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DP/UN/GBS-86-006/1
GUINEA-BISSAU

UNITED NATIONS

DEPARTMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

INSTITUTIONAL SUPPORT TO MINISTRY OF NATURAL RESOURCES AND INDUSTRY

PROJECT FINDINGS AND RECOMMENDATIONS

DP/UN/GBS-86-006/1

UNITED NATIONS
DEPARTMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

INSTITUTIONAL SUPPORT TO MINISTRY OF NATURAL RESOURCES AND INDUSTRY GUINEA-BISSAU

PREPARED FOR THE GOVERNMENT OF
GUINEA-BISSAU
BY THE UNITED NATIONS
DEPARTMENT OF TECHNICAL COOPERATION
FOR DEVELOPMENT
ACTING AS EXECUTING AGENCY FOR THE
UNITED NATIONS DEVELOPMENT PROGRAMME

NEW YORK, 1991

NOTES

References to dollars ($) are to United States dollars unless otherwise stated.

Abbreviations used

BRGM	- Bureau de Recherches Geologiques et Minieres
DGGM	- Direction General of Geology and Mines
DGI	- Direction Générale de l'Industrie
DTCD	- Department of Technical Cooperation for Development
ICE	- Instituto de Cooperacao Economica
mg eq	- milliequivalents
MRNI	- Ministry of Natural Resources and Industry
m.y.	- million years (before present)
ppb	- parts per billion
ppm	- parts per million
UNDP	- United Nations Development Programme

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DP/UN/GBS-86-006/1: Points to be included in letter of transmittal

The report emphasizes the contribution that the quarrying activity in Guinea-Bissau makes to the mining sector and how it could eventually be furthered. It also points to a number of potential objectives and specific targets, both non-metallic and metallic, that could contribute to broader development, thereby providing suggestions for the furthering of institutional support in that direction.

Finally, the report points to the significant contribution that the setting up of a bibliographic data bank by the project has made to enable the Ministry of Natural Resources to respond to inquiries by potential investors.

ABSTRACT

From May 1987 to January 1991, the United Nations, in cooperation with the Government of Guinea-Bissau and supported by a contribution of $662,200 by the United Nations Development Programme, established the organizational and legal framework of the Direction General of Geology and Mines, inventoried 12 mineral resources, advised on the adoption of a minerals policy, and gave training to eight national staff. Recommendations are made to establish a mining fund, strengthen tax collections from mining companies, pursue joint development with Guinea (Conakry) of the Boé bauxite, expand sources for construction material (quartzite and dolerite), improve geologic mapping and continue the search for diamonds and gold.

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INTRODUCTION

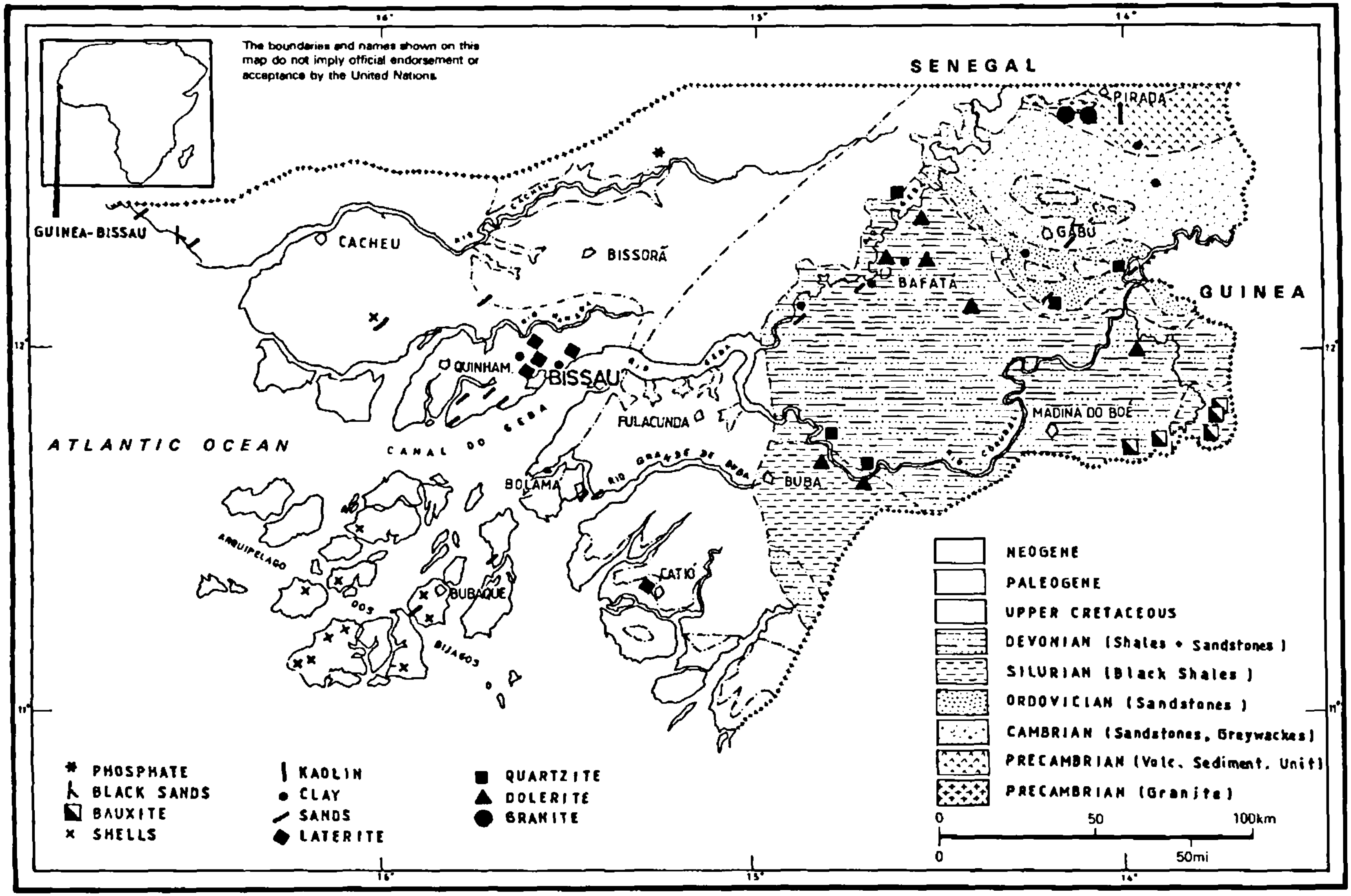
General geography

The Republic of Guinea-Bissau is located on the west coast of Africa, between Guinea (Conakry) and Senegal. Its area is 36,125 sq km of which about 8,000 sq km is a well developed estuary and associated mangroves. The sub-tropical climate is marked by two contrasting seasons. The wet season goes from mid-June through mid-October and the dry period lasts the following eight months. Relics of the original humid forest are confined to about 10 percent of the southwest region; the rest is secondary bush savanna.

The physiography is characterized by an estuary coast that gradually rises northwards to a flat peneplain between 40 and 80 m above sea level. To the east, in the Boé region, a plateau morphology has table mountains between 100 m and 290 m. These higher elevations are ascribed to an erosion surface of upper Cretaceous age, while the predominant and lower erosion pediplains evolved during middle to upper Tertiary times. A common feature is the widespread occurrence of wide flood-plains (bolanhas) at the banks of the low and middle courses of the two main rivers, the Cacheu and Geba, which are affected by sea water influx during high tide. The Bijagos archipelago, off the south coast, also has low and flat relief, here produced by three marine terraces.

The bedrock geology is nearly everywhere buried under thick lateritic soil (figure 1). The existing geologic map sheets are but a guess of the actual lithology, except for some information gathered from deep water and oil boreholes and geophysical surveys. About five percent of the land surface, in the northeast, is occupied by Precambrian formations (upper Proterozoic). They represent a westward extension of the volcanic sedimentary Youkounkoun and Koulountou Series of Senegal, plus the granite homologue of the Niokolo-Koba granite. South of it lies the Bowel Syncline, consisting of Paleozoic marine sediments (Cambrian molasse, Ordovician sandstone with minor shale, Silurian black shale and Devonian sandstone, shale and siltstone) intruded during the Early Triassic by tholeiitic dolerites. To the west is a transgressive marine Cretaceous sequence and Tertiary sediments of the Senegal Basin. Unconsolidated

GUINEA-BISSAU: GEOLOGY AND MINERAL RESOURCES



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continental deposits cover the Mesozoic and Cenozoic formations, and parts of the Precambrian and Paleozoic rocks.

The population - about one million people - is composed of several ethnic groups, dominated by Balantas (30%), Fulas (21%), Manjacos (15%), Mandingas (12%) and Pepeis (8%). The official language is Portuguese, the national language is Krole, and many speak neither but rather some tribal tongue.

The country exports cashew nuts, peanuts, fish and timber. With a per-capita income of less than $200, Guinea-Bissau is rated as one of the least-developed countries with an economy largely dependent on foreign aid (69 International aid agencies in 1990).

Project background and objectives

The project document for Institutional Support to Ministry of Natural Resources and Industry (GBS-86-006), funded by a contribution of $662,267 from UNDP, and executed by DTCD, was signed on 27 May 1987. Project staff and equipment provided are given in annexes I and III.

As one of the immediate objectives, the final project revision included Renforcement des capacités institutionnelles et juridiques de la Direction Générale de l'Industrie (DGI) en vue de la promotion et du développement des petites industries et industrie villageoise. Following a tripartite review on 4 May 1989, the objectives related to the DGI were incorporated in a separate project (GBS-89-009). Thereon, the immediate objectives of the project were limited to:

a) Technical and juridical restructuring and reinforcement of the technical capacity of the Direction General of Geology and Mines (DGGM), aiming at the development of a mining policy adapted to the national needs and to the international economic environment.

b) Training of personnel aiming at the adequate management of the natural resources of the country.

The development objective reads as follows:

> *By bringing its assistance to the Direction General of Geology and Mines (DGGM) of the Ministry of Natural Resources and Industry (MRNI), the project should reinforce the self-administrating capacity of the Government and contribute to the social and economic development of the Republic of Guinea-Bissau through the continuous and rational exploitation of its mineral resources.*

In order to accomplish the above objectives, the primary functions of the project comprised the following:

Direct Support

1. Organization Flowchart of DGGM; to propose the basic administrative structure.

2. Legal Statute of DGGM; to define functions and posts.

3. Mining Code; to elaborate the mining legislation and make it compatible with the existing Quarry Law and investment codes.

Institution Building

4. Documentation Centre; to organize the existing documents (books, maps, airphotographs, reports) of DGGM.

5. Mineral Inventory; to include rock and industrial minerals, black sands and gold.

6. Plan of Mining Development; to propose the main guidelines to orient the mining policy of the Government.

7. Training Programme for the DGGM staff; scholarships and study tours.

The four-year project expended $662,200 (rounded nearest hundred dollars) as follows:

Experts	$378,300
Equipment	105,900
Consultants	46,000
Training	38,600
Laboratory analyses	13,000
Administration, Travel	36,100
Other	44,300

Summary of findings

The immediate objectives of the project were achieved. An organization flowchart and a legal statute of the Direction General of Geology and Mines (DGGM) have been approved; a Documentation Center for DGGM now includes a computerized data base system; mining legislation has been approved by the Council of Ministers; and a mineral inventory has been completed. The records cover 85 mineral deposits comprising 12 mineral commodities (sand, gravel, clay, kaolin, laterite, limestone shells, quartzite, granite, dolerite, bauxite, black sands and phosphate); the mineral potential of the country has been preliminarily appraised and a plan for mining development has been designed to help the Government orient its mineral policy; finally, the planned training programme was also completed.

Guinea-Bissau is poor in raw materials; metals, coal and oil are, so far, altogether lacking. Mineral production consists of dolerites (one quarry producing expensive blocks and crushed stone for aggregate), which amounts to 78 percent of the total production value, followed by clay (12%) (one pit supplies the only brick and tile factory in the country), laterite (8%) (mostly for artisan work and concretions used as cheap and low-quality aggregate) and sand (3%), besides some local artisan production of lime from calcareous shells. Quartzites might represent a future substitute for the dolerites.

The value of the mineral production (January 1989 - June 1990) is roughly estimated at 6 million dollars, on which only $20,000 have been paid in taxes; the amount due is about $200,000.

The existing data point to a low potential for precious metals, diamonds, iron, ferrous metals and base metals, with the exception of aluminium. However, the exploration surveys done in the past are not conclusive. Some environments and conceptual models remain to be checked in detail (Silurian black shales for base metals; the series of seasonal lakes (vendus) for diamonds, and the Precambrian units for gold).

The known deposits of bauxite, phosphate and ilmenite (black sands) are not feasible for economic exploitation. The Boé bauxite could be exploited through a joint programme to develop the neighbouring and rich bauxite deposits of Guinea (Conakry); such a project would include a harbour and an alumina plant at Buba, Guinea-Bissau and a 175-km railroad.

The present report deals mostly with the period following the tripartite review of May 1989 and briefly describes the activities and results obtained during 1990 to project completion.

I. ACTIVITIES AND RESULTS

A. Organization and legal basis of DGGM

The project proposed the following organization for the Direction General of Geology and Mines (DGGM) of the Ministry of Natural Resources and Industry (MRNI). It should consist of two departments (called Serviços): one in charge of geology and exploration, comprising three divisions to handle: a) geology, exploration and evaluation of mineral deposits; b) geochemistry, petrography and mineralogy; and c) geophysics and engineering geology. The other department should comprise the mining and mineral production division and the control (inspection) division. The director is to be further assisted by an advisory board, a legal board, a cabinet for general studies and planning, and by a documentation centre. Three regional branches (delegacias regionais) will be created, each one providing for each Região of the country (North, South and East). Administrative functions would constitute a separate department; a Government commission is in charge of defining these functions to make them compatible with similar functions of other ministerial branches.

The proposed structure is relatively simple, but should meet its purpose. It represents a final version to be submitted to the Council of Ministers for approval.

B. Mining legislation

The Mining Code drafted by the project staff was approved by the Council of Ministers on 11 July 1990. It provides Guinea-Bissau with basic rules upon which can be built a solid base to orient the fiscal and the legal framework of national and international mineral policies. Two principal features are:

a) Creation of the National Mining Fund, the resources of which would be employed to supply DGGM with the means to develop its activities.

b) Provisions for a model contract between the Government and foreign investors interested in spending large sums of money during the prospection and exploration phases. The establishment of an international forum and the introduction of specific tax and fiscal rules should protect and motivate foreign investment.

The Mining Code as drafted covers several laws and rules in only a broad way. Legislation is necessary before implementation.

C. Documentation and mineral inventory

A documentation centre was established and about 300 documents (books, publications, reports, air-photographs) were catalogued and classified by the project.

Two index maps (scale 1:500,000) were compiled to help identify flight lines and photo numbers, and show the layout of 63 topographic sheets (scale 1:50,000).

The documents were organized in a computerized database allowing the listing of documents according to the following different indexes: register number, author, subject, title, place (bookshelf and room number), check-in and check-out dates, and names of users.

An inventory was taken of what is known of the country's mineral resources. It includes a computerized database covering 85 minerals (occurrences, deposits, quarries) arranged in 12 groups of substances i.e. sand, clay, kaolin, gravel, calcareous shells, laterite, quartzite, dolerite, granite, ilmenite (black sands), aluminium (bauxite) and phosphate. Supporting documentation was organized in filing cabinets.

A map of the Mineral Resources (1:500,000 scale) was prepared showing location and relevant information on each mineral commodity.

Seven reports were prepared summarizing the following aspects for each occurrence: name, type of substance, status, location, region, coordinates, map number, physiography, geology, exploration works, reserves, grades and production, recommendations and bibliography. The reports are listed in annex IV.

The computerized database greatly improved on the original stated objective. Information can now be easily retrieved, the files can be quickly updated and several reports can be printed with a minimum of effort. An important aspect is the potential for future use of the database system to monitor, for example, the legal situation of mineral claims, the actual status of claimed substances, deposits and mines, the updating of production figures, and reserves.

The inventory proved to be of daily use by DGGM staff. The director is continually requested by investors for information contained in the mineral inventory. The computing database meets these needs promptly and efficiently.

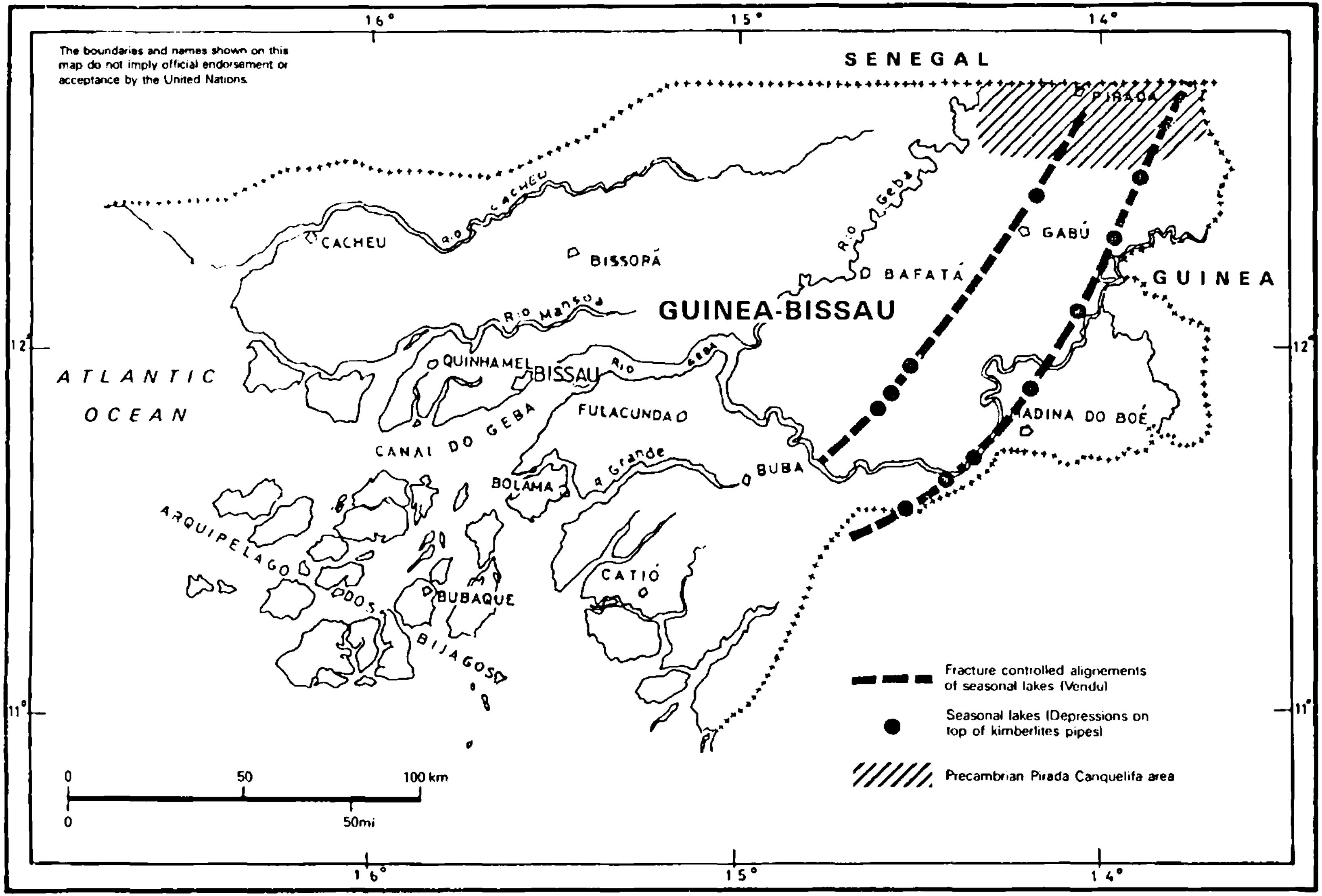
D. Preliminary gold programme

The project was not originally expected to meet the costs of a gold exploration survey. Priority was placed on seven other authorities. But concerning gold, the tripartite review meeting held in May 1989, recommended that the project review the literature, study the characteristics of the different geologic environments, understand the development of the morphology and the laterite soil profiles, carry out limited geochemical surveying and test the available samples. With that information at hand, the project provided a preliminary evaluation of the geologic environments and made recommendations for a final appraisal of the gold potential.

A review of the literature revealed nothing on gold mineralization in Guinea-Bissau. The only reference to gold is a note on the possibility of gold sales by merchants who might have brought it from Senegal in pre-colonial times. Old workings have not been found, as would be the case if the ancients had made any significant discovery. The only environments that could possibly hold economic gold mineralization in Guinea-Bissau are discussed and evaluated below (see also figures 1 and 2):

1) The Upper Precambrian volcanogenic and granitic units of northeastern Guinea-Bissau, in the Pirada-Canquelifa regions are correlated, respectively, to the Koulountou and the Youkounkoun

POTENTIAL GOLD AND DIAMOND AREAS



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Series and to the Niokolo Koba Granite m.y. by strontium age dating in eastern Senegal. They are ascribed to the Pan-African tectono-thermal event. In Senegal, the Koulountou is viewed as a metamorphic facies (low greenschist facies) of the Youkounkoun Series. The series starts with felsic sub-aerial volcanics and passes upward into a thick molasse formation that culminates with mature orthoquartzites. The Koulountou Series proved to be weakly and only locally mineralized in eastern Senegal. In Guinea-Bissau, the prolongation of the Youkounkoun Series has been mapped by BRGM as Lower Cambrian.

Only ten small outcrops of granite have been found in Guinea-Bissau (Bidigor and Maule Jaube rivers) and the volcanogenic unit crops out only in three points, as schistose rocks in the Bidigor River bed. Rare, irregular and thin, quartz veinlets occur within the volcanogenic unit and in the granite, which locally develop a cataclastic foliation. Elsewhere the granite is granular, medium to coarse grained, relatively homogeneous and mainly composed of quartz, albite-oligoclase, perthite, chloritized biotite and muscovite; the minor constituents and accessories are epidote, apatite, sphene, zircon and ilmenite. The lack of magnetism shows it to belong to Ishihara's ilmenite series, which is more akin to the S-type granite series.

Such types of environment are virtually nowhere associated with economic gold mineralization. The volcanogenic unit, according to the literature, is sub-aerial. As has been widely recognized, sub-aerial volcanics could constitute an appropriate host for epithermal gold where they are of younger age (Cenozoic). In older formations, the shallow epithermal zones in the upper part of the volcanic system are rarely preserved, since they are usually eroded away. Under such conditions, it is unlikely that economic gold mineralization related to magmatic fluids will be found in Guinea-Bissau.

The only practical possibility for primary gold mineralization is linked to metamorphically derived fluids emplaced in shear zones. Deep-seated faults cutting the Birrimian basement could have provided channels for mineralizing solutions; gold would then be deposited in structurally prepared zones (shear zones) within the overlying Koulountou Series. One of the candidates for such a deep structure may be disguised in a lineament called the Canquelifa Fault. Although the model is theoretically feasible, it is based on felicitous assumptions: first, we assume the Birrimian basement underlies the Proterozoic and Lower Cambrian units. That is possible, but the depth is unknown; then we have to assume that the local Birrimian basement had gold available to be extracted by the transporting solutions. But the Birrimian is not everywhere a gold-bearing unit; the driving mechanism could have been triggered during the Pan African tectonothermal event; and we further assumed deep fractures, shear zones and so on. It is a completely theoretical model, and the geology of the country might not fit it, yet it is a possibility.

2) Secondary gold mineralization could develop in economic grade and quantity in the overlying mineralized bedrock. The Bauxite deposits of the Boé district, could host secondary economic gold mineralization through enrichment of mineralized bedrock during soil formation, as was the case of the Boddington deposit in Australia. The process leading to formation of bauxite or laterite, is quite efficient in concentrating gold in economic quantities, but a gold-bearing source rock is necessary to provide for the metal, as it is the case of Boddington and, as we shall see later, not of the Boé bauxite deposits.

3) A third possible target for gold is the Cenozoic volcanics of Surir, which are reported only from drill-holes. According to the source, a thick section of coarse, basic to felsic volcanoclastic unit overlies the Devonian formations and the Mesozoic dolerites of Surir. The description makes one think of volcanic events of a highly explosive nature. Such an environment would suffice to host epithermal gold deposits. Such are the potential targets for gold in Guinea-Bissau.

Aiming at a preliminary appraisal of these environments, the project selected 154 samples collected from old surveys. Of these were 65 soil samples of the volcanogenic area from a Portuguese 1986 prospection survey for diamonds; 4 samples of kaolin overlying the Pirada granite (auger-drill samples); 77 bauxite samples, taken at various depths from 12 boreholes and excavations done in the Boé district; 2 samples from the soil overlying the Cenozoic volcanics in Surir. The samples were analyzed for gold in the laboratory of the Malian geological survey, in Bamako. The results and conclusions are as follows:

1) The kaolin and the Surir samples assayed 5 ppb gold;

2) The 65 soil samples of the Precambrian era yielded 7 anomalous gold values ranging from 46 ppb to 132 ppb (32 samples were below detection limit (5 ppb), and 25 samples ranged from 6 ppb to 45 ppb gold). The project checked the data through a detailed soil sampling survey at the sites, but the anomalies could not be confirmed: of a total of 53 new samples all assayed less than 5 ppb gold. The new samples were taken at the surface plasma and at 30 cm depth, in a triangular grid consisting of 4 sampling stations, one at each corner and one at the triangle centre (total of 6 to 8 samples, spaced at 15 metres, per anomaly). Despite the negative results, another sampling in a square grid of wider dimensions is warranted.

The Portuguese samples were apparently collected along the roads, and so represent the surface and washed road sands, not the local autochthonous soil. Further away from the roads, the soils retain their original characteristics because vegetation protects them from the heavy rain fall during the wet season; the same is not the case among the roads, which behave like actual stream beds during rain fall. The consequence is a strong leaching and washing away of the fine fractions, leaving behind a sand with concentrated heavier minerals along the roads. That way, background or below-background gold values in the soil are concentrated and upgraded in the washed sands. The detected anomalies could thus be the result of poor and irregular sampling procedures and not indicative of mineralization.

There is another possible reason why the project's assays did not match those of the Portuguese sampling. The Portuguese have plotted the sample stations on a 1:50,000-scale base map lacking local reference points. Therefrom, it is likely that the project's sample sites did not coincide, exactly, with the Portuguese sampling sites. That is one of the reasons a wider grid should ensure a sampling of like zones (i.e., within an error of 50 to 100 metres).

3) Only 6 of the 77 bauxite samples analyzed yielded gold values above the detection limit. All 6 were taken from one borehole (S-35). The two largest values are 17 ppb (bauxite, between the surface and 0.6 m) and 16 ppb (bauxite-rich soil at 15 m). The bedrock here is dolerite, which shows an extremely high nickel content (0.1 - 0.3% Ni). One sample of fresh dolerite at 26 metres depth assayed 6 ppb gold. The gold values found in the weathered zone represent normal enrichment - three-fold upgrading - of the dolerite background values and are not connected with mineralization. The source rock seems not to be mineralized, at least at the analyzed site. The other samples, all without gold, come from boreholes in areas where the bauxite bedrock is Devonian or Silurian shale.

E. Training

The training programme consisted of five scholarships at the Mining and Geological Survey of Portugal (DGGM-PO) and three study tours to Portugal with Portuguese Cooperation assistance (names in annex II). One geologist spent two months in the DGGM Documentation Centre for training on filing of documents and organization of rock, mineral and drill-core samples. Another was briefly trained in geophysical exploration methods and mining. A third attended a one-month course on mineral economics. One geologist had the opportunity to be trained by the project itself, through participation in detailed mapping of construction material deposits, exploration methods, geochemical soil sampling, reserve determination and evaluation of mineral deposits. This experience suggests that training within project activities may be more effective than training abroad.

During the study tours in Portugal the Director General and the Director of Projects of DGGM were convinced of the technical and economic potential of the mining of clay, sand and stone in Guinea-Bissau. During a visit to the Instituto de Cooperacao Economica (ICE) they reviewed the guidelines for proposed bilateral cooperation. These study tours for senior professionals proved to be of great benefit.

F. Evaluation of mineral resources

1. Need for inventory

To provide the broad lines, as specified in the project document, for the Government to set mineral and mining policy, the project inventoried all the mineral deposits of Guinea-Bissau.

In so doing, several aspects were taken into account as affecting a national mineral policy. The legal parameters are covered by the new Mining Code, but the fiscal and political parameters were matters beyond the scope of the project. Accordingly, only the natural and technical aspects are considered as affecting the internal economy of the country.

These include, so far as possible, a description of the mineral resources in such objective terms as size, shape, grade, quality, and value. The significance of some of these may change over time, for example, what is valuable today, might not be in the future; product requisites might be influenced by the market; and what constitutes economic ore grades may change.

Of more subjective nature is the estimate of the mineral potential of this or that commodity, whenever that estimate is based on scanty data. Commonly, the evaluation of a certain mineral potential must be made on purely geological grounds, by designing genetic models and drawing comparisons with other geologic environments. Thus, the balancing of similarities and differences between the environment to be evaluated and the model-environment will indicate the potential in a rather probabilistic way. The difficulty increases when the focused geologic environment cannot be satisfactorily defined, which is often the case in deeply weathered terrain. Not only are the primary mineral deposits hidden, but also the bedrock geology is itself hidden. Such is the case in Guinea-Bissau.

Exogenous processes, such as soil and laterite formation, beach and placer formation, and flood-plain sedimentation, were responsible for development of most of the mineral deposits in the country. The same process, however, which was responsible for formation of a productive laterite or bauxite hardcap at the top of a thick soil profile, also increases the overburden thickness above productive dolerite and granite bedrocks. The geology of Guinea-Bissau is the surface expression of such exogenous processes, which were active during the past ten million years. The result was two well-developed peneplain surfaces of Neogene age with relics of an old erosion surface of Cretaceous to lower Tertiary ages.

The evolution of such terrain took place under alternating semi-arid and tropical paleoclimatic conditions in a relatively stable mainland that was gradually uplifting. A deep chemical weathering system and interplay between dry and wet seasons formed typically a soil profile (up to 30 metres thick): a hard laterite layer underlying a thin and loose red latosol (the plasma) and overlying a thick altered zone (a kaolin-rich palid zone, mottled-zone and a saprolite zone, similar to profiles in Australia and Brazil). The following summarizes the main natural and technical characteristics of the potentially economic minerals of Guinea-Bissau.

2. Bauxite

Five deposits of bauxite still lack a final feasibility study (table 1). Most of the reserves are of relatively low grade, with little potential for finding any higher grade material. An integrated joint project to develop the huge deposit of Gasual, Guinea (Conakry), sharing the same railway, harbour and alumina plant at Buba is possible.

Table 1. Bauxite deposits

Deposit	Reserves (in thousands of tons)	Al_2O_3 (in percent)
Cain	16,100	36.44
Eva	19,179	46.16
Felo-Canhage	6,213	44.21
Rachel-Rebecca	6,878	46.42
Vendu Leidi	18,560	47.05
Total	76,930	Ave. 46.33

3. Ilmenite

At Varela beach, a tourist resort, is a small deposit of black sand. The deposit measures 440,000 t averaging 20 percent ilmenite and 4 percent zircon with traces of rutile. It is apparently not economic and there is little chance of finding additional reserves.

4. Phosphate

There is one deposit of phosphate rock in Farim. The indicated reserves amount to 94.7 million tons grading 36.5 percent P_2O_5 with a 65 percent recovery rate. The rock host is of mid-Eocene to mid-Miocene age; the productive beds range from 1 and 6.2 m in thickness and are deeply buried under 35-45 m of overburden and below the level of the nearby Cacheu river. Exploitation is apparently not economic, but a final feasibility study has yet to be made. The possibility of direct use as a natural fertilizer and extraction through slurry mining might enhance its viability.

5. Sand

There are 8 active pits and 16 additional deposits (table 2) of sand of which several are of good quality for construction material and glass. Although the potential is high, actual exploitation is irregular and extraction leaves much waste. Some sand deposits should be investigated for possible feldspar, which if mixed with the kaolin of Tabassi, could be used in the production of ceramic sanitary ware.

Table 2. Sand deposits

Deposit	Status	Reserves (in cubic metres)
Aqueiram	Deposit	Unknown
Areia Branca	Sand pit	10,400
Bidel	Deposit	66,000
Biombo	Deposit	129,500
Bolama de Baixo	Deposit	15,600
Bubaque	Sand pit	16,500
Bula	Deposit	62,500
Cajeuol	Deposit	93,000
Canchungo	Deposit	75,000
Canjadude	Deposit	808,000
Catao Joninque	Deposit	347,000
Catio	Sand pit	Unknown
Colonia de Baixo	Deposit	13,400
Gabu	Deposit	352,000
Galinhas	Sand pit	9,300
Juncuma	Sand pit	75,000
Malu Mandinga	Deposit	28,500
Niquim	Deposit	847,000
Oco	Deposit	17,900
Porto de Areia	Sand pit	3,000
Prainha	Sand pit	63,000
Quinhamel	Sand pit	249,300
Sucujaque	Deposit	793,000
Varela	Deposit	163,800
Total		4,237,900

6. Clay

Three clay pits (Campossa, Nema, and Santa Helena) supply raw material for the brick and roofing tile factory at Bafata and the pottery factory in Antula. In addition there are 8 deposits (a new brick factory in Bissau includes development of the Geba deposit) and 2 prospects. The potential for new discoveries is good; the high-quality material is concentrated in the bolanhas (flood plains), which are a few metres above sea level. Therefore, good material close to the coast line can be constrained by salt water contamination during high tide (the content of soluble salts should be 20 mg eq/100 g of rock). More to the interior, the flood plains attain altitudes of three metres but even there mining operations are restricted to the dry season.

Table 3. Clay deposits

Deposit	Status	Reserves (in cubic metres)
Bandim	Deposit	Unknown
Campossa	Pit	2,000,000
Candemode	Deposit	1,753,000
Cangalem	Prospect	66,000
Code	Prospect	Unknown
Codesane	Deposit	1,000,000
Colufi	Deposit	Unknown
Geba	Deposit	253,000
Jolo	Deposit	12,938,000
Nema	Pit	50,000
Santa Helena	Pit	550,000

7. Gravel

One placer site is exploited at Corubal. Access is difficult and the gravels are poorly sorted; they are irregularly mined for use as water well filters, but production is costly and not competitive with imported gravel. There is a reasonable potential for new discoveries of well sorted material in the Corubal River.

8. Kaolin

There is one measured deposit of kaolin at Tabassi, with 403,000 m^3 of reserves containing up to 70 percent kaolinite and 45 percent quartz; the deposit has an average thickness of 3.5 m under 2 m of soil. It represents an advanced stage of chemical weathering of the granite bedrock. The potential for new discovery is high around the Pirada granitic area, but there is no foreseeable use of kaolin in Guinea-Bissau. Sanitary ware and porcelain could be made from the Tabassi kaolin, but that would require supplemental, probably imported, feldspar. The economic aspects of such an enterprise are unknown, but rapid population growth and increased demand for houses in the country, suggests the need to consider it.

9. Limestone shells

There are about 40 deposits of limestone shells distributed in elevated ancient marine terraces on 9 islands in the Bijagos Archipelago as tabulated below:

Island	Reserves (in tons)
Bubaque	3,500
Canogo	12,880
Formosa	18,070
Meneque	3,150
Orango	35,450
Orangozinho	6,100
Soga	15,070
Uno	2,500
Uracane	500
Total	97,220

The $CaCO_3$ content ranges from 45 percent to 95 percent in the granulometric fraction 1.0 cm, depending on the amount of quartz sand. A preliminary study suggests production of 40-50 tons of lime per month for use by local artisans.

Shell-derived lime is produced at Canchungo. The refractory kilns are termite clay mounds, a good demonstration of native creativity.

10. Granite

There are three prospects for granite. The only fresh outcrops are found in the river bed of the Bidigor and Mael Jaube rivers at about 15 m above sea level. The nearby plateau rises another 15 m to the flat erosion surface. Further, 11 diamond drill-holes in the Male Jaube prospect and 2 at Sincha Sambo prospect demonstrated that, as a general rule, a 15-m-thick weathering section overlies the granitic bedrock. This means that most of the reserves are below the water table and under a thick overburden.

11. Quartzite

There are five recognized deposits or prospects of quartzite and the potential for large reserves with shallow cover is high.

Deposit	Reserves (in cubic metres)
Cabuca	100,000
Canjadude	300,000
Contuboel	2,000,000
Cusselinta	1,140,000
Saltinho	686,400
Total	4,226,400

The Devonian and Ordovician sandstones have also been affected by chemical weathering under tropical conditions, but the exogenous processes here were largely translated as silicification and induration of the sandstones. The end product is orthoquartzite, a sandstone in which the quartz grains are tied together by secondary growth of silica. The effect is much like cement, greatly increasing rock cohesion and strength. The drill-holes show that silicification is controlled by distance from the actual soil surface and from the joint planes underground. Several sections show different degrees of silicification in different domains intercalated with non-silicified rock. The latter would be waste, and care should be taken in measuring or estimating recoverable reserves which would comprise only the hard and silicified material. The quartzites represent a possible substitute for dolerite as aggregate. Rock mechanics and crushing tests are recommended.

12. Dolerite

There are 2 quarries, 6 deposits and 3 prospects of dolerite (table 4). The Mesozoic dolerites constitute, by far, the most important industrial rock for construction material in Guinea-Bissau. They were mostly emplaced as sills in the Devonian formations. The rocks are generally homogeneous, granular, fine- to medium-grained, medium to dark grey with greenish varieties; the microscopic texture ranges from subophitic to intergranular; plagioclase (andesine-labradorite) and augite with minor olivine make the bulk of the mineral constituents, followed by minor epidote, stilpnomelane, biotite, hornblende, olivine, sphene, apatite, calcite, ilmenite, magnetite and pyrite. The so-called conga-diabase represents a variety carrying free quartz and specks of micropegmatite.

Table 4. Dolerite deposits

Deposit	Status	Reserves (in cubic metres)
Bafata	Deposit	42,297,500
Cancolim	Deposit	338,000
Cobolóm	Prospect	Unknown
Dirsire	Prospect	Unknown
Finete	Deposit	4,000,000
Jabicunda	Prospect	Unknown
Pajanhe	Deposit	19,250
Quiliquili	Deposit	1,350,000
Soares da Costa	Quarry	Unknown
Somec	Quarry	Unknown
Surir	Deposit	3,400,000

Outcrops are restricted to rapids in the river beds or to boulders on the base of slopes, therefore they also occur close to the neighbouring drainage. The elevation difference between the slope boulders and the top of the local erosion surface averages 20 metres, which constitutes the overburden thickness as soon as the boulders are mined out and the mine face reaches the plateau scarpment. Another constraint is the proximity to the water table (a few metres). Those two boundaries (water table below and base of saprolite above) dramatically reduce the amount of those reserves that could be mined at a reasonable operational cost. In the only operating mine in the country, in Finete, 3 to 4 metres of dolerite is mined under a cover of more than 15 metres; the crushed stone is sold (1990) for $100 per cubic metre (probably four or five times what it should cost).

The use of dolerite for dimension stone in a competitive international market is additionally constrained by the following facts:

1. Boulders occur at Bafatá, Jabicunda and Quiliquili, but few are larger than a cubic metre.

2. The larger the boulders, the more common is a dense system of joints filled with quartz, calcite or epidote.

3. The boulders are progressively smaller downwards. The weathering process responsible for onion-skin exfoliation was more intensive underground owing to a longer residence time of infiltrating water and humidity. The surface boulders are relatively stable in shape and size, while exfoliation is still active in the buried boulders, thus contributing to a progressive size reduction.

4. Ornamental slabs of the dolerite, polished or not, invariably develop a spotted reddish stain due to sulphide alteration.

13. Laterite

Laterite is taken from quarries. Most is for artisan production. It is also a cheap material for road paving and low-quality concrete. Most of the known and mined laterite deposits are concentrated around Bissau. Apparently, they are stratigraphically controlled and occur between the second and fourth marine terraces. The deposits form indurated crusts

(1-5 m thick) below a few metres of loose latosoil (plasma). The induration ranges from hard, vermiform to pisolithic, to a totally disaggregated material consisting of 30-65 percent laterite concretions 0.5-5 cm in diameter, also called gravilha or casqueiro, mixed with loose soil. The potential for new discoveries is high.

Quarry	Reserves (in cubic metres)
Antula	Unknown
Bambadinca	3,000
Bono	*50,000
Buno	Unknown
Catió	Unknown
Cemitério	*50,000
Com	*100,000
Contumo	*50,000
Impernal	1,390,000
N'Hacra	1,156,000
Safim	1,500,000
Total	4,254,000

*Probably much larger; figures are minimum proved.

14. Copper, lead, zinc

Overall, the potential for copper, lead or zinc is low, but the Silurian black shales (Buba shales) are set in a promising environment to host economic (sedimentary exhalative) deposits. A regional geochemical survey carried out by BRGM (1979-1982) did not disclose any significant anomaly, but the work should not be considered conclusive.

15. Tin, tungsten

The potential for tin or tungsten is low. Theoretically, the only possible environment is the granitic area of Pirada and the surrounding country rocks of the volcanic-sedimentary unit. A regional soil geochemistry survey carried out by a Portuguese exploration team in 1986 showed tin and tungsten values invariably below detection limits.

16. Ferrous metals

The possibilities of finding iron, manganese, or any other ferrous metal in Guinea-Bissau are, with one exception, remote. In drill-hole S-35 (Boé bauxite region, Eva deposit), the interval between 15.6 m and 26 m yielded nickel values ranging from 450 ppm to 0.31 percent, four 3,100 ppm. One section of four metres averaged 2,000 ppm (0.2%) nickel. The samples come from the weathered dolerite making up the bedrock of the Eva bauxite deposit. The fresh rock assayed 900 ppm Ni. Although that does not constitute ore grade, there is a highly anomalous system. The chances for economic nickel is low, since dolerites generally do not provide the environment for nickel mineralization; nevertheless doleritic magma could yield gabbroic and ultrabasic differentiates (layered intrusives) with segregated nickel sulphides in economic quantities and grade. Such Ni-sulphide-rich environments are mostly from the Precambrian, and the Boé dolerites are early Mesozoic. However, the anomalies do point to mineralization and should be checked, regardless of the conventional genetic models. The possibility of a new model should not be dismissed.

17. Diamonds

Diamond mineralization is not known to have occurred within the country. Mature gravels are found only in the middle course of the Corubal River. The placers are not welldeveloped and the gravels are poorly sorted. A Portuguese prospection survey (1986) tested two bulk samples for diamonds with negative results. Traces of pyrope and ilmenite have been found, but the magnesium content of the ilmenites is below that of Mg-ilmenite of kimberlites.

All this, however, does not preclude the existence of kimberlite or lamproite pipes. One hypothesis should be tested. Figure 2 illustrates it: there are two parallel northeast-trending lineaments, along which are small seasonal lakes (vendus). It is possible that the lineaments represent fracture systems controlling the emplacement of kimberlite pipes; in South Africa several pipes are roofed by so-called salt-pans, which are depressions that evolved through a more intensive differential weathering of the kimberlitic yellow ground. Possible paths of exploration to prove or disprove the hypothesis are given below in the section on Conclusions and Recommendations.

18. Gold

The potential for gold is low. The subject has been dealt in some detail above and is further discussed below in the section on Conclusions and Recommendations.

G. Mineral production

The dolerite products - blocks and aggregates - represent by far the most important mineral resource, amounting to 78 percent of the net mineral production. It is followed by clay (12%), laterite (8%) and sand (3%).

Table 5. Comparison between due and paid taxes

Substance	Estimated Production (in cubic metres)	Taxes Due in $US	Declared Production (in cubic metres)	Taxes Paid in $US
Sand	18,326	9,351.75	2,210	1,105.00
Laterite	55,941	23,653.00	1,525	762.50
Dolerite	76,130	227,390.00	14,756	18,667.00
Total		260,394.75		20,534.50

Tables 5 and 6 indicate that in order to evade taxes, more than 90 percent of actual production is not declared. The actual production figures for sand, dolerite and laterite were the result of a great effort by the Control Division of DGGM in sorting through mining company records. Unfortunately, the Control Division has no vehicle and little means to implement inspection. The project helped, but the Government should follow up and support DGGM in a regular monitoring of mining production.

Table 6. Mineral production, January 1989 - June 1990

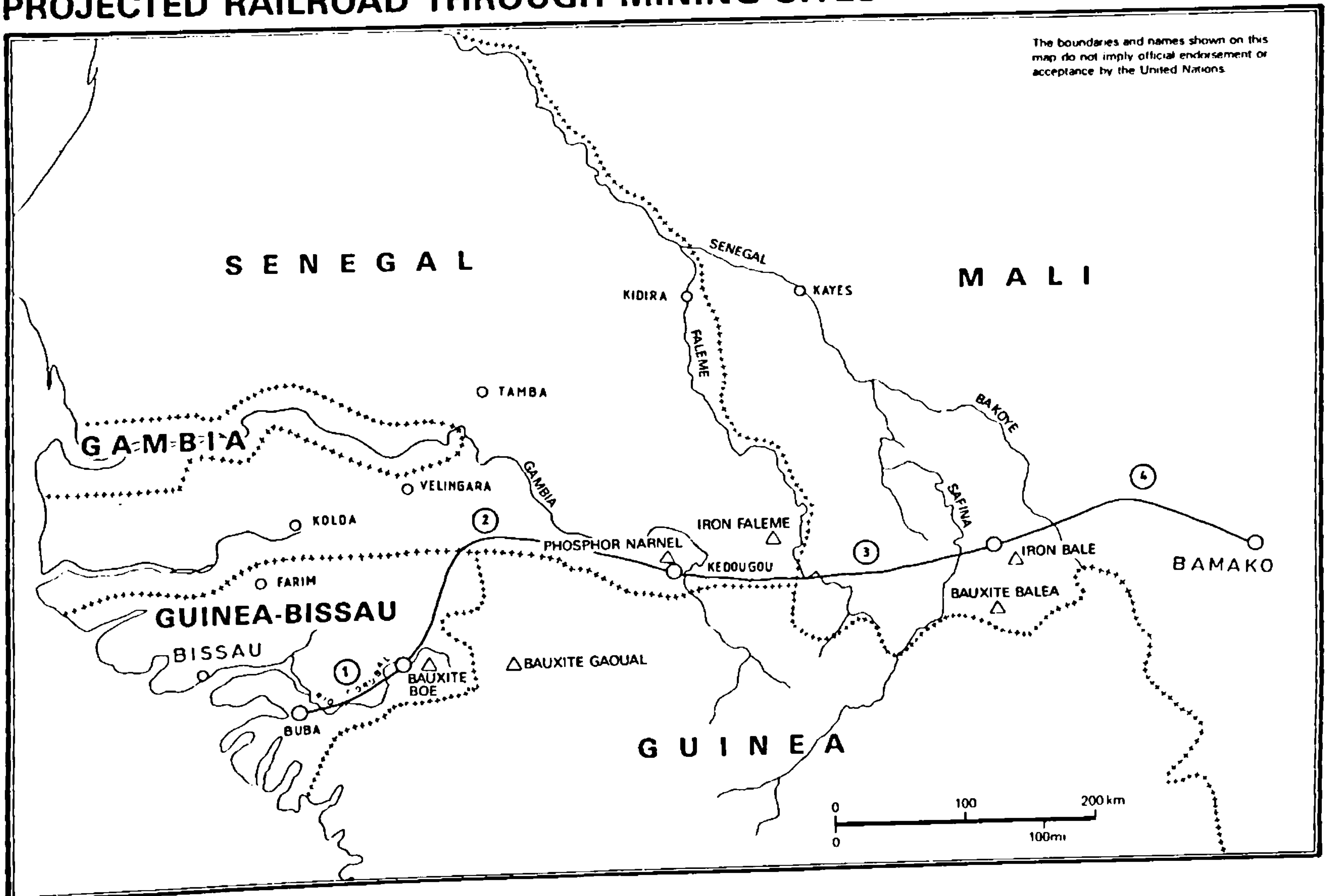
	Region	Estimated Production (in cubic metres)	Value	Taxes Due (in US dollars)
		A. White sand		
	Bafata	415	4,150	825.00
	Cacheu	1,550	15,500	775.00
	Gabu	2,985	29,850	1,492.50
	Oio	575	5,750	287.50
		B. Beach sand		
	Bijagos	120	1,200	60.00
	Biombo	7,785	7,850	3,892.00
	Gabu	750	7,500	375.00
	Tombali	884	8,840	442.00
		C. Road sand		
	Bafata	203	1,421	71.05
	Biombo	1,385	9,695	484.75
	Bissau	815	5,705	285.25
	Gabu	844	5,908	356.45
	Oio	15	105	5.25
Total sand		18,326	103,474	9,351.75
		D. Clay		
	Bafata	35,105	702,100	35,105.00
	Bissau	1,340	26,800	1,340.00
	Gabu	50	1,000	50.00
Total clay		36,495	729,900	36,495
		E. Aggregate laterite		
	Bafata	2,845	28,450	1,422.50
	Biombo	1,650	16,500	825.50
	Bissau	21,400	214,000	10,700
	Cacheu	185	1,850	92.50
	Gabu	3,250	32,500	1,625.00
	Oio	8,581	85,810	4,290.50
	Tombali	760	7,600	380.00
		F. Block laterite		
	Bafata	2,655	10,775	663.75
	Biombo	3,365	16,825	841.25
	Bissau	3,350	16,750	837.50
	Gabu	4,775	23,875	1,193.75
	Oio	3,125	15,625	781.25
Total laterite		55,941	470,560	23,653.50
		G. Block dolerite		
	Bafata	51,420	2,571,000	128,550
		H. Aggregate dolerite		
	Bafata	24,710	1,976,800	98,840
Total dolerite		76,130	4,547,800	227,390
Total value			$5,851,734	$296,890.25

The present tax values are 5 percent of a fixed price for each product. The current price values, which are determined by the Government, are as follows:

Commodity	Price (in US/m^3)
Dolerite (aggregate)	80
Laterite (block)	5
Laterite (aggregate)	10
Beach/white sand	10
Road sand	7
Clay	20

These prices are all unrealistic. The value of clay is too high, that of dolerite aggregate is too low. The project persuaded the Government to change its fixed-price mineral policy and charge duties according to market prices. This policy was to be implemented during fiscal year 1991. The new Mining Code regulates the taxation at 3 percent.

PROJECTED RAILROAD THROUGH MINING SITES



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II. CONCLUSIONS AND RECOMMENDATIONS

A. National minerals policy

The above presents an overview of the geologic and economic characteristics of the known mineral deposits in Guinea-Bissau, an evaluation of the possibility for enlarging the reserves of the existing commodities and a reappraisal of the potential of the geologic environments as possible hosts of economic mineralization. The following conclusions are inferred:

1. The potential for metal deposits, other than aluminium, is extremely low.

2. The possibility of increasing the bauxite reserves or finding new deposits with a better grade should also be considered very low. The same must be concluded for the Varela ilmenite and Farim phosphate deposits.

3. The other known industrial rock and mineral deposits comprise sand, gravel, clay, kaolin, calcareous shells, laterite, dolerite, quartzite and granite. The known gravels are of low quality and there is no immediate use for kaolin; the granites do not constitute economic targets; the limestone (calcareous) shell deposits should interest only artisans; the quartzite represents a large potential as to reserves, but still lacks technological studies to determine its possible use as aggregate. Therefore, the active mineral potential of the country is reduced to dolerites, clays, sands and laterites. There is some potential for the development of the bauxite deposits and a fair probability for a future inclusion to the country's economy of such other non-metallic minerals and rocks as kaolin, quartzite and, possibly, diamonds. Although the chances are not high, the possibility of finding economic deposits of gold and base metals should not be dismissed.

The above conclusions on present and future mineral potentials should be taken into consideration by the Government in formulating a realistic mineral policy.

B. DGGM and control of mineral production

Concentrated effort is needed on two basic points, which in combination are essential in studying the geology and managing the mineral resources of the country through DGGM.

The Mining Code created the National Mining Fund, which should be supported by taxes collected from exploration and mining activities. The resulting resources should be employed to provide DGGM with adequate equipment and installations for the regional branches and the means to maintain its staff in field work.

Regulation of the Fund is of utmost importance, and should be accompanied by a realistic definition of mining taxes and royalties.

The value of the mineral production (total sales) in the period 1989 through June 1990 is estimated at about 6 million dollars. The collected taxes amounted to just $20,000, less than 0.35 percent of the companies' revenues. According to the actual duty values, the taxes paid should be more than fifteen-fold higher. Total tax evasion may have reached a figure between $250,000 and $300,000, considering that the average mineral tax should have been 4.5 percent of gross sales. The situation is more striking when the evaded figure is compared with the DGGM budget, which was less than $10,000 in 1990.

In order to provide funds for the National Mining Fund, there should be close and convincing inspection of mineral production through DGGM. Otherwise, the National Mining Fund would have no meaning and the DGGM remain stagnant, impotent and inoperative, and its trained staff members would soon leave for more attractive and challenging work. Steps to implement these goals include:

a. The immediate establishment of the National Mining Fund and the Mining Code, with full definition of tax values and penalties.

b. The acquisition of one four-wheel drive vehicle for the Control Division of DGGM to monitor production and determine proper taxes.

c. A complete inventory and registration of all the individuals and companies involved in mineral exploitation.

d. The organization of seminars for instruction and exchange of ideas among those involved in the production of mineral substances.

C. Boé bauxite

Probably the only project that could eventually bring economic self-sufficiency to Guinea-Bissau is the sub-regional project for joint development of the Boé bauxite of Guinea-Bissau and the Gaoual bauxite of Guinea (Conakry). The project includes a harbour in Buba, an alumina plant and two railway tracks, linking Buba to Boé (140 km) and Boé to Gaoual (35 km). The project foresees a railroad extension of 450 km to reach the Faleme region of Senegal, and that could totally change the economic scenario of the Faleme iron ore deposits. An additional variant of 200 km could benefit Mali by giving access to a harbour and changing the economic features of the bauxite district of Balea and, possibly, the iron ore deposits of Bale.

DGGM has a complete dossier on the subject. Although letters of intention have been exchanged between Guinea-Bissau, Mali and Guinea (Conakry), the project has been dormant since 1981. Three alternatives have been discussed to develop the Boé bauxite deposits: a) investment of 317 million dollars (to include the mine, harbour, railway, roads and towns) to export 3 million tons per year of high-grade bauxite ore; b) investment of 904 million dollars (alumina plant added) to export 1.5 million tons per year of crude bauxite ore and 500,000 tons per year of alumina; c) investment of 1,174 million dollars to export a million tons per year of alumina. Alternatives b) and c) would be feasible only at a minimum alumina price of $270 per ton.

The above figures should be updated and the studies already done critically revised. The first step would consist of compilation of the available data in one single document, followed by a critical analysis and data evaluation in the light of actual prices and costs. It should take into account the tremendous and positive impact such a project would have on the macro-economic and social environments. Such a study would require one international expert for three months and the assistance of six national experts, to cover industry, mining, energy, agriculture, international law and environment protection.

D. Construction material

The value of good-quality crushed stone (aggregate) in Bissau is equivalent to a gold ore grading 3-4 grams per ton of gold. The extremely high price is due in part to the need to remove as much as 20 m of overburden to reach fresh rock (dolerite). Further, quarrying is limited to a narrow zone between the water table below and the saprolite above. The absence of any competition also contributes to the high price of dolerite.

The situation would change if a substitute could be found for crushed dolerite that could be exploited at a lower cost. To date such material is not available - gravilha (laterite concretion) is a cheap but low-strength aggregate - but there is one rock type that could eventually replace the dolerite for concrete aggregate: the quartzites (Devonian and Ordovician). The quartzites represent the only formation in the country with fresh outcrops at the upper part of the slopes or protruded above soil level, and therefore overburden thickness would not add significant stripping cost; undoubtedly they could be mined at a much lower cost than the dolerites.

Crushing and rock mechanics tests would have to be run to check such parameters as recovery, amount of fines, tensile and compressive strengths. Tests should be carried out from surface material and large-diameter diamond drill cores.

It would be a challenging task to mine these quartzites but it would be worth the effort and cost to try. Were it successful, and the odds are not against it, the rewards would be far more than just a return on investment. The entire population would benefit by having access to an important construction material at a reasonable price.

The Contuboel deposit should be investigated under the guidelines just mentioned. An initial bulk sample should be taken of the outcrops. About five tons should be extracted (explosives are necessary) and shipped to a crushing plant (Soares da Costa, at Finete, or Somec, at the Volta de Bissau) for industrial crushing and screening tests. If the results are positive, detailed drilling should begin and blocks and aggregate samples sent to a laboratory (Laboratório de Engenharia Civil de Lisboa) for technological tests of the raw material and its concrete. Drilling should be inclined 10 degrees off the vertical to allow intersection of vertical joints.

E. Geologic mapping

DGGM should also play the role of a geological survey and carry out systematic geologic mapping. The existing 1:100,000-scale maps (BRGM, three sheets) are not satisfactory, since they entail a high degree of extrapolation. The connective link between geologic mapping and mineral resources demands detailed maps at the scale of 1:25,000 on a precise topographic base. At that scale, several new deposits of dolerite, quartzite, laterite, clay, kaolin, sand and calcareous shell should certainly be discovered, and beneficial training would be given to DGGM geologists. Priority should be placed, initially, in mapping the Devonian formations and associated dolerite intrusives, between Bafata and Surir, and mapping the regions around Bissau, for laterite, sand and clay.

F. Diamonds

As noted above, there are two parallel northeast-trending lineaments along which is an alignment of small seasonal lakes called vendus. It is only a hypothesis, but the lineaments might represent fracture systems controlling the emplacement of kimberlite pipes. It is worth investigating the heavy-mineral fraction (for Mg-ilmenite, pyrope and Cr-diopside) and the magnetometric signature of the vendus. Special attention should be paid to any vendu lying on top of the divides, which has no ready explanation for its development. It is a high-risk, low-cost/high-return enterprise that could be carried out in about one month of field work and another month for laboratory determination of the heavy minerals.

G. Gold

The project work reaffirmed the likelihood that finding gold in Guinea-Bissau is slight. Nonetheless, so long as there is any chance, continuing search should be made. Two approaches have been proposed.

In one, a regional geochemical survey would be made in the Pirada-Canquelifa area, which is underlain by the Precambrian volcanic-sedimentary and granitic formations. The programme would consist of soil geochemistry in a grid of 1,000 m by 500 m (3,600 samples, analyzing 10 g/sample), at a cost of $250,000 for one year.

The second alternative would carry out a checking of the faint anomalies disclosed by the Portuguese samples. It is estimated that it could be done in two months at a cost of about $15,000 (100 samples to be collected in an area of 1 km^2 around each anomaly, in a grid of 100 m by 100 m).

The first would test for gold potential over a fairly large region, but at a cost 16 times as high as that of the second. Of course they are not mutually exclusive, since both approaches are distinct, but the second approach is recommended. If the results are negative it would, at low cost, be fairly conclusive that no gold is to be found. In case they are positive and the existence of true anomalies demonstrated, then the regional exploration survey would be more than recommended. An independent consultant, Mr. M. Diallo, proposed a regional soil geochemistry survey for gold and base metals in the same volcano-sedimentary area - grid of 1,000 m by 200 m (9,000 samples, analyzing 5 g/sample) ground geophysics and an atomic absorption laboratory at a cost of $880,000 for three years.

Annex I

PROJECT PERSONNEL

Name (Nationality)	Title	Period
	A. International staff	
Moutinho Dacosta, L.A. (Brazil)	Chief Tech. Adv.	Jan. 1990 - Jan. 1991
Hunger, G. (Germany, Fed. Rep.)	Assoc. Expert	July 1988 - July 1990
Becker, J. (France)	Chief Tech. Adv.	Sept. 1987 - Sept. 1989
Larese, E. (France)	Expert	June 1988 - April 1989
Patissou, J. (France)	Expert	April 1989 - May 1989
Sabater, J. (Spain)	Consultant	Nov. - Dec. 1987
Fath, J. (Hungary)	Consultant	Nov. - Dec. 1987
Ruy Barbosa, A. (Brazil)	Consultant	Oct. - Nov. 1988 and 1989
Blanchet, R. (Canada)	Consultant	Nov. - Dec. 1988, Dec. 1989 - March 1990
Diallo, M. (Mali)	Consultant	19-26 Dec. 1990
	B. National staff*	
Baio, Seco Bua	Director - DGGM	Oct. 1987 - Jan. 1991
Balde, Umaru	Geologist	May 1989 - Jan. 1991
Da Luz, J.R.	Geologist	Feb. 1989 - Jan. 1991
Nafampelne, A.	Geologist	Feb. 1990 - Jan. 1991
Silla, Mamadu	Mining Engineer	May 1989 - Jan. 1991
Fernandes, Maria	Mining Engineer	Feb. 1989 - Jan. 1991
Gama, Pedro	Mining Engineer	Feb. 1990 - Jan. 1991
Nola, Joaquim	Geophysicist	Feb. 1990 - Jan. 1991
Loque, Paulo	Technician	Feb. 1990 - Jan. 1991
Sani, Bacar	Driller Foreman	Feb. 1990 - Jan. 1991
Sani, Babagale	Driller	Feb. 1990 - Jan. 1991
Senha, Jeronimo	Driller	Feb. 1990 - Jan. 1991
Cande, Mamadu	Driver	Feb. 1990 - Jan. 1991
Quebe, Toneca	Driver	Feb. 1990 - Jan. 1991
N'Bana, Sumba	Driver	Feb. 1990 - Jan. 1991
N'Zally, Henry	Technician	Feb. 1990 - Jan. 1991

*Umaru Balde and J.R. Da Luz were full time, all others part time.

Annex II

TRAINING

Name*	Field of Study	Year (Months of Study)
N'Zaly, H.	Documentation/filing	1990 (3)
Silla, M.	Exploration and mining	1990 (2)
Fernandes, M. (Ms.)	Mineral economics	1990 (1)
Baio, Seco Bua	Study tour	1990 (0.5)
Gama, Pedro	Study Tour	1990 (0.5)
Barros, J.	Geology	1988 (2)
Sambu, N.	Geology	1988 - 1989 (2)
Baio, Seco Bua	Study tour	1988 (0.3)

*Seco Bua Baio visited Mali, all others were in DGGM/Portugal.

Annex III

MAJOR ITEMS OF EQUIPMENT PROVIDED BY UNDP

Land Cruiser, Toyota
Vehicle, Peugeot 305 GL
Pick-up truck, Nissan
Air conditioners (4)
Office copier, Xerox Zoom
Typewriter, Olivetti electric
Tents, field (2)
Compasses (2)
Water filters (4)
Beds, field (10)
Computer, Toshiba and Epson

Annex IV

PROJECT REPORTS AND DOCUMENTATION SUPPORT

(Portuguese except as noted)

1 - Statute and Organization Flowchart - DGGM. 16 pp., 1 Chart, 1990, GBS/86/006, Bissau, RGB.

2 - Documentation Center - DGGM. 74 pp., 300 documents indexed by Author, Subject, Title and Number. 1990, GBS/86/006, Bissau, RGB.

3 - Mineral Inventory - Republic of Guinea-Bissau. DGGM, 45 pp., 5 Maps. Index by Substance, Deposit Name, Inventory Number, Region, Reserves, Production, Map Sheet, Geology, etc. 1990, GBS/86/006, Bissau, RGB.

4 - Mining Code - Republic of Guinea-Bissau. 1990, 41 pp. Text approved by the Council of Ministers. GBS/86/006, Bissau, RGB.

5 - Map of Mineral Resources of Guinea-Bissau - 1:500,000. DGGM, 1990. GBS/86/006, Bissau, RGB.

6 - Mining Development Program/Evaluation of the Mineral Deposits - DGGM, 1990. 32 pp., GBS/86/006, Bissau, RGB (in English).

7 - Gold Exploration Program - 1990. 34 pp., 2 maps, GBS/86/006, Bissau, RGB.

8 - Fellowship and Study Trip Reports - DGGM, 1990, 52 pp., GBS/86/006, Bissau, RGB.

Nº 22 GEBA
ARGILA — JAZIGO
Aplicação: Cerâmica.

Reserva Medida de 253 mil m^3, com teor de sais hidrosolúveis < 20mg/100g (boa qualidade para indústria cerâmica). Testes industriais positivos após mistura com as areias emagrecedoras de JÒLO. Jazigo explorável durante 6 a 7 meses do ano.

Nº 65 N 'HACRA
LATERITE — PEDREIRA
Aplicação: Brita

Reserva Medida de 1.156 mil m^3 com cerca de 45% de gravilhas. Espessura entre 2,0 e 6,0 m, sob cobertura de 0,4 a 1,5 m (localmente 5,0 m). Produção artesanal irregular e não legalizada.

Nº 10 FINETE
DOLERITO — JAZIGO
Aplicação: Brita, Pedra Ornamental

Reserva Medida, explorável, acima do lençol freático, de 4 milhões de m^3. Espessura da cobertura: 10 m a 18 m.
Duas pedreiras em exploração:

Nº 11 - SOARES DA COSTA. Produção (1989) de 1.075 m^3 de blocos e 1.510 m^3 de brita. Em 1990 (1º semestre) produziu 380 m^3 de blocos e 180 m^3 de brita. Extração atualmente paralizada. Britagem em atividade.

Nº 12 - COLLAS. Produção total entre 1986 e o 1º semestre de 1990: 43.616 m^3 de blocos e 58.000 m^3 de brita. Atualmente Licença de Exploração transferida para a empresa SOMEC.

Nº 7 FARIM
FOSFATO — JAZIGO
Aplicação: Fertilizante

Reserva (Indicada?) de 94,7 milhões de toneladas (razão estéril/minério entre 6 e 15); concentrado de 36,5% P_2O_5 com recuperação de 65% do P_2O_5 contido no minério.
A espessura da camada útil varia entre 1,0 m e 6,2 m, situando-se abaixo do lençol freático, sob uma cobertura estéril de 32 m a 45 m de espessura.
Faltam estudos finais de viabilidade. Ensaios promissores no emprego como adubo natural.

Nº 23 CAMPOSSA
ARGILA — BARREIRO
Aplicação: Cerâmica.

Reserva estimada em mais de 2 milhões de m^3. Produção de 10 mil t por ano (1986) pela Empresa de Cerâmica de Bafatá.

Nº 46 AQUEIR…
AREIA
Aplicação: Construção C…

Reservas não calculadas … brancas, finas, algo arg… suras de até 1,5 m, sob … profundidade.

Nº 24 NEMA
ARGILA — BARREIRO
Aplicação: Cerâmica

Reserva estimada em 72 mil m^3. A producção dessas argilas emagrecedoras pode se manter por mais 10 anos. Em exploração pela fábrica de cerâmica de Bafatá.*

Nº 64 IMPERNAL
LATERITE — JAZIGO
Aplicação: Britra

Reserva Medida de 1,39 milhões de m^3 contendo uma média de 65% de gravilha sob cobertura de até 2,5 m de espessura.

Nº 44 BULA
AREIA — JAZIGO
Aplicação: Construção Civil (?)

Reserva Inferida de 62,5 mil m^3 em lente de 1,5 m a 2,5 m de espessura. Trata-se de material argiloso e não de areia para construção civil

Nº 63 SAFIM
LATERITE — PEDREIRA
Aplicação: Brita

Reserva Inferida de 1,5 milhões de m^3 com 33% recuperável como gravilha, sob cobertura de até 1,2 m de espessura. Exploração artesanal irregular.

Nº 48 NIQUIM
AREIA — JAZIGO
Aplicação: Construção Civil, Ind. Vidro.

Reserva Medida de 847 mil m^3; areias finas, puras, abaixo de 0,8 m de cobertura rica em resíduos vegetais.

Nº 49 SUCUJAQUE
AREIA — JAZIGO
Aplicação: Const. Civil, Ind. Vidro.

Reserva Medida de 793 mil m^3. Areia quartzosa muito pura (> 95% Quartzo) abaixo de 0,5 m de cobertura.

Nº 50 VARELA
AREIA — JAZIGO
Aplicação: Construção Civil

Reserva Medida de 163,8 mil m^3. Areias de praia, quartzosas, relativamente puras, de granulação média. Possibilidade de exploração limitada pelo impacto sobre o meio-ambiente e pelo turismo, que se encontra em plena atividade.

Nº 8 VARELA
ILMENITA (+ ZIRCÃO) — JAZIGO
Aplicação: Indústria Química, Ind. Metalúrgica

Reserva Indicada de 440.000 t de Areias Pretas, *contendo 87.000 t de Ilmenita e 17.000 t* de Zircão. Reserva pequena, sem valor econômico imediato; mínimas possibilidades de aumento de reserva.

Nº 51 CATÃO JONINQUE
AREIA — JAZIGO
Aplicação: Const. Civil, Ind. Vidro.

Reserva Medida de 347 mil m^3 de areias quartzosas puras.

Nº 45 CANCHUNGO
AREIA — JAZIGO
Aplicação: Construção Civil

Reserva Inferida de 75 mil m^3 de areias finas e relativamente homogêneas. Depósito inundado durante a maré alta.

Nº 66 COM
LATERITE — PEDREIRA
Aplicação: Brita

Reservas estimadas em centenas de milhares de m^3. Espessura minerável de até 6,0 m sob 0,4 m a 5,0 m de cobertura.

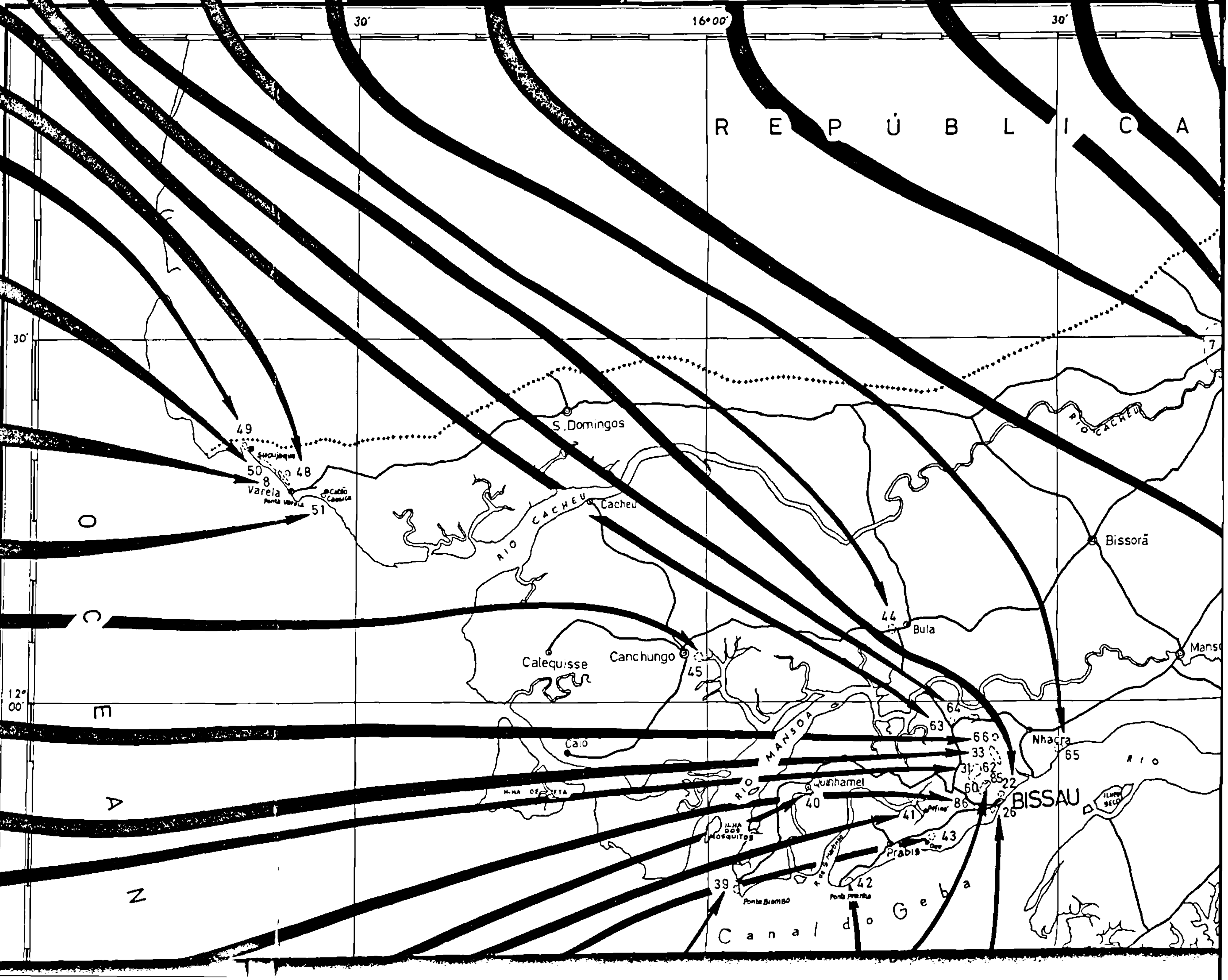
Nº 33 ANTULA
LATERITE — PEDREIRA
Aplicação: Brita

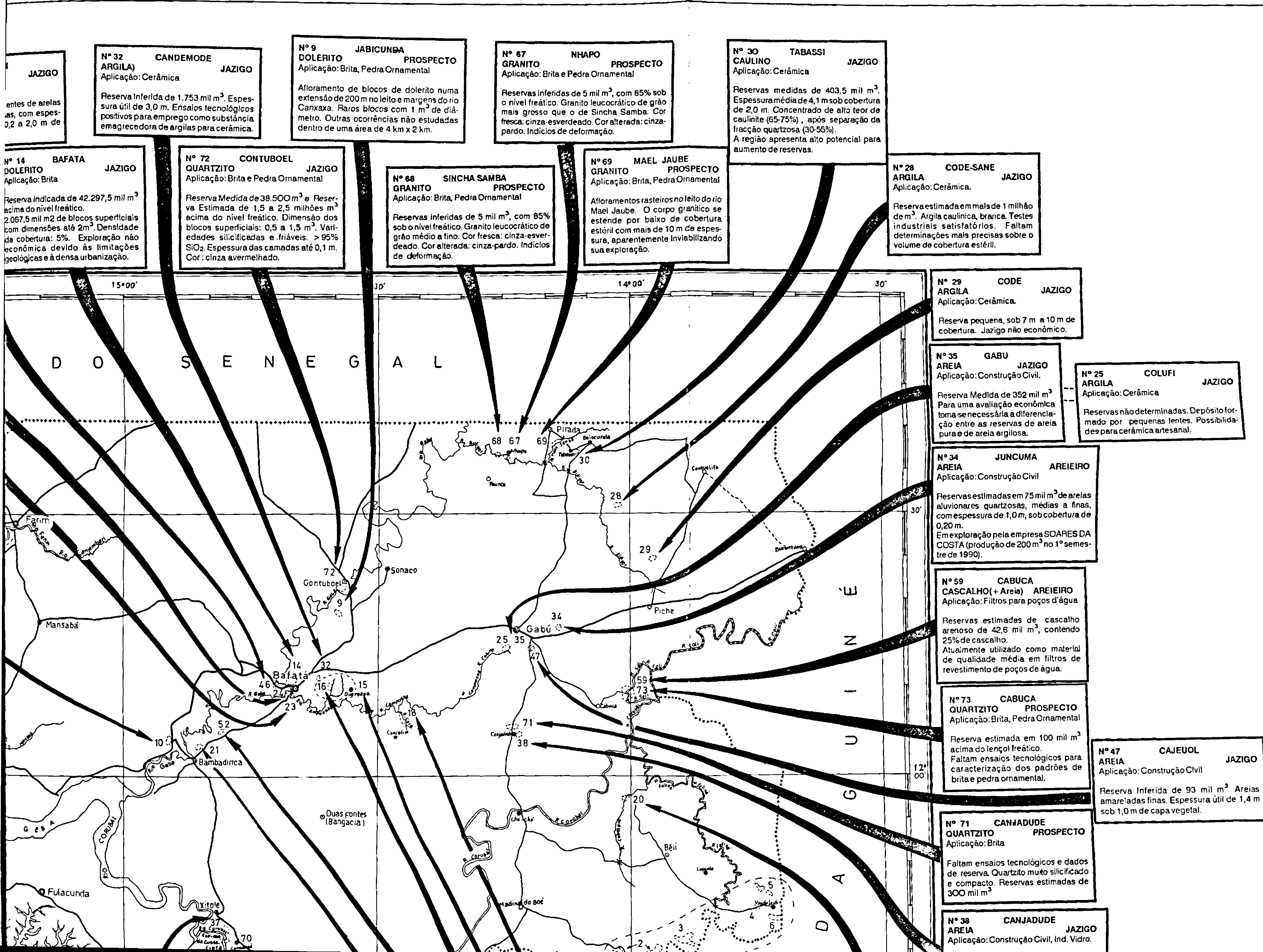
Reservas desconhecidas. Exploração esporádica pela população local. Não legalizada.

Nº 31 JOLO
ARGILA — JAZIGO
Aplicação: Cerâmica

Reservas Medida de 8.900 mil m^3 e Inferida de 4.036 mil m^3. Espessura de até 10,0 m. Argilas arenosas, constituindo excelente substância emagrecedora para o fabrico de cerâmica.

Nº 86 BAMBADINCA-BALANTA
LATERITE — PEDREIRA





JAZIGO
entes de areias
as, com espes-
0,2 a 2,0 m de
Nº 32 CANDEMODE
ARGILA) JAZIGO
Aplicação: Cerâmica
Reserva Inferida de 1.753 mil m³. Espessura útil de 3,0 m. Ensaios tecnológicos positivos para emprego como substância emagrecedora de argilas para cerâmica.
Nº 9 JABICUNDA
DOLERITO PROSPECTO
Aplicação: Brita, Pedra Ornamental
Afloramento de blocos de dolerito numa extensão de 200 m no leito e margens do rio Canxaxa. Raros blocos com 1 m³ de diâmetro. Outras ocorrências não estudadas dentro de uma área de 4 km x 2 km.
Nº 67 NHAPO
GRANITO PROSPECTO
Aplicação: Brita e Pedra Ornamental
Reservas inferidas de 5 mil m³, com 85% sob o nível freático. Granito leucocrático de grão mais grosso que o de Sincha Samba. Cor fresca: cinza-esverdeado. Cor alterada: cinza-pardo. Indícios de deformação.
Nº 30 TABASSI
CAULINO JAZIGO
Aplicação: Cerâmica
Reservas medidas de 403,5 mil m³. Espessura média de 4,1 m sob cobertura de 2,0 m. Concentrado de alto teor de caulinite (65-75%), após separação da fracção quartzosa (30-55%).
A região apresenta alto potencial para aumento de reservas.
Nº 14 BAFATA
DOLERITO JAZIGO
Aplicação: Brita
Reserva indicada de 42.297,5 mil m³ acima do nível freático.
2.067,5 mil m2 de blocos superficiais com dimensões até 2m³. Densidade da cobertura: 5%. Exploração não econômica devido às limitações geológicas e à densa urbanização.
Nº 72 CONTUBOEL
QUARTZITO JAZIGO
Aplicação: Brita e Pedra Ornamental
Reserva Medida de 38.500 m³ e Reserva Estimada de 1,5 a 2,5 milhões m³ acima do nível freático. Dimensão dos blocos superficiais: 0,5 a 1,5 m³. Variedades silicificadas e friáveis. > 95% SiO2. Espessura das camadas até 0,1 m. Cor: cinza avermelhado.
Nº 68 SINCHA SAMBA
GRANITO PROSPECTO
Aplicação: Brita, Pedra Ornamental
Reservas inferidas de 5 mil m³, com 85% sob o nível freático. Granito leucocrático de grão médio a fino. Cor fresca: cinza-esverdeado. Cor alterada: cinza-pardo. Indícios de deformação.
Nº 69 MAEL JAUBE
GRANITO PROSPECTO
Aplicação: Brita, Pedra Ornamental
Afloramentos rasteiros no leito do rio Mael Jaube. O corpo granítico se estende por baixo de cobertura estéril com mais de 10 m de espessura, aparentemente inviabilizando sua exploração.
Nº 28 CODE-SANE
ARGILA JAZIGO
Aplicação: Cerâmica.
Reserva estimada em mais de 1 milhão de m³. Argila caulinica, branca. Testes industriais satisfatórios. Faltam determinações mais precisas sobre o volume de cobertura estéril.
Nº 29 CODE
ARGILA JAZIGO
Aplicação: Cerâmica.
Reserva pequena, sob 7 m a 10 m de cobertura. Jazigo não econômico.
Nº 35 GABU
AREIA JAZIGO
Aplicação: Construção Civil.
Reserva Medida de 352 mil m³
Para uma avaliação econômica torna-se necessária a diferenciação entre as reservas de areia pura e de areia argilosa.
Nº 25 COLUFI
ARGILA JAZIGO
Aplicação: Cerâmica
Reservas não determinadas. Depósito formado por pequenas lentes. Possibilidades para cerâmica artesanal.
Nº 34 JUNCUMA
AREIA AREIEIRO
Aplicação: Construção Civil
Reservas estimadas em 75 mil m³ de areias aluvionares quartzosas, médias a finas, com espessura de 1,0 m, sob cobertura de 0,20 m.
Em exploração pela empresa SOARES DA COSTA (produção de 200 m³ no 1º semestre de 1990).
Nº 59 CABUCA
CASCALHO (+ Areia) AREIEIRO
Aplicação: Filtros para poços d'água
Reservas estimadas de cascalho arenoso de 42,6 mil m³, contendo 25% de cascalho.
Atualmente utilizado como material de qualidade média em filtros de revestimento de poços de água.
Nº 73 CABUCA
QUARTZITO PROSPECTO
Aplicação: Brita, Pedra Ornamental
Reserva estimada em 100 mil m³ acima do lençol freático.
Faltam ensaios tecnológicos para caracterização dos padrões de brita e pedra ornamental.
Nº 47 CAJEUOL
AREIA JAZIGO
Aplicação: Construção Civil
Reserva Inferida de 93 mil m³ Areias amareladas finas. Espessura útil de 1,4 m sob 1,0 m de capa vegetal.
Nº 71 CANJADUDE
QUARTZITO PROSPECTO
Aplicação: Brita
Faltam ensaios tecnológicos e dados de reserva. Quartzito muito silicificado e compacto. Reservas estimadas de 300 mil m³
Nº 38 CANJADUDE
AREIA JAZIGO
Aplicação: Construção Civil, Ind. Vidro.
15°00'
30'
14°00'
30'
12°00'
D O S E N E G A L
G U I N É
Pirada
Farim
Sonaco
Contuboel
Mansabá
Bafatá
Gabú
Piche
Bambadinca
Duas Fontes (Bangacia)
Fulacunda
Xitole
Madina do Boé
Bêli

Reserva estimada em 3,0 mil m³, já tendo sido explorados cerca de 1,86 mil m³. Espessura média de 1,5 m sob cobertura de até 2,0 m. Sem perspectivas de aumento de reservas.
Em produção pela SOMEC (produção de 1989/2º Semestre: 670 m³

Nº 40 QUINHAMEL
AREIA — AREIEIRO
Aplicação: Construção Civil

Reserva Medida de 77,6 mil m3 e Indicada de 171,7 mil m3, com espessura de 0,5 m. Areias quartzosas, médias, mal classificadas, com alguns fragmentos lateríticos e conchas. Exploração irregular pela população local. Depósito inundado pela maré alta.

Nº 41 PORTO DE AREIA
AREIA — AREIEIRO
Aplicação: Construção Civil

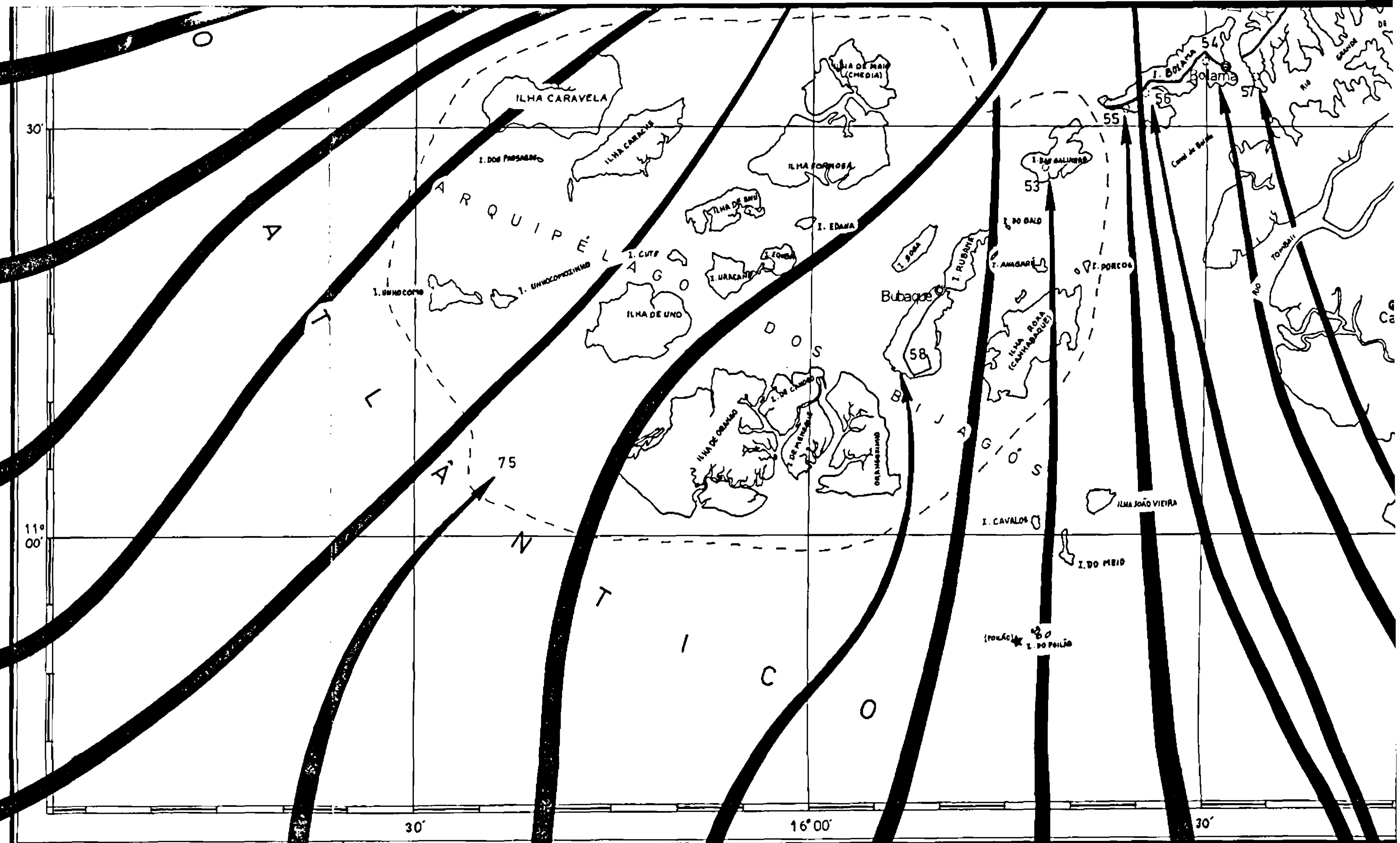
Reserva Medida de 1.000 m³ e Inferida de 2.000 m³, com parte renovável (300 a 400 m³/ano) durante estação chuvosa e maré alta. Areias médias a finas, quartzosas com poucos fragmentos lateríticos, conchas e argilas. Exploração artesanal legalizada.

Nº 43 OCO
AREIA — JAZIGO
Aplicação: Construção Civil

Reserva Indicada de 17,9 mil m³ de areias siltosas. Pequenas lentes de areias finas e relativamente limpas.

Nº 39 BIOMBO
AREIA — AREIEIRO
Aplicação: Construção Civil

Reserva Medida de 129,5 mil m³, com pequena espessura (0,3 a 0,7 m). Areias quartzo feldspáticas, finas, com 12% de nódulos ferruginosos e fracção argilosa < 1,9%. Exploração irregular pela população local. O depósito é inundado durante a maré alta.



Nº 75 BIJAGOS
CONCHA CARBONÁTICA — JAZIGOS
Aplicação: Cal

Segundo Mamedov (1980) as Reservas Medidas em 6 ilhas (40 jazigos) atingem 97.220 t:

Nº	ILHAS	RESERVAS (t)
76	ORANGO	35.450
77	FORMOSA	18.070
78	SOGA	15.070
79	CANOGO	12.830
80	ORANGOZINHO	6.100
81	BUBAQUE	3.100
82	MENECA	3.150
83	UNO	2.500
84	URACANE	500
	TOTAL	97.220

Aproveitamento de 45% a 90% de conchas na fracção acima de 1 cm. O concentrado de conchas revela teor de $CaCO_3$ sempre superior a 98% e $MgCO_3$ entre 1 e 1,2%. Depósitos pequenos, mas com possibilidade de serem explorados semi-artesanalmente para a fabricação de 50 t/mês de cal.

Nº 60 BONO
LATERITE — PEDREIRA
Aplicação: Brita

Reserva Inferida de dezenas de milhares de m³. Espessura útil de 1,5 m, sob cobertura de 0,5 m. Teor de gravilha de 30% a 40%, acima de 1 cm de diâmetro. Produção legalizada pela população local.

Nº 61 CEMITÉRIO
LATERITE — PEDREIRA
Aplicação: Brita

Reserva estimada em dezenas de milhares de m³. Espessura de até 4,0 m, sob cobertura de até 3,0 m. Teor de gravilhas entre 25% e 50%, com até 0,4 cm de diâmetro.
Produção legalizada pela população local.

Nº 85 BUNO
LATERITE — PEDREIRA
Aplicação: Construção Civil

Reserva estimada em centenas de milhares de m³. Espessura de até 2,5 m, sob cobertura de até 1,0 m. Teor de 40% de gravilha.
Produção legalizada pela população local.

Nº 62 CONTUMO
LATERITE — PEDREIRA
Aplicação: Brita

Reserva estimada em dezenas de milhares de m³. Espessura de até 4,0 m, sob cobertura de 0,5 m. Teor de gravilha entre 40% e 50%.
Pedreira em atividade, legalizada pela população local.

Nº 42 PRAINHA
AREIA — AREIEIRO
Aplicação: Construção Civil

Reserva Medida de 63 mil m³ de areias de praia, finas, puras e homogêneas. Exploração esporádica não legalizada.

Nº 58 BUBAQUE
AREIA — JAZIGO
Aplicação: Construção Civil

Reserva Inferida de 16,5 mil m³. Areias de praia, de granulação média, relativamente homogêneas. Exploração limitada pelo impacto sobre o meio ambiente e o turismo, que se encontra em plena atividade.

Nº 55 BOLAMA DE BAIXO
AREIA — JAZIGO
Aplicação: Construção Civil

Reservas estimadas em 15,6 mil m³ de areia de praia, quartzosa, granulação média, homogênea e relativamente pura.

Nº 53 GALINHAS
AREIA — AREIEIRO
Aplicação: Construção Civil

Reserva Medida de 9,3 mil m³ de areia de praia quartzosa de granulação média.

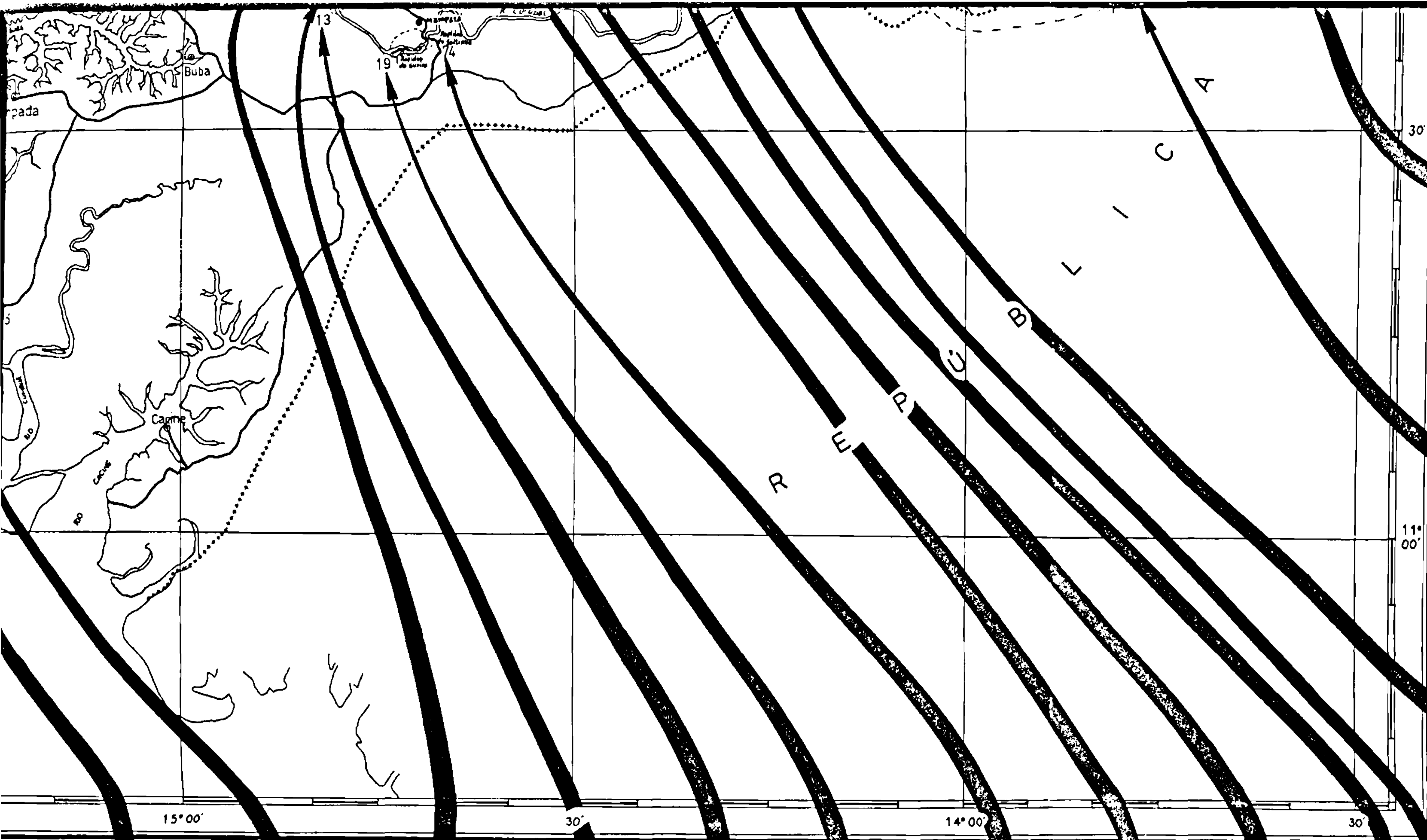
Nº 26 BANDIM
ARGILA — PROSPECTO
Aplicação: Cerâmica

Reservas não determinadas. Análises químicas revelam alto teor de magnésio e cálcio, impossibilitando o emprego para cerâmica.

PROJECTO GBS / 86 / 006
PNUD / DTCD / M R N I

Os limites e os nomes que figuram neste mapa não implicam seu apoio ou aceitação oficial pelas Nações Unidas.

0 10 20 30 40 50
QUILÔMETROS



de 400 mil m^3. Espessura média de 2 m sob cobertura de 0,2 m. Areias quartzosas (> 95% Quartzo), puras, finas, com fracção argilosa < 2,7%.

Nº 20 COBOLON
DOLERITO PROSPECTO
Aplicação: Brita e Pedra Ornamental

Reserva Inferida: 100 mil m^3 em blocos na superfície. Doleritos maciços, em blocos grandes. Faltam ensaios tecnológicos e estudos mineiros.

Nº 1 BOÉ
ALUMINIO JAZIGO
Aplicação: Metal Estrutural Leve

Reservas Medida e Indicada de 76,93 milhões de toneladas de BAUXITE com teor médio de 46,33% de Al_2O_3 distribuidas pelos seguintes jazigos:

Nº	NOME	MINÉRIO $x10^3t$	Al_2O_3 %	SiO_2 %
2	EVA	19,179	46,16	
3	CAIN	16.100	46,44	1,88
4	VENDU-LEIDI	18,560	47,05	4,62
5	RACHEL-REBECCA	16,878	46,42	5.39
6	FELO CANHAGE	06,213	44,21	
	TOTAL	**76,930**	**46,33**	**3,74**

Baixa perspectiva de aumento de reservas de minério de boa qualidade. Apesar de 70 milhões de toneladas representarem minério potencialmente exportável, economicamente existe uma aparente falta de competitividade em face ao mercado internacional. Faltam estudos finais de viabilidade. A DGGM estuda possibidiade de projeto integrado visando o aproveitamento conjunto com depósitos da Guiné-Conakry.

Nº 18 CANCOLIM
DOLERITO JAZIGO
Aplicação: Brita e Pedra Ornamental

Reservas Medida (50%) e Reserva Indicada (50%) de 337,5 mil m^3, com 80% sob o nível freático. Sill ou dique de dolerito. Cor fresca: cinza escuro. Espessura da cobertura de 0 a 13,45m.

Nº 54 AREIA BRANCA
AREIA JAZIGO
Aplicação: Construção Civil

Reserva Inferida de 10,4 mil m^3. Areias de praia, puras e homogêneas.

Nº 37 BIDEL
AREIA JAZIGO
Aplicação: Construção civil

Reserva medida de 66 mil m^3, com espessura média de 2,5 m e cobertura de apenas 0,4 m. Areias quartzosas finas, relativamente puras, com fracção argilosa < 4,5%.

Nº 13 DIRSIRE
DOLERITO PROSPECTO
Aplicação: Brita.

Afloramentos nos rápidos do rio Corubal, ocupando uma área de 200 m por 500 m.

Nº 74 SALTINHO
QUARTZITO JAZIGO
Aplicação: Brita e Pedra Ornamental

Reserva Medida de 686,4 mil m^3, acima do nível freático. Espessura média da cobertura de 1,8 m. Variedades silicificadas e friáveis. > 95% SiO_2. Espessura das camadas: 0.2 a 1,0 m. Cor: cinza claro com variedades rosadas e esverdeadas.

Nº 52 CANGALEM
AREIA E ARGILA JAZIGO
Aplicação: Cerâmica

Reservas Medidas de areia argilosa de 66 mil m^3 e de argila plástica de 42 mil m^3.

Nº 15 QUILIQUILI
DOLERITO JAZIGO
Aplicação: Brita

Reserva Indicada de 1,35 milhões de m^3. Cerca de 2/3 do dolerito encontra-se alterado. Afloramentos de blocos localizados em áreas restritas. Raríssimos blocos com 1 m^3 de volume.

56 MALU MANDINGA
EIA JAZIGO
licação: Construção Civil

serva Inferida de 28,5 mil m^3. ias de praia, finas a médias, itivamente homogêneas.

Nº 57 COLONIA DE BAIXO
AREIA JAZIGO
Aplicação: Construção Civil

Reserva Inferida de 13,4 mil m^3. Areias de praia, finas a médias, relativamente puras.

Nº 70 CUSSELINTA
QUARTZITO JAZIGO
Aplicação: Brita, Pedra Ornamental

Reserva Medida acima do lençol freático de 1,14 milhões de m^3, com cobertura estéril de 5,7 a 11,3 m de espessura.
Faltam ensaios tecnológicos para caracterização dos padrões de brita e pedra ornamental.

Nº 19 SURIRE
DOLERITO JAZIGO
Aplicação: Brita

Reserva Medida e Indicada, acima do nível freático, de 3,4 milhões m^3. Provavelmente, 2/3 das reservas não são aproveitáveis devido à intensa alteração. Cobertura de 2 a 7,6m.

Nº 21 SANTA HELENA
ARGILA BARREIRO
Aplicação: Cerâmica.

Reserva estimada em 550 mil m^3. Pequena exploração pela COOPAC - Cerâmica de Antula.

Nº 16 PAJANHE
DOLERITO JAZIGO
Aplicação: Brita

Reservas: Corpo 1: 11.250 m^3.
Corpo 2: 8.000 m^3.
Reserva limitada pelo alto grau de alteração acima do nível freático. Área de 11.500 m^2 sendo raros os blocos de 1 m^3.

REPÚBLICA DA GUINÉ-BISSAU

MAPA DE RECURSOS MINERAIS

MINISTÉRIO DOS RECURSOS NATURAIS E INDUSTRIA
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS
DIRECÇÃO GERAL DE GEOLOGIA E MINAS
- 1990 -