Human Capacity Building for Natural Resources Development and its Environmental Impacts

Tsukuba, Japan, Nov.-Dec., 2007

APEC Industrial, Science and Technical Working Group

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(2) Tohoku Region (11th-13th, December)

Guided by MARUMO Katsumi (Geological Survey of Japan, AIST)

IST01/2007A

Human Capacity Building for Natural Resources Development and its Environmental Impacts

Introduction

Eikichi Tsukuda
Director General of Geological Survey of Japan, AIST

Welcome to Geological Survey of Japan, AIST (Advanced Industrial Science and Technology). First of all, I would like to express a great thanks to all the participants, China, Korea, Russia, Thailand, Viet Nam for attending the training course.

The project "Human capacity building for natural resources and its environmental impacts in APEC region" has been approved in 2007 by Asia Pacific Economic Cooperation, Industrial Science and Technology working Group (APEC-ISTWG). I would like also to thank co-sponsoring economies, Korea, Chinese Taipei, New Zealand, Thailand, Philippines, Papua New Guinea, Chile, Viet Nam, for supporting the project.

Recently man-made disasters have increased with the development of natural resources: soil contamination, landslide, subsidence due to pumping groundwater. The developments are necessary to maintain our society. Therefore, the objective of the training is the technology transfer about guideline of natural resources development and its environmental impacts, environmental impact assessment, natural resources assessment, public awareness, and measurement of aggregate quality. This will bring about national regulations and guidelines about natural resources development and its environmental impacts in order to ensure the long-term sustainable growth in APEC region. This will contribute much to developing economies, where a rapid economical growth may cause environmental deteriorations. Therefore, the training course will be beneficial to learn the advanced technology and share the scientific knowledge to minimize the impacts of human intervention to nature.

Japan is a densely populated island and suffered from natural hazards which impact was enhanced by aggregate and mineral resources development for long years. Therefore, Japan has developed its scientific knowledge and technologies to control resource development in sustainable manner. Recently almost ore mines in Japan have been closed, and only the environmental problems remain to be solved. We will show you previous Japanese cases without considering the environmental effects in Japan. We are trying to remove the effects.

The participants are requested to present country reports on the environment impacts, so that we can exchange the information and experience. We have more than 17 lectures and two field excursions in this training course: the developments of energy, mineral resources, ground water, aggregates and their environmental impacts, soil contamination, risk management. Active discussions are invited in the training course. Moreover, we have plans two field trips: in Chiba prefecture, Kanto district, and in Iwate and Akita prefectures, northeast Japan.

The total management for natural resources development and its environmental impacts contributes not only to APEC member economies but also to the entire world, because the issue is borderless and global. APEC region has Earth Scientists' and Engineers' networks with two intergovernmental organizations, CCOP and SOPAC, and a non-profit international organization, CPC.

I would like to recommend you to construct the human network with the participants and lecturers, GSJ members as well as to accumulate the knowledge.

Human capacity building for natural resources development and its environmental impacts in APEC region

	Date		AM	PM
1	26.Nov	Mon	Arrival	
2	27	Tue	Orientation and GSJ tour	Economy report
3	28	Wed	Economy report	Remote sensing
				[Isao Sato]
4	29	Thu	Methane hydrate	Groundwater contamination
			[Osamu Matsubayashi]	[Mio Takeuchi, Ming Zhang]
5	30	Fri	Oil resource	Environmental impact assessment
			[Yoshihisa Okuda]	[Dr. Tatiana Selivanova]
6	1.Dec	Sat	Tsukuba tour	Holiday
7	2	Sun	Holiday	Holiday
8	3	Mon	Water resource	Geological sequestration of CO_2
			[Kasumi Yasukawa, Isao Machida]	[Toshiyuki Tosha]
9	4	Tue	Landslide	Geo-Information Technology
			[NIED, Naoki Sakai & Ryohei Misumi]	[Shinji Takarada]
10	5	Wed	Risk governance	Geothermal resource
			[Atsuo Kishimoto]	[Hirofumi Muraoka, Tsuneo Ishido, Mituhiko Sugihara]
11	6	Thu	Aggregates resources	Aggregates Resources
			[Ken Ikehara]	[Masafumi Arita]
12	7	Fri	Risk management	Natural gas
			[Dr. Durucan]	[Yoshihisa Okuda]
13	8	Sat	Field Seminar	Field Seminar
			[Dr. Arita & Sudo]	[Dr. Arita & Sudo]
14	9	Sun	Holiday	Holiday
15	10	Mon	Crisis of concrete civilization	Soil contamination
			[Masafumi Arita]	[Takeshi Komai]
16	11	Tue	Field Seminar (Mining)	Field Seminar (Mining)
			[Katsumi Marumo]	[Katsumi Marumo]
17	12	Wed	Field Seminar (Mining)	Field Seminar (Mining)
18	13	Thu	Field Seminar (Mining)	Field Seminar (Mining)
19	14	Fri	Evaluation of Course	Evaluation of Course
20	15	Sat	Departure	

※ 8 Dec: Field Seminar for aggregate quarry in Boso Area

※ 11-13 Dec: Field Seminar in Akita and Iwate Prefectures

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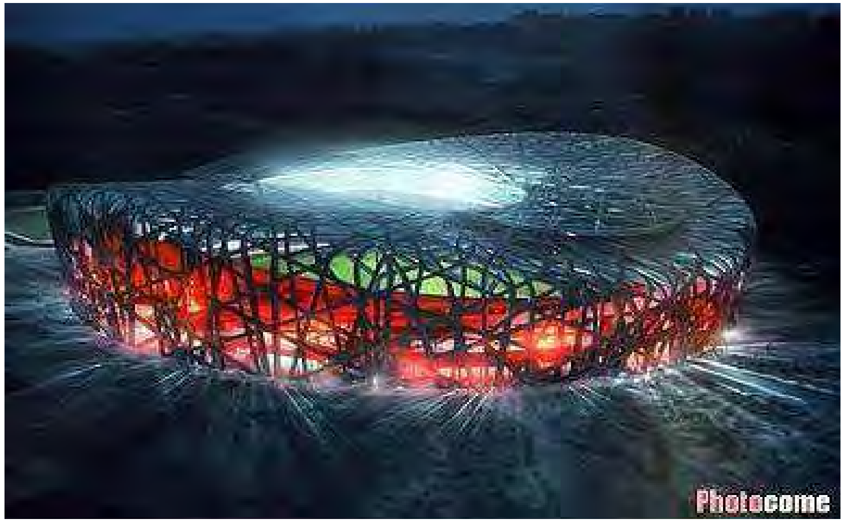
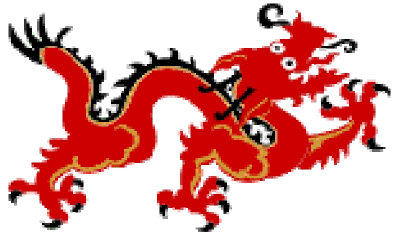
GEO-RESOURCES & GEO-ENVIRONMENTAL ASSESSMENT IN CHINA

ZHANG DAQUAN

(China Geological Survey)

2007.11.27





One World One dream

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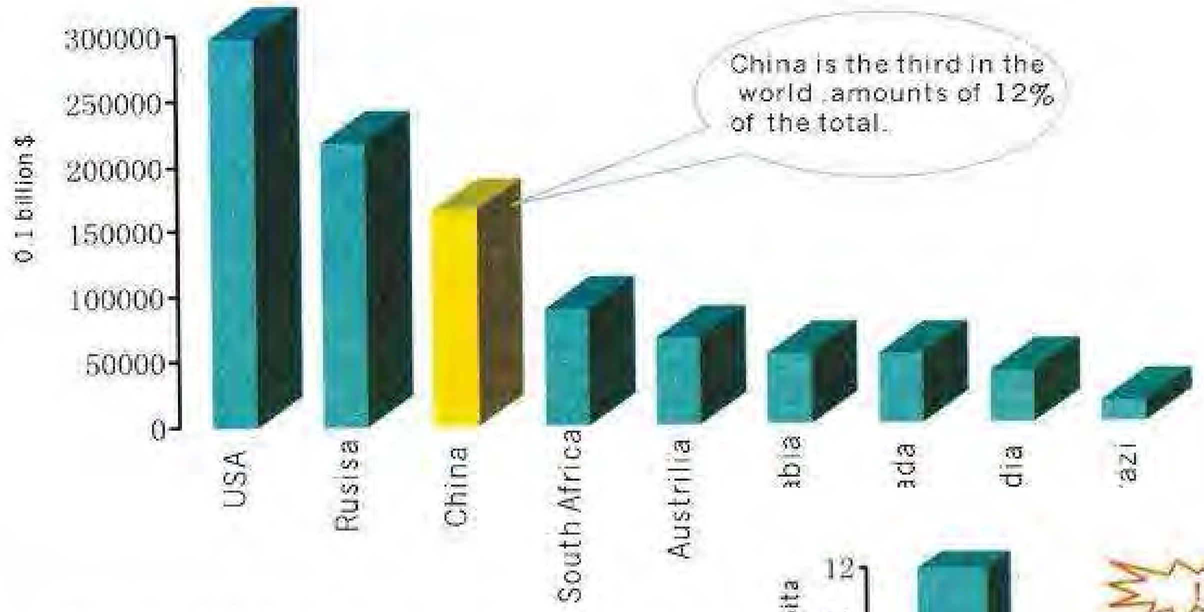
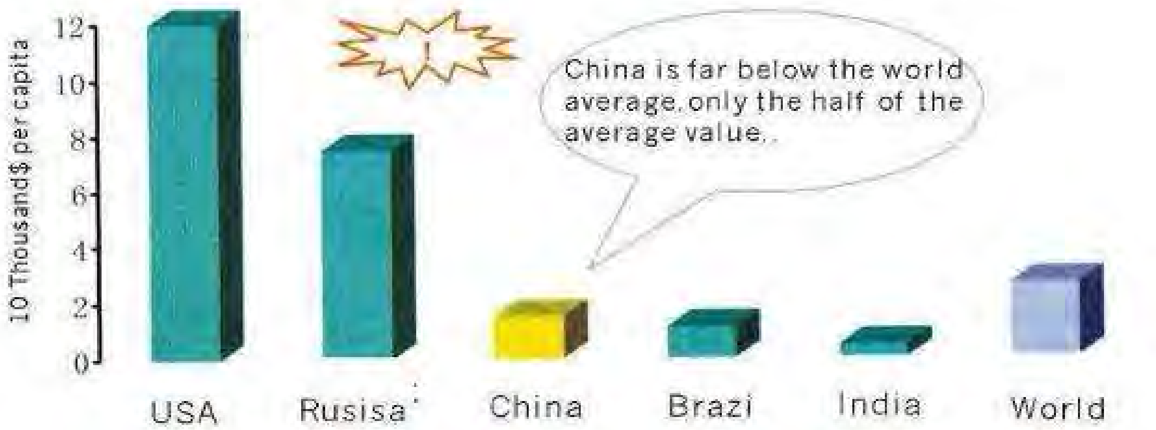
1. The state of mineral resources in China
2. Some major achievements for geo-resources exploration
3. Geo-environmental assessment
4. Some environmental issues

The state of mineral resources in China

CGS

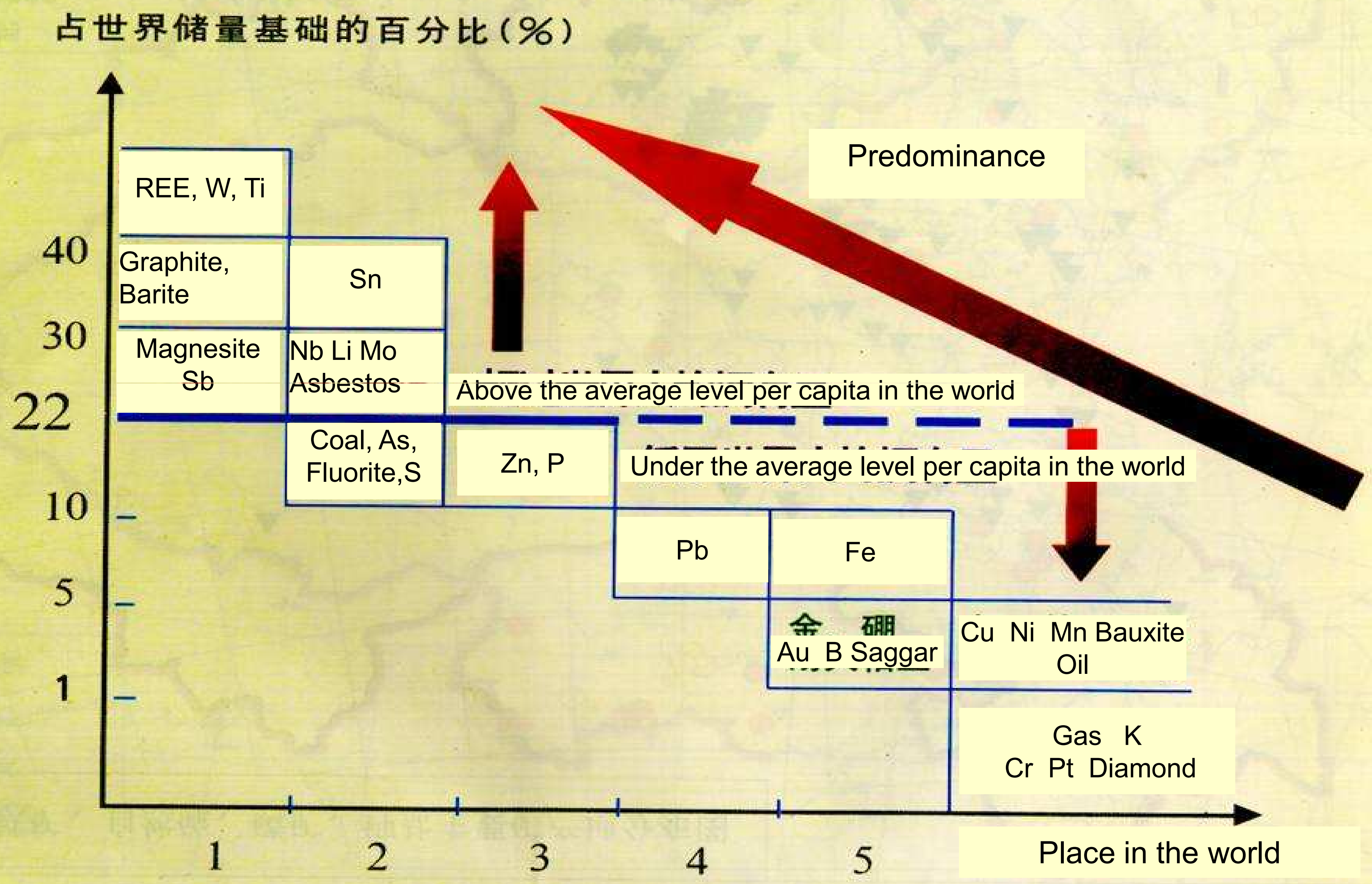


The contrast of the mineral reserves(t
between some major countries



The contrast of the individual mineral reserves(total value of potentiality) between some major countries

Percentage of Reserve Foundation in the World



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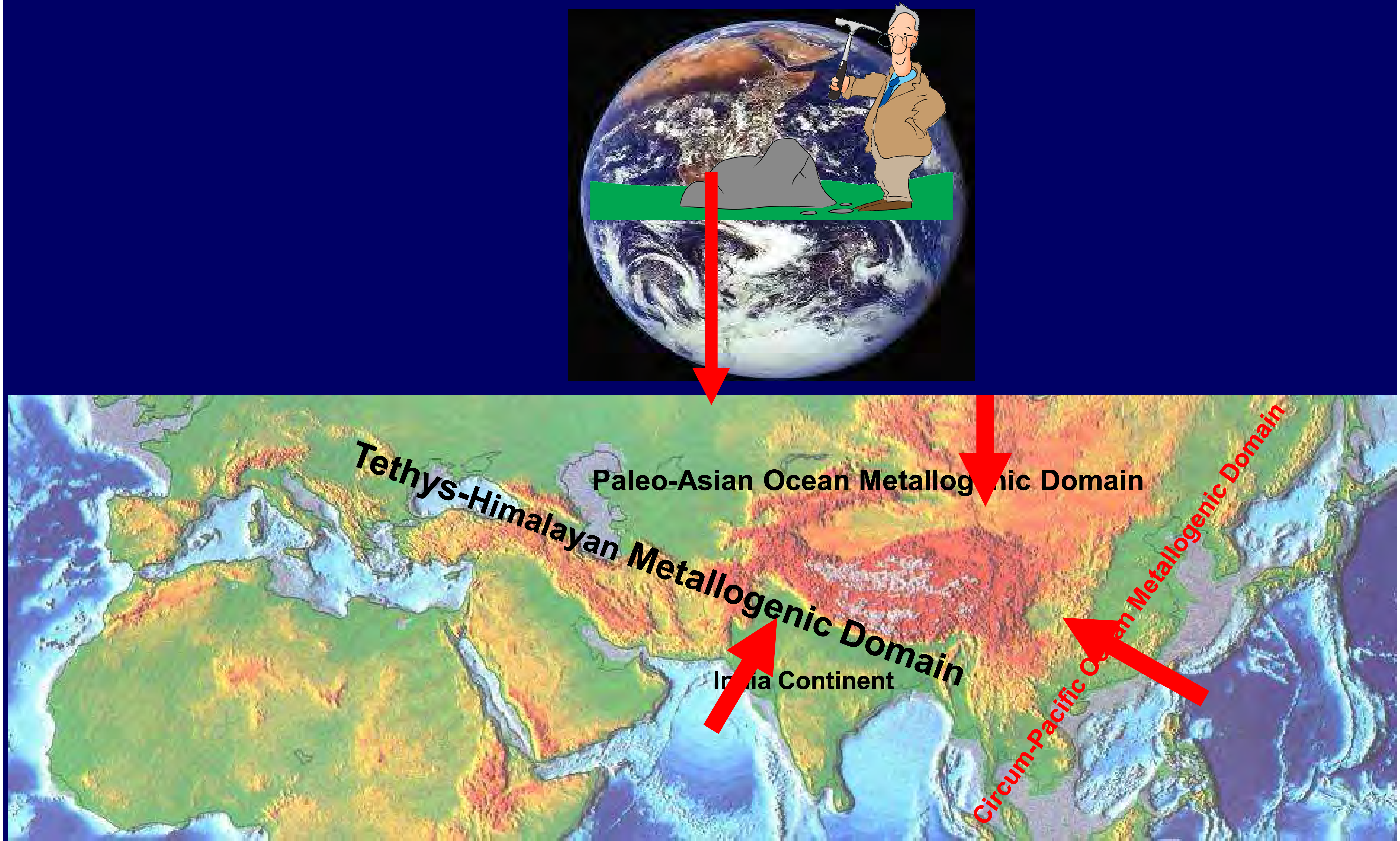
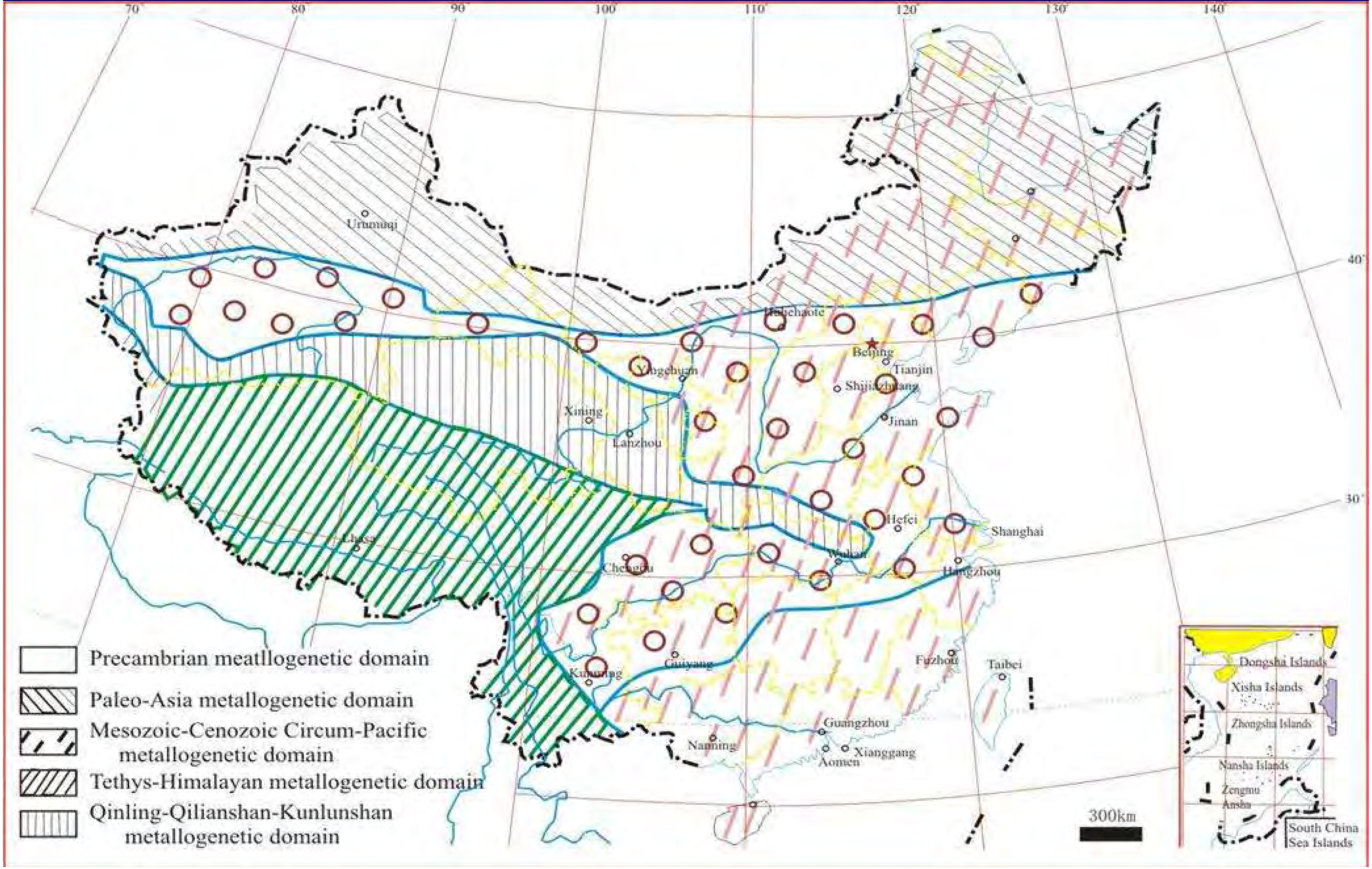


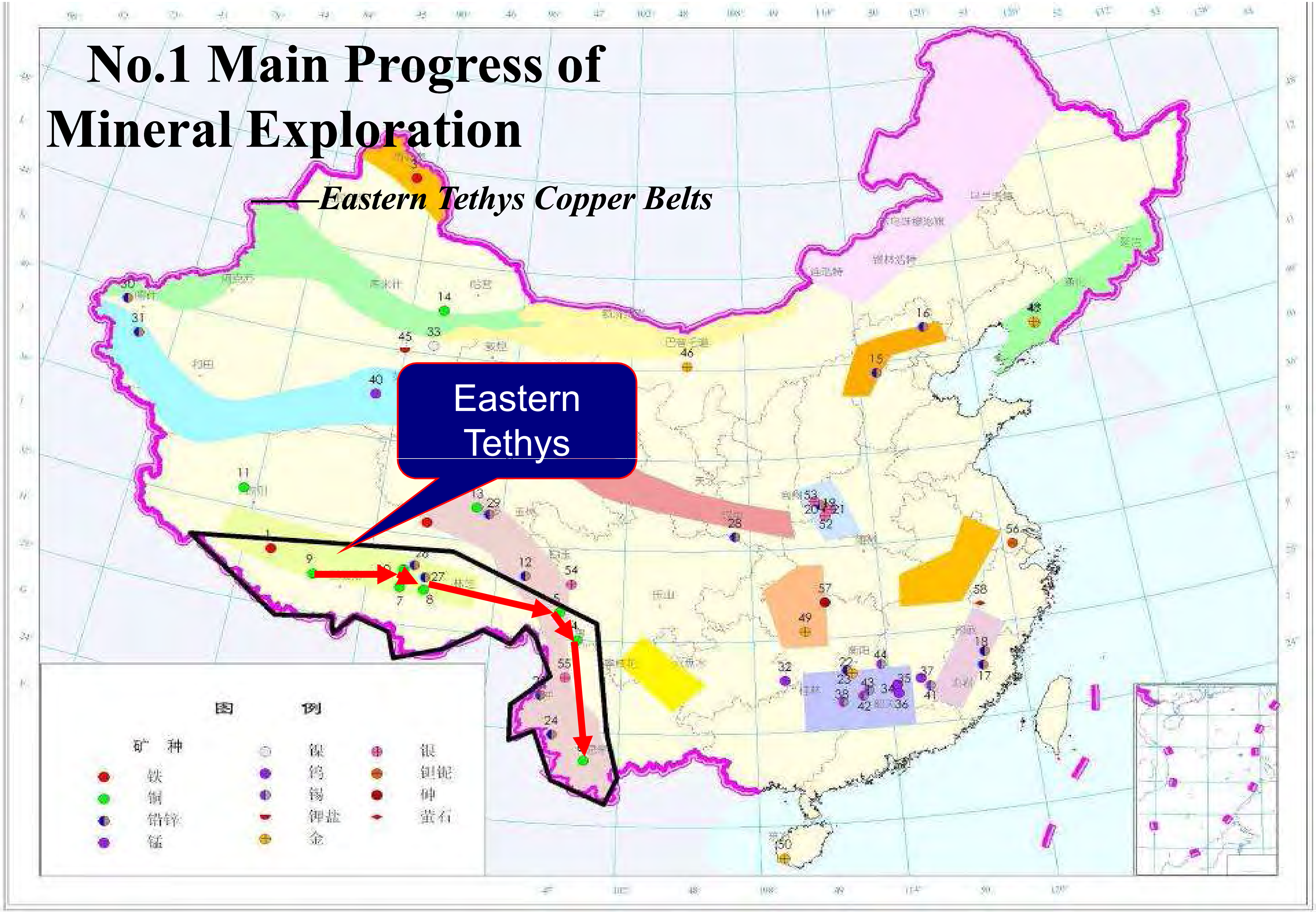
Tethys-Himalayan Metallogenic Domain
Paleo-Asian Ocean Metallog nic Domain
Circum-Pacific O an Metallogenic Domain
In ia Continent

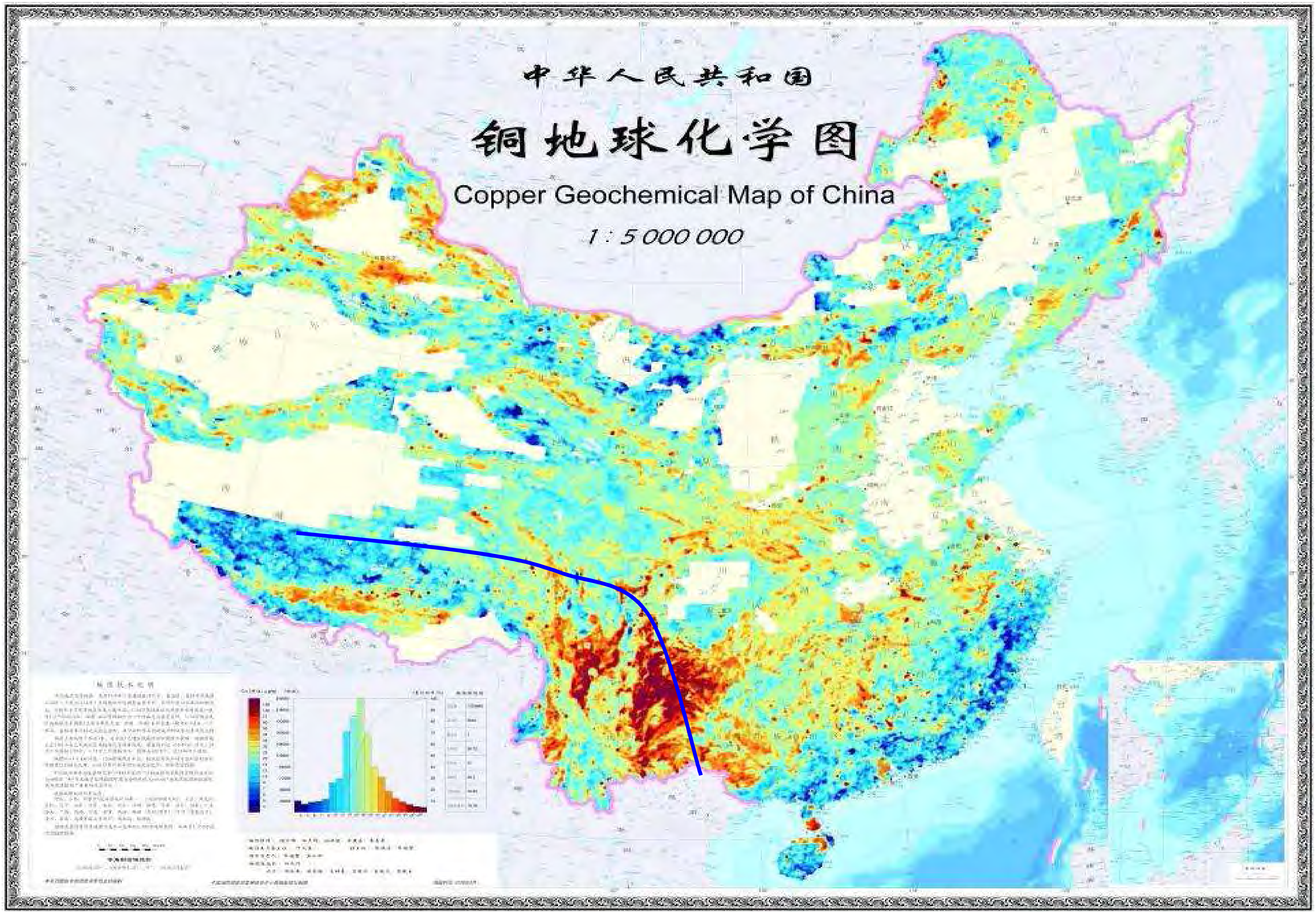
The five metallogenic domains in China



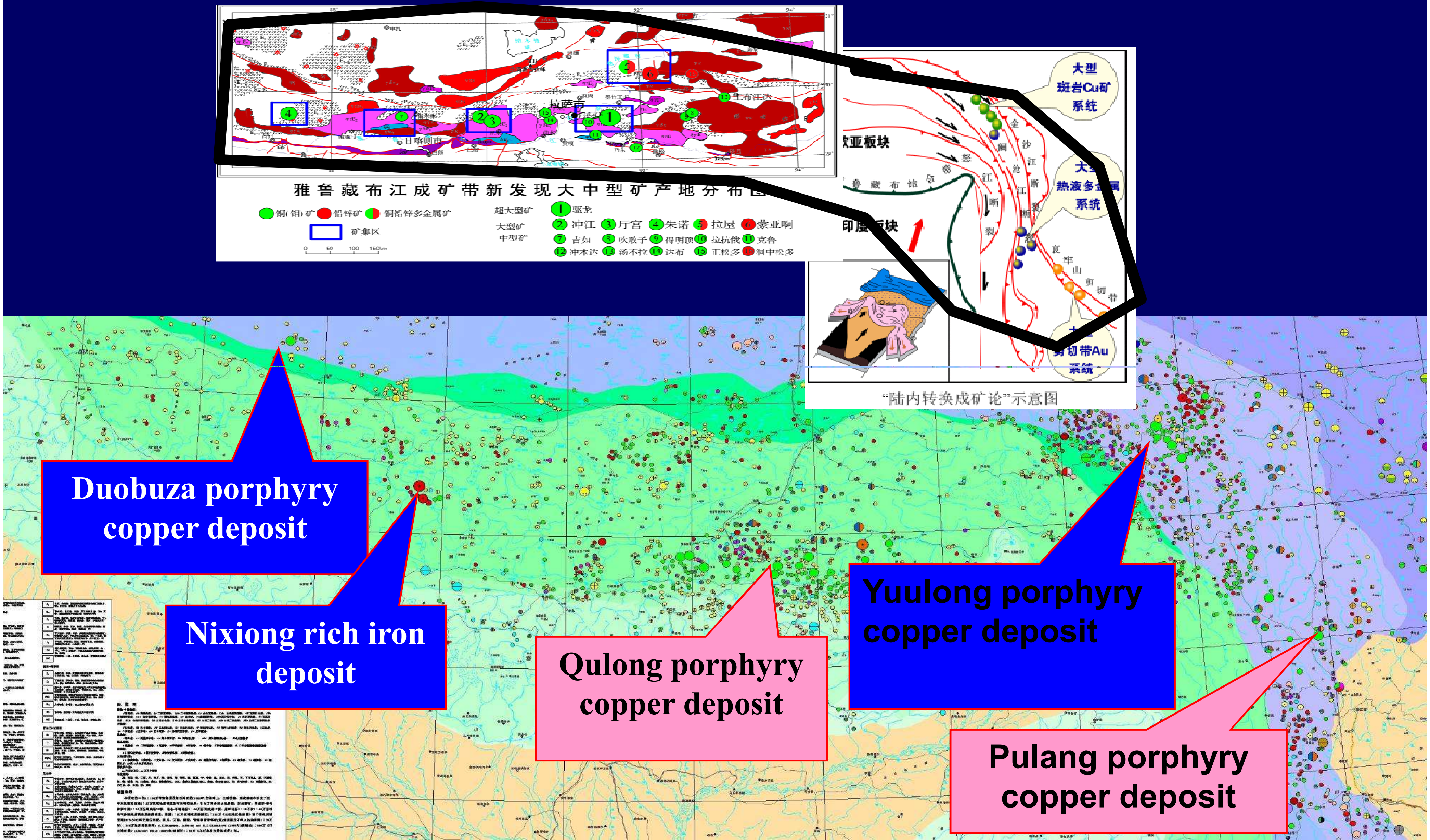
No.1 Main Progress of Mineral Exploration

——Eastern Tethys Copper Belts

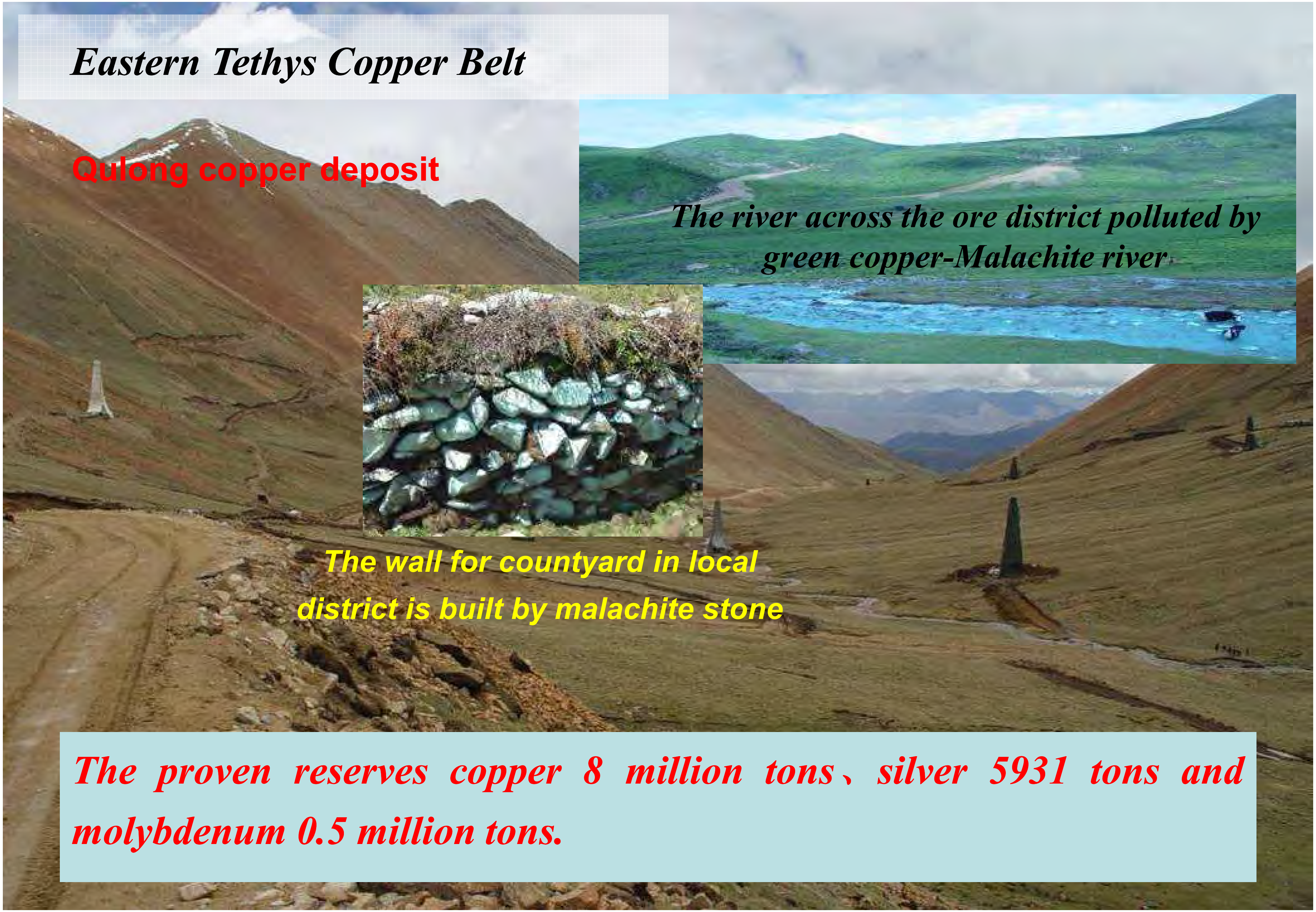



中华人民共和国
铜地球化学图
Copper Geochemical Map of China
1 : 5 000 000

Eastern Tethys Copper Belt



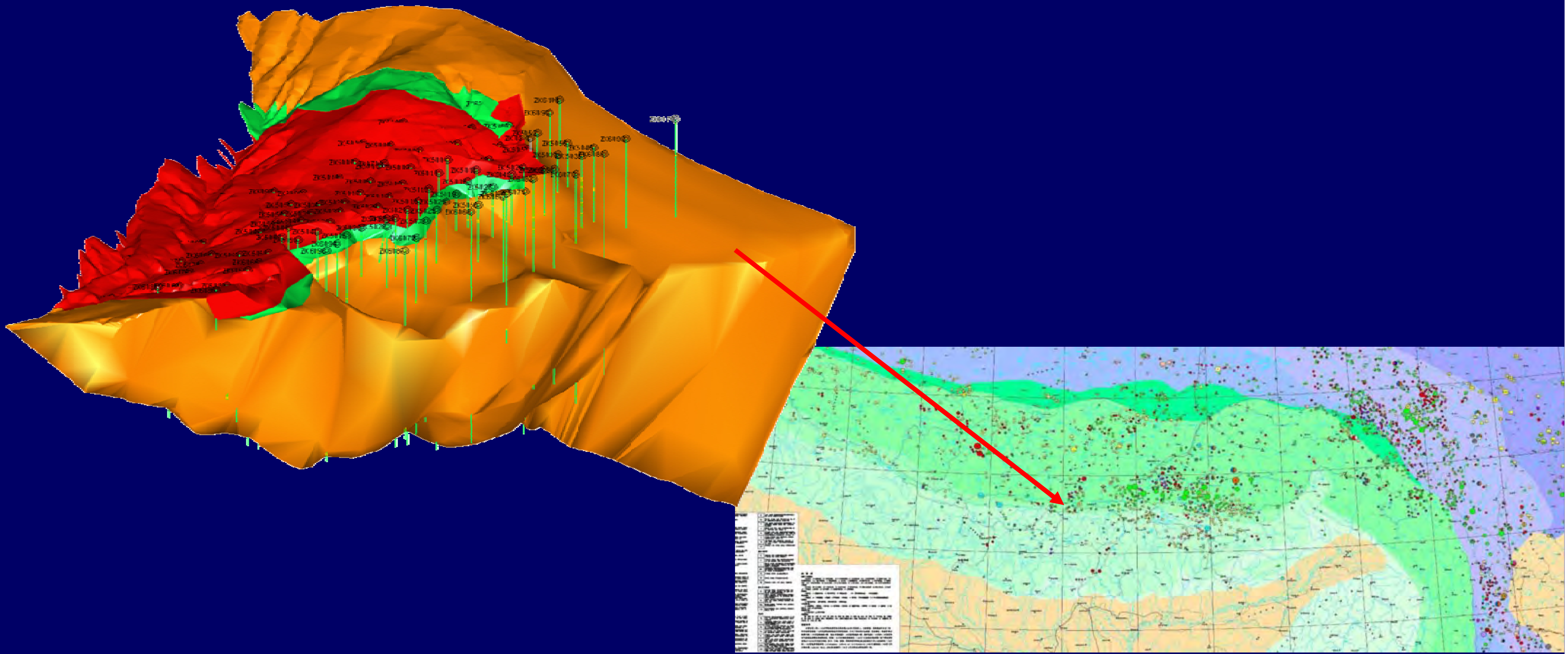
Eastern Tethys Copper Belt



The wall for countyard in local district is built by malachite stone

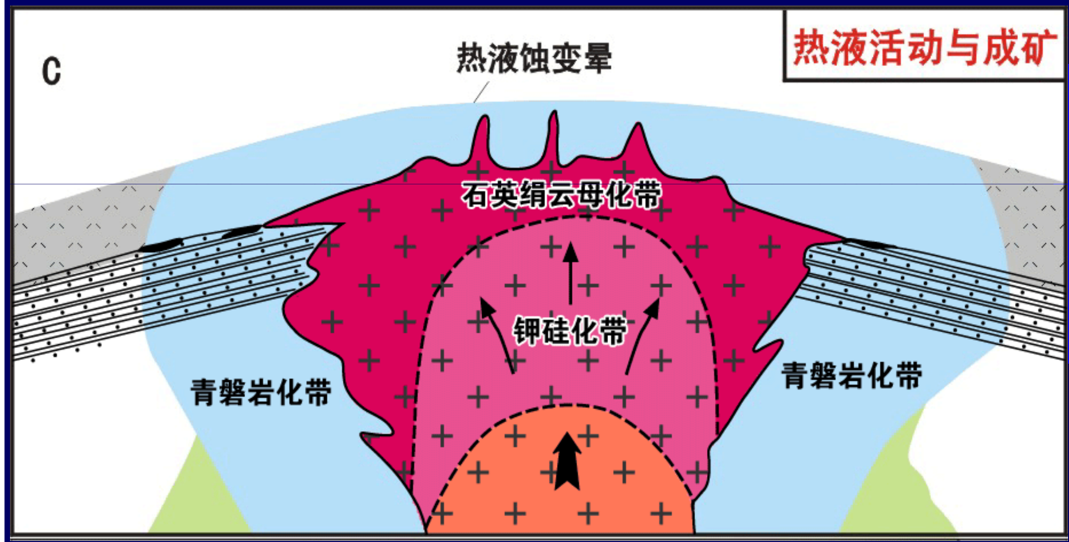
The proven reserves copper 8 million tons、silver 5931 tons and molybdenum 0.5 million tons.

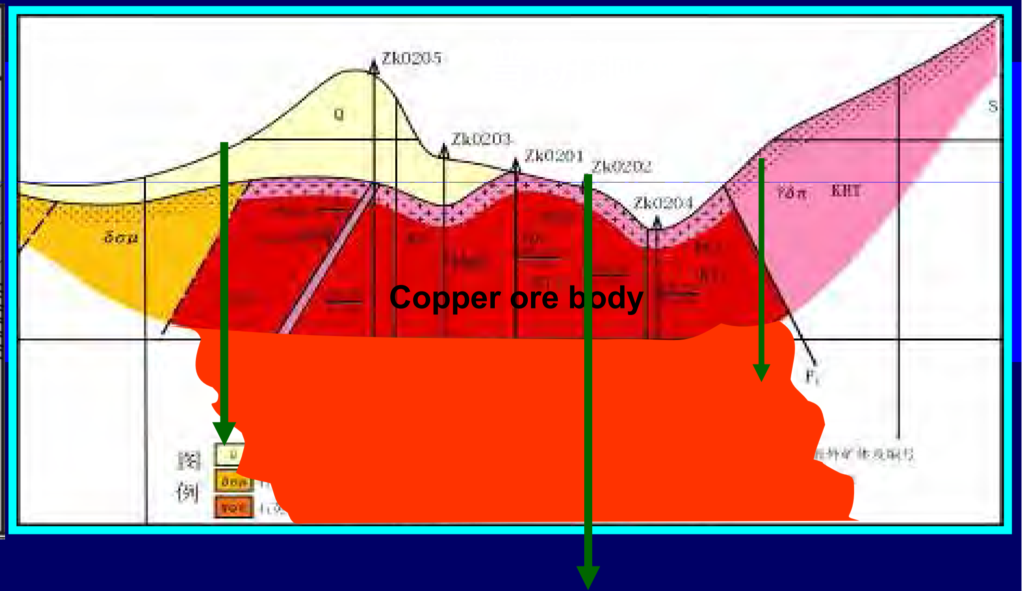
Xiongcun gold & copper deposit:



Eastern Tethys Copper Belt

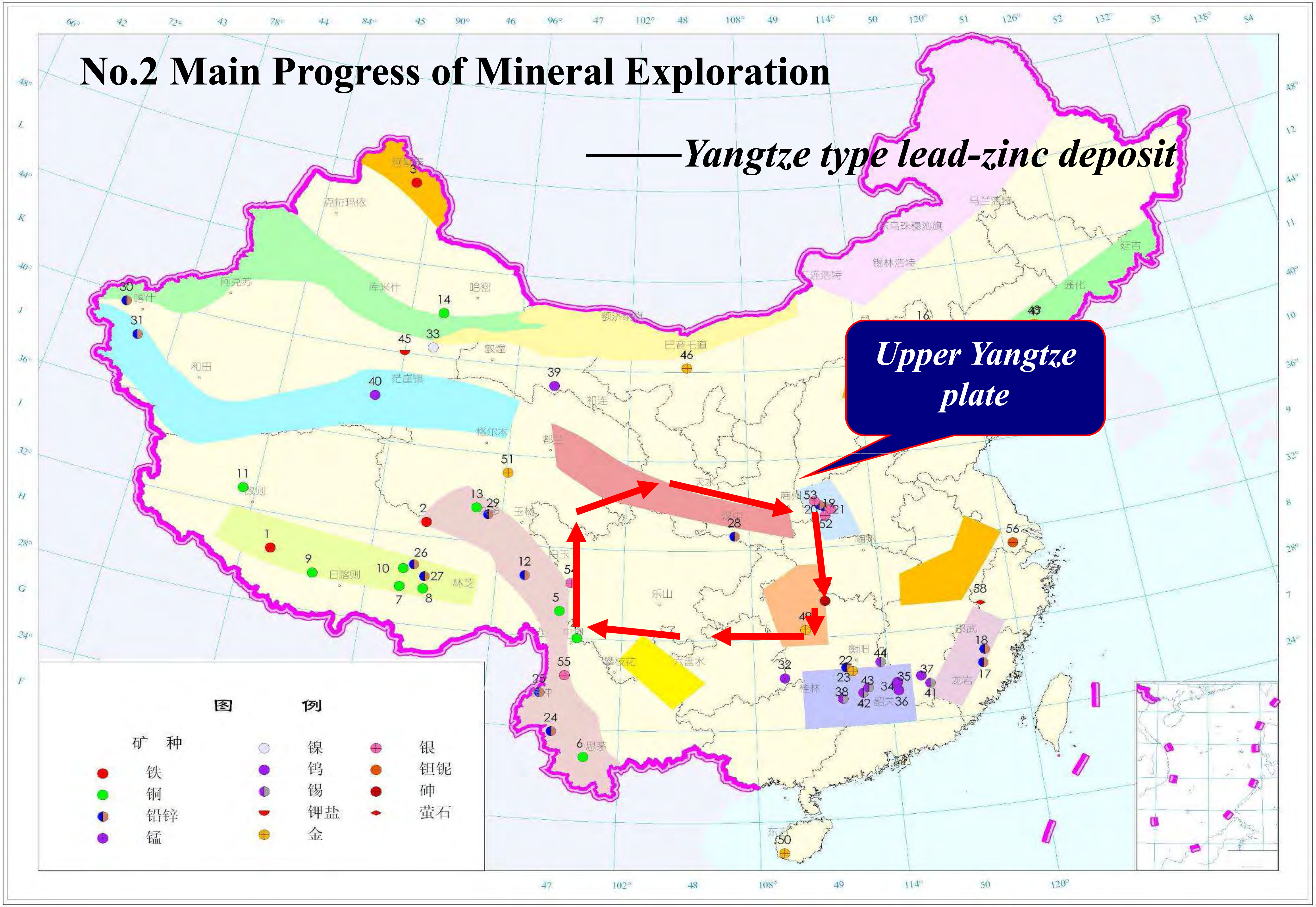
Pulang copper deposit



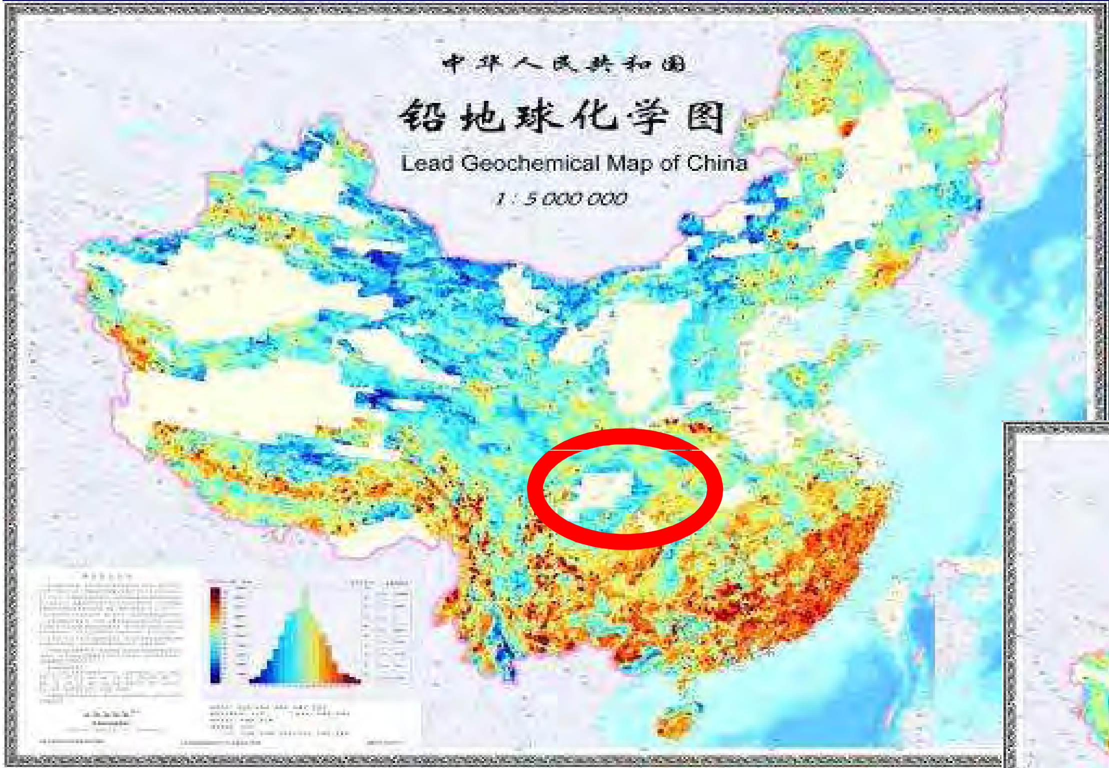


No.2 Main Progress of Mineral Exploration

——Yangtze type lead-zinc deposit

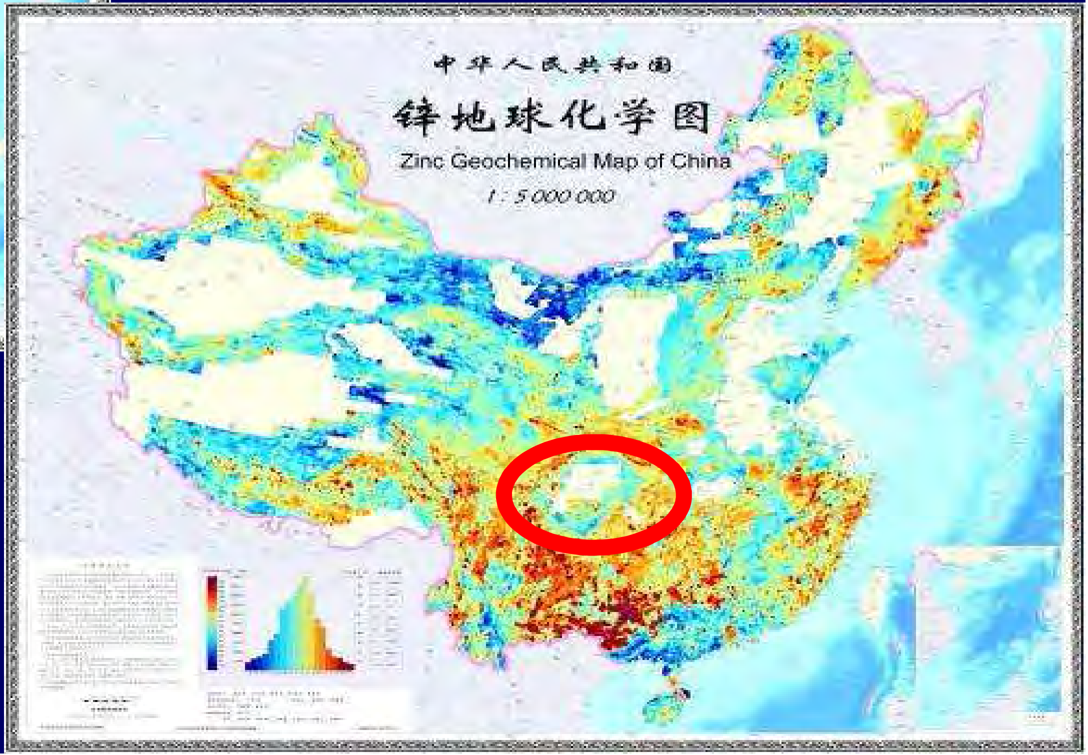


Upper Yangtze plate



Zn

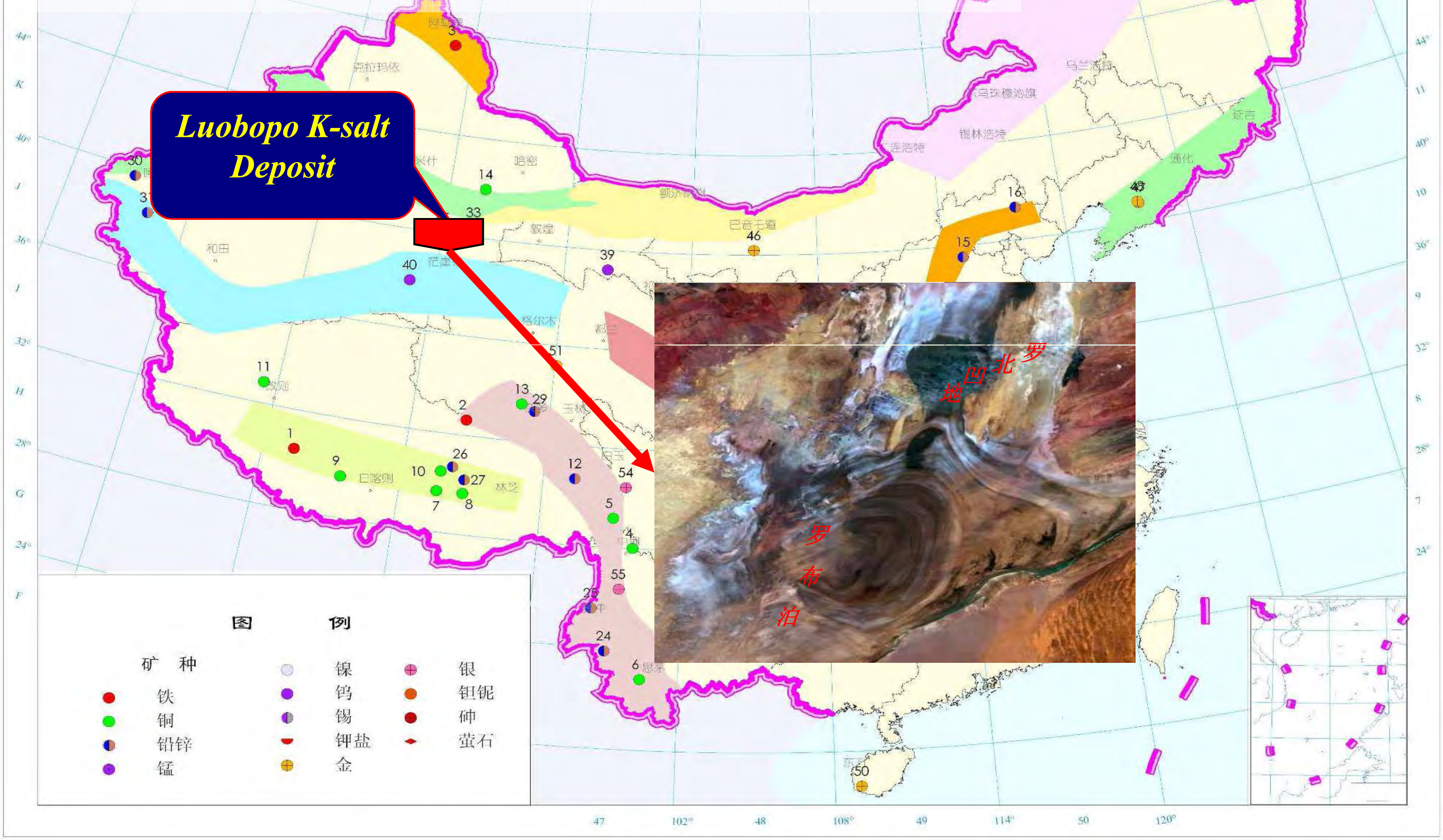
Pb



Upper Yangtze plate

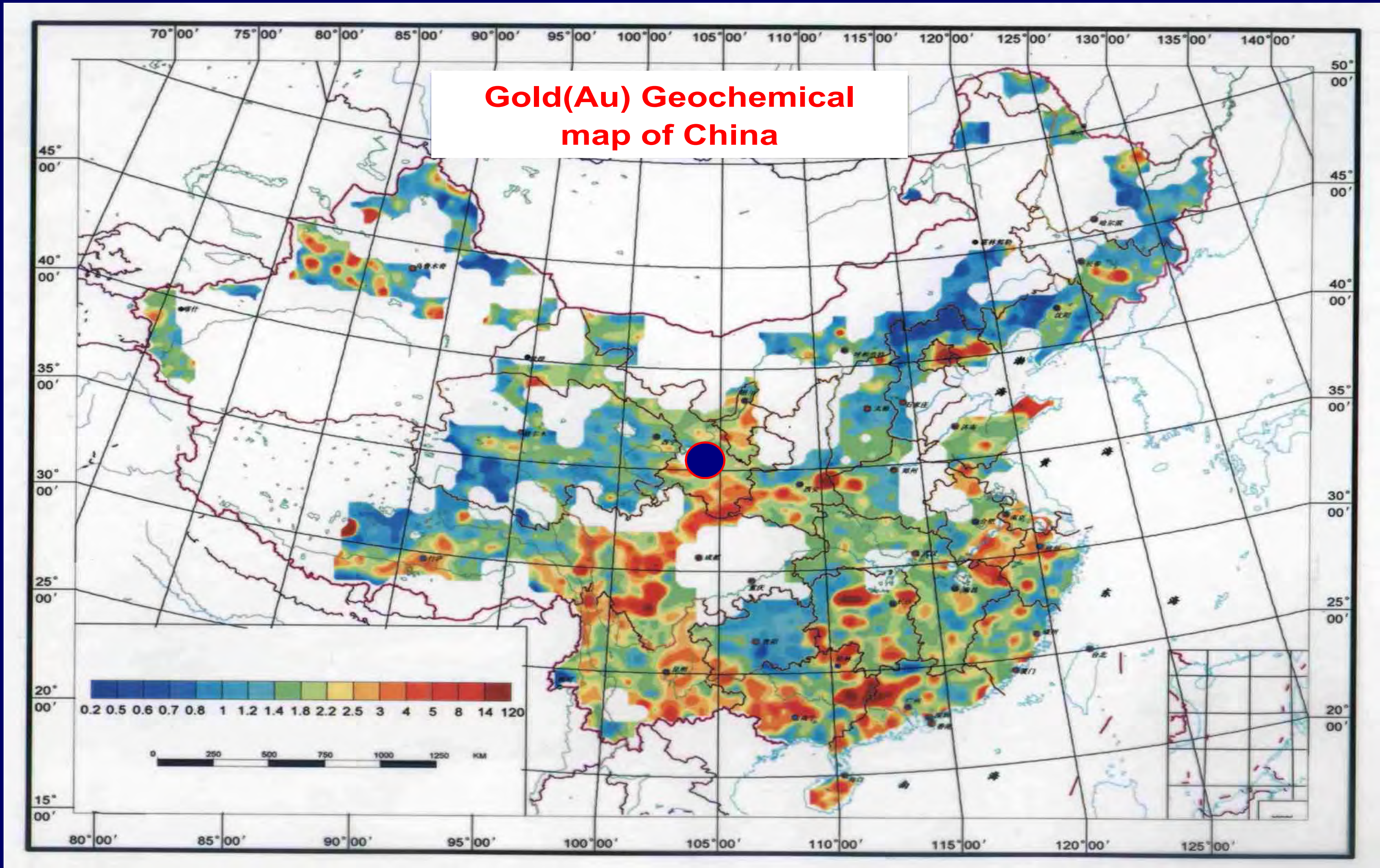
Yangtze type lead-zinc deposits

No.3 Main Progress of Mineral Exploration —Luobopo K-salt Deposit:



Luobopo K-salt Deposit:

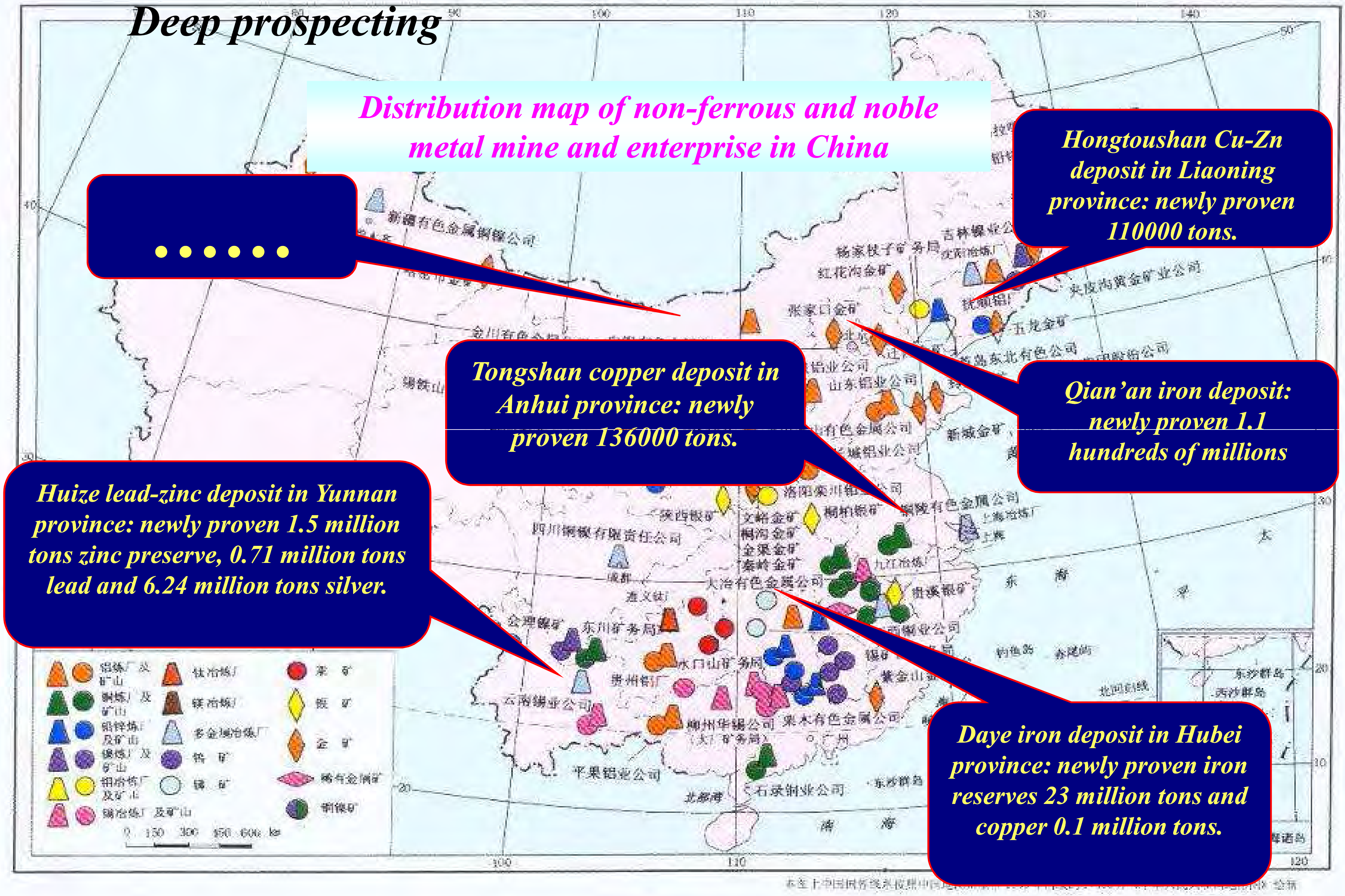
No.4 Main Progress of Mineral Exploration
—Prospecting of Gold deposit



No.5 Main Progress of Mineral Exploration —Deep prospecting

Newly core drilling machine

Deep prospecting



Distribution map of non-ferrous and noble metal mine and enterprise in China

……

Hongtoushan Cu-Zn deposit in Liaoning province: newly proven 110000 tons.

Tongshan copper deposit in Anhui province: newly proven 136000 tons.

Qian’an iron deposit: newly proven 1.1 hundreds of millions

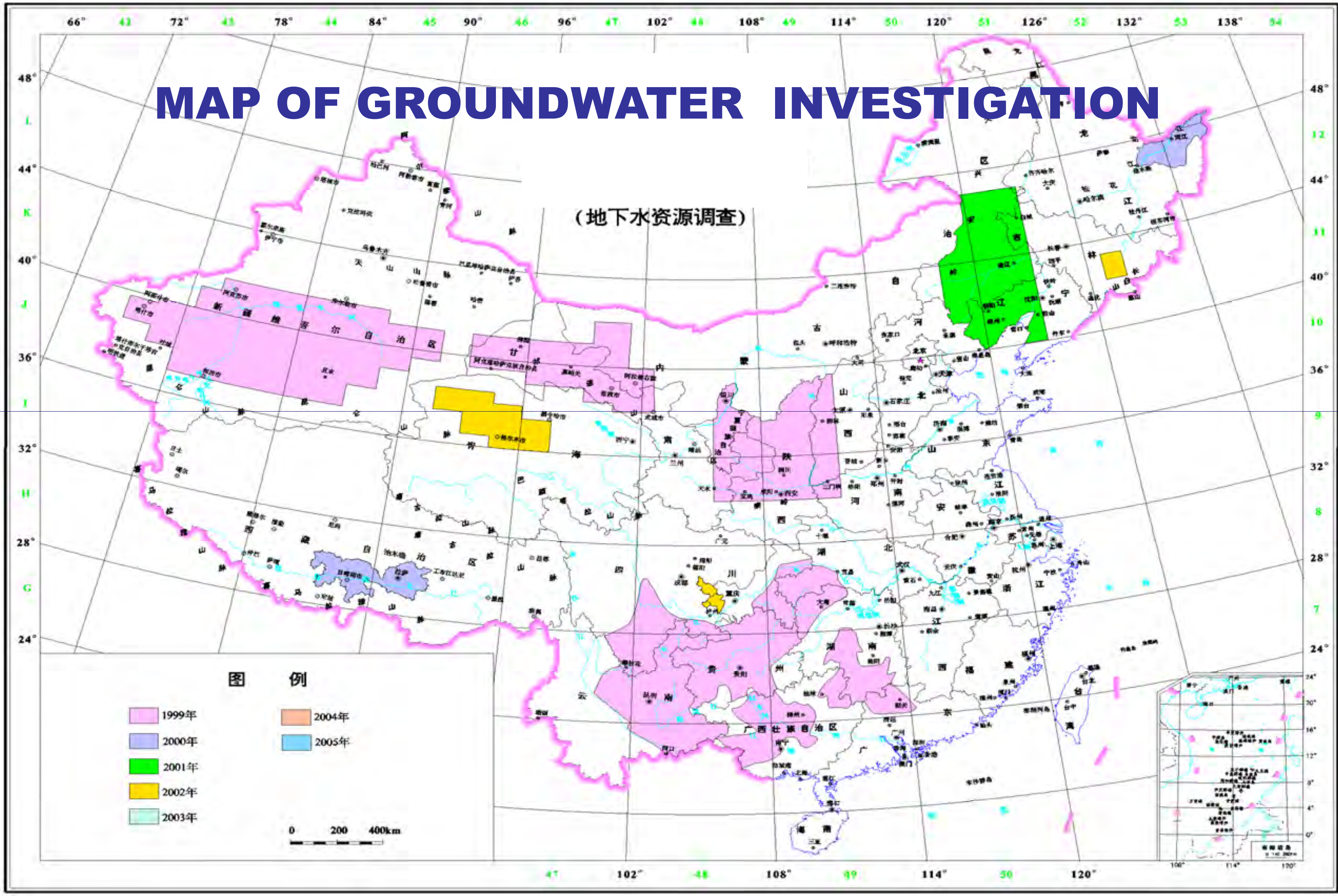
Huize lead-zinc deposit in Yunnan province: newly proven 1.5 million tons zinc preserve, 0.71 million tons lead and 6.24 million tons silver.

Daye iron deposit in Hubei province: newly proven iron reserves 23 million tons and copper 0.1 million tons.

No.6 Main Progress of Mineral Exploration —Water exploitation

MAP OF GROUNDWATER INVESTIGATION

（地下水资源调查）



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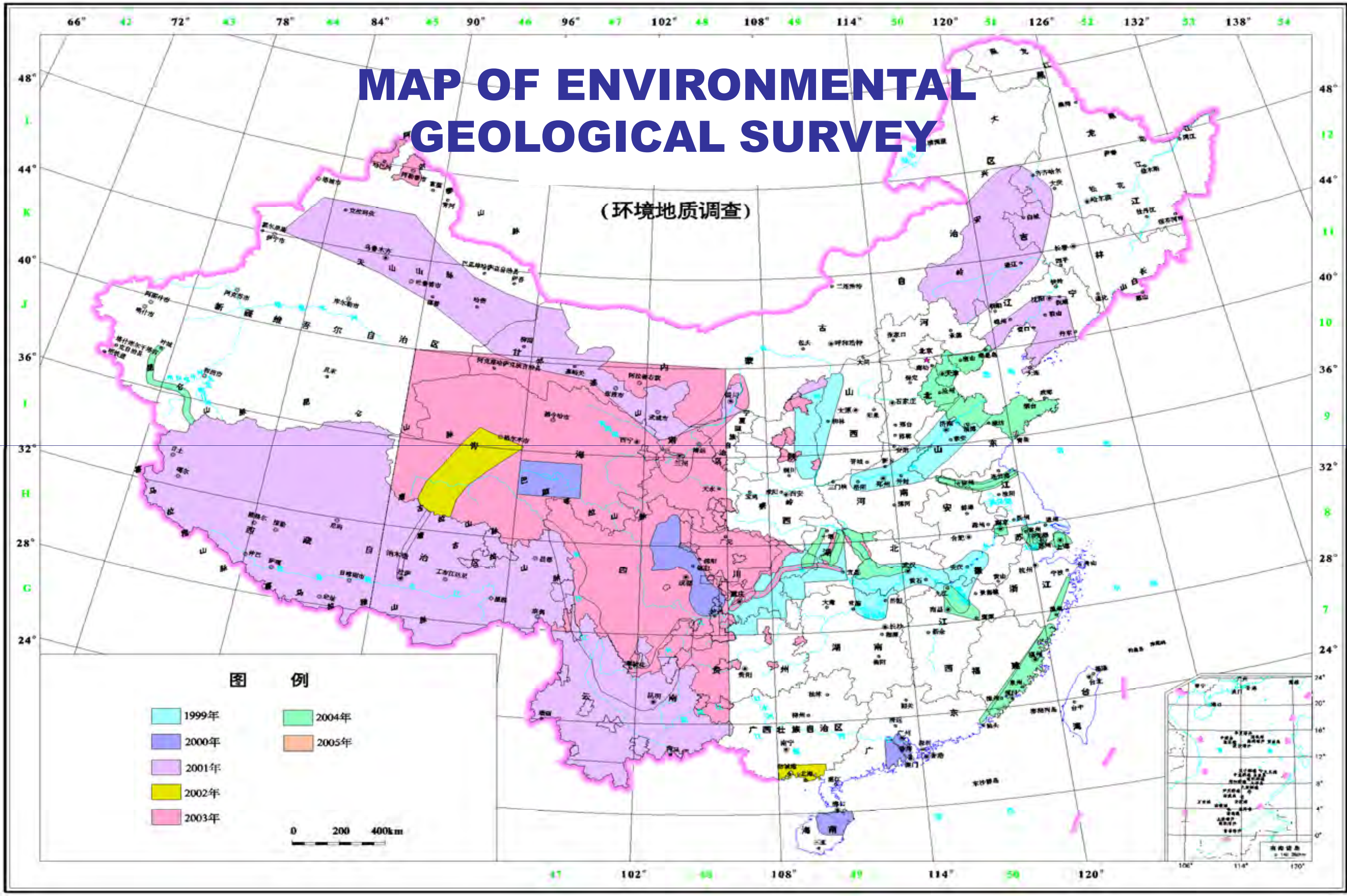
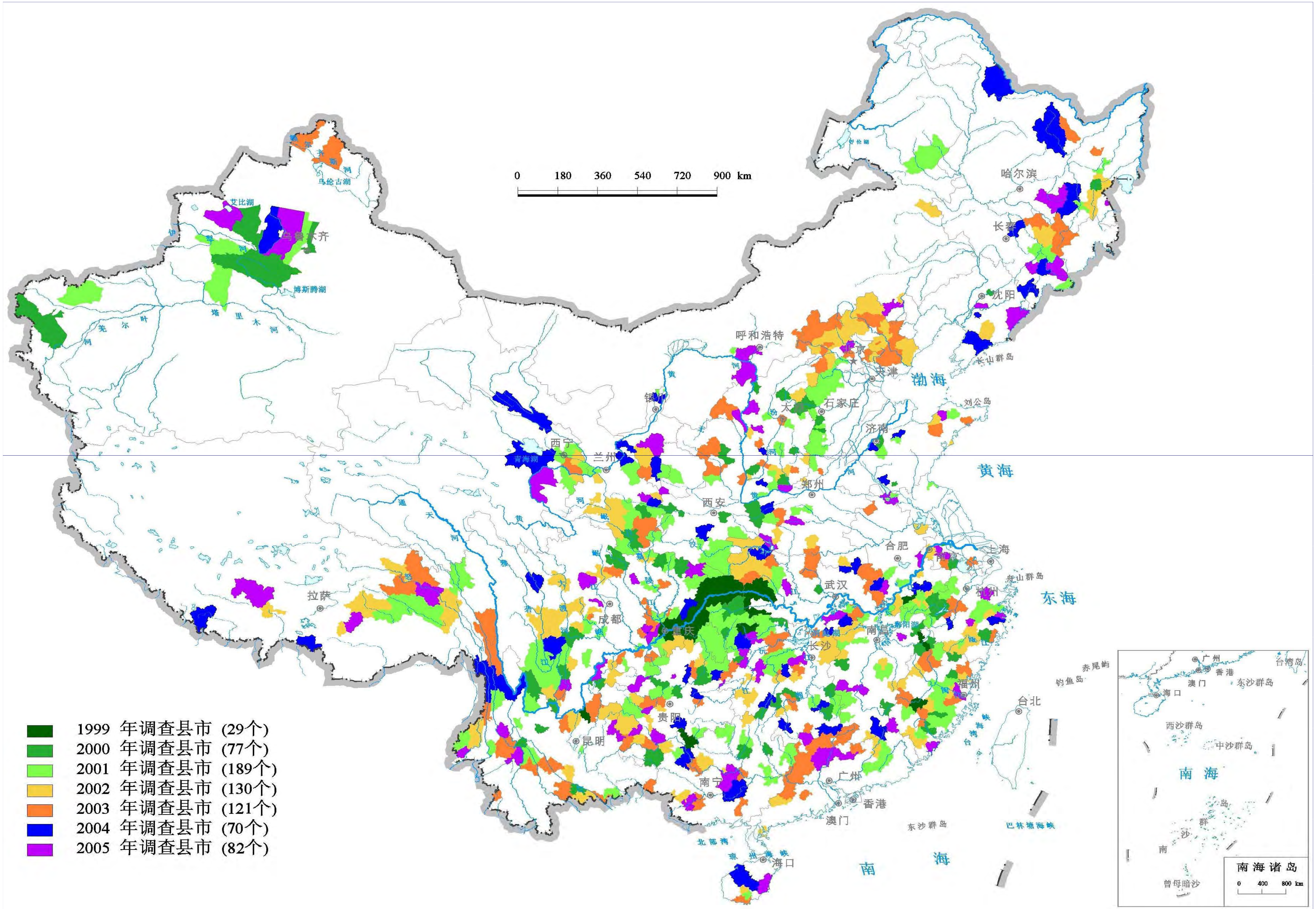
Geo-environmental Investigation and Assessment in the Important Economic Zones and Fragile Environment Areas

- ✓***3 economic zones:*** ***Geo-environment investigation and planning;***
- ✓***Main plain basins in north China:*** ***groundwater dynamic investigation and groundwater pollution investigation;***
- ✓***Karst area in southwest China:*** ***hydro-geological investigation and rock desertification mitigation;***
- ✓***Geo-hazards investigation, monitoring and pre-warning in high risk areas.***

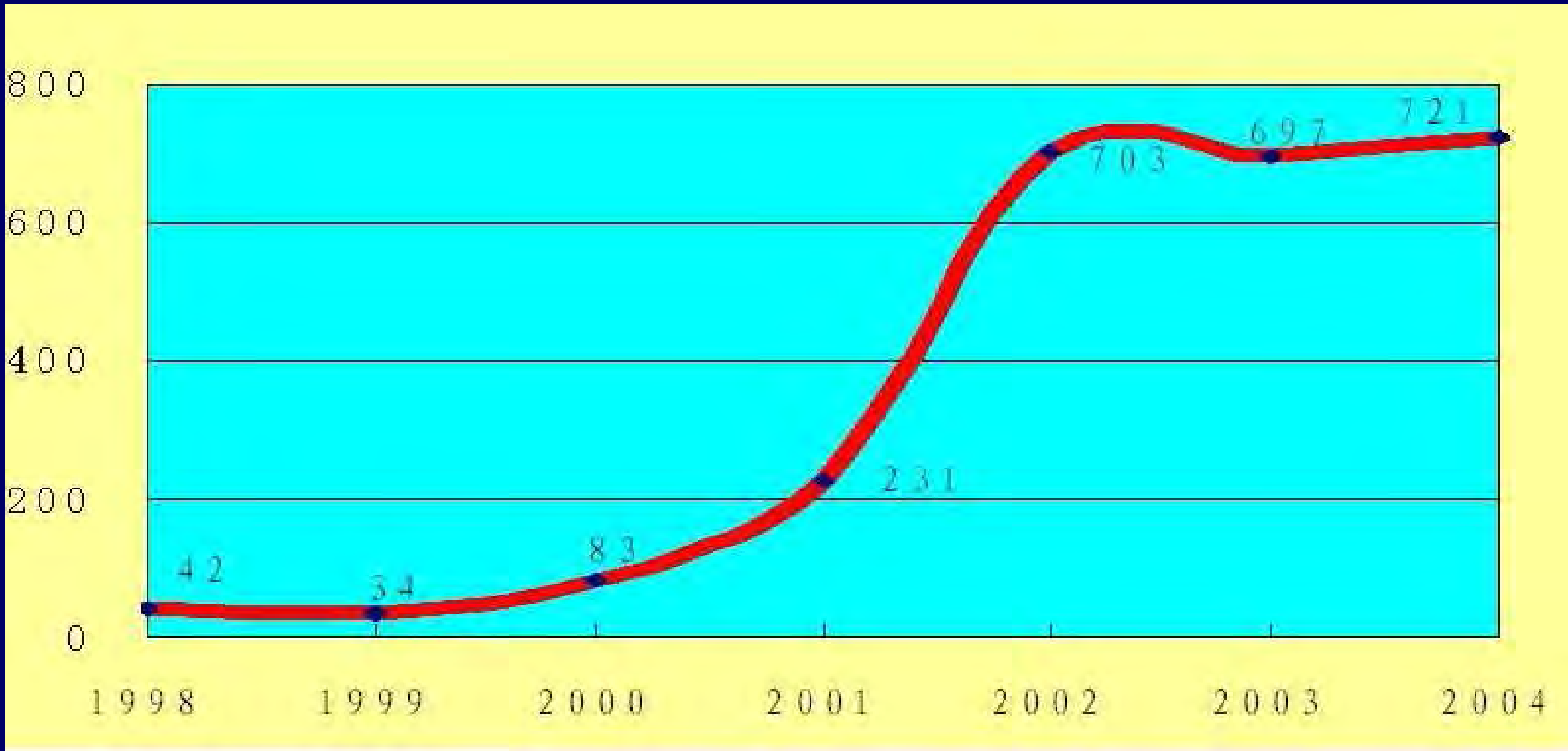
MAP OF ENVIRONMENTAL GEOLOGICAL SURVEY



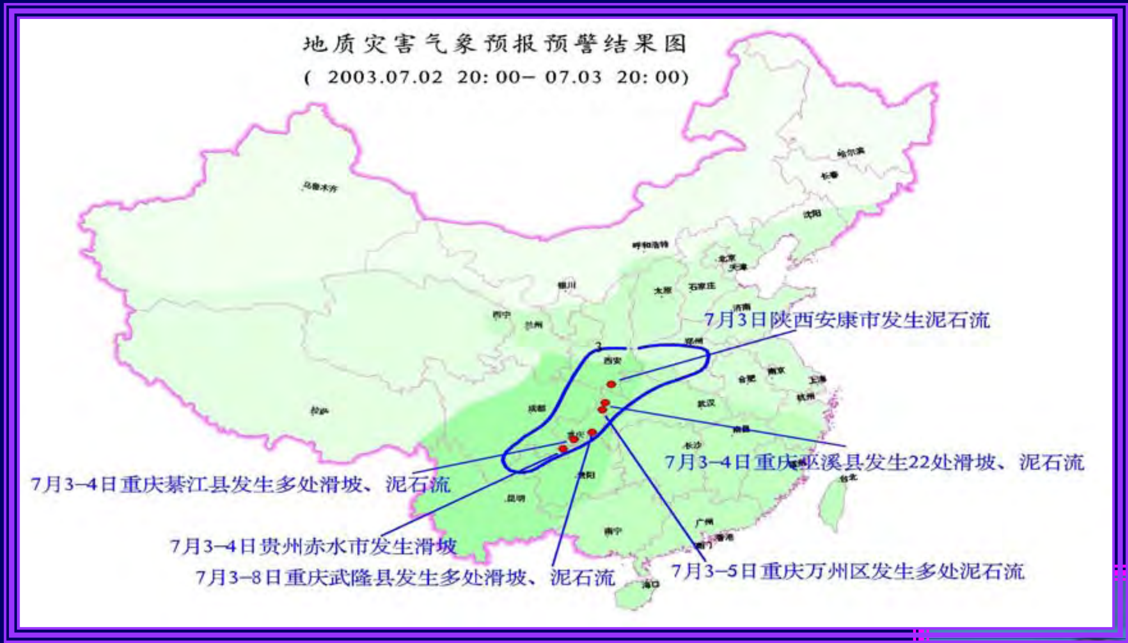
Main economic zones and fragile environment areas


0 180 360 540 720 900 km
哈尔滨
长春
沈阳
呼和浩特
北京
天津
石家庄
太原
济南
郑州
西安
兰州
西宁
银川
乌鲁木齐
拉萨
成都
重庆
武汉
长沙
南昌
合肥
南京
上海
杭州
福州
台北
贵阳
昆明
南宁
广州
香港
澳门
海口
渤海
黄海
东海
南海
长山群岛
刘公岛
舟山群岛
钓鱼岛
赤尾屿
东沙群岛
巴林塘海峡
台湾海峡
北部湾
琼州海峡
青海湖
博斯腾湖
艾比湖
乌伦古湖
塔里木河
南海诸岛
0 400 800 km
西沙群岛
中沙群岛
南沙群岛
曾母暗沙
台湾岛
1999 年调查县市 (29个)
2000 年调查县市 (77个)
2001 年调查县市 (189个)
2002 年调查县市 (130个)
2003 年调查县市 (121个)
2004 年调查县市 (70个)
2005 年调查县市 (82个)

Successful landslides forecasting

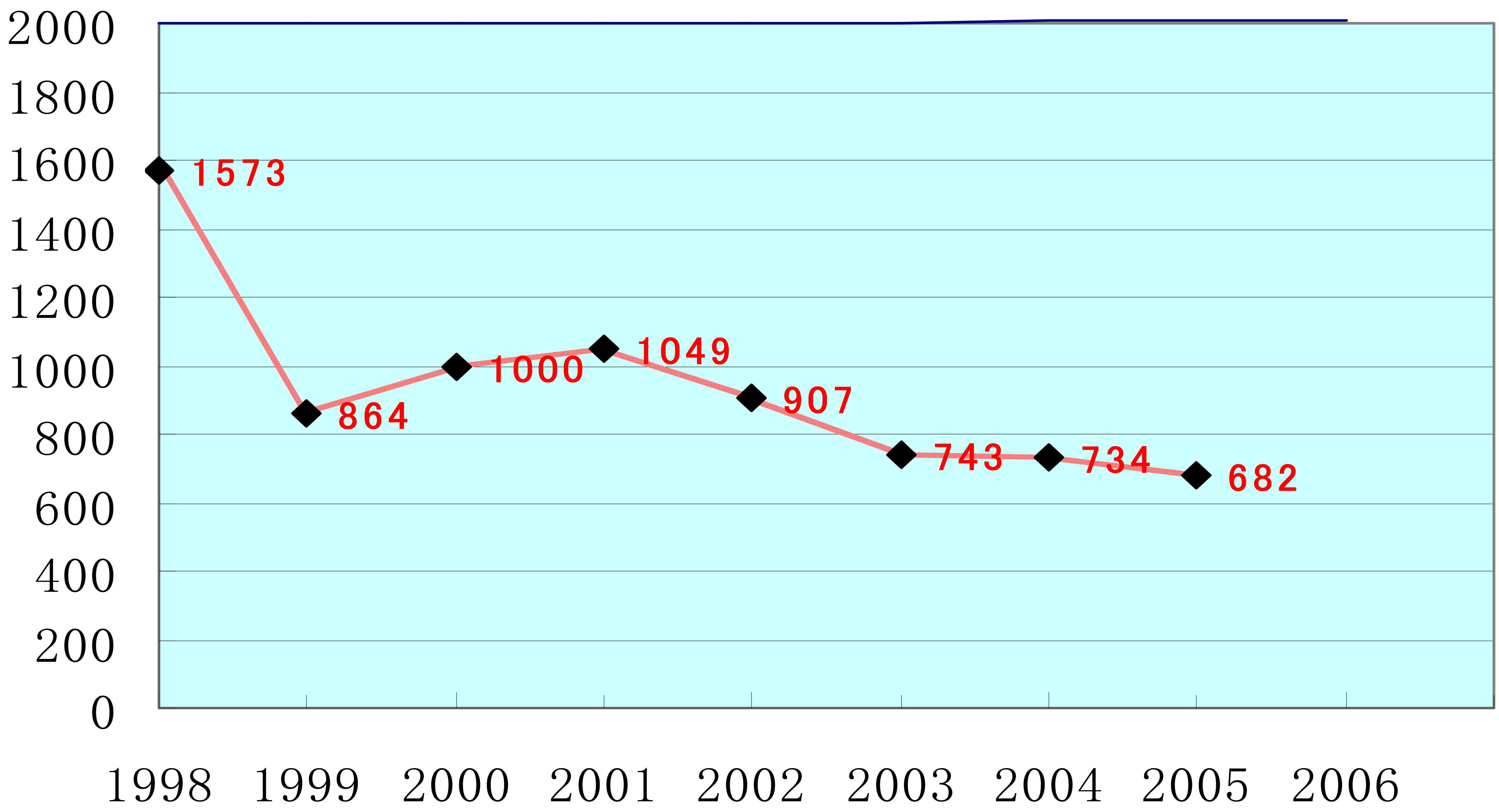


With the data of Geo-hazards census , the annual successful forecasting number of Geo-hazards increased from 34 in 1999 to 721 in 2004.



National prediction system for rainfall-induced landslides

The death toll caused by geo-hazard from 1998 to 2005



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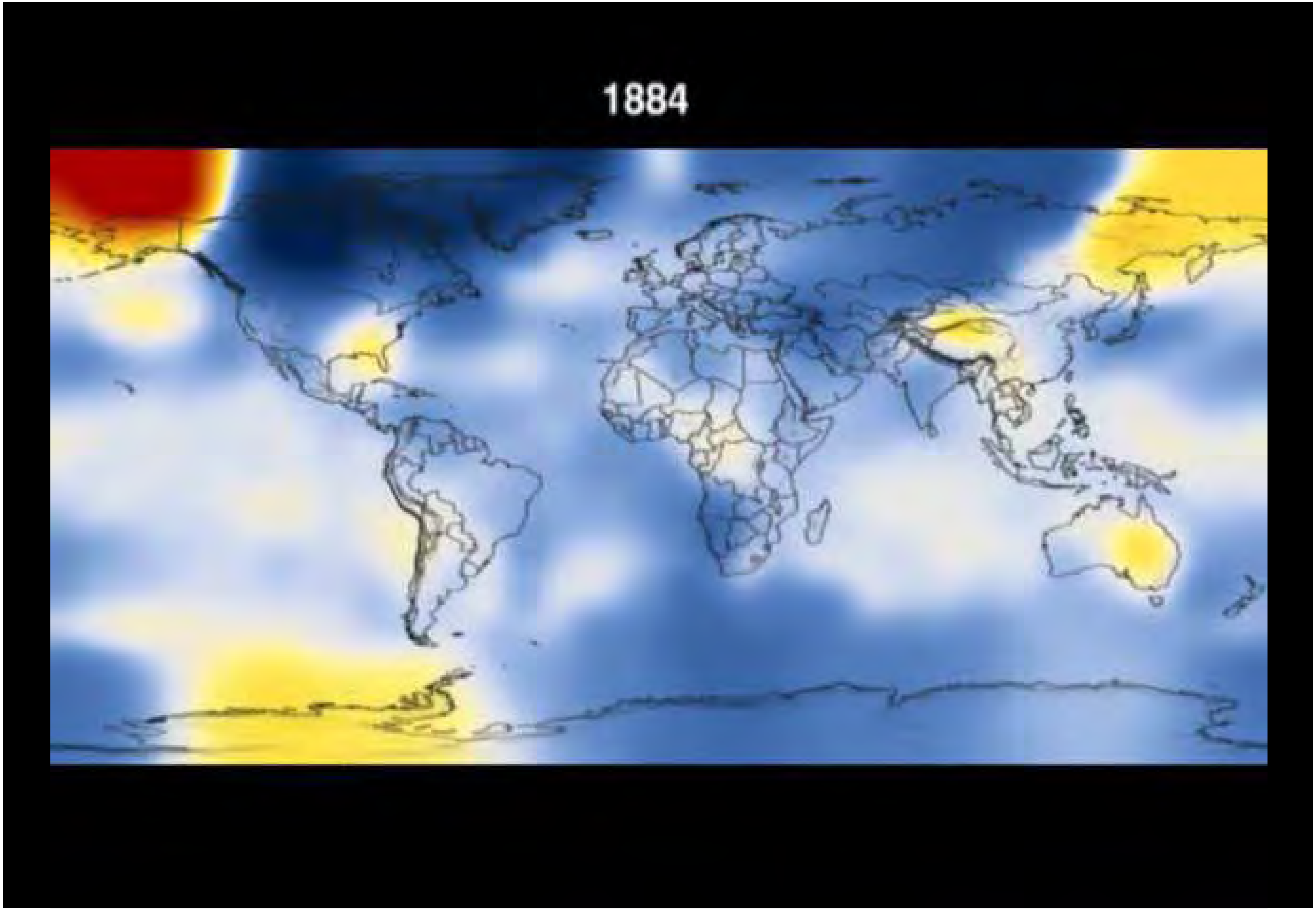
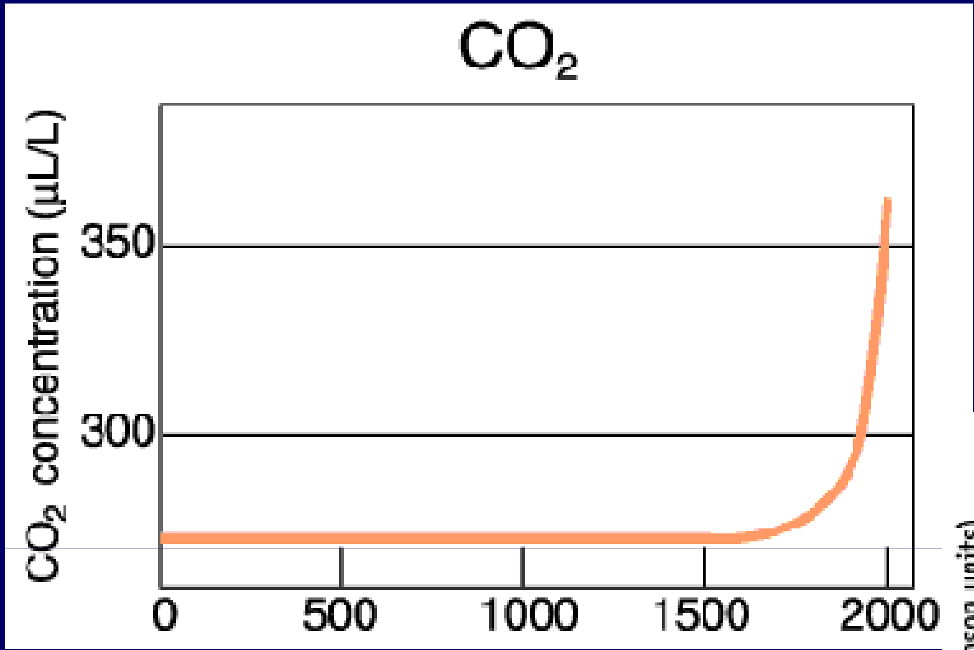
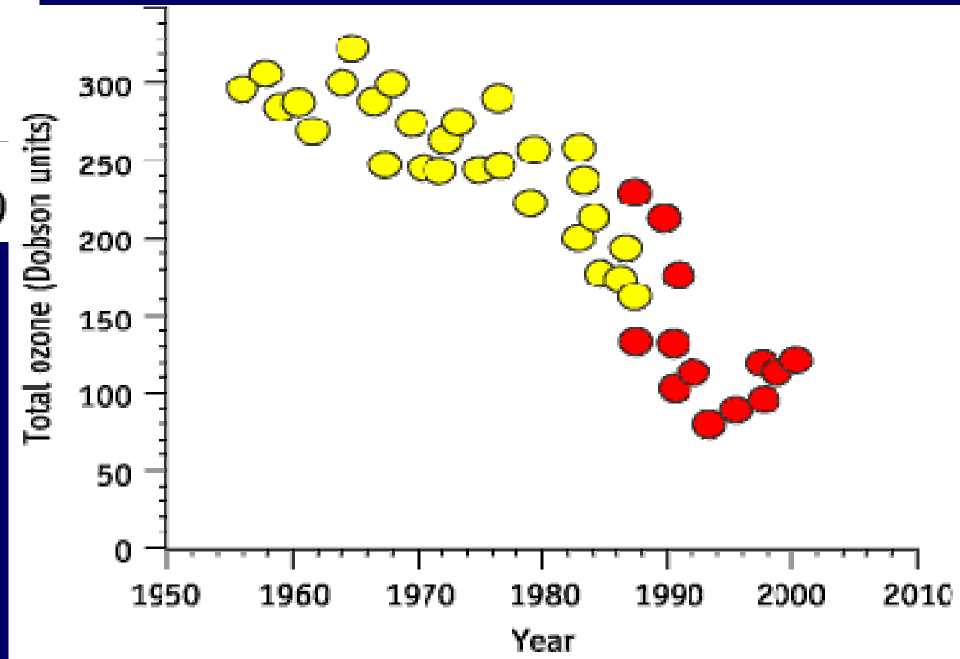
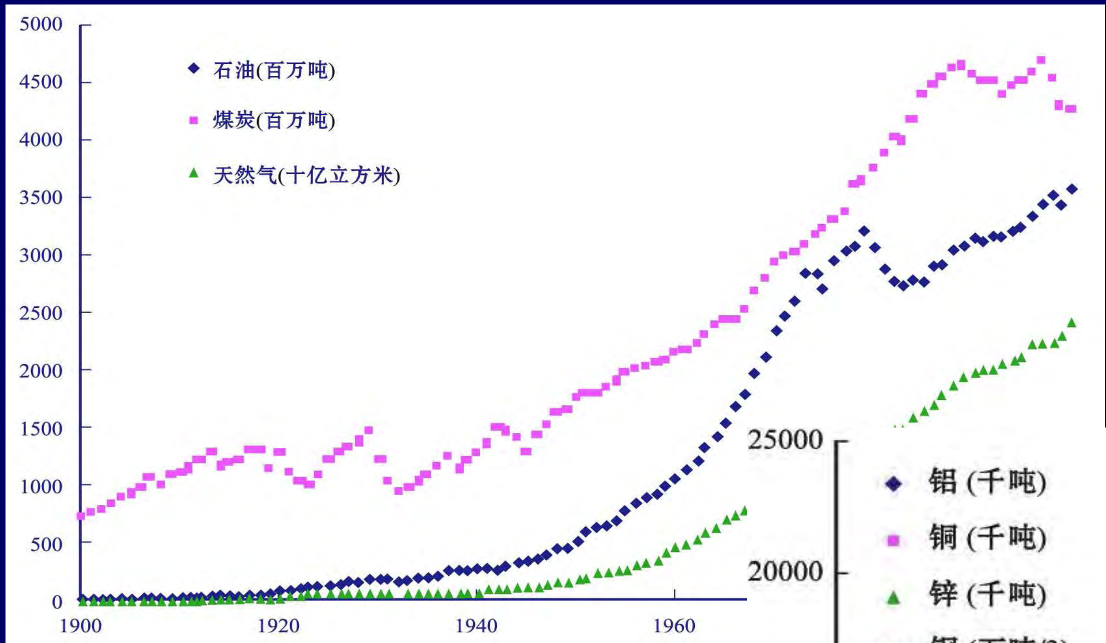
Our common families: Earth

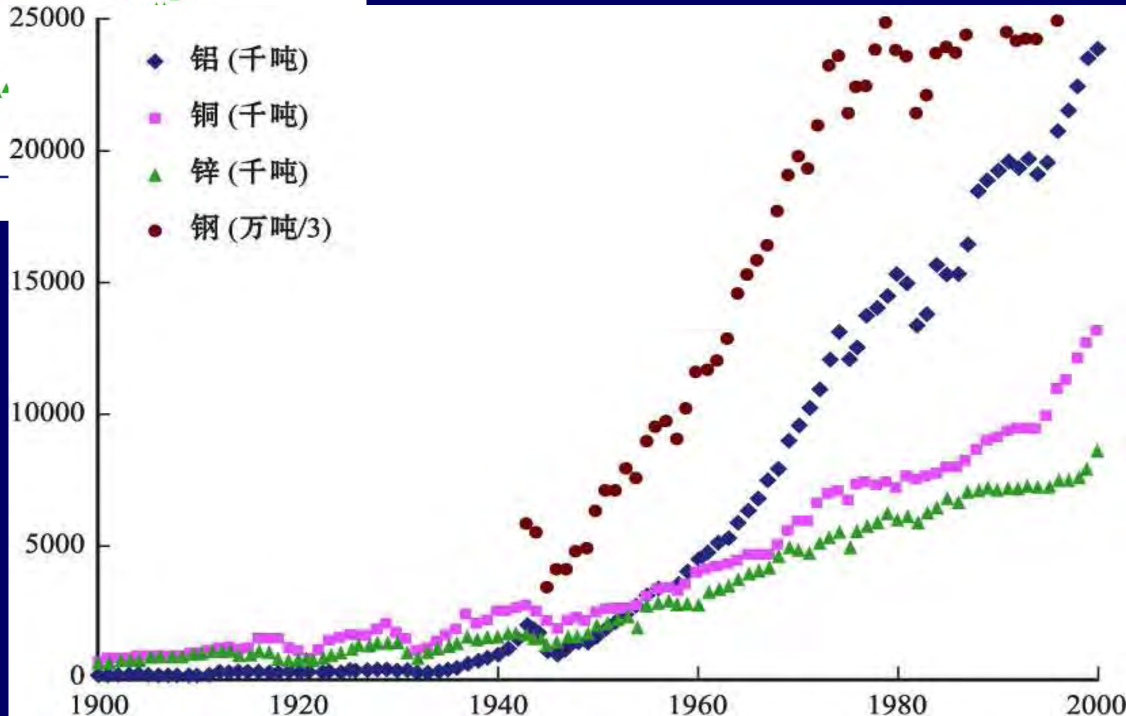

1884


CO2
CO2 concentration (µL/L)
350
300
0
500
1000
1500
2000


Total ozone (Dobson units)
300
250
200
150
100
50
0
1950
1960
1970
1980
1990
2000
2010
Year

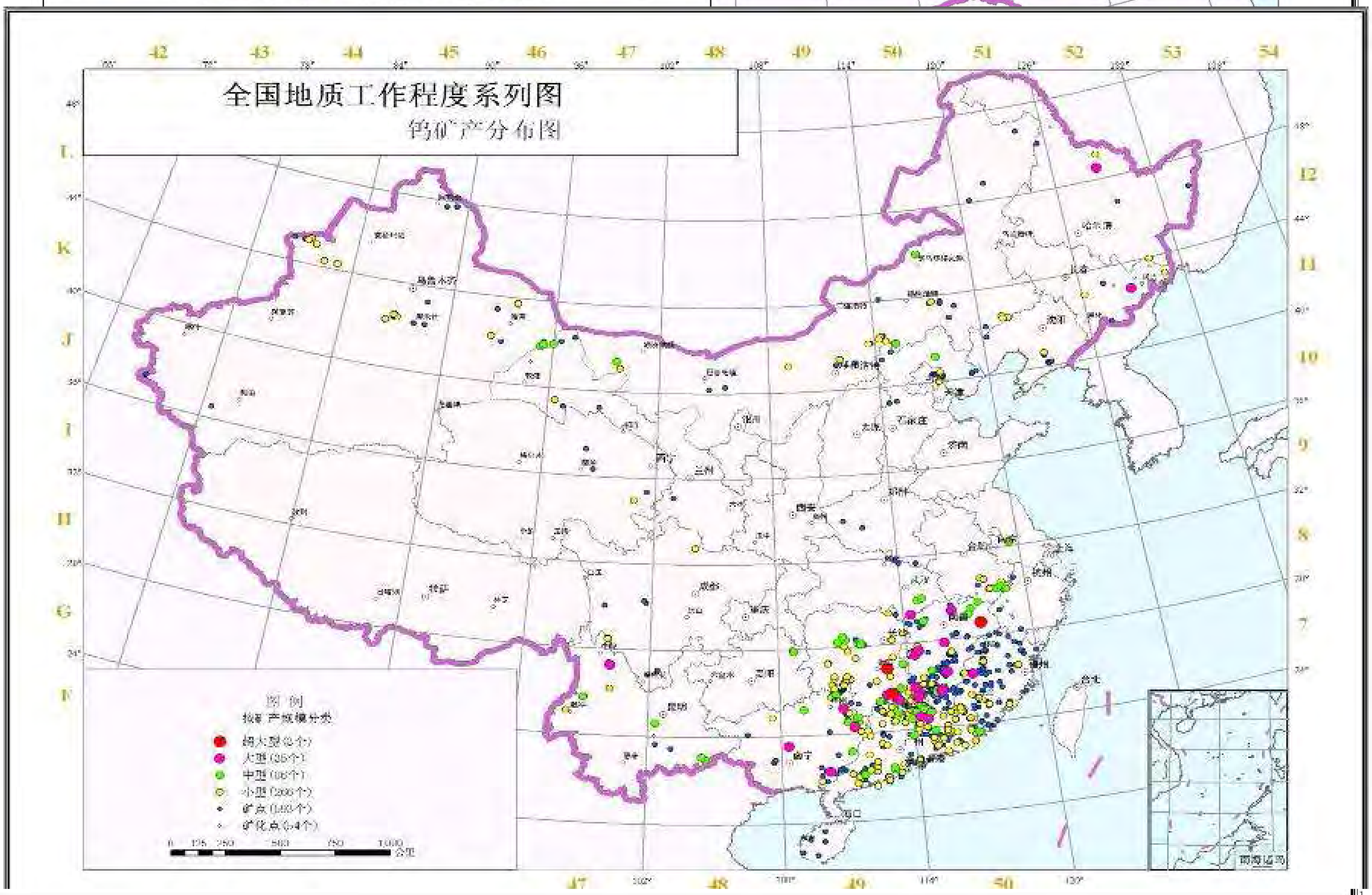


石油(百万吨)
煤炭(百万吨)
天然气(十亿立方米)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1900
1920
1940
1960



铝 (千吨)
铜 (千吨)
锌 (千吨)
钢 (万吨/3)
25000
20000
15000
10000
5000
0
1900
1920
1940
1960
1980
2000

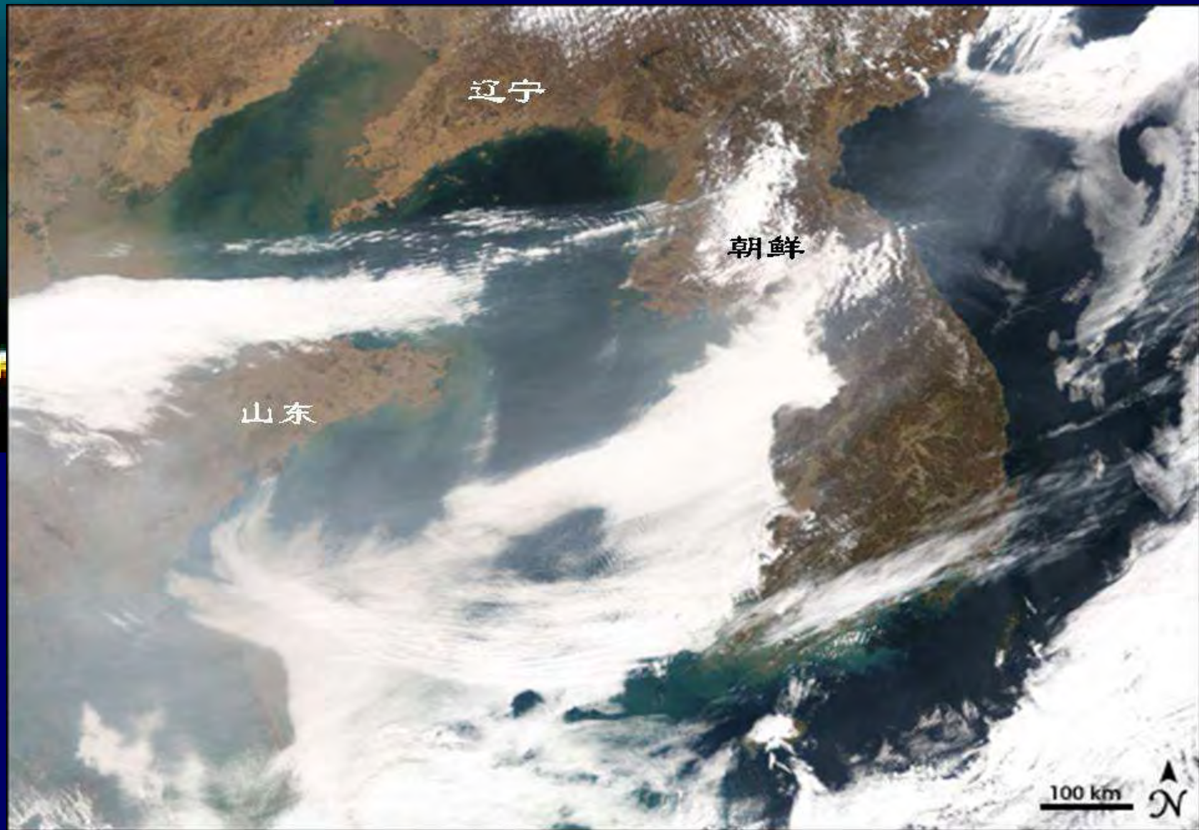
In China, because of the rapid progress of economy, the mineral resources exploration & production & consumption are increasing very fast.


全国地质工作程度系列图
钨矿产分布图
图 例
公里

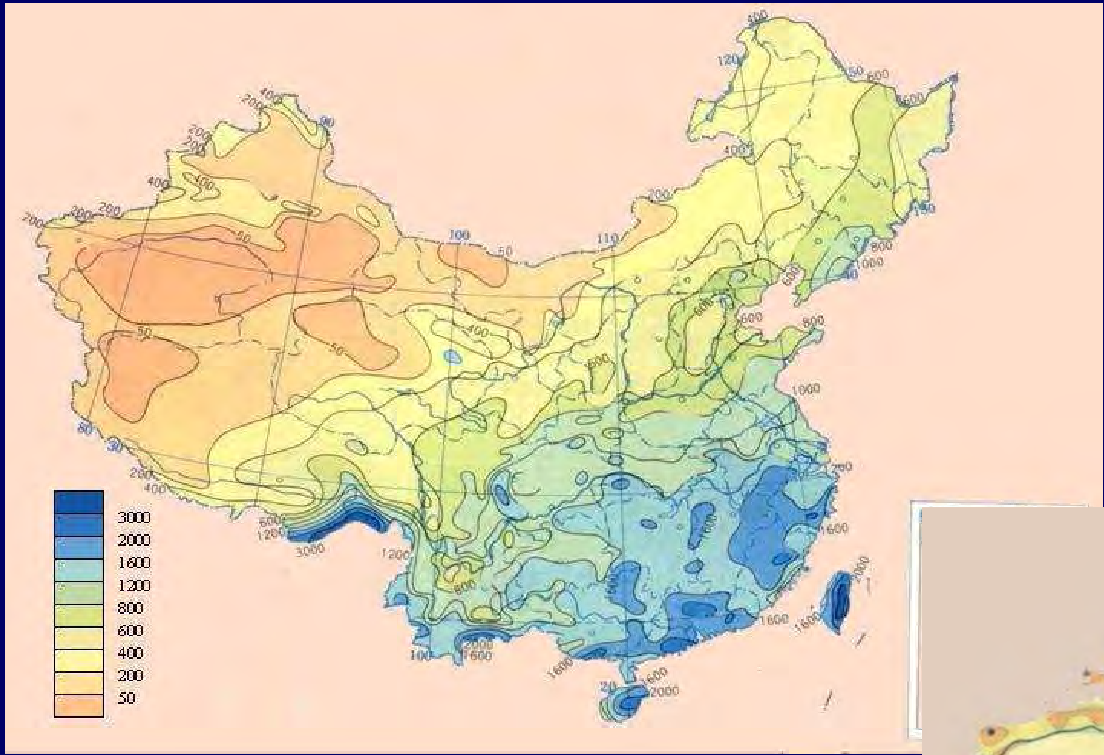
In 2006, the China's GDP accounts of 5.5% of the world total, but consumed 54% cement, and 30% iron, 15% energy resources. Water pollution, air pollution, and acid rain, are very severe.

sandstorm

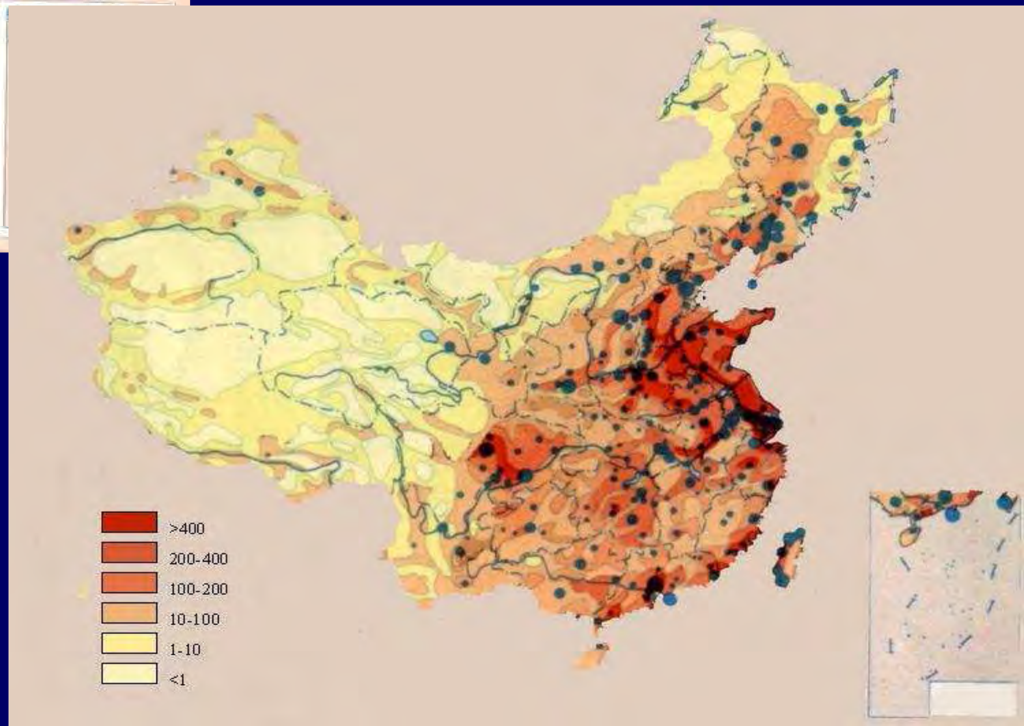
July 13th, 2004, Sand dust attack Gansu province



March 28th, 2005, Sand dust blew from West to East



Water resources



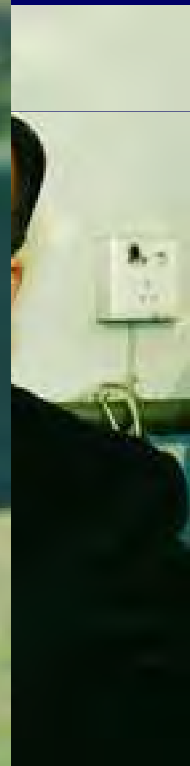
The population density of China

Water pollution

land slide

Grand sink


RITSUMEI
cnsphoto



China's economic growth is realized at an excessively high cost of resources and the environment.

"Geological sciences and geological structures do not end at national boundaries. Working on the same planet, geologists need to communicate and share knowledge with each other, and to draw on each other's experiences."

Quote from speech by Chinese Premier Wen Jiabao
19 June 2007 Episodes, Vol 30, no 2


Thank You!

GEO-RESOURCES & GEO-ENVIRONMENTAL ASSESSMENT IN CHINA

(ABSTRACT)

ZHANG DAQUAN (China Geological Survey)

Following the rapid development of China economy, the demand for geo-resources increases fairly fast, the investment from all around of world come into China, and the mining market is "flourishing" today. Meanwhile, the concern about the national sustainability of nonfuel minerals production and environmental quality are growing, too.

1. The state of mineral resources in China

China is rich in mineral resources. After the long period work, especially large-scale geological exploration conducted since the founding of the People's Republic of China (1949), 171 kinds of mineral resources have been discovered. Among which, 156 commodities have explored reserves, including 9 types of energy resource, 54 metallic minerals, 90 nonmetallic minerals, plus groundwater, mineral water and carbon dioxide gas. The total value of potential reserves places China third in the world. but the amount per person is relatively low, accounting for only 58% of the average in the world, ranking 53rd. Various deposits are among the richest, including rare earth element, W, Sn, Sb, Mo, Bi, Be, coal, magnesite, barite, fluorite, talc, graphite, bentonite, fireclay, asbestos, gypsum, wollastonite, diatomaceous earth, and building stone. On the other hand, the country is lacking in oil, high-grade iron, Cr, Mn, Cu, PGE, potash salt and diamond. By now, about 200 thousand localities of ore deposits or mineral occurrences have been discovered, among which, 20 thousand ore deposits have been investigated in detail, including 90 super giant deposits.

However, few geological work has been done in the vast western territory of China or under the depth of 500m below surface, suggesting a great potential for more discovery. Owing to the diversity of geological settings for mineralization in China, there is great potential for ore prospecting.

2. Geological Setting

The present Chinese continental crust has evolved from the process of jointing, *deformation and developing of paleo-cratons or paleo-massif through the long history of geology. The basic geological and tectonic units of the Chinese continent include the relative stable regions (paleo-plates or massif) and the active belts (suture zones and/or collision belts). There are three large land mass or plates and five active belts in China.*

The three main landmass (plate) include: (1) the North China landmass, which were formed after the Lvliang Movement (1800 Ma) and at the basement of Archean and/or Lower Proterozoic metamorphic rocks; (2) the Tarlimu lanmass, formed after the Jinning Movement (1000Ma) and at the basement of pre-Sinian metamorphic rocks; (3) the Yangtze landmass, also formed after the Jinning Movement and mainly at the basement of Proterozoic metamorphic rocks.

The five active belts include: (1) the Tianshan-Xing'an active belt, which consist with a series of fold belts and micro-plates and formed after the Caledonian-Hercynian movement; (2) the Kunlun-Qilianshan-Qinling active belt, which is an important belt between North China and South China and activated at different epoches of Jinning, Caledonian, Hercynian, Indosinian, Yanshanian and Himalayan; (4) the Sichuan- Yunnan-Qinghai-Tibet active belt, which is the most important active belt of Tethys- Himalayan in the southwestern China; and (5) the western circum-Pacific active belt, mainly overprinted on the Paleozoic and pre-Paleozoic tectonic belts in the eastern China and featured by strong activation of Mesozoic-Cenozoic volcanism-magmatism in East China, large-scale granitoid intrusion in the Nanling Region, NE-NNE-trending movement of blocks and rifting-magmatism in the margin area of paleo-landmass.

3. Some major achievements for geo-resources exploration

In recent years, Chinese government pay much attention to the geo-resources exploration, and the encouraging commodities are: Fe, Cu, Al, Pb, Zn, Mn, Ni, W, Sn, K, Au; the encouraging metallogenic belt：Three Rivers Areas of Southwest China, Gandis, Tianshan Mountains, Nanling, Great Xing'an Mountains, Altai, Kunlun-Arjin, Beishan, Qinling and so on.

Some expert predict that the total proven extent of mineral exploration is about 1/3, among which, the proven reserves of Fe, Cu, Al, Pb, Zn, Mn, Ni, W, Sn, Au, are 26%~59. According to the prediction, the non-proven reserves of iron are 70 billion tons, the proven extent 47%. Copper 120~156 million tons, 34%~41% extent；bauxite

4 billion tons, 40%。In the later several years, we accessed the 565 middle-large size mines, and about 200 mines still have the resources potential for further exploration.

3.1 Great potential in West China for exploring some short commodities—Copper exploration in East Tethyan

The East Tethyan Copper belts almost has the same potential with that famous Andeans belts in South America. Along the belts, we found a series of middle-large size deposit, such as: the Zhunuo, Chuibaizi, Tinggong, Chongjiang, and so on. The perspective reserves are over 20 million tons, plus the proven Yulong copper deposit, the whole reserves will be near 50 million tons.

***Pulang copper deposit:** In Three Rivers belts, proven reserves over 4 million tons, and some good mineral occurrences in the periphery, the total reserves nearly over 10 million tons.*

***Qulong copper deposit:** the proven reserves copper 8 million tons, and molybdenum 0.5 million tons.*

3.2 Great potential in West China for exploring some short commodities—Lead & Zinc exploration around the Upper Yangtse block.

Around the Upper Yangtse block，a series of "MVT" type and "SEDEX" type Lead & Zinc deposit have been found. We called it "Yangtse" type. This type of deposit are mainly controlled by the Early Paleozoic carbonate rocks, and represent the future exploration target of China.

***Mayuan lead & zinc deposit in Shanxi province:** lay in the dolomite of |Dengying fomation, Sinian Period, the proven reserves 2.2 million tons.*

***Bingdong Mountain lead & zinc deposit in West Hubei:** lay in the dolomite of Doushantuo formation, Sinian Period, with the reserves 1.45 million tons.*

3.3 Great potential in West China for exploring some short commodities—Mineral exploration in very low working extent metallogenic belts

Lots of new exploring clues has been found in these areas though the 1:250 thousand regional mapping and the 1:200 thousand aeromagnetic mapping. Including some rich iron deposit in West Kunlun mountains, along the Qinghai-Tibet realway, and Nouth Gandis.

***Baiganhu tungsten & tin deposit in Qimantage areas:**In west part of East Kunlun belts, we found a new tungsten & tin resources base.*

3.4 Great potential in West China for exploring some short

commodities—K-salt resources exploration in Luobopo saline

Luobopo K-salt Deposit: Liquid KCl reserves 155 million tons. And the mine has been developed, and will reach a output nearly 1.2 million tons in the year 2009.

3.5 Great potential in West China for exploring some short commodities—Gold exploration

Xiongcun gold & copper deposit: *invested by Canada Southwest Corporation, and only the No.1 ore body proved the reserves 120 tons of gold; the No.2 ore body has much more potential than the No.1.*

Yangshan Gold Deposit: *a super-large size gold mine discovered by the financial invest especially for gold surveying. From 2001-2006, the total reserves are 258 tons of gold. The deposit are disseminated quartz veins type.*

Dachang Gold deposit: *25 ore bodies, average grade 5.97g/t, the total reserves 115.09 tons. Now the local government (Gansu Province) are cooperating with CANADA INTER-SITIC Corporation for further exploration.*

3.6 Great potential in Middle & East China for exploring the deep—Iron exploration in North China's Landmass

A series of discoveries have been found in Anshan-Benxi city in Liaoning province, the East Hebei province, Hengshan-Wutaishan in Shanxi province, Wuyang-Xincai in Henan Province, and the West Shandong Province, for exploring the iron ore in the deep of the mine.

3.7 Great potential in Middle & East China for exploring the deep—Bauxite exploration in Shanxi & Guangxi province

The newly found large size bauxite deposits: *Tianhe, Kuancaoping, Bayanquan, Tieshuigou, Xiangwang, Pangjiazhuang, Wangrun, and so on in Shanxi province; and the Longhe, Tiandong periphery, Pingguo periphery, Fushui-Chongzuo in Guangxi Province.*

3.8 Great potential in Middle & East China for exploring the deep—Gold exploration in the old mine

Qingchengzi Gold deposit in Liaoning: *Wandigou reserves 135 tons; Linjia-Sandaogou reserves 46tons.*

Sizhuang gold mine in Laizhou, Shandong province: *East Shandong areas are the most important gold base in China, the whole proven reserves 1000 tons of gold. But the reserves are calculated mainly 500m shallow underground, he "Second*

Exploration Space" 500～1500m maybe have the potential 2000 tons. Sizhang gold mine is the perfect example for exploring in the deep, with reserves 51.83 tons.

3.9 Great potential in Middle & East China for exploring the deep—Further exploration in the deep or exterior of the old mine

Qiaotou Iron deposit in Benxi, Liaoning: *Near the 1:10000magnetic abnormity, we implemented a dill hole (ZK001), and the ore body appear from 1279m till the end of the hole 1500m (without penetrated the ore). The Perspective reserves will be 1 billion tons of iron.*

Copper, Zinc exploration in Hongtousan, Liaoning: *newly increased reserves 110 thousand tons of copper.*

Qian'an Iron Mine: *10603m dillhole, and increased reserves 110 millin tons of iron.*

Daye Iron deposit in Hubei: *newly increased reserves 23 million tons of iron, and 100 thousand tons of copper.*

Huize Lead & Zinc deposit in Yunnan Province: *Newly increased reserves 1500 thousand tons of zinc, 710 thousand tons of lead, 624 tons of silver, and 1370 thousand tons of slfur.*

Jining iron deposit in Shandong Province: *after 1600m deep in the drill hole, three layers of magnetite 107.8m has been discovered, average grade 25～35%, and the potential reserves over 1 billion tons of iron.*

Tongshan Copper Deposit: *8 dill holes, the increased copper reserves 136 thousand tons.*

Fuxin Coal Mine in Liaoning: *3 dillholes, reserves 73 million tons of coal, and enlarge the exploiting time over 30 years.*

3.10 Groundwater exploitation in water shortage area of western China

In about 80 counties in 13 western provinces, we have drilled 334 deep wells in NW China and 60 thousand shallow wells in SW China, which supply totally 0.7 million m^3/a drinking water for 3 million peoples. Through this project, new exploitation methods and development models have been established.

4. Geo-environmental assessment

About 1000 lives and tens of billions RMB estates were lost every year. Reducing the consequence of the landslides is an important work for the government and the geologists in China.

Geo-hazards census in mountainous counties were carried out in 1999. Up to now, geo-hazards census of 700 mountain landslide-prone counties was finished. Another 800 counties census is in its progress. The result shows that the landslide-prone area is about 1,800,000 Km2. A set of combined warning system was set up in every county.

With the data of Geo-hazards census , the annual successful forecasting number of Geo-hazards increased from 34 in 1999 to 721 in 2004.

With the database of geo-hazards census, we set up a prediction system and issued the warning through CCTV. Example: in 2003, 800 landslides fatalities were predicated.

The effective landslide monitoring and management system has setup, and the casualties decreased from 1573 in 1999 to 724 in 2004.

For further understanding of geo-hazard distribution and formation , a detailed geo-hazard survey started in serious hazardous areas at a scale of 1: 50000 in 2005. This survey will emphasizes the geological condition, formation mechanism, character and distributing rule of landslides and supply abundant data for geo-hazard prevention.

MANAGING THE ENVIRONMENTAL IMPACTS OF NATURAL RESOURCES DEVELOPMENT in PAPUA NEW GUINEA

Mineral Resources Authority

November 2007
AIST Centre
Geological Survey of Japan
Tsukuba, Japan

Presentation by:
Edward Nicholas
Environmental Scientist
Minerals Resources Authority
Papua New Guinea

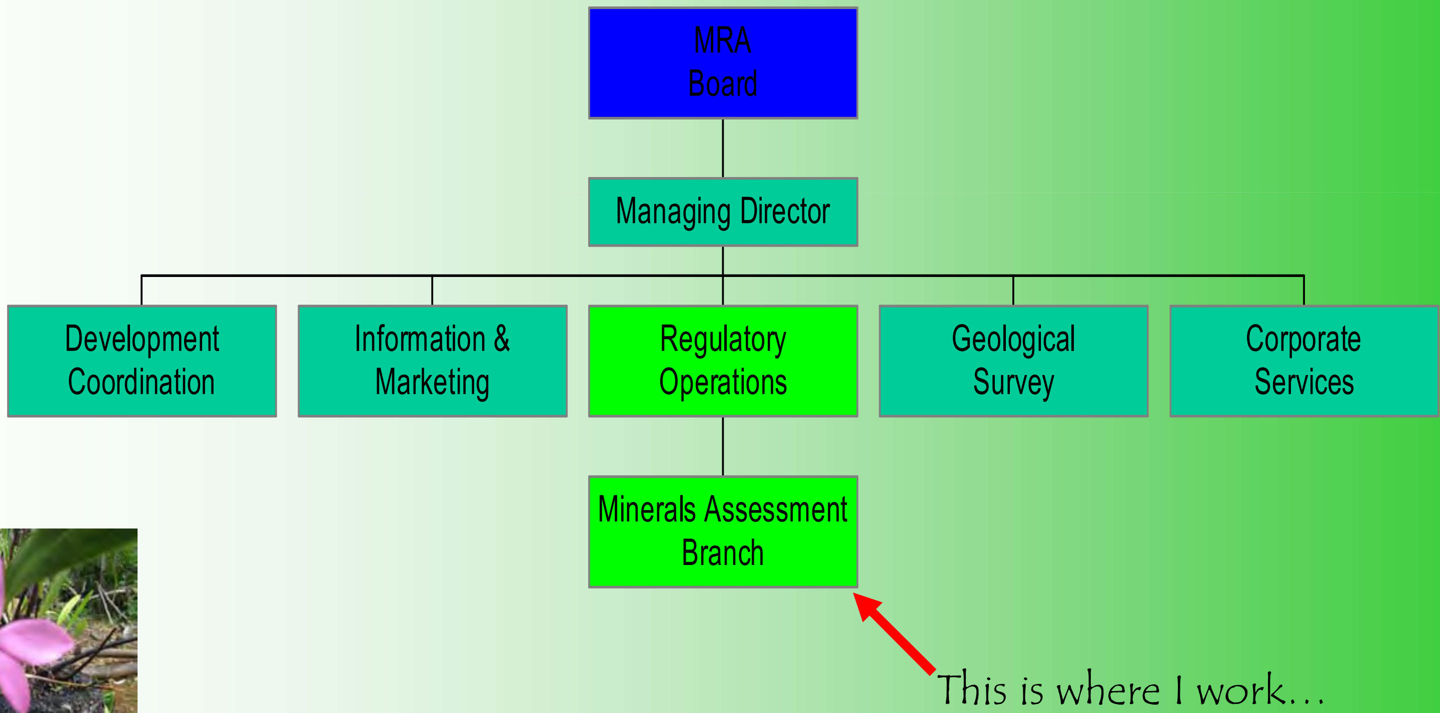
Mineral Resources Authority

Outline…

- Introduction (my organization, my country
- Overview of natural resources development (Mineral resources)
- Overview of Environmental Management of naturals resources development
- Environmental problems in mining
- Industry responsibilities
- Summary

My Organization…

MINERAL RESOURCES AUTHORITY
ORGANISATIONAL STRUCTURE



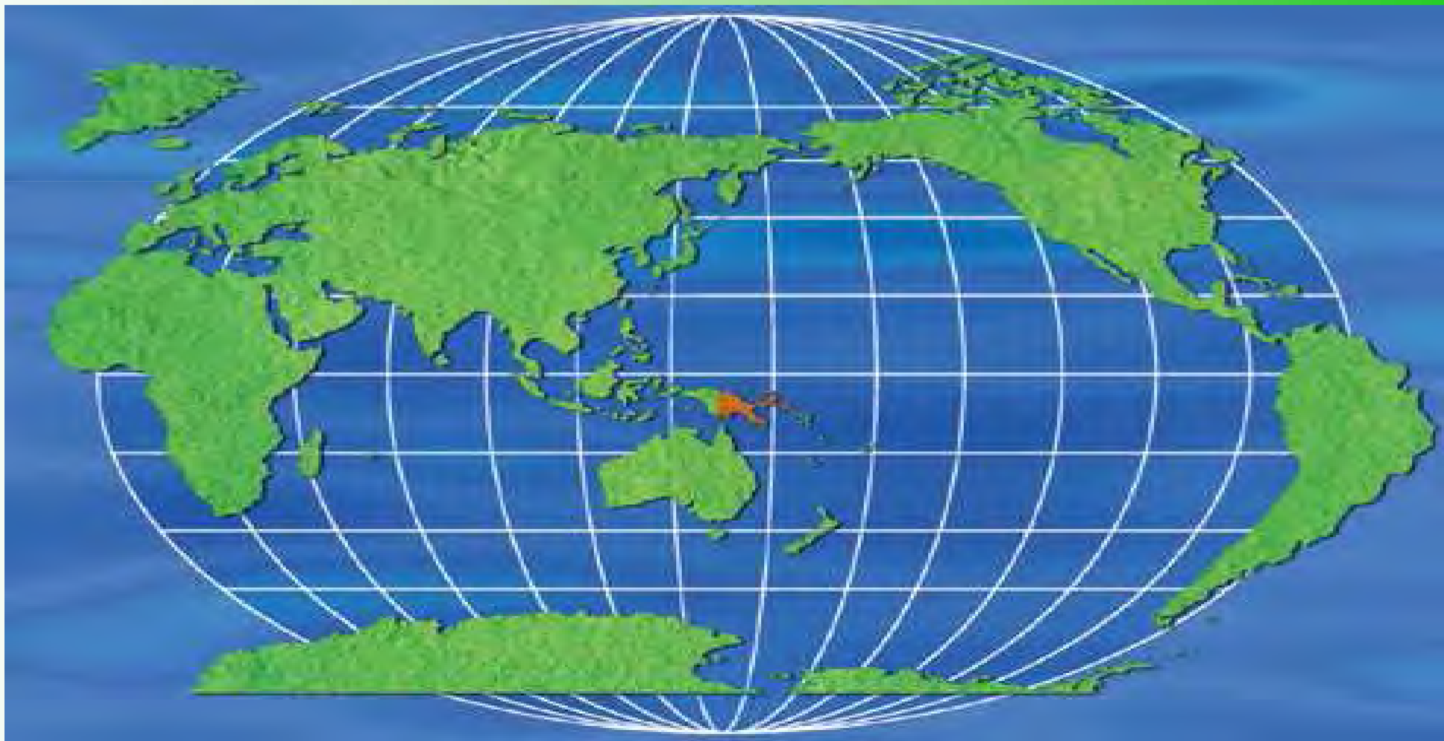
Mineral Resources Authority

MRA Mandate

1. Effectively promote a healthy and sustainable mineral industry;
2. provide a regulatory environment which maximizes mining opportunities to ensure optimum benefits for the people of PNG

My Country…..

- Situated in the South Pacific
- Lies between 1-12 degrees S latitude and 141-157 degrees E longitude



Brief cont…

- Comprises of 600 islands, 8, 300km of coastline. Total land area is 462, 840sq.km-largest nation in the South Pacific

Mineral Resources Authority

Brief cont…

- Climate is tropical/monsoonal-dry and wet with temp. varying b/w 4 -24 degrees in the highlands and 23-33 degrees in low coastal areas Population: approx. 5 million of which 80% live in rural areas
- Pop. density is very low with about 8 people/sq. km of land.
- Also have a very diverse society which includes 800 languages and ethnic groups

Brief cont…

- Gained independence on 16th September 1975 from Australia
- Use the Westminster System of Government
- House of Representatives consists of 109 elected members.
- Have 20 provinces, which have their own prov. Governments including the local governments.

Overview of Natural Resources Development in PNG

Oil & Gas

- First substantial oil reserves discovered in 1980s in the Southern Highlands of PNG by Chevron Niugini & British Petroleum (BP) (first oil discovery in 1911)
- Commercial production began in late 80s
- BP and Chevron assets take-over by Oil Search (PNG) Limited in 1998 & 2002 respectively.
- Export of crude oil resources contribute about 24% of GDP
- Plans underway to develop PNGs gas resources with 3 LNG projects in advance planning stages

Mineral Resources Authority

Pictures of oil resource development in PNG

Mineral Resources Authority

Overview cont…

Mining

- First reported traces of gold in PNG were from pottery collected in Redscar Bay to the west of Port Moresby in 1852.
- 1896 – development of 1st underground mine on Sudest Island by British New Guinea Gold Pty.
- 1922-26: Laloki Copper mine was one of only 2 mines supplying Cu to Australia.
- 1920's – development of Wau goldfields
- Panguna Copper – first large scale commercial operation
- More mines have been discovered and developed since

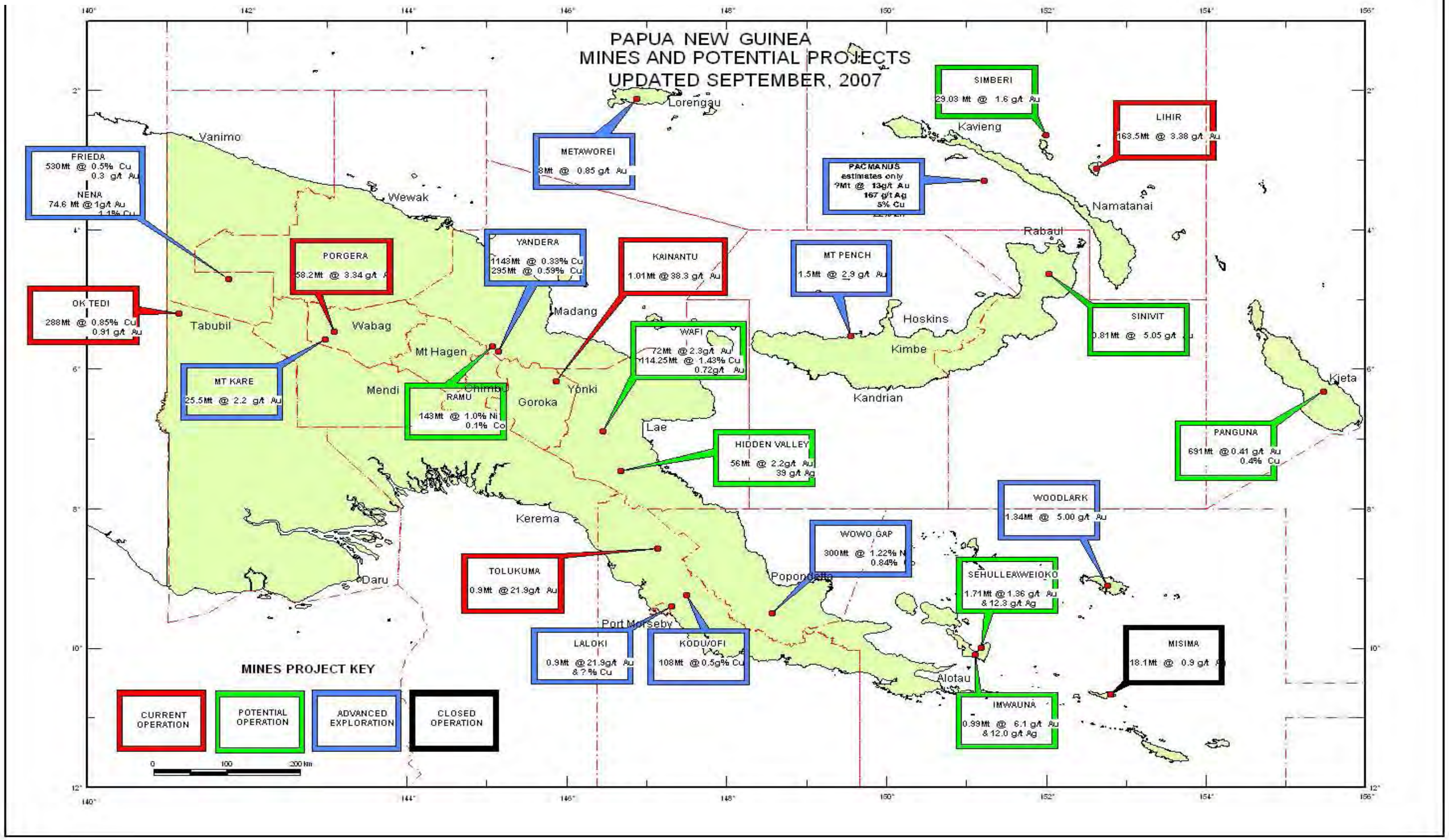
Overview cont…

Operating Mines

- Porgera, Kainantu, Ok Tedi, Tolukuma Sinivit and Lihir. The Sinivit gold mine commenced commercial operations in September 2007 and is the latest addition
- In 2006, the mines produced 55.34 tonnes of gold, 175,902 tonnes of copper and 48.39 tonnes of silver to contribute K7.5 billion (~US$2 Billion) representing 59% of PNG's total export merchandise in that year.

Mineral Resources Authority

Mines & Potential Mineral Projects



Overview of Environmental Management of Naturals Resources Development

Environment Regulatory Process

- Enshrined in the 4th National Goal of the Constitution
- Mandated by the Environment Act 2000
- Requires all developers of naturals resources to undertake EIA and submit EIS for consultations, review, verification etc..before approvals are given
- Ensures monitoring of naturals resources development activities by developers/regulators
- Provision for ENFORCEMENT actions to be taken against offenders

Environmental Problems - Mining

Mine Construction)

- Loss of specific ecological habitats
- Short term increase in sedimentation of rivers/shorefront
- Increase generation of construction related mine waste
- Loss of access to wild resources by local communities

Pictorial examples of mine construction pollution on immediate & surrounding environs

Increased construction related mine waste

Loss of ecological habitat

Mud Flow

Increased sediment in river channel

Increased turbidity in river channel

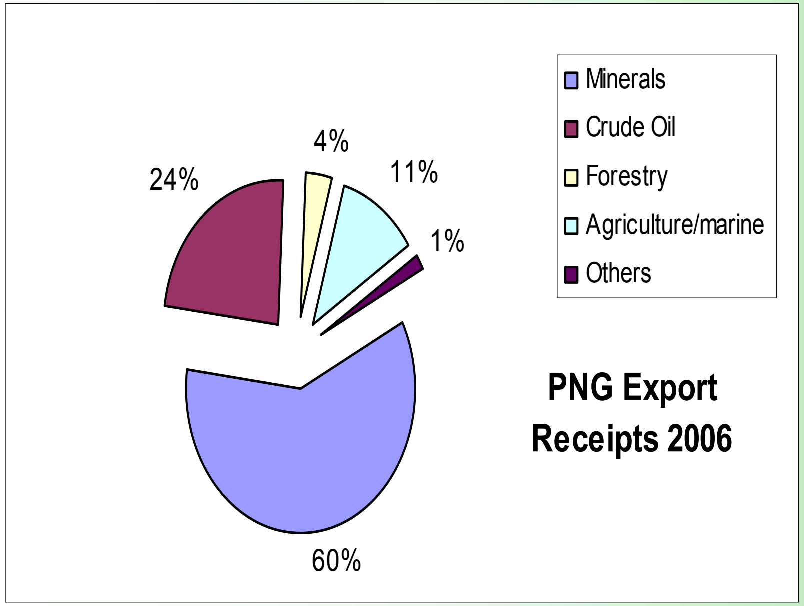
Mine Operations

- Management of Mine Waste Rock (ARD issues)
- Management of Mine Tailings
- Management of hazardous solid and liquid mine derived waste
- Management of general (non-hazardous) mine waste
- Management of Mine related noise and air pollution

Industry's Responsibility to Environmental Management

- Most companies have developed their own EMS in line with regulatory requirements and BEP
- A few companies are now accredited to ISO 14001 EMS
- All most all companies in the mining sector in PNG work in close consultation with PNG Government to address environmental problems affecting their operations

In Summary…



- Exploitation and development of PNG's natural resources is the foundation for its future growth and prosperity, since they contribute 99% of PNG's export revenues.
- While our development aspirations are high, we have to find a balance in between naturals resources development and environmental protection.

Sustainable Development…?!@#$

- Russian Federation
- Far Eastern National Technical University
- (Vladivostok)

- SELIVANOVA TATIANA
  - (PhD, geophysics)

Geographical Location of Russia

Geographical Location of Russian Far East

The River Lena

- The River Lena begins in the Eastern Siberia, but it mostly runs on Yakutia, involving move than a half of the republic territory;
- Its total length is 4 400 km;
- The area of the basin is 2,490 thousand square km;
- River flow in the creek is 17 000 cub. м./ seк;
- Average annual flowing is 488 cub.м
- For quantity of the water the River Lena takes the 9-th place in the world and the 2-d place in Russia, being inferior only to the River Yenisei;

- A thickness of snow cover is not great, however an intensive snow thaw and a little absorption of water by the soil result in great spring floods;
- The river system is very brunching: its density is 0.42 km / sq. km;
- Permafrost, mountainous relief and sharply continental climate have a great influence on the water regime of the basin rivers.

The River Amur

- The River Amur flows out Mongolia, but the most part of the river flows on the Russian territory;
- The Amur river is 4 440 km long, and out of them 2 800 km belong to the Russia;
- The area of the basin is 1 855 000 square km, out of them 1 933 000 belong to Russia;
- The vest part of the water-modular area distributes between China (48 %) and Mongolia (2 %);

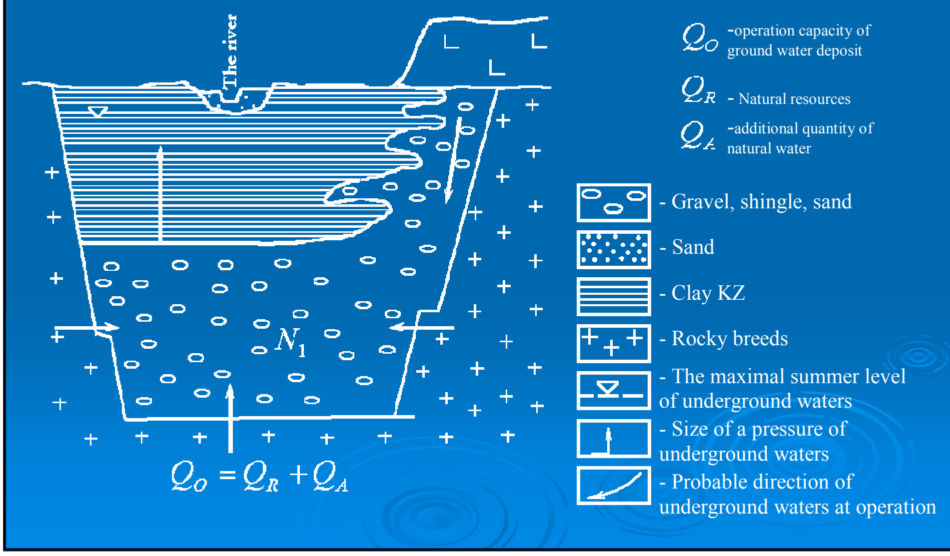
- The Amur is one of the largest rivers of Russia;
- The average flow of several years standing of the Amur basin is 1.85 l / sec from 1 km;
- The volume of the annual flow of the Amur in the mouth is
346 cub. m;
- The rivers of the Amur basin are full-flowing, it results from monsoon climate, little evaporation and large woodlands;

- The characteristic features are intensive riverbed processes, riverbed branching in the flat parts of the basin and frequent summer and autumn rainy freshets, connected with summer monsoons;
- More than 550 floods, of which 54 are catastrophic, have been registries on the Amur River for the recent 60 years.

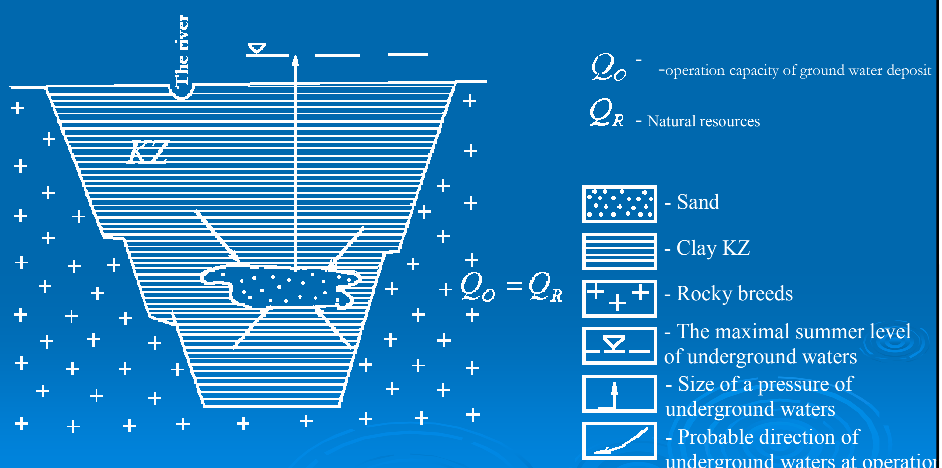
Typical Hydro-geological Sections
of Underground Water Deposits
Of Russian Far East

Underground-water Deposits of Neozoic Depressions

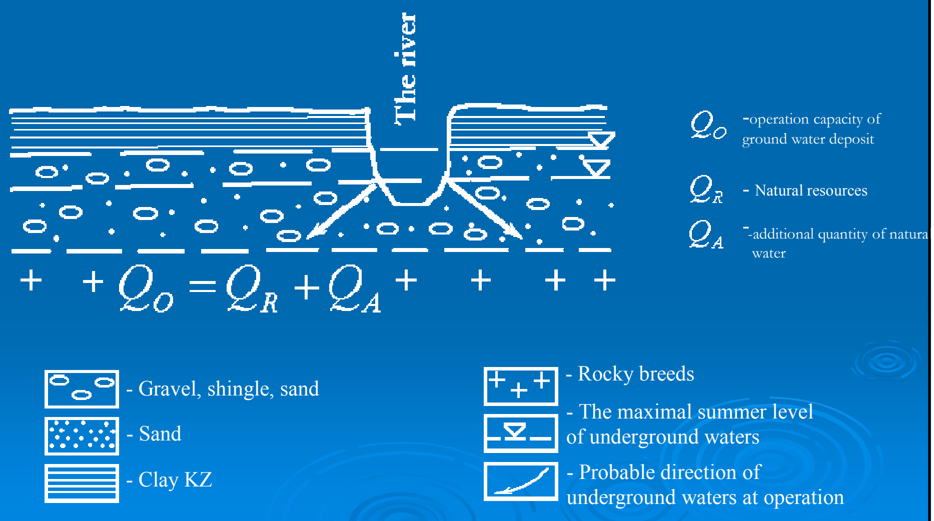
Underground-water Deposits of Neozoic Depressions



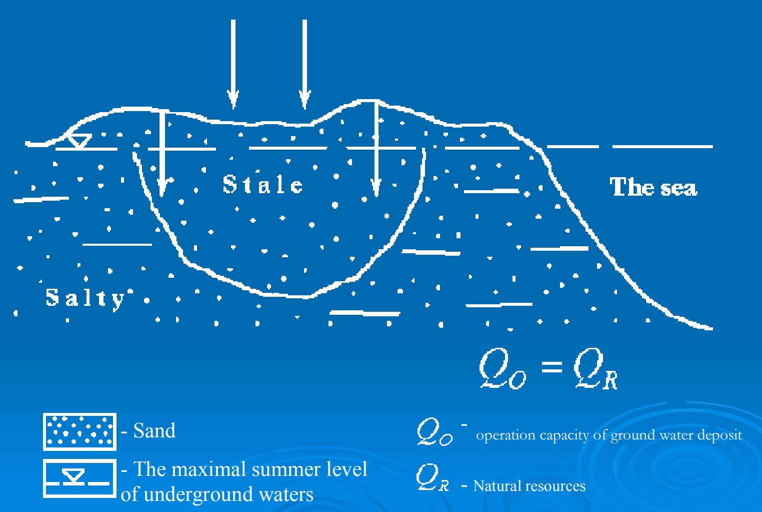
Underground-water Deposits of Neozoic Depressions



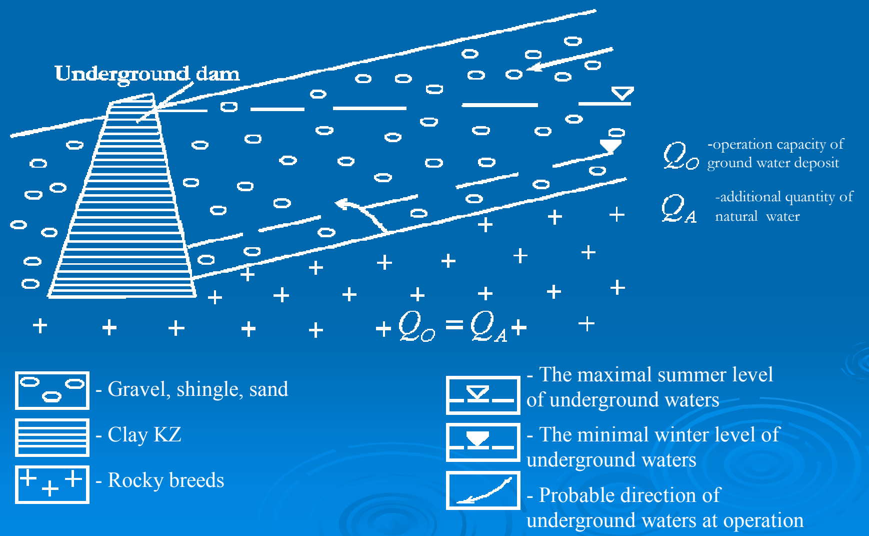
Underground-water Deposits Situated in a River Valley



Underground-water Deposits Situated Along Seashore



Underground- water Deposits Concerned with All-the-Year-Round Dewatered Underground Water Horizon



Criteria of natural division into districts:

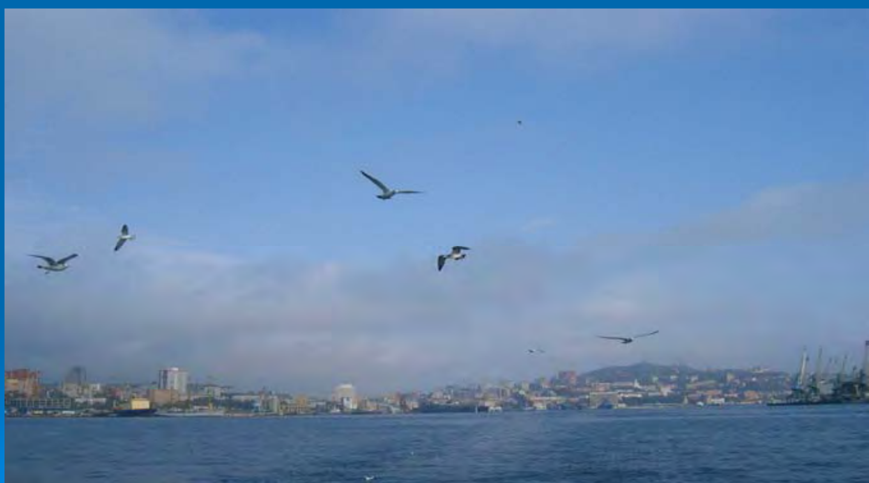
- Structure of an earth's crust
- Relief
- Climate
- Ground
- Specific structure flora and fauna

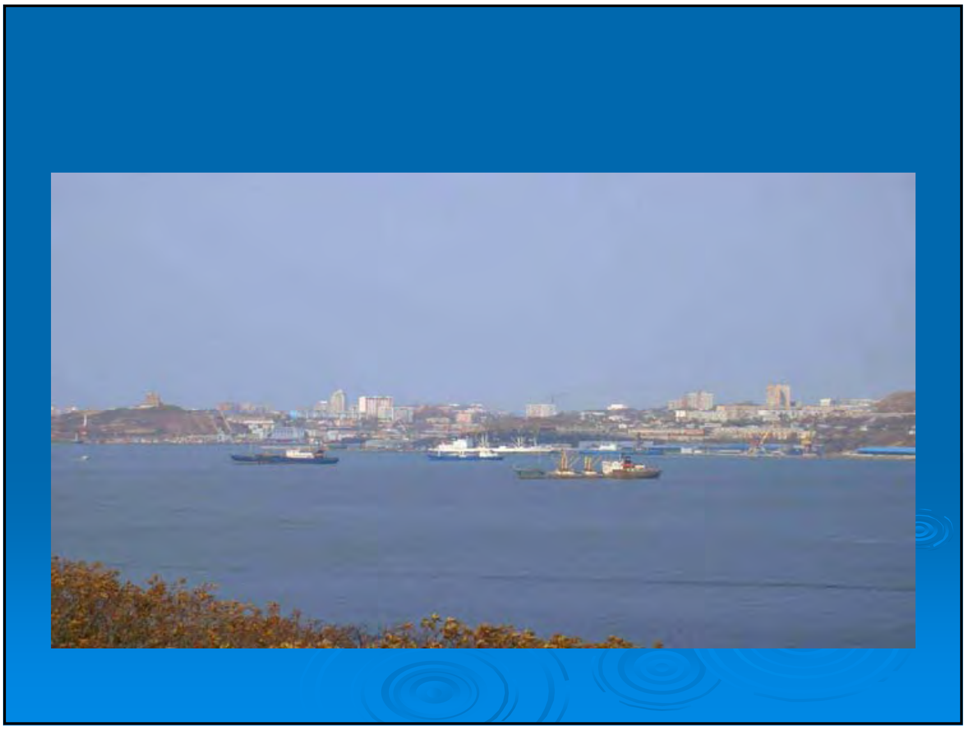
Natural Regions of Russia

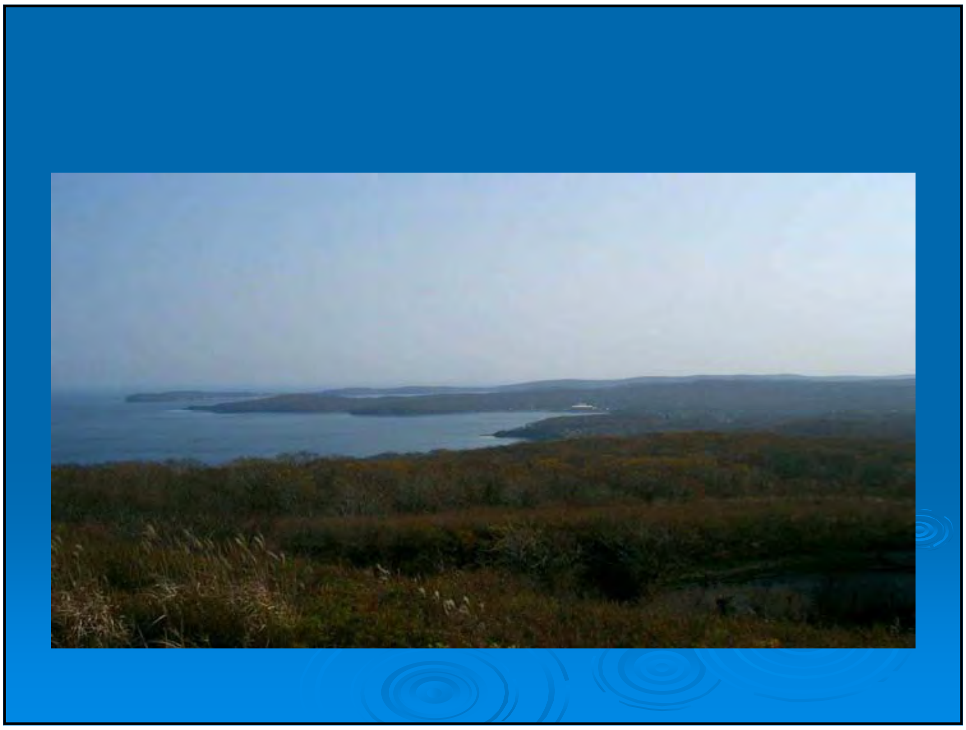
RUSSIAN FEDERATION

The Structure of the Russian Far East Includes the Following Territories:

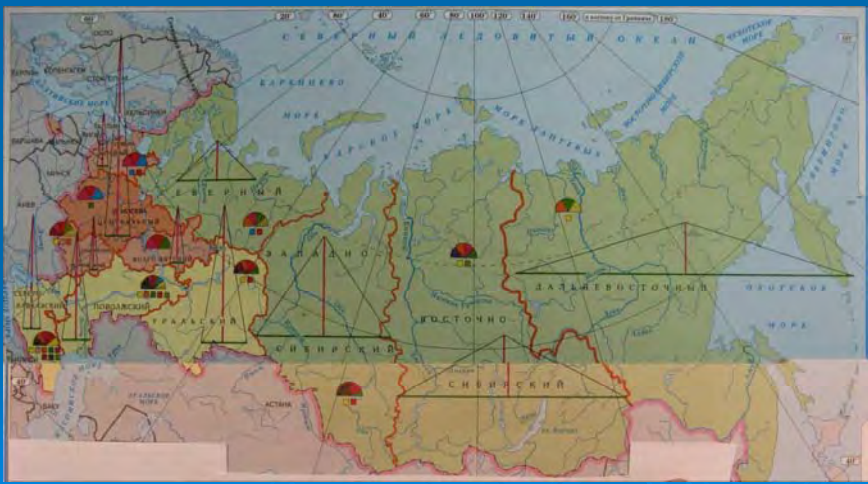
Sakha republic (Ykutiy)
Primorskii Krai
Khabarovskii Krai
Amurskay Oblast
Kamchatskay Oblast
Magadanskay Oblast
Sakhalinskay Oblast
Chukotskii Okrug
The Jewish autonomous region



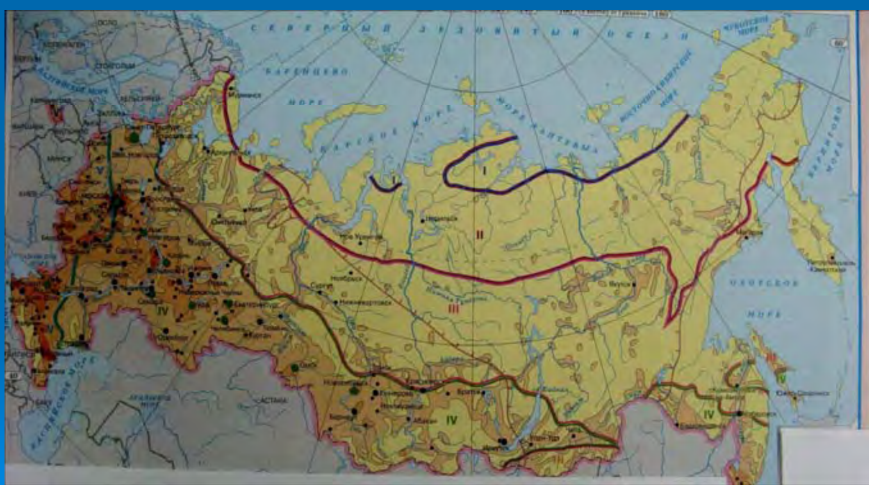




Economic Zoning of Russia



Density of Population of Russian Federation

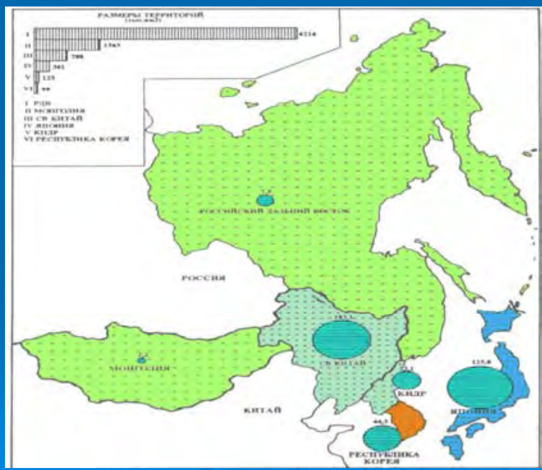


The area of Far East is 6 215 900 sq. km

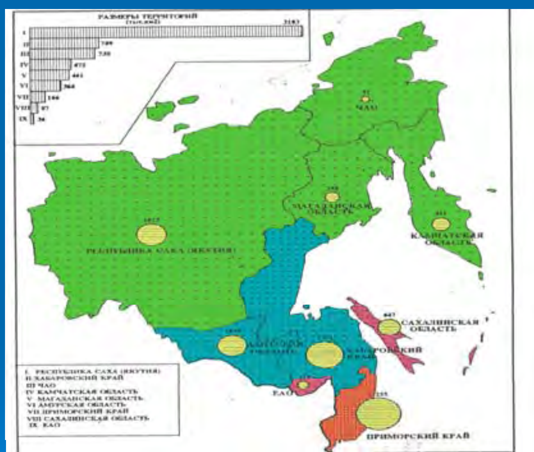
The population of Far East is 6 593 000 (2005.01.01)
Including:

city – 5 011 000
country – 1 582 000

Population of North-East Asia



Population of Russian Far East



Employment of the Population
on Branches of Economy

The industry – 19%
Trade – 18 %
Education – 10 %
Transport -10%
Construction – 7 %
Public health services – 7 %
Agriculture – 6 %
Culture and art – 2 %
Science -1 %
Other - 20 %

Natural Resources of Russia

Mineral Resources of Russian Far East

Here are concentrated more than

80 % of diamonds,
95% of tin,
90 % of boron,
88 % of stibium (antimony),
63 % of mercury,
41 % of fluorite,
24. 5 % of tungsten,
8-10 % of iron ore,
4 % of zinc

of the Russian stocks

Diamonds

In republic Saha (Yakutia) 84.1 % of diamond reserves of the Russian Federation are concentrated.

99.7 % of the Russian diamonds are extractedin Yakutia.

The total of the extracted diamonds contains approximately 30 % of jeweller and 70 % technical ones.

Gold

- In the Russian Far East about 70 % of all Russia's gold reserves are concentrated.

In Russian Far East the prospected gold deposits are distributed as follows:

Ykutiy-44 %;
Magadanskay Oblast -17 %;
Kamchatskay Oblast – 16 %;
Khabarovskii Krai – 14 %;
Amurskay Oblast – 8 %;
Primorskii Krai and Sakhalinskay Oblast – 1 %.

Silver

In Russian Far East silver deposits is not present, silver is only a part some polymetallic complex ores.

Distribution of the prospected silver polymetallic complex ores reserves between regions are following:
Magadanskay Oblast -57 %;
Khabarovskii Krai – 24 %;
Ykutiy -9 %;
Primorskii Krai- 8%;
Amurskay and Kamchatskay Oblast – 2 %;

Tin

Practically all prospected and extracted tin reserves of Russia are concentrated in Russian Far East.

Distribution of the prospected tin reserves between regions are following:

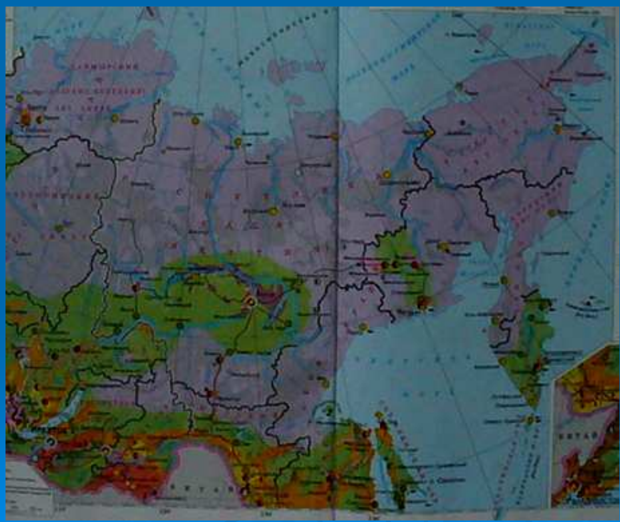
Ykutiy -44 %;
Magadanskay Oblast -21 %;
Khabarovskii Krai – 21 %;
Primorskii Krai- 14%.

Primorskiy Kray's Providing with Mineral Resources

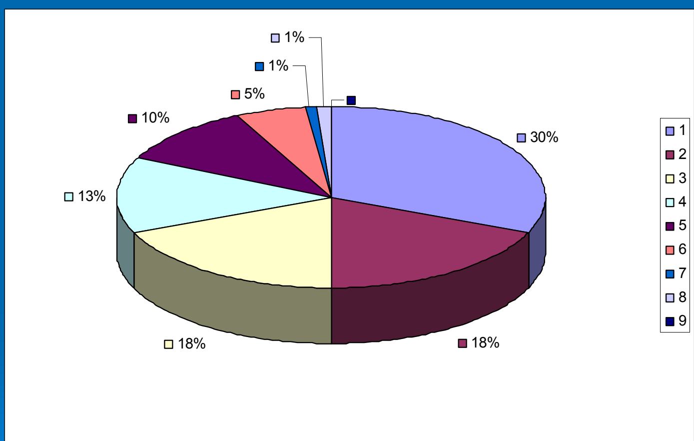
/%, from Resources of Russian Federation or Russian Far East/

Wolfram /W/	Lead /Pb/	Zinc /Zn/	Boron /B/	Fluorit
100 % of RF	81 % of RFE	80 % of RFE	100 % of RF	100 % of RF

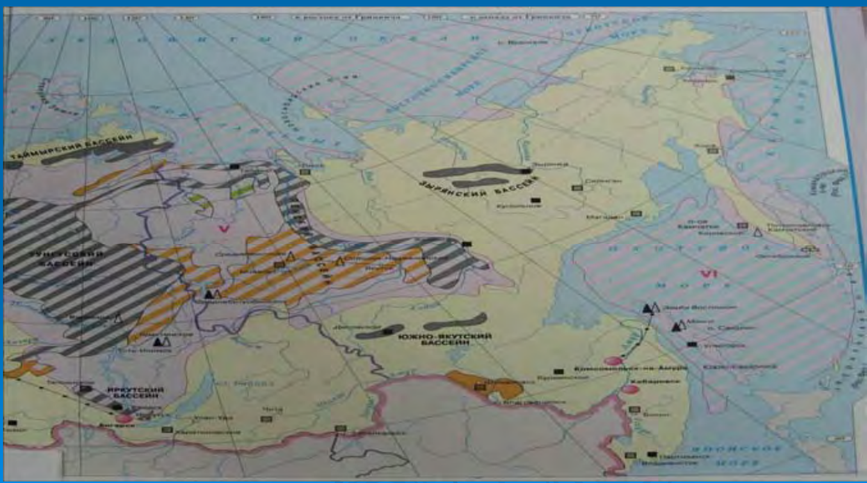
Industrial Mix of Russian Far East



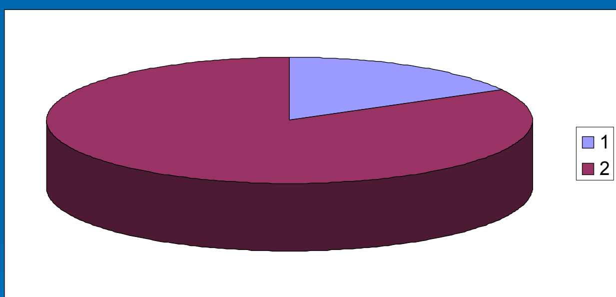
Industrial Structure



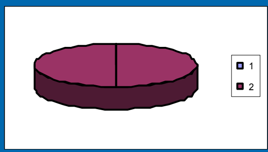
Fuel Industri



Share of Fuel Industry in Industrial Structure of Russia

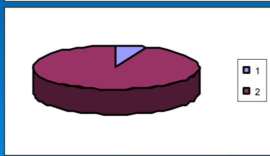


Share of Russia in Global Fuel Production



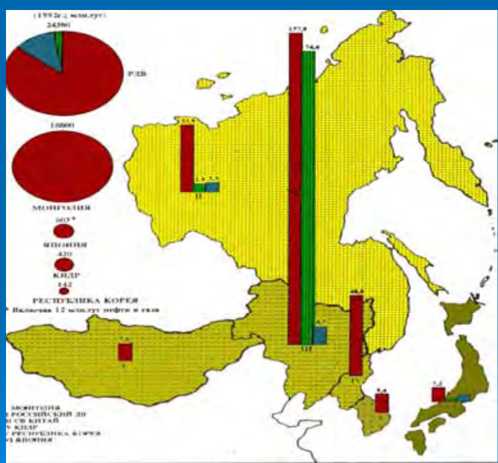
- 5,5 % - coal

- 24 % - natural gas



- 12% - oil

Oil and Coal Production in the North-East Asia



Extraction of Natural Fuel and Energy Resources in Russian Far East

COAL
(thousand ton)

Ykutiy	11 785
Sakhalinskay Oblast	2 700
Magadanskay Oblast	1 470
Chukotskii Okrug	874
Kamchatskay Oblast	27

OIL
(thousand ton)

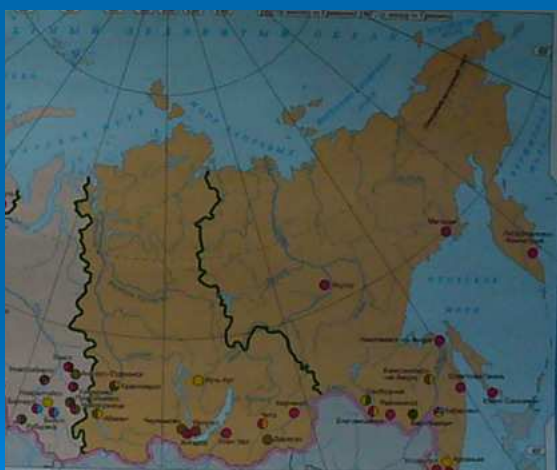
Ykutiy	185
Sakhalinskay Oblast	1 724

Natural Gas
(million cub. m)

Ykutiy	1 606
Sakhalinskay Oblast	1 637

Electric Power Industry

Machine-building Complex



Wood Industry

Wood Resources of Russia and their Accommodation

Territory	Area, covered with a wood (million hectares)	reserve of wood (%)	woodworking industry (%)
European part	116	25	60
Siberia and the Far East	605	75	40

The Basic Tree Species in Structure of Woods of Russia

Larch-39%

Pine-17%

Birch- 13%

Fur-tree-11%

Cedar-6%

Fir-2%

Oak-1%
Others-11%

Ecological Results of Forest Fires

- Destruction of young woods;
- Destruction the top productive layer of ground horizon;
- Formation of taluses and erosion;
- For a year as a result of forest fires 2 million tons of firm substances as a smoke and 50 million gas products of burning is thrown out in an atmosphere;
- The smoke contains poisonous substances.

Agricultural Conditions

Cultivation of Grain Crops

Animal Industries

Some North-East Asia Regions' Providing with Natural Resources /on 1 Km/

Regions	Population	Agricultural ground , hectare	Forests, hectare	Coal, thous. of tons
		Russian Far East		
Primorskiy Kray	13.6	8.5	67.8	24.7
Khabarovskiy Kray	2	0.5	60	2.5
Amyrskay Oblast	2.9	6.7	60.1	10.6
Sakhalinskay Oblast	7.4	1.5	61.5	27.6
		NorthEast Asia		
Mongolia	1.4	0.8	9.7	15.3
NE China	130.8	20.7	21.1	*
PDR of Korea	184.4	18.4	*	*4.8*

** Useing:National Statistical Data; Natural Resources,1995; World Resources,1996; "Natural Resources Use Of the Russian Far East and Northeast Asia" /A.S Sheingauz/,1997.*

For last 15 years there was a extraction decrease of natural resources on the Russian Far East:

wood – 71.3 %
oil – 27.5 %
coal – 70 %

Change of Natural Resource Potential of the Russian Far East

The reasons:

- Full use of easily available natural resources at the minimal financial expenses;
- Extensive methods of extraction of natural resources (due to increase the areas)
- Environmental problems of natural resources use

Environmental Problems of Natural Resources Use in Russian Far East

- Reduction of fertility of the grounds, erosion and degradation of soil because of extensive use of chemical fertilizers and application of heavy technical equipments.

  For example, annually 1 % of arable lands of Russian Far East become not suitable for use.

- The area of young woods annually increases for 1.2 %.

  The part of deciduous woods annually increases for 0.7 %.

- Reduction of quantity of fresh-water and coastal sea fishes.

  In comparison with 1940 mid-annual catch in a river basin Amur have decreased in 8.3 times, and catch of salmon fishes has decreased in 70 times.

- Pollution of surface water.

  For example, for 50 years of gold extraction in Kolyma river basin more than 200 rivers have lost the fish economical meaning.

Environmental Problems Connected on Development of Mineral Deposit:

- Pollution of superficial waters
- Change of a level of underground waters
- Exit on a day- surface of underground gases
- Infringement of landscapes
- modification of ground quality
- Incomplete extraction of mineral resources,
  for example by development of deposits is taken only 50-60 % of tin, 60 % of copper, 40 % of tungsten, 25-35 % of lead and zinc.

Health and Vital Activity of the Population

- The above factors have direct influence on health and vital activity of the population.
- Drinking water is one of the nutrients which determine the basis of the internal environment of an organism. As for chemical contents, natural waters of the Russian North-East are lightly mineralized and have deficit in calcium, potassium, magnesium with low contents of such important elements as fluorine, manganese, cooper, zinc.
- The misbalance in microelement picture (deficit of Ca, Co,Cu,Mg,Mn,Se,Zn,J) of the North children was differed.

Incidence Changes of Primorskiy Region's Inhabitants

(comparison with 1999,%)

Disease	%
Blood disease	12.2
Heart-disease	10.39
Peptic (round) ulcer	3.29
Mental disease	5.2
Infectious disease	4.11
Endocrine disease	31.29
Skin disease	6.56
Connective-tissue	17.39
Respiratory disease	3.99

- The most important medical problem is the deficit of iodine.

Correlation between Number of Teenagers having Endocrine Disease (goiter, wen)

(total population 100 000)

environmental condition	**number of teenagers**
1.Continental territories	
Critical environmental condition	4844
Good environmental condition	1736
Favourable environmental condition	57
2.Coastal zone	
Critical environmental condition	4243
Good environmental condition	2399
Favourable environmental condition	162

Biodiversity of Primorskiy Region

The Bikin River valley is boundary between the north boreal biota and the southern Manchurian biota, a unique and ecologically special mix in the Far East.

Hasanskii region of Primorskii Krai is a glacial refugium and harbors plants and animals, including many Pleistocene and even tertiary relict species, found nowhere else in all of Russia.

The wetland areas of the Russian portion Of Lake Khanka are included under the Ramsar Convention (UNESKO 1972). Of the 287 species of birds protected by the Soviet-Japanese (1973) and Soviet-Korean (1987) conventions, 225 species inhabit the Lake Khanka.

Biodiversity of Primorskiy Region

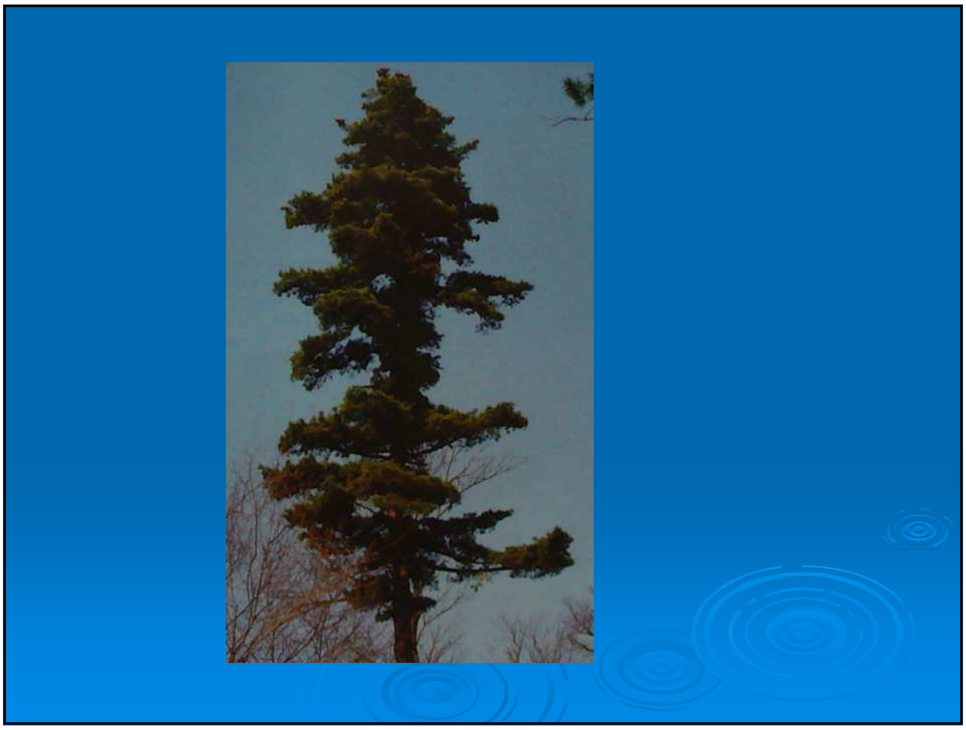
Primorskii Krai containes:

- 25 percent of Russian's biodiversity;
- 10 percent of the world's gene pool;
- 20 percent of Red Book species;
- 77 persent of the fauna of the Far East (over 70 species) are concentrated in the southern half of the Primorye region;
- Primorye is home to 350 bird species;
- The Primorye region is at the northern range boundary for nearly 100 bird species;
- One-hundred species of fish inhabit the rivers and lakes and one-fifth of these are endemic, found only in Lake Hanka / Xingkai and the Amur basin.

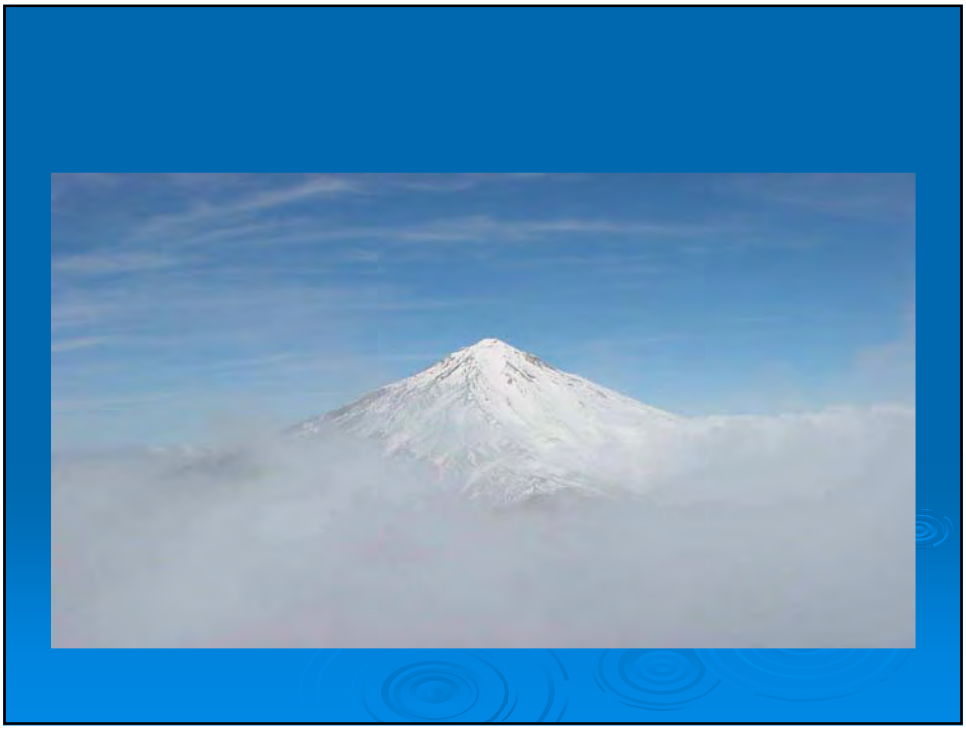
The Program of Biological Diversity Preserve

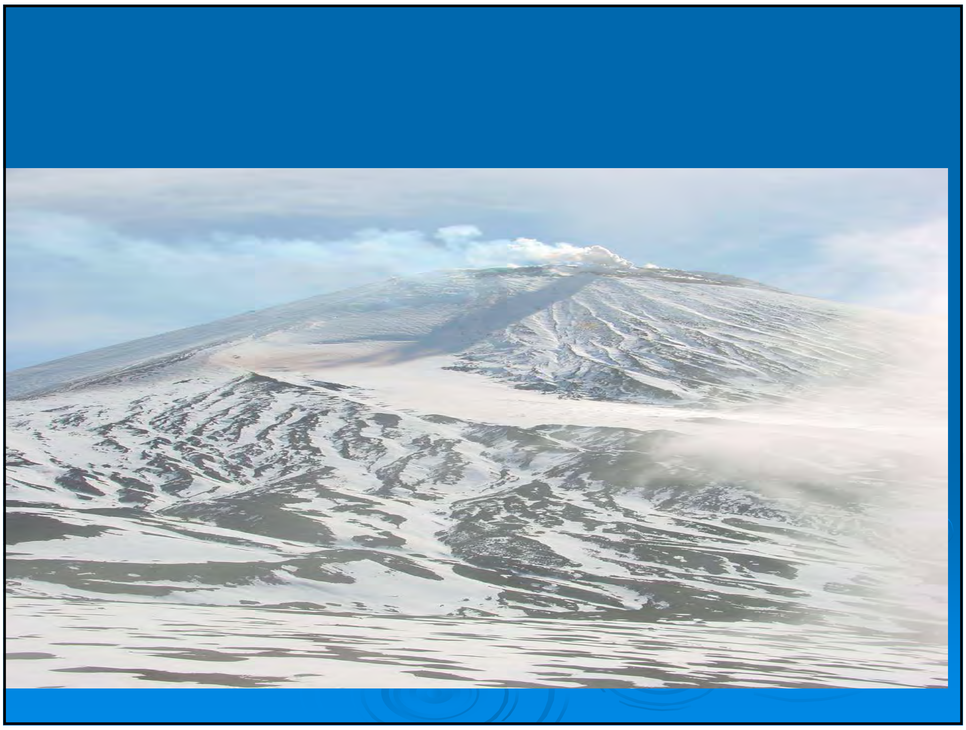
- The Program of preservation, restoration and management will be needed to sustain biological diversity and resource use.
-
- A system of large strategically placed reserves with connective corridors must be designated in the form of national parks, scientific reserves, and other protected areas.
- Protected connective corridors, such as rivers and greenways, allow species migration and genetic exchange.

The Reserves of Russian Far East

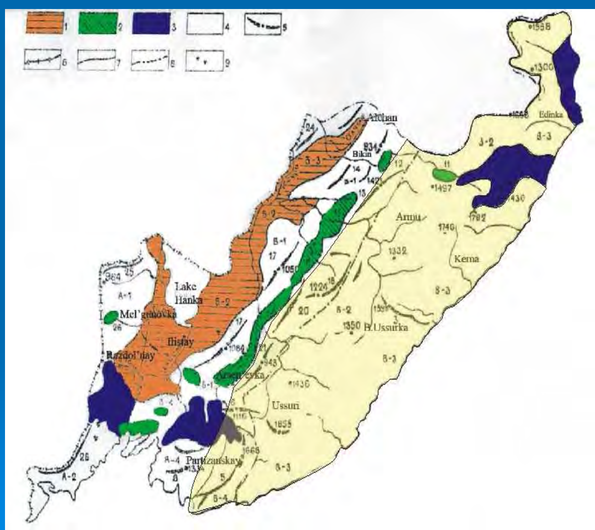


Zoning on the Development of Dangerous Geological Processes in Russian Far East





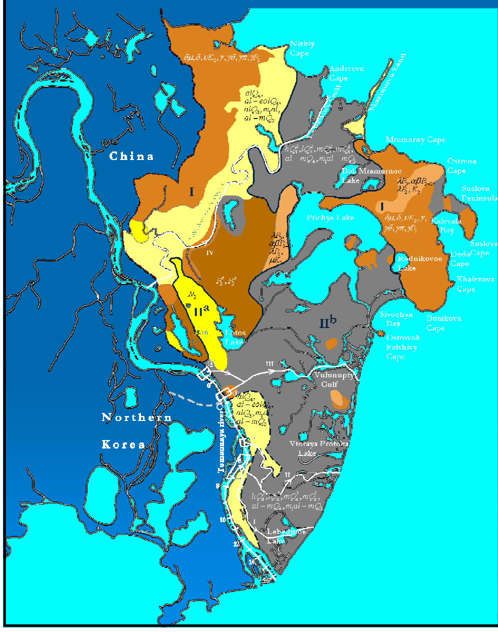
Zoning on the Development of Dangerous Geological Processes in Primorskiy Region



Channel Deformations in the Region are Caused:

- Down gradient of the river channels is not large (about 20 %);
- Presence of easily washed away sediments: sandy loams, loams, clay;
- Increase the volume of water in the rivers during the summer-autumnal period of year, speed of water current increase in 1.5-2 times.

Zoning Map of Ground Water of Tumangan River Basin and Future Change of Tumangan River Channel



- Up-Quanternary water-bearing horizon. Sand,loam.
- Middel-Quanternary alluvial water-bearing horizon. Sand,loam,pebbles
- Pliocene water-bearing horizon. Sand,loam,pebble.
- Cretaceous water-bearing horizon. Basalt.
- Up-Paleozoic water-bearinghorizon Schistose sandstone,shaly clay,lime stone
- Up-Permian water-bearing horizon. Tuff, granite
- Boundary of area
- Boundary of zone
- Geophysical measuring station
- Area of geophysical profiles
- Scenario of future change of Tumangan River Channel
- …

The Future Changes of Tumangan River Channel were Predicted:

- Scenario 1

The river will go with a channel of River Swan, through Lake Swan and then run into the sea.

In this case, Russia will lose 22 sq km of land.

- Scenario 2

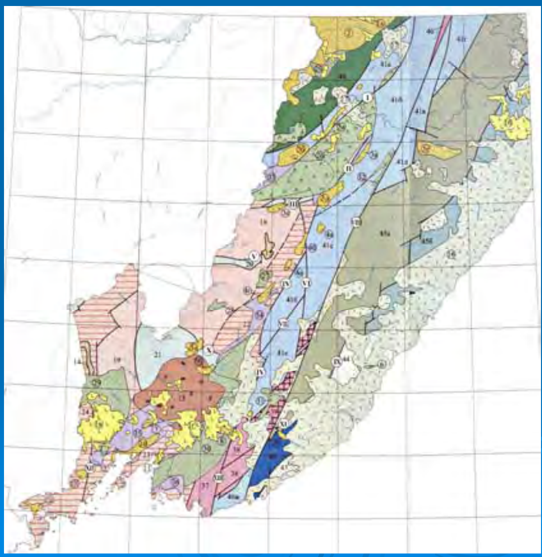
The river will choose a new direction to the channel of the First Channels and sharply turn eastwards.

In this case, Russia will lose 35 sq km of land.

The Reasons of Exist Spreading of the Superficial Marshiness in Russian Far East

- Irregular seasonal precipitations;
- Seasonal frozen subsoil of several years standing or over a long period of time;
- Slow surface flow;
- Heavy mechanical soil structure;
- River floods over a long period of time.

Geological Map of Primorskiy Region



Hankayskiy Region

- In the tectonic meaning the Region represents the **Hankayskiy median massif;**
- The rocks submitted the **terrigene, carbonaceous, granite formations;**
- Cover rocks compose imposed **Cainozoic depressions;**
- **Paleogen-Neogen coaly-terrigene** formations are bedded in the basin of the depressions;
- The top structural horizons of the depressions are formed by **Quaternary lacustrine-marsh, polygenetic formations, alluvial sediments of the flat river.**

Geomorpological Characteristics of the Hankaiskiy Region

- The Region is located on the **Prihankayskay plain and east part of the East-Manchurian uplands edge;**
- The Region's relief is **flat, sloping-wavy, with low hills and mounds;**
- For low hills and mounds is typical:
- *- the steepness of a top part of the hill and mounds is 15-20 degrees, the bottom part of the slopes is 3-4 degrees;*
- *- the horizontal erosive of rocks is 0.2-0.4 km/sq km*
- *- the depth erosive penetration is 200 m*
- *- ravined erosion is widely distributed*
- *- absence of outcropping of rocky beds*
- *- products of chemical weathered sharply prevail in the zones of rock distruction*

Underground Water of the Hankayskiy Region

- **The water of Quanternary sediments and artesian aquifer waters** are widely distributed;
- The capacity of the water horizons is **5-20**m;
- The filtration factor changes from **3 up 50 m/day;**
- The capacity of the covered clay, loams layers is **2-3 m;**
- Chemical compound of water is **hydrocarbonate, mainly calcic;**
- The water mineralization is **75-680 mg/l;**
- The waters have **leaching aggression.**

The Factors Determining Dynamics of the Channel Erosion in the Hankayskiy Region

- Litological structures properties (prevalence of well washed away loamy, sandy, clay, sandy-argeillaceous sediments);
- Rather stable the tectonically condition of the region (weak lowering) in a combination gently sloping biases of the river channel causes the big tortuosity (1.6-3) of the rivers;
- Often and long time floods at which speed of water current increase in 1.5-2 time.

That all promotes development of lateral erosion.

Piedmont Region

- The Region includes **Southern Sikhote-Alin, spurs of the East-Manchuria upland;**
- The Region cavers **South-Primorskiy, West-Primorskiy, Arsenevskay, Alchanskay, Bikinskay zones;**
- **The depressions with precise borders** distribute there;
- **Low mounds, tableland (basalt plateaus), river and coastal valleys** are most distributed in the Region.

Low- Mound Area of the Piedmont Region

- Incidental demonstration of the **landslide-taluses** phenomenas;
- About **an equal ratio of products of physical and chemical weathered** in total amount of the material of the rocky destruction zones;
- A value of the horizontal erosive is **0.4-0.8** km/sq km;
- The depth of the erosive processes is **200-300** m;
- Small quantity of **rock outputs**.

The Tableland of the Piedmont Region

- The tablelands borrow in the South (Shufanskoe and Shkotovskoe plateaus) and small territories in the north of the Region;
- The tablelands have **equal surface, lightly lopsided aside the sea**;
- For the tableland **hollows with small lakes, bogs, turbaries** are characteristic;
- The tableland break abrupt rocky ledges in a direction to valleys of the rivers and sea coast;
- The decay crust clay-structure has areal distribution;
- The water-separate spaces have equal low lopsided surface;
- Wide development **creep and landslide-taluses processes** in the regional parts of the plateaus and on boards of the erosive valleys.

The River Valleys Area of the Piedmont Region

- The valleys have an **equal surface**, frequently with the **ramified network of ravines**;
- Clay structure of sediments;
- Prevalence in the section the rocks **underdoed long transformation and strong physical and chemical processing**;
- **Channel, inundated, former river-bed phases** allocate among alluvial sediments;
- **Marsh sediments** considerably distribute;
- **Channel deformations** are observed.

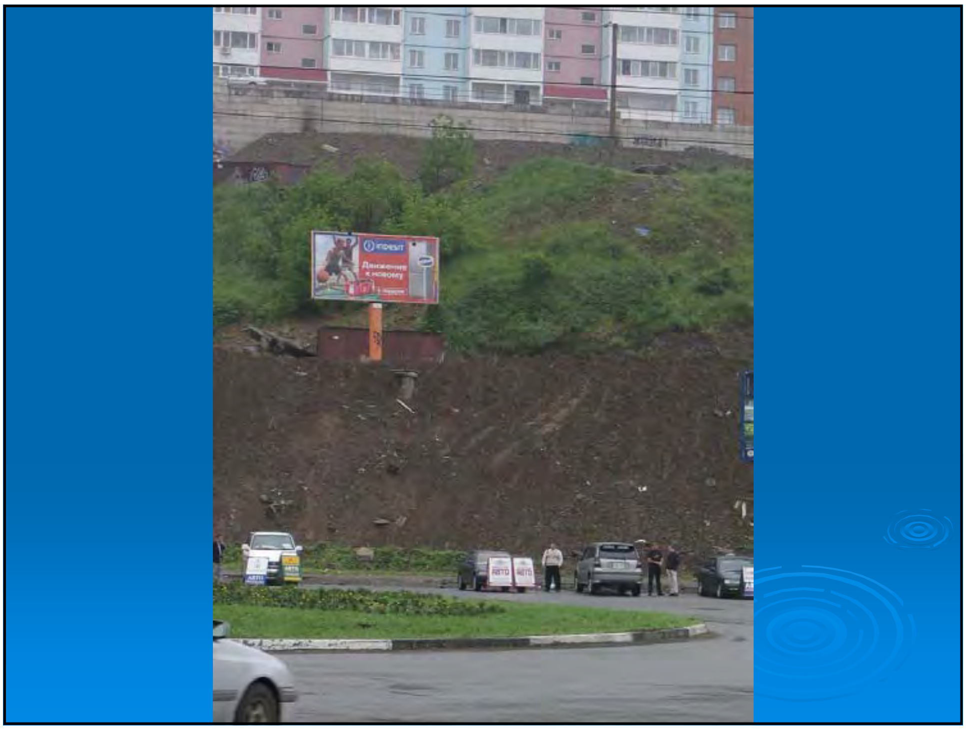
Hydrogeology of the Piedmont Region

- Presence **23 small artesian basins** framing the Hankaiskiy massive;
- Presence **bedded-fractured subsoil waters neogen basalts**;
- **Alluvial water horizons** have widespread;
- **Waters of top fractured zones** have insignificant distribution;
- The water horizons are dated to **gravel, gravel-pebble, sand-gravel, sand sediments**;
- The clay streaks causes formation several **water horizons hydraulicly connected among themselves**;
- The filtration factor is **1- 344 m/day**;
- The chemical composition is **hydrocarbonate, less often chloridical, calcic, natrium**;
- Waters have **leaching aggression**;
- The water horizons of the sea and alluvial-sea sediments located below of the sea level have **mineralization up to 25.7 mg/l, acidic aggression, less often leaching aggression**.

The Use of Slopes for Construction

1. Slopes of 30% (17 degrees) or more have high erosion hazard and severe development constraints;
2. Slopes of 9 % (5 degrees) to 30 % have moderate disturbance hazard characteristics that restrict their use to timber harvest and low density housing. Careful design and construction practices must be followed;
3. On slopes exceeding 15 % (9 degrees), structural should be undertaken only with special care.
4. Normally roads should not be constructed across slopes exceeding 30 %.

By Ministry of Agriculture of USA,1971


Движение к новому

A Sustainable Land Use and Allocation Program for the Ussuri / Wusuli River Watershed and Adjacent Territories (Northeastern China and the Russian Far East)

A Cooperative Project of:
Ecological Sustainable Development, Inc. (USA)
FEB-RAS Institute of Aquatic and Ecological Problems (Russia)
FEB-RAS Pacific Geographical Institute (Russia)
Heilongjiang Province territory Society (PRC)
National Committee on United States-China relations (USA)

Land Use Policy Development and Subsequent Land Allocation

1. The concept of land use policy is base on use zoning.
   Use zoning is simply the placing of limits on how land can be used

The specific limits should be determined by:

- the land's characteristics,
- the use of surrounding land,
- the demand for resources,
- cultural norms.

2. A basic of use zoning of his Program is that landower, private or public, should have the right to use land in a way that will degrade the environment of others.
3. Changes in land use should be subject to the expressed approval of society.

   The process of generating such approvals should be in two stage:

   a) a use zoning plan should be formulated by a government agency with extensive public involvement,

   b) that plan should incorporate a permit process where by new land uses are reviewed for environmental impact, sustainability, and compatibility with the zoning plan, again with full public involvement.

4. All aspects of administration should be characterized by open meetings, scientific forums, and opportunities for legal appeal

5.Economic policy include:

- Taxation of ecologically undesirable activities include excessive use of water and nonrenewable energy;
- Dumping fees for waste products;
- Economic incentives for protective measures benefittingthe atmospheric, land, and aquatic environment;
- Strengthening economic sanction for violations of environmental laws.

USSURI'S / WUSULi'S WATERSHED

- The Ussury / Wusuly river forms part of the border between Russia and China
- Two-thirds of the watershed ecosystem is in Russia, one-third- in China
- The region consists of approximately 26,000,000 hectares and 1,100 kilometers is Russian-China state border
- Ussury / Wusuly is the tributary of Amur / Heilong River
- Ussuri's watershed melds two different ecosystems: boreal and subtropical

Endangered Species in the Ussuri Region

The Chinese portion of the Ussuri region:

- 4 mammals, 12 species of plants, and 11 birds national endangered;
- 10 mammals, 4 species of plants, and 41 birds nationally endangered;
- 10 mammals and 40 birds locally rare and unique species;
- As an example, the population of wild Amur tigers in the Chinese portion of the Ussuri region change from about 76 in 1975 to 12 in 1991 and probably less today (HLJPC 1994).

The Chinese Portion of the Ussuri Region

- On the western part of the river, comprising a third of the watershed, is Heilongjiang:
- The population of the province is about 36 million;
- There are extensive forest, deposits of coal, oil, minerals;
- Globally significant remnants of the nation's largest wetland-
- (Helongjiang's Sanjiang –Three Rivers Plain)

The Russian Portion of Ussuri Region

Primorskii Krai:
- 15 species of vascular plants;
- 3 species of mammals;
- 10 species of birds;
- 2 species of reptiles and amphibians

Are listed as endangered in the Russian Red Book.

Khabarovsk Krai:
5 vascular plant species are endangered and 57 – rare.

50 vertebrate species of animals have become extirpated, endangered or rare (Amur tiger, Himalayan bear, Amur horol, Far Eastern tortoises, cranes, storks)

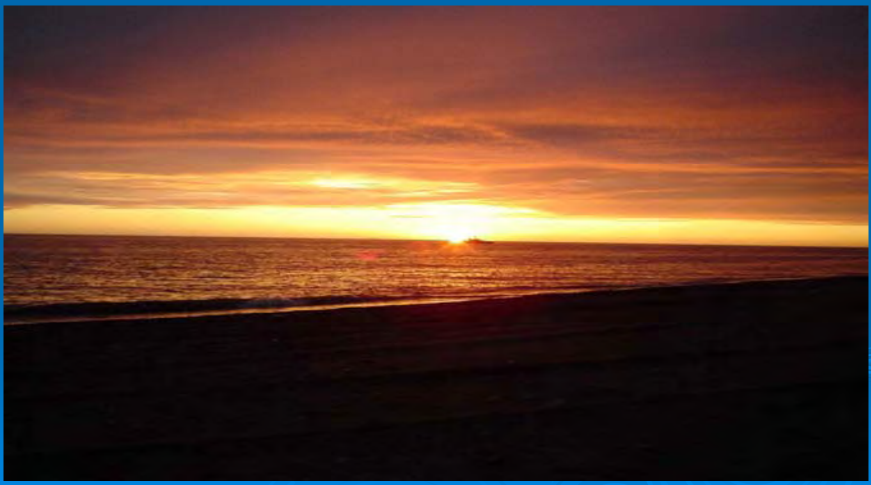
The Russian Portion of the Ussuri Region

- On the eastern side of the Ussuri / Wusuli, two-thirds of the watershed lies within two territories of Russian's Far East: Khabarovsk Krai (south part) and Primorskii Krai (western part),

together about twice the size but a tenth the population of Heilongjiang

- The Russian portion of the Ussuri region is made up of the mountainous Sikhote-Alin in the east, and the Priussuriisky Amur plain and Prikhankaisky plains in the west
- The watershed lies between two climatic zones: the oceanic monsoon and the moderate continental(умеренный).Air masses are displaced from the ocean onto the continent in summer, and vice versa in winter

- Approximately 60 percent of the Russian Ussuri basin is forested
- Forest resources are estimated to average(в среднем) 150 cubic meters per hectare
- Less than 10 percent of the region's land is used for agriculture
- The Ussuri basin contains most of the Primorskii Krai's 2.4 billion tons of coal reserves, with the main deposits at Bikinskoye (coal) and Pavlovskoye (lignite)



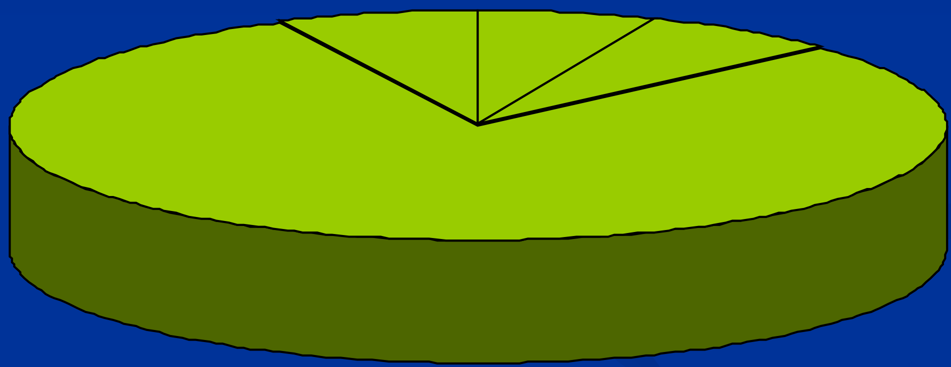
ECONOMY REPORT

Human Capacity Building for Natural Resources Development and its Environmental Impacts in APEC Region

Ms Patchara Sangoen
Department of mineral Resources
Thailand

Department of Mineral

Before 3 October 2002

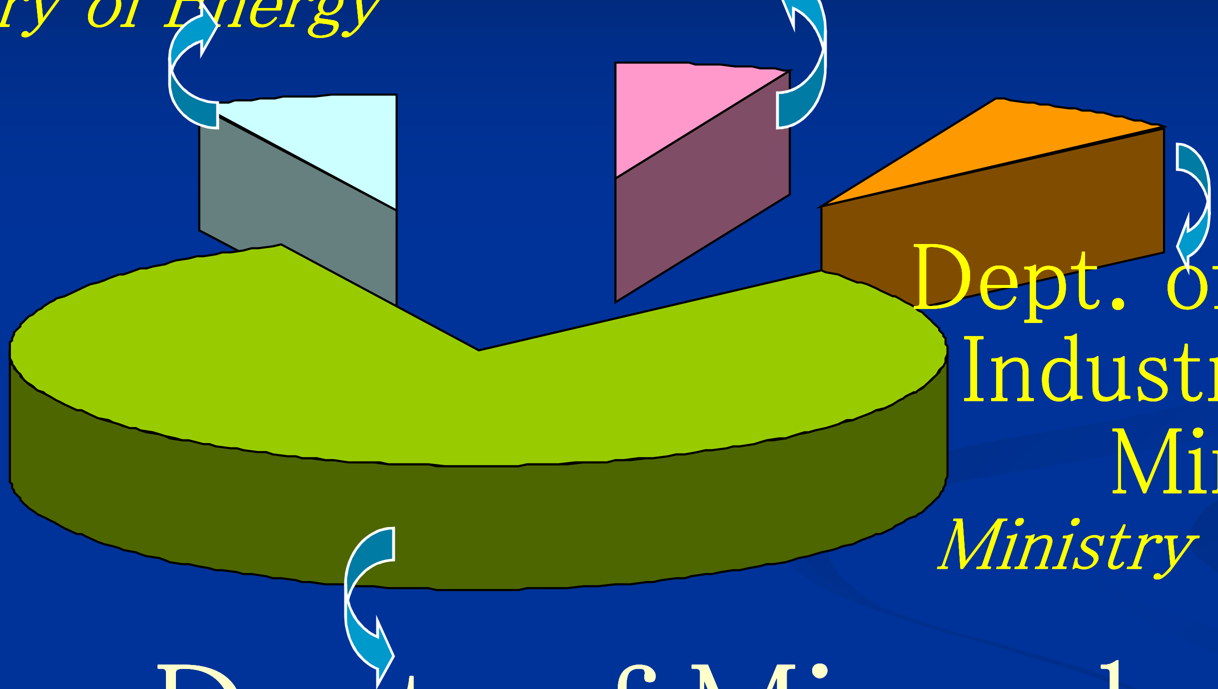


Department of Mineral Resources

Ministry of Industry

Dept. of Mineral Fuels,
Ministry of Energy

Dept. of Groundwater Resources,
Ministry of Natural Resources and Environment



Dept. of Primary Industries and Mines,
Ministry of Industry

Dept. of Mineral Resources,

Ministry of Natural Resources and Environment

DEPARTMENT OF MINERAL RESOURCES

MISSION

Manage geological resources and geology-related activities efficiently with participation of all stakeholders in order to contribute to sustainable use and an improved quality of life.

DEPARTMENT OF MINERAL RESOURCES

Authorized Functions

1. Submit opinions for the designation of areas, the formulation of policies and plans for preservation, conservation and rehabilitation of geological resources, and the management of geological resources and geology-related activities.

DEPARTMENT OF MINERAL RESOURCES

Authorized Functions

2. Submit opinions for the formulation or amendment of laws, regulations and measures of preservation, conservation and rehabilitation of geological resources, and the management of geological resources and geology-related activities,

DEPARTMENT OF MINERAL RESOURCES

Authorized Functions

as well as perform monitoring, evaluating and regulating in compliance with the laws, regulations and measures.

3. Perform functions as specified by the related Sections of the Mineral Law.

DEPARTMENT OF MINERAL RESOURCES

Authorized Functions

4. **Perform surveying, inspecting, studying, researching, knowledge developing, data providing, knowledge disseminating, technical servicing and international cooperating in geology and geological resources.**

DEPARTMENT OF MINERAL RESOURCES

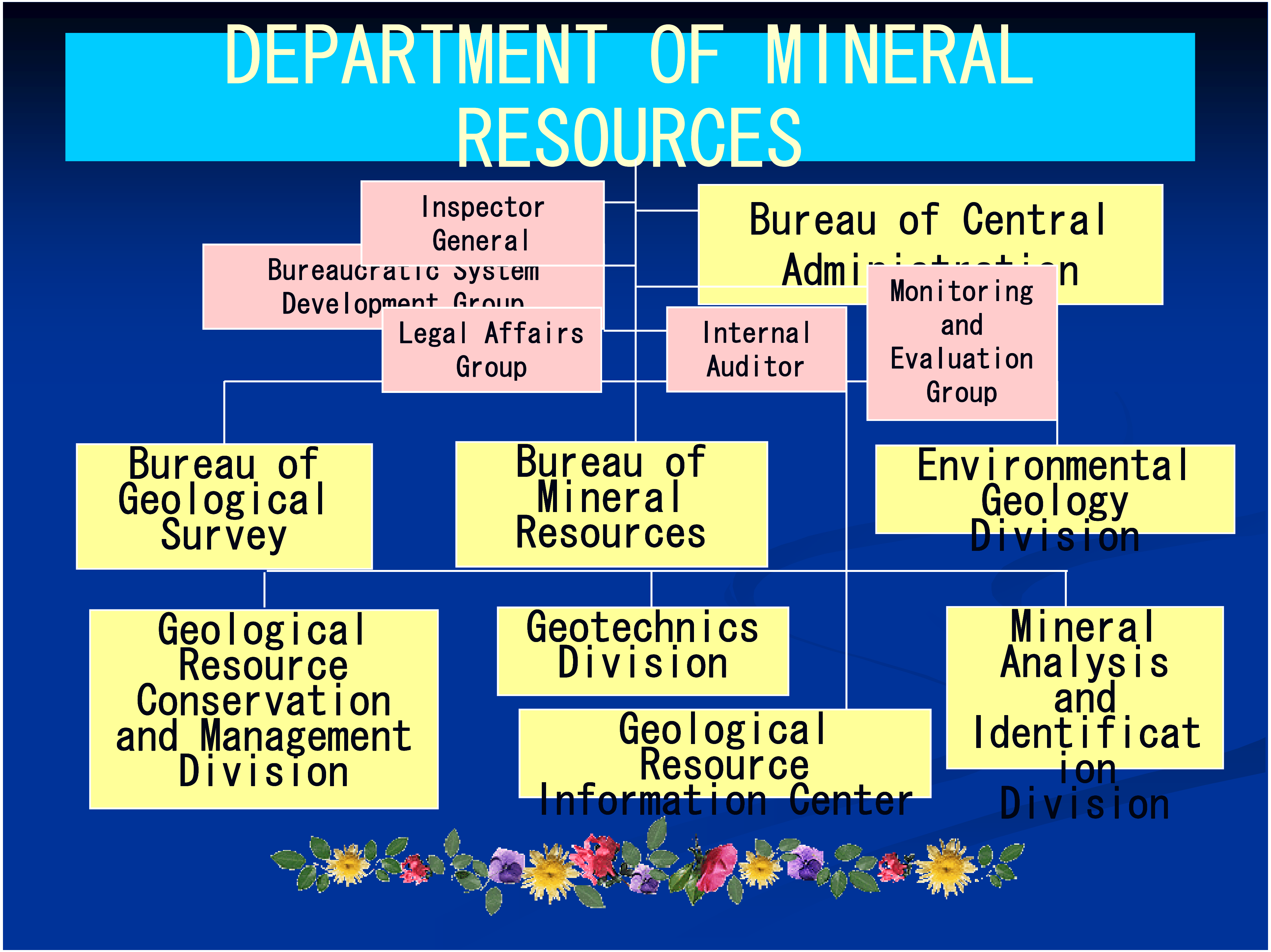
Authorized Functions

5. Set the geological and mineral standards, collect and preserve the geological and mineral samples for the national reference.

DEPARTMENT OF MINERAL RESOURCES

Authorized Functions

6. And to perform other functions as specified by the related laws to be the functional authorities of the Department, or by the assignment of the Ministry or the Cabinet.


DEPARTMENT OF MINERAL RESOURCES
Inspector General
Bureau of Central Administration
Bureaucratic System Development Group
Legal Affairs Group
Internal Auditor
Monitoring and Evaluation Group
Bureau of Geological Survey
Bureau of Mineral Resources
Environmental Geology Division
Geological Resource Conservation and Management Division
Geotechnics Division
Geological Resource Information Center
Mineral Analysis and Identification Division

OUTLINE OF COUNTRY REPORT

I. Mineral Resources

II. Groundwater Resources

III. Energy Resources

OUTLINE OF PRESENTATION

I. Mineral Resources

1. Production
2. Environmental Impacts
3. Geological conservation sites
4. Mineral Resources management
5. A selected case of environmental impact from mining activity

OUTLINE OF PRESENTATION

II. Groundwater Resources

1. Department of Groundwater Resources (DGR)
2. Recent and on-going projects
3. Department of Groundwater Resources' present key roles

OUTLINE OF PRESENTATION

III. Energy Resources

1. Energy in Thailand
2. Gasohol
3. Bio-diesel
4. Natural Gas for Vehicles (NGV)
5. Campaign on energy saving program

I. Mineral Resources

1. Production

- 40 kinds of mineral ores produced in 2006
- The production value increased from that of 2005 by 11.67%
- Export and import values slightly increased from those of 2006 by 2.79% and 1.33% respectively

I. Mineral Resources

2. Environmental Impacts

- Mae Moh coal-fired power plant in Lampang Province
- Saline soil in the northeast region caused by rock salt production
- Cadmium problem from zinc mining in Tak Province

I. Mineral Resources

2. Environmental Impacts

- High concentration of dust from stone crushing mills in Saraburi Province
- The protest against potash mining in Udonthani Province
- Physical impacts on archeological sites, ancient cities, and cultural environment
- Landslides and land subsidence

I. Mineral Resources

3. Geological conservation sites

- Mineral resource museum, fossil sites, geo-tourism sites and geological and ancient biological evidences
- Places for seeking geological knowledge
- Finished the draft act to protect the fossil

I. Mineral Resources

4. Mineral resources management

- Acceleration of enforcement on control measures to prevent illegal mining, improvement of mining process
- Effective enforcement on environmental rehabilitation during and after mining

I. Mineral Resources

4. Mineral resources management

- Promotion of geological education and survey to support the protection and remedial guidelines for solving geological related disasters,
- Promotion of survey and development of geo-tourism

I. Mineral Resources

5. A selected case of environmental impact from mining activity:

- Sulfur dioxide emission from Mae Moh coal-fired power plant in Lampang Province, Northern Thailand

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  ➢ *Lampang Province, Northern Thailand*

  ➢ *Electricity Generating Authority of Thailand (EGAT)*

  ➢ *13 generating units*

  ➢ *Capacity: (3x75)+(4x150)+(6x300)*

  = 2,625 MW

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  - ***Year of commission :*** **1978 -** ***present***
  - ***Fuel : an open-pit lignite mine covering an area of 135 square kilometers, the largest of its kind in Thailand***
  - ***Production in 2006: 43,000 Tons per day***
  - ***Southeast Asia's largest coal-fired power plant***

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  - **Impacts of this project**

    - *30,000 people have been displaced from their homes*
    - *1.6 million tons of sulfur gas is released annually into the air*
    - *4,033,932 tons of carbon dioxide emission into the atmosphere per year*

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  ❖ **Impacts of this project**

➢ ***Coal dust consisting of toxic chemicals has been carried by winds into rivers, reservoirs and nearby communities in the Mae Moh valley, including the reservoir that supplies drinking water for the local people***

➢***In 1992, Thousands have experienced severe health and respiratory problems***

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  - **Solutions**

    - *EGAT has set up the Flue Gas Desulphurization (FGD) system to eliminate sulfur dioxide emitted from the mine*

    - *The emissions became lower than the standard set by the National Environment Board (NEB), being safe for human beings and the environment*

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  ❖ **Solutions**

➢ *Since 1992, the Pollution Control Department (PCD) set up the measure for solution of the pollutions with related organizations.*

➢ *87 % villagers acknowledged the process of solving pollution problems*

➢ *59 % being satisfied with such problems solving performance.*

I. Mineral Resources

- **Mae Moh coal-fired power plant**

  ❖ **Solutions**

  ➢ *55 % villagers realized that sulfur dioxide is lower than in the past.*

  ➢ *Local people requested serious and continuous process of solving pollution problems in Mae Moh area from related governmental organizations in order to solve these environmental problems permanently.*

II. Groundwater Resources

1. Department of Groundwater resources (DGR)

- Established in 2002 under the Ministry of Natural Resources and Environment
- Controlling and inspecting of groundwater activities all over the country

II. Groundwater Resources

1. Department of Groundwater resources (DGR)

- The Department's mandates concern research, investigation and development managing the country's groundwater resources.

II. Groundwater Resources

2. Recent and on-going projects

- Study and research on groundwater potential assessment in order to support the Royal development projects in the mountainous areas.
- Groundwater potential assessment and development in tsunami affected areas, Southern Thailand.

II. Groundwater Resources

2. Recent and on-going projects

- Groundwater contamination from domesticated aquatic animals at Sating Phra Basin, Songkhla Province, Southern Thailand.
- Development and conservation of groundwater at Songkhla Basin.

II. Groundwater Resources

2. Recent and on-going projects

- The study of groundwater potential assessment in Moon-Chii river basin
- Feasibility and detailed design artificial recharge into aquifer at Eastern Coastal Area.

II. Groundwater Resources

2. Recent and on-going projects

- Feasibility and detailed design underground dam at Samui Island.
- National groundwater quality analysis.
- And training and disseminating in groundwater development local authorities.

II. Groundwater Resources

3. Department of Groundwater Resources' present key roles

- Groundwater supply system for rural areas all over the country
- The research and control of groundwater usage in Bangkok metropolitan and suburban areas where the environmental impact has occurred in terms of land subsidence.

III. Energy Resources

1. Energy in Thailand

- Reserved energy has been decreased due to the demand of energy has markedly been increased especially for transportation and industrial sectors
- Import energy from other countries and develop alternative fuels to compensate the use of fossil fuels.

III. Energy Resources

1. Energy in Thailand

- Nowadays, the government gives priority to the utilization of alternative fuels especially bio-fuels such as gasohol, bio-diesel, and natural gas for vehicle (NGV).

III. Energy Resources

2. Gasohol

- Gasohol is widely recognized and the gasohol stations are rapidly increased.
- In 2007, the average sale per day was around one million liters.
- The use of gasohol instead of fossil fuel will reduce air pollutants since gasohol is more environmentally friendly than gasoline.

III. Energy Resources

3. Bio-diesel

- The government has supported the use and production of bio-diesel by setting the goal for 2011 in which the use of bio-diesel will reach 720 million liters per year.

III. Energy Resources

4. Natural gas for vehicles (NGV)

- NGV is less widely used as compared to gasohol due to limitation of gas stations and requirement for gas containers.
- The government has launched projects to promote the use of NGV, such as installment of NGV equipment for 10,000 volunteered taxis, and increase stations for service of NGV.

III. Energy Resources

5. Campaign on energy saving program

- The campaign on “turning off air conditions for one hour and turning off at least one light for five minutes” on the first of June achieved the energy saving up to 822 MW and 702 MW.
- Ten energy saving measures were set as guidelines for practice in households as well as other regulations to help solving energy crisis of the country.

Thank You

ECONOMY REPORT

Human Capacity Building for Natural Resources Development and its Environmental Impacts in APEC Region

Ms Patchara Sangoen
Department of Mineral Resources
Thailand

1. MINERAL RESOURCES

Overview

The production of Mineral Resources has been increasing to serve demand in the country. There were more than 40 kinds of mineral ores produced in 2006. The production value increased from that of 2005 by 11.67%. The highest production value was from mineral of fuel or energy group with was followed by minerals of cement industry group and industrial stone group respectively. With regard to export and import of mineral production, the increasing trend was observed in 2006. The export and import values slightly increased from those of 2006 by 2.79% and 1.33% respectively.

Production process of mineral resources may cause serious problems and impacts on environment and human health. The evidence of impacts are such as air pollution from Mae Moh coal-fired power plant in Lampang Province, saline soil in the northeast region caused by rock salt production, cadmium problem from zinc mining in Tak province, high concentration of dust from stone crushing mills in Saraburi province, the protest against potash mining in Udonthani province, physical impacts on archeological sites, ancient cities, and cultural environment, as well as problems of land slides and land subsidence.

With regard to geological conservation sites such as mineral resource museum, fossil sites, and geo-tourism sites, Department of Mineral Resources has considered them as the places for seeking geological knowledge, as well as geological and ancient biological evidences. The Department has finished the draft act to protect the fossil. At present, it is in the process of consideration by concerned agencies.

Recommendations for mineral resources management consist of the followings: acceleration of enforcement on control measures to prevent illegal mining, improvement of mining process and effective enforcement on environmental rehabilitation during and after mining, promotion of geological education and survey to support the protection and remedial guidelines for solving geological related disasters, and promotion of survey and development of geo-tourism.

- A selected case of environmental impact from mining activity: Sulfur dioxide emission from Mae Moh coal-fired power plant in Lampang Province, Northern Thailand

Secluded in the mountains of northern Thailand lies a massive lignite coal-fired power plant equipped with 13 generating units with a total capacity of 2,625 Megawatts. Mae Moh, Thailand's largest mine, is located in Mae Moh district, Lampang Province of northern Thailand. It began operating on a small scale in the 1960s and was significantly expanded in the 1978s. Owned and operated by the Electricity Generating Authority of Thailand (EGAT), the Mae Moh Power Plant is Southeast Asia's largest coal-fired power plant. The fuel of the power station is supplied by an open-pit lignite mine covering an area of 135 square kilometers, the largest of its kind in Thailand. The current production from the mine is 40,000 tons per day.

Every year approximately 1.6 million tons of sulfur gas is released into the air from this power plant, resulting in severe health problems for local people and irreversible damage to the natural environment. It has been estimated that the Mae Moh power plant has annually contributed approximately 4,033,932 tons of carbon dioxide emission into the atmosphere, making the biggest regional contributor to climate change.

Since the inception of the Mae Moh coal-fired power plant, more than 30,000 people have been displaced from their homes. In 1992 thousands have experienced severe respiratory problems and four law suits have been filed against the Electricity Generating Authority of Thailand (EGAT). More than 600 villagers continue to suffer from acute respiratory problems caused by the inhalation and exposure to sulfur dioxide emitted from the mine. Coal dust consisting of toxic chemicals has been carried by winds into rivers, reservoirs and nearby communities in the Mae Moh valley, including the reservoir that supplies drinking water for the local people. The lignite burnt at Mae Moh continues to release massive amounts of sulfur gas which has blackened streams, burnt rice fields and resulted in severe health problems for local communities.

As a result of the air pollution from the power plant in 1992, EGAT has set up the Flue Gas Desulphurization (FGD) system to eliminate sulfur dioxide emitted from the mine. The emissions became lower than the standard set by the National Environment Board (NEB), being safe for human beings and the environment. Pollution problems recurred in 1996, but less severe than the problems in 1992. Since 1992, the Pollution Control Department (PCD) has been the main organization to set up the measure for solution of the pollutions from the power plant and environmental rehabilitation in Mae Moh power plant with related organizations.

According to the opinion survey conducted by PCD in Mae Moh local people, 87 percents of villagers acknowledged the process of solving pollution problems in Mae Moh power plant with 59 percents being satisfied with such problems solving performance. 55 percents of villagers realized that sulfur dioxide emitted from the mine is lower than in the past. However, the local people requested serious and continuous process of solving pollution problems in Mae Moh area from related governmental organizations in order to solve these environmental problems permanently.

2. GROUNDWATER RESOURCES

Overview

In Thailand, main groundwater activities are under provision of the Department of Groundwater resources (DGR) which was established in 2002 under the Ministry of Natural Resources and Environment. The Department of Groundwater Resources has the key functions in controlling and inspecting of groundwater activities all over the country. The

Department’s mandates concern research, investigation and development managing the country’s groundwater resources.

The list of recent and on-going projects are as follows:

1. Study and research on groundwater potential assessment in order to support the Royal development projects in the mountainous areas.
2. Groundwater potential assessment and development in tsunami affected areas, Southern Thailand.
3. Groundwater contamination from domesticated aquatic animals at Sating Phra Basin, Songkhla Province, Southern Thailand.
4. Development and conservation of groundwater at Songkhla Basin.
5. The study of groundwater potential assessment in Moon-Chii river basin.
6. Feasibility and detailed design artificial recharge into aquifer at Eastern Coastal Area.
7. Feasibility and detailed design underground dam at Samui Island.
8. National groundwater quality analysis.
9. Training and disseminating in groundwater development local authorities.

The Department of Groundwater Resources’ present key roles are such as groundwater supply system for rural areas all over the country, the research and control of groundwater usage in Bangkok metropolitan and suburban areas where the environmental impact has occurred in terms of land subsidence.

- A selected case of environmental impact from groundwater development : A cause of Bangkok land subsidence

The Lower Chao Phraya Basin has a very flat topography with elevations as low as 2 meters above mean seal level even at a distance of 80 km north of the present-day coastline. Due to this the plain is frequently flooded. The basin filling consists of thick, unconsolidated Quaternary sediments. Sandy deposits, forming major aquifers, are intercalated with clayey deposits, which act as aquitards. Some of these clays have been deposited during marine ingressions, e.g. the topmost sediment, the 'Bangkok clay'. This most recent marine ingression reached up to the area around Ayuthaya. The thickness and distribution of these clays varies considerably.

These clays have a high water and organic compounds content, and are not very well compacted, whereas the sandy sediments are already compacted to a higher degree. Compaction generally increases with depth, so that the compaction rate (or rate of subsidence), i.e. the rate at which the thickness of a sediment layer decreases with time (because water is squeezed out due to the weight of the sediment resting on it), is lower in the lower part of the system.

The effects of land subsidence are clearly visible at the land surface and cause substantial damages to buildings and infrastructure. Most of these effects however are related to compaction in the Bangkok clay, since the foundations of most buildings and infrastructures rest on sands of the Bangkok aquifer. In this context it has to be mentioned that many of these damages are due to faulty construction of the foundations (e.g. broken or too short concrete pillars).

However, compaction affects also the other underlying young sediments, especially the clays. A network of around 500 benchmarks has been installed in Bangkok and its surrounding provinces to monitor the land subsidence at different depths.

Land subsidence in the lower part of the sedimentary sequence is mostly due to groundwater over-exploitation. In Bangkok an estimated 2 million cubic meters are extracted daily from the groundwater system. Most of this amount is used by private enterprises. As a result the groundwater level in the Nakhon Luang (NL) and Nonthaburi aquifer (NB) have declined to around 70 m below sea level. There are two main centers of depression, one in eastern Bangkok, extending in a north-south direction, about 15-20 km east of the Chao Phraya River. The other one is located slightly west and north of Samut Sakhon.

The lowered hydraulic heads in these aquifers lead to downward leakage of water from the interbedded aquitards, so that the clays are dewatered. This leads to an irreversible compaction of the clays. Land subsidence caused by groundwater over-exploitation is thus mainly a result of compaction in the aquitards.

3. ENERGY RESOURCES

Overview

At present, reserved energy in Thailand has been decreased due to the demand of energy has markedly been increased especially for transportation and industrial sectors. Consequently, Thailand needs to import energy from other countries and develop alternative fuels to compensate the use of fossil fuels. Nowadays, the government gives priority to the utilization of alternative fuels especially bio-fuels such as gasohol, bio-diesel, and natural gas for vehicle (NGV).

Gasohol is widely recognized and the gasohol stations are rapidly increased. In 2007, the average sale per day was around one million liters. The use of gasohol instead of fossil fuel will reduce air pollutants since gasohol is more environmentally friendly than gasoline.

Bio-diesel is another alternative fuel. The government has supported the use and production of bio-diesel by setting the goal for 2011 in which the use of bio-diesel will reach 720 million liters per year.

Natural gas for vehicles or NGV is less widely used as compared to gasohol due to limitation of gas stations and requirement for gas containers. The government has launched projects to promote the use of NGV, such as installment of NGV equipment for 10,000 volunteered taxis, and increase stations for service of NGV.

In 2007, the government has actively campaigned on several energy saving programs. The campaign on “turning off air conditions for one hour and turning off at least one light for five minutes” on the first of June achieved the energy saving up to 822 megawatts and 702 megawatts respectively. In addition, ten energy saving measures were set as guidelines for practice in households as well as other regulations to help solving energy crisis of the country.

Mr. Supachai Skawsang

Thailand Economy Report: Course on Human Capacity Building for Natural Resources Development and Its Environmental Impacts in APEC Region

27 November – 14 December 2007

Tsukuba, Japan

GISTDA
Geo-Informatics and Space Technology Development Agency (Public Organization)

Content

- Overview Thailand
- Natural Resources and its Environmental Impacts
- About GISTDA
- GISTDA and Natural Resources and its Environmental Impacts

Overview : Thailand

- Formal Name : Kingdom of Thailand
- Short Name : Thailand
- Area : ≈ 514,000 sq.km.
- Population : ≈ 64 million
- Capital : Bangkok

  (≈ 6.9 million)

Overview :Thailand

Geographical

- It is located from 5° to 21° N and 96° to 106° E
- Neighbors boundary

  North : Myanmar and Laos

  East : Cambodia and Laos

  West : Myanmar

  South : Malaysia
- Length of Coastline

  860 kilometers

  on the Andaman Sea

  1,840 kilometers

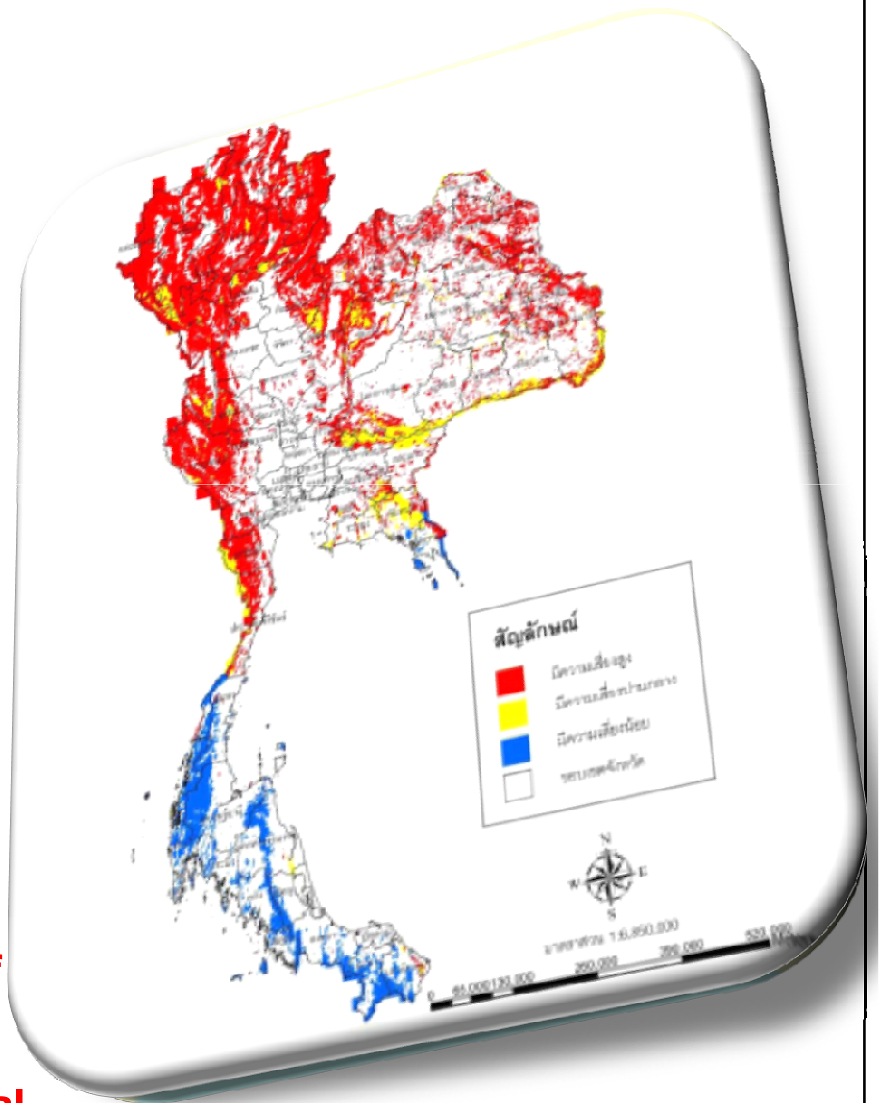
  on the Gulf of Thailand.

Natural Resources and its Environmental Impacts

Forest Resources

Evergreen forest
- Tropical rain forest
- Dry evergreen forest
- Hill evergreen forest
- Coniferous forest
- Mangrove forest
- Swamp forest
- Beach forest

Deciduous forest
- Mix deciduous forest
- Dry dipterocarp forest

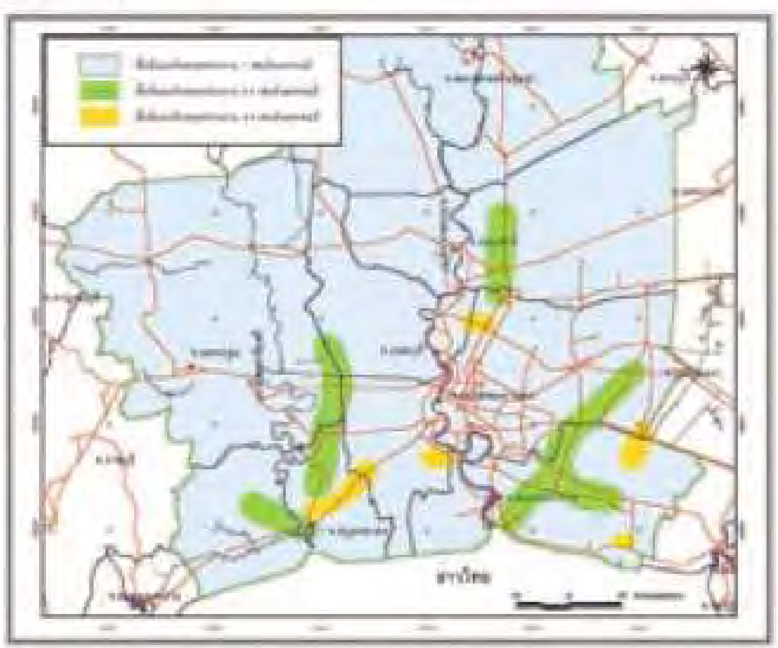


During the past four decades, the reduction on acreage is about 107,200 sqkm. From satellite data, with scale of 1:50,000 in 2000 the forest was 1/3 of the total country area or 33.15% of total country area. However, in 2004 the number had been diminished more than 6,000 sqkm mostly from illegal logging, habitat and agriculture.

Natural Resources and its Environmental Impacts

Groundwater Resources

- The number of wells are 998,539 wells in 2006
- In the present, groundwater usage are estimated 2.2 mcm/day
- effected on Land subsidence in some area such as bangkok and circumference



Natural Resources and its Environmental Impacts

Mineral Resources

- Thailand's major minerals include fluorite, gypsum, lead, lignite, natural gas, tantalum, tin, and tungsten.
- In 2003 Thailand produced more than 40 types of minerals with an annual value of about US$740 million.
- However, more than 80 percent of these minerals were consumed domestically.

Sources : Library of Congress – Federal Research Division
Country Profile: Thailand, July 2007

Natural Resources and its Environmental Impacts

Without any appropriated in mineral management, this will lead to the depletion of natural resource and pollution as well.

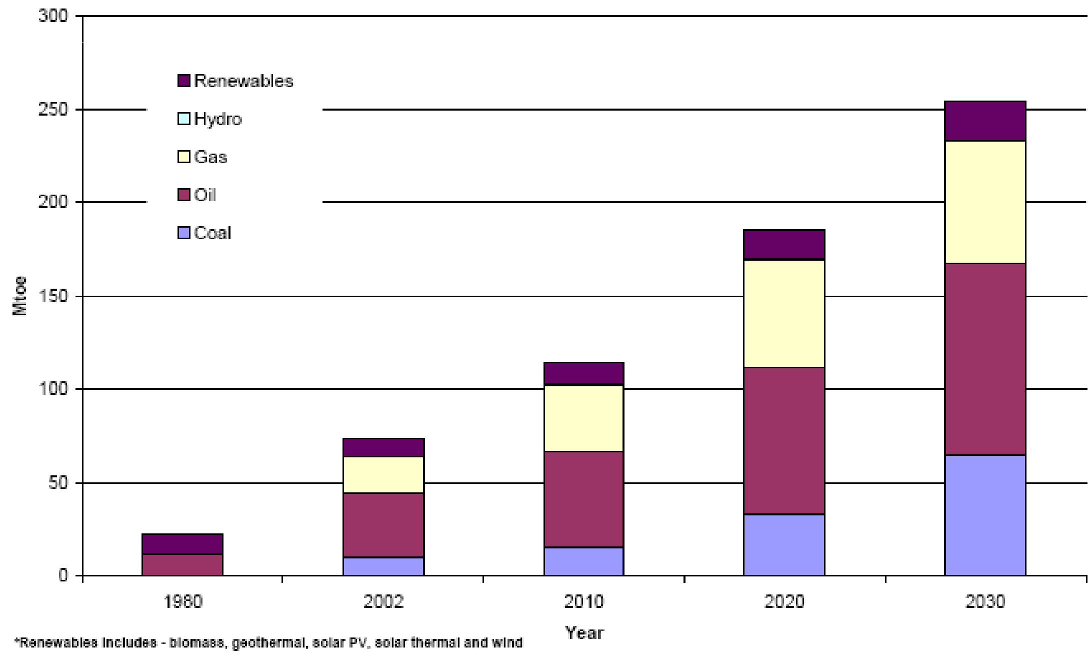
- contamination of cadmium, lead, arsenic in the nature
- Lack of the rehabilitation of waste mining land
- Soil erosion
- Soil contamination
- fugitive dust concentration from stone-processing plants

Natural Resources and its Environmental Impacts

Energy Resources

Thailand's total primary energy demand is projected to grow at an annual rate of 4.6 percent over the analysis period, from 74 Mtoe in 2002 to 258 Mtoe in 2030. Among the fossil fuels, coal is projected to grow fastest (7.0 percent per year), followed by natural gas (4.5 percent) and oil (3.9 percent).

FIGURE 1.1: THAILAND PRIMARY ENERGY DEMAND BY SOURCES



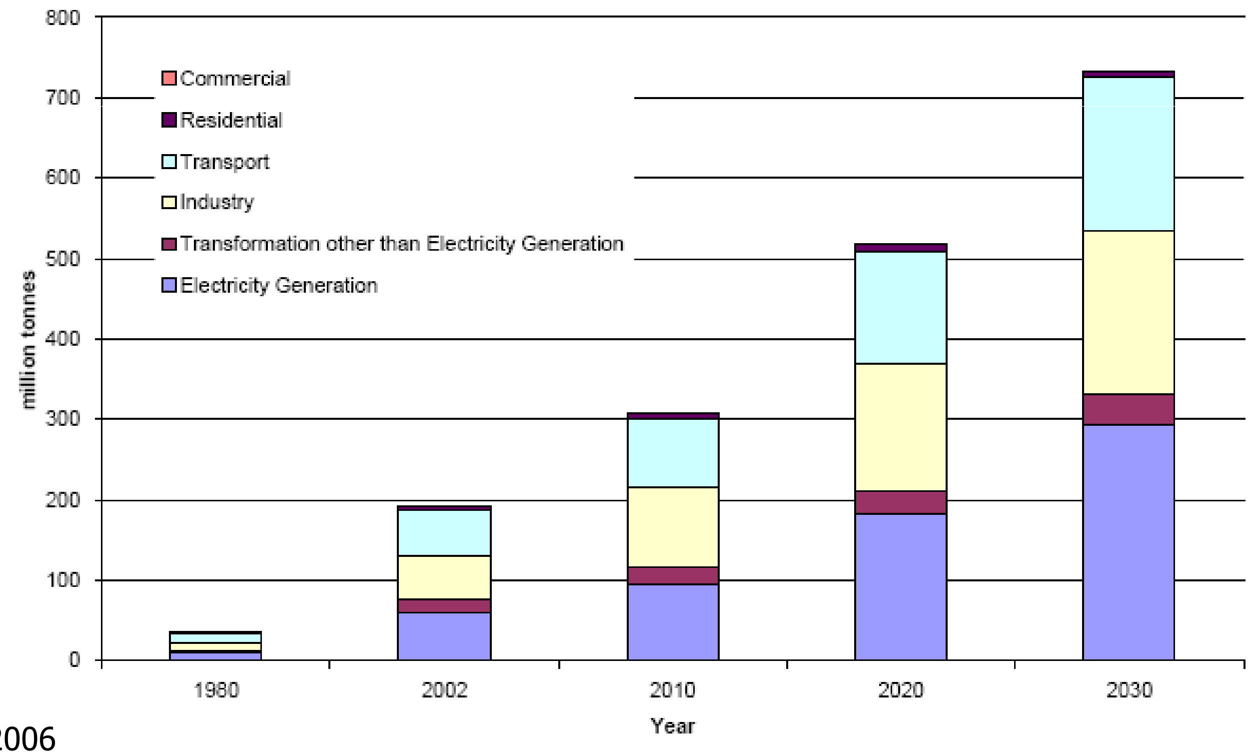
Source: APERC, 2006.

Natural Resources and its Environmental Impacts

Impact of energy use

Emissions of CO_2 from the energy sector are expected to increase from about 192.6 million metric tons (Mt) in 2002, to 516.7 Mt in 2020, and more than 700 Mt in 2030

FIGURE 1.2: SHARE OF ENERGY-RELATED CO2 EMISSIONS BY SECTOR



Source: APERC, 2006

Natural Resources and its Environmental Impacts

Geo-hazard and Geology environmental

- Finding suitable area for sanitary landfill
- Researching of high salinity degree area
- Land slide
- Earthquake
- Tsunami

Thailand has a number of activities in geo-hazard and geo-environmental, such as finding suitable area for sanitary landfill and researching of high salinity degree area. Geo-hazard in the country includes, among others, land slide, earthquake, land settlement, shoreline and bank erosion. These cause damages to the human being and property, which higher degree in each year. Fortunately, earthquake in the country is minimal, except the quake from Sumatra Island of Indonesia in 2004, that made a large number of casualties, both human and property.

About GISTDA

- a public organization under the supervision of the Ministry of Science and Technology

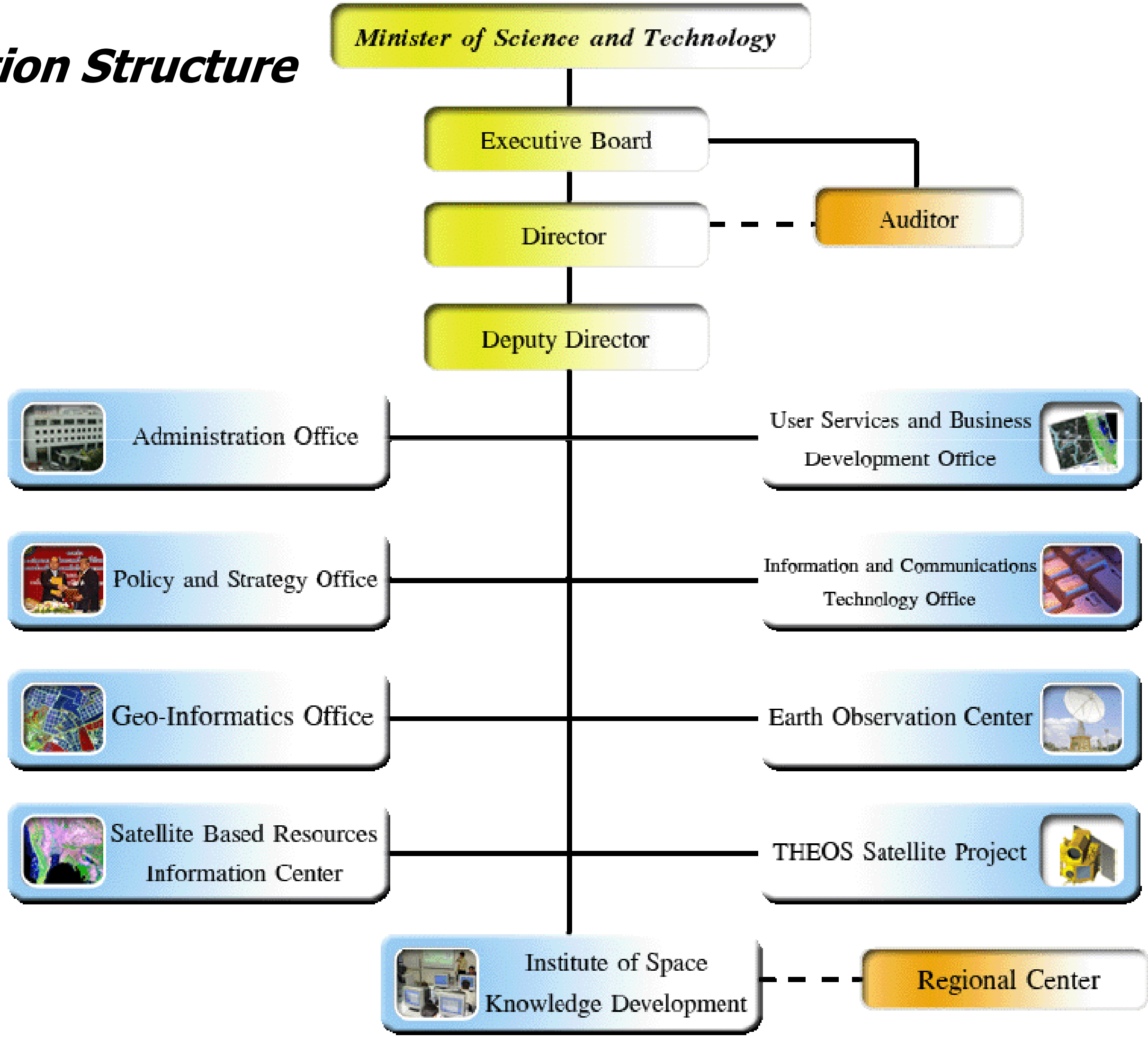
- The objectives are to develop space technology and geo-informatics applications to be beneficial to the general public and to provide technical services and develop human resource in satellite remote sensing and geo-informatics

- The main strategies of GISTDA include: investment, services, research and development, technology transfer and data exchange in space technology and its applications and geo-informatics with relevant national and international agencies/institutes in both public and private sectors

About GISTDA

About GISTDA

Organization Structure



About GISTDA

ISKD, under GISTDA, has main mission in promoting, supporting and operating in capacity building in the fields of space technology and geo-informatics. ISKD organizes various training in geo-informatics, both general and specific, from introduction to advanced, for public and private agencies. Furthermore, ISKD also distributes knowledge of space technology and geo-informatics, via conference and workshop in national and international forum.

GISTDA and Natural resources and Environmental Impact Management

GISTDA service includes satellite data providing and its applications, altogether with GIS for Natural resource and Environmental management and Natural disaster. The services provided through various channels, by research project with domestic and international agencies, these are some of the applications :

Forestry

Land use

Coastal

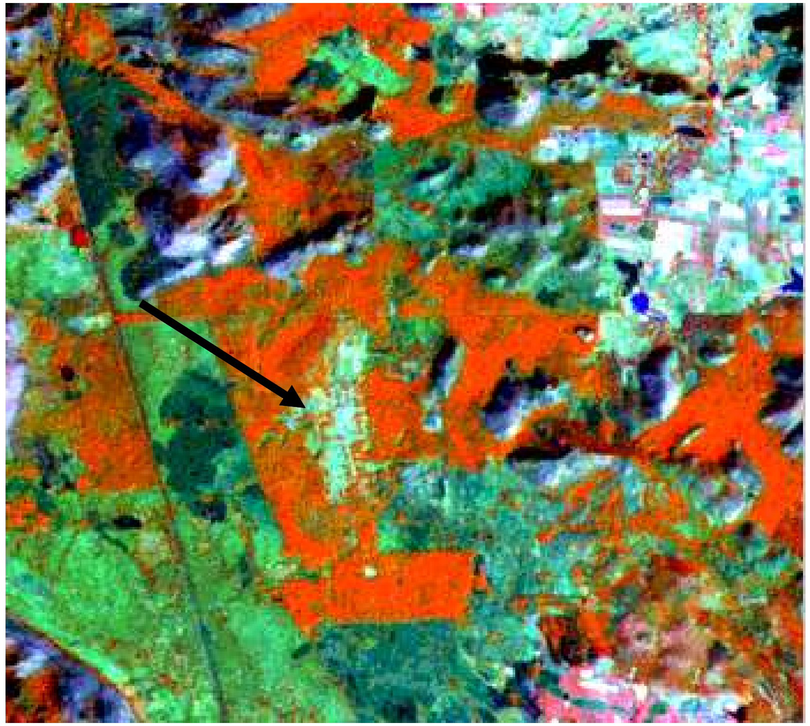
Geology and Geo-Morphology

Environment

Natural Disaster

GISTDA and Natural resources and Environmental Impact Management

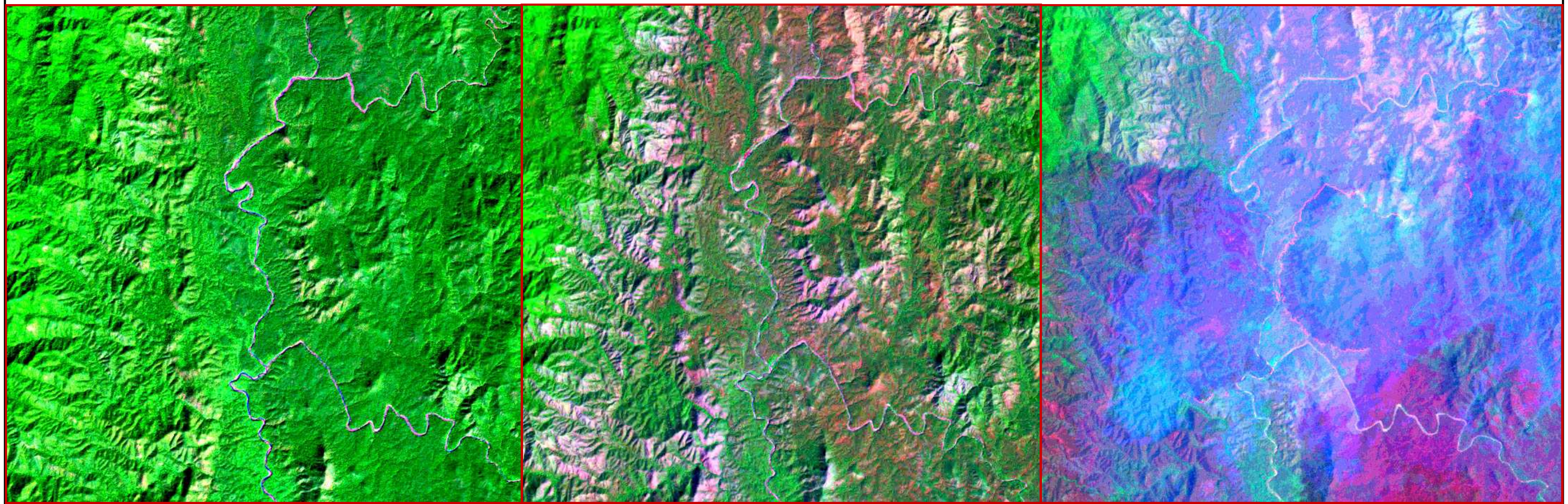
Forestry **_Deforestation_**



GISTDA and Natural resources and Environmental Impact Management

Forestry

Forest fire



LS-5 TM 11 Dec 1997 B742

LS-5 TM 25 Jan 2001 B742

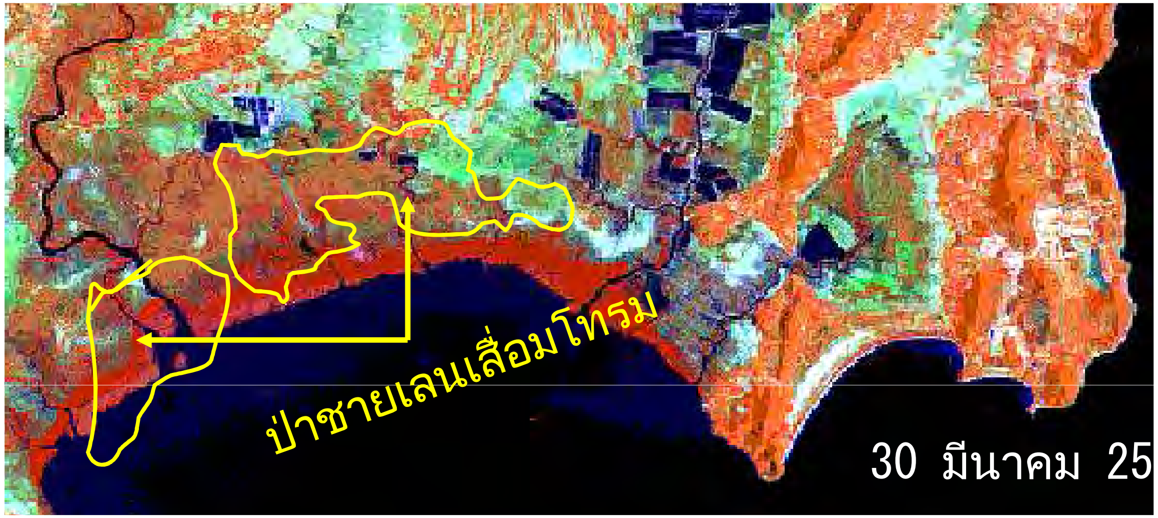
LS-5 TM 17 Mar 2001 B742

Huai Khakaeng Wildlife Sanctuary, Uthai Thani province

GISTDA and Natural resources and Environmental Impact Management

Landuse

Landuse change monitoring

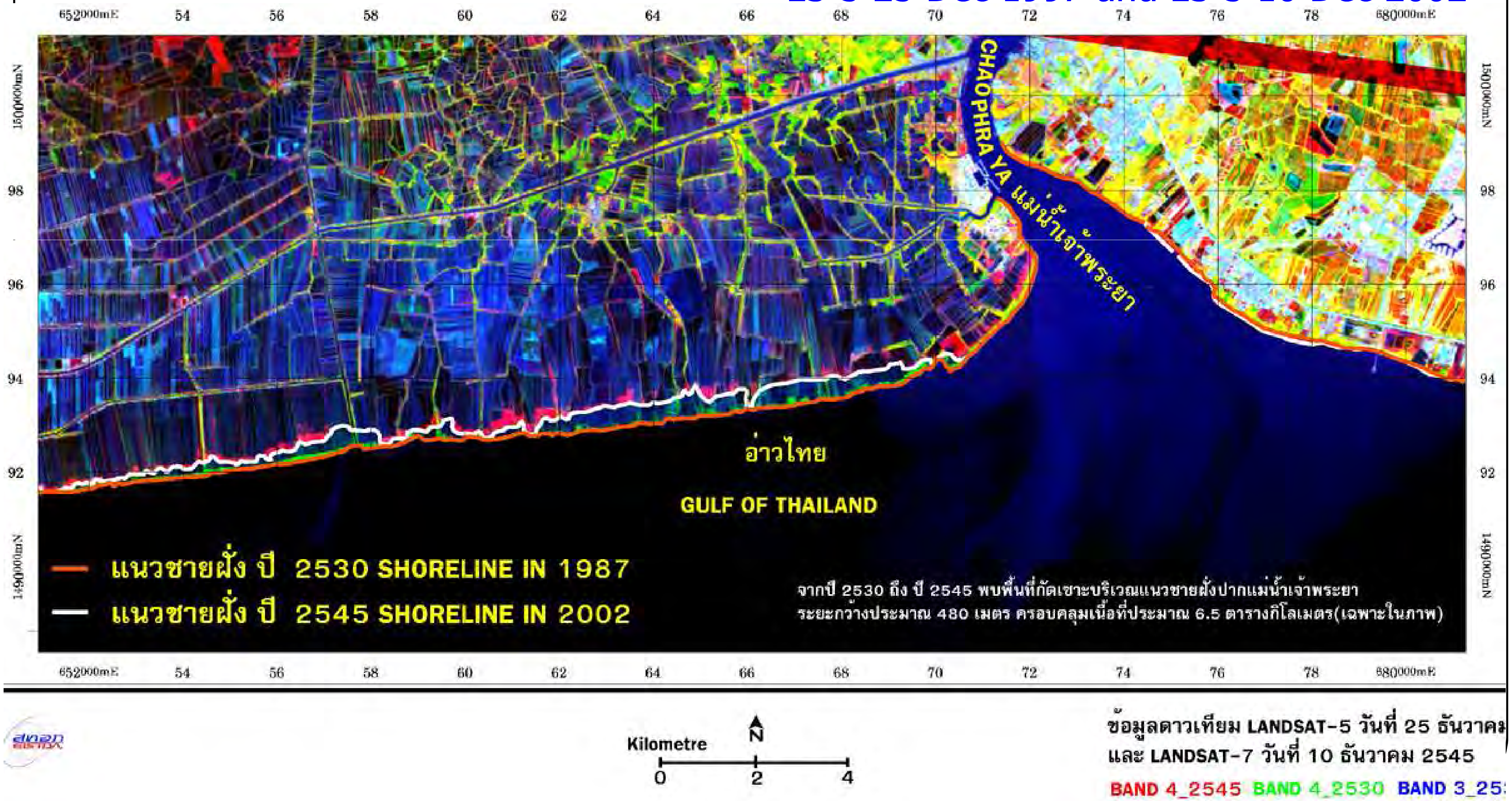


GISTDA and Natural resources and Environmental Impact Management

Coastal

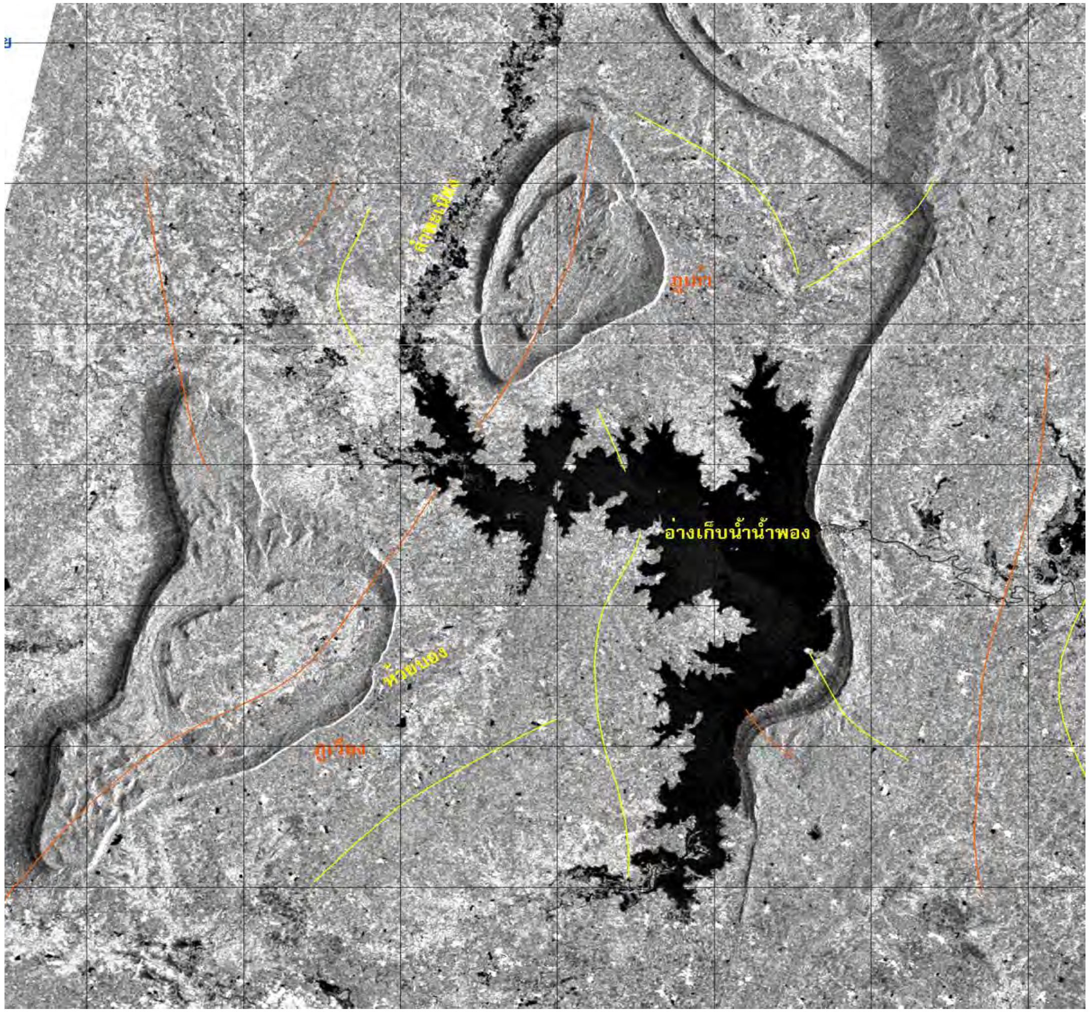
Coastal Erosion

LS-5 25 Dec 1997 and LS-5 10 Dec 2002



GISTDA and Natural resources and Environmental Impact Management

Geology and Geo-Morphology



Geomorphology study

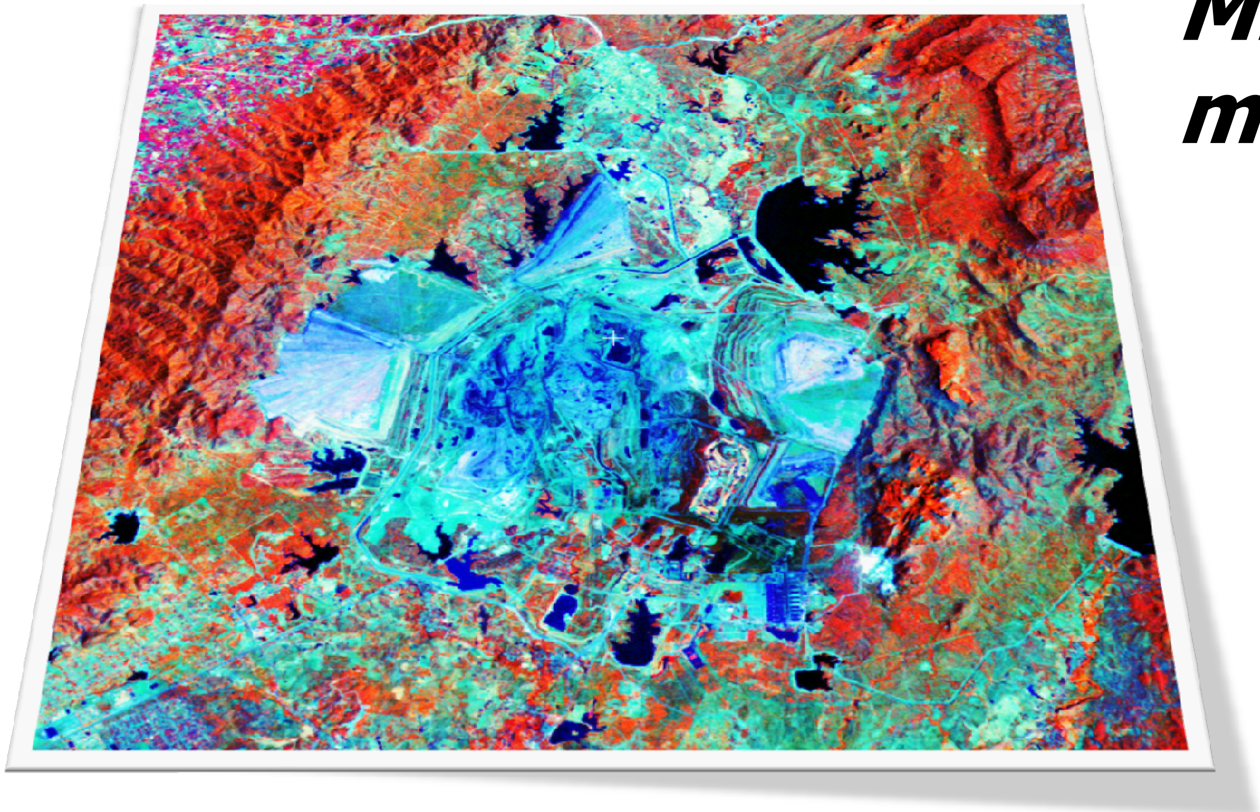
RADARSAT-1

14 September 2

Khonkan province

GISTDA and Natural resources and Environmental Impact Management

Geology and Geo-Morphology

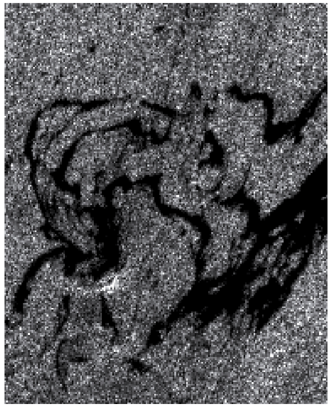


Mine management

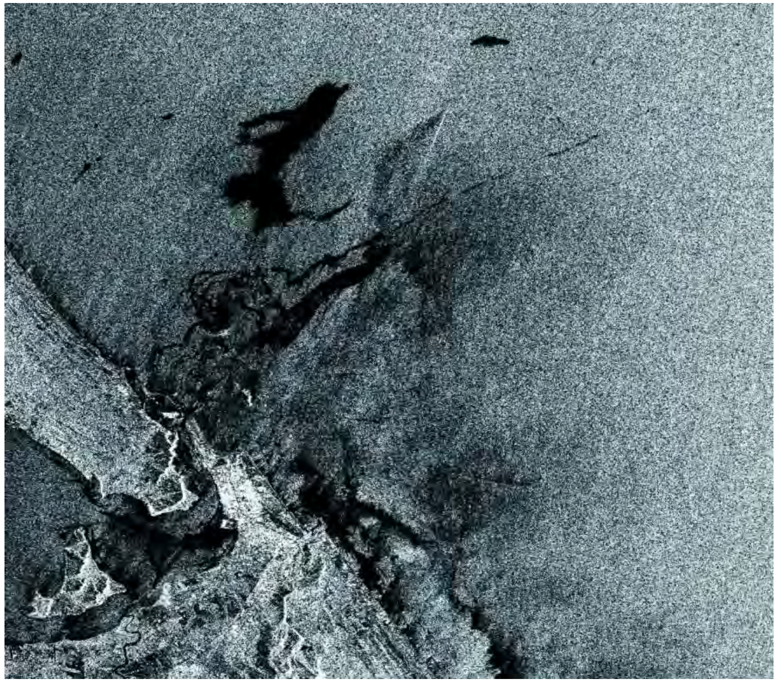
GISTDA and Natural resources and Environmental Impact Management

Environment

Songkhla Deep Seaport
ERS-1 acquired on 21 Jul 1994



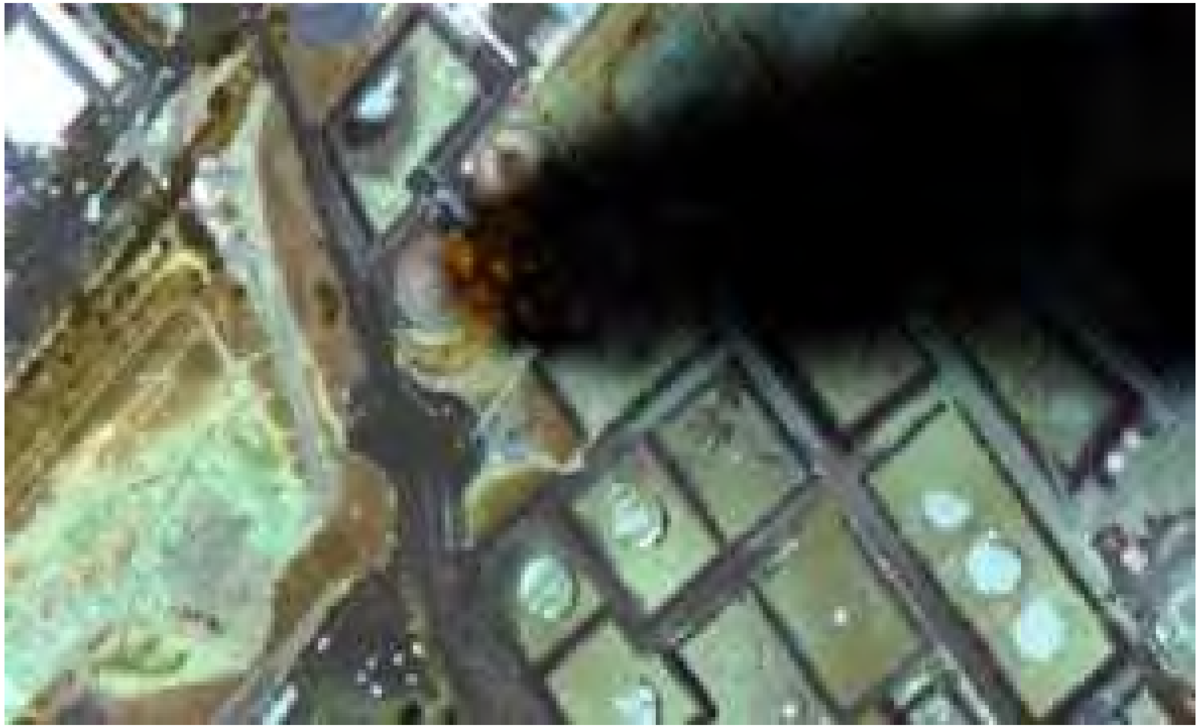
Oil pollution



GISTDA and Natural resources and Environmental Impact Management

Environment

Air pollution



QuickBird, 2.8-meter multispectral imagery, sharpened with 70-centimeter panchromatic, will be capable of detecting and monitoring various types of airborne pollutants.

GISTDA and Natural resources and Environmental Impact Management

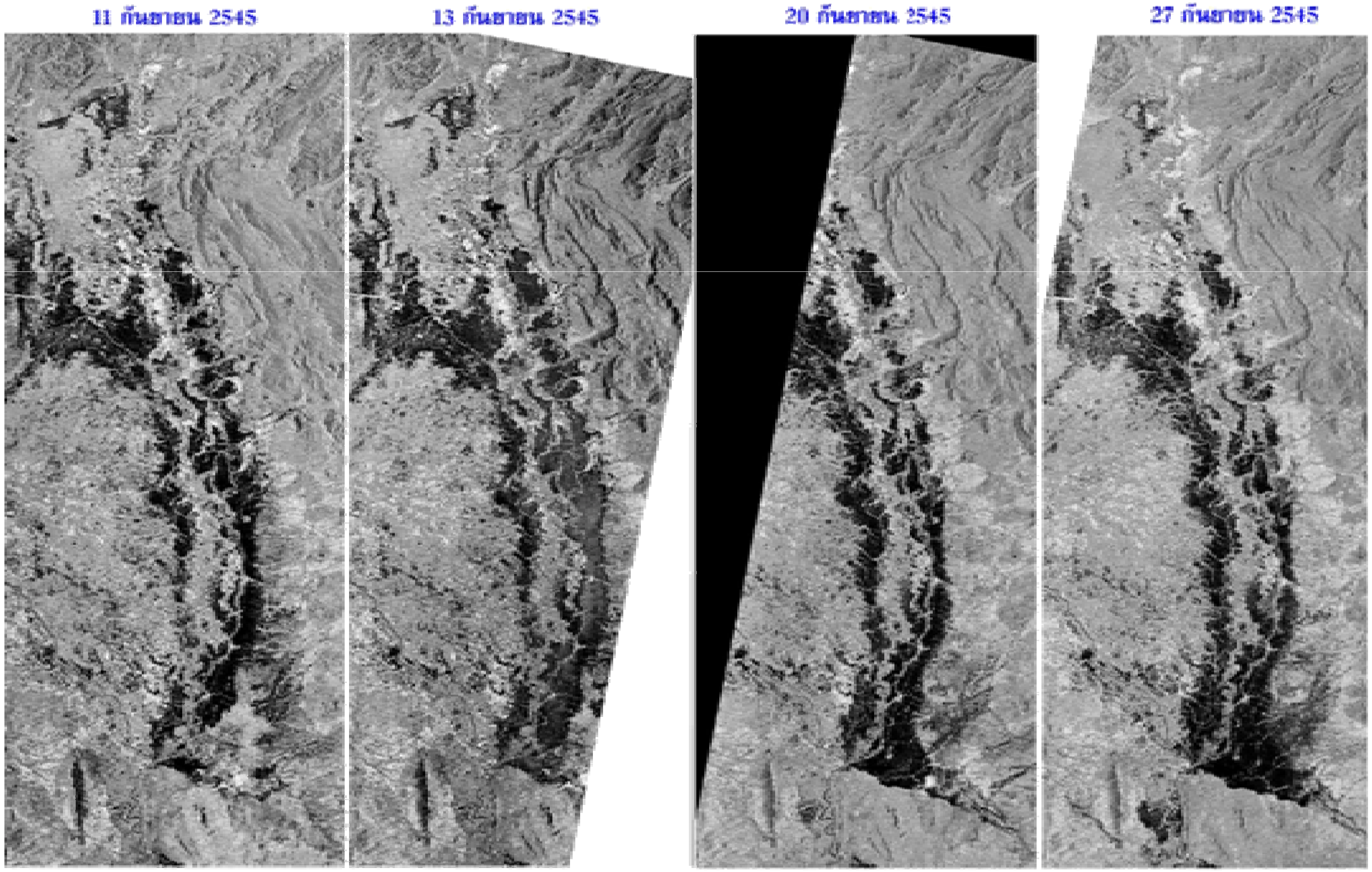
Natural Disaster

Landslide

GISTDA and Natural resources and Environmental Impact Management

Natural Disaster

Flooding



GISTDA and Natural resources and Environmental Impact Management

Natural Disaster Phangnga province ***Tsunami***

Before IKONOS 30 January 2003

After IKONOS 29 December 2004

Thank you for your attention

Thailand Economy Report

Introduction

Nestled in the heart of Southeast Asia, Neighbored by Cambodia, Lao PDR, Myanmar and Malaysia, Thailand spreads out over 514,000 square kilometres of land and stretches some 1,620 kilometres from north to south and 775 kilometres from east to west, with a coastline of approximately 1,840 kilometres on the Gulf of Thailand and 750 kilometres along the Indian Ocean. In geographically coordinate, It is located between N 5° 40’ - 20° 35’ latitude and W 93° 30’ - 105° 40’ longitude.

Thailand is governed by a constitutional monarchy and is administratively divided into 76 provinces which further divided into district, sub-district or Tambon and village consecutively. Province is the local administration unit headed by provincial governor. The provincial governor is appointed by the central government, excluding Bangkok, whose governor is directly elected by Bangkokians. The population of Thailand consists of over 30 ethnic groups of people making up approximately 64 millions. About 6.9 million people are registered in the capital city of Bangkok.

Geographically, Thailand is divided into six regions; the North, the Central or the Chao Phraya River Basin, the Northeast or the Korat Pleateau, the East, the West and the south or the Southern Peninsula. The northern region terrain is mountainous which render this region to be proned to water-related disasters such as flashflood, landslide and debris flow. The northeastern region is an arid area on Korat Plateau and frequently suffers flashflood and inundation during rainy season, severe drought and cold spell during summer and cool season. The central region, the vast fertile land which is dubbed as the “Rice Bowl” of the country often encounters the repeated riverine flood and urban inundation during the rainy season. The southern region terrain is hilly on the west coast and the coastal plain on the east. This part of Thailand has occasionally frequented flashflood, mudslide, tropical storm and forest fire.

The climate, Thailand is a warm and rather humid tropical country with an average high temperature of 34.1◦c and the low of 22.6◦c. There are three overlapping seasons: the monsoon that lasts from July to October, from when it turns moderate to cool until February and warms up to sweltering heat until June.

Natural Resources and its Environmental Impacts

In the past, Thailand natural resources are fertility of forest, wildfire, land, water, mineral, coastal and fishery. Now, natural resource and environmental in Thailand have faced degrading problem as a result of economic development and confliction between environmental policy and development policy. Many development projects were pursued without careful consideration given to the natural and cultural environment.

Forest Resources

One of the main natural resource in the country, forest in Thailand can be classified into 2 types : Evergreen and Deciduous. The first can be divided into 7 types, they are Mangrove forest, Swamp forest, Beach forest, Tropical rain forest, Dry evergreen forest, Coniferous forest and Hill evergreen forest and the later can be divided into 2 types, they are Mix deciduous forest and Dry dipterocarp forest.

During the past four decades, the reduction on acreage is about 107,200 sqkm. From satellite data, with scale of 1:50,000 in 2000 the forest was 1/3 of the total country area or 33.15% of total country area. However, in 2004 the number had been diminished more than 6,000 sqkm mostly from illegal logging, habitat and agriculture.

Water Resources

With plenty of water resource but inappropriate managing, Thailand faces water shortage during dry season and floods in rainy season. In the past decade, the drought causes adversely affect to the community and agriculture, some 200 million USD per annum. Floods also causes damage up to 4 billion USD in each year. The increasing number of population will, then, increase in the number of water consumption. At present the number of reserved water is only 73 million cubic meters, however, this will alarming increase to 126.3 mcm in 2011.

In addition, water consumption in metro, most from deep well source, is up to 1.54 mcm/day, ironically, the number of water resource is only 1.25 mcm/day, hence, the more consumption the higher in metro land settlement and the more invasion of brackish water to the gulf. However, since 1998, the authority has a number of plan to mitigate the deep well water problem, then the shortage of metro water has declined respectively, but deep well water still plays the major role in supplying to the metro area for consumption.

Mineral Resources

Utilization of mineral resources of the country mostly from continuously the import and the export of mineral. The mineral contributes to the value added of various industry, like construction, cement, ceramic, glass and mirror.

Thailand has a number of mineral such as fluorite, gypsum, lead, lignite, natural gas, tin, rubber, tantalum and tungsten.

Without any appropriated in mineral management, this will lead to the depletion of natural resource and pollution as well. It will also adversely effect from the exploration, particularly to the other resources and human being, for example, from arsenic to dust in gravel industry, contamination of cadmium in the nature, and the rehabilitation of waste mining land.

Geo-hazard and Geo-Environmental

Thailand has a number of activities in geo-hazard and geo-environmental, such as finding appropriated land for waste filling and researching of high salinity degree area. Geo-hazard in the country includes, among others, land slide, earthquake, land settlement, shoreline and bank erosion. These cause damages to the human being and property, which higher degree in each year. Fortunately, earthquake in the country is minimal, except the quake from Sumatra Island of Indonesia in 2004, that made a large number of casualties, both human and property.

Energy Resources

Energy is one of the major factor in both socio-economic and security of any country. The higher degree of economic development, the higher number of energy importing. However, more than half of the energy depends on the importation, then, the authority is trying to use alternate energy such as from water resource, solar, biological gas and wind.

Energy resources in the country mostly from natural gas and lignite, but there is a number of controversy between the conservation and the development. One of the main contribution is the lack of participation of stake holders, in addition, pollution from producing and using energy, including toxic gas emission, causes effects on the climate, especially the higher density of carbon dioxide gas.

Overview of GISTDA

Geo-Informatics and Space Technology Development Agency (Public Organization) – GISTDA is a public organization under the supervision of the Ministry of Science and Technology.

The objectives are to develop space technology and geo-informatics applications to be beneficial to the general public and to provide technical services and develop human resource in satellite remote sensing and geo-informatics.

The main strategies of GISTDA include: investment, services, research and development, technology transfer and data exchange in space technology and its applications and geo-informatics with relevant national and international agencies/institutes in both public and private sectors. Now, the master plan on earth observation satellite is established for the development of Thailand Earth Observation Satellite (THEOS) which will be own and operated by GISTDA under cooperation between Thailand and France and will be launched in 2007. It will provide worldwide geo-referenced image products and Geo-Informatics application.

GISTDA and Natural resources and Environmental Impact Management

GISTDA service includes satellite data providing and its applications, altogether with GIS for natural resource, environmental management and natural disaster. The services provided through various channels, by research project with domestic and international agencies, these are some of the cooperation :

Forestry

The applications are used in the study and monitor the forest change in the country, for example surveying of deforestation, forest fire damage assessment, shoreline change from mangrove to shrimp farm

Geology and Geo-Morphology

Geology structure data, particularly on geographic scene, and geo-morphology are appraised by satellite data. There type of data can be used in the study on geology such as country geo-structure to find the sources of minerals like ore, natural petroleum, deep well water and planning for dam construction.

Environment

Satellite data can be used in the study area of environment which has some adversely effect, for example air pollution from fog and forest fire smoke and pollution / chemical substance in the sea like oil spill from tankers

Natural Disaster

Satellite data can be used in monitoring the circumstance of mother nature in order to prevent or to mitigate the after match such as floods and land slide.

GISTDA, then, establishes the Institute of Space Knowledge Development (ISKD) as a centre of knowledge-base and technology transfer in the area of space technology and geo-informatics for local, regional, national and international as well, in order to keep pace with the advancement of space technology and geo-informatics.

About ISKD

ISKD, under GISTDA, has main mission in promoting, supporting and operating in capacity building in the fields of space technology and geo-informatics. ISKD organizes various training in geo-informatics, both general and specific, from introduction to advanced, for public and private agencies. Furthermore, ISKD also distributes knowledge of space technology and geo-informatics, via conference and workshop in national and international forum. The Institute has R&D in those particular fields and provides fund for public agencies, including educational institutions in the R&D of geo-informatics. In addition, course curriculum and textbook, including multi-media in training also are being developed for the training. Lastly, the Institute has cooperated with various agencies, both national and international, in academic consortium as well.

ECONOMY REPORT
OF
VIET NAM

GROUNDWATER PROGRAMME

1. Summary

In the period from July 2006 to June 2007 the Department of Geology and Minerals of Viet Nam carried out hydrogeological survey at 1: 50,000 scale in some areas, groundwater monitoring in three regions (the Red river delta, the Mekong river delta and the Central plateau) and groundwater assessment in some areas, especially the specially difficult areas in 7 provinces in the Northern mountainous region, 5 provinces in the Central Plateau and the provinces in the remote area of Southern plain

GROUNDWATER PROGRAMME

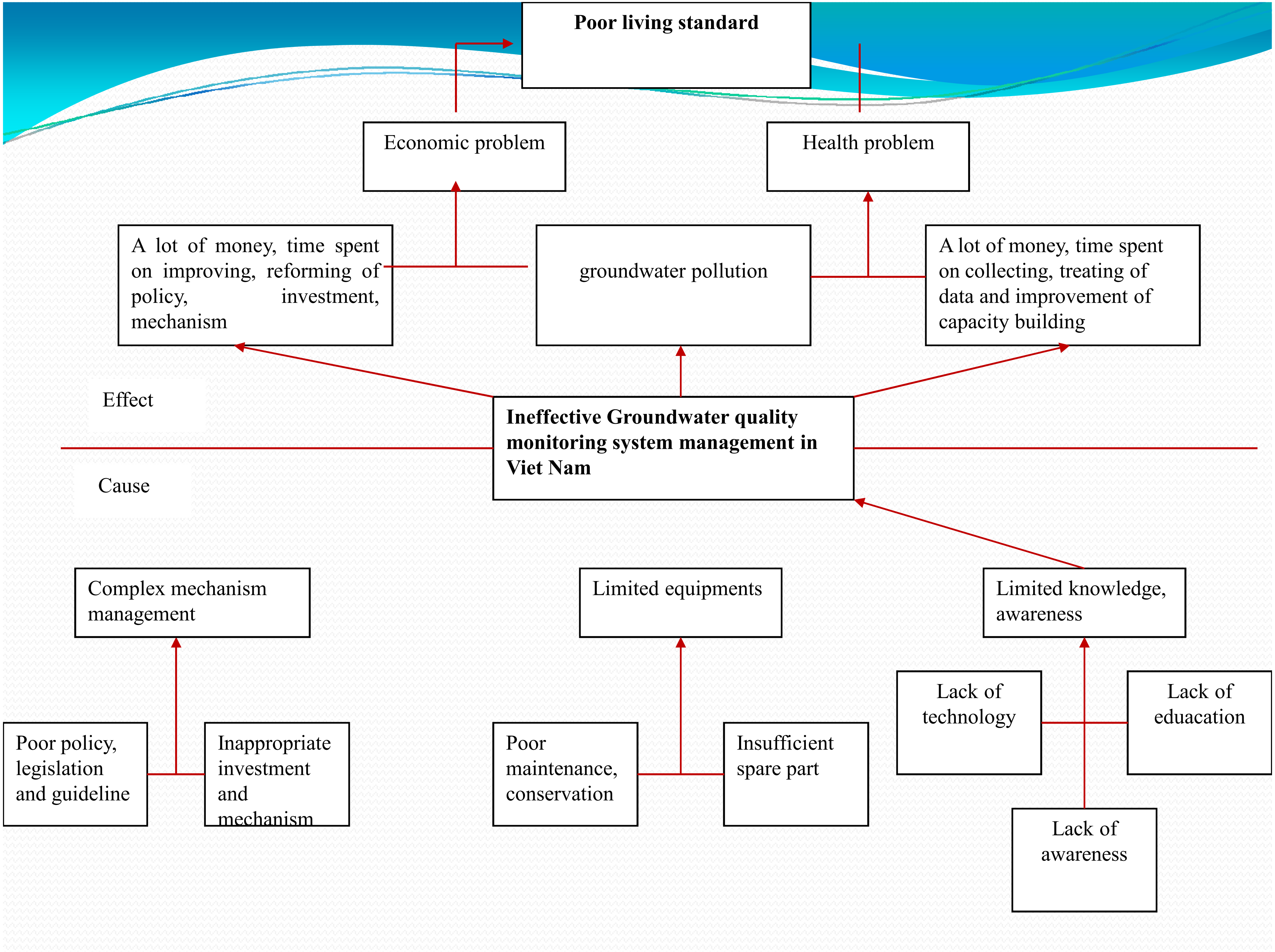
a. Results

- Total boreholds: 641
- North: 212
- South: 224
- Centre: 107
- Have monitored 583, N: 187, S: 204, Highland: 192
- Making the annual calendars
- Have Analised the water levels and contents

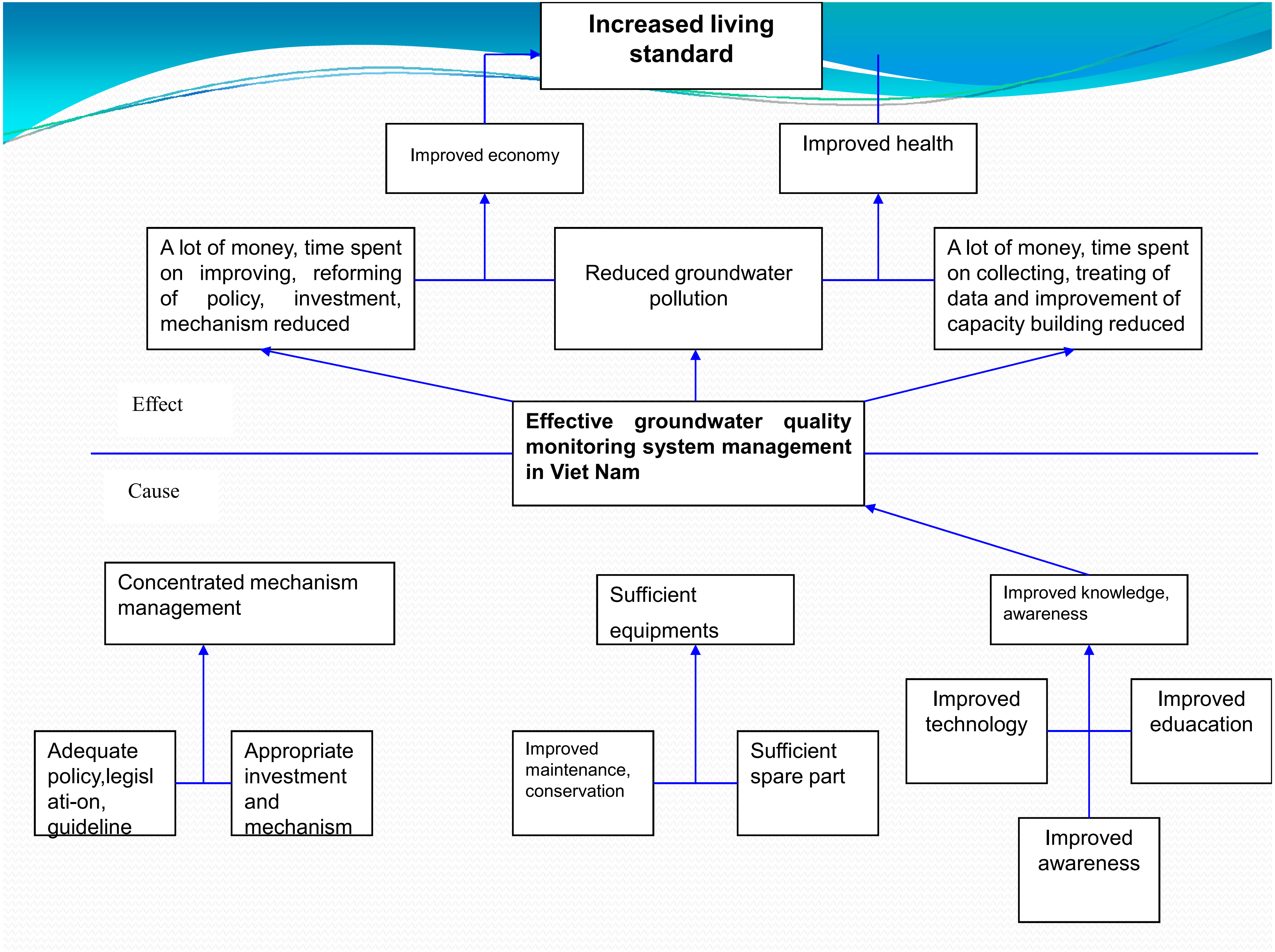
GROUNDWATER PROGRAMME

b. Shortcomings

- Monitoring thinly scattered
- Rarely researching the deep levels
- Old equipments
- Old structures
- Lacking of fee anf fund



Poor living standard
Economic problem
Health problem
A lot of money, time spent on improving, reforming of policy, investment, mechanism
groundwater pollution
A lot of money, time spent on collecting, treating of data and improvement of capacity building
Effect
Ineffective Groundwater quality monitoring system management in Viet Nam
Cause
Complex mechanism management
Limited equipments
Limited knowledge, awareness
Lack of technology
Lack of eduacation
Poor policy, legislation and guideline
Inappropriate investment and mechanism
Poor maintenance, conservation
Insufficient spare part
Lack of awareness


Increased living standard
Improved economy
Improved health
A lot of money, time spent on improving, reforming of policy, investment, mechanism reduced
Reduced groundwater pollution
A lot of money, time spent on collecting, treating of data and improvement of capacity building reduced
Effect
Effective groundwater quality monitoring system management in Viet Nam
Cause
Concentrated mechanism management
Sufficient equipments
Improved knowledge, awareness
Improved technology
Improved eduacation
Adequate policy,legislati-on, guideline
Appropriate investment and mechanism
Improved maintenance, conservation
Sufficient spare part
Improved awareness

GROUNDWATER PROGRAMME

2. Annual Review of Technical Programmes / Activities

2.1. Hydrogeological survey

- Project "Hydrogeological mapping at 1:50.000 scale of Song Cau -Tuy An area, Phu Yen province"
- Project "Hydrogeological mapping at 1: 50,000 scale of Tan Uyen area, covering 1,825 km^2
- Project "Hydrogeological mapping at 1: 50,000 scale of Lao Bao area, Quang Tri
- Project "Hydrogeological mapping at 1: 50,000 scale of Ninh Thuan, Binh Thuan provinces (near 8,000 km^2)

GROUNDWATER PROGRAMME

2.2 . Assessment of groundwater resources

- The project “Investigation and assessment groundwater in some key areas of 5 Central highland provinces” has been completed
- The project “Investigation and assessment groundwater in some key areas of 7 province of Northern mountain region"
- Projects being implemented:

- Project "Groundwater investigation on remote areas of Southern region (phase 3)";
- Project “Evaluation of groundwater resources of Moc Hoa area, Long An province” (462 km^2)

GROUNDWATER PROGRAMME

- Assessment of groundwater resources in Lai Vung area, Dong Thap province (540 km2)
- Assessment of groundwater resources in water scanty areas of Ninh Tuan and Binh Thuan provinces
- Groundwater investigation and evaluation of Meo Vac area, Ha Giang province.
- Groundwater investigation and evaluation of 15 mountain and midland provinces of North Viet Nam.
- Groundwater investigation and evaluation of western planned areas of Nghe An province
- Investigation and evaluation of groundwater in Neogene sediments of Hanoi area

GROUNDWATER PROGRAMME

3. **Future Activities and Assistance Required from international donors in Support of Future Activities**

3.1. Future Activities

- Continue the groundwater monitoring program in the national natural resources and environmental monitoring system.
- Start the project "Upgrading and rehabilitation of the national groundwater monitoring network" (2008-2010)
- Construction of national groundwater monitoring network in North Central coastal area (2008-2010) covering 11.000 km^2

GROUNDWATER PROGRAMME

3.2.Assistance Required from international donors

International donors are requested to support groundwater monitoring and groundwater pollution evaluation projects

4.Others

Two research projects are being implemented:

- Application of modelling method for assessment of groundwater reserve in Ho Chi Minh city and surrounding areas
- Application of modelling method for assessment of groundwater reserve in the Red river delta

GEO-ENVIRONMENT SECTOR

1. Summary

In the period from July 2006 to June 2007, many activities related to the coastal zone, geohazards and environmental geology have been carried out by the units of the Department of Geology and Minerals of Viet Nam and the Viet Namese Academy of Sciences and Technology.

GEO-ENVIRONMENT SECTOR

2. Annual Review of Technical Programmes / Activities

2.1 Activities implemented by the Department of Geology and Minerals of Viet Nam

- Project “Survey and assessment of the risk of landslide along the Hieu river" was one of emergency tasks which has been accomplished by DGMV

GEO-ENVIRONMENT SECTOR

It has been identified that the landslides and erosion are due to complicated activities of the groundwater in the karstic cavities under the unconsolidated sediments with small thickness (<8m) and the flow of the Hieu river with tide actions

- Project "Delineation of areas with toxic minerals, assessment of the environmental status in Lao Cai, Lai Chau, Dien Bien, Son La areas to serve sustainable development planning" implemented by the Radioactive and Rare Earth Geological Division

GEO-ENVIRONMENT SECTOR

- Project "Investigation of radioactive environment status in some mines in Lai Chau, Lao Cai, Yen Bai, Phu Tho, Quang Nam province" implemented by the Radioactive and Rare Earth Geological Division:

As a result of investigation, in the above 7 areas 45 radioactively unsafe zones covering 190 km^2, have been delineated, where 16883 households are living

A report and a radioactive environment status zoning map have been prepared for each particular area

GEO-ENVIRONMENT SECTOR

- Project "Investigation and assessment of the status of environmental pollution due to mining activities in the Central region and Central Highland provinces" implemented by the Office of DGMV, and Central Viet Nam Mineral Branch.

  As a result of investigation by rapid field measurement of pH and DO; NO_2, CO, SO_2 and suspended dust; mercury vapour in the air and in the soil; radon concentration in the air, the soil and water of 100 mines in 10 Central region and Central Highland provinces, the environment status of mines in three groups: fuel, metallic and construction material, have been assessed

GEO-ENVIRONMENT SECTOR

- The project "Investigation of geo-hazards in southern central coastal region" (n-shore from Khanh Hoa to Binh Thuan province) has been completed with the following results

- Coastal erosion: 68 eroded sections with the total length of 59.8km have been recognized
- Riverbank erosion: the total length of medium to strongly eroded sections is 58,000m
- Landslides and mudflow : 19 points and point groups of typical landslides and mudflow have been delineated
- Sand drift : there are 08 places which are suffering from the sand drift, comprising an area of 284km2
- Flash floods: The statistics show that flash floods occurred at 11 locations

GEO-ENVIRONMENT SECTOR

- Project "Geological, mineral resources, environmental geology and geohazard survey of South central shallow offshore area with 0-30m water depth at 1/100,000 scale and some key areas at 1/50,000 scale":
- The area of 1: 100,000 scale survey was 9,750km^2, and 1: 50,000 survey was 389km^{2,} with the following results :

\- The quaternary sediments have been differentiated in the principle of age and genesis. A unified geological section and stratigraphic column have been established for the zone from inland seaward to 30m water depth of the South Central region

GEO-ENVIRONMENT SECTOR

- The presence of the Q_1 basalt on the sea floor of South Central region has been confirmed, the existence of an old shoreline of Early Holocene has been identified
- Tens of faults have been discovered by shallow high resolution seismic bands and described, of which many are still active in Quaternary
- The sea water in the area is being polluted by metals such as Zn, Cu, Pb, Mn, Cd; the sea bed sediments are being polluted by Hg, Cu, Pb and have the risk of being polluted by Sb, As
- On the basis of environmental geology investigation, the South central offshore area has been divided into 14 subareas

GEO-ENVIRONMENT SECTOR

2.2. Projects being implemented

- Project "Mineral potential survey and evaluation of the shallow offshore area of Soc Trang province at 1/100,000 scale", covering 7,200km2, within Soc Trang province, of which the area with mineral prospect covers 3,870 km^2.
- Project "Investigation of geology, mineral resources, geodynamics, environment, geohazards of Quang Ninh - Hai Phong offshore area at 1: 100,000 scale, covering 4,600 km^2

GEO-ENVIRONMENT SECTOR

3. Future Activities

- Start implementing the project “Establishment of the network for forecasting and warning of environmental accidents to 2010, with vision to 2020” led by the Ministry of Natural Resources and Environment.
- Continue the projects on geological, mineral resources, geohazard and environmental geology survey of shallow offshore area of Viet Nam.
- Continue the projects on geohazards survey in the mountainous and coastal areas of Viet Nam

GEO-ENVIRONMENT SECTOR

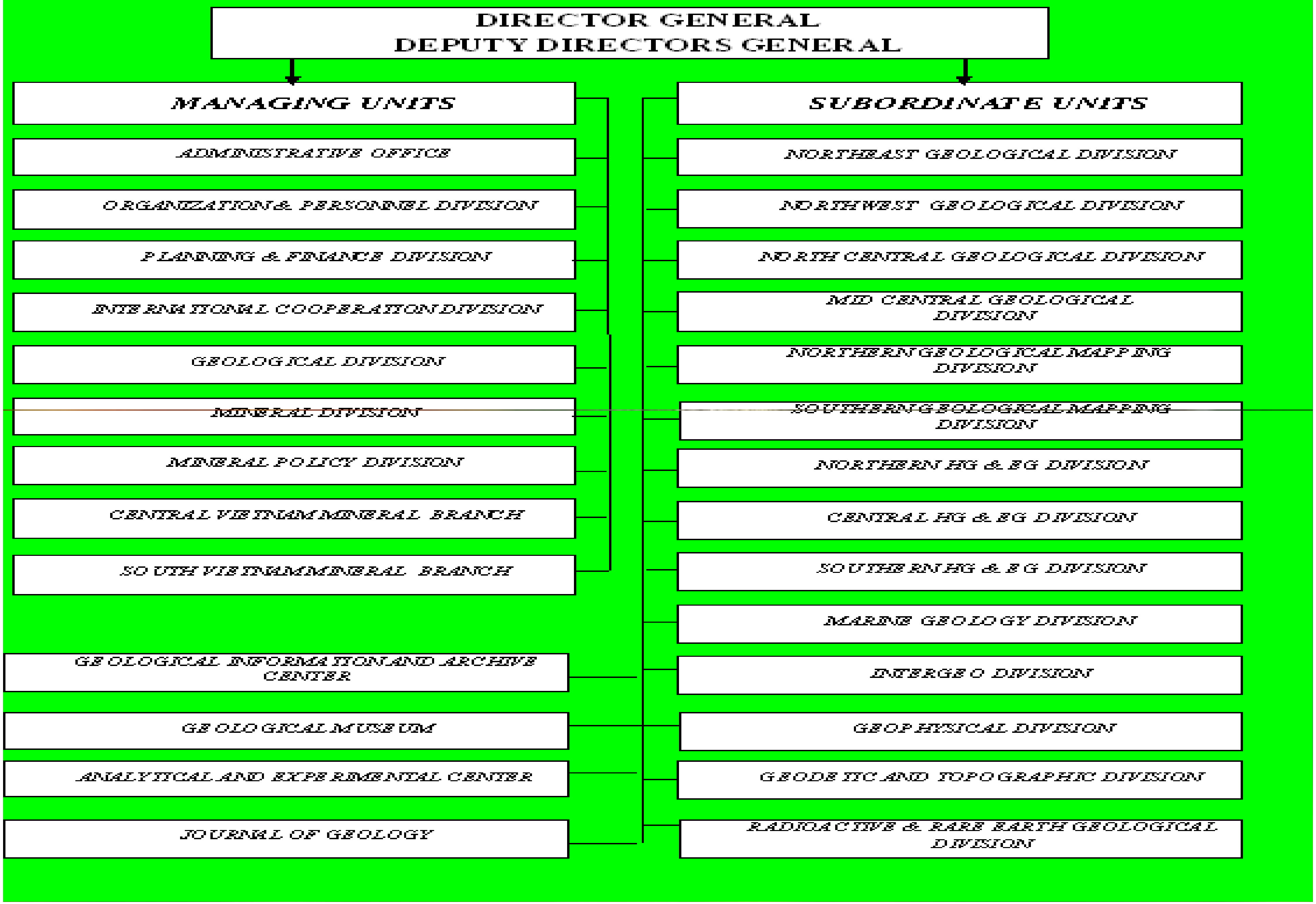
- Start the implementation of the project ”Investigation and evaluation of positional resources and geo-ecological landscapes in the coastal and island areas of Viet Nam ” (2007 - 2010).
- Continue the project on modernization and strengthening the seismic stations network of Viet Nam to serve earthquake notification and tsunami warning (2008 – 2010).

GEO-ENVIRONMENT SECTOR

- Start the implementation of the key national research project “Evaluation of earthquake and tsunami risks in the offshore and island areas of Viet Nam and recommendation of preventive measures" (2007 – 2010).
- Continue the operation of Earthquake Notification and Tsunami Warning Centre under the Institute of Geophysics (from July 2007)


MINISTRY OF NATURAL RESOURCES
AND EMVIRONMENT (MONRE)
DEPARTMENT
OF GEOLOGY AND MINERALS OF VIET NAM
(DGMV)

ORGANIZATION CHART OF THE DEPARTMENT OF GEOLOGY AND MINERALS OF VIETNAM

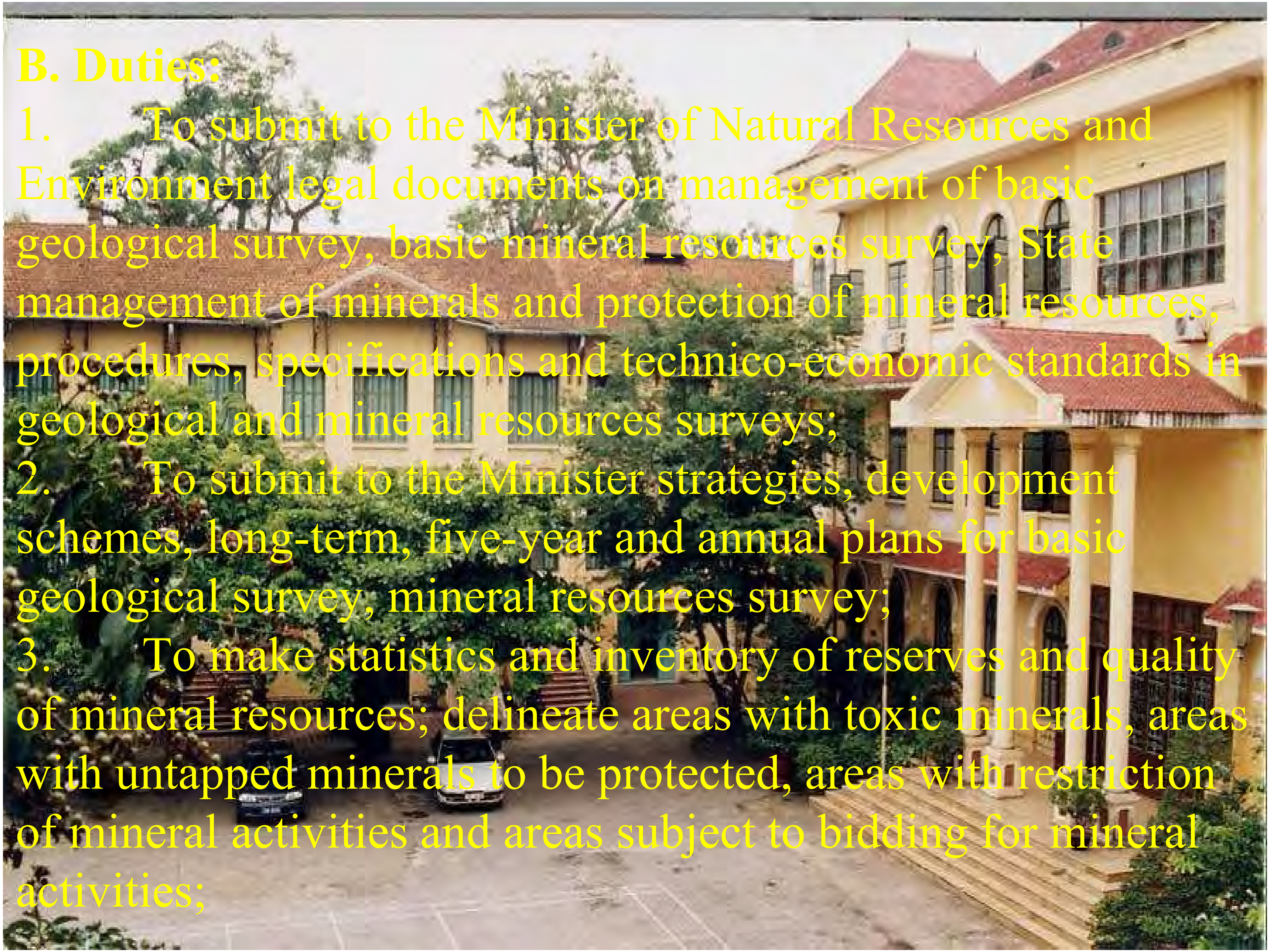


Functions, duties and powers

The functions, duties and powers of the Department Of Geology and Minerals of Viet Nam are prescribed in Articles 1 and 2 of Decision No 08/2004/QD-BTNMT dated 26 May 2004 of the Minister of Natural Resources and Environment, in particular as follows:

A. Functions

The Department of Geology and Minerals of Viet Nam is an organization directly under the Ministry of Natural Resources and Environment, having the function to assist the Minister in State management of geology and mineral resources, comprising: basic geological survey, basic mineral resources survey, mineral activities, protection of mineral resources and to organise the implementation of basic geological survey, basic mineral resources survey, assessment of mineral resources potential and the discovery of mineral deposits throughout the country



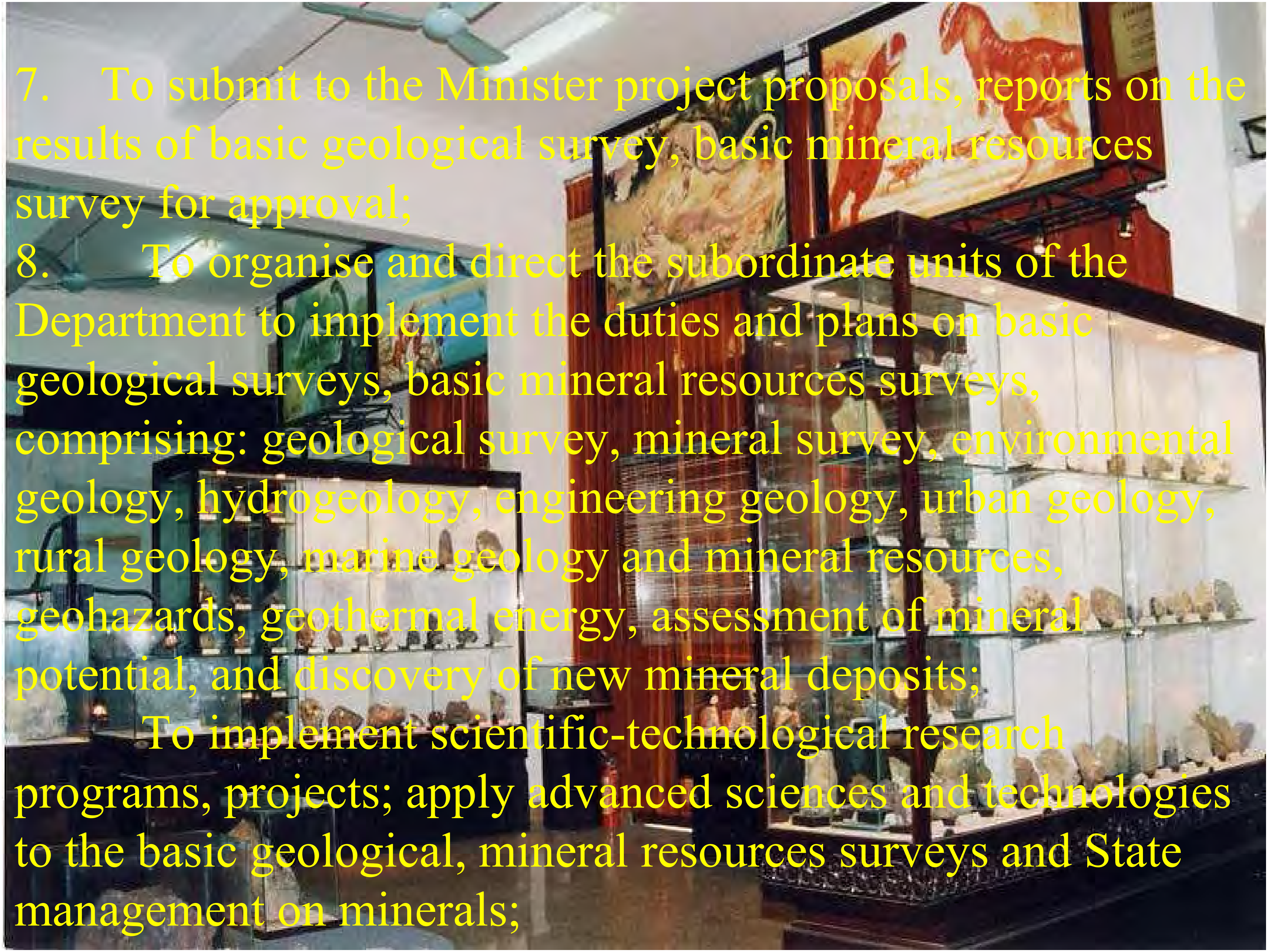
B. Duties:

1. To submit to the Minister of Natural Resources and Environment legal documents on management of basic geological survey, basic mineral resources survey, State management of minerals and protection of mineral resources, procedures, specifications and technico-economic standards in geological and mineral resources surveys;
2. To submit to the Minister strategies, development schemes, long-term, five-year and annual plans for basic geological survey, mineral resources survey;
3. To make statistics and inventory of reserves and quality of mineral resources; delineate areas with toxic minerals, areas with untapped minerals to be protected, areas with restriction of mineral activities and areas subject to bidding for mineral activities;

4. To participate and coordinate with the Peoples committees of provinces, cities directly under the Central authority, relevant Ministries and sectors in delineating areas with prohibition or temporary prohibition of mineral activities; to work out strategies and master plans for mineral exploration, exploitation, processing and utilization as assigned by the Ministry.

5. To submit to the Minister regulations on the authorities and procedures of grant, extension, withdrawal and permission for surrender of permits for mineral activities; permission for transfer and bequest of rights of mineral activities; regulations on bidding for mineral activities.

6. To submit to the Minister of Natural Resources and Environment for decision on the grant, extension, withdrawal, permission for surrender of permits for mineral activities, permission for transfer of rights of mineral activities, and for approval of areas for artisanal mining under the competence of the Ministry;



7. To submit to the Minister project proposals, reports on the results of basic geological survey, basic mineral resources survey for approval;

8. To organise and direct the subordinate units of the Department to implement the duties and plans on basic geological surveys, basic mineral resources surveys, comprising: geological survey, mineral survey, environmental geology, hydrogeology, engineering geology, urban geology, rural geology, marine geology and mineral resources, geohazards, geothermal energy, assessment of mineral potential, and discovery of new mineral deposits;

To implement scientific-technological research programs, projects; apply advanced sciences and technologies to the basic geological, mineral resources surveys and State management on minerals;

9. To register and assemble data, results of basic geological and mineral resources surveys and mineral activities; to archive, manage and keep confidential the data and information on geology and mineral resources according to the provisions of the law; to provide geological, mineral documents and samples according to the relevant regulations; to certify the legality of geological and mineral data and samples, and non-commercial minerals to be remitted abroad according to the provisions of the law;

10. To publicize, disseminate information, guide and inspect agencies, organizations and individuals in complying with the regulations of the mineral legislations; provide professional and technical guidance in geology and minerals to Departments of Natural Resources and Environment of provinces, cities directly under the central authority and the subordinate units of the Department ;

11. To take the lead in checking the basic geological survey, basic mineral resources survey activities and mineral activities; coordinate with the Inspectorate of the Ministry in settling or settle within the Departments authority disputes, claims, denunciations in basic geological survey, basic mineral resources survey and mineral activities; answer to questions of organizations and individuals in the field of geology and mineral resources as assigned by the Ministry;

12. To implement international co-operation programs and projects and to represent the geological and mineral sector of Viet Nam to take part in international activities in the field of geology and minerals as assigned by the Ministry;

13. To maintain the relationship with associations, non-government organisations; follow up and report to the Minister of Natural Resources and Environment on activities of associations, non-government organisations in the field of geology and minerals;

14. To organize scientific conferences, seminars, workshops; edit and publish documents on geology and minerals as allowed by the provisions of the law.

15. To manage activities related to geological and mineral service and other services carried out by subordinate units of the Department in accordance with the provisions of the law.

16. To manage and use efficiently financial sources and properties allocated by the State; to manage capital construction investment projects in accordance with the provisions of the law and the assignment by the Ministry;

17. To manage the organisation, staffing and organise courses of training and intensive improvement of technical and professional capabilities for officials, employees of the Department as assigned by the Ministry.


18. To make statistics and prepare periodical and immediate reports on the implementation of the assigned duties
19. To implement other tasks as assigned by the Minister of Natural Resources and Environment.

Earthquakes, landslides, and flash floods In the NorthWest of Viet Nam

Ngo Thien Thuong
Geological Mapping Division of Northern Viet Nam
Department of Geology and Minerals of Viet Nam.

The economy report to be read in the training course: “Human capacity building for natural resources development and its environmental impacts”.

Some lines about the natural hazards in Viet Nam

- Only in the 90s (1990-2000), in Viet Nam:
- 7,495 people has been died and lost;
- 750,000ha of rice and argicultural products has been wrong;
- 5.5 million houses has been collapsed or damaged;
- 8,823 ships, boats has been sant;
- Total damage is about 2 bln USD.

  (by VN People Police Newspaper № 884, April 28st 2000).

Abstract

- In recent years, geo-hazards are increasing all over the world as well as Viet Nam. They have been causing for great loss of lives and properties. Viet Nam Government has been well warning of these dangers and early investing infrastructural basement in the right researches in areas of having risk highly on geo-hazards, especially in the Northwest region where geo-hazards are occurring so seriously. With different types of hazards, the most dangerous types are earthquakes, landslides, and flash floods.

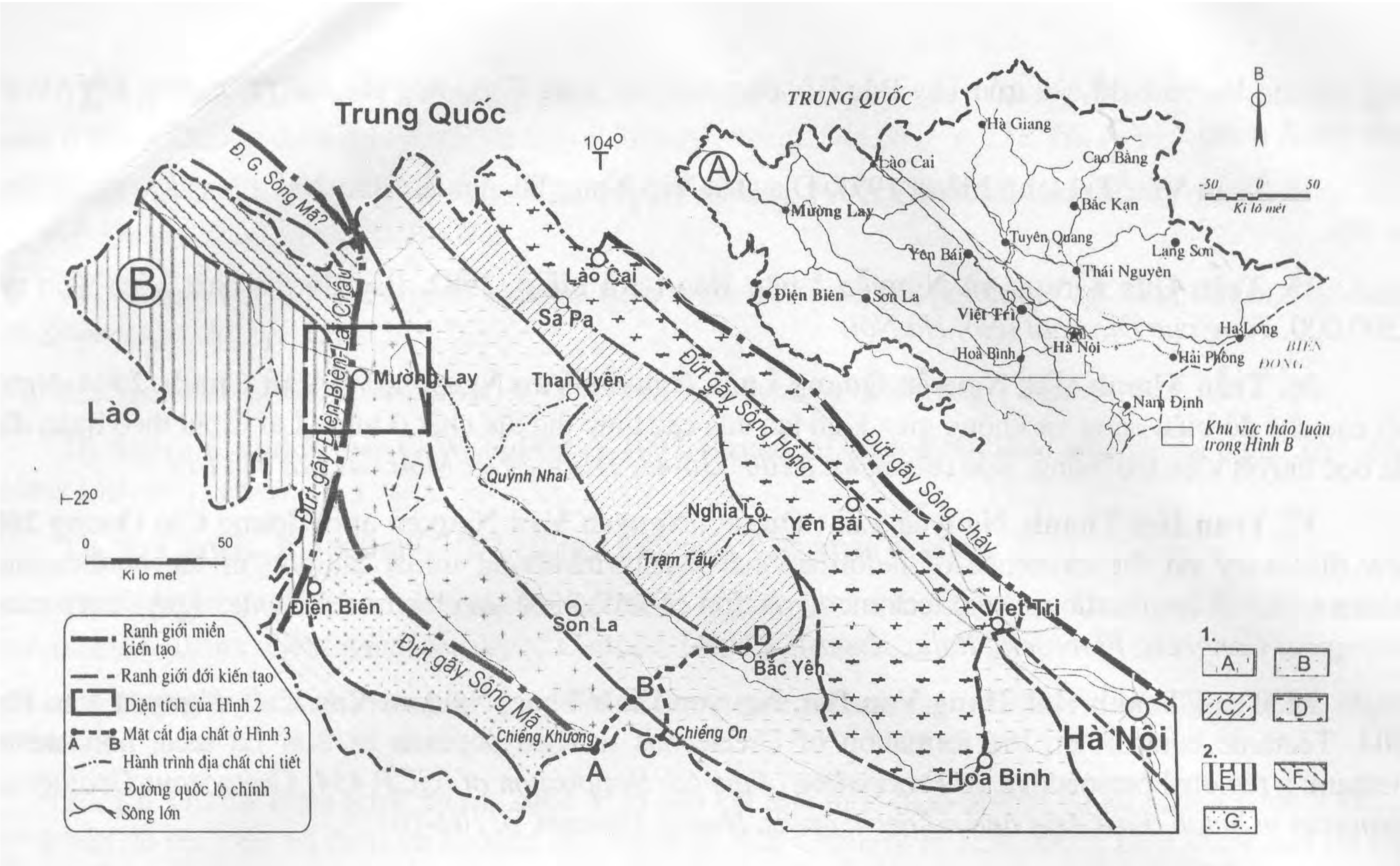
Introduction (about NW of Viet Nam)

- The North-western region of Viet Nam is a beautiful and splendid land where has potentiated overhaulting, safe and sustainable economic development. It borders on China in the North; lies by the Red River fault in the East and Northeast; the West and Southwest is Laos and the Song Ma fault, the South and Southeast is Tonkin Gulf, where geohazards frequently take place of which most dangerous and significant types are earthquakes, landslides and flash floods.

A valley in NW of Viet Nam

The Position of the Northwest of Viet Nam

Tectonic faults in NW of Viet Nam



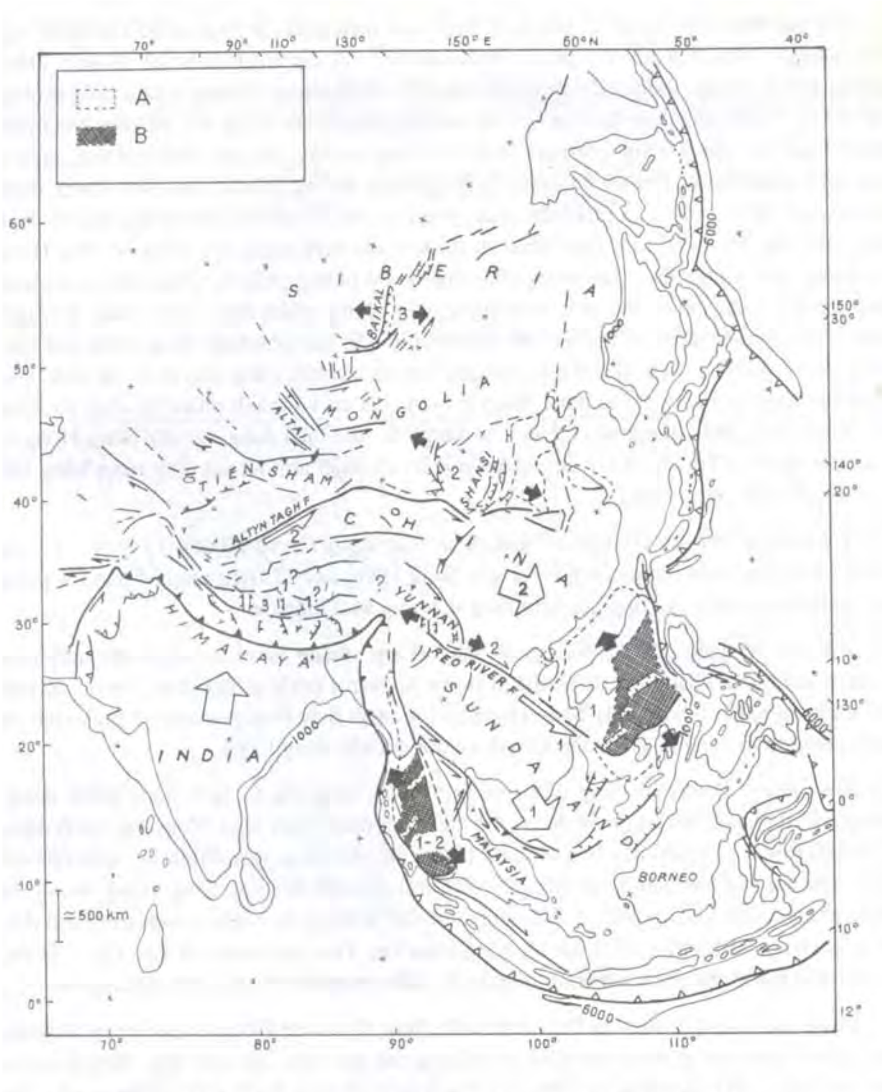
Red River fault is one of the famous and important tectonic fault in the Asian continent. It has been presented in Tsukuba, Japan on March 1998 by Dr Dao Van Thinh

- ***About the Dien Bien - Lai Chau fault***
- This is a deep fault reaching Moho surface. Originating depth is 50 - 60km. Eventual depth is 0 - 2km with the width of the maximal zone reaching 20 - 30km. The most deforming zone could be 1 - 5km wide within the Viet Nam territory extending about 150km (from Ma Li Pho to Tay Trang). This fault still prolongs as far as South Bangkok (Thailand) with total length of almost 2,000km. Prolonging direction is sub - meridian (NNE) ranging 0 - 12^{o}. The sliding slope changes within 90 - 110^{o}. This is an activating and seismo - generating fault that is named to be strongest in NW of Viet Nam.

- ***About the Tuan Giao - Tua Chua fault***
- It is a deep fault reaching the Konrad. Originating depth reaches 35km. Eventual is 0 - 1km. It is a faulting zone comprising of 02 main faults parallel to each other with maximal width of 1 - 3km. The most deformed zone is 300 - 700m wide. It is 160km long within Viet Nam land (from Sin Ho to Noong E village). It still extends southwards for nearly 300km and joins the Dien Bien - Lai Chau one. Its direction is sub - meridian (NNE) ranging within 0 - 20^{o}. Sliding plane dips eastwards ranging within 80 - 120^{o}. This is an activating and seismo - generating fault that is grouped as strongest in the NW of Viet Nam (after the Dien Bien - Lai Chau fault only).

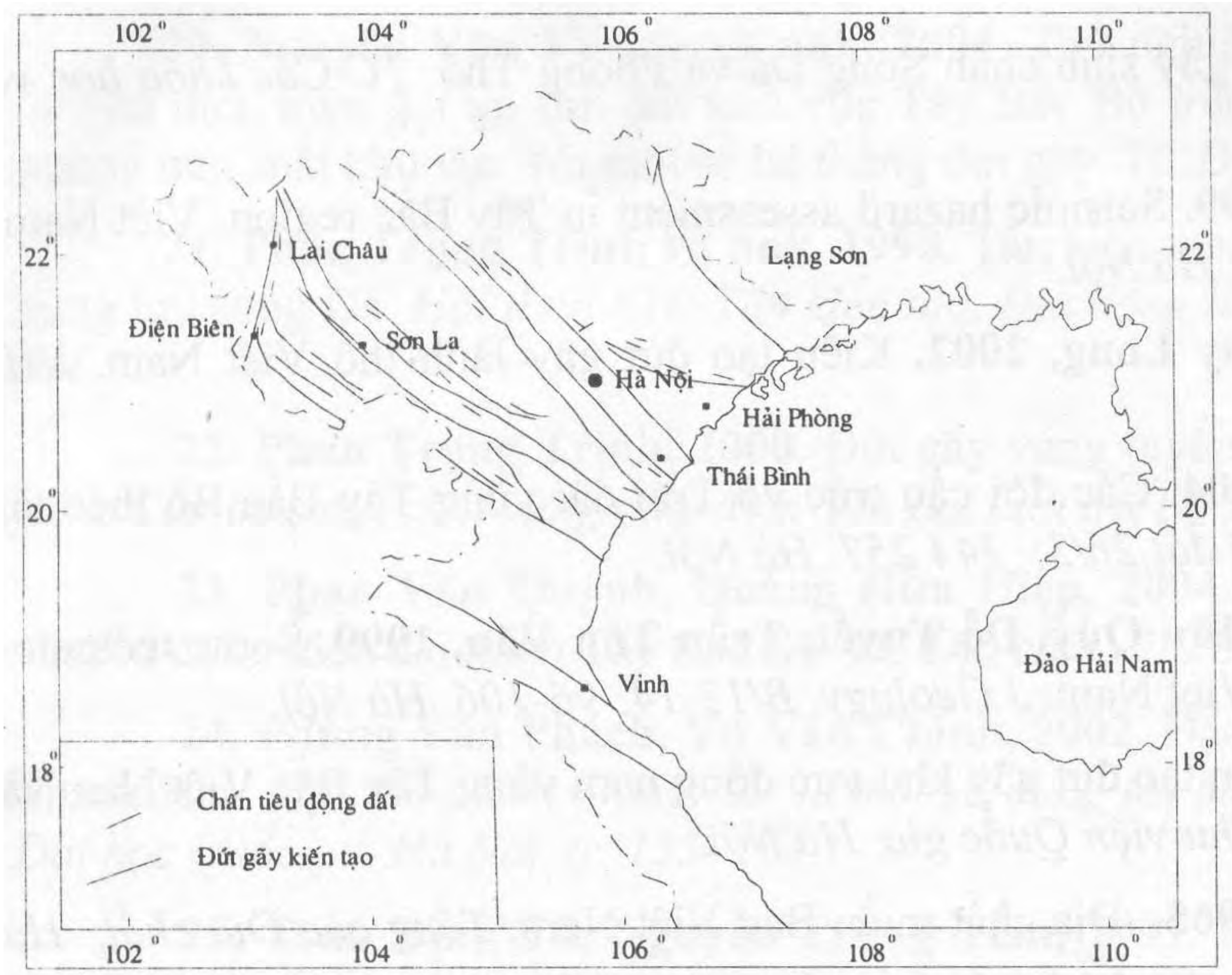
Movement of geoblocks
(by Tapponnier P, 1994)

Hình 2: Khu vực nghiên cứu trong bối cảnh địa động lực Kainozoi Châu Á và Đông Nam Á
(Theo Tapponnier P, et al, 1994)



Hình 1. Sơ đồ kiến trúc Kainozoi và các đới đứt gãy chính ở Châu Á (theo Tapponnier và nnk, 1982). A. Vùng tách giãn Kainozoi ; B. Vỏ đại dương Biển Đông và Anctaman

Earthquake centers and faults



Earthquakes in NW of Viet Nam

- Within April 1903 to 31st July 2003 in NW of VN have been 340 earthquakes with different levels.
- Ms < 4 of the Richter Scale: 244 events taking 71.76%
- 4 < Ms < 4.5 of the Richter Scale: 43 events taking 12.64%
- 4.5 < Ms < 5 of the Richter Scale: 43 events taking 12.64%
- 5 < Ms < 5.5 of the Richter Scale: 8 event taking 2.35%
- Ms > 6 of the Richter scale: 2 events (happened in 1935 at Ms = 6.75 and in 1983 at Ms = 6.7) taking 0.58% (these two are the strongest in Viet Nam). They are:

➢The first was in eastern Dien Bien city with magnitude Ms = 6.75 in Richter scale. Center depth h = 25km; tremor at the center was probably at 8 - 9 in Richter scale. Shakes broke out surface as widely as 10 - 15cm near outer center. The area of Ms = 8 - 9 was as large as less than 1,500km2. Within Dien Bien area a lot of houses had been damaged.

➢The second was in 11km NE of Tuan Giao town with magnitude Ms = 6.7 in Richter scale. Center depth h = 23km; shake at the center could reach 8 - 9 in Richter scale. The area of Ms = 8 - 9 probably occupied as largely as less than 1,500 sq. km. The towns of Tuan Giao, Quynh Nhai, prov. town of Lai Chau were within this limit. Many houses, constructions were heavily damaged. The low – quality houses were collapsed. All the building houses were damaged. Within the center area, landslides, subsidence, cracks of 10 - 15cm wide and 20km long happened. The area with Ms = 7 covered 13,000 sq. km including the Son La and Dien Bien prov. towns and Thuan Chau, Sin Ho, and Muong Te dist. towns.

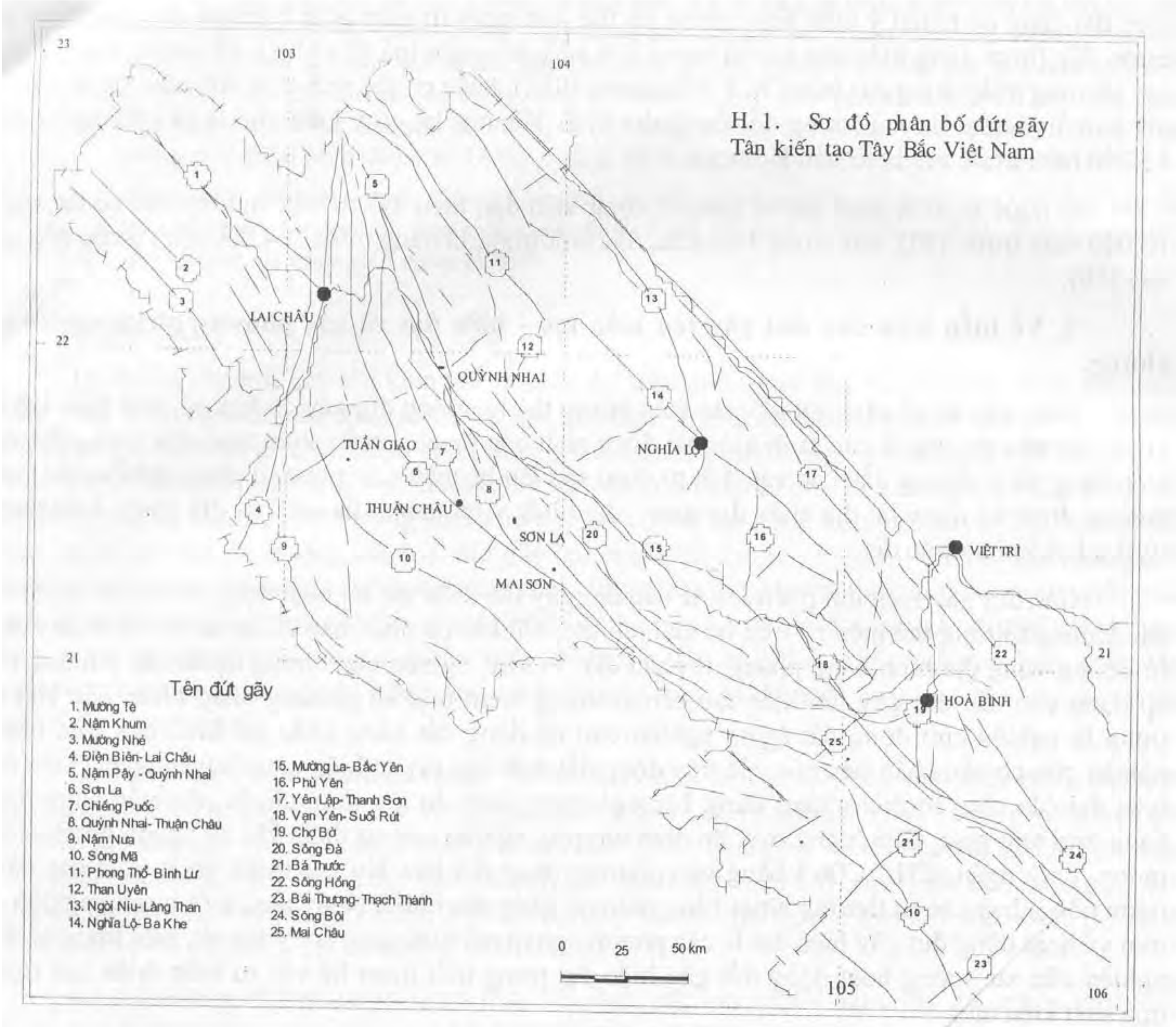
➢The latest was on 22h 52m, 19 February 2001, with magnitude Ms = 5.3 in Richter scale, in Dien Bien city, About 200bln VND has been lost.

Occurring probability of earthquakes in NW Viet Nam

(According to Cao Dinh Trieu, Dang Thanh Hai, 2003)

Earthquake zone	Magnitude (Ms in Richter scale)	Occurring probability after (years)				
		10	20	30	40	50
Red River	5.0	0.596	0.826	0.920	0.962	0.982
	5.5	No conformable data				
	6.0	No conformable data				
Da & Ma Rivers	5.0	0.534	0.873	0.952	0.981	0.992
	5.5	0.359	0.618	0.775	0.866	0.919
	6.0	0.102	0.244	0.394	0.529	0.637
Muong Te & Dien Bien	5.0	0.608	0.831	0.927	0.966	0.984
	5.5	0.434	0.676	0.808	0.884	0.930
	6.0	0.246	0.432	0.573	0.678	0.758

Neo tectonics in NW of Viet Nam




01/03/2006

Lanslides in NW of Viet Nam

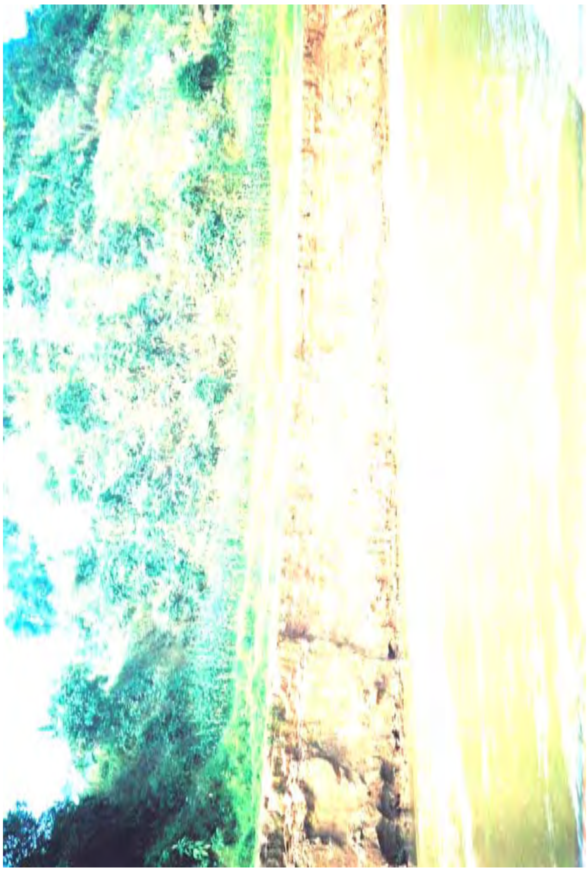
- NW Viet Nam is a potential region of landslide with various scales and intensities. There have been thousands of plots investigated, studied and mapped with scales from very large to average. According to statistics of some most recent works on landslides in NW Viet Nam the followings could be given: 1,000m^3<mass<10,000m^3: 153 localities; mass = 10,000 - 100,000m^3: 134 localities; and mass>100,000m^3: 16 localities (Dao Van Thinh, 2004). Landslides frequently take place in rainy season damaging lots of lives and properties, ruining lots of housing, trafficking, and sewage... works.

3 great lanslides in NW of Viet Nam

- Plot 1, in Mong Sen II bridge coordinate center: 22°24'48"N; 103°53'46"E; happened in: 1990, 1994, 1996, 1998, Oct 2000; Oct 2001; Jun 2002; Mass: about 207,300m^3 (very great); damage: 1998 - 2 peoples died, 2002 - 1 people died, before years: 4 - peoples died; spended 10 bln VND for processing in 2000.
- Plot 2, South of Huoi Leng, on roard No12; coordinate center: 21°52'48"N; 103°07'18"E; happened in: 1994, 1996, 1998, Aug 2000; Mass: about 28,300m^3, (great); damage: destroyed 200m of roard; trafficking was stoping in several days.
- Plot 3, in Lai Chau Pro town, coordinate center: 22°03'06"N; 103°09'26"E; happened in: Jul 2000; Mass: about 19,625m^3 (great).

Some landslide images in NW of Viet Nam


JAN 18 2007



Rockfalls

Torrential and flash floods in NW of Viet Nam

- The Northwest of Viet Nam is evaluated to have a highest potential of flash and torrential floods in Viet Nam due to the topographical, geomorphologic, pedologic, and climate features in consonance with traditional farming practices such as slope fielding on the basins, upstream deforestation. The recent statistical data show that occurring frequency of the flash floods is increasing and concentrating on the areas of Sin Ho (1990), Dien Bien (1994, 1995, 1996), Tua Chua (1995, 1996), Tuan Giao (1994, 1995, 1996), Lai Chau province town (1990, 1991, 1992, 1996), Son La province town (1990, 1991), Mai Chau and Hoa Binh.

Torrential and flash flood images in NW of Viet Nam


2 10:45AM

Conclusion

- Earthquake is the most dangerous geohazard in the Northwest of Viet Nam with the very high threat. During a period from April 1903 to 31st July 2003 there have been 340 shaking events of various grades.
- The two strongest earthquakes in the Northwest of Viet Nam and strongest in Viet Nam as well happened in 1935 with Ms = 6.75 in Richter scale at SE Dien Bien city and in 1993 with Ms = 6.7 in Richter scale in the Northeast of Tuan Giao town.
- Landslide is the secondly dangerous geohazard in the Northwest of Viet Nam occurring numerous landslides. Landslides frequently occur along the national roads, in Lai Chau - Muong Lay, southern Hoang Lien Son Mt. range, Tuan Giao - Tua Chua… At some places, landslides have been continuously occurring in many years such as Muong Sen bridge, Muong Lay…
- Torrential and flash floods are the thirdly dangerous geohazards after earthquakes and landslides. Northwest is an area of the most torrential and flash floods within Viet Nam territory. From 1958 to 2002 there had been 97 statistical flash and 5 torrential floods.

- ***Great thank to Geological Survey of Japan (GSJ), AIST,***
- ***Great thank to Asia-Pacific Economic Cooperation (APEC),***
- ***Thank you very much for your attentions.***

Remote Sensing
- Principle and applications in geology -

Isao SATO
Institute of Geology and Geoinformation

for APEC Training Material

My talks

- Overview of Remote Sensing in Geology
  - Physical background of 'remote sensing'
    - Optical region
    - Microwave region (SAR)
- Selective topics
  - Geologic structure and unit mapping
  - Volcano monitoring
  - Hyperspectral analysis
  - InSAR (Interferometric SAR technique)
  - SAR Polarimetry

Overview of Remote Sensing in Geology

AIST

One definition of 'remote sensing'

(there are variants in the literature.)

"***the observation of a target by a device separated from it by some distance thus without physical contact***"

target

In geology, natural targets (rocks, minerals, soils, terrain structures) over the Earth are observed. In general, all materials distributed over the surface are targets in remote sensing for various fields.

device

Optical, microwave, laser instruments are often used as device onboard cars, airplanes, satellites. Ground instrument is also used in the field work. Instruments are categorized into passive and active devices.

Overview of Remote Sensing in Geology

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◆ ***The advantage and limitation in remote sensing***

Merits of satellite observation

- Wide coverage
- Simultaneous observation over large area
- Repeatability

Limitations

- Most of instruments can observe physical parameters of very thin ground surface. Microwave instruments can penetrate very dry materials, but its penetration depth is about a few meters, which depends on surface moisture.
- Optical imagers can not observe any material under the cloud.

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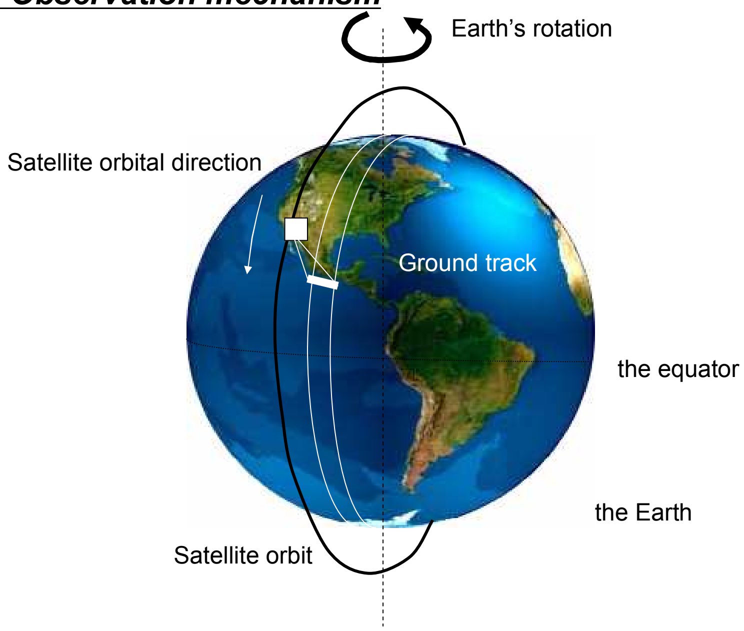
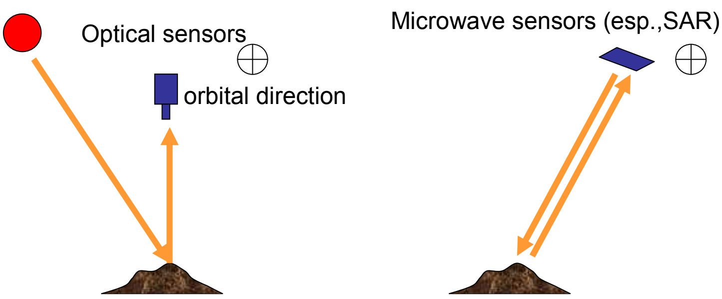
Global Observation mechanism

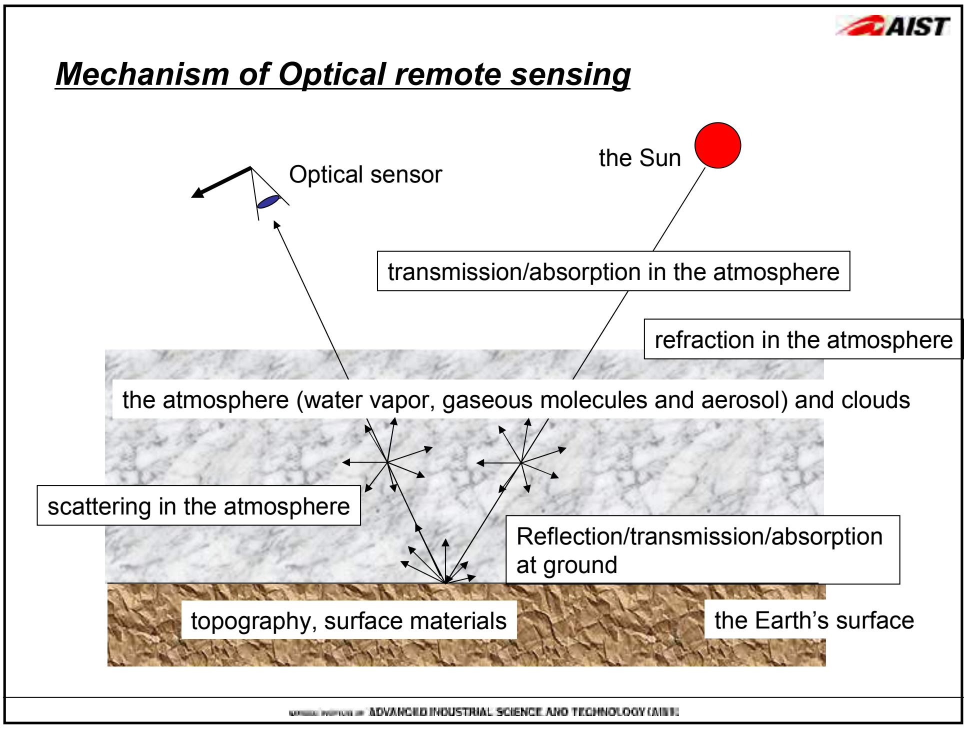


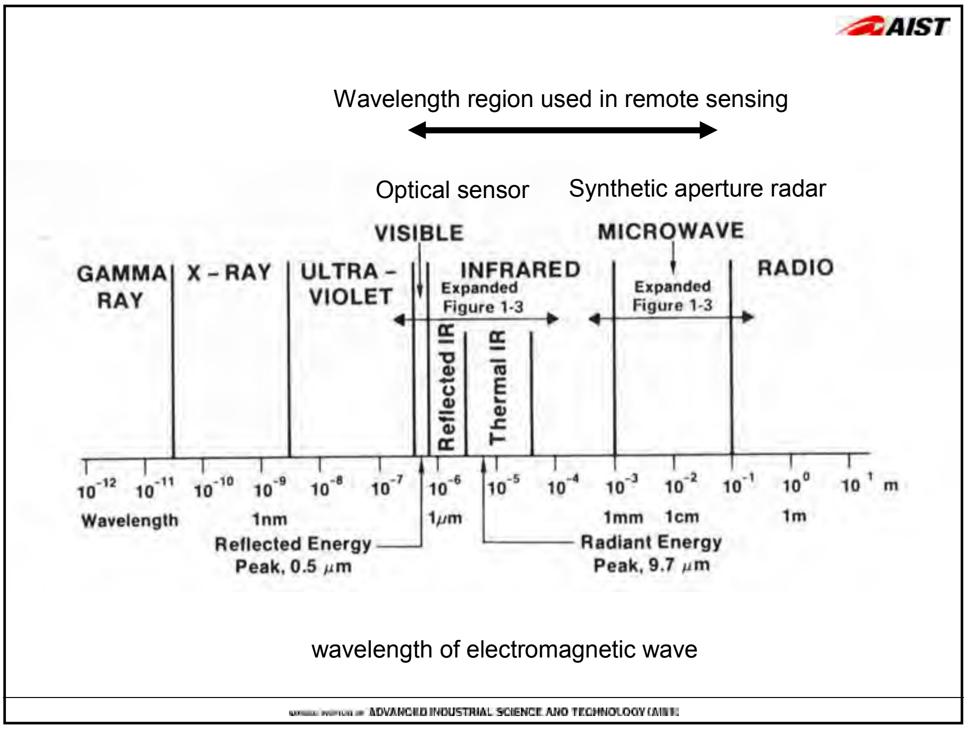
Observation from satellite

Instrument oriented to the Earth detects digital signals, which contains direct and diffused lights reflected at the surface, and diffused light in the atmosphere, through the telescope, A/D converter, detectors. Multi-spectral image can be obtained by using different wavelengths. Optical and microwave instruments have different observation geometry, as illustrated the bellow.



Mechanism of Optical remote sensing



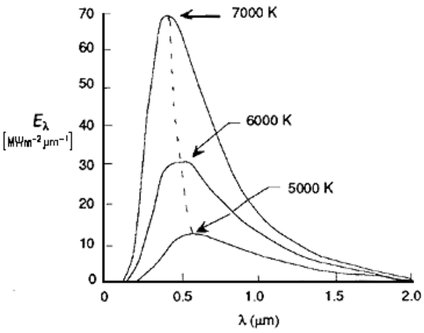


Interaction between the Sun and the Earth's surface

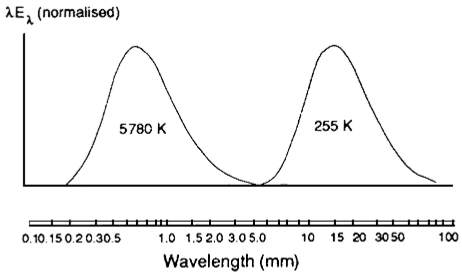
AIST

Sun's energy and radiant energy from materials

Planck's Eqn. $E_\lambda = B(\lambda, T) = \dfrac{c_1}{\lambda^5\left[\exp(c_2/\lambda T) - 1\right]}$ $T = \dfrac{c_2}{\lambda \ln\left(\dfrac{c_1}{\lambda^5 E_\lambda}\right) + 1}$



Blackbody radiation



Normalized radiation

Atmospheric transmittance and atmospheric window

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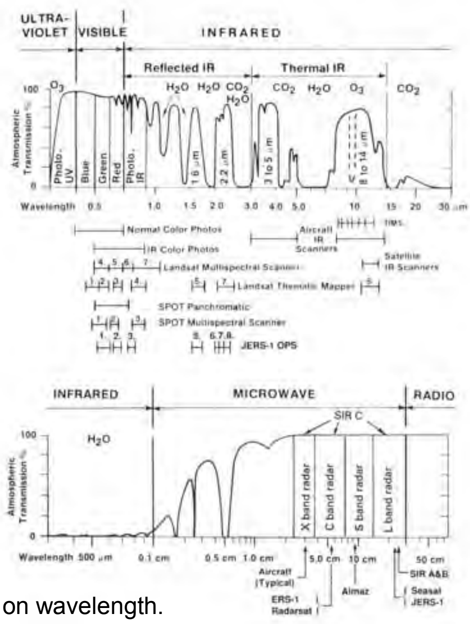
for optical sensor

'Atmospheric window' have been used for observation from space.

for SAR



Atmospheric transmittance depends on wavelength.

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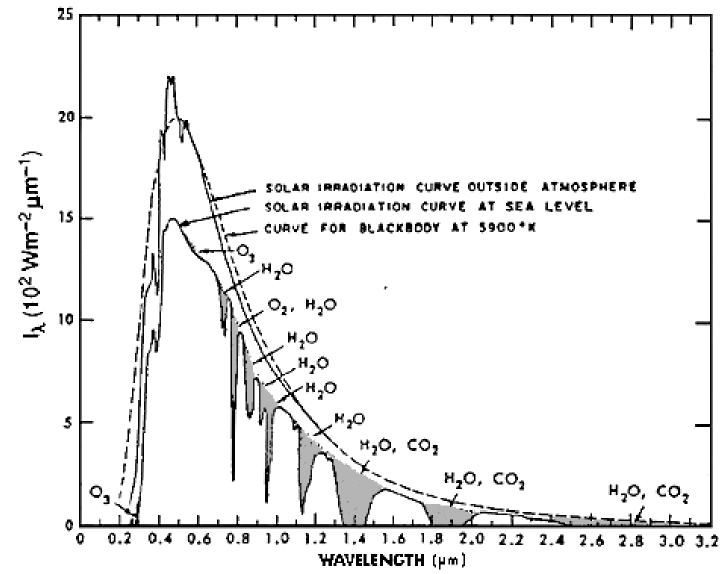

Spectral irradiance at the top of atmosphere and at sea level

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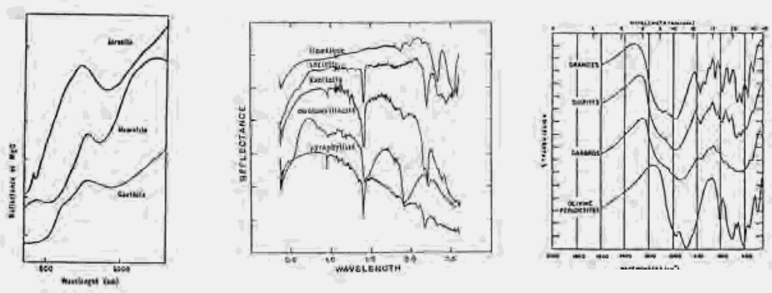
Reflectance and emissivity features of rocks and minerals



Visible and near-infrared spectra of iron-oxide minerals

(Hunt and Ashley 1979)

Shortwave infrared spectra of altered and carbonate minerals

Thermal infrared spectra of igneous rocks

(Hunt,1980)

Spectral characteristics from visible to thermal infrared regions of typical rocks and minerals

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Absorption wavelength in VNIR region and its principle

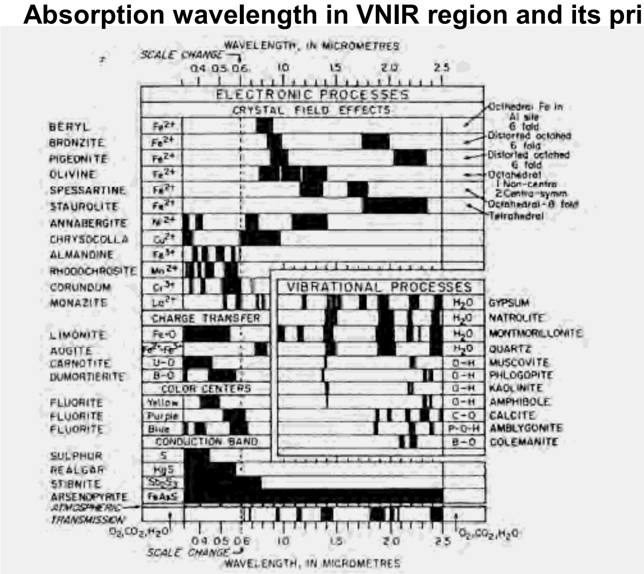

FIGURE 17. Composite diagram showing the location of the spectral features (wavelength of the center of black areas) and half-width (width of black areas) of most common minerals.*

Ref: Handbook of Physical Properties of Rocks

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Typical rocks and their emissivity characteristics in the thermal region

Absorbed wavelength (called as the Si-O reststrahlen band) in emissivity is systematically shifted to shorter wavelength, when the content of SiO2 is increased.

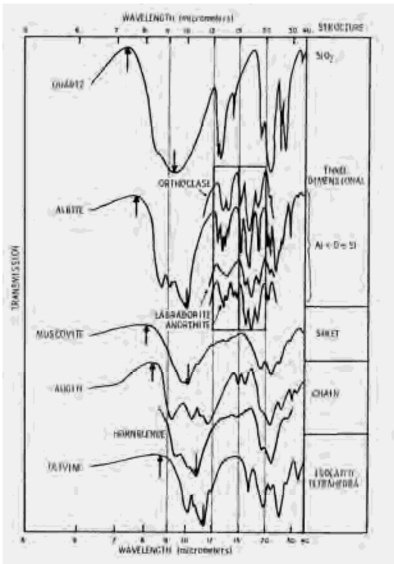

FIGURE 61. Transmission spectra of silicate minerals recorded in air. Five spectral regions are indicated and the causes of the features that occur there are discussed in the text.

Ref: Handbook of Physical Properties of Rocks

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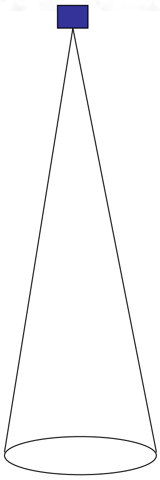
Spectral radiance, observed by the sensor

Radiative transfer function

$$L_\lambda(z) = T_\lambda \uparrow \cdot R_\lambda \cdot (E_{0\lambda} \cdot T_\lambda \downarrow \cdot \cos\theta + E_{a\lambda} \downarrow)/\pi + T_\lambda \uparrow \cdot \varepsilon_\lambda \cdot B_\lambda(Ts) + L_{p\lambda}(z)$$



- $L_\lambda(z)$: at-satellite spectral radiance at altitude z
- $T_\lambda \uparrow$: upward atmospheric transmittance
- $T_\lambda \downarrow$: downward atmospheric transmittance
- R_λ : surface reflectance
- ε_λ : surface emissivity
- $E_{0\lambda}$: exatmospheric spectral irradiance
- $E_{a\lambda} \downarrow$: surface incident spectral irradiance, reflected, scattered and emitted from the atmosphere
- $B_\lambda(Ts)$: emission from the blackbody of temperature Ts
- Ts : surface temperature
- θ : sun zenith angle
- $L_{p\lambda}(z)$: upward spectral radiance from the atmosphere at altitude z

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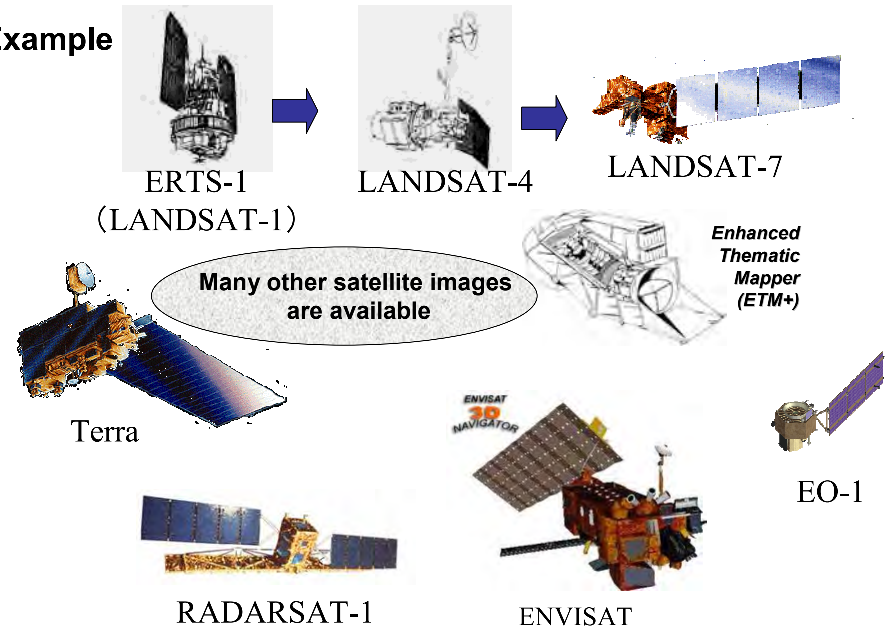
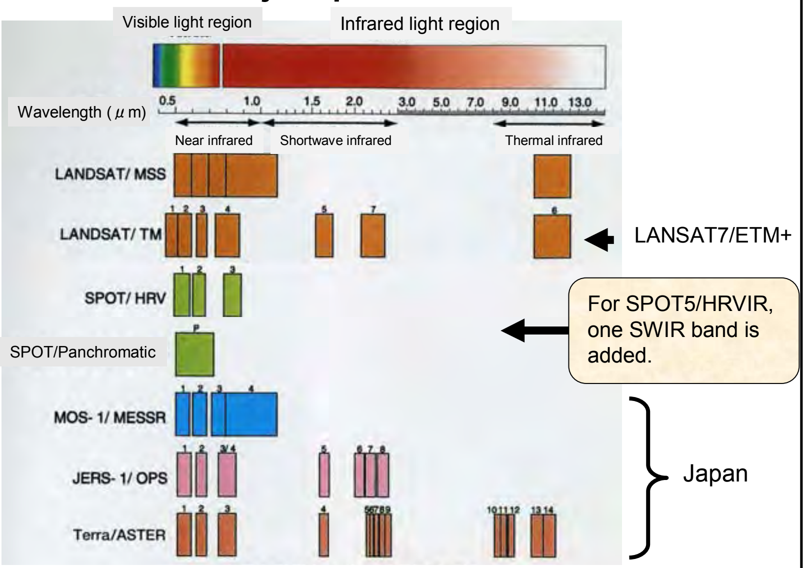
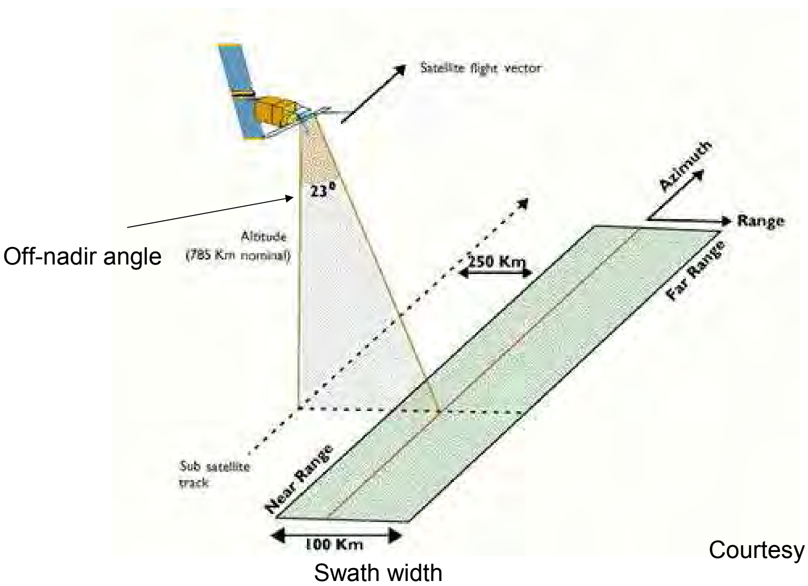
Example



Observation bands of major optical sensors



Courtesy of ERSDAC

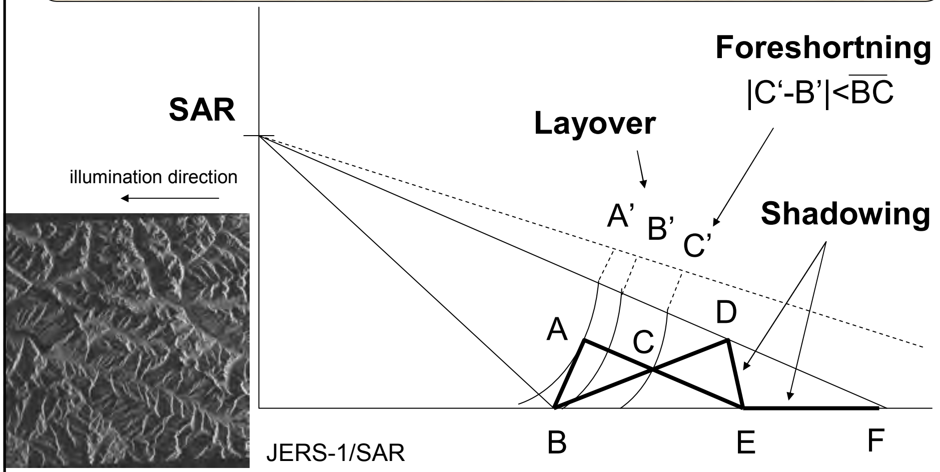


Courtesy of ESA

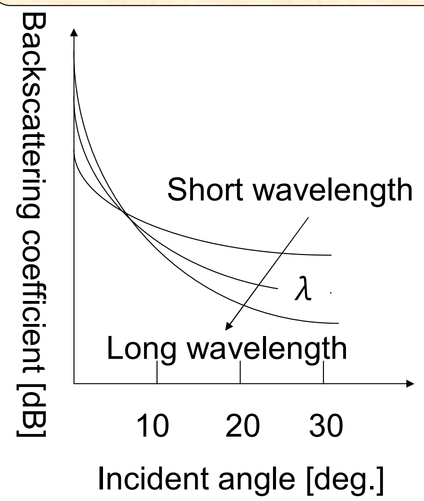
Observing geometry of SAR (in the case of AMI, onboard ESA's ERS satellite)

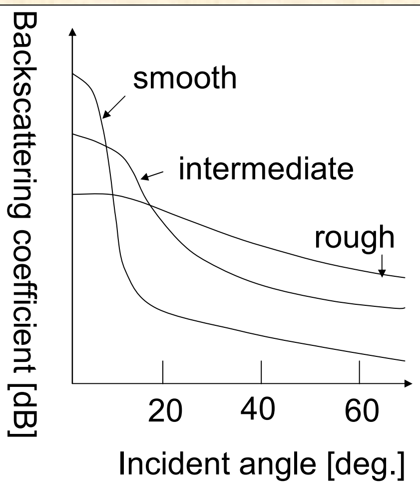
Geometric distortion of SAR observation

In SAR image, observed signal is imaged by slant range distance. Therefore, observed terrain is shifted to the sensor direction. Thus, it is required DEM data, when you make orthographic image of SAR.



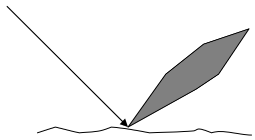
Relationship between incident angle and backscatter coefficient (which corresponds to the intensity of returned signal to the sensor) is affected by wavelength and roughness in SAR.



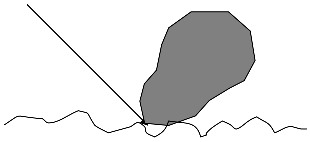


Radar scattering

1) smooth surface



2) ragged terrain surface



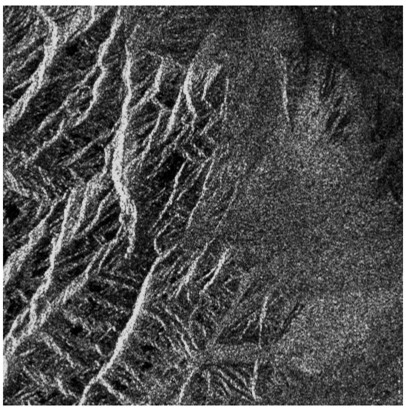
A criteria of smoothness (Rayleigh criteria)

$$\Delta h < (\lambda / 8 \cdot \cos\theta)$$

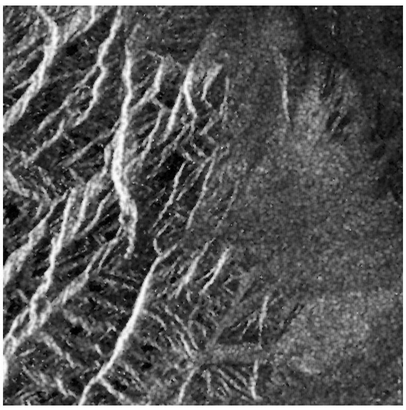
where, Δh is standard deviation of surface roughness, λ is wavelength, θ is incident angle.

Image display (Noise reduction)

Speckle reduction for SIR-C data (L-HH polarization)

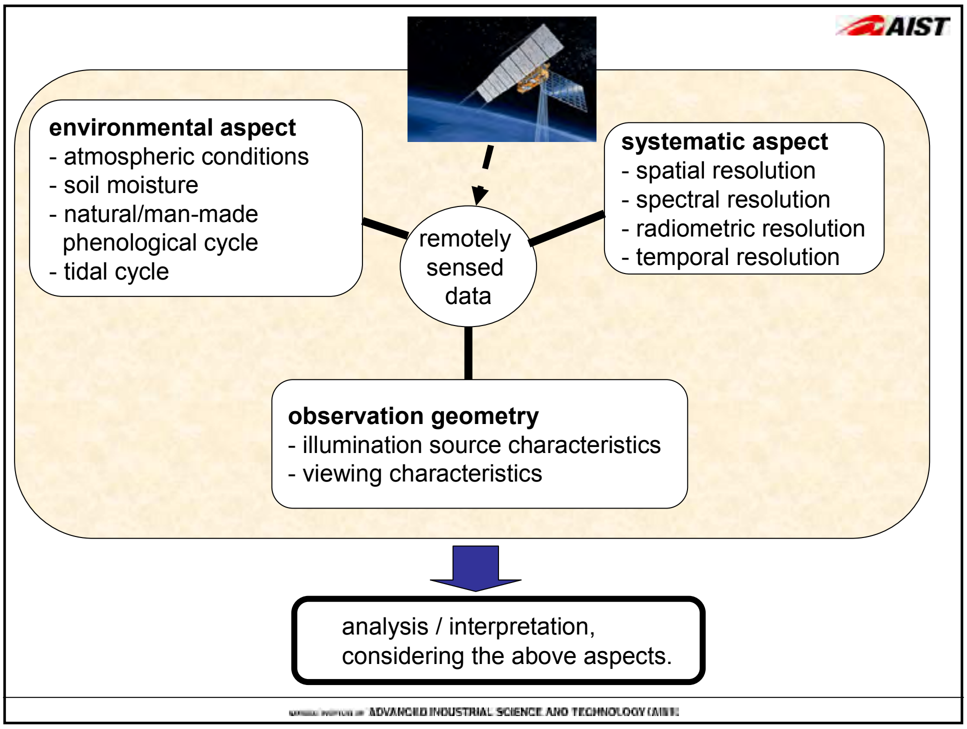


Original image



Filtered image by 3x3 Gamma filtering

There are several filters for speckle reduction.



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◆ ***Current trends on remote sensing (selective)***

- from qualitative to quantitative
  the calibrated and validated data is handled

- the increase of resolution (or data volume), but lower cost
  the highest spatial resolution is less than 1 m.
  the highest spectral resolution is more than 200 chs.

- the sophisticated multi-sensor analysis
  data fusion

- the availability of numerous and variety of data
  Landsat, SPOT, ALOS, Terra, Aqua, Radarsat, IRS, FORMOSAT, KOMPSAT, IKONOS, QuickBird, EO-1, ･････ (excluding airborne data)

Overview of Remote Sensing in Geology

◆ Brief overview of remote sensing in geology

Remote sensing is widely used in a variety of applications relevant to geoscience since 1970s.

For example, remote sensing data have been used in:

- Mineral and petroleum exploration,
- Mapping geology, and geomorphology,
- Monitoring disasters (volcano eruptions, earthquake, land subsidence, and others), and
- Geologic environmental investigation

Geologic Remote Sensing Research Group

The group will take a major role for creating geo-scientific information and knowledge from remotely sensed images, promoting effective use of the land and natural resources, and mitigating geo-hazards.

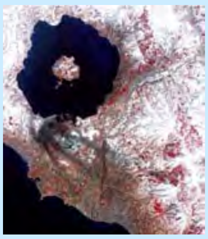
The **second mid-range research (2005 – 2009)**

- Geo-information products development
- Geo-information infrastructure
  - *Satellite Image DB of active volcanoes
- Others
  - *Geology-related applications of Terra/ASTER and ALOS/PALSAR images
  - *Environmental research

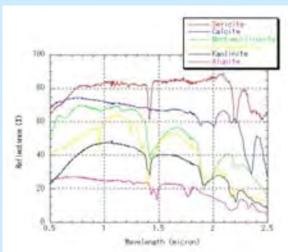
Terra Satellite and ASTER instrument

ALOS satellite and PALSAR instrument

JERS-1 Satellite

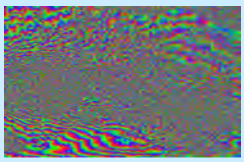


ASTER image after the eruption



Spectra of typical clay minerals

Bird-view of Satuma-io-jima

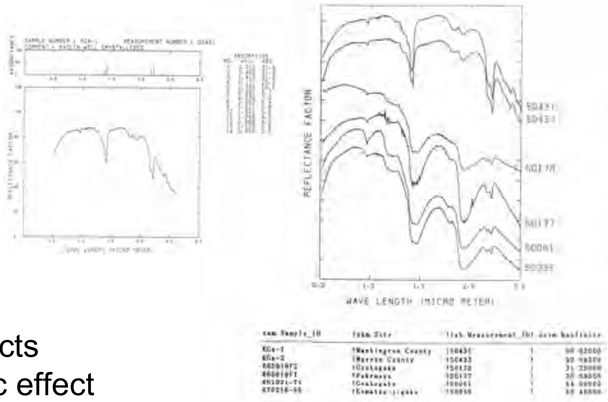


InSAR fringe after Izmit earthquake in Turkey

Spectra database of rocks/minerals

Reflectance spectra of typical minerals at laboratory is fundamental information for analyzing optical images for geology

- powder samples
- chemical analysis
- X-ray analysis



In-site spectra
→ coating effects
→ atmospheric effect

Reflectance spectra of kaolinite, measured at laboratory.

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Vicarious Calibration for ASTER Instrument

Instrument calibration is monitored and validated through this activity.

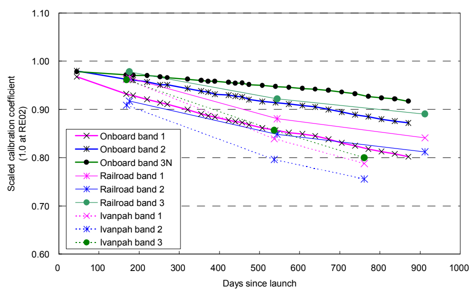
Reflectance and atmospheric measurements

Ground validation experiments In U.S.A.

Onboard Cal. data
Image data

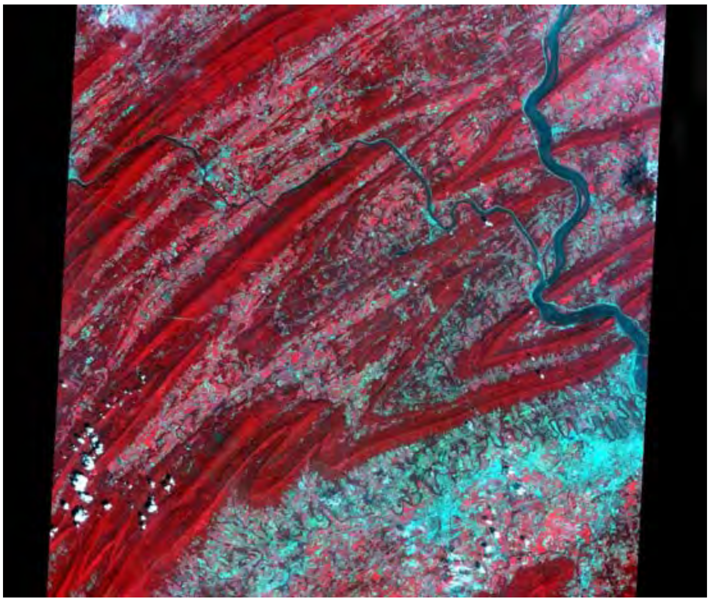
Simulation

Estimated Calibration Coefficients



TIME after launch

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)



Specific terrain features, which are characterized by different resistance of erosion, are visible.

Fold structures in Pennsylvania, USA (ASTER Visible and Near-infrared image)

The continuous layers and their superposition can be easily recognized in sparse vegetated region.
Visible and near-infrared color composite image with 15 m resolution.

Zagros Mountains, Iran (ASTER image observed on 2004/8/16)

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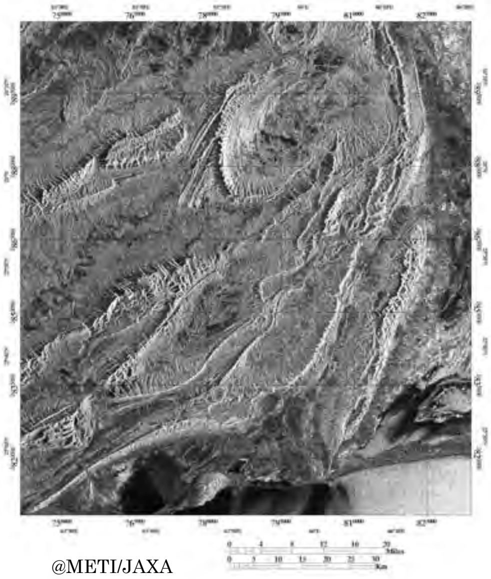
PALSAR image can be used for geologic structure analysis

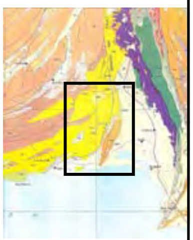
PALSAR ScanSAR image, which observes wide area, will help the interpretation of regional geologic structure.



@METI/JAXA

Observed on 2007/02/02

(Published geologic map of 1/2,000,000)



PALSAR ScanSAR image (Southern part of Pakistan) 1:500,000

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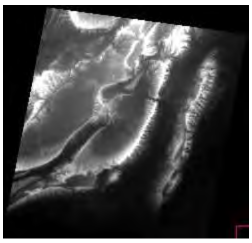
ASTER DEM will help the analysis of geologic structural features.

ASTER color composite image

3D image, viewing from the South.

Viewing direction and exaggeration can be easily selectable.



ASTER DEM

3D image, viewing from the North.

observed on 2006/11/11

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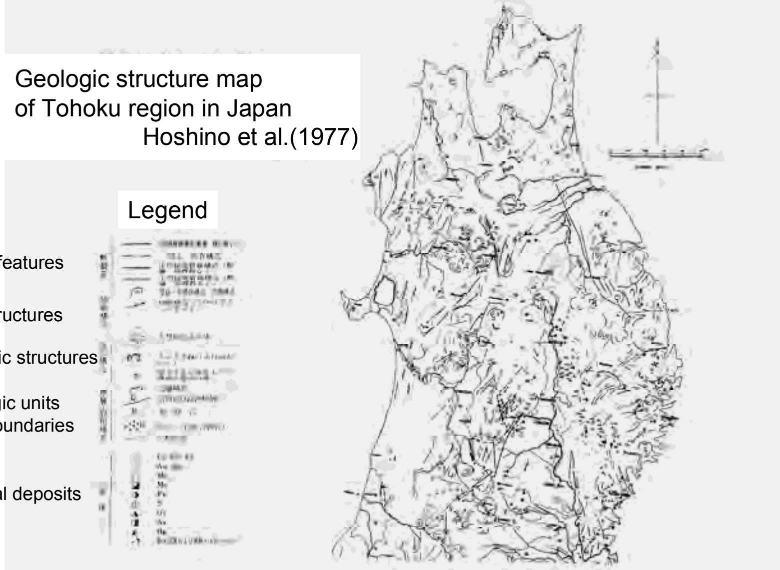
Visual interpretation by expert, using Landsat satellite imagery



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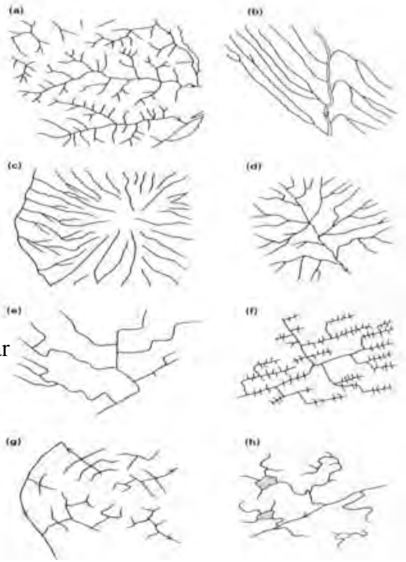
AIST

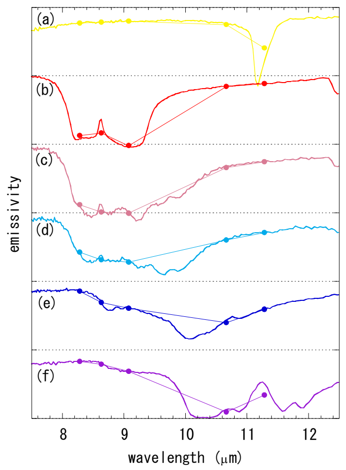
Example of photo-interpretation elements in geology



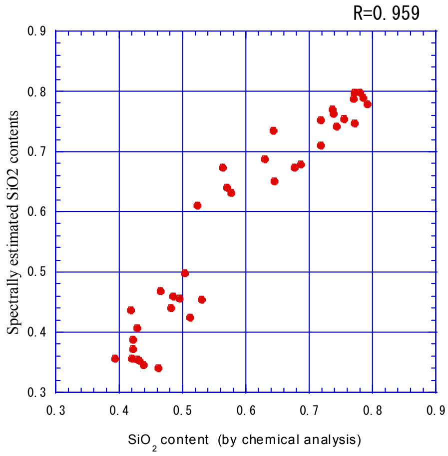
Typical drainage patterns

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Silicate rock mapping using ASTER TIR data



Emissivity spectra of typical terrestrial rocks: a) limestone, b) siliceous rock (quartzite), c) felsic rock (granite), d) intermediate rock (quartz diorite), e) mafic rock (gabbro), f) ultramafic rock (peridotite). (by Y. Ninomiya)

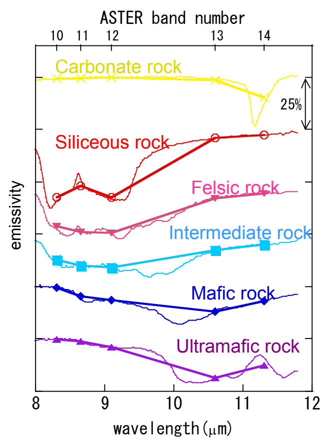


The relationship between the chemically determined SiO2 contents and the spectrally estimated ones. (by Y. Ninomiya)

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Defining lithologic indices for ASTER-TIR

(Ninomiya and Fu, 2002)



Carbonate Index $CI = \frac{D_{13}}{D_{14}}$.

Quartz Index $QI = \frac{D_{11} \times D_{11}}{D_{10} \times D_{12}}$.

(Mafic Index $MI_{old} = \frac{D_{12}}{D_{13}}$)

Improved **Mafic Index**

$$MI = \frac{MI}{CI^3}$$

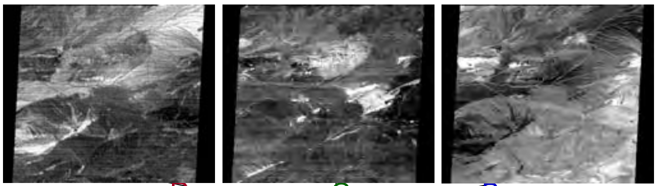
Siliceous rock: usually sedimentary, relatively high quartz content with low feldspars content rock.

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

AIST

Geological mapping in China, using ASTER data

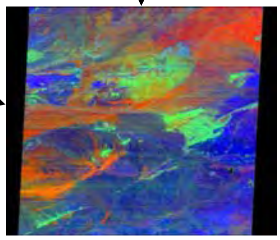
Calcite Index　Carbonate Index　SiO_2 Content



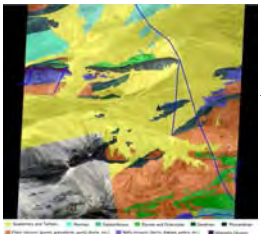
（Research area：
The Beishan mountain, Gansu Province, China）

R　G　B

Color composite



Comparison

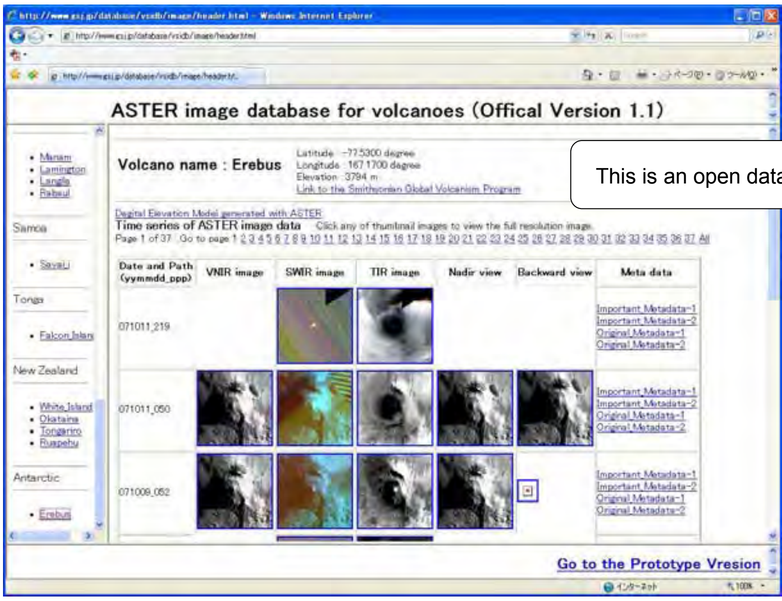


Geologic Map
（Combined with ASTER VNIR image）

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

AIST

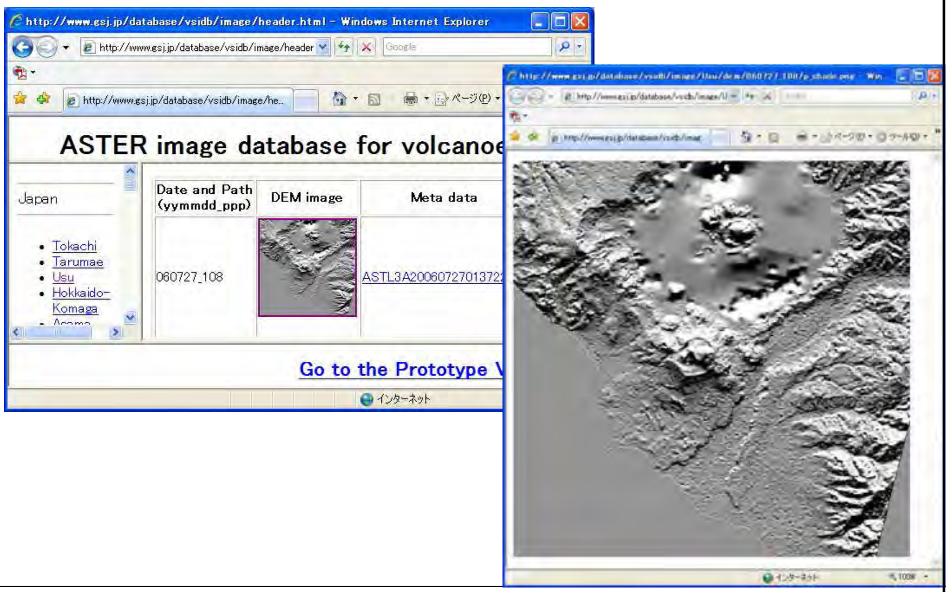
ASTER is always monitoring selected active volcanoes in the world regularly.



This is an open database.

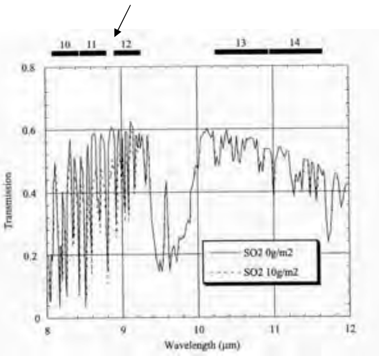
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

ASTER DSM data is also provided.

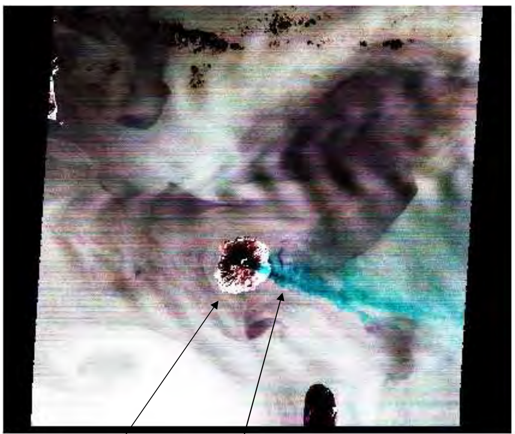


Sulfur dioxide flux monitoring using ASTER TIR data

ASTER TIR bands



Atmospheric transmission spectrum calculated with/without sulfur dioxide in the thermal region



(C) METI GSJ, 2001

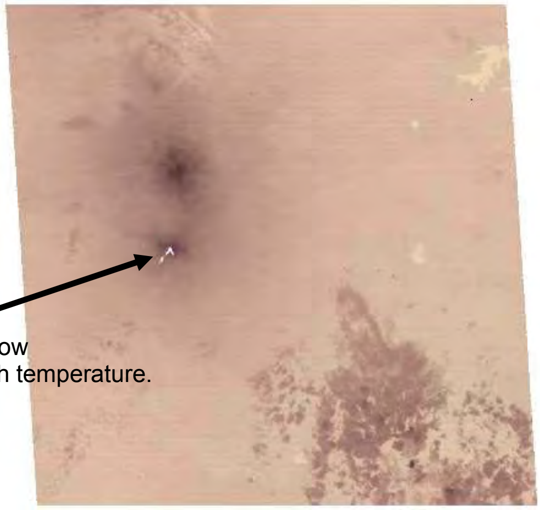
0 10 20 30km

Miyake-jima island

Blue color shows sulfur dioxide flux emitted from the crater

AIST

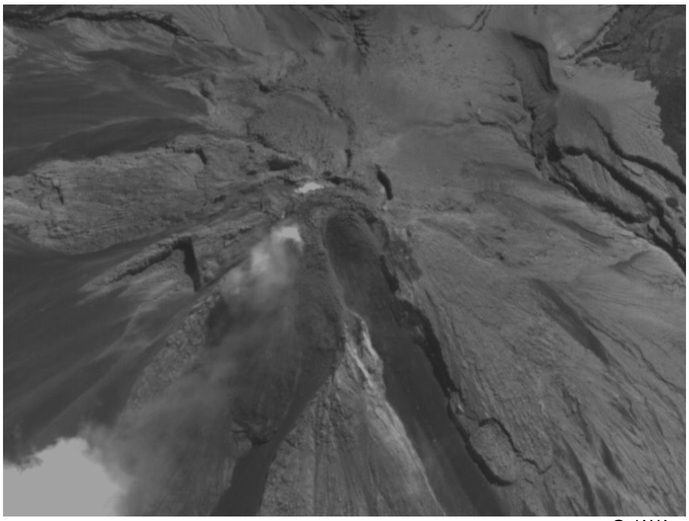
ASTER shows lava flow at the summit of Mt. Merapi, Java island, Indonesia.



ASTER TIR image (acquired at night on 2006/05/30)

ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

AIST



@ JAXA

PRISM image with high spatial resolution (2.5 meters) shows details of the summit area. Stereo-viewing will help more for volcanic interpretation..

PRISM image (nadir-viewing) of Mt. Merapi, Indonesia

Observation date is 2006/09/12.

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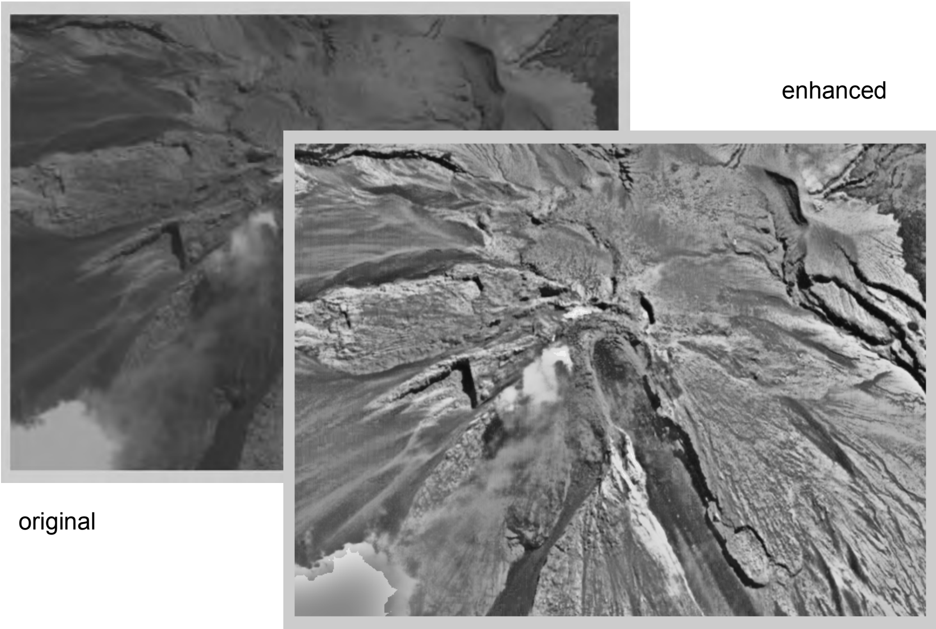
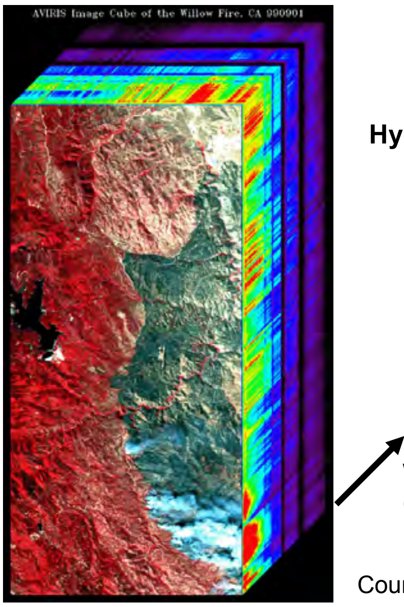
Image enhancement (left: original, right: enhanced)

AIST



AIST



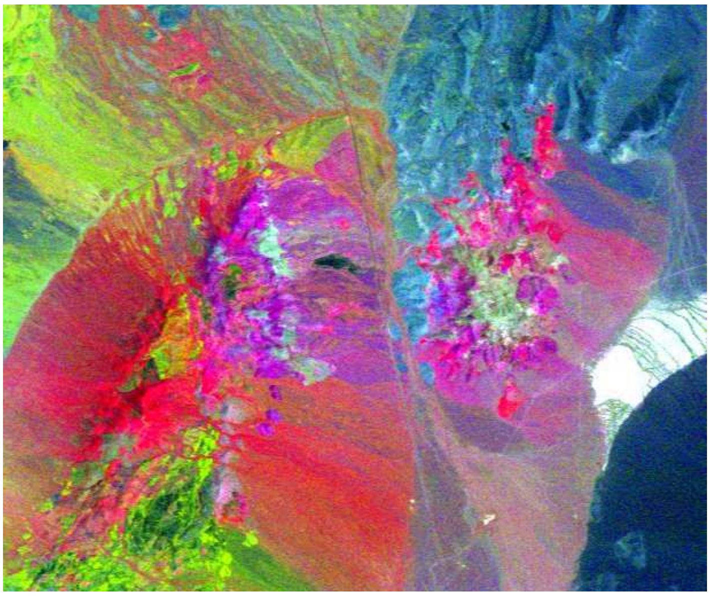
Data concept of Hyperspectral Imager

Wavelength
(224 channels of AVIRIS)

Courtesy of NASA

Hyperspectral data is often called as 'image cube'.

AIST

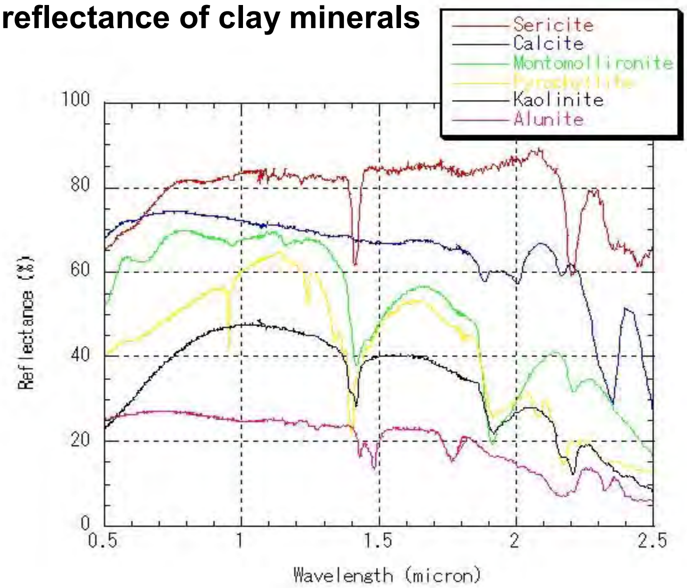


Cuprite, NV. USA

Decorrelation stretch image of AVIRIS data (183 band, 193 band, 207 band)

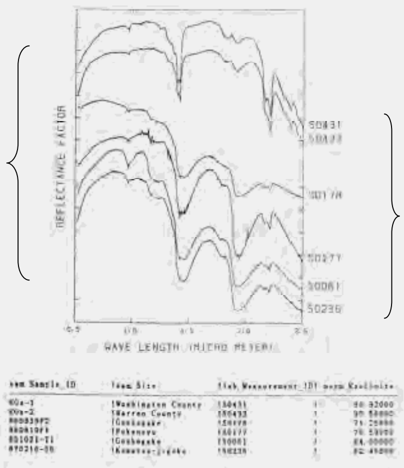
AIST

Spectral reflectance of clay minerals



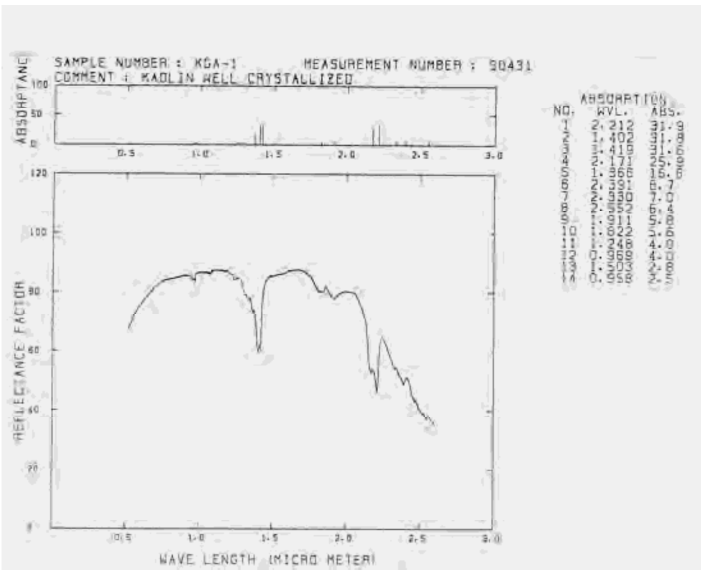
Spectra library is useful data for analysis

Reflectance values are shifted for visual purpose.

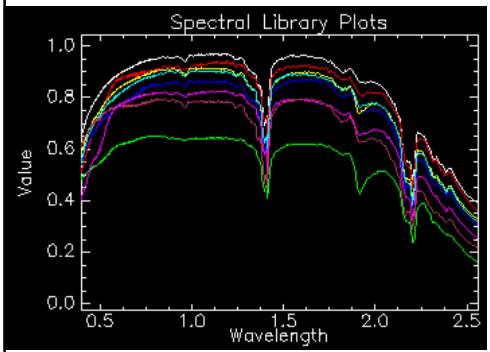


Sample number

Example of AIST’s spectra library (Kaolinite)

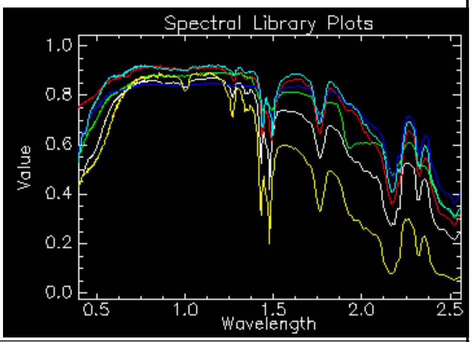


Spectra library at AIST (continued)
This figure shows absorbed wavelength and absorption depth of kaolinite.



Spectra of various kaolinite minerals (using USGS's SpecLab data)

Spectra of various allunite minerals



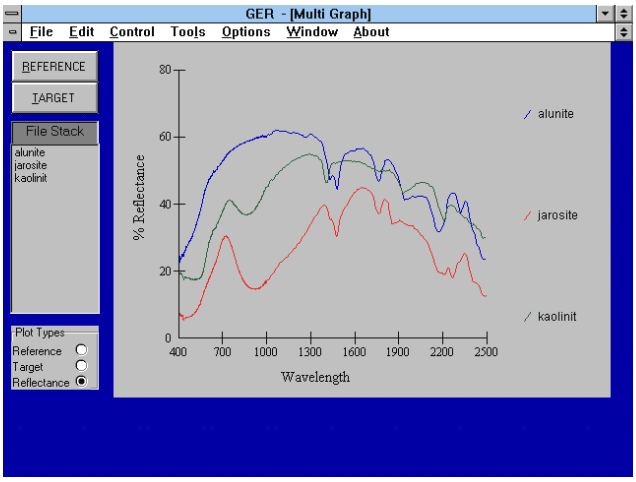
You can see similar reflectance pattern for both minerals with different level.

Reflectance spectra measurement in the field

GER's Field Spectrometer

Possible to measure in visible and near-infrared (0.4～2.5 μm) region

After reflectance conversion



from GER's site (http://www.ger.com)

AIST

Satellite-borne SAR

Polarization mode

1) L-band SAR

SEASAT/SAR (1978)
JERS-1/SAR (1992-1998) HH
(ALOS/PALSAR) (2005-) HH+HV+VH+VV

2) C-band SAR

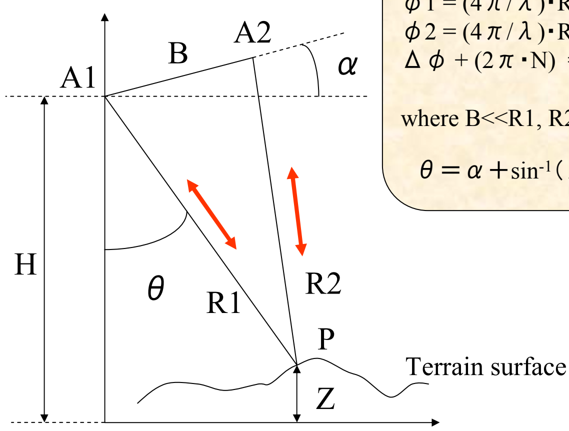
ERS-1/AMI (1991-)
ERS-2/AMI (1995-) } VV
RADARSAT-1/SAR (1995-) HH
ENVISAT/ASAR (2002-) HH+VV
(RADARSAT-2/SAR)

For airborne SAR, various kinds of frequency (Ku, X, C, L, P) and polarization are utilized to observe the Earth's surface. For example, CV-580 (Canada/CCRS), AIRSAR (US/JPL), Pi-SAR (Japan/JAXA, NICT), ERR SAR (China), and others.

AIST

Repeat-pass interferometry for Satellite SAR system

Observation geometry

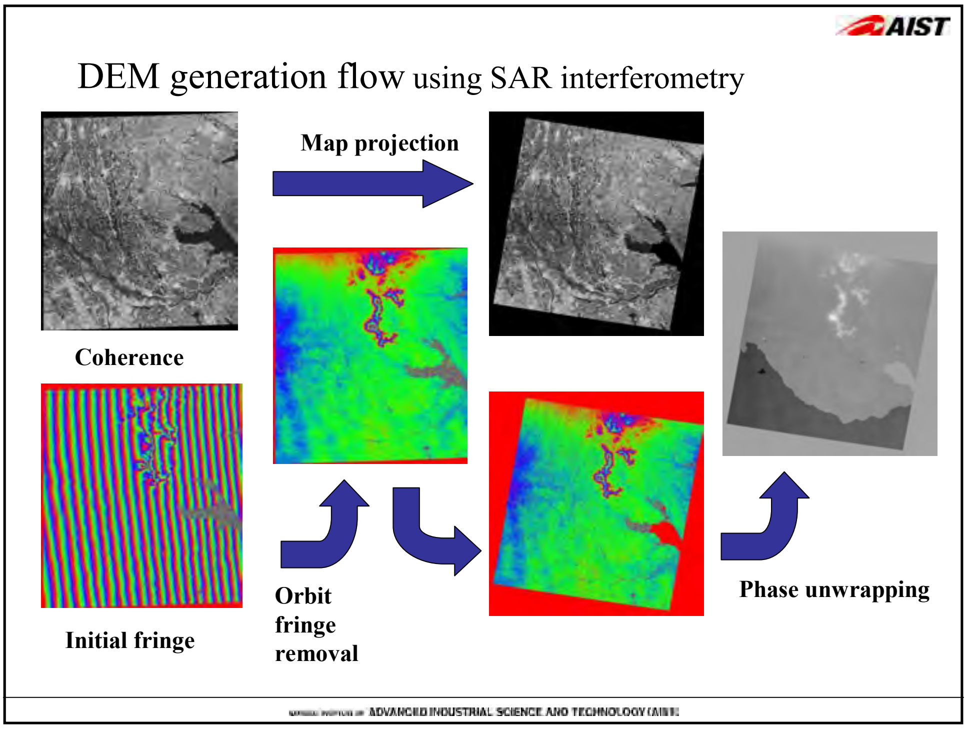


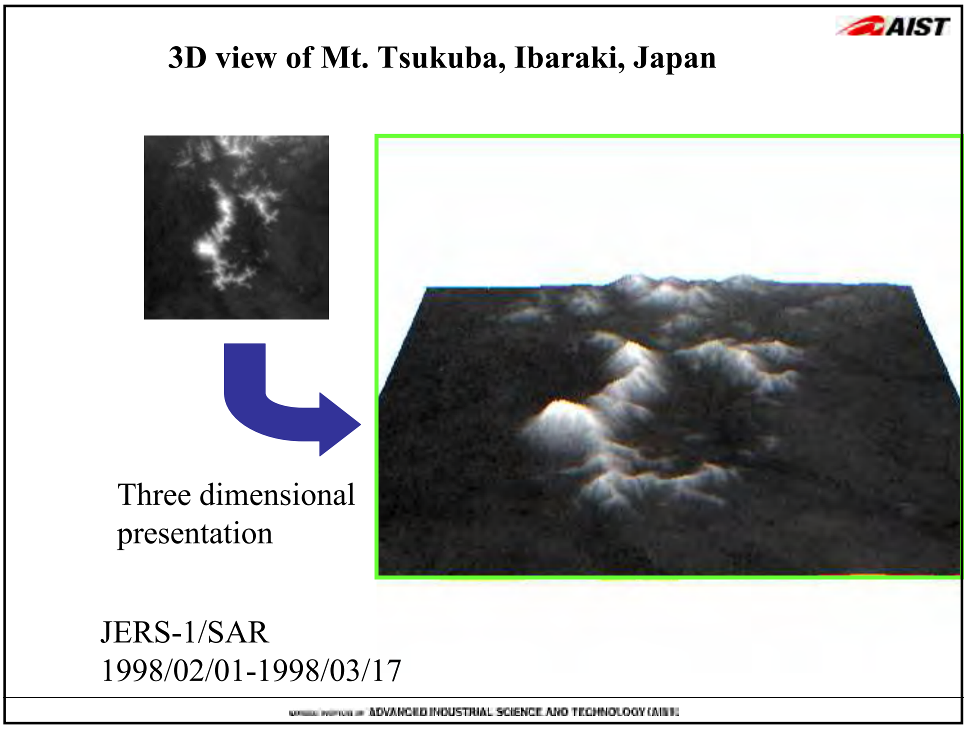
Basic equations

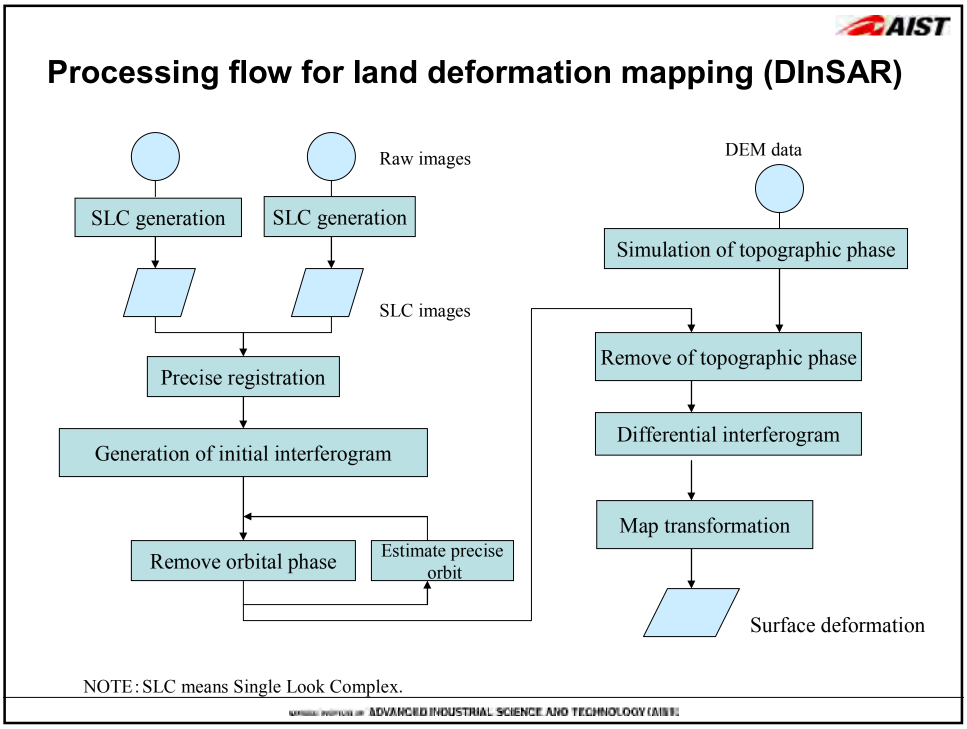
$Z = H - R1 \cdot \cos\theta \cdots (1)$
$\phi 1 = (4\pi/\lambda) \cdot R1$
$\phi 2 = (4\pi/\lambda) \cdot R2$
$\Delta\phi + (2\pi \cdot N) = \phi 2 - \phi 1 = (4\pi/\lambda) \cdot (R2 - R1)$
$= (4\pi/\lambda) \cdot B \cdot \sin(\theta - \alpha) \cdots (2)$
where B<<R1, R2

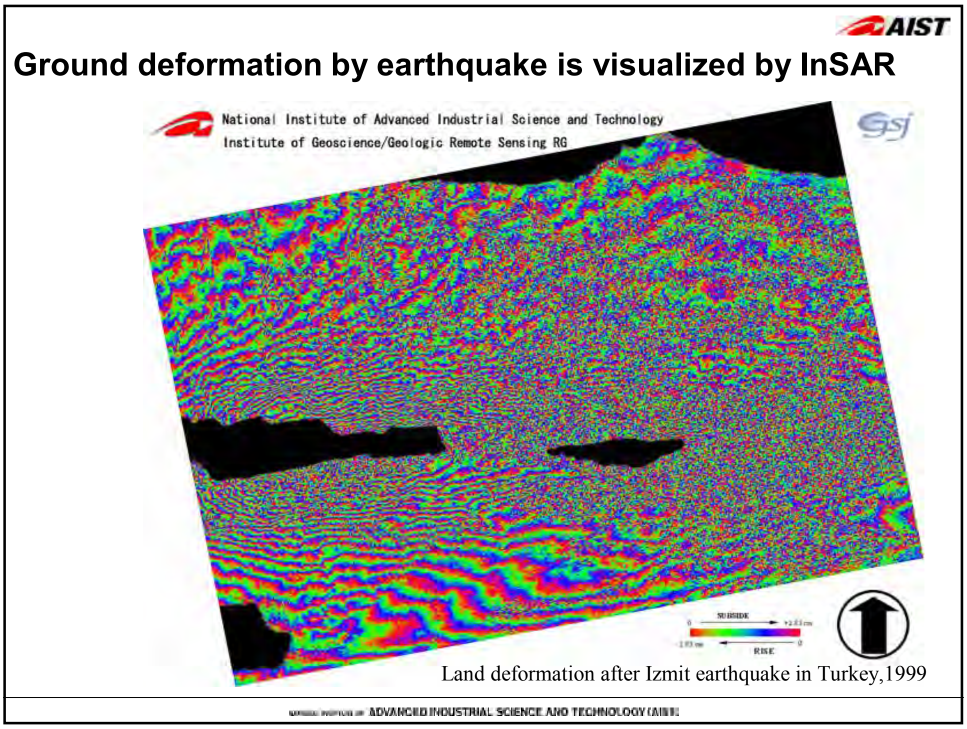
$\theta = \alpha + \sin^{-1}(\Delta\phi \cdot \lambda / 4\pi / B)$

Right part can be derived using observed data.


AIST
DEM generation flow using SAR interferometry
Map projection
Coherence
Initial fringe
Orbit
fringe
removal
Phase unwrapping
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

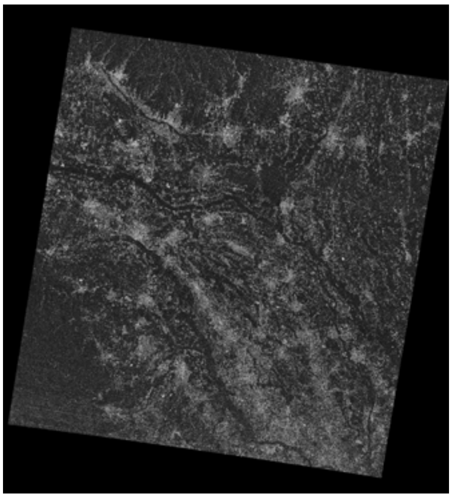

AIST
3D view of Mt. Tsukuba, Ibaraki, Japan
Three dimensional
presentation
JERS-1/SAR
1998/02/01-1998/03/17
ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

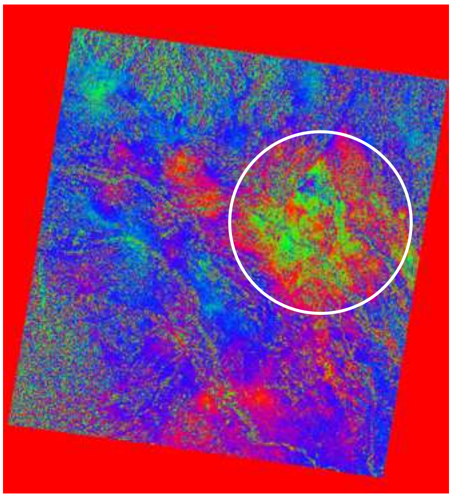

AIST
Processing flow for land deformation mapping (DInSAR)
Raw images
SLC generation
SLC generation
SLC images
Precise registration
Generation of initial interferogram
Remove orbital phase
Estimate precise orbit
DEM data
Simulation of topographic phase
Remove of topographic phase
Differential interferogram
Map transformation
Surface deformation
NOTE: SLC means Single Look Complex.


AIST
Ground deformation by earthquake is visualized by InSAR
National Institute of Advanced Industrial Science and Technology
Institute of Geoscience/Geologic Remote Sensing RG
Land deformation after Izmit earthquake in Turkey,1999

Northern Kanto Area (1993/02/24-1996/11/19)

The Red>Yellow>Blue color change shows subsidence in land.

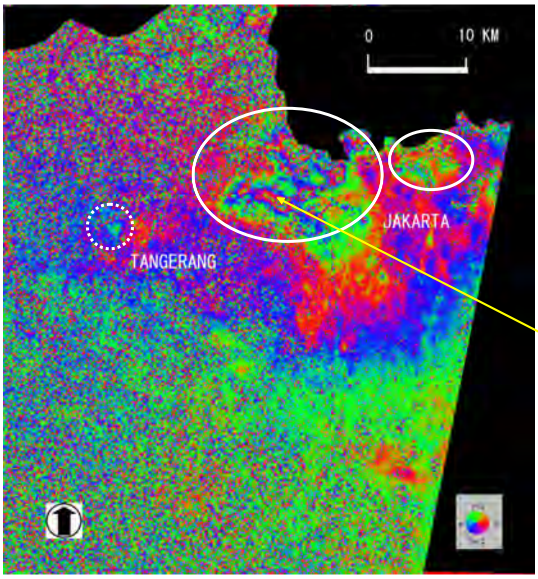




Bp=-170 m

50 m mesh GSI's DEM is used.

Example : **Western Jakarta / Indonesia**



Well known subsided area

JERS-1/SAR (1996/01/17 - 1998/03/19)

AIST

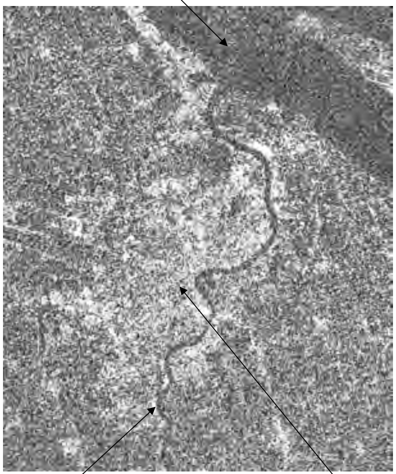
Land subsidence mapping in China

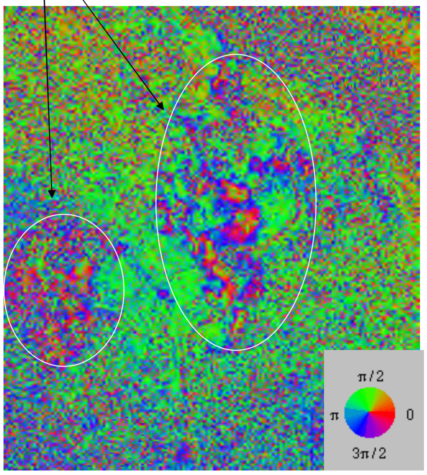
Chang Jiang (Yangtze)

Coherence

Subsided regions

Phase





During 1995/03/01-1998/01/20

Huangpu Jiang

Shanghai city and its suburbs

One color cycle shows approx. 12 cm deformation in the slant range.

JERS-1/SAR

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Overview of Airborne Synthetic Aperture Radar (Pi-SAR)

Pi-SAR consists of X-band and L-band SAR systems.

X-band (frequency: 9.55GHz, wavelength: approx. 3cm)
L-band (frequency: 1.27GHz, wavelength: approx. 24cm) from http://www.das.co.jp
from http://www2.nict.go.jp/dk/c215/index.html

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Pi-SAR L-band color composite (RGB=HH,HV,VV) sample image

Osaka city

Observed on 2003/05/03

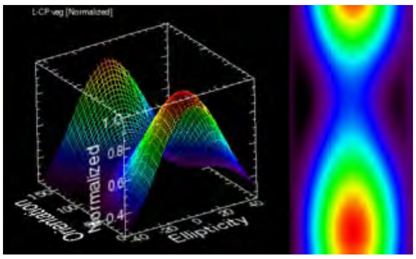
L-band (frequency: 1.27GHz, wavelength: 24cm)

from http://www.eorc.jaxa.jp

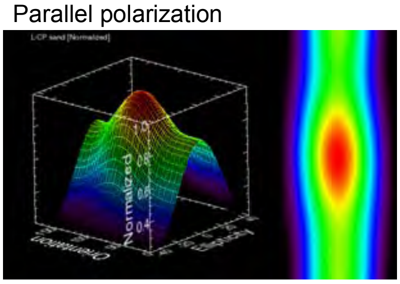
AIST

Polarization analysis of SIRC data (Vegetation and Sand)

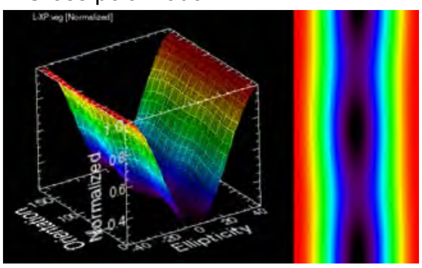
Parallel polarization



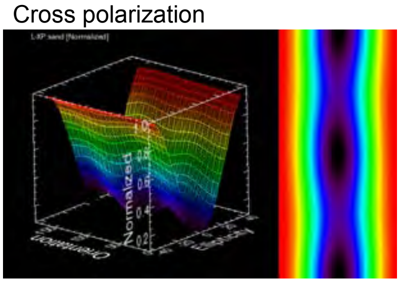
Parallel polarization



Cross polarization



Cross polarization



(a) vegetation

(b) sand

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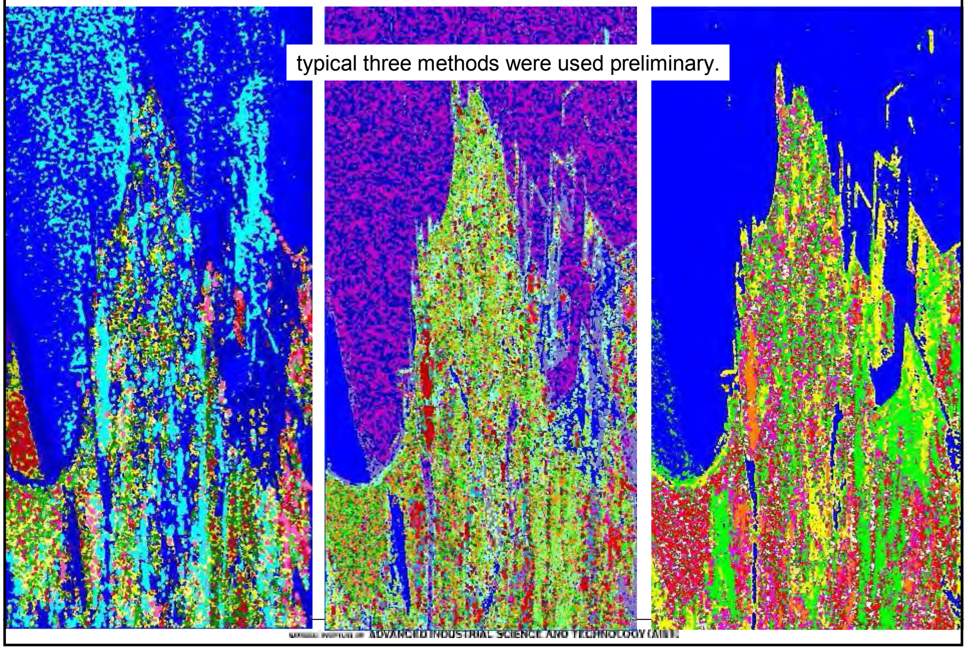
Classification example using PALSAR polarimetric data



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Available tools for image processing and analysis

Simple image handling is possible using PC.

- GIMP
- HyperCube（US Army） and MicroMSI（DMA/USA）
  - possible to handle hyperspectral data
- MultiSpec
  - famous image processing freeware
- many other freewares are available now.

Image viewers: there are many freeware, such as Freelook, ENVIview, others.

I hope this will help you to use and interpret remotely sensed imageries for your interested applications.

Thanks !

Remote Sensing

– Principle and applications in geology –

Isao SATO
Institute of Geology and Geoinformation,
Geological Survey of Japan, AIST

Abstract

In the training, I introduce basic principle and knowledge of remote sensing, which is related to geologic applications. Remote sensing is widely applied to geoscience, however, it is impossible to introduce all of them. You can overview the spectral features of geologic objects. In addition, several selected topics are introduced through our past research activities. These topics cover traditional geologic mapping and novel applications in geology, such as InSAR applications (DEM generation, deformation mapping), hyperspectral remote sensing, SAR polarimetry.

Geo-scientific Studies

on Methane Gas Hydrates

Osamu Matsubayashi

Institute for Geo-Resources and Environment, AIST-GSJ

Contents

Natural Methane Gas Hydrate:

A. Methane Hydrate, what is it, and where we can find ?
B. Implications for the Earth's Environment
C. Geothermics and Methane Hydrates
D. Various Research Subjects

Chapter A.

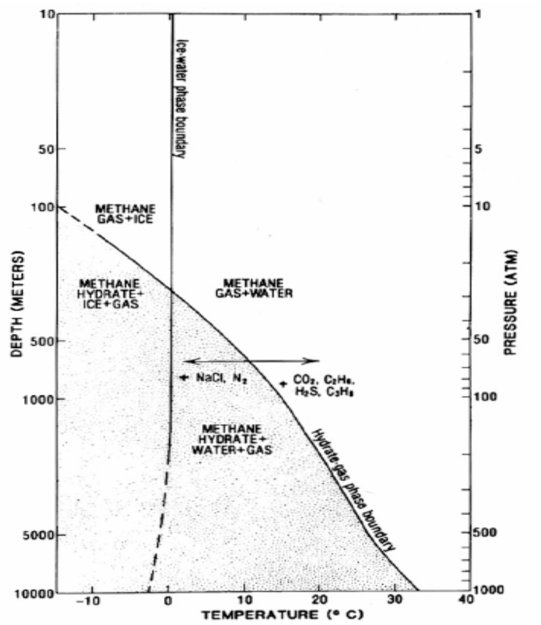
Methane Hydrate, what is it, and where we can find it ?

A-1) Basic facts about MH
A-2) Its distribution on the earth

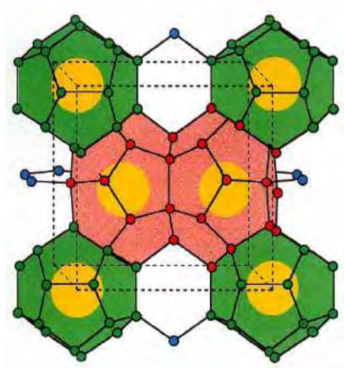
A-3) Case of onshore occurrence
A-4) Case of offshore occurence

A-1) Basic facts about Methane Hydrate

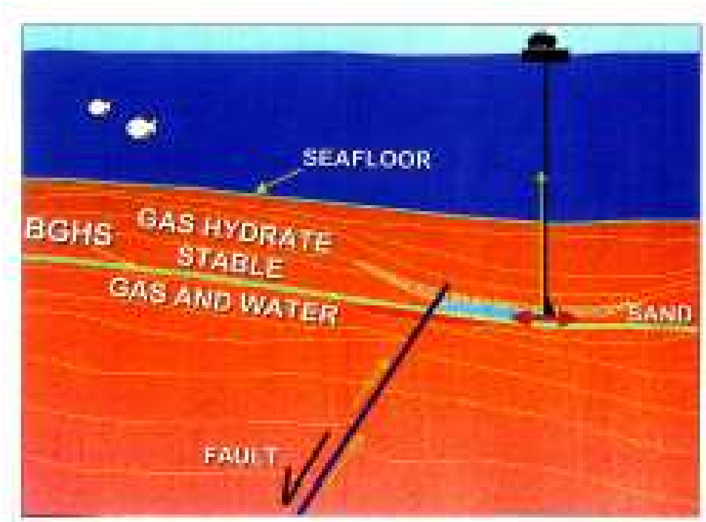
- Hydrates are solidified form of gas species (methane, ethane, etc.);
- Hydrates occur in nature under special P-T conditions;
- Their physical properties are unique.



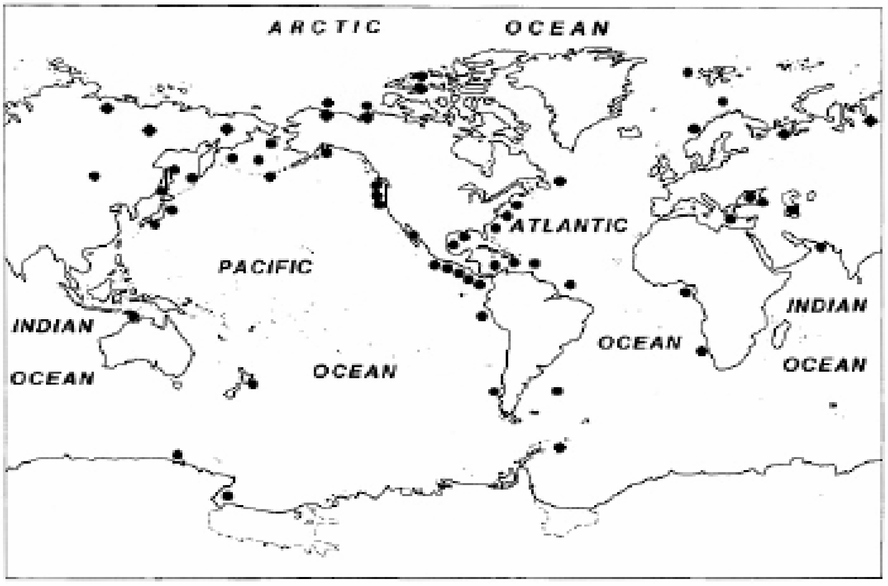
Phase Diagram (L) and Molecular Structure (R) of Methane Hydrate



Natural Hydrates:
A big Buffer-tank for Global Carbon Cycle, as well as our Fuel Resource (from: The Leading Edge Vol.22, 2003)

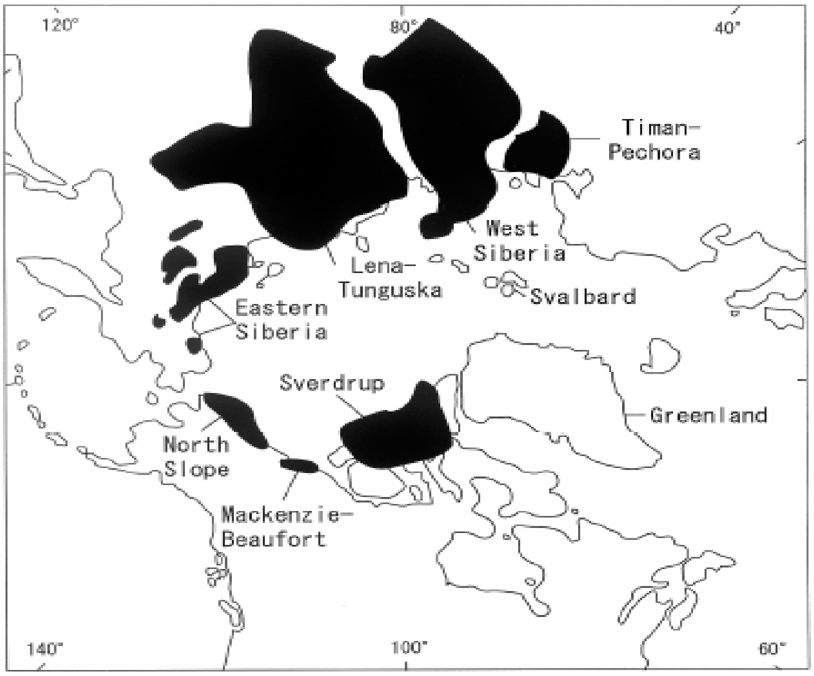


A-2) Distribution on the earth



On-land methane hydrate occurrences

- Mackenzie delta, Canada (Mallik site)
- North Slope, Alaska
- Siberian basins, Russia
- and others



Onshore hydrate drilling program, Mallik in Canada
taken from G.S.C. Bulletin Vol. 585 (2005)

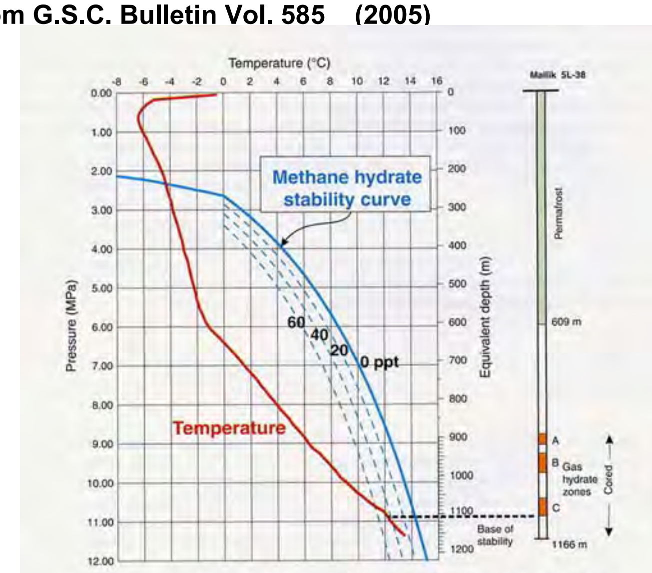
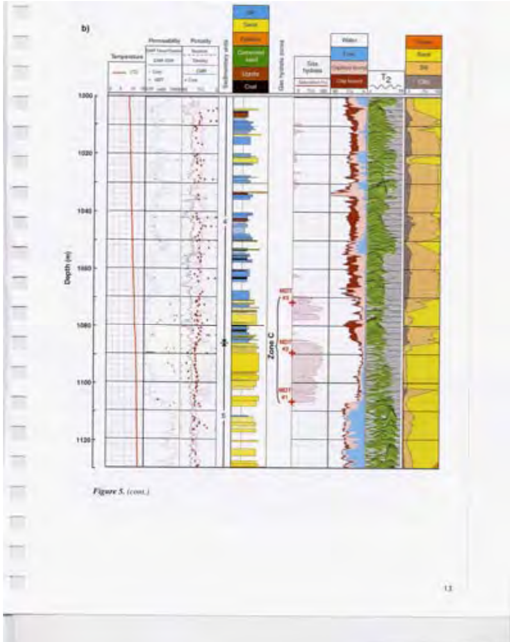


Figure 4. Temperature versus depth plot for the JAPEX/JNOC/GSC et al. Mallik 3L-38 well, as determined by Henninges et al. (2005) using fibre-optic distributed temperature sensing (DTS) cables. Phase-equilibrium curves for methane hydrate stability at 0, 20, 40, and 60 ppt (parts per thousand) water have been plotted to allow estimation of in situ stability (after Sloan, 1998).

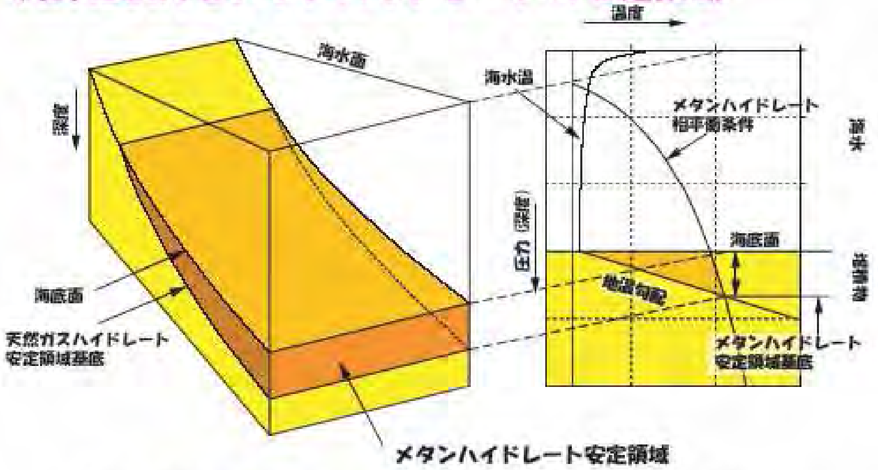
From Dallimore et al. (2005)



Offshore methane hydrate occurrences
(case of vicinities of the Japanese Islands)

- High-P, Low-T is the general requirement of MH occurrence
- Geological conditions which favor the accumulation of methane
- Along the Pacific margin, including the *Nankai slope* area
- Also on the Japan Sea margin

海洋におけるメタンハイドレートの安定領域



メタンハイドレートは、深海堆積物中の適当な温度・圧力条件のもとで安定に存在．その安定領域は，メタンハイドレートの相平衡条件や堆積物の地温勾配より推定される．

Chapter B.

Implications for Global Environment

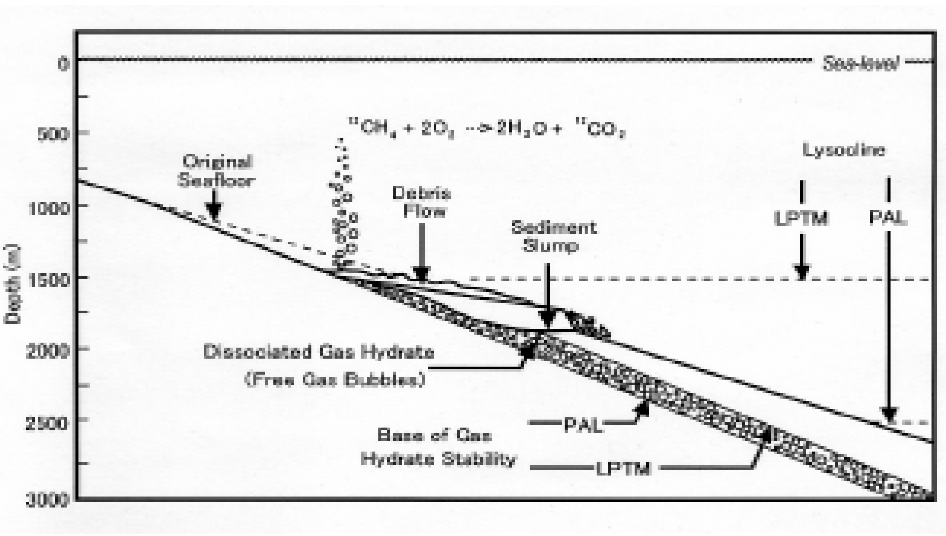
1) Methane hydrate quickly dissociates into gas phase at certain (P,T) condition, with a remarkable change of volume.

2) The phase change (P,T) is close to that normally found in the sub-sea formations of continental margin areas.

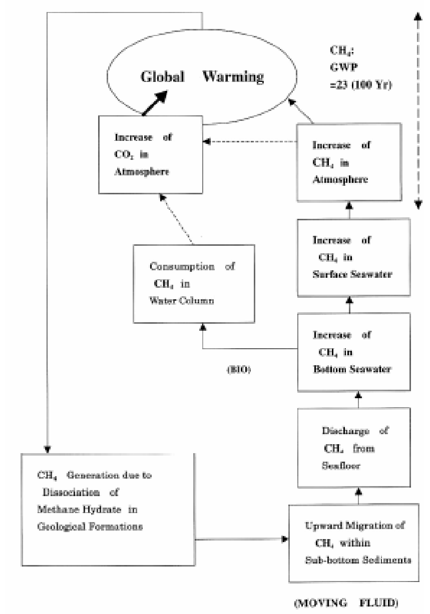
3) Natural feed-back system has not yet been clarified.

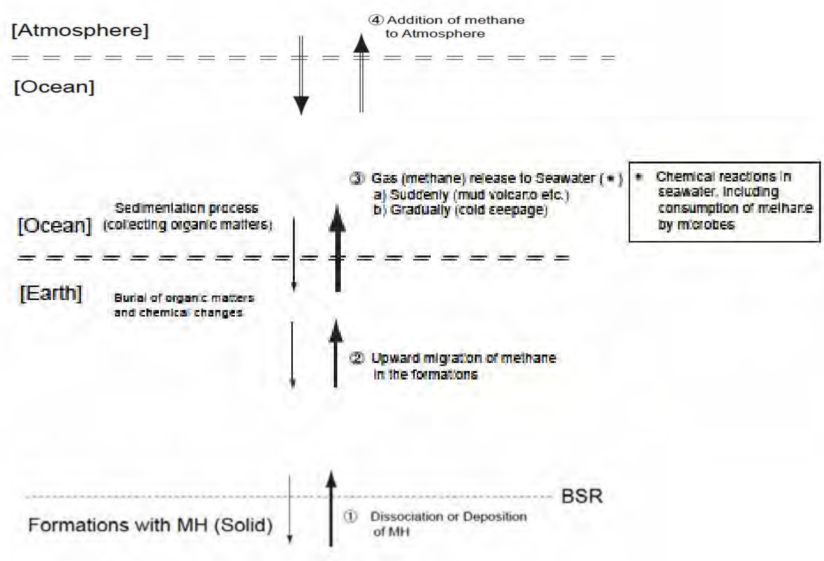
4) If large amount of CH4 gas is released to atmosphere, it does enhance he so-called greenhouse effect.

Sub-sea landslides might be caused by the act of hydrate dissociation (from Dickens, 2001)



Global warming and the role of MH (positive F.B. !)





Chapter C.

Geothermics and Submarine Hydrates

(Originally for "Geo-Temperature Workshop" held @JAMSTEC Tokyo, on June 16, 2006)

A review on BSR-derived HF
in Japanese offshore areas

- In the beginning :
  Yamano et al. (1982)
  pointed out the usefulness of hydrate BSR as novel data-source for HF estimation (giving a continuous HF profile).

Many research works along this idea
have followed it until present day:

i.e., Akazawa et al. (1996) for Kumano Basin, Nankai Trough;
Ganguly et al. (2000) for Cascadia
and some others.

However, there are basic unsolved problems
in the method of "BSR-derive Heat Flow" !!

1) Does "BSR" really coincide with the phase boundary (P,T) of gas-hydrates, or not ?

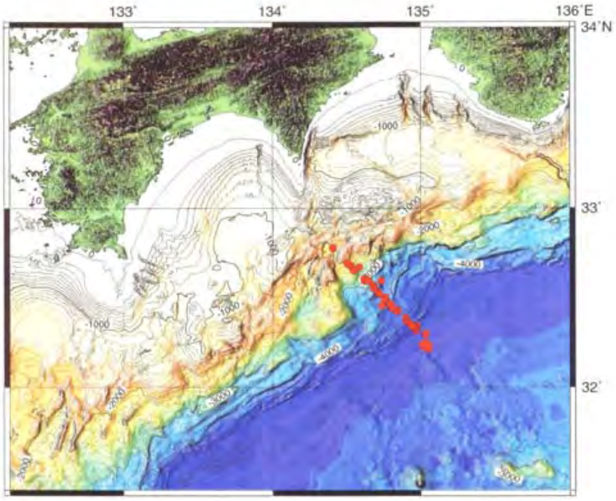
2) Pressure in-situ has never been reported (hydrostatic or lithostatic not clarified yet).

3) Thermal Conductivity used is from
conversion of seismic velocity, therefore it
contains uncertainly.

AS A WHOLE
ACCURACY MAY NOT
BE VERY HIGH.

四国沖の実験海域周辺の海底地形図

Topographic Map Showing the Survey Area off Shikoku.



赤丸は NGH99 実験航海での地殻熱流量測定点

Seismic profile off Shikoku Is.

Nankai 3D Line 137 (On board Migration)

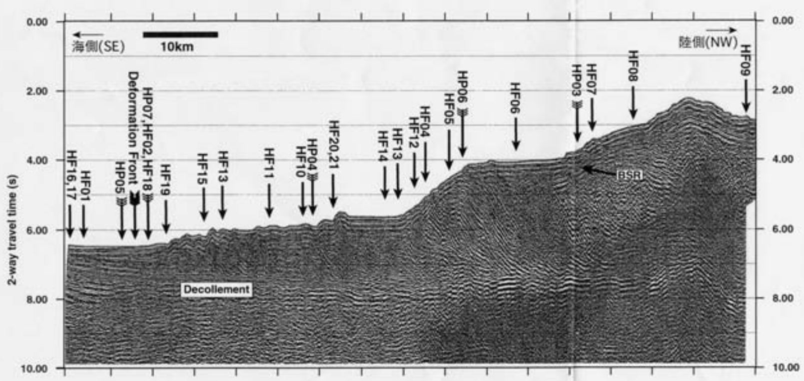
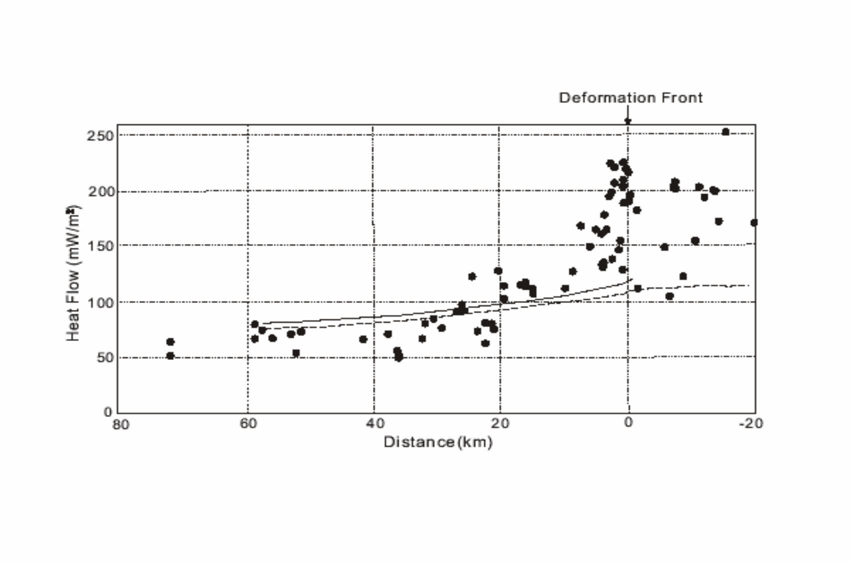


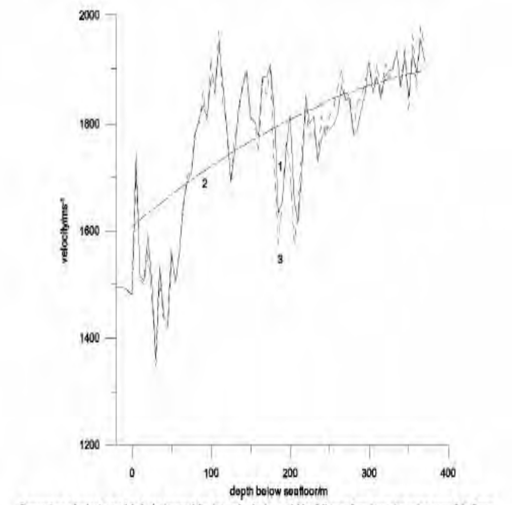
図5-1-2 Ewingの航海(Line137)で得られた西部南海トラフの地震探査断面図
（熱流量測定点を矢印、採泥点を羽矢印で示す）



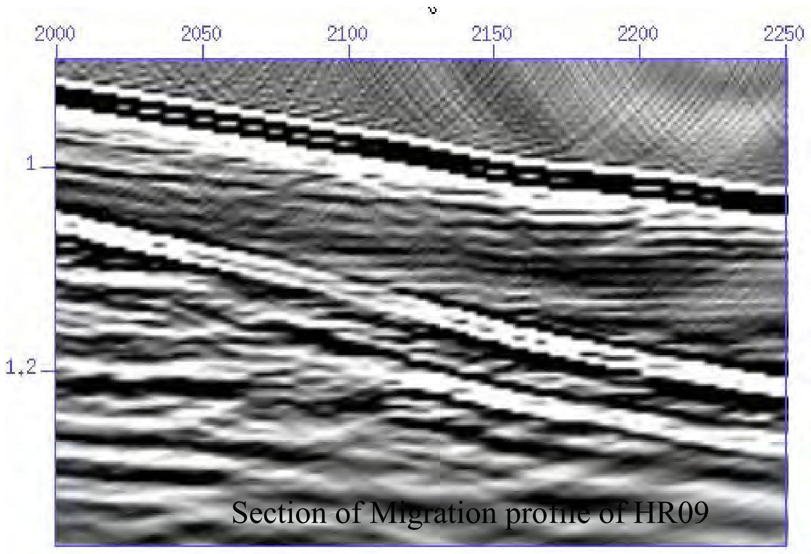
We should be fully aware of all those facts that have become available by recent gas-hydrate field programs.

- Seismic "hydrate-BSR" sometimes <u>does not correspond</u> to phase boundary (P,T) of methane-hydrates.

Song, Matsubayashi, and Kuramoto(2003) →



Comparison of velocity models 1. the inverted 5m-interval velocity model by full waveform inversion using curve 3 in figure 6 as the starting model; 2. Velocity trend model based on curve 1 in figure 6; 3. the inverted 5m-interval velocity model by full waveform inversion using curve 4 in figure 6 as the starting model.



Four CMP gathers around CMP 2140 are combined to form a supergather with the group interval of 12.5m to avoid the spatial alias problem. At CMP 2140, the first BSR and the second BSR are clear, where the slope of the first BSR is about 4°, both the seafloor and the second BSR subparallel to it and a one-dimensional structure can be approximately assumed. Then it is transformed to the data in intercept time-slowness domain.

Problem of Double-BSR

ELSEVIER

Marine Geology 187 (2002) 161–175

MARINE GEOLOGY
INTERNATIONAL JOURNAL OF MARINE GEOLOGY, GEOCHEMISTRY AND GEOPHYSICS

www.elsevier.com/locate/margeo

Observation and tentative interpretation of a double BSR on the Nankai slope

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Received 16 March 2000; received in revised form 21 December 2000; accepted 15 June 2001

Abstract

Seismic data collected during the French–Japanese KAIKO-Tokai cruise of R/V *L'Atalante* on the upper slope of the eastern Nankai margin reveal the simultaneous presence at two distinct depths below the seafloor of two bottom simulating reflector (BSR)-type reflectors. The upper BSR is traced as a continuous reflector over about 10 km. As water depth decreases from 850 m to 550 m, its depth below seafloor decreases from 200 m to 40 m. The lower BSR is traced at 50–100 m below the upper one. The two BSRs end abruptly near the summit of the Daichii-Tenryu Knoll into an area where the 3.5-kHz record suggests active gas expulsion through the seabed. The observed depth of the upper BSR fits the predicted one for the base of the methane gas hydrate stability zone as estimated from present temperature and pressure conditions at the seafloor and in the slope sediments. Thus, we interpret the upper BSR as an active methane hydrate BSR. We further suggest that the lower BSR is a residual hydrate-related BSR. This could have followed a recent migration of the base of the methane hydrate stability zone from the lower BSR to the upper one. As possible causes for this migration we discuss sea bottom warming and tectonic uplift. The BSR migration could have occurred as a response to a 1–2°C sea bottom warming or, with an equivalent effect, an event of fast uplift of the seafloor by about 90 m. We do not discard other interpretations of the lower BSR, such as an active hydrate-related BSR formed from a mixture of gases.

Keywords: active margins; bottom-simulating reflectors; gas hydrates; fluid dynamics

J.-P. Foucher et al. / Marine Geology 187 (2002) 161–175 165

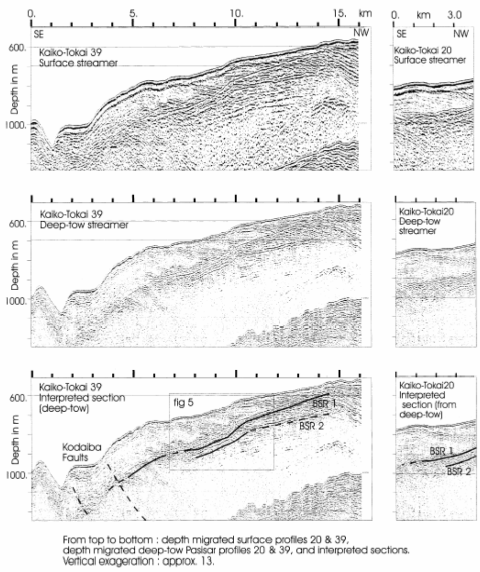
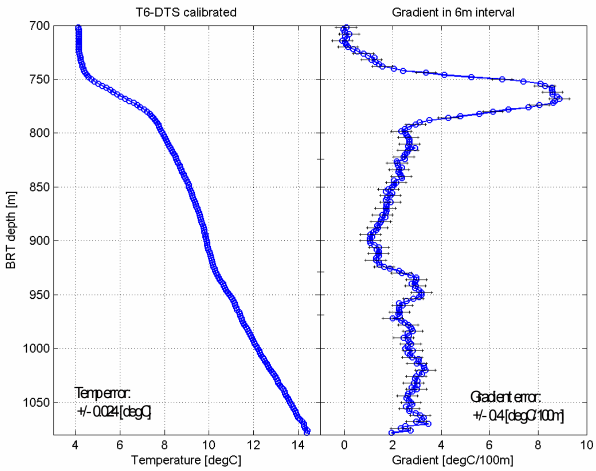


Fig. 3. Seismic sections 20 and 39 (locations in Fig. 1) showing the two BSRs in water depths of 550–850 m. Seismic section 20 ends after a short distance upslope along the double BSR extension (Fig. 1).



Temperature profile obtained by a new sub-sea DTS fiber optic measurement system within a exploration hole (No.14) at eastern Nankai site **(Fukuhara et al., "Proc. of ICGH-5" in 2005)**

Remarks for the results of Fiber Optic measured T profile:

For the T(z) measurement at the east Nankai (as part of Japan's "MH21" National Program) site using a sub-sea Fiber Optic temperature system, some important problems are not settled yet.

- **Measurement time was only 50 days, hence observation of T was not long enough for "thermal equilibrium condition", while the time-constant involving hydrates should be much longer.**
- **Water flow upward through the bore is suspected, which may be disturbing the true formation T(z).**

Chapter D.

Various Research Subjects Related to Natural Methane Hydrates

D-1) Geophysical detection methods;
D-2) Fluid geochemical studies on hydrates;
D-3) Seafloor geological phenomena (i.e., cold seeps) and hydrates;
D-4) Dynamic modeling;

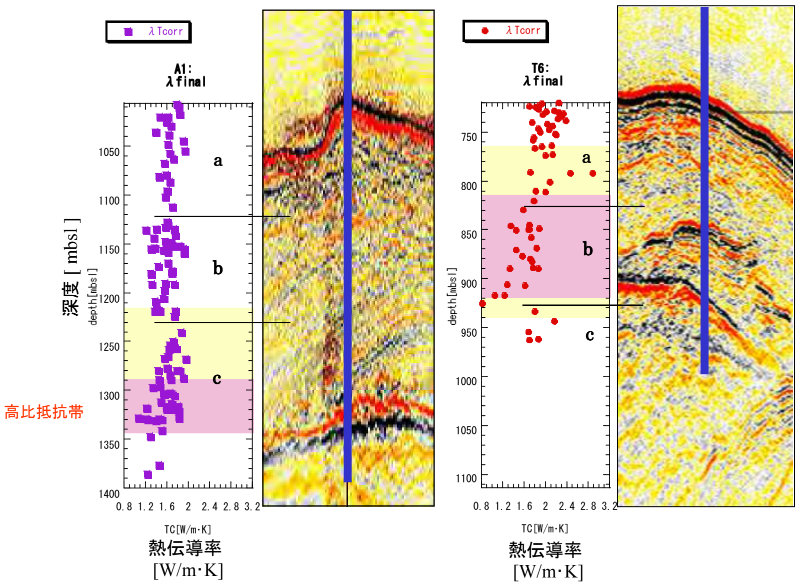
etc. , etc.

Geophysical detection methods

- Multi-channel Seismic Profile
- Electrical Resisitivity Survey
- Heat Flow Measurement
- Others

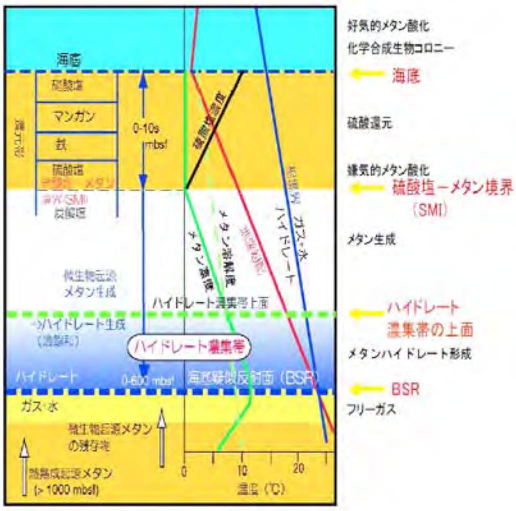
Thermal Conductivity of Cores（as referenced to seismic profile）

A Site, Nankai　　　　T site, Nankai



Geochemical studies

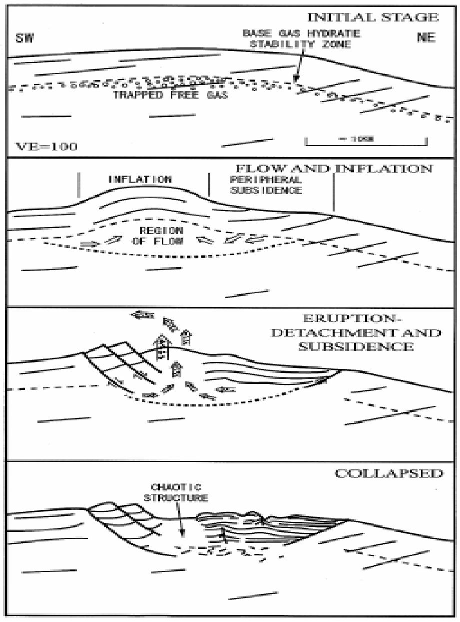
- Dynamic behavior of fluids in the sediments are playing a major role in accumulation process of ***methane hydrates***.



Hydrates and seafloor pock-marks

- Relationship of forming process of seafloor pock-mark structures and accumulation and release of methane to seawater

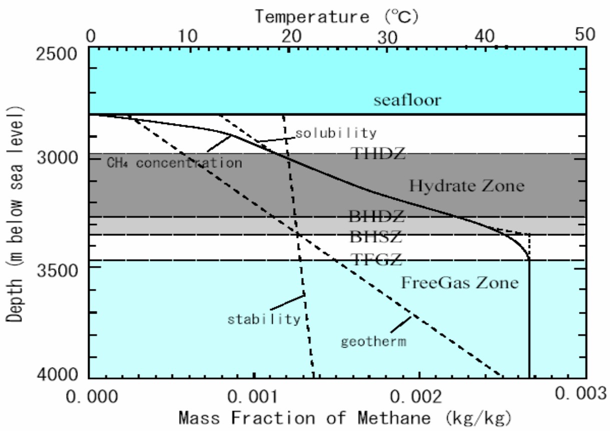
(Dillon et al., 2001)

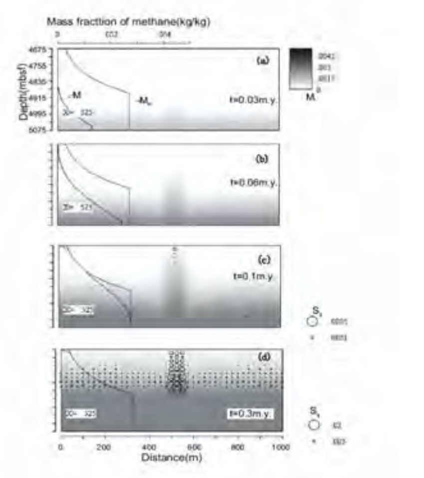


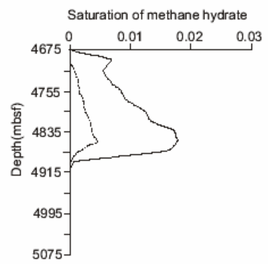
Numerical Modeling of Fluid/Energy Transfer

We can numerically simulate the physical processes which involve fluid transport and methane hydrate formation/dissociation in sediments, as function of time.

Ex. Model by Xu and Ruppel (1999)







- Example of numerical modeling results by He, Matsubayashi, and Lei (2006)

Suggested books to read on the topics

- Natural Gas Hydrates - occurrence, distribution, and detection (2001) Eds. by C.K. Paull and W.P. Dillon) Geophys. Monograph 124, A.G.U.
- Methane Hydrates in Quaternary Climatic Change (2003) J.P.Kennett et al., A.G.U.

Geo-scientific Studies

on Methane Gas Hydrates

End

Thank you !!

Geo-scientific Studies on Methane Gas Hydrates

Osamu MATSUBAYASHI
Institute for Geo-Resources and Environment,
Geological Survey of Japan, AIST

Abstract

It has become recognized that the total amount of natural methane hydrates present globally below the earth's surface is likely to be very large and their carbon content might even be comparable to the whole reserves of oil/gas resource of the earth. Hence, those methane hydrates may be regarded to be part of our energy resource in future, although there certainly remains the problem of technologies which enable us to economically utilize them as a form of hydrocarbon resource. More than that, from the viewpoint of global carbon cycle consideration, methane hydrates are one of the important components in the natural system that has been controlling and now controls the greenhouse effect of the atmosphere, and have a significant impact on the global warming. For these reasons, we are engaged in scientific studies on the detection, characterization and quantification of methane hydrates found in the geological formations at depths down to several hundred meters below the ground-surface, which includes the seafloor in offshore areas adjacent to certain coastlines like those of the Japanese Islands.

This talk is intended to give an introductory scope to the participants about the geo-science research efforts on natural hydrates, by covering a few topics as follows:
First, the basic physico-chemical nature of methane hydrate is briefly reviewed. Secondly, our current knowledge on the world-wide distribution of methane hydrates is presented. Then as the consequence of those facts, a possible scenario of the dynamic behaviors of hydrate dissociation in the sedimentary formations in the context of carbon budget of the earth is mentioned. Finally, some subjects of geo-scientific studies on the distribution and behaviors of sub-surface hydrates, with an emphasis on the geothermal conditions, will be discussed.

Remediation of subsurface contamination using bacteria

Institute for Geo-Resources and Environment,
National Institute of Advanced Industrial Science and Technology (AIST)
Mio TAKEUCHI

Today's talk

1 Subsurface contamination in Japan
2 What is "bacteria", a key player in bioremediation?
3 Various functions of bacteria
4 How to investigate subsurface contamination
5 Bioremediation utilizing bacteria

1. subsurface contamination in Japan

(geo-pollution, soil&groundwater contamination)

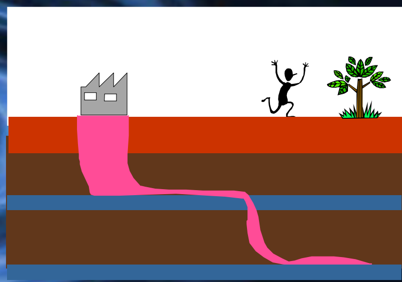
When contaminated,

Direct inhalation of soil

Direct intake of groundwater

⇩

Risk for human health



Regulated by "Soil Contamination Countermeasures Act"

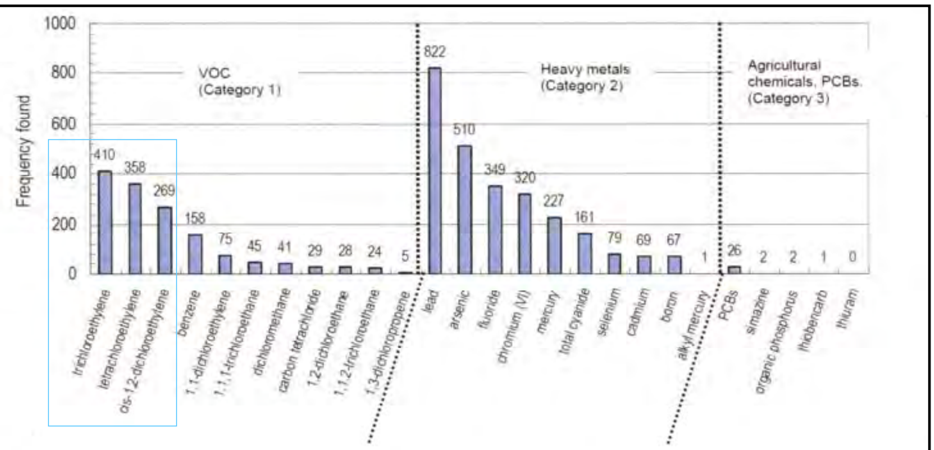
Environmental Quality Standards are set for...

Inorganic substances

Cd, Pb, Cr(VI), As, Hg, Cu, Se, F, B

Organic substances

total cyanide, organic phosphorus, PCBs, dichloromethane, carbon tetrachloride, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, tetrachloroethylene, 1,3-dichloropropene, thiuram, simazine, thiobencarb, benzene



Frequency of designated hazardous substances exceeding standards (Ministry of Environments, 2006)

Tetrachloroethylene and its degradation products are major VOCs (volatile organic compounds)

Remedial actions adopted in the past (Ministry of Environments, 2006)

# of countermeasures			VOCs Category 1		Heavy metals Categories 2 & 3		complex contaminations	
	FY2004	total	FY2004	total	FY2004	total	FY2004	total
Monitoring of groundwater quality	9	(315)	7	(166)	1	(101)	1	(48)
Removal of Soil Contamination	382	(1,860)	81	(622)	211	(898)	90	(340)
Excavations	296	(1,246)	32	(209)	205	(844)	59	(193)
Insitu Cleanup	86	(614)	49	(413)	6	(54)	31	(147)
Bioremediation	18	(44)	10	(27)	0	(3)	8	(14)
Chemical Decomposition	16	(54)	7	(25)	2	(7)	7	(22)
Soil Vapor Extraction	20	(199)	13	(160)	1	(4)	6	(35)
Pump and Treat	24	(282)	13	(189)	2	(31)	9	(62)
Soil Washing	5	(15)	4	(5)	0	(6)	1	(4)
Others	3	(20)	2	(7)	1	(3)	0	(10)
Insitu Containment	11	(85)	0	(7)	7	(54)	4	(24)
Sheetpiles	8	(37)	0	(3)	5	(21)	3	(13)
Soil/Cement Mixing Walls	0	(20)	0	(2)	0	(13)	0	(5)
Others	3	(28)	0	(2)	2	(20)	1	(6)
Offsite Containment	3	(8)	0	(0)	2	(5)	1	(3)
Stabilization (insitu)	3	(62)	0	(2)	2	(51)	1	(9)
Stabilization (exsitu)	2	(51)	0	(2)	2	(43)	0	(6)
Concrete Vault Containment	0	(31)	0	(2)	0	(23)	0	(6)
Topsoil shuffling	13	(25)	3	(4)	7	(15)	3	(6)
w/ on-site clean soils	3	(4)	0	(0)	2	(3)	1	(1)
w/ off-site clean soils	10	(21)	3	(4)	5	(12)	2	(5)
Soil Caps	10	(72)	0	(2)	10	(61)	0	(9)
Pavements	24	(167)	0	(8)	21	(129)	3	(30)
w/ concrete	12	(81)	0	(4)	11	(66)	1	(11)
w/ asphalt	12	(86)	0	(4)	10	(63)	2	(19)
Signs and fence	1	(58)	0	(11)	1	(37)	0	(10)
Others	6	(249)	1	(112)	4	(109)	1	(28)
total	362	(1,681)	66	(431)	232	(1,018)	64	(232)

Bioremediation has been used for VOCs (volatile organic carbons) contamination

Today's talk focuses on...

Bioremediation of VCOCs

(Volatile Chlorinated Organic Compounds)

1,1-dichloroethylene (1,1-DCE)
cis-1,2-dichloroethylene (c-DCE)
trichloroethylene (TCE)
tetra(per)chloroethylene (PCE)

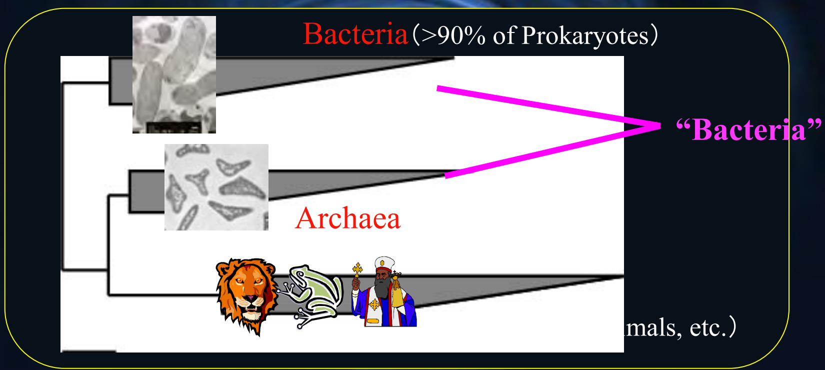
Bioremediation:

Remediation of contaminated environment utilizing organisms such as plants, fungi, and bacteria.

2. What is " bacteria"

Microorganisms: organisms
with small size (bacteria, fungi, algae)

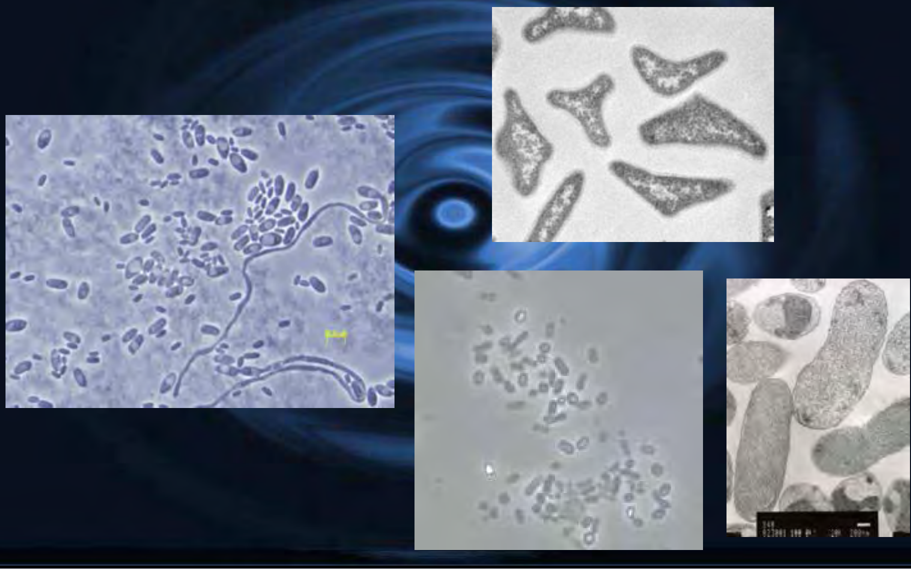
Phylogenetic tree of life



" Bacteria" : important microorganisms in subsurface environment

Size: around 1 µm

Shape: variable



What do they need?

(1) Carbon source

- CO_2 autotrophs
- organic chemicals heterotrophs

(2) Energy source

- light phototrophs
- chemical compounds chemotrophs

(3) Minerals

N, P, Mg, K, Ca, Fe…..

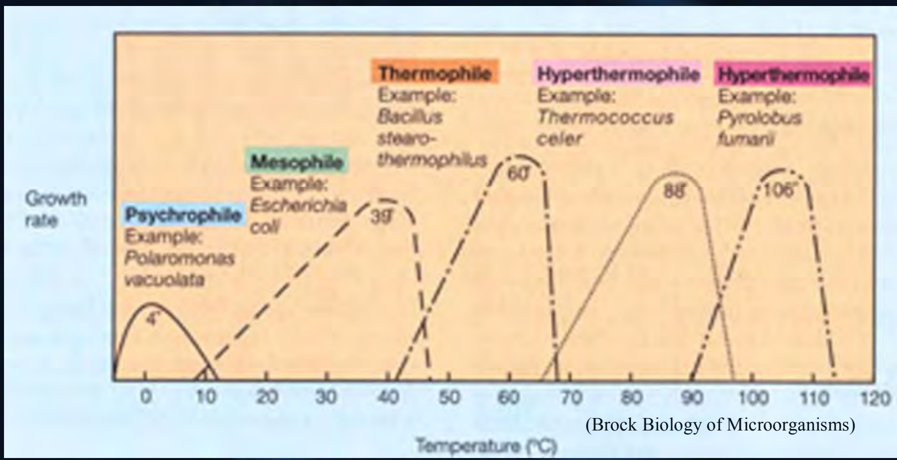
(4) Oxygen

aerobes use oxygen as terminal electron acceptor

anaerobes use chemical compounds as terminal electron acceptor

(5) water

(6) temperature



(Brock Biology of Microorganisms)

(7) pH

Acidophile, alcaliphile....

3. Various functions of bacteria

With organic contaminants: degradation

1. **Hydrocarbons** (aromatic, alkanes, alkenes..)

   effectively degraded under aerobic condition

   (*Pseudomonas*, *Acinetobacter etc.*)

2. **VCOCs (PCE, TCE, DCE…)**

   Low-Cl VCOCs are effectively degraded by aerobic bacteria

   High-Cl VCOCs are effectively degraded by anaerobic bacteria

With metals

1. **Leaching (direct or indirect)**

   leaching with *Thiobacillus* in the copper ore is famous

   $Cu_2S + O_2 \rightarrow CuS + Cu_2+ + H_2O$

2. **Absorption/accumulation**

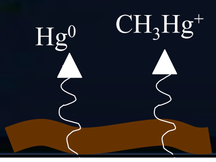
   utilization as a bioreactor (Cd, Cu, Ni, As, Pb, Fe, U..)

3. **Oxidation/Reduction**

   Cr(VI), U(VI) can be insoluble and less toxic when reduced to Cr(III), U(IV)

4. **Volatilization**

   Hg^{2+} is volatilized when reduced to Hg or methylated



Degradation of VCOCs by aerobic bacteria

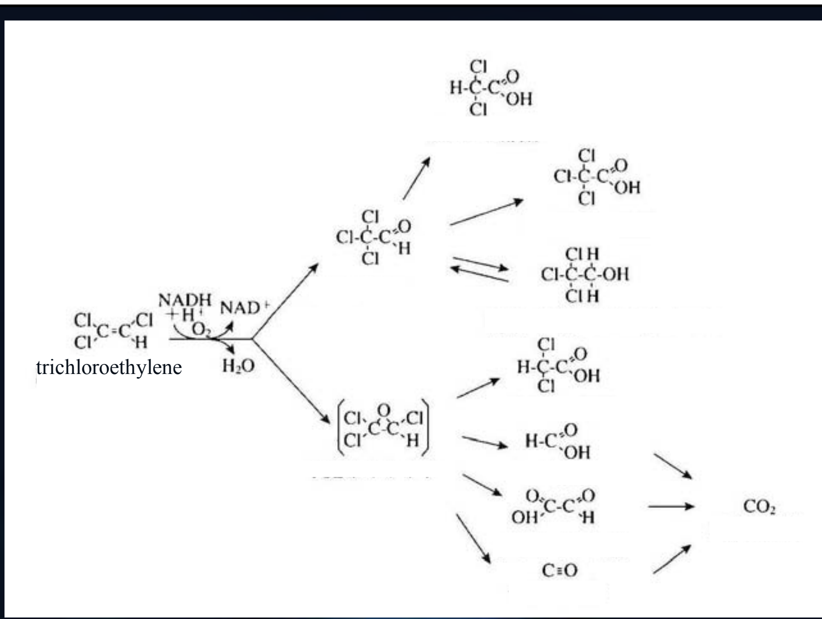
- **Toluen/phenol degrading bacteria**
  - *Pseudomonas cepacia* G4
  - *Psedomonas putida* F1
  - *Pseudomonas mendocina* KR1
  - *Pseudomonas stutzeri* OX1
- **methanotrophic bacteria**
  - *Methylosinus trichosporium* OB3b
  - *Methylocystis* sp. M
  - *Methylomonas methanica* 68-1
- **propane degrading bacteria**
  - *Mycobacterium vaccae* JOB5
- **ammonium oxidizing bacteria**

Nitrosomonas europaea

Degradation by co-metabolisms by oxygenase

↓

They can't use VCOCs as carbon source nor as energy source



Degradation pathway of trichloroethylene by aerobic bacteria

（「バイオレメディエーション実用化への手引き」）

Characteristics of aerobic degradation

- VCOCs are degraded to non-toxic CO_2 and Cl^-
- Degradation is caused by co-metabolism,
  they need other substance
- High-Cl compounds are less degradable

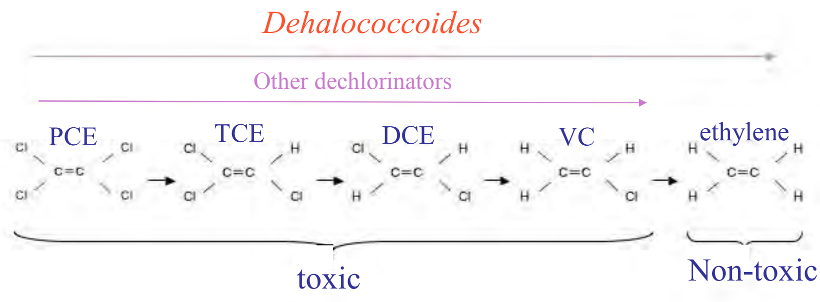
Degradation of VCOCs by anaerobic bacteria

Methanogens, sulfate reducing bacteria, *Dehalococcoides*

Enterobacter agglomerans biogroup 5
Methanosarcina sp. DCM
Sporomusa ovata
Dehalococcoides ethenogenes 195
Dehalobacter restrictus
Dehalospirillum multivorans
Desulfitobacterium sp. Viet1
Desulfuromonas michiganensis BB1

Halorespiration : obtain energy by VCOCs degradation

Utilize H_2, acetate as electron donor, utilize VCOCs as electron acceptor

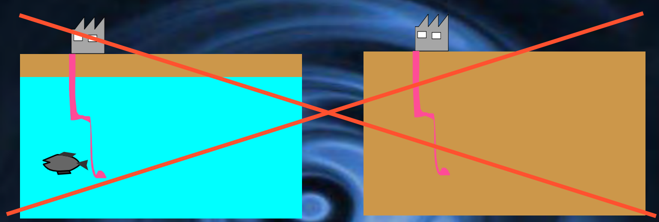


Degradation pathway of tetrachloroethylene by anaerobic bacteria

Characteristics of anaerobic degradation

- In many cases, degradation stops at vinyl-chloride (still toxic)
- Halorespiration, obtain energy through the degradation process
- High-Cl compounds are more degradable

4. How to investigate subsurface contamination

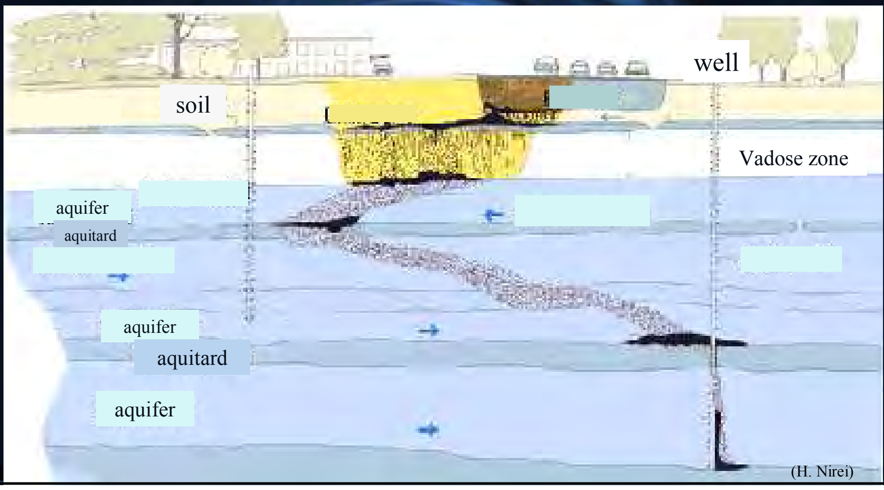


It's not a simple world

It's not a black box

Importance of Geology & Hydrology

It is regulated by geological structure, groundwater flow, and structure of monitoring well



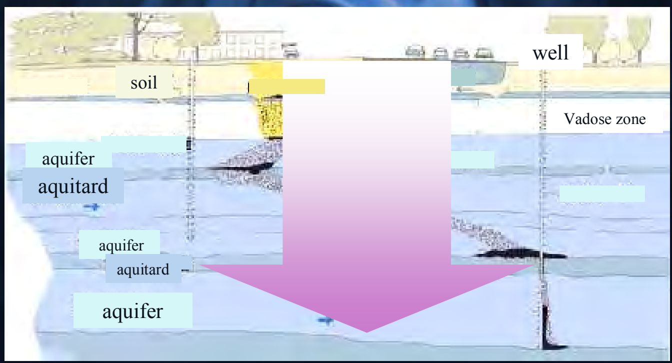
Example of VCOCs contamination

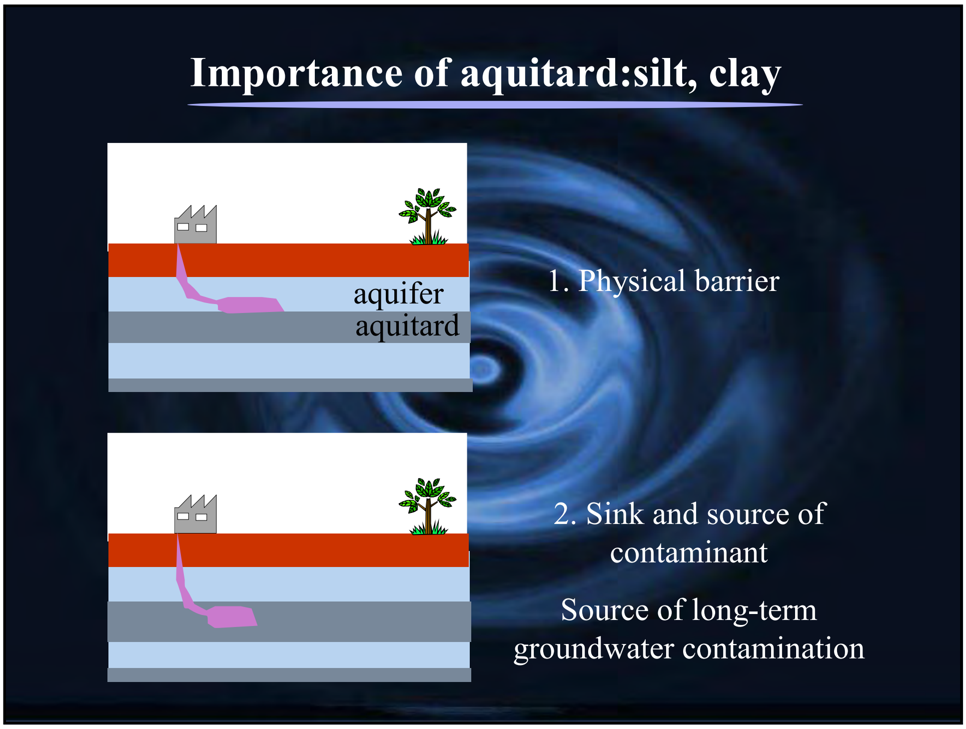
High specific gravity

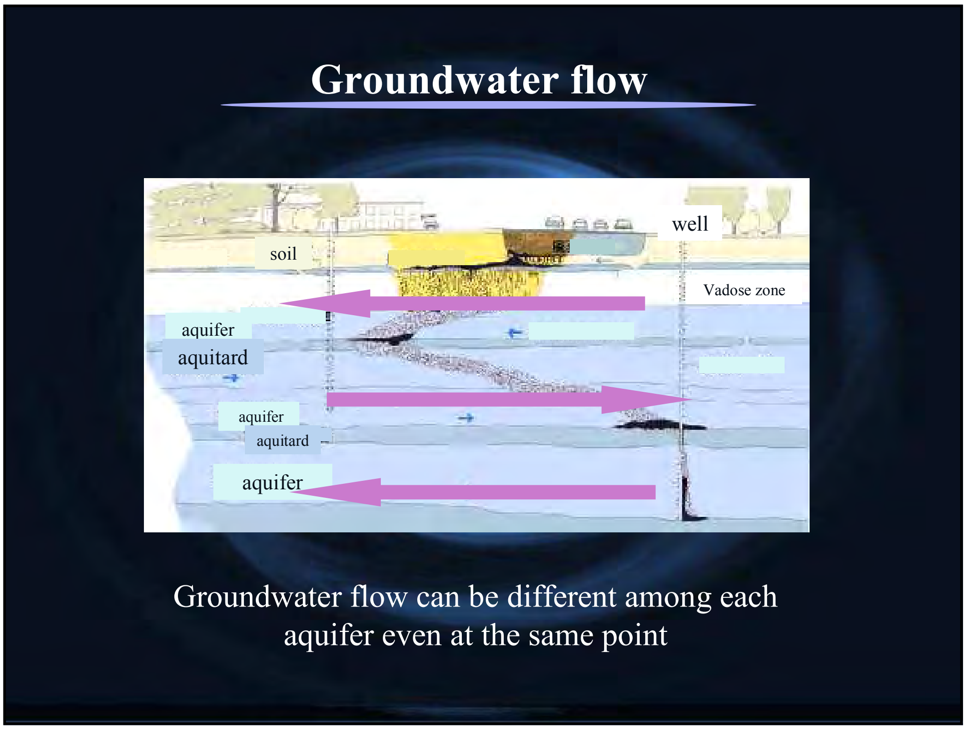
Generally migrate to downward

Hydrauric conductivity varies from

clay: 10^{-7}cm/sec to sand: 10^{-1} cm/sec



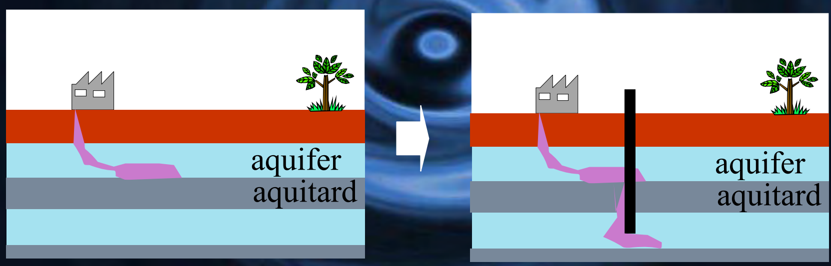

Importance of aquitard:silt, clay
aquifer
aquitard
1. Physical barrier
2. Sink and source of contaminant
Source of long-term groundwater contamination


Groundwater flow
well
soil
Vadose zone
aquifer
aquitard
aquifer
aquitard
aquifer
Groundwater flow can be different among each aquifer even at the same point

Important drilling strategy

1. Check sedimentary facies and contamination at each 1m to find aquitard

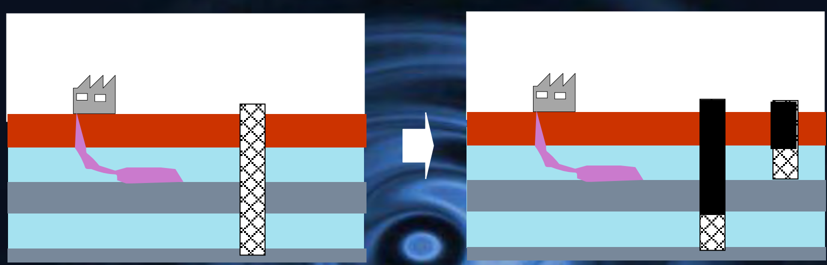
Penetration of aquitard without care can lead to unnecessary expansion of the contaminant



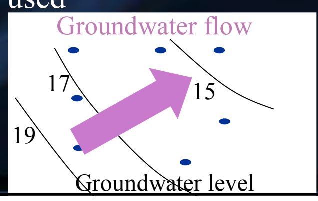
If VCOCs are detected in above the aquitard, casing is necessary

(NPO, The Geo-pollution control agency, Japan)

2. Install monitoring well which has a screen to each one aquifer



- Water from each aquifer, and even surface water can mix inside all-screened well
- In a proper well, groundwater level can be used to know the groundwater flow



(NPO, The Geo-pollution control agency, Japan)

5. Bioremediation utilizing bacteria

1. Biostimulation
   Inject nutrients to contaminated subsurface to stimulate the bacterial activity to degrade contaminants

2. Bioaugmentation
   Incubate bacteria with ability to degrade contaminants in the lab, and inject the cells into the contaminated subsurface

3. Monitored Natural Attenuation (MNA)
   When natural attenuation by intrinsic bacteria are occurring, the risk for the human health can be reduced by monitoring the contamination and controlling it not to further expand (US EPA,1999).

Bioremediation studies on VCOCs contaminated site utilizing methanotrophs

Site	Type of bioremediation	depths(m)	contaminants	Conc.(ppb)	Injected substrate	effect
Moffest[1]	stimulation	4.3-5.8	TCE*	100	CH_4, O_2	23%（2 m downgradient）
Kururi[2]	stimulation	8-17	TCE	200	CH_4, O_2, N, P	10%（ 0.75-1.5m downgradient）
Savanna River[3]	stimulation	27-45	TCE	<14,000	CH_4, O_2, N, P	<95%（monitoring wells）
Chikura[4]	stimulation	12-20	DCE*	35	CH_4 rich groundwater	50&（2 mdowngradient）
Chico[5]	augmentation	26-28	TCE	425	*M. trichosporium*	<98%（injection well）
Abiko[6]	augmentation	3-5	TCE	128	CH_4 rich groundwater	>78%（2 mdowngradient）

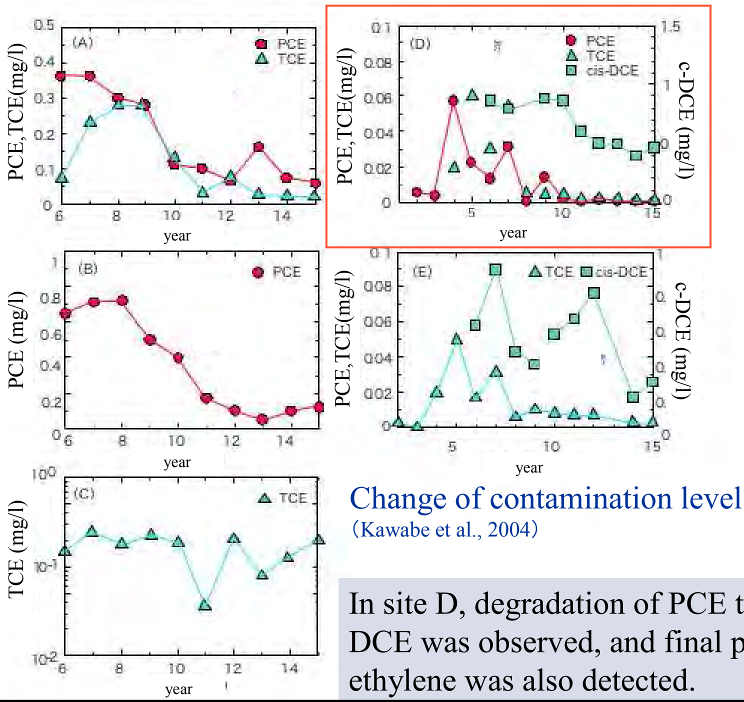
References

1: Roberts et al., 1990; Semprini et al., 1990; Semprini et al., 1991, 2: Eguchi et al., 2001, 3: Pfiffner et al., 1997, 4: Takeuchi et al., 2005, 5: Duba et al., 1996, 6: Takeuchi et al., 2004

Case study-MNA site in Japan

For MNA, precise evaluation of the contamination (source of the contaminant, movement of the contaminant based on geology and hydorology) and microbiology are important.

In Yamagata Prefecture, Japan, we have been monitoring groundwater contamination with VCOCs at 5 sites for almost 10 years.

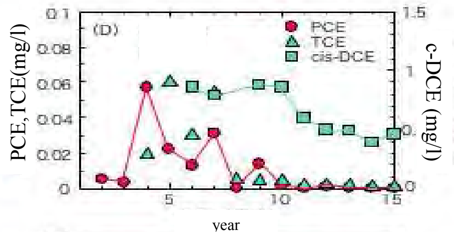


Change of contamination level
(Kawabe et al., 2004)

In site D, degradation of PCE to TCE and DCE was observed, and final product, ethylene was also detected.

PCE is degraded to c-DCE, and gradually decreasing

PCE→TCE→DCE→VC→ethylene (non-toxic)

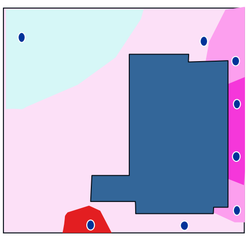


Highest concentration in one well in each year

Site D was designated as MNA candidate, and further study was conducted in this site.

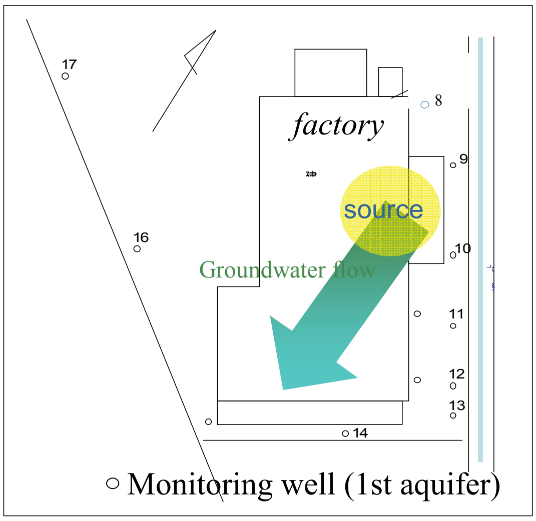
Are there bacteria with PCE degrading ability?

If so, why are they living there?



Contour of groundwater contamination

PCE was considered to be spilled at inside the building of laundry, and spread into the 1st aquifer.



Location of the monitoring wells

・Groundwater was collected from the monitoring wells and served for chemical and microbiological analyses

・Bacteria in the groundwater was collected by filtering 150 ml of groundwater.

・DNA was extracted from the cells, and the copy number of 16S rRNA gene of *Dehalococcoides* (biomass) was determined by Real-time PCR.

Chemical characteristics and the number of *Dehalococcoides* in GW

Deha/Eub (%)	TOC (mg/l)	CH4 (mg/l)	Fe (mg/l)	ORP (mV)	NH4 (mg/l)
0.01-3.7	1.4-16	0.2-4.6	21-181	-42 - +100	0.5-3.5

Deha/Eub: Percentage of *Dehalococcoides* to total bacteria

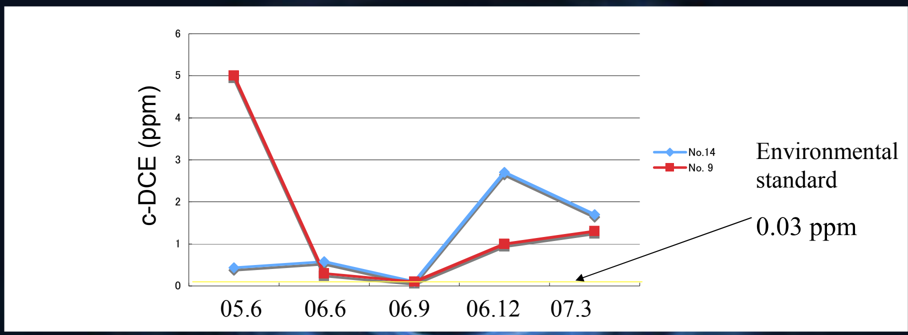
・*Dehalococcoides* existed in every well

・Percentage of *Dehalococcoides* was highest in the well with lowest ORP (highly reduced condition)

・Incubation of groundwater added with PCE exhibited degradation activity.

Natural attenuation must be occurring. Contamination was expected to disappear.

However....



High concentration of c-DCE were still detected in some wells.

Something is wrong.
There must be a source of contamination

When we joined the monitoring program, monitoring wells already existed there.

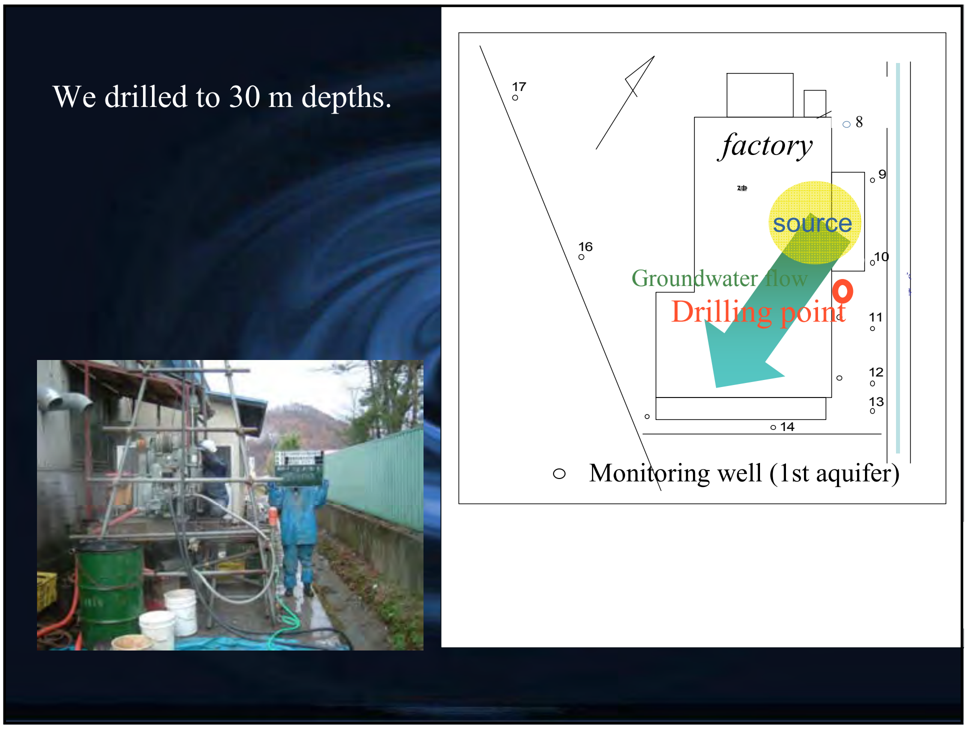
Monitoring wells were all-screened well installed by a private company.

Mechanism of contamination was not very clear.

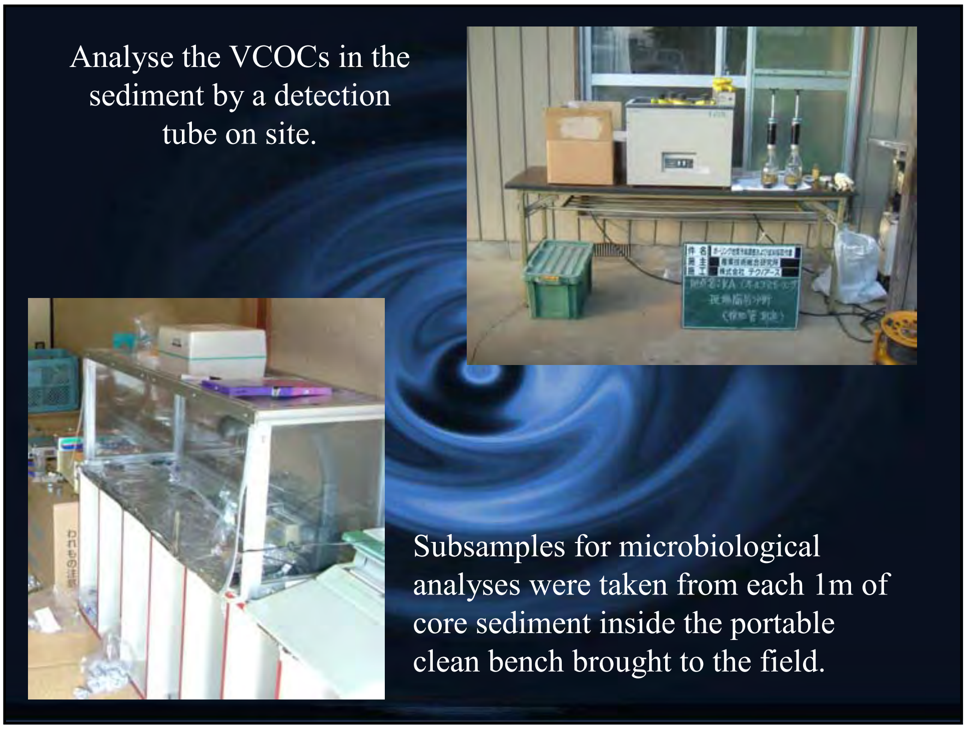
Investigation should be done to get fundamental information on the contamination, geology and hydrology.

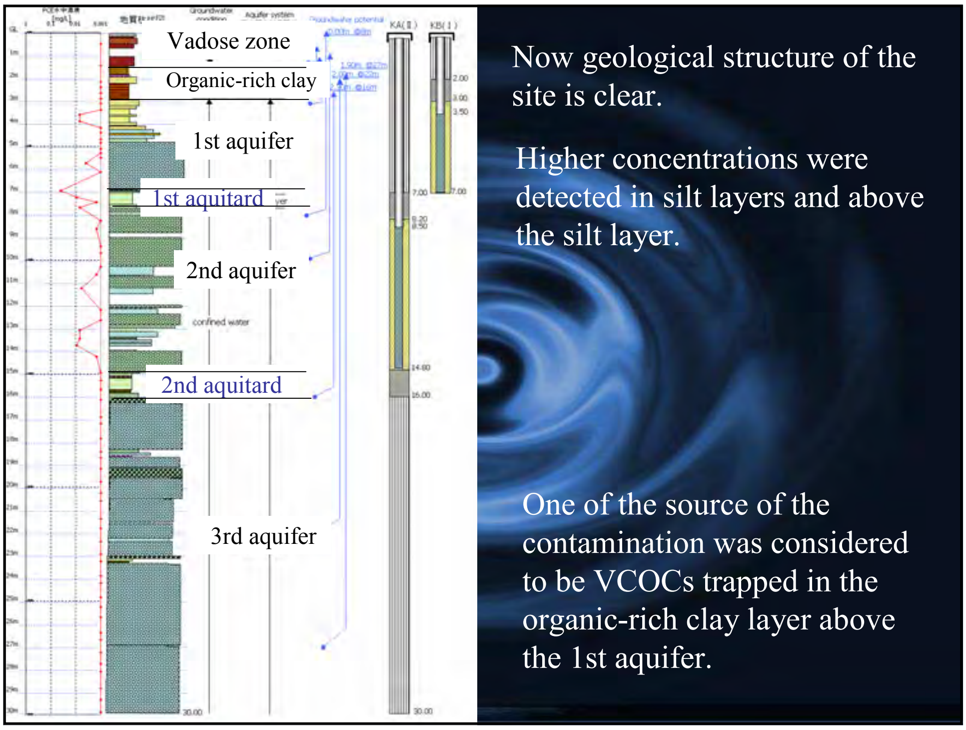
We decided to get a core sediment and install a new monitoring wells to reveal,

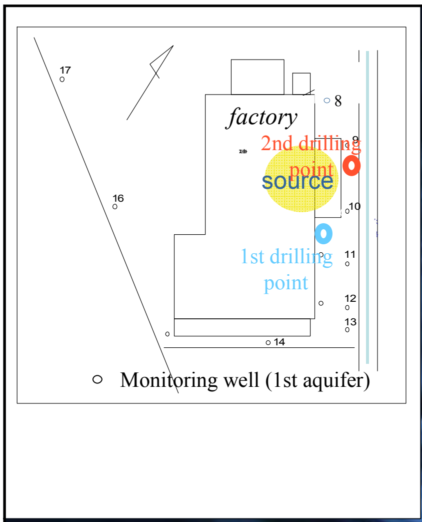
1. Mechanism of contamination, geology, and hydrology
2. Detailed ecology of bacteria which degrade VCOCs


We drilled to 30 m depths.
17
16
8
9
10
11
12
13
14
factory
source
Groundwater flow
Drilling point
Monitoring well (1st aquifer)


Observe sediment facies to reveal geological structure
Take samples from each layer.
Above and below the interface are important zones.

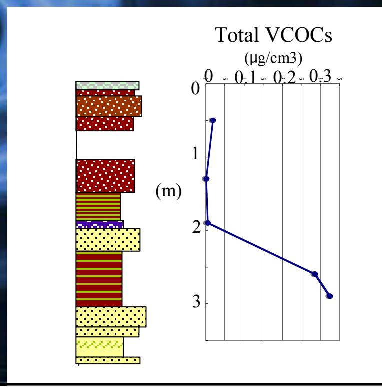

Analyse the VCOCs in the sediment by a detection tube on site.
Subsamples for microbiological analyses were taken from each 1m of core sediment inside the portable clean bench brought to the field.


Vadose zone
Organic-rich clay
1st aquifer
1st aquitard
2nd aquifer
confined water
2nd aquitard
3rd aquifer
Now geological structure of the site is clear.
Higher concentrations were detected in silt layers and above the silt layer.
One of the source of the contamination was considered to be VCOCs trapped in the organic-rich clay layer above the 1st aquifer.

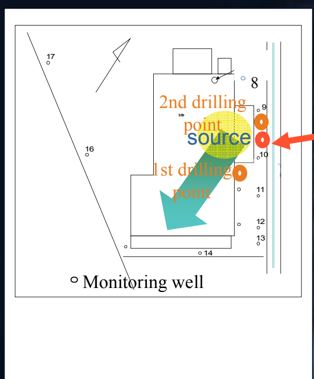


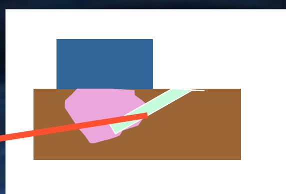
We conducted another boring by hand auger at the nearest point to the VCOCs spill.

High concntration of VCOCs were detected in the clay layer. This was considered to supply VCOCs to the adjacent groundwater.



We found another important source of contaminant.

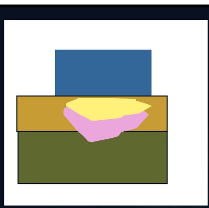




There was another diagonal well directly reach to under the spill point.

We found an oil layer at the upper part of the well containing >200 ppm of c-DCE.

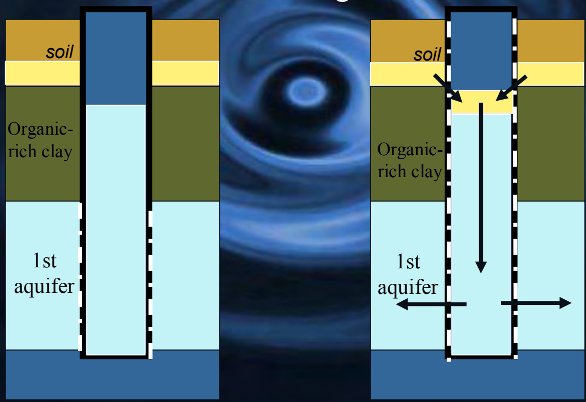
What does this mean?



After they spilled VCOCs, they spilled oil.

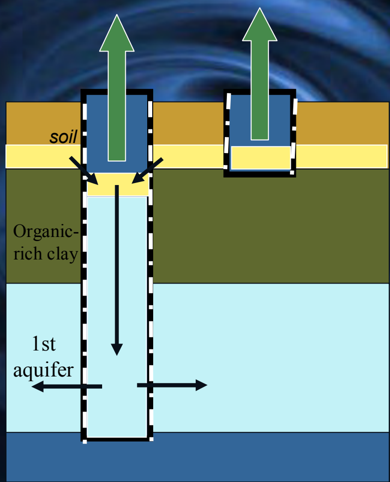
Oil dissolved VCOCs at high concentration and stayed above the clay layer.

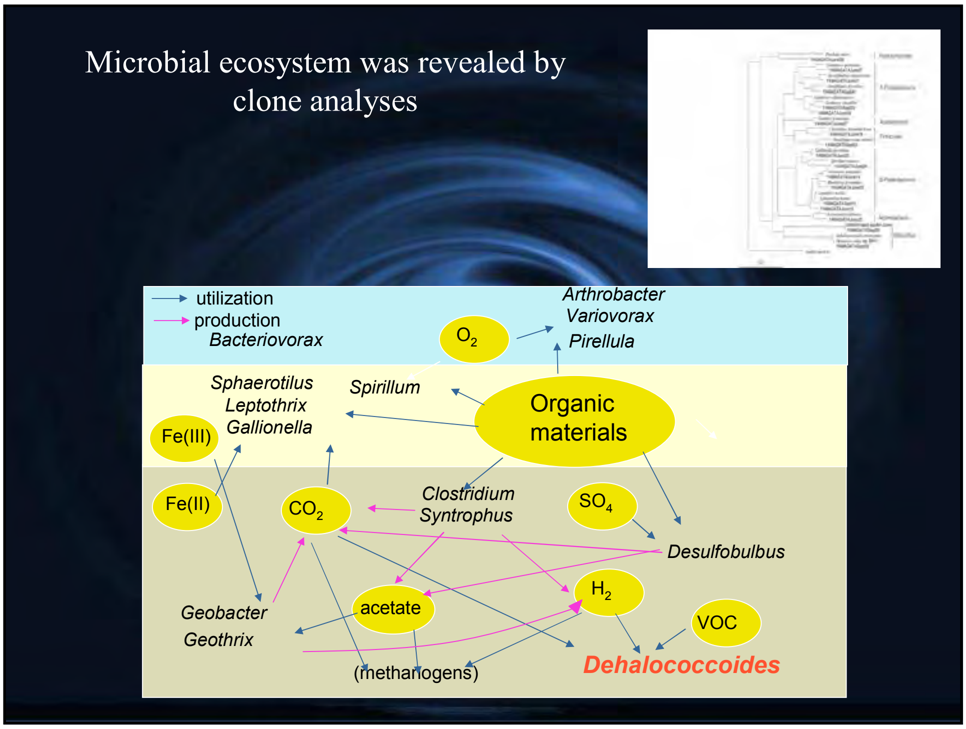
Because it was an all-screened well, the oil moved into the well, may have supplied VCOCs into the groundwater.

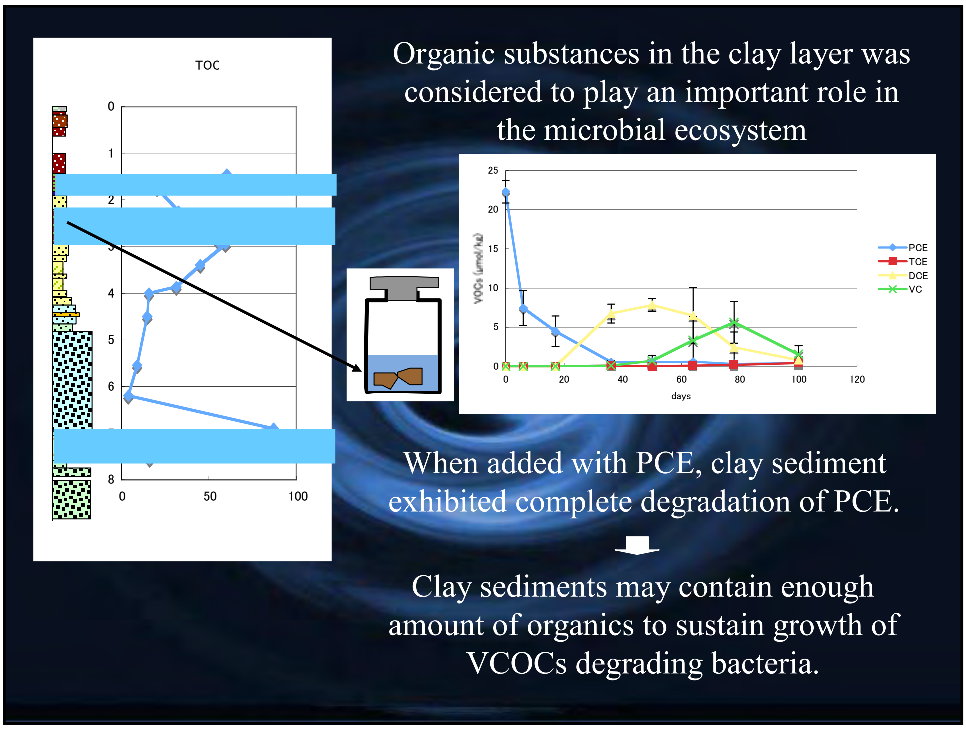


Well for the vadose zone was also installed.

Oil layer with contaminants was extracted.




Microbial ecosystem was revealed by clone analyses
utilization
production
Bacteriovorax
O2
Arthrobacter
Variovorax
Pirellula
Sphaerotilus
Leptothrix
Gallionella
Spirillum
Organic materials
Fe(III)
Fe(II)
CO2
Clostridium
Syntrophus
SO4
Desulfobulbus
H2
acetate
Geobacter
Geothrix
VOC
(methanogens)
Dehalococcoides


TOC
0
1
2
4
5
6
8
0
50
100
Organic substances in the clay layer was considered to play an important role in the microbial ecosystem
25
20
15
10
5
0
0
20
40
60
80
100
120
days
VOCs (μmol/kg)
PCE
TCE
DCE
VC
When added with PCE, clay sediment exhibited complete degradation of PCE.
Clay sediments may contain enough amount of organics to sustain growth of VCOCs degrading bacteria.

Natural attenuation is considered to be occurring in the clay layer and adjacent aquifer using H_2 produced by a degradation of organics in the clay layer.

Monitoring is still on-going after removing the oil layer with high concentration of c-DCE.

By using a proper methodology, we can know what' s going on in subsurface.

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Remediation of Subsurface Contamination Using Bacteria

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Institute for Geo-Resources and Environment,
Geological Survey of Japan, AIST

Abstract

Contamination of subsurface environments (soil, groundwater) is a world wide environmental issue. There are many bacteria in subsurface environments and some of them help us to maintain clean environments. I would like to introduce various abilities of bacteria and a case study at the contaminated site in Japan.

独立行政法人
産業技術総合研究所
National Institute of Advanced Industrial Science and Technology (AIST)

APEC Seminar
GSJ, AIST, 071129

Soil and Groundwater Contamination

Determining the transport properties of low-permeability geological materials in the laboratory

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Institute for Geo-Resources and Environment,
National Institute of Advanced Industrial Science and Technology (AIST)
(m.zhang@aist.go.jp)

Outline

The accurate characterization of transport properties of low-K Environments has important practical implications:

*Soil and Groundwater Contamination
*Geological disposal of radioactive nuclear wastes

Principal mechanisms of mass/fluid transport in geologic media

*Advection	Hydraulic/flow properties	Permeability tests	PART I
*Dispersion	Diffusive transport properties	Diffusion tests	PART II

*Chemical reaction, *Chain decay, *Biochemical retardation, etc.

Characteristics of geologic media	Test methods
Fractured Heterogeneous	In-situ
Continuous Homogeneous geologic materials	In laboratory

Part I: Laboratory permeability tests

1) Review advancements in theoretical analyses of 3 techniques
   (Const.-Head, Const.-Flow Rate & Transient-Pulse K Tests)
2) Present potential strategies for effectively decreasing the time
   (Required to estimate the low-K)
3) Introduce a new and versatile laboratory system
   (Can implement any of the 3 test methods)
4) Show a series of experimental results
   Demonstrate the accuracy and efficiency
5) Re-classification & further developments of lab. K tests
   6 kinds of test methods and rigorous solutions to them
6) Further improvements in laboratory system
   Automation of lab. system operation & data analyses

* Lab. Permeability Tests and Theories *

4 Laboratory Techniques

- Constant-Head(CH)
- Falling-Head(FH*)

Measuring induced flow rates

(Estimate the K of A Saturated Specimen)

- Const. Flow-Rate(FP)
- Transient-Pulse(TP)

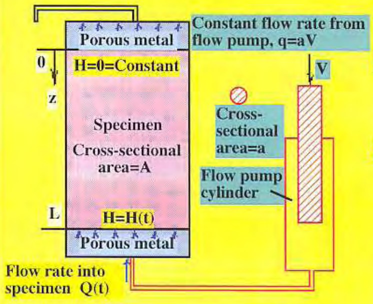
Measuring time-dependent variations of differential hydraulic head

*A special case of a TP permeability test

• Cont. F. R. Technique as an Example

* Lab. Permeability Tests and Theories *

Constant Flow-Rate



Schematic diagram

Governing Equ.

$$\frac{\partial^2 H}{\partial z^2} - \frac{S_S}{K} \cdot \frac{\partial H}{\partial t} = 0$$

Initial condition

$$H = 0 \quad at \quad 0 \le z \le L$$

Boundary condition

$$H = 0 \quad at \quad z = 0$$

$$\frac{\partial H}{\partial z} = \frac{1}{KA}\left(q - C_e \frac{\partial H}{\partial t}\right) \quad at \quad z = L$$

$Q\ (t)$

➡ Rigorous Analytical Solution

The initial condition: hydraulic head within the specimen before a test is zero;
Boundary conditions: at the outflow end the hydraulic head is kept to be zero;
at the inflow end, the actual flow rate into specimen Q(t) equals the constant flow rate from flow pump q minus the volume absorbed within the permeating system per unit time interval due to the increase in hydraulic head within it. Ce: equipment compliance.

* Lab. Permeability Tests and Theories *

Rigorous analytical solution

$$H = \frac{qL}{AK}\left[\frac{z}{L} - 2\sum_{n=0}^{\infty} \frac{exp\left(-\frac{K}{S_S}\beta_n^2 t\right) sin\left(\beta_n z\right)}{L\delta\beta_n cos\left(\beta_n L\right)\left[L\left(\beta_n^2 + \frac{1}{\delta^2}\right) + \frac{1}{\delta}\right]}\right]$$

Darcy's Law

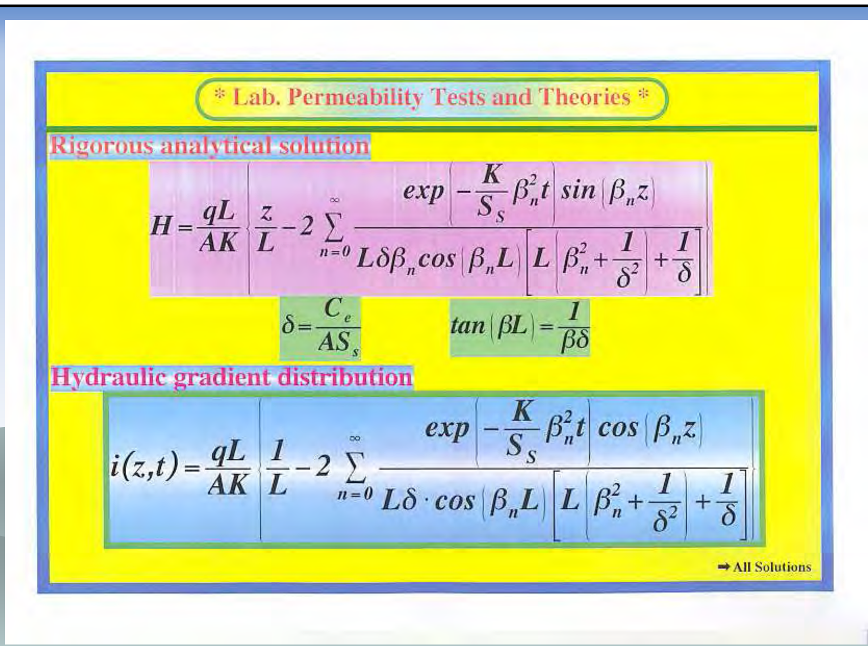
$$\delta = \frac{C_e}{AS_s} \qquad tan\left(\beta L\right) = \frac{1}{\beta\delta}$$

Morin and Olsen (1987)

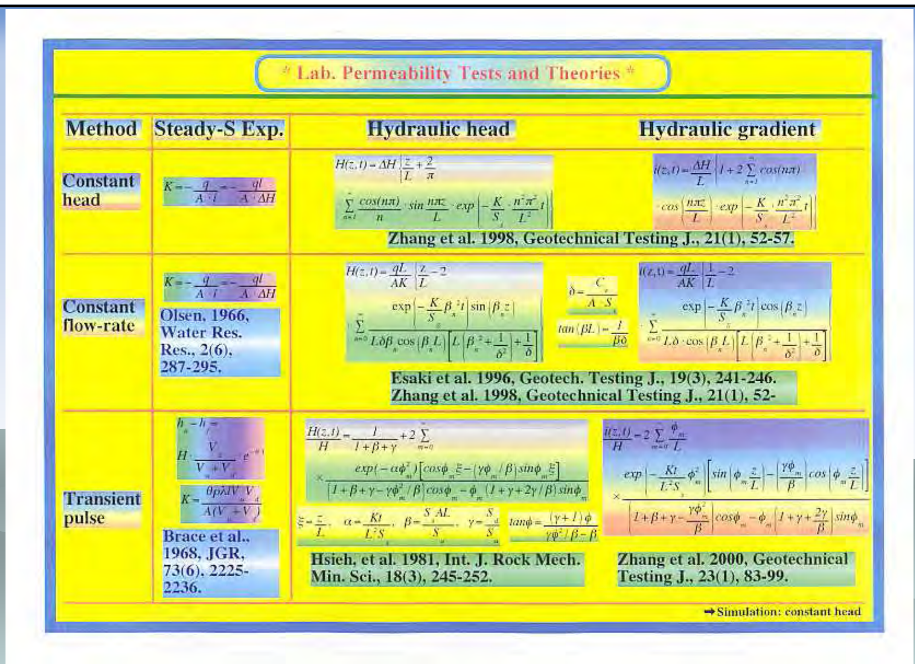
$$H = \frac{qL}{AK}\left[1 - \frac{8}{\pi^2}\sum_{n=0}^{\infty} \frac{exp\left[-\frac{K}{S_S}\left(2n+1\right)^2 \pi^2\, t / 4L^2\right]}{\left(2n+1\right)^2}\right]$$

➡ Hydraulic Gradient Distribution

Allow z=L & disregard the Ce, the solution reduces to the expression as developed by Dr. Morin & Dr. Olsen. A large times, simplifies to the steady state expression as defined by Darcy's Law.

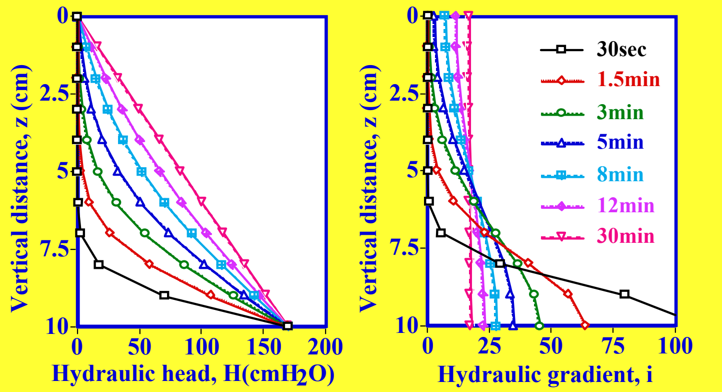


***i* can be obtained by differentiating the analytical solution with respect to the variable z**
Maximum value of *i* during a test can be controlled by q of the pump.



Using the rigorous analytical solutions together with properly set conditions, particular response characteristics of each technique can be simulated and evaluated.

* Lab. Permeability Tests and Theories *



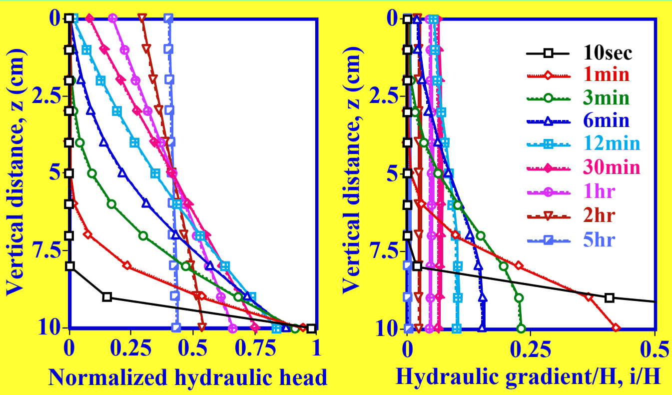
Constant-Head Permeability Test

Conditions used for simulation:
A=19.625 cm^2; L=10 cm; △H=170 cmH$_2$O; K=5E-9 cm/s; Ss=2E-7 1/cm
Geometric dimensions Const.-Head Hydraulic parameters

• Simulation: TP

Increase in hydrau. head at the base of specimen at the onset of the experiment is abrupt, Magnitude of imposed i can be significantly greater than the final steady state magnitude.

* Lab. Permeability Tests and Theories *



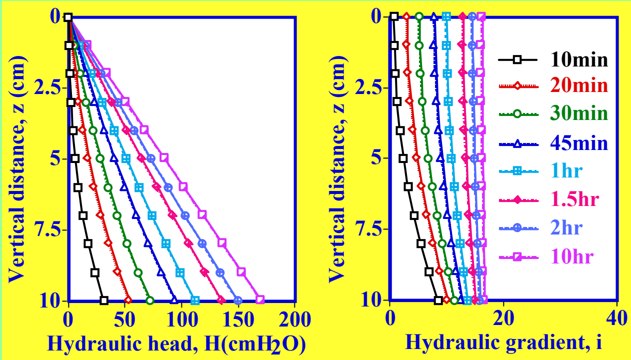
Transient-Pulse Permeability Test

Conditions used for simulation: A=19.625 cm^2; L=10 cm;
K=5E-9 cm/s; Ss=2E-7 1/cm; C_{ew}=1E-6 1/cmH$_2$O; V_u=V_d=100 cm^3

• Simulation: FP

Similar observations can be made, except that the boundary conditions are different.

* Lab. Permeability Tests and Theories *



Constant Flow-Rate Permeability Test

Conditions used for simulation: A=19.625 cm^2; L=10 cm; K=5E-9 cm/s; Ss=2E-7 1/cm; q=0.1 μ L/min; C_e=2E-5 cm^2

Control the maxim. *i*

• Simulation: Summary

At the onset of the experiment, the increase in hydr. head at the base of the specimen is gradual *i* are established slowly across the entire specimen until a steady-state bound is reached that is also the maximum *i* controlled by the flow rate of the pump.

* Lab. Permeability Tests and Theories *

Systematically changing the values of selected parameters

- Effects on individual lab. tests

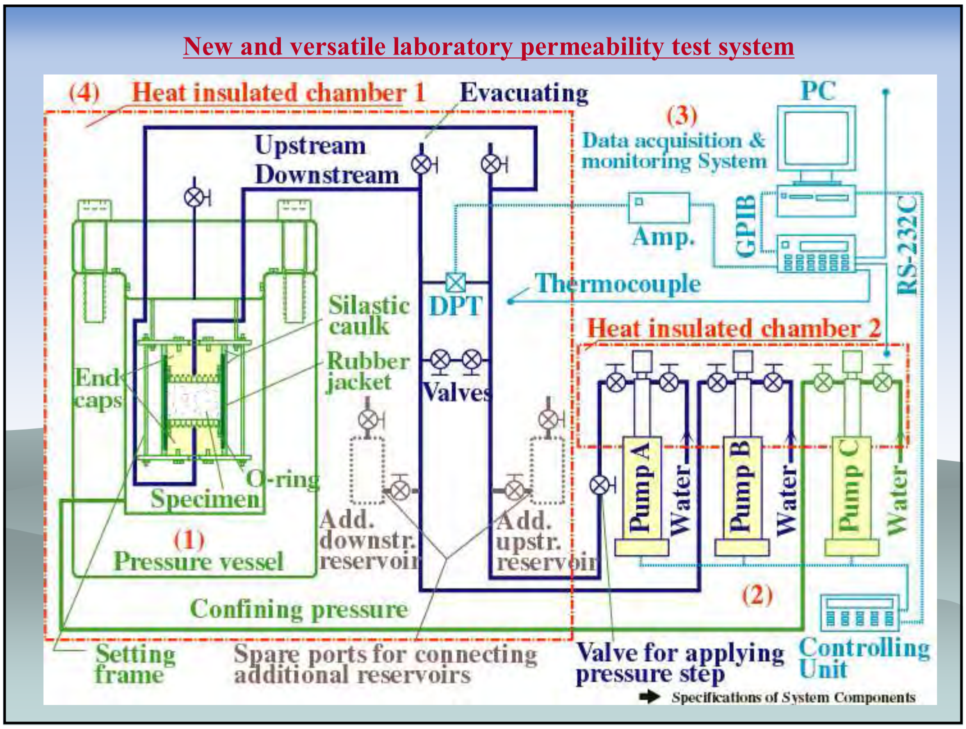
Major observations:

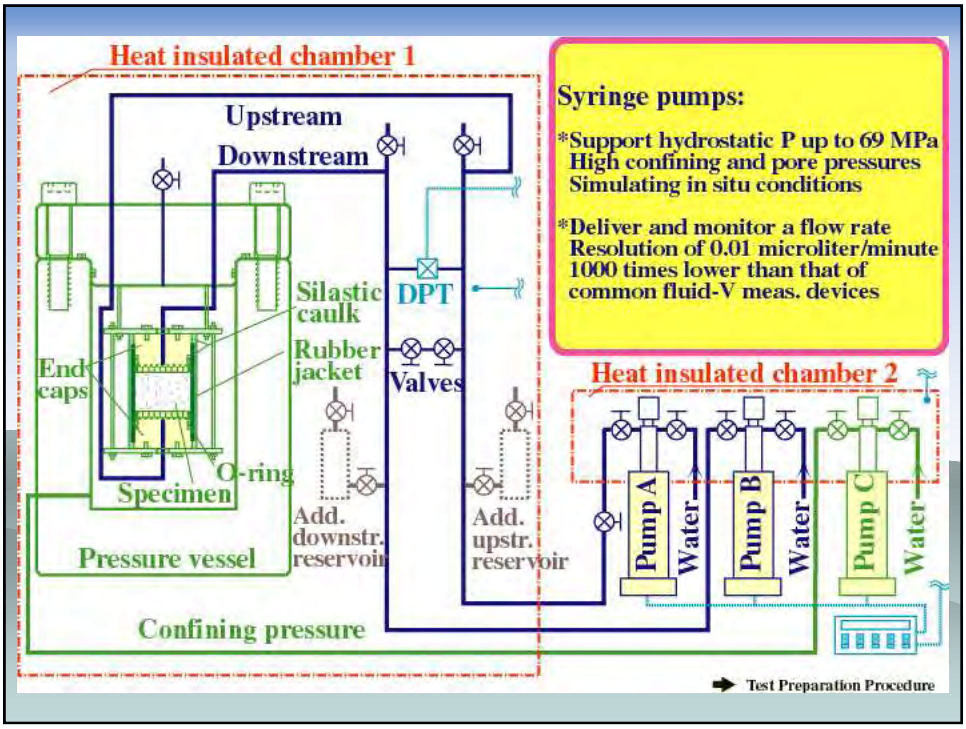
- To shorten the T required to measure low K
  To use a shorter specimen having a larger A

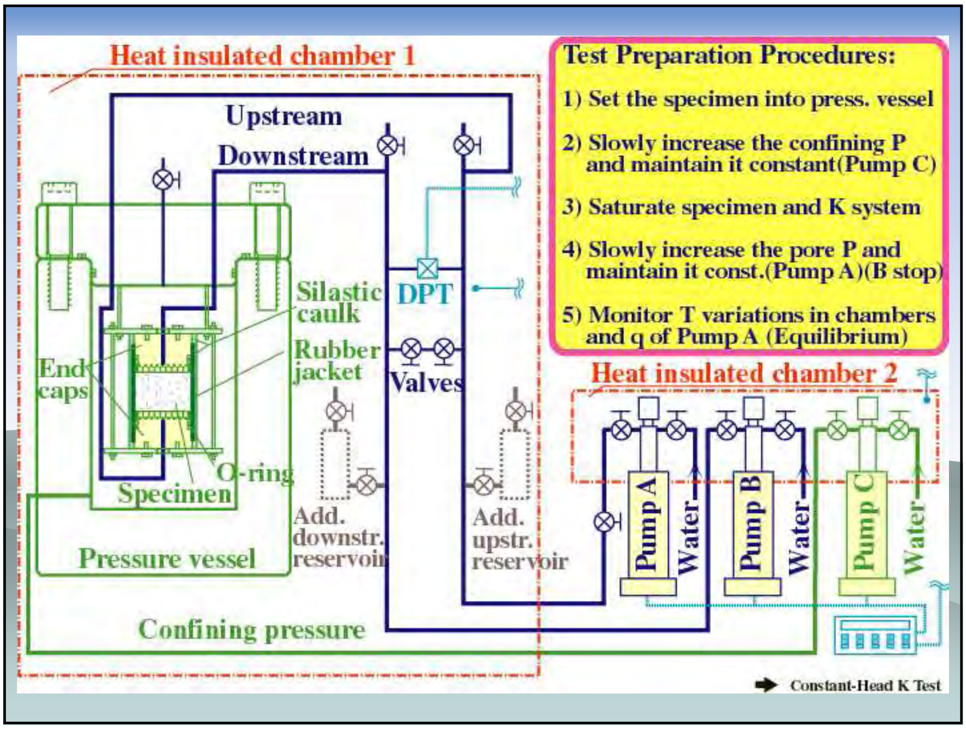
New criteria for determining the optimum specimen size
*The miximum grain size
*The miximum length of micro-crack

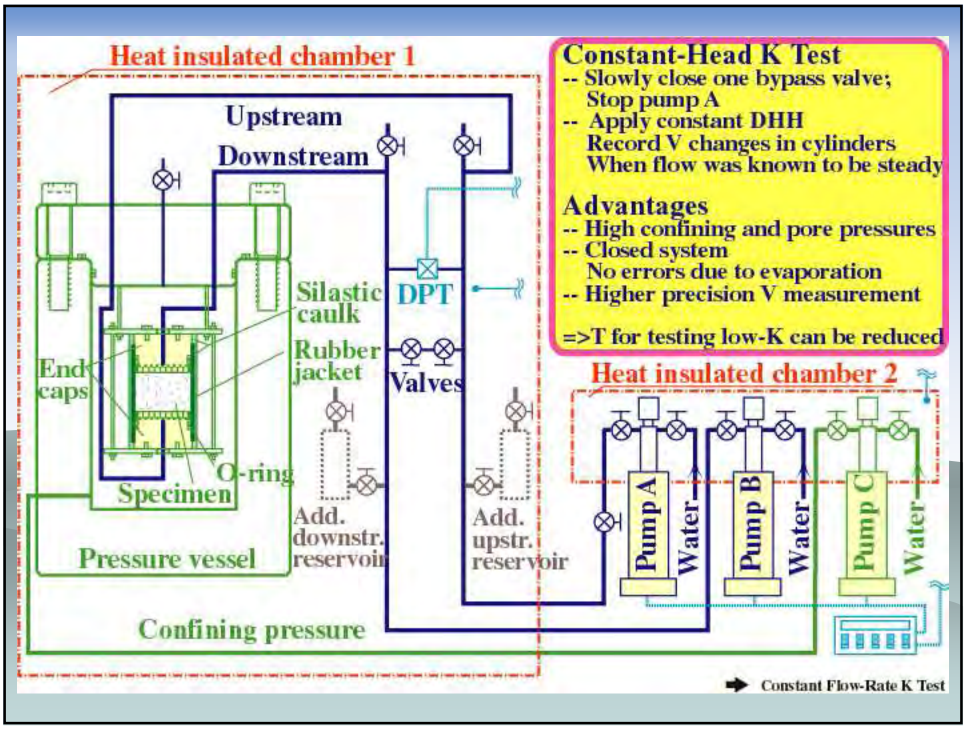
D, L of specimen > 5-10 times the physical parameters ?!

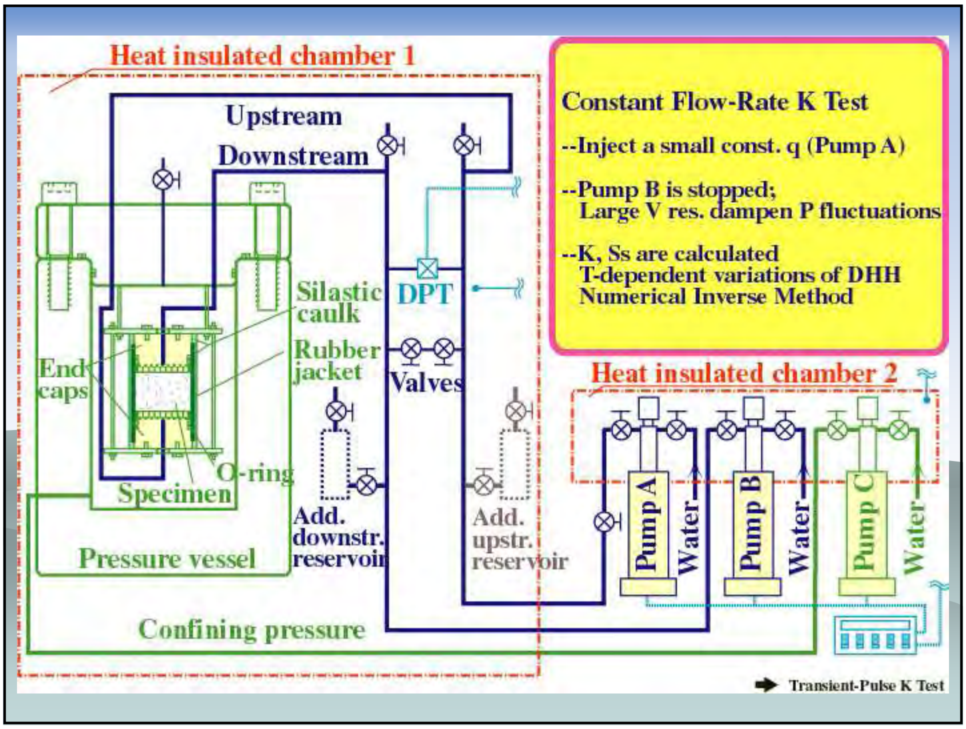
Omit Numerical Inverse Method: • New & Versatile Lab. K Test System

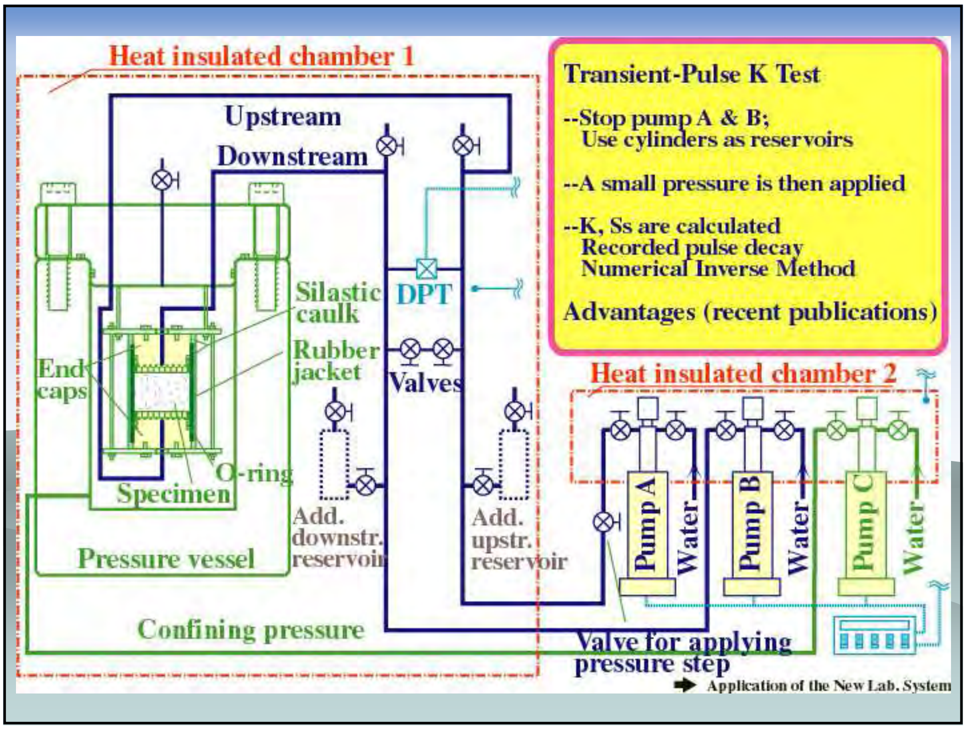

New and versatile laboratory permeability test system
(4) Heat insulated chamber 1
Evacuating
PC
(3)
Data acquisition & monitoring System
Upstream
Downstream
Amp.
GPIB
RS-232C
Thermocouple
Silastic caulk
DPT
Heat insulated chamber 2
Rubber jacket
End caps
Valves
Pump A
Water
Pump B
Water
Pump C
Water
O-ring
Specimen
Add. downstr. reservoir
Add. upstr. reservoir
(1)
Pressure vessel
(2)
Confining pressure
Setting frame
Spare ports for connecting additional reservoirs
Valve for applying pressure step
Controlling Unit
Specifications of System Components

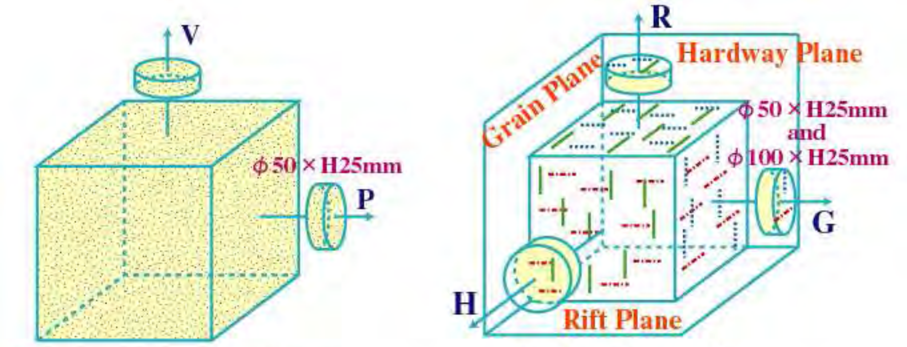

Heat insulated chamber 1
Upstream
Downstream
Syringe pumps:
*Support hydrostatic P up to 69 MPa
High confining and pore pressures
Simulating in situ conditions
*Deliver and monitor a flow rate
Resolution of 0.01 microliter/minute
1000 times lower than that of
common fluid-V meas. devices
Silastic caulk
DPT
Rubber jacket
Valves
End caps
Heat insulated chamber 2
O-ring
Specimen
Add. downstr. reservoir
Add. upstr. reservoir
Pump A
Water
Pump B
Water
Pump C
Water
Pressure vessel
Confining pressure
Test Preparation Procedure


Heat insulated chamber 1
Upstream
Downstream
Silastic caulk
Rubber jacket
End caps
O-ring
Specimen
Pressure vessel
DPT
Valves
Add. downstr. reservoir
Add. upstr. reservoir
Confining pressure
Test Preparation Procedures:
1) Set the specimen into press. vessel
2) Slowly increase the confining P and maintain it constant(Pump C)
3) Saturate specimen and K system
4) Slowly increase the pore P and maintain it const.(Pump A)(B stop)
5) Monitor T variations in chambers and q of Pump A (Equilibrium)
Heat insulated chamber 2
Pump A
Water
Pump B
Water
Pump C
Water
Constant-Head K Test


Heat insulated chamber 1
Upstream
Downstream
Silastic caulk
Rubber jacket
End caps
O-ring
Specimen
Pressure vessel
DPT
Valves
Add. downstr. reservoir
Add. upstr. reservoir
Confining pressure
Constant-Head K Test
-- Slowly close one bypass valve; Stop pump A
-- Apply constant DHH Record V changes in cylinders When flow was known to be steady
Advantages
-- High confining and pore pressures
-- Closed system No errors due to evaporation
-- Higher precision V measurement
=>T for testing low-K can be reduced
Heat insulated chamber 2
Pump A
Water
Pump B
Water
Pump C
Water
Constant Flow-Rate K Test


Heat insulated chamber 1
Upstream
Downstream
Silastic caulk
DPT
Rubber jacket
Valves
End caps
O-ring
Specimen
Add. downstr. reservoir
Add. upstr. reservoir
Pressure vessel
Confining pressure
Constant Flow-Rate K Test
--Inject a small const. q (Pump A)
--Pump B is stopped;
Large V res. dampen P fluctuations
--K, Ss are calculated
T-dependent variations of DHH
Numerical Inverse Method
Heat insulated chamber 2
Pump A
Water
Pump B
Water
Pump C
Water
Transient-Pulse K Test


Heat insulated chamber 1
Upstream
Downstream
Silastic caulk
DPT
Rubber jacket
Valves
End caps
O-ring
Specimen
Add. downstr. reservoir
Add. upstr. reservoir
Pressure vessel
Confining pressure
Transient-Pulse K Test
--Stop pump A & B;
Use cylinders as reservoirs
--A small pressure is then applied
--K, Ss are calculated
Recorded pulse decay
Numerical Inverse Method
Advantages (recent publications)
Heat insulated chamber 2
Pump A
Water
Pump B
Water
Pump C
Water
Valve for applying pressure step
Application of the New Lab. System



a) Shirahama sandstone (Sedimentary rock)

b) Inada granite (Igneous rock)

- To investigate the effects of heterogenity on rock K
  Parallel to and perpendicular to bedding for sandstone
  Perpendicular to Rift, Grain and Hardway Planes for granite
- Disc-shaped cylindrical specimens (see Figs) were used
  To reduce the time required for a test.

➡ Testing Strategies

* Application of the New Lab. System *

Testing Strategies

- To evaluate the capabilities of the new lab. system
- To cross-check the results obtained from the 3 methods
  Sandstone (SVS) & Granite (GHL)
  A series of confining & pore P conditions
- To investigate the effects of confining P & rock heterogenity
  A series of K tests was performed
  Specimens cored in different orientations for both rocks
  Confining P was increased stepwise up to 60 MPa
  A TP test was conducted at each step

• Conditions for Cross-check K Tests; Test No.

* Application of the New Lab. System *

Part of the Conditions

Table 4 Conditions for cross-check K tests.

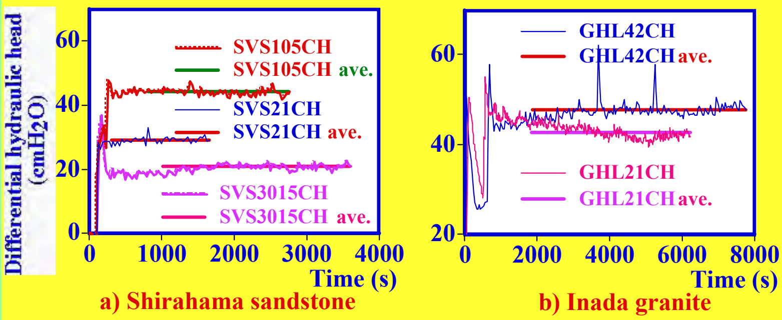
Shirahama sandstone				Inada granite			
Test No.	Conf. P (MPa)	Pore P (MPa)	Other condi.*	Test No.	Conf. P (MPa)	Pore P (MPa)	Other cond.*
SVS21CH			29.1	GHL1.5CH			29.4
SVS21FP	2	1	0.005	GHL1.5FP	1	0.5	0.002
SVS21TP			68.4	GHL1.5TP			34.9
•	•	•	•	•	•	•	•
SVS4020CH	40	20	31.4	GHL302FP	30	2	0.0002
SVS4020TP			76.2	GHL302TP			117.7

Rock type: S-sandstone; G-granite
Orientation: V, P-Perpend. to & parall. to bedding for sandstone
R,G,H-Perpend. to Rift, Grain & Hardway Planes for granite
Specimen size: S-D50 X H25mm; L-D100 X H25mm
Pressure conditions: Confining and pore P in MPa
Test method: CH-Constant Head; FP-Constant Flow Rate(Flow Pump); TP-Transient Pulse

*Other conditions: Hydraulic head in cmH_2O for CH; q in cm^3/min for FP; Pulse pressure in cmH_2O for TP

• Examples of CH Results

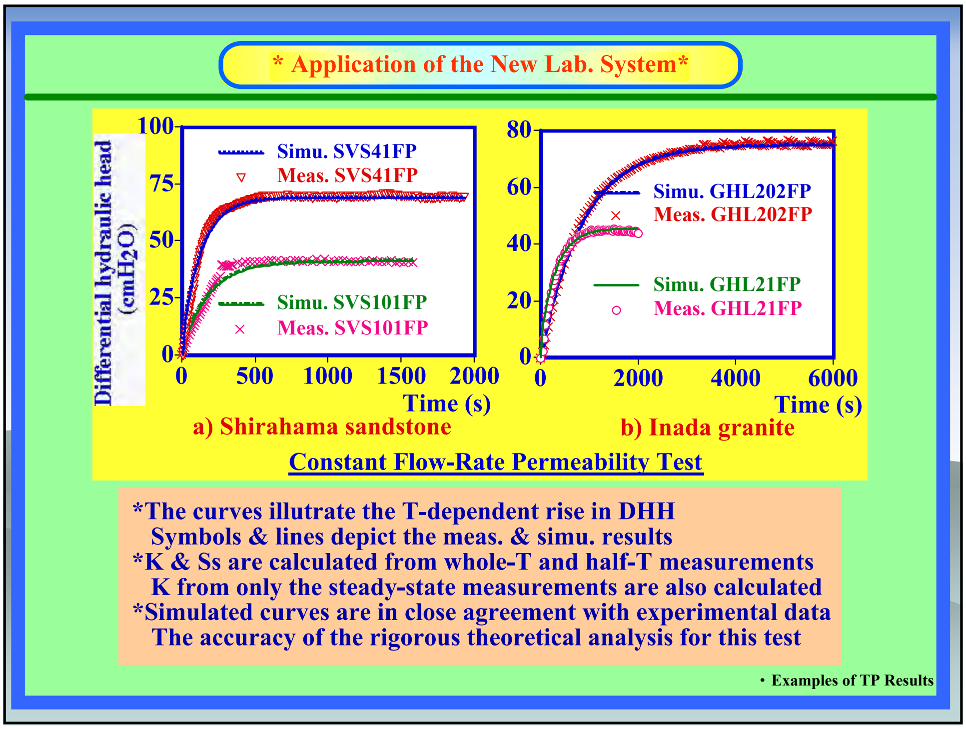
* Application of the New Lab. System*

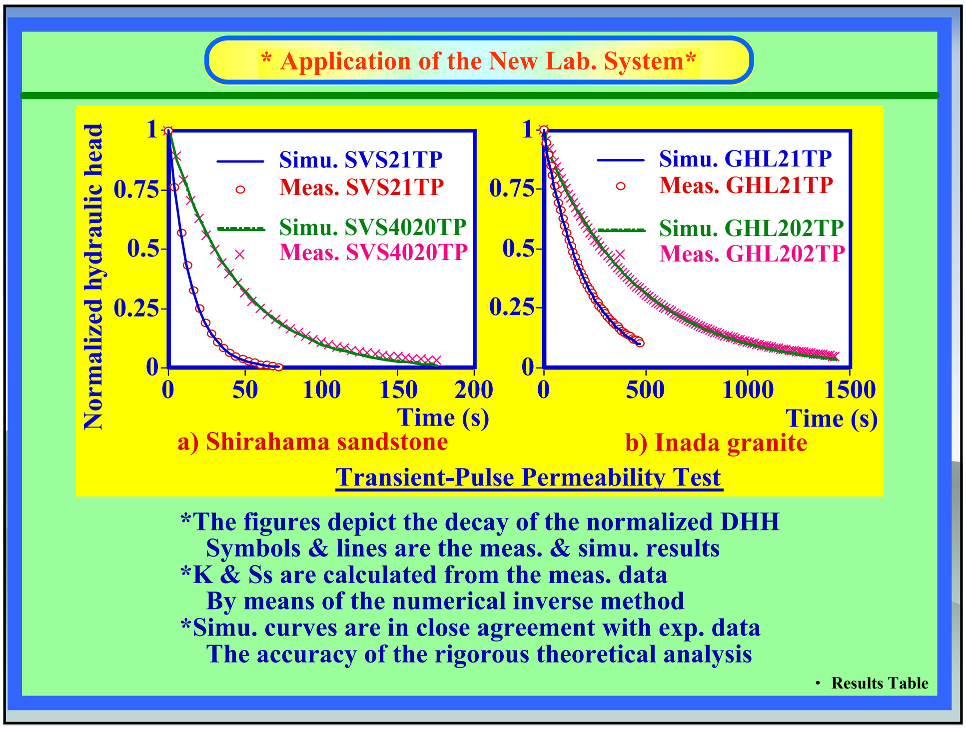


Constant-Head Permeability Test

*Each curve illustrates the T-dependent variations in DHH across the specimen
*After a certain period of T, the DHH approaches a quasi-steady state
*Changes in inflow & outflow volumes are measured over a certain T span
*The values of K are calculated from the inflow & outflow rates and their ave.

• Examples of FP Results


* Application of the New Lab. System*
Differential hydraulic head (cmH2O)
Simu. SVS41FP
Meas. SVS41FP
Simu. SVS101FP
Meas. SVS101FP
Time (s)
a) Shirahama sandstone
Simu. GHL202FP
Meas. GHL202FP
Simu. GHL21FP
Meas. GHL21FP
Time (s)
b) Inada granite
Constant Flow-Rate Permeability Test
*The curves illustrate the T-dependent rise in DHH
Symbols & lines depict the meas. & simu. results
*K & Ss are calculated from whole-T and half-T measurements
K from only the steady-state measurements are also calculated
*Simulated curves are in close agreement with experimental data
The accuracy of the rigorous theoretical analysis for this test
• Examples of TP Results


* Application of the New Lab. System*
Normalized hydraulic head
Simu. SVS21TP
Meas. SVS21TP
Simu. SVS4020TP
Meas. SVS4020TP
Time (s)
a) Shirahama sandstone
Simu. GHL21TP
Meas. GHL21TP
Simu. GHL202TP
Meas. GHL202TP
Time (s)
b) Inada granite
Transient-Pulse Permeability Test
*The figures depict the decay of the normalized DHH
Symbols & lines are the meas. & simu. results
*K & Ss are calculated from the meas. data
By means of the numerical inverse method
*Simu. curves are in close agreement with exp. data
The accuracy of the rigorous theoretical analysis
• Results Table

* Application of the New Lab. System*

Table 5 Results obtained from the cross-check tests. (T= 15 ℃)

	Test No.	Constant-head				Constant-flow rate(FP)				Trans.-pulse	
		K_i	K_o	K_{ave}.	Time	K_h	K_w	K_s	Time	K	Time
Sand-stone		Omit				Omit				Omit	
Granite	GHL1.5	3.06	4.29	3.68	3 240	4.57	4.51	4.53	2 970	5.91	792
	GHL21	4.14	3.10	3.62	5 775	4.28	4.77	4.85	1 980	6.61	470
	GHL42	3.51	3.28	3.40	5 788	3.88	4.10	4.11	2 790	7.12	940
	...	...	...	...	...	...	...	...	...	...	...

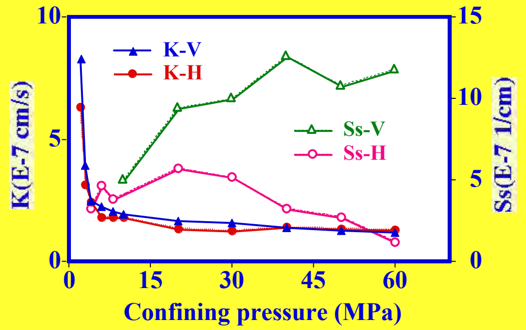
K : ($\times 10^{-9}$ cm/s); Time: s; K_i & K_o : K obtained from inflow & outflow;
h, w & s: Half-time, whole-time and steady-state

*K values obtained from the three tests are on the same order
- Measuring substantial changes in hydr. P at early T in TP test?
- Very small plumbing leaks?
- Slight temperature variations?

*K from half-T & whole-T estimation during a FP test are the same
In close agreement with the steady-state estimation
=> Numerical inverse method based on rigorous theoretical analysis permits to reduce the T required for testing low-K specimens

• Effects of Pc on K, Ss of Shirahama sandstone

* Application of the New Lab. System*

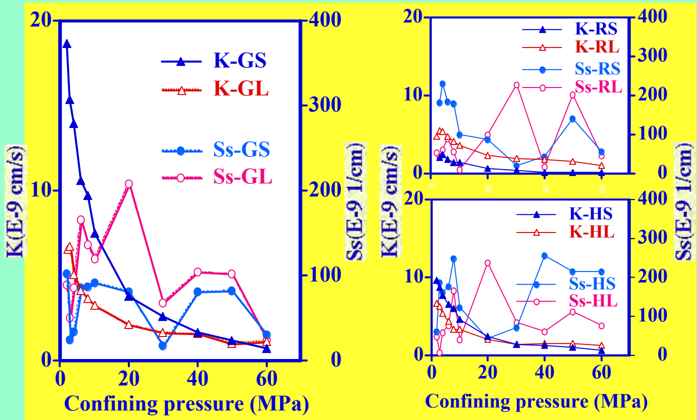


Effects of confining P & heterogeneity on K & Ss of Shirahama sandstone.

• Effects of Pc on K and Ss of Inada granite

The tests were performed under Pp be kept at 1 Mpa and the Pc increased stepwise up to 60 Mpa.
K ranged from about 8 to 1 E-7 in cm per second, and Ss ranged from about 13 to 1 E-7 in per cm, respectively.
The reduction in K is due to the closure of microcracks with increment in confining pressure.
The variation in Ss may be due to a cyclical generation and closure of secondary microcracks formed perpend. to the contacting surface between grains during hydrostatic crushing.
The K in the directions perpendicular and parallel to bedding are almost the same.
This implies that Shirahama sandstone is relatively isotropic in a hydraulic sense.

* Application of the New Lab. System*



Effects of confining P and heterogeneity on K and Ss of Inada granite.

• Conclusion

Ranges are about two orders lower than those of Shirahama sandstone.

稲田花崗岩の計測例

Permeabilities in the three directions perpendicular to Grain, Rift and Hardway planes are different, especially in the direction perpendicular to Rift Plane.
This implies that Inada granite is an isotropic geologic material.

* Summary and Conclusions*

*To reduce the time required to measure low-K
- Use a disk-shaped specimen
  - Max. grain size & max. length of microcracks
  - Incorporated to developing a new standard

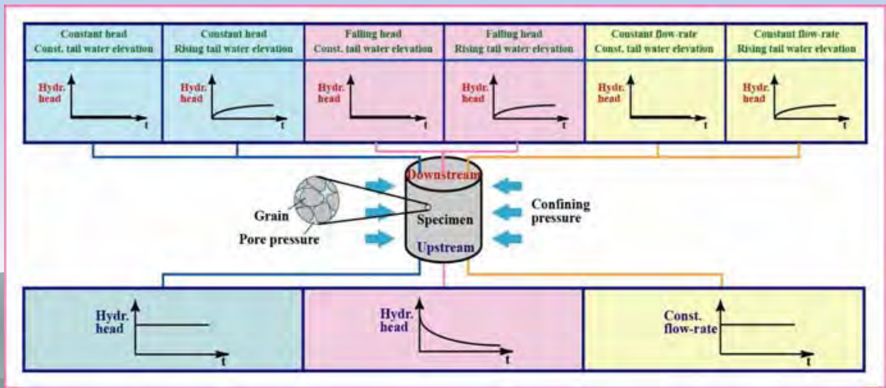
*Numerical Inverse Method
- Based on rigorous theoretical analyses
- Permits the test duration to be significantly shorted
- Without sacrificing accuracy in estamating both K & Ss

*The new lab. system
- An effective & versatile equipment for testing low-K
- K derived from the 3 complementary methods are in agreement

*K & Ss of a rock are functions of confining pressure
- K decreases monotonically with increasing stress
- Ss varies circularly

Re-classification & further developments of lab. K tests

Re-classification of lab. K tests



Constant-Head

Falling-Head Transient Pulse

Constant Flow-Rate

Re-classification & further developments of lab. K tests

Rigorous solutions to the other 3 tests are now available

Upstream Boundary:	Downstream Boundary:
Constant-head	Rising tail water elevation
Upstream Boundary:	Downstream Boundary:
Falling-head	Constant tail water elevation

Zhang, M., et. al., 2004, Simultaneous Determination of the Hydraulic Conductivity and Specific Storage of A Test Specimen From Laboratory Permeability Tests, Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract H21E-1065.

Upstream Boundary:	Downstream Boundary:
Constant flow-rate	Rising tail water elevation

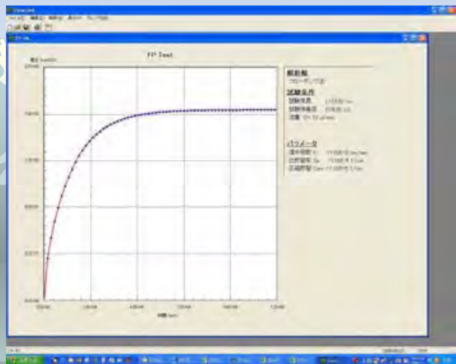
Song, I., et. al., 2004, One-Dimensional Fluid Diffusion Induced by Constant-Rate Flow Injection: Theoretical Analysis and Application to the Determination of Fluid Permeability and Specific Storage of a Cored Rock Sample, Journal of Geophysical Research - Solid Earth, 109 (B5): doi:10.1029/2003JB002395.

Further improvements in laboratory system

Picture of Automated Versatile Laboratory K System

Further improvements in laboratory system
Automated system operation

Further improvements in laboratory system
Automated data analyses



Part II: Laboratory diffusion tests

Lab. diffusion test is a well-established & widely adopted approach
  Characterizing the diffusive transport properties of geo-materials
Several types of diffusion tests currently available
  Through-diffusion has been extensively used for testing rock samples

Contents of today's talk

1) Review concept and theory of conventional through-diffusion test
   Indicate potential problems

2) Present 2 rigorous solutions to through-diffusion test

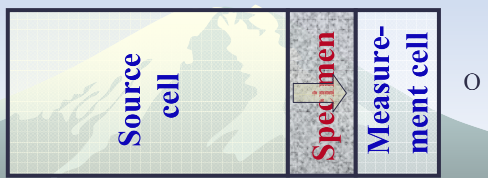
3) Theoretically evaluate applicability & limitations of conventional through-diffusion test

4) Show an example of improved technique

Concept of conventional through-diffusion test

Place a large cell at inlet side to dampen concentration variations

Replace the solution in measurement cell with fresh solution



Approximate solution: constant inlet & outlet concentrations

Effective diffusion coefficient: steady-state measurements

Potential problems: Time-consuming & cumbersome

Difference between analysis assumptions & test conditions

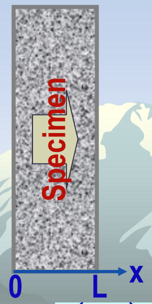
Rigorous solutions to through-diffusion test
(Mathematical models)

Boundary conditions

Source cell

Conventional & improved

$c(0,t) = c_1$



Measurement cell

Conventional

$c(L,t) = 0$

Improved

$$V_d \cdot \left.\frac{\partial c}{\partial t}\right|_{x=L} + A \cdot De \cdot \left.\frac{\partial c}{\partial x}\right|_{x=L} = 0$$

Initial condition $c(x,0) = 0$

Governing Equation

$$\frac{\partial c}{\partial t} = \frac{D_e}{\alpha}\frac{\partial^2 c}{\partial x^2}$$

$$\alpha = \varepsilon_{tot} + K_d \rho$$

c: Concentration; t: Time; De: Effective diffusion coefficient; α: Rock capacity factor; x: Distance; C1: Const. concentration in source cell; L: Length; Vd: Measurement cell volume; A: Cross-sectional area; ε_{tot}: total porosity; Kd : sorption coefficient; ρ : density

Approximate solution to through-diffusion test (Conventional)

Solution

$$c(x,t) = c_1\left[1 - \frac{x}{L} - \frac{2}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}\cdot\sin\left(n\cdot\pi\cdot\frac{x}{L}\right)\cdot\exp\left(-\frac{n^2\cdot\pi^2\cdot D_e}{\alpha\cdot L^2}\cdot t\right)\right]$$

Total quantity diffused into measurement cell after time t

$$Q(t) = -D_e\cdot A\int_0^t \left.\frac{\partial(x,\tau)}{\partial x}\right|_{x=L} d\tau$$

$$= A\cdot L\cdot c_1\left\{\frac{D_e}{L^2}\cdot t - \frac{\alpha}{6} - \frac{2\alpha}{\pi^2}\sum_{n=1}^{\infty}\frac{(-1)^n}{n}\exp\left(-\frac{n^2\cdot\pi^2\cdot D_e}{\alpha\cdot L^2}\cdot t\right)\right\}$$

At long times or steady state

$$\left.Q(t)\right|_{t\to\infty} = A\cdot L\cdot c_1\left[\frac{D_e}{L^2}\cdot t - \frac{\alpha}{6}\right]$$

Time-lag method

Slope: $(A\cdot c_1\cdot D_e)/L$

Intercept on t axis: $(\alpha\cdot L^2)/(6D_e)$

Rigorous solution to through-diffusion test
(Improved, CIC-IOC)

Solution

$$c(x,t)=c_1\left\{1-2\sum_{m=0}^{\infty}\frac{(\lambda_m^2+\beta^2)\cdot\exp\left(-\frac{D_e\cdot\lambda_m^2}{\alpha\cdot L^2}\cdot t\right)\cdot\sin\left(\lambda_m\cdot\frac{x}{L}\right)}{\lambda_m\cdot\left[\lambda_m^2+\beta(\beta+1)\right]}\right\}$$

$$\beta=(\alpha\cdot A\cdot L)/V_d \qquad \tan(\lambda)=\frac{\beta}{\lambda}$$

Total quantity diffused into measurement cell after time t

$$Q(t)=-D_e\cdot A\int_0^t\frac{\partial(x,\tau)}{\partial x}\bigg|_{x=L}d\tau$$

$$=2\alpha\cdot A\cdot L\cdot c_1\left\{\sum_{m=0}^{\infty}\frac{(\lambda_m^2+\beta^2)\cdot\cos(\lambda_m)}{\lambda_m^2\left[\lambda_m^2+\beta(\beta+1)\right]}\cdot\left[1-\exp\left(-\frac{D_e\cdot\lambda_m^2}{\alpha\cdot L^2}\cdot t\right)\right]\right\}$$

At steady state: c(x, t)=c1; Q(t)->constant; No more diffusion

Theoretical evaluation
(Approach)

1) Numerically producing "experimental data" using the rigorous solution

2) Back-calculating effective diffusion coefficient & rock capacity factor using the conventional time-lag method

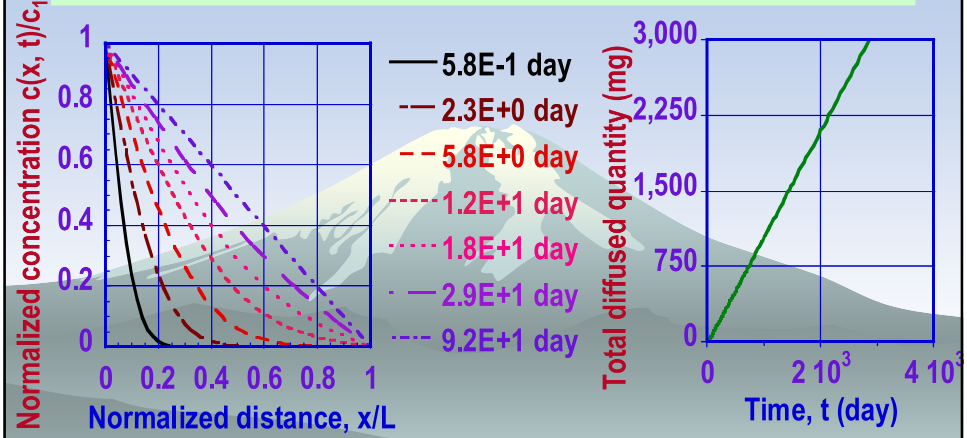
3) Comparing the back-calculated & input values for the two parameters

Theoretical evaluation
(Hypothetical test conditions)

Hypothetical test conditions for theoretical simulations		
Specimen (D=7cm, L=1cm)	Cross-sectional area (m2) Length (m) Effective diffusion coefficient (m2/s) Rock capacity factor	3.85E-3 1.00E-2 2.5E-13 3.5E-2
Source cell	Concentration (ppm)	127000
Measurement cell	Volume (m3)	4.00E-5

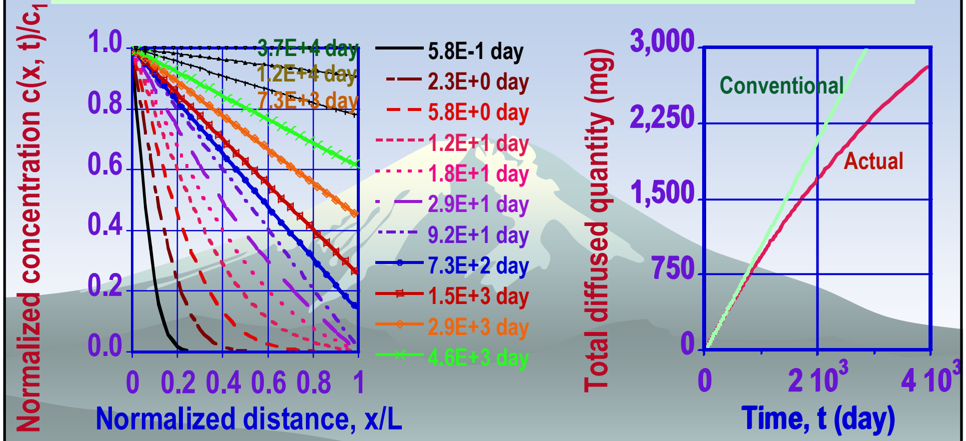
Specimen dimensions: our on-going experiments
Other parameters: test results reported in a number of articles

Theoretical evaluation
(Simulated results of conventional test)



At onset of experiment, concentration at inlet end is suddenly increased
Concentrations along the specimen axis gradually increase
Finally reaching a linear distribution, i.e., a steady-state condition
Total diffused quantity increases linearly

Theoretical evaluation
(Simulated results of improved test, CIC-IOC)



At onset of experiment, concentration at inlet end is suddenly increased
Concentrations along the specimen axis gradually increase
Finally reaching the concentration of source solution
Total diffused quantity converges to a certain value

Theoretical evaluation
(Errors from time-lag method)

Definition of elative errors:

$$D_{e-err} = \frac{D_{e-determined}}{D_{e-input}} \cdot 100\% \qquad \alpha_{err} = \frac{\alpha_{determined}}{\alpha_{input}} \cdot 100\%$$

Relative errors in determining effective diffusion coefficient & rock capacity factor by using the time-lag method

Relative errors	Concentration increase in measurement cell (% of constant concentration in source cell)			
	1%	3%	~~3%~~ 5%	9%
D_{e-err} (%)	96	96	94	88
α_{err} (%)	93	90	73	26

Conventional through-diffusion test based on time-lag method tends to underestimate both the two parameters

Another improvement to through-diffusion test

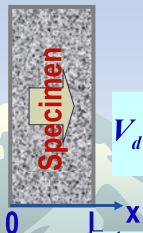
(Decreasing inlet concentration-Increasing outlet concentration)

Boundary conditions

Source cell

$$c(0,0) = c_1$$

$$V_u \cdot \left.\frac{\partial c}{\partial t}\right|_{x=0} - A \cdot De \cdot \left.\frac{\partial c}{\partial x}\right|_{x=0} = 0$$



Measurement cell

$$c(L,0) = 0$$

$$V_d \cdot \left.\frac{\partial c}{\partial t}\right|_{x=L} + A \cdot De \cdot \left.\frac{\partial c}{\partial x}\right|_{x=L} = 0$$

Initial condition $c(x,0) = 0$

Rigorous solution:

$$c(x,t) = \frac{c_1}{\delta + \gamma + 1} - 2c_1 \sum_{m=0}^{\infty} \frac{\exp\left(-\frac{D_e \cdot \phi_m^2}{\alpha \cdot L^2} \cdot t\right) \cdot \left[\delta \cdot \cos\left(\phi_m \cdot \frac{L-x}{L}\right) - \gamma \cdot \phi_m \cdot \sin\left(\phi_m \cdot \frac{L-x}{L}\right)\right]}{\left[\gamma \cdot \phi_m^2 - \delta(\delta + \gamma + 1)\right]\cos(\phi_m) + \left[\delta \cdot \gamma + \delta + 2\gamma\right]\phi_m \cdot \sin(\phi_m)}$$

$\delta = (\alpha \cdot A \cdot L)/V_u$ $\gamma = V_d / V_u$ $\tan(\phi) = \frac{\delta \cdot (\gamma + 1) \cdot \phi}{\gamma \cdot \phi^2 - \delta^2}$

Technique for interpreting test data

(Parameter identification technique)

Solutions are rigorous; Difficult to determine analytically.
Graphical methods possible; Procedures cumbersome; Accuracy limited.

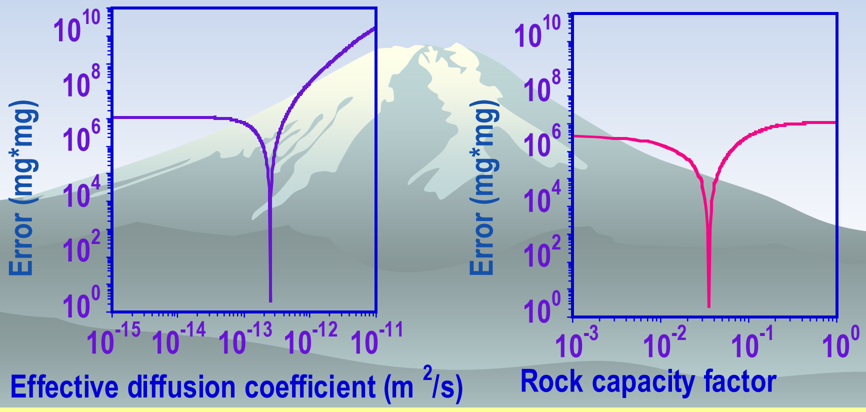
Error function:
(for CIC-IOC method)

$$\varepsilon = \sum_{i=1}^{n} \left\{ Q(t_i) - Q(t_i)^*_{(D_e,\alpha)} \right\}^2$$

A least-squares reduction of discrepancy between measured and theoretically calculated results
N: the number of measured data points

Technique for interpreting test data
(Characteristics of the error function, CIC-IOC)

Varying one parameter across a certain span of magnitude
Maintaining the other parameter constant & equal to its "real value"



Error curves are convex in the neighboring domains of the "real values"
It is possible to uniquely quantify the magnitudes of the parameters

PARAMETER BACK-CALCULATION TECHNIQUE
(Decreasing inlet concentration-Increasing outlet concentration)

Error function

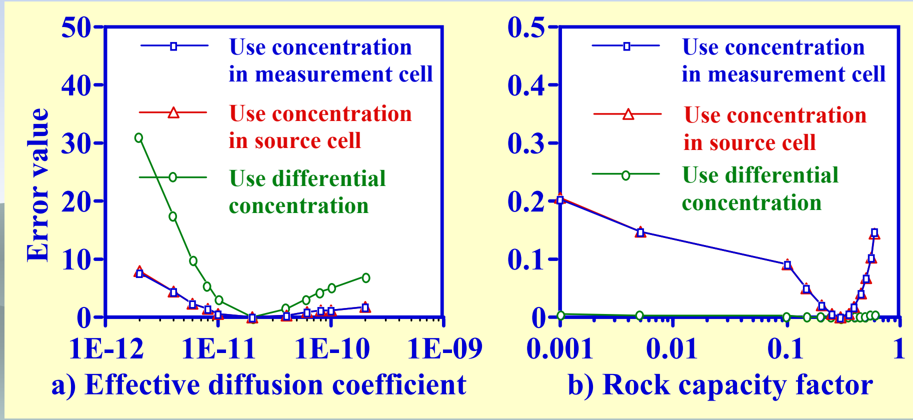
$$\varepsilon = \sum_{i=1}^{n} \left\{ c(t_i)_{(D_{e,\alpha})} - c(t_i)^{*}_{(D_{e,\alpha})} \right\}^2$$

n is the number of measured data points; $c(t_i)$ and $c(t_i)^*$ are the concentrations measured at time t_i

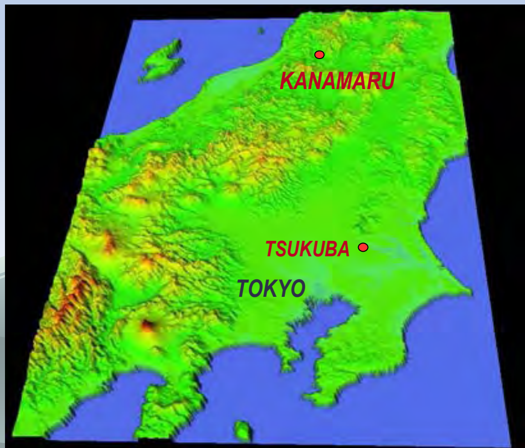
Hypothetical test conditions for the theoretical simulations

Specimen dimension	Diameter (m) Equivalent cross sectional area (m^2) Length (m)	0.064 3.22E-3 0.01
Transpor properties	Effective diffusion coefficient (m^2/s) Rock capacity factor	2E-11 0.15
Initial concentration	Normalized concentration	1
Volumes of cells	Source cell (m^3) Measurement cell (m^3)	4.4E-5 4.4E-5

Characteristics of the error function
(Decreasing inlet concentration-Increasing outlet concentration)



Location of Kanamaru research site



The specimen was taken from a depth of 12.03 to 12.04m below ground level. At about this depth, a several centimeters thick, poor quality uranium deposit has been detected. The diameter of the specimen was 64mm.

Test conditions

a) Front view b) Side view c) Oblique view

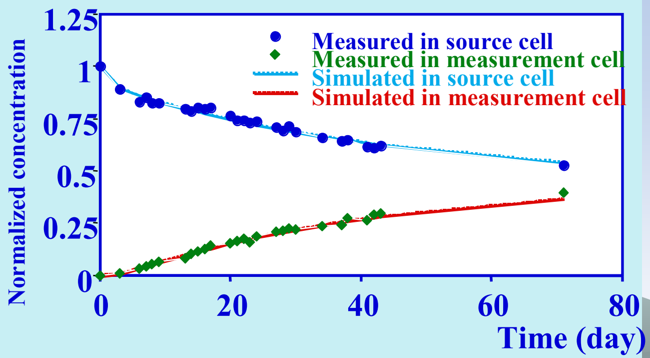
The volume of cells was 44 ml.

Non-sorbing ion Cl^- was chosen as a tracer (NaCl) and its concentrations were measured using Ion Chromatography. 20 micro-liters of solution was taken for each sampling.

The final pH values : 7.37 and 7.33 respectively.

Temperature controlled room (22Centigrade).

Test results



Transport property (Tracer ion, Cl^-)	Data used for the analyses		
	Concentration decrease in source cell	Concentration increase in measurement cell	Differential concentration between the two
Effective diffusion coefficient (m^2/s)	1.80E-11	2.03E-11	1.98E-11
Rock capacity factor	0.38	0.30	0.34

Note: Rock type: Sedimentary rock; Specimen number: M1-S-2A

Concluding remarks (1)

Laboratory diffusion test:

Well-established & widely adopted approach for characterizing the transport properties of geo-materials

Conventional through-diffusion tests:

May be time-consuming, cumbersome

May cause errors in the effective diffusion coefficient & rock capacity factor due to the difference between actual test conditions & analytical assumptions

Concluding remarks (2)

If solution in measurement cell is not replaced with fresh solution to maintain 0 concentration condition &
data are interpreted with conventional time-lag method

There will be a tendency to underestimate both the effective diffusion coefficient & rock capacity factor

The higher the concentration increase in the measurement cell, the larger will be the error in estimating the two parameters

Concluding remarks (3)

The effective diffusion coefficient & rock capacity factor can be uniquely back-calculated from the measurements of the improved (i.e., CIC-IOC and DIC-IOC) diffusion tests

Rigorous theoretical solution

+

Parameter identification technique

Concluding remarks (4)

The improved technique enables the use of the data continuously measured in the measurement cell

May allow automation of laboratory diffusion tests if the concentrations can be automatically detected by appropriate sensors

Test management may become easier & test efficiency may be highly increased

独立行政法人
産業技術総合研究所
National Institute of Advanced Industrial Science and Technology (AIST)

To end this talk…

Accurate determination of parameters related to mass transport assessment is very important

Traditional test methods, although considered to be well-established and are widely adopted in engineering practices, does not necessarily provide accurate results if their applicable conditions are not well confirmed

Considerations and approaches presented in this talk may offer basic ideas to avoid misinterpreting the experimental data

Thank you very much for your kind attention!

Soil and Groundwater Contamination

-Determining the transport properties of low permeability geological materials in the laboratory-

Ming ZHANG, Ph.D
Geo-analysis Research Group,
Institute for Geo-Resources and Environment,
Geological Survey of Japan, AIST

Abstract

The accurate characterization of transport properties of low permeability environments has important practical implications, such as in the fields of soil and water contamination and geological disposal of radioactive nuclear waste. Although principal mechanisms of mass and/or fluid transport in geologic media include advection, dispersion, chemical reaction, chain decay and/or biochemical retardation, etc, the most fundamental phenomena are advection and dispersion. When fluid flow is very flow, such as in the case of flow in low permeability environment, the dispersion becomes all most equivalent to diffusion. The advection phenomenon basically related to the hydraulic or flow properties, and the dispersion phenomenon basically related to the diffusive transport properties can be evaluated from the permeability and diffusion tests, respectively. Although characteristics of geologic media are generally fractured and heterogeneous, and tests can also be performed in situ, this talk will concentrate only on laboratory tests on continuous and homogeneous geologic materials in the laboratory, due to the limit of time.

Although several types of laboratory permeability and diffusion tests are available and have been widely used in geotechnical and/or geo-environmental fields, traditional test methods based on simple solutions corresponding to simplified boundary conditions have limitations in testing low permeability geo-materials, either due to the need of very long testing time and/or low accuracy.

This talk will be divided into two parts. In part I, the speaker will review recent advances in theoretical analyses of laboratory permeability tests, present potential strategies for effectively decreasing the test time, introduce a new and versatile laboratory system which can implement any of 6 test methods and show a series of experimental results which demonstrate the accuracy and efficiency of the new laboratory system. In part II, the speaker will review the concept and theory of conventional through-diffusion test, indicate potential problems, present 2 rigorous solutions to the through-diffusion test, theoretically evaluate the applicability and limitations of conventional through-diffusion test, and show an example of improved technique. Considerations and approaches presented in this talk may offer basic ideas to avoid misinterpreting the experimental data.

2005/11/30
APEC Symposium

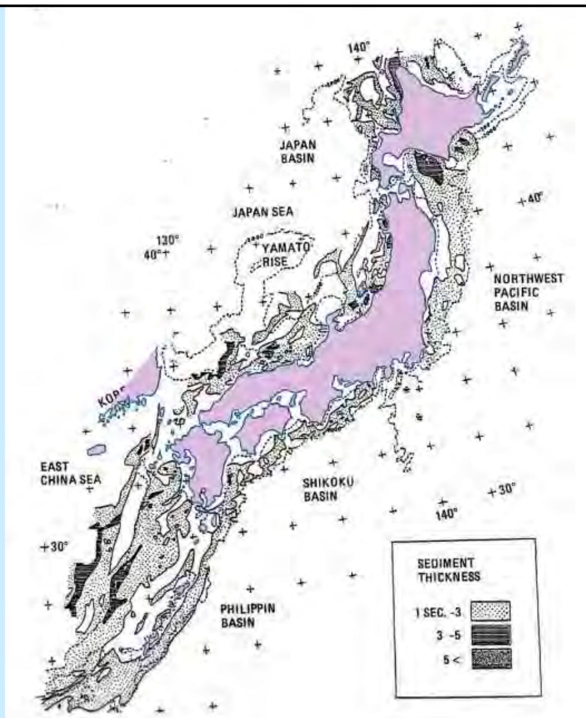
Characteristics of sedimentary basins around Japanese Islands

Institute for Geo-resources and Geo-environment
GSJ, AIST
Yoshihisa OKUDA

Content

- Distribution of sedimentary basins around Japanese Islands.
- Distribution of methane hydrates around Japanese Islands.
- Characteristics of offshore sedimentary basins around Japanese Islands.
- Scale of sedimentary basins on the estimate of the hydrocarbon resource potential.
- Sedimentary basins in the East China Sea.
- Sedimentary basins with high potential of hydrocarbon resources originated from coal source rocks.
- Unconventional oil and gases
- Summary

Distribution
of
Sedimentary Basins
around
Japanese Islands



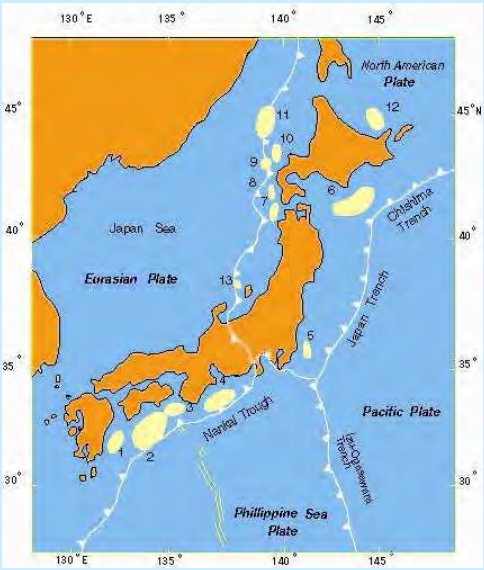
Okuda (1984)

Distribution of
Methane Hydrate
around Japan

Subsiding Basins along the Trenches
- **・Nankai Trough**
- **・Southern part of Japan Trench**
- **・South of Hokkaido**

Eastern rim of Japan Sea
Okhotsk Sea

- **Low Heat-flow**
- **Compression**
- **BSR → Natural Gas in deep**



Characteristics of Hydrocarbon Sedimentary Basins

Area	Age of Sediments	Basin Characteristics	Vol-cano	HY/ potential	HY Resources
Okhotsk	Paleogene, Neogene	Shelf basin / Pull apart sinking basin	○	○	oil
Western Hokkaido	Paleogene, Neogene	Shelf basins from onshore	○	○	Oil & Gas
Southern Hokkaido	Paleogene, Neogene	Shelf basins from onshore	○	○	Oil & Gas
Japan Sea side of NE Honshu	Neogene	Shelf basin from onshore	○	○	Oil
Japan Sea side of SW Japan	Neogene	Shelf basins	○		Oil & Gas
Pacific Ocean side of NE Honshu	Paleogene, Neogene	Warping-sinking basins			Gas
Kanto	Neogene	Shelf from onshore basin / warping-sinking		○	Gas
Pacific Ocean side of SW Honshu	Neogene	Warping-sinking basin		○	Gas
Ryukyu Islands	Neogene	Shelf from onshore basin / warping-sinking basin	○	○	Gas
Okinawa Trough	Neogene	Rift Basin	○		Gas
East China Sea	Paleogene, Neogene	Shelf Rift Basins		○	Oil & Gas
Izu-Ogasawara Arc	Paleogene, Neogene	Sinking/ Median/Rift basin	○	?	Gas **?**

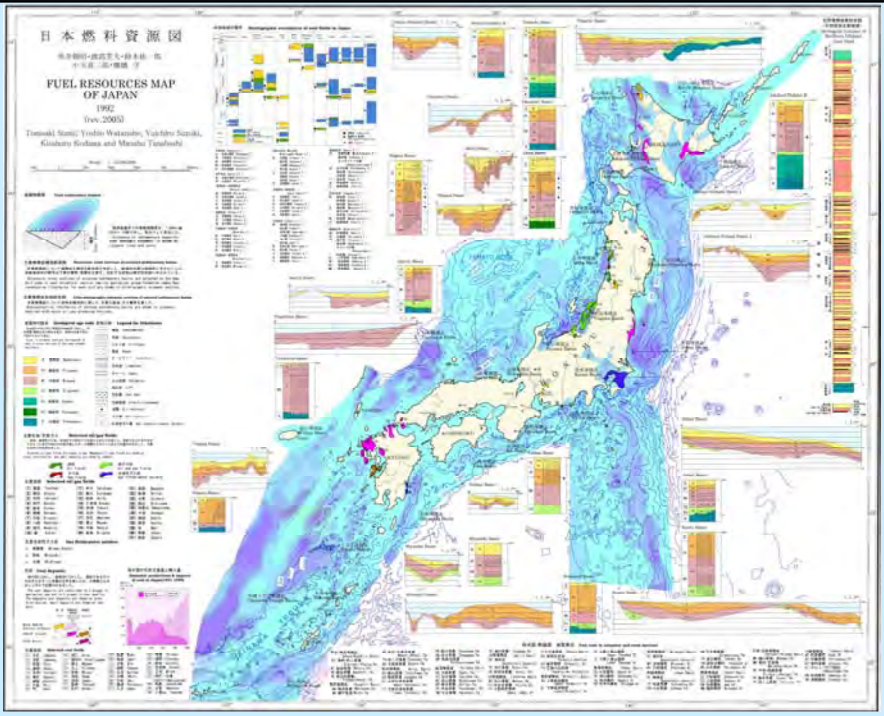
Characteristics of two types of Sedimentary basins

Japan Sea Side

- Marginal Sea
- Back Arc Basin
- Rifted Basin
- High Heat Flow
- high TOC Content (=~2%)
- Type I Kerogen

Pacific Ocean Side

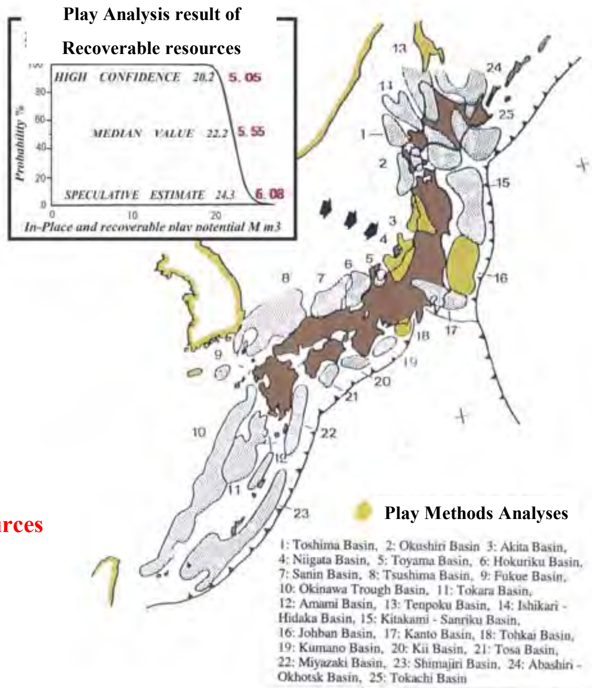
- Open Sea
- Fore Arc Basin
- Accretionary Prisms
- Low Heat Flow
- Low TOC Content (=~0.5%)
- Type III Kerogen



Petroleum Basin Analysis

Play Methods

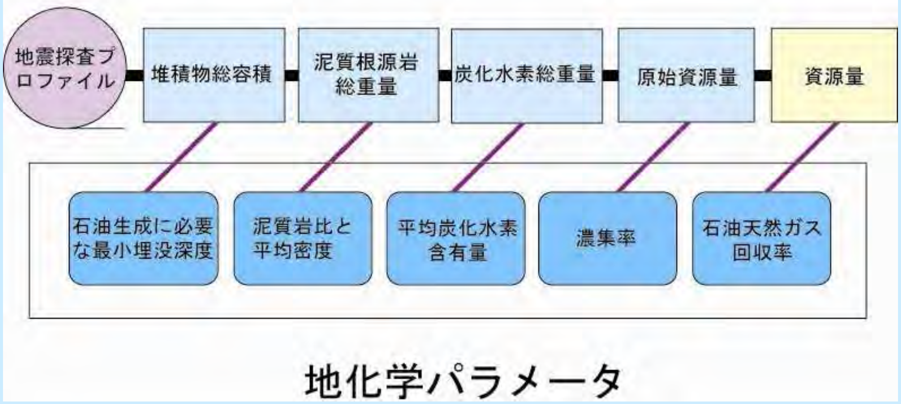
Volumetric Methods



Total Hydrocarbon Resources

= 1.0~1.3 billion KL

堆積物に基づく地化学物質収支法



0～200m in water depth

Basins	Ultimate Recorable reources (oil equivqllent)		Ultimate Recorable reources	
	10^6ton wt	10^6kl vol	Crude Oil (10^6kl)	Gases (10^9m^3)
Ihikari～Rebun	16	19	6	13
Soya～Abashiri	28	33	11	22
Hidaka	4	5	0	5
Shimokita～Kuji	1	1	0	1
Tokachi～Kushiro	2	2	0	2
Oshima～Nishitsugaru	0	0	0	0
Akita～Yamagata	28	32	10	22
Niigata	27	33	11	22
Noto～Oki	1	1	0	1
Oki～Tsushima	25	29	9	20
Fukue	3	4	1	3
Amakusa	0	0	0	0
Miyazaki	1	2	0	2
Kitakami	0	0	0	0
Joban	15	17	0	17
Boso	1	1	0	1
Tokai～Shikoku	9	11	0	11
Nansei Islamds	0	0	0	0
Okinawa Trough	37	44	14	30
East China Sea	210	247	80	167
Izu～Ogasawara	0	0	0	0
Yamato Bank	0	0	0	0
Total	408	481	142	339

0～200m in water depth

Basins	Ultimate Recorable reources (oil equivqllent)		Ultimate Recorable reources	
	106ton wt	106kl vol	Crude Oil (106k	Gses (109m3)
Ihikari～Rebun	16	19	6	13
Soya～Abashir	28	33	11	22
Hidaka	4	5	0	5
Shimokita～Ku	1	1	0	1
Tokachi～Kusl	2	2	0	2
Oshima～Nishi	0	0	0	0
Akita～Yamaga	28	32	10	22
Niigata	27	33	11	22
Noto～Oki	1	1	0	1
Oki～Tsushima	25	29	9	20
Fukue	3	4	1	3
Amakusa	0	0	0	0
Miyazaki	1	2	0	2
Kitakami	0	0	0	0
Joban	15	17	0	17
Boso	1	1	0	1
Tokai～Shikok	9	11	0	11
Nansei Islamd	0	0	0	0
Okinawa Trou	37	44	14	30
East China Se	210	247	80	167
Izu～Ogasawar	0	0	0	0
Yamato Bank	0	0	0	0
Total	408	481	142	339

area	Age of Sediments	Basin Characteristics
Okhotsk	Paleogene, Neogene	Shelf basin / Pull apart sinking basin
Western Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Southern Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Japan Sea side of NE Honshu	Neogene	Shelf basin from onshore
Japan Sea side of SW Japan	Neogene	Shelf basins
Pacific Ocean side of NE Honshu	Paleogene, Neogene	Warping-sinking basins
Kanto	Neogene	Shelf from onshore basin / warping-sinking
Pacific Ocean side of SW Honshu	Neogene	Warping-sinking basin
Ryukyu Islands	Neogene	Shelf from onshore basin / warping-sinking basin
Okinawa Trough	Neogene	Rift Basin
East China Sea	Paleogene, Neogene	Shelf Rift Basins
Izu-Ogasawara Arc	Paleogene, Neogene	Sinking/ Median/Rift basin

200～500m in water depth

Basins	Ultimate Recorable reources (oil equivqllent)		Ultimate Recorable reources	
	106ton wt	106kl vol	Crude Oil (106kl)	Gases (109m3)
Ihikari～Rebun	2	2	1	1
Soya～Abashiri	6	7	2	5
Hidaka	2	2	0	2
Shimokita～Kuji	1	1	0	1
Tokachi～Kushi	1	1	0	1
Oshima～Nishits	0	0	0	0
Akita～Yamagata	1	1	0	1
Niigata	22	26	8	18
Noto～Oki	7	8	3	5
Oki～Tsushima	14	16	5	11
Fukue	0	0	0	0
Amakusa	0	0	0	0
Miyazaki	0	0	0	0
Kitakami	1	1	0	1
Joban	3	3	0	3
Boso	0	0	0	0
Tokai～Shikoku	2	2	0	2
Nansei Islamds	0	1	0	1
Okinawa Trough	55	64	21	43
East China Sea	3	4	1	3
Izu～Ogasawara	0	0	0	0
Yamato Bank	0	0	0	0
Total	120	139	41	98

area	Age of Sediments	Basin Characteristics
Okhotsk	Paleogene, Neogene	Shelf basin / Pull apart sinking basin
Western Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Southern Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Japan Sea side of NE Honshu	Neogene	Shelf basin from onshore
Japan Sea side of SW Japan	Neogene	Shelf basins
Pacific Ocean side of NE Honshu	Paleogene, Neogene	Warping-sinking basins
Kanto	Neogene	Shelf from onshore basin / warping-sinking
Pacific Ocean side of SW Honshu	Neogene	Warping-sinking basin
Ryukyu Islands	Neogene	Shelf from onshore basin / warping-sinking basin
Okinawa Trough	Neogene	Rift Basin
East China Sea	Paleogene, Neogene	Shelf Rift Basins
Izu-Ogasawara Arc	Paleogene, Neogene	Sinking/ Median/Rift basin

500～2000m in water depth

Basins	Ultimate Recorable reources (oil equivqllent)		Ultimate Recorable reources	
	106ton wt	106kl vol	rude Oil (106kl	Gases (109m3)
Ihikari～Rebun	1	1	0	1
Soya～Abashiri	38	45	14	31
Hidaka	4	5	0	5
Shimokita～Kuji	44	52	1	51
Tokachi～Kushi	1	1	0	1
Oshima～Nishits	0	0	0	0
Akita～Yamagata	0	1	1	0
Niigata	48	56	18	38
Noto～Oki	32	38	12	26
Oki～Tsushima	7	7	2	5
Fukue	1	1	0	1
Amakusa	0	0	0	0
Miyazaki	1	1	0	1
Kitakami	8	10	0	10
Joban	6	8	0	8
Boso	0	0	0	0
Tokai～Shikoku	11	13	0	13
Nansei Islamds	4	4	0	4
Okinawa Trough	130	153	49	104
East China Sea	1	1	0	1
Izu～Ogasawara	3	4	0	4
Yamato Bank	1	2	1	1
Total	341	403	98	305

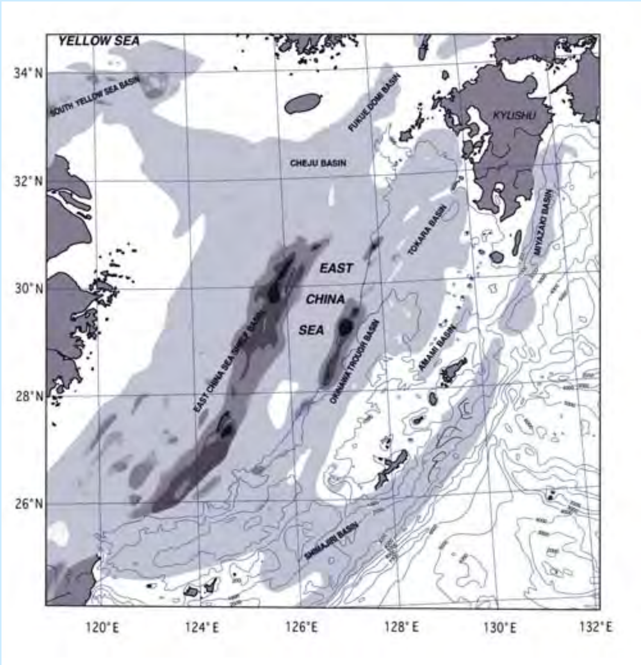
area	Age of Sediments	Basin Characteristics
Okhotsk	Paleogene, Neogene	Shelf basin / Pull apart sinking basin
Western Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Southern Hokkaido	Paleogene, Neogene	Shelf basins from onshore
Japan Sea side of NE Honshu	Neogene	Shelf basin from onshore
Japan Sea side of SW Japan	Neogene	Shelf basins
Pacific Ocean side of NE Honshu	Paleogene, Neogene	Warping-sinking basins
Kanto	Neogene	Shelf from onshore basin / warping-sinking
Pacific Ocean side of SW Honshu	Neogene	Warping-sinking basin
Ryukyu Islands	Neogene	Shelf from onshore basin / warping-sinking basin
Okinawa Trough	Neogene	Rift Basin
East China Sea	Paleogene, Neogene	Shelf Rift Basins
Izu-Ogasawara Arc	Paleogene, Neogene	Sinking/ Median/Rift basin

Estimated hydrocarbon Resources around Japanese Islands

Million KL

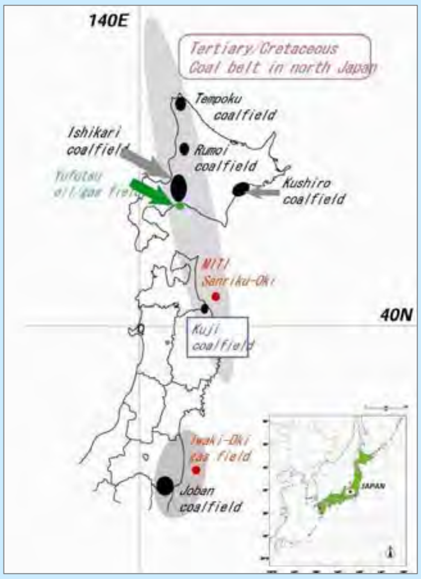
Million kl Oil EQ

Area		Resources(Ultimate Recorable reources)		
Area		Offshore	Onshore	Total
Hokkaido	Offshore No：1, 2, 3-1, 4 Onshore：Hokkaido	123 (12.0) [126 (10.2)]	208 (60.1)	331 (24.2) [334 (21.2)]
Pacific Ocean Side of NE Honshu	Offshore No：5, 6-1, 6-2 Onshore：Akita, Yamagata, Niigata	149 (14.6) [136 (11.1)]	128 (37.0)	277 (20.2) [264 (16.8)]
Japan Sea side of NE Honshu	Offshore No：3-2, 11, 12, 13 Onshore：Aomori, Iwate	94 (9.2) [83 (6.8)]	5 (1.4)	99 (7.2) [88 (5.6)]
Japan Sea side of SW Honshu	Offshore No：7, 8-1, 8-2 Onshore：Toyama, Shimane	102 (10.0) [120 (9.8)]	3 (0.9)	105 (7.7) [123 (7.8)]
Pacific Ocean side of Honshu	Offshore No：10, 14 Onshore：Shizuoka	29 (2.8) [33 (2.7)]	2 (0.6)	31 (2.3) [35 (2.2)]
NW kyushu	Offshore No：8-2, 9	5 (0.5) [8 (0.6)]		5 (.04) [8 (0.5)]
Okinawa-East China Sea	Offshore No：15-1, 15-2, 16	518 (50.6) [719 (58.5)]		518 (37.8) [719 (45.6)]
Izu-Ogasawara	Offshore No：17	4 (0.4) [4 (0.3)]		4 (0.3) [4 (0.3)]
ALL Japan		1,024 (100) [1,229 (100)]	346 (100)	1,370 (100) [1,575 (100)]



Expected geological structures for hydrocarbon accumulation in the East China Sea

Oil and Gases originated from coaly source rocks



Classification of natural gases in sedimentary basins and research issues

Origin	Reservoir	Occurrences	Research Item
Thermogenic Gases	Structural Natural Gases		
	Basement rock reservoir		Granite Reservoir, Volcanic Reservoir
	Deep reservoir	Low permeability	Tight sand Gases
		Low permeability	Shale Gases
(Deep Natural Gases)			Deep Gases
			Microbial Gases with subduction
(Natural Gases originated from Coal)		Variable occurrences	Coal Bed Methane
			Gases from Originated from Coal
	Natural Gases dissolved in oil type.		
	Methane Hydrate	Low permeability Solid→Vapor	
Biogenic Gases	Natural Gases dissolved in water type.	High pressure type	Mobara Type
		Intermittent gas rift type	Geo-pressured Type (Mexico Bay)
		Conventional Type	
Ultra-Deep Gas	?		

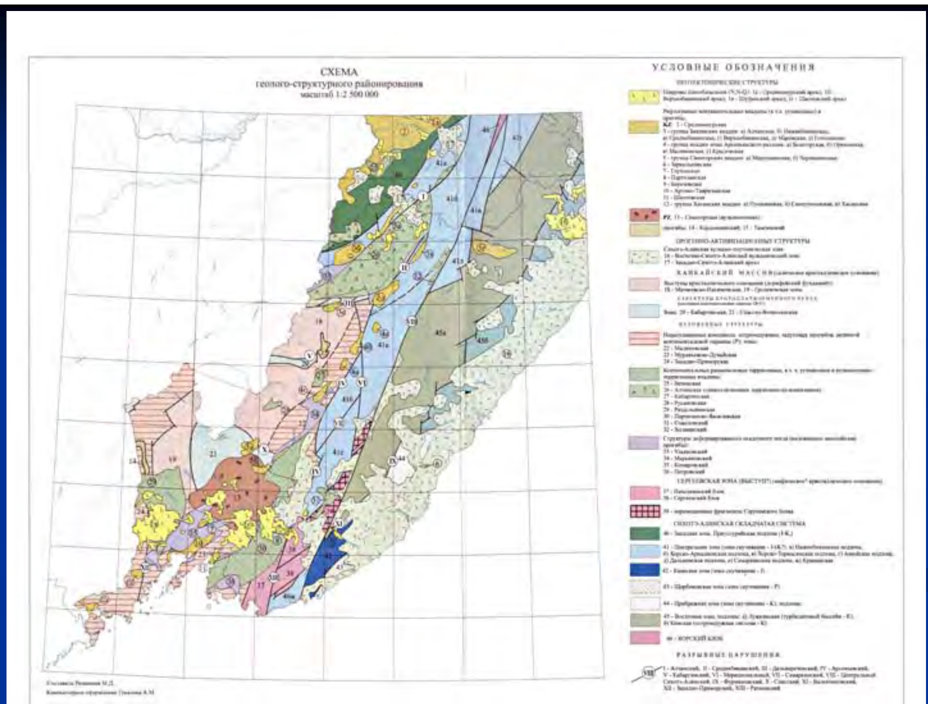
Summary

- There are fore-arc, back-arc, median, and rift basins around Japanese Islands.
- Generally speaking, the sedimentary basins on the Pacific Ocean side are mainly expected bearing gas reservoirs including gas hydrate layers, and those on the Japan Sea sides are mainly expected bearing oil reservoirs.
- To generate thermogenic oil and gases in the young strata of Neogene, high heat sources from present and/or past volcanoes are necessary.
- Paleogene from Hokkaido to Kanto along the Pacific coast, which contains coal beds, have high potential to produce thermogenic oil and gases, if they have been under compression stress fields.
- There are giant rift basins beneath the continental shelf of the East China Sea and in the Okinawa trough.
- The rift basins beneath the continental shelf in the southern part of the East China Sea have suffered from thermogenic alternations by tertiary volcanoes, and high potential to produce thermogenic hydrocarbons.

Characteristics of Sedimentary Basins around Japanese Islands

Yoshihisa OKUDA
Institute for Geo-Resources and Environment,
Geological Survey of Japan, AIST

An application of Resistivity and Induced polarization sounding methods on ground water research by the example of Primorski Krai



Hankayskiy Region

- In the tectonic meaning the Region represents the **Hankayskiy median massif;**
- The rocks submitted the **terrigene, carbonaceous, granite formations;**
- Cover rocks compose imposed **Cainozoic depressions;**
- **Paleogen-Neogen coaly-terrigene** formations are bedded in the basin of the depressions;
- The top structural horizons of the depressions are formed by **Quaternary lacustrine-marsh, polygenetic formations, alluvial sediments of the flat river.**

Underground Water Of The Hankayskiy Region

- **The water of Quanternary sediments and artesian aquifer waters** are widely distributed;
- The capacity of the water horizons is **5-20**m;
- The filtration factor changes from **3 up 50 m/day;**
- The capacity of the covered clay, loams layers is **2-3 m;**
- Chemical compound of water is **hydrocarbonate, mainly calcic;**
- The water mineralization is **75-680 mg/l;**
- The waters have **leaching aggression.**

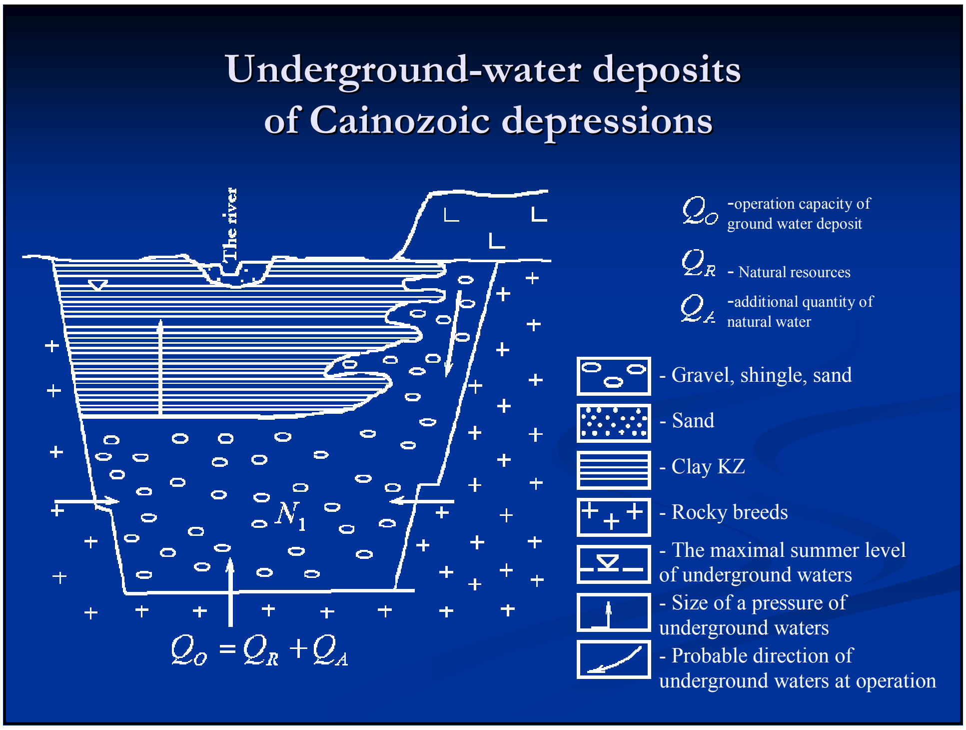
Hydrogeology Of The Piedmont Region

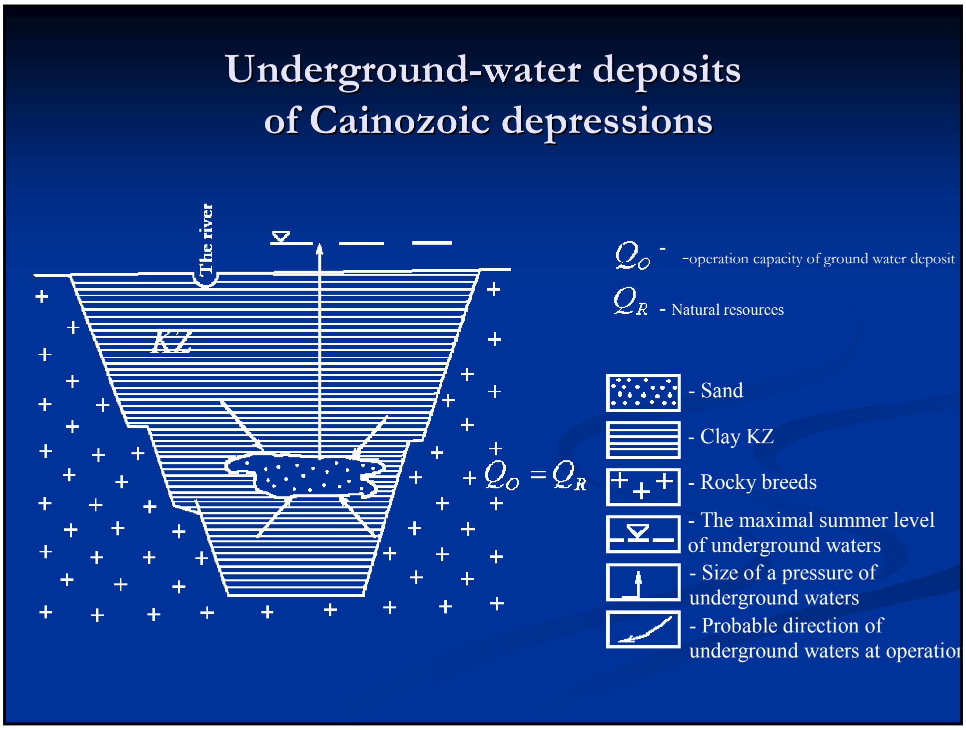
- Presence **23 small artesian basins** framing the Hankaiskiy massive;
- Presence **bedded-fractured subsoil waters neogen basalts**;
- **Alluvial water horizons** have widespread;
- **Waters of top fractured zones** have insignificant distribution;
- The water horizons are dated to **gravel, gravel-pebble, sand-gravel, sand sediments**;

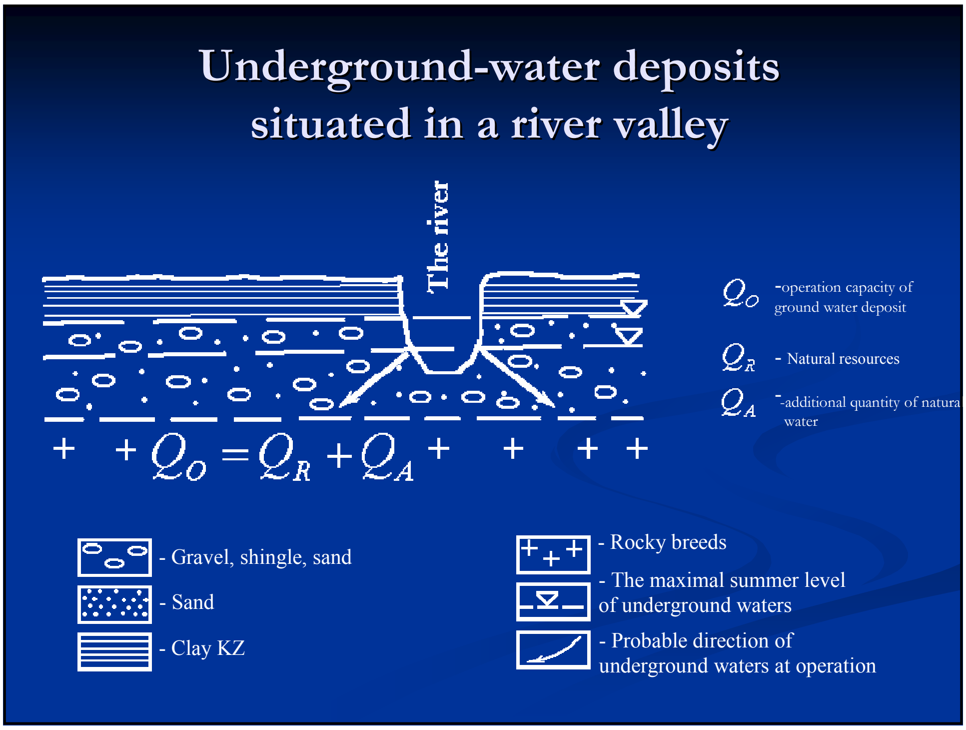
- The clay streaks causes formation several **water horizons hydraulicly connected among themselves**;
- The filtration factor is **1- 344 m/day**;
- The chemical composition is **hydrocarbonate, less often chloridical, calcic, natrium**;
- Waters have **leaching aggression**;
- The water horizons of the sea and alluvial-sea sediments located below of the sea level have **mineralization up to 25.7 g/l, acidic aggression, less often leaching aggression**

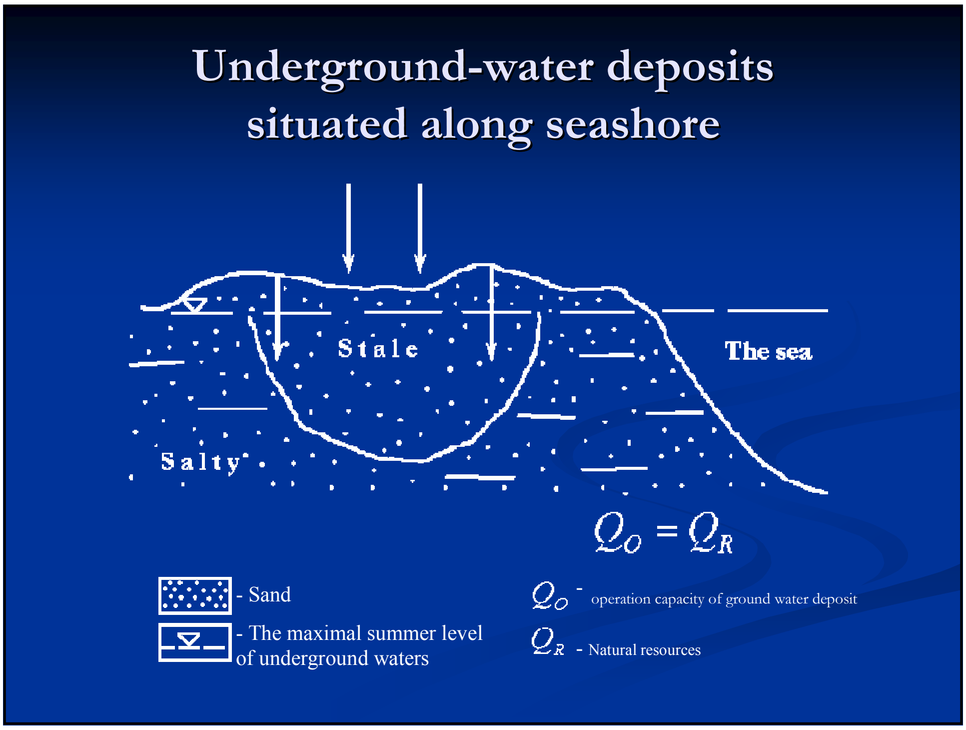
Typical hydro-geological sections of underground water deposits of Primorski krai

Underground-water deposits of Cainozoic depressions

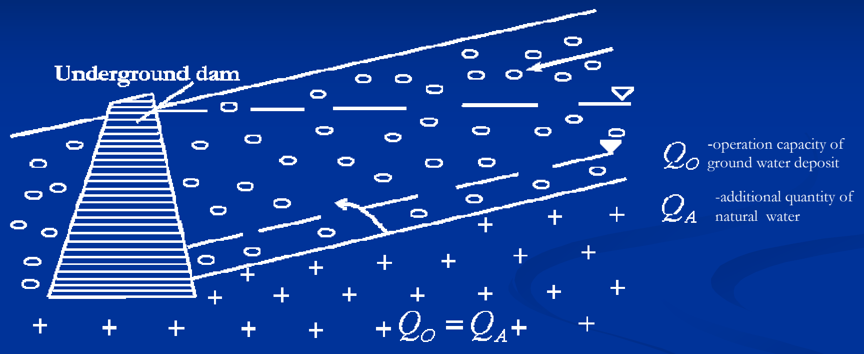

Underground-water deposits
of Cainozoic depressions
The river
N_1
$Q_O = Q_R + Q_A$
Q_O -operation capacity of ground water deposit
Q_R - Natural resources
Q_A -additional quantity of natural water
- Gravel, shingle, sand
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Size of a pressure of underground waters
- Probable direction of underground waters at operation


Underground-water deposits
of Cainozoic depressions
The river
KZ
$Q_O = Q_R$
Q_O - -operation capacity of ground water deposit
Q_R - Natural resources
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Size of a pressure of underground waters
- Probable direction of underground waters at operation


Underground-water deposits
situated in a river valley
The river
$Q_O = Q_R + Q_A$
Q_O -operation capacity of ground water deposit
Q_R - Natural resources
Q_A -additional quantity of natura
water
- Gravel, shingle, sand
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Probable direction of underground waters at operation

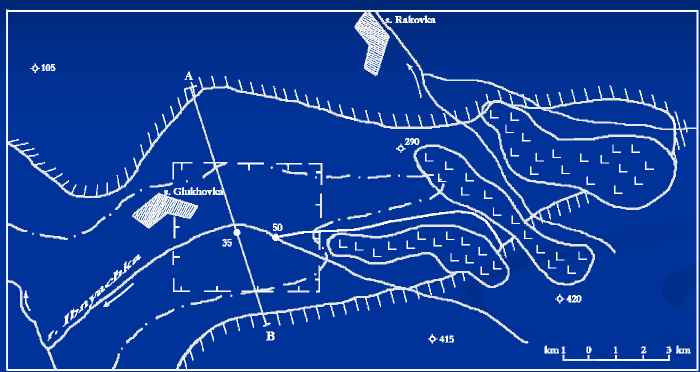

Underground-water deposits
situated along seashore
Stale
The sea
Salty
$Q_O = Q_R$
- Sand
- The maximal summer level of underground waters
Q_O - operation capacity of ground water deposit
Q_R - Natural resources

Underground water deposits concerned with all-the-year-round dewatered underground water horizon



- Gravel, shingle, sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- The minimal winter level of underground waters
- Probable direction of underground waters at operation

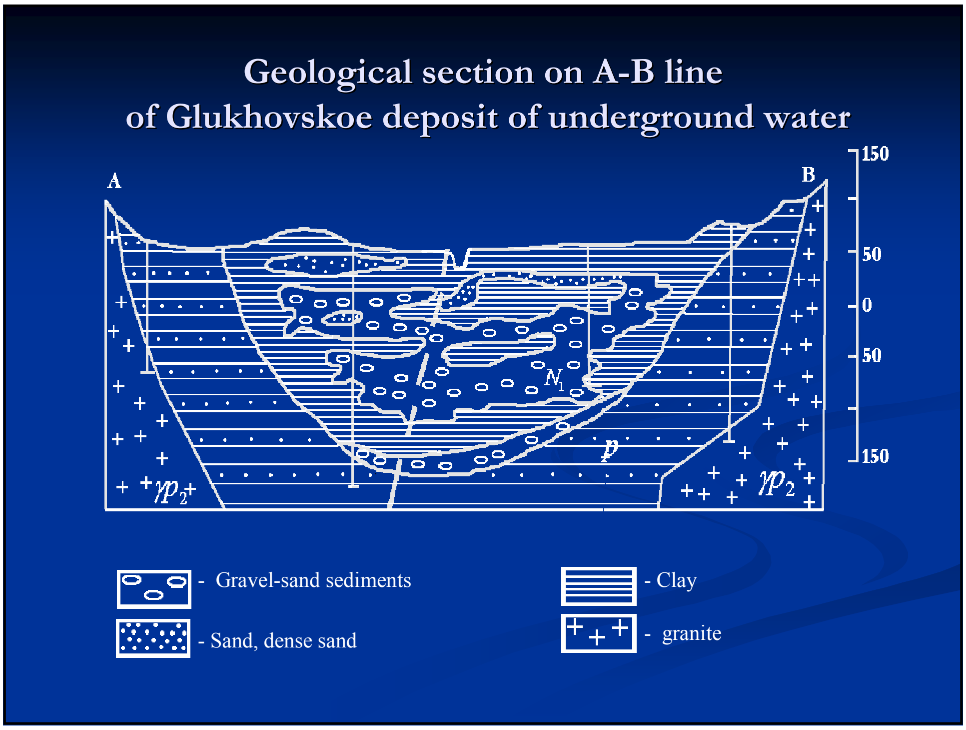
Glukhovskoe deposit of underground water



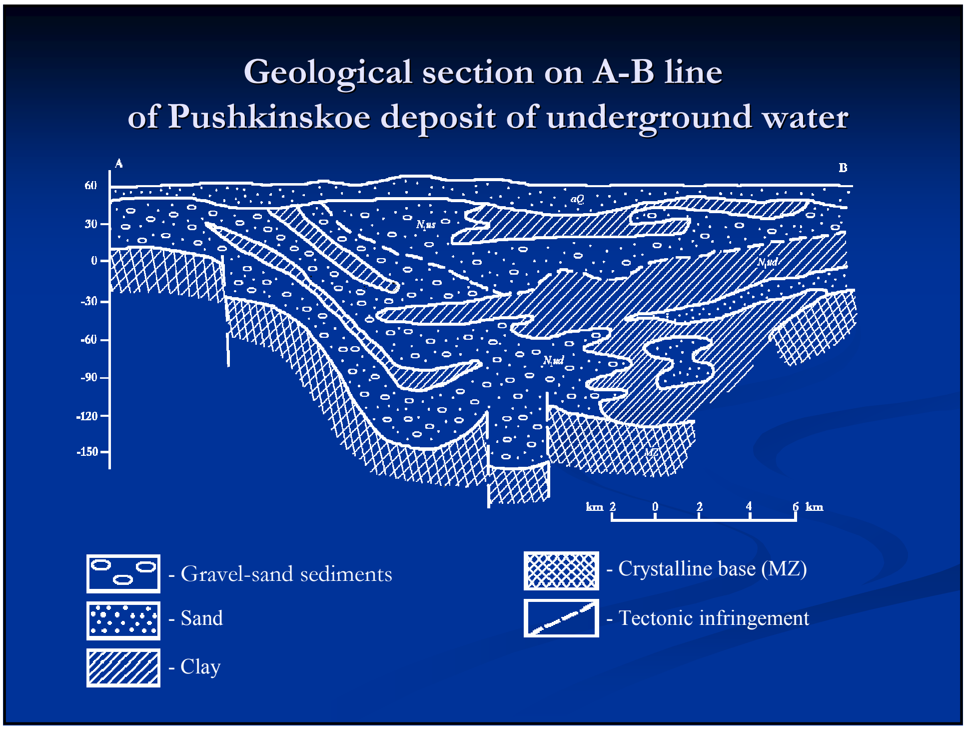
- Basalt
- Contour of tectonic depression (KZ)

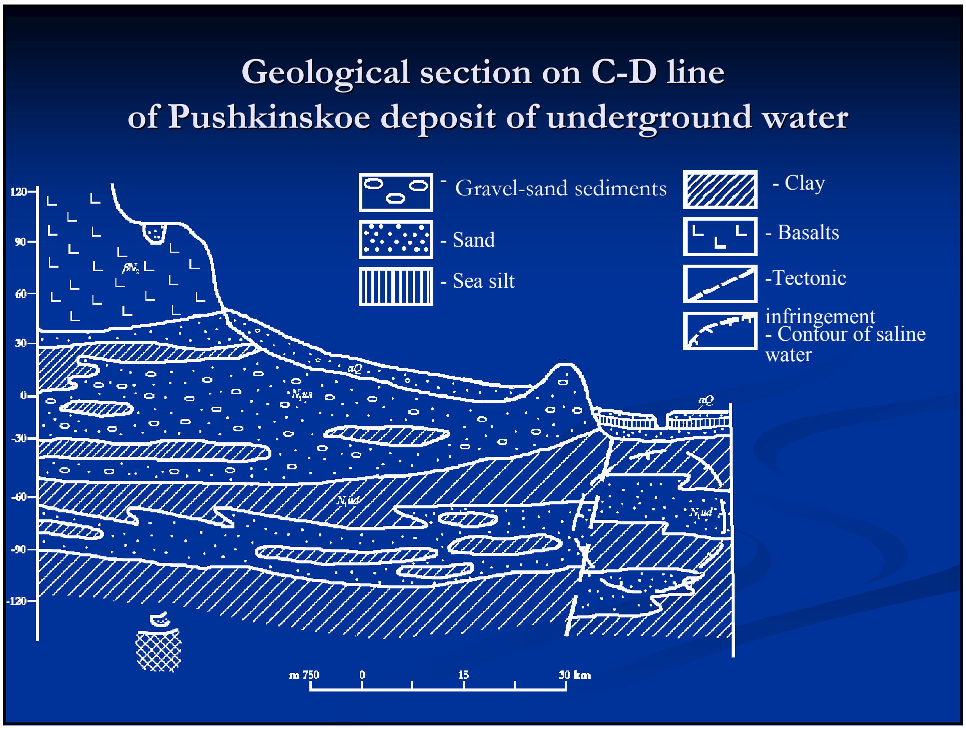
Miocene rock

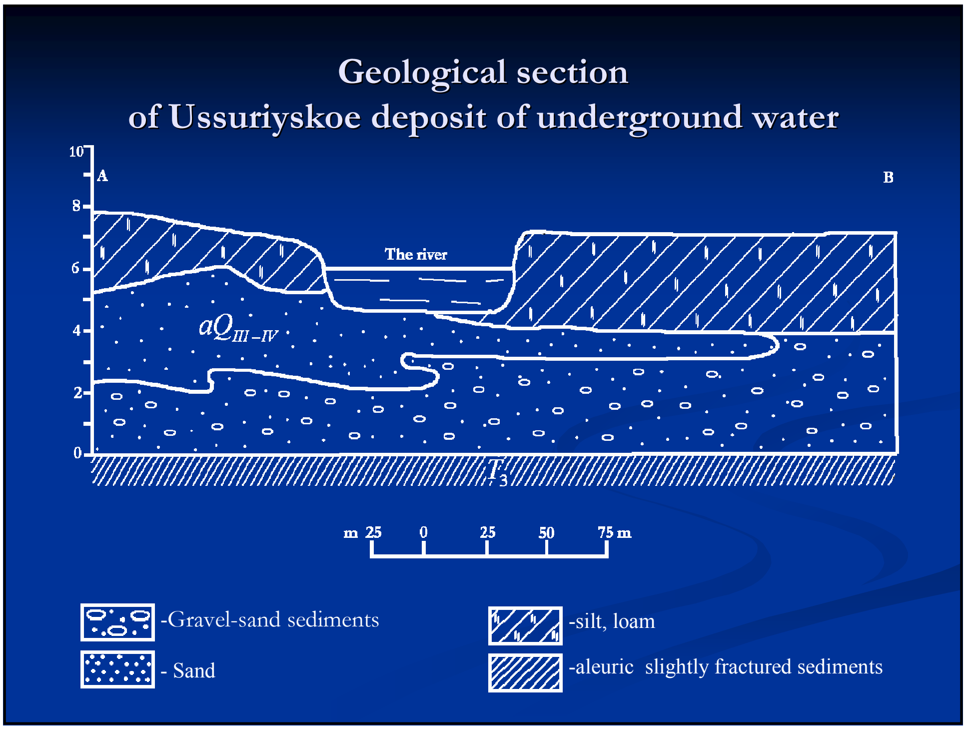
- Contour of Glukhovsky underground water deposit

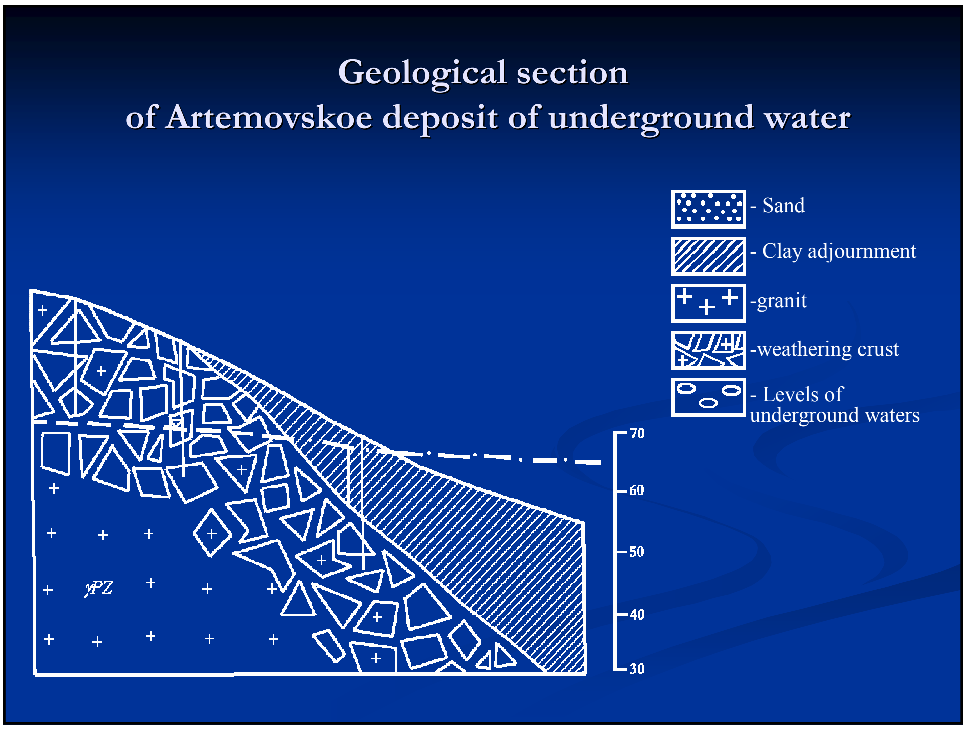

Geological section on A-B line
of Glukhovskoe deposit of underground water
A
B
150
50
0
50
150
N1
P
γP2
- Gravel-sand sediments
- Sand, dense sand
- Clay
- granite


Pushkinskoe deposit of underground water
Ussuriysk
II
I
666
MZ
China
Artyom
Vladivostok
The Amur gulf
- River valley
- Sand-clay sediments
- Basalt plateau
MZ -Highlands; range of dense fractured rocks(MZ)
- mountain ridges
- Pushkinskay depression (KZ)
Contour of underground salty relic wa
- Pushkinskoe deposit of fresh underground water
I - Borisovsly section
II- Razdolnensky section

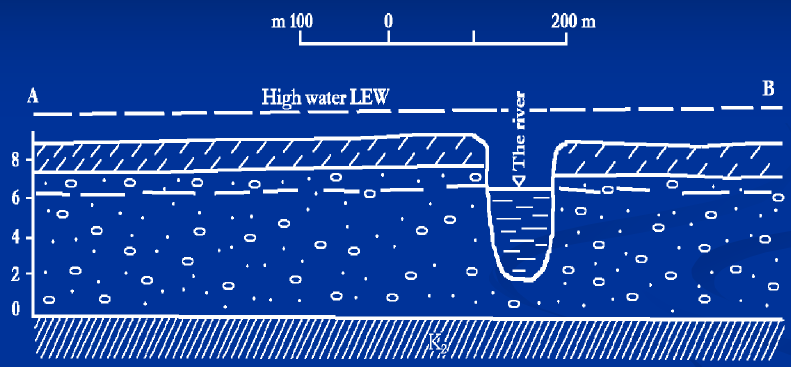

Geological section on A-B line
of Pushkinskoe deposit of underground water
A
B
60
30
0
-30
-60
-90
-120
-150
km 2 0 2 4 6 km
- Gravel-sand sediments
- Sand
- Clay
- Crystalline base (MZ)
- Tectonic infringement


Geological section on C-D line
of Pushkinskoe deposit of underground water
120
90
60
30
0
-30
-60
-90
-120
m 750 0 15 30 km
- Gravel-sand sediments
- Sand
- Sea silt
- Clay
- Basalts
-Tectonic
infringement
- Contour of saline
water


Geological section
of Ussuriyskoe deposit of underground water
10
8
6
4
2
0
A
B
The river
aQIII-IV
T3
m 25 0 25 50 75 m
-Gravel-sand sediments
- Sand
-silt, loam
-aleuric slightly fractured sediments


Geological section
of Artemovskoe deposit of underground water
- Sand
- Clay adjournment
-granit
-weathering crust
- Levels of
underground waters
70
60
50
40
30
γPZ

Geological section
of Bolshekamenskoe deposit of underground water



- Gravel-sand sediments
- sand, clay sediments
- alluvial sediments

An application of geophysical methods for carrying out hydro-geological tasks requires:

- \- To reduce field engineering saving hardware (such as chisel) as well as workloads in laboratory;
- \- To monitor continuously the information of hydro-geological parameters of underground water horizons in area and depth.

An application of geophysical methods allows achieving the following geological-hydrogeological tasks:

1. Lithological stratification of a section from the surface up to the depth of the first regional aquifer;
2. Division and zonation of a section in terms of geological/hydro-geological type;
3. Determination of overall parameters of mineralization including salinity, pH and other chemical indicators in underground waters, for understanding the spatial changes in area and depth;
4. Determination of permeability parameters and their special change of water-socked rocks.

Geophysical researches on underground waters are carried out in combination with the following activities:

- - On-site borehole logging for obtaining regarding parameters;
- - Laboratory works on classification of samples and corresponding tests.

Electrical investigation measuring the resistance of direct current physics are following:

1. The intensity of electric conductivity of rocks depends on bearing free-ion content in ground water;
2. Mineralization and the degree of halomorphic featureof an aquifer are defined mainly the electric resistances of country rocks;
3. Free ions move along capillaries in rocks or soils. Therefore, the porosity influences on resistance of rocks.

The following factors influence the resistance of rocks:

- - Water content of rocks;
- - The form and structure of pore spaces of rock;
- - Temperature;
- - Granulometric heterogeneity of rocks;
- - The content and structure of clay fraction.

Mathematical expression the dependence of resistance on rocks' temperature

$$\rho_t = \frac{\rho_{18}}{1 + 0{,}025(t - 18^\circ)}$$

Mathematical expression the dependence of resistance on porosities of water-contained rocks

$$P_n = A_n / K^m$$

P_n- Parameter of porosity or relative resistance water content rocks and resistance of water contained in rocks' pories;

A_n- The constant factor changing for sandy-argillaceous rock from 0.9 up 1.3;

K_m - Average porosity of rocks;

m - The parameter connected to the form rocks' pore channels.

Interpretation of electro-prospecting data

Interpretation of electro-prospecting data is carried out by two stages:

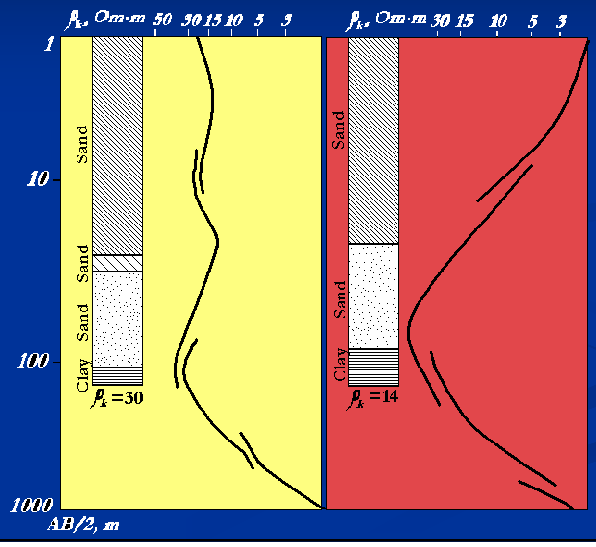
1. Qualitative interpretation

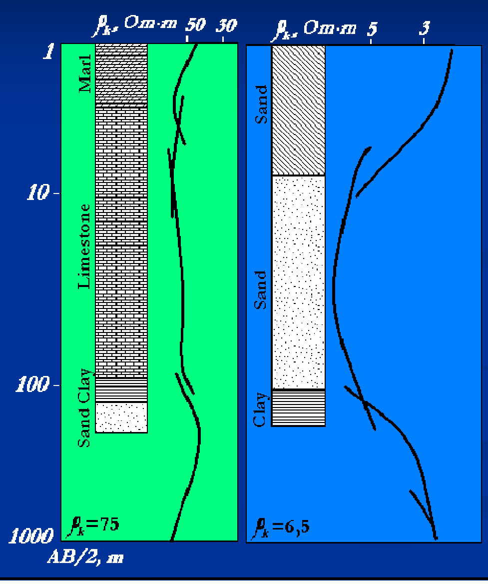
2. Quantitative interpretation

Qualitative interpretation of electro-prospecting data

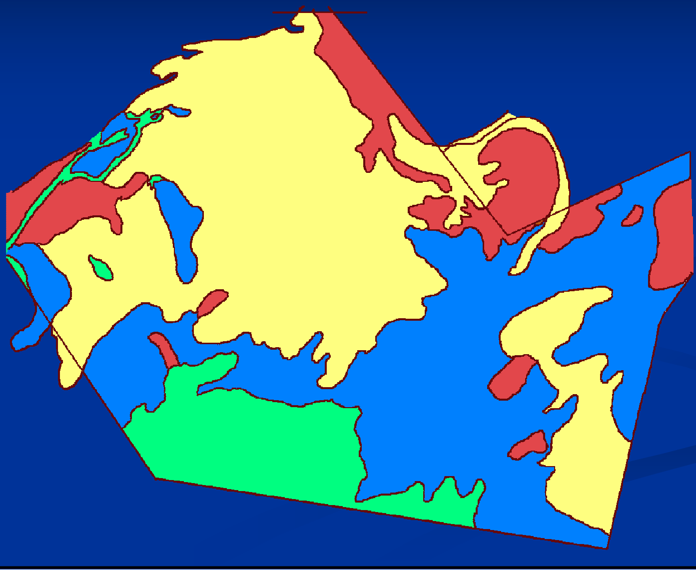
Qualitative interpretation is based on zoning of sounding curves contained hydro-geological section information

Standard sounding curves





Zoning map of sounding curves



As resistance of rocks is influenced simultaneously by some factors,

the functional dependence between resistance of rocks and hydro-geological parameters can be established only by correlation method

Quantitative geological/hydro-geological interpretation is based

on the correlation between geophysical and geological/hydro-geological parameters

Many experimental researches with many parametrical measurements taken in

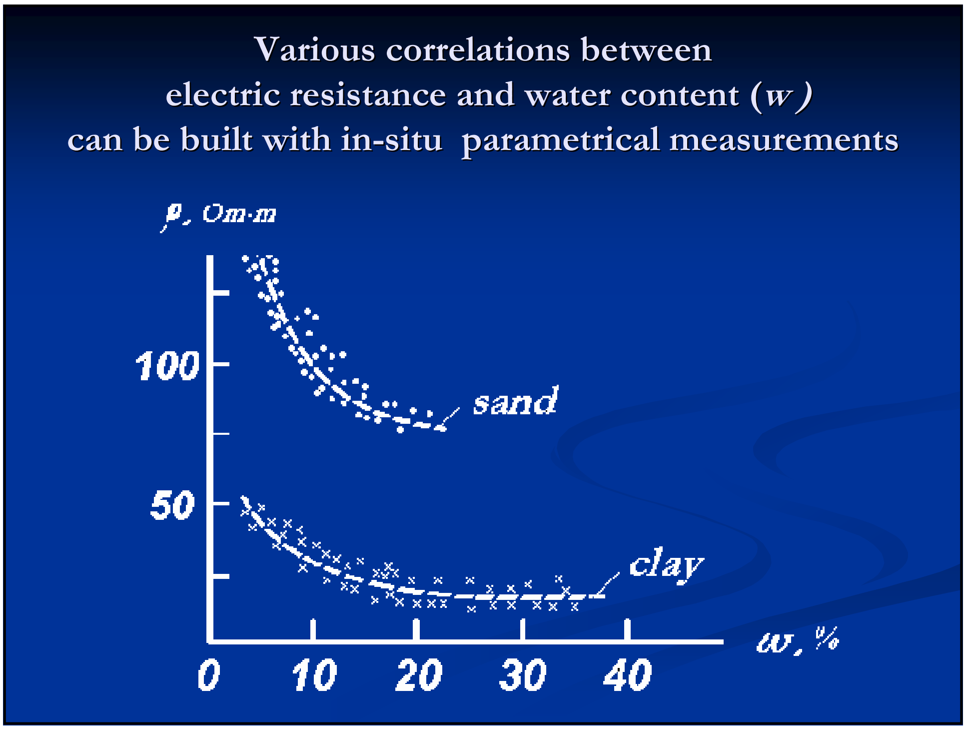
prospecting shafts, drill holes, ground surface, and also laboratory,

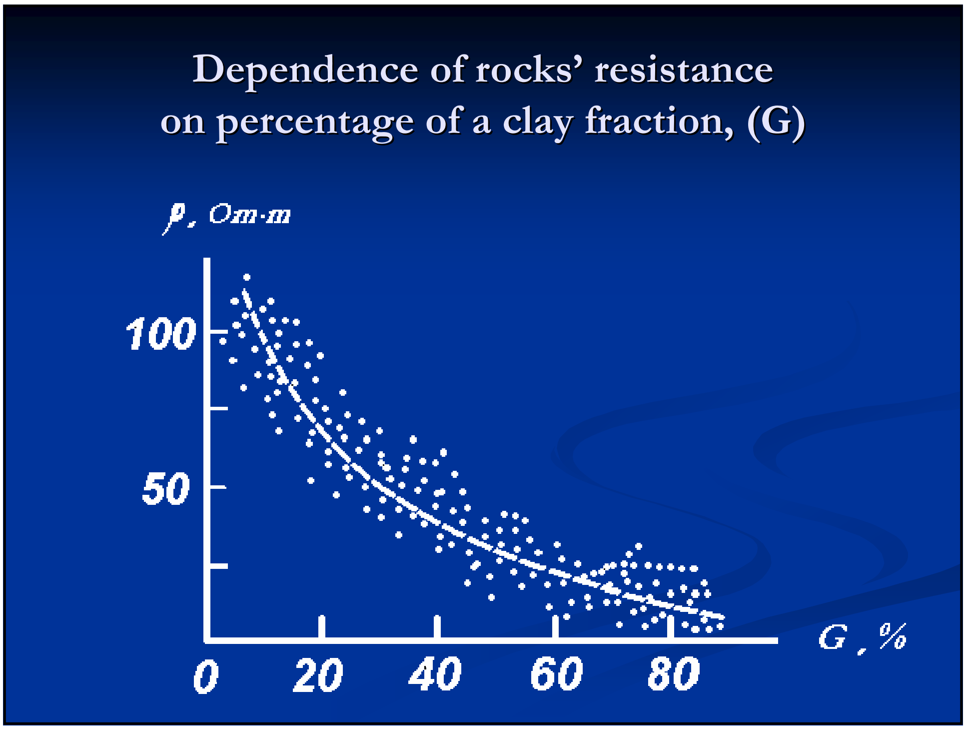
from which correlation between

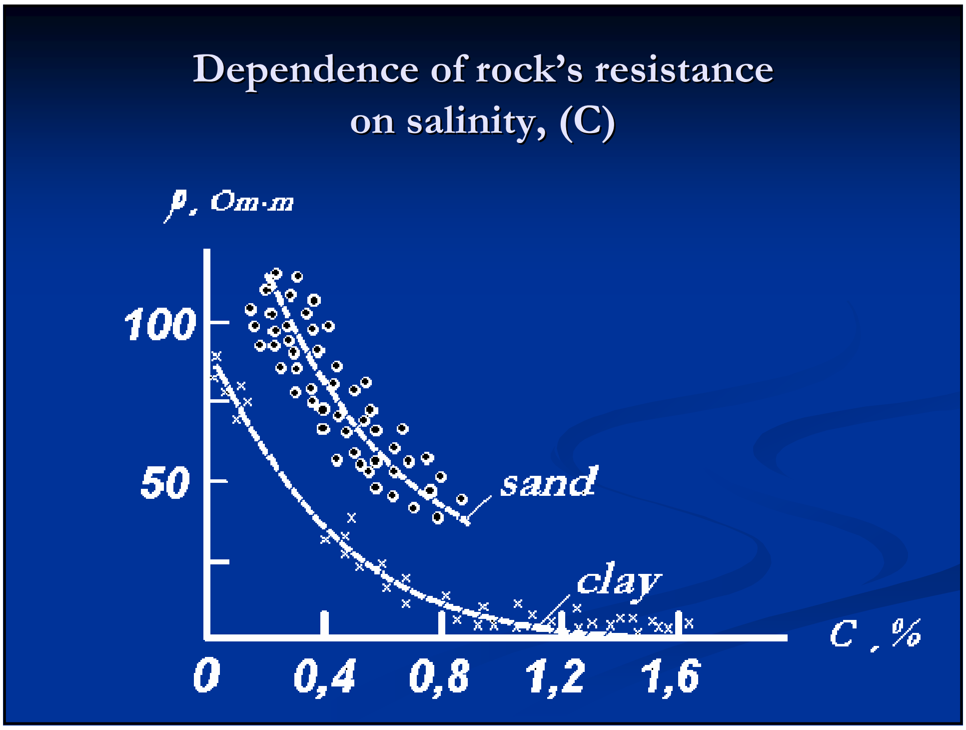
specific electric resistance and

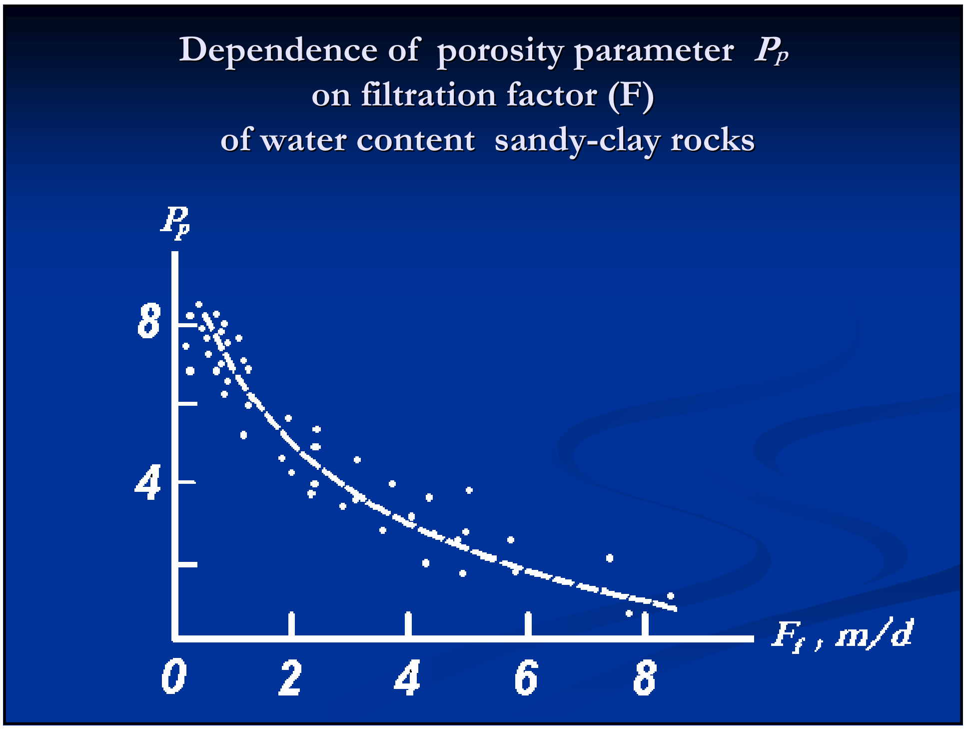
rocks' hydro-geological parameters

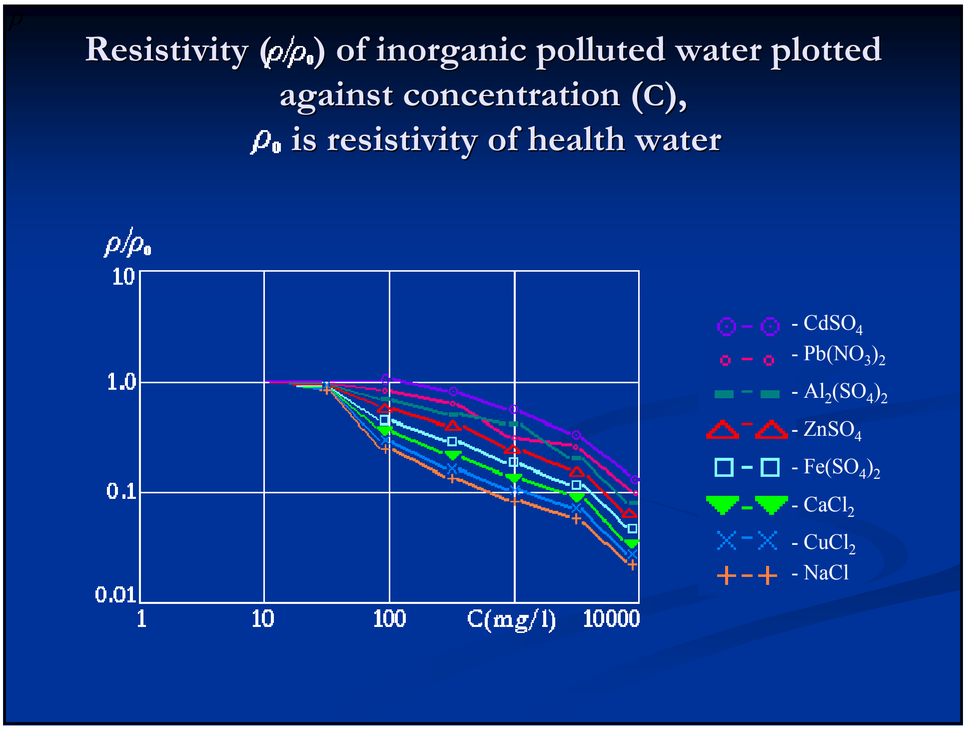
have been established and statistically proved

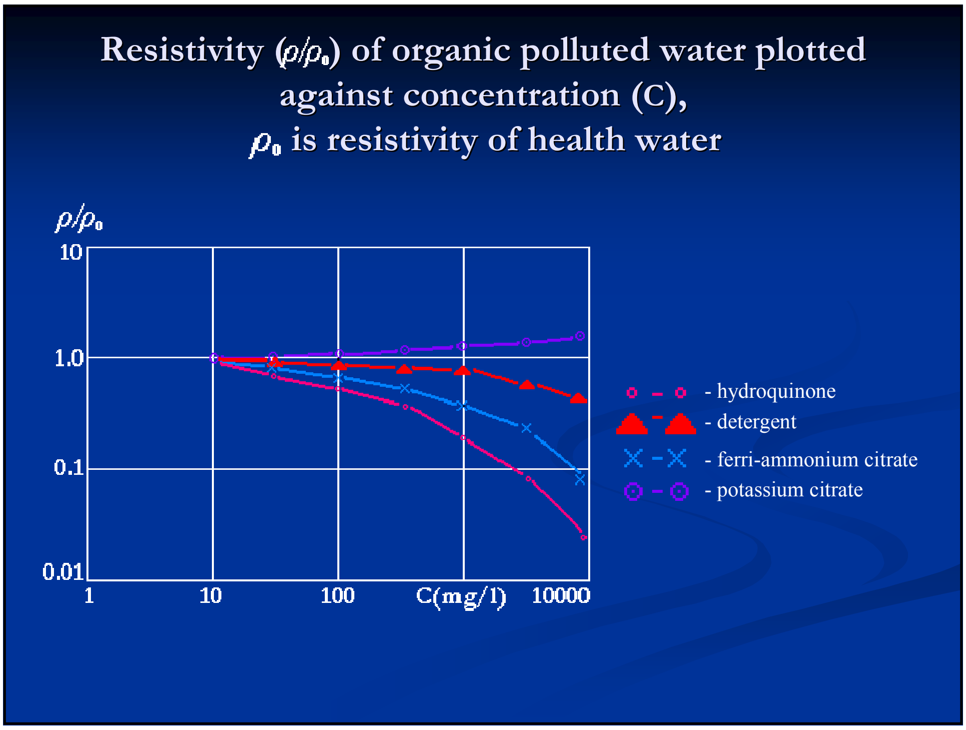

Various correlations between
electric resistance and water content (w)
can be built with in-situ parametrical measurements
ρ, Om·m
100
50
sand
clay
0
10
20
30
40
w, %


Dependence of rocks' resistance
on percentage of a clay fraction, (G)
ρ, Om·m
100
50
0
20
40
60
80
G, %


Dependence of rock's resistance
on salinity, (C)
ρ, Om·m
100
50
sand
clay
0
0,4
0,8
1,2
1,6
C, %


Dependence of porosity parameter P_p
on filtration factor (F)
of water content sandy-clay rocks
P_p
8
4
0
2
4
6
8
F_f, m/d


Resistivity (ρ/ρ₀) of inorganic polluted water plotted against concentration (C),
ρ₀ is resistivity of health water
ρ/ρ₀
10
1.0
0.1
0.01
1
10
100
C(mg/l)
10000
- CdSO4
- Pb(NO3)2
- Al2(SO4)2
- ZnSO4
- Fe(SO4)2
- CaCl2
- CuCl2
- NaCl


Resistivity (ρ/ρ₀) of organic polluted water plotted against concentration (C),
ρ₀ is resistivity of health water
ρ/ρ₀
10
1.0
0.1
0.01
1
10
100
C(mg/l)
10000
- hydroquinone
- detergent
- ferri-ammonium citrate
- potassium citrate

Electrical investigation by a method of the induced polarization

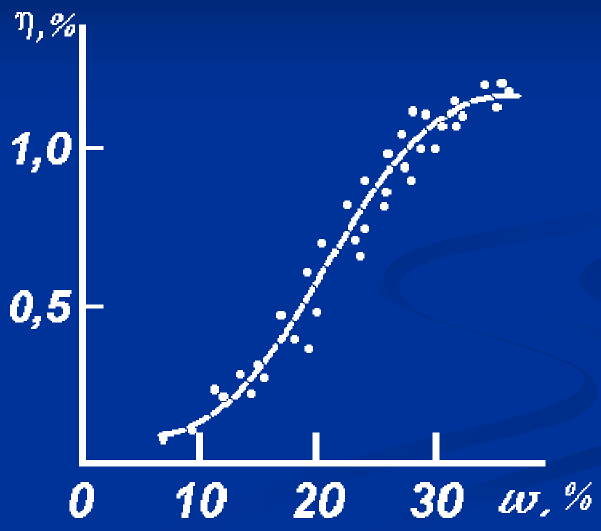
For quantitative estimation on the effect of induced polarization, the factor of polarizability is used

$$\eta = \Delta U_{VP}(t) / \Delta U_{pr}$$

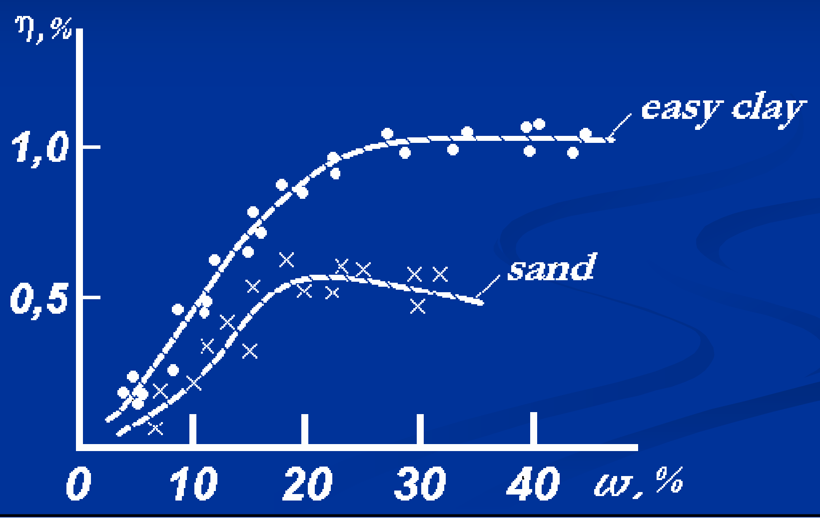
Where U1 is potentional defference of the first field,
while U2 is potentional defference of the second field.

n is amplitude characteristic of depolarization effect

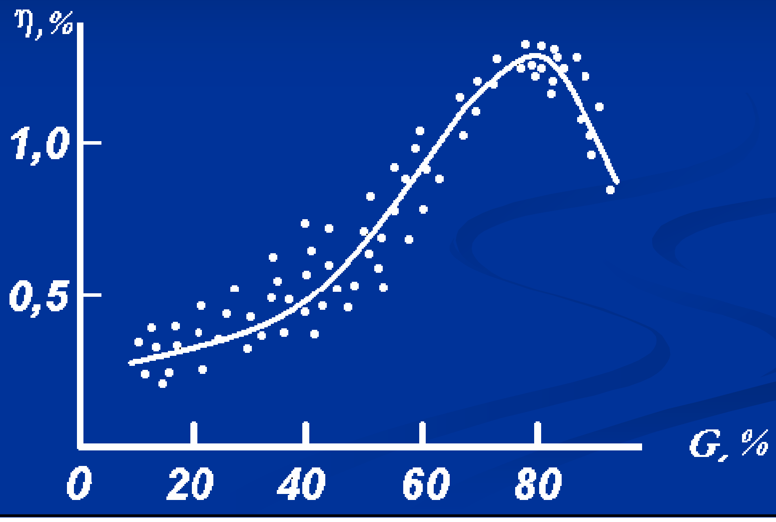
Correlations between factor of polarizability and water content (*w) for loam*



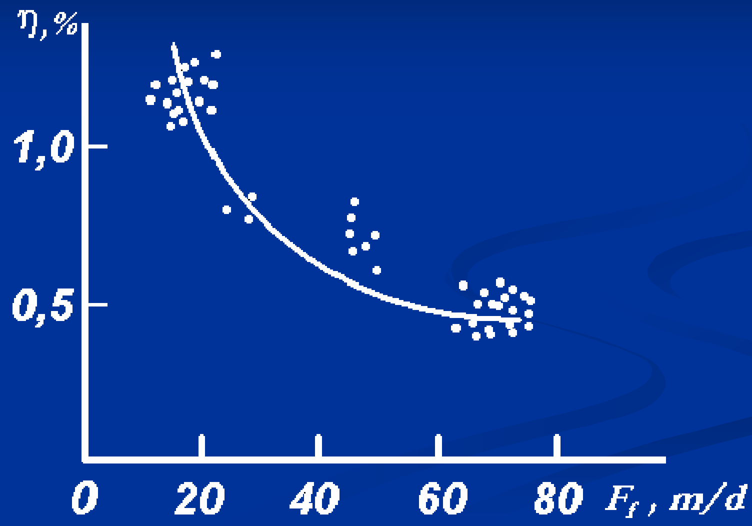
Correlations between factor of polarizability and water content, (*w)*



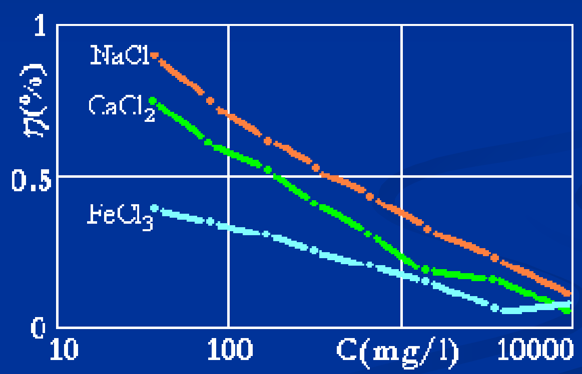
Dependence of factor of polarizability on percentage of a clay fraction, (G)



Dependence of factor of polarizability on filtration factor, (F)



η of quartz sand plotted against and dissimilar composition concentration (C) in the pore solution
ω=5%; d=50~100mesh; T=30s



Integrated factor A is used for characterizing the speed of hydro-geolocal-dependent depolarization effect

$$A = \frac{\Delta U_{VP}(1) - \Delta U_{VP}(11)}{\Delta U_{pr}} \cdot 100\% = \eta(1) - \eta(11)$$

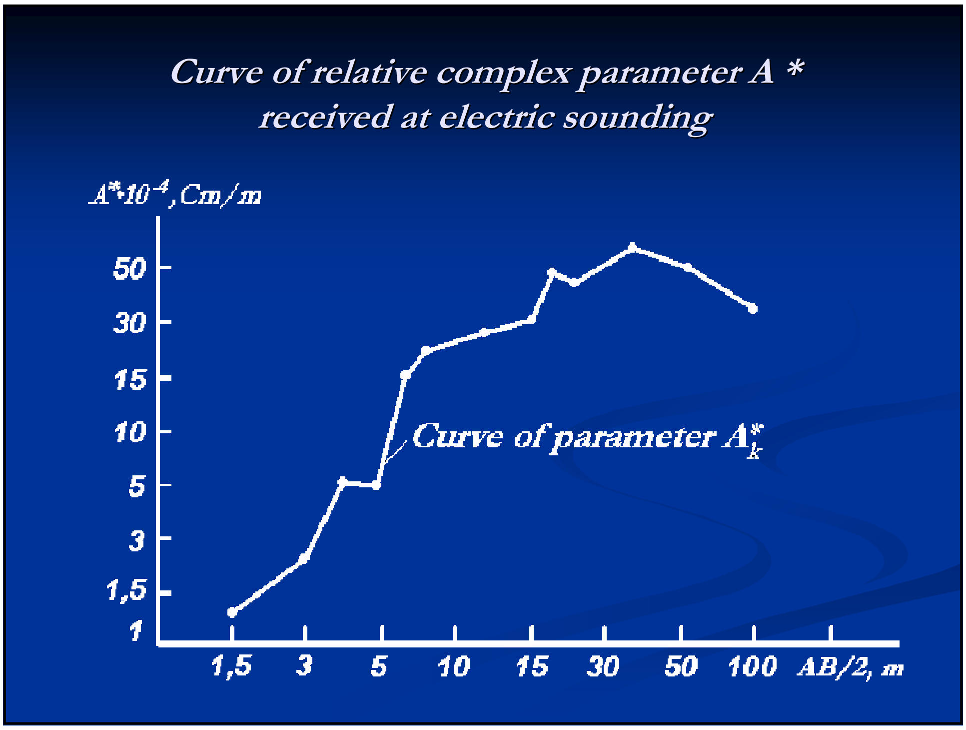
where U1 is polarizability after 1-st second electricity is cut off, U11 is polarizability after 11-n second electricity is cut off

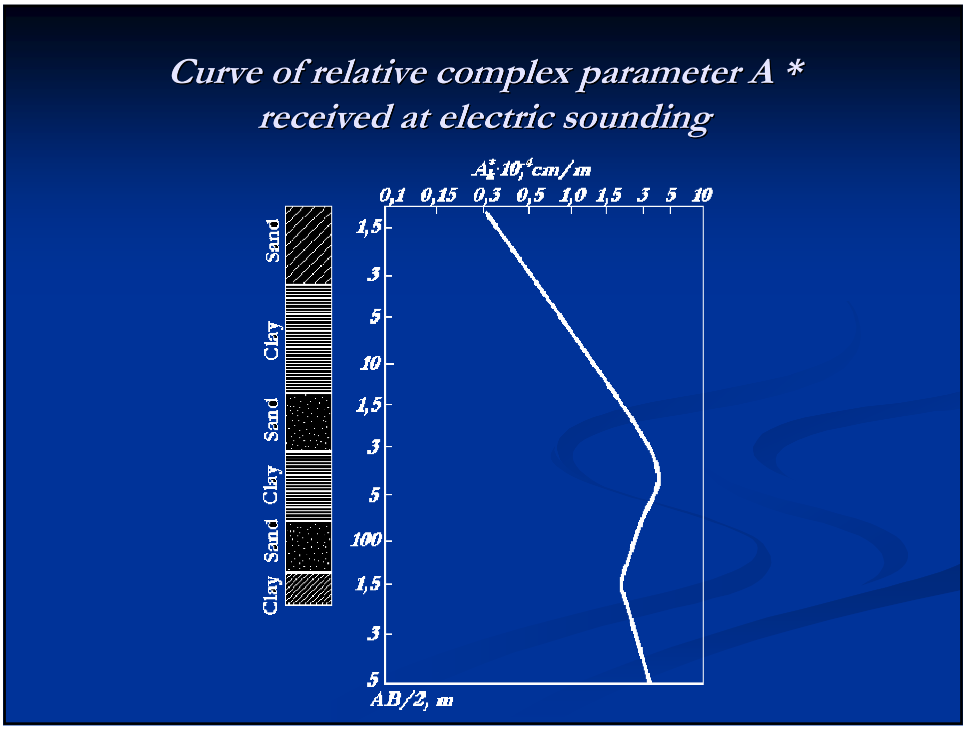
Effect of induced polarization depends on resistance of rocks

Relative integrated index A *

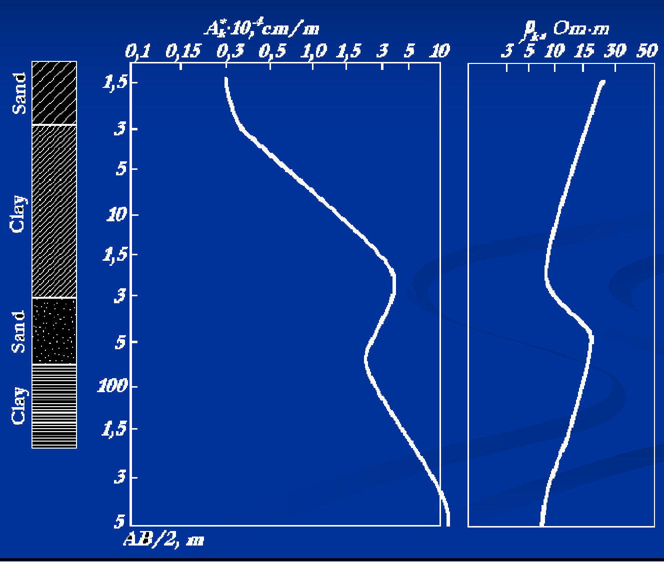
$$A^* = A / \rho$$

Relative integrated parameter A *
has the big comprehension for hydro-geological parameters determination

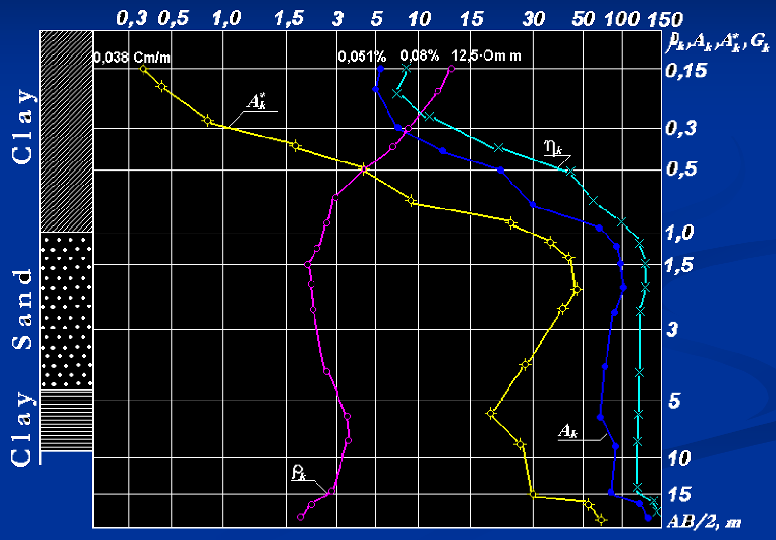

Curve of relative complex parameter A *
received at electric sounding
A*·10⁻⁴, Cm/m
50
30
15
10
5
3
1,5
1
1,5
3
5
10
15
30
50
100
AB/2, m
Curve of parameter A_k^*

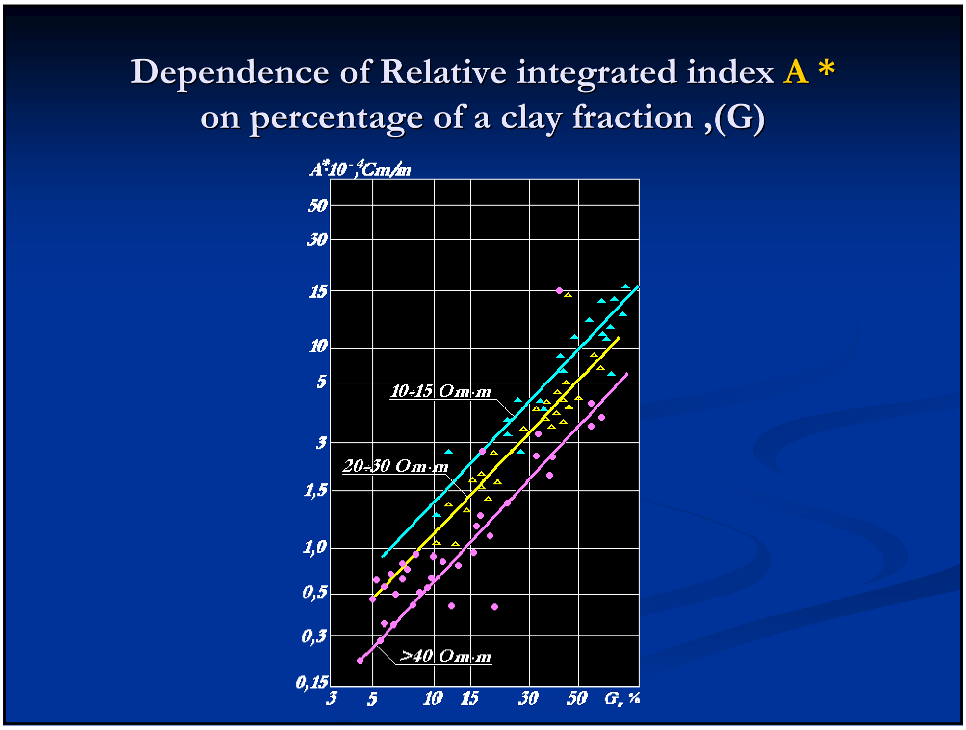

Curve of relative complex parameter A *
received at electric sounding
A_k^*·10⁻⁴ cm/m
0,1 0,15 0,3 0,5 1,0 1,5 3 5 10
Sand
Clay
Sand
Clay
Sand
Clay
1,5
3
5
10
1,5
3
5
100
1,5
3
5
AB/2, m

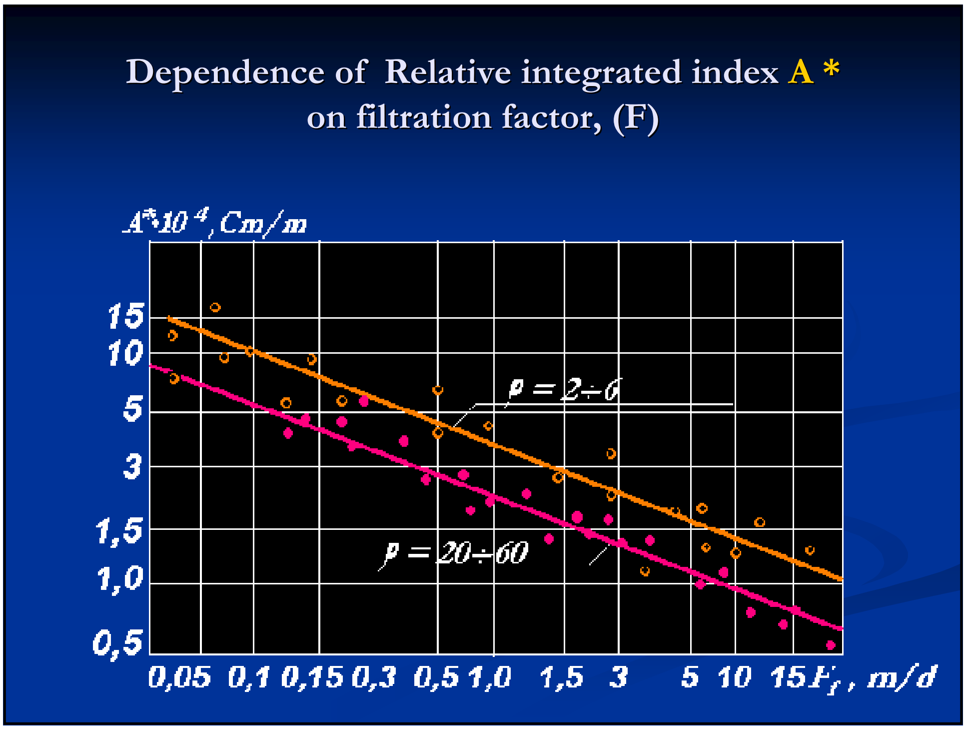
*Curve of relative complex parameter A **
received at electric sounding



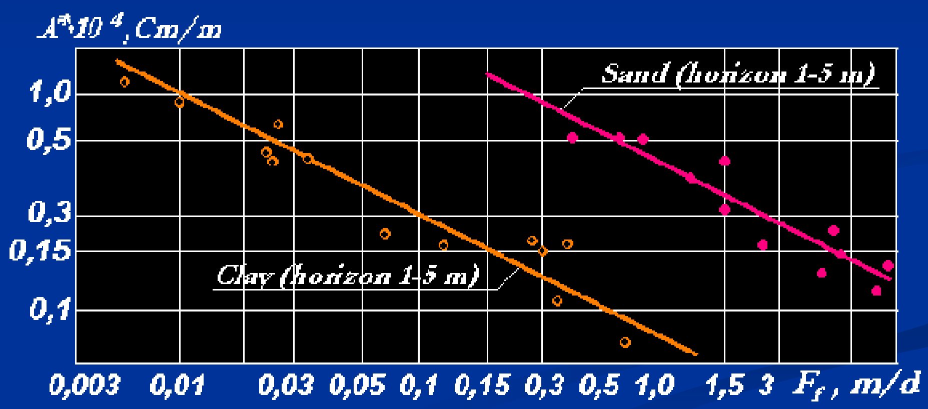
Curves of apparent resistance, polarizability, integrated index A, relative integrated index A * sounding for a typical hydro-geological section




Dependence of Relative integrated index A *
on percentage of a clay fraction ,(G)
50
30
15
10
5
3
1,5
1,0
0,5
0,3
0,15
10-15 Om·m
20-30 Om·m
>40 Om·m
3
5
10
15
30
50
G, %


Dependence of Relative integrated index A *
on filtration factor, (F)
15
10
5
3
1,5
1,0
0,5
0,05
0,1
0,15
0,3
0,5
1,0
1,5
3
5
10
15
m/d

Dependence of Relative integrated index A * on filtration factor (F) for various aeration zones



Tumangan River Basin

(Russian part)

- The Tumangan River Basin 25.8 sq. km in area and 16 km long
- 0.1 % of the reservoir area are Russian territory
- Rivers flow throught the Hasanskaj Plain, forming lagoons offshore
- Hasanskaja Plain is located in a modern low land in subsidence at a rate of 1 mm/a
- In the area of the river basin, sandy and fertile soil cover is wide-spread cover in 1-6 m thick
- In the river valleys, cobble, pebble, and sandy deposits dominate

Deformation of the Tumangan River channel are:

- In narrow part of the river route, deep erosion is observed;
- Average depth on the river channel are 4-4.5 m;
- As a result of deep erosion, the depth of the river channel increased up to 12-15 m;
- Lateral erosion widened the river channel, moving a channel of the river across a valley in the left party.

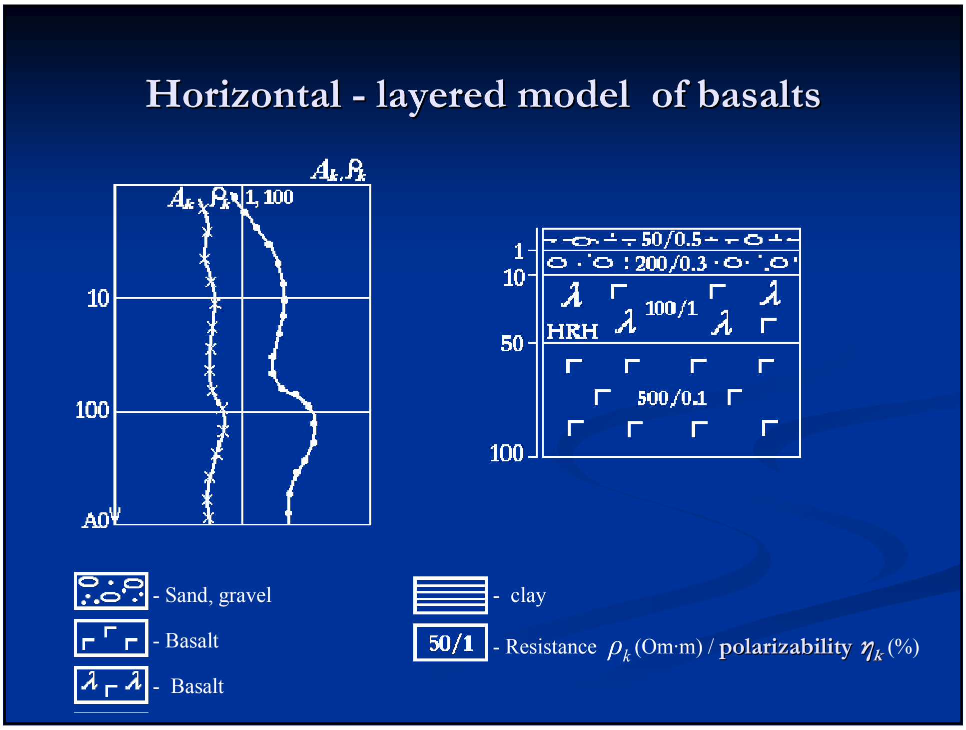
Tumangan River channel migration

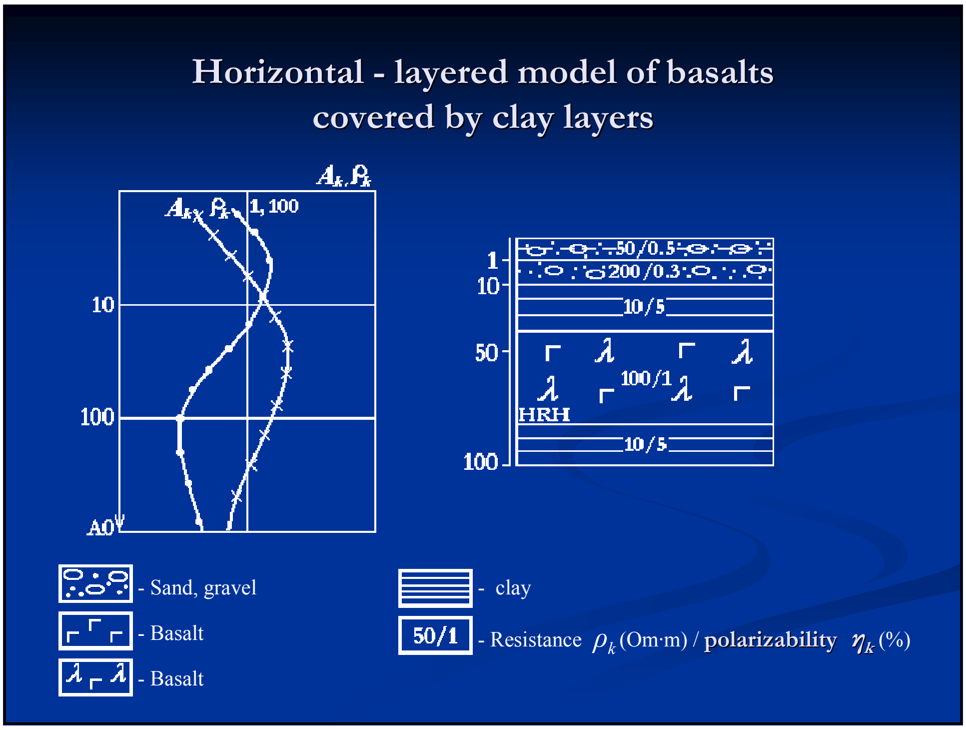
- The average rate **river channel migration** of for the river during the period of 1950-2002 is 2.04 m/a;
- As a result of lateral erosion, in the Russian side, 1.21 hectare of land were washed away every year;
- The displacement of coastal edge of the river in 2000 is 60-70 m for high water.

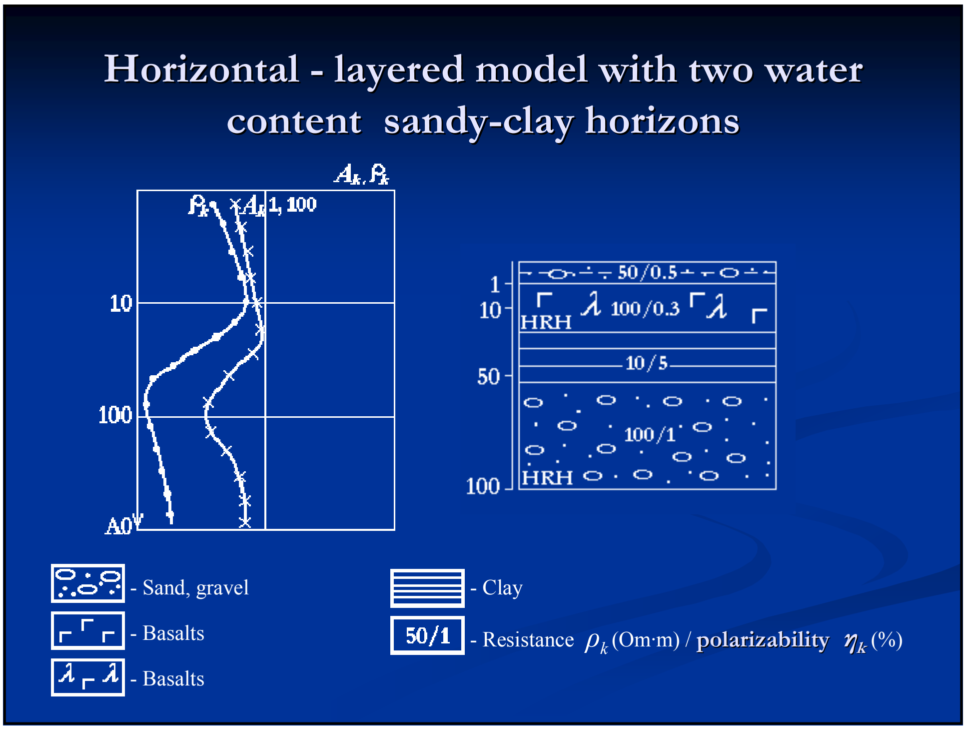
The underground water beneath the Tumangan River Basin features:
(Russian part)

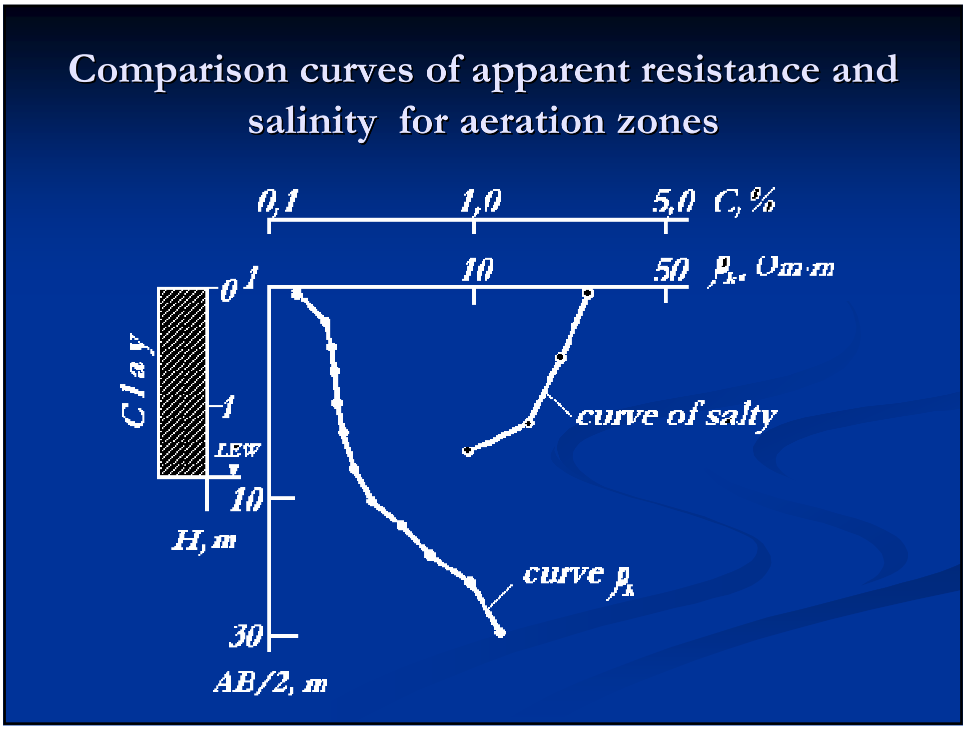
- free flow; flow through porous and water-socked rocks made of very coarse-grained gravels and pebbles;
- few are fractured zones of basalt, limestone, and granite;
- the underground water horizons alternate with clay layers levels between 1 up to 10 m. Sometimes, these clay layers build up pressures in underground water;
- Altitude of underground water varies from 0.5 to 15 m;
- The thickness of water-socked complex changes from 10 to 60m;

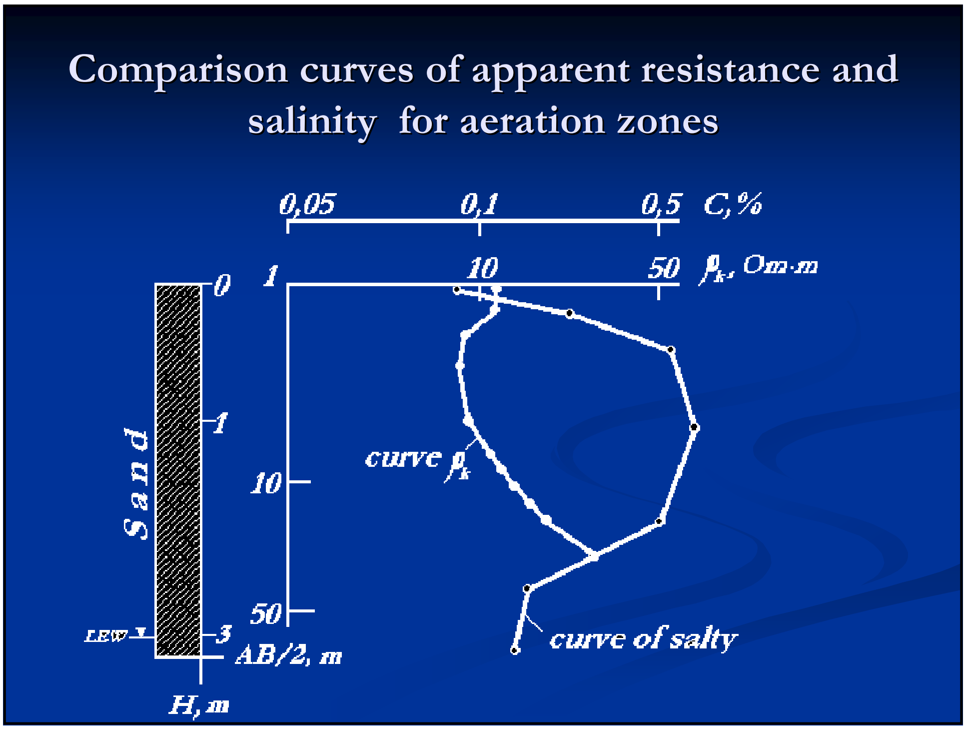
- a replenishment of underground waters is by atmospheric precipitation;
- gravity unloading of underground waters occurs in the sea, in reservoirs, and in underlaying horizons.
- undergroud waters have not been protected from ground surface pollution.
- the mineralization of underground waters changes from 75 to 500 mg/l.
- the increase in a mineralization of underground waters is possible due to penetration of sea waters and relic sea waters from deep horizons.

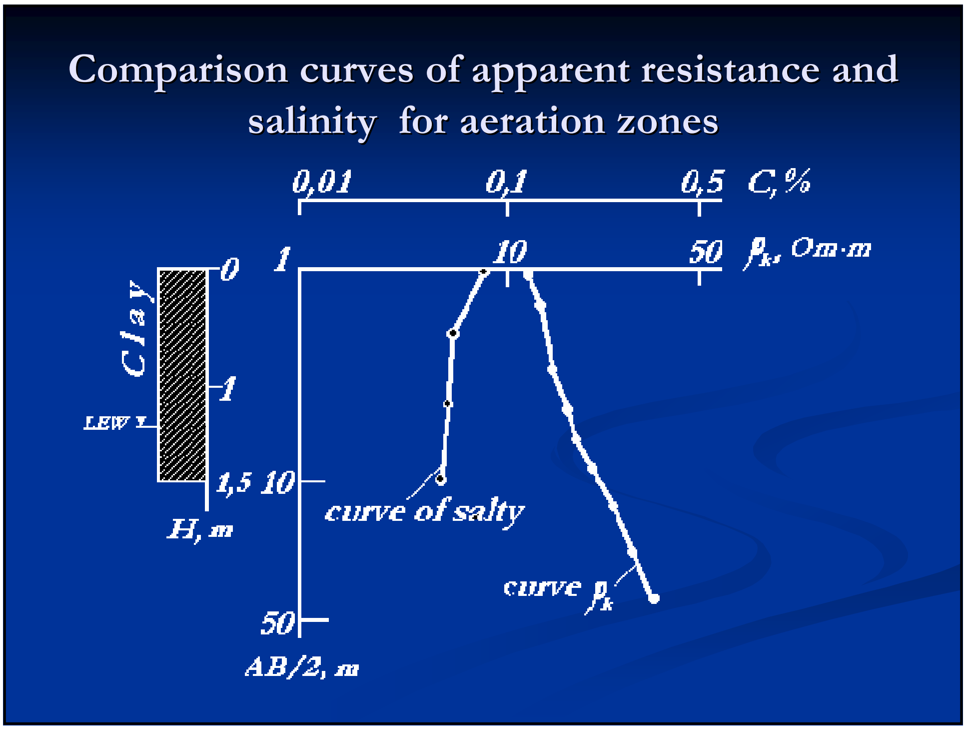

Horizontal - layered model of basalts
A_k, P_k
A_k P_k 1, 100
10
100
A0
1
10
50
100
50/0.5
200/0.3
100/1
HRH
500/0.1
- Sand, gravel
- Basalt
- Basalt
- clay
50/1
- Resistance ρ_k (Om·m) / polarizability η_k (%)

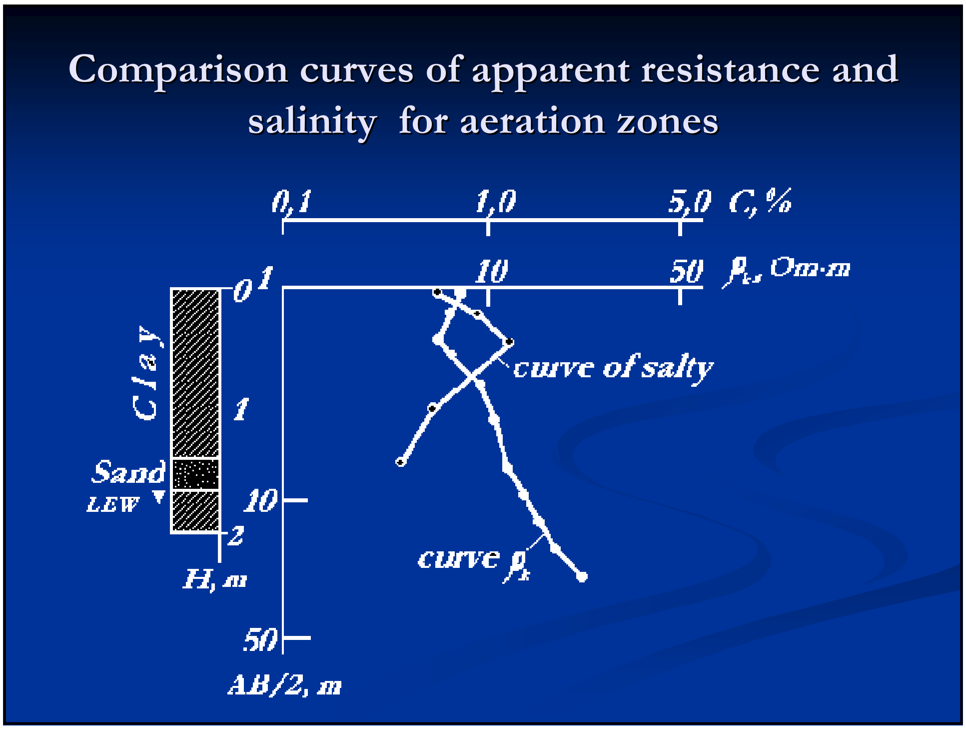

Horizontal - layered model of basalts
covered by clay layers
A_k, P_k
A_k P_k 1, 100
10
100
A0
1
10
50
100
50/0.5
200/0.3
10/5
100/1
HRH
10/5
- Sand, gravel
- Basalt
- Basalt
- clay
50/1
- Resistance ρ_k (Om·m) / polarizability η_k (%)

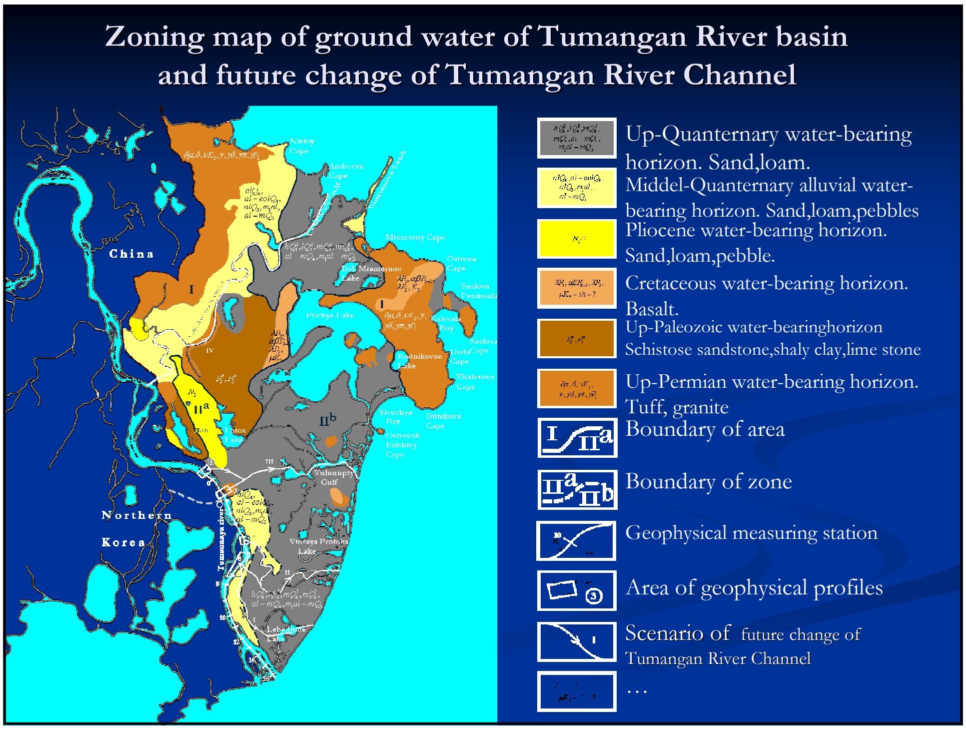

Horizontal - layered model with two water content sandy-clay horizons
1, 100
10
100
A0
1
10
50
100
50/0.5
100/0.3
HRH
10/5
100/1
HRH
- Sand, gravel
- Basalts
- Basalts
- Clay
50/1
- Resistance ρk (Om·m) / polarizability ηk (%)


Comparison curves of apparent resistance and salinity for aeration zones
0,1
1,0
5,0
C, %
10
50
Om·m
0
1
10
30
Clay
LEW
H, m
AB/2, m
curve of salty
curve


Comparison curves of apparent resistance and salinity for aeration zones
0,05
0,1
0,5
C,%
1
10
50
ρk, Om·m
0
1
3
Sand
LEW
10
50
AB/2, m
H, m
curve ρk
curve of salty


Comparison curves of apparent resistance and salinity for aeration zones
0,01
0,1
0,5
C,%
1
10
50
ρk, Om·m
0
1
1,5
Clay
LEW
H, m
10
50
AB/2, m
curve of salty
curve ρk


Comparison curves of apparent resistance and salinity for aeration zones
0,1
1,0
5,0
C,%
10
50
ρ_k, Om·m
Clay
Sand
LEW
1
2
10
50
H, m
AB/2, m
curve of salty
curve ρ_k


Zoning map of ground water of Tumangan River basin and future change of Tumangan River Channel
China
Northern
Korea
Up-Quanternary water-bearing horizon. Sand,loam.
Middel-Quanternary alluvial water-bearing horizon. Sand,loam,pebbles
Pliocene water-bearing horizon. Sand,loam,pebble.
Cretaceous water-bearing horizon. Basalt.
Up-Paleozoic water-bearinghorizon Schistose sandstone,shaly clay,lime stone
Up-Permian water-bearing horizon. Tuff, granite
Boundary of area
Boundary of zone
Geophysical measuring station
Area of geophysical profiles
Scenario of future change of Tumangan River Channel
…

The future change of Tumangan River Channel is predicted:

- Scenario 1

The river will go with a channel of River Swan, through Lake Swan and then run into the sea.

In this case, Russia will lose 22 sq. km of land.

- Scenario 2

The river will choose a new direction to the channel of the First Channels and sharply turn eastwards.

In this case, Russia will lose 35 sq. km of land.

- Scenario 3

The river will develop on an ancient paleo-channel and run into gulf Pigeon, and then go to the sea. Russia will lose 100 sq. km of land.

- Scenario 4

The river on ancient paleo-chennel will run to the River Lebedinka, then to the Gulf Swan and the Expedition Bay.

400 sq. km will be lost for Russia.

Environmental Impact Assessment of Exploration Coal Deposits and Project Constructions

— on example of Primorskiy Region (Russian Far East) —

Dr. Tatiana SELIVANOVA
Geophysical and Geoecological Chair,
Far Eastern State Technical University

Abstract

Will be use 6 graphics packages of a few coal deposits and technical constructions consisted from schematic geological, hydro-geological and technical maps.

The practical course include following:

1. Zoning of territory on man-caused environmental impact:

Will define borders of the following zones:
1) Zone of direct man-caused environmental impact;
Zone of considerable man-caused environmental impact;
Zone of zero man-caused environmental impact.

Will define the environment component has the most man-caused impact.

2. Environmental quality monitoring:

- Engineering-geological monitoring networking.
- Underground water quality monitoring networking.
- Surface water quality monitoring networking.
- Air quality monitoring networking.
- Soil quality monitoring networking.

3. Recreational stability impact of territory:

- Will calculate factor of a recreational development of territory (K).
- Will type of a recreational landscape.

Groundwater Survey for Geothermal Heat Pump Application in East Asia

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AIST

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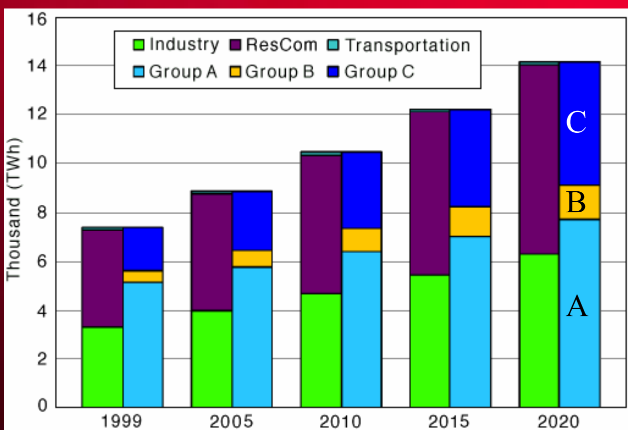
1. Environmental and energy problems in East Asian countries
2. Geothermal heat pump (GHP) system
3. Groundwater temperature study for GHP
4. GHP installation in Thailand

1. Environmental and energy problems in East Asian countries

a) Rapid growth of electricity demand
b) CO_2 and toxic gas emissions
c) Urban Heat-Island phenomenon

a) Rapid growth of electricity demand

-> and shortage of energy supply ?



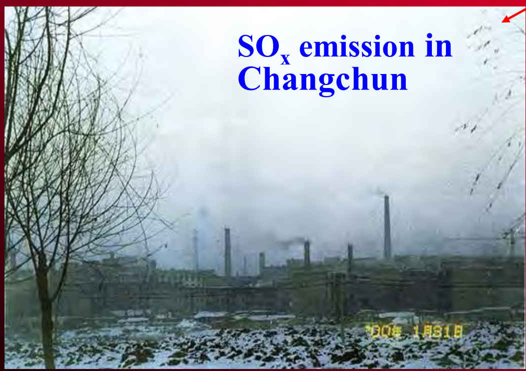
Economical Groups B & C:

Korea, Malaysia, China, Indonesia, Papua N. Guinea, Philippines, Thailand, Viet Num

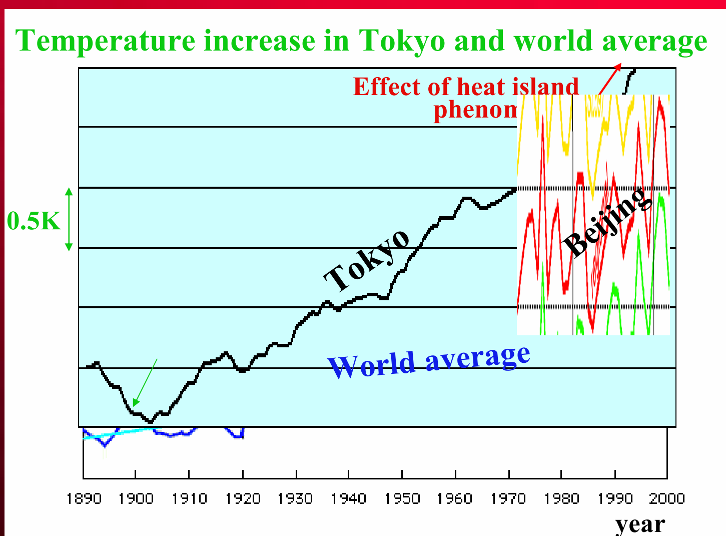
Prospect of electricity demands in APEC countries (APEC, 2002)

b) CO_2 and toxic gas emissions

- Greenhouse gas (CO_2) emission is of great concern over the world
- Toxic gas (NO_x, SO_x) emission by fossil fuels for space heating locally occurs



c) Urban Heat Island (UHI) phenomenon



- Human activity simply releases heat into the atmosphere (local warming problem)

Problems:

a) Rapid growth of electricity demand
b) CO_2 and toxic gas emissions
c) Urban heat-island phenomenon

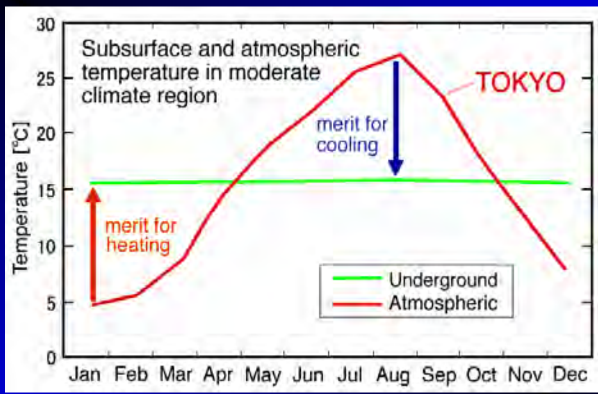
Geothermal heat pump system may be a solution!

What is Geothermal heat pump system?

2. Geothermal heat pump (GHP) system

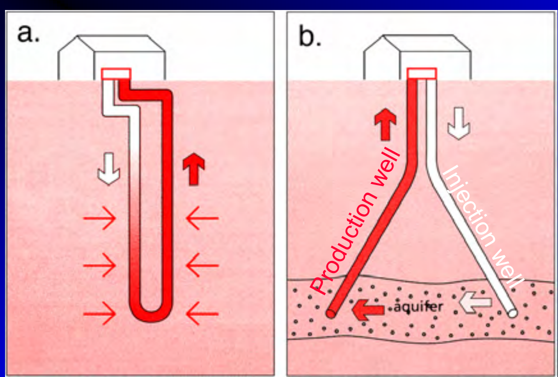
- **Subsurface vs. atmospheric temperature**
- **Heat exchange with underground**
- **Geothermal heat-pump (GHP)**
- **Positive effects of GHP system**

Subsurface vs. atmospheric temperature in moderate climate regions



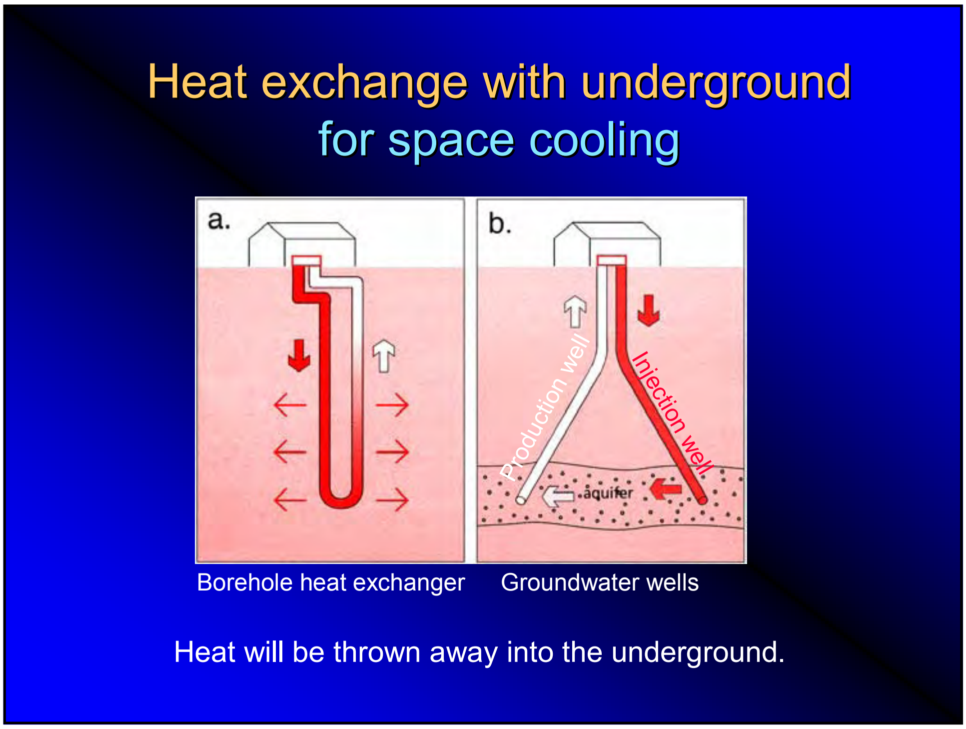
- Subsurface temperature is constant through a year.
- Therefore, it can be used as warm and cool heat sources against atmospheric temperature.

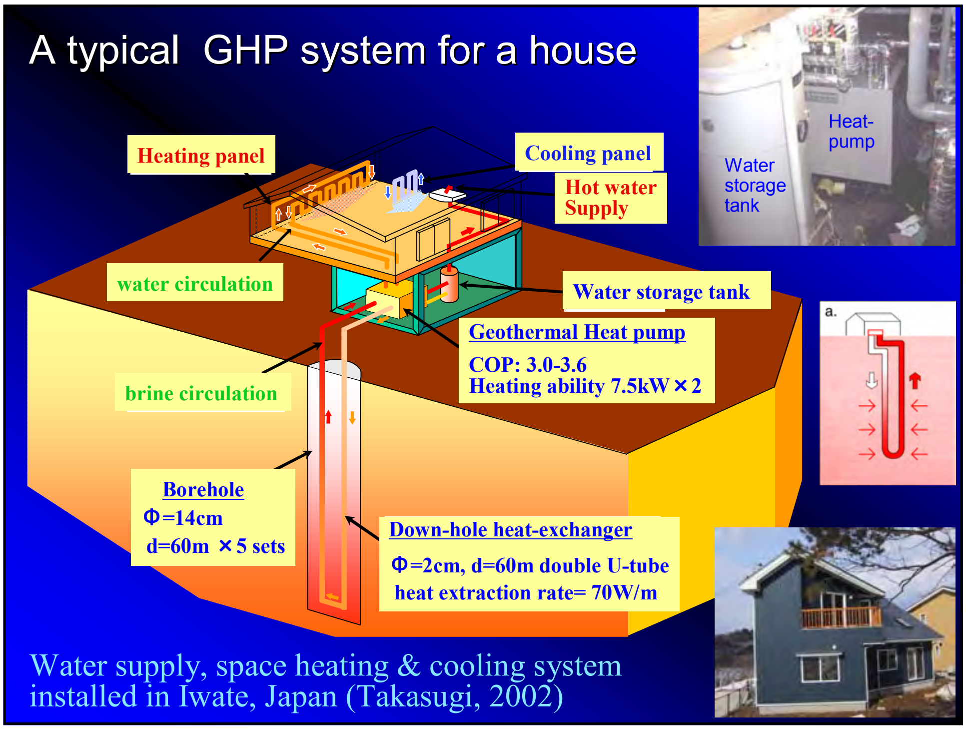
Heat exchange with underground for space heating



Borehole heat exchanger   Groundwater wells

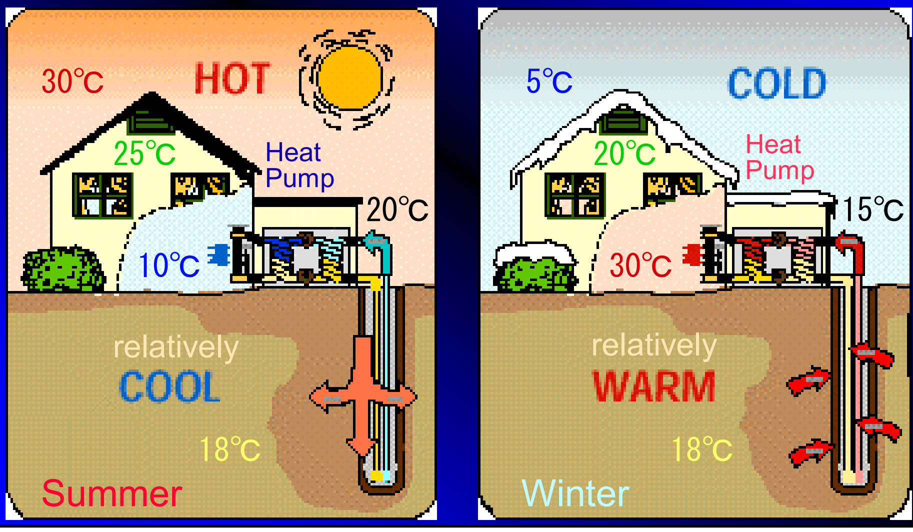
- Heat will be taken out from the underground.
- Hot water supply, snow melting can be also done.


Heat exchange with underground
for space cooling
a.
b.
Production well
Injection well
aquifer
Borehole heat exchanger
Groundwater wells
Heat will be thrown away into the underground.

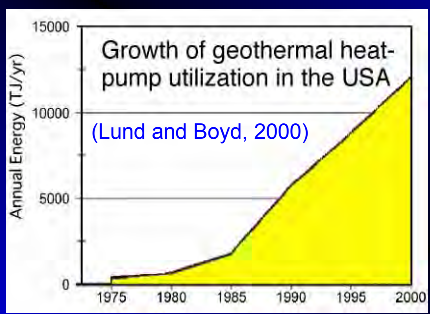

A typical GHP system for a house
Heating panel
Cooling panel
Hot water Supply
water circulation
Water storage tank
Geothermal Heat pump
COP: 3.0-3.6
Heating ability 7.5kW×2
brine circulation
Borehole
Φ=14cm
d=60m ×5 sets
Down-hole heat-exchanger
Φ=2cm, d=60m double U-tube
heat extraction rate= 70W/m
Heat-pump
Water storage tank
a.
Water supply, space heating & cooling system installed in Iwate, Japan (Takasugi, 2002)

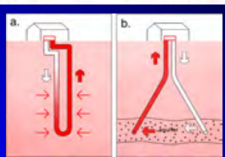
Geothermal Heat-pump (GHP)

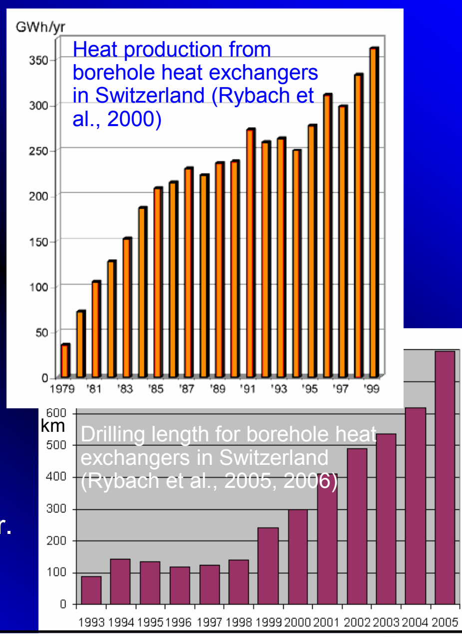
Although subsurface heat can be directly used without heat-pumps, combination with a heat-pump enables to achieve wider temperature range of utilization for air-conditioning, hot-water supply, etc. Subsurface heat exchange system with a heat pump will be called as GHP system.



Growth of GHP in the USA and Switzerland







- GHP saves electricity up to 50 % compared to normal air-conditionar.
- GHP is widely used in European countries and in the USA.

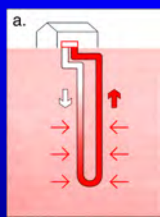
GHP utilization in the world

	Capacity (MWt)	Used heat (GWh/yr)	Number of installation	Capacity factor (%)	Average capacity (kWt)	installation per million people
USA	6,300	6,300	600,000	11.4	10.5	2,048
Sweden	2,000	8,000	200,000	45.6	10.0	22,256
China	631	1,825		33.0		
Germany	560	840	40,000	17.1	14.0	485
Switzerland	440	660	25,000	17.1	17.6	3,355
Canada	435	300	36,000	7.9	12.1	1,107
Austria	275	370	23,000	15.3	12.0	2,814
others	5,082	5,780				
world total	15,723	24,075	>1,000,000	17.5		

Reference: Curtis et al, (2005), Zheng et al.(2005), Lund et al.(2005).

Installation in Switzerland

Construction of an apartment complex and a drilling machine for borehole heat exchanger



U-tube for borehole heat exchanger

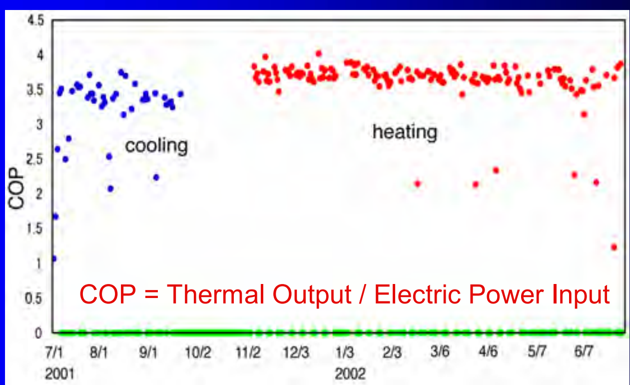
Surface top part of the borehole and double u-tubes. They will be connected to a heat-pump.

Thermal response test: measurement of effective heat conductivity of underground layers. Heated water will be pumped into u-tubes and inlet & outlet temperature will be measured.

Positive effects of GHP system

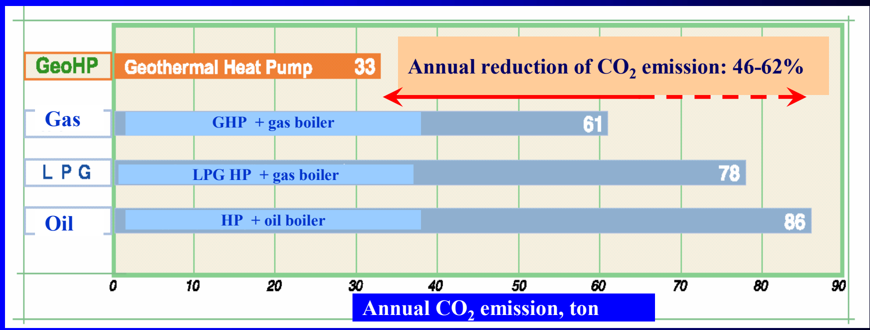
a) Save electricity with high COP
b) Reduce CO_2 and toxic gas emission
c) Reduce urban heat-island phenomenon

a) Save electricity with high COP



COP(Coefficient of Performance) of Geo-HP
Observed for a system in Iwate, Japan (Takasugi, 2002)

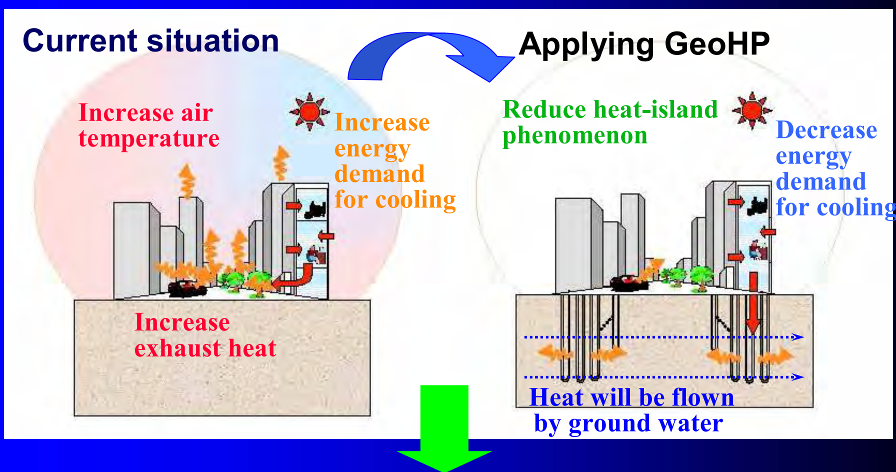
b) Reduce CO_2 and toxic gas emission



GHP installation in Changchun, China

- CO_2 gas emission will be reduced as above.
- SO_x gas emission from space heating in Changchun, China is estimated to be reduced 1.5 tons/year by full installation of GHP system (Takasugi et al., 2001).

c) Reduce urban heat-island phenomenon

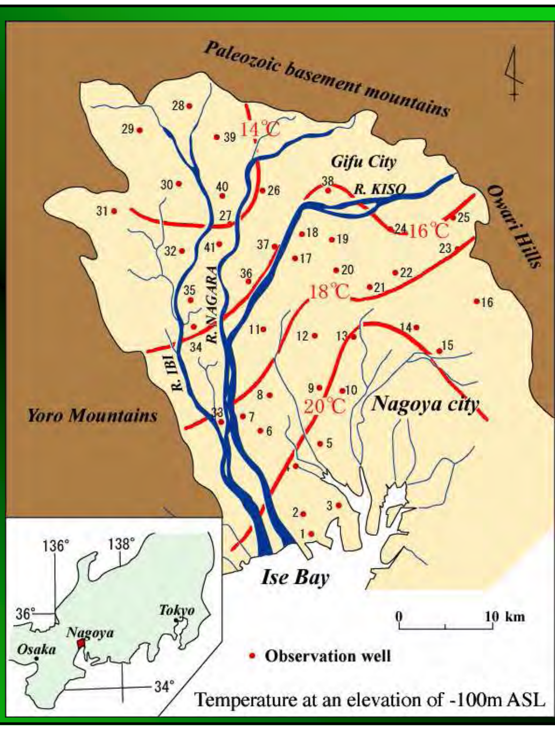


Estimation: GHP system with a 3m pitch, 234m long borehole heat exchanger installed over 0.21km² of Shinjuku, Tokyo would reduce over 100W/m² of sensible heat flux in daytime (Genchi et al., 1999)

3. Groundwater temperature study for GHP

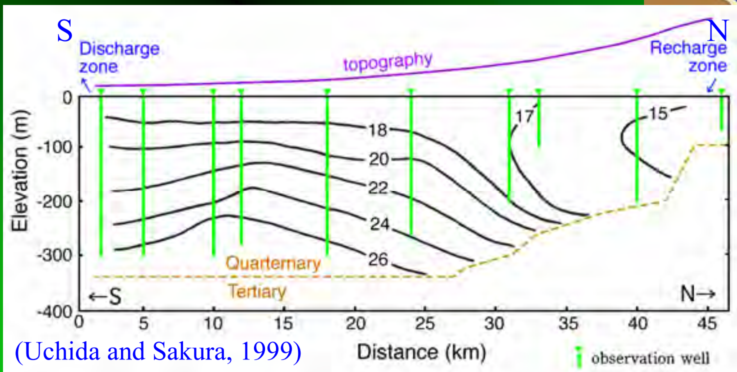
- **Subsurface temperature distribution**
- **Case study at the Sendai plain**
- **GHP system in tropical countries?**

Subsurface temperature distribution at the Nobi plain, Japan



(Uchida and Sakura, 1999)

N-S cross-section of subsurface temperature at the Nobi plain, Japan

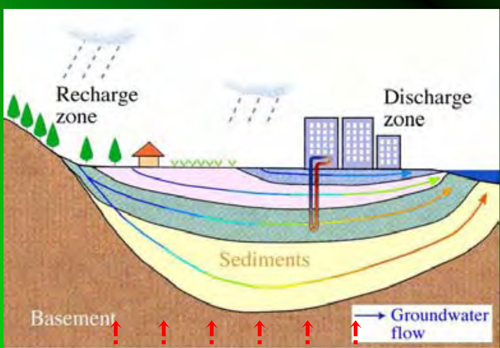


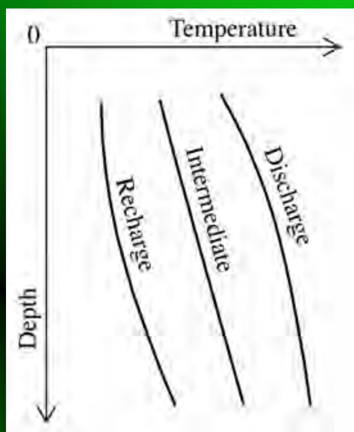
(Uchida and Sakura, 1999)

*Subsurface temperature is one of the natural tracers of the groundwater flow.

Shallow subsurface temperature affected by groundwater flow

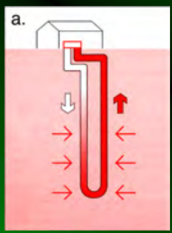
At recharge zones (high elevation), shallow temperature is lower, while it is higher at discharge zones because ground water is heated by heat flow from a depth while flowing laterally.



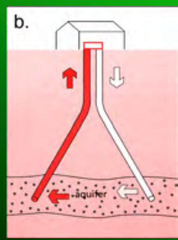


Subsurface temperature profile with groundwater flow

Possible contribution of ground water survey results to GHP promotion



Subsurface information needed for GHP system design:



Borehole heat exchanger
- vertical temperature profiling
- effective thermal conductivity (aquifer depth & velocity)
- effective specific heat (aquifer depth & velocity)

Groundwater wells
- aquifer temperature
- aquifer depth
- aquifer flow direction (for injection well)

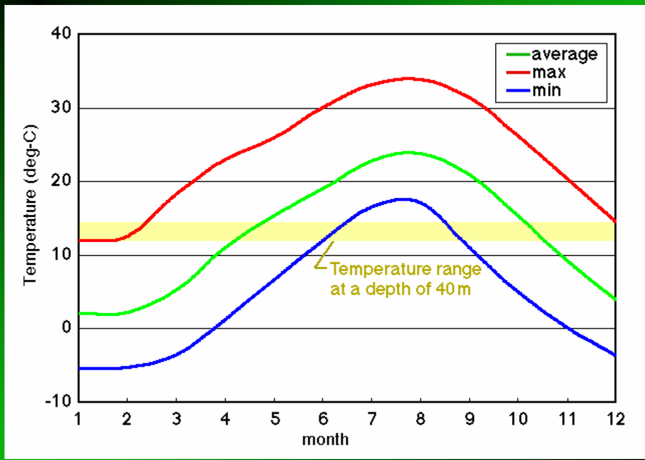
Temperature profiling and aquifer depth can be obtained by measurement at site. 3D numerical modeling enables to estimate temperature profiling, aquifer depth and flow direction & velocity at any point.

Case study at the Sendai plain

- Since subsurface temperature is largely affected by ground water flows, ground water survey and numerical modeling is needed to get 3-D temperature distribution.
- A case study in Sendai, Japan will be introduced.

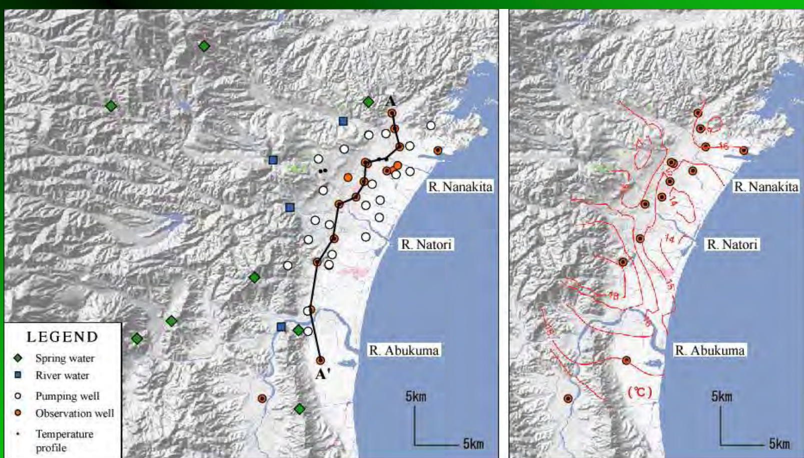
Location of the Sendai plain

Atmospheric temperature in Sendai



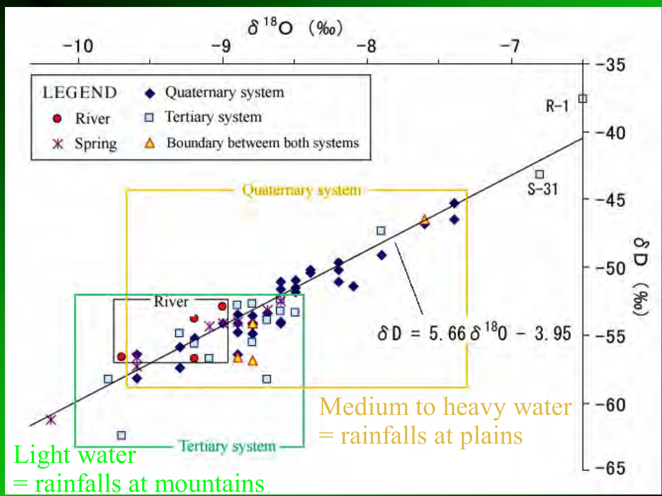
It shows GHP system is good for both heating and cooling

Measured subsurface temperature at the Sendai plain



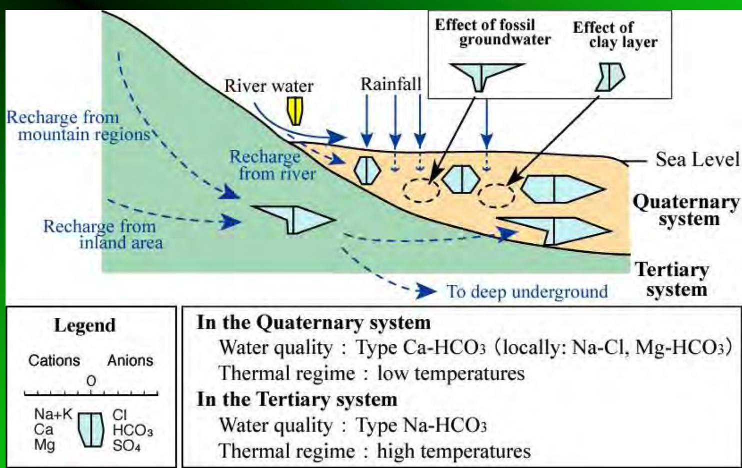
Sampling points (left) and resultant contour map of isotherms at an elevation of –50m (right)

Isotope components of the samples from the Sendai plain



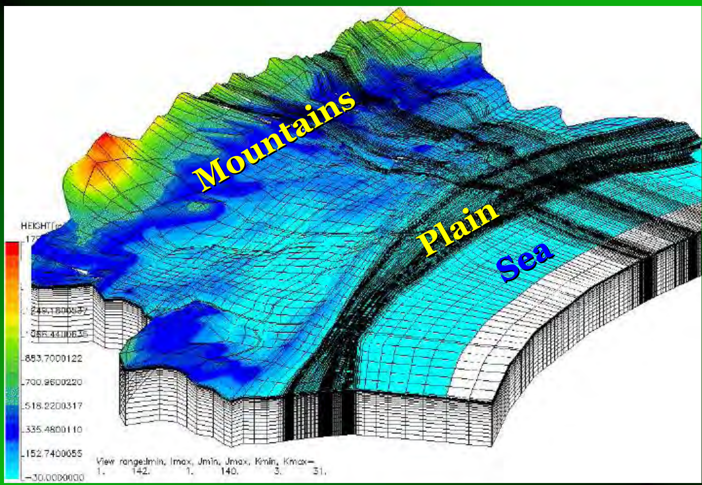
Separate flows in Tertiary and in Quaternary are suggested.

Schematic subsurface flow model of the Sendai plain



*Chemical and isotope components are natural tracer of the groundwater flow.

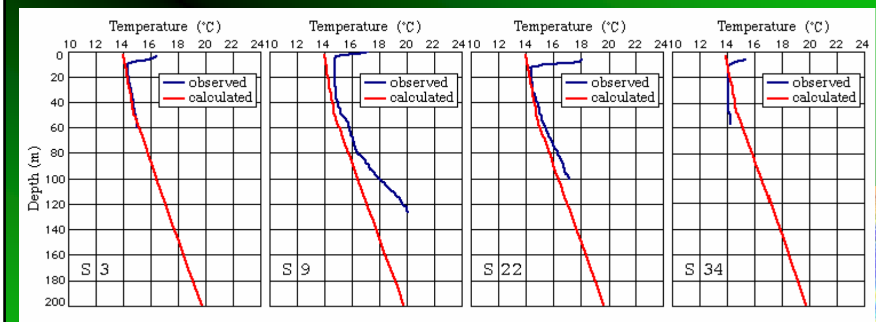
Numerical modeling of the Sendai plain

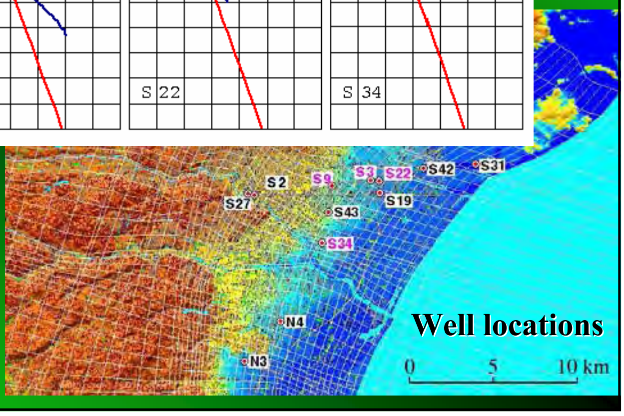


Mesh for 3D modeling (3D image)

The simulated area is approximately 60 x 60 km^2. The number of grid mesh is 19,599 in plan view and 587,970 in total.

Calculated and observed temperature profiles in wells in the Sendai plain

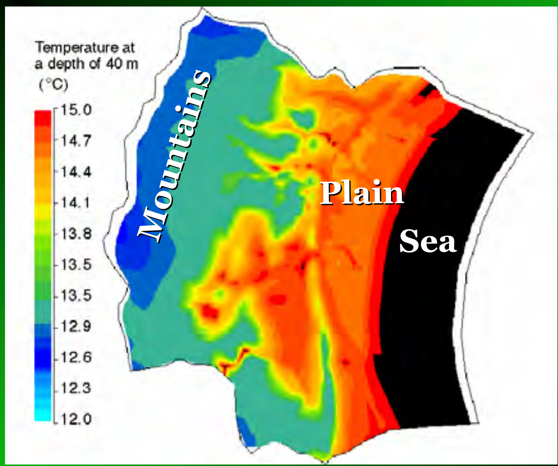




Good match of calculated and observed temperature is obtained.

*Temperature is one of the fitting parameters of a model.

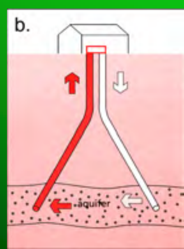
Calculated subsurface temperature distribution



It can be used for system design of geothermal heat pumps at any location in the model region.

Thermal environmental effect of heat exchange: Simulation results for Sendai Plain

Heat exchanges at R1, PL, and 3D are simulated.

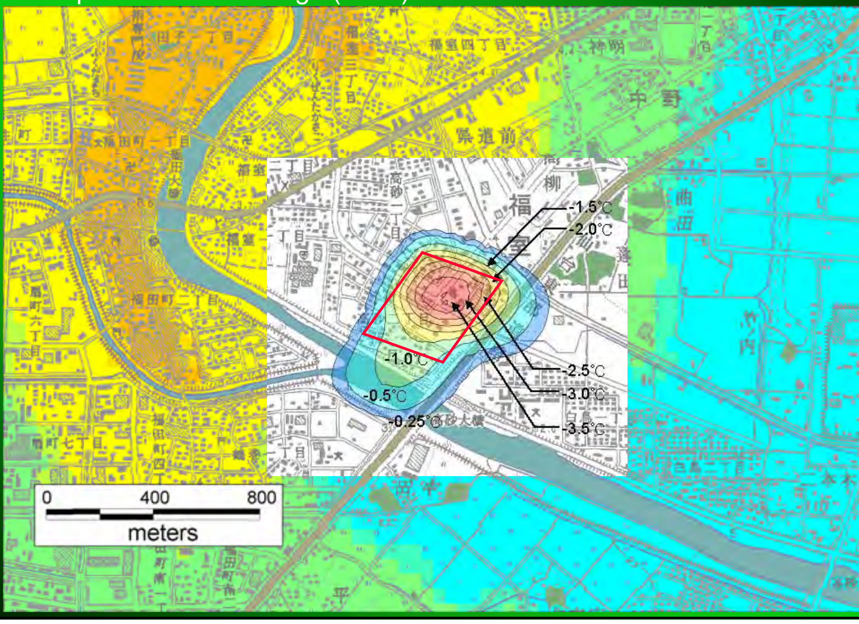


Groundwater well type heat exchange (at a depth of 50 m)

- 50% replacement of traditional heating with GHP for a 900-household district heating/cooling at R1, PL and 3D
- 40 GJ/day (0.463 MW_t) is withdrawn from underground for 4 months for space heating, and 10 GJ/day (0.116 MW_t) is sequestered for 2 months for space cooling each year.
- 30 years of calculation result for 3D will be shown

Temperature change around 3D

at the depth of heat exchange (50 m)



Temperature change around 3D

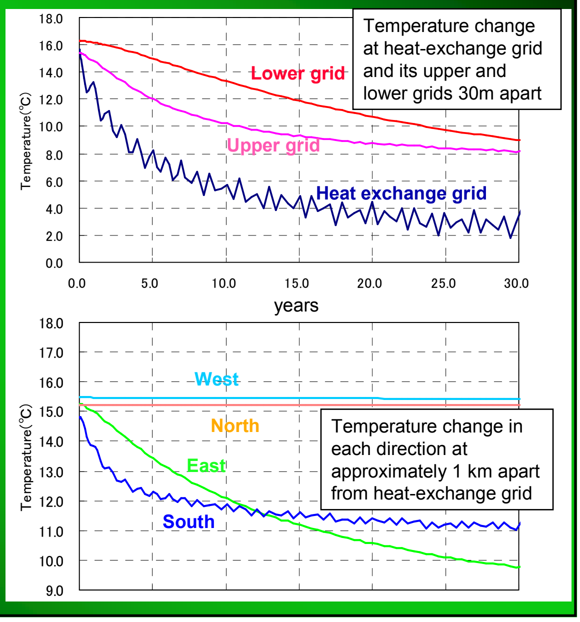
●Quasi-steady state at heat exchange grid, after 25 years of gradual temperature decrease with seasonal change

●●Relatively high effects on upper and lower grids due to high permeability in Quaternary layer.

●●High effects on downstream grids (south & east) with seasonal change at south.

●●Almost no change at upstream grids (north & west)

Thus thermally affected region is estimated by detailed subsurface flow simulation.

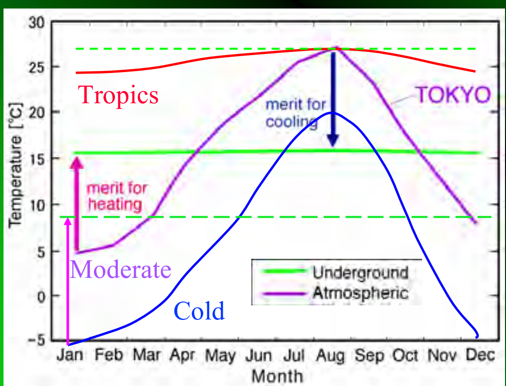


Geothermal heat-pump in east Asia?

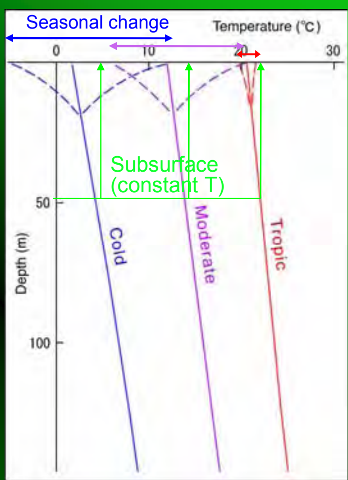
- In east-Asia, where significant economical growth in this century is expected, energy saving and environmental protection will be major matters of importance.
- Intensive installation of geothermal heat-pump may contribute to energy (electricity) savings and protection of the environment.
- However, generally in tropics where air cooling system is needed, subsurface temperature is higher than atmospheric one through a year and underground is not suitable as a cool heat source.
- Nevertheless in tropical regions, underground may be used as cold source if there exist slight change of atmospheric temperature and subsurface temperature is rather low.
- Therefore, subsurface temperature measurement was conducted in Thailand to investigate the possibility of geothermal heat-pump application in tropical regions.

Atmospheric and subsurface temperature changes at different climatic regions

Is geothermal heat-pump applicable everywhere? **Not really in tropics…**

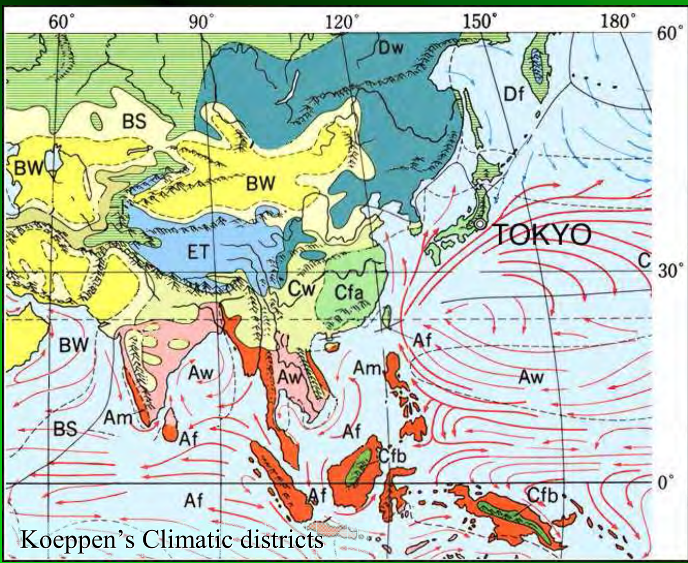


Monthly mean atmospheric and subsurface temperature

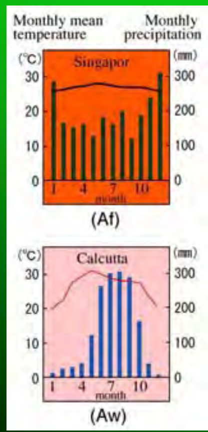


Subsurface temperature profiles without groundwater flow

Geothermal Heat Pump in Tropics?



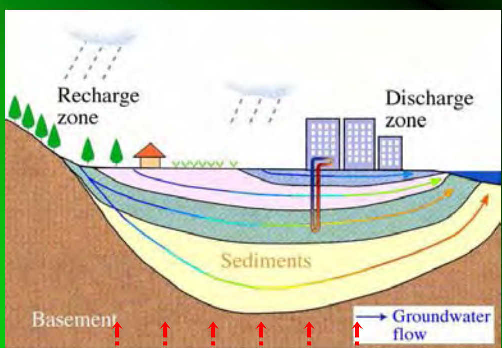
Koeppen's Climatic districts

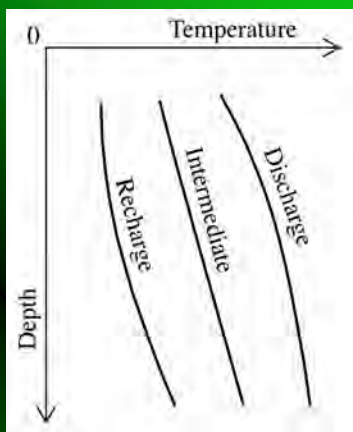


Impossible in Af (rainforest) and Am (monsoon), But possible in Aw (savannah)?
THAILAND??

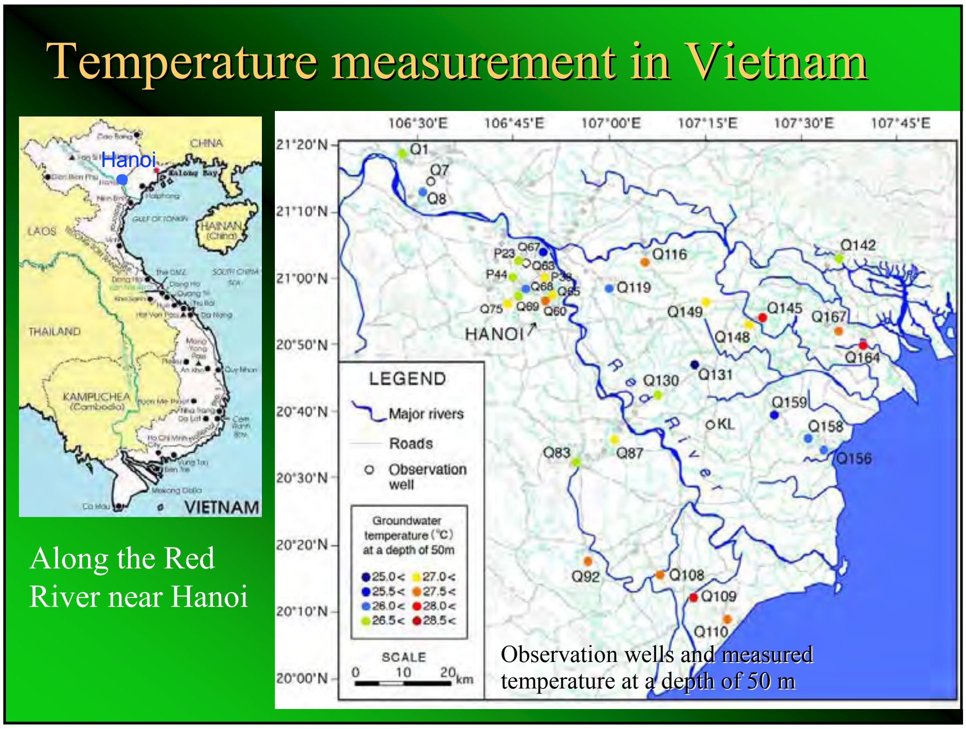
Shallow subsurface temperature affected by groundwater flow

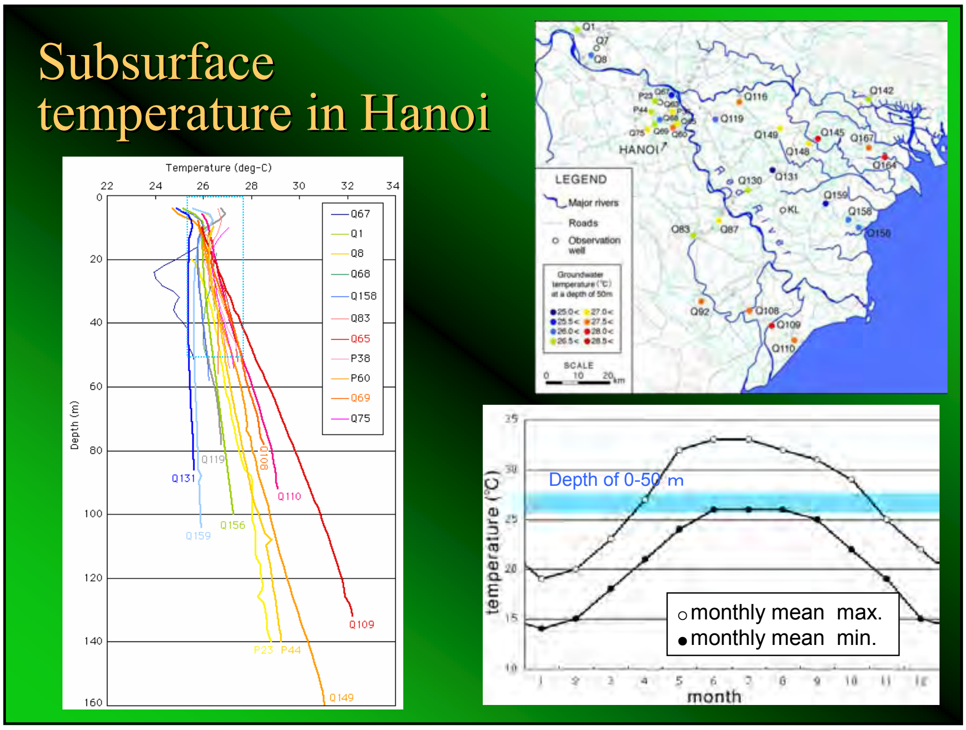
- At recharge zones (high elevation), shallow temperature is lower, while it is higher at discharge zones.
- At recharge zone, underground may be used as cold source in tropics?





Subsurface temperature profile with groundwater flow


Temperature measurement in Vietnam
Hanoi
CHINA
LAOS
THAILAND
KAMPUCHEA (Cambodia)
HAINAN (China)
VIETNAM
Along the Red River near Hanoi
106°30'E
106°45'E
107°00'E
107°15'E
107°30'E
107°45'E
21°20'N
21°10'N
21°00'N
20°50'N
20°40'N
20°30'N
20°20'N
20°10'N
20°00'N
HANOI
LEGEND
Major rivers
Roads
Observation well
Groundwater temperature (°C) at a depth of 50m
25.0< 27.0<
25.5< 27.5<
26.0< 28.0<
26.5< 28.5<
SCALE
0 10 20 km
Observation wells and measured temperature at a depth of 50 m

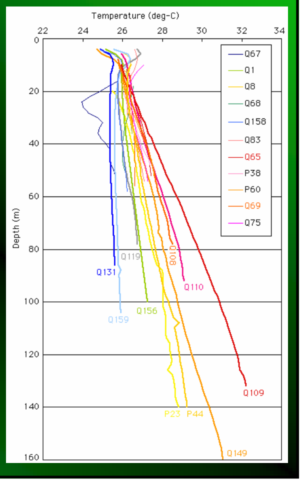

Subsurface temperature in Hanoi
Temperature (deg-C)
Depth (m)
Q67
Q1
Q8
Q68
Q158
Q83
Q65
P38
P60
Q69
Q75
Depth of 0-50 m
temperature (°C)
month
monthly mean max.
monthly mean min.

Summary of the Red River Plain

Regional variation of subsurface temperature at depths from 20 to 50 m of 2.0K was observed in the whole Red River plain.

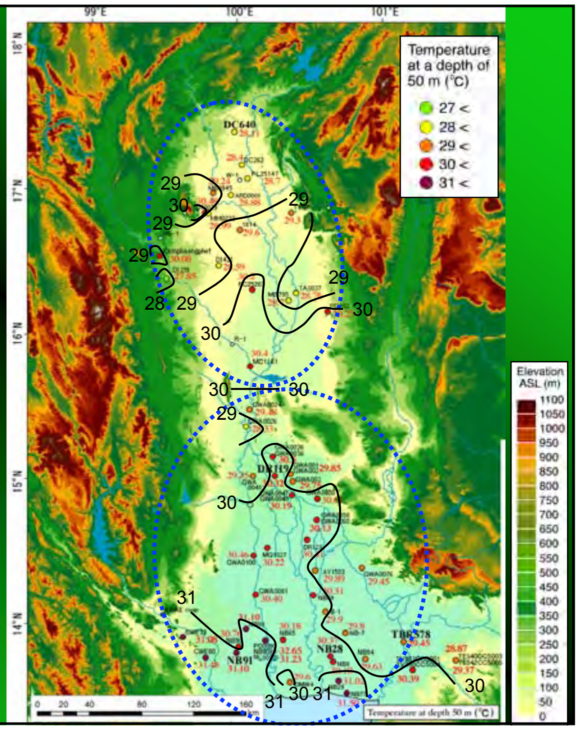
Generally the wells near the sea has higher temperature. However, in the region between the Red River and another river in the north has lower temperature even near the sea, suggesting different subsurface flow system from that along the Red River.

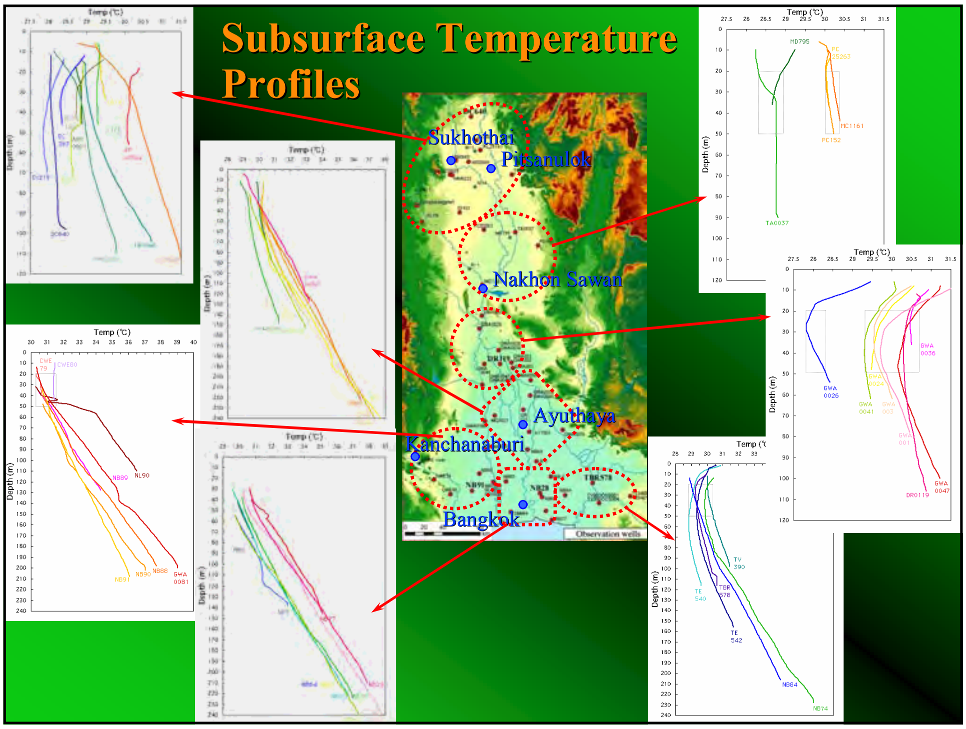
In Hanoi, subsurface temperature is lower than surface monthly mean max for 5K or more over 6 months.

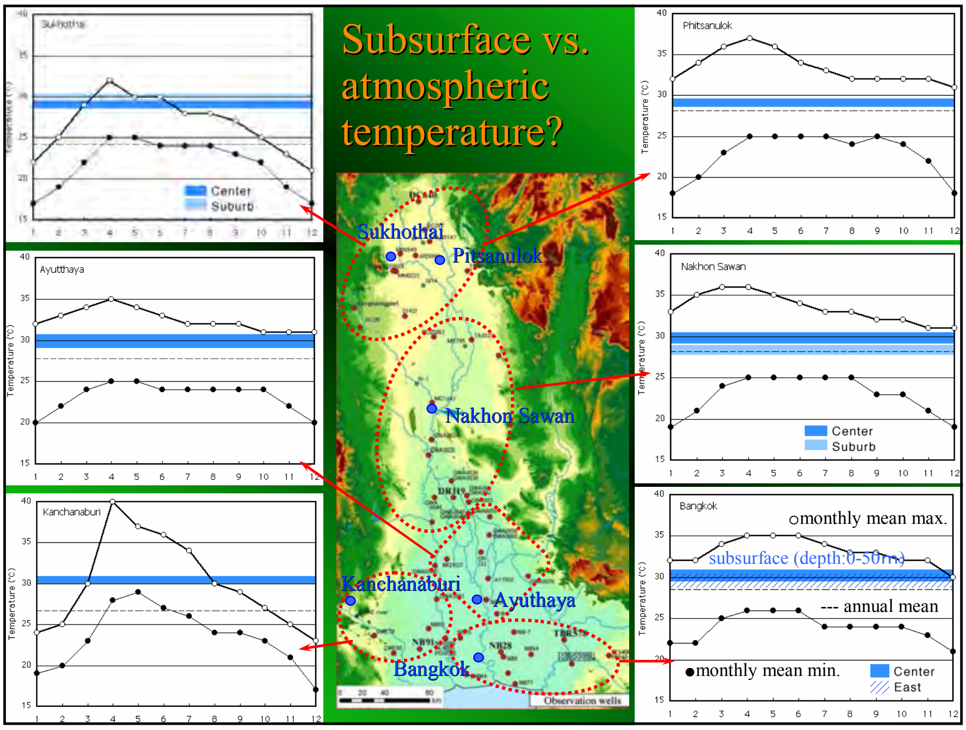


Temperature measurement in Thailand

Chao Phraya river

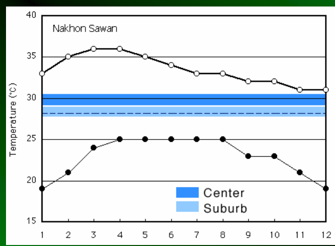



Subsurface Temperature Profiles
Sukhothai
Pitsanulok
Nakhon Sawan
Ayuthaya
Kanchanaburi
Bangkok
Observation wells
Temp (℃)
Depth (m)


Subsurface vs. atmospheric temperature?
Sukhothai
Phitsanulok
Ayutthaya
Nakhon Sawan
Kanchanaburi
Bangkok
Temperature (℃)
Center
Suburb
East
○monthly mean max.
subsurface (depth:0-50m)
--- annual mean
●monthly mean min.
Observation wells

Summary of the Chao-Phraya plain

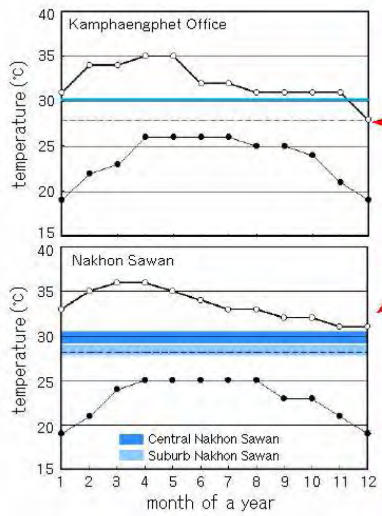
- Temperature profiles in observation wells are widely measured in the Chao-Phraya plain, Thailand.
- As a result, subsurface temperature becomes lower than atmospheric one soundely in hotter season in some places, suggesting the possibility of geothermal heat-pump application in tropics.



4. GHP installation in Thailand

- Borehole heat-exchanger and heat-pump was installed for a room air-conditioner.
- System performance and capacity of the subsurface heat exchange system will be measured over a year.

Experiment at Kamphaengphet



Subsurface temperature in Kamphaengphet is rather high and not really suitable for GHP system for space cooling.

However, experimental result here will be applied for other regions: system performances at other places can be estimated based on suburface temperature and ground water flow data.

Thus places more suitalbe for GHP system will be found as a result of this experiment and groundwater survey.

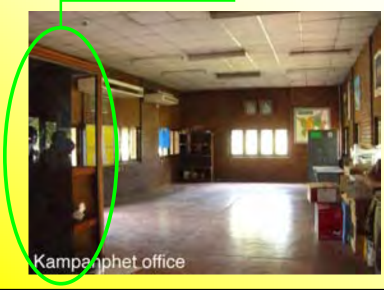
Experiment (Oct. 2006 -)

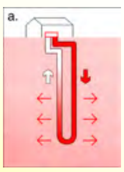
Temperature changes in the borehole and in the vicinity are monitored during the experiment.

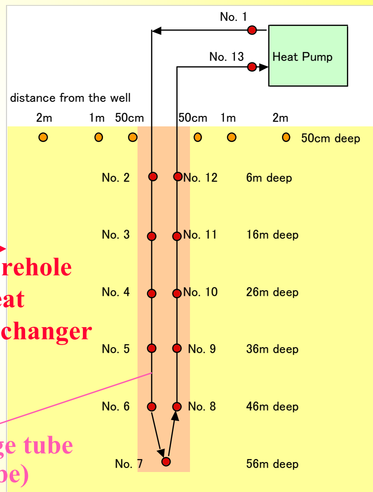
The room to be cooled

Heat pump

Borehole Heat Exchanger





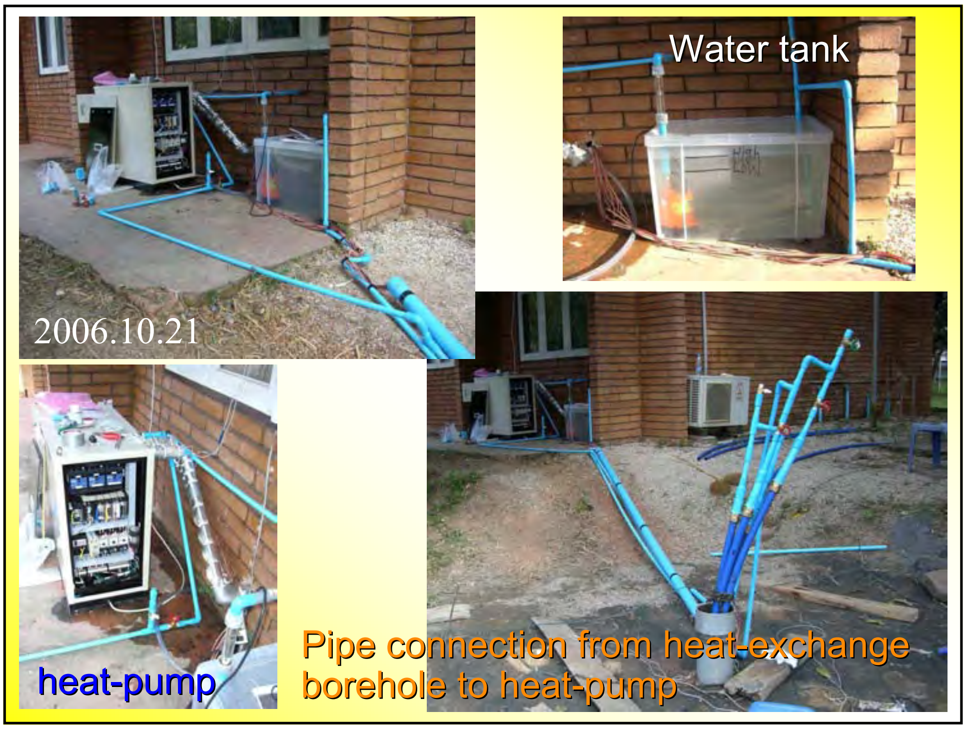


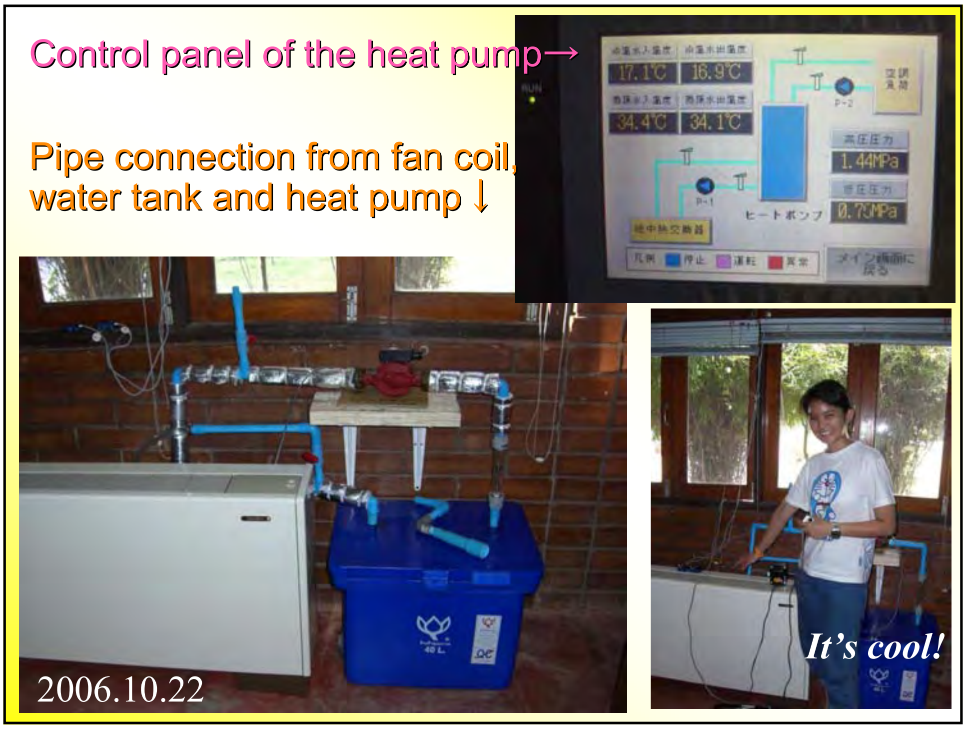
Heat exchange tube (double U-tube)

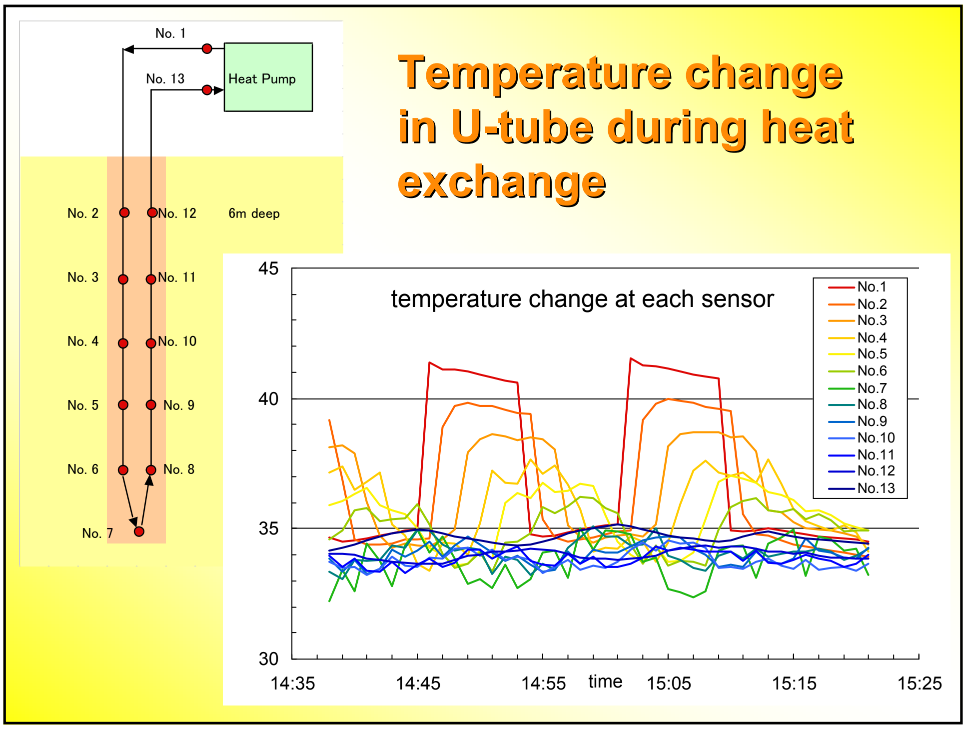

Drilling of heat exchange
borehole, 2006.10.17


Putting temperature
sensors inside/outside
heat exchange tube
(U-tube)


2006.10.20
Installation of U-tube


Water tank
2006.10.21
heat-pump
Pipe connection from heat-exchange borehole to heat-pump


Control panel of the heat pump→
Pipe connection from fan coil, water tank and heat pump ↓
2006.10.22
It's cool!


Temperature change in U-tube during heat exchange
Heat Pump
No. 1
No. 13
No. 2
No. 12
6m deep
No. 3
No. 11
No. 4
No. 10
No. 5
No. 9
No. 6
No. 8
No. 7
temperature change at each sensor
45
40
35
30
14:35
14:45
14:55
time
15:05
15:15
15:25
No.1
No.2
No.3
No.4
No.5
No.6
No.7
No.8
No.9
No.10
No.11
No.12
No.13

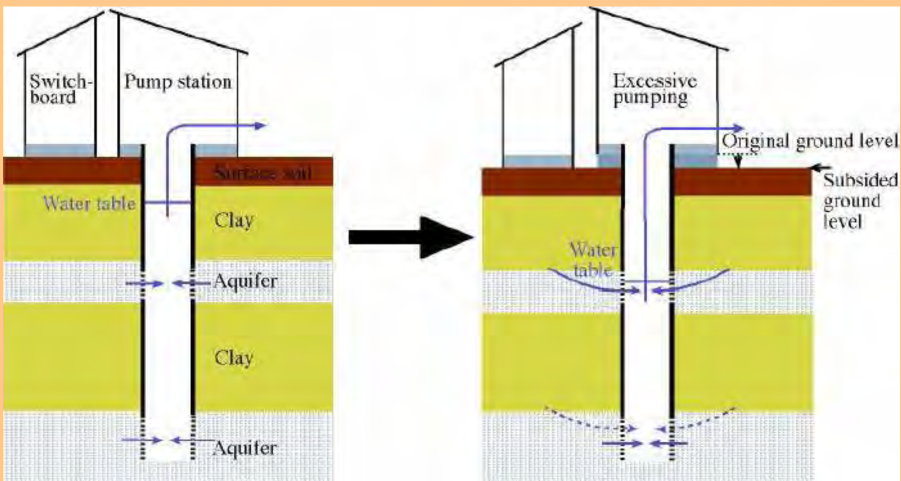

ACKNOWLEDGEMENTS
The temperature measurement and heat exchange experiment in Thailand are conducted by co-operation with Department of Groundwater Resources, Thailand. The temperature measurement in Vietnam is done with Department of Geology and Minerals of Vietnam.
Thank you!

Groundwater in the cities

- its past and present -

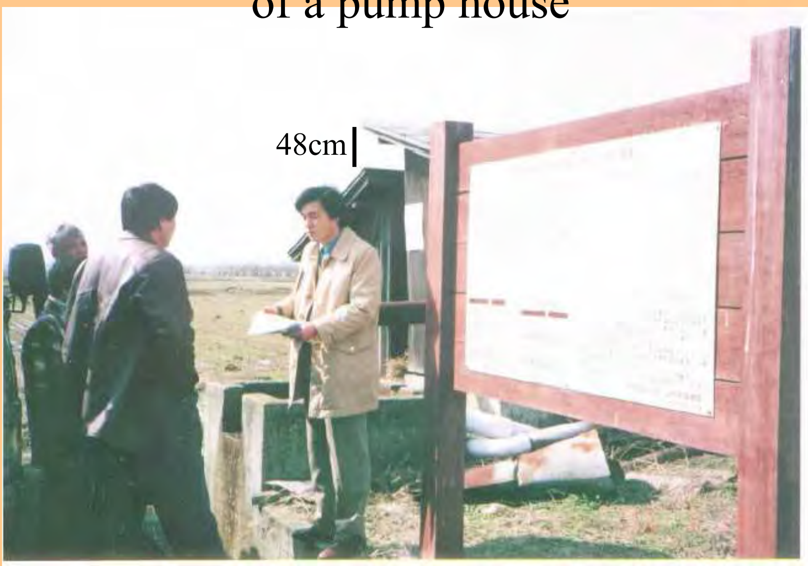
Geological Survey of Japan, AIST

Schematic diagram of land subsidence



Geological Survey of Japan, AIST

48cm difference occurred at the roof part of a pump house



Geological Survey of Japan, AIST

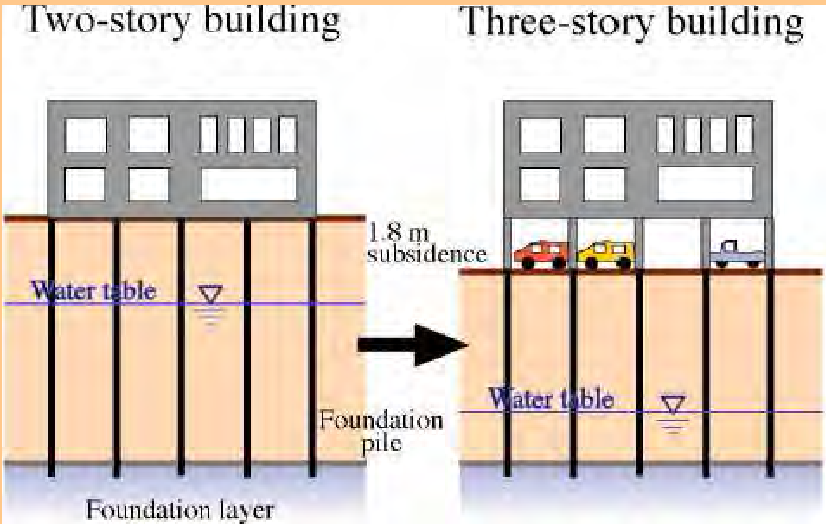
Damages by land subsidence

Geological Survey of Japan, AIST

Two-story or three-story?

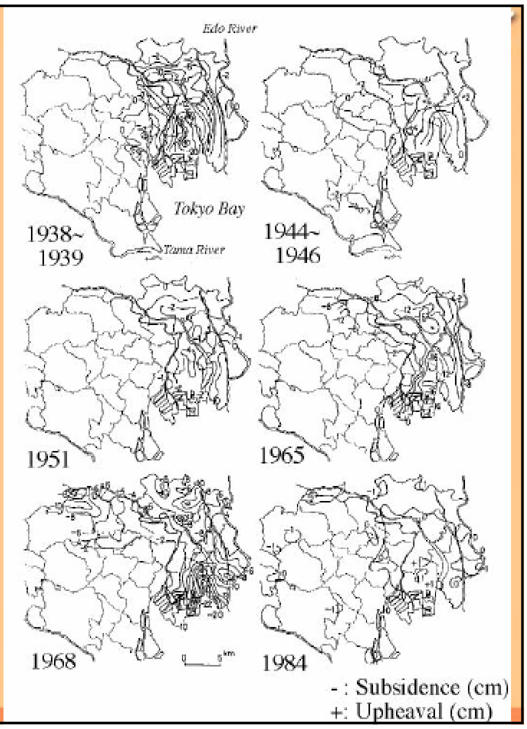
Geological Survey of Japan, AIST

Appearance of parking area



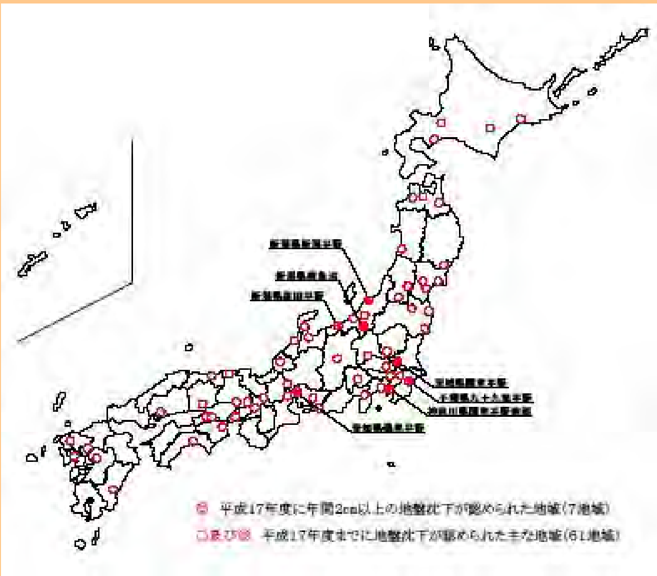
Geological Survey of Japan, AIST

Land subsidence in Tokyo



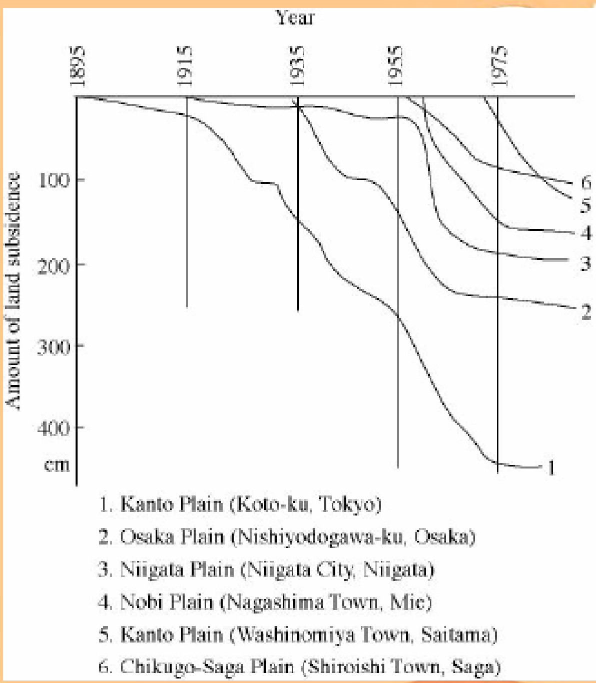
Geological Survey of Japan, AIST

Land subsidence in Japan



Geological Survey of Japan, AIST

Cumulative curve of land subsidence



Geological Survey of Japan, AIST

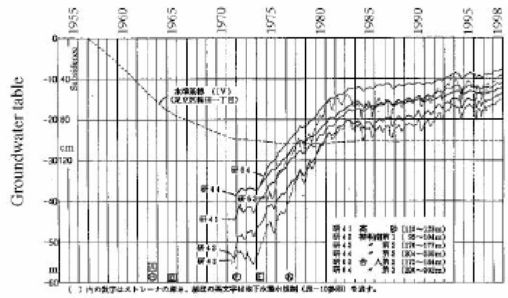
Moderation of land subsidence

Decrease in amount of groundwater use
and stop of the lowering of groundwater level

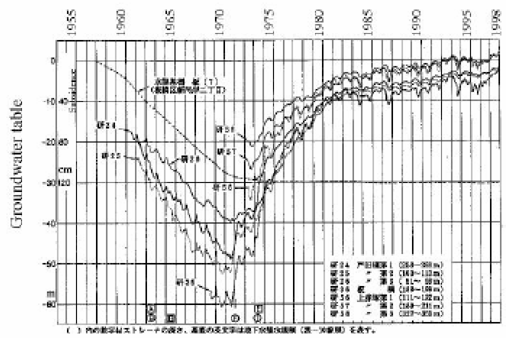
1. Enactment of laws and regulations
2. Saving and reuse of water
3. Changing water source from groundwater to surface water
4. Use of sea water
5. Leakage from water supply networks

Geological Survey of Japan, AIST

Groundwater observation in Tokyo



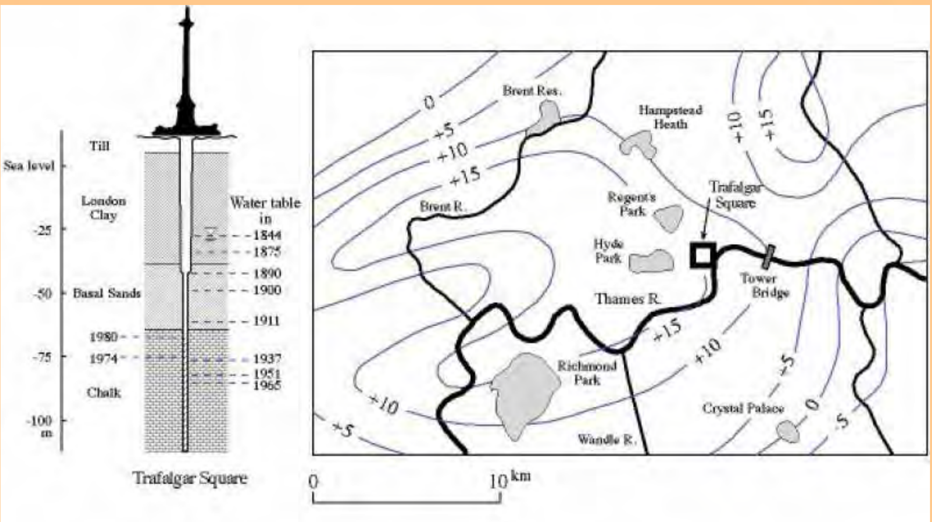
Groundwater table change and amount of land subsidence (Adachi and Katsushika, Tokyo)



Groundwater table change and amount of land subsidence (Itabashi, Tokyo)

Geological Survey of Japan, AIST

Rising groundwater in London



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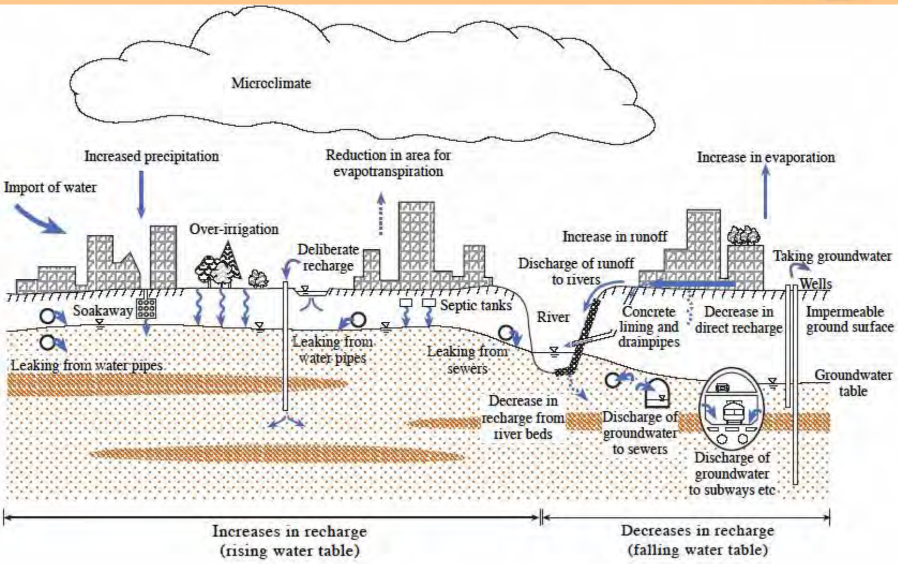
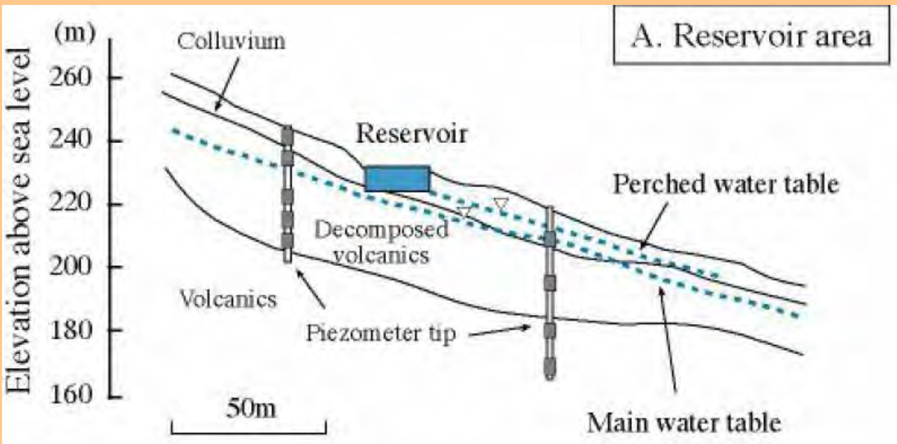
Water flow in urban area



(modified from Lerner, 1989)

Geological Survey of Japan, AIST

Perched water in Hong Kong



Geological Survey of Japan, AIST

Groundwater balance in Tokyo

(10^{4}m^3/day)

Region	Ku*	Tama**	Total
Groundwater recharging from :			
Precipitation	23	72	95
Leaking mains	38	6	44
Sub-total(A)	61	78	139
Groundwater discharging to :			
Sewers	27	6	33
Subways	3	0	3
Pumping wells	11	55	66
Sub-total(B)	41	61	102
Balance (A-B)	20	17	37

* Central Tokyo
** Suburban Tokyo

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Recharge and discharge of groundwater in Tokyo

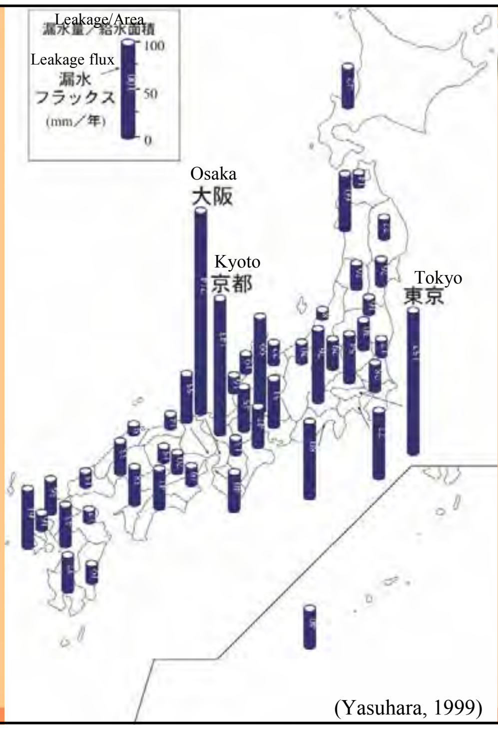
	Recharging from (1,000m3/day)	Discharging to (1,000m3/day)	Total length (km)
Subway		30	240
Water supply	440		22,000
Sewage		330	15,000

Groundwater abstraction for water supply in Tokyo (1,000m3/day)

1989	409
1990	402
1991	395
1992	391
1993	415
1994	415
1995	422
1996	416
1997	445

Geological Survey of Japan, AIST

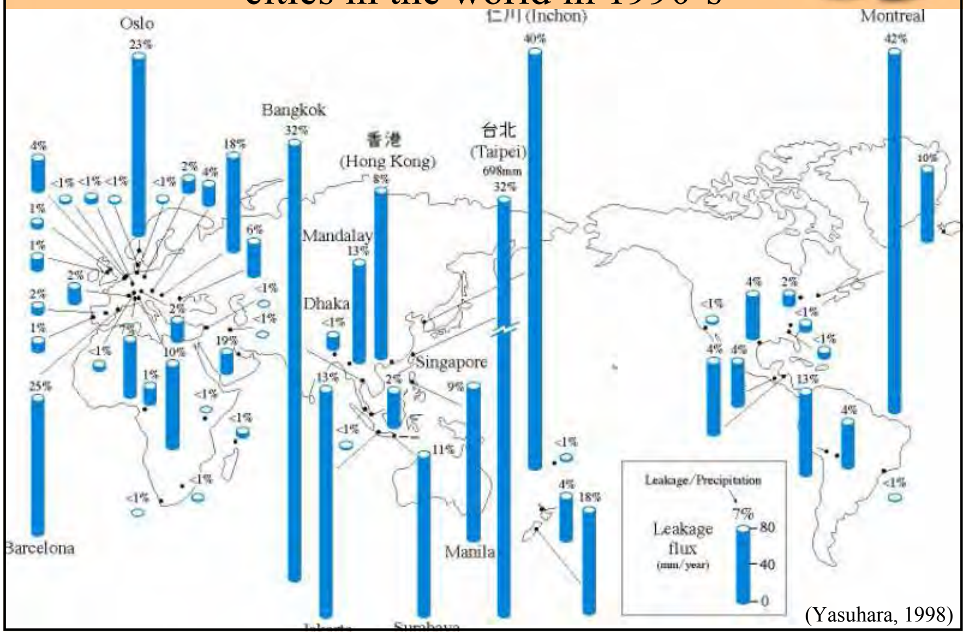
Annual leakage flux of water supply at capital cities in Japan in 1995



(Yasuhara, 1999)

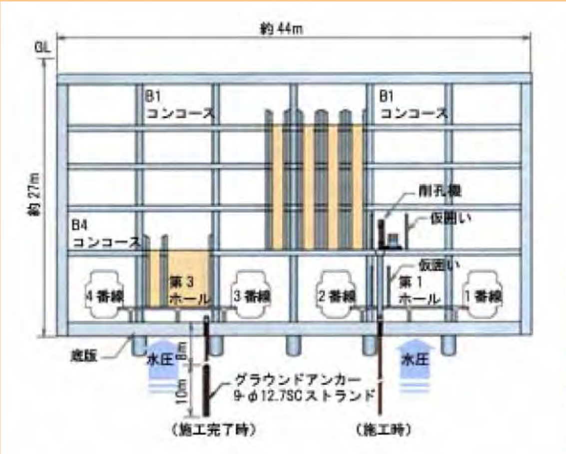
Geological Survey of Japan, AIST

Annual leakage flux of water supply at major cities in the world in 1990's



(Yasuhara, 1998)

Groundwater pressure at the underground level of the JR Tokyo Station



Discharging 1600m^3

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Groundwater comes out from the Tokyo Metro subway tunnel

Discharging 290m3

Geological Survey of Japan, AIST

Any new idea for using groundwater in the big cities?

Geological Survey of Japan, AIST

Groundwater in the Cities – its past and present –

Kasumi YASUKAWA
Institute for Geo-Resources and Environment,
Geological Survey of Japan, AIST

Abstract

Remarkable land subsidence phenomena, caused mainly by domestic groundwater pumping and natural gas mining, took place in major plains in Japan. Since the middle 1950s, Japanese government and local authorities enforced lows and regulations for land subsidence control, which contributed to the stop of lowering groundwater table and serious ground sinking.

After the land subsidence control was recognized effective, a progressive rise in groundwater levels has been reported in big cities in Japan. The principal cause for the rise is the reduction of groundwater abstraction. Another important cause is leakage from water supply networks. In central Tokyo, over the last forty years more than 30m rise of groundwater table has been observed.

A rising groundwater level gives us benefits such as rebirth of dried springs, supply of emergency water etc. It, however, possibly causes negative effects to our daily life environment. It has already been reported that flooding of building basements, leakage into sewers and subway tunnels, increase in hydrostatic pressures on basement structures actually occurred at several places in Tokyo. We need to establish new groundwater control policy against the rise in water table.

National Institute of Advanced Industrial Science and Technology AIST

GREEN Institute for Geo-Resources and Environment

Geological sequestration of CO_2

Toshiyuki Tosha

CO_2 Geological Storage Research Group
Institute of Geo-energy and Environment
National Institute of Advanced Industrial Science and Technology (AIST)

03/December/2007 APEC Seminar 1

CONTENT

1. Global Warming by Carbon Dioxide
2. Carbon Dioxide Storage
3. CO_2 Sequestration Fields
   (Sleipner Field, North Sea, Norway)
4. Fundamental geophysical parameters
5. Geophysical monitoring at the Nagaoka Field, Japan

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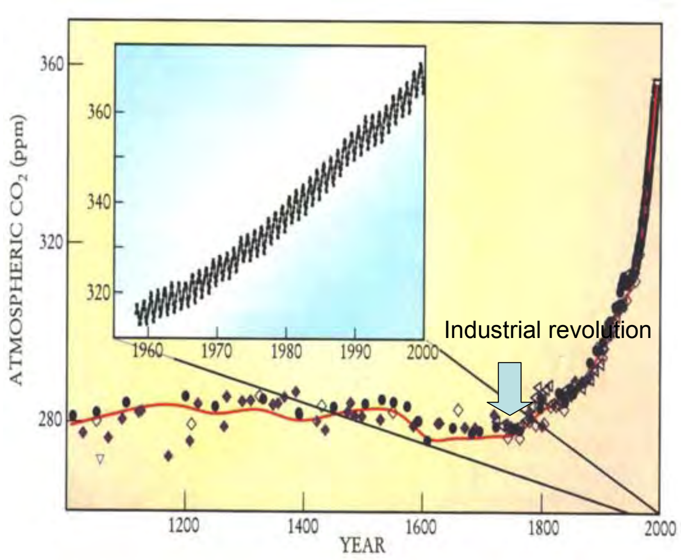
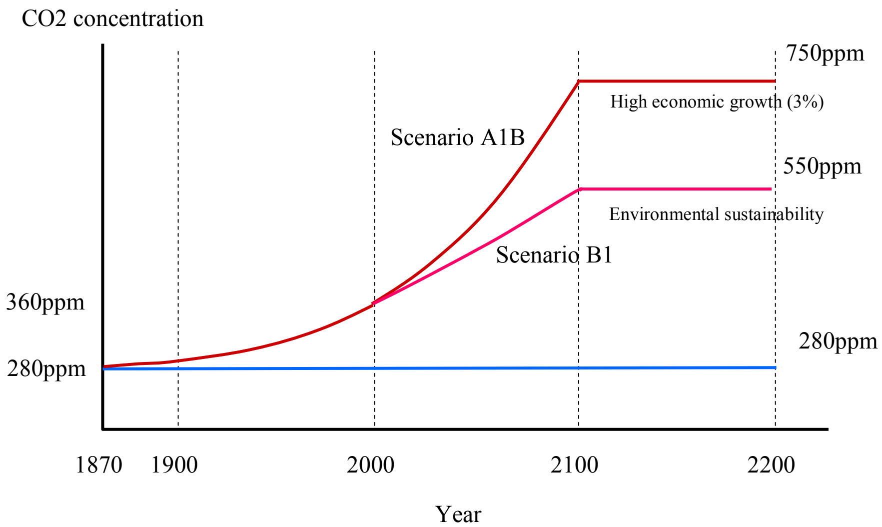
Atmospheric CO_2 levels



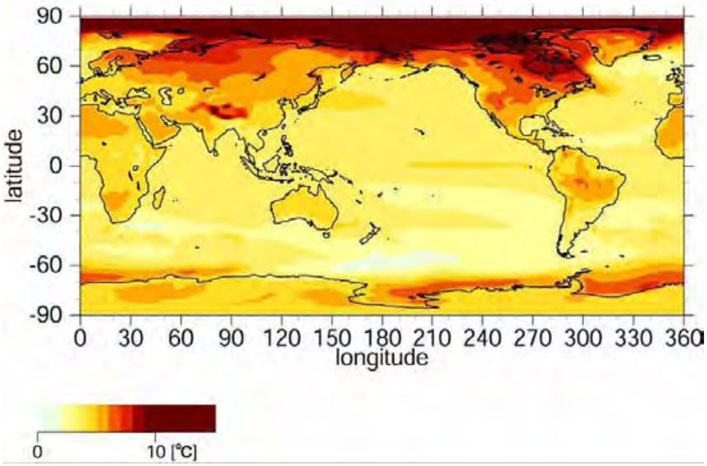
Erosion by the sea level rise

Majuro Atoll at the Marchall Islands

Scenarios for CO_2 concentration at the atmosphere



Simulation



Annual mean temperature difference between 2100 and 2000

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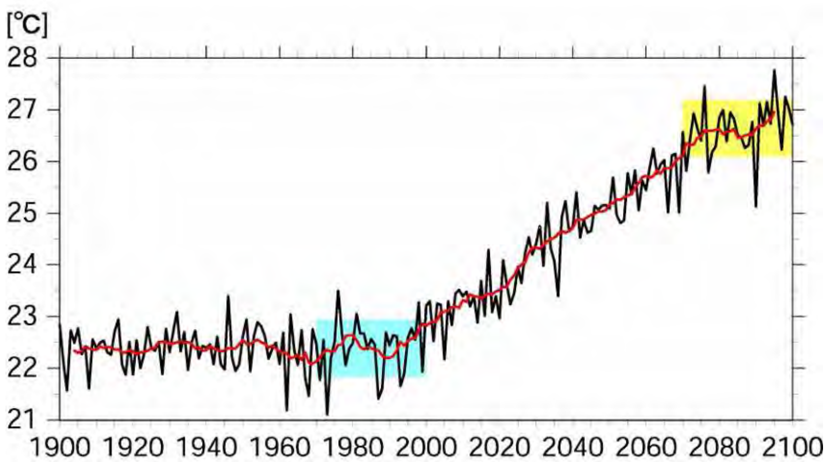
Calculated Temperature in Summer in Japan



Calculation is based on the global warming scenario A1B

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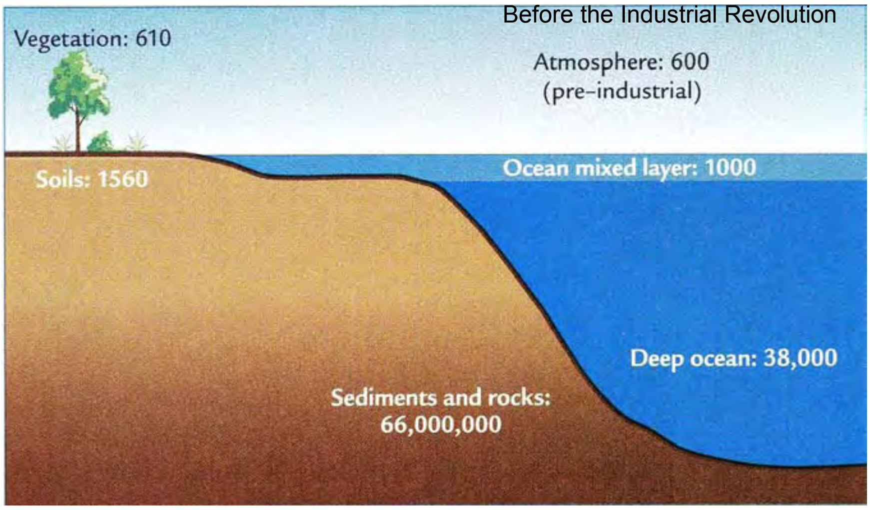
Major Carbon Reservoirs



Unit in gigatons = 10^{15} grams

Problems today

Production of Carbon dioxide by human activities after the industrial revolution

⇒

Rapid increase of the discharge rage of Carbon dioxide into the atmosphere

Earth's system can accept a gradual increase of CO2

High Capacity of the reservoir is expected on land

CO2 sequestration : reduction of CO2 increase rate at the atmosphere

CONTENT

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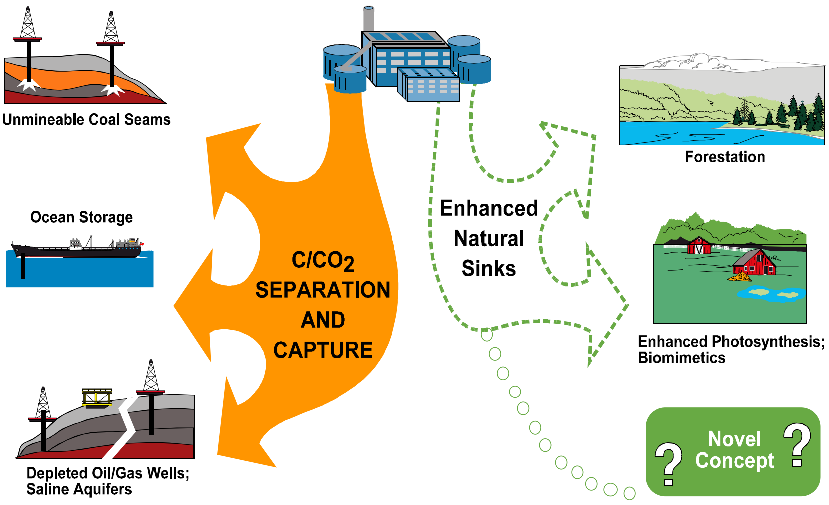
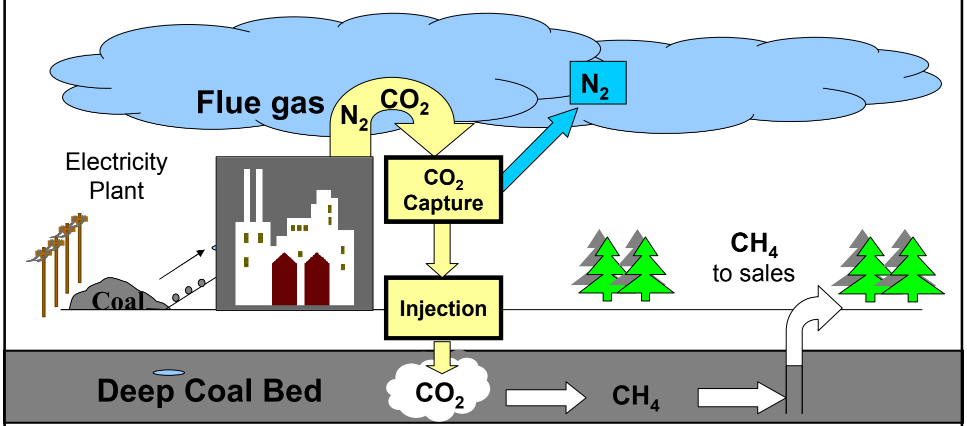
Sequestration Sinks

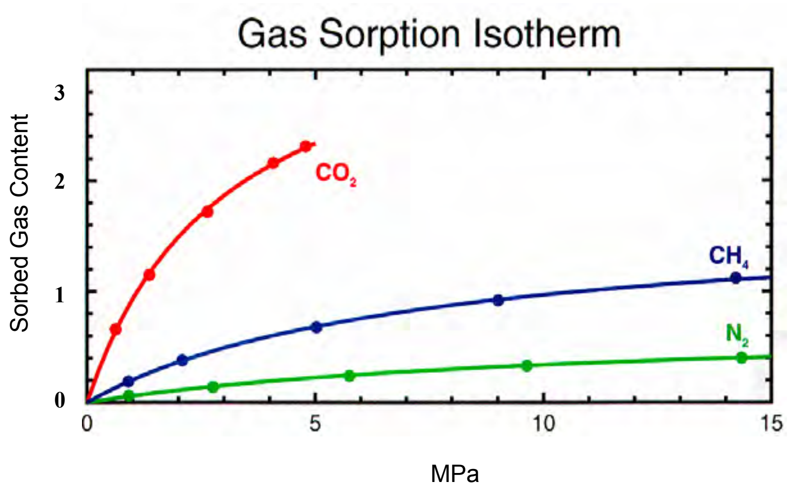


Enhanced Coal Bed Methane Recovery (ECBM)



One-well field tests indicates that the amount of CO_2 that can be stored varies from two to five times the volume of methane produced

Sorption Data for Different Pure Gases

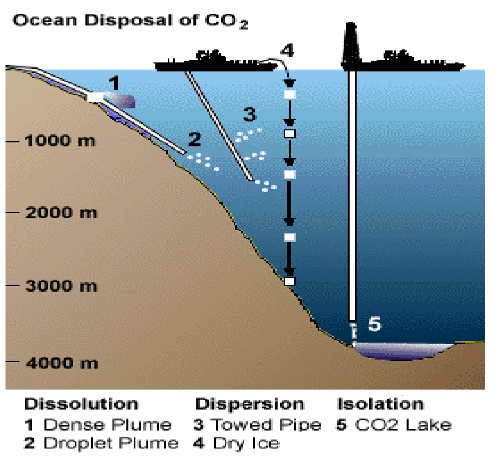


Ocean Sequestration

- Deep Ocean Injection CO_2
  - Theoretically the largest sink (>100,000 GTs)
- Potential for Significant Indirect Carbon Sequestration

Suspension of the project

Environment at the deep wat



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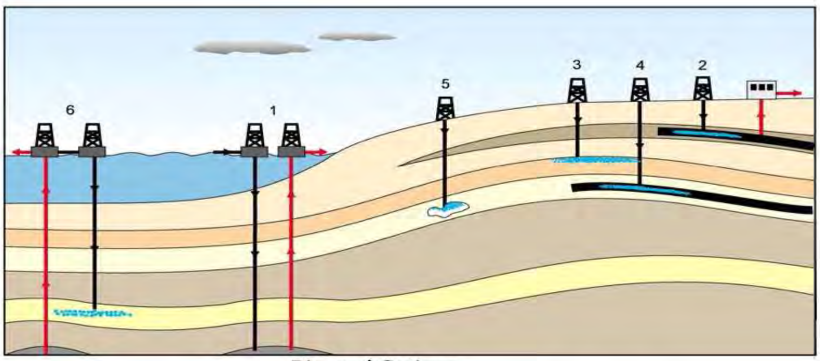
Depleted oil/gas field, saline aquifer Storage



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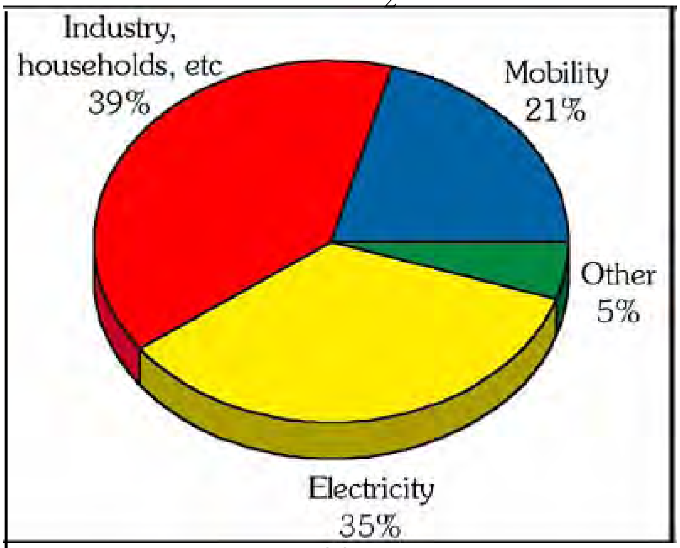
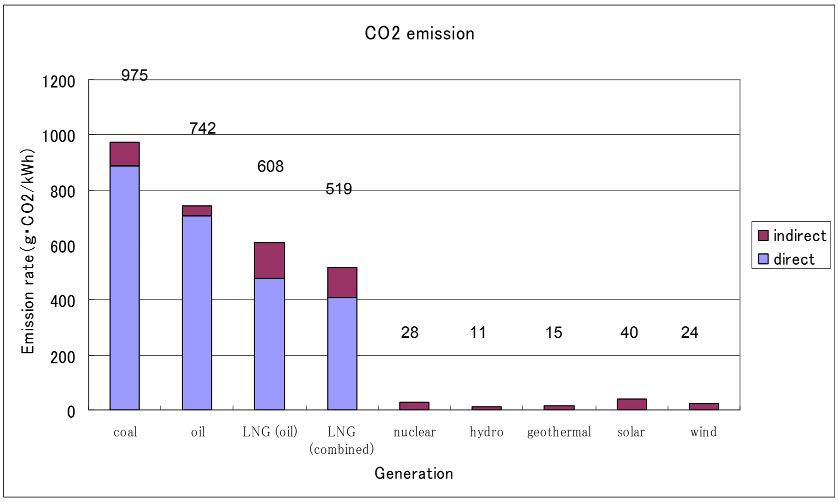
Sources of CO_2 emissions

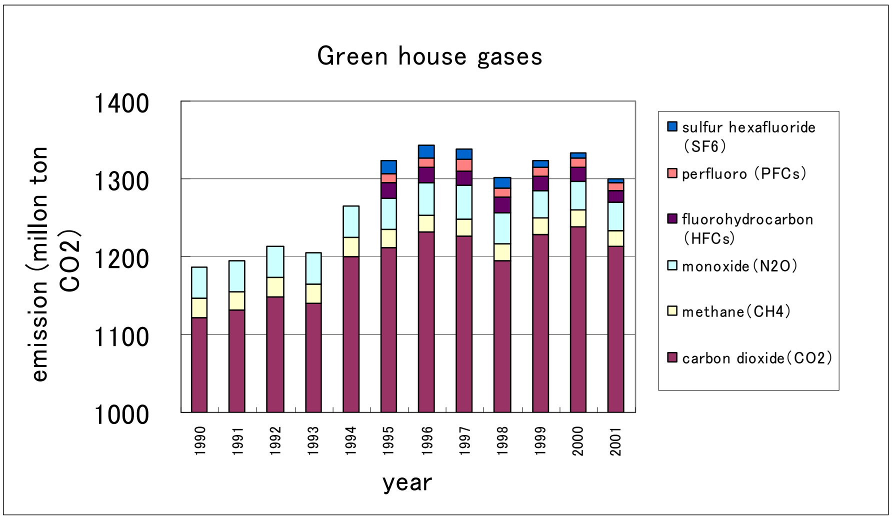


in 1995 (IEA World Energy Outlook, 1998)

Typical CO_2 emission in major power plant



Green house gases in Japan



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CO_2 Emission of Japan

Major CO_2 output sources

- coal fired thermal power plants: 13 mol%
- cement plants: 25 mol%
- steel plants: 27 mol%

Output of CO_2 in 1990: 112,600 $\times 10^5$ ton (=1.1 billon ton)

6% = 67 million ton

Output of CO_2 in 2001: 1.3 billion ton

→ reduction more than 250 million ton

Carbon in 1 m^3 (standard condition): 0.539 kg

Emission of CO_2 by coal fired thermal power plants: 778t/h (6.8 Mt/y)

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CO_2 Capture & Storage

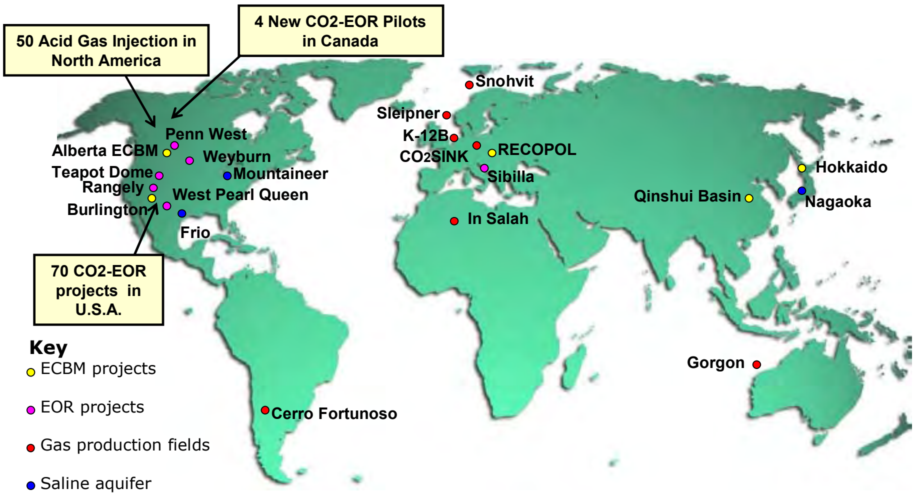
Main message of IPCC Special Report on Carbon Dioxide Capture and Storage:

"With continued reliance on fossil fuel energy, deep reduction of CO_2 emission is attainable by this technology"

"Subsurface storage of CO_2 requires the skill of underground engineering"

CONTENT

CO2 Storage Projects Worldwide



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CO_2 Storage Projects Summary

- Only a dozen projects are injecting commercial scale volumes of CO_2 (e.g 1 Mt/CO_2/y)
  - Weyburn (Canada), In-Salah (Algeria), Sleipner (Norway), Rangely (US)
- Many are research projects that will inject 100's to 1000's tonnes CO_2
  - Frio (US), West Pearl Queen (US), CO2SINK(EU)
- Several large projects in the development stage
  - Snöhvit (Norway) and Gorgon (Australia)

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Major Project Experiences

✓Weyburn (Canada)

No evidence of surface seepage after 3 years of CO_2 injection

Presence of CO_2 within oil field identified using seismic surveying

✓Sleipner (North Sea)

Injected CO_2 accumulating under cap rock can be monitored with seismic surveying

No evidence of migration out of the reservoir after 8 years of injection

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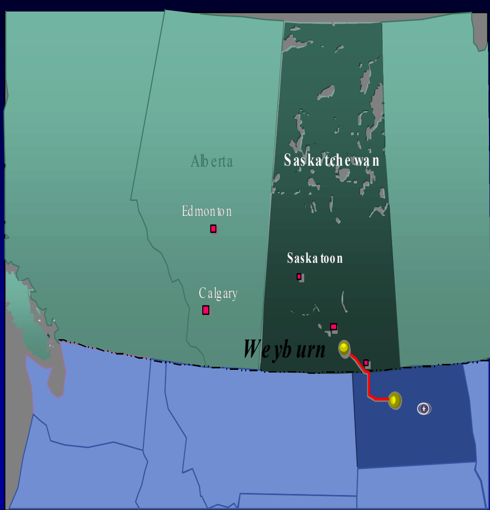
Weyburn CO_2 Miscible Flood Project



- PanCanadian Petroleum project EOR (C$1.1 billion)
  - Duration 15-20 years
  - CO_2 from Dakota Gasification Co., North Dakota
  - Pipeline, 325 km, delivers 5000 t/d of CO_2
  - 70% of CO_2 will remain in reservoir
- IEA CO_2 Monitoring Project (C$35 million over 4 years)
  - Assessments of long-term storage integrity, migration and fate of CO_2
  - Participants include Canadian and European Governments and companies

Location of the Sleipner Field

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Sleipner field in North Sea

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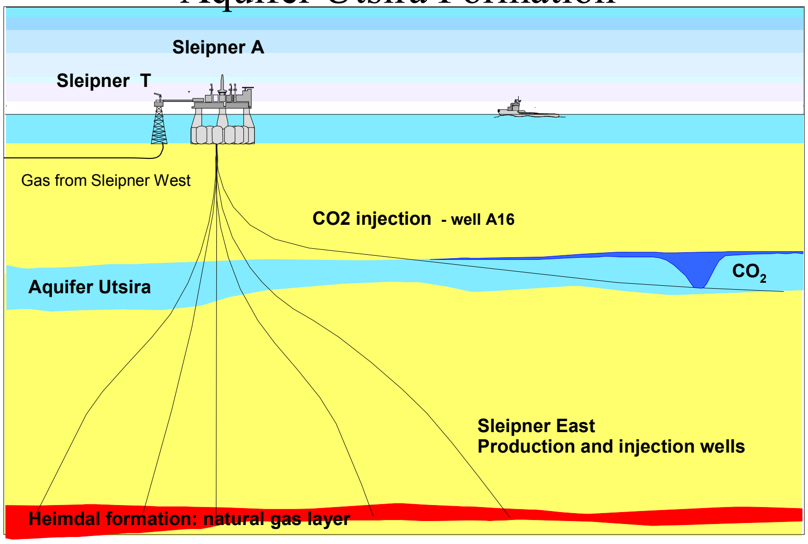
Aquifer Utsira Formation



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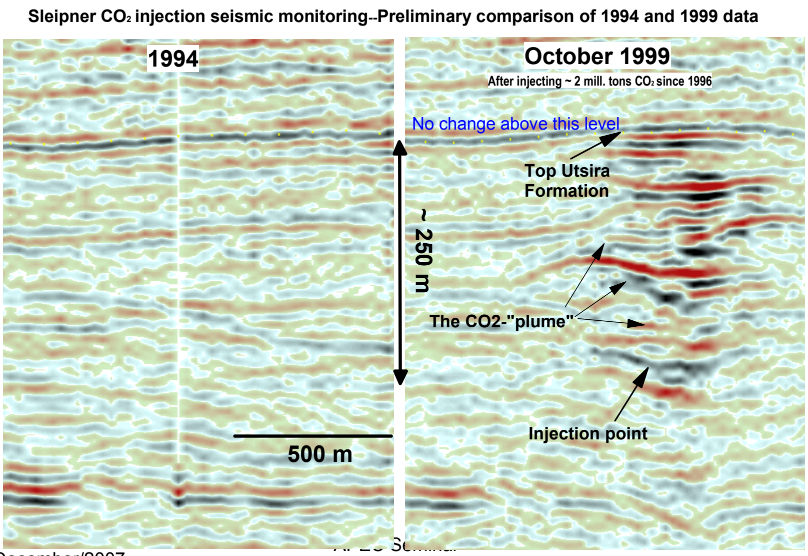
Seismic monitoring



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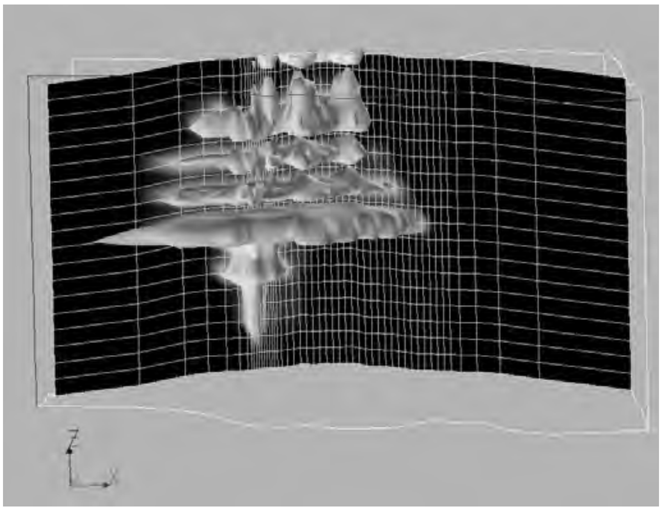
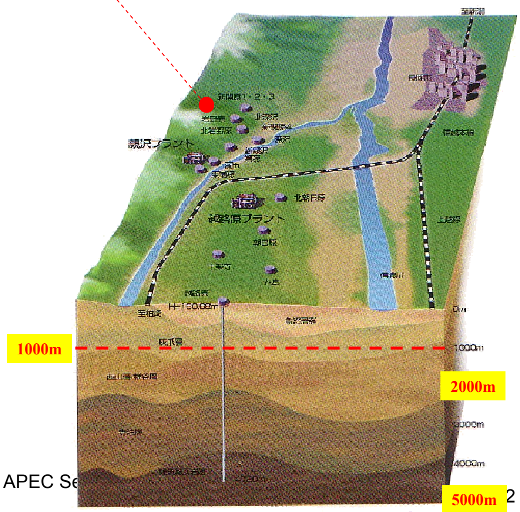
Seismic monitoring at Sleipner field

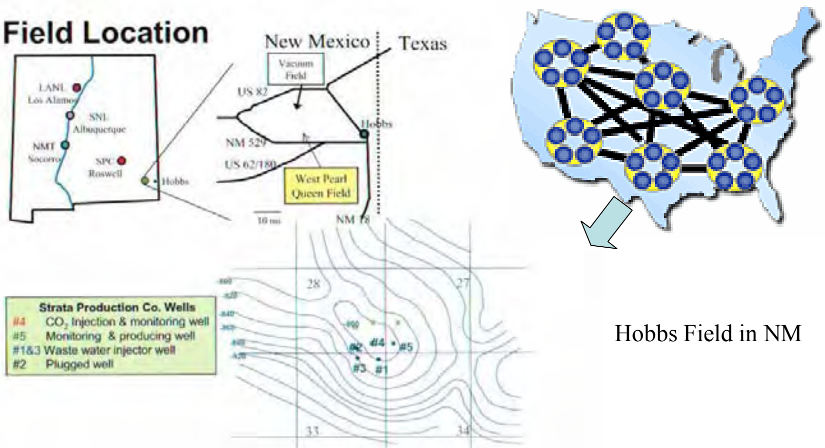


Nagaoka Field (Test field)

Teikoku Oil, Niigata Prefecture



Carbon Sequestration - Regional Partnerships



Hobbs Field in NM

Southwest Regional Partnership for Carbon Sequestration

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Critical point of CO_2

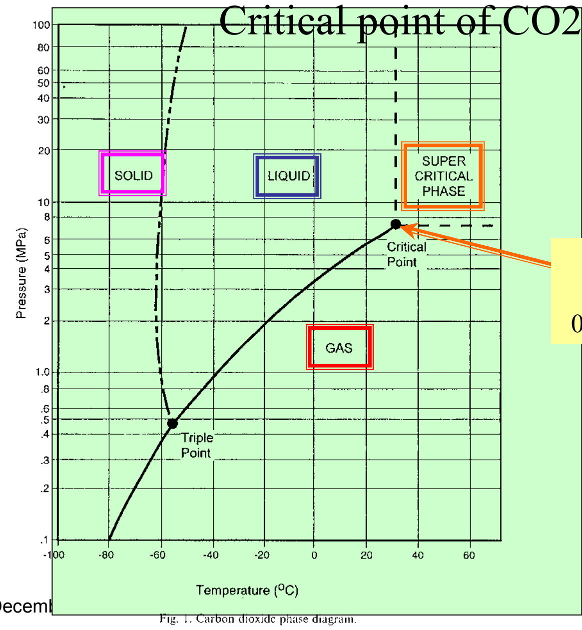

Fig. 1. Carbon dioxide phase diagram.

31.1℃
7.39MPa
0.464g/cm³

Typical thermal gradient 2 ℃/100m

Temperature at the Depth of 1,000m

T=20℃(surface)+20℃ = 40℃

Basic Studies : Laboratory-Scale Research

Injection of CO_2

Decrease of wave velocity

Increase of pore pressure

Field Monitoring

Lab Experiments are required to Convert Field Results of Wave Velocity and Attenuation to CO_2 Saturation

Laboratory work: Objectives

- ***What's really going to happen after injecting CO_2 into rock mass?***

  Pore pressure buildup, CO2-water- rock reactions (induced seismicity, mineral dissolution, CO2-water displacement)

- ***How quickly the injected CO_2 migrates in rock mass?***

  Permeability, viscosity, electric conductivity etc.

Gas, liquid, and supercritical conditions of CO_2

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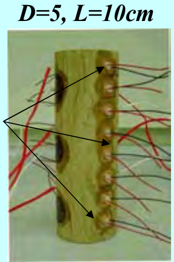
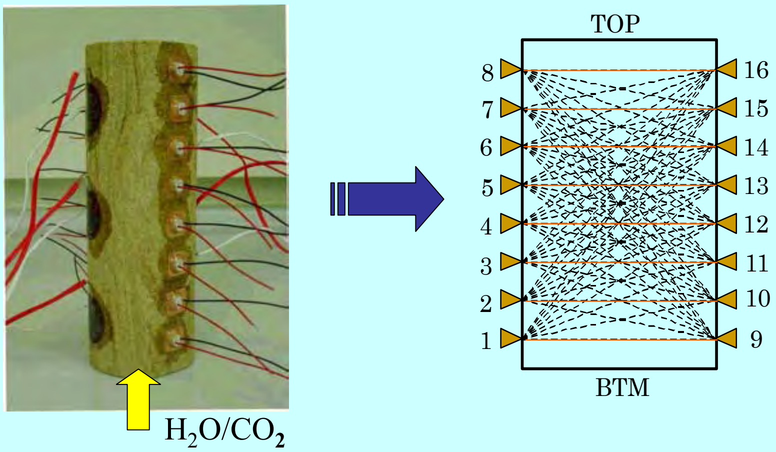
Experimental setup for P-wave velocity tomography

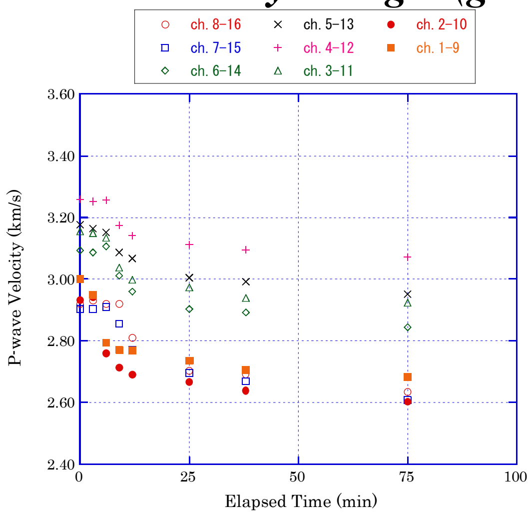


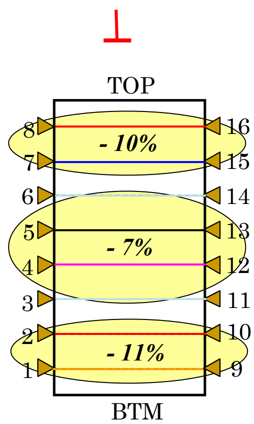
Experimental Study of Seismic Wave Tomography



Xue and Lei, 2006

P-wave velocity changes (gaseous CO_2)





P-wave velocity changes vs the elapsed time when injecting gaseous CO_2 into water saturated Tako sandstone. Pc=10MPa, Pp=3MPa and Pi=5MPa (at 25°C)

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Xue and Lei, 2006

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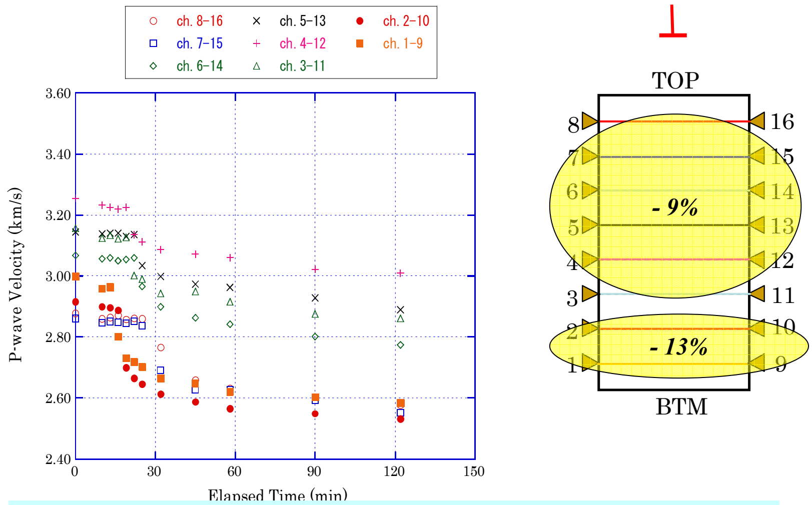
P-wave velocity changes (liquid CO_2)



P-wave velocity changes vs elapsed time when injecting liquid CO_2 into water saturated Tako sandstone. Pc=15MPa, Pp=10MPa and Pi=12MPa (at 25 °C)

Xue and Lei, 2006

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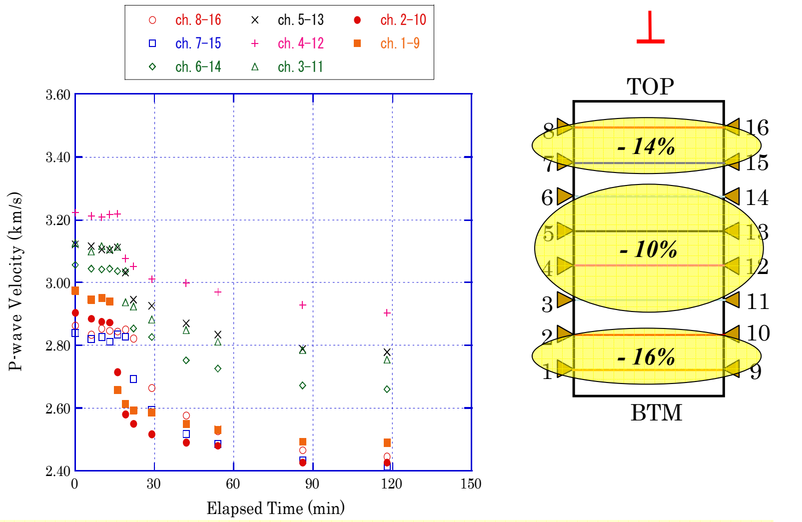
P-wave velocity changes (super critical CO_2)



P-wave velocity changes vs elapsed time when injecting super critical CO_2 into water saturated Tako sandstone. Pc=15MPa, Pp=10MPa and Pi=12MPa (at 33 °C)

Xue and Lei, 2006

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Experimental Results

Velocity changes caused by the CO_2 injection are typically on the order of -10%.

Injecting super critical CO_2 has greater effect on velocity changes than cases of injecting gaseous and liquid CO_2

Effect on velocity changes caused by the pore pressure buildup is less than -3%, comparing with the pore water displaced by the injected CO_2, ranged from -8% to -16%.

Monitoring P-wave velocity could be a useful tool for mapping the movement of the injected CO_2 in geological sequestration projects.

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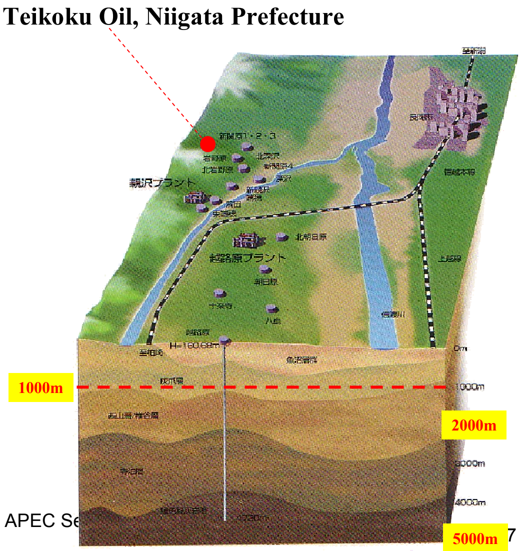
Nagaoka Field (Test field)



APEC Se 7

Field Injection Studies for Aquifer Sequestration

	Target formation	CO_2 injection rate & source	status
SACS at Sleipner Field	offshore saline aquifer with a depth of 1.0 km	1 mil. ton/year, captured from natural gas	Ended (1998 – 2002) Continued to CO2STORE
Weyburn Monitoring Project	on-land oil reservoir with a depth of 1.0 km	1 mil. ton/year, generated in a gasification plant	Phase II started
RITE field demonstration at NAGAOKA	on-land saline aquifer with a depth of 1.1 km in a gas field	20 – 40 tonne/day, purchased in the market	500-day injection

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Nagaoka site

– site facilities –

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Nagaoka site

– storage tank –

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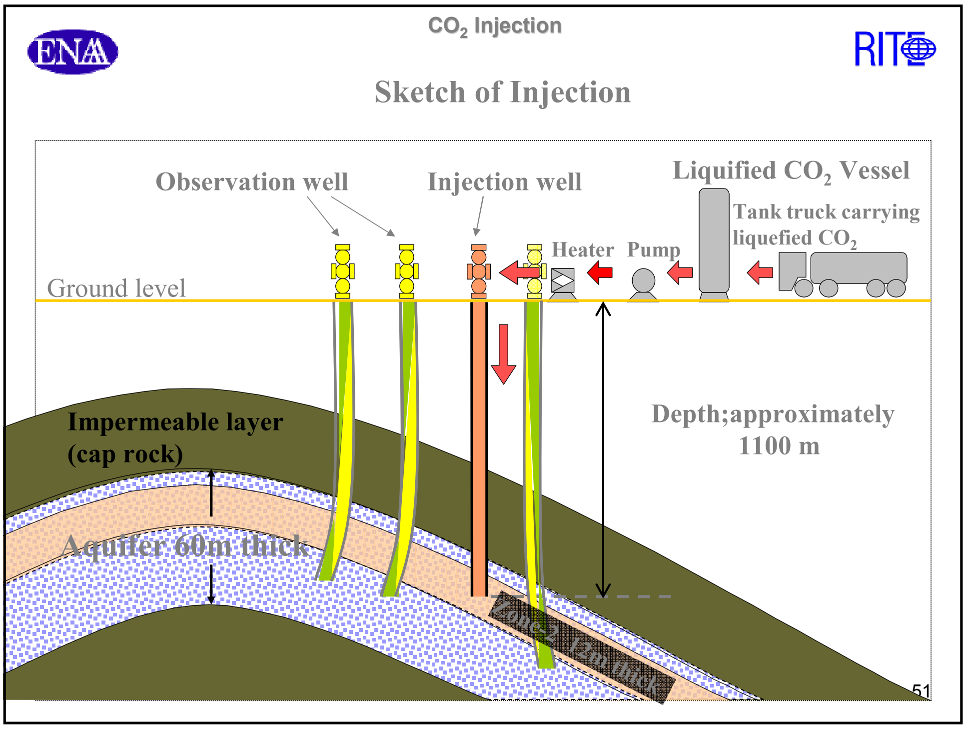
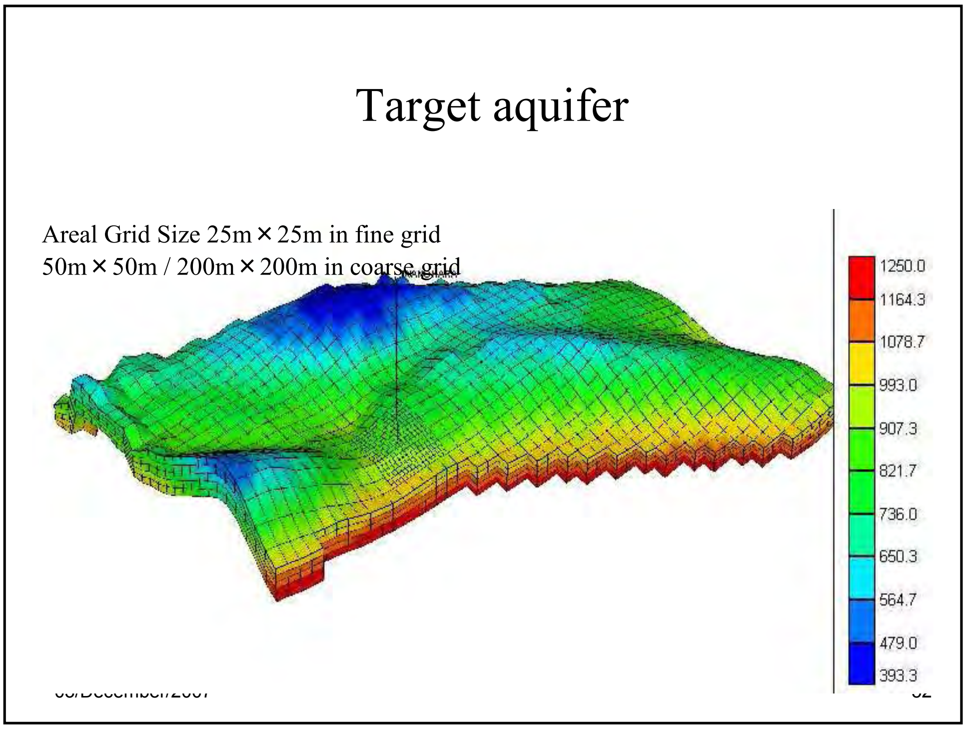
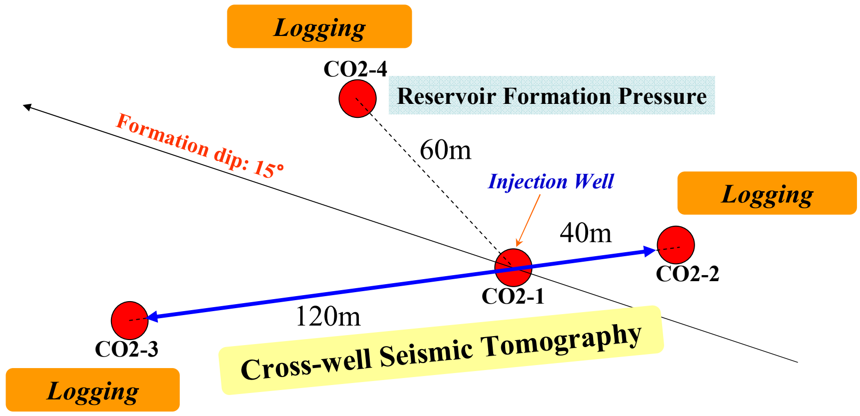

CO_2 Injection
ENAA
RITE
Sketch of Injection
Observation well
Injection well
Liquified CO_2 Vessel
Tank truck carrying liquefied CO_2
Heater
Pump
Ground level
Impermeable layer (cap rock)
Aquifer 60m thick
Depth;approximately 1100 m
Zone-2 12m thick
51


Target aquifer
Areal Grid Size 25m × 25m in fine grid
50m × 50m / 200m × 200m in coarse grid
1250.0
1164.3
1078.7
993.0
907.3
821.7
736.0
650.3
564.7
479.0
393.3

Geophysical Monitoring of CO_2 Sequestration



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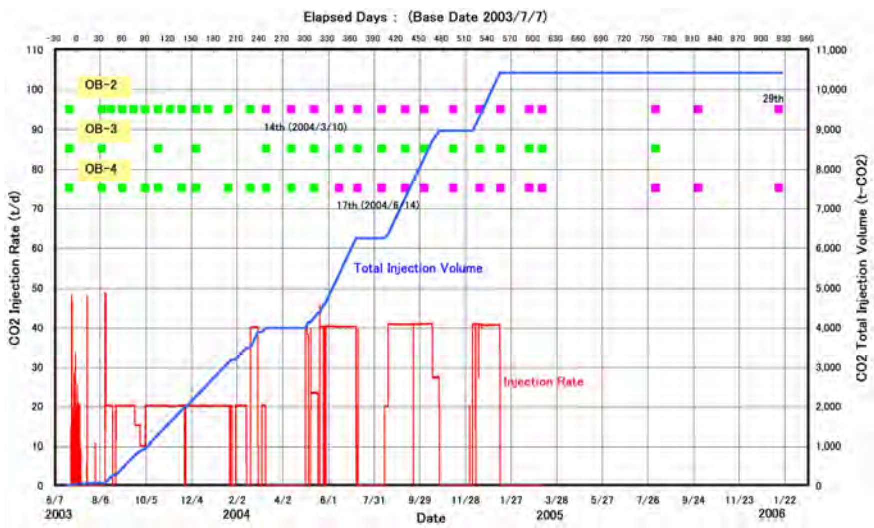
Time lapse logging schedule



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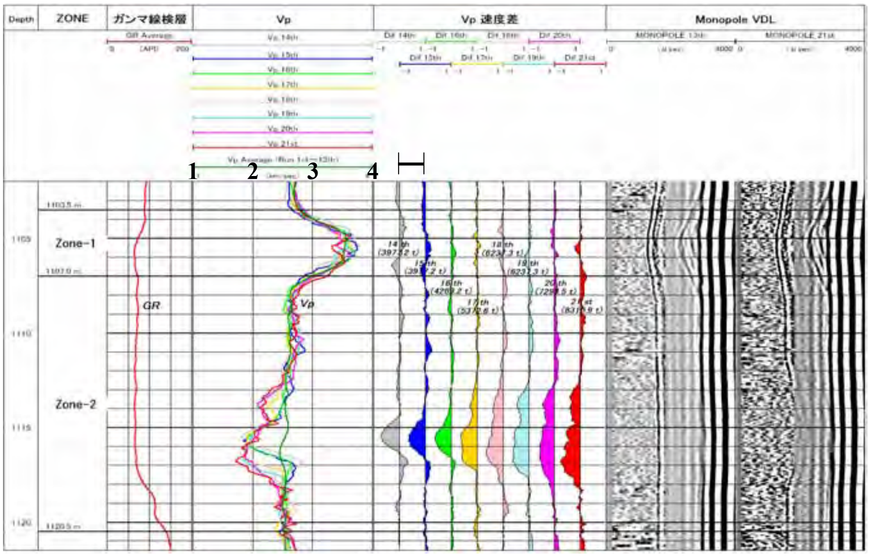
CO2-2 Vp (Sonic)



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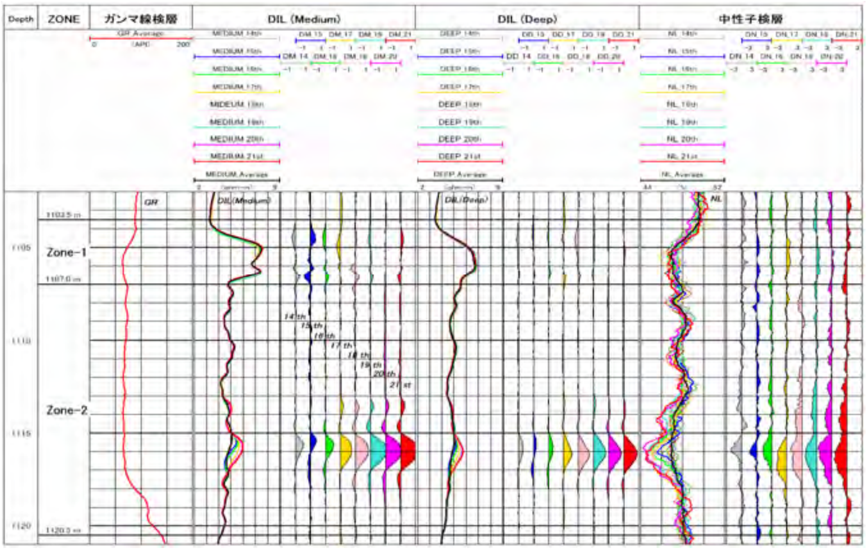
CO2-2 (Induction & Neutron)



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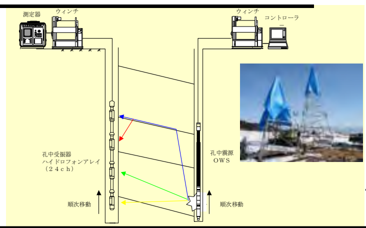
Crosswell Seismic Tomography

Baseline Survey	BLS	Before injection	Feb. 2003
Monitoring Survey		Injection started	Feb. 2003
	MS1	3,200t-CO_2	Jan. 2004
	MS2	6,200t-CO_2	Jul. 2004
	MS3	8,900t-CO2	Nov. 2004
		Injection ended	Jan. 2005
	MS4	10,400t-CO2	Jan. 2005
	MS5	10,400t-CO2	Oct. 2005



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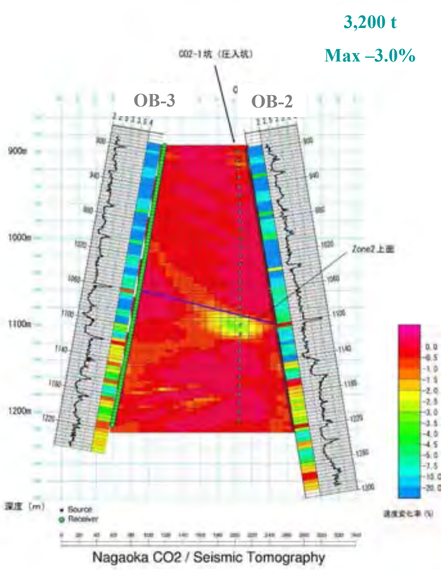
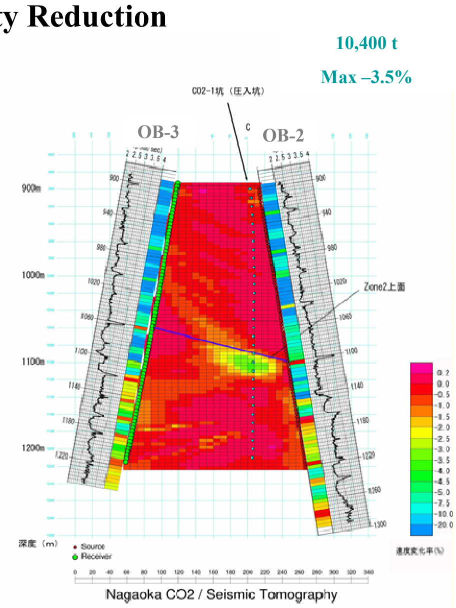
Rate of Velocity Reduction



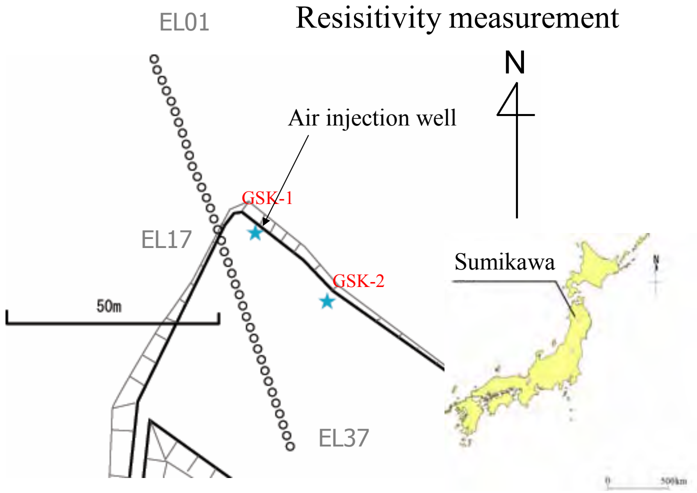
MS1/BLS



MS4/BLS

Watanabe et al., 2006

Another example of the detect of CO_2 injection



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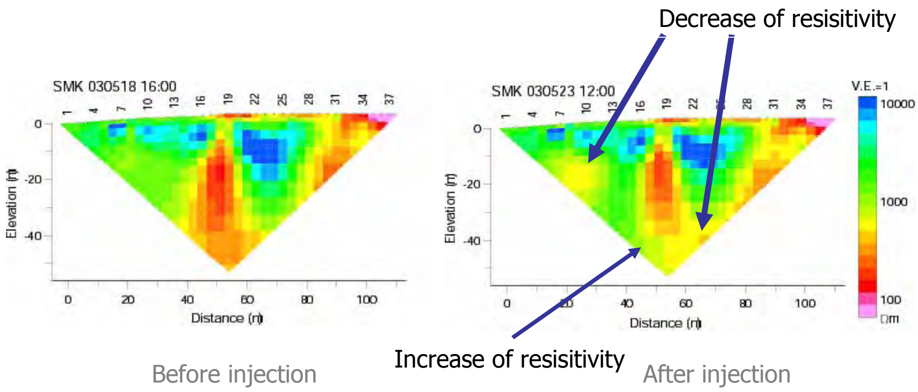
Resistivity change



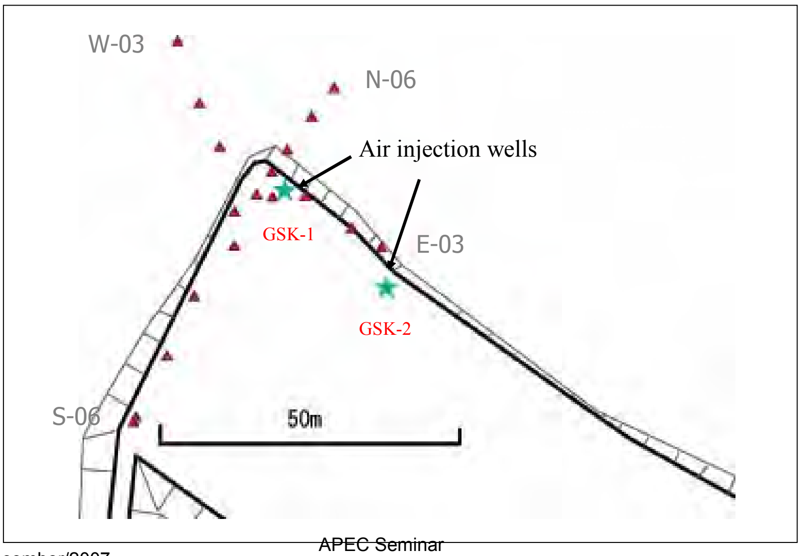
Before injection

After injection

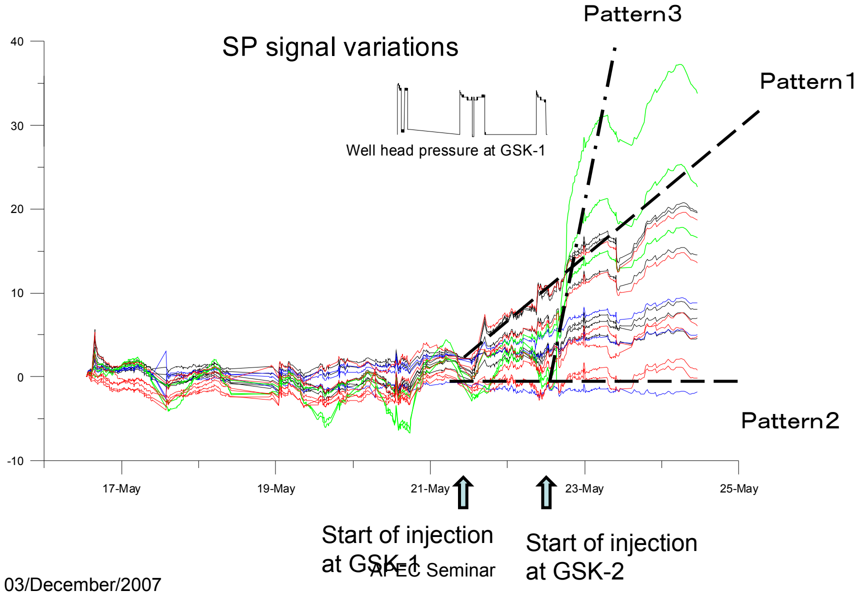
Archie's law $R_t = \frac{aR_w}{\eta^m S_w^n}$

resisitivity change in 60% ⇨ saturation change in 37%

Self-potential observation



Temporal SP changes



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Summary

- Rapid increase of CO_2 at atmosphere after the industrial revolution
- CO_2 sequestration (storage) is one of the way to reduce the CO_2 content
- Development of renewable energies is another option
- Geological sequestration into aquifer is tested in several fields
- Electric measurements as well as seismic measurements are possible to detect the change due to the sequestration
- Combining geophysical monitoring with the computer simulation makes a good model for the sequestration

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Thank you for your attention

For the better Global Environments

Toshiyuki Tosha
toshi-tosha@aist.go.jp

APEC Seminar

03/December/2007 65

Geological Sequestration of CO_2

Toshiyuki TOSHA
CO_2 Geological Storage Research Group
Institute of Geo-energy and Environment
Geological Survey of Japan, AIST

Abstract

The IPCC Fourth Assessment Report (AR4) has been released on 17 November 2007 and notes that warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. The report also suggests that there is *high agreement* and *much evidence* of substantial economic potential for the mitigation of global GHG (Green House Gas) emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels.

CO_2 capture and storage (CCS) is one of the most feasible mitigation ways of global GHG emissions with several options on the storage of CO_2 in the CCS program. One of the options is to store CO_2 in a geological formation. CO_2 is stored for a long time in oil, gas, and coal layers and the geological formations have large capacity to store global GHG. We have to inject CO_2 into the geological formations without environmental impacts. Monitoring is, therefore, necessary not only during but also after CO_2 injection in order to show how CO_2 is stored in the geological formations. Time-lapse seismic measurements were carried out to demonstrate CO_2 migration within the aquifer and no leakage beyond the cap rocks happened in the CO_2 sequestration fields. The seismic monitoring creates high accurate reflection images, which are very helpful to understand the movements of CO_2. The survey using the active source, however, does not provide the continuous change of CO_2. Measurement tools with passive sources are also necessary to monitor the CO_2 migration continuously. In this presentation several examples for the storage of CO_2 in the geological formations and geophysical studies for the monitoring are shown.

APEC Seminar 2007/12/4

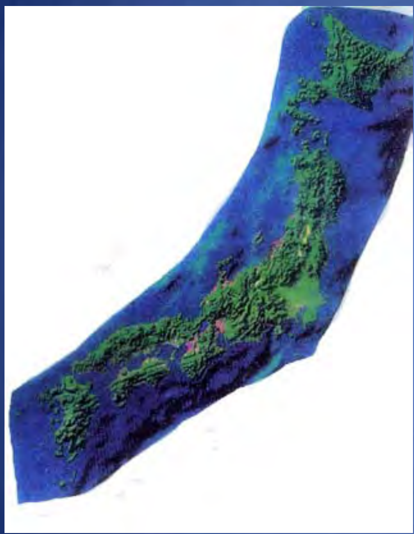
The battle against landslide disaster in the recent history of Japan

Naoki SAKAI
Storm Flood and Landslide research department
National research Institute for
Earth science and Disaster prevention

Contents

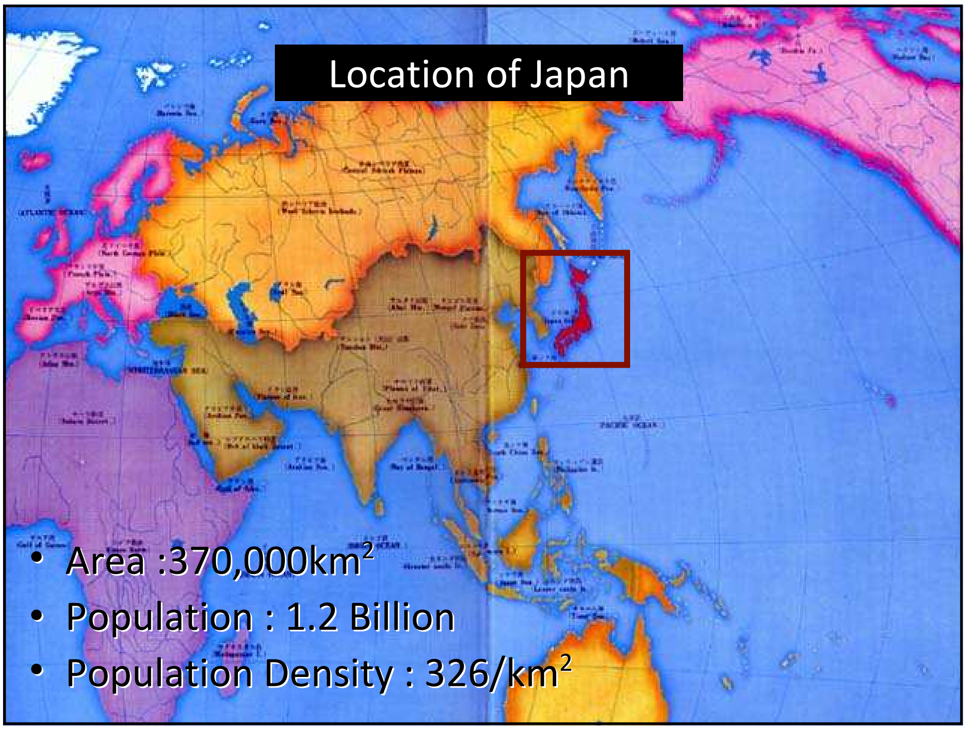
1. Introduction
2. Landslide disasters in Japan
3. Countermeasures
4. Early-Warning and Evacuation
5. The problems for the future of warning
6. Conclusion remarks

Natural conditions in Japan ~ Steep mountains and Volcanoes

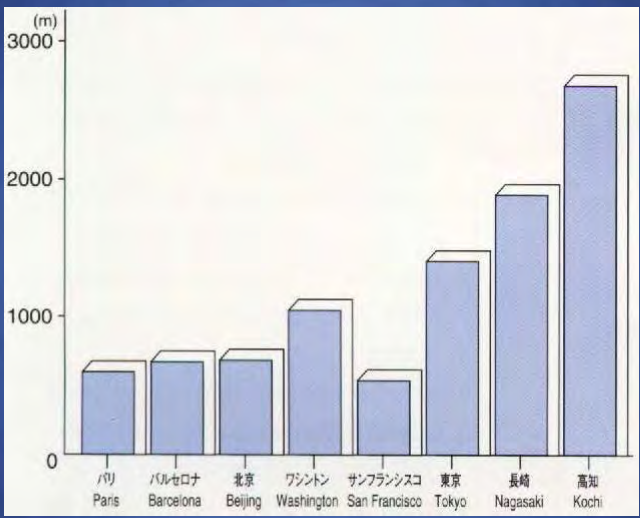


Mountains and hilly areas make up 70% of the total land area of Japan

Location of Japan



- Area :370,000km^2
- Population : 1.2 Billion
- Population Density : 326/km^2



Mean annual rainfall intensity values for world stations

City area and mountainous area

(Kobe city in Japan)

3 types of sediment-related disasters

Slope failure

A phenomenon where soil is weakened by the rain, earthquakes, etc. causing a slope to crumble suddenly

Debris flow

A phenomenon where long or localized torrential rainfall causes mountainside soil, sand, and gravel (debris) from hillsides or stream beds to fall into lower reaches, where they are suddenly washed away downstream at speeds from 20 to 40 km/h

Landslide

A phenomenon where dirt clods on a slope are slowly moved downward by groundwater, etc., along a landslide surface at speeds from 0.01 to 10 mm/day.

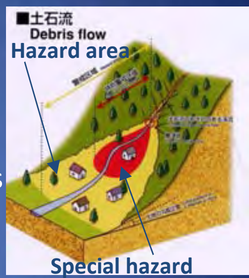
'Sediment-related Disaster Prevention Law'

- Was in effect on *April 1, 2001,*
- In order to protect the public from sediment-related disasters caused by slope failure, debris flow and landslide with *non-structural preventive measures.*

  – Non-structural preventive measures mean development of a warning and evacuation system, designation of restrictions on land use.

Debris flow case for instance…

Restrictions on land use
- Debris flow -



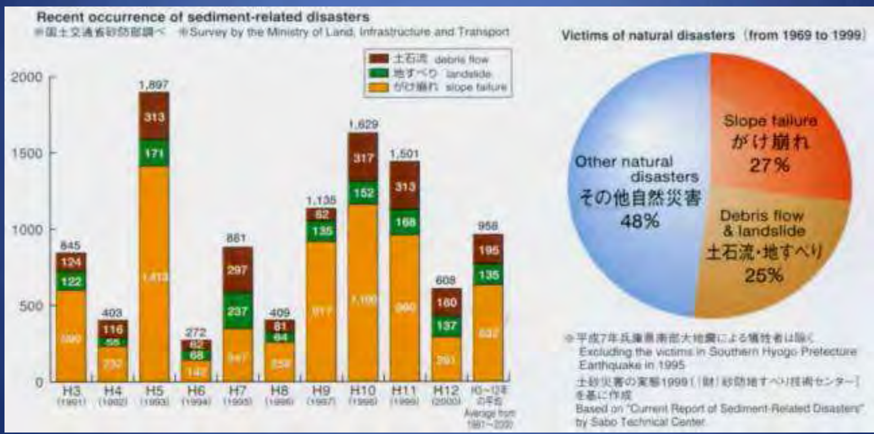
- 'Hazard areas'
  - Areas prone to sediment-related disasters
    / Downstream from valley mouth
    / Ground slope is steeper than two degrees.
- 'Special hazard areas'
  - Areas prone to sediment-related serious disasters
    /Areas where the hydrodynamic force of a debris flow exceeds the structural strength of a building is designated as the special disaster hazard area.

We need to improve the method to designate the hazard areas and special hazard areas, because this law restricts private right.

An important traffic network and its vulnerable areas

Damaged in August 1993

Recent occurrence of sediment-related and Victims of natural disasters



Contents

① Debris flow

2. Classification of debris flows

2.1 Classification according to flowing characteristics

(1) Gravel-filled debris flow

A. The tip of a debris flow moves quite straight with a large concentration of gravel and boulders that are two to five meters in diameter, or larger in some cases.

B. Behind the tip of a debris flow follows a muddy water flow (a subsequent flow) that contains less gravel than the tip of a debris flow.

C. The velocity of the flow is about three to ten meters.

D. Boulders are concentrated at the tip of a debris flow, and it takes about several tens of seconds for the tip of a debris flow with concentrated boulders to pass. Subsequent flows are muddy, and they gradually slow down.

E. Debris flows rise and flow in an outer direction around the corner of a watercourse.

Flowing conditions of gravel-filled debris flows

Kamikamihorisawa, Yakedake Volcano on August 3, 1976
(width of waterway of groundsill: 16 m; tip speed: 3.8 m/sec)

Photo 1. Start of overflowing at the head of a debris flow

Flowing conditions of gravel-filled debris flows

Photo 2. Two seconds after the occurrence

Flowing conditions of gravel-filled debris flows

Photo 3. An additional three seconds later

Flowing conditions of gravel-filled debris flows

Photo 4. An additional two seconds later

Longitudinal section of debris flows

(Kamikamihorisawa, Yakedake Volcano in July 21, 1985)

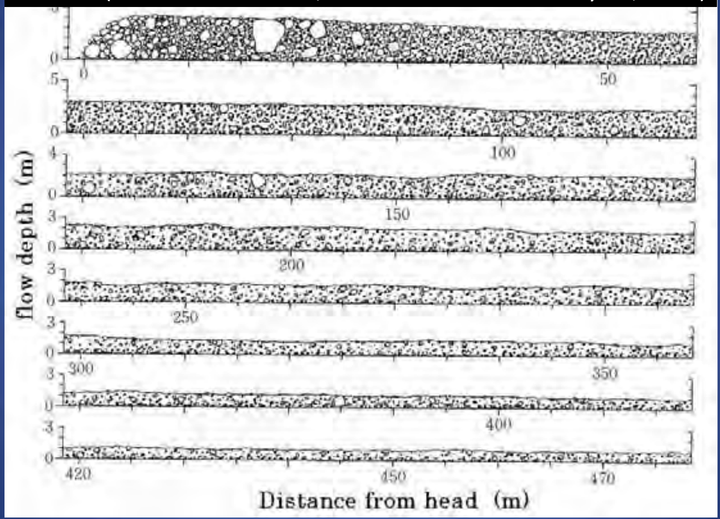
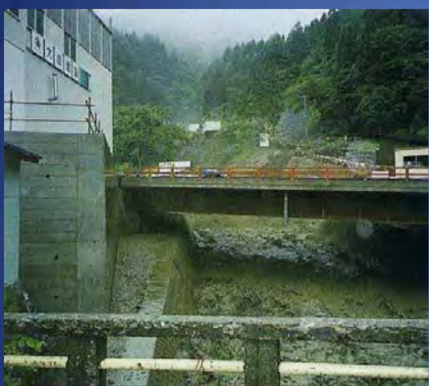


Figure 2. Longitudinal section of debris flows, and distribution of gravels (sketch)

Northern part of Nagano Prefecture in 1995



Before the occurrence of a debris flow around 6:30 pm on July 11, 1995

After the occurrence of a debris flow on the morning on July 12, 1995

Photo 19. Comparison of conditions before and after the occurrence of a debris flow

Minamata City, Kumamoto Prefecture, in 2003

Before the occurrence of a disaster in 1974

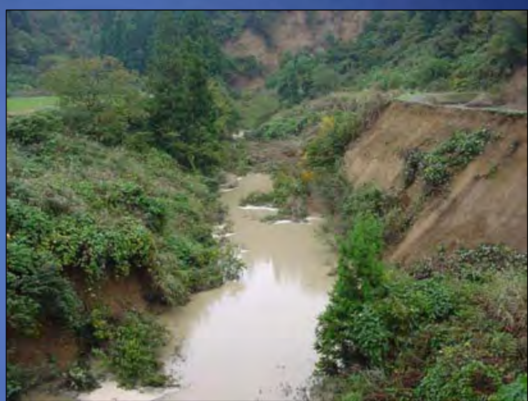
Immediately after the occurrence of a disaster in July 2003

Photo 22.

Photos taken before and after the occurrence of a disaster

Niigata Chuetsu Earthquake in 2004

River before the earthquake on September 3, 2002



River after the earthquake on October 26, 2004

Photo 32. Conditions of a blocked river course

Occurrence of sediment-related disasters 1

Hime river in Itoigawa city

Before the disaster in 1987

After the disaster in 1995

Occurrence of sediment-related disasters 2

Debris flow disaster occurred under the influence of the seasonal rain front. 2003 Minamata

Hokawachi

Shinyashiki

Occurrence of sediment-related disasters 3

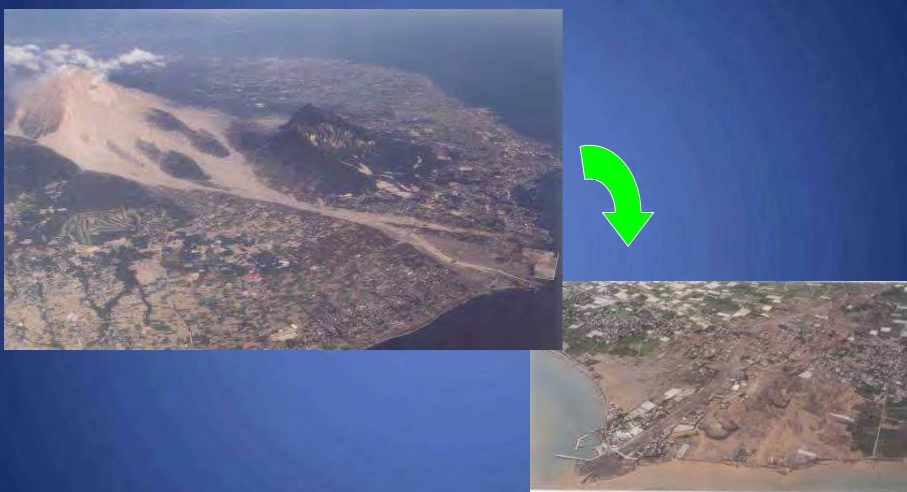
Sediment-related disaster caused by a localized torrential downpour
(Social welfare facility)

August 1998 Nishigo Fukushima

disaster of debris flow accompanied by trees

2001 Tosashimizu kouchi

Occurrence of sediment-related disasters 4



Volcanic disaster in the area of Mt. Unzenfugendake. June 1991

Occurrence of sediment-related disasters

Miyake island

Boutazawa

Volcanic disaster and mudflow in Miyake Island. 2000

② Slope failure

Occurrence of sediment-related disasters 5

Slope failure caused by earthquake.

July 2003 Miyagi

Hillside landslide caused by earthquake

January 1995 Nishinomiya

③ Landslide

Occurrence of sediment-related disasters 6

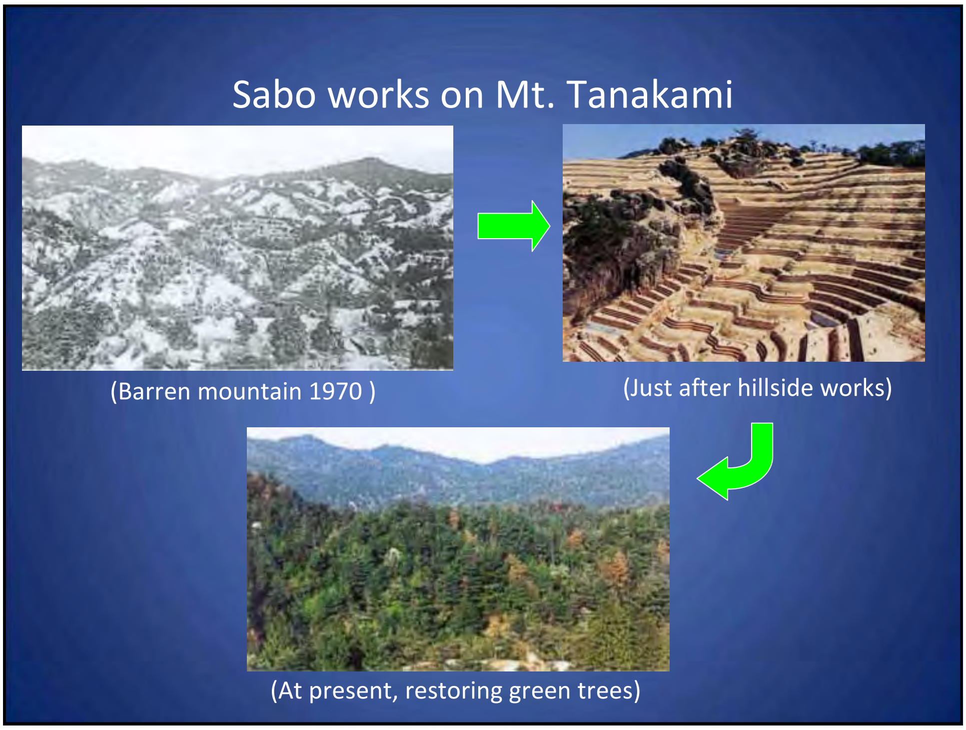
Landslide caused by snowmelt

May 1997 Kazuno

Avalanche caused by heavy snowfall

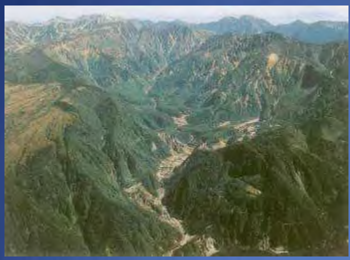
January 1986 Nou
Niigata

④ Others (Volcanic eruption)


Sabo works on Mt. Tanakami
(Barren mountain 1970)
(Just after hillside works)
(At present, restoring green trees)


Sabo works on Oya Collapse
(Barren mountain about 40 years ago)
(At present, restoring green trees)

Sabo Works in Joganji



Tateyama caldera

Shiraiwa sabo dam

Joganji river is very rapid. Sabo works in Joganji protects Toyama plain from floods caused by riverbed rising-up.

The effect of sabo works

A debris flow was caused along the Nisinogaito River in Mie prefecture in July 2002. Sabo dams captured debris flow

Permeable-type dam captured flowing drift-wood and debris, thereby preventing damages in down-stream areas

Landslide and Prevention works

July 1985　　　　June 1990

Landslide prevention works have made this area safe on Mt. Jizuki

26killed, 4 injured, houses completely destroyed 52, amount of soil slid 3.6 million m^3

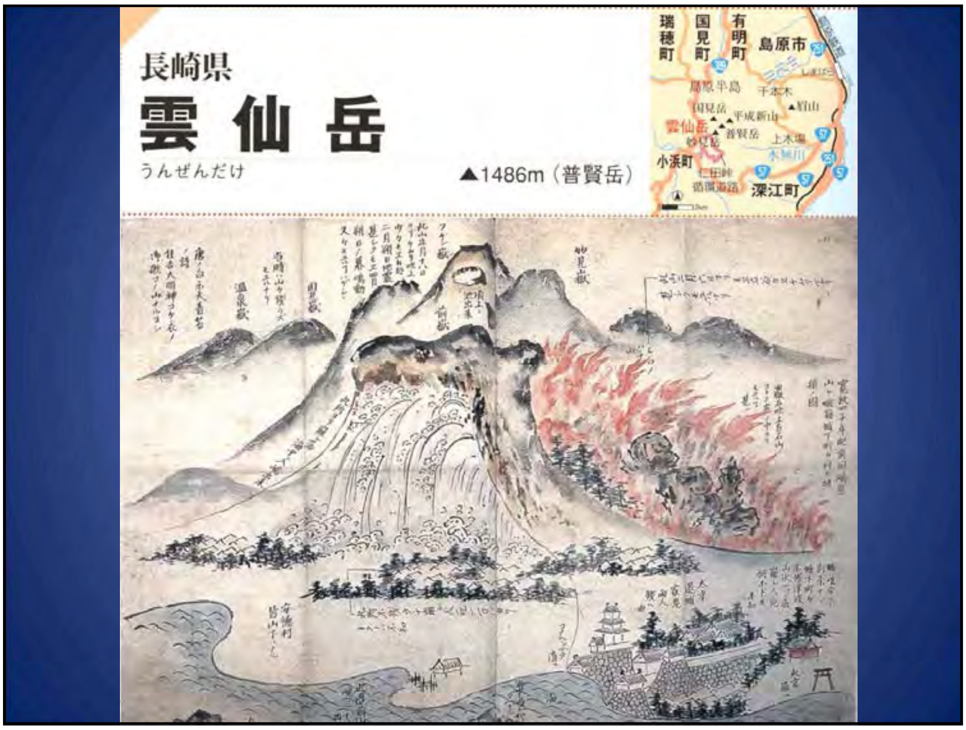
Slope failure prevention works for safe living

Immediately after a slope failure disaster

Immediately after the completion of the works

Several years after the completion of the works

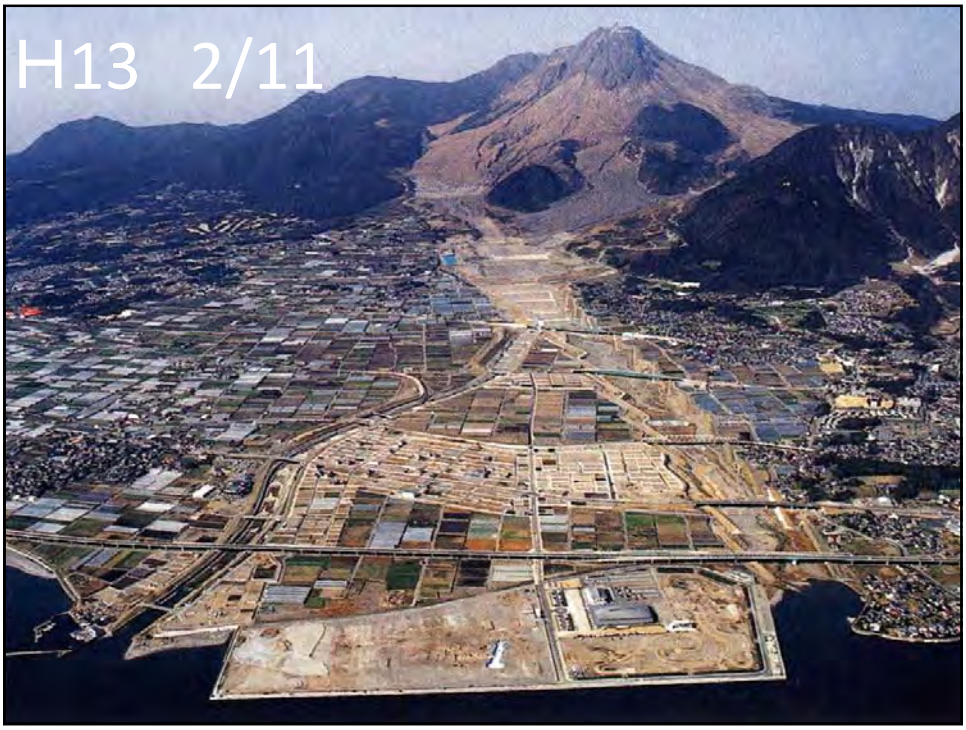
Kagoshima city


長崎県
雲仙岳
うんぜんだけ
▲1486m（普賢岳）
瑞穂町
国見町
有明町
島原市
小浜町
深江町


H3 9/18


H5 9/6

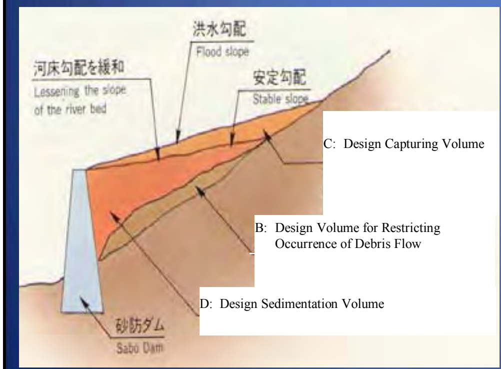

H10 5/27

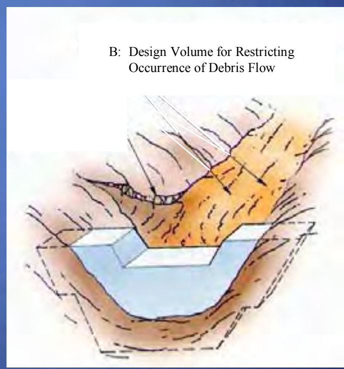


Contents

Debris Flow Countermeasure Facilities Arrangement Plan

$$Q\text{-}E\text{-}(C+D+B)=0$$





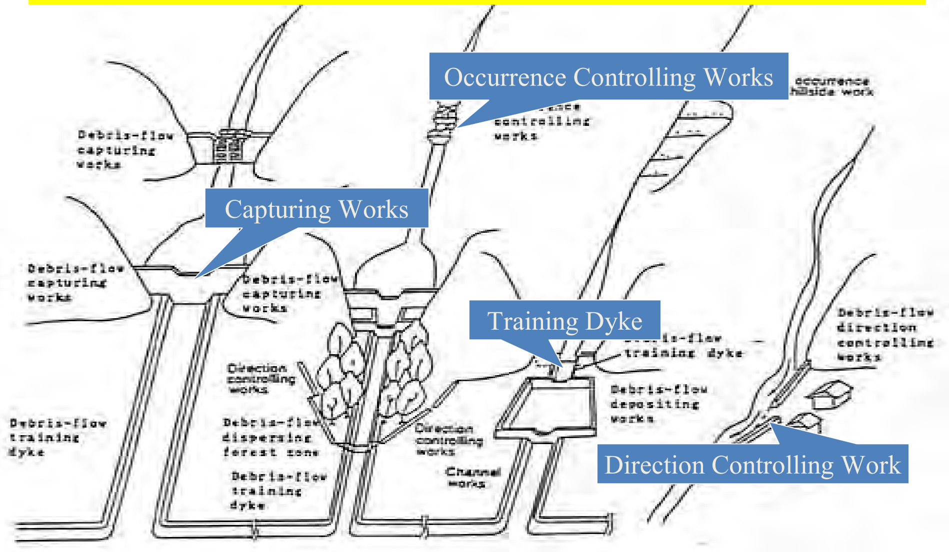
Basis of Debris Flow Countermeasure Facilities Plan

- to Decrease the Sediment Discharge of Debris Flow
- to Safely Discharge the Subsequent Flows
- to Consider
  - the Facilities Order which Brings about the Best Effect

Kinds of Debris Flow Countermeasure Facilities

- Debris Flow Capturing Works
- Debris Flow Depositing Works
- Debris Flow Training Works
- Debris Flow Dispersing Works
- Debris Flow Direction Controlling Works
- Works for Restricting the Occurrence of Debris Flow

Typical Example of Debris Flow Counter Measure Facilities



Debris Flow Capturing Works
Typical Structure: Dam

- to Reduce the Scale
- to Lengthen the Travel Time
- to Prevent the Movement of Fluvial Deposits
- to Capture the Boulders and Woody Debris
- to Turn the Debris Flow into Sediment Flow
- to Reduce the Peak Discharge

Sabo Dam

- Impermeable Dam
  - Concrete Dam
  - Steel-Framed Dam
- Permeable Dam
  - Steel-Pipe Dam
  - Slit Dam


Impermeable Dam (1)
Concrete Dam


Impermeable Dam (2)
Steel-framed Dam

Permeable Dam (1)

Steel-pipe Dam

Permeable Dam (2)

Slit Dam

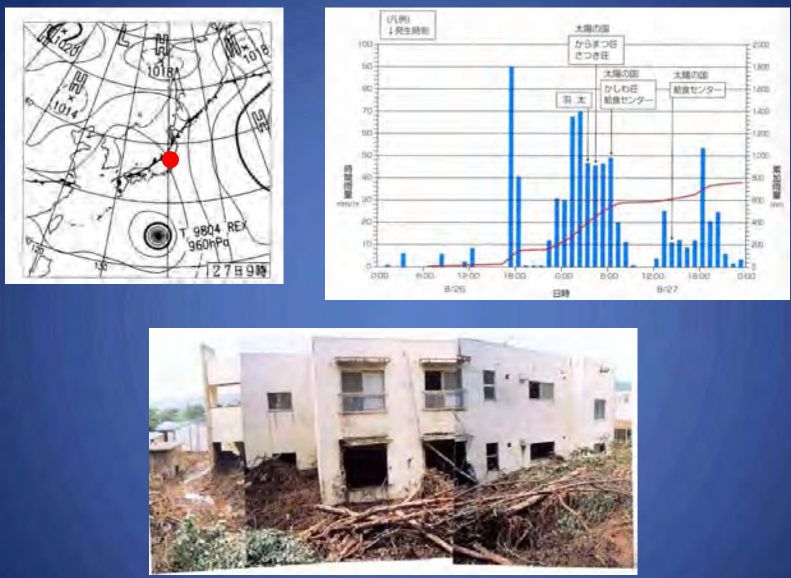
Contents

Sediment-Related Disaster Forecasting and Warning System

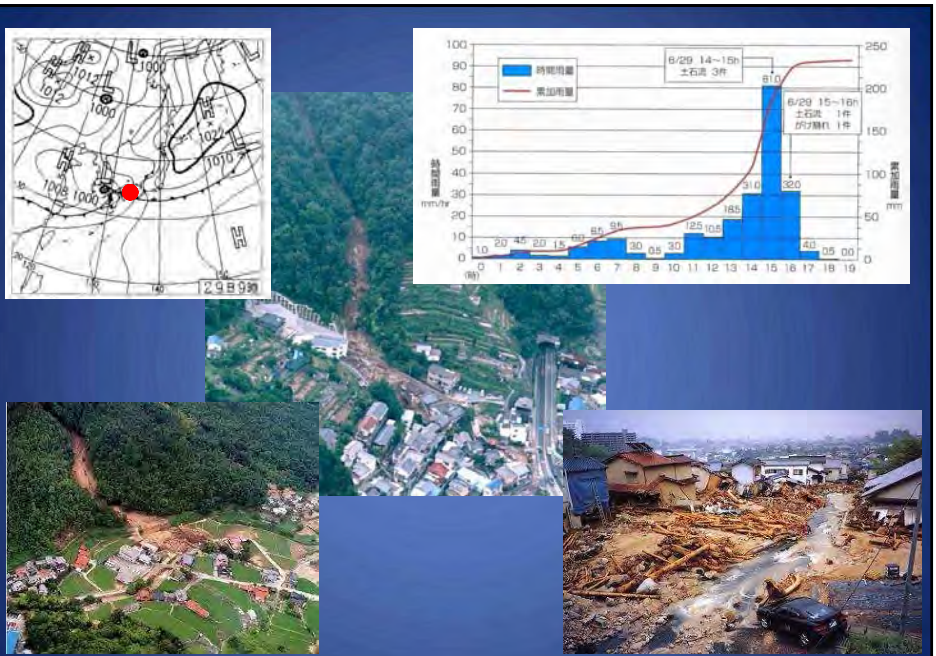
Evacuation to the place of safety before the disaster occurs by adequate information transmission is important to defend the life from the sediment-related disaster.

↓

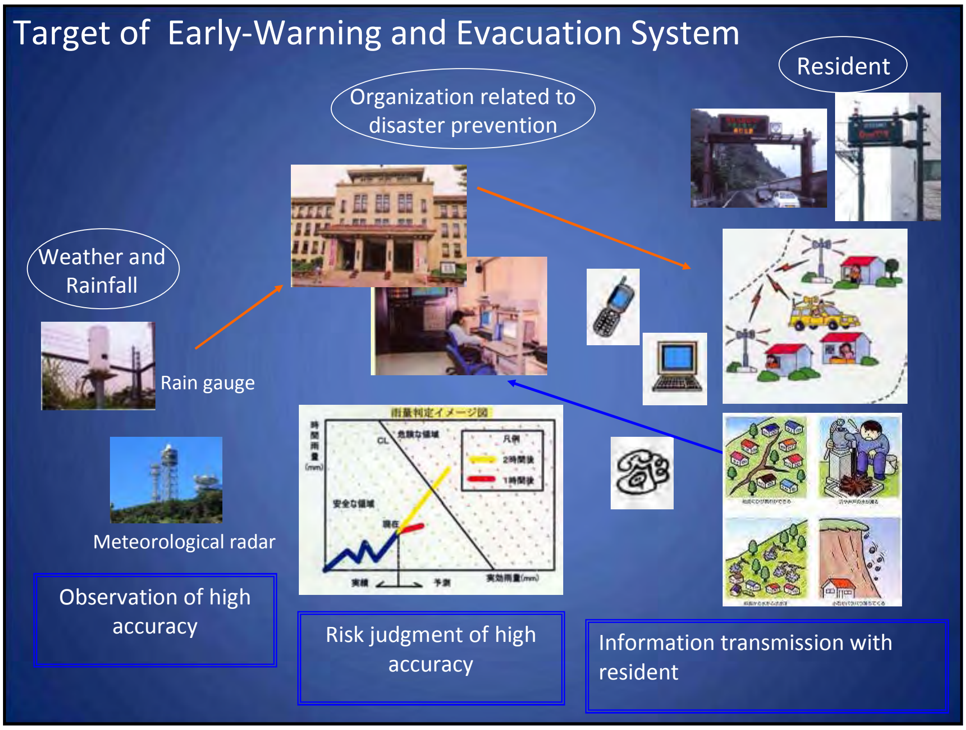
The monitoring and the observation equipment such as rain gauges and the debris-flow detection sensors are arranged, and the resident's warning and evacuation activity are supported.

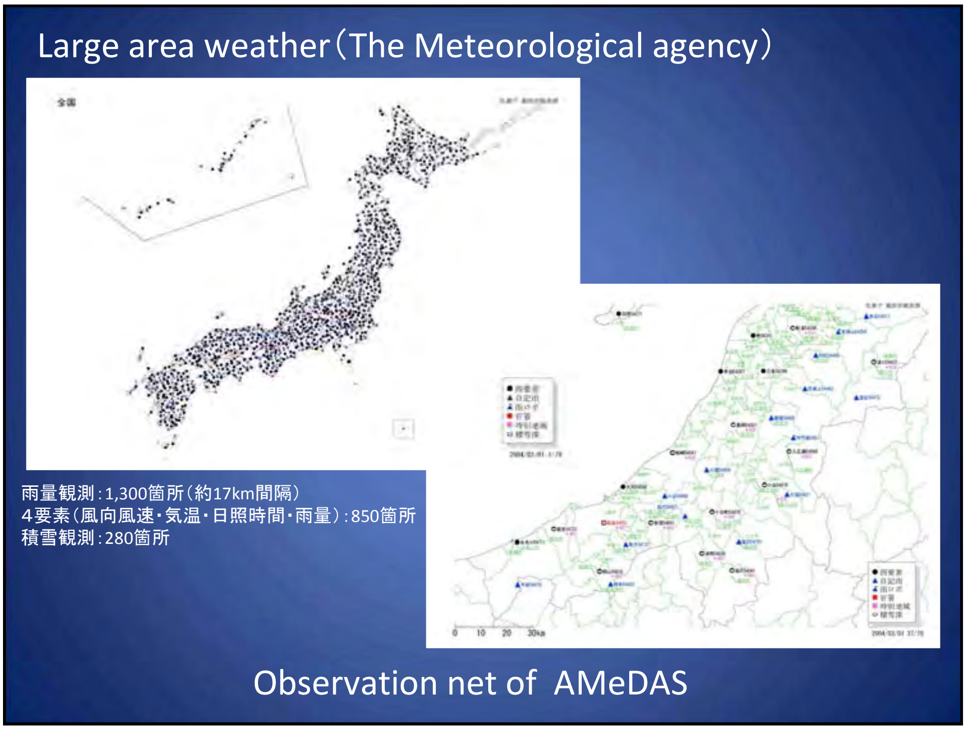


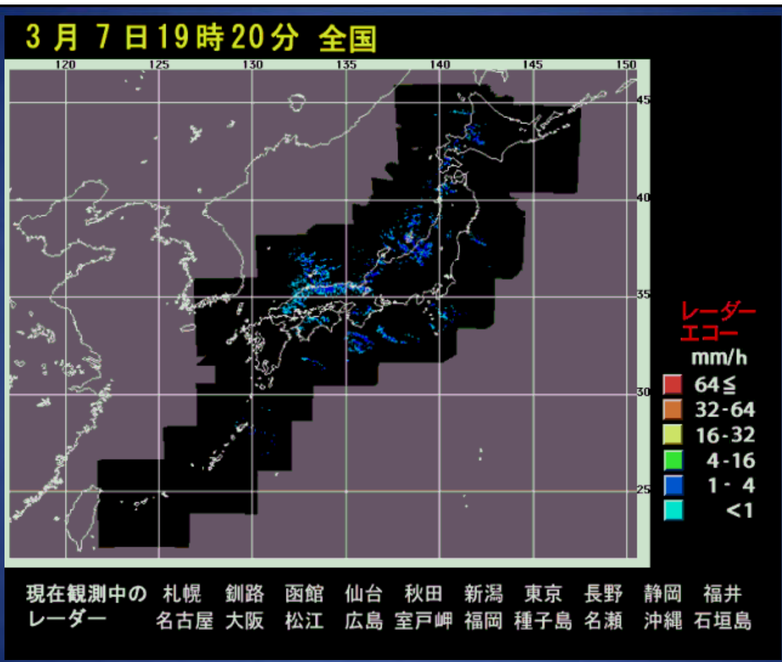
Weather at sediment-related disaster（1998/8 Hukushima Pref.）



Weather at sediment-related disaster（1999/6 Hiroshima Pref.）


Target of Early-Warning and Evacuation System
Resident
Organization related to disaster prevention
Weather and Rainfall
Rain gauge
Meteorological radar
Observation of high accuracy
Risk judgment of high accuracy
Information transmission with resident


Large area weather（The Meteorological agency）
雨量観測：1,300箇所（約17km間隔）
4要素（風向風速・気温・日照時間・雨量）：850箇所
積雪観測：280箇所
Observation net of AMeDAS



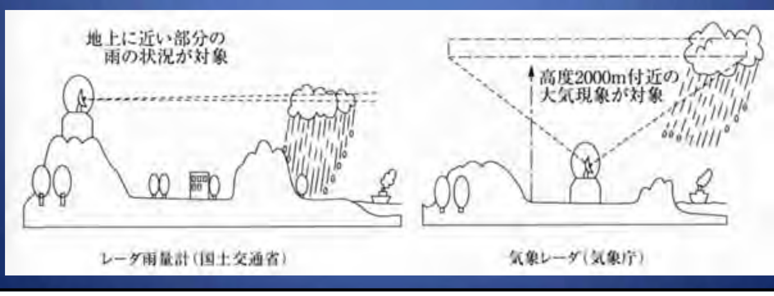
Rainfall distribution with Meteorological radar（5km×5km)

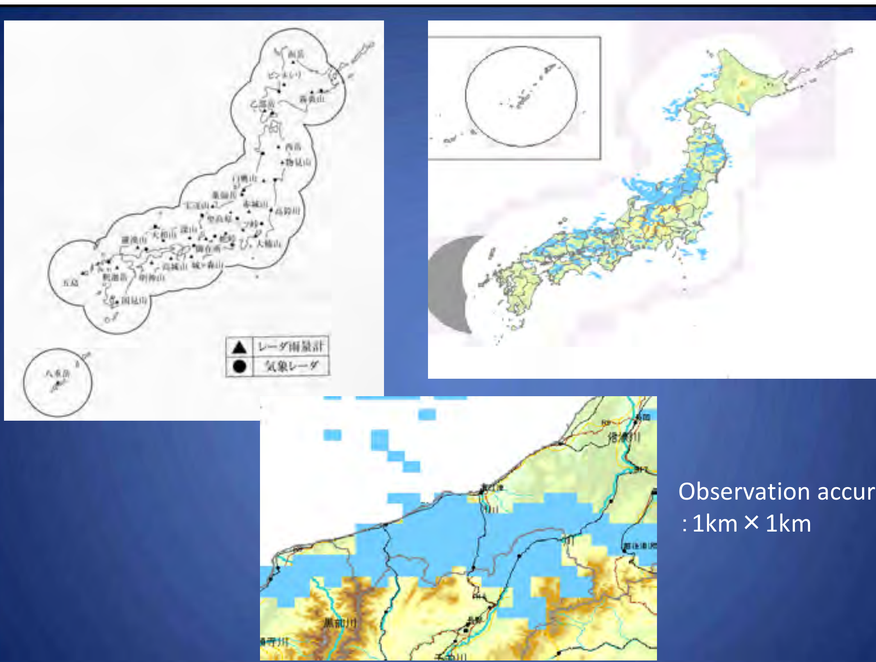
Large Area Meteorological Observation

The Weather Forecast and General Condition of Rainfall

Fault to sediment-related disaster prevention

1）The difference of the rainfall on the mountains ground where the sediment-related disaster occurs is large.
2）It is necessary to understand a part near surface of the ground, because the meteorological radar target a high space in the coast part.

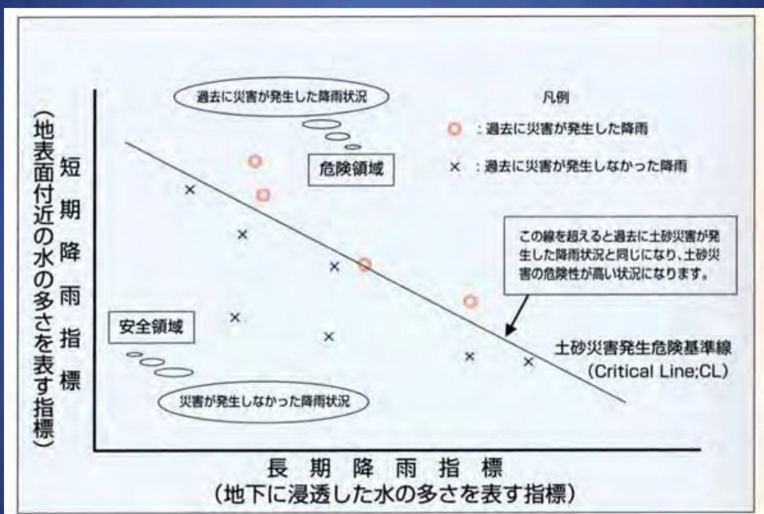




Observation accuracy
:1km×1km

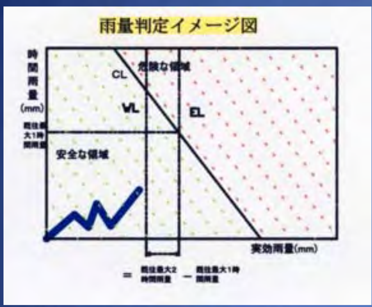
Arrangement at radar rain gauge and situation of rainfall

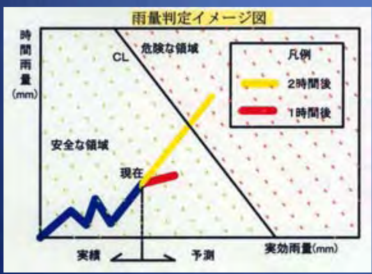
1）Critical rainfall for warning and evacuation

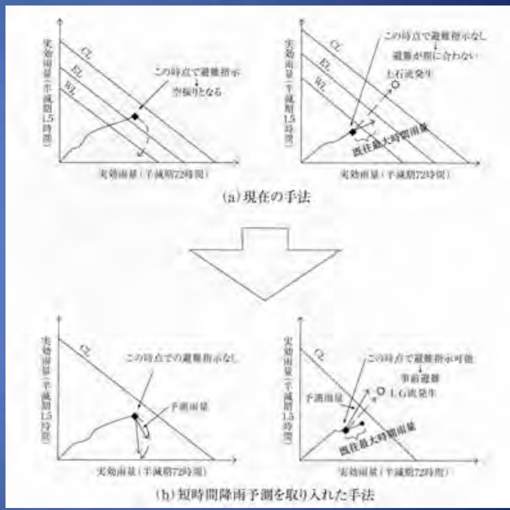


Set concept chart of Critical rainfall

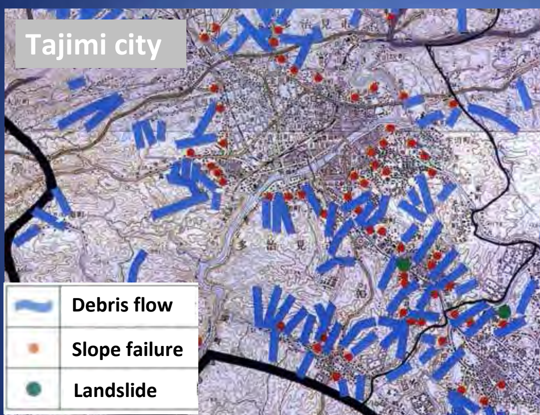
2）Critical rainfall for warning and evacuation that uses rainfall forecast







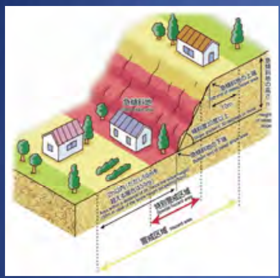
Dissemination of sediment-related disaster information



Distribution of a hazard map on sediment-related disasters

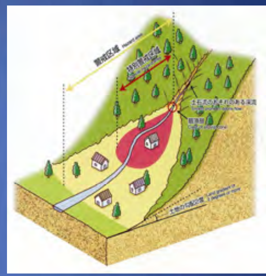
Dissemination by direct mail

Designation of Hazard Areas and Preventive Measures



Steep slope failure

Landslide



Debris Flow

Yellow zone :Sediment-related disaster hazard area

Red zone :Special sediment-related disaster hazard area

The Law for Promoting Prevention Measures Against Sediment Disasters

Subjects of Sediment Disasters : Slope Failures, Debris Flow, Landslide

Preparation for Guidelines on Sediment Disasters Prevention Measures［Minister of Land, Infrastructure and Transport］

- Basic matters related to measures for sediment disasters prevention
- Guidelines on basic survey
- Guidelines on designation of potential sediment disasters areas
- Guidelines on moving structures from high potential sediment disasters areas

↓

Implementation of Basic Survey［Each Prefecture］

- Investigation for designation of potential and high potential sediment disasters areas

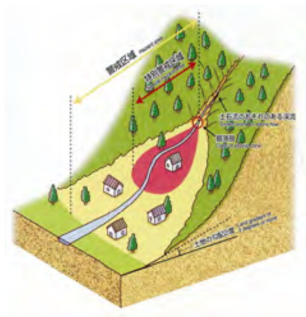
↓

Designation of Potential Sediment Disasters Areas［Each Prefecture］
〈The Areas in Danger of Sediment Disasters〉

○ Preparing for the warning, information and evacuation system
○ Informing inhabitants of matters on the warning and evacuation

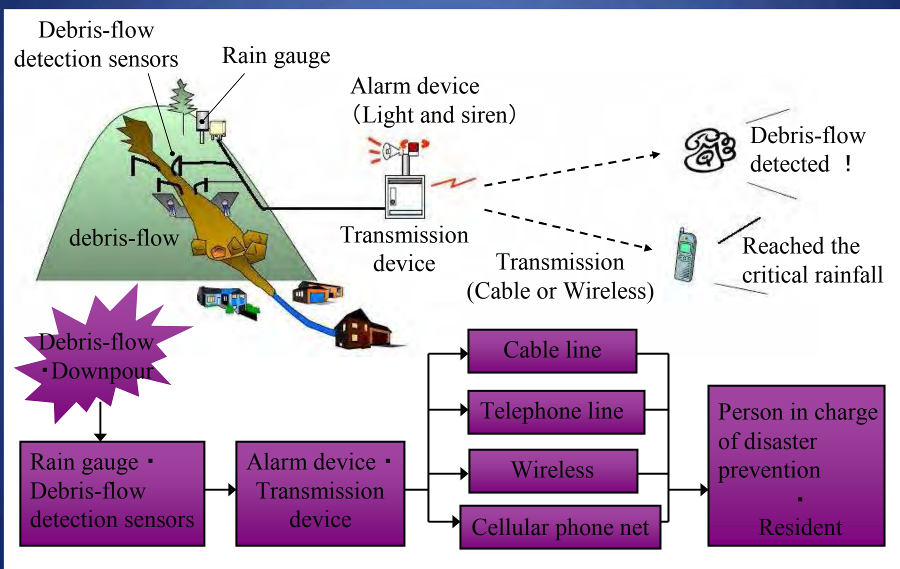
Designation of High Potential Sediment Disasters Areas［Each prefecture］
〈In the areas, buildings and inhabitants might suffer heavily from the disasters〉

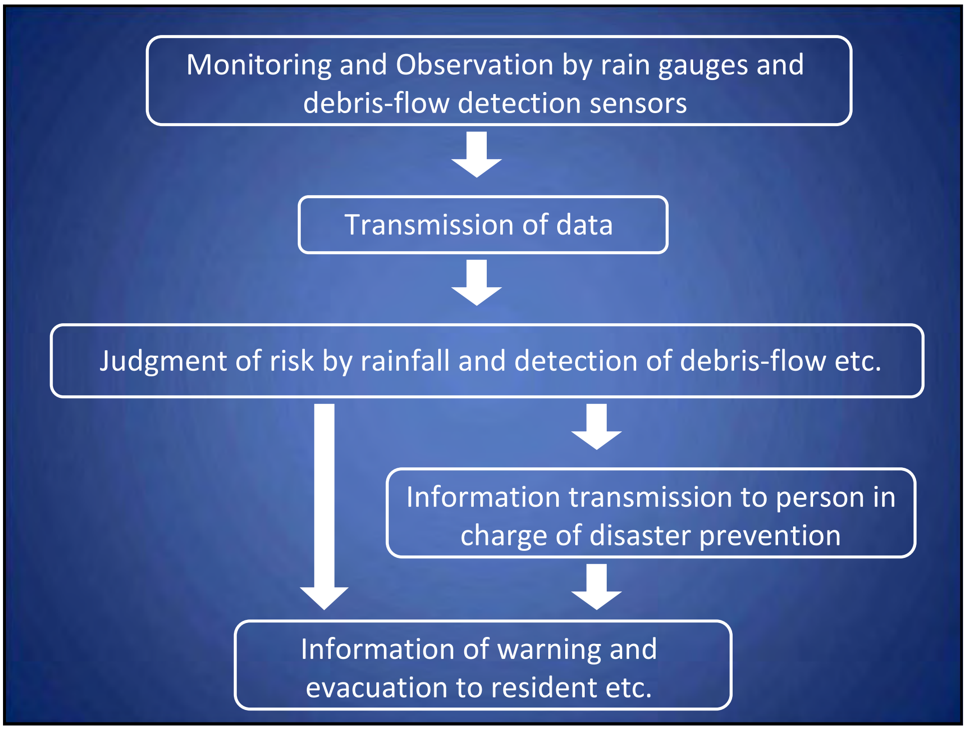
○ The permission for certain development works
examples : development works aimed at sale of building lots for residence or constructing social welfare facilities
○ Setting up of building regulations
○ Advice of moving the building which might be destroyed in case of sediment disasters
○ Organizing financial support system for the people who move according to the advice



Contents

Monitoring and observation of debris-flow on the debris-flow-torrent etc.

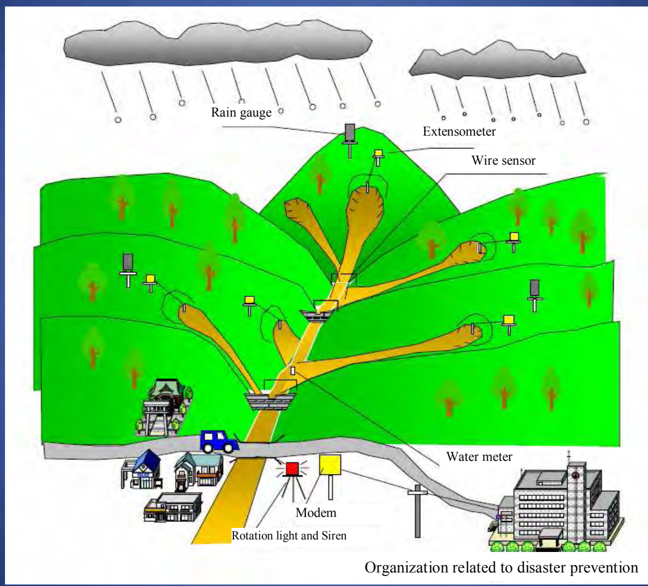




Contents

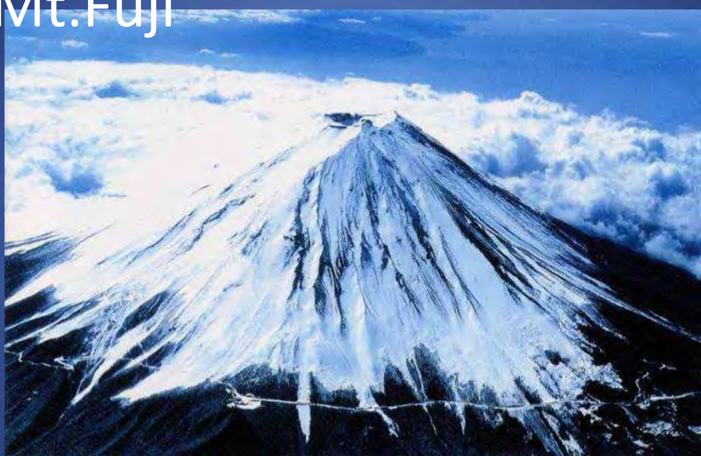
1. Introduction
2. Landslide disasters in Japan
3. Countermeasures
4. Early-Warning and Evacuation
5. The problems for the future of warning
6. Conclusion remarks

What shall I do for landslide disaster mitigation?



Slope failure and debris-flow observation model chart

Mt.Fuji



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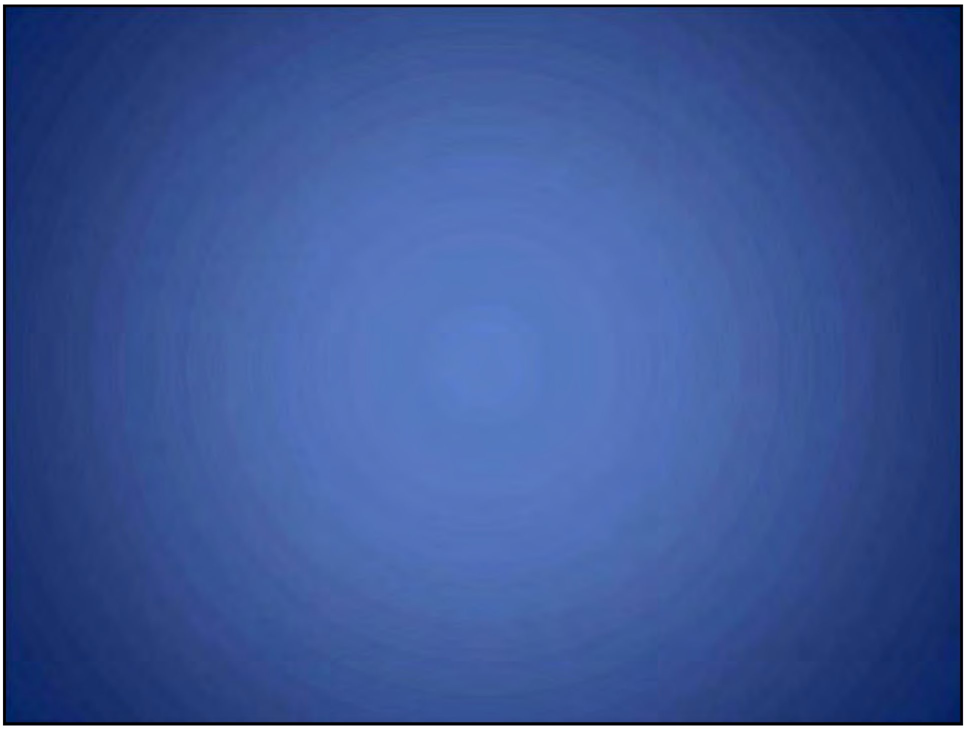


The Battle against Landslide Disaster in the Recent History of Japan

Naoki SAKAI
Storm Flood and Landslide Research Department,
National Research Institute for Earth Science and Disaster Prevention

Abstract

In these years, there are many landslide disasters occurred in city ares and mountainous area of Japan. Some of them were triggered by heavy rainfall, and some were induced by earthquake or snow-melting.

In this presentation, we focus on landslide disaster due to heavy rainfall.

Then the countermeasure facilities and the warning systems are described as a mitigation plan.

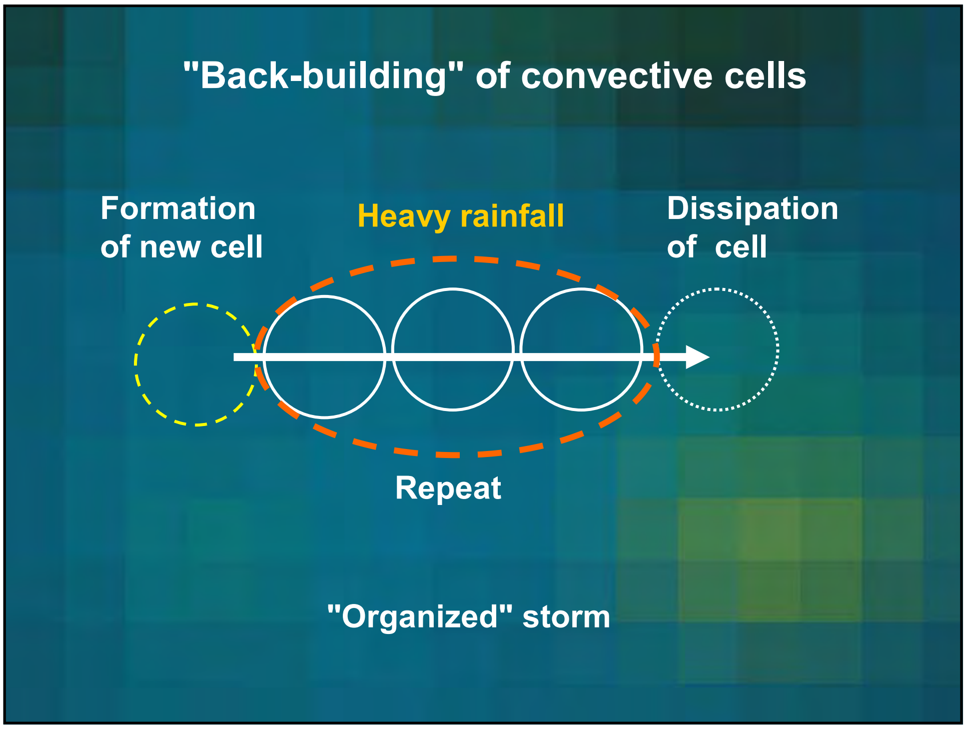
Finally, we show the some suggestions on the question of "What shall we do for landslide disaster mitigation in our life?"

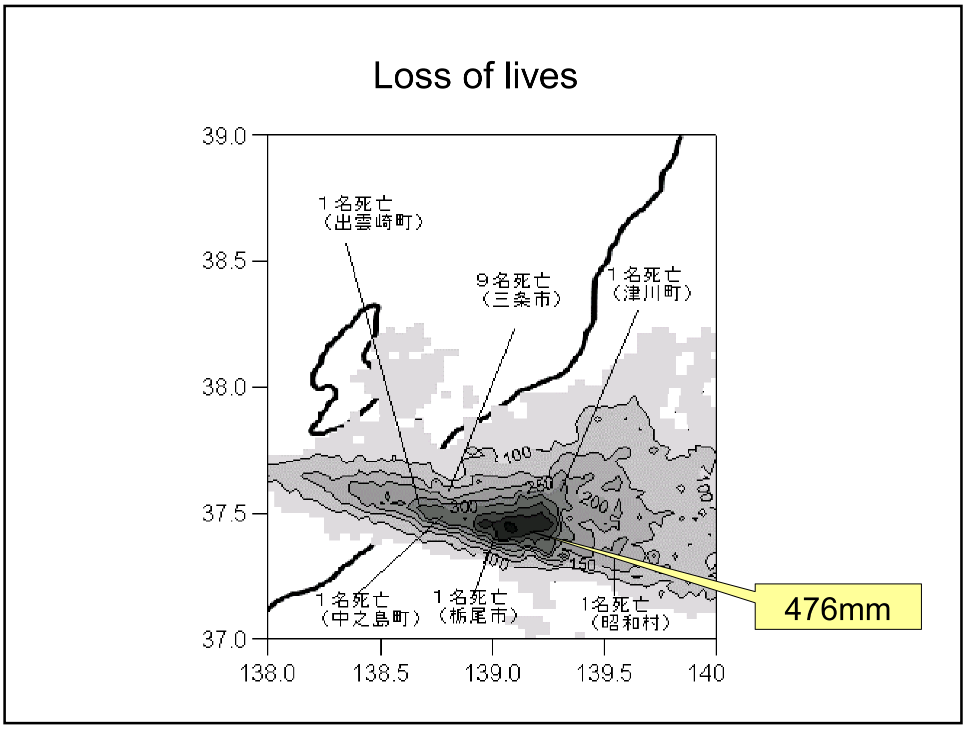
REALTIME MONITORING OF SHALLOW-LANDSLIDE POTENTIAL AREA USING MULTI-PARAMETER RADAR

Ryohei Misumi

National Research Institute for Earth Science and Disaster Prevention, Japan

Recent rainfall disasters in Japan

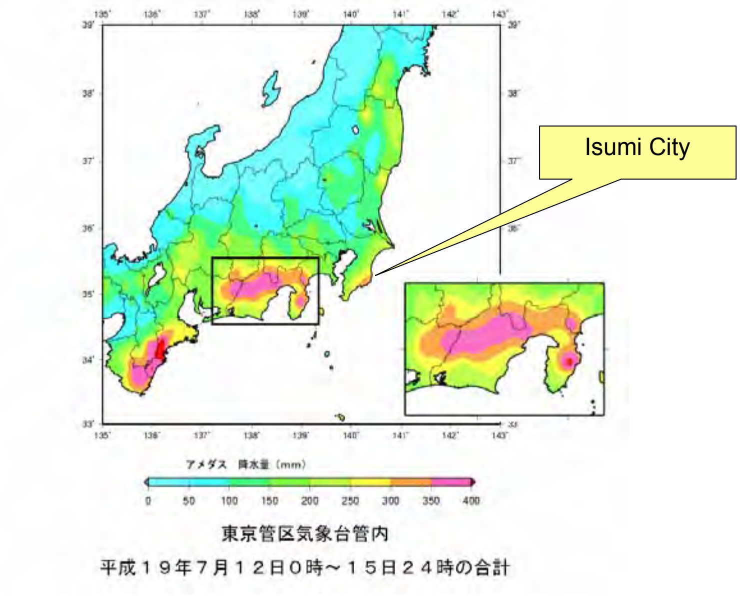

"Back-building" of convective cells
Formation of new cell
Heavy rainfall
Dissipation of cell
Repeat
"Organized" storm


Loss of lives
1名死亡（出雲崎町）
9名死亡（三条市）
1名死亡（津川町）
1名死亡（中之島町）
1名死亡（栃尾市）
1名死亡（昭和村）
100
150
200
250
300
476mm
39.0
38.5
38.0
37.5
37.0
138.0
138.5
139.0
139.5
140


Shallow landslide
(Tochio City)
2004 09 03


Debris flow
(Izumozaki Town)
2004 09 03

Typhoon Man-Yi on 14-15 July 2007




Landslide (Isumi City)


A car carried by debris flow
(Isumi city)

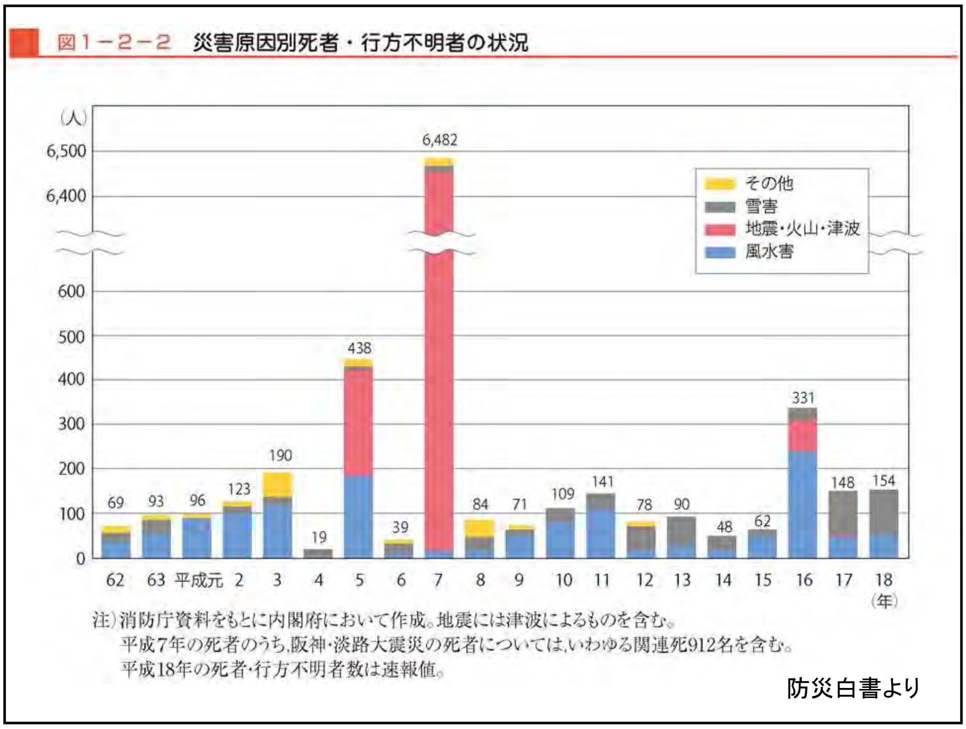
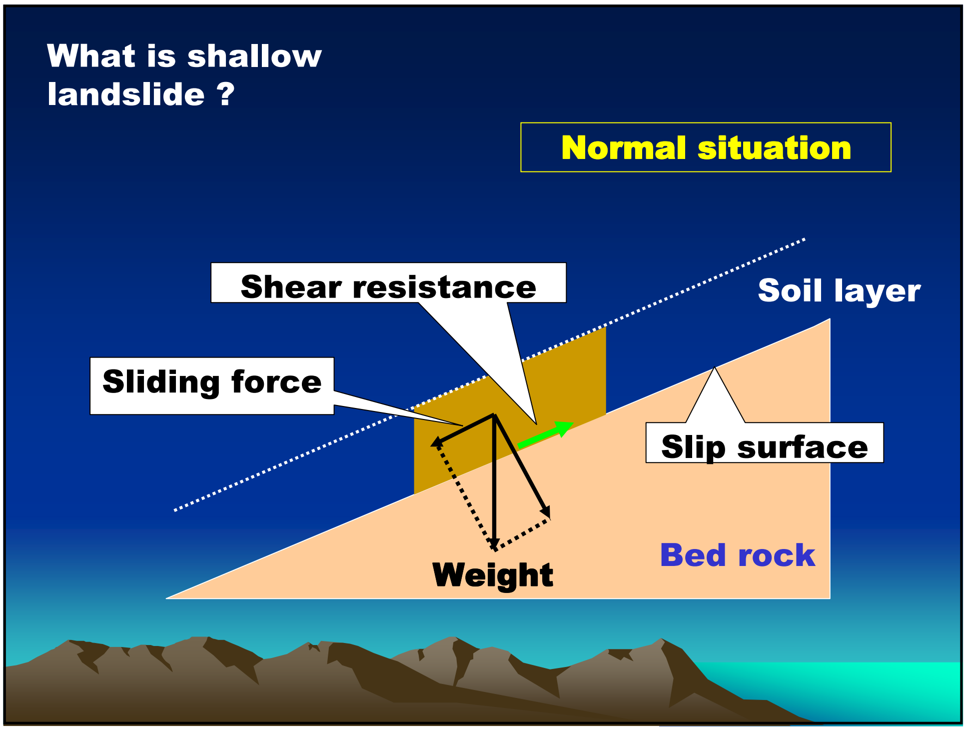
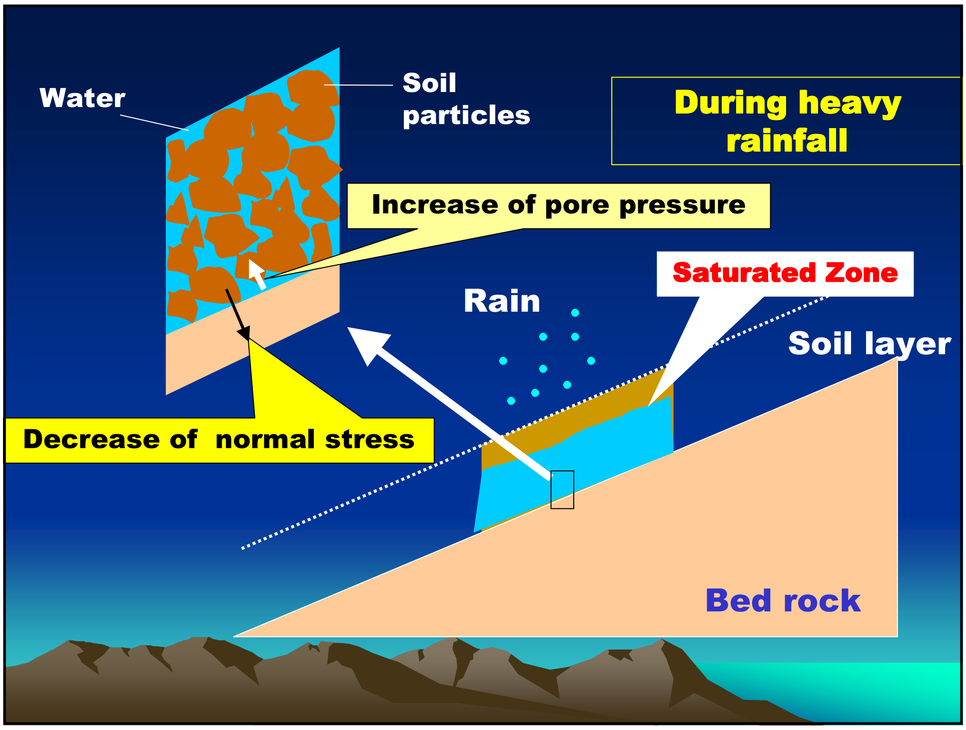


図1－2－2　災害原因別死者・行方不明者の状況
(人)
6,500
6,400
600
500
400
300
200
100
0
6,482
438
331
190
123
69
93
96
19
39
84
71
109
141
78
90
48
62
148
154
その他
雪害
地震・火山・津波
風水害
62
63
平成元
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
(年)
注）消防庁資料をもとに内閣府において作成。地震には津波によるものを含む。
平成7年の死者のうち，阪神・淡路大震災の死者については，いわゆる関連死912名を含む。
平成18年の死者・行方不明者数は速報値。
防災白書より

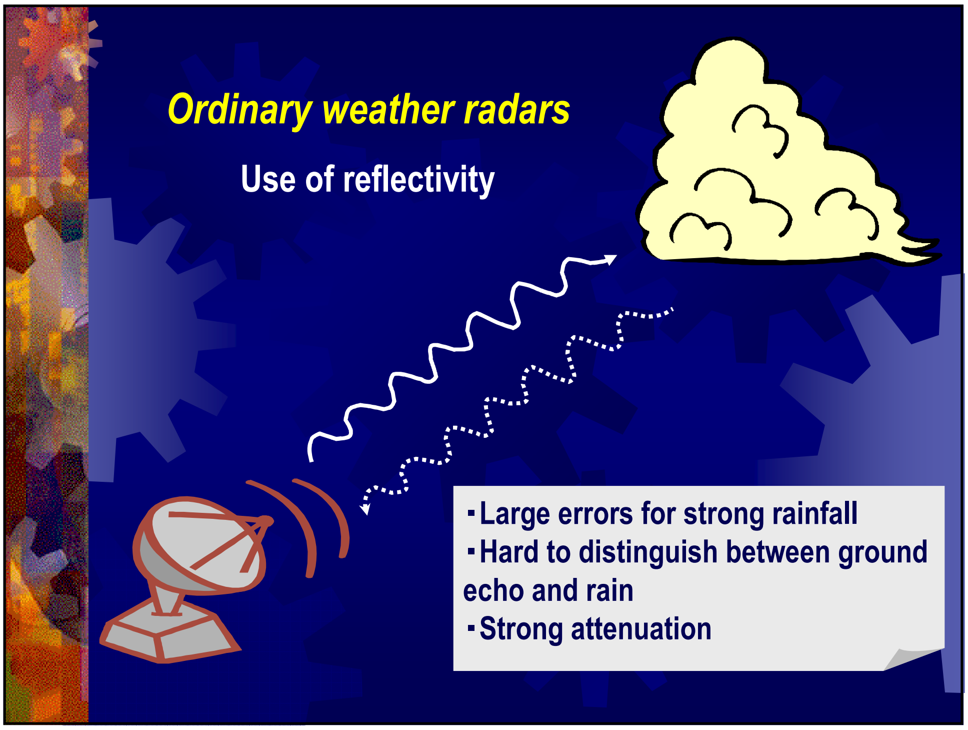

What is shallow landslide ?
Normal situation
Shear resistance
Soil layer
Sliding force
Slip surface
Weight
Bed rock

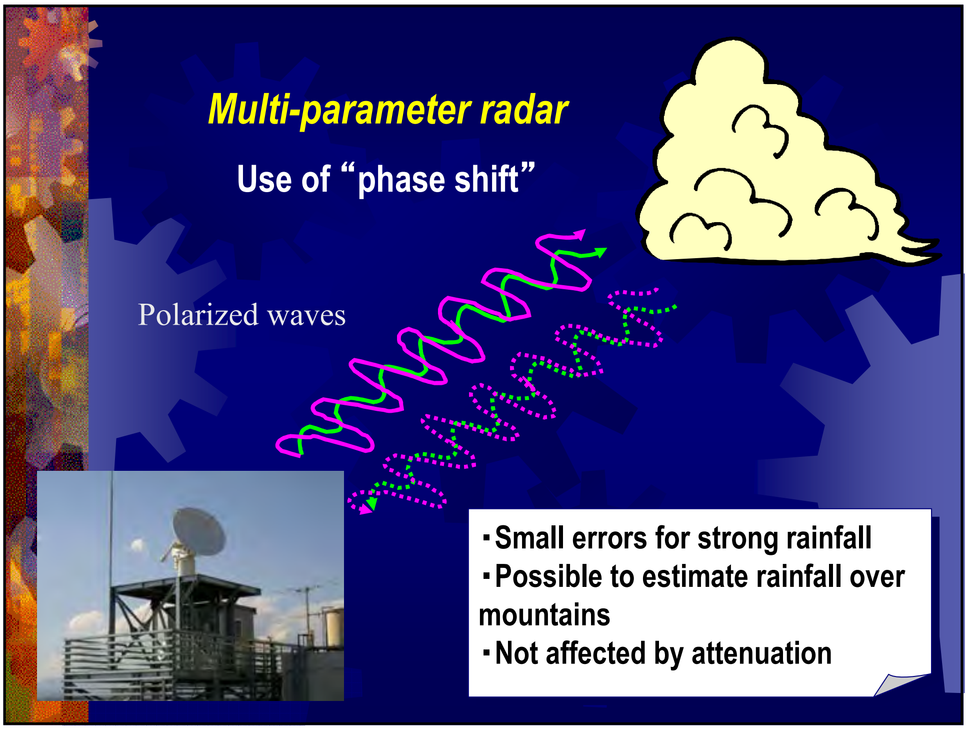


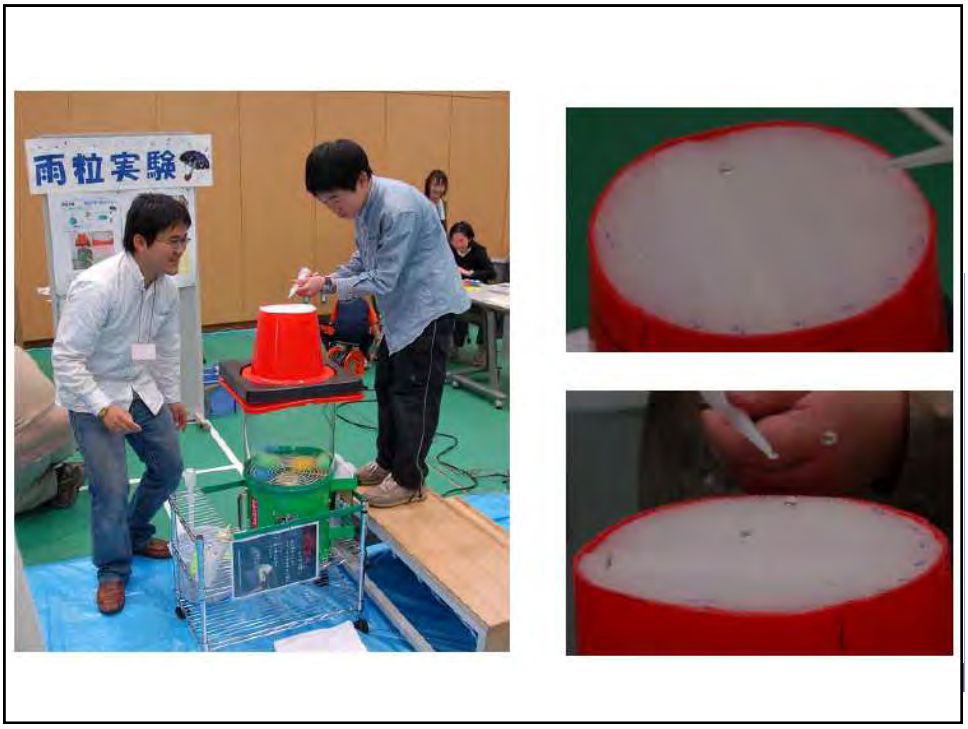
Why do rainfall induced disaster occur ?

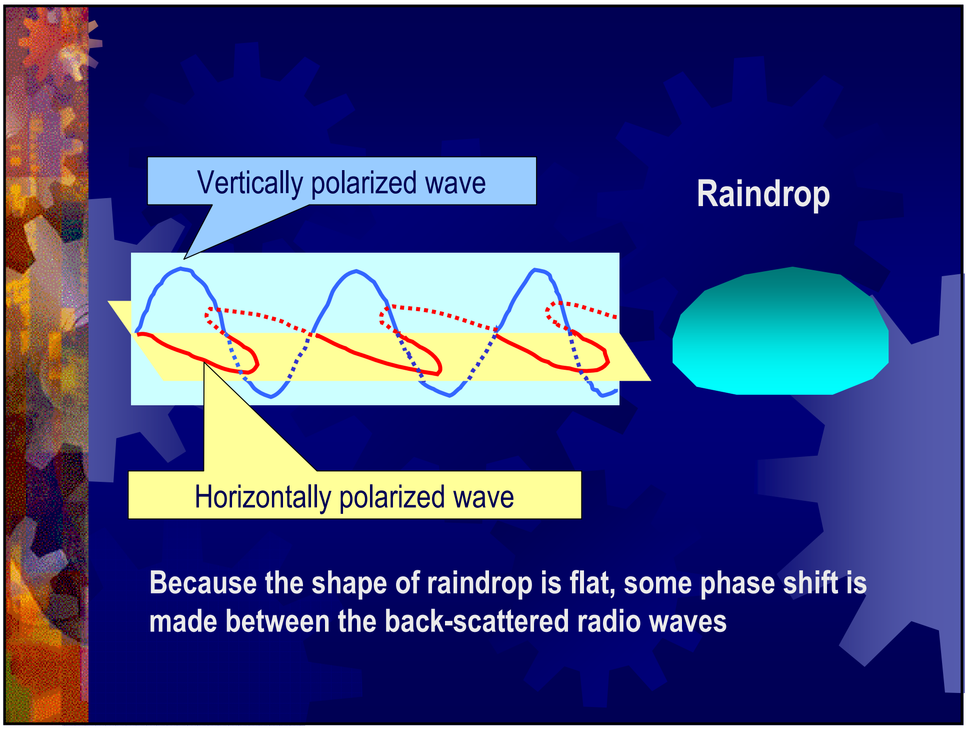
- Problems in rainfall forecasting
- Difficulty in making appropriate warning
- Problems of "aging society" etc.

Monitoring heavy rainfall using Multi-parameter radar


Ordinary weather radars
Use of reflectivity
▪Large errors for strong rainfall
▪Hard to distinguish between ground echo and rain
▪Strong attenuation

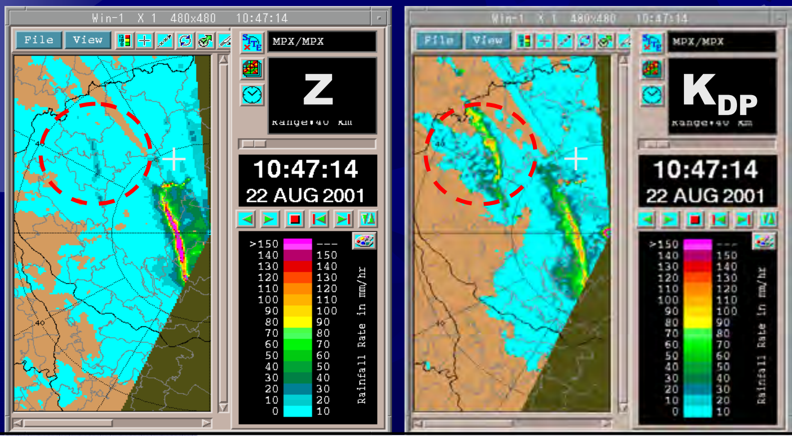

Multi-parameter radar
Use of "phase shift"
Polarized waves
▪Small errors for strong rainfall
▪Possible to estimate rainfall over mountains
▪Not affected by attenuation

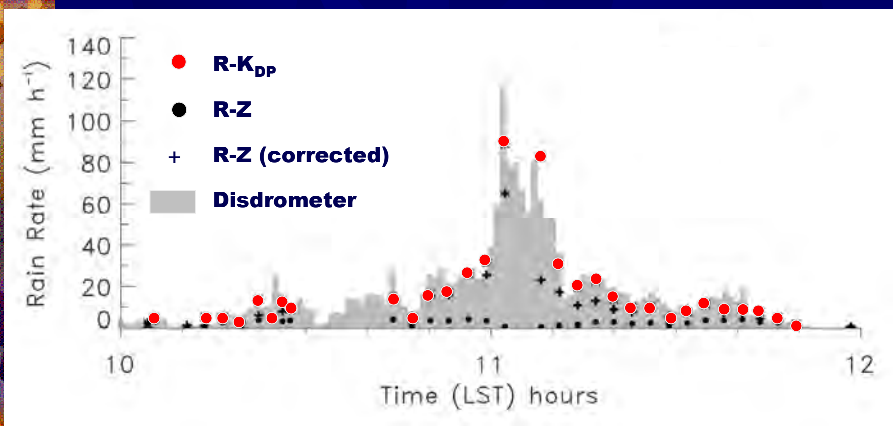

雨粒実験

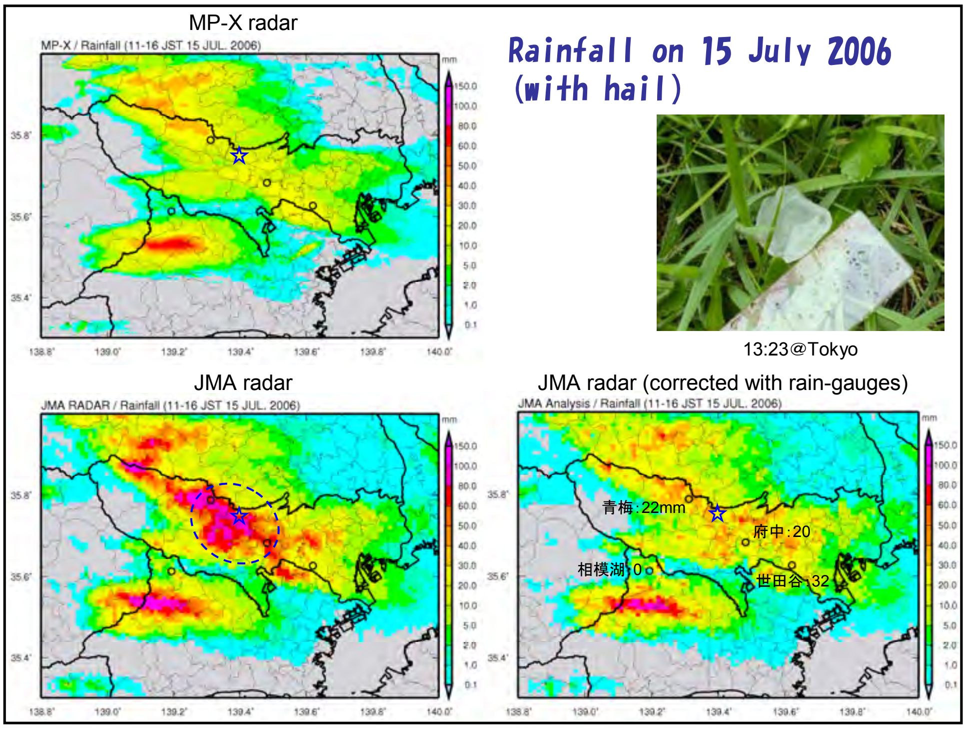

Vertically polarized wave
Raindrop
Horizontally polarized wave
Because the shape of raindrop is flat, some phase shift is made between the back-scattered radio waves

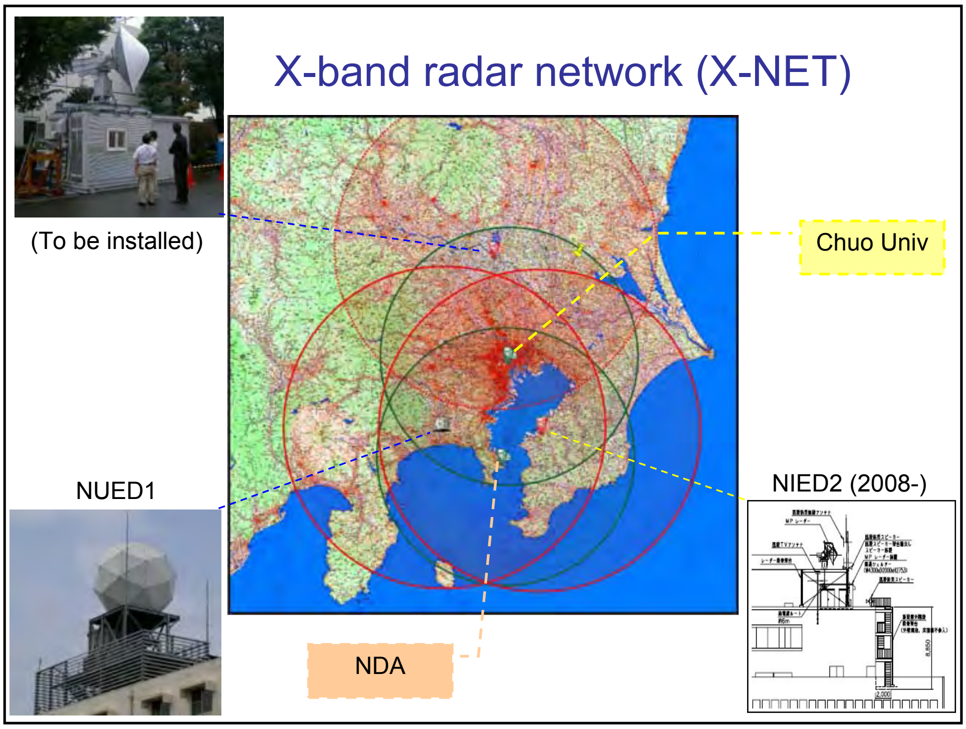
Estimation of rainfall intensity using the specific differential phase (K_{DP})

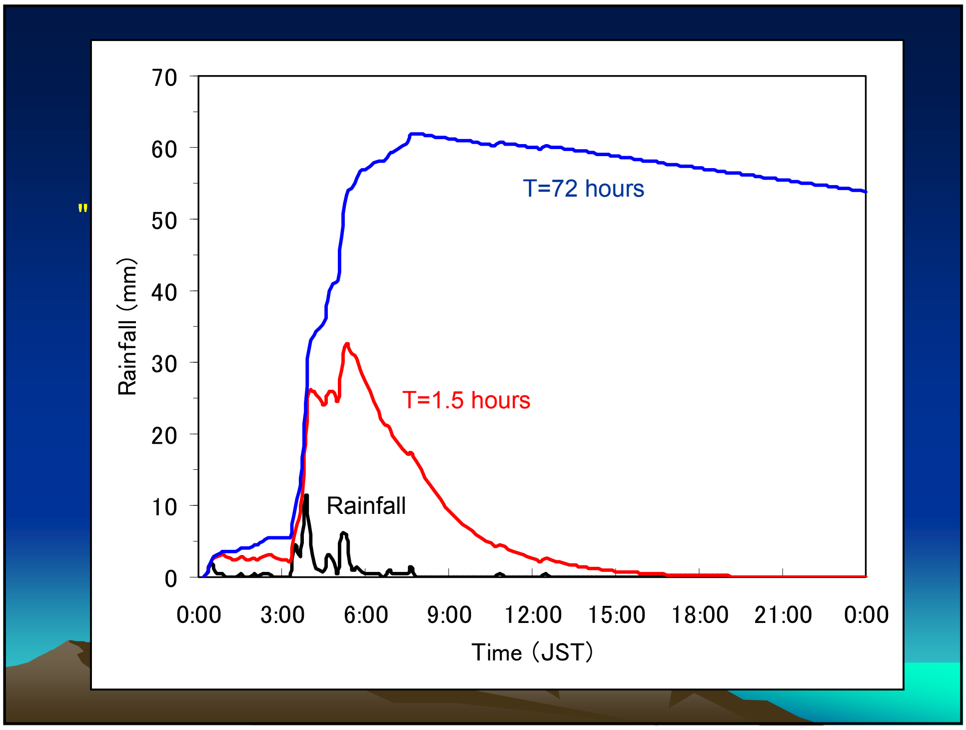
- not affected by rain attenuation
- immune to beam blockage
- less sensitive to beam filling and drop size distribution



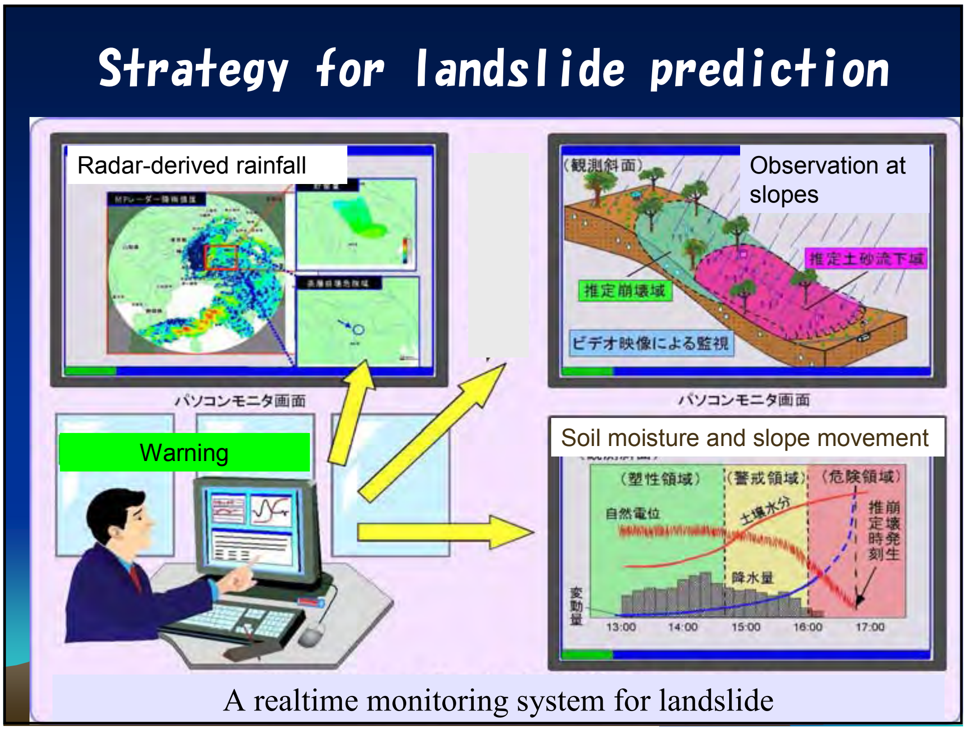



MP-X radar
MP-X / Rainfall (11-16 JST 15 JUL. 2006)
Rainfall on 15 July 2006
(with hail)
13:23@Tokyo
JMA radar
JMA RADAR / Rainfall (11-16 JST 15 JUL. 2006)
JMA radar (corrected with rain-gauges)
JMA Analysis / Rainfall (11-16 JST 15 JUL. 2006)
青梅:22mm
府中:20
相模湖:0
世田谷:32

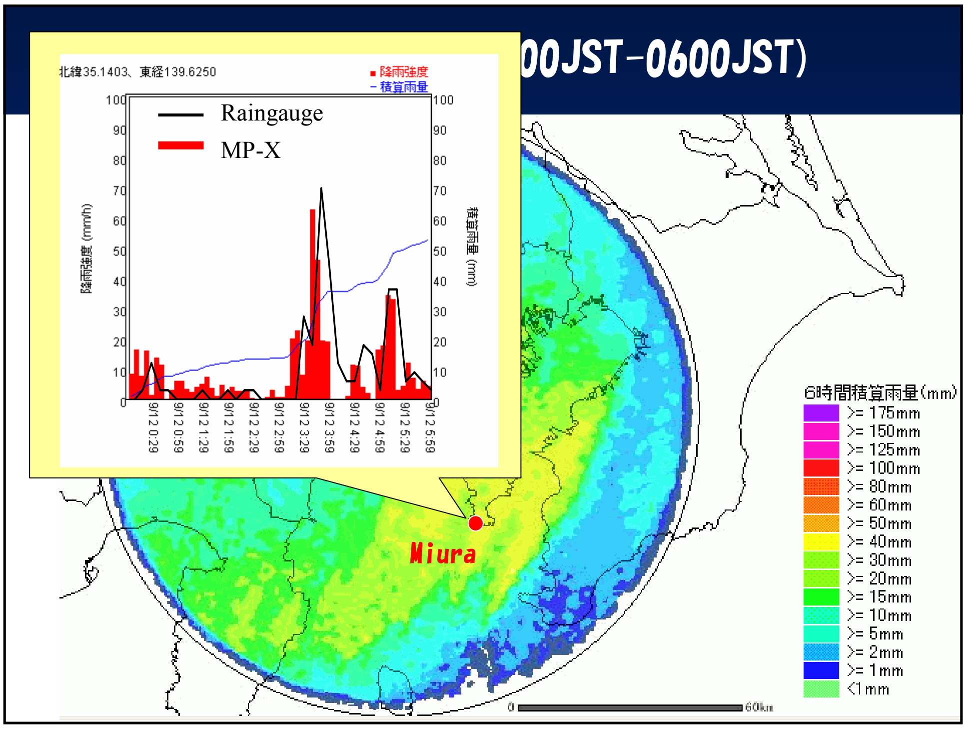

X-band radar network (X-NET)
(To be installed)
Chuo Univ
NUED1
NIED2 (2008-)
NDA



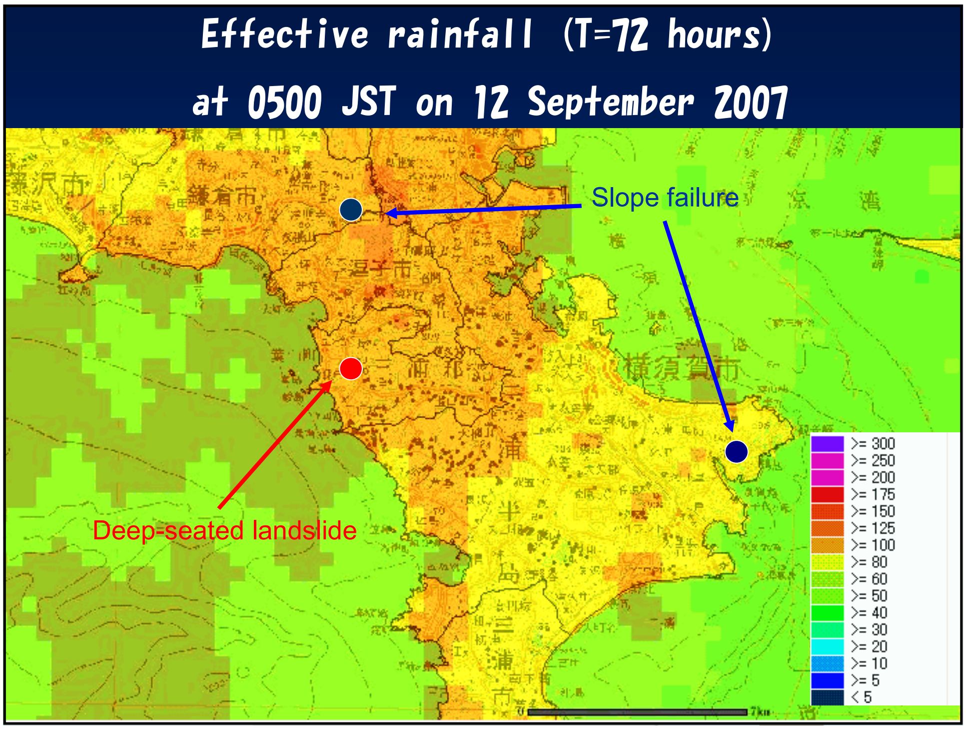
70
60
50
40
30
20
10
0
Rainfall (mm)
T=72 hours
T=1.5 hours
Rainfall
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Time (JST)

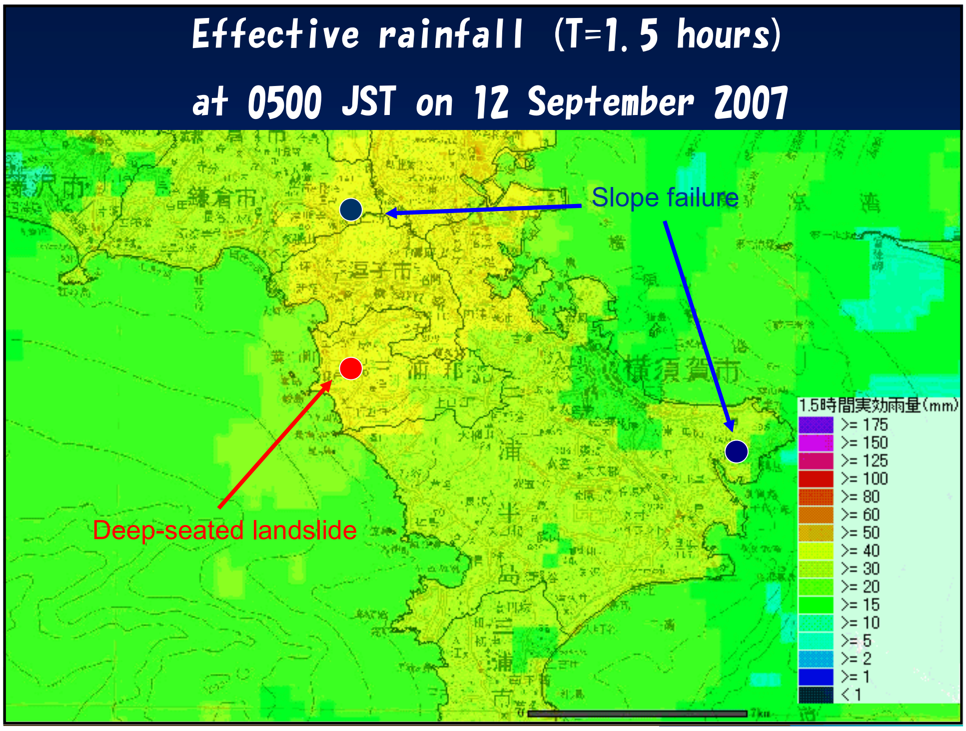


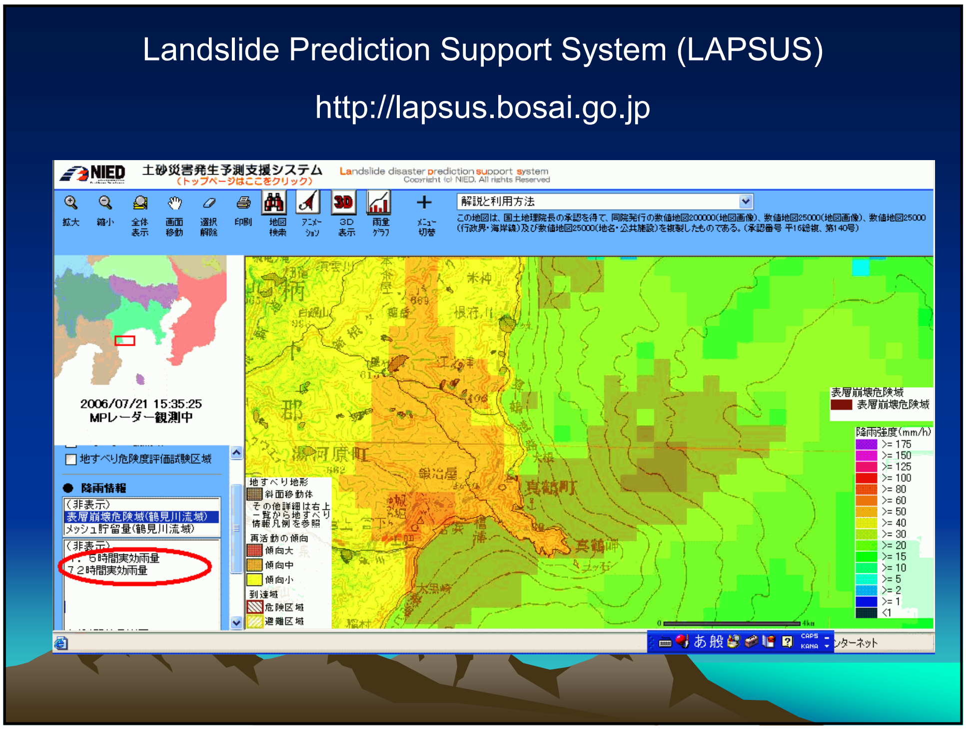
Strategy for landslide prediction
Radar-derived rainfall
パソコンモニタ画面
Observation at slopes
(観測斜面)
推定土砂流下域
推定崩壊域
ビデオ映像による監視
パソコンモニタ画面
Warning
Soil moisture and slope movement
(塑性領域)
(警戒領域)
(危険領域)
自然電位
土壌水分
降水量
変動量
13:00
14:00
15:00
16:00
17:00
A realtime monitoring system for landslide



Slope failure (shallow landslide) at 0530 JST


Effective rainfall (T=72 hours)
at 0500 JST on 12 September 2007
Slope failure
Deep-seated landslide
>= 300
>= 250
>= 200
>= 175
>= 150
>= 125
>= 100
>= 80
>= 60
>= 50
>= 40
>= 30
>= 20
>= 10
>= 5
< 5


Effective rainfall (T=1.5 hours)
at 0500 JST on 12 September 2007
Slope failure
Deep-seated landslide
1.5時間実効雨量(mm)
>= 175
>= 150
>= 125
>= 100
>= 80
>= 60
>= 50
>= 40
>= 30
>= 20
>= 15
>= 10
>= 5
>= 2
>= 1
< 1


Landslide Prediction Support System (LAPSUS)
http://lapsus.bosai.go.jp
NIED
土砂災害発生予測支援システム
Landslide disaster prediction support system
2006/07/21 15:35:25
MPレーダー観測中
降雨情報
72時間実効雨量

Realtime Monitoring of Shallow-landslide Potential Area Using Multi-parameter Radar

Ryohei MISUMI
National Research Institute for Earth Science and Disaster Prevention

Abstract

In this lecture, we introduce recent rainfall-induced disasters in Japan and our researches for reducing them with the use of the multi-parameter radar system. As for the heavy rainfall in Japan, precipitation extremely concentrates on narrow regions by peculiar behavior of the convective clouds that is called "back-building". Forecasting of such phenomena is still difficult at present, thus real-time monitoring of rainfall area with meteorological radars and providing information are important for disaster reduction. In National Research Institute for Earth Science and Disaster Prevention, the multi-parameter radar system, which is able to estimate rainfall accurately with 500m mesh, is operated to detect heavy rainfall area in real time and provide information on the WEB. This technology is expected to reduce disasters caused by urban floods and rainfall-induced landslides.