GEOSCIENCE INNOVATIONS FOR SUSTAINABLE DEVELOPMENT: THE FUTURE WE WANT

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Editors:

Lim Choun Sian

Mohd Shafeea Leman

Anthony J. Reedman

Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)

Abstracts of the Thematic Session on

GEOSCIENCE INNOVATIONS FOR SUSTAINABLE DEVELOPMENT: THE FUTURE WE WANT

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Lim Choun Sian
Mohd Shafeea Leman
Anthony J. Reedman

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

MINERALS AND GEOSCIENCE DEPARTMENT

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FOREWORD

The Rio+20 UN Conference on Sustainable Development (UNCSD), recently concluded in June 2012, mapped out the way forward for the next decades. A key driver among the six outcomes of the Conference is "green economy in the context of sustainable development and poverty eradication". Green economy supported by green technology is considered a tool for achieving sustainable development. Aspects of green economy and green technology have direct relevance to geoscience. CCOP has promoted many geoscience innovations in support of green economy and green technology through its programmes and activities in sustainable energy and mineral development, sustainable tourism, and disaster risk reduction to ensure human security. The focus has been on strengthening technical and scientific cooperation, enhancing national capabilities and the quality of research for policy and decision-making processes, developing resource-efficient and inclusive economies through sharing of sustainable practices and promoting public-private partnerships.

This compilation of abstracts for the thematic session held in conjunction with the 48th CCOP Annual Session includes essence of technical papers presented. The theme for this session, "Geoscience Innovations for Sustainable Development: The Future We Want", is to show-case geoscience innovations contributing to sustainable development, alone or as part of a multi-disciplinary effort particularly in relation to attaining green economy. The presentations in this thematic session highlight:

- GEOPARK AND GEOHERITAGE: their contributions to sustainable tourism (eco-tourism) to enhance green growth;
- SUSTAINABLE MINERAL DEVELOPMENT: good policy and practices of mining, and post mining rehabilitation including green technology;
- DISASTER PREVENTION AND CLIMATE CHANGE ADAPTATION: and enhancing resilience of cities and communities to disaster;
- ENERGY RESOURCES AND GREEN TECHNOLOGY: address the challenge of access to sustainable modern energy services for all;
- GROUNDWATER RESOURCES: innovative groundwater programmes that have enabled more people access to clean water supply and ensure water security;
- CAPACITY BUILDING: for enhancing capabilities and quality, sharing sustainable and good practices and promoting regional cooperation.

We hope that the participants of this thematic session will benefit from the papers presented. It is our dearest wish that this session will serve to inspire geoscientists from East and Southeast Asia to innovate and realize their potential in contributing to green economy in the context of sustainable development and poverty eradication and help create "The Future We Want".

Dato Yunus Abdul Razak
Director General of Minerals
and Geoscience Department, Malaysia

Dr. He Qingcheng
Director
of CCOP Technical Secretariat

Prof. Mazlin bin Mokhtar
Acting Director of SEADPRI-UKM

PREFACE

The Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) is an intergovernmental organization whose mission is to facilitate and coordinate the implementation of applied geoscience programmes in East and Southeast Asia in order to contribute to economic development and the improvement of the quality of life in the region. A technical session focused on a specific theme is held during the Annual Session to address scientific and strategic issues of common interest in the CCOP region. The thematic session thus serves as a forum for exchanges on experiences and showcase best practice among the member countries and organizations.

In conjunction with the 48th CCOP Annual Session held in Langkawi, Malaysia. The Thematic Session focused on "Geoscience Innovations for Sustainable Development: The Future We Want". This is in line with the promotion of utilising geoscience innovations to support green technology through sustainable energy and mineral development, sustainable tourism, and disaster risk reduction to ensure human security. The thematic session was jointly organized by the Minerals of Geoscience Department, Malaysia (JMG), Ministry of Natural Resources and Environment Malaysia, PETRONAS and Universiti Kebangsaan Malaysia, in collaboration with CCOP. Universiti Kebangsaan Malaysia is honoured to be given the opportunity to jointly host the event in Langkawi Geopark, the first geopark of the Global Geopark Network in Southeast Asia.

We would like to thank Mr. Niran Chaimanee and members of the CCOP Technical Secretariat and lead organisers JMG, especially Dato' Yunus Abdul Razak and Mohd Badzran Mat Taib for their support and contribution in the successful organization of the thematic session. We also thank Mr. Chen Shick Pei, Honorary Advisor of CCOP and National Fellow of SEADPRI-UKM for his immense support and guidance in conceptualizing the Thematic Session.

We take this opportunity to express our appreciation to the authors for their contributions in the session and to the delegates for their active participation in the discussions. Last but not least, we thank the Representatives of CCOP Member Countries, Representatives of Cooperating Countries and Organizations and Honorary Advisors for their support and encouragement that led to the success of the session.

Editors
Lim Choun Sian
Mohd Shafeea Leman
Anthony J. Reedman

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Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)

Minerals and Geoscience Department Malaysia

Universiti Kebangsaan Malaysia

PETRONAS Malaysia

Ministry of Natural Resorces and Environment, Malaysia

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Che Aziz Ali
Langkawi Research Centre, Institute for Environment and Development (LESTARI)
Universiti Kebangsaan Malaysia

Langkawi has been known as a beautiful island with high geological and biological diversity. For a long time Langkawi remained undeveloped though it was already known and popular among nature-loving local and international tourists. Twenty years ago it was declared a duty free island since when it has and experienced rapid development. The rapidly growing and unsupervised tourism industry and its physical development have left great impacts on the natural resources and socio-economics of the island. The development cannot be allowed to wipe out most of the highly significant geological features of this oldest landmass of the country, hence it has ignited awareness amongst the geologists in the country of the importance of conserving these geological features. Consequently, a group known as the Geological Heritage Group of Malaysia (KWGM) was formed in 1996 to carry out research and promote the concept of geoheritage conservation. Though working on a limited research budget the group managed to gather enough information to propose the first comprehensive sustainable development approach for Langkawi island using the geopark concept devised by the Global Geopark Network (GGN). The new concept of managing Langkawi's natural resources, especially the geological resources, using the geopark concept was accepted by the Kedah state government in 2006 and it was subsequently endorsed as a member of the Global Geopark Network under UNESCO in June 2007. The establishment of the Langkawi geopark as an innovation for the protection of geological and biological natural heritages plays an important roles in development of new geotourism products in Langkawi. Geosites and geoconservation areas such as the renowned geoforest parks were introduced and promoted to for tourism. Geoforest park is the first ever conservation concept introduced in the world by the Langkawi geopark. Within these established geoforest parks (which are coincidently located in the forest reserves) the geological resources are totally protected but at the same time geosites are promoted as new tourism sites. This triggers new economic activities, job opportunities and empowerment of the local communities in rural regions. It also encourages the production of local handicrafts and other local products which create new additional sources of income to the communities.

CONTRIBUTION OF GEOSCIENCES TO SUSTAINABLE DEVELOPMENT

Franca SCHWARZ
Head International Cooperation, Bundesanstalt fuer Geowissenschaften und Rohstoffe / BGR (Federal Institute for Geosciences and Natural Resources), Germany

Geosciences play a central role for the sustainable management of the livelihoods of successive generations. Overexploitation and improper use of mineral resources, energy resources, water and soil cause many social, environmental and economical problems not only to the poorest people of the community. Therefore it is necessary to support measures safeguarding the sustainable use of georesources, which make important contributions to alleviating poverty, improving economic development, environmental and resource protection as well as sustainable resource management. Ultimately, the involvement of geosciences in sustainable management leads to boosting social justice and preventing conflicts.

Based on scientific expertise and the results of research and development activities, Geological Surveys should analyse development-policy problems at an integrated geological level, taking into account various disciplines of geosciences.

There is not only a huge difference in the level of development of countries worldwide, there is also enormous variance in the instruments used to work at the above-mentioned objectives. Some countries are at an early development stage, others have strong economy characteristics. Societies in each country wait for solutions to challenges which affect them today and which could turn out to be more urgent in future.

Experience has shown that the questions regarding the contribution of geosciences to sustainable development in each country generally come in the same order: geological exploration, resource evaluation, resource projection, regional planning, participation and good governance.

As the overall development of the country progresses, the activities in geosciences move increasingly towards assisting decision making at a regional and socio-political level, involving all stakeholders. Geological institutions should consequently make contributions to these issues as well.

RAISING PUBLIC AWARENESS OF GEOSCIENCE IN EAST AND SOUTHEAST ASIA: THE ROLE OF GEOLOGICAL MUSEUMS AND GEOHERITAGE CONSERVATION

A J Reedman[1], Chen Shik Pei[1] & Mohd Shafeea Leman[2]
[1]Honorary Advisors, CCOP
[2]Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia

In recent years there has been surge in public interest in the geosciences, largely inspired by the popular media. Television channels, newspapers and the cinema, increasingly stimulate their audiences with documentaries, articles and films that feature topics such as earthquakes, tsunami and volcanic eruptions including, in the cinema, stories with dinosaurs amongst their stars. This growth in public interest is to be applauded; an enhanced awareness and knowledge of the earth's composition and its processes and the of role of geoscientists in understanding these processes, will make the task of the national agencies responsible for minimising the destructive effects of a variety geohazards and for protecting the public at risk much easier.

Explanation of a nation's geoheritage and conservation of important geological localities, together with public access to geological museums containing imaginative and popular displays, can be powerful educational tools for raising public awareness of the significance of geological information. Two books, "Geoheritage of East and Southeast Asia" and "Geological Museums of East and Southeast Asia" have recently been published by the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) in collaboration with the Universiti Kebangsaan Malaysia, these being a contribution to the United Nations International Year of Planet Earth.. The first book describes numerous natural sites, many with spectacular scenery, that display important aspects of each CCOP member country's geoheritage. The book also describes each country's efforts, including legislation, aimed at conserving such sites. The second book describes over fifty individual and varied geological museums within the CCOP region and highlights imaginative schemes and new technologies being applied to stimulate the interest of the public and thereby increase geosciences awareness. Analysis of all the data gathered during CCOP's two book projects, allow an overview of the current state of geoheritage research and conservation, together with trends in geological museum development in the region. Some interesting contrasts between the countries of the region emerge and some pointers to the future and further possible initiatives are discussed.

GLOBAL HERITAGE STONE RESOURCE

Hirokazu Kato
AIST Fellow, Geological Survey of Japan, AIST Japan

What is the Global Heritage Stone Resource (GHSR)? The GHSR designation provides international recognition of natural stone resources that have achieved important utilisation in human culture. Stones used for heritage construction and sculptural masterpieces, as well as in utilitarian (yet culturally important) applications, are obvious candidates for the GHSR designation.

The GHSR designation is essentially a "world heritage" naming of a stone type. The benefits of the designation include legal definition of an historic stone type, prevention of stone resource depletion, and improved restoration of stone heritage. The GHSR designation may encourage developers of new stone materials to aspire to major projects, international exports, and hence new market opportunities.

The Heritage Stone Task Group (HSTG) was established by the International Union of Geological Sciences (IUGS). The HSTG is also a working party under the Building Stone and Ornamental Rocks Commission of the International Association of Engineering Geology and the Environment (IAEG C-10).

The HSTG Board of Management was established in August 2012 at the 34th International Geological Congress. The board is supposed to approve GHSR nominations and promote the designation. It is composed of President Dr. Bjorn Schouenborg (SP Swedish National Testing and Research Institute), Secretary General (also Vice President representing Oceania) Dr. Berry J. Cooper, and Vice Presidents representing Southern, Central and Western Europe, North and South America, East and South Asia, and Africa. I was assigned as the Vice President representing East Asia.

Trial nominations are being prepared for Portland Stone and Welsh Slate in the United Kingdom and Podpeč Limestone in Slovenia. I will introduce the Hiroshima-type Granite (Cretaceous), which is one of the most famous building stones for Japanese castles, as an example of the potential GHSR designation. East and Southeast Asia have many stone types to be designated as the GHSR, and it would be possible to publish a book entitled "Stone Heritage in East and Southeast Asia" as a CCOP book in the future.

GEO-HERITAGE VALUES OF THE DONG VAN KARST PLATEAU GEO-PARK THROUGH A QUANTITATIVE GEOMORPHOLOGICAL AND TOPOGRAPHIC ANALYSIS

Pham Viet Ha[1], Tran Tan Van[1], Quach Duc Tin[2],
Ho Huu Hieu[1], Nguyen Dinh Tuan[1] & Nguyen Quang Hưng[2]
[1]Vietnam Institute of Geosciences and Mineral Resouces, Hanoi, Vietnam
[2]General Department of Geology and Minerals of Viet Nam, Hanoi, Vietnam

The main purpose of this study is to analyse geomorphological charactertistics of the Dong Van Karst Plateau Geopark (DVKPG) in the Ha Giang province of Vietnam. Firstly, a digital elevation model (DEM) was generated using SPOT5 imagery, then elevation and slope maps were extracted from the DEM. Secondly, a geological map at the scale of 1:200,000 was constructed and used for analyzing and visualizing carbonate rock in three dimensions. The results show that there are two prominent topographic formations in the studied area. The first one was formed by tectonic movement and affected by major faults. The first topographic formation distributes along the NW–SE direction. The second one was formed by exogenous geomorphological processes and influenced both small and major faults. The second topographic formation distributes mainly in the NE–SW direction. The analysis result of geology shows that there are 10 stratigraphic formations outcroping in the studied area, only 6 formations have correlations with karst landscapes. Carbonate rocks are mainly distributed in the Dong Van district. They cover an area of 329. 7 km^2 (71. 7% of the district areas and 36. 5% of the studied area). In constrast, there are few carbonate rocks in the Quan Ba district. In the case of slopes, the slopes with angles from 15–30°cover about 53. 5% of the studied area. There are 1261 karst sinkholes in the studied area with an average density of 1. 4 sinkholes per km^2.

THE GEOLOGICAL HERITAGE VALUES AND POTENTIAL GEOTOURISM DEVELOPMENT OF THE BEACHES IN NORTHERN SABAH, MALAYSIA

Joanes Muda
Minerals and Geoscience Department, Sabah, Malaysia

A study was carried out on 13 beaches in Northern Sabah, Malaysia to identify their geological heritage values and geotourism potential. Northern Sabah has some of the finest beaches in Sabah and most of them are still undisturbed and in pristine conditions. However, with the increasing demand for tourism facilities, several developments are now being carried out in the coastal areas and their impact upon the beaches are greater now than ever. The natural geomorphological processes could be disrupted and the beaches in the area might be degraded and damaged. The main attractions of the beaches are their sandy nature and beautiful landscape. The geological heritage values are usually unnoticed and unappreciated due to lack of awareness and information. By unraveling their hidden natural qualities, the attractions of the beaches could be enhanced. This study has identified the scientific values of the beaches such as the composition, morphology and sources of the beach sediments. Black sand comprising mainly chromite was found at Marasimsim Beach and pink sand comprising mainly garnet was found at a pocket beach in Tanjung Simpang Mengayau. The study also revealed that several of the beaches in the area have aesthetic, recreational, cultural and historical values. These values could be conveyed to visitors so that they can appreciate the importance of the heritage values that can be found on the beaches. The beaches are recommended to be conserved to protect their beautiful landscapes. Geotourism could be developed and promoted on some of the beaches. The development of geotourism will help to ensure the sustainability and protection of the beaches. The promotion of beach geotourism could be carried out together with the other potential geotourism sites in Northern Sabah. The study on beaches for geotourism development is an innovative way to add value to their existing aesthetic attractions in order to enhance and sustain the tourism industry in the state.

OPPORTUNITY TO THE DEVELOPMENT OF GEODIVERSITIES AND GEOHERITAGE IN INDONESIA BECOME NATIONAL GEOPARKS

H. Samodra & S. Permanadewi
Geological Survey Centre, Geological Agency, Bandung, Indonesia

In terms of its geological setting, Indonesia is located between two continents (Asian and Australian), two oceans (Indian and Pacific), and in an area of three converging tectonic plates (Indian-Australian, Eurasian, Pacific). In accordance with this setting, Indonesia displays a great diversity of rocks, minerals, fossils, geological structures and landscapes components. Various types of rocks (sedimentary, igneous, metamorphic, volcanic, melange) and their stratigraphy, fossils (plants, animals, hominids) and geological structures all originated when either past or present tectonic plates were active. Various landscapes (tectonic-origin, dissolving-origin) also record some events during the geological evolution of the Mesozoic and Cenozoic Eras.

Precambrian or Early Palaeozoic sandstones of the Kariem Formation, exposed in the Central Range of Papua appear to be the oldest rocks in Indonesia and were formed about 650 million years ago. These rocks are therefore nearly one-seventh of the age of the Earth. Younger Palaeozoic rocks are found in Sumatra, while the Cenozoic rocks that have a wide distribution and allow us to identify significant geological events from their from lithology and stratigraphy Prehistoric man, sometimes living inside caves, inhabited some areas since the beginning of Quaternary time or slightly earlier (Late Neogene).

Such unique, rare and aesthetic geodiversity, meeting the criteria of scientific and educational value, is defined as a protected geological heritage. The Geological Agency, Ministry of Energy and Mineral Resources, has established some geoheritage objects in Sumatra and Bali as geological conservation geosites. Conservation activities related to geosites will continue to be improved in the future.

With regard to the preservation of natural resources for conservation, educational and geotourism purposes, Indonesia prefers the Geopark concept as a model for sustainable regional development. The diversity of geology, biology and culture in the area of Batur Volcano (Bali) and in the Pacitan karstic region (East Java) have caused these areas to be designated as National Geoparks. In time, other National Geoparks, such as Toba Lake (North Sumatera), Merangin (Jambi), Rinjani Volcano (Lombok), and Raja Ampat (West Papua) will be defined. The Pacitan Geopark will be expanded to Gunung Sewu Geopark. The development of Geoparks in Indonesia follows the global principle of "Celebrating Earth Heritage and Sustaining Local Communities."

SANO NGGOANG: DEEPEST VOLCANIC LAKE IN SOUTHEAST ASIA

Oki Oktariadi, Suhari & Rudy Suhendar
Geological Agency, Indonesia

Komodo Island in West Manggarai, East Nusa Tenggara Province, or rather in the southern part of the island of Flores, has a world heritage fauna, the giant lizard called the Komodo dragon (*Varanus komodoensis*). The existence of the Komodo dragon has attracted domestic and world travelers. To enrich the tourist resorts in the West Manggarai, an inventory of natural diversity, including geological diversity, is necessary. Inventory results will indicate that there is a rich diversity of West Manggarai geology and scenery as well as the diversity of flora and fauna. Amongst the geological heritage of the area is the deepest volcanic lake in Southeast Asia called Sano Nggoang. According to the World Wildlife Fund (WWF), the volcanic lake has a depth of ± 600 m, located at an altitude of 750 m above sea level. The vast lake is about 513 ha, with a range of lakes between 2.5 - 3 km.

Geologically, Sano Nggoangs and the surrounding areas are composed of elements of a Cenozoic calc-alkaline volcanic arc, which is still active. The arc was formed by the subduction of crustal India-Australia to the north. The island arc's shape is still changing in the east as the collision with the edge of the continent of Australia - New Guinea continues. Hall (1998), suggested that the island of Flores emerged as land at 5 Ma ago after existing as submarine volcanoes since 10 Ma. The oldest sedimentary rocks found in the vicinity are of Tertiary age, exposed in the northern part of the Werang area. Quaternary volcanic rocks from the eruption of Mount Sanonggoang form the Sanonggoang Caldera and around the caldera lake characteristic volcanic activity results in the presence of rocks that have undergone hydrothermal alteration. Generally, the hydrothermal alteration is of weak to strong intensity, as evidenced by the appearance of hot springs around Sano Nggoang with temperatures of 370°C to 1000°C with a high sulfur content. Volcanic Lake Sano Nggoang can potentially become part of a tour package to visit the island of Komodo. There, travelers can enjoy the natural beauty and in addition, can enjoy a natural spa, in a small pool on the edge of the lake. Here one may camp while boiling eggs in three minutes straight and, if lucky, one may welcome a group of mountain duck (*Anas superciliosa*) swimming nearby or gold tiong birds gold (*Gracula religiosa*) pecking mulberry fruit.

THE INTERDEPENDENT RELATIONSHIPS OF THE MINERALS SECTOR WITHIN THE MALAYSIAN ECONOMY

Mohd Suhaili Ismail
Minerals and Geoscience Department, Sabah, Malaysia

This paper examines the interdependent relationship of the minerals sector (which includes the downstream mineral-based industries) with other sectors of the economy within the overall economy of Malaysia based on data from the Malaysian input-output table. Over the years, the significance of the minerals sector in the Malaysian economy seems to be diminishing with depleted resources for some minerals and the economy being highly industrial-based. However, the dynamic development of the country with the manufacturing sector becoming increasingly important suggest increased demand for minerals and mineral-based products. Thus there are greater interactions by the minerals sector with the other sectors of the economy. The input-output table which shows the flow of inputs and outputs in value amongst sectors within an economy allows identification of those sectors that have closed a relationship in terms of purchasing of inputs(backward linkage) and selling of outputs(forward linkage). The analysis on the backward and forward linkages showed that the Malaysian minerals sector has close relationship with about 25 other non-minerals sectors. The most significant relationship is with the construction sector where five of the top ten sectors that have close relationship with the construction sector were sub-sectors of the minerals sector. It is also revealed that almost all the minerals-subsectors had strong backward linkage with the energy supply sectors such as the petroleum and coal sector and electricity and gas sector. Other sectors identified to have a close relationship with the minerals sector include transportation, business services and the wholesale and retail trade sector for the backward linkages while for the forward linkages the sectors are much more diverse. The interdependence relationship of the minerals sector with the rest of the other sectors in the economy indicates the continuous importance of the minerals sector to the Malaysian economy.

GEOLOGICAL INTERPRETATION BASED ON SATELLITE IMAGERY: UPDATING GEOLOGICAL MAPS OF INDONESIA TO 1:50,000 MAP SCALE

Jamal, Sidarto, Ipranto & Sonny Mawardi
Geological Agency, Indonesia

Indonesia is an archipelago country with a territory of more than seven million square kilometres in over 13,700 islands. Geologically, the country is underlain by crust varying in thickness between 5 km and 30 km. The earth's crust in this region has many unique features as a result of the collision of three mega plates, the Eurasian, Indiaustralian and Pacific Plates, which resulted in various related geological features such as island arcs, volcanic belts, seismic zones, gravity anomaly zones, and deep see trenches. The complexity of plate tectonics in the Indonesian region is reflected in the complex structures and morphology of the region.

Currently in Indonesia systematic geological mapping has been completed at the scale of 1: 100,000 in Jawa and Madura Island, at 1:250,000 in the islands outside Jawa and Madura and at the scale of 1:1,000,000 in the rest of the entire Indonesian region. Based on these systematic maps, geological and thematic maps at a scale of 1:5,000,000 have been compiled.

The needs of geological information at larger scales in Indonesia are increasing. This demand is related to national development programs as well as to industrial growth. Exploration for geological resources such as energy minerals and ground water together with information for land use planning and geological hazards avoidance, are the main issues that require the development of geological maps at the scale of 1:50,000. In order to answer this demand, The Geological Agency, as the Institution that is responsible for geological survey, has planned a 15 year geological mapping program which is being conducted from 2010 until 2025. This program is being initiated by 'Geological Interpretation based on Satellite Imagery' combined with existing field data from previous work.

The methodology for geological interpretation is based on visual interpretation of remotely sensed data of morphostructural aspects combined with field data existing in a GIS environment (Figure 2). Interpretation elements to define interpretation keys which provide guidelines on how to recognize certain geological objects on satellite imagery are tone/hue, texture, shape, size, pattern, site and association. Preparation of data including creation of shaded relief of digital surface models (DSM) and intensity layer of orthorectified images (ORRI) taken

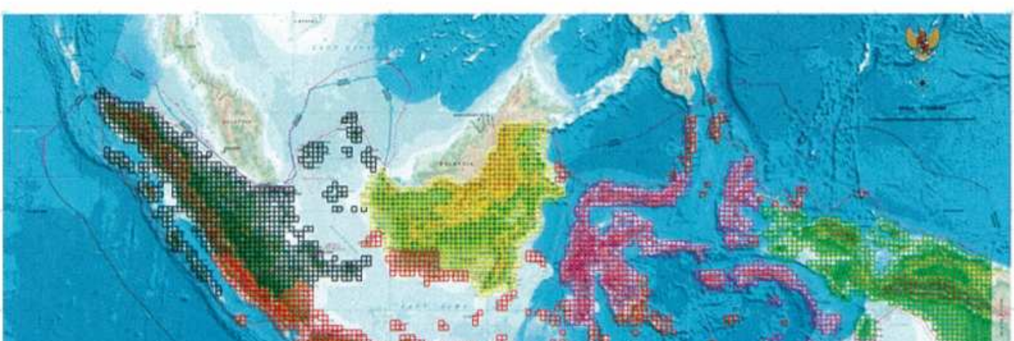

Fig. 1. Area of interest for geological interpretation

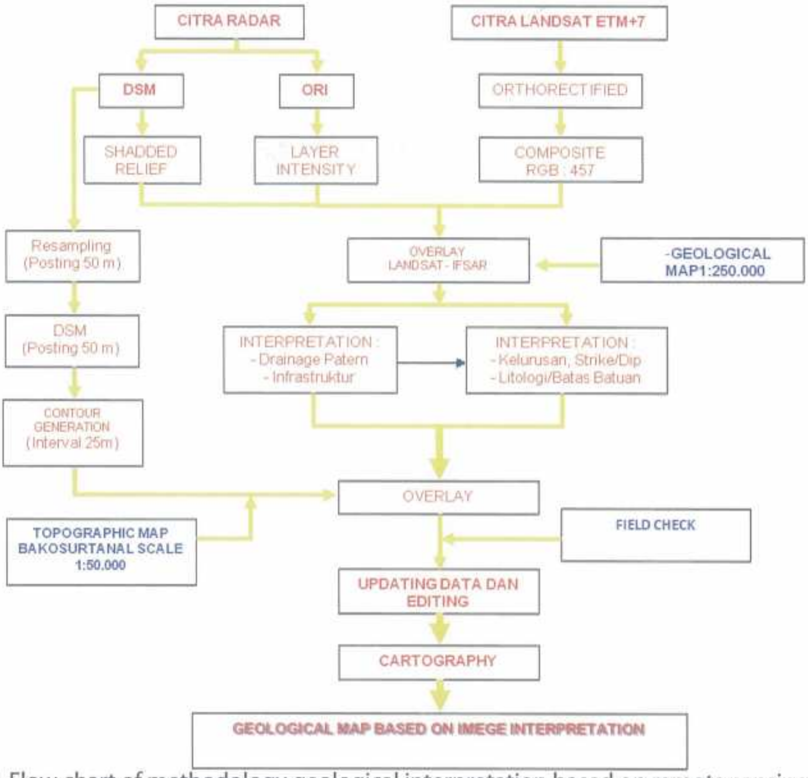

Fig. 2. Flow chart of methodology geological interpretation based on remote sensing data

from satellite radar images are posted by 50 m to generate contours at 25 m intervals. Data preparation on optical images (Landsat ETM+7) includes the creation of orthorectified images and color composite of R/G/B:4/5/7 in order to highlight geological features in the area of interest. Image fusion of active and passive satellite imagery is also done in this preparation process. The drainage pattern is an essential tool for geological interpretation and was derived from digital surface model data by using particular hydro-enforcement software. Overlays of various data sets including field data in the form of vector data from previous projects are combined to analyze and develop preliminary geological maps. Ground truth and stratigraphic surveys were undertaken for some areas of interest which are believed to be key areas in order to validate geologic interpretation results. For this purpose a limited number of objects or areas are selected (using a sampling approach) and visited in the field. The data collected in the field are referred to as 'ground truth'. Updating geological maps to a larger scale is focusing on the breakdown of geological formations into smaller lithologic units by introducing various classes or categories. On the other hand, lineaments, scarps and land offsets are assigned to geological structures which are variously categorized as faults, joints, calderas and bedding traces. Preparation of maps as digital layouts were done at 1:50,000 map scale. The maps are represented as 'Geological Maps based on Interpretation of Satellite Data'.

The project has so far been conducted for two years from 2010. To date, it has produced geologic interpretation maps for at least 1700 map sheets (figure 1). Covered areas are Sulawesi, Kalimantan, Bali, Nusa Tenggara and Papua Island. Some quality aspects are considered to be improved. The quality of the results of an image interpretation depends on a number of factors: the interpreter, the image data used, and the guidelines provided. Professional experience, including experience of image interpretation, determine the skills of the interpreter. Professional background in geological interpretation is essential in order to relate image features to geological phenomena. Furthermore, local knowledge, derived from field visits, is required to help in the interpretation. Finally the quality of interpretation guidelines is of considerable influence; for example standardization guidelines for development of Indonesian geologic maps have an important role in ensuring the replicability of the work.

STORAGE OF CO_2 OFFSHORE NORWAY

Per Blystad
Norwegian Petroleum Directorate (NPD), Stavanger, Norway

To get a good overview of where and how much CO_2 that can be stored in the Norwegian North Sea, a team in the Norwegian Petroleum Directorate (NPD) has evaluated all relevant data in this area in order to identify potential storage sites. The results in terms of CO_2 storage options and monitoring are presented in a handy Atlas together with a description of the methodology used and a geological description of the North Sea. The Norwegian Minister of Petroleum and Energy launched the CO_2 Storage Atlas for the Norwegian North Sea, December 13th 2011.

The on-going CO_2 storage from the Sleipner and Snøhvit Fields of offshore Norway has given us more than 15 years' experience with CO_2 storage. The results from these two projects have been valuable in the work with evaluating different CO_2 storage sites.

For the past 40 years, an active petroleum industry has collected a lot of data offshore Norway; 2D and 3D seismic data, drilled approximately 5000 wells and collected reservoir data from these wells. Vested in the Petroleum Act and subsequent regulations, NPD has access to all data collected on the NCS. This gives us a huge database to embark on such studies that have has led to the CO_2 Storage Atlas. The work presented in this Atlas includes evaluation of 21 geological formations (saline aquifers) and 12 abandoned hydrocarbon fields. 62 producing oil and gas fields have been evaluated for storage potential and for enhanced oil recovery.

Through a systematic evaluation process, detailed characterization forms were established with sets of criteria. These criteria are covering critical factors for both reservoir properties and for sealing qualities, which have to be met before it can be defined as a CO_2, storage site. A CO_2 maturation pyramid with four levels has been established, ranging from theoretical capacity as the starting point, through levels with selected cut off criteria and up to the mature level ready for injection projects. This paper will describe the methods and results of the CO_2 Storage Atlas.

PETROLEUM PLAY IN THE CROSS-BORDER AREA OF NORTH SUMATRA-MERGUI BASIN

Simplicio P. Caluyong[1], M Razali Che Kob[2], Jonathan Setyoko[3] & Wanida Chantong[4]
[1]CCOP Technical Secretariat
[2]Petroleum Resource Exploration, PETRONAS
[3]PPTMGB "LEMIGAS"
[4]Ministry of Energy, Thailand

The North Sumatra-Mergui Basin has been a prolific gas producing basin. The giant gas/condensate field, the Arun Gas Field, has recorded in-place 18-20 TCFG and more than 700 MMBC from the Miocene Carbonate reservoirs. A similar play has also been successful in the Central and South Sumatra basin, which make it a primary exploration target in Indonesia's Sumatra basins and also in nearby Malaysia and Thailand that share parts of the North Sumatra Basin.

The Miocene Carbonate play has been successful in the onshore Sumatra area, however, in the offshore, the search for a similar play type is mostly futile or results in only sub-commercial discoveries. The play had also been tested on the Malaysia and Thailand sides but most of the ventures have been unsuccessful.

A closer look at the Miocene Carbonate play in the North Sumatra – Mergui Basin through CCOP's Cross-Border P1 Project, reveals a more complete picture of the play. The new cross-border data interpretation and integration has enabled this paradoxical Miocene Carbonate Play be better understood. The success of the Play in onshore Sumatra is attributed to its proximity to the kitchen area which provides the source that charged the reservoirs. Hence, the charge system is critical for the play to be successful. Conversely, the unsuccessful tests of the play in Thailand and Malaysia area are believed to be due to the absence of charge systems.

Through collaboration of the neighboring countries that share the North Sumatra-Mergui Basin, namely Indonesia, Malaysia and Thailand, an integrated approach has been taken to understand the petroleum system in the cross-border area, which is still an exploration frontier. The study involves basin modeling, structural back-stripping and facies mapping.

The hydrocarbon in the North Sumatra-Mergui Basin is associated with a series of Oligocene to Early Miocene graben and half graben, filled with source-prone of fluvio-lacustrine facies, comparable to other prolific Southeast Asia basins such as the Malay, Sumatra, Cuu Long and Nam Con Son basins. The modeling results indicate potential generation of 6000 MMBOE of hydrocarbon from these grabens, including the isolated half-grabens on the Melaka Platform and Mergui Shelf.

The North Sumatra-Mergui basin was controlled by structural elements throughout its development stages. The rifting, subsidence, inversion and pot-inversion phases are mainly controlled by prominent vertical to sub-vertical north-south trending faults. This includes the distribution of sedimentary facies and fluid migration. Consequently, the hydrocarbon accumulations are found to be associated with these faults. However, the faults can also be a threat to the trap integrity, especially in areas affected by younger tectonic movements.

Besides the Miocene Carbonate Play, the Miocene Clastics Play also has equal potential for hydrocarbon accumulation. This play is well developed in the eastern margin of the basin (mainly in Malaysia and Thailand). The other plays are the Turbidities Play, which mainly occurs in the Thailand's territory, the Synrift Play and also the untested Stratigraphic Play.

ASEAN MINERAL RESOURCES INFORMATION SYSTEM USING FOSS AND OGC BASED STANDARDS

Joel Bandibas, Koji Wakita & Tetsuji Ohno
Geological Survey of Japan, AIST, Ibaraki, Japan

Highly accessible mineral resources information encourages investment and more sustainable utilization of mineral resources. The Geological Survey of Japan, AIST developed the web based ASEAN mineral resources information system using Free and Open Source Software (FOSS) and the Open Geospatial Consortium (OGC) standards. The use of FOSS and OGC compliant standards aims to make the mineral resources information system cost efficient, interoperable and user friendly. The developed system is composed of 3 modules which are the online spatial database system PostGIS, Web Map Service (WMS) and the ASEAN Mineral Resources WebGIS portal. PostGIS is a PostGreSQL object-relational database management system that supports simple features defined by OGC, and simple feature Sequential Query Language (SQL). WMS is a standard protocol that provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases (OGC). WMS provides remote access of the mineral resources databases and the display of the information on the WebGIS portal. The system's WebGIS portal provides the user interface for the data upload and download, database queries and display of the mineral resources information. The mineral resources information are provided by the countries in the ASEAN region. This project aims to make the mineral information easily available for use by policy makers, investors and the general public in the ASEAN region. The portal is named ASOMM WebGIS System. The portal could also be used to upload and display any kind of geospatial information. ASOMM WebGIS system should be available for use by the general public in late 2012.

PATHWAYS OF COAL MINING WASTES INTO THE GROUNDWATER AQUIFER IN MUKAH COAL MINING AREA, SARAWAK

Joseph Jubin Aro & Shaharin Ibrahim
Dept. of Environmental Sciences, Universiti Putra Malaysia, Serdang, Selangor

With the present global trend of an increasing crude oil price, coal will become an attractive alternative energy resource for electricity power generation in Malaysia. Consequently, the Mukah coal mining area, covering an area of about 192 km^2, mights pose a threat to the existing biodiversity and the surrounding environment, with no exemption for surface water and groundwater. The study area is mostly dominated by an unconfined aquifer system and in several localities the aquifer has been locally divided into multiple layers by the presence of discontinuous aquitards.

The presence of major elements (SiO_2 Al_2O_3, Na_2O, K_2O, Fe_2O_3, MnO, MgO, P_2O_5 and SO_3) and trace elements (As, Bi, Cu, Mo, Nb, Ni, Pb, Rh, Sn, Sr, Ta, Th, U, W,Y, Zn, and Zr) in coal , together with the production of acid mine drainage, could eventually transport such contaminants into groundwater. Visual features of coal mining such as workshops, preparation plants, coal stockpiles, overburden dumps and refuse emplacement within vicinity of mining area are other major threats to the environment surrounding the mining area.

The pathways of the coal mining contaminants are influenced by the local hydrogeological and hydrological conditions, depth of groundwater aquifer, coal mine tailing components and concentration of the contaminants. Time and the 'effective dispersion area' of contaminants from coal mine tailings are factors that determined the deterioration of groundwater. The groundwater contaminants can be transported together with groundwater flowing at speeds ranging from 0.2 meter per day to 0.8 meter per day. Generally, under most circumstances, groundwater moves at less than 305 meter per year. The ions Cl^-, Na^+ and K^+ are washed out quickly and measurable deterioration of groundwater is mainly by the Cl^- and is limited to a short period of 1 to 2 years. The shallow groundwater table within the Mukah mining area, ranging from 0.1m to 1.0m below the vadose zone, causes the groundwater to be exposed to coal mining contaminants. The rainwater infiltrates into the ground in the recharge area, moves down to the water table, and percolates through the aquifer together with the soluble chemicals and heavy metals of organic or inorganic contaminants, acidic solutions and microbiological contaminants such as viruses, bacteria, protozoa and parasites. The bulk of groundwater moves very slowly through the tiny hairline cracks or minute intergranular spaces of the aquifer. The hydrostratigrahic interpretation and the groundwater flow modeling are supported by lithologic data analysis, wireline logging, resistivity imaging lines, and from the Ground Penetrating radar runs within the study area. Generally, the flow of groundwater as predicted by using visual MODFLOW method is towards the western part of the mining area. The flow direction is not in one direction; as seen from the north it flows from northeast to southeast, as from central part of the mining area the direction of flow is westerly.

LINEAMENT DENSITY AND LITHOLOGY FOR GROUNDWATER POTENTIAL MAPPING IN THE MUAR BASIN, MALAYSIA

Mohamad Abd Manap[1], Mohammed Hatta Karim[1], Noraini Surip[2], Hisam Ahmad[3], Norhazidi Masrom[4] & Nurul Nadia Abd Malek[2]

[1]Minerals and Geoscience Department (JMG Headquaters), Kuala Lumpur, Malaysia
[2]Malaysian Remote Sensing Agency, Kuala Lumpur, Malaysia
[3]Minerals and Geoscience Department (JMG Negeri Sembilan/Melaka), Negeri Sembilan, Malaysia
[4]Minerals and Geoscience Department (JMG Johor), Johor, Malaysia

The aim of this study is to map groundwater potential zones at the Muar Basin using Geographical Information Systems (GIS) and remote sensing data. Landsat images have been utilized to extract information on the groundwater controlling features of lineament and lithology in the study area. In addition, published geological and topographical map were used a supplement. Lineaments were analysed using length density. Meanwhile there are different types of hard rock lithologies such as acid intrusive rocks, phyllite with slate and shale, sandstone and limestone, hornfels and quartz veins in the study area. Results were then integrated to delineate areas into four zones i.e. very high, high, moderate and low groundwater potential zones. The predicted groundwater potential map shows that about 16.4 percent of the study area can be classified as a zone of low potential, with 58.3 percent of moderate potential, 22.8 percent with high potential and only 2.5 percent having very high potential.

FINLAND – LEADER IN GREEN MINING 2020

Elias Ekdahl
Geological Survey of Finland, Espoo, Finland

Finland is located in the middle of the Fennoscandian Shield, which has geology and potential similar to the famous mining districts in Canada and Australia. There are currently nine metal mines and 32 industrial minerals mines in operation in Finland. The main commodities produced from metal mines are chromium, zinc, nickel, copper, sulphur, gold and silver. The new Tier 1 deposit Sakatti (Cu-Ni-PGE) found in northern Finland shows that there is still a good possibility to find outcropping deposits but brownfields deep exploration in known mineral belts is already very important.

The availability of mineral raw materials in Europe, contributing around 3% and consuming over 20% of metals, has been raised as an important issue for the European Union (Raw Materials Initiative 2008). Finland was one of the first EU member states to react and published a national Minerals Strategy in 2010. Our main goal is to govern the whole value chain from exploration, via mines and processing, to high-value added products. This includes development of innovative technologies and solutions for the whole sustainable raw materials supply chain. We developed the Green Mining concept in the mineral sectors to answer future challenges, with the main goal to be a global leader in Green Mining by 2020.

Finnish Green Mining program is part of the concept. It is a development program aiming to strengthen the Finnish mineral cluster in terms of fostering eco-efficient mining technology and socially and environmentally accepted mining. Every project to be funded must include at least one of the following concepts and aims: energy and material efficiency; new mineral resources for future generations; minimizing adverse social and environmental impacts; sustainable mine closure practices. Additionally the program aims to increase the number of SMEs capable of providing services and technology on global mining industry markets. The five years and €60 million project is funded and coordinated by The Finnish Funding Agency for Technology and Innovation, Tekes. By now almost 30 projects are ongoing with a total budget of more than €25 million.

GSJ'S TECHNOLOGY DEVELOPMENT MOVEMENT FOR ENERGY AND ENVIRONMENT AFTER THE 2011.3.11 BIG EARTHQUAKE IN JAPAN

Yusaku Yano
Deputy Director, Geological Survey of Japan

The 11 March 2011 earthquake brought about a tremendous disaster along the Pacific coast of Tohoku mainly by the incredible tsunami. The tsunami also destroyed the Fukushima Daiichi nuclear power plant, and that caused the evacuation and fear of many Tohoku people. This disaster completely changed the Japanese way of thinking about the risk of earthquake and tsunami, and also the risks of nuclear power plants.

The Geological Survey of Japan (GSJ) has a long history working on geological sciences and exploration for underground resources and geological disaster prevention. Before the Tohoku earthquake, we had made a projection of the near future re-ocurrence of a similar earthquake that occurred about 1000 years ago. We also had made a simulation image of the tremendous tsunami along the coast. The experience also changed our thinking about the importance of reinforcing our ability of informing our research output to society.

The main buildings of AIST, including GSJ, are in Tsukuba City, which is located between Tohoku and Tokyo. They were also damaged by the big earthquake, and it took several months to reconstruct our research facility. In this difficult situation, we started survey and analysis of groundwater movement, soil conditions, and faults, in order to contribute to the recovery of Tohoku area. We started the Geo-risk project which includes survey and analysis of geologic and environmental risks caused by the earthquake, movements of active faults, tsunami and the nuclear power plant accident. We also started a plan for reinforcing research activity on geothermal energy and geothermal heat pump systems, contributing to the new energy supplying framework of Japan. GSJ is now trying to shift our research effort to the direction for contributing to the recovery of our country from the earthquake disaster.

VOLCANIC HAZARD POTENTION INVESTIGATION OF ILI WERUNG VOLCANO, EAST NUSA TENGGARA

Eka Kadarsetia
Center for Volcanology and Geological Hazard Mitigation, Geological Agency, Indonesia

Ili Werung is one of the active volcanoes aligned along the southern peninsula of Lomblen Island, East Nusatenggara. The elevation of the crest is about 586 m above sea level, with geographic position of 08°32'24" South Latitude and 123°35'24" East Longitude.

The pheriodicity of eruption ranges between 1 year and 40 years (1870 – 1910), with an average interval of 26 years. From the eruptive history it is known that this volcano generally erupts explosively, accompanied by lava flows, pyroclastic flows, heavy ash fall and ejected rock fragments. Lahars could occur depending on the amount of local rain fall. The last eruption occurred continuously from 1950 to 1951. Accordingly, in the future, it is expected that the high intensity eruptions could reoccur.

To minimize the risk to the local population, some actions should be taken, such as continuous monitoring, hazard mitigation and socialization (education and hazard awareness and training). One of the mitigation efforts is to identify likely potential hazards and undertake volcanic hazard mapping. The volcanic hazard map shows details of the kind and types of volcanic hazard, hazard zones, direction of evacuation, location of evacuation routes and Disaster Relief Posts. For hazard zoning, Hazard Zone III has been arranged both for normal until increasing volcanic activity, with the summit, area especially inside the crater, potentially affected by, ejected materials (R = 2 km from the main crater) lava flows, toxic gases and pyroclastic flows. Hazard Zone II includes the area potentially affected by pyroclastic flows, lava flows, ejected materials (R = 5 km from the main crater), thick accumulation of heavy ash falls and lahars. Hazard Zone I is an area which is mainly potentially affected by lahars and also possibly vulnerable to destruction by enlarged areas of pyroclastic flows and lava flow zones. In the case of a large magnitude eruption, this area could be affected by ballistic trajectories such as thick ash rain (R = 8 km from the main crater).

DEBRIS FLOW SIMULATION AT BAWAKARAENG MOUNTAIN, SOUTH SULAWESI

Sumaryono
Geological Agency, Indonesia

Debris flow is a phenomenon in which large quantities of water, mud, and gravel flow down stream at a high velocity. Because the debris flows have such high density and velocity, they can be highly destructive and can have severe and tragic results such as destruction of homes, bridges, and infrastructure, as well as loss of life. Slope collapse at Mount. Bawakaraeng occurred on 26 March 2004. The slope collapse was followed by the flood that killed 32 people, injured 8, destroyed 10 houses and 1 school, buried dozens of hectares of rice fields and resulted in hundreds refugees. The rest of the avalanche material is situated upstream of the Jeneberang River and could be a potential debris flow hazard, so we need debris flow prevention measures and reduction of sedimentation at Bili-Bili dam. Numerical simulations are important to ensure that countermeasures such as sabo dams will be efficient before further construction work. This paper presents two-dimensional numerical simulations of a debris flow using Kanako, a user-friendly GUI-equipped debris flow simulator that allows good visualization and easy explanation. Kanako (Ver. 2.0) was applied to a case study at Bawakaraeng Mountain, south Sulawesi, Indonesia. Simulations tested various conditions including cases without any sabo dams and with a series of sabo dams. The simulation results showed that in Paragang, Lengkese and Raulo, without sabo dams there could be potential affects by debris flows. Over flow and debris flows could be prevented by a series of 4 slit sabo dams. This method should be effective to control sedimentation in Bili-Bili Dam.

LANDSLIDE RISK ASSESSMENT IN VOLCANO ERUPTION AND EARTHQUAKE PRONE AREA AT KABUPATEN ENDE, NUSA TENGGARA TIMUR, INDONESIA

Arifianti Yukni[1], Saputra Sukahar Eka Adi[1], Pischke Bianca[2] & Hoffman-Rothe Arne[2]
[1]Geological Agency, Bandung, Indonesia
[2]Georisk Project, Federal Institute for Geosciences and Natural Resources (BGR), Germany

The application of geological hazard and risk assessment in Kabupaten Ende is one of the activities of joint technical cooperation between the Geological Agency of Indonesia and the BGR Georisk Project which is involved with the local government of Kabupaten Ende. One of the projects is conducting a landslide risk assessment in volcanic eruption and earthquake prone areas. Landslides are often induced by earthquakes as experienced in the case of the 2009 Padang earthquake episode in West Sumatera, Indonesia. It was reported that over 1000 landslides were triggered by this earthquake and caused 400-600 fatalities.

Kabupaten Ende on Flores Island of Indonesia is an extremely mountainous area with several peaks exceeding 1700 m in height. Additionally, Flores island, as a segment of the volcanic inner Banda Arc, shows high seismic activity and also has several active volcanoes. These geological hazards pose a serious threat to people's lives and social and economic development of Kabupaten Ende in Nusa Tenggara Timur Province. A quantitative risk assessment is focused on landslides in volcanic eruption and earthquake prone areas. Population density, infrastructure and health system capacity will be taken into account to assess the risk posed by these geological hazards. Landslides occur regularly throughout the entire Kabupaten Ende, the types of landslide are mass movements, including rock fall, debris flows and slumps. They are triggered by heavy rainfall or earthquake related shaking. Earthquakes in this region usually are caused by ruptures along the subduction zones or by active faults and divide into five hazard zones. 50% of Kabupaten Ende area is located in very high to high earthquake hazard susceptibility and potentially affected by landslide. Results of the risk assessment for Kabupaten Ende will support local governments and other intermediaries who are commissioned to implement disaster mitigation countermeasures at the local level.

HEAVY RAINFALL TRIGGERING THE DEWATA TEA PLANTATION LANDSLIDE

Yunara Dasa Triana[1], Imam A. Sadisun[2] & Herry Purnomo[1]
[1]Geological Agency, Indonesia
[2]Bandung Institute of Technology (ITB), Indonesia

Landslides are common geological disasters in Indonesia. A large landslide occurred in Dewata Tea Plantation on February, 23rd 2010. This landslide took place after high intensity rainfall in which 675.9 mm accumulated during 15 days of recording. The aims of the current study was to determine the factors causing landslides.

Determination of the factors causing landslides was done through the analysis of slope stability using limit equilibrium methods. Field investigations were conducted to gather related field data for these landslides.

The heavy rainfall that fell earlier were able to reduce the safety factor by 22.75% to 0.971 as compared to 1.257 in normal conditions. Acceleration caused a decrease in the value of the safety factor of 12.76% from normal conditions to become 1.113. The mechanism of landslide occurrence began by impairment of the safety factor of slopes due to earthquakes. Then water seeped into the ground and increased pore water pressure. As the driving force increased, the slope was not able to withstand the loads that existed and eventually collapsed.

Technical Session IV

ENGINEERING GEOLOGY EVALUATION ON LAND SUBSIDENCE IN NORTHERN JAKARTA

Muhammad Wafid & Dodid Murdohardono
Geological Agency, Indonesia

Results of surface monitoring at several places within the City of Jakarta region have provided clear evidence that land subsidence in northern Jakarta region. clearly exists. Data from "Tongkol" monitoring point shows that this area subsides by about 7 cm annually. Other places show a different pattern (asymmetric subsidence). Unfortunately, until now, the factors causing that phenomenon are still not clear. Some researchers believe that the most important factor affecting land subsidence in Jakarta is ground water abstraction, whilst others think that the contribution of ground water withdrawal is responsible for not more than one fifth of the total subsidence.

This paper discusses some factors other than ground water extraction that affect subsidence and is focused on such factors as the: physical and mechanical properties of soil and sedimentary lithology related with building construction. From this evaluation it can be concluded that the different patterns of subsidence in northern Jakarta are the result of different dominant factors; in some places ground water extraction is the dominant factor, but in other places subsidence results from natural consolidation and building construction.

NOTES

About SEADPRI-UKM

The Southeast Asia Disaster Prevention Research Institute, Universiti Kebangsaan Malaysia (SEADPRI-UKM) was established in June 2008 at Universiti Kebangsaan Malaysia. The Institute addresses crucial challenges on disaster risk reduction in the Southeast Asian region. The importance of having a research focal point in this region was felt when Malaysia and neighbouring countries grappled with various issues related to science and governance in facing the 26.12.04 tsunami disaster. SEADPRI-UKM was created to provide basic solutions for disaster prevention through multi– and inter–disciplinary research on risk management to bridge the science-governance interface. The focus of research is on climatic hazards, geological hazards and technological hazards. The emphasis is on capacity building, mainly through postgraduate programmes and specialised training.

Southeast Asia Disaster Prevention Research Institute (SEADPRI-UKM)
Universiti Kebangsaan Malaysia
Level 6, Block 1, Keris Mas Building
43600 UKM BANGI, Selangor Darul Ehsan
tel | **+603-8921 4852** fax | **+603-8927 5629**
url | **http: www.ukm.my/seadpri**
email | **seadpri@ukm.my**