FINAL CONSULTANCY REPORT.

EAST TIMOR NATURAL AND MINERAL RESOURCES INVENTORY,
POLICY AND DEVELOPMENT STRATEGY
(ESCAP/UNDP/TIM 01/022)

ECONOMIC GEOLOGY, DEVELOPMENT STRATEGY. AND CAPACITY BUILDING

Ir. Pieter J. Bakker
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Executive Summary.

The report reflects the results of a six week review and study of the mineral resources potential of East Timor and the possibilities that these resources may play a role in the future of the country.

While every effort has been made to be complete, the limited availability of reports and other backgrounds documents on the geology and mineral resources of East Timor has been a constraint as has the fact that field inspection of mineral occurrences could only be made for some of the most important indications.

The most significant conclusion coming out of the work is that East Timor does have mineral potential and that some of that potential will almost certainly attract foreign mining companies.

Before discussing the details of this mineral potential it should be emphasized that mineral potential is not necessarily equivalent to the existence of economically minable mineral deposits. In most cases extensive and costly exploration work needs to be done before a conclusion can be drawn as to the size and grade of an occurrence and the characteristics of the commodity to be extracted. This is high-risk work that is best done by the private sector as it needs solid financial and technical resources.

The most attractive potential of East Timor is in base metals, mainly copper, and associated gold and silver. This potential is in the proven occurrence of so-called Cyprus type volcanogenic massive sulfides related to ophiolite sequences. While a rather spectacular outcrop of this style of mineralization was observed in just one instance, geological reasoning and extrapolation allow for the conclusion that these commodities will be found in other locations as these ophiolite sequences occur widespread in East Timor.
Chromite and vein type gold represent other exploration targets in which the private sector will be interested.

Possible interest will be in the clay mineral potential, in phosphorites as well as in marble and other stone resources. Some of these resources may represent targets for domestic investment.

Immediate attention should be directed to the drafting and discussion in parliament of a regulatory framework that will allow investors to apply for the necessary licenses to investigate and, if successful, develop this potential. It is not recommended that any licensing be concluded before this process has been completed.

Oil and gas potential in East Timor has long been recognized and investor interest is already apparent. Several applications for the development of these potential resources have been submitted to government. Again, it may be in the interest of government to draft and enact oil and gas investment legislation without delay. Successful exploration of on-land and near-shore hydrocarbon resources will have a significant effect on the near term prosperity of East Timor.

East Timor needs a mineral policy that will allow the responsible and profitable exploration and development of its natural and mineral resources. This policy should allow for private sector involvement and should put the responsibility and the risk for the exploration and development of the resources squarely in the hands of the private sector. In accepting the risk and responsibility, the private sector should be allowed to make profits and be assured of the security of their investments.

In formulating a mineral policy, an appropriate balance should be maintained between the risks and responsibilities of the private sector and the interests of the government and the people of East Timor.
The mineral policy should also reflect due regard for history, tradition and the environment and be sourced from best practice and mineral policies that have been successfully implemented elsewhere.

In advancing government planning for departmental structure and capacity building, East Timor would initially be best served by a simple structure of a Department of

Natural and Mineral Resources consisting of a Geological Survey and Mines Division and an Oil and Gas Division. These two, initially small Divisions would be complemented with an administrative Section.

Capacity building in the initial years would be an ongoing priority concern for the government. This has elsewhere been adequately discussed and adopted by the government. It would be in the interest of capacity building in the natural and mineral resources sector to include obligatory training and education in mining and hydrocarbon projects, with successful projects delivering well trained and educated technical personnel during and at the end of the project's life.

The present report makes several other recommendations for capacity building and data collection that may be of use in the immediate planning process.

The natural and mineral resources in East Timor may, if enabling legislation is enacted and subsequent exploration is successful, play a useful role in the economy and development of the country. If appropriately regulated, these resources may generate income in the form of taxes and royalties, may improve local and regional infrastructure, they may create employment and local educational and health services. In recognizing the rights of the most immediately involved local people, natural and mineral resources development in East Timor may increase local industrial and agricultural development and should assure people at the sub-district and village level of an appropriate share of the income generated by their development.

INVESTMENT PROFILE.

BASE METALS AND ASSOCIATED GOLD AND SILVER.

Background.

The Government of East Timor has decided that the development of the country's mineral resources is best done in appropriate licensing arrangements with capable exploration and mining companies.

To attract foreign investors to the exploration and development of these resources, the Government has enacted a Mineral Resources Management Law and attendant regulations. The Government believes that the provisions laid down in this framework are attractive and recognize the high-risk character of mineral exploration and the need for title security over the years.
In combination with the other relevant laws of East Timor, this regulatory framework forms an enabling mineral investment climate.

Technical background.

East Timor has proven potential for base metals and gold in ophiolite related massive sulfide deposits.
In the Ossuala area, Baucau District, stringers filled with complex sulfides occur in serpentinite rocks. The sulfides are chalcopyrite and pyrite. Sampling by the Allied Mining Corporation in 1937 returned values of 10% copper, 3g/t gold and 170 g/t silver.
Nearby in the Ossu area, Viqueque Distrct, float and large boulders of pyrite and chalcopyrite are found on a ridge of serpentinite.
This area has been recently revisited by government and United Nations technicians who were able to confirm the occurrence: Several spectacular and large boulders of copper/gold/silver massive sulfide, of between 5 – 15 ton estimated weight are found at the bottom of a serpentinite ridge along the track from Ossu to Leca, just across the Vei Berek stream.
These are the same boulders that the Allied Mining Co. reported in 1937. AMC sampled the site and reported the average assays from 27 samples of this material as: 3-4g/t Gold, 70g/t Silver and 10% Copper. The area is 15x15 meters wide and the float seems to occur in situ.
Similar occurrences have been reported from the Manufahi and Lautem Districts in East Timor.

The opportunity.

The Government of East Timor believes that the massive base metal occurrences form attractive exploration targets and invites foreign exploration and mining

companies with the necessary technical and financial capacity to apply for the requisite license(s) to explore and evaluate these massive sulfide base metal occurrences.

A detailed United Nations technical report and copies of the Mineral Resources Management Law and regulations are available for review at the offices of the Secretary of State for Natural and Mineral Resources of the Government of East Timor in the Capital Dili.

INVESTMENT PROFILE.

CHROMITE DEPOSITS.

Background.

The Government of East Timor has decided that the development of the country's mineral resources is best done in appropriate licensing arrangements with capable exploration and mining companies.

To attract foreign investors to the exploration and development of these resources, the Government has enacted a Mineral Resources Management Law and attendant regulations. The Government believes that the provisions laid down in this

framework are attractive and recognize the high-risk character of mineral exploration and the need for title security over the years.
In combination with the other relevant laws of East Timor, this regulatory framework forms an enabling mineral investment climate.

Technical background.

East Timor has proven potential for podiform chromite. Chromite has been reported from Baucau, Manatutu and Manufahi Districts. The occurrence in the Manatutu District has been evaluated to such an extent that it may be included in the list of possible economic deposits. This does not mean that the other occurrences do not have any potential but not enough work has been done on these yet.

Chromite occurs in the Hili Manu sub-district of Manatutu. The occurrences are located south of the village of Behada at km 53 on the main coastal road. (1:25 000 topographic map series, sheets Laclo and Behau.). The best exposures are reported form Biau Hill at an elevation of 699 meters, three kilometers to the south.

Geologically the area is characterized by good exposures of a variety of rock types and evidence of extensive contact metamorphism with diorite intrusive in a setting in which serpentinized ultra basic rocks, amphibolite schists, massive limestone and mesozoic marine sediments are represented.

Chromite lenses and schlieren occur in several places in the ultra basic mass in a general direction coinciding with the trend of the massif. Several outcrops of chromite have been observed along a trend of some 2500 meters long, mainly along the crest of the ridge.
Two outcrops are up to 6x6 meters in size and other smaller outcrops exist. These outcrops may be connected and certainly the continuity of the schlieren and the regular intervals between outcropping lenses suggests a possible connection between individual outcrops and the promise of large tonnages.

The quality of the chromite is good, with grades between 36% and 51%, while the mineralization has a sharp contact with the serpentinite suggesting the possibility of easy separation.

Several other areas in East Timor have the potential for similar occurrences.

The opportunity.

The Government of East Timor believes that the chromite occurrences form attractive exploration targets and invites foreign exploration and mining companies with the necessary technical and financial capacity to apply for the requisite license(s) to explore and evaluate these metal occurrences.

A detailed United Nations technical report and copies of the Mineral Resources Management Law and regulations are available for review at the offices of the Secretary of State for Natural and Mineral Resources of the Government of East Timor in the Capital Dili.

INVESTMENT PROFILE.

GOLD DEPOSITS IN THE MANUFAHI DISTRICT.

Background.

The Government of East Timor has decided that the development of the country's mineral resources is best done in appropriate licensing arrangements with capable exploration and mining companies.

To attract foreign investors to the exploration and development of these resources, the Government has enacted a Mineral Resources Management Law and attendant regulations. The Government believes that the provisions laid down in this framework are attractive and recognize the high-risk character of mineral exploration and the need for title security over the years.

In combination with the other relevant laws of East Timor, this regulatory framework forms an enabling mineral investment climate.

Technical background.

The Manufahi district has long been known for its gold potential and there are several known occurrences of gold. Some of these have been known and mined since the middle of the 19th century. Hard rock gold occurs and there is widespread evidence of alluvial gold in recent and older gravels.

Vein Gold has been observed in several forms.

- Quartz veins as lenticular bodies in shales and schists. These veins and veinlets are fairly constantly mineralized, at times with free and visible gold.
- Quartz – calcite veins:
    1. with disseminated pyrite in altered diabase. The veins are pyritized and mineralized with gold.
    2. with chalcopyrite at the contact between diabase and black shales.
    3. mineralized fractures in the black shales and the diabase; these fractures carry gold.
- Calcite veins.
    1. These occur in fissure veins and lenses in shales and are mineralized with pyrite. Downstream of these veins intense panning has taken place. There is evidence of large nuggets being associated with the gravels.

The opportunity.

The Government of East Timor believes that the Manufahi gold occurrences form attractive exploration targets and invites foreign exploration and mining companies with the necessary technical and financial capacity to apply for the requisite license(s) to explore and evaluate these gold occurrences.

A detailed United Nations technical report and copies of the Mineral Resources Management Law and regulations are available for review at the offices of the Secretary of State for Natural and Mineral Resources of the Government of East Timor in the Capital Dili.

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Introduction.

From 29th of April 2002 to the 8th of June 2002, the writer undertook a mission to East Timor to review the mineral potential of the country, to draft an exploration strategy and to make recommendations for capacity building in Natural and Mineral Resources Management to the Government of East Timor.

The work was commissioned by ESCAP as the executing agency for the UNDP funded SPPD Project entitled: "East Timor Natural and Mineral Resources Inventory, Policy and Development Strategy" (TIM/01/022.), and was guided by the following terms of reference:

1. Review the mineral and on-shore oil and gas potential in East Timor and formulate a draft exploration strategy, with special focus on attracting foreign direct investment, and domestic private investment.
2. Evaluate the present status of government and private sector institutions engaged in natural and mineral resources development and identify capacity building programs including new institutional structure, equipment, personnel and training.
3. Draft investment profiles for selected mineral commodities and on-shore oil and gas prospects to be presented to private domestic and foreign investors.

4. Carry out activities 1 – 3 jointly with professionals from the Environment and Natural Resources Development Division of ESCAP who will also coordinate the project activities.
5. Conduct a workshop and present findings and recommendations on 1 – 4.
6. Submit a comprehensive report on activities 1 – 3 (Which should be 'donor focused' for follow-up activities.) to the Director, Environment and Natural Resources Development Division of ESCAP, for inclusion in the final project report.

The work was completed in close cooperation with the Office of the Secretary of State for Natural and Mineral Resources of the Government of East Timor. The Dili office of the UNDP provided logistical support to the mission.

In carrying out the prescribed tasks, the writer worked together with the other members of the ESCAP/UNDP team, Jon Rau, who prepared the minerals and oil database, and Jack Garnett, to whom the drafting of legal framework was assigned. Constant exchanges of views and ideas between the team members regarding aspects of geology and resources and the manner in which they could be explored and developed was typical throughout the mission and enhanced the result considerably.

The efficient support of the UNDP office in Dili, especially the efforts of the mission coordinator Ms Vibeke Risa, programme officer, enabled the mission to complete the work on time.
Mr. S. S. Khan and Mr. Barid Manna, UNTAET advisors to the Secretary of State for Natural and Mineral Resources introduced the mission members to aspects of government policy and the ongoing planning for capacity building.

Mr. Amandio Soares and Mr. Vicente Lacerde supplied the much needed oral information there where the written information had been destroyed or taken away.

Mr. Lourenco Pedro, national expert and mission counterpart was active and supportive throughout, both in the office and in the field, sometimes in fairly rough circumstances.

The contribution of all is recognized with gratitude.

History of the project.

In late 2000 the ETTA addressed a request to ESCAP for assistance in several sectors of economic activity, including in the field of Natural and Mineral Resources. Based on an initial review the Secretariat concluded that:

"Although the island Timor does not belong to one of the main mineralized arcs of the Indonesian archipelago (van Leeuwen, 1994.), it could have an attractive mineral potential but practically none of that potential has been developed. The reason for this may be that East Timor has for a long time been a politically contested area from where private sector investors traditionally shy away and therefore little exploration has been recorded although the Indonesian state mining company Aneka Tambang has been active in some areas.

Van Bemmelen (1949) notes the occurrence of several minerals on the island, including copper, nickel, gold, manganese and antimony, as well as the industrial minerals limestone, marble and gypsum.

Timor as a whole is geologically very complex, possibly characterized by its close relation to an active(?) subduction zone, affecting the southernmost part of the island. The northern margin is partly underlain by volcanics of the Banda Arc.

Large sections are underlain by a major ophiolite complex; of note also is the occurrence on land of typical ocean floor manganese nodules, as recorded by Umbgrove (1948.).

From initial review, it would seem that the best potential of E Timor may be for nickel/cobalt laterites and Cyprus type massive copper sulfides. Rio Tinto/CRA is on record as having explored for porphyry copper deposits in the volcanics underlain North-Central part of the island.

With respect to hydrocarbons, East Timor has at least three oil fields/occurrences. The status of their development is not known, but it seems obvious that they could play an important role in the future energy planning of the new state.

Of special importance is the demonstrated off shore oil and gas potential. In part this is contained in an area that was the subject of a dispute between Australia and Indonesia; a dispute that was resolved in the agreement between Australia and Indonesia on the joint development of the so-called "Timor Gap".

Practically the whole "Timor Gap" would now fall within the EEZ claim of East Timor. The country would therefore need assistance in Law of the Sea matters, an area where ESCAP could provide some initial advise.

The assistance now needed by the transitional authority should not be confused with the needs of the country once it has elected its own government. Drafting of laws and promotion of foreign investment has to wait until then, even though the Secretariat could provide suitable examples of mining codes and regulations for future review.
At the present time it is necessary to look into the institutional needs and possibly into the collection of geology and mineral resources data from all potential sources.

Important considerations would be the review and support of the existing structure – if any - for the management of minerals and oil and advise on how to deal with an

onslaught of applicants for permits to explore/exploit minerals and construction materials."

Continued communications on the issue between ETTA/UNTAET, and ESCAP, led to a request from UNTAET, in a letter from the SRSG to the Executive Secretary, in early 2001.
This request was for assistance in the assessment of its resource potential for natural and mineral resources, for a review of the needed capacity building in the natural and mineral resources sector and to explore the possibilities for the fielding of ESCAP advisory services in the area of natural and mineral resources.

ESCAP fielded a multi disciplinary mission to East Timor in April/May 2001. This mission formulated a number of conclusions and proposals in the different fields.
In the field of mineral resources the mission observed that a large volume of data on minerals and geology was available.
Most of the data had been collected through voluntary initiative. The information indicated a definite, but as yet mostly unsubstantiated potential for number of commodities.

The Industry, Mineral and Tourism Division of UNTAET, through the Secretary of State for Natural and Mineral Resources of the Second Transitional Government of East Timor, submitted through the Donor Coordination Unit a request for technical assistance for the natural and mineral resources survey and development strategy in East Timor to the UNDP. In agreeing to support the request, the UNDP Resident Representative and UN Development Coordinator indicated to the Secretary of State that the TA would be funded through the Support Services for Policy and Programme Development, SPPD, funding mechanism.

Informal consultations between UNDP and the Industry, Mineral and Tourism Division and between UNDP and ESCAP have laid the groundwork for the issues to be covered in the TA, with the detailed terms of reference being provided by the Division, as amended, in October 2001.

The project document reflects the results of these consultations and incorporates necessary actions and policy coverage sourced from Asia Pacific country experience in this field. It identified the following issues to be covered and problems to be addressed:

"In any assistance in the natural resources and minerals sector the collection and review of pertinent data is essential. While the collection of new data will largely depend on the facilities available to the Government and on the activities of the private sector, the review and study of available data from earlier work is a must for appropriate planning of the sector.

The voluntary Mining & Energy Source Commission working under the CNRT umbrella have accumulated Portuguese and Indonesian data and have established contacts with resource persons conducting studies and research in the area.

The review of this material is essential as a starting point for the project and interviews and discussions with the identified resource persons will facilitate the process of understanding the resource potential of East Timor.

Based on the review, study and evaluation of the above data, a strategy for the responsible and economically advantageous exploitation of the natural and mineral resource base will be formulated; this will be a critical factor in support of the overall economic development planning of the country.

The policy choice and the selection of the strategy is the domain of the Government of East Timor, but the sharing of experience and other countries' "best practices" and " lessons learnt", particularly in the Asia Pacific region, would facilitate the policy choice for the strategic management. Once the vision and policy direction of the strategic management is clear, a robust strategy would need to be formulated to translate the vision into reality.

This translation of the representative government's vision and policy into action is dependent on the formulation of an enabling integrated legal and regulatory framework, addressing all related issues including environment.
While as a transitional measure the Indonesian laws and regulations on the subject are still effective, there is a need to review this framework and to align it to the indigenous realities and representative policy direction.

Enabling the private sector to explore and develop the resource base, within the policy and regulatory parameters set, is considered a key success factor.

Successful approaches and best practices from other regional countries will be considered for inclusion in the overall mineral policy, regulatory – the one-stop-shop licensing facility– as well as with regard to fiscal, environmental and social practices and stakeholder policy.
In order for the government to be able to appropriately manage the sector, institutional development and capacity building are required.

At the outset the needs in this respect need to be identified and addressed, so that prioritized recommendations can be made for the sector to be met in the short, the medium and long term, in contribution to the recently developed Capacity Development Program Plan.

It is the express wish of the government that investors at the time of independence can be presented with a number of practical and attractive opportunities in the natural and mineral resources sector.

It would therefore be needed to:

1. Review and identify the natural and mineral resource base of East Timor.
2. Plan and design and develop a strategy for the responsible and economically advantageous exploitation of the natural and mineral resources in East Timor.

3. Advise the Government of East Timor on the appropriate legal, regulatory & environmental issues in the development of natural and mineral resources and outline the basic framework required for their exploitation and development.
4. Recommend enabling natural and mineral resources licensing arrangements:
5. Assist in the designing of efficient and effective public and private sector institutions essential for the development of the natural and mineral resources potential of East Timor and render support in the design and implementation of private and public sector capacity building programs essential for the natural and mineral resources development in East Timor.
6. Initiate the drafting of investment profiles for selected commodities so that a portfolio of investment opportunities can be presented to private domestic and foreign investors in the sector."

These considerations were all included and laid down in a draft SSPD project document, prepared by the writer and ESCAP staff in late 2001. In early 2002 an ESCAP staff member traveled to East Timor for discussion of the project document and after review by the UNDP Project Approval Committee, the project was approved on 27th February 2002 by the UNDP representative and almost immediately afterwards by the Executive Secretary of ESCAP.

Project implementation commenced in early April 2002 and the first two mission members traveled to East Timor on 29th April to commence the work.

Photo 1. Exotic limestone block in Bobonaro Mélange.

Laleia, Baucau.

PART ONE.

Metallogeny and mineral occurrences.

Metallogeny of East Timor and the Outer Banda Arc.

Determined – and restricted - by geology, geological history and structure, assumptions on the metallogeny of East Timor require review of the existing interpretations of the geology of the island. Extensive coverage of the geology and the different interpretations will be presented in the report dealing with the development of the data base. For the purpose of discussing metallogenetic aspects, the following remarks are pertinent.

Timor island is part of the non-volcanic outer Banda arc. There are many different opinions on how Timor was formed, there is however general agreement that Timor occupies a suture zone between the Asian and the Australian plates. Formed by mechanical accretion of underthrust Australian continental margin material, this material underlies the island and is covered by several autochtonous sequences. Ophiolitic so-called Banda terrane and a scaly clay melange are the main overlying sequences and these are two of the three main aspects of the geology and geologic history that influence the metallogeny:

- *The ophiolite sequences.*
- *The wide spread occurrence of the mélange unit.*
- *The active tectonics and the continuing uplift of the territory.*

1. The ophiolite.

While the individual basic to ultra basic rocks of this sequence had been mapped by the Allied Mining Corp. (1937.), the recognition of these rocks as an ophiolite series is first clearly mentioned in van Bemmelen (1947.).

"…….Schist-Ophiolite Complex is probably widely distributed…." and :"…it forms the overthrust unit of the North Coast Schist-Manufahi Diabase Complex." Van Bemmelen based his descriptions on the earlier work of Dutch geologists, particularly that of de Roever (1940.) and interpreted the work of the Allied Mining Corp. (1937.) along the same lines.

A geological sketch by van Bemmelen clearly shows the large areas in East Timor that are underlain by ophiolites. (Fig. 1.)

Possibly the best and most complete description of the ophiolitic rocks – though not named ophiolite. - is found in the annotation to the geologic map of the Kupang – Atambua Quadrangle in West Timor (Rosidi, 1978.). In this annotation, the *Manamas Formation* (Tmm.) corresponds to the upper section of the accepted ophiolite sequence, while the *Ultra Basic Unit (UB.)* forms the lower part and completes the sequence.

Rather than a single rock type, an ophiolite is a stratified group of three separate rock types, known as the "Steinman Trinity." The lowermost members consist of ultramafic peridotites, above which are layered to massive gabbros that in turn are source to and overlain by a volcanic member composed of sheeted dikes and pillow basalts.

Ophiolite rocks are formed at the spreading ridges as reduced pressure allows partial melting in the Earth's mantle, generating the gabbro plutons which then feed the pillow basalts through fissures opened during spreading.

Field evidence from the Hili Manu area near Manatutu support the observations quoted above. The mission team noted, admittedly without being able in the allotted time to construct a 'top-to-bottom' profile, the individual ophiolite rock types, including significant ultra basic *cumulate* occurrences in stream beds.

Fig. 1. Distribution of ophiolitic rocks, East Timor. (van Bemmelen, 1948.)

Massive sulfide copper and gold deposits.

Ore deposits in ophiolites (Coleman, 1977; Cox and Singer, 1986.) include Massive Sulfides as stratabound bodies in the pillow lavas, mainly as copper bearing massive pyrite lenses with some gold and silver. At times these lenses also carry lead and zinc values.

These Cyprus Type Volcanogenic Massive Sulphides are usually between 500 000 and a few million tons in size, though larger deposits exist. They account for significant ancient and modern mining in Cyprus, Oman, Turkey, Greece, the Philippines and elsewhere and, with copper grades between 1% and 10%, are attractive exploration targets.

Manganese and manganese-iron-silica formations overly these type VMS deposits. They may account for, mostly low grade, accumulations of manganese oxides and silicates.

Chromite occurs in ophiolites, in podiform chromite deposits and as 'schlieren'. These ophiolite related chromite deposits include some of the most important in the world such as those in Iran, Greece, Turkey, the Philippines and New Caledonia. Descriptions of the chromites at Hili Manu (Allied Mining Corp., 1937.) confirm that these occur also in East Timor.

Nickel deposits can form as secondary concentrations in laterite weathering profiles on the dunites and peridotites of ophiolitic sequences. Most notable are the examples from New Caledonia where huge laterite nickel concentrations exist. The ultra basic rocks of East Timor contain approximately 2000 ppm Ni (Harris, 2000.) and could therefore in theory also be the base for the formation of concentrations of laterite nickel. Field observations in East Timor however seem to indicate the absence of deep laterite weathering profiles, probably due to the constant uprising of the island, and therefore no evidence exists for the occurrence of this type of mineral concentration.

The occurrence of platinum group minerals (PGMs.) related to ophiolites has been reported from Oman where platinum group minerals have been found in the Samail ophiolite (BRGM, 1995.) and from Iran. No indication exists that these may also occur in East Timor but excluding the possibility is, as always in exploration, risky.

2. The Mélange.

The Melange, the Bobonaro Melange (Harris, 2000.), the Bobonaro Scaly Clay (Charles, 1968.) or the Sonnebait Series of the older Dutch workers, covers large parts of Timor island and about 60% of the territory of East Timor.

The unit consists of soft scaly clay with exotic blocks and lenses of rocks of all ages and sizes in it, sometimes dominating the landscape as abrupt outcrops as in Laleia, where a huge knoll of limestone with no apparent roots and surrounded by Melange stands towering over the city. *(Photo. 1.)*

The clay itself has probably been derived from the sub-marine weathering of volcanic ash material and has been – structurally – interpreted as marking the

collisional suture between the Australian lower plate and the Asian upper plate (Harris *et al*, 2000.). With the overwhelming diversity of exotic rocks and blocks of all sizes in it, it is tempting to suggest that the Mélange acted equivalent to a slow moving and dense lahar or as something between a lahar and till, collecting blocks and pieces of rock of whatever nature it encountered during its emplacement as overthrusted seafloor material.

The Melange has an important metallogenic aspect in that much of the clay is bentonitic in nature with a dominance of smectite clay minerals.

3. Uplift.

Raised beaches, reefs and alluvial terraces including the occurrence of raised reef material at altitudes of 500 meters and more above, clearly indicate that the recent and probably ongoing tectonic movements have caused continuous uplift of the island.

Amongst the consequences of this uplift are firstly the likely absence of any thick accumulations of deep tropical weathering, and thus the probable absence of large nickel laterites.

On the positive side the uplift results in aggressive erosion and the possible formation of concentrations of mineral sands. Large concentrations of ordinary sand and gravel will result though these concentrations may be 'bouldery' and unsorted. *(Photos 2, 3.)*

Photo 2. Comoro River sand pits near Dili.

Photo 3. Badly sorted alluvial material, Comoro River, Dili.

Mineral Occurrences.

Metallic minerals.

1. Cyprus type massive sulfide copper and gold mineralization.

The mission's foremost conclusion on the mineral endowment of East Timor is that significant potential exists for the occurrence of Cyprus style massive sulfide base metal-gold deposits.
This conclusion is based on a review of earlier found indications described in the reports of the Allied Mining Co. (1937.) and Indonesian government reports (Likely, but not confirmed, to be copied from AMC without further interpretation or verification.).
The mission was able to verify in the field the most relevant statement of the AMC report, the occurrence of massive sulfide float at Ossu in the Viqueque District.

In this chapter several copper, copper-gold and gold occurrences are included as they all appear to have the same or similar settings, all being closely associated with a suite of basic to ultra basic rocks that have a close similarity to Cyprus type ophiolite sequences and have indeed been mapped as such by van Bemmelen (1949.) and others, even though some discussion with regards to the adequacy of the usage of this precise term has been going on (Harris, 2000.)

These occurrences include the copper, copper/gold and sulfide mineralization of the Ossuala and Verac areas in the Baucau District and the Ossu area in the Viqueque District as well as the copper and some of the gold indications in the Manufahi District. Some consideration will also be given to the occurrences of ochre in the Lautem District, as they may be type indicators for this style of mineralization.

The geological setting in all areas is dominated by the occurrence of ultra basic units, with extensive serpentinite *(Photo 4.)* alteration and with evidence of intrusive diorite/diabase. The basic/ultra basic units are in many palaces covered by more

recent marine sediments and therefore the total extent of the serpentinite' in each individual area is unknown. The available descriptions (AMC, 1937.) are referring to "serpentine plugs and irregularly shaped masses exposed in places through the mantle of chaotic sediments …" The possibility that there is a connection between the ultra basic occurrences in some of the districts should be considered, but geophysical surveying (magnetics.) might be needed to supply the evidence. These ophiolites represent the anomalous superposition of oceanic crust on top of continental crust. Few geologic features more clearly reveal the dynamic effects of seafloor spreading.

Photo 4. Serpentinite,Ossu area, Viqueque..

Indications in the Manufahi District.

In the Manufahi District there are several showings of chalcopyrite in the ophiolite sequence, none of these has been described in sufficient detail to enable accurate

evaluation, but the sum of the indications suggests great similarity with the ophiolite related mineralization elsewhere.
The District has considerable outcrop of basic and ultra basic rocks.
In the Southern Foothills and along the ridges these outcrops are of dense greenish grey meta-igneous rock of diabase appearance. Fractures in these rocks are quartz filled with shows of pyrite and other sulfides.

The described rock sequences are similar to the ophiolite sequences observed in the Manatutu and Viqueque districts that have been mentioned earlier.
In the ophiolite sequences as mapped by van Bemmelen (1948.) there is indeed a considerable sector of the northern part of the Manufahi district that is underlain by these rocks. This has significance for the exploration potential of the district.

Occurrences in the Baucau and Viqueque Districts.

Native copper occurs at Virac where it has been found in large lumps of several kilos weight. A dense brown breccia of " uncertain character …" (AMC 1937.) is cemented by calcite, which in the larger cracks appears as a coarse crystalline, banded and iron stained filling; the native copper mineralization is possibly connected to these vein fillings.
In the Ossuala area, in a similar setting, stringers filled with complex sulphides occur in the serpentinite. The sulphides are chalcopyrite, pyrite and others. Sampling by the AMC (1937) returned values of 10% copper, 3g/t gold and 170 g/t silver. The wall rock appears to be mineralized as well, be it with much lower grades.

" ..In the Ossu area, float and large boulders of pyrite and chalcopyrite are found on a ridge of serpentinite. The area is 15x15 meters wide and the float seems to occur in situ. Grades in the pyrite are reported to be 10% copper, 3-4g/t gold and 70g/t silver. No other assays were done on the samples. Gossanous material was observed encrusting the sulphides…" (AMC 1937.)

"…The total area over which these occurrences have been found measures some 20x10 kms.The copper-gold occurrences related to diabase and ultra basic intrusives of the Baucau and Viqueque Districts…." (AMC 1937.)

The mission was able to verify the occurrences of massive pyrite and chalcopyrite in the Ossu area, Viqueque District.

In an exceptional outcrop, several spectecular and large boulders of Copper/gold/silver massive sulfide, of between 5 – 15 ton estimated weight are found at the bottom of a serpentine ridge along the track from Ossu to Leca, just across the Vei Berek stream. *(Photos 5,6.).*

These are the same boulders that the Allied Mining Co. reported in 1937. AMC sampled the site and reported the average assays from 27 samples of this material as: 3-4g/t Gold, 70g/t Silver and 10% Copper (At today's market price equivalent to US$ 200-250 per ton of ore, copper contributing about 80% of the value.)

While in earlier reports the occurrence was evaluated as probably small, with today' s knowledge, the indication must be interpreted as significant and diagnostic for the whole ophiolite sequence, wherever it is found in East Timor, while the outcrop itself may well be the tip of a much larger ore body.

Photo 6. Low hilly terrain underlain by ophiolitic rocks, Ossu, Viqueque. Massive sulfide boulders occur in area in box to the left..

The confirmation in the field of the occurrence of these boulders in close association with serpentinized basic/ultra basic rock sequence, allows the conclusion to be made that the other areas underlain by these ultra basic rock/serpentinite units, the ophiolites, have potential for the same mineralization.

As discussed some of these areas are already on record as having either copper or copper/gold indications (Vemasse/Ossuala and Virac, both in the Baucau District.). Others include locations in the Manufahi, Manatutu and Lautem Districts. Yet other parts may not yet have been explored, such as the area near Daudere, about two kilometers South off the coastal road about ten kilometers before Lautem.
Here extensive clay alteration on two prominent hills marks the landscape over several hundreds of square meters while in the immediate neighbourhood ochres and umber type rocks are found. It is expected that these occurrences are wider spread over the country than presently known. They warrant close inspection.

It is recommended that the copper-gold potential of the ophiolite sequences be the first mineral development priority and that foreign investment be invited to play a leading role in the exploration and development of this potential.

In the western part of Timor island similar occurrences of massive sulfides had been reported as early as 1925 by 't Hoen en van Es (Jb vh Mijnwezen 1925, II.).
They reported on work done on the Bonė ore body and several other, smaller occurrences. While apparently the grade of these mineral occurrences was attractive, the size of the occurrences was almost invariably small.
From a review of their work, it seems that all the occurrences investigated were embedded in clay-like material, suggesting that the mineralized blocks may have been 'exotic' and occurred in the Bobonaro Melange. This is of course not impossible and this may also be found in East Timor.
This does not diminish the importance of the occurrence at Ossu, though it may indicate that exploration programs for these massive sulfides may be costly and time consuming.

2. Podiform Chromite

Chromite occurrences are reported from Baucau, Manatutu and Manufahi Districts. Of these only the occurrence in the Manatutu District has been evaluated to such an extent that it may be included in the list of possible economic deposits. This does not mean that the other occurrences do not have any potential but not enough work has been done on these to allow any further statement to be made with respect to their potential.

The chromite in the Manatutu District is an occurrence of so-called podiform chromite and is similar to chromite mineralization in allochtone ophiolite bodies found in the Circum Pacific belt in the Philippines, New Caledonia and Kalimantan, Indonesia. Typically these chromite deposits occur in highly deformed dunite and harzburgite units of ophiolite complexes.

A tentative evaluation of the Manatutu chromite has been done by the Allied Mining Co. (1937.), and the description below is taken from their report.

Chromite occurs in the Hili Manu sub-district of Manatutu. The occurrences are located south of the village of Behada at km 53 on the main coastal road. (1:25 000 topographic map series, sheets Laclo and Behau.). The best exposures are reported form Biau Hill at an elevation of 699 meters, three kilometers to the south.

Geologically the area is characterized by good exposures of a variety of rock types and evidence of extensive contact metamorphism with diorite intrusive in a setting in which serpentine, amphibolite schists, massive limestone and mesozoic marine sediments are represented.

These main rocks types include:

- An intrusive diorite, schistose and possibly emplaced along the contact of the ultra basic unit. The diorite has an outcropping volcanic equivalent at km 52.

- Mesozoic marine sediments mainly calcareous. In places these can be seen to form a cover over the ultra basic unit.
- The so-called North Coast Schists (AMC 1937, van Bemmelen 1949.). Mainly amphibolite schists, but varieties with quartz, mica and/or chlorite dominant have been found. The unit shows a prominent schistose structure and ranges in color from grey to light green. The age for this unit has been given as pre Permian. These schists are the equivalent of the Lolotoi Complex (*Charles* A-, 1968; Tobing, 1989.).
- The Lolotoi Complex is an extended version of the North Coast Schists and includes strongly folded phyllites, schists and metagabbro.
- 'Serpentine', a broad term in which are included a serpentinized ultra basic unit and a deep black coarsely crystalline rock with bronzite phenocrysts, at times with pyroxinite segregations and chromite schlieren and lenses. The unit forms a NNE-SSW steep ridge running from km 53 on the main coastal road to Biau Hill, over a length of 3000meters.

  The ultra basic rock units are not represented on the Charles A- (1968.) geology map of East Timor, nor are they described on any of the other existing East Timor geology maps. The formation is referred to on the Kupang and Atangu quadrangles of the West Timor geological map (Rosidi et al 1979.). It is described as a mixture of basalt, lherzolite and serpentinite. The basalt being dark grey, porphyritic and vesicular in nature. The Lherzolite is greenish and hypidiomorphic, is fractured and contains opaque minerals and is to a large extent serpentinized.

  The serpentinite is foliated at the fringes. These rocks are usually associated with thrust zones and are considered to be pre-Permian.

Chromite lenses and schlieren occur in several places in the ultra basic mass in a general direction coinciding with the trend of the massif. Several outcrops of chromite have been observed along a trend of some 2500 meters long, mainly along the crest of the ridge.

Two outcrops are up to 6x6 meters in size and other smaller outcrops exist. These outcrops may be connected and certainly the continuity of the schlieren and the regular intervals between outcropping lenses suggests a possible connection between individual outcrops and the promise of large tonnages.
The quality of the chromite is good, with grades between 36% and 51%, while the mineralization has a sharp contact with the rock suggesting the possibility of easy separation.

80% of the world's major podiform chromite deposits are between 2000 and 200 000 tons in size. Few deposits are larger and deposits of one million tons are an exception.

As for grade, 80% of the world's major deposits have between 33% and 52% Cr203.
(Cox and Singer, 1986.)
The reported grade of the Hili Manu chromite falls well within the norm for an economic deposit. The tonnage remains to be determined, but the several reported outcrops with exposures of up 36 meters square and the extensive length of 3000 meters over which the mineralization has been followed, indicates that the potential for an economic size chromite deposit exists at Hili Manu.

The location of the chromite, at a very short distance from the sea is a positive element in the evaluation of the potential the abrupt hilly terrain and the location close and above the main coastal road will be a negative factor.

It is recommended that the chromite of Hili Manu be a priority investment project.

3. Gold occurrences in the Manufahi District.

As in the earlier discussed Manatutu, Baucau and Viqueque Districts, the Manufahi District has considerable outcrop of basic and ultra basic rocks.

In the Southern Foothills and along the ridges there are outcrops of dense greenish grey meta-igneous rock of diabase appearance. Fractures in these rocks are quartz filled with shows of pyrite and other sulphides.
In Bubussussu small bodies of coarse grained gabbro-dioritic rocks crop out and along the S. Laclo river a dense dark basaltic rock that appears to be made up almost entirely of ferromagnesian minerals is seen to intrude a black shale unit.
Near Ailalec(?), N of the Morok Creek, large massive bodies of volcanics are noted. Erosion of these rocks leaves behind small green glassy pebbles. Recent volcanics occur near Turiscae and Maubisse.

Of note is an earlier description of these rocks under the collective name of Manufahi diabase. According to this description (AMC 1937.) the name covers apparently not just a single rock type but a collection of different igneous rocks including ultra basic rocks, in places serpentinized, dyke rocks and volcanics. It is again similar to the ophiolite sequences observed in the Manatutu and Viqueque districts.
In the ophiolite sequences on the van Bemmelen map (Fig. 1.), there is indeed a considerable sector of the northern part of the Manufahi district that is underlain by these rocks. This has significance for the exploration potential of the district.

As elsewhere, limestone and other sedimentary rocks cover these igneous and volcanic rocks in several places.
Gravels and older terraces are abundant in the Lower foothills. A very large older gravel deposit occurs along the Sue River.

Gold occurrences.

The district has long been known for its gold potential and there are indeed several known occurrences of gold. Some of these have been known and mined since the middle of the 19th century. Hard rock gold occurs and there is widespread evidence of alluvial gold in recent and older gravels.

Vein Gold has been observed in several forms.

- Quartz veins as lenticular bodies in shales and schists. These veins and veinlets are fairly constantly mineralized, at times with free and visible gold.
- Quartz – calcite veins:
    4. with disseminated pyrite in altered diabase. The veins are pyritized and mineralized with gold.
    5. with chalcopyrite at the contact between diabase and black shales.
    6. mineralized fractures in the black shales and the diabase; these fractures carry gold.
- Calcite veins.
    2. These occur in fissure veins and lenses in shales and are mineralized with pyrite. Downstream of these veins intense panning has taken place. There is evidence of large nuggets being associated with the gravels.

All the above vein types have associated gold.

Alluvial gold.

There is widespread evidence of placer gold along the sections of the Sue, South Laclo and Cler rivers. Extensive re-working of old terraces has taken place giving rise to the formation of large placers.

Manganese.

While the environment of East Timor's massive sulfide deposits is also marked by the occurrence of manganese minerals, these may be expected in the form of an exhalative blanket much like iron formation in greenstone style massive sulfide environments. The manganese occurrences will therefore be mainly low grade and highly siliceous.

Material of one such occurrence was shown to the mission members in Lautem, but was not observed in outcrop. The available indications of manganese occurrences

from the literature are limited, with the best indication being described as 1000 ton large.
Literature from the western part of the island ('t Hoen en van Es, 1925.) confirms the absence of large manganese concentrations on Timor island.

Industrial minerals.

4. Bentonite clay. (Districts Bobonaro, Baucau and Manatutu.).

Large accumulations of bentonite clay are known from the above provinces, all occurring in the Bobonaro Mélange (Charles A-, 1968; Hamilton, 1979; Harris 2000.)
The clays are also reported in Rosidi (1975.) who refers to the typical 'popcorn' swelling texture of exposed bentonite, produced during successive periods of wetting and drying out.
Geologically the Bobonara unit is a tectonic/sedimentary melange and occurs very widespread over East Timor. It consists, simply put, of a clay matrix in which a large and wide variety of exotic blocks are found, all derived from older formations. The clays vary widely in color but are remarkably uniform in character and mainly smectitic.

The origin of the clay matrix has been discussed over the years and different opinions abound, the most acceptable for the purpose of this report being the sub marine alteration/conversion and subsequent uplifting of volcanic ash and tuffs.

The Bobonara Mélange being the most wide spread occurring unit on the island, there should be no shortage of clay deposits of good size and characteristics, however until now only the occurrence at Venilale in Baucau province has been evaluated in some detail. This occurrence contains some 400,000 cubic meters, say 1 million tons of bentonite clay.

In the field the Venilale deposit is readily observed from the road between Baucau and Viqueque.

It shows up as a major bed of the Bobonaro scaly clay formation in an incised riverbed. The thickness of the clays is several tens of meters and the extension along the gully is of several hundreds of meters. It may be estimated that the width is of several hundreds of meters as well, roughly confirming the available estimate of 400 000 cubic meters. *(Photo 7,8.)*

There is no information at hand on the quality of the clays but the typical popcorn texture of dried out bentonite is in evidence. Much further work needs to be done on the Venilale deposit and on reported deposits elsewhere.

To accommodate this need, a recommendation is made in the report for assistance in the evaluation of clay minerals through a small project that may be financed by the United Kingdom or the European Union and be executed by the British Geological Survey, who have wide experience in this kind of evaluation.

5. Phosphorites (Baucau Province.)

Phosphorites are known from Baucau (Badan Koordinasie Penanaman etc. 1987.), where they reportedly occur as accumulations in the Bobonaro Fm in Deamena near Abo village. The phosphate 'pellets' have the color of dark chocolate and are found as loose, unconsolidated materials, from sand to boulder size on ridges and slopes of hills. The location of interest is Bukit Makalosso.

Photo 8. Bentonite 'popcorn' texture, Veninale, Baucau.

Assays of the phosphate rocks return between 9 – 22% P_2O_5. A Japanese Consulting firm in 1975 reported a grade of 31%.
The minerals in the occurrence include Francolite and Grandalit.
The reports of earlier work, including the Japanese work, are not available and therefore no hard facts are at hand with respect to the size and outline of the occurrence. Neither is anything known about the style of mineralization, though the mineral Francolite, a fluor-apatite, points to a marine sedimentary setting i.e. a sedimentary phosphorite (Mathers, 1989.).

Upwelling type deposits may be large. Typical upwelling type phosphorite deposits may be between 20 and 400 million tons in size with grades between 15% and 25%.
If residual weathering and enrichment has taken place a so-called Tennessee style deposit may have formed with even higher grades.

An unsuccessful attempt to reach the location was made involving a long and difficult route between a point 5 kilometers North of Venilale due East towards Quelicai, but this attempt was abandoned due to time constraints. The direct route to Quelicai via Seical on the coastal main road is at the time of writing blocked by a large landslide.

The phosphorites remain to be evaluated. They may represent an interesting resource for a local small-scale fertilizer plant, if not for something bigger.

6. Other industrial minerals.

A variety of other industrial minerals is reported, these include the evaporites gypsum and salt, wollastonite, graphite and talc, silica sands, sulfur and ochre. Phosphorites are also reported, these have been discussed elsewhere.

Gypsum and salt are found in Ambeno, Bobonaro and Manatutu districts. Mostly just as indications, although a small tonnage has been quoted for the Manatutu district. The exact setting in which these evaporites occur has not been answered. Charles

(1968.) notes the occurrence of gypsum in the Wai Lulu formation (Jurassic.) but contends that this does not prove that this formation was not marine. He suggests that a highly anaerobic saline deep-sea environment was responsible for the deposition of salts. This would make it unlikely that large, good quality gypsum deposits may be available.
Rosidi (1979.) puts the gypsum occurrences of West Timor in the Bobonara mélange. This does not supply an indication as to the environment of formation as the mélange is characterized by a high incidence of exotic materials.

Also in East Timor gypsum occurs in the Bobonaro mélange, as observed by the mission in outcrop near Laleia in Baucau along the coastal road.

World wide most economic, large and high quality gypsum deposits occur in the Miocene or date back to the Triassic. In the absence of these indications, gypsum might not be a major potential mineral commodity in East Timor.

Wollastonite occurs in Bobonaro and Ermera districts. No details are provided for this high-grade metamorphic mineral.

Silica sands of uncertain quality is reported from several sites in Ambeno and from Manufahi district. In Manufahi large volumes seem to be indicated, reportedly close to one billion cubic meters. These concentrations on land would be the product of repeated alluvial concentration and washing of high silica content rocks. As such it would be an end member of the sand and gravel occurrences all over the country.
In the field good sands have only been observed along some of the beaches in Baucau and Lautem. *(Photo 9.)*
Developing those will no doubt be prohibited by environmental and coastal management policies. However, a serious search should be done for silica sand on raised beaches. These could be exploited within the constraints of coastal management policies.

Graphite occurs in Liquisa district; just an indication is apparently known.

Talc is reported from Aileu and Manatutu districts. In both cases there is only an indication with no further details.

Ochre is indicated in Lautem. This may be the so-called Cyprus ochre, related to massive sulfide mineralization.

In the field this ochre is seen in an area of significant clay alteration, near
Daudere, just South of the coastal road some 10 kilometers before the city of Lautem.

Sulfur is reported from Aileu, Bobonaro and Dili/Autaro. In Autaro and Bobonara the sulfur is a hot spring occurrence while in Aileu a volcanic rock association is reported.
No further details are available on these occurrences.

7. Construction and building materials.

Occurrence.
Extensive deposits of industrial rocks and sand and gravel are found all over the island.

1. Materials that are or are derived from igneous and volcanic rocks.

- *Gabbro, Andesite, Basalt, Diorite and Tuffs* are reported from 10 districts. The occurrences are mostly noted without details of reserves being provided, with the notable exception of the Ainaro district that has reportedly huge basalt resources with a total volume of well over 2 billion cubic meters.
- *Clays and mudrocks*, including *Bentonite and Kaolin*, are reported from 9 districts. Especially large reserves of clays from the districts of Ainaro, Bobonara and Manufahi where the total indicated resources are close to or well over one billion tons. A large resource of 400 million cubic meters Bentonite is reported from Baucau district. The largest kaolin deposit is in

Ailieu with a resource of 2.5 million cubic meters indicated. Many villages in the district are built on kaolin. *(Photo 10.)*

2. *Limestone and Dolomite* are wide spread and are reported from all but one (Liquisa.) district. Huge tonnages are found in Manufahi where billions of cubic meters have been outlined. Large resources also occur in Ainaro and Baucau.

3 *Marble* is reported from 10 districts, while *Travertine* is reported to occur in Baucau. The Manatutu district has the largest indicated volume of marble, a total of well over 100 million cubic meters has been indicated in several occurrences and deposits.

4. *Sand and gravel* occur most anywhere in East Timor and is reported from all districts, practically everywhere the indicated volumes are huge. The quality of sand and gravel, seen in many different river beds all over the country is low, being composed of a variety of mineral constituents, the name 'sand' just referring to the particle size.

Potential uses.

1. Basalt and Andesite for "rock armor". A priority opportunity would be in the use of basalt, andesite or other igneous or volcanic rocks to be quarried, on or near the southern coast and exported for use in the protection of pipelines in

Photo 10. Village in Aileu kaolin belt.

This so called “armor rock” could be developed very timely so that when decisions are made on laying pipelines from the Timor Gap oil field to the Australian Coast, East Timor, through a contractor or a developer would be in a position to supply this material.

2. Clays for brick making. This should, certainly in a country underlain for 60% by the Bobonaro Scaly Clay unit, where there is as yet no fuel source for cement production and where good construction sand is scarce, be a cottage industry. Given entrepreneurship and access to modern brick making technology, one could even think of larger operations.

3. Marble quarrying. The quarry at km. 52 along the Dili – Manatutu coastal road has been destroyed and is now inactive. It was however an active quarry before and can be one again if problems of land and resources ownership can be resolved. Country wide, but especially there where distances to a port are not excessive, marble quarrying can be an income and employment generating activity.Little is known about the quality of the marble in the various deposits; from initial observation the marble near Manatutu is of dubious quality as numerous streaks of a dark basic schistose material are crisscrossing the marble blocks but better material may be available and local entrepreneurship can play a role in exploring the marble occurrences and

4. 

Photo 12. Marble blocks rolled down-slope from inactive quarry, beach road, Manatutu.

Photo 13 Raised beaches, Manatutu.

Photo 14. Cemented coral reef. Close-up of photo 13.

8. Possible and speculative mineral occurrences that have not been reported but might occur East Timor.

1. Lateritic nickel. Based on the widespread occurrence of ultra basic rock units and based on trace element assays of samples of these rocks as presented in the literature (Harris, 2000.) one might expect concentrations of laterite nickel. Rosidi (1978.) reports garnerite, a nickel silicate typical for laterite deposits, in the explanatory note on the geology of West Timor.
2. However, no significant thickness of any kind of tropical weathering profile has been reported or seen in East Timor. This is in all likelihood due to the constant uplifting of the island, a factor which would inhibit the formation and preservation of thick soils.
3. Platinum group elements. Also in connection with wide occurrence of ultra basic rock suites, the potential for PGEs should not be dismissed out off hand. In fact, given the opportunity the government should encourage the assay of a limited number of samples from the ultra basic rock occurrences and from chromite deposits for these elements.
4. Diamonds. The 'underthrusting' of Australian continental margin crust, suggests that the 'basement' of Timor is made up of this material. Hence it would not be impossible to encounter diamonds on the island, maybe in alluvial or beach deposits. This is for all practical purposes a highly speculative observation but interested investors and/or researchers, providing they bear all the costs should be given every opportunity to investigate this possibility.

Oil and Gas.

9 Oil and gas occurences and potential.

Better than for any other mineral, oil and gas occurrences are well documented in East Timor. These occurrences are in the form of oil and gas seeps and saturated sands. Oil and gas has been found during drilling and has been exploited to a limited extent by local people. The exact number of the oil and gas seeps is not known, but a report submitted by Timor Oil in 2001 lists 30 seeps in an appendix.

Exploration for the real potential behind these indications has for a time been the driving factor for renewed geological mapping, starting with review of the oil and gas potential by the Allied Mining Company in 1937 and the mapping effort by Timor Oil in the late 1960s, later published as a memoir of the Geological Society of London (Charles, A-, 1968.) Sponsored work includes the report by Hunting Geology and Geophysics (1971.), for International Oil Exploration.

Most of the exploration work for oil and gas in East Timor has been carried out by Timor Oil. This company has been active since 1911 with an intense campaign completed between 1957 and 1975.
The work carried out during those years included 2000 kms of seismic lines, gravity work, geologic mapping and the drilling of 20 wells.
According to the company a total of close to 100 million US $ has been expended over the years.

Wells were drilled in the Aliambata area as early as 1911 – 1914, but the next generation of wells were spudded after an interval of almost 45 years. These were located in Ossulari, Matai, Clara Ullo, Suai Loro, Cota Taci and Ranuc in 1971. The off shore well at Mola was drilled in 1975, just before the company left the island at the time of the Indonesian invasion.

Initial drilling produced some positive results in the Matai anticlinal structure where oil was struck at depths of 700 – 800 meters. This discovery was never developed. Later wells at Suai intersected oil and gas shows at several depths of 200 meters, 1000 meters and at 1500 meters. Aside from these indications there have been no further discoveries.

Nevertheless, Timor Oil, in 2001, submitted a new a proposal for on-shore and near shore exploration and development work.
The proposal consists of a combination of data reviews, aeromagnetic surveys, seismic work and drilling for a total expenditure of 76 million US $. The drilling would include 10 on shore and 3 off shore wells.
While one of the more important reasons for the Timor Oil proposal is the progress made in the interpretation of Seismic data over the years, the proposal itself underpins the confidence of that company in the potential for commercial resources of oil and gas.

Other proposals for exploration and development of on shore and near shore oil and gas resources have been submitted to the Government, one of those from China, another from Independence Oil and Gas Joint Venture. The latter proposes to start operations with a mini refinery based on the flow of one or more of the known seeps, to be followed by exploration and development work if warranted.

These three proposals attest to the fact that some confidence exists in the oil and gas potential in the on- and near shore areas, however not all agree that this potential is really very good or, does exist at all.

In a review of the structural and depositional history of East Timor, Reed *et al* (1996.), using field and well data gathered by Mobil Oil Indonesia and Pertamina as well as historic data, are less than positive in their review of East Timor's potential for hydrocarbons.
They conclude that poor quality source and reservoir rocks as well as the probable hydrocarbon generation in the Eocene and the recent uplift would be limiting factors in the hydrocarbon potential on shore.
At the same the authors are inclined to believe that the best potential, if any, would be along the southern coast and immediately off shore. The latter however being very high risk and uncertain.

While the severe deformation of the compressed and uplifted rocks North of the Timor through will indeed seriously affect the hydrocarbon prospectivity, a more positive outlook is presented by workers from Gulf Indonesia for the potential of areas similar in geology to for instance off shore northwest Java. Encouragement may also be taken from successful plays in 'foreland' environments such as those in the Canadian foreland basins East of the Rockies and the South Falkland Plateau Basin off Argentina. In the latter geophysical interpretation has identified some key exploration targets including rotated block faults and open anticlinal folds, fault block and pinched out plays and thrust plays in deformed areas, equivalent to the southern margin of East Timor. Similar work has been proposed for the Makran accretionary prism in Pakistan/Iran.

The most optimistic statements for the petroleum potential of East Timor have recently appeared in an oil industry consultancy report by consulting geologist Tim Charlton (www.manson.demon.co.uk).

Charlton, basing his review on extensive evaluation and field experience in Eastern Indonesia, notes that East Timor has had little onshore hydrocarbon exploration for the last quarter century through the period of Indonesian annexation and that the hydrocarbon prospects are widely considered to be only moderate due mainly to tectonic complexity.
He considers however that good potential does exist, and that in particular several large and structurally simple inversion anticlines can be interpreted as having the potential to host giant hydrocarbon accumulations.

East Timor's Upper Triassic to Lower Jurassic restricted marine source rocks, are comparable to proven source rocks in the geologically similar and hydrocarbon productive island of Seram to the North of Timor and geochemical studies suggest similarities between Jurassic source rock sequences in Timor and those on the adjacent and hydrocarbon productive Australian Northwest Shelf.
The primary reservoir target in Charlton's study is a shallow marine siliciclastic succession of Upper Triassic-Middle Jurassic age encountered subsurface in an

exploration well in West Timor. Potential reservoir sequences are likely to be sealed by the Middle Jurassic Wai Luli Formation.

Charlton suggests that the most attractive structures for hydrocarbon exploration are inversion anticlines developed from Permo-Mesozoic grabens or half-grabens beneath
complex Late Jurassic-Tertiary imbricate thrust stacks. One such inversion structure was intersected by the Banli-1 exploration well drilled by in West Timor.
In East Timor a comparable structure is recognized North of Betano, this North Betano inversion structure is several tens of kilometers long, about 5 kilometers wide, and with a vertical closure of up to several hundred meters. Comparably sized but more deeply eroded anticlines are exposed in northern and central East Timor (e.g. the Cribas, Aitutu and Bazol anticlines). Along with the North Betano structure, these are considered to be the main targets.
Source rocks for the North Betano structure are likely to be oil-prone, marine sediments of Triassic and Jurassic age, deposited within a pre-inversion graben which developed during Permian-Triassic continental rifting.

In addition to these major structures, inversion anticlinal structures have also been – provisionally – identified in the Aliambata, Iliomar, Suai and Suete areas.
A second, related type of potential structural trap is an extensional rollover anticline at Pualaca formed during Permo-Mesozoic extension, but not inverted during Neogene collision. The Pualaca structure is associated with voluminous surface oil seeps.

The real test for East Timor's oil and gas potential will be the readiness of genuine oil companies to spend time and money to explore for it.

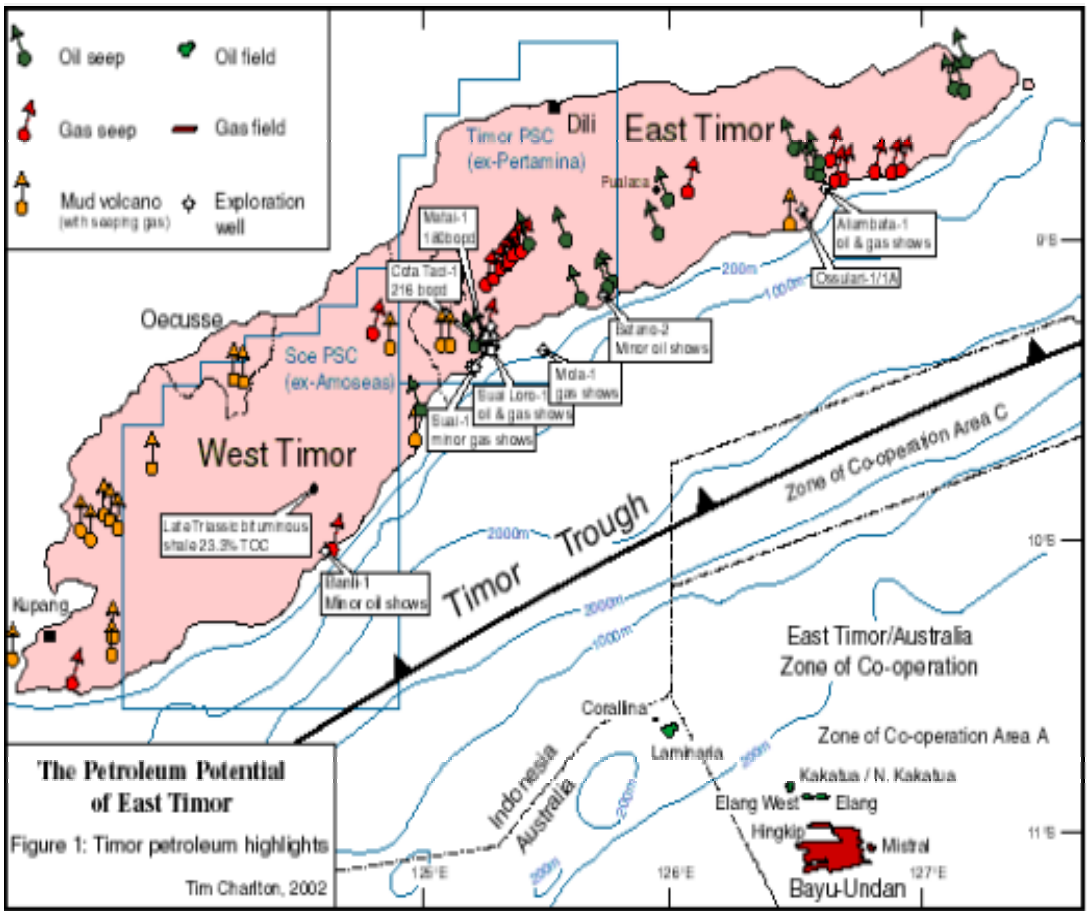

Fig. 2. Oil and gas composite overview map of Timor island. **(Author Tim Charlton)**

PART TWO.

DEVELOPMENT STRATEGY.

Mineral policy:

The decision on how to develop natural and mineral resources of East Timor is with the Government and the people of East Timor and only with them.

Exploration strategy.

Mineral development and mining is an economic activity best done by the private sector. Therefore in principle all further and future exploration in East Timor should to the extent possible be done by the private sector. In practice, this will be limited to those commodities in which there is a commercial interest and which may have demonstrated commercial potential. This may initially be limited to oil and gas, the metallic minerals sector and to selected industrial minerals and construction materials.

The government of East Timor can do some of the preparatory work for exploration, but this should be limited, even if not limited by resources, to work on data compilation and geologic mapping. All data collected, collated and gathered in such preparatory work should be made available at moderate costs to interested private investors, researchers and to the general public.

In the initial years, the Department of Natural and Minerals will to a large extent depend on outside assistance in data collection and training.

Foreign investment in the mining industry.

If the Government decides to develop and commercialize the natural and mineral resources of the country through private investment and invite foreign investors as well as domestic private investors to develop these resources, the Government must consider formulating and adopting investment policies for the mining sector along the lines of some of the policies that have been successful in attracting such investment elsewhere.

Such policies should put the responsibility and the risk of investing squarely in the hands of the private sector. In accepting the risk and the responsibility for investing, the private investor should receive assurances for the safety of the investments and the right to hold on to good discoveries and make profits.

At the same time these policies should aim for a balance between the interests of the investor and those of the government in such a manner that the government is assured a reasonable share of the commercial success of projects through royalties and taxation, improvements in infrastructure and employment.

Being successful in attracting foreign investment to the development of natural and mineral resources depends on several conditions, some of which can be influenced by government policy making, others not.

Perception.

In deciding to risk investment in any country, mining companies consider a number of variables before they move. Of these overall perception is an important consideration and may make or break investment interest.
This is not specific to the mining sector but applies to foreign investors across the board. A simple example in today's terms would be: Malaysia ----- Yes, Afghanistan ----- No!
Decisions based on perception are taken in corporate offices far away and often without the benefit of any local knowledge. They are however hard decisions and can not be easily changed.

For a formerly contested territory like East Timor it can realistically be estimated that before 1999 and between 1999 and May 20th 2002, perception would have been negative from a corporate point of view. After May 20th 2002, this perception will have changed dramatically and may be expected to be positive, even if in many cases cautiously positive.

Mineral potential, political stability, investment conditions.

Assuming an overall positive perception of the country as an investment destination, mining companies will then look at a series of conditions, some more important than others, but all part of the final equation.
Amongst these other factors, three stand out as being of primary importance, these are:

- Geological potential.
- Stability, including political stability.
- Investment conditions.

a.) Geological potential refers to the probability that mineral deposits will be found in the geological terrain of the country's territory. It is the most important consideration because, logically, if there is no geological potential, then no investment in minerals will be done, even if all other factors are positive.
If geological potential is good, other factors such as stability and investment conditions will be decisive in the decision to invest or not.
If geological potential is exceptionally good, mining companies may try to invest anyway, independent of how good other factors normally influencing such a decision may be. An example of the latter may be found in mining companies investing in the copper and gold potential of the Democratic Republic of Congo, even if long term political stability in that country is still not guaranteed.

b.) Stability includes political stability as well as expected or guaranteed stability of conditions laid down in licenses and other agreements, including fiscal conditions. In other words mining companies will expect guarantees that the contractual conditions they have entered into with the government will not too easily be changed over time.

c.) Investment conditions. This refers to the attractiveness of all combined conditions for investment in the mining industry. It includes the conditions laid down in the Mining Law and the regulations, the rates of royalties and corporate taxation, investment incentives and a host of other factors.

Some of the conditions a mining investor may expect in the country's Mineral Law and regulations are given below:

- When applying for a license to explore for minerals, a company expects that the principle of 'first-come-first-served' is applied.

- When an exploration license is granted, a company expects to have 'security of title'. This means that the license holder will keep the license and all the rights attached to it as long as the company is not in default or has not returned the license to the government. It also means that the license holder will automatically be granted a mining license if it applies for one over the exploration license area it holds. Most importantly it implies that in principle only holders of exploration licenses can apply for mining licenses over the exploration license area.
- Companies expect that there is no limitation on the export and sales overseas of mine products, concentrates and refined metals, including gold. If there is a requirement to sell gold or any other commodity to the central bank or any other government institution, they expect that such sales will be guaranteed at the world market prices in hard currency.

- Foreign investors want to have management control over their operations.

Several countries have mining policies that have been successful in attracting foreign investment many of those have recently adapted or reformulated these policies. The Indonesian Contract of Work, revised on several occasions, is one example. Others may be found in the new Mongolian mining legislation and the Pakistan 1995 Mineral Policy.

Typically these policies allow exploration of reasonably large areas during a time of five years and longer, they provide for security of title, a stable investment and taxation regime, transfer of title, repatriation of capital and profits, international arbitration and management control.

Obligations include normally minimum exploration expenditure per unit area, land rental fees, holding fees, royalties and taxes, reporting requirements, sharing of acquired information, environmental controls and guarantees.

Attractive policies are the Mongolian and the Pakistan mineral policies. Some aspects of these policies are discussed below.

The Mongolian mining investment conditions.

Mongolia, also recently emerged as a truly independent country, encourages investment overall, and there are several investment incentives in place, many are sector specific. Power, thermal plants and transmission of energy and transport infrastructure projects are strongly encouraged. Tax holidays of up to 10 years are available for investors in these sectors. For the mining and mineral processing sector and related downstream activities, tax holidays of up to 5 years are permitted, with another 5 years at 50%.

Import of equipment and other capital goods are VAT exempt, profits may be repatriated without charges.

Procedures for establishment and incorporation are simple and straightforward. Mongolia is a member of MIGA and has signed the New York Convention on the recognition and enforcement of foreign arbitral awards. Mongolia has signed separate investment treaties with several countries.
The Foreign Investment and Foreign Trade Agency is the ‘one-stop-shop’ for foreign investors. It employs simple and streamlined procedures.

Mongolia is one of a few countries worldwide emphasizing the development of the mineral sector as an important potential contributor to economic development and growth.

The main reason for this policy is the perceived mineral potential of the country, combined with the fact that with the exception of agriculture (Cashmere, wool, hides and leather, meat, grains and timber.), the other economic sectors are of less importance and may have limited growth possibilities.

The first mining law of the 'market economy era' was written with assistance from the World Bank and promulgated in 1995. The resulting inflow of foreign mining companies included BHP and Rio Tinto and a large number of other, smaller entities; more than 50 companies received licenses in 1996.

Yet, the government decided that the law was not attractive enough and therefore, in order to promote development of the mining industry more vigorously, the government adopted a new mining law in 1997. This new law may be considered as one of the most liberal mining laws in the developing world.

Mongolia's new Minerals Law (1997.) contains easy procedures for obtaining exploration and mining licenses, allows generous periods of validity for both, allows areas of up to 4000 square kilometers per exploration license, but does not limit the number of licenses that can be held, assures license holders of security of title, does not require a minimum work program, specifies an overall royalty rate of 2½ %. Licenses can be transferred and used as collateral. In order to provide for a stable tax structure for the long term, companies can negotiate 'stability agreements' that may last up to 15 years
The procedures for license application and registration are simple and straightforward.

Licensing is the responsibility of the Mineral Resources Authority of Mongolia, the implementing agency for geology and mining. It manages the licensing process,

provides information to investors, encourages investment in the mining sector, carries out research and collects information in geology and mining.

Overall the Mongolian mining investment conditions may be too lenient with not sufficient control over the individual investor and no requirements for the investor to submit a business plan at an earlier opportunity. Also the large areas available for exploration licenses and the absence of any requirements for submission of financial and technical capabilities

The Pakistan National Mineral Policy.

This mineral policy was formulated in 1995 by the Prime Minister's ' Task Force on Minerals' .
The Mineral policy provides the essential conditions required for the entrance of foreign mining companies in to the exploration and development of the country's resources.
Overall the policy is attractive to the extent that all major issues normally pursued by industry are addressed with a set of rules that are clear concise and transparent with most of them acceptable in general terms.

The regulatory regime defines 4 types of licenses;

- A reconnaissance license for up to 10,000 square kilometres , valid for one year, usually not exclusive
- An Exploration License, three years, up to 1000 square kilometres, renewable twice for a total of nine years.
- A Mineral Deposit Retention License, valid for two + one years. This license is available if market conditions prohibit bringing a deposit into production.
- A Mining Lease, max. 250 square kilometres, valid for 30 + 10 years.

License fees range from 300 to 2000 dollars. Land rentals are nil for a reconnaissance license, and range from 5 to 60 dollars per square kilometres for an exploration license.
Licenses can be transferred after the first two years of exploration, with the usual government approvals of the new licensee required.
In the whole sequence of licensing, security of tenure is guaranteed. There is a possibility for non license holders to apply for mining permits but not while an area is held under an exploration license by another party.

The MinPol allows for the possibility of the formulation of a Mineral Investment Agreement in order to stabilize the terms and to predetermine procedures.
Further the MinPol allows international arbitration, as well as full repatriation of capital invested and profits.

Royalties decreed in the MinPol are 3% for gold and 2% for base metals.

Unfortunately for Pakistan the well written mineral policy has not been very successful. This is mainly due to a perception problem and due to serious doubt in the mind of investors as to the stability of the political regime and the consequences for signed investment agreements.

How attractive is a mineral policy?

A cheap and efficient way to 'compare notes' on investment conditions in the mining sector and their attractiveness to the private sector is the holding of a so-called Round Table Conference between the Government and the private sector. Participation at such a meeting is for a selection of 10 – 12 private mining companies, small and large. The Government may present a limited number of papers on relevant legislation and investment conditions for a subsequent 'free and open' discussion between private sector participants and the Government.
The discussion can be chaired by a representative of the United Nations, UNDP or ESCAP. Private sector participants would attend by invitation but at their own

expense. A selection of field trips to ongoing projects or prospects for investment can be organized, also 'at cost'.
The discussion would indicate to the government how attractive the investment policies are and how the mining companies view the potential of East Timor.

Dealing with private mining companies.

An important aspect of the investment process is the ability to deal with private investors at their own level. In this, the experience and ability of the responsible department is crucial.
At the outset the importance of being able to evaluate the technical and financial strength of applicant companies or individuals and to listen to or read their intentions, making the right interpretation of commitments and guarantees cannot be overemphasized. Many governments have problems doing this properly.
Add to this the technical and financial capability to read and interpret technical reports, feasibility work, financial analyses etc, and it is clear that capability and expertise are indispensable.
This capability and expertise are not yet present in the government department of East Timor dealing with natural Resources and Minerals. Therefore as an interim solution and for the purpose of training of selected staff, it may be needed to place an international advisor at the disposal of the department or to retain an international advisor on an 'as neede' basis.

PART THREE.

Departmental structure, capacity building and data collection.

In view of the limited initially available capacity in East Timor, it seems justified to recommend a simple initial departmental structure for the Natural and Mineral

Resources. A first approach would be the creation of the office of the Secretary of State for Natural and Mineral Resources, under the responsible minister. The office of the Secretary of State would have two small departments responsible for minerals and geology and oil and gas respectively.

The Geological Survey and Mines Division.

However modestly, East Timor is in time in need of a Geological Survey and Mines Department to manage the resources of the country, to collect and collate data and information, to examine occurrences in the field, to prepare maps and reports, to evaluate license applications, to issue licenses and to interact with the private sector and potential investors.

Other tasks that may be assigned to the department include the review and management of groundwater resources, handling geotechnical issues and natural hazards.

A small departmental group is needed to administer Mines and Quarries. This group should handle the administrative and cadastral aspects of the licensing process, inspection, production statistics and a host of other aspects. It will also be the focal point for interaction with the industry.

More detailed recommendations in this respect are made in the sectoral report on Mineral Policy.

The Oil and Gas Division.

This department is to be charged with similar tasks as the Mines and Quarries Group in the Geological Survey and Mines Department but in the field of hydrocarbons. In view of the essential differences between oil and gas and mines, this should be set up separately.

Capacity strengthening.

The available capacity of the government is limited and needs strengthening. This strengthening can only be expected to be accomplished over the years. This report

suggests that initially most of this strengthening be done with the assistance of multi-lateral and bi-lateral sources.
Following are some project proposals that may address both the strengthening of the capacity as well as the issue of initial dat collection.

A PROJECTS THAT ADDRESS CAPACITY BUILDING, TRAINING AND THE FUNCTIONING OF THE OFFICE OF THE SECRETARY OF STATE FOR NATURAL AND MINERAL RESOURCES.

I. Capacity building and institutional strengthening in Geology, Mining and overall Resources Management. (Financed by USAID, executed by the United States Geological Survey.)

As every country, East Timor will in time need a well-organized government department responsible for the control and management over mineral, energy and water resources and eventually for addressing other related work such as geo-technical needs.
The appointment of a Secretary of State responsible for Natural and Mineral Resources is the first step in the process leading to the establishment and proper functioning of such a department.

Subsequent steps include the organization and above all, the training of the staff involved in the execution of the functions of a Natural and Mineral Resources Department.

Presently there are 3 trained geologists in East Timor. Of these, just one is directly working in the Department of the Secretary of State for Natural and Mineral Resources and one indirectly (On assignment to the Timor Gap office in Darwin.). The Department employs also a small number of geo-technicians.

In addition up to 7 nationals of East Timor are reportedly following studies in geology and/or engineering in Australia and Indonesia. When upon completion of their studies they return home, they could form the core around which an efficient functioning government service could be built.

Of necessity the initial staffing will have to be drawn from the available pool of human resources and cannot realistically include many trained geologists. The goal should be to have within the next decade a group of maybe 10 – 12 geologists, mine engineers, oil and gas specialists employed in the department.

Informally there has been an expression of interest in a capacity building project from the side of the United States Geological Survey, who have been engaged in similar projects elsewhere. The USGS is possibly the largest and certainly one of the best and best organized geological surveys in the world with a very large pool of expertise and would be an excellent executing agency for this project. It would be logical to approach USAID for funding.

II. Building, including a basic laboratory facility, equipment and associated training.
(Financed by the Government of Japan, executed by JICA.).

In order to be able to function properly, a Natural and Mineral Resources Department needs a place to work, prepare maps, store samples and perform some basic tests and analyses. No such a facility exists at present and, in view of the many still un-repaired facilities, no such facility can reasonably be expected to become available in the short term.

The Government of Japan has supplied a number of countries in the world but especially in Asia, with this type of facility and the necessary training.
It is assumed likely that the Government of Japan would positively receive a request for such a project in East Timor.

III. "On-the-job" training and scholarships in geology, mining and oil field engineering.
(To be provided and financed by all licensed exploration and production companies in oil and gas development and in mining.)

It should be considered a matter of course that all companies licensed by the government to explore for oil and gas and for minerals, have the obligation to train East Timor nationals in all aspects of their operations while in the exploration stage. In the absence of a large pool of trained geologists and engineers, companies should be encouraged to hire trainees with a completed secundary education and guide and train them as they progress in their work.

Once these companies enter the production or mining stage they may provide scholarships for those trainees, to study abroad in a field related to exploration and production. The number and duration of the scholarships should be reasonable and in proportion to the size of the operation. Appropriate clauses in the regulations appended to the mining law/oil and gas law, should reflect this obligation.

IV "On-the-job" training in evaluating exploration and development contract proposals from Oil and Gas and Mining companies.
(To be supported by the United Nations and executed by individual experts.)

With independence it may be expected that proposals for oil/gas and for exploration and mining projects will come in. One proposal for on-shore and near-shore hydrocarbon exploration has already been tabled by Timor Oil. Other proposals may be expected.
Proposals to evaluate and eventually mine the base metals resources of East Timor and other resources will undoubtedly also materialize in the near future.
It is essential that the Government of East Timor be assisted in the evaluation of these proposals by international personnel that have "hands-on" experience in reviewing and evaluating such proposals and that are familiar with government-company negotiations.

These services may be provided by the United Nations or through UNDP on an "as-and-when" required' basis, or on temporary, but regular assignment.
National counterpart personnel should be closely involved in these evaluations and/or negotiations.

B PROJECTS ADDRESSING DATA COLLECTION AND RESOURCES INVENTORIES.

The Government of East Timor should make a start with data collection and the execution of the basic tasks of a Geological Survey and Mines Department. In view of the limited capacity, this should initially be done with the help of bi-lateral or multi-lateral assistance programs. The following project ideas are data collection programs, but training and capacity building would be logical by-products.

V. A new geologic map for East Timor using and interpreting existing data and complemented by new data from an airborne magnetic survey.
(Financed by the Government of Australia; Executed by Australia's department charged with geological surveying, formerly AGSO.)

There is a need for a good geological map for East Timor, reflecting the re-interpretation of existing data and incorporating newly acquired data, with due attention for the unique tectonic history and location of the island.

Over the last decade modern re-mapping of large tracts of territory has been done in Australia by using the 'gray-scale-image' results of air-borne magnetic surveying at a line spacing of 250 meters, completed by limited fieldwork.
This technique could be applied to the territory of East Timor and the re-mapping should supplement the data of the various existing geological maps that have been produced over time.

VI. A clay mineral survey for East Timor
(Financed by the UK; BGS executed.)

East Timor is endowed with a very large potential for clay minerals. This is due to the fact that a large percentage of the country is underlain by the Bobonaro Melange, a geologic unit consisting mainly of clays and exotic blocks.
Earlier surveys have already identified large Bentonite resources, but detailed evaluations are lacking.
The potential also exists for the existence of valuable special clays.
A thorough review of the clay mineral resources may be done through a small, easily financed project that could be implemented by the specialized industrial minerals section of the British Geological Survey.

V. Industrial Minerals and Ornamental Stone Review and Inventory.
(Government of Finland; Finnish Geological Survey.).

Numerous indications for industrial minerals and building and ornamental stone such as Wollastonite, Phosphorite, Marble and others are included in the provisional database of minerals in East Timor.

For practically none of these minerals a detailed description of the location, quality and tonnage is available, partly because reports have been destroyed, partly because these details have never been investigated.

Industrial minerals and stone will play a role in the further development of the state. Some will be used in construction and agriculture, others may be good enough to be economically mined or quarried and exported. A thorough review of these resources will benefit the Government and also local and potential foreign investors in this sector.

The Geological Survey of Finland has extensive experience in the execution of country wide industrial minerals survey; they have successfully completed these for Kenya and other countries, and the he Government of Finland could well be inclined to provide funding for such a project.

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