

## Eritrea : Great Spot in the Eastern Africa?

### —Hidden Oil and Gas exploration/development potentials

- Only 12 exploration wells have been drilled in the Eritrean Red Sea vast sedimentary basin (100,000km<sup>2</sup>), mainly because of political risk such as border dispute with Ethiopia.
- Totally 12 blocks are open now including Red Sea, onshore near Red Sea, and western inland. There is a gas discovery well, and also oil/gas shows were confirmed in the most of wells. It is assumed that exploration potentials are remain.
- Oil/gas development environments are also favorable, because there are high population areas near the Eritrea such as Jeddah in Saudi Arabia. Also Red Sea is busy principle ship route, which will be favorable for the transportation.
- Recently activity of mineral exploration is high. Production from gold mine will be started from later half of 2010. 14 foreign companies are conducting exploration activity now. Particularly activities by Chinese companies are outstanding. They have strong relationship with Eritrean government through financial support to medical organizations.
- Asmara is very safe city and political risk is also relatively low.

#### 1. Introduction

Republic of Eritrea is the youngest independent country (**Figure 1**) in Africa (attained independence from Ethiopia in 1993) where it faces the Red Sea. It has long petroleum exploration history which started in 1920s by Italian company, but only 12 exploration wells have been drilled in the Eritrean Red Sea vast sedimentary basin (100,000km<sup>2</sup>), because of political instability such as independent dispute more than 30 years, and border dispute with Ethiopia (from 1998 to 2000).

“Recently, petroleum exploration in Uganda’s basin, which is located in the same Eastern African Basin, is very active. But areal distribution of sedimentary basin of the Eritrean Red Sea is more than 4 times of Uganda’s basin, and also the petroleum system is confirmed ”

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Director of Hydrocarbon Division of Ministry of Energy & Mines, Eritrea emphasized. In this report, I will discuss petroleum exploration potential of Eritrea, based on the information obtained during the visit of Ministry of Energy & Mines and Petroleum Corporation of Eritrea (PCE), in Asmara city.

## 2. Geological background and Oil/Gas exploration history of Eritrean Red Sea

Southern Red Sea, where Eritrean Red Sea is located in, is plate boundary between African Plate\*<sup>2</sup> and Arabian Plate, which is defined as extensional boundary\*<sup>3</sup>(Figure 1). It is Tertiary rift basin formed by separation of Arabian Plate from African Plate in the Miocene.

Petroleum exploration in Eritrea has started in 1920s. It has started by shallow exploration by Italian company at Bu el Issar Island in 1921, followed by exploration by Agip in 1930-1940, Mobil, Gulf and Shell in 1960-1970, Anadarko and Perenco in 1990s. It has long history but only 12 exploration wells have been drilled in the Eritrean Red Sea of vast sedimentary basin (100,000km<sup>2</sup>) (Figure 1, Table 1).

The most outstanding and only one discovery is gas discovery by Mobil in 1969 at C-1 well in the Defnin block. This well has drilled by targeting the Habab sand in the Miocene (pre salt), but it was encountered 55 days blow out around the bottom of salt (3,007m) and abandoned. Assumed pressure is 7,700psi, and estimated production rate from Habab sand is 5~20 MMcfg/d. After that, evaluation well (Chita-1) was drilled at 400m offset location of C-1 well by Perenco in 2005, but it was ended in gas show. Structural interpretation for the drilling may not be enough because line intervals of 2D seismic survey is around 5~15km.

On the other hand, oil and gas shows are confirmed in the most of wells (Table 1). For example, tar is exposed in the surface of Dahlac Island, which is related to exploration well drilled by Agip in 1930s. It is also observed a number of offshore oil seepages although they are sight observation by habitants (Figure 1). Therefore we can expect both oil and gas accumulation in this sedimentary basin.

Seismic survey data is acquired almost all area except around the Dahlac Island (shallow depth) and deep water north-eastern area, but they are 2D seismic survey data which has course survey intervals (Figure 2). It has not acquired seismic survey data onshore area, but it

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is assumed that data acquisition in Gulbub block is relatively easy because it is plane area.

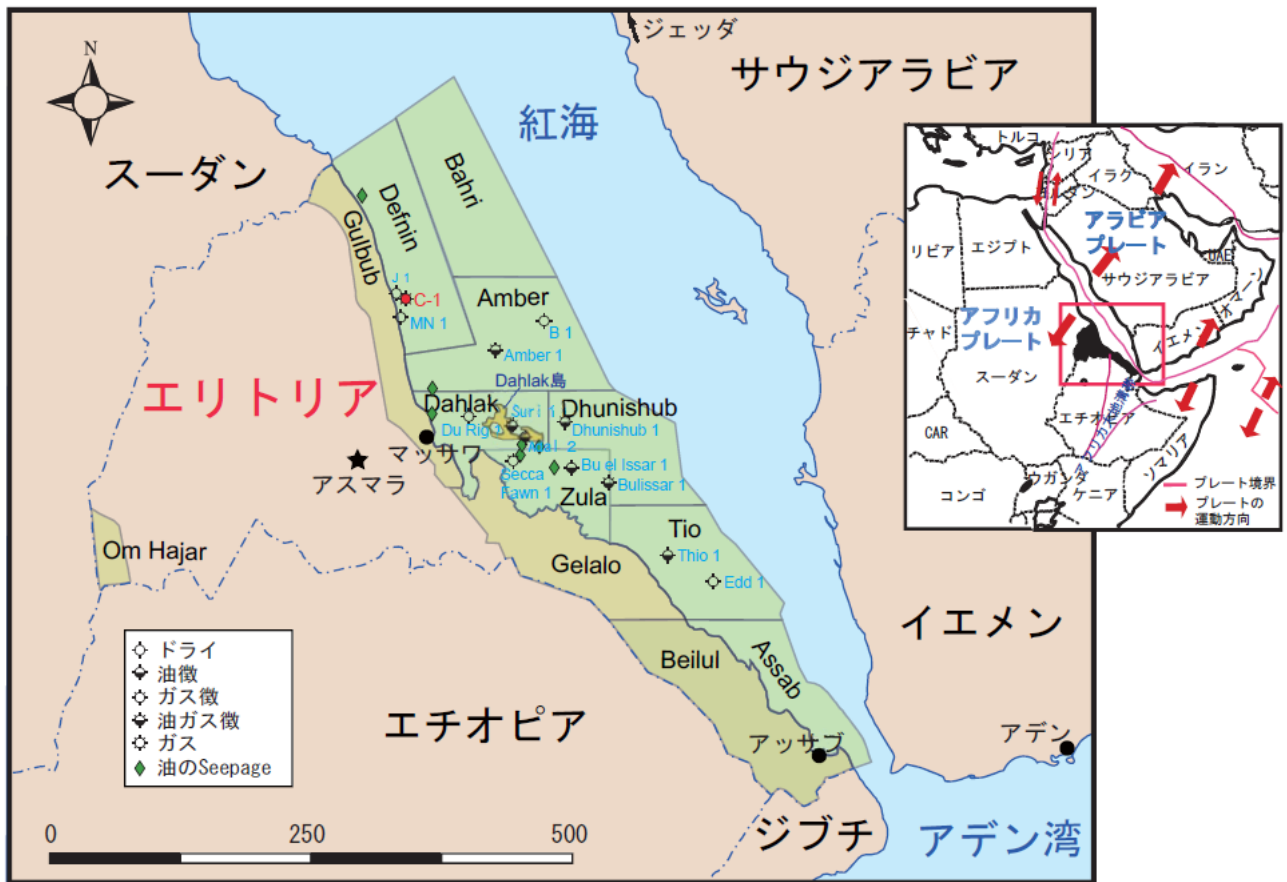


Figure 1 Petroleum Exploration Blocks and existing wells in Eritrea.

(Based on the publication of Ministry of Energy & Mines, Eritrea)

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Table 1 Existing exploration wells in Eritrean Red Sea and drilling results (order of drilling)

(Based on the publication of Ministry of Energy & Mines, Eritrea, Savoyat et al. (1989), etc.)

Well Name	Brock Name (Present)	Drilling year	TD (m)	Drilling company	Drilling Results	Thermal gradient (°C/100m)
Bu el Issar-1 (Onshore: island)	Zula	1921	n.a. shallow	SMAO	Oil show	n.a.
Dahlak-1 (Onshore: island)	Dahlak	n.a.	152	Agip	n.a.	n.a.
Suri-1	Dahlak	1940	1,700	Agip	Oil show	n.a.
Adal-2 (Onshore: island)	Dahlak	1940	2,475	Agip	Oil show	n.a.
Ras Shoke-1 (Onshore: island)	Dahlak	1940	603	Agip	Dry	n.a.
Amber-1	Amber	1966	3,557	Mobil	Oil/Gas show	n.a.
Dhunishub-1	Dhunishub	1966	3,867	Gulf	Oil/Gas show	n.a.
C-1	Defnin	1969	3,010	Mobil	Gas discovery	5.06
MN-1	Defnin	1969	2,868	Gao	Dry	4.06
B-1	Amber	1969	2,965	Mobil	Oil/Gas show	5.58
Secca Fawn-1	Zula	1969	3,363	Gulf	Gas show	6.18
J-1	Defnin	1973	3,137	Gao	Dry	4.42
Thio-1	Tio	1977	3,119	Shell	Oil show	4.18
Bulissar-1	Zula	1998	4,199	Anadarko	Oil/Gas show	n.a.
Du Rig-Rig -1	Dahlak	1998	2,200	Anadarko	Dry	n.a.
Edd-1	Tio	1999	3,262	Anadarko	Dry	n.a.

n. a. – Data is not available. Drilling results are based on the publication of Ministry of Energy & Mines, Eritrea

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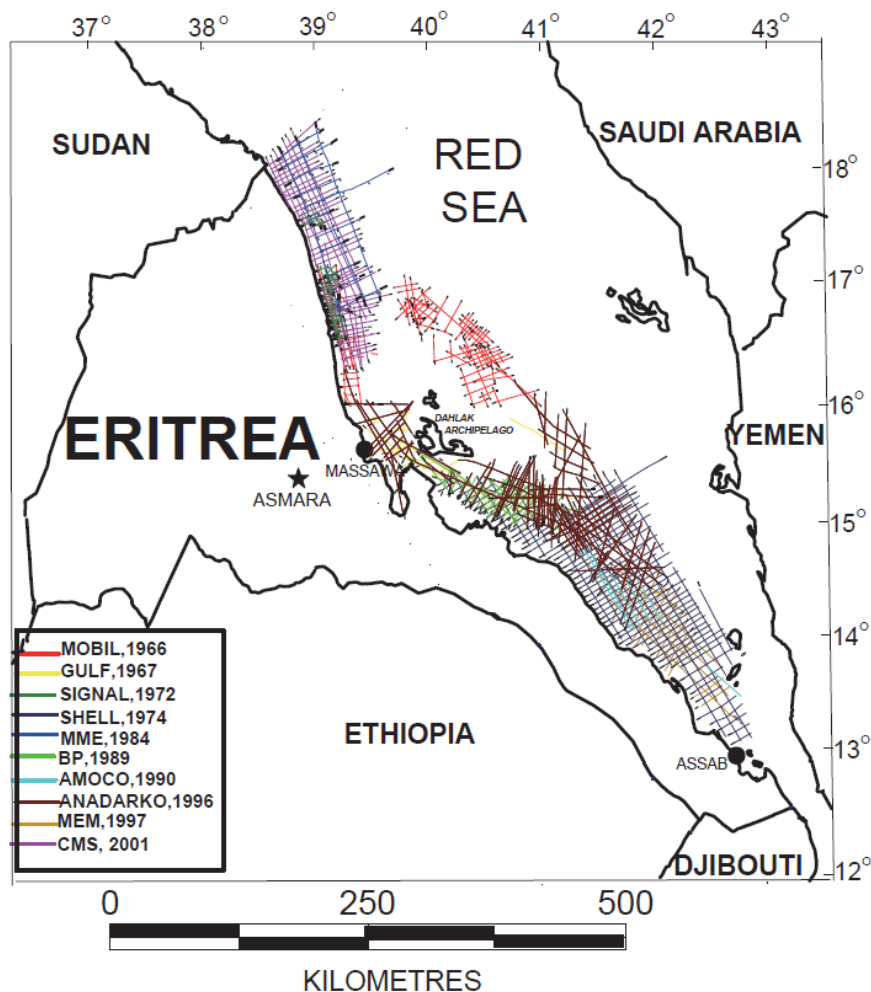


Figure 2 Existing 2D seismic survey lines

(Quoted from the publication of Ministry of Energy & Mines, Eritrea)

### 3. Outline of Open Blocks—Totally 12 Blocks are possible to join—

Totally 12 blocks are open now including Red Sea, onshore along Red Sea, and western inland (Figure 1). Defba Oil Share Co. (Joint venture between PCE and Energy Alliance) was joined northern 2 blocks (Bahri, Defnin) in October 2008, but office in Asmara has not yet opened and there is no progress in exploration activity. Saudi Arabian company (royal family) and Bahrain company, which was the investor of Energy Alliance, were withdrawn from the project because of the influence of financial crisis and M&A. Presently only BGP (geophysical company under CNPC) is remain and they are looking for the partner. On the other hand, one western company is applying the Dhalak block. Therefore, basically every block is applicable

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now.

Production Sharing Contract (PSC) is applied for the basic contract with 4 years exploration (maximum 4 years extension) and maximum 25 years development/production period (possible to extend to 10 years). It is negotiable for the minimum obligation and expenditure during the exploration terms, and royalty. Income Tax is 35% (it was decreased from 50% in 2000). More detail, please refer to the website of Ministry of Energy & Mines, Eritrea.

Ministry of Energy & Mines prepared technical report about exploration potential of Eritrean Red Sea (Two Volumes), which can be purchased by 500 US\$. Data reviewing by Japanese companies in Asmara are welcome at any time, and it is free of charge. CA is basically not requested for the reviewers.

#### 4. Discussion about exploration plays and exploration/development potentials

In this section I would like to discuss petroleum system and petroleum exploration potentials in this area. I fortunately had a chance to discuss with the Director of Hydrocarbon Division of Ministry of Energy & Mines, Eritrea, about this subject when I visited Asmara. His background is geology and geophysics, and he has experience of studying the subject at the Leningrad Institute of Mines for 6 years.

Main source rocks in this area are assumed to be the Miocene marine shale of the Desset formation, Amber formation, and Habab formation (Figure 3). Actually, good oil prone (Type 2) source rock with 3-8.5% TOC\*<sup>5</sup> (in 305m gross thickness sediments) has confirmed at the upper Habab formation of J-1 well in the Defnin block. On the other hand, upper Jurassic Agula shale and Antalo formation are also expected to have source rock potential, although they have not been drilled. Main reservoir rocks are also sands in the Desset and the Habab formation (Figure 3). Sand layers for the reservoir rock have been confirmed most of wells, but they are slightly silty. We can expect Pre-rift (Jurassic and Cretaceous) play in onshore blocks. Regarding to the trap type, fault trap and horst structure with northwest-southeast trending faults are principle. Salt in the Amber formation and shale in the Desset formation are expected as a seal formation.

Director of Hydrocarbon Division commented to me as following. “Generally speaking,

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extending plate boundary such as the Red Sea has higher thermal gradient (thinner sediment) and thought to be not ideal for oil/gas accumulation. However, actual width of the trough in the Red Sea is narrower and thermal gradient is not so higher than every exploration geologist think, particularly at the outside of the trough. Recently, petroleum exploration in Uganda's basin, which is located in the common Eastern African Basin, is very active. But areal distribution of sedimentary basin of Uganda is only 23,000km<sup>2</sup>, while the Eritrean Red Sea is more than 4 times of Uganda's basin (100,000km<sup>2</sup>). Although geological setting is not exactly same, we can expect oil/gas accumulation in the Eritrea”.

Certainly when we look at the bathymetry map, the trough area in the Eritrean Red Sea is very limited and most of the part is continental shelf, which has shallower water depth than 200m. Sediment thickness in this area is more than 4,000m based on existing offshore wells (All existing wells were not penetrated into the basement). In addition, thermal gradient is not extremely high (around 4.0~5.0°C/100m) except Secca Fawn-1 (6.18°C/100m) although there are areal variation from 2.56 - 6.18°C/100m (Table 1). Thermal maturity modeling by Savoyat et al. (1989) suggested that main source rock, upper Habab formation, at well J-1 (4.42°C/100m) is presently in the oil window. If we look at the Albert basin in Uganda, for example, thermal gradient is reported to be 5.5°C/100m (Curd et al., 2009). Overall, his comment is interpreted to be quite reasonable.

I also asked his personal comments about the possibility (potential) of inorganic natural gas\*<sup>6</sup>. It is not wondering even if there are gas accumulations due to mantle source gas, because Eritrea is one of the most famous volcanic regions in Africa. About this question he commented that Eritrea could be one of the most ideal places for it if this (inorganic source) theory is effective.

I asked him “Which block will be the most recommendable for you” in a straightforward manner. His answer was the Zula block. In this block, Anadarko conducted seismic survey from 1996 to 1997, and as a result of followed reprocessing and interpretation they extracted several prospects. Anadarko was withdrawn from this block in 1999 because of the decision by managements, but technical people were interested in further exploration because of high remaining potential.

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Regarding to the development environment, gas discovery is active in Egypt (northern direction) and gas exporting infrastructure in Yemen (Gas production from Marib field and LNG facility of Balhajaf in the Gulf of Aden) is going to be established. Not only oil transportation but also natural gas transportation may not be difficult.

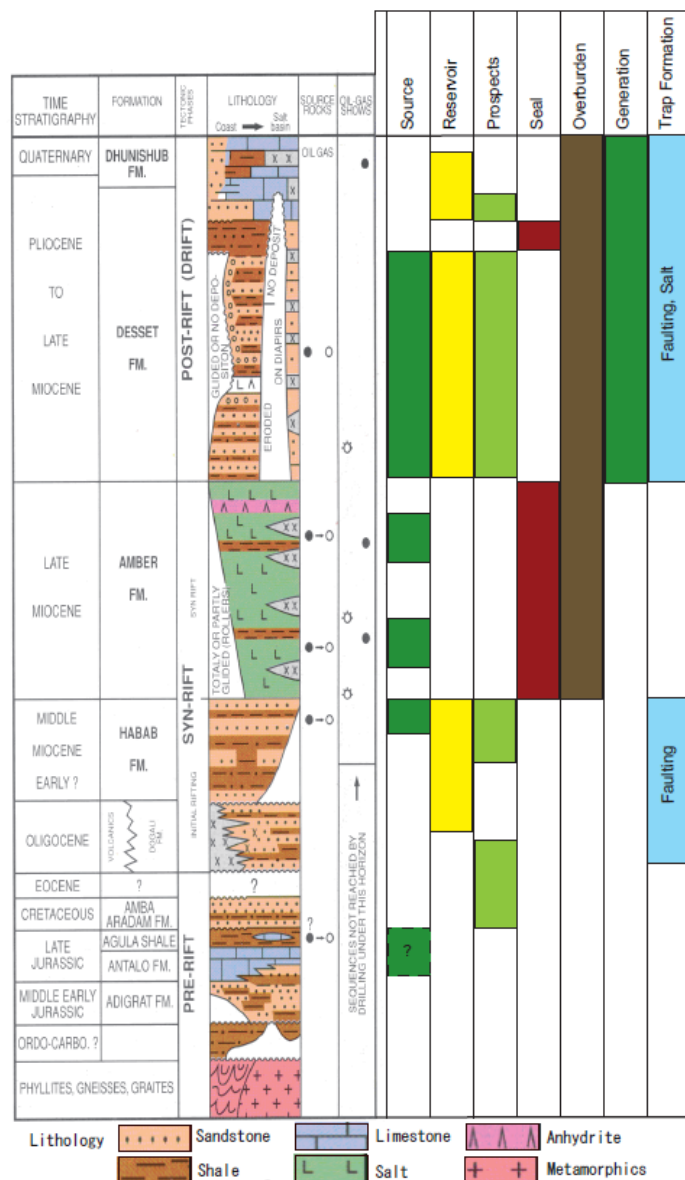


Figure 3 General stratigraphy and petroleum system in Eritrean Red Sea  
(Based on publication of Ministry of Energy & Mines, Eritrea)

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## 5. How about marketing environment ?—Comments by General Manager of PCE—

I had an opportunity to have a meeting with General Manager of PCE in Asmara.

He is a specialist of oil refinery and marketing. He has been working at an oil refinery company (it was stopped in 1990) in Assab (port city at the south Eritrea) more than 10 years as a manager before the independence from Ethiopia. PCE is the public enterprise established by Eritrean government in 2008, for the promotion of domestic oil and gas exploration and development. PCE invests in projects together with domestic or foreign companies. It is similar to so-called “NOC” in producing countries, but the magnitude of budget and employee is smaller at present stage. Presently downstream investment such as LPG is main business, but they are investing 35% for Defba Oil Co. when it was established.

He gave me a comment about oil/gas marketing environment in Eritrea, in case of there is large oil/gas discovery in Eritrean Red Sea. Oil has no problem needless to say, but it is also good geographical setting for natural gas development. Eritrea can be a favorable gas supplier for surrounding large cities such as Jeddah in Saudi Arabia (3.4 million people in only Jeddah city area in 2007), where gas shortage is critical. Red Sea is worldwide “busy line” for ships (transportation) and it is ideal place for gas supply. In addition, north neighboring country Sudan has petroleum exploration activity in the Red Sea. If these projects are successful, it may possible to have joint projects.

## 6. Accelerating mining development projects and hopeful geothermal development

I also asked about present status of mining development to the acting Director of mineral resources development. Totally 14 companies are involved in exploration activities in the Eritrea presently (Figure 4), and there are about 10 offices in Asmara city. Mining development is becoming more and more active because first production from gold mine after the independence will be started by Bisha Mining Share Company (Canadian Nevsun Resource: 60%, Eritrean government: 40%) from the latter half of 2010.

Participation by Chinese companies is also outstanding. Minister of Energy and Mines visited China at later 2009 and joint study contract about mineral resource development (Geochemical sampling from geothermal water) was agreed at the end of November. On the

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other hand, impression for Japanese company seems to be generally good because Ethiopian-Japan Joint company(Ethio-Nippon) used to have exploration project near Asmara city (South of Asmara) at 1970s (in early stage of mining exploration).

In addition, geothermal exploration has been conducted at the south of Masswa by financial support of Iceland government. This area is called as Alid Volcanic area, largest geothermal area in Eritrea, where hot water is bubbling in the surface. It is expected as one of the important energy resources for Eritrea, one of the energy resource poor countries.

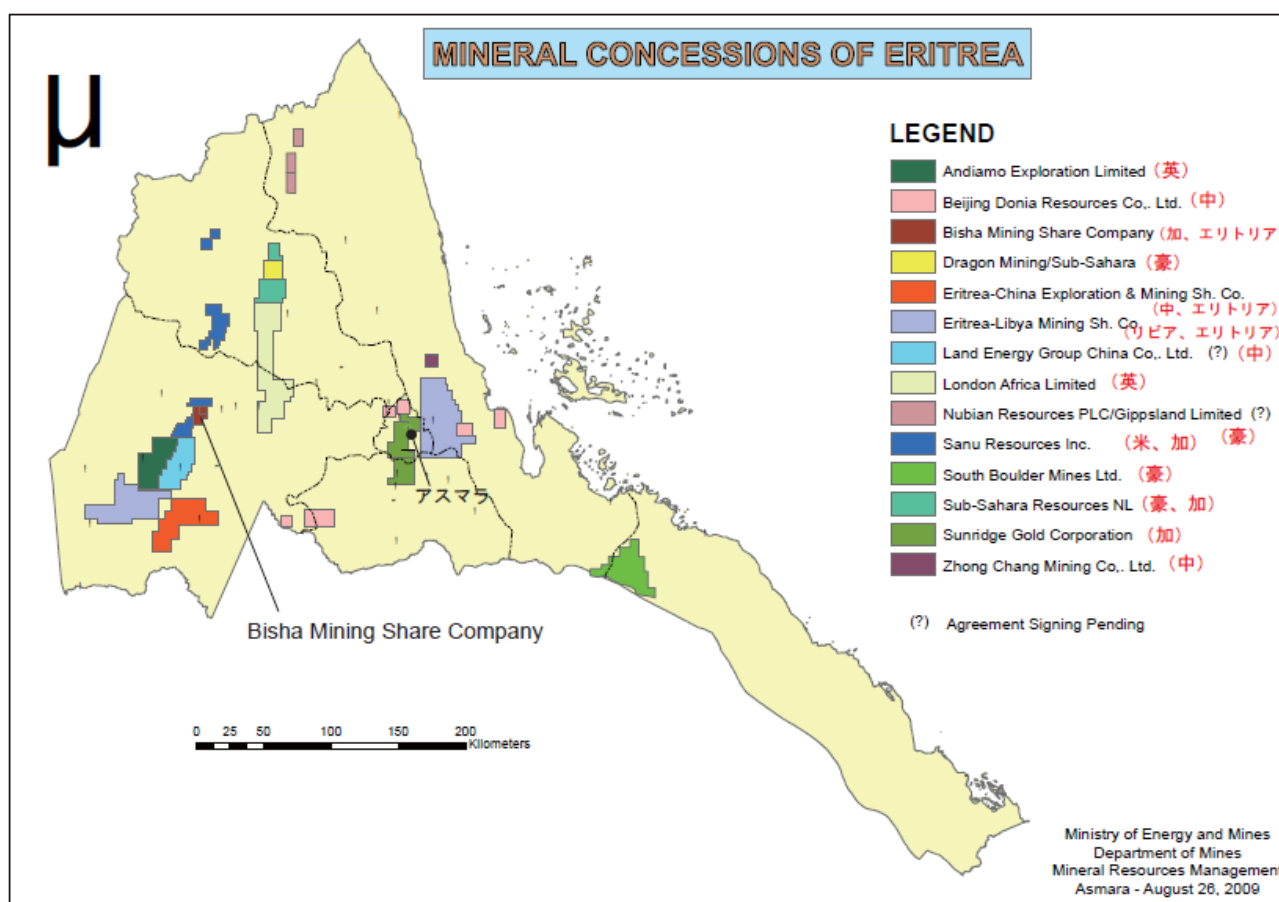


Figure 4 Mining exploration blocks in Eritrea (as of August 2009)

(Based on the publication of Ministry of Energy & Mines, Eritrea)

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## 7. Entry and departure, public safety/climate of Asmara

Baggage inspection and foreign currency inspection in Asmara airport is strict. When we entered the country, we needed to fill the declaration form and also fill the remaining balance at hotels or exchange counters. We also need to fill the details of PC such as serial number in the declaration form. This is because of crackdown on the black market.

Asmara is very safe city (at least in December of 2009 when I visited there). When I asked about public safety of Asmara to the General Manager of PCE, he emphasized that “It is the most peaceful capital city in Africa and Europe among I visited before”. He said “I would like to show you how safe Asmara city is” and introduced me the city after the meeting, 7:00 pm. Certainly, everybody looks very friendly and kind, and there is no dangerous atmosphere at all. It was understandable for me that Asmara is called as “one of the few countries where woman can walk alone at night”. In that way, we don't need to concern about public safety issue for the office establishment.

About weather, it is not humid at all and it is very comfortable because it is located at the highland area of 2,350m elevation. It was anticipated that it should be very cold before my visit, but actually it was very comfortable and I could walk the city without jacket at day time due to the strong sunshine (Figure 5).



Figure 5 Pictures of Asmara city

(Left: Main street, Light: St Mary's Cathedral and public bass and taxi)

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## 8. Summary

I occasionally met one Japanese technician in Asmara who was sent from Japan for the medical project by Japanese government. He told me that Chinese financial support or temporary staffing is being conducted extensively in Orotta hospital, one of the largest hospitals in Asmara. This seems indicating the strong relationship between Eritrea and China. On the other hand, he mentioned that President of Eritrea is recently focusing so much on Japanese education method and workplace slogan (so-called 5S). Eritrean people are diligent, and Asmara is very safe city. About political risk, it can't be said that it is low, because temporary government by single party has been governed the country since 1993. However, it is important to look at this kind of unexplored area which has good exploration conditions as one of the future target. In the actual exploration stage, technology and education, some of the Japanese strength will work effectively for the acquisition of new interests.

## Comments

\* 1: Definition of petroleum system.

\* 2: Definition of plate

\* 3: Definition of extensional plate boundary.

\* 4: Based on the publication by Ministry of Energy & Mines, Eritrea, 2006, it is described as 12 wells. It is assumed that above 12 wells are excluding wells drilled onshore (island) in Table 1.

\* 5: Definition of Total Organic Carbon.

\* 6: Definition of inorganic source natural gas.

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