The GEF/UNDP/Unido Global Mercury Project
Removal of Barriers to the Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies

Small-Scale Mining Expert Report

The Challenge for Tapajos Garimpos

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Abstract

The Tapajos Region is the most important garimpeira gold producer in Brazil, and was the first area to organize the garimpo's owners named Tapajos Association Gold Mining (Amot). Before 1978, the garimpeira activity was carried out as rudimentary mining. After that year the gold mining in the main drainages with introduction of machines and motors started. Later, it was also started the gold mining in *sequeiros*, through *chupadeiras* or *par de maquina*, and after, primary gold occurrences were discovered in the region.

The Promin Project made geophysic surveys in four areas, involving 20 garimpos. In some garimpos were accomplished geology and the typology in quart vein deposits. In other primary gold occurrences, some mining companies conducted surveys including prospection and feasibility studies.

The gold primary deposits occur preferentially in the volcanic sequences and intrusive granites, upper to the older granites. The Tapajos Gold Province can be a polymetallic mineral province of which the gold represents the mineral resistant to the natural lixiviation. The areas worked represent only a "window", called gold enriched place. Probably the gold *in situ* occurs away from garimpos and closer to the mountains.

The mining methods developed from manual method, to dredge or raft, *chupadeira* or *par de maquina*, and hammer mill. The three last methods are considered as an advance in gold mining in the region. The dredge or raft recovers mineralized level or gravel at the active alluvial sediments in the main drainages and *chupadeira* or *par de maquina* recovered gold from elluvial and colluvial deposits. The hammer mills exploited primary gold in quartz veins. In all methods, the final concentration uses mercury, and the amalgam is almost always burnt in open air without protection and no use of individual protection equipments.

The excess of tailing formed great waste disposal in stock piles some of them with economic gold concentration. For that reason, is possible to recover gold by cyanide in carbon in pulp and heap leaching plant; of which Palito Property is the best example.

Environmental impacts in Tapajos Region are reflected in the water and the effects can be observed at the river through siltation. The mercury introduced in habitat is transformed in inorganic and organic mercury, and later it reaches the food chain, as showed in the samples of fishes analyzed for the total and organic mercury.

For sustainable development issues the garimpeira activity still has to be analyzed from the economic point of view and depends of a series of factors, as infrastructure, gold price, governmental support, garimpeiros organization, legislation, mining prospections, new auriferous occurrence discovery, Brazil unemployment level, and mainly mineral promotion. The challenge for Tapajos Region will be transforming the current garimpeira activity in small mining companies, according to mining, environmental and social legislation.

1 – Introduction

Environmental impacts resulting from the application of mercury in the processing of gold within the artisanal mining sector and their effects on International Water bodies require concerted and coordinated global responses. The long-term objective of the Project is to assist a pilot suite of developing countries located in several key transboundary river/lake basins in assessing the extent of pollution resulting from current activities, to introduce cleaner gold mining and extraction technology which minimize or eliminate mercury releases and to develop capacity and regulatory mechanisms that will enable the sector to minimize negative environmental impacts. The Project will be co-funded by a suite of ongoing activities, which are financed through either the countries' own resources and/or bilateral programmes leading to a reduction of mercury emissions from the artisanal mining sector in the respective country. These costs are considered as co-financing.

The objective of the GEF/UNDP/Unido Project is to replace mercury amalgamation in the project demonstration sites to the extent possible with improvement of new technology and income to the garimpeiros through more efficient recovery, increasing knowledge and awareness and providing policy on the regulation or artisanal gold mining with due consideration for gender issues.

The ultimate goals of the present GEF/UNDP/Unido project are: to reduce mercury pollution of international waters by emissions emanating from small-scale gold mining; to introduce cleaner technologies for gold extraction and to train people in their application, to develop capacity and regulatory mechanisms that will enable the sector to minimize mercury pollution; to introduce environmental and health monitoring programmes, and to build capacity of local laboratories to assess the extent and impact of mercury pollution, build capacity in local laboratories to assess the extent and impact of mercury pollution

However, in the Tapajos Region there are several peculiarities to consider. Therefore, this report contains information on the accomplished surveys, including primary gold occurrences, artisanal, mechanized, and cyanide gold exploitation

2 – General Aspects

The Tapajos Region is located in the Southwest of the State of Para, distance 1,300 km in straight line from Belem. The main access is from Itaituba through commercial and private flight, mainly monoengining (small air taxi), through Tapajos River and Transamazonica and Santarem-Cuiaba road (map 1)

The Para gold garimpagem is very important to the regional economy. It was considered the biggest Brazilian garimpeira gold area.

In the Amazon Region, the garimpagem (map 2) has an area of 236,000 km^2 (4.34 per cent of the total area). In the State of Para, these areas reach 150,000 km^2 being Tapajos the largest garimpeira area in the world – 100,000 km^2 – and the most important garimpeira gold producer in Brazil (map 3). From 1979 to 1984, the Federal Government delimited a series of Official Garimpeira Areas that correspond to 31,500 km^2 (13.3 per cent of the Amazon Garimpeira area – table 1).

Table 1 – Garimpeira Official Areas

DNPM Number	*Date*	*Area (ha)*	*Place*
1.345	*10/07/79*	*18,935*	*Rondonia (Rio Madeira)*
1.034	*21/07/80*	*24,642*	*Rondonia (Rio Madeira)*
143	*03/02/84*	*12.000*	*Roraima*
882	*28/07/83*	*2,874,500*	*Para (Tapajos)*
Law 7.194	*11/06/84*	*100*	*Para (Serra Pelada)*
25	*10/01/84*	*95,145*	*Para (Cumaru)*
550	*10/05/83*	*121,000*	*Mato Grosso (Peixoto de Azevedo)*

Source: DNPM

MAP 2 - AMAZON GARIMPO AREAS

Place	Area (km^2)
Para	150,000
Mato Grosso	30,000
Amazonas	20,000
Amapa	15,000
Roraima	12,000
Maranhao	8,000
Roraima	1,000
Total	236,000

The gold has been found in Brazil since 1500, when the Letter of Pero Vaz de Caminha mentioned Brazil as a gold producer. The Magna Letter of 1603, which instituted the tax, called gold fifth (*quinto do ouro*) already considered the State of Para as a gold producer. In 1747 gold was discovered for the first time in the Tapajos Region.

In 1958, the first great gold rush began in the Tapajos, transforming that area in the main gold producer in Brazil. It was supplanted only by Serra Pelada's garimpo that was discovered in 1980 and whose gold production decreased year by year, from 1983.

The main Tapajos characteristics are: the number one Brazilian gold mining with an official garimpeira area (28,000 km^2), but the garimpagem involves 100,000 km^2. Its area is similar to Portugal (92,000 km^2) and superior to the areas of Switzerland and Nederland together (75,000 km^2). The garimpagem started up in 1958, the historical real production is about 10 to 12 ton a year, and it is the biggest world gold

garimpeira area, with almost 500 airstrip and gold mining in secondary and primary gold with more than 2,200 sites of gold extraction. The area has about 500 occurrences for primary gold, including about 200 quartz veins, of which almost 100 are in activity. The new reality imposes to the Tapajos auriferous province a new profile and the production is mostly from veins and quartz lodes that correspond to more than 60 per cent of the Tapajos gold production. Its region is better researched with 6,000 total mercury and 355 organic mercury samples. Tapajos was the first area to organize the garimpo's owners named Tapajos Association Gold Mining (Amot) and introduced the joint venture involving garimpeiros and mining companies as well.

In August 1994, the State of Para Government, through the Camga-Tapajos Program, tried to implant the Gold Regional Secondary Market, in Itaituba. The task force had the collaboration of many institutions, but the Brazil Central Bank leaded the operation. The Gold Regional Secondary Market did not obtain success; however, it began the garimpos model transformation, including the official areas legalized in the Tapajos Region in according mining and environmental legislation.

3 – Gold Mining Aspects

3.1 – Mining Evolution

Some moments characterize gold garimpeira activity in Para.

Before 1978, when the garimpeira activity was carried out in compliance with Mining Code (Law 227/67) that characterized the garimpagem as a rudimentary mining, characteristics of the deposit, individual labour, and always independent. In that time, the garimpagem was made in a manual way, with garimpeiro's groups working to remove the overburden and the gravel to the final purpose of recovering gold. To remove the gravel the garimpeiros rudimentary equipments, whose material was accumulated beside the *cata* or *barranco* (place where garimpeiros exploited gold). The gravel was benefited in the sluice or cradler rocker (garimpeiros named this equipment as *cobra-fumando*), with addition of the mercury at the final concentration. The amalgam (mercury and gold alloy) was burnt in open air without any environmental care. The site was marked in strips (*trechos*) and subdivided *barrancos*. Near *trechos* for logistic infrastructure the garimpeiros selected the area for the airstrip and village (*currutela*).

After 1978, with the gold discovery out of flat alluvial, the gold mining in the main drainages began as well. The mechanization improved and works with dredges or rafts started with the introduction of machines and motors. This operation started up in the Tropas River, in 1977, tributary of Tapajos River. One year after, in the Marupa River, also tributary Tapajos River, the innovation obtained success.

In addition, in the garimpos area, the exhaustion of gold alluvial flats, the logistics in garimpos (airstrip, shopping, etc.), and the gold's discovery in the active bed of the

rivers, without or with reduced overburden, allowed garimpeiros to look for more investments in the mineralized areas providing garimpo gold production mechanization.

The dredges or rafts made gold mining in the active sediments of the main drainages and they are mounted on two wood boats or two iron tubes, with about six meters in length each, coupled to the boards also of wood with diesel motors (from 40 to 65 HP). They are covered with nylon protection and are moved along the drainages by 15 HP motors.

Later, with the gold discovery out of flat alluvial, the gold mining in *sequeiros* also was started (elluvial and colluvial ores), through *chupadeiras* or *par de maquina* garimpeiros denomination (two suction pumps, the first one, to remove the overburden and the other one, to make the suction of the gravel or mineralized level).

For this reason, there was a contradiction: meanwhile, garimpeiros removed large ore volumes through potent equipment utilization, the final concentration continued in the traditional *cobra-fumando*. Then, the garimpeiros mining exhausted the secondary deposits, accumulating great tailing volume.

Later on, they began to detect primary gold mineralization in quartz veins, whose exploitation technology is not well dominated by them. In fact, there were great environmental impacts and the discovery of series of primary gold mineralization occurrences. Nowadays, primary gold mineralizations show the transformation of the garimpagem model, as occurred in South Africa, Canada, United States, Australia, etc.

All these facts contributed for transgressing the Brazilian Mining Law, and the garimpos mechanization rose. Then, in Tapajos and the Amazon Region emerged many gold garimpagem focuses.

Some factors influenced drastic changes in the garimpos, some in a direct way and others in an indirect way. One of them were the various Government Economics Plans. In this period the gold price evolution was smaller than the petroleum price evolution in the stock market (in the Tapajos garimpos the `main access is through commercial and private flight mainly monoengining – small air taxi). The other one was the international gold price (the ounce declined from 1998 to 2001, in the principal stock market in the world).

Today, there is a harmonic and democratic coexistence between garimpo owners and the mining companies. The first one considers the joint venture the only alternative to advance in the garimpos mining. And the second one is conscious that the work of the garimpeiros is very important to eliminate the survey's initial risk, because once garimpeiros discover the primary gold mineralization, the mining company's prospection will be facilitated.

Nowadays, it is very common in the State of Para, mainly in Tapajos Region, joint ventures between mining companies and garimpeiros.

The garimpeiros were conscious that it was very decisive to start joint ventures with international mining companies. It has also been started up after the Promin project (CPRM – Brazil Geological Survey) a geophysical survey in the selected areas which present primary gold occurrence.

Between 1990 and 1999, the Government of the State of Para and Amot promoted joint ventures involving mining companies and garimpeiros. In that period about 35 negotiations were conducted (joint ventures) involving 19 mining companies. All negotiations had the Amot participation (table 2).

Table 2 – Mining Companies: Tapajos Surveys

Company	*Country*
Barrick Gold	*Canada*
Rio Tinto	*England*
TVX Gold	*Canada*
WMC	*Australia*
Pegasus	*USA*
Placer Dome	*Canada*
Homestake	*USA*
Minero Peru	*Canada*
Newmont	*USA*
Austral Inc.	*USA*
Rio Algom	*USA*
Jordex	*Canada*
Enterpa	*Brazil*
William Resources	*Canada*
Golden Star	*Canada*
Phelps Dodge	*Canada*
Anaconda	*Canada*
CVRD	*Brazil*
New Bullet	*Canada*

Source: Seicom

4 – Primary Gold Occurrences

The primary gold in Tapajos was appearing when garimperios conducted excavation in alluvial, colluvial and elluvial deposits. Actually there are above 500 sites with primary gold and 200 with quartz veins (figure 1). Many of these occurrences were studied by Promin projects and gold mining companies (map. 3).

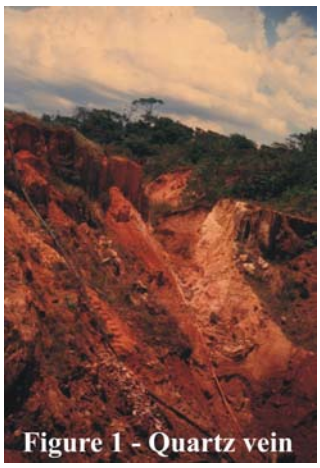
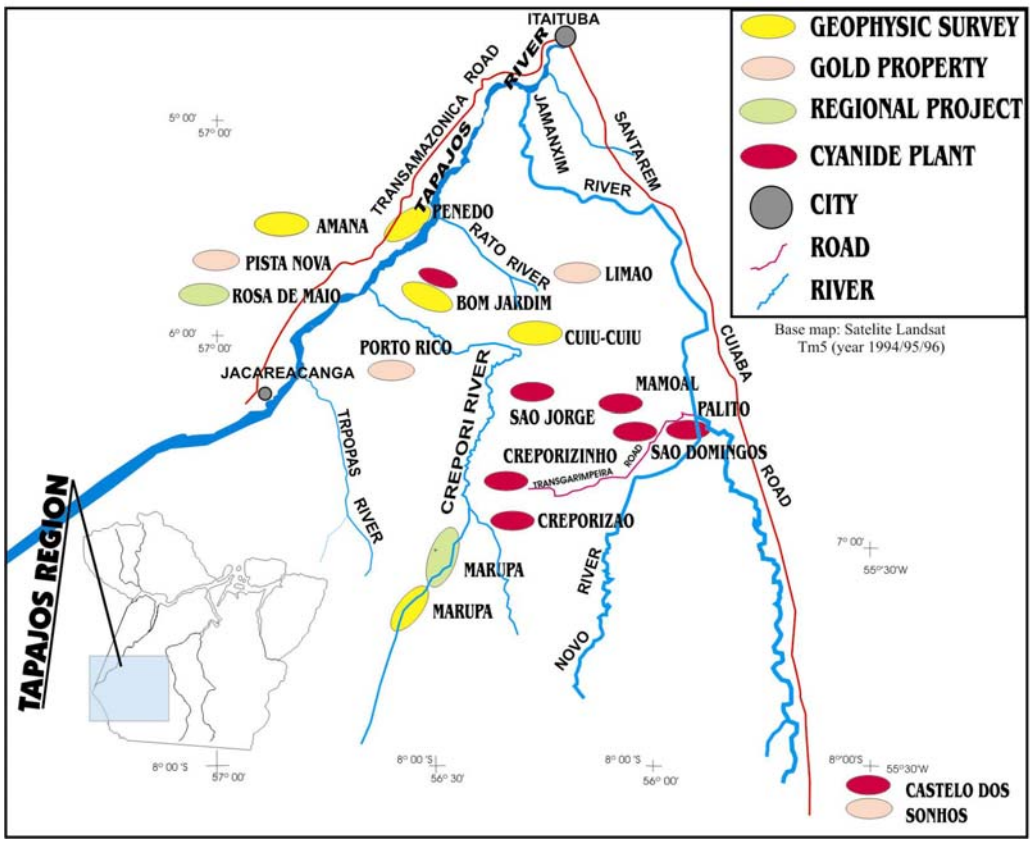


Figure 1 - Quartz vein

The prospection carried out by international and national gold mining companies in joint venture with garimpeiros look for enclosing all the site exploited by garimpeiros. Some garimpos mainly Ouro Roxo, Riozinho,

Independencia, Patrocinio, Limao and Sao Felix showed high gold content, with possibility to one million ounce reserve and 2g/ton gold.

MAP 3 - TAPAJOS: SURVEY AND GOLD MINING



In general, the survey involved the open horizontal channel in subvertical quartz veins or other anomaly (saprolite, shear zone, etc.). In some places, trenches and small trenches were opened (figure 2). The other garimpos did not present any interest in continuing evaluations.

In the Tapajos Region, with an area of 100,000 km^2, there is only 25,000 m drill. This is very small for an area with big gold anomaly.

5 – Geophysic Promin Surveys

The geophysical surveys in the primary gold mineralization accomplished by Promin Project involved magnetometric interpretation, only considering magnetic current induction field and the location in areas of low latitude, where there are horizontal magnetic fields.


Figure 2 - Trench (mining sample channel)

It is very important that the qualitative interpretation of a geophysical method cannot be analyzed separately as standard estimates on the physical properties that involve a

geological context. The geophysical methods normally present some problems as noises, cross of anomalies, lateral and superficial sources. All these problems cause reflexes in the qualitative analysis. Thus, the interpretation should be based on a previous geological know how, or on magnetic models that can facilitate the different phases of adjustment on the geological-geophysics integration.

In the elaboration of Magnetic Field Total Intensity Map was analyzed the deepness and distributions for low magnetism rocks, as well as regional tendencies scale. The qualitative aeromagnetic and aerospectrometric map interpretations were already accomplished in the 1:250,000 scale, and later reduced for the 1:500,000 scale. Those interpretations had as main objective to support the geological cartography, besides supplying parameters for the regional economic mineral favorability studies.

In the magnetic interpretations were used magnetic domains, magnetic units, and magnetic alignments. These components were analyzed qualitatively in order to evaluate the tectonic outline, as well as of the magnetic rocks in surface or subsurface, whose composition belongs to the area's regional geology.

The aeromagnetometric survey was divided in two magnetic groups, interpreted as magnetic domains.

The magnetic domain I is represented by quite accentuated and relief active magnetic, characterized by the strong E-W alignment. Usually, it indicates mafic and ultramafic intrusions, affected or not by metamorphism and cisalhaments.

The magnetic domain II is characterized by more moderate magnetic relief active than the domain I and medium magnetic variation. It is composed by isodinamic lines that maintain, with a little pronounced spacing between lines.

Those magnetic characteristics indicated that the rocks belonged to the domain were in a heterogeneous deformation, and also had small presences of the magnetic units. The magnetic lines in this domain did not have a preferential direction, but it presents a slow preference to E-W, later modified, to the performance of tectonic events. It was clearly observed the presence of some expressive magnetic anomalies, negatives and monopoles, related to magnetic bodies, most of them in outcrop. Those anomalies can represent basic and amphibolitic rocks.

Considering magnetic anomaly, the magnetic axes, and the directions of the magnetic gradients, the magnetic halos have contrast of magnetic susceptibility in the studied area; through the magnetometric map four magnetic units were enclosed, numbered in decreasing order of their intensities.

The first one is characterized by the highest magnetic anomaly of the area; it constitutes magnetic plan and linear appearance, forming elliptic and prolonged anomalies, showing great wavelengths and low frequencies, usually distributed in surface. There is presence of frequent negative monopoly anomalies. The lens form anomalies with the direction E-W, some inflections to the NE–SW, and can be related as mafic rocks (amphibolites).

The second one is represented by the presence of many negative poles, with orientation of the magnetic axes E-W and NE-SW. The units present also the magnetic mono and dipoles, usually with circular or elliptic form. Those anomalies represent vertical and subvertical intrusive bodies near surface or in surface. Usually, it is associated with a low radioactivity field and probable represent basic bodies. The magnetic axes come with different types, indicating varieties of sizes in the magnetic bodies.

The third one shows rarefect lines, almost always without any mono and dipolar anomaly and at same time, with a tendency of general orientation NW-SE, NE-SW and E-W. When the isohels have strong presence, they can indicate possible basic rocks, probably associated to the amphibolite rocks. It is also observed magnetic dipoles that represent basic intrusive rocks, almost always near the surface. In general it delimits geological bodies as sedimentary rocks, or areas with a low magnetic susceptibility.

The last one is represented by a magnetic moderate anomaly, besides its magnetic field suggests a transparent magnetic unit. The isohels usually come with great wavelength and, in a general; it is observed a parallelism degree among the magnetic lines. The isodynamics lines are oriented to the E-W and NE-SW directions, but in some places, present inflections to the direction N-S. There are few magnetic dipoles that occur in this unit, and represent probably basic composition in surface or subsurface. It is probable that it is related to the archean volcanic or granitic rocks or Proterozoic Inferior granites.

6 – Summary Description of Gold Primary Occurrences

6.1 – Geophysic Surveys

The auriferous primary mineralization surveys (map. 3) were accomplished in the garimpos areas of Penedo, Bom Jardim, Cuiu-Cuiu, Amana and Marupa. The surveys involve geology and the typology of the deposits.

6.2 – Penedo Area

Batalha Garimpo

Map 4 - Geophysic Survey (Penedo Area)

The geology is composed by igneous rocks (volcanic-plutonics), whose chemistry and mineralogical compositions indicate varieties of the alkaline sien-granite, even types of intermediary composition to the basic, probably through the fluidal ascension to the areas of weaknesses of the terrestrial crust (faults and fractures). The hostess rocks of the mineralized

quartz veins are quite altered (lateritic), porphyry texture, with fenocrystals varying from fine the medium ones, involved by fine matrix quartz (map 4).

The deposit typology is represented by a principal pit in the altered supergenic granitic, with general direction E-W. The quartz veins present a simple or ramified arrangement, crossing stockwork systems and predominance direction N30ºW, where has largest gold concentrations. In the N60ºE direction there are subordinated concentrations. The quartz is characterized by symmetry in external strips of up to 5 cm width, with radial breccia structures. The ore contents pyrite's boxwork and euhedric quartz crystals. The lateritic profile developed in the pit shows in the bottom horizon yellow-red, and in the top clay material.

Quincas Garimpo

The local geology includes magnetic rock constituted by coarse rose to the clay granite. The predominant mineralogy is quartz, k-feldspar and plagioclase. Secondarily, the mineralogy is supported by ferromagnesian minerals (biotite and hornblend), as well as sulfide disseminations (pyrite and chalcopyrite), with rapakivi texture. This body presents strips foliated according to the direction N70ºE and oblique secondary strips. Hydrothermal transformations are observed in the strip of the veins (map 4).

The deposit typology shows in the pit five mineralized veins. They are constituted by white quartz and in the veins have sulfites (pyrite and probably chalcopyrite, arsenopyrite, and bornite). The mineralization is typified by diverse quartz veins in the ductile shear zone**.**

Sao Domingos/Raimundo Cruz Garimpo

The local geology is represented by isotropic granite with granulation from fine to medium and high alteration (laterization and saprolitization). The lateritic profile presented in the bottom are argillaceous material and residual material at the top. Intense centimetric foliated areas were observed along of the main veins. Obliquely to them occur secondary veins (map 4).

The deposit typology in the pit is inserted white quartz vein mineralized with local alteration and brecciation. Texture reliquaries called "dog tooth" are frequent, as well as the sulfide dissemination zones in fractures (pyrite and marcasite), besides small iron and manganese oxide geods. The real thickness of the vein is inferior to the meter, but the length is more than 300 m, according to the direction N60ºE.

Edilena Garimpo

The local geology, although the pit was much altered, the presence of fragments alkaline granite indicates that this rock occurs like hostess of mineralization (map 4).

The deposit typology is constituted by two main quartz veins, in according to the N85ºE direction and subvertical dip. The thickness is 0.60 meters and presents

medium to coarse granulometry. Sometimes breccias in local point with dissemination and geods contents pyrite, arsenopyrite and metallic oxides. The presence of alteration products, like propilitization and cloritization including pyrite dissemination indicates alteration hydrothermal process.

Rei das Frutas Garimpo

The local geology is constituted by regolitic masses (minerals with dispersed coarse quartz, keeping an intimate textural relationship with the hostess clay rocks, resembling granitic rocks) with varied colors, prevailing the red and white, with iron concretions. At the top there is yellowish colluvial material isolated by stone line (map 4).

The deposit typology shows a pit with quartz vein and N80ºE direction. The mineralization presents clear vertical visual variation in function of the supergenic differentiation. In the top there is leached white quartz material and intermediary part white quartz material is rose color, fractured with old texture "dog tooth". In the bottom part (rich zone) the quartz is of red coloration, brecciation, with alteration iron and manganese oxide. In this part there is other quartz vein with gold dissemination.

Torrao Garimpo

The local geology includes coarse granite, red colored and intensely fractured according to the directions N85ºW and N60ºW. The granite has a hard foliation denoted by the mineralogical orientation (map 4).

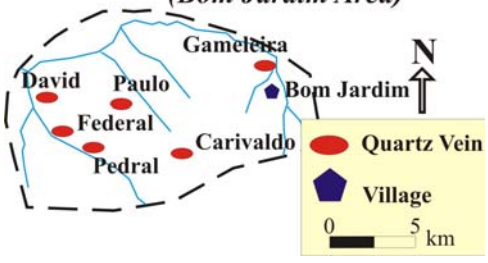
The deposit typology is a quartz vein with general direction N80ºE, 15cm width approximately. Secondarily, there are two other quartz veins with similar thickness. The carbon and manganese, especially close to the quartz vein area, present visible brecciation with tendency to the breccia.

6.3 – Bom Jardim Area

Federal Garimpo

The local geology is represented by hostess rock composed by saprolitized granite, of red-yellow coloration with fractured k-feldspar presence. The mineralogical characteristics indicate that it belongs to Xingu Complex and which there are auriferous quartz veins (map 5).

Map 5 - Geophysic Survey (Bom Jardim Area)



The deposit typology is composed by three auriferous quartz veins, with directions to the N80ºE and N50ºE. They have in surface an extension of approximately 400 m length and with thickness between 0.40 and 1.50 m. The

quartz is white and fractured with "dog tooth" texture. Dissemination of sulfide minerals is well evidenced, prevailing the pyrite, marcasite and chalcopyrite. The hydrothermal alteration occurs in outcrop quartz veins, represented by cloritization, epidotization and propilitization

David Garimpo

The local geology is represented by quartz mineralized veins in metamorphosed basic rocks, with gray to black coloration, fine grain, and composed by pyroxene or hornblende, besides the biotite, flogopite, plagioclase, k-feldspar and quartz. As accessory, it has pyrite, chalcopyrite, pyrrotite, sfalerite, titanite, and iron oxide. Those characters indicate a classification of those rocks can be mycrogabro and diorite. The structural features, when found positioned the main and secondary systems veins indicate the presence of mylonitic strips, with general orientation N45ºE. The secondary strips are oblique and convergent to the main system. In the southern zone there is granite, with granular texture, composed by quartz, k-feldspar, plagioclase, augite, and amphiboly. Locally has rapakivi texture (map 5).

The deposit typology is quartz veins that occur near surface exploited, where garimpo started up working. Nowadays the survey is in the gallery. The mineralization is a rose quartz, altered, semi-hard, with iron and manganese oxides, and little auriferous concentrations strips.

Gameleira Garimpo

The local geology includes hostess adamelite, with grain medium, clear gray coloration, mineralogical paragenesis represented by quartz crystals, k-faldspar, plagioclase, and minerals ironmagnesian (map 5).

The deposit typology is quartz vein with 0.40 m width, general direction N40ºE, clear gray coloration, and sulfide agglomerated (pyrite, marcasite and chalcopyrite). When altered and leached together with the quartz vein shows boxwork structures, secondary quartz recristalization, and iron or manganese oxide and hydroxides.

Pedral Garimpo

The local geology is granite as hostess auriferous veins quartz, medium grain, constituted, predominantly by quartz crystals, secondarily k-feldspar crystals, and plagioclase prisms. This rock is cut, close to the vein, by an another basic rock, medium gray coloration. The mineralogy involves pyroxene and plagioclase crystals. Close granite contact has rich manganese minerals (map 5).

The deposit typology is a mineralized vein with gray coloration, fine to medium grain, with sulfides dissemination (pyrite and arsenopyrite), besides manganese impregnations.

Paulo Garimpo

The local geology is composed by mineralization hostess rock with basic composition (gabbros or diorite), gray color, and medium grain, isotropic, with plagioclase and iron magnesium minerals (pyroxene or amphibole). There is also granite (adamelite), in narrow area of intense faulting (map 5).

The deposit typology indicates that the gold occurs in white quartz vein, altered and intensely fractured in three preferential directions. The most important is N35ºE direction, concordant with the direction of the vein. There are concentrations of pyrite, chalcopyrite and sfalerite.

Carivaldo Garimpo

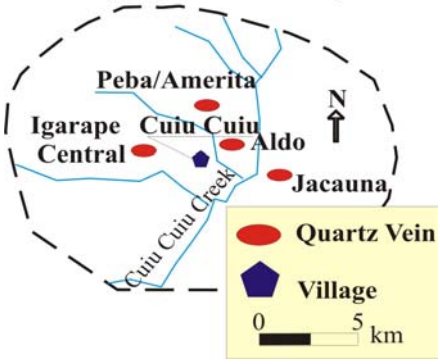
The local geology is a hostess rock basic to intermediary composition, metamorphosed (metabasalt and metandesite), gray color. The laterite alteration profile is defined by three horizons. At top is clay, in the medium concretionary and bottom saprolitized, near mineralized zone (map 5).

The deposit typology indicates that vein has tubular form, constituted by white quartz vein and red when altered, intensely fractured and foliated. The preferential orientation is according to N 10ºE. In the quartz vein occurs sulfide dissemination with pyrite, marcasite, chalcopyrite and sfalerite, besides altered iron oxides.

6.4 – Cuiu-Cuiu Area

Aldo Garimpo

Map 6 - Geophysic Survey (Cuiu-Cuiu Area)



The local geology is represented by altered hostess rock (saprolite), greenish coloration, foliated, intensely fractured. The mineralogy is represented by the quartz, altered feldspar, clay-minerals, and altered epidote. The rocks, probably granodiorite, were submitted to intense epidotization process or propilitization (map 6).

The deposit typology is a pit with mineralized tubular quartz vein, constituted by white quartz partly red, when altered (laterization). The gold is presented in the quartz vein related to the fractures and boxwork structures. The main vein shows some ramifications in small quartz veins

Peba/Amerita Garimpo

The local geology is represented by geological structure with fine granulometry rock, porphyritic texture, acid to medium composition. This deposit is located in the Morro da Lua bottom (map 6).

The deposit typology is represented by white quartz vein, with general direction N20ºE, partially rose, when altered, fine granulation, intensely fractured, foliated, with sulfide auriferous disseminations, as well as iron and/or manganese oxides and hydroxides. Two galleries support the gold production. The gallery presents a vein rich in sulfides, and free gold occurrence.

Jacauna Garimpo

The local geology is the hostess rock possibly a granodiorite or an altered tonalite, medium to coarse granulometry, constituted by plagioclase, k-feldspar and quartz, as well as amphibole and/or pyroxene. All intensely fractured and altered. Near to the quartz vein the hostess rock is quite foliated, with gneissic structure evidence (map 6).

The deposit typology is a quartz vein mineralized, white to red coloration, medium to coarse granulometry, intensely fractured, semi-compacted, containing sulfite dissemination (pyrite and marcasite), supported by iron and manganese oxides and hydroxides. In the main vein occurs a series of deformed little quartz veins too.

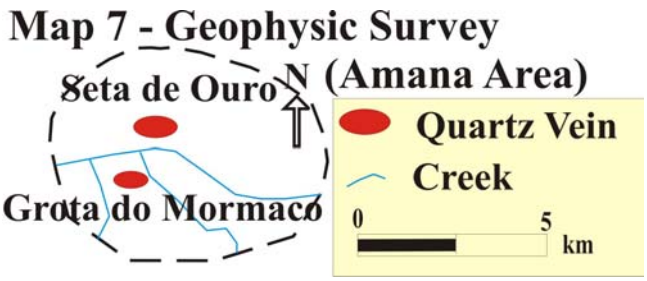
Igarape Central Garimpo

The local geology in Morro da Lua site shows an acid effusive rock or a microgranite, quite fractured and silicificated, crossed by small fractures and faults. The deposit typology is veins usually of small dimensions and varied thickness (map 6).

6.5 – Amana Area

Seta de Ouro Garimpo

The local geology indicates that the mineralized quartz veins hostess rock is metamorphosed, fine granulometry, altered, probably volcano-sedimentary type. The fractures have general direction N40ºE (map 7).



The deposit typology is a mineralization associated to the white quartz veins, medium granulometry, extremely fractured, containing sfalerite dissemination and iron and manganese oxides. There is disseminated carbonous material in the vein, but when superficially altered, transforms into silky material. The alteration halo of the vein is constituted by iron and manganese sulfide. The lateritic profile on the hostess is saprolitic material at the bottom and at the top lateritic beds.

Grota do Mormaco Garimpo

The local geology indicates a hostess rock alterated, constituted by solid clay without original rock fragments and local structure. The lateritic profile is represented by a kaolinic layer at the bottom and at the top a material constituted by yellow clay and quartz fragments (map 7).

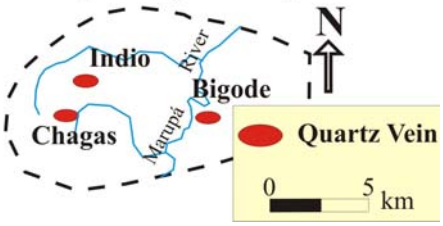
The deposit typology is a vein constituted by white quartz, altered and fractured intensely. The vein presents evidences of "dog tooth" texture. The general direction is N70ºE. The foliated strips are cut by fractures in several directions.

6.6 – Marupa Area

Chagas Garimpo

The local geology indicates that the hostess mineralized to the quartz veins is granite of medium to coarse granulometry, some times presents brecciaed aspects, with indications of mineralogical transformations by hydrothermalism (map 8).

Map 8 - Geophysic Survey (Marupa Area)



The deposit typology is a mineralized zone constituted by two distant quartz veins. Small quartz veins also occur parallel to the main bodies. They have massive aspects, fractured with coloration from white to the red, when altered near surface, and present sulfides dissemination with pyrite, as well as epidote. There is also breccia aspect in vein and in hostess granite

Bigode Garimpo

The local geology is the hostess rock, represented by granite with medium to coarse grain, sometimes with brecciaed aspect, because the deformation processes affected the area. There are two fracture types N25ºW and N75ºE, the first one is more evident, generating lenses with boudinade inside the siliceous extensive masses (map 8).

The deposit typology is a pit with saprolitezed granite and yellow color. The mineralized veins show direction N25ºW, with massive and fractured aspect and

continuous extension. The vein boudinade aspect, with granite fragments, defines to the variable character of the width as a structural standard and veins in breccias mineralizated.

Indio Garimpo

The local geology, although without any outcrop granite exhibitions, is considered as auriferous mineralization hostess; mainly by saprolitic aspect rocks that occur in the others garimpos (map 8).

The deposit typology occurs in quartz vein zones and little veins in parallel direction

6.7 – Others Primary Gold Occurrences

Vila Porto Rico

Vila Porto Rico is a gold property that belongs to the New Bullet Mining Company (map 3).

Vila Porto Rico property is one of the first gold mining activities (garimpagem) in the Tapajos Region. Three major garimpos were situated on the property (Ouro Roxo, Nova Brasilia, and Cantagalo, from south to the north). Garimpeiros have produced more than two million ounces of gold from these properties. The Vila Porto Rico property consists of four 10 km x 10 km Authorization Systems (DNPM license) totaling 40,000 hectares.

The mineralization occurs in shear zone trends N-S for more than 30 km through the middle of the property. Garimpeiros workings are evident along approximately 100 km of the larger streambeds within a half-circle about 30 km N-S by about 10 km E-W, in the hanging wall of the shear zone.

Rio Tinto Mining Company took an exploration program from 1994 to 1996 in the Ouro Roxo area, the smallest of the three garimpos. Two anomalies were defined and 26 holes totaling 4839.8 m were drilled. Rio Tinto reported the northern anomaly (Ouro Roxo North), with a north-south strike length of 350 m, as having a 'measured resource' of 533,000 ounces of gold. An E-W cross section through Ouro Roxo North shows an east-dipping mineralized zone ranging from 3 to 8 m in thickness that is open at depth.

Using the geologic setting established by the Rio Tinto drilling data as an exploration model, New Bullet believes the potential is for numerous ore bodies totaling multimillion ounces of gold.

Limao

Limao is a gold property that belongs to the New Bullet Mining Company too (map 3). The property consists of approximately 12,000 hectares in the northeastern portion of the Tapajos Gold Province. The area is underlain by Archean basement and Proterozoic granitic plutons. Near vertical shear zones cut the area and trend NW to WNW.

Garimpeiros have worked a few of the streams on the property and developed a small pit on a bonanza-grade mineralized gold zone that eventually became impossible to work. Subsequent drilling in 1989 intersected the bonanza-grade ore (47 and 18 grams per ton at 30 m and 100 m depth, respectively), but nothing further was done. Based on the geologic model established from the drilling and by a soil geochemistry gold survey, New Bullet believes Limao has the potential for more than one million ounces of gold.

Castelos dos Sonhos

Castelos dos Sonhos gold property was surveyed by Barrik Gold (map 3). The preliminary evaluation results in anomalie geochemical, geological and geomorphologic maps. The garimpo was divided in South Esperanca and Center Esperanca for the distribution pattern of the anomalies around the main plateaus, it is suggested some kind of lithological control for the source of gold. The linear distribution of part of the Esperanca Sul and Norte anomalies might also suggest some tectonic control to the rocks which contain gold.

Several significant gold rock assays have been found within the Castelo dos Sonhos structure being related to different rock types, some associated to fault zones.

Pista Nova

The work program was also executed by Barrik Gold (map 3) and included geochemistry soil interpretation, auger drilling, topographic and geochemical work soil sampling.

The geochemical results in statistical evaluation and soil samples gold map. A major gold geochemical anomaly, 1,200 m long, has NW direction. The anomaly is related to contact zone between volcanic rocks (mafic and acid) and intrusive granite with igneous breccia rock.

Geological mapping of the area showed a NS trending distribution for the quartz - vein, stockwork alteration and for mafic volcanic rocks that exactly in the Morro do Joao open pit, take a NE direction. However, in the pit all the fractures, hematite veins, acid dykes and quartz veins have a NW direction

The same NW structure controls the Parente's Creek water flow, the main drainage in the area. The soil anomaly has NNW direction to the north from Morro de Joao pit and NW direction to the South of the pit.

The first auger drilling results have confirmed an anomalous gold zone. Saprolitic rocks have showed gold values. Auger drilling results located to the southeast from Morro do Joao pit did not show anomalous gold values, except to the eastern end of the line.

6.8 – Gold Regional Projects

The regional projects were carried out by Barrick Gold and included two areas named Marupa District and Rosa de Maio Property (map 3).

Marupa District

The program at Marupas's District included geochemical survey in Serra Verde and Baixao da Lata sites, where previous rock sampling has revealed encouraging gold results.

Rosa de Maio Property

Rosa de Maio Property is characterized by intrusive granite rocks including porphyry granodiorite with local rapakivi texture. Locally it can be k-feldspar rich, becoming more alkaline and similar to potassium rich Maloquinha type granite. The rocks shows an intensive deformation and hydrothermal alteration represented by sericite and chlorite which were observed in the area near the headwaters of the Baixão do Graxeta, where some high gold values were found.

A possible 4 to 6 km long gold mineralization presents a NE trending contact between a gabro and sheared granite that cuts through the alluvial deposits Baixao da Sela and Baixão da Graxeta. In this contact there are two significant gold anomalies related to the sheared granite to a laterite.

Figure 3 - Cobra-fumando

7 – Mining Methods

The Tapajos Region is an area mined since 1958. For this reason the evolution from manual exploitation methods until cyanide recovered gold.

7.1 – Manual Method

The manual method is the most traditional manner to recover gold in the world. This method consists in the use of rudimentary equipment. It is defined as an individual or collective extractive work, manual devices or simple portable machines for immediate exploitation of a mineral which, by its nature, dimension, location and economic use, can be worked, independently of previous exploration work, according to criteria from the old mining code or orientation from traditional garimpeiros (figure 3). Normally the area exploited is alluvial flat and it running common rules. After removed the gravel or mineralized level, the gold is recovered in cradler rocker or sluice (*cobra-fumando*, in portuguese). In the cradler rocker or sluice the garimpeiros use mercury to make amalgam with gold. In all operation water is added. For separating the amalgam is necessary filtering and burning it. Usually this operation is executed in open air with no protection and no use of individual protection equipments (figure 4).

Figure 4 - Gold final concentration

7.2 – Dredge or Raft Method

Dredge or raft is considered an advanced in gold mining in the Tapajos Region (figure 5). This method was introduced to recover mineralized level or gravel at the active alluvial sediments in the main drainages of Tapajos hydrographic basin.

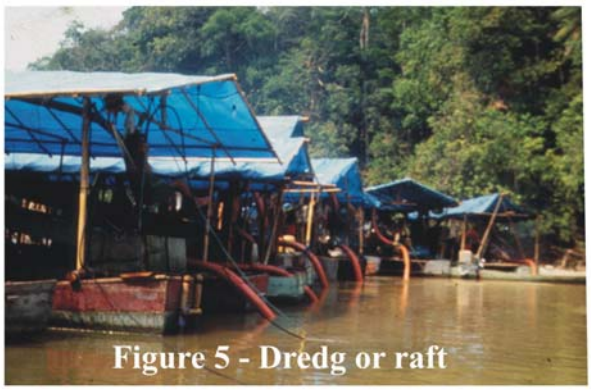


Figure 5 - Dredg or raft

Dredge or raft is mounted on two wood boats or two iron tubes, with about six meters in length each, coupled the boards also of wood with diesel motors (from 40 to 65 HP). It is covered with nylon protection and move along the drainages by 15 HP Yamaha motors.

The motor engines with larger potencies move a centrifugal pump adapted to two hoses with diameter from 4 to 6 inches. In one of the hose, whoses extremity is inside water, has the *abacaxi* scrapper (garimpeira denomination to define metallic cylinder to make the suction of gravel or mineralized level). The *abacaxi* makes suction of the gravel or mineralized level from drainage's bed, underwater, that is

handled by divers equipped with special clothes and that breathe oxygen from inner tube. This material is thrown at a box where there is a sorting screen to select the material. The divers use lead belts with 20 kg and a protection mask for the eyes too.

The gold recover and final concentration is accomplished in cradler rocker or sluice, adding mercury to the concentrate (material from box recovery by carpet and the slat transversals), and put it in the drum, where mercury can be added as well. The next, in the pan, the amalgam is recovered and filtered. Finally, the amalgam is put in the bowl and burnt to separate gold and mercury. Likewise, this operation is carried out in open air without protection and no use of individual protection equipments, like in manual exploitation.

7.3 – Chupadeira or Par de Maquina Method

The *chupadeira* or *par de maquina* operation (figure 6) begins like a manual exploitation. The work sequence follows varoius steps: the first one is to clear the *barranco* (extraction of the vegetable covering). The second one is the dismount and

Figure 6 - Chupadeira

disaggregation of the *barranco*, supported by two engine pumps. The water engine pump adapted with hose from 2 to 3 diameter inches that transports pumped water under pressure. The other engine pump, similar to the first, is made for the pulp suction, through hose, whose in the extremity there is a metallic cylinder called *abacaxi*, like dredge or raft operation. The hose transports the pulp onto the box, where there is a sorting screen to select the material. The bottom box is covered by carpet, fixed by slat transversals. After, the material is put it in the drum, where about 100 to 200 grams of mercury can be added. The concentrate (accumulated material in the carpet and in the slats) is removed and put in a plastic bottler. The next operation, in the pan, the amalgam is recovered and filtered.


Figure 7 - Hammer mill

The final procedure is similar to the manual methods; the amalgam is put in the bowl and burnt to separate gold and mercury. In most of time, this operation is carried out in open air without protection and no use of individual protection equipments.

7.4 – Hammer Mill Method

The hammer mill method started up in Tapajos Region with the primary gold discovered in quartz veins. In this case, the mineralized quartz veins with their dispersion halos contents gold mineralization presence exploited, as well the altered rocks with mineralization too, are recovered by hammer mill method. The operation sequence follows many steps: the first one, used for dismounting of the material in situ. After the material is carried until the hammer mill assisted by dredge stationary engine and stationer engine pump. The second one grind the material. The third input of water on the system. After the material is thrown on the box (sluice) and falls down on the inclinator plan whose bottom is covered by carpet, fixed by slat (figure 7).

The last operation is adding mercury; following, the concentrate is removed and put in a drum, where mercury can be added. After, in the pan, the amalgam is recovered and filtered. The final procedure is similar to the other methods, which means the amalgam is put in the bowl and burnt to separate gold and mercury. In same way, this operation is carried out in open air without protection and no use of individual protection equipments.

In all mentioned methods the tailing is throw in the drainage or close to the gold operation pit and forming great volume that normally the garimpeiros exploited by *reque* or *reco* (little ore material volume with lower gold content that unemployed garimpeiros worked daily).

7.5 – Cyanide Method

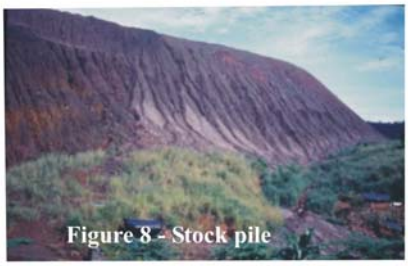


Figure 8 - Stock pile

From 2001 to today other factors appeared at the garimpos. The excess of tailing formed great waste disposal in stock piles (figure 8). Most of the piles presented economic gold concentration. The gold price fell down in the international and national stock market, turning many garimpeira zones unfeasible. In fact, the garimpeiros applied cyanide in some garimpos mainly trough carbon in pulp (CIP) and heap leaching. Today there are many garimpos operating these plants in Tapajos, many of them already have laboratories in the garimpo, as example is Serabi Mining, in the Palito garimpo.

Recent factors as big volume of tailing worked by garimpeiros; the gold price increase in the international and national stock market, and some experiences with cyanide in the garimpos, the garimpeira activities took a new turn in Tapajos Region. Actually the garimpeiros are developing cyanide plants in eight garimpos: Creporizao, Creporizinho, Mamoal, Sao Jorge, Palito, Bom Jardim, Sao Domingos and Castelo dos Sonhos. The Palito Property is a good example for gold's carbon in pulp in the Tapajos Region.

7.5.1 – Palito Property

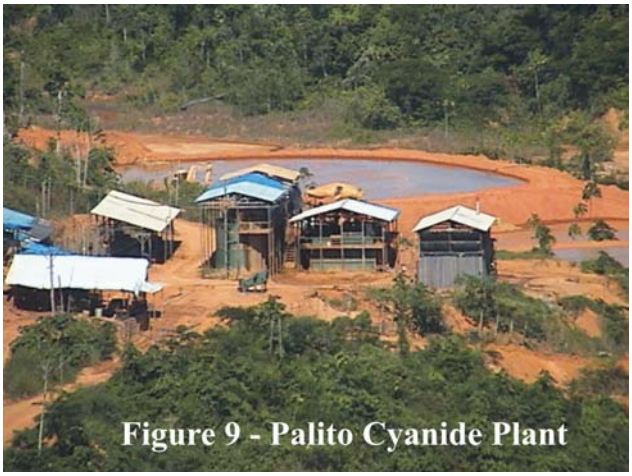


Figure 9 - Palito Cyanide Plant

The Palito Property is the best cyanide plant (CIP) in the Tapajos Region (figure 9). The tailings are constituted by coarse sands generated through mill auriferous quartz veins. These sands will be pumped by mining traditional methods. The decantation tank will be making on the soil and the pre-treated ore will be stocked at the stockpiling area, close to the smelter. The plant has nominal capacity for 200 ton per day and operates 24 hour per day and, seven days a week.

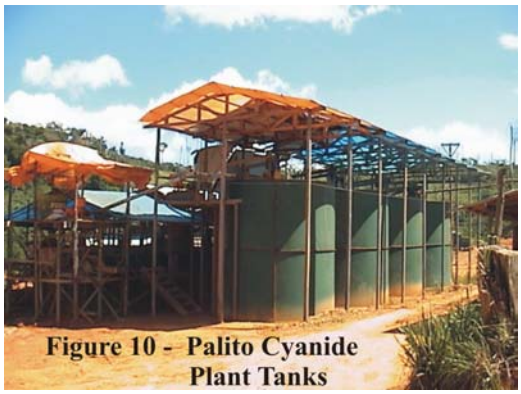


Figure 10 - Palito Cyanide Plant Tanks

The metallurgic tests indicate that the leaching process with cyanide is completed in a 24 hours period. The system has four wash tanks (figure 10) with capacity for 85 m^3 each, positioned in series for retention of the pulp in 24 hours. Inside, each tank has an shaker that maintains the material in suspension. Cyanide and lime are added to the first tank in the proportion of 1.5 kg/ton, according to specifications of the bench tests. The lime is used to maintain the alkalinity of the pulp in a pH 10 to avoid that the sodium cyanide (NaCN) escapes for the atmosphere in the gas form of (HCN). The cyanide is an important gold solvent, forming complex molecules of cyanide and gold.

The gold in the leaching process is a mixture with 1.22 water for 1.0 solid part. The tailing that leaves the plant in a period of 24 hours contains 200 ton of waste ore and 244 m^3 of water. In the beginning of the process 1.5 kg per ton sodium cyanide is added in the process or 300 kg sodium cyanide for every 24 hours. In the plant about 80% sodium cyanide is used by reactions with the soluble metals contained in the ore as gold, iron, copper, zinc and others. Only 20% out of the 300 kg sodium cyanide added to the process will be present in the tailing or the last tank. If a larger sodium cyanide concentration is found in the tailing it is necessary to reduce the initial dose of 1.5 kg/ton.

In the adsorption plant the gold is extracted of coal, precipitating from solution and melted in ingots. The adsorption tanks produce 300-400 kg of gold. In the extraction department the coal is washed, after stocked, and finally treated later in the adsorption column.

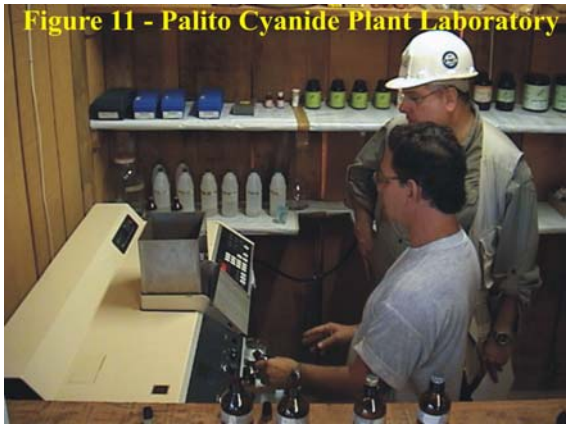


Figure 11 - Palito Cyanide Plant Laboratory

An analytical laboratory (figure 11) will support to the plant operation. The laboratory will have the atomic absorption spectrometer, which will be used for the determination of gold and other metal concentrations.

The cyanide concentration is measured by titulation using silver nitrate in one hour interval. Liquid effluents composed samples will be collected daily for determination of cyanide concentration. Samples from liquid effluent that leave the waste dam will also be collected daily Those samples will be analyze by titulation to check the cyanide absence. A file with all analyses will be kept for control and safety inspection.

8 – Environmental Impacts


Figure 12 - Waste dispoasal material

The garimpeira activity, mainly because of its semi-artisanal and mechanized exploration, has caused serious damages to the environment (figure 12), some almost irreparable, for instance: the antrophic activity, physical chemistry and biological degradation, reflecting in drainages.

The garimpagem does not differ from the other mining activities regarding to the forest degradation. The deforestations are limited to the garimpos sites, reaching the ciliary forests (vegetation along drainages) and the areas where they build their villages or *currutelas* (community population nuclei). When the access is difficult, it is necessary to construct airstrips, the main logistic support to the garimpeiros (personal goods and equipments movement). In fact, there are not many garimpeira areas with agricultural activities and cattle raising.

The *currutelas* were formed without any previous planning causing the population increase and a chaotic dispersion. Therefore, sanitation and public health is not usually a concern to these communities and it reflects in forest alteration.

The physical degradation in the garimpos gold exploitation is a serious problem because it occurs inside or next to the drainages, causing great environmental impacts to the water, and reflections in the alteration of the drainages, provided by overburden removal in the unconsolidated deposits (alluvium, elluvium and colluvium) and mineralized levels recovery. The physical degradation occurs in any mining exploitation, manual or semi-mechanized (*chupadeiras*, dredges or rafts)

provoking a considerable solid effluents in the river and resulting in a great visual environmental impact observed hundreds of kilometers downstream.

The bigger environmental impacts are presented in the drainage altering the waters coloration, reducing visibility and expelling life from their natural habitats, and it imposes the elimination and removal of the original phlore and phaune in the ecosystems.

The physical impact effects are well characterized in the drainages worked by garimpeiros. They cause the appearance of small lakes dammed by the gold recovery in the garimpeiro proprieties, which are truly endemic focuses.

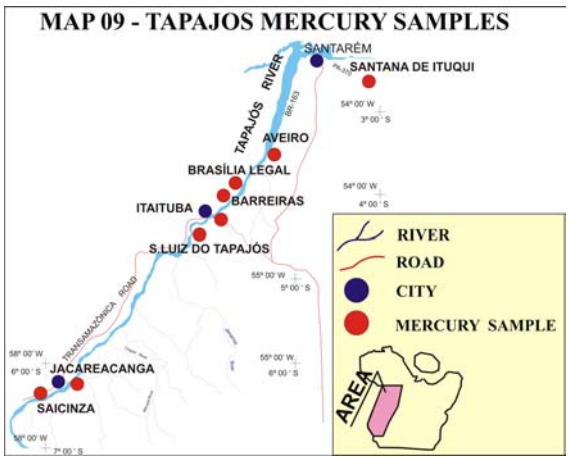
The effects of activities can be observed at 300-500 km downstream, in the Tapajos River, to near Santarem city. And these effects reached the particulated sediments in the rivers and biota. These environmental impacts are reflected by the great siltation volume thrown in the main drainages of the area. These sediments have physical and chemical characteristics and are diluted in the Tapajos hydrographic basin.

Another environmental impact, even more reduced, but equally serious, is trash left by garimpeiros in the area, such as recipients and food packages (canned and plastic, mainly). They are thrown near home and carried away to the drainages or dammed in depressions.

The mercury used for recovering gold is thrown in the water, introduced in habitat and transformed in inorganic and organic mercury, and later it reaches the food chain.

To measure the intensity and introduction of pollution in the food chain, some institutions accomplished a series of samples dosage for total and organic mercury.

The data bank showed different aspects of analyzed fishes. The carnivorous present the highest mercury concentration, for example.



In the attached report, 29 files show 6,219 mercury samples, including 375 organic mercury samples. All collected in the period between 1989 and 1998, from Tapajos Basin, including Aveiro, Barreiras, Brasilia Legal, Itaituba, Jacareacanga, Saicinza, Santana do Ituqi and Sao Luiz do Tapajos (map 09).

9 – Tapajos Gold Production

The Tapajos historical official gold production is 180.6 ton, reached US$1,960 million (table 3), but the real production is estimated about 650 ton (US$ 6,877 million). Between 1993 and 2002, it represented 36 per cent of the Para gold production, three times more than the Cumaru-Redencao-Tucuma Region and ten times more than any other Para gold production area. It is very important to notes that Para gold performance was influenced by Igarape Bahia gold mine located at the Carajas Mining Province which belongs to the Companhia Vale do Rio Doce, whose produced around 10 tons per year (table and fig 13).

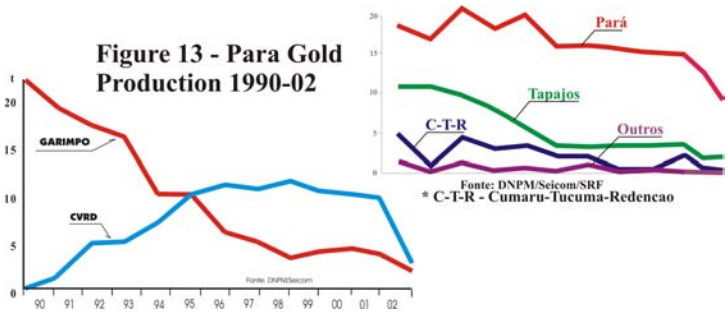


Figure 13 - Para Gold Production 1990-02

10 – Sustainable Development Issues

In the last fifty years, the environmental impacts of the mineral industry projects in the Amazon Region were divided in three phases.

Table 3 – Tapajos Historical Official Gold Production

Period	Volume-ton	Value-US$ million
1958-60	2.4	2.4
1961-70	6.2	19.2
1971-80	13.1	110.3
1981-90	86.4	1,085.6
1991-00	67.5	692.3
1901-02	5.0	50.0
Total	180.6	1,959.8

Source: DNPM, Seicom and LME

The fist one involves no environmental impact conscience. The best example is the Serra do Navio Project, that belongs to Icomi Mining Company (Industria e Comercio de Minerios), located in the State of Amapa. It was responsible for a big environmental impact, including topography alteration, aggression to the forest and a considerable tailing volume.

The second one includes minimum environmental impacts conscience. The best example is Trombetas Project, Oriximina District, State of Para. In that region the Mineracao Rio do Norte polluted the Batata Lake and invested US$ 80 million to recover it and change the bauxite exploitation method.

The last one is applied with maximum environmental impacts conscience. This is a current phase and the best example is Carajas Project (iron, manganese and gold), Rio Capim Project, Albras and Alunorte smelters, Paragominas Project and all the projects in implantation.

In the last years mining projects had an important evolution. At first, were the economic aspects. After, the various attempts were spent in environmental engineering. Until a few years ago, the projects spent about 10-15 percent at the medium to big mining projects. Today the percentile for environment in mining projects is not larger than 4 percent.

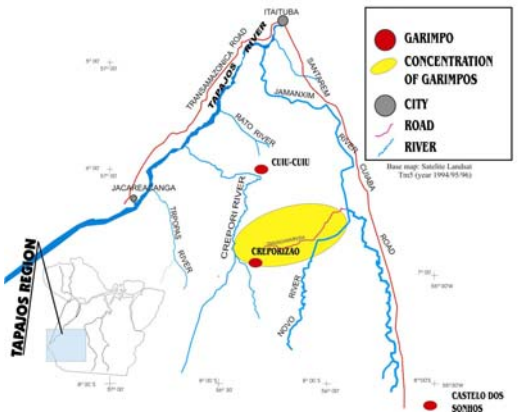
For the mining projects the last challenge is a social engineering. The most important reason is the difficulty to assume what each person thinks, but all that is possible to understand and be dominated by the researchers through the economical and environmental engineering.

However, the garimpeira activity, mainly because of its semi-artisanal and mechanized mining, has caused serious damages to the environment, some almost irreparable, for instance: the antrophic activity, physical chemistry and biological degradation, are reflected in the water. For this reason, almost all environmental impacts from garimpeira activity affect the river. And the negative effect is reflected in the water. All tailing thrown in the drainage cause siltation that can be observed for hundreds km downstream. For example, the siltation effect from Crepori River can be recognized in front of Itaituba and Santarem city.

Unfortunately, the garimpeira activity still has to be analyzed through economic point of view. If the economic focus is understood, the other variants as social, environmental, education, legal aspects, and fiscal can be resolved.

The sustainable development issues in garimpos depend on a series of factors, as infrastructure, gold price, governmental support, garimpeiros organization, legislation, mining surveys, new auriferous occurrence discovery, Brazil unemployment level, and mainly mineral promotion. For example, if the Santarem-Cuiaba road would be asphalted the garimpeira activity will have a new little gold rush, because the road will reduce the price of the goods used at the garimpos (map 10).

MAP 10 - SANTAREM-CUAIBA ROAD



The garimpos management model, although updated and always looking for larger management performance has not been reaching the good revenue, because of the methods used in gold exploitation. In reality, in spite of some projects from governmental promotion, including researches, no concrete action was executed for professionalizing the garimpos owners, transforming their administration in a competitive enterprise.

This is the great challenge of enforcing the Tapajos Region, with special importance to the mining method alternatives and processes improvement, in pre-selected garimpos, involving operational costs quantification, characterization to gold recovered in rock, in substitution to the current garimpagem methods.

The development of the work including characterization of the exploited material, detailed study of the current method, quantification of equipments used and the planning for underground mine.

The last step will be conduct reserve measure and feasibility studies of the mineralized bodies, transforming the current garimpeira activity in small mining companies, according to mining, environmental and social legislation.

10.1 – Training Program

A training program should be designed to address crucial issues regarding project EG/GLO/01/34 on the following topics;

10.1.1 – Environmental and Health Awareness and Preparedness

Where the facts and results obtained at the first round of the project objectives, i.e., environmental and health assessments are brought about to the stakeholders and a series of workshops, on the spirit of Train-X methodology, are thus conducted of extreme importance is to make clear the dangers associated to the garimpeiros, as an occupational exposure, and their families and general community, of the presence and release of mercury in the biota and atmosphere, causing in the long run acute neurological problems, that are easy evitable if the necessary awareness is present at the every day life aspects of the users and community; also, a preparedness chapter, i.e., what to do in case of mercury poisoning or mercury intake, presence of mercury in eaten fishes, has to be addressed and a Mercury Preparedness Voluntary Association stimulated to be formed at the sites. The same should be done for the silting out effects due to the extraction operations.

10.1.2 – Technological improvements

From the technological state of the art report thus prepared we may see that lots of training and guided procedures are to be developed and conducted at the selected sites, as for instance:

a) Extracting techniques: how to extract the ore containing material with minimal damage to river bottoms, banks and river placers; costs associated to the present operating practices and the new ones, without major investment costs in equipment and machinery. Newer machinery, capacities and costs; experiences!

b) Processing techniques: optimization of the *cobra fumando* slope, minimizing gold losses, maximizing mercury recovery; costs associated to the actual practices and those to be proposed; the use of retorts; sensibilization towards

the need of avoiding atmospheric emission and human inhalation of vapours; home made retorts, how to make them, how to learn the discipline of using them and why to use them; lessons on mercury recovery; costs associated with such a practice.

c) How to assess gold purity in the field: some simple techniques; practices in several gold fields in order to have reliable results.

d) Specially designed course to the local mining and health authorities on mercury and silting out monitoring and practices; how to prepare them to act as monitoring agents for that matter.

Train-X methodology

Introduction

Training is essential for all development. All developing countries and countries in transition need to train their personnel to maintain modern communication, transport and environmental services. The smooth functioning of telecommunications, mail, civil aviation, shipping, trade, and environmental services consequently requires human resources to develop appropriate and effective training courses in these areas. Garimpos area this program is absent yet.

Training strategies have often floundered due to the inability of national training institutions to design good courses which address specific local needs. These institutions have found it difficult to cope with the rapid turnover of instructors. At the same time, the expensive one-time seminar delivered by a visiting expert has often failed to have a lasting impact. Train-X was created to fill this need.

What is the Train-X network?

The Train-X network is a UNDP sponsored co-operative network of UN Agency Human Resource Development Programs, using the Train-X methodology. The Program Coordinator in each Agency manages a system for the preparation and sharing of high quality course packages treating specialized fields of importance for national, regional and global development. All Train-X Programs use a common course development methodology. Together, Train-X programs help almost two hundred national and regional training centers in sixty two countries to provide improved training to thousands of people annually. In the current period of financial constraints, purposeful collaboration between UN Agencies, sectors and countries through the Train-X network and its programs represents a viable means for upgrading and developing the UN Systems capacity building effort.

What is the Train-X approach?

This Train-X approach, used by each partner agency for its Train-X program, has the following major elements:

1. a common training development methodology
2. co-ordinated development of training material to maximize resources and avoid duplication
3. a co-operative network for the exchange of material and instructors among training centers
4. a series of courses and meetings for the training of trainers, including human resources development/training managers, course developers and instructors
5. use of modern training techniques including open learning and computer assisted and multi-media learning
6. use of training information systems for the management of large co-operative networks.

This Train-X approach has the following distinct advantages:

- money is concentrated on building national capacity which is technically and financially sustainable, not consultants
- training packages are developed locally to defined pedagogical standards
- training is matched closely to a specific job to provide more effective training in the shortest time
- each package is made available to many countries
- receiving countries acquire skills to make minor adaptation for their own environment
- central support concentrates on quality control and training of course developers & trainers
- support activity is quickly decentralized to regional centers.

What are the benefits of Train-x?

Train-X offers benefits for all concerned with adding to countries' reserves of skilled human resources for development:

- *for developing countries* – a unique opportunity to improve the quality of their training, build capacity to recognize and satisfy priority training needs and add to their catalogue of high quality training packages.
- *for developing and developed countries* – a chance to make more effective use of course development staff by focusing on the preparation of a limited number of high quality courses; and at the same time, to gain access to courses prepared by network partners.
- *for donors* – a cost-effective way of investing in training for important areas of development within a self-sustaining network, involving collaboration among UN agencies.
- *for UN agencies* – better training modules, savings in cost and staff time, and opportunities to learn from one another's considerable experiences.

How has train-x evolved?

Train-X has been growing in importance and consolidating its approach since the early 1970s, when the International Telecommunication Union (ITU) pioneered the Train-X approach with its Codevtel program.

In 1980, the UN Conference on Trade and Development (UNCTAD) drew on the successful experience of ITU to establish Trainmar. Having proved that the cooperative training approach could be transferred successfully to new sectors, in the 1980s, both programs provided support for the creation of Trainair by the International Civil Aviation Organization (ICAO), and for Train-For-Trade by UNCTAD.

In 1992, UNDP's Division for Global and Interregional Programs organized a global review of the four programs to determine areas of possible collaboration and the suitability of a cooperative network approach. The positive assessment of this review was discussed at the first T Train-X-X round table, held at UNDP Headquarters in December 1992. UNDP became the first Train-X Coordinator.

With the second round table (held at UNCTAD in Geneva, September 1993) and the third round table (held at ICAO in Montreal, March 1995) effective collaboration increased. UNDP successfully encouraged three additional agencies to adopt the Train-X methodology, which had become the standard by which other UNDP training programs were being judged: Train-Sea-Coast (United Nations); CC:Train (United Nations Institute for Training and Research); and Trainpost (Universal Postal Union).

The fourth Train-X round table (held in ITU in Geneva, June 1996) consolidated the past achievements and established the working framework used by the system today.

Each UN agency contributes between US$ 200,000 and US$ 500,000 per year to support its own central team for the program. UNDP serves as network facilitator.

How does the Train-X network work?

Today, Train-X is a full-fledged network comprised of the following elements:

a) Institutional framework

- virtual Train-X Central Unit through the Train-X Home Page on the World-Wide-Web (http:\www.undp.org\seed\networks)
- Train-X round tables every 18 months
- a work plan monitored by the train-x coordinator (Itu for 1996/1997).

b) Information exchange system, including e-mail bulletins on

- courses open to other programs (e.g. course developers' workshop)

- meetings/conferences open to other programs
- needs for consultants, national experts, and study tours to other Train-X Programs
- availability of study tour opportunities, literature, courses, data on best practices
- planned travel which could include up to 1/2 day for assistance to other programs.

What has Train-X network accomplished?

In addition to the significant achievements of the individual agency Train-X programs (which are not covered here), the Train-X network itself is building a track record of success.

Collaboration through the Train-X network commonly takes place at the global, regional and national levels and can involve all programs, several programs or two programs. The following gives an indication of recent types of collaboration:

1) Global

a) All Programs:

- establishment of a Train-X brochure and home page
- sharing and improvement of methodology
- ITU training in computer-based learning.

b) Several Programs: common simplified course development methodology for Train-For-Trade, Train-Sea-Coast and CC:Train.

c) Two Programs:

- participation in each others annual conferences, seminars and workshops
- sharing of material
- Train-For-Trade = Train-Sea-Coast joint course on coastal tourism;
- CC:Train - Train-Sea-Coast joint course on integrated coastal management and climate change.

2) Regional

a) All Programs: none yet

b) Several Programs: none yet

c) Two Programs: ILO-Trainmar joint meeting

Trainair/Trainmar joint Course Development

3) National

a) All Programs: none yet

b) Several Programs: Kenya review of Train-X programs

c) Two Programs: (Trainair-Trainmar joint course development in Panama) and numerous cases of established programs helping new ones through trained national personnel available in a country.

11 – Conclusions

The alluvial gold mining represented big environmental impact reflected mainly in the water. For that reason, the hydrographic basin received a large volume of siltation. The garimpeiros will not use tailing dams and for that, accumulates a big volume of tailings near the alluvial flat mined. Most of the old tailings rehabilitated due to their own nature.

If Santarem-Cuiba road will be asphalted the garimpeira activity will improve, mainly sites near the road and along Transgarimpeira road.

The gold prospection by mining companies had two phases. The first one was adapting to the garimpeiros work. The mining companies looked for old garimpos sites. After, they made the evaluations. The results were negative because the gold content was about 1.2 g/ton and it fell down when the gold was in the rock. The second one is away from the garimpo and near to the mountain. In this case drilling gave positive results in copper and gold anomalies with high content

The part of the alluvial auriferous deposit in the Tapajos Central Area represents erosion of the primary gold deposits. And the primary gold occurrences worked by garimpeiros correspond to the roots of these old deposits.

The pits worked by garimpeiros are just secondary expressions, forming small gold deposits high-grade, intersected by alluvium flat and surrounded by deposits with larger expression, some times not intersected by the current erosion surface.

The gold primary deposits occur preferentially in the volcanic sequences and intrusive granites, upper to the older granites.

According to mining companies surveys the Tapajos Gold Province can be a polymetallic mineral province of which the gold represents the mineral resistant to the natural lixiviation.

The Tapajos Gold Province can be divided in three parts. The first one includes several mineralized alluvium flat worked by garimpeiros. The origin of those alluvial

deposits is granitic and volcanic rocks. The second one is represented by little mineralized alluvium flat whose sources are volcanic rocks close to the mountain and granites in the low topography. The last one is without mineralized alluvium flat, but presents sediments and pyroclastic rocks.

The Tapajos garimpos area, where the garimpeiros worked and recovered gold, represent only a "window", called gold enriched place. Probably the gold in situ occurs away from garimpos and closer to the mountains. But for researching those areas is necessary to keep long drilling program.

All the researches carried out until now looking for small deposits (smaller than one million ounce), but larger deposits with two or more million ounce can be feasible with evaluations near to the hydrothermal sequences, as an example Sao Jorge Property.

All projects executed in Tapajos Region had positives and negatives considerations.

The Garimpeiros Assistance Foundation (FAG) was the first research in the Region. The merit of the project was opening discussion on the gold garimpagem in the largest area of the country; nevertheless, the team inexperience did not allow reaching its objectives. The objective was to transform garimpeiros into small miners such as there was in other countries. On the other hand, some factors impede it such as: "Amazonian factor", garimpeira regional culture, logistics obstacles, and high operational costs, peculiar characteristics of the alluvial deposits, mineralization types and volume of deposits.

The alteration of gold commercialization was strictly tax focus, always seeking to recover the tribute and offering nothing to motivate the garimpeiro to keep in the formal market. And this is the way that today they still sell gold in the garimpos in the informal market. Besides, the most important thing to garimpeiro is to get paid, but most of them do not even know what tax means. These are some of the reasons because the project proposal was filed.

The metal commercialization by Banco do Brasil – the official bank of the country – it is important to consider that the gold is a metal with different and peculiar characteristics; it has a big relation value versus volume, according to its high density and high unitary value (today a gram of gold costs about US$ 12). Different of its value in monetary unit, a kilogram of gold is accommodated in a small space.

The DNPM was responsible for the first collection of samples dosed for total mercury, including qualitative evaluations, environmental impacts studies, garimpeiros statistics, and environmental education, this one included in the Camga-Tapajos Program. The researches conduct by DNPM in 90's involved all the garimpeira area, but were not articulated with garimpeiros. By the way, the researches did not internalize positive return to the garimpeiros and there was not continuity in those projects.

The Commission of the European Union (CUE), Sol 3 – Center for Studies and Researches of Europe, London's Imperial College, Seicom and Group for Studies and Defense of the Ecosystems of the Lower and Medium Amazonas (Gedebam) has as goal to conduct study in the Tapajos Region, however it just carried out the first project phase for Mercury contamination on the Brazilian Amazon. There were collected samples in four areas, two considered as critics, both inside of the garimpos area (Crepori and Cuiu-Cuiu), and two outside of the garimpos area (Jacareacanga and Itaituba). The researches tried to articulate with garimpeira activity, but as it was a project financed by CUE the final proposal did not return to the garimpeiros. In fact, the project began well, but the final part had problems.

The Commission of the European Union (CUE), Imperial College Consultancy (Icon), Seicom, DNPM, Evandro Chagas Institute (IEC) and Tapajos Gold Mining Association (Amot) was considered as the second phase of the first project financed by the Commission of the European Union. It had four goals: technical alternatives (improvement in the evaluation of the garimpeira sites), mercurial impacts studies, but targeting to the occupational health; preliminary evaluation in garimpos sites; laboratories to assist people affected by possible mercurial contamination; and environmental information, compatible with garimpeiros culture.


Figure 14 -New Model Box

The principal merit of this project was to introduce the preliminary evaluation in garimpos mining, whose purpose was to reduce the risk for garimpeiros. This proposal includes open line with samples collected, heavy mineral concentration in pan gold, counting of *pintas* (gold particles) and preliminary evaluation. The project also introduced the new box (sluice) format, improved performance for garimpeiros, including angle of inclination (figure 14). All actions were developed with Amot participation. The initial proposal was that all the methodologies introduced in garimpos would be continued by garimpeiros, but in the project budget this part was not included.

The Cetem, Seicom, Evandro Chagas Institute (IEC) and DNPM Project were applied in the Rato Creek. The researches involved mercurial contamination and impacts evaluations. This project had Amot participation, but with academic objectives, lacking introduction of clean technologies or better techniques to the garimpeiros.

The Tropical Medicine Center of the Para Federal University (UFPa) and Japan International Cooperation Agency (Jica) was represented by a doctor's team that has studied mercury risk groups, located in the Tapajos River. The merit of this research is the clinical accompaniment of possible mercurial intoxication, but researches are frequently interrupted.

The Evandro Chagas Institute (IEC), DNPM, Seicom and Japan International Cooperation Agency (Jica) were responsible for occupational health and the

mercurial contamination evaluation. The Evandro Chagas Institute keeps the largest mercury database in the Amazon Region, with about 16,000 samples, most of them already treated. It reaches about 6,000 in the Tapajos Region. The other positive consideration was that the project introduced in garimpos a small assistance in occupational health

The Promin Project was elaborated still in the Camga-Tapajos Program. The Company for Researches Mineral Resources – Brazil Geologic Survey (CPRM) carried out surveys in the Tapajos Region. The Tapajos Mineral Province Project (Promin) had as its principal intent to make the regional geological mapping. However, it also executed a series of the primary gold evaluation occurrences, including geophysical surveys as well as mercurial contamination studies in some garimpo areas. The principal merit was geophysical surveys, because it can be an approach tool for future primary gold evaluations.

Camga-Tapajos Program was executed through the State of Para Government, by The Secretariat for Industry, Commerce and Mining (Seicom). The Tapajos Region was chosen because the garimpeira activity is very important to the regional economy. For this reason, the State of Para Government decided to study the area and created the Program for Garimpagem Control (Camga-Tapajos Program), which as final goal, in the medium/long-terms, was to minimize the great impacts in the garimpeira area as well as to transform the actual garimpo model. From that moment, the gold could be recovered according to the mineral, environmental and social legislation, with benefits to the communities involved in the gold garimpos and with focus to the sustainable development.

The most important points to the Camga-Tapajos Program are: being target to the Region, involving previous actions discussion, capitalizing positive effects from the other projects, partnership involving the public government and communities, responsibilities participation, promoting the activity organization (Amot), and democracy in the actions.

The Camga-Tapajos Program consisted of six subprograms: social and economy, impacts studies, solid tailing dams contention, technological alternatives, environmental information as well as establishment for agriculture-extractivism, with garimpagem model's change.

The Camga-Tapajos Program conducted studies in social and economy context – extractivist structures, including soil and subsoil occupation; garimpeira shopping, the social relationships study in the gold garimpos sites; agriculture and garimpeiros workers – the relationship between the mineral extractive activity and the agriculture; women of the gold – the feminine labor in the garimpos; gold production unit study; and the urban nuclei studies.

In the impact studies context, the monitoration for mercurial contamination in the water and fish in the Tapajos River, study for the current environmental impacts of the mineral extrativism and mercurial pollution, and mercury in Itaituba, (coordinatinated by Cetem), Environmental Information Campaigns. These actions

involved informative campaigns and courses highlighting the main garimpeira communities.

Establishment and transformation of the garimpagem model to increment the gold production. The objective was to attract investments, through joint ventures between mining companies and garimpo owners. It is, in the specific case, necessary the promotion of the State of Para Government and all areas could be in mineral and environmental legalization. The first one by DNPM (Small-Scale Mining Permission System) and the second one by Sectam (Environmental Licenses).

The program introduced in Itaituba, the Secondary Gold Market which allowed the garimpeiros to sell gold in Stock Market. This phase of project did not have success but it was very important to change the garimpeira culture in terms of gold commercialization.

As a program discussed with all communities the Camga-Tapajos Program could have more success, but it had reduction in budget, what limited their actions. On the other hand with State Government's changes the program was paralyzed.

The Tapajos gold mining has to be focused as an economic activity. If it is understood through economic focus, the other variants as social, environmental, education, legal aspects, and fiscal can be resolved. Everything because the garimpo do not include modern methods in gold recovery. The garimpo still is considered in semi-artisanal or semi-mechanized phase and depending on introduction of new technologies with technical assistance to progress and succeed in the future steps.

The garimpeira activity will continue for a long time, but the sustainable development issues depend of internal and external factors, but it is important to introduce infrastructure, because it will have much influence in the garimpo gold cost operation.

The Amot represents today a leadership in the Tapajos Region and can take carry of the project continuity, but it is necessary an assistant day-to-day running the new activities and provide working facilities.

The ideal case study for next project, including the implementation of sites for the demonstration of efficient and cleaner technology could be effective in garimpo with primary gold occurrence (quartz veins). The future for garimpagem in Tapajos Region is primary gold deposits. The secondary gold flat (alluvium deposits) is reduced and near the end.

The presence of cyanide plant (CIP and heap leaching) in the region shows a new garimpo face and it cannot be forgotten on the project, once that the project will have continuity.

To the garimpo future is very important looking for the opportunities to the financial project at the global, national and regional levels. This proposal can increase many

opportunities in Tapajos Region, and create the potential economic sources and mechanisms to improve the garimpeira activity.

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