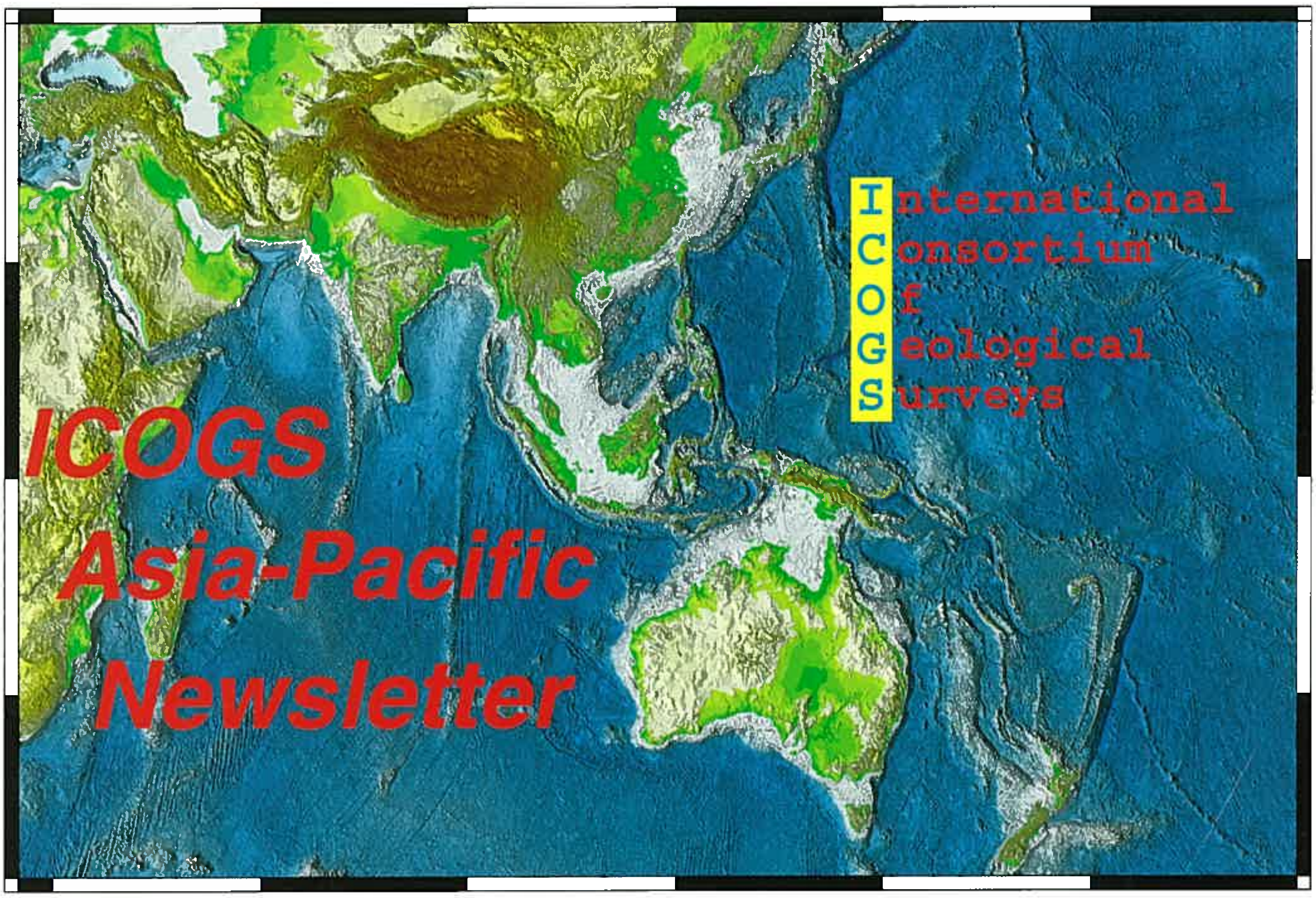


ICOGS ASIA-PACIFIC NEWSLETTER

No.7, March 2005

CONTENTS

From ICOGS Secretary for Asia and the Pacific

At first, I would like to express my deep sympathy to all people who suffered from the devastating Sumatran earthquake and tsunami, which hit Indonesia and other countries around the Indian Ocean. It was particularly sad and tragic that so many people had died and were wounded because of the lack of knowledge and warning system regarding tsunamis. An adequate knowledge among the public with an early warning system would have considerably reduced the number of victims. It goes without saying that this was a strong message that further strengthening of cooperation in the mitigation of geohazards in the Asia-Pacific region is a matter of utmost urgency.

Now, it is my great pleasure to send you the seventh issue of the ICOGS Asia-Pacific Newsletter. We sought articles for this issue with a plan to publish a special volume on natural resources. As a consequence, we have received five articles from Indonesia, Nepal, Taiwan and Japan. I hope these articles would be of interest to you.

Dr. Hadiyanto, Director of Mineral Resources Inventory, Indonesia, submitted an article on Indonesian coal resources. Indonesia is well known as an oil producing country, but he shows that coal is also very important for Indonesian domestic energy-source as well as for export, and that this importance will increase in the future.

Messrs. N.R. Sthapit and Krishna P. Kaphle of Department of Mines and Geology, Nepal sent us an article, "Present Status of Gold Prospects in Nepal". They describe placer and primary gold occurrences in Nepal on the whole. Although there is only one article on mineral resources in this issue, metal and other mineral resources are still important study targets of geological survey organizations, and it is obvious that the importance of mineral resources will increase in the future with rapid economic development of the region.

Gas hydrate is now attracting worldwide attention as a new type of energy resource. Dr. Yungshuen Wang from the Central Geological Survey, Taiwan, submitted two short articles on gas hydrate. The first one gives us information on a four-year (2004-2007) investigation programme, which is being carried out by the Survey, while the other is a report of 2004 International Workshop on Gas Hydrate Exploration and Exploitation, which was held in November 2004 in Taipei. Dr. Y. Okuda of Geological Survey of Japan also reported on the very active studies being carried out on gas hydrates in Japan.

I plan to continue publishing this Newsletter regularly. Any information which would be of interest to other geological survey organizations will be accepted for future issues. I would particularly welcome items such as new trends in your country and organization. All correspondence relating to the ICOGS Asia-Pacific including its newsletter should be addressed to Takemi Ishihara.

Finally, I would like to express my sincere thanks to all the authors of the above articles as well as to Dr. Yoshihiko Shimazaki, who kindly read and edited all the manuscripts, and also to Mrs. Sumiko Miyano and Mrs. Akane Shima, who carried out editorial work with utmost care.

Takemi Ishihara
ICOGS Secretary for Asia and the Pacific
Geological Survey of Japan, AIST

INDONESIAN COAL RESOURCES: RECENT UPDATE

Hadiyanto

Director of Mineral Resources Inventory
Department of Energy and Mineral Resources
Republic of Indonesia

1. INTRODUCTION

Coal is the world's most abundant and widely distributed fossil fuel. It currently accounts for 30% of the world's consumption of primary energy and provides fuel for the generation of around 40% of the world's electricity. Coal has also historically been a key source of energy and a major contributor to economic growth in many industrial countries.

It is predicted that the world coal consumption will increase from 5.3 billion tons in 2001 to 7.5 billion tons in 2025. In the ASEAN region demand for energy, especially for electricity, also continues to grow. Coal is one of the main fuel meeting this rising demand with a market share of about 20% of the energy mix.

Indonesia has significant coal resources. Since the 1980s (after the first oil shock), Indonesia's coal has increasingly become important and plays a key role in fulfilling national and regional energy demand. In Indonesia, coal provides a reliable supply of domestic energy-source while it is also one of the sources of foreign exchange revenue.

It is the aim of this paper to present a current situation of Indonesian coal resources. Data was compiled from several sources, including the most recent data from Directorate of Mineral Resources Inventory and Directorate of Mineral and Coal Enterprises Indonesia.

2. INDONESIAN COAL DEPOSIT

The most important coal bearing sequences in Indonesian Tertiary basins are Paleogene intermontane and continental margin basins and Neogene continental margin basins. More than 90% of Indonesia coal resources occur in Sumatra (67%) and Kalimantan (32%).

The Paleogene (Eocene) coals measures are known to occur in Ombilin basin in west Sumatra, Central Sumatra basin in Riau, Pasir and Asam-asam basins in South

Kalimantan and East Kalimantan, Barito basin in South and Central Kalimantan and Ketungau in West Kalimantan. Small deposits of Eocene coal are also present in South Sulawesi and West Java. Neogene (Miocene) economic coal measures are deposited in South Sumatra basin in South Sumatra, Bengkulu basin in Bengkulu, Meulaboh basin in Aceh, Kutai and Tarakan basin in East Kalimantan and Barito basin in South Kalimantan.

Indonesian coal was formed from peat deposits in an equatorial paleoclimate similar to that prevailing today. Some of these peats were domed peats, which grew above the level at which water borne mineral matter can enter the system, under a climate of year-round rainfall. These conditions resulted in coal with low to very low ash and sulphur content, which make Indonesian coal environmentally-friendly and relatively attractive for export.

3. COAL RESOURCES IN INDONESIA

Table 1. Indonesia coal resources, reserves and calorific value 2003

Class	Criteria	Resources (M ton)						Reserves
		Measured	Indicated	Inferred	Hypothetic	Total	Total %	
Low	<5100	4,021.03	9,581.22	1,511.82	0.00	15,114.07	26.13	3,452.04
Medium	5100-6100	4,997.27	10,255.22	17,462.51	475.53	33,190.53	57.37	1,809.06
High	6100-7100	3,328.85	695.80	4,887.84	57.27	8,969.76	15.51	1,661.84
Very high	>7100	119.27	1.32	452.79	0.00	573.38	0.99	58.68
Total		12,466.42	20,533.56	24,314.96	532.80	57,847.74	100	6,981.62

The 2003 statistics show that coal resources in Indonesia totals 57,847.74 M tons, about 12% (6,981.62) of which is categorized as reserve deposit (Table 1). From Table 1, it can be seen that most Indonesian coal resources is low (26.13%) to medium (57.37%) class. Only about 15 % of this reserve is categorized as high rank, while the rest is in the form of brown coal and lignite coal with calorific value less than 5100 cal/gr adb (lignite) account for about 50% (3,452.04) of total coal reserves.

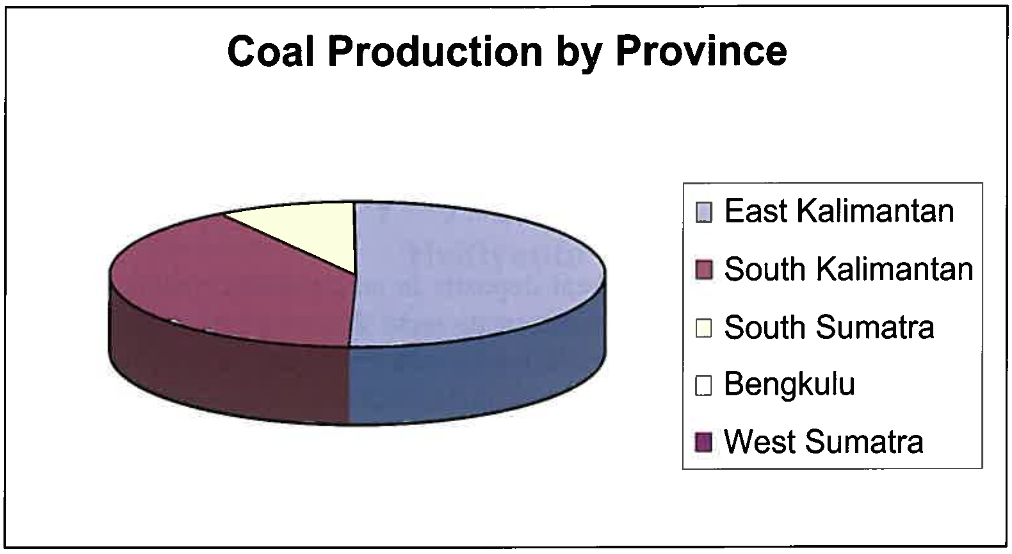


Fig. 1. Coal production by province

In more detail, the statistics also reveal that East Kalimantan province, currently is the largest coal producers in Indonesia with 57,693,479.71 ton coal production in 2003 (Fig. 1). The second largest coal producers is South Kalimantan (46,11,289.79 tons), followed by South Sumatra with 10,017,074.00 ton coal production respectively.

Most of Indonesian coal production is for export. Currently, Indonesia is the third largest thermal coal exporter after Australia and South Africa. Domestic market consumes about 30% of total coal production. More than 70% of it, consumed by power plant, whereas the rest by industries and household. Presently, coal is the third largest as primary source of energy for domestic consumption, after oil and natural gas (Fig. 2), whereas coal ranks first as primary source of energy for power sector (Fig. 3).

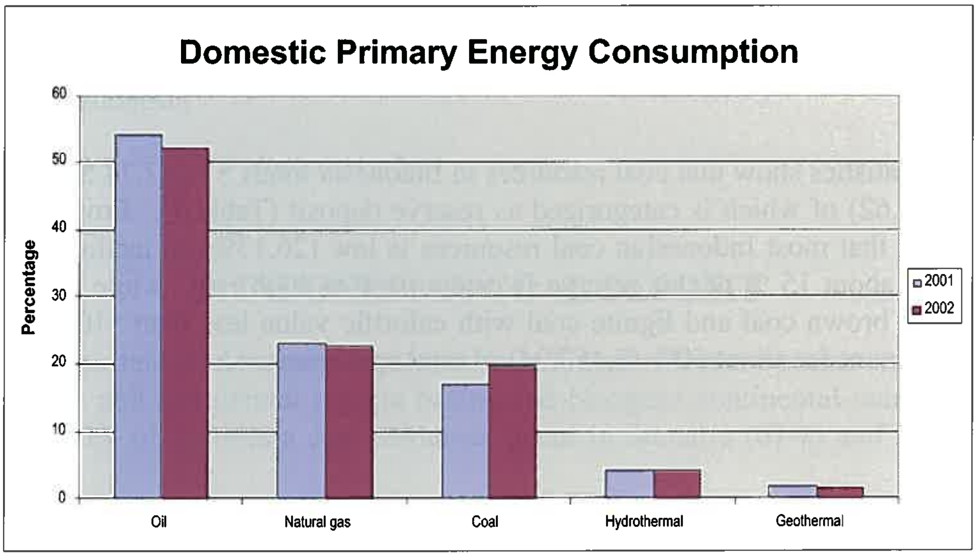


Fig. 2. Domestic primary energy consumption

Coal consumption by Indonesian steam coal-fired power plants is expected to increase from 14.7 M tons in 1999 to 27.8 M tons by 2005. There are several benefits using coal for the source of energy compared to other fossil fuel resources, such as oil or natural gas. The coal price is quite cheaper compared to any other fossil fuel, its CO_2 emission is also lower than oil, natural gas or biomass. It is projected that coal in the next decade will become the main alternative energy for Indonesia.

From Fig. 2 it is clearly seen that, during 2001-2002, there was an increase in coal usage for domestic primary energy consumption, while the consumption of four other major energy-sources decreased significantly. Similar phenomena are also noted in power sector. Coal became the biggest source of energy used for power generation, and its ratio among other power sources also rose from about 40% in the year 2001 to around 43% in 2003 (Fig. 3).

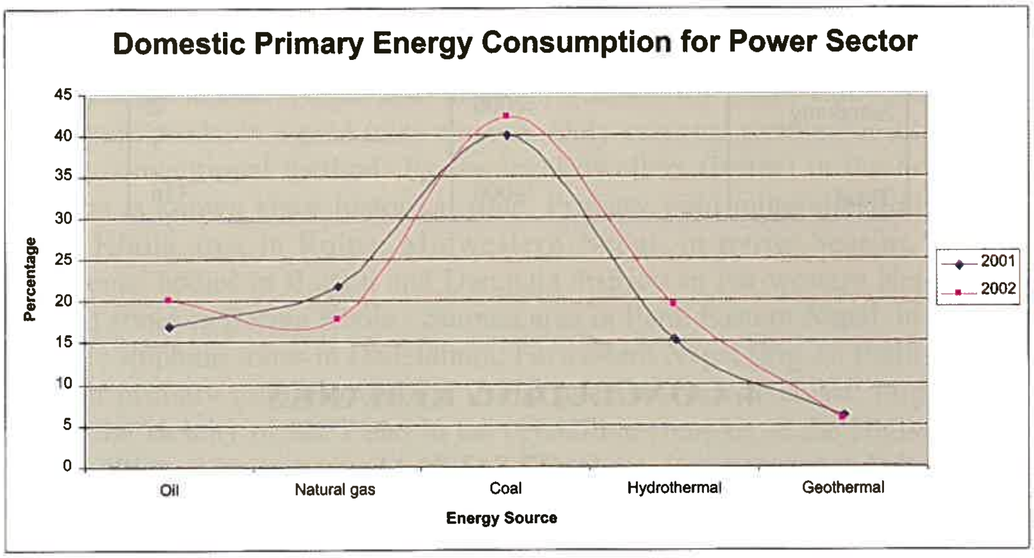


Fig. 3. Domestic energy consumption for power sector

Indonesian coal resources consist mainly of low rank, which has limitation due to high moisture content (30-50%) and low calorific value (<5000 cal). However as this type of coal is very abundant in Indonesia, it is an important asset of economy and long-term energy planning of Indonesia. This low-rank coal can be used locally for power generation or utilized with upgrading process to reduce moisture content. There is also a possibility to increase the adding value of low rank coal, such as the conversion of lignite to gas, liquid or electricity form or to be used for small-scale industry such as brick or roof tile making.

Indonesian coal seams also have potential for coal-bed methane resources. This is a new alternative energy, particularly for natural gas which has recently depleted its reserves. CBM potential spread along coal basins in Sumatra and Kalimantan, currently the largest known CBM resources in Indonesia, is in the South Sumatra basin.

Table 2. CBM resources of Indonesia (Tcf)

Basins	Prospective area (km^2)	CBM resources (Tcf)
Kalimantan		
Barito	15000	75
Berau	2000	10
Kutai	10000	50
N.Tarakan	6500	20
Pasir	1000	3
Sumatra		
C.Sumatra	15000	50
S.Sumatra	20000	120
Bengkulu	3000	5
Java		
Jatibarang	500	1
Sulawesi		
Sengkang	1000	2
Total	74000	336

4. CONCLUDING REMARKS

Indonesian coal resources account for 57,847.74 M ton resources, with about 12% (6,981.62 M tons) categorized as reserve deposits. Most of Indonesian coal reserves is in the form of brown coal and lignite, with only about 15 % categorized as high rank.

Coal plays an important role in the future energy prospect of Indonesia. It provides a reliable supply of domestic source energy while also being one of the sources of foreign exchange revenue. As Indonesian coal is dominated by low-rank coal, the development of this type of coal is a crucial key to sustain and maintain future energy of Indonesia.

PRESENT STATUS OF GOLD PROSPECTS IN NEPAL

N.R. Sthapit*, and Krishna P. Kaphle**

Department of Mines and Geology
Lainchaur, Kathmandu, Nepal
E-mail:dmg_plan@infoclub.com.np

1. INTRODUCTION

Gold is a precious metal, which is widely used in jewelery, ornaments, coins, scientific instruments, electroplating, dental appliances and many other purposes. It has very active worldwide market. Nepal also has high demand for gold mainly for ornaments. But there is no productive gold mine as such. Only seasonal panning of alluvial/ placer gold using conventional methods by the local dwellers (Botes) in the floodplains of major rivers is known since historical time. Primary gold mineralization is recorded in Lungri Khola area in Rolpa, Midwestern Nepal, in pyrite-bearing radioactive quartzite veins/ bodies in Baitadi and Darchula districts in Far-western Nepal, in pyrite mineralized zones in Bering Khola - Sunmai area in Ilam, Eastern Nepal, in Bamangaon polymetallic sulphide zones in Dadeldhura, Farwestern Nepal (Fig.1). Preliminary study reveals that primary gold also occurs in the gneissic rocks, schists, migmatites and granites in the vicinity of MCT and in the crystalline complex in the Higher Himalaya. Erosion of these rocks and transportation of these eroded materials by the rivers such as Mahakali, Chamliya, Seti, Karnali, Kaligandaki, Modi, Marshyangdi, Trishuli, Budigandaki, Sunkoshi and their tributaries flowing through the Higher Himalayan and Lesser Himalayan region have deposited the sediments with some placer gold along their flood plains. As a result placer/ alluvial gold could be traced in these sediments. Further investigation was able to trace possible primary sources of alluvial gold and also confirm few primary gold occurrences/ sites.

2. BACKGROUND HISTORY

Most part of the Sub Himalayan and Lesser Himalayan regions were investigated in various details for metallic and nonmetallic minerals since the 1970's. In those days, high priority was given for exploration of metallic minerals like gold, base metals, iron etc. Significant number of scattered historical old workings and small-scale iron, copper, lead, nickel, cobalt mines and seasonal panning of placer gold by the local people were in operation in different parts of Nepal. In this regard, the exploration history of gold in Nepal is quite long. Bowman (1932) was the first person who studied placer gold occurrences in Nepal. Later on, Chatterjee (1935), Welch (1955), O'Rourke (1959),

* Director General, ** Senior Divisional Geologist

Hagen (1959), Nadgir (1965-1966), Nanda (1964) and Department of Mines and Geology (DMG) from 1961 onward (Manandhar, 1961-1964; Sing, 1964-1965) had conducted several placer gold exploration activities. During the course of gold exploration, DMG was able to identify a number of potential alluvial gold occurrences in Kaligandaki, Burhigandaki, Trishuli and Madi Rivers, Modi Khola and Reu Khola (Fig.1 & 2). In early days, gold exploration activities were not systematic and least attention was paid for primary gold exploration and the studies were also never adequately focused for locating primary sources of placer gold. In almost all cases the alluvial gold deposits were found uneconomic for medium to large-scale mining in spite of some local concentration with encouraging results. Only since 1983, DMG has started systematic reconnaissance surveys and follow up geological and geochemical exploration of gold in Lungri Khola, Rolpa district by Paikara (1983), Joshi (1984 - 1989); Mahakali, Chamaliya and Seti Rivers in Baitadi, Darchula, Bajhang, Doti and Achham districts in Far-western Nepal by Kaphle and Khan (1992-2000), in Mahakali River by Jnawali and Jha (1993 -1994) and Kali Gandaki valley by Kaphle and Khandka (1999). All these studies were able to identify some potential target areas for placer gold as well as possible primary source areas (Fig.1 & 2). However, sources of some alluvial gold in other areas are still unknown because of inadequate studies. As a result, gold potential of the country still remains unconfirmed.

3. GENERAL GEOLOGICAL SETTING

The Kingdom of Nepal lies in the central part of the 2500 km long stretch of the Himalaya extending from Burma in the east to Pakistan in the west. Nepal Himalaya is only about 800 km in length. It is a land of extreme differences in elevation with rugged relief. From south to the north Nepal Himalaya can be divided into five distinct morphotectonic zones. They are 1. Indogangetic plain of Quaternary alluvial deposits, 2. Sub Himalaya (Churia Zone) of sedimentary rocks, 3. Lesser Himalaya of metasedimentary rocks with klippen and nappes of high-grade metamorphic rocks and granite intrusions, 4.Higher Himalayan Crystalline Zone of high-grade metamorphic rocks and 5. Tibetan Tethys sedimentary rocks. Three distinct linear structures, i.e. Main Central Thrust (MCT), Main Boundary Thrust (MBT) and Main Frontal Thrust (MFT), are the signature of structural discontinuity. MFT separates the Terai alluvial plain from Sub Himalaya, MBT separates Sub Himalayan rocks from the rocks of Lesser Himalaya and MCT separates the Lesser Himalayan from Higher Himalayan Crystalline rocks. A number of granitic intrusions of Ordovician age are present in the Lesser Himalaya. Similarly leucogranites of Tertiary (Miocene ?) age are present in the Higher Himalaya. Some of the pegmatite, aplite and quartz veins present in gneisses, calc-schist, migmatite, quartzite, granites and pegmatite in the MCT zone and in Higher Himalayan Crystalline rocks could be the possible source of alluvial gold in these major rivers. However, it has yet to be confirmed by detail exploration.

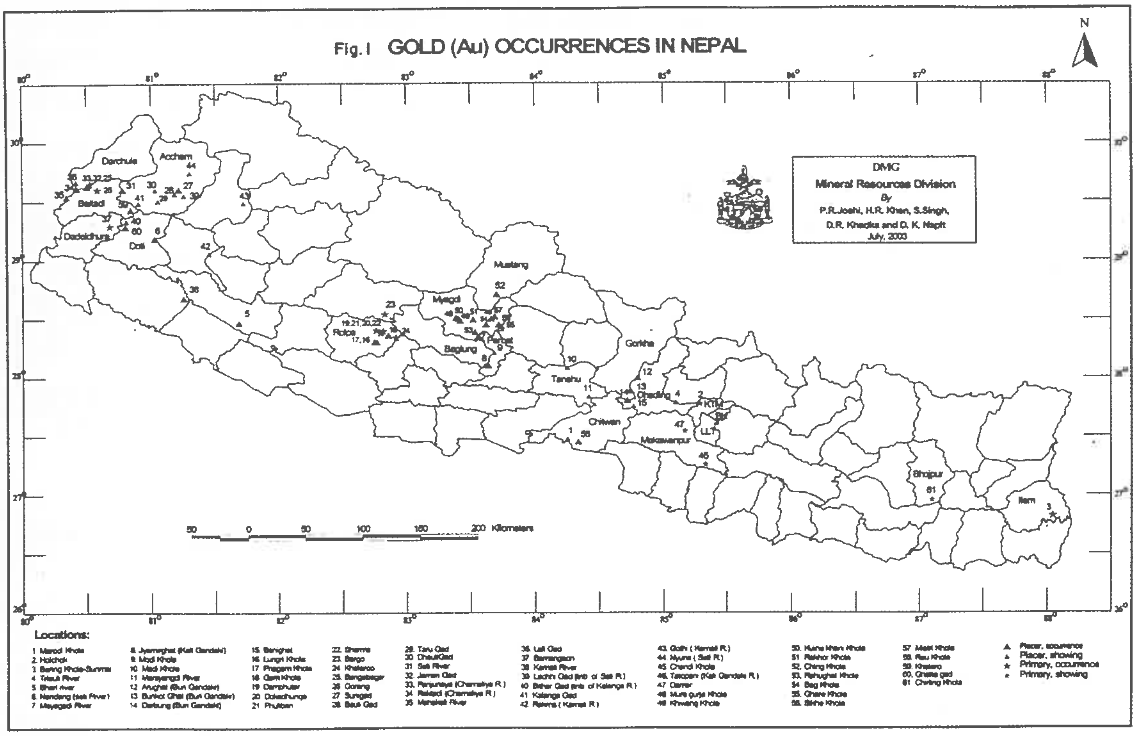


Fig. 1. Gold (Au) occurrences in Nepal

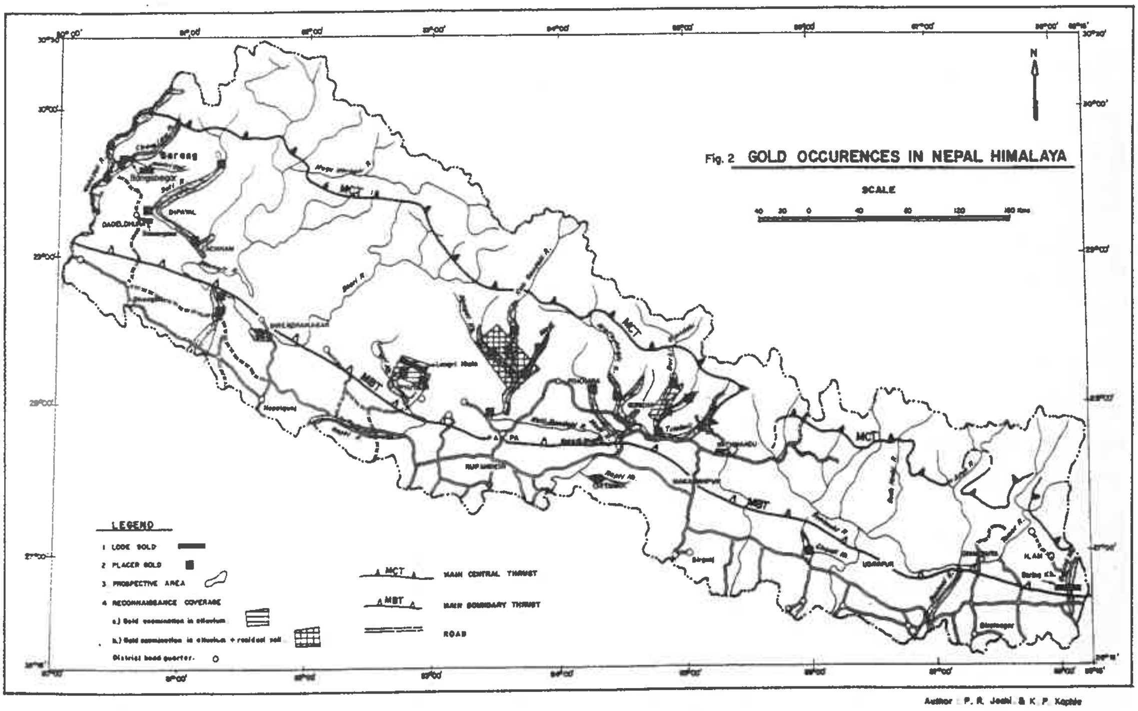


Fig.2. Gold Occurences in Nepal Himalaya

4. PLACER GOLD OCCURRENCES / DEPOSITS

Among the placer gold occurrences only alluvial placers are important in Nepal. They are recorded in the river flood plain as well as in the old river terraces in Kaligandaki, Modi, Burhigandaki, Marshyangdi, Trishuli, Rapti, Karnali, Bheri, Seti, Chamaliya and Mahakali rivers (Fig.1, 2, 3 & 4). Since historic time, placer (alluvial) gold has been the important source of gold in Nepal. Local people still use traditional panning to win placer gold normally just after monsoon. However, there is no mechanized gold mine in the country to this day. Systematic gold exploration was carried out by DMG in Lungri Khola area (Rolpa district, during 1983-1989) and in Chamliya, Mahakali and Seti Rivers and their tributaries (in Baitadi, Darchula, Achham and Bajhang districts during 1992-2000). Out of these 66.5 line km in Lungri Khola, about 100 line km in Chamliya River and 100 line km in Mahakali River and some parts of Seti River (west Seti) were explored (Fig.2, 3 & 4). Few check analysis of some samples from old terraces of Lungri Khola and Chamliya River confirmed occurrence of placer gold (Fig.3 & 4). However, gold content in these veins appears considerably low.

4.1 Lungri Khola Area

Occurrence of alluvial gold in Lungri Khola has been known for a long time, and geological study has confirmed it in 1972 (Tschering). Preliminary exploration was carried out by Paikara (1983), Joshi (1984-1986) in 66.5 line km long river channel (Gajul Khola 6 km; Phagam Khola 17 km; Lungri Khola 16 km; Gam Khola 7.5 km; Bhojyang Khola 10 km; Uma Khola 3 km; Jigribang Khola 4 km; and Ghoseng Khola 3 km (Fig.3). Follow up exploration by Joshi (1985-1992) was able to trace 18.5 km long river channels (in Lungri Khola 9.5 km; Phagam Khola 6.5 km and Gam Khola 2.5 km) and delineate some of the potential gold bearing gravel deposits in high flood plains. Evaluation of potential placer gold by test mining using sluice box, puddle box and small dredge operation has revealed an average recovery of 0.2 g/ cubic feet gravel. From the preliminary evaluation of some of these potential targets revealed 0.4 million cubic meter of proved reserve and 9 million cubic meter of possible reserve of gold bearing gravel. Gold content in this gravel varies from 100 to 3100 colours (particles)/ ton gravel. The recovered gold particle size varies from submicroscopic to 9 mm (Photo1 and 2).

Photo1. Alluvial/ placer gold in a pan concentrate, Lungri Khola, Rolpa

Photo2. Primary gold bearing carbonate rock in Rolpa

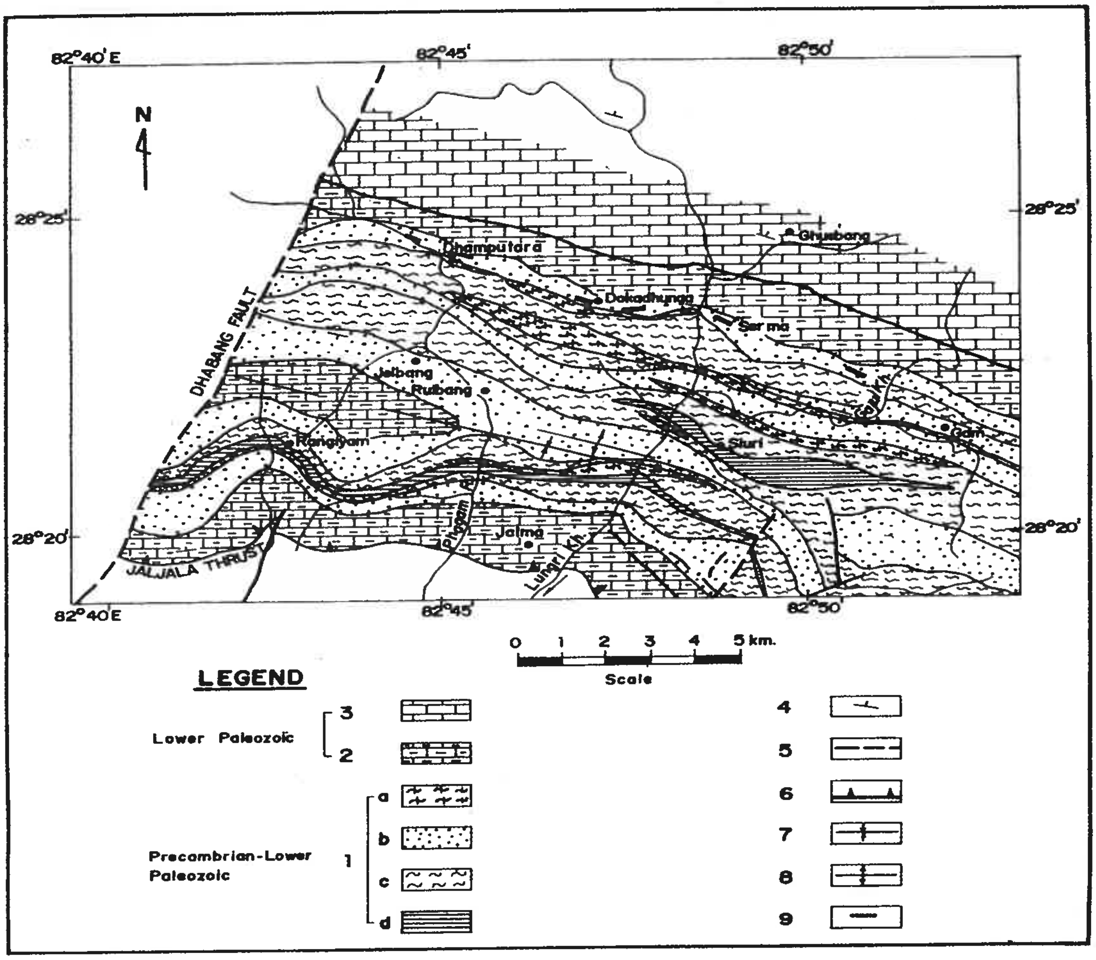


Fig.3. Geological map of the Lungri Khola gold prospect, Rolpa district, far western Nepal. Legend: 1a. gneiss; 1b. Quartzite, gritty quartzitic schist and chlorite schist; 1c. Garnetiferous quartz-muscovite-schist, sericite schist and psammatic schist; 1d. Carbonaceous schist; 2. Tel Khola Formation; 3. Mirul Formation; 4. Strike and dip; 5. Fault; 6. Thrust; 7. Syncline.; 8. Anticline; 9. Primary gold mineralization.

4.2 Chamliya River, Jamari Gad Sections

Reconnaissance geochemical survey of alluvial gold by Kaphle and Khan (1992, 1993, 1994) in Chamliya River section (about 100 line km from Shera to Lwathi) and its main tributaries such as Jamari Gad was able to trace floats of primary gold source and placer gold occurrences in both recent river bed/ flood plain as well as in old river terraces. The size of gold colours (particles) varies from <0.001 mm to 2.5 mm and the number varies from 50 to over 5000 colours/ton gravel (Kaphle & Khan 1993, 1994). Gold content is calculated to be 0.001 g to 1.56 g/ton gravel. However, in the heavy concentrate samples gold content is up to 2900 g/ton. This study was able to delineate two potential targets in Raktadi and Panjunaya along the Chamliya river section (Fig.2 & 4). Further semi-detailed investigations in Jamari Gad, Chamliya and Laligad and Mahakali rivers were able to trace primary gold occurrences in pyrite bearing radioactive quartzite band

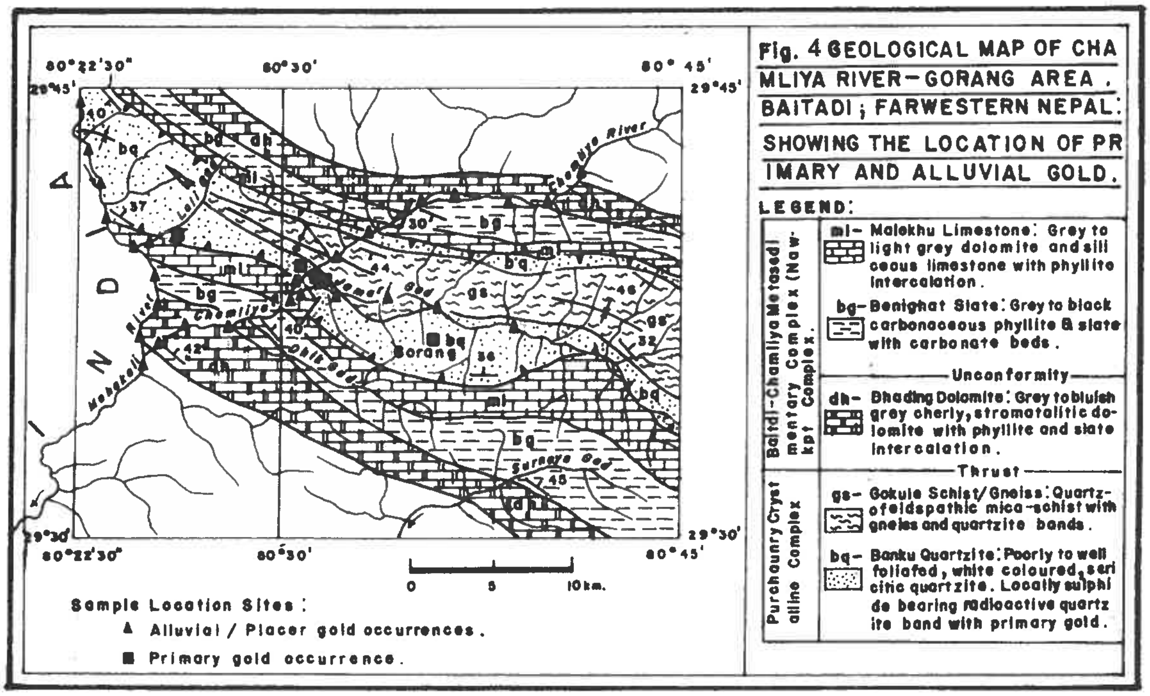


Fig.4. Geological map of Chamliya River - Gorang Area, Baitadi, farwestern Nepal

in Gorang, Jamarigad, Baggoth, Bangabagar and Boregad (Fig.4). Ore float analysis of the source rock collected from Jamarigad/ Gorang revealed up to 5 ppm gold in them. In Gorang (Baitadi) the host rock of primary gold is medium-grained, slightly foliated, sericitic white to light yellowish brown, low sulphide bearing slightly radioactive quartzite. Visible fine gold particles are recorded in crushed and panned samples. Further detailed investigation is warranted to evaluate the deposit at Gorang and other places to confirm the shape, size and gold content in them.

4.3 Mahakali River Section

Reconnaissance survey in Mahakali River section was able to trace placer gold occurrences (Fig.2 & 4) in the riverbeds. Gold colours (particles/ flakes) were observed in most of the sample sites from Pancheshor up to Sunsera (about 100 km along the river course). Beyond Kuntisangu, there is no indication of alluvial gold. Significant amount of placer gold has been recorded at Lali, Uku, Dattu, and Khairyani areas in the meandering parts of Mahakali River (Fig.1 &2). Here the peak value of gold is 1.32 ppm at the site between Dattu and Dhap. In this part visible size of gold colours varies from <0.001 to 2 mm and the number of the grains varies from 30 to 60 colours per pan (8 to 10 kg gravel) concentrate. Possible primary source of placer gold in Mahakali and Chamliya River is most probably associated with Kuntisangu Formation, which consists of calc-silicate gneiss, interbedded with psamatic biotite gneiss/ schist and diopsidic marble pervasively intruded by network of dykes and veins of aplite, pegmatite and granite as well as vein quartz.

4.4 Kaligandaki River Section

Bowman (1932), Chattarjee (1935), Hagen (1969), Manandhar (1964), Nadgir (1966) and Nanda (1966) carried out preliminary prospection of alluvial occur gold in different parts of Kaligandaki River. They were able to trace fine alluvial gold colours (particles) at Danda, Modipokhari, Khaniyaghat, Riri, Keladighat, Tribeni and Aiseluchaur area of Kaligandaki section and traced very fine to medium size colours of placer gold up to 1.3 g/t gravel. However, the overall grade appears low. Preliminary follow up exploration and assessment of alluvial and primary gold (source) in Kaligandaki valley, Modi Khola and Myagdi Khola sections by Kaphle and Khandka (2000) was able to trace placer gold in the flood plains/ riverbeds and river terraces. The amount of gold colours recovered from the flood plains in Kaligandaki river section varies from 60-4240, in Myagdi Khola section 200-650 colours, in Modi Khola 225-700 colours and in Rahu Khola section <5 to 200 colours/ ton gravel (Fig.2). The size of the gold colours/ flakes varies from <0.01 mm (very fine) to 3 mm (coarse). It was able to identify few promising sites for placer gold e.g. in Dana- Tatopani section, Myagdi - Rahugad section, Myagdi - Khaniyaghat section in Kaligandaki; Myagdi - Tatopani section in Myagdi Khola section and Dobilla area in Modi Khola (Fig.1 & 2). All these clearly indicate that the primary source of the placer gold must occur further upstream in the higher crystalline rocks such as calc schist, gneiss, migmatites, pegmatites etc. in the MCT zone and beyond in the Higher Himalayan region. However, further investigation is essential to detect the primary gold mineralization source.

4.5 Burhigandaki and Other Major River Section

Preliminary investigation of placer gold in Burhigandaki revealed encouraging results in 26 localities in the river section (from Benighat to Birkhu Khola junction, 45 line km). Beside these, similar placer gold occurrences are also reported in various quantity and quality from several other major rivers of Nepal such as Trishuli, Marshyangdi, Sunkoshi, Rapti, Bheri, Karnali, Seti (west) Rivers and Modi, Marodi, Reu Khola sections and many other streams (Fig.1 & 2). Follow up investigation of these deposits has yet to be carried out. Further investigations may lead to trace the primary sources that could be a economic gold deposit in Nepal Himalaya.

4.6 Shape, Size and Fineness of Placer Gold

Placer gold exploration in different parts of Nepal revealed that the shape of the gold particles/ colours is subrounded to well rounded nuggets/ flakes (flattened). The maximum size recorded in Kali Gandaki, Chamliya and Lungri Khola is 3 mm, 2.5 mm and 9 mm respectively. The colour of the gold flakes/ nuggets/ particles varies from redish yellow, yellow and whitish yellow depending upon the impurities present in them. From the fineness test it was found that the fineness varies from 500 to 999 (Joshi, 1992).

5. PRIMARY GOLD OCCURRENCES/ PROSPECTS

Preliminary investigation of primary gold in selected areas was able to trace only a few minor occurrences either in quartz veins, quartz sulphide veins, quartz carbonate veins and / or in polymetallic sulphide mineralized body. Some of the known primary gold occurrences are briefly described below.

5.1 Lungri Khola Area (Rolpa)

Detail geological mapping and geochemical prospection in Lungri Khola area, Rolpa district traced a 0.8 to 40 m thick and almost 30 km long but discontinuous primary gold mineralized zone (Joshi, 1998). It is well exposed at Dhamphutara, Dokadhunge, Phuliban, Sherma, Bargo and Khaleroo Khola. (Fig.3, Table1). In this area eight distinct types of gold loads were identified (Joshi, 1988; Kaphle et al., 1996). Gold loads are associated with (a) Massive magnetite and hematite body, (b) Load quartz and quartz carbonate veins and lenses, (c) Hydrothermal carbonate, (d) Magnetite rich quartz, (e) Chlorite quartz schist, (f) Shear zone (mylonite), (g) Altered limestone and (h) Metamorphosed acid volcanics (gneiss). The chemical analysis of auriferous rock/ ore sample showed 0.1 to 6.7 ppm gold. 33 primary gold mineralized zones had been reported in Lungri Khola area.

Table 1. Primary Gold occurrences in Lungri Khola Area, Rolpa

Area/ location	Location	Auriferous Band & size (m)	Gold content (ppm)	Total ore (Tonnage)
Damphutara	Lat.28°24'15"N Long. 82° 45'45"E	3 auriferous bands of 1.2 to 3.5m thick; 7 auriferous bands 1 to 31m thick; and 8 auriferous bands with 0.8 to 15.7m thickness	1.05 - 1.7ppm Au	0.4 million tons with 0.1-0.3ppm gold and 0.2 – 0.4%Cu
Dokadhunge	Lat. 28°23'00"N Long. 82°47'45"E	1.5 to 8.5m thick 600m long auriferous quartz veins	0.1 - 0.8Au 0.1 - 0.8%Cu	not calculated
Phuliban	Lat. 28°23'10"N Long.82°48'10"E	1.9m thick 120m long 1.9 -14m thick qtz + chl schist consisting 1 – 1.4ppm Au	0.9 ppm Au (average)	0.38 million tons
Sherma	Lat.28°23'50"N Long.82°49'05"E	6 bands of 11.7 to 14.2m thick 1.9 to 4m thick qtz + chl schist consist 1 to 1.4ppm Au	0.9 ppm Au (average)	not calculated
Bargo	Lat. 28°32'35"N Long.82°49'45"E	4 auriferous qtzt bands of 0.9 to 3m width	0.2 ppm Au (average)	not calculated
Khaleroo Khola	Lat.28°20'30"N Long. 82°55'00"E	load quartz vein	in float 0.2 - 3.25ppm Au	not calculated

5.2 Chamliya - Mahakali River Sections (Baitadi and Darchula Districts)

Very fine-grained primary gold mineralization have been reported in copper - iron sulphide bearing radioactive quartzite band (at places occurs close to basic rock bodies) within the Banqu Quartzite Formation and floats in Chameliya and Jamarigad Khola (Kaphle 1993, 1996). This mineralized band is exposed in Boregad, Bangabagar, Baghgoth, Jamari Gad and Gorang (Fig. 4). Analytical results of these mineralized samples revealed 0.2 to 1.2 ppm gold. Some sulphide ore bearing radioactive quartzite floats in Chamliya River and Jamari Gad have shown up to 5.6 ppm gold. This clearly indicates that sulphide bearing radioactive quartzite band in Banqu quartzite Formation is the source of primary as well as alluvial gold. However, alluvial gold occurrence to the north of Banqu Quartzite must have derived either from Khandeshwari, Danfechuli copper mineralization in Marma or from the migmatites, granites (gneisses) and aplitic pegmatite bodies and quartz veins occurring close to MCT zone (Kaphle and Khan 1992 & 1994; Kaphle et al 1996). Jnawali & Jha (1995) believed that quartz veins and granite in the uppermost part of the silicates, gneiss and schist occurring in MCT zone to the north might have contributed to placer gold in Mahakali River. Detail investigation is warranted to confirm the source.

5.3 Sunmai - Bering Khola Area (Ilam)

Talalov (1972) reported occurrence of gold flakes in quartz veins with sulphide mineralization in Bering Khola. The auriferous zone is up to 10 m thick and lies about 200 m above the Bering Khola polymetallic sulphide deposit (Fig.2). Chemical analysis of a few auriferous quartz vein samples and host rocks has shown 0.039 ppm gold (Talalov, 1972). Recent preliminary follow up field investigation by Kaphle and Khan (1997) has indicated that alluvial gold in the riverbed and old terrace is extremely rare or none. Gold particles could not be detected either in the hand specimen or in the concentrate made from the crushed mineralized samples and host rock. This clearly indicates that the chances of finding out economically viable primary gold is extremely low both in Bering Khola as well as in Sunmai. Chemical analyses of all types of samples were performed in DMG and selected samples in BGR (Germany). Analytical result from Germany revealed that the gold content in the ore sample is < 0.2 ppm.

5.4 Dadeldhura Area

1 to 2 m thick auriferous pinkish yellow quartz lenses/ veins in sericitic quartzite and quartzitic chloritic phyllite host rocks are recorded in the uppermost part of the polymetallic sulphide mineralization band in Bamangaon, Dadeldhura district, Farwestern Nepal (Fig.2). Crushing and heavy mineral concentrate/ panning of crushed auriferous quartz sample showed 0.75 mm size gold flake. Analytical result of this sample shows up to 0.8 ppm gold. Only one ore sample from pyrite rich quartz vein contains up to 14 ppm gold. All these clearly indicate that primary gold association occurs with polymetal sulphide mineralization at Bamangaon prospect.

5.5 Kaligandaki Valley (Basin) and Other Areas

Occurrence of auriferous quartz lode was reported by Boman (1932) in Keladighat and by Manandhar (1964) in between Myagdi and Rahughat in Kaligandaki section. But no detail information is available about the size, thickness, extension and gold content. Beside these, some of the previous workers have also reported primary gold occurrences from Halchock ridge (Katmandu), Pandav Khani (Baglung), Chhirling Khola (Bhojpur), Wapsa (Solukhumbu) and Damar (Makwanpur) areas but the gold content varies considerably (from < 0.001 ppm to 2 ppm). Follow up investigation has yet to be carried out to confirm the grade and quantity.

6 SYNSEDIMENTARY GOLD MINERALIZATION

Talalov (1972) in Dubichaur, and Kaphle and Khan (1989) in Chandi Khola, reported the occurrence of a few gold colours (particles) in the basal part of pebble conglomerate bed of Upper Siwalik Formation and alluvial gold in the stream beds of Chandi Khola and Tinbhangale Khola (Makwanpur). Follow up investigation is warranted to confirm whether such occurrences are of economic interest or not.

7. GENESIS OF PLACER AND PRIMARY GOLD

Occurrences of disseminated primary gold in some quartzite and chloritic-mica schist bands in Lungri Khola, Chamliya River and Sunmai - Bering Khola area in Lesser Himalaya appear to be of synsedimentary origin. Occurrences of primary gold in association with hydrothermal carbonate and hematite and quartz veins in Lungri Khola as well as auriferous quartz veins in Chmeliya (Baitadi), Bamangaon (Dadeldhura) and in Lungri Khola indicate hydrothermal origin. Similarly occurrences of primary gold in quartzite, amphibolite bodies in Bangabagar area indicate that some of these basic rocks could be the possible contributer for primary gold.

Migmatites, granites, aplitic pegmatite veins / bodies and quartz veins occurring in the uppermost part of the silicates, gneiss and calc-schist in MCT zone may contain considerable amount of primary gold and it might have contributed to placer gold in Mahakali, Chamliya, Seti and other major rivers.

8. GOLD POTENTIAL AND JUSTIFICATION FOR FUTURE WORKS

In the past, gold exploration was carried out in different parts of the country. From available information, it is quite clear that wide spread occurrences of placer gold have been recorded in the flood plain (river gravel) of the major rivers of Nepal. These are the indications of existence of auriferous zones with gold lode in different parts of the Himalaya. Recent investigations by DMG identified a numbers of primary showings (native gold occurrences) in different parts of Nepal, but these exploration activities were not sufficient to locate exploitable economic primary gold deposits in the country. They occur either in association with various quartzites or with rocks of green schist facies in Lesser Himalaya and gneiss, schist, granite, migmatites and carbonate formations in high grade metamorphic rocks associated with shear zones, gold bearing skarn and hydrothermal alteration zones. In view of the regional geological setting, metallogenesis and small areas explored so far for gold, all these data are quite encouraging. This suggests that there is a high potentiality for primary gold deposits in Nepal.

Many identified sulphide mineralizations and polymetal sulphide mineralization likely to contain gold e.g. Bamangaon polymetal sulphide, Khandeshori and Danfechuli copper prospect, Pandav Khani copper, Bhutkhola copper, Chhirling Khola copper, Kalitar coper and Dhusa copper prospects were not studied in sufficient detail.

DMG activities must be concentrated for further systematic gold exploration in the known prospective areas that may lead to discovery of some economically viable gold deposits. Therefore, first of all known gold occurrences should be reassessed and evaluated. Follow up exploration of gold in identified areas and also preliminary exploration in geologically favourable host rocks, suitable structure and depositional environment for gold mineralization must be carried out first in Lesser Himalaya and later in MCT zone and Higher Himalaya. A nationwide gold exploration programme must be launched. It is not necessary to emphasize that skilled technical personnel for field works and adequate laboratory facilities are essential for successful gold exploration. And the following is strongly recommended.

(i) Develop best panning device, apply new technology suitable for small volume surface mining methods to mine potential gravel.

(ii) Invite foreign technical assistance in gold exploration and evaluation of the prospects.

9. FOREIGN TECHNICAL ASSISTANCE SOUGHT

It is a known fact that the economic development of a country mainly depends on the available natural resources and their proper industrialization. In Nepal, till today, mining and mineral industries played very marginal role in the national economy. Most of them are concerned with limestone for cement and agriculture lime; marble and block stone for construction works; talc for industrial use; coal, lignite and semiprecious stones are extracted for local use. Mine development and industrialization of magnesite, iron, zinc-lead and natural gas are in progress. Exploitation of precious metals like gold; precious stones like ruby and sapphire and semiprecious stone like aquamarine, tourmaline, topaz etc. and their export in the international market will definitely help to boost the economy of the country. Precious metal like gold and precious stones like ruby are the small volume high price minerals and easily saleable in the world market. Therefore exploration and mining of gold should get high priority.

DMG has carried out several exploration activities for gold in the past. Several alluvial gold occurrences and few primary gold occurrences/ prospects have been discovered (Fig.1 & 2). To further develop the gold exploration program, HMGN/ DMG needs to carefully evaluate these occurrences/ prospects and promote small-scale mining activities in Nepal. Therefore, DMG seeks bilateral technical assistance to develop some of the selected gold occurrences/ prospects up to the stage of exploitation. This can be done possibly in two phases (in 1 + 3 = 4 years time frame). In this case HMG Nepal could bear 10-20% of the total cost mainly in logistics, manpower, offices space, vehicles etc.

First phase :

- Assess existing information and identify the prospective areas / potential targets for gold exploitation and mining

- Transfer of technology (train DMG manpower, supply modern equipment to DMG in order to strengthen its operational capabilities (laboratory and field equipment).

Second Phase:

- Carry out detailed exploration, evaluation and pre-feasibility study of potential gold prospects.
- Prove the deposit.
- Recommend mining methods for economic exploitation of gold and test mining.

Approach /Accessibility

Kathmandu — (By air) → Rolpa Airport → (on foot) → Lungri Khola Gold Prospect
↓
(By road) → Dang Ghorahi → Sulichaur → (on foot) → Lungri Khola Gold Prospect

Kathmandu — (By air) → Patan / Baitadi → (By road) → Raktadi Panjunaya → (on foot) → Gorang gold prospect
↓
(By air) → Gokule / Darchula → Chamliya / Mahakali River → → Bangabagar / Baggoth, Jsmari Gad → Gorang gold prospect

REFERENCES

Bowman, T.S. (1953) Preliminary survey reports on the work on gold in the Kali Gandaki area. DMG unpublished report 16pgs

Jnawali, B.M. and Jha, S.N. (1995) Preliminary report on gold and uranium expolration in the Mahakali River of Baitadi and Darchula districts, Far-Western Nepal. DMG unpublished report

Joshi, P.R. (1991) Gold exploration project (UNDP/NEP 87/006)

Joshi, P.R.(1992) Gold exploration project (UNDP/ NEP/87/006)Technical report of preliminary exploration of primary and secondary gold potential of Rolpa Region, Western Nepal.

Kaphle, K.P., Joshi, P.R. and Khan, H.R. (1996) Placer gold occurrences along the major rivers of Nepal Himalaya. Journal of Nepal Geological Society vol.13 pp.51-64.

Kaphle, K.P. and Khan, H.R. (1993) Geological report on geochemical reconnaissance and preliminary follow up investigation of gold, uranium and base metals in part of Bajhang and Baitadi districts Farwestern Nepal. DMG unpublished report.

Kaphle, K.P. and Khadka, D.R. (2000) Report on preliminary follow up gold exploration along Kali Gandaki valley in some parts of Myagdi, Parbat and Baglung districts Western Nepal. DMG unpublished report.

Kaphle, K.P. (2000) Present status of gold exploration and justification for further investigation. DMG unpublished report.

Khan, H.R. and Khadka, D.R. (2000) Preliminary follow up gold exploration in Gorang gold prospect in Baitadi district, Farwestern Nepal.

Manandhar, G.R.(1964) Report on examination of placer gold along Kali Gandaki and Myagdi, DMG unpublished report.

Sing, S.P. (1965) Report on prospecting and exploration of placer gold along Burhi Gandaki. DMG unpublished report.

Talalov, V.A. (1972) Geology and ores of Nepal.Volume-2, DMG unpublished report.

GEOLOGICAL EXPLORATION OF GAS HYDRATE PROSPECTS OFFSHORE SOUTHWESTERN TAIWAN

Yunshuen Wang

Central Geological Survey
P.O.Box 968, Taipei, Taiwan
E-mail: wangys@moeacgs.gov.tw

Offshore southwestern Taiwan is located at the juncture of the Chinese continental margin and the accretionary wedge of the Luzon subduction-collision system. Seismic reflection profiles demonstrate a complex system of faults, mud diapirs, submarine channels, and sedimentary basins in the area. Bottom Simulating Reflector (BSR) commonly found on seismic records suggests that gas hydrate occurs broadly in certain areas within the thick Quaternary marine sediments.

A 4-year gas hydrate investigation program conducted by the Central Geological Survey including geological investigation, geochemical exploration, geophysical survey, and data bank establishment will be undertaken. After survey for an area extending over 10,000 km, gas hydrate prospects will be selected for detailed investigations, drilling sites will be identified and studied, then drilling, coring and gas hydrate sampling will be carried out in the 4th year.

Various kinds of geophysical investigation techniques, including multi-channel seismic reflection, chirp sonar sub-bottom profiling surveys, regional structure and seismic stratigraphy studies, and structure and sedimentary characteristics analyses will be applied to the whole study area. Special techniques such as ocean bottom seismometer experiment and heat flow measurement will be carried out only in the selected prospects. Gravity coring cruises will be conducted to collect bottom water and near surface sediment (30-100 cm) by grid-sampling for general survey. Piston cores (1-5 m long) will be collected from the prospect areas where BSR are highly concentrated. Marine sediment of the cores will be analyzed for the physical properties, mineral assemblages, fossil assemblages, and magnetic properties. Pore water samples extracted from the sediment were analyzed to determine their sulfate, chlorine, oxygen isotope, and dissolved organic carbon concentrations. Salinity and methane concentration will be measured on bottom water. Gas hydrate formation and dissociation processes within natural sediments will be performed in the laboratories. Besides, international cooperation on gas hydrate research will be emphasized in this program.

The objectives of these investigations are to map the regional gas hydrate distribution, and to understand the regional geological, geophysical and geochemical characteristics. These results will be used to estimate the probable reserve of gas hydrate and the possibility of future exploration and exploitation.

"Burning ice" : a future energy source

2004 INTERNATIONAL WORKSHOP ON GAS HYDRATE EXPLORATION AND EXPLOITATION

Yunshuen Wang

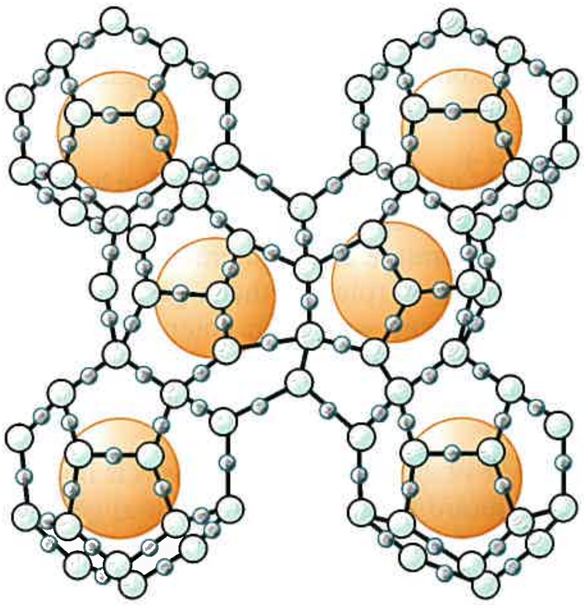
Central Geological Survey
P.O.Box 968, Taipei, Taiwan
E-mail: wangys@moeacgs.gov.tw

The Central Geological Survey of Ministry of Economic Affairs, Taiwan and the Institute of Oceanography, National Taiwan University recently hosted an International Workshop on Gas Hydrate Exploration and Exploitation in Taipei. The workshop was convened in Condensed Matter Science and Physics Building, National Taiwan University from November 8 to 9, 2004. The purposes of this workshop were to present a comprehensive expert review of the latest development in the rapidly emerging field of gas hydrate research, examine gas hydrate investigation status in the Western Pacific region, provide expert advice on Taiwan's national gas hydrate investigation program, and encourage international cooperation on gas hydrate research.

The workshop committee invited 5 experts from foreign countries including America, Canada, Germany and South Korea to present their recent research results on gas hydrate and advise the Central Geological Survey to strengthen the gas hydrate investigation program in offshore southwestern Taiwan. About one hundred and twenty local participants from academia, government agencies, and industry attended the workshop, reflecting the popular interest in gas hydrates in Taiwan. During the workshop, both local and invited experts featured 17 oral presentations, 12 poster presentations and a formal discussion session. Two keynote speeches were given by T.S. Collett and B. Dugan entitled: Natural Gas Hydrates: Energy Resource and Geo-hazard, and C.K. Paull and W. Ussler entitled: Continental Margin Gas Hydrate: Geo-hazard, Detection, and Climate Connections. Local experts presented their research on geophysical, geological and geochemical studies of gas hydrate prospects offshore southwestern Taiwan. Based on the preliminary geophysical investigation, gas hydrates are widely distributed in an area extending over 10,000 km^2 in offshore southwestern Taiwan. BSRs are observed in both the passive margin of the South China Sea continental slope and the Luzon accretionary wedge, from water depths of 700 m to over 3500 m. Chemical analyses of the pore water and pore-space gas from core sediments also indicate the possibility of wide distribution of gas hydrate in the target area. Rapid sulfate reduction was observed at several coring sites where high concentrations of methane were also detected.

The workshop concluded with a panel discussion on the growing need for international cooperation that would promote the gas hydrate investigation program in Taiwan. Both the foreign and local experts believe that the unique natural setting of having gas hydrate distribution in the active accretionary wedge and adjacent passive continental slope provides an excellent opportunity for offshore southwestern Taiwan a prime area in the world for gas hydrate investigation.

This workshop was organized by Professor Char-Shine Liu, Institute of Oceanography, National Taiwan University and sponsored by the Central Geological Survey and was very successful and offered a good channel for future international collaboration on gas hydrate exploration and exploitation in the Taiwan area.



Structure of Methane Hydrate Molecule

- Methane Molecule
- Oxygen
- Hydrogen

GEOLOGICAL AND GEOPHYSICAL STUDIES ON GAS HYDRATE IN JAPAN

Yoshihisa Okuda

Geological Survey of Japan, AIST

1. INTRODUCTION AND BACKGROUND

Natural gas hydrates are a kind of clathrates, which contain a framework of water molecules including natural gases such as methane. In case of pure methane hydrates, 1 cubic meter of the hydrates under the ground can contain up to 172 cubic meters of methane gases in volume at standard conditions. Therefore, natural gas hydrates are regarded as one of unconventional resources in future.

The occurrences of the natural gas hydrates are controlled by conditions of temperature, pressure, and composition. For the formation of the methane hydrates, it is necessary to meet a condition with low temperature and high pressure to existence of water saturated with methane gases and of more surplus methane gases as shown in Fig. 1. So, the hydrates are restrictedly distributed with high potential in the permafrost regions of Arctic and Antarctic onshore and offshore areas and in the offshore deep sea basins of the continental margins including those around the Japanese Islands.

In Japan, approximately 95 % of consumed natural gases is imported as liquefied natural gas (LNG) at present, and future consumption of natural gas is forecasted to increase nearly 1.3 times in 2010, because the natural gas is regarded as a clean energy resource which reduces approximately 25 to 30 % of the total carbon dioxide emission per unit energy in comparison with other petroleum resources. Annual consumption of primary energy resources in Japan was 405 million tons equivalent of crude oil in FY 2002, in which 82% of the total energy supply was imported from foreign countries. Domestic production of hydrocarbons (oil, natural gas and coal) is only about 1 to 2 % of the total energy supply. In addition, the LNG supplements and demands in Eastern Asia are rapidly increasing due to the rapid economic growth of China, Korea and Taiwan. Therefore, supply of LNG supplements in Japan will become tight in early 2110's, and exploration of the unconventional natural gas resources such as gas hydrates is becoming extremely important in Japan.

2. PREVIOUS MAJOR WORKS IN JAPAN

Specifically, marine gas hydrates are the largest prospective hydrocarbon resources in Japan, attracting growing interests of the Government and industries as future sources of natural gas. The occurrences of gas hydrates are often inferred by some reflectors on

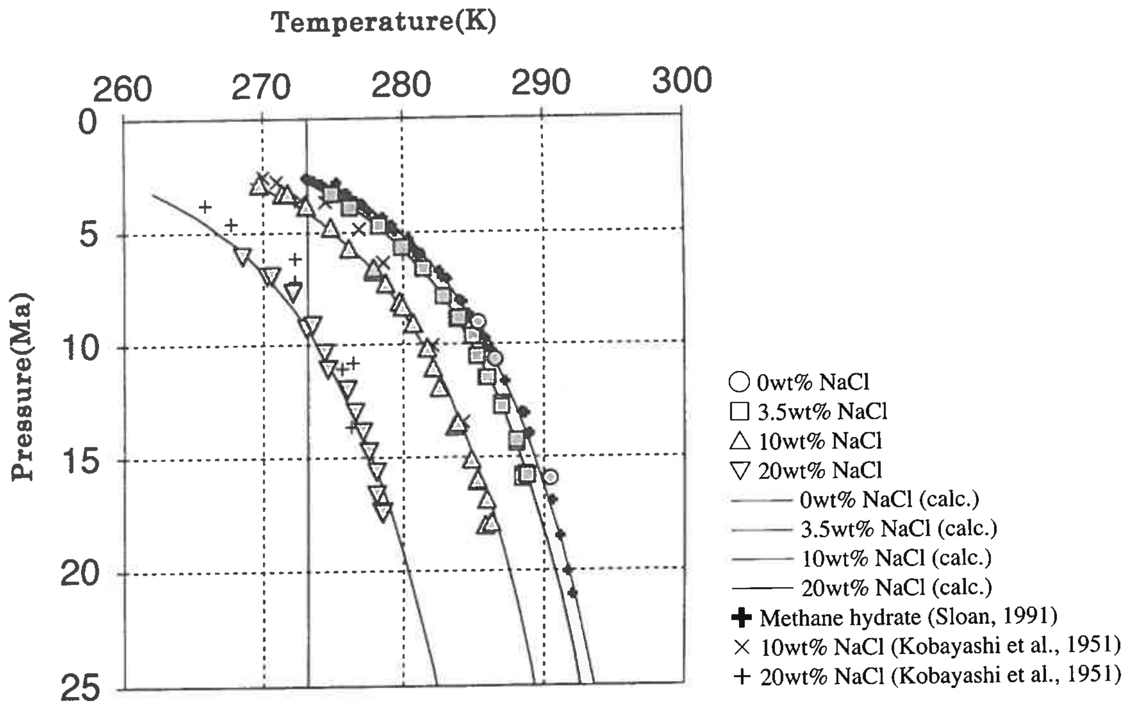


Fig.1. Phase diagram of methane hydrates (Maekawa et al., 1995)

seismic reflection profiles which are called bottom-simulating-reflections (BSRs; Fig. 2). The BSRs usually coincide with the depth predicted from phase diagram as the base of the methane hydrate stability zone. These studies on natural gas hydrates in Japan have been initiated by the pioneer studies on the occurrence of BSR in late 1970's to early 1980's.

Around the Japanese Islands, the BSRs are widely distributed off Southwest Japan in the Nankai Trough area, and in the areas of sea around Hokkaido (Fig. 3). Since 1970's, the Nankai Trough has become the focus of the BSRs and natural gas hydrate studies in relation to the tectonic evolution of the accretionary prism based on seismic reflection profiles. Thus, extensive geophysical surveys have been conducted to delineate the occurrences and aerial distributions of BSRs, and its relationship to the development of accretionary prism during the last two decades. As a result, BSRs and other direct/indirect evidences for the presences of gas hydrates have also been reported from several locations off the central and northern Honshu Island and Hokkaido. Furthermore, ODP Leg 131, which was devoted to drilling the edge of Nankai accretionary prism, recovered small chunks of solid gas hydrates and observed anomalously low salinity waters at site 808 just outside the BSR distribution area.

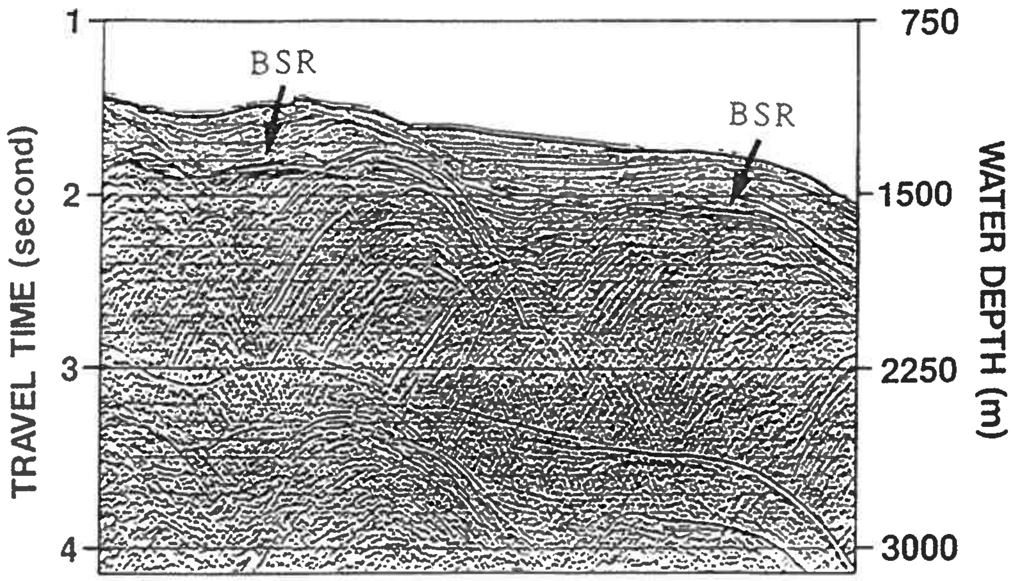


Fig.2. Typical BSR on the seismic reflection profiles in the fore arc basins inside of the Nankai Trough (Okuda, 1998).

At present, a huge amount of gas hydrates is expected to occur mainly off Southwest Japan and around the Hokkaido Island in the Japanese Economic Exclusive Zone. This was inferred from the BSRs on seismic profiles obtained by the Geological Survey of Japan (GSJ), the Japan National Oil Corporation (JNOC; presently Japan Oil, Gas Metals National Corporation, JOGMEC) and the Japan Petroleum Exploration Co. (JAPEX) since the 1970's, and the estimated resources are more than 100 times the present annual consumption of natural gases in Japan.

3. SCOPE OF THE PRESENT GAS HYDRATE STUDIES IN JAPAN

Present studies on gas hydrate resources in Japan are encouraged and stimulated by action programs of the Ministry of Economy, Trade and Industry (METI). the former Ministry of International Trade and Industry (MITI), and current research efforts are apparently focused on seismic reflection survey and drilling exploration as mentioned earlier.

But, some research groups are also interested in the role and potential importance of marine gas hydrates both as a sink and a source of green house gases and also as a huge sink of reduced carbon in the outer earth. Considering the proposed size of the world inventory of gas hydrates (~10^4 Giga tons as carbon), dissociation of even a small portion would result in a dramatic increase of atmospheric CO_2 and CH_4, and in oceanic circumstances, it would result in changes of anaerobic - anoxic conditions and of negative excursion of oceanic $\delta^{13}C$. Gas hydrates also play an important role during sediment diagenesis, modifying physical properties, chemistry and isotopic compositions of pore waters, and fluid migrations. Studies on methane seep and pockmark and isotopic analyses of carbonate nodules and crusts are important as remnant indications to identify and characterize fleeting hydrates in sediments and sedimentary rocks.

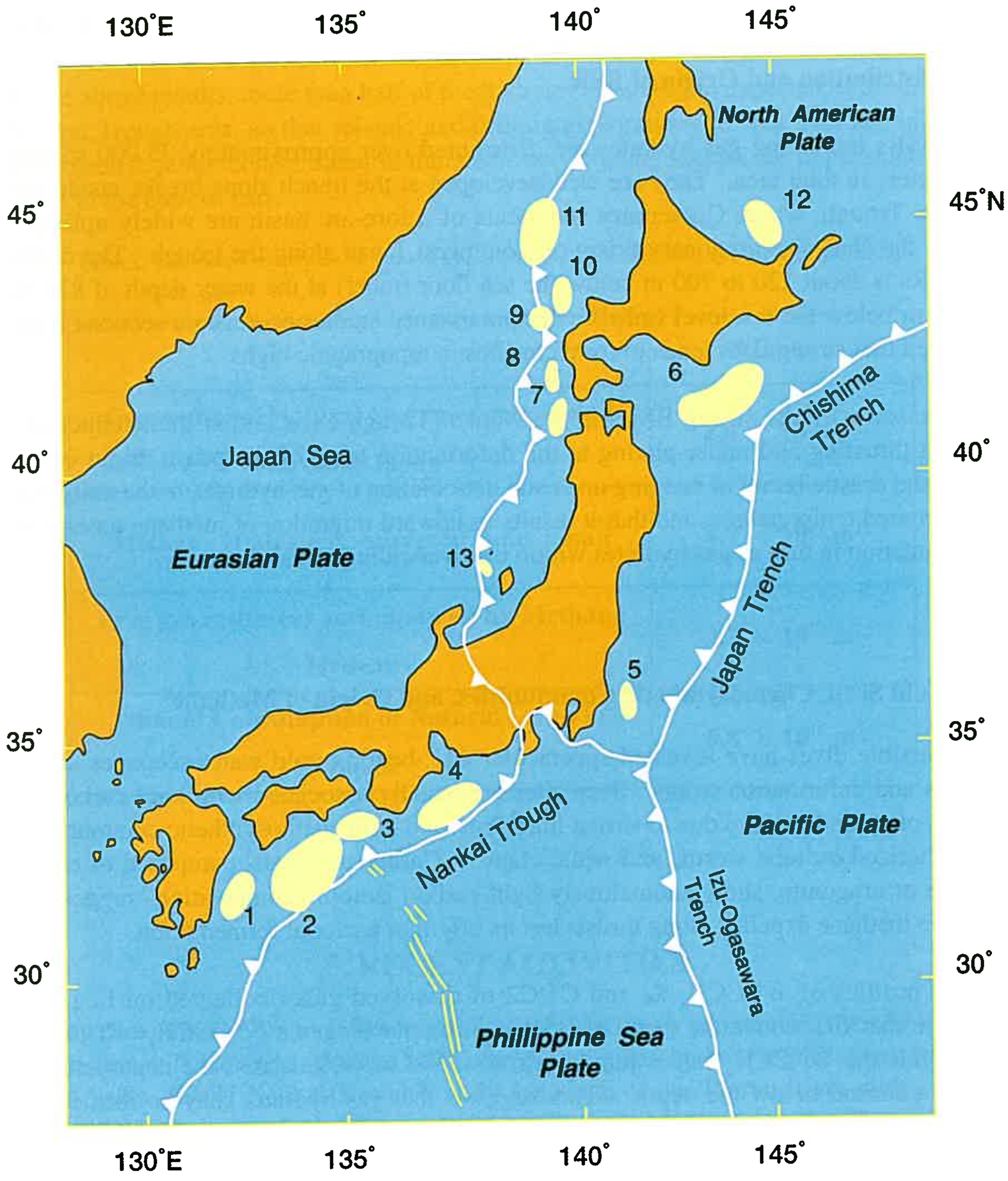


Fig.3. Possible distribution of methane hydrates around the Japanese Islands (revised from Okuda 1998).

There is another active gas hydrate research issue of carbon dioxide (CO_2) hydrates. Reduction of CO_2 emissions is another important and urgent issue for the Japanese Government, and disposal of CO_2 in deep oceans or in sediments as CO_2 hydrates is arguably one of the realistic and effective methods to reduce carbon dioxide emissions. Extensive feasibility studies have been conducted for several years and are still going on in an attempt to propose action plans.

4. ASSESSMENT OF GAS HYDRATES IN THE NANKAI TROUGH

4-1. Distribution and Origin of BSR

The BSRs indicating gas hydrates are distributed over approximately 35,000 square kilometers in total area. They are well developed at the trench slope breaks inside the Nankai Trough, where Quaternary sediments of a fore-arc basin are widely uplifted, and in the Nankai accretionary prism off southwest Japan along the trough. The depth of BSRs is about 220 to 700 m below the sea floor (mbsf) at the water depth of 820 to 4,100 m below the sea level (mbsl). Reconnaissance studies on seismic sections have revealed that strong BSR tends to form closures in topographic highs.

The reason why the strong BSRs in the Nankai Trough exist is that the subduction-related thrusting and under-plating at the deformation front of the prism might cause rapid and drastic burial of hanging units and dissociation of gas hydrates in the units due to increased temperatures, and that it results in upward migration of methane gases and accumulation in turn as gas hydrates within the over-riding thrust sheets.

4-2. Cold Seep, Chemosynthetic Communities, and Origin of Methane

Submersible dives have revealed spectacular CH_4-bearing cold water seepages along thrusts and deformation fronts. Seep sites are usually associated with hard carbonate crusts, often undermined due to strong fluid flow, and with chemosynthetic communities characterized by tube worms and white clams. Carbonate crusts, composed of either calcite or aragonite, show anomalously light carbon isotopic composition, suggesting that the methane expelled along thrusts has its origin in bacterial fermentation.

Depth profiles of $\delta^{13}CCH_4$ ‰ and C1/C2 of dissolved gases collected on Leg 131 indicate that CH_4 above the depth of BSR is primarily biogenic ($\delta^{13}CCH_4$=-81 to -53 ‰), while the $\delta^{13}CCH_4$ values jump up from -53‰ to -40‰ across the depth and are nearly constant below the depth. This suggests that gas hydrates may be formed by biogenic methane while free gases may be composed of the mixture of biogenic and thermogenic gases.

4-3. Estimated Amounts of Methane in Gas Hydrates and Free Gas Methane

Based on such exploration data, the Geological Survey of Japan has estimated the gas hydrate resources by volumetric methods since 1980's, and the results show that the estimated natural methane hydrate resources around Japan are approximately equivalent to 4.7 trillion cubic meters of natural gases at standard conditions, and associated free gases are estimated to be 2.7 trillion cubic meters, and the methane hydrate resources including associated free gases around the Japanese islands have enormous potential, amounting to more than hundred-fold greater than the annual consumption of the natural gases in Japan (Table 1).

In the above results, more than half of the hydrate resources are expected to occur in the Nankai Trough area, so that seismic and drilling explorations for gas hydrates in Japan have been recently concentrated in the area, specially targeted on the upper continental slope in the eastern part.

Table1. Estimated resources of natural gases and methane hydrates around Japan (Satoh et al., 1997)

	Amount
Conventional Natural Gas resources in and around Japan	**4.0×10^{10} m^3**
Methane Hydrate resources around Japan	**4.7×10^{12} m^3**
Free gas resources accompanied by Methane Hydrates	**2.7×10^{12} m^3**
Annual Consumption of Natural Gases in Japan	**6.8×10^{10} m^3**

5. RECENT ACTIVITIES

During November 1999 to February 2000, the JNOC, as a program of the Ministry of International Trade and Industry (MITI) for the methane hydrate exploration, drilled a set of wells, "MITI Nankai Trough", at 50 km south of the Tenryu River with a water depth of 945 m, using the semi-submersible drilling rig M. G. Hulme Jr. The set of the wells is composed of a main well, two pilot wells, and three post survey wells located within 100 m from each site. The wells firstly clarified the existence of the methane hydrates in the fore-arc basin in the eastern Nankai Trough and confirmed the existence of methane hydrate-bearing turbidite sand layers with total thickness of 12 to 14 m. But each layer is thin, less than 1 m thick, and the bases of the hydrates were clearly correlated to the BSRs on the seismic profiles (Tsuji et al., 2004).

During January to May in 2004, approximately 30 shallow exploration wells for gas hydrates were drilled at the water depths between 700 and 2,000 m with 250 to 500 m of total depths below the sea floor to confirm their occurrences in the eastern part of the Nankai Trough by the JNOC/JOGMEC as a METI program using an American drilling vessel "JOIDES Resolution" following the "MITI Nankai Trough" in 1999 and 2000. Various kinds of logging, including logging while drilling (LWD) and wire line logging, were carried out, and methane gas hydrate samples were successfully recovered in the Kumano deep sea terraces and around the Atsumi sea knoll. Some of the hydrate samples were recovered by newly developed "Pressure-Temperature Core Sampler" which can maintain the pressure and temperature in situ during the sampling and the transportation of samples to laboratories for analyses.

As the methane hydrates are stable at cold high pressure, the temperature becomes an important factor. But temperature distribution in the mathane-hydrated-containing strata have not been measured extensively so far. Therefore, the Geological Survey of Japan developed the optical fiber thermometer for measuring the stratum temperature distribution below the sea floor, and it was installed in the drill hole after the wire line logging measurements. This equipment measured underground temperatures for about two months and the thermometer was collected just before the drilling ended.

Recently, the GSJ has conducted the marine geochemical studies in the Nankai Trough region for detection of the top of methane generation zone, the sulfate-methane interfaces (SMI), and methane by measuring the sulfate reduction rates in the sediment samples of piston and gravity core samplings. Combination of the BSR which indicates the base of the hydrates, and SMI which indicates the top of the hydrates will be very useful to acquire crucial information regarding marine methane hydrate resources.

6. CONCLUSION

Recently, potential of methane hydrates around the Japanese Islands has been vigorously examined by seismic reflection profiling, exploration drilling and geochemical surveys in order to assess their feasibility as a source of natural gas and to assess the environmental impact of their utilization in the near future. To meet the demands of global environment and of energy in Japan, the exploitation and utilization of the natural gas hydrates is a matter requiring urgent attention, and thus the present feasibility studies on the exploration, engineering techniques and environmental assessment of the methane hydrate in the Japanese EEZ will hopefully produce positive results.Then the use of methane hydrates as domestic energy-source is expected to be realized in 2010's.

REFERENCES

Maekawa, T., Itoh, S., Sakata, S., Igari, S. and Imai, N. (1995) Pressure and temperature conditions for methane hydrate dissociation in sodium chloride solution. Geochem. Jour. 29, 325-329.

Okuda, Y. (1998) Introduction to exploration research on gas hydrates in Japan. Bull. Geol. Surv. Jap., 49, 10, 494-500.

Satoh, M., Maekawa, T., and Okuda, Y. (1997) Estimation of amount of methane and resources of natural gas hydrates in the world and around Japan. Jour. Geol. Soc. Jap., 102, 11, 959-971.

Tsuji, Y., Ishida, H., Nakamizu, M., Matsumoto, R., and Shimizu, S. (2004) Overview of the MITI Nankai Trough wells; A milestone in the evaluation of methane hydrate resources. Res. Geol. 54, 1, 3-10.

Asia and the Pacific members of ICOGS

As of 1 January 2005

This list includes phone and facsimile numbers and e-mail addresses (if available).

Australia **Geoscience Australia**
- Address: GPO Box 378, Canberra City, Act 2601
- Representative: Dr. Neil Williams, Executive Director
- Phone: +(61-2)62499600
- Fax: +(61-2)62499988
- E-mail: neil.williams@ga.gov.au

Bangladesh **Geological Survey of Bangladesh**
- Address: 153 Pioneer Road, Segunbagicha, Dhaka 1000
- Representative: Mr. Mizanur Rahman, Director General
- Phone: +(880-2)8312599
- Fax: +(880-2)9339309
- E-mail: gsb@agni.com

Bhutan **Department of Geology and Mines**
Ministry of Trade and Industry
- Address: Post Box 173, Thimphu
- Representative: Mr. Dorji Wangda, Director
- Phone: +(975-2) 323096/322879/323349
- Fax: +(975-2)323013
- E-mail: gsbmti@druknet.net.bt

Cambodia **General Department of Mineral Resources**
Ministry of Industry, Mines and Energy
- Address: 45, Preah Norodom Blvd., Phnom Penh
- Representative: Mr. Chea Socheat, Deputy Chief of Geological Office
- Phone: +(855) 015914187
- Fax: +(855-23) 426283/426011
- E-mail: dgm@camnet.com.kh

China **China Geological Survey**
Ministry of Land and Resources
- Address: 24 Huangsi Dajie, Xicheng District, Beijing 100011
- Representative: Dr. Zhang Hongtao, Deputy Director General
- Phone: +(86-10) 51632806
- Fax: +(86-10) 51632907
- E-mail: zhongtao@mail.cgs.gov.cn

India		**Geological Survey of India**
	Address:	27, Jawaharlal Nehru Road, Kolkata 700 016
	Representative:	Dr. K. N. Mathur, Director General
	Phone:	+(91-33) 2286 16/1661
	Fax:	+(91-33) 2286 1656
	E-mail:	gsi_chq@vsnl.com
Indonesia		**Geological Research and Development Centre** **Agency for Research and Development of Energy and Mineral Resources**
	Address:	Jalan Diponegoro No. 57, Bandung 40122
	Representative:	Dr. Djadjang Sukarna, Director
	Phone:	+(62-22) 7272601/7203205, ext.101
	Fax:	+(62-22) 7202669
	E-mail:	kap3g@grdc.esdm.go.id, grdc@grdc.esdm.go.id
Iran		**Geological Survey of Iran**
	Address:	P.O. Box 13185-1494, Tehran
	Representative:	Mr. M. T. Korehie, General Director
	Phone:	+(98-21)60043 43
	Fax:	+(98-21)6009338
	E-mail:	info@gsi.org.ir
Japan		**Geological Survey of Japan, AIST**
	Address:	1-1-1, Higashi, AIST Central 7, Tsukuba, Ibaraki 305-8567
	Representative:	Dr. Eikichi Tsukuda, Director General
	Phone:	+(81-29)8613946
	Fax:	+(81-29)8613672
	E-mail:	e-tsukuda@aist.go.jp
Kazakhstan		**Academy of Mineral Resources of the Republic of Kazakhstan**
	Address:	91, Abylay Khan Av., Almaty, 480091
	Representative:	Prof. Ginajat R. Bekzhanov, President
	Phone:	+(7-3272) 795950
	Fax:	+(7-3272) 795921
	E-mail:	bekzhanov@nursat.kz
Kiribati		**Ministry of Fisheries and Marine Resources Developments**
	Address:	P.O.Box 64, Bairiki, Tarawa
	Representative:	Mr. Raimon Taake, Deputy Secretary
	Phone:	+(686)21099
	Fax:	+(686)21120
	E-mail:	raimont@mfmrd.gov.ki

Republic of Korea **Korea Institute of Geoscience and Mineral Resource**

Address: 30,Gajeong-dong, Yuseong-gu, Daejeon 305-350
Representative: Dr. Tai Sup Lee, President
Phone: +(82-42) 868-3000/3270
Fax: +(82-42) 868 3004/3808
E-mail: tslee@kigam.re.kr, hyshin@kigam.re.kr

Kyrgys Republic **Institute of Geology**
National Academy of Sciences

Address: Erkindik Aveneu, 30, 720481 Bishkek
Representative: Academician Apas Bakirov, Director
Phone: +(996-312)664737
Fax: +(996-312)664256
E-mail: geol@aknet.kg

Lao People' s Democratic Republic **Department of Geology and Mines**
Ministry of Industry and Handicraft

Address: Khounboulom Road, Vientiane
Representative: Mr. Thongphath Inthavong, Director General
Phone: +(856-21)212080
Fax: +(856-21)222539
E-mail: dgmnet@laotel.com

Malaysia **Minerals and Geoscience Department Malaysia**

Address: 20th Fl., Tabung Haji Building,
Jalan Tun Razak, 50658 Kuala Lumpur
Representative: Mr.Chu Ling Heng, Director-General
Phone: +(603)21611033
Fax: +(603)21611036
E-mail: jmgkll@jmg.gov.my

Federated States of Micronesia **Department of Economic Affairs**

Address: P.O. Box PS-12, Palikir, Pohnpei FM 96941
Representative: Mr. Ishmael Lebehn, Acting Secretary
Phone: +(691)320-2646/5133
Fax: +(691)320-5854
E-mail: fsmdea@mail.fm

Mongolia **Geological Survey of Mongolia**
Mineral Resources Authority of Mongolia

Address: Builder's Square 13, Ulaanbaatar 211238
Representative: Dr. Oidoviin Chuluun, Director General
Phone: +(976-11) 310370/322940/317797/ 328578
Fax: +(976-11) 310370/322940/317797/327307
E-mail: mram@magicnet.mn, geolcentre@mongol.net

Nepal	**Department of Mines and Geology**
Address:	Lainchaur, Kathmandu
Representative:	Mr. Nanda Ram Sthapit, Director General
Phone:	+(977-1) 4414740/4412065
Fax:	+(977-1) 4414806
E-mail:	dmgdgo@infoclub.com.np, dmg_plan@infoclub.com.np, nscdmg@mos.com.np
New Caledonia	**Service de la Géologie et des Mines** **Direction de l' Industrie, des Mines et de l' Energie**
Address:	BP 465, 98 845 Nouméa Cedex
Representative:	Mr. Dominique Le Poac, Head
Phone:	+(687)273944
Fax:	+(687)272345
E-mail:	dominique.le-poac@gouv.nc
New Zealand	**Institute of Geological and Nuclear Sciences Ltd.**
Address:	P.O. Box 30-368, Lower Hutt
Representative:	Dr. Alex Malahoff, Chief Executive
Phone:	+(64-4)5701444
Fax:	+(64-4) 5704 723
E-mail:	a.malahoff@gns.cri.nz
Pakistan	**Geological Survey of Pakistan**
Address:	P.O. Box 15, Sariab Road, Quetta
Representative:	Mr. Syed Hasan Gauhar, Director General
Phone:	+(92)81-9211032
Fax:	+(92)81 9211018
E-mail:	hasangauhar@hotmail.com
Papua New Guinea	**Geological Survey of PNG** **Department of Mining**
Address:	Private Mail Bag, Port Moresby
Representative:	Mr. Joe Buleka, Director
Phone:	+(675)3224324/3215888
Fax:	+(675)3211360
E-mail:	joe_buleka@mineral.gov.pg, gspng@mineral.gov.pg
Philippines	**Lands Geological Survey Division** **Mines and Geosciences Bureau**
Address:	North Ave., Diliman, Quezon City
Representative:	Mr. Antonio N. Apostol, Jr., OIC
Phone:	+(63-2)928-8544/8819
Fax:	+(63-2) 928-8544
E-mail:	geology@mgb.gov.ph, an_apostol@yahoo.com

Solomon Islands **Ministry of Energy, Mines & Mineral**

Address: P.O. Box G37, Honiara
Representative: Mr. Renell Zauma Magu, Deputy Director Geology (Mapping)
Phone: +(677)21521
Fax: +(677)25811

Sri Lanka **Geological Survey and Mines Bureau**

Address: No.4, Galle Road, Senanayake Building, Dehiwala
Representative: Dr. Wijayananda Nanayakkarawasam Pallage, Director
Phone: +(94-1) 725745/739307/739309
Fax: +(94-11)273 5752
E-mail: gsmb@slt.lk

Taiwan **Central Geological Survey**

Address: P.O.Box 968, Taipei
Representative: Mr. Lin Chao-Chung, Director General
Phone: +(886-2)2942-9306
Fax: +(886-2) 2942 9244
E-mail: lincc@moeacgs.gov.tw

Thailand **Bureau of Geological Survey**
Department of Mineral Resources

Address: Rama VI Road, Bangkok 10400
Representative: Mrs. Benja Sektheera, Director
Phone: +(66-2)202-3735
Fax: +(66-2)202-3754
E-mail: benja@dmr.go.th

Tonga **Ministry of Lands, Survey and Natural Resources**

Address: P.O.Box 5, Nuku'alofa
Representative: Mr.Tevita Malolo, Secretary & Surveyor General
Phone: +(676)23-210
Fax: +(676)23-216
E-mail: malolo@lands.gov.to

Turkey **General Directorate of MTA**

Address: Eskisehir Yolu-06520, Balgat, Ankara
Representative: Mr. Ali Kemal Isiker, General Director
Phone: +(90-312)2879150
Fax: +(90-312)2879151
E-mail: mta@mta.gov.tr

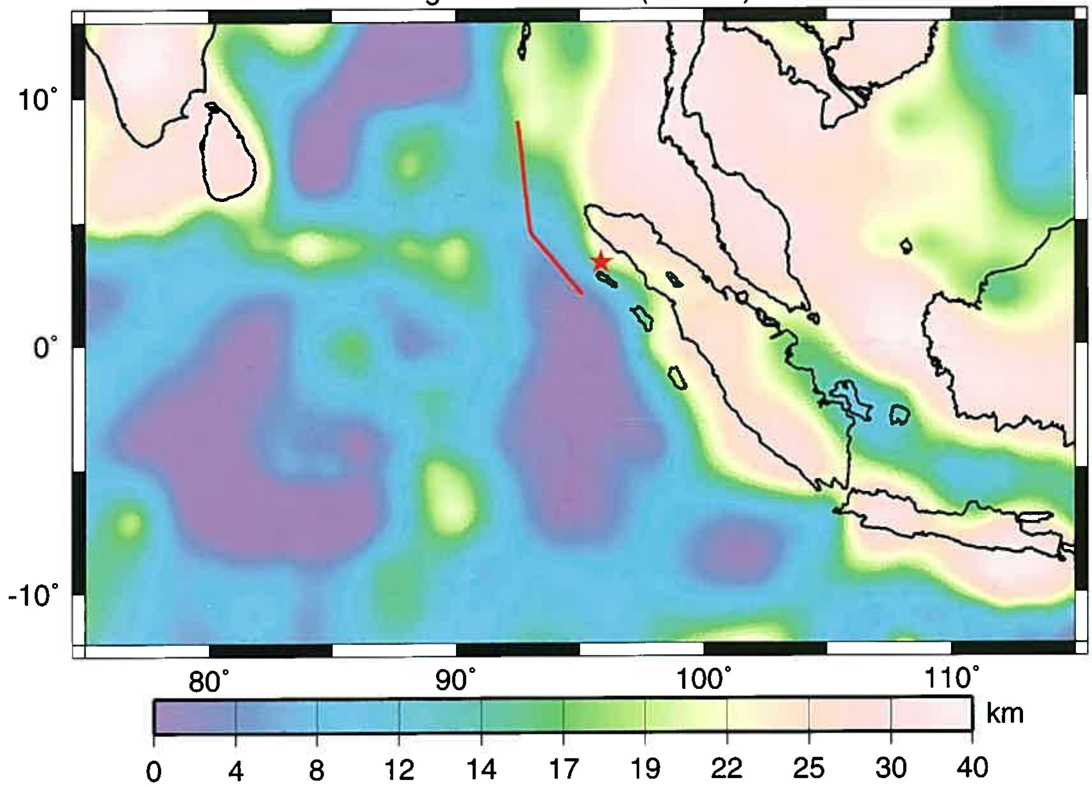
Vietnam	**Department of Geology and Minerals of Vietnam**
Address:	6 Pham Ngu Lao Str., Hanoi
Representative:	Dr. Nguyen Thanh Van, Deputy Director General
Phone:	+(84-4)8260671/8261779
Fax:	+(84-4)8254734
E-mail:	nguyenthanhvan@dgmv.gov.vn

We would like to keep the above list up to date and accurate. Please let me know about any changes or inaccuracies in it:

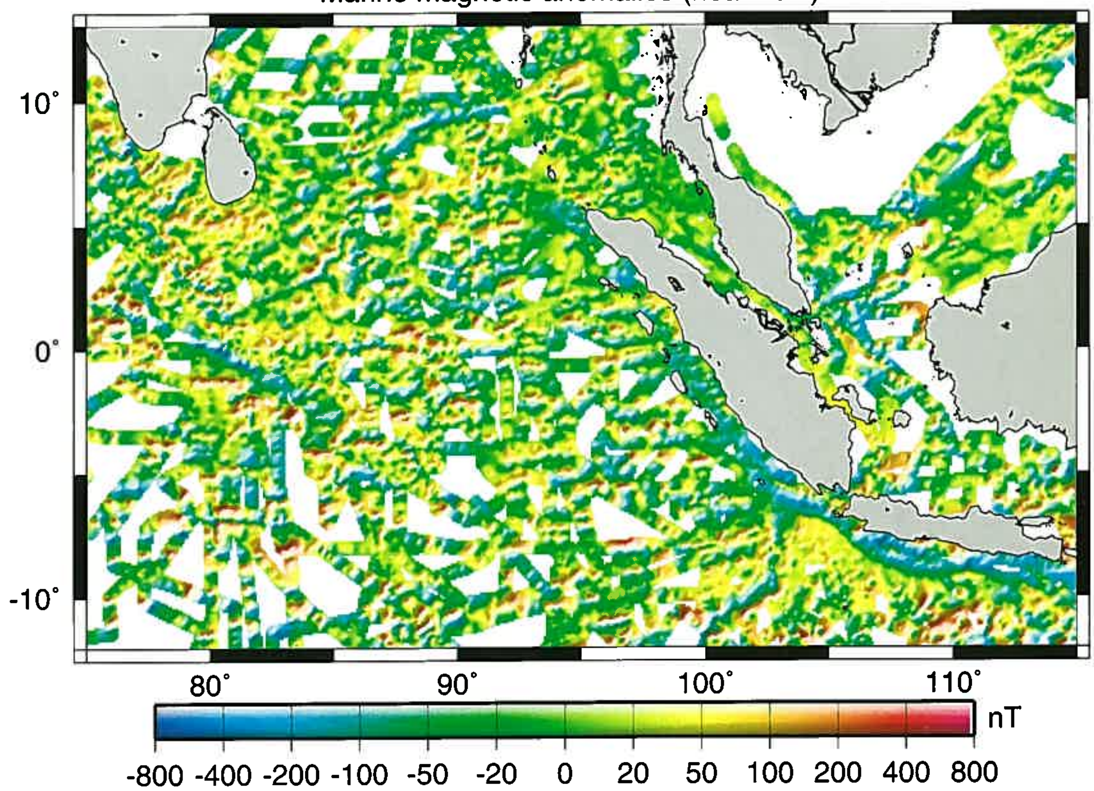
Takemi Ishihara
ICOGS Secretary for Asia and the Pacific
Geological Survey of Japan
National Institute of Advanced Industrial Science and Technology
AIST Tsukuba Central 7, Tsukuba, 305-8567 JAPAN
Fax: +81-29-856-4989 E-mail: t-ishihara@aist.go.jp

Magnetic images of the earth's crust in the vicinity of the 2004 Sumatran earthquake

Magnetic thickness (far field)



Marine magnetic anomalies (near field)



For more information visit http://www.planetary-mag.net/sumatra/ or contact M. Purucker (purucker@geomag.gsfc.nasa.gov) or T. Ishihara (t-ishihara@aist.go.jp).

ICOGS Asia-Pacific Newsletter is published by the ICOGS Regional Secretariat for Asia and the Pacific
c/o Geological Survey Planning and Coordination Office, Geological Survey of Japan
National Institute of Advanced Industrial Science and Technology
AIST Tsukuba Central 7, Tsukuba, 305-8567 JAPAN.
Fax: +81-29-856-4989; E-mail: t-ishihara@aist.go.jp
T. Ishihara, Secretary; Y. Shimazaki, Advisor; S. Miyano and A. Shima, Assistant.