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Eastern Asia Natural Hazards Mapping Project

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Abstract: Asian countries have been severely damaged by various natural hazards because of their complicated and disastrous geo-environment. Eastern Asia Natural Hazards Mapping Project was proposed by the Geological Survey of Japan in 1992 and implemented in1994 to focus on the geological hazards in eastern Asia. It aims to compile small-scaled (1:5,000,000) hazards maps and relevant databases. Following conferences were held in succession in order to promote the project : International Forum for Natural Hazards Mapping in June 1993, International Meeting on Eastern Asia Natural Hazards Mapping Project in May 1994, First Workshop on Eastern Asia Natural Hazards Mapping Project in September 1994, International Symposium on Asian Natural Disasters and Hazards Mapping in September 1994, Second Workshop on Eastern Asia Natural Hazards Mapping Project in September 1995, Third Workshop on Eastern Asia Natural Hazards Mapping Project in August 1996, Symposium on Eastern Asia Natural Hazards Mapping in August 1996, International Symposium on Geology for Geohazards Mitigation in Asia in February 1997. The outline of the Hazards Map has been established throughout these conferences. At first, geological maps were presented showing geological background. Identified hazards such as earthquake hazard, volcanic hazard, landslide, coastal erosion/deposition, land subsidence, karst collapse and seawater intrusion are expressed by respective symbols on the geological map. The distribution of densely populated areas is shown on the same map in order to evaluate the vulnerability by natural hazards qualitatively. Detailed hazards data are all described on the data sheets on which the relevant databases have been developed. The index of several kinds of published maps has also been developed, and will be distributed among concerned people.

1. Introduction

Asian countries have been severely damaged by various natural disasters such as geological hazards and meteorological events. The former are mainly because of their complicated and disastrous geo-environments. For example, island arc regions such as Japan, the Philippines , Indonesia etc. are situated in the active plate tectonic regime, therefore, they have been attacked by so many earthquakes and volcanic eruptions etc. Furthermore, continental regions such as China and other southeastern Asian countries could not avoid suffering from a lot of natural disasters caused by their own geologic characteristics.

In order to mitigate these damages, it is necessary to investigate natural disasters in the past time, to make an assessment of such hazards and to publicize them for the concerned people widely. For this purpose, it is especially useful to compile hazards maps and to develop the relevant databases written in English as the first step at least.

The Geological Survey of Japan (GSJ) was asked to take the responsibility of this project and organize a project team. The team focused on the geological hazards in eastern Asia and has been promoting the project under the international cooperation (Kato, 1994a, b; 1996).

Eastern Asia Natural Hazards Mapping Project, which are coordinated by the Geological Survey of Japan (GSJ), aims to compile small-scaled (1:5,000, 000) hazards maps and to develop relevant database focusing geological hazards in eastern Asia (Fig.1).

The main objectives of the Project are:

-to enhance awareness on natural hazards among planners and policy makers of natural and regional development, as well as general public in a given region

-to promote scientific studies on geological hazards

-to transfer technology to developing countries through collaborative activities

-to contribute to the International Decade for Natural Disaster Reduction (IDNDR)

This project was endorsed as one of the 39 International Demonstration Projects by the Scientific Technical Committee (STC), IDNDR in 1993 and linked with Global Hazards Mapping Project by the Commission for the Geological Map of the World (CGMW) and Global Seismic Hazard Assessment Program (GSHAP).

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Keywords: Eastern Asia, natural hazard, disaster, mitigation, hazard mapping

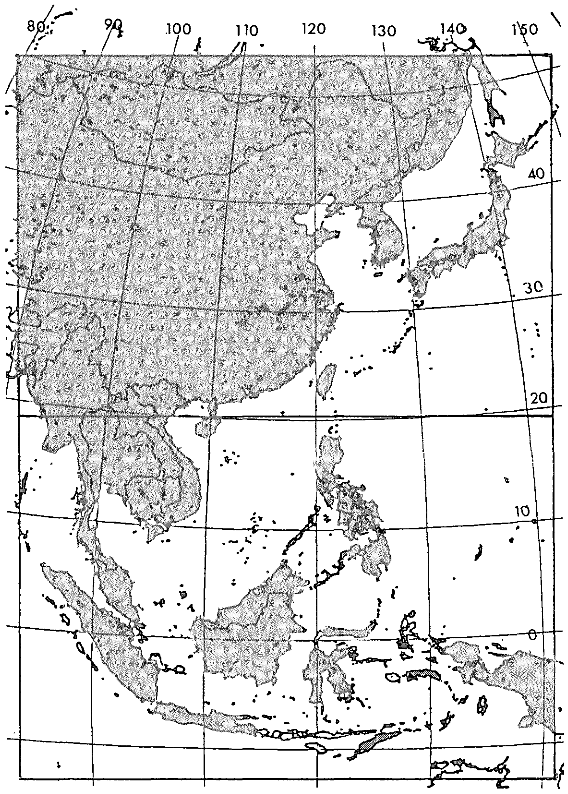

Fig. 1 Target area of the Eastern Asia Natural Hazards Mapping Project

2. Activities under the Eastern Asia Natural Hazards Mapping Project

To promote the Project, several international forums, symposiums, workshops and business meetings were held. Implementation of this mapping project and related works have been described below.

2.1 Preparatory Phase; 1992-1993

2.1.1 The 29th International Geological Congress

In his address to the Opening Ceremony of the 29th International Geological Congress held in Kyoto from 24th August to 3 rd September,1992, Mr. Kouzou Watanabe, the Minister of International Trade and Industry of Japan, proposed an international scientific programme to cope with natural hazards and related environmental issues. In the proposed programme, a worldwide natural hazards map will be compiled and relevant databases will be developed through international collaboration among geological institutes. Application of remote sensing data obtained from satellites such as the Earth Resources Satellite (JERS-1) to natural hazards research was also proposed.

This proposal came in good time to promote the objectives of the United Nations International Decade for Natural Disaster Reduction (IDNDR).

The Geological Survey of Japan (GSJ) has been preparing and promoting the Project with international cooperation since then.

2.1.2 International Forum for Natural Hazards Mapping

In order to promote the Eastern Asia Natural Hazards Mapping Project, the International Forum for Natural Hazards Mapping was held in the Auditorium of the Tsukuba Research Center of the Agency of Industrial Science and Technology (AIST) on 22-23rd June,1993.

The program consisted of three regular sessions and a poster session:

Session I Global Hazards Mapping
Session II Database and GIS for Natural Hazards
Session III Natural Hazards in Eastern Asia

Proceedings of the International Forum were published in 1994 (Kato etc. ed.,1994).

The business meeting was held on 24th June, 1993 after this forum and the participants reached the following consensus:

1) Concept of Small Scale Hazards Map

The first consensus was to aim the map at policy makers as a first stage and to leave the door open for producing other maps useful for local land-use planners in the future.

The second consensus was to produce a hazard potential map. However, it is difficult on the small-scaled map. Therefore, we should start from description of past events, and then break into thematic groups and let each discipline decide how to proceed in determining hazard potential.

2) Identified Hazards

The map should include, geological hazards such as earthquake, mass-movement, volcano, tsunami, karst/sinkhole, ground subsidence and coastal erosion/deposition in the first stage.

3) Organization of the Project Coordination Body

The National Committees would be responsible for collecting and organizing information for their part of the region, and would report their progress annually.

The Steering Committee would review national contribution and oversee the central compilation of the Map and the development of the hazards database.

The International Advisory Board should have a representation of scientists from international organization and relevant international projects and appropriate scientists from the countries outside eastern Asia.

Subcommittee for each hazard would also be established. The data compiled at national level would all be compiled centrally, and then would go back to the countries as an expanded database. (See Fig. 2)

2.2 Implementation Phase

Eastern Asia Natural Hazards Mapping Project started in 1994 as a five-year project. Following symposiums and workshops were held to promote the

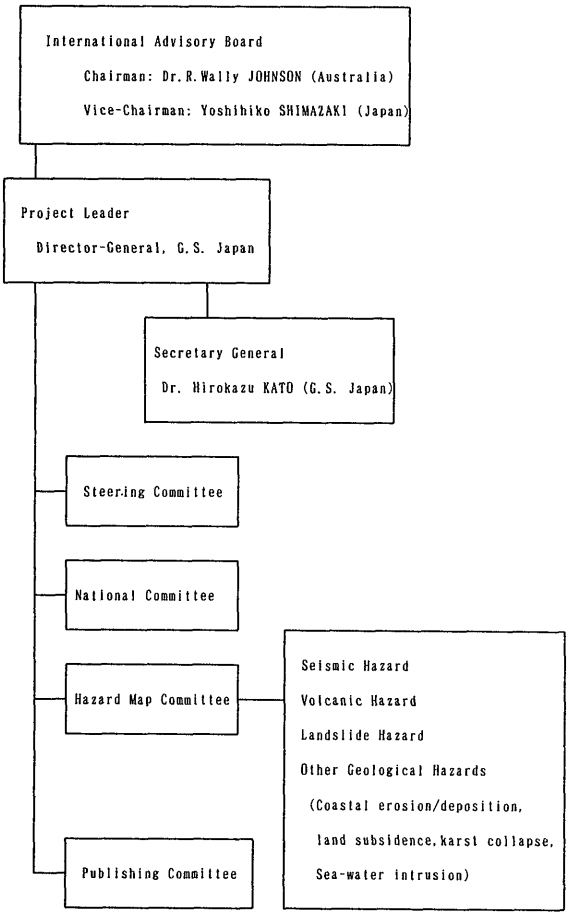

Fig. 2 Organization of the project coordination body

Project.

2.2.1 International Meeting on Eastern Asia Natural Hazards Mapping Project

This ad hoc meeting was held in Yokohama, Japan on 25th May, 1994 during the World Conference on Natural Disaster Reduction by IDNDR in order to promote our Hazards Mapping Project.

The program was as follows:

Annual Reports:

"The Progress of Natural Hazards Mapping Project in Japan" H. Kato (GSJ)

"The Progress of Natural Hazards Mapping Project in China" W. Baoping (CIHEGE)

"The Progress of Natural Hazards Mapping Project in Indonesia" I. Bahar (GRDC)

"The Progress of Natural Hazards Mapping Project in the Philippines R. S. Punongbayan (PHIVOLCS)

"Seismic Hazards and Seismic Risks in China" Chen Yong (SSB)

Relevant Comments:

"An Integrated Tsunami/Seismic Hazard Project" D. Sigrist (ITIC)

"The Progress of Hazards Mapping in Australian region" R. W. Johnson (AGSO)

2.2.2 First Workshop on Eastern Asia Natural Hazards Mapping Project (EANHMP)

The First Workshop of EANHMP was held at the GSJ in Tsukuba, on 6-7th September, 1994. The workshop was attended by members from the following countries: China, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan, USA and Vietnam.

1) General Discussion

The importance of development of databases on natural hazards was stressed. It was proposed that databases be essentially a catalogue of disasters and that selected events be recorded in data sheets.

The copies of the basemap (1:5,000,000), whose digitized data (The Digital Chart of the World) was provided by the USGS, were distributed

The present state of geological map production in member countries which is useful as background for compiling the hazards map, was introduced.

2) Group Discussion

Source data, legend, data format etc. were discussed.

The system of maps should comprise a series of 1:5,000,000 scale geo-hazard maps showing historical records of each hazard event and background geology with various inset maps such as rainfall, tectonic settings et cetra at 1:10,000,000 or smaller scale and an integrated geo-hazards map showing risk probability.

3) Seismic Hazard

Some seismic and seismotectonic maps were introduced. It was proposed that historical data should be divided into three groups, namely, before 1900, 1900-1963, 1964-present, with the cut-off magnitude of 7.5 for pre-1900 and 5.0 for 1901-present.

The regional coordinator of GSHAP proposed a close cooperation concerning seismic hazard activity and it was accepted.

A format for data sheets and a set of legends were proposed. These would be modified and finalized by the committee on seismic hazards.

4) Volcanic Hazard

Some volcanic hazard maps were introduced. It was agreed that all Quaternary volcanoes, 2 milion years old or younger, be mapped. As the scale is 1:5,000,000, all of the volcanoes should be plotted as symbols.

The shape, size and color of each symbol is classfied by the type of volcanic activity, volume of volcano and rock type. Distribution of the widely distributed ash fall deposit should also be plotted including the prehistoric ones.

Legend proposed by Japan and Indonesia would be modified and finalized by the committee on volcanic hazards.

5) Landslide

Landslide maps of China, Japan and Indonesia were introduced. Korea and Taiwan introduced their status reports on landslide. A format for data sheet and legends of the map were proposed, which would be modified and finalized by the committee on landslide.

6) Other Geologic Hazards

Dr.Wu Jing Yang , Director General of the Institute of Hydrogeology and Engineering Geology Exploration (CIHEGE), and Dr. Yin Yuping, Chief of Geohazard Division, Institute of Environmental Geology, China visited the GSJ just after the Workshop and discussed other geological hazards with the GSJ members. It was agreed that we should deal with coastal erosion and deposition, karst collapse, surface collapse (Loess), land subsidence and ground fissure in the Project. A data sheet format for coastal erosion and deposition and that for other geological hazards were proposed from Japanese and Chinese side, respectively. A format for data sheet and legend of the map were also proposed, which would be modified and finalized by the committee .

2.3 International Symposium on "Asian Natural Disasters and Hazards Mapping"

On the day before the First Workshop, the International Symposium on "Asian Natural Disasters and Hazards Mapping" was held in Tsukuba in 1994 in order to support and promote EANHMP.

The program was as follows:

Oral Session

"Progress of Eastern Asia Natural Hazards Mapping Project" Hirokazu Kato (GSJ)

"Seismic Hazards Problems in Asian Countries" Satyendra P. Gupta (AIT)

"Outline of Seismotectonics in Vietnam" Tran Van Tri (GSV)

"International Forums on Seismiconation and Post Earthquake Evalution Program" W.W. Ha ys (presented by M. J. Terman)

"Global Seismic Hazards Assessment Program and Seismic Hazards Mapping in Central and Southern Asia" Peichen Zhang (SSB)

"Mapping and Maps of Volcanic Hazards in the Philippines" Raymundo P. Punongbayan (PHIVOLCS)

"Role of Geological Survey in Natural Hazards Mapping in Malaysia: A status report" Zakaria Mohamad (GSM)

"Environmental Geologic Mapping in Korea" Gyo-Cheol Jeong & Won Young Kim (KIGAM)

"The Flood Disaster of Cambodia" Thach.Sovalsay (MEME)

"A Brief Review of Natural Hazards Potential in the Southwest Pacific" Maurice J. Terman (USGS)

Poster Session Irwan Bahar (GRDC) etc.

2.4 Second Workshop on the Eastern Asia Natural Hazards Mapping Project

The Second Workshop was held in Tsukuba on 30th September, 1995. The Workshop was attended by members from China, Indonesia, Japan, Korea, the Philippines, Thailand, USA and Vietnam.

1) General Meeting

Kato (GSJ) reviewed the progress of the project and defined the objectives of the Workshop.

Xu (MGMR, China) introduced their project,"Mapping of Marine Geological Hazards of East and South-East Asia Seas" . Cooperation of this project and the EANHMP will be considered.

2) Geological Background Data

A legend for the geological background map was proposed by Wakita (GSJ), and then officially adopted after amending.

The Workshop agreed to prepare a Map Index of the region as one of its activities. The software for the map has been developed in Japan.

3) Earthquake Hazards

Tsukuda (GSJ) reported on the historical earthquakes in central Japan and the devastation caused by the 1995 Hyogoken-nanbu earthquake.

Hinthong (DMR,Thailand) presented the overview of the present status of the "Active Fault Study Program" in Thailand.

Tri Van Tri (GSV,Vietnam) reported on the historical earthquakes of Vietnam, particularly of Dien Bien Phu, where considerable damage has been reported.

It was agreed to classify earthquakes into (a) pre-1900, (b) 1900-1963 and (c) 1964-present, on the basis of the seismic hazard descriptions for the map proposed by Kato (GSJ) and Bahar (GSDC, Indonesia). The data and legends would be hereafter prepared and revised. Taking future seismic hazards into consideration, a classification of hazardous zones was proposed and discussed.

4) Volcanic Hazard

Suto (GSJ) reported on the volcanic eruption of the Unzen Volcano and the format of the data file of past volcanic eruptions in Japan. Data of

Taiwan, the Philippines and Indonesia were being prepared for the draft.

5) Landslide

Kamai (Nihon Univ., Japan) presented a map of noteworthy landslide distribution in Japan (1:5,000, 000).

Landslide susceptibility map for Indonesia was presented by Siagian (DEG, Indonesia).

Landslide data sheets of Japan and Indonesia were presented.

As for landslide susceptibility, Terman (USGS, USA) stressed on the significance of slope maps and offered to compile such maps of the area. Also the importance of rainfall map was considered.

6) Other Geologic Hazards

Isobe (GSJ) reported on the coastal erosion and deposition in Japan during the 20th century and showed the draft map.

Wen (MGMR, China) reported the noteworthy case for land subsidence, karst collapse, coastal erosion and deposition and seawater intrusion in China. She also proposed this category to title "Land subsidence and coastal geological hazards"

Terman (USGA, USA) raised the questions of plotting all types of hazards and disasters on a single map. His argument was on mapping each type of hazard and event on a seperate sheet.

Excursion "Sustainable Development at Bay Area and Geologic Environment" was held on 1st October.

2.5 Third Workshop on the Eastern Asia Natural Hazards Mapping Project

The Third Workshop was held in Beijing , China on 10th August, 1996 during the 30th International Geological Congress (IGC), which was attended by participants from China, Indonesia, Japan, Korea, the Netherlands, the Philippines, Thailand, USA and Vietnam.

1) General

Kato (GSJ) reported the progress made since the Second Workshop in 1995:

1) EANHMP was assessed as high/medium demonstration value in IDNDR,

2) the status of data collection of geological hazards and of developing database was discussed.

2) Basement Map

Wakita (GSJ) proposed revised legend scheme of geology and tectonic features and showed the draft map (1:5,000,000).

In the discussion, it was agreed that more simplified hazards map was required by non-professionals, therefore, we should more simplify the legend and state plainly the potential of hazards occurrence. For example, V1 and V2 of volcanic rocks are included into PM hard rocks.

3) Earthquake Hazards Including Tsunami

Databases of noteworthy earthquakes of Japan, China, Indonesia, Korea, the Philippines are being developed. The data including Tsunami in and around Japan were shown on the base map.

Earthquake data of Vietnam were given and would be digitized.

4) Volcanic Hazard

Suto (GSJ) proposed revised legend scheme of volcanic features, and compiled Japanese volcanoes on the map.

Databases of noteworthy volcanic hazards in Indonesia and Japan were being developed.

5) Landslide

Noteworthy landslides of Japan and contour lines (750-1,000m1,000-1,500m,>1,500m) of uplifting during the Quaternary were shown on the map. Databases of noteworthy landslides in Indonesia and Japan had been developed.

6) Other Geologic Hazards: Land Subsidence, Karst Collapse, Seawater Intrusion, Coastal Erosion and Deposition

Yonghou (MGMR, China) presented "Geological Hazard and its Provincial Map Series Compilation in China".

Wen (MGMR, China) showed the draft digital map and the database of other geological hazards using a PC.

Isobe (GSJ) showed the draft map of coastal erosion/deposition and land subsidence in Japan.

7) Vulnerability

It was proposed that the distribution of highly populated areas should be shown in order to evaluate the vulnerability qualitatively. Other factors should be discussed in the next meeting.

2.6 Symposium on Eastern Asia Natural Hazards Mapping

The symposium was held in Beijing on 11th August, 1996. Following presentations were made:

"Atlas of provincial geological hazards of China"
Duan Yonghou (MGMR, China)

"Hazards zone map for volcanoes with very explosive eruptions and ground shaking hazard map for large magnitude earthquakes"
Punongbayan S. Raymundo (PHIVOLCS, the Philippines)

"Status of earthquake hazards research in China"
Zhang Peizhen (SSB, China)

"The main features of geological hazards in Vietnam" Tran Van Tri (GSV, Vietnam)

"Hyogoken-nanbu earthquake, Japan 1995"
Eikichi Tsukuda (GSJ, Japan)

"Control and prevention against large scale landslides in China" Yin Yueping (MGMR, China)

2.7 International Symposium on Geology for Geohazard Mitigation in Asia

This symposium was held in Osaka, Japan on 14-15th February, 1997. Following activities took place:

Session 1: Hazards Maps

"Status of Eastern Asia Natural Hazards Mapping Project" Hirokazu Kato (GSJ, Japan)

"Geologic Hazards in Korea-Perspectives"
Won Young Kim, Nam Chill Woo and Byung Gon Chae (KIGAM, Korea)

"Mapping Landslide Potential in Southwestern Part of Korea" (Poster Session)
Byung Gon Chae and Young Kim (KIGAM, Korea)

"The Applicablity of Geographic Information System in Geohazard Assessment and Mitigation Utilizing Secondary Data" (Poster Possion)
E. J. M. Diegor, A. E. G. Berador, J. T. Aleta and S. L. Batucan (MGB, the Philippines)

Session 2: Landslide

"Assessment of Landslide Hazards Based on Inte-

grated Analysis of Remote Sensing Data and Digital Elevation Models"
Takayuki Odajima, Yasushi Yamaguchi, Toshitaka Kamai, Satoshi Tsuchida, Yousana O. P .Siagian and Sugalang (GSJ & DEG, Indonesia)
"Landslide at Cadaspangern Road, Sumedang Regency West Java" Wahjono (DEG, Indonesia)
"Landslide Hazards in Papua New Guinea"
Gabriel Kuna (GSPNG, Papua New Guinea)
Special Lecture
"Remote Sensing in Geohazard Mitigation in the Asia Pacific Region: the BGS Approach"
David Greenbaum (BGS, UK)
Session 3 : Volcanic Hazard
"Volcanic Disaster Prediction Technology in Asia"
Shigeru Suto (GSJ, Japan)
"Five Years of Lahars at Pinatsubo Volcano: Declining but Still Potentially Lethal Hazards"
Jesse V.Umbal (PHIVOLCS, the Philippines)
Special Lecture
"Reduction of Volcanic Disasters"
Shigeru Aramaki (Nihon Univ., Japan)
Session 4: Country Reports I
"Geological Hazard in Vietnam"
Cao Dinh Trieu (Hanoi Inst. Geoph., Vietnam)
"Natural Hazard in Bangladesh and Role of Geology for their Mitigation"
K.M.Khorshed Alam (GSB, Bangladesh)
Session 5: Country Report II-Geohazard on the Coastal Area
"Geological Informations for Development and Management of Coastal Zone in Sarawak, Malaysia"
Henry Lithong Among (GSM, Malaysia)
"Main Geological Hazards in the Coastal Zone of Eastern China" He Qingcheng and Zhong Lixum (CIHEGE, China)
"The Vulnerability of Geohazards in the Coastal Lowland of Thailand"
Niran Chaimanee (DMR, Thailand)
"An Approach to Geohazard in Cambodia"
Mak Boly (DGM, Cambodia)
Special Lecture
"Liquefaction of Natural and Reclaimed Lands along Osaka Bay by Great Hanshin Earthquake"
Yasuo Tanaka (Kobe Univ., Japan)
"Postearthquake Investigations-Lessons Learned by the U.S.Geological Survey"
Thomas L. Holzer (USGS, USA)
Session 6: Seismic Hazard
"Studies of Active Faults by the Geological Survey of Japan" Yoshihiro Kinugasa (GSJ, Japan)
"Paleo-earthquakes on the Arima-Takatsuki-Rokko Fault Zone and the 1995 Hyogo-ken Nanbu (Kobe) Earthquake, central Japan"
Yasuo Awata, Akira Sangawa and Yuichi Sugiyama (GSJ, Japan)
"Fault Characterization by Drilling and Seismic Methods" Hisao Ito (GSJ, Japan)
"Research on Consealed Active Fault in the Tokyo and Osaka Metropolitan Areas"
Yuichi Sugiyama, Hidenori Endo and Akira Sangawa (GSJ, Japan)
"Rupture History and Segmentation of the Itoigawa-Shizuoka Tectonic Line Active Fault System" Koji Okumura and Ryusuke Imura (Hiroshima & Kagoshima Univs., Japan)
"Strong Ground Motion in Epicentral Region during Kobe Earthquake" Yoshinori Iwasaki (Geo-Research Institute, Japan)
Special Lecture
"Paleoseismology and Paleogeodesy of the Sumatran Subduction Zone: Unusual Opportunities for Understanding the Complexities of Earthquake Cycles" Kerry Sieh, Judith Zachariasen, Frederick W. Taylor, R. Lawrence Edwards and Wahyoe S. Hantoro (USA and Indonesia)

2.8 Fourth Workshop on the Eastern Asia Natural Hazards Mapping Project and Geological Study Tour

The Fourth Workshop was held in Osaka on 13th February, 1997 and was attended by members from the following countries: China, Indonesia, Japan, the Philippines, Thailand and Vietnam. This was only a short business meeting and members reported each progress of the Project after the 3rd Workshop. Japanese Committee showed draft map of the geological base map, and Chinese Committee presented legend of geological hazards such as coastal erosion, land subsidence etc.

Excursion from Osaka to Kobe area titled Geology for Geohazard Mitigation in Asia was carried out on 16 February, 1997.

3. Outline of Hazards Map

3.1 Geological Background Data

Occurrences of geological hazards are closely related to geological background in a given area, but there are some difficulties to express in them on the small-scaled map equally, because the quality of geological data is different in each country. Therefore, we must simplify the legend of geology as shown in Fig. 3.

Here, the legend of the hazard map is based on the following concepts:

1) The geological background data include both engineering geological aspects and geologic ones.

2) As we make a digital data set, we need to change the geological data to engineering geology data. For example, we try not to use technical terms in geology such as Tertiary, Mesozoic and so on.

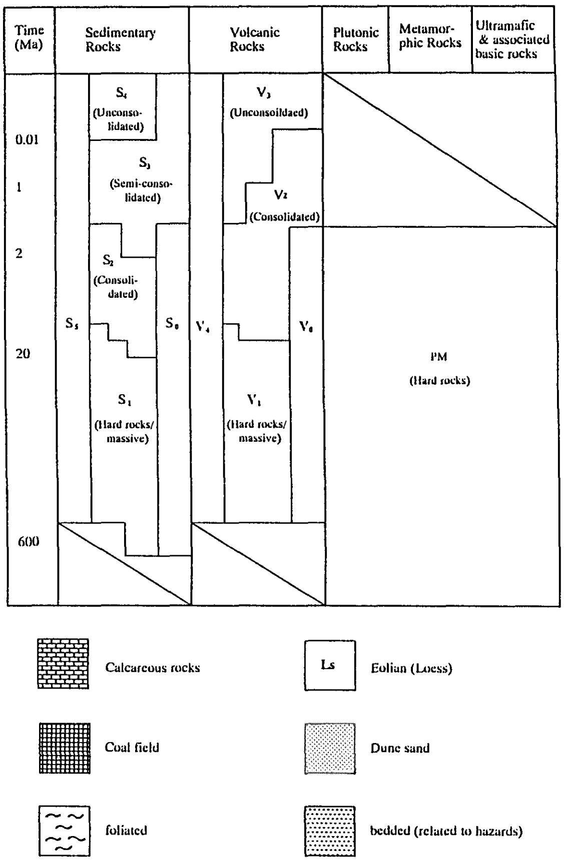

Fig. 3 Geological legend

3) Lithological nature is important for distinguishing the type of hazards, so several lithocacies are shown on the basement geology by using patterns.

4) Age of rocks is a good indicater for the state of consolidation as a whole. In this map, the absolute age instead of geologic time scale, has been shown , partly because it is available for the general public to estimate the hardness of the rock.

5) Definition of lithology is not the same as in the case of pure geologic map, but usually it is simplified. For example, foliated granite is included into the metamorphic rock group.

6) Bedded rocks do not always cause the hazard. Only the bedded rocks, which are intimately related to special hazards, such as a kind of landslide or collapse, should be shown by the pattern.

7) It is very difficult to show the detailed lithology such as lacustrine in a scale of 1:5,000,000. They are omitted from the map.

The selected legend of geology is shown in Fig. 3.

Sedimentary rocks are classified into four categories; S_1 (mainly unconsolidated Holocene deposits), S_2 (mainly semi-consolidated Pleistocene deposits), S_3 (mainly consolidated Tertiary rocks) and S_4 (mainly hard pre-Tertiary rocks). There are some areas with little geological data. So we must have non-classified categories, S_0 (non-classified Tertiary) and S_5 (non-classified sedimentary rocks).

Volcanic rocks are classified into three categories; that is V_1 (mainly hard and massive pre-Tertiary rocks), V_2 (consolidated Tertiary-Pleistocene rocks) and V_3 (unconsolidated Quaternary rocks). In the case of volcanic rocks, there are also some areas with little geological data. So we must have non-classified categories; V_0 (non-classified Tertiary) and V_4 (non-classified volcanic rocks).

Other rocks such as pre-Quaternary hard rocks including plutonic, metamorphic, ultramafic rocks and associated basic rocks are not classified.

Some lithofacies are overlaid on the above mentioned geological legend such as calcareous rocks, coal field, eolian (Loess), dune sand foliated and bedded (related to hazards).

The legend of tectonic factors is shown in Fig. 4.

Plate tectonic settings, shore lines, uplifting contour etc. are expressed. Active faults are divided into three groups such as earthquake (surface) fault, precautionary active faults, whose activities have been violent in the late Quaternary, and other active faults partly including Quaternary faults, whose activities have been relative less violent than those of the precautionary ones. Detailed characteristics of these faults are described in the data sheet (Fig. 6).

3.2 Earthquake Hazard

3.2.1 Legend

Focal depth is categorized into six groups and shown by different colors as shown in Fig. 5.

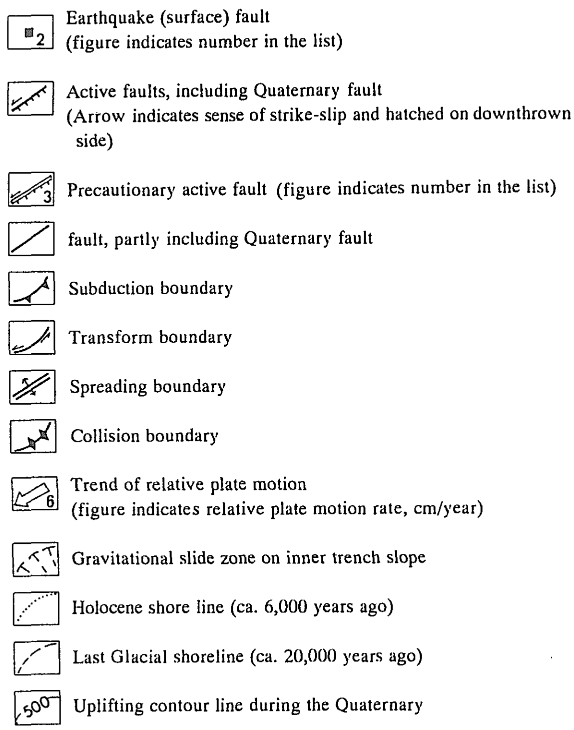

Fig. 4 Legend of tectonic factors

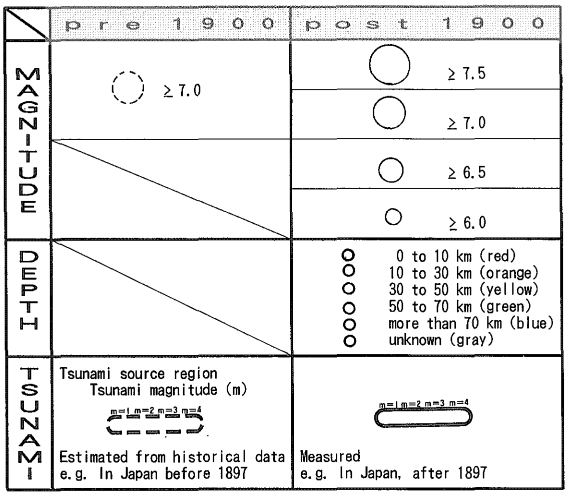

Fig. 5 Legend of earthquake and tsunami

Although moment magnitude data is mostly available, we cannot always get it for each earthquake, especially historical ones. At that case, other magnitude data should also be listed in the data sheet. Magnitude is divided into five groups and shown by the different scale circles (Fig. 5).

Tsunami source region and magnitude are also compiled on the map as shown in the legend (Fig. 5).

3.2.2 Source Data

Seismic data are divided into three time-period categories recommended by GSHAP as follows:

1) Pre-1900 (pre-instrumental)

Data sources are historical and macroseismic only.

2) 1900-1963

Only non-instrumental data are collected in this Project.

3) 1964-Present

Only non-instrumental data of disasterous earthquake (M>7.0 with associated surface faults and/or tsunami, making some victims) are collected .

All data are described in data sheets (Fig. 6) .

3.3 Volcanic Hazard

Symbols based on characteristics of volcano and deposits are shown in Fig. 7. Volcanic activity and their damages will be described in a data sheet for each noteworthy volcano (Fig. 8).

3.4 Landslide

Only large landslides, whose volumes are larger than 10^7 km^3, are described on the map. In Japan, the occurrence of these landslides are closely related to the vertical movements during the Quaternary, whose contour lines are also shown on the map (Fig. 9). Smaller landslides are not shown on the map, but susceptibility including density of distribution of smaller landslides should be shown on the small-scale map, because they indicate the potential of landslide occurrence. Detailed data are shown in the data sheets (Fig. 10).

3.5 Other Geological Hazards

3.5.1 Coastal Erosion/Deposition

Coastal erosion/deposition are affected by many complicated natural factors such as tectonic uplift, subsidence, sea level change, river channel change, sediment deposition etc. And additinal artificial factors are reservoir construction, river modification etc.

Although detailed data are described in the database (Fig. 12), they are simply presented by color symbols on the map (Fig. 11). For example, stable coast means that the shore line changes between 1.0m and -1.0m/year.

3.5.2 Land Subsidence

Land subsidence is mainly caused by over extraction of groundwater, therefore, it is not a natural hazard in the strict sense. But it is also affected by the geological conditions and causes severe damage. Therefore, they should be presented on the map. The legend and data format are proposed in Figs. 11 and 13.

3.5.3 Karst Collapse

Eighty percent of the causes of the karst collapse are due to human activities such as overwithdrawal of groundwater, mining, reservoir construction etc. Twenty percent are due to natural factors such as rainfall, earthquake and so on. The situation of this hazard is similar to land subsidence in the sense of semi-natural hazard. The legend and data sheet format are proposed in Figs.11 and 14.

3.5.4 Sea Water Intrusion

Sea water intrusion is mainly caused by over extraction of groundwater, too. Eighty percents of sea water intrusion occurrs along the coastal area. Coastal areas prone to sea water intrusion is shown on the map (see Figs.11 and 15).

3.6 Vulnerability

In small-scale hazard maps, the distribution of highly populated areas should be shown in order to evaluate the vulnerability qualitatively at least. Sites have been classified into following four categories by their population (P) and shown on the map with their names:

1) 500,000<P<1,000,000
2) 1,000,000<P<5,000,000
3) 5,000,000<P<10,000,000
4) 10,000,000<P

Other vulnerability factors are not shown on the map, but will be described in the database (GIS).

4. Map Index

For the purpose of compilation of the hazard map, we need to know what kinds of maps, for example, geological map, tectonic map, hazard map and so on,

EARTHQUAKE DATA SHEET

Please refer to earthquakes of Magnitude more than or equal to 6.5

Date (dd/mm/yy) ___/___/___/

Reporter: Name________________ Affiliation________________

Address________________________ Phone________________

________________________ Fax ________________

Earthquake Locality: Nation ________________ Local area________________

Name of earthquake________________

Date and time of occurrence: GMT or Local time

Year ____/Month ____/Day____/ Hour___/Minute ____/ (GMT / Local time)

Magnitude: _______ M, Mo, ML, Ms

Hypocenter / Epicenter: Latitude ________

Longitude ________

Depth _____km

Locality name of epicenter ________________

Maximum seismic intensity: ________________

Source fault : Strike and dip ________________

Length__________km Width __________km

Type of faulting________________________

Amount of Slip_____________m

Surface fault : Major fault name________________________

Strike and dip ________________ Length__________ km

Type of faulting________________ Amount of slip__________ m

Casualty: Deaths ________

Injuries ________

Major disasters:

❑ Collapsing of houses and buildings

reinforced concrete building / wooden houses / adobe houses

❑ Flooding area________________________earthquake lake________________

❑ Fire area________________________________

❑ Landslide area________________________________

❑ Crustal movement / surface deformation

❑ Tsunami Tsunami magnitude_________ Maximum height________ m

❑ Liquefaction Area names ________________________

Other seismic phenomena (foreshocks, aftershocks, precursors, coseismic, postseismic, etc.):

Special remarks:

References:

Fig. 6 Earthquake hazard data sheet

△ (black color)	active volcano with special priority for observation (36)
△ (black color)	other active volcano (49)
▲ (red color)	with magma eruption in last 2,000 years (48)
△ (orange color)	no record of magma eruption in last 2,000 years (37)
◬ (black color)	with crater lake and/or snow capped (57)
Ⓐ (black color)	with topographic large caldera depression, larger than 10 km in diameter (16)
⌒ (black color)	large scale volcanic ash fall deposit (11)

Fig. 7 Legend of volcanic hazard map

VOLCANIC HAZARD DATA SHEET

Name :
Catalouge No. : Longitude : Latitude :
Country, region :
Height above mean sea level : Height of volcanic edifice :
Volume of the volcano :
Type of the volcano :
Main rock type :
Near by city, population :
Organization of observation :
Sequence, site and character of the eruption :
year month day site character damage

Fig. 8 Volcanic hazard data sheet

● (red color)	large landslide (avalanche type. Volume lager than $10^7 m^3$)
• (red color)	landslide (repeated slide, flow and creep)
⁄ >1500m	contour line of uplifting during the Quaternary (0.5-1Ma)
⁄ 1000-1500m	ditto
⁄ 750-1000m	ditto

Fig. 9 Legend of landslide map

LANDSLIDE DATA SHEET FOR NOTEWORTHY CASE

Reporter: Name Nandang R Sutarto Affiliation Directorate of Environmental Geology
Address Jl. Diponegoro 57, Bandung 40122, Indonesia Phone + 62 22 706167
Date of report 4 (day)/ 6 (mo.) / 1979

(Number) (Orientation) (Location)
Landslide Locality : Name (Alias) : Debris Avalanche : 2.5 km East from Bukit Tinggi
City or Village Gn. Marapi, Agam T Datar, West Sumatra Nation: Indonesia ID#
Latitude 0.2960780° Longitude 100.4803920°

Elevation : crown of the rupture surface : 2325 m a.s.l. Slope : Source : 65 Deg.
toe of the rupture surface : 2000 m a.s.l. Deposits : 10 Deg.
tip of the total landslide mass: 2000 m a.s.l.

Date of occurrence : 2 (day) / 6 (mo.) / 1979 or intermittelly, unknown
First time slide or Repeated occurrence, and Frequency ——————
Caused by (earthquake, volcanic eruption, precipition, human work, unknown)

Geology : Rock type, geological age and stratigraphical name (formation/group)
Tuffaceous Sandstone, Pumice Tuff, and Volcanic Product
Structure (surface of discontinuity/fracturing condition)
Dip slope structure of Tertiary Sedimentary Rock underlaying by **Volcanic product**
Soils or weathering (clay minerals) : **weathered volcanic product**
Water table depth : **unknown**

Vegetation cover : 90 % rice field, houses, and crops

Type : **Source area**
Material : 1. bed rock 2. fractured rock 3. sandy soil 4. clayey soil
Movement : 1. fall 2. topple 3. slide 4. liquefaction 5. screep 6. other ( )
Transportation deposition area
Material : 1. bed rock 2. fracture rock 3. sandy soil 4. clayey soil
Movement : 1. flow 2. fast slide 3. slow slide 4. other ( )

Geometry :

	Rupture Surface	Displaced Mass	
Length (horizontal)	Lr = 1100 m	Ld = 13200 m	L= 13300 m
Width	Wr = 1000 m	Wd = m	

Depth Dhave = m Dhmax. = 30 m Dhdepoits = m

Volume or area : V= 3.99 $m^3 \times 10^n$ n = 8 or A= m2x10n n =

Damage : killed 73 people, injured -- people, economic loss (not detected)
postdisaster remediation (cost) ---

Reference : Report of Marapi Landslide, Agam T Datar, West Sumatra, DEG (1979).

Some description and remarks : Velocity of landslide has been estimated 60 km/hour

Fig. 10 Landslide data sheet

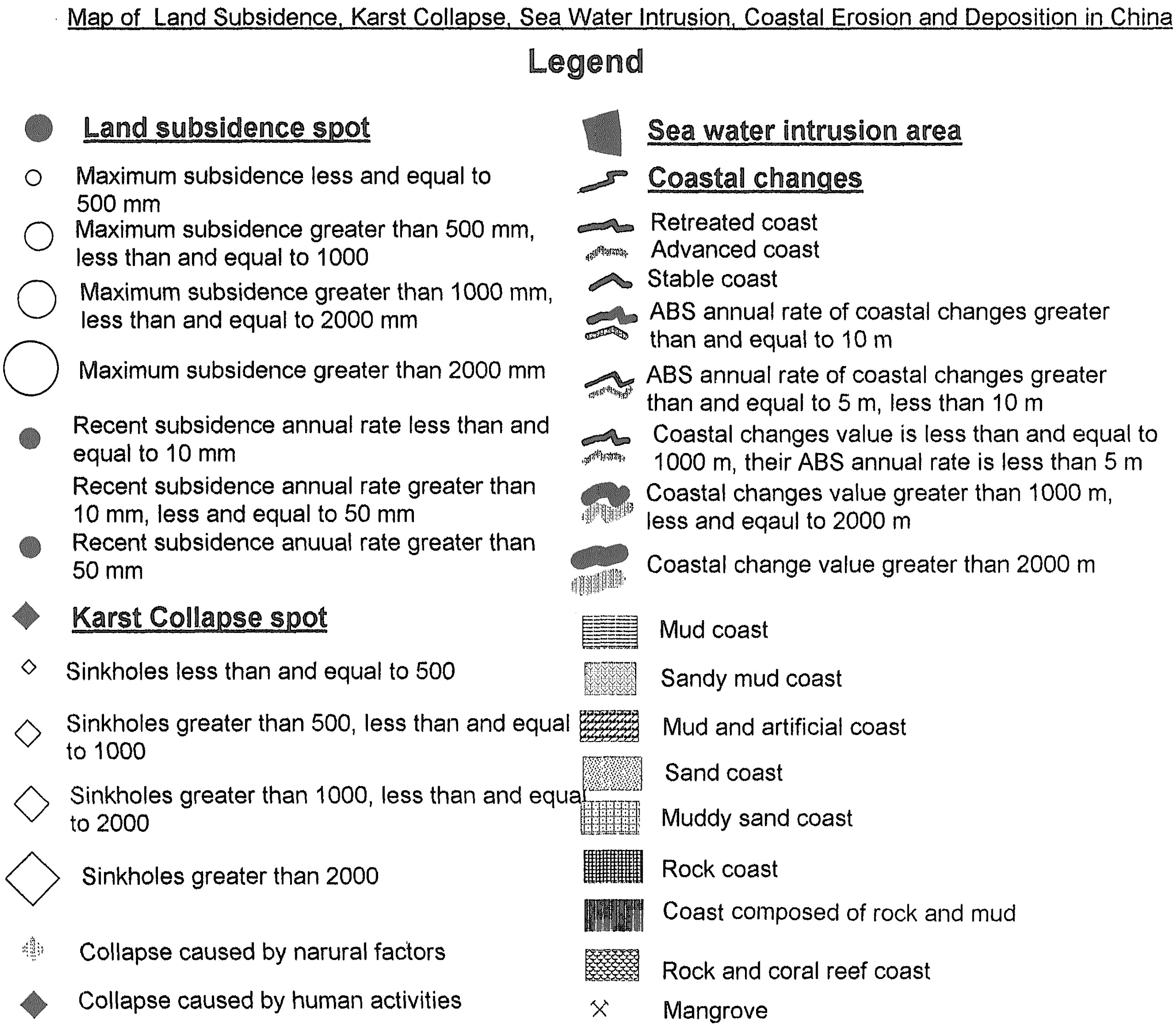

Fig. 11 Legend of other geological hazards (coastal erosion/deposition, land subsidence, karst collapse, seawater intrusion)

are published in each country. But there is a little knowledge of synthetic map index written in English in the eastern Asia region. Therefore, we developed the software of the map index handled by the IBM compatible personal computer (Fig. 16). Input data is being collected. An example of the data format is as follows:

081-001, Geological Map of Japan, 1000000, Geological Survey of Japan, 19950930, 1, 30:00, 130:00, 45:00, 150:00, 5, 1, 81, N, GSJ, Lbr. stand for Map number, Map name,Scale,Publishing office,Published date,Map type,Latitude of left bottom,Longitude of left top, Latitude of right bottom,Longitude of right top, Projection, Language, Category, Remarks, respectively.

COASTAL EROSION AND DEPOSITION DATA SHEET

Unified Number:

Location: Central Latitude:

Length (Km):

Start place:

S_Longitude: S_Latitude:

End place:

E_Longitude: E_Latitude:

Period:

Type of hazard:

Maximum value of erosion or deposition (m):

Retreat or advance rate per year (m/yr):

Coastal landform:

1. Mainland beach 2. Headland3. River mouth 4. Beach 5. Bay 6. Other

Coastal type:

1. mud 2. sandy mud 3. muddy sand 4. sand 5. rock 6. mangrove 7. coral reef 8. artificial 9. others

Rock or soil of coast:

Cause:

Natural factors: 1. subsidence 2. uplift 3. mass movement 4. sea level change 5. volcanic eruption 6. sediment

Artificial factors: 7. dam construction 8. river modification 9. diversion channel 10. extracting sediment 11. jetty construction 12. port and harbor construction 13. fluid withdrawal 14. beach nourishment 15. Others

Dominated dynamic

1. wave 2. tidal 3. fluvial 4. protected from coral-reef 5. longshore current 6. Others

Damage:

Secondary hazards:

Monitoring methods (monitor)

1. Levelling survey 2. Aerial photographing 3. Remote sensing 4. GPS 5. Others

Control measures (control)

1. Jetty 2. Spur 3. Shelter forest 4. Others

Data sources

1. On site investigation 2. topographic maps 3. bathymatric maps 4. aerial photographs 5. remote-sensing image data 6. historic records 7. document 8. others

Reference:

Other:

Reporter: Time:

Affiliation:

Address: Post code:

Phone: Fax:

** Positive number show coastal deposition, while negative one is coastal erosion.

Fig. 12 Coastal erosion/deposition data sheet

LAND SUBSIDENCE DATA SHEET FOR NOTEWORTHY CASE

Unified number:

Location of land subsidence area:

City or County: Province

Nation:

Latitude: Longitude:

Magnitude of land subsidence:

Occurrence time:

Area of land subsidence (Km2):

Maximum land subsidence (mm):

Period of record:

Maximum annual land subsidence (mm) or rate (mm/yr.): Period 1:

Average/present rate (mm/yr.): Period 2:

Morphological unit where land subsidence area is located (landform):

1. Delta plain 2. Coastal plain 3. Alluvial plain 4. Lacustrine plain 5. Coastal-alluvial plain 6. Lacustrine-alluvial plain 7. Pluvial-alluvial plain 8. Fault basin 9. Others

Compressive soil:

Cause of land subsidence

Natural factors: 1. Tectonic subsidence 2. Sea level rising

Artificial factors: 3. Over-pumping ground water 4. over-extraction of oil or gas 5. Others

Damage

Economical losses (ten thousands RMB)

Direct loss: Indirect loss:

Secondary hazards

1. Flood 2. Storm tide 3. Salinization 4. Swamping 5. Others

Methods of monitoring land subsidence (monitor)

1. Leveling survey 2. Bedrock markers 3. Layer makers 4. Others

Countermeasures (control)

1. Limiting the extraction of underground resources 2. Recharging groundwater

3. Adjusting the explored layer of underground resources 4. Others

Data resources

1. Investigation 2. Drilling 3. Geophysics 4. Deformation monitoring 6. Documents 7. Others

References

Others Phone:

Reporter: Time:

Affiliation: Post code:

Address: Fax:

Fig. 13 Land subsidence data sheet

KARST COLLAPSE DATA SHEET FOR NOTEWORTHY CASE

Unified number:

Location of the area of karst collapse:

City or Country: Province:

Nation:

Latitude: Longitude:

Magnitude of karst collapse

Area of karst collapse (Km2):

Collapse spots: Numbers of sink holes:

Diameter of the maximum sink hole (m): Depth of the maximum sink hole (m):

Period of record:

Karst type

1. Earth 2. Rock 3. Others

Soluble rock:

Overburden:

Cause of Karst collapse

Natural factors: 1. Rainfall 2. Draught 3. Earthquake 4. Gravity
Artificial factors: 5. Extraction of ground water 6. Reservoir construction 7. Water bursting of mine pit
8. Water drainage from mine pit 9. Mechanical vibration 10. Loading
11. Drainage of surface water 12. Mining 13. Others

Casualty

Deaths: Injuries:

Other damage

Economical losses (ten thousands RMB)

Direct loss: Indirect loss:

Secondary hazards

Precursors of karst collapse:

Monitoring methods (monitor)

Object: 1. Ground 2. Buildings 3. Water spots 4. Soil layers
Methods 5. Leveling survey 6. Seismograph 7. Layer markers
8. Bore hole inclinometer (or strainometer) 9. GPS 10. Others

Control measures (control)

Plugging 1. Debris 2. Concrete
Grouting 3. Gunite 4. Concrete 5. Bitumen
6. Others

Data sources

Reference

Other description

Reporter: Time:

Affiliation:

Address: Post code:

Phone: Fax:

Fig. 14 Karst collapse data sheet

SEA WATER INTRUSION DATA SHEET FOR NOTEWORTHY CASE

Unified number:

Location of sea water intrusion area:

City or County Province:

Nation:

Latitude: Longitude:

Length of intruded coast (km):

Starting point:

Latitude: Longitude:

End point:

Latitude: Longitude:

Magnitude of sea water intrusion

Occurrence time:

Area of sea water intrusion (km2):

Maximum distance of sea water intrusion toward continent (width) (m):

Maximum annual rate of sea water intrusion (km2/yr adn m/yr):

Maximum density of chlorideion in groundwater (mg/1):

Maximum degree of mineralization groundwater (mg/1):

Period of record:

Coastal landform

1. Mainland beach 2. Headland 3. River mouth 4. Bay 5. Other

Coastal type

1. Mud 2. Sandy mud 3. Muddy sand 4. Sand 5. Rock 6. Mangrove 7. Coral reef 8. Artificial 9. Others

Rock and soil of the intruded coastal zone:

Channel of sea water intrusion

Shape: 1. Tabular 2. Wedge 3. Vein 4. Tubular 5. Faults 6. Buried valley 7. Karst
Type: 8. River channel 9. Tide channel 10. Low land 11. Others

Cause of sea water intrusion

Natural factors: 1. Drought 2. Storm 3. Sea level rising 4. Over-pumping of ground water
Artificial factors: 5. Nourishment utilization 6. River modification 7. Diversion channel 8. Dam construction 9. Others

Economic losses (ten thousand yuan)

Direct economic loss: Indirect economic loss:

Damage:

Monitoring methods (monitor)

Contents: 1. Groundwater table 2. Water quality 3. Water pressure 4. Water quality analysis
Methods: 5. Pressure meter 6. Infrared scan 7. Others

Control measures (control)

1. Restriction on groundwater extraction 2. Recharging groundwater 3. Impermeable barrier with sand, gravel and clay
4. grouting concrete screen 5. Underground reservoir with impervious walls 6. Plantation 7. Others

Data sources

1. Investigation 2. Drilling 3. Geophysical 4. Monitoring of water quality 5. Isotope analysis 6. Documents 7. Others

References

Others

Reporter: Time:

Affiliation:

Address: Post code

Phone: Fax:

Fig. 15 Sea water intrusion data sheet

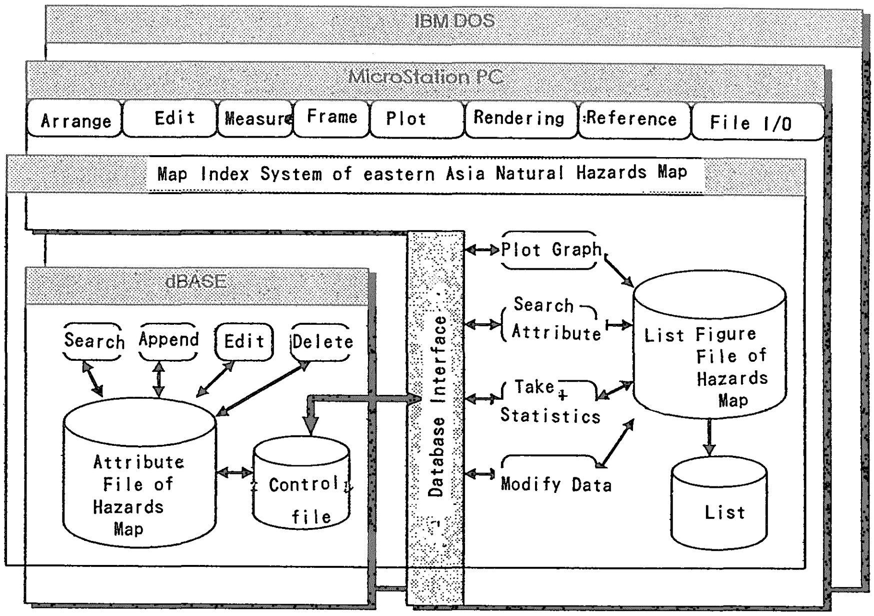

Fig. 16 Map index using IBM AT, IBM DOS Version J5.00/V, MicroStation PC V5 and dBase IV DOS 2.0J

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東アジア自然災害図計画

加藤碩一

要　旨

本計画は，自然災害による被害が著しい東アジア地域の地質災害軽減をめざして，地質調査所が主唱して進　が図られている多国間国際研究協力テーマであり，防災10年(IDNDR)の国際デモンストレーション・プロジェクトとして認知されているものである．さらに世界地質図委員会(CGMW)や国際地震災害評価計画(GSHP)ともリンクして進められている．本計画は第一段階(1994-1998)として東アジアの地震・火山・地すべり・海岸浸食／堆積，カルスト崩壊，地盤沈下及び塩水化などの地質災害に焦点をしぼり，国内外及び国際的なの関係研究機関と協力して，同地域の地質災害及び関連資料のデータベースの構築やそれをもとにした小縮尺(1:5,000,000)の地質災害図を編さんしようとするものである．

おもな対象国は日本，中国，韓国，フィリピン，インドネシア，タイ，ベトナム，カンボジア，ラオス，ミャンマー及び周辺地域である．