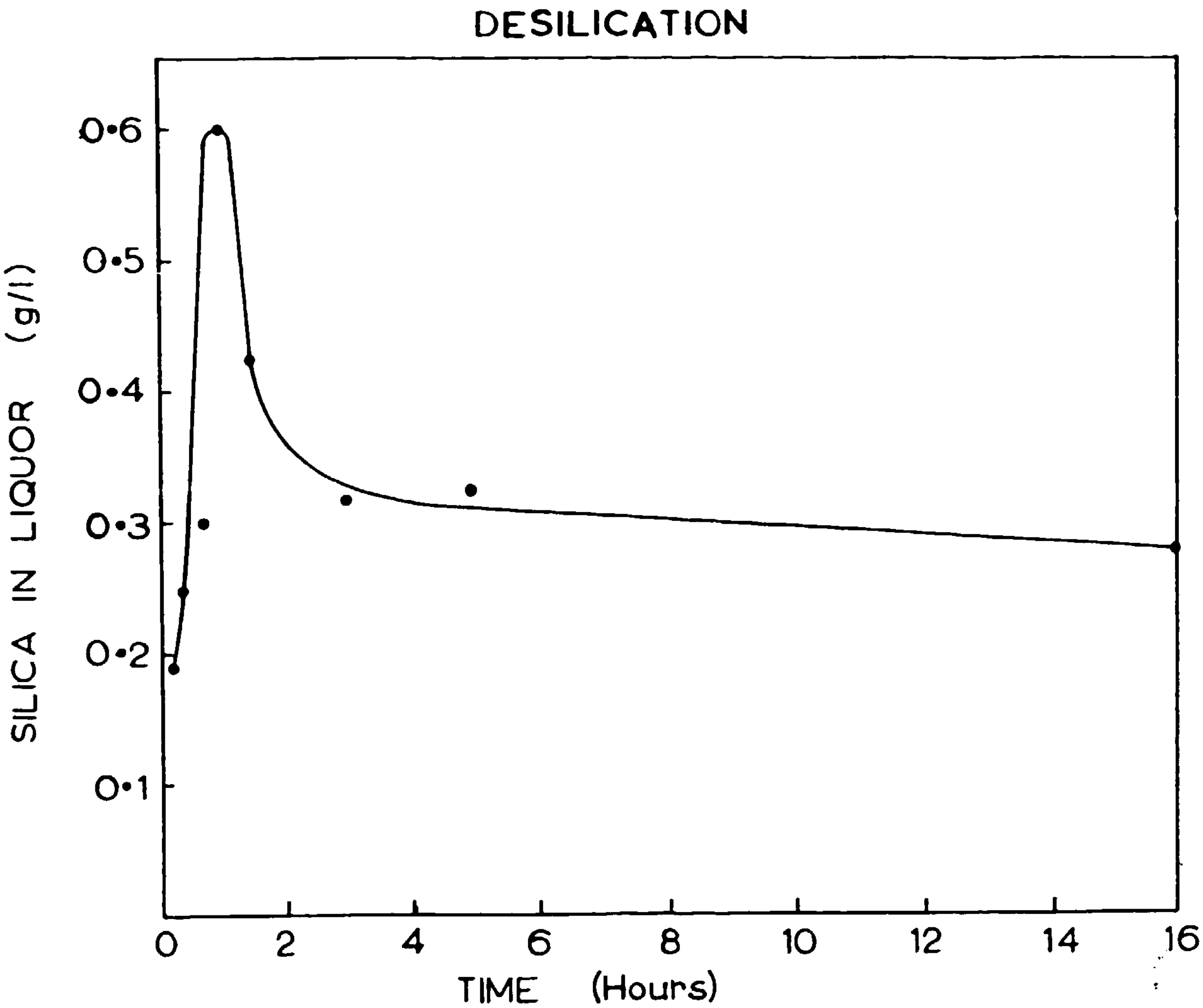

Fig. 4

TECHNOLOGICAL TESTING OF BAUXITE

DIGESTION

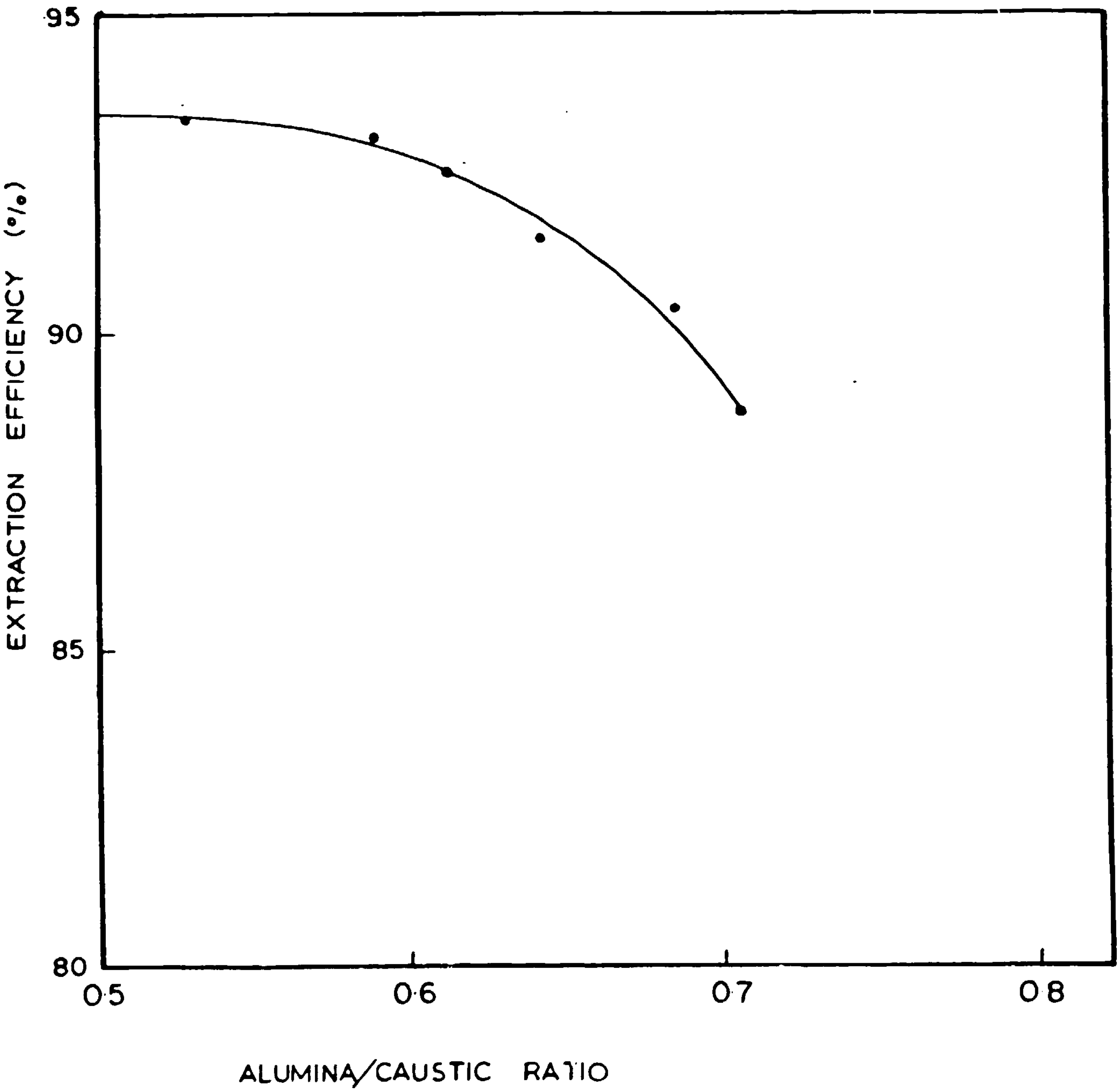

Fig. 5

TECHNOLOGICAL TESTING OF BAUXITE.

SETTLING

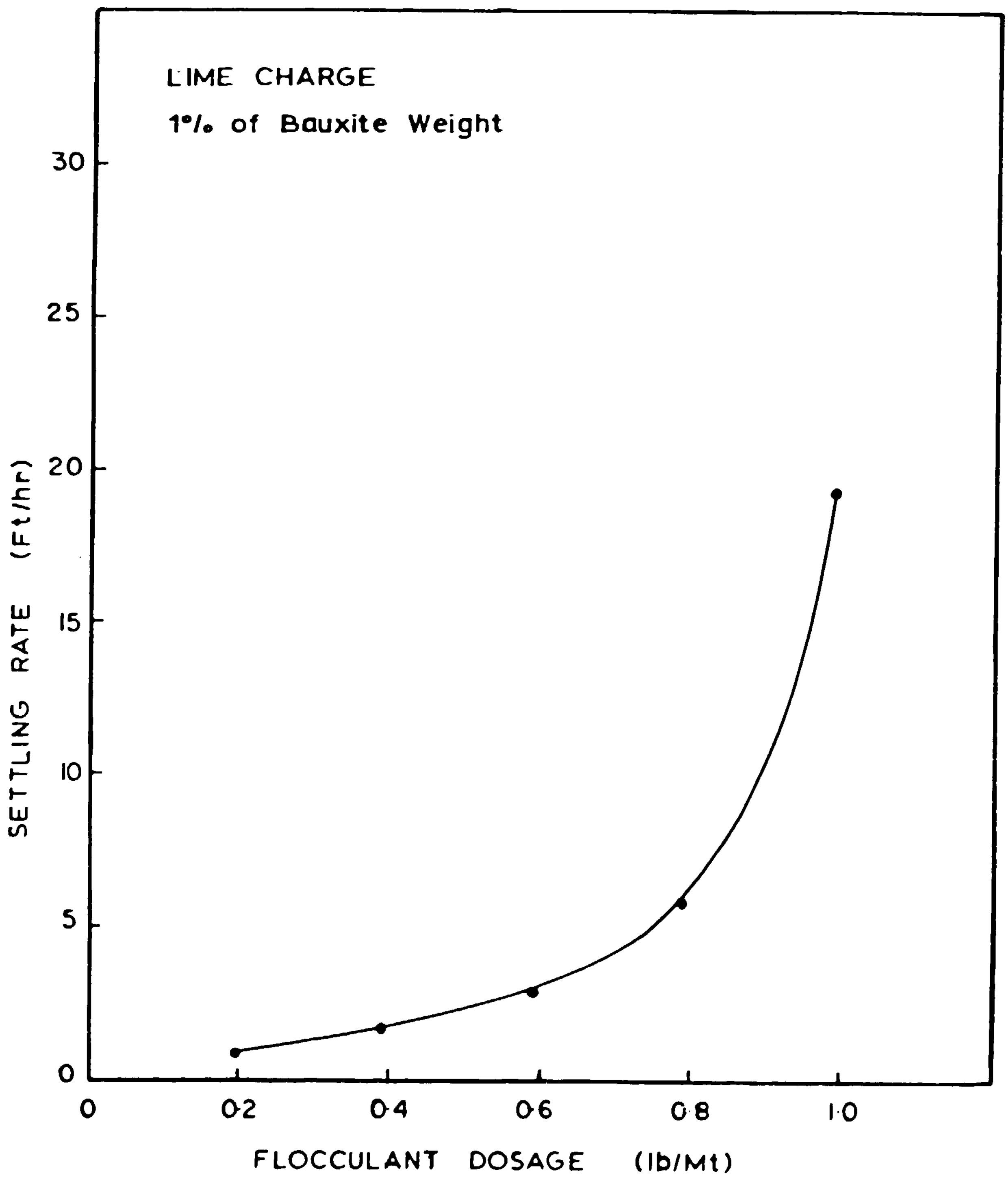

Fig. 6

TECHNOLOGICAL TESTING OF BAUXITE FOR UNIDO-UNTCDC WORKSHOP
OPERATIONS FLOWSHEET
PREDESILICATION

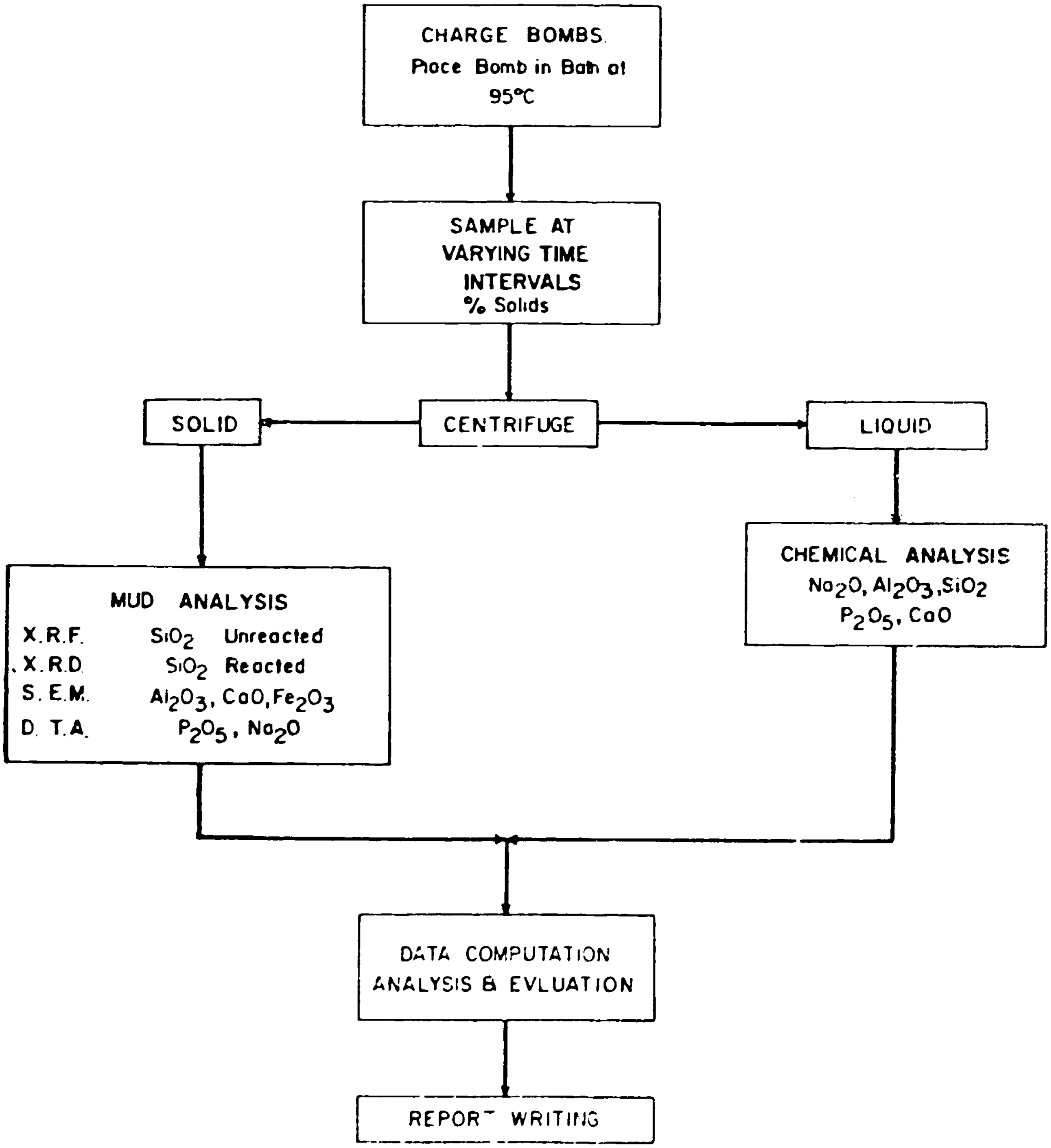

Fig. 7

TECHNOLOGICAL TESTING OF BAUXITE FOR UNIDO-UNTCDC WORKSHOP
OPERATIONS FLOWSHEET
DIGESTION & SETTLING