ISSN 0366-5542
CODEN: CCHHAQ

Natural Hazards Mapping-
Proceedings of the International Forum
Geological Survey of Japan

Report No. 281

Geological Survey of Japan

1994

REPORT No.281
GEOLOGICAL SURVEY OF JAPAN

Takeo Sato, DIRECTOR GENERAL

NATURAL HAZARDS MAPPING-INTERNATIONAL FORUM

Editor	H. KATO
Co-editors	Y. KINUGASA
	E. TSUKUDA, K. WAKITA

December 1994
Geological Survey of Japan

CONTENTS

Preface

OPENING SESSION

Opening Address by Shunso Ishihara
First Opening Speech "Expectations for the Natural Hazards Mapping Project" by Tsuyoshi Nakai
Second Opening Speech "International Contribution of the Geological Survey of Japan" by Katsuro Ogawa

SESSION 1 Global Hazards Mapping

1. Introduction of Environmental Geologic Map Series of China ········ 1
   By Duan Yonghou
2. Geologic al Hazards Map of Japan ········ 7
   By Haruo Yamazaki
3. Natural Hazards Mapping in East Asia by CPMP and USGS ········ 9
   By Maurice J.Terman
4. Natural Hazards Mapping and GIS development in the Australian region ········ 11
   By R. Wally Johnson
5. Progress in the International Decade for Natural Disaster Reduction ········ 13
   By Ken Sudo
6. Hazard Map and International Cooperation ········ 19
   By Michio Hashizume and R. Missotten
7. A Framework for Regional Global Seismic Hazard Assessment ········ 25
   By Domenico Giardini
8. ESCAP's Position vis-a-vis Natural Hazards Mapping in Asia and the Pacific Region ········ 37
   By Huub Van Wees
9. Hazard Map Project and Related Activities of Natural Disaster Science in Japan ········ 45
   By Shinjiro Mizutani
10. Eastern Asia Natural Hazards Mapping Project-a contribution to the IDNDR and GSHAP ········ 51
    By Yoshihiro Kinugasa

SESSION 2 Database and GIS for Natural Hazards

1. Natural Hazards DATA and Information in the United States ········ 57
   By Paula K. Dunbar, Sylvia C. Dane and Paul Kilho Park
2. Applications of Satellite Remote Sensing and GIS, to the Inventory and Analysis of Geological Hazards:A Review of the Results of an UNESCO Sponsored Project of International Cooperation ··· 85
   By Niek Rengers and Robert Soeters
3. Methodology for Regional Mapping of Natural Hazards using Remote Sensing and Geographical Information Systems. The Experience of the GARS Programme in Colombia ········ 101
   By Eric Leroi, Robert Missotten, Oliver Rouzeau, Jean-Yves Scanvic,
   German Vargas and Christian Weber
4. The International Directory Network and Connected Data Information Systems for Research in the··· 109
   Earth and Space Sciences
   By James R. Thieman

SESSION 3 Natural Hazards in Eastern Asia

1. Institutional Program at Asian Institute of Technology and Asian Disaster Preparedness Center ···115
By Satyendra P. Gupta
2. Seismic Hazards and Mapping of China ···119
By Ding Guoyu
3. Geologic Hazards in China and Their Prevention ···125
By Xie Zhangzhong, Zhang Guoxiang, Que Lieding and Duan Yonghou
4. Volcanic Hazards Mapping in Indonesia ···129
By R. Sukhyar
5. Geological Hazards in Indonesia ···135
By Irwan Bahar
6. Geohazard in Peninsula Malaysia ···139
By Zakaria Mohamad
7. Natural Hazards in Korea ···145
By Su-gon Lee
8. Seismoactive Faults in relation to Earthquakes of Mongolia ···149
By D. Dorijnamjaa, G. Badarch and L. Ganbaatar
9. Overview of Geologic Hazards in Vietnam ···153
By Tran Van Tri
10. Natural Hazards in Cambodia: Flood Disaster ···155
By Thach Xovalsay
11. Natural Hazards Mapping in India ···159
By P. L .Narula

APPENDIX
Participants in the International Forum for Natural Hazards Mapping (Business Meeting)

Preface

This is the report of the International Forum for Natural Hazards Mapping.

In his address to the Opening Ceremony of the 29th International Geological Congress held in Kyoto from 24 August to 3 September, 1992, Mr. Kouzo Watanabe, the Minister for International Trade and Industry of Japan, proposed an international scientific programme to cope with natural hazards and related environmental issues. In the proposed programme, worldwide natural hazards maps will be compiled and relevant databases will be developed through international collaboration among geological institutes worldwide. Application of remote sensing data such as Japanese Earth Resources Satellite (JERS-1) to natural hazards research was also proposed. This proposal was synchronized to promote the objectives of the United Nations International Decade for Natural Disaster Reduction (IDNDR, 1990-99).

Considering limited resources available to the project, compilation of a Natural Hazards Map of Eastern Asia and relevant research activities are proposed to be undertaken as the first phase of an international collaboration. The project of this size could be accomplished within the time frame of the Decade that ends in 1999. The geographic area covered in this project will be Eastern Asia, where population density is very high and large percentage of world natural disasters occur.

Natural hazards that could be covered in the collaboration of geological institutes would be geologic hazards. However, flood and related climatic hazards are still open to discussion whether to be included by calling for provision of data sets from relevant non-geological institutes.

Under the background mentioned above, the International Forum for Natural Hazards Mapping was held in Tsukuba, Japan, on 22-25 June 1993.

The Forum was organized by the Geological Survey of.Japan (GSJ), Agency of Industrial Science and Technology (AIST), Ministry of International Trade and Industry (MITI), and supported by New Energy and Industrial Technology Development Organization (NEDO), The United Nations Educational, Scientific, and Cultural Organization (UNESCO), The International Decade for Natural Disaster Reduction (IDNDR) of the United Nations. The Advisory Group members of the Forum are as follows:

Shigeo ARAMAKI	Professor, Hokkaido University
Katsuhiko ISHIBASI	Senior Scientist, Building Research Institute
Norio OYAGI	Director, Fukada Geological Research
Tsuneo KATAYAMA	Professor, University of Tokyo
Yoshiaki KAWATA	Professor, Kyoto University
Jiro KOMAKI	Director, Earth Resources Satellite Data Analysis
Shinjiro MIZUTANI	Professor, Nagoya University

(The titles of those who are presented in this proceeding are those at that time of the Forum.)

The Organizing Committee members within the Geological Survey of Japan (GSJ) are Yoshihiro KINUGASA, Hirokazu KATO, Ichiyou ISOBE, Haruo YAMAZAKI, Toshitaka KAMAI, Yoshihisa KAWABE, Yasushi YAMAGUCHI, Yoshinori MIYAZAKI and Harufumi NORO.

The meeting secretariat was carried out by International Geology Office, Geological Survey of Japan, 1-1-3, Higashi, Tsukuba, 305 Japan, Phone: +81-298-54-3576, Fax: +81-298-56-4989

One hundred and fifty participants including invited speakers attended the Forum. The Forum consists of three oral sessions, that is, Session 1, Global Hazards Mapping; Session 2, Database and GIS for Natural Hazards, and Session 3, Natural Hazards in East Asia. During the oral session, poster session also was held. A business meeting following the Sessions was held on 24 June 1993. At this meeting participants reviewed the project proposal and discussed the detail of international collaboration in compiling natural disaster data and assessing risk of disasters at regional perspective. An post-Forum field excursion in Nikko region was carried for interested participants.

The programs are as follows:

International Forum for Natural Hazards Mapping -program-

June 22, 1993 (TUE)
9:00-9:30 **Registration**
9:30-10:00 **Opening Session**
Chairperson: Hirokazu Hase (Director, International Geology Office, Geological Survey of Japan)
9:30 **Opening Address** Shunso Ishihara (Director-General, AIST, MITI, lapan)
9:40 **Introductory Remarks** Tsuyoshi Nakai (Director, IRDCD, AIST, MITI, Japan)
9:50 **International Contribution of GSJ** Katsuro Ogawa (Director-General Geological Survey of Japan)

10:00-17:00 **Session I: Global Hazards Mapping**
Chairpersons: Wu Jing Yang (China Institute of Hydrogeology & Engineering Geology Exploration)
Maurice J. Terman (U.S. Geological Survey)
Yoshihiro Kinugasa (Geological Survey of Japan)
10:00 **The Atlas of Geologic Hazards in China**
Wu Jing Yang (China Institute of Hydrogeology & Engineering Geology Exploration)
10:30 **Geologic Hazards Map of Japan**
Haruo Yamazaki (Geological Survey of Japan)
11:00 **Natural Hazards Mapping in East Asia by CPMP**
Maurice J. Terman (U.S. Geological Survey)
13:00 **Natural Hazards Mapping and GIS development in the Australian region**
R. Wally Johnson (Australian Geological Survey Organization)
13:30 **International Projects by IDNDR**
Ken Sudo (IDNDR, Switzerland)
14:00 **UNESCO Contributions to Natural Hazards Mapping**
Michio Hashizume (UNESCO, France)
14:30 **Assessment on Seismic Hazards**
Domenico Giardini (Instituto Nazionale di Geofisica, Italy)
15:20 **Escap's Position Via-a-vis Natural Hazards Mapping Programs**

Huub Van Wees (ESCAP, Thailand)

15:50 **Project Proposal for Natural Hazards Mapping of Eastern Asia**
Yoshihiro Kinugasa (Geological Survey of Japan)

16:20 **Suggestion for Natural Hazards Mapping Program**
He Qixang (CCOP, Thailand)

16:50 **Discussion**

18:00 **Welcome Reception**

June 23 (WED)

9:30-11:30 **Session II: Database and GIS for Natural Hazards**

Chairpersons: Satyendra P. Gupta (Asian Disaster Preparedness Center, Thailand)
Paul Kilho Park (NOAA, USA)
Harufumi Noro (Geological Survey of Japan)

9:30 **Natural Hazards and Relevant Files in the U.S.A.**
Paul Kilho Park (NOAA, USA)

10:00 **Database "SAIGAI" for Natural Disaster Science in Japan**
Yoshiaki Kawata (Kyoto University, Japan)

10:30 **Application of Satellite Remote Sensing and GIS, to the Inventory and Analysis of Geological Hazards: A Review of the Results of an UNESCO Sponsored Project of International Cooperation**
Niek Rengers (International Institute for Aerospace Survey and Earth Sciences, the Netherlands)

11:00 **Research on Natural Hazards in Japan**
Shinjiro Mizutani (Nagoya University, Japan)

11:20 **Discussion**

11:30 **GIS of the Geological Survey of Japan** (demonstration at lobby)
Norio Matsumoto (Geological Survey of Japan)

13:00-17:00 **Session III: Natural Hazards in Eastern Asia**

Chairpersons: Tran Van Tri (Geological Survey of Vietnam)
Niek Rengers (International Institute for Aerospace Survey and Earth Sciences, the Netherlands)
Hirokazu Kato (Geological Survey of Japan)

13:00 **Institutional Program at Asian Institute of Technology and Asian Disaster Preparedness Center**
Satyendra P. Gupta (Asian Disaster Preparedness Center, Thailand)

13:20 **Seismic Hazards and Mapping in China**
Ding Guoyu (State Seismological Bureau, P.R.China)

13:40 **Volcanic Hazards in Indonesia**
R. Sukhyar (Volcanological Survey of Indonesia)

14:00 **Natural Hazards in Indonesia**
Irwan Bahar (Geological Research and Development Center, Indonesia)

14:20 **Geohazards in Malaysia - An Overview**
Mohamad Zakaira (Geological Survey of Malaysia)

Natural Hazards in Korea
Lee Su-gon (Korea Institute of Geology, Mining & Materials)

15:20 **Geological Studies on Active Faults in Relation to Earthquakes of Mongolia**
Dorynamyao (Institute of Geology, Academy of Science, Mongolia)

15:40 **Country Report on Natural Hazards in the Philippines**

Raymundo S. Punongbayan (Philippine Institute of Volcanology and Seismology)

16:00 **Review of the Geologic Hazards in Viet Nam**

Tran Van Tri (Geological Survey of Vietnam)

16:20 **Natural Hazards in Cambodia**

Thach Xovalsay (Department of Geology and Mines, Cambodia)

16:30 **Natural Hazards in India**

P. L. Narula (Geological Survey of India)

16:50 **Closing Address**

Takeo Sato (Deputy Director, Geological Survey of Japan)

June 24 (THU) **Business Meeting**

Chairpersons: Raymondo S. Punongbayan (Philippine Institute of Volcanology and Seismology)
R. Wally Johnson (Australian Geological Survey Organization)
Shigeo Aramaki (Hokkaido University, Japan)

June 22-24 **Poster Session**

Natural Hazards in Korea Lee Su-gon (Korea Institute of Geology, Mining & Materials)
Seismotectonic Map of the Middle East Philippe Bouysse (CGMW, France)
JERS—1 Opens New Era of the Earth Observation ERSDAC(Japan)

June 25 (FRI) **Field Excursion**

Leader Haruo Yamazaki (Geological Survey of Japan)

Opening Address

Shunso Ishihara, Director General

Agency of Industrial Science and Technology (AIST)

Good morning, I am Ishihara of the Agency of Industrial Science and Technology. First of all I would like to express my thanks for the participation of so many of you at this international forum today. On opening the forum, I am very honored to make opening remarks on behalf of the sponsoring organization.

With the presence of this distinguished and very active delegation from research institutes around the world, including delegations from East Asian countries, I expect there will be a vigorous exchange of views. Among the participating nations and international organization there is extensive research finding to report current status of on going research to discuss as well as future plan for natural hazards related activities. This international forum is an evidence that the issue of natural disaster has now become a global issue.

Personally speaking, I used to be engaged in surveys and research in mineral resources. I conducted my research in Asian countries to study granite resources in order to better understand granite deposit distribution patterns and characteristics. By expanding my research scope to the Asian Continent, I was able to reclassify the granites found in Japan. The resultant discovery about granite deposits proved to be very hopeful in understanding overall geological structure and mineral distribution.

Based on my experience I feel it is only appropriate to expect the forum shall surpass the boundary of natural hazards and attempt to understand the geo-environment from a wider geological perspective.

Now I want to take this opportunity to briefly introduce AIST's policies.

As part of the Ministry of International Trade and Industry, AIST formulates comprehensive plans and initiatives and implements them in line with its industrial technology policies. It has always assisted private research and development activities especially in the areas where market forces alone cannot facilitate smooth technological progress. In other words, AIST has been active in those R&D endeavors that national technology policies can only undertake successfully. To this end, AIST promote various national projects based on the cooperation among industry, government and academic communities.

AIST issued a report in May, 1990 entitled "Regarding the Industrial and Scientific Technology Policies in the 90's". The report now serves as fundamental guideline for AIST's policies and its specific measures are discussed in light of these guidelines.

I would like to describe three major aspects of this report. The first point is an increased focus on basic research. It is important to maintain the correct balance between basic and applied research. Although it has been pointed out that Japan, in comparison to its applied research efforts, is relatively behind in basic research. In the future there will be more stress on basic research, particularly in public supported R&D efforts.

The second aspect is the promotion of international contribution in both science and technology. Japan is now taking initiatives to raise and address some of the common issues facing all human beings. Such an

Keywords: Hazard mapping, AIST, International Cooperation

initiative is the "Human Frontier Science Programs" and the response to the global environmental problems. Japan is and will remain committed to vitalize these activities.

Promoting science and technology in harmony with people and nature is the third point. Due to the world's rapid technological and scientific progress, the gap between technology and society has widen recently, resulting in the cautious attitude and fear that we, the human beings are losing control over technology. In addition to society's attitude towards new technologies, technology must all address new requirements of the post industrial society. Consumer needs have become more diverse and sophisticated. The issues surrounding aging populations presents new challenges to many nations. With the support of national research institutes, AIST directs its R&D endeavors to keep pace with these social changes.

These three points are also critical to the natural hazards mapping project, AIST intends to aggressively engage itself in the tasks of this projects, in conjunction with, global environmental issues.

AIST has enjoyed many opportunities to do joint research with foreign research organizations with various objectives. I sincerely hope this forum will be another such occasion to increase our collaboration in the national hazards area. I wish to close my remarks by thanking all participants from both within and outside Japan for their cooperation and support which made this forum possible.

FIRST OPENING SPEECH

Expectations for the Natural Hazards Mapping Project

Tsuyoshi Nakai, Director

International R&D Cooperation Division of AIST

Good morning ladies and gentlemen, and thank you for the kind introduction. I am Nakai of the International R&D Cooperation Division of AIST. I am very happy to address the opening of this international forum. Having ample opportunities to take with and exchange views with distinguished delegations from abroad, I believe, is quite significant to the mission of all participating members.

Now, please allow me to explain some of our activities for international cooperation and our attempts at, and expectations for, the natural hazards mapping projects. Please refer to the acronym, ITIT on the cover page of the forum program, ITIT stands for the Institute of Transfer of Industrial Technology and represents part of our activities in international cooperation.

ITIT's cooperative activities started 20 years ago in 1973. Our efforts involved the process of using the research results of AIST for joint research efforts with research organization of developing nations. Much of our efforts were focused on the highly demanded area of industrial technology.

Since our inception, 140 projects with 22 nations have been implemented. Examples include the technological support in producing ceramic ware in Indonesia and extracting Vitamin E from palm oil in Malaysia. Since 1990 we started research cooperation in the global environment which has become increasingly critical in recent years. Furthermore, AIST carries out international research exchange programs and regularly extends invitations to foreign researchers to ITIT international symposiums.

Today's international forum marks the stating point of the natural hazards mapping project. We anticipate this process of continued international cooperation will bear a rich fruit that all the nations can share.

There are several points of significance in this projects. The first is the hope of building a network for the exchange of human resources and data distribution. To assess and reduce the impact of disasters requires the collection and communication of accurate information. Therefore, in drawing natural hazard maps, it is of primary importance to construct an initial network of surveys and research.

Secondly, although issues about natural hazards and the global environment are critical to developing nations, the lack of a direct relationship to economic growth results in the reluctance of prospective investors to support related industries. Technological advanced nations have an obligation to provide technical support to developing nations. I expect the technologies developed under this project will be fully transferred to other Asian countries.

Lastly, we should recognize that natural hazards mapping increases public awareness of the importance of protecting against disasters. As a policy tool, it can serve many purposes such as national land development and planning and safety assurance for power plants and oil pipelines. My hope is that all your efforts will result in a useful map that assists you in policy and planning. Having said that, we will assure you of effective infragovernmental communication so that we can be of service to your cooperative work. In closing I wish to ask for your continued support and understanding of the international research cooperation projects of AIST.Thank you.

Keywords: AIST, Hazard Mapping, International Cooperation, Disaster

SECOND OPENING SPEECH

International Contribution of the Geological Survey of Japan

Katsuro Ogawa, Director General

Geological Survey of Japan

Good morning, I am Ogawa of the Geological Survey of Japan. I am very grateful that so many of you are participating today. On behalf of the organization of this forum I wish to say a few words of greeting and briefly discuss the recent trends and, the mid to long term policies of geological surveys across the world.

Upheavals are sweeping the world not only political and economically, but also in industrial circles. Especially global environmental problems, which become so controversial in the 1980's, are now a top priority, as its importance is now widely recognized.

Beside directly damaging society without any notice, natural hazards affect the global climate and environment. Natural disasters and environmental deteriorations are caused partly by the rapid increase in the world population and the excessive expansion of industries, and these issues are hardly irrelevant to resource depletion and energy.

In order to respond to these problems as one of the national institutes for earth sciences, the Geological Survey of Japan has repeatedly discussed what must be done to make well focused policies when necessary. The recognition derived out this process is shared with other geological institutes.

In April 1992, the Geological Survey of Canada convened the first International Conference of Geological Surveys in Ottawa to commemorate its 150th anniversary. The delegations of geological surveys representing 14 different nations participated. On the occasion of the International Geological Congress held in Kyoto in August of the same year, we sponsored the Second Conference of Geological Surveys. We received delegations from 44 nations and seven international organizations. During this conference we reached the consensus that the role of the geological survey should evolve in this rapidly changing world such that institutes of geological surveys all over the world should share their experiences and expand mutual cooperation.

Also, we discussed specific measures for more extensive international cooperation in finding common challenges, introducing new technologies, expanding the scale of research, and establish information networks. In the backdrop of the emerging general conventions there were increasingly notable global issues that cannot be addressed separately by one nation or one institute.

The Natural Hazards Mapping Project that we will be discussing in the following days is based on the recent global nature of geological surveys and it is considered in the following three perspectives.

First, to understand natural phenomena on earth, such as natural disasters, we must have a better grasp of the dynamic earth system itself. At the same time we also have to understand the long evolutionary history of the earth and formulate counter measures in a time scale of several decades.

Secondly, a global research network to encourage international joint research programs is called for. It is

Keywords: International Contribution, Geological Survey of Japan, Hazard Mapping, Disaster

essential to agree upon a common network structure that can meet the appropriate target levels and needs of each participating nation.

Thirdly, basic research should carry more significance, so that society can benefit from information made available to it from assembling data out of various research and surveys on the earth sciences around the world. We intend to continue our efforts keeping in mind that one of the roles of geological surveys is an information provider to citizens.

With these three fundamental policies - the understanding of the earth systems, the establishments of global research network, and the creation of information service on earth sciences, we commit ourselves to the mapping of earth sciences including natural hazards, in collaboration with other nations, to meet the needs of the society.

Lastly, I would like to express my appreciations for tremendous support we received from MITI, not to mention AIST, in organizing this forum. I wish to conclude my speech by praying this International Forum on Natural Hazards Mapping will fully serve its purpose and play a part in vitalizing international cooperation.

Thank you for your attention.

Ⅰ. Global Hazards Mapping

Geological Survey of Japan Report, No.281, 1995 p.1-5

Introduction of Environmental Geologic Map Series of China

Duan Yonghou

China Institute of Hydrogeology and Engineering Geology Exploration, China

ABSTRACT

Compiling Environmental Geologic Map Series by China Institute of Hydrogeology and Engineering Exploration began in 1989. The map series is divided into four groups: (1) Basic environmental geologic maps; (2) Geologic resources maps; (3) Environmental geologic problems maps and (4) Environmental evaluation, administration and protection maps.

INTRODUCTION

Geologic environment provides human with a living place and abundant natural resources. However, with rapid growth of human population and economic activities, the environment is severely deteriorated, regional geologic-environmental problems occur frequently, and geologic hazards become an active member of natural disasters. Nowadays people have realized the importance of the study, protection and administration of geologic environment.

In the past decades, a great amount of study has been done on geologic environment by different part of Chinese geoscience society during their exploration for mineral resources and engineering construction, and abundant results and information have been obtained. Since the 70's the study of geologic environment in China is focused on ecologic system, especially on the interaction of human activities and geologic environment. Then in the early 80's, regional environmental-geologic study was done to provide information for economic planning, environmental protection and utilization.

In all the above-mentioned studies various environmental geologic maps are major components of the study result. Environmental Geologic Map Series are compiled by China Institute of Hydrogeology and Engineering Geology Exploration in the purpose of reflecting regional environmental geologic features, analyzing the relationship between human and the nature, meeting the needs of land use planning and land administration. The mapping began in 1989.

Since the mapping is done on the basis of a great amount of environmental geologic results of China, the map series can be used in education, scientific research and construction. It is also a promotion to academic communication and development of environmental science, and a contribution to global environmental study.

In the light of the complex interaction of geologic environment and human engineering - economic activities and considering the counter measures to the geologic hazards, the map series is compiled in four groups:

1. Basic environmental geologic maps;
2. Geologic (global) resources maps;
3. Environmental geologic problems (geologic hazard) maps;
4. Environmental evaluation, administration, and protection maps.

Keywords: Environmental Geologic Map, Landslide, Rockfall, Debris Flow, Karst Collapse, Groundwater-induced Hazards, Desertization, Soil Salinization, Swamping, Soil Erosion, China

According to the present needs and study level, the Environmental Geologic Map Series is composed of 18 maps. Eleven of them are published and being published, including 8 maps of the geologic hazard group.

Map of Type and Distribution of Landslide and Rockfalls in China

As one of the most severe geologic hazard in China, at least 22 provinces out of the total provinces out of the total 30 suffer from landslides and rockfalls. The hazards are characterized by abrupt occurrence and wide distribution. Each year heavy economic losses and large death toll are reported caused by them, and in many mountainous regions they become a hindering factor to local economy.

On the basis of the affecting factors such as topography, ground dissection, geotechnical property, active fault, earthquake, rainstorm and human activities, etc., the map high lights the type and distribution of landslide and rockfall. In landslide classification, material composition and movement feature are emphasized. In time sequence they are trimly divided, as: I. before 1949; II. 1949-1979 and III. after 1980. According to sliding scale they are divisible into small (less than 0.1 million m^3), medium (0.1-1), large(1-10), and huge ones (larger than 10 million m^3).

Landslide and rockfall in China are concentrated in the following zones:

1. Neotectonic-active zones;
2. Regions covered with thick Mesozoic and Cenozoic deposits and easy-sliding soil;
3. Heavily dissected regions by surface water;
4. Regions where human activities destroyed the natural environment systems;
5. Rainstorm concentrated and geologically favorable regions.

The provinces which suffer greatly from landslides and rockfalls are Sichuan, Yunnan, Shaanxi, Gansu, Hubei and Liaoning, which include 15 frequently occurring regions such as the Hengduan Mountains, the Loess Plateau, Sichuan-Shaanxi bordering region, the Jinsha River, etc. They cover a total area of 1.73 million km^2 and future exploration and hazard prevention will be concentration there.

Map of Karst Collapse of China

Karst collapse are widespread in 24 provinces, mostly happened in eastern China, such as Guangxi, Guangdong, Guizhou, Hunan, Jiangxi, Sichuan, Hubei, etc. The sites of karst collapse total about 2840 and collapse holes over 30000, covering an area of 332 km^2 .

Karst collapse denotes the ground collapse in buried Karst caves caused by natural and artificial factors. Its harness lies in the destruction to the building, industry and mining facilities on ground surface.

The map of Karst collapse shows the distribution and developing trend of the hazard and it contains 3 major contents. (1) Types, distribution and extent of karst collapse; (2) Solvable rocks, karst and other geologic conditions;

(3) Regionalization of karst collapse, reflecting the occurrence of collapse under various geologic settings and the regulation and trend of karst collapse.

Genetic types and mechanism of the collapse are demonstrated as 2 types: natural and induced. The natural type is divisible into 4 subtypes: rainstorm, flood, gravity, earthquake; and the induced one divided into 6: mine tunnel water discharge, groundwater pumping, water storage in reservoir, vibration or loading, water seepage in reservoir, and multiple cause ones.

The purpose of such a map is to provide basic information for the treatment, prevention and prediction of karst collapse hazard.

Map of Groundwater-induced Hazards in China

As a major factor of geologic environment and most active one in earth system, groundwater joins the environment evolution and can induce a series geologic hazards, owing to poor administration of water exploitation.

1. Excessive pumping of groundwater, causing land subsidence, water source exhaust and sea water intrusion;
2. Irrational irrigation and improper hydraulic structure causing soil salinization and swamping;
3. Sewage discharge causing water pollution;
4. Hydrogechemical anomaly causing endemic diseases;
5. Heavy mining causing water eruption in mining tunnels.

Map of Debris Flow in China

Mud-boulder flow is a fluid composed of large amount of mud, boulder and water and flowing down the valley and slopes. With its wide occurrence, abruptness and great destructiveness, it ranks as the top natural hazards in China. It is found that China has over 60000 mud-boulder flow valleys and about 8500 of them are disastrous. Reports of mudflow come from as many as 24 provinces, with the most severe ones developed in Sichuan, Yunnan, Gansu, Shaanxi, Tibet and Qinghai. The Map of Debris Flow Hazards in China summarizes the regional distribution and damage level of debris flow. The map shows both development of the hazard and its impact on human lives, and a prediction of the trend of the disastrous flow. Thus the regions such as southeastern Liaohning, western Shanxi, northern Shanxi, Xining-Lanzhou area, northern Tianshan mountains, middle reaches of the Lancang River, panics-Liupanshui area are defined as seriously affected terrains.

The genetic type of debris flow is distinguished by color and the extent of damage is shown by tone. The sites of the hazard are marked with single symbols, the regionalization is expressed by boundary lines and developing trend by patterns.

As for genetic types debris flow is divided into storm type, glacial type, freeze-thaw type and compound type. Based on synthetic analysis 4 debris flow hazard regions are found, i. e.

I. Typhoon-storm region in hilly eastern China;
II. Rainstorm region;
III. Monsoon-storm region in medium-high mountains of southwestern China;
IV. Frigid glacial region in high mountains and plateau of western China.

Region I has debris flows comparatively weak and less frequent, generally occurred once in several years. But owing to its large coverage and concentration of well developed industry and population, the damages caused by one occurrence could be very great. Region II has abundant loose materials but poor water source, and topographic relief is not significant. So debris flow is developed only in loess areas. Region III on the other hand, has both favorable landform and inexhaustible materials as well as plenty of water. Hence it turns out to be the worst mudflow regions in the country. Region IV is largely sparsely populated and less developed area, and the hazard is not serious except in some local localities.

Map of Desertization in China

China is a country severely threatened by deserts and desertization, with deserts covering 1.53 million km^2 and desertizing land totalling 334000km^2 (176000 km^2 desertized and 158000 km^2 deserting). For a long time, desertization has been eating large area of land in 12 provinces in northern and western China and has claimed heavy losses to people's production and life.

Map of desertization in China shows the distribution, harm and trend of desertization. Deserts in China lie mostly between 37°-42°N latitude and desertization takes place on the margin of the deserts. It nibbles farmland and villages. Only in Inner Mongolia, deserts are growing at 3000 km^2 per year. It is predicted that by the year of 2000, another 75000 km^2 of land will be desertized in China. Since the 50's, although the country has invested a large sum of fund and man power and gained remarkable achievement, such as the thousands of kilometers long protecting forest belt across the north, northwest and northeast China, the advancement of deserts has not be stopped and environment of desert periphery regions is keeping deteriorated. Apart from reflecting the distribution of 12 large deserts in China, the map shows 26000 km^2 of reversed desertized land into oasis after treatment.

Map of Soil Salinization and Swamping

As a gradually growing hazard, salinization has a widespread occurrence in China, mostly in arid and semiarid regions of northern China. Statistics show that there are totally 818000 km^2 of salinization land in China (369300 km^2 of modern one and 448700 km^2 of remnant one), and potential ones cover another 173300 km^2 . Swamping land largely lies in the Northeast China plain the Tibet Plateau and northern Sichuan, covering 110000 km^2 .

On the basis of marking the occurrence of the two kinds of hazards, the Map of Salinization and Swamping reflects the development process of them, taking into consideration artificial and natural factors and defining the potential area exposed to the two hazards.

The treatment of salinization and swamping in China experienced frustration in the 50-60's. When large scale irrigation was done without effective drainage system, the elevation of groundwater table caused extensive and rapid secondary salinization. Then drainage works were developed and the situation improved significantly.

Map of Soil Erosion in China

China has the most serious soil erosion in the world. The eroding area reaches 1.84 million km^2 and in the last 40 years the erosion area increased by 340000 km^2 . The amount of eroded soil totals 5 billion tons per year, causing a direct loss as much as US Dollar 1.6 billion. It has been a major block to the regional economy.

In information contained in the map covers:

1. Geologic settings of the soil erosion regions;
2. Types and distribution of soil erosion;
3. Intensity of soil erosion and its regional features;
4. Sand-mud source area and trend of erosion.

Soil erosion is divisible as water erosion, wind erosion, freeze-thaw erosion, gravity erosion and artificial erosion. Water erosion ranks as the top hazard and is the major target of the map. Soil erosion is seen in all provinces of China, but with diverse development. The most developed erosion occurs in the region east of Helan Mts-Eastern margin of the Qinghai-Tibet Plateau, with the Loess Plateau and hilly area in South China suffering from the worst disasters. Only the loess Plateau has an eroding area of 430000 km^2 and an erosion module of 8000 T/a. km^2. Second to the Loess Plateau, the regions south of the Yangtze River and on the Yunnan-Guizhou Plateau has a module of 3000 T/a. km^2 .

Soil erosion usually makes the farmland barren and causes silting in lake, reservoir and river channel. The development of soil erosion is in reverse proportion to vegetation. The main cause of erosion is irrational land use and deforestation. China has spent great fund and power to harness erosion and optimistic examples can be seen in Beijing, Shaanxi and Shanxi. However, once deforested, an environment will be hard to resume. Therefore, in the near future soil erosion will keep growing in China and remain to be a tough problem.

Map of Special Soils in China

The term Special Soils denotes the earths which have special geotechnical property and thus apt to cause damages in structures and constructions.

On the map, color tone expresses the distribution of special soils and symbol and pattern show the type and harm of them. In terms of distribution, frozen soil and loess mainly lie in the northern and western China, soft earth in coastal plain in eastern China, and literate in the hilly area south of the Yangtze River. All demonstrate a latitudinal zonation.

The hazard in loess region is found as its easiness to collapse when soaked and to be eroded, usually accompanied by landslide, collapse, mudflow and erosion; soft earth is harmful for its deformation when heavy loading is opposed; expansive earth may cause damage as it swells when soaked with water; frozen soil deforms in thawing season, and laterite is easy to crack, collapse and slide.

Based on their geotechnical features, special geotechnical indexes are set up, such as soak-collapse grade, compressive grade and grade of lateritification.

Map of Environmental Geologic Division of China

It is a highly comprehensive environmental map embracing environmental geologic settings, human constructing and economic activities and major environmental problems.

Geologic settings covers quantitative expression of landform types, tectonic activity and geotechnical properties. Intensity of human activities is based on density of population and environmental problems are evaluated by combined hazard types and their intensity.

Apart from reflecting the present state of environmental geology, the map emphasizes the developing trend of environment. Since it is a changing system, under the influence of human activities, local environmental change can be drastic and abrupt. Aimed at serving for economy, regionalization is quite significant to regional development. Since geographic and geology factors are decisive to an geologic environment, they are taken as the first order criteria in division. The interaction between environment and human activities is the source of environmental geologic problems, thus the environmental features and the intensity of human activities are criteria for second order division.

The geologic environment of China is divided into 6 regions and 25 subregions. The regions are:

I. Hilly-mountainous-plain region of North China and Northeast China;
II. Hilly-mountainous region of South China;
III. Basin-mountainous-plateau region of Northwest China;
IV. Loess Plateau-mountainous region of Shaanxi, Gansu Ningxia-Inner Mongolia;
V. Medium mountains-plateau region of the Qinling-Dabashan Mts. and southwestern China;
VI. Qinghai-Tibet Plateau region.

Such a division is significant both in theory and in practice.

Geological Survey of Japan Report, No.281, 1995 p.7-8

Geological Hazards Map of Japan

Haruo Yamazaki

Geological Survey of Japan

ABSTRACT

Geological Survey of Japan compiled the Geological Hazards map of Japan in 1992. This map displays the distribution of large-scale and significant geological events such as seismic disasters, volcanic disasters and landslide during the late Quaternary and relevant geologic factors such climitic changes and soft ground.

GEOLOGIC HAZARDS MAP OF JAPAN

A unique geological map titled Geological Hazards Map of Japan was compiled as a sheet map for the second edition of Geological Atlas of Japan by Yamazaki, Kamai and Endo (1992).

This map is a first order assessment of the potential for various hazards in the Japanese Islands that would be caused by historically rare, large-scale geological events such as great earthquakes and huge volcanic eruptions. Therefore, this map is not intended for the purposes of the hazard prevention and prediction in a specific region.

Many catastrophic geological events of various types have occurred in the Japanese Islands in the Quaternary. The evidence for these events is preserved in the stratigraphical succession of the Quaternary sediments. But most people, including geologists, do not sufficiently understand the concept that if similar events were to occur in the future, we would suffer destructive damage greatly exceeding that which our ancestors experienced in the historical period. Because industrial operations are highly developed and integrated in the Japanese Islands, the occurrence of such events will cause the direct severe damage to human beings and materials and also the indirect grave disruption of the economical and social systems in Japan.

Needless to say, we can not control or not manage the occurrence of the large-scale geological event at present. But if we can estimate the behavior and recurrence time of events through the detailed survey of the Quaternary geology, the damage and impact of these events could be reduced to a minimum extent. Therefore, information on catastrophic events during the Quaternary is very important for protecting economic prosperity and social safety in Japan.

From this point of view, the map displays the distribution of significant geological events in the Japanese Islands during the late Quaternary and of some geological factors associated with these geological hazards. This map includes the following five items.

1. Earthquake hazard.

This map expresses the distribution of active faults, earthquake faults, tsunami source regions and epicenters of significant earthquakes. Active faults have the potential for future reactivation in the present tectonic stress field. An earthquake fault is an active fault which has a record of fault movement in the historical period. Tsunami source regions are areas of co-seismic crustal deformation associated with the offshore great earthquakes.

Keywords: Geologic Hazards, Earthquake, Volcanic Eruption, Landslide, Hazards Map, Climatic change, Japan

2.Volcanic hazard.

The lithology and distribution of Quaternary volcanoes and calderas are expressed on this map. The maximum volume of explosive materials for one cycle and the distributions of marker tephra and pyroclastic flow are also shown as indicators of volcanic activity.

3.Large-scale landslide.

Most of the large-scale landslides are located in the highly mountainous area of central Japan. They have affected in impact on geomorphic development of the area concerned. This map describes five categories of large-scale landslides. Four of them indicate the cause of landslide and the fifth shows the surge and flood area caused by the landslide.

4.Climatic change.

The eustatic sea-level fluctuations originated by climatic change in the Quaternary has strongly affected the development of geological and geomorphological features in Japan. This map shows two paleo-coastlines; one is the Holocene shoreline associated with the Johmon transgression at ca. 6,000 years ago and the other is the shoreline of Last Glacial associated with the maximum regression at ca 20,000 years ago.

5.Soft ground.

Soft ground is an important geological factor that controls the damage caused by seismic ground motion. This map shows the distribution of unconsolidated Holocene sediments and Late to Middle Pleistocene sediments. The former occupies the major part of lowland plains and the bottom of narrow valleys. The latter consists of the broad terraces on the edge of modern plains.

Geological Survey of Japan Report, No.281, 1995 p.9

Natural Hazards Mapping in East Asia by CPMP and USGS

Maurice J. TERMAN

U.S. Geological Survey, USA

Since 1974, the Circum-Pacific Map Project (CPMP) has compiled a series of maps of the Circum-Pacific showing a variety of geoscience parameters. Those which constitute perennial hazards have been selectively recompiled on a Pacific Basin Map at a scale of 1:17,000,000, including: (1) earthquake epicenters (<70 km depth, M 5-7.5 for 1964-80, M>7.5 for 1899-1983), (2) volcanic centers (active in past 1,000 or 10,000 years), (3) faults with historic rupture, (4) plate boundaries currently active, and (5) tsunami sites (run up of 2.0 M or more).

New compilations by the National Oceanic and Atmospheric Administration have added a number of seasonal hazards, including:
(6) wintertime maximum and summertime minimum ice edges in polar regions; (7) probability for areas of wintertime ship superstructure icing;
(8) percent frequency for areas of wintertime wave heights of 6.0 m or more; (9) preferred tracks for tropical storms; (10) percent probability for areas having at least one tropical storm within a given 5 degree square in any given year; and (11) mean tornado frequency by areas with local probability in centuries for USA.

This CPMP map and text was published in April 1991 as a contribution to IDNDR.

The United States Geological Survey (USGS) during the last decade has conducted several other projects involving mapping natural hazards in East Asia, the most important of which are the following:

During the early 1980's, USGS seismologists worked with counterparts in the Southeast Asia Association of Seismology and Earthquake Engineering (SEASEE) to publish five volumes (Summary, Indonesia, Malaysia, Philippines, and Thailand) that contained: (1) a catalogue of destructive earthquakes (5,000 pages) including damage and casualties, (2) a catalogue of instrumentally located earthquakes from 1904 to 1984 (3,000 events on magnetic tape), (3) a catalogue of focal-mechanism (2,000 events), (4) an analysis of the attenuation of earthquake intensity with distance from the epicenter for selected destructive events, (5) an interpretation of regional seismotectonics (8 maps at 1: 3,000,000 scale), and (6) an identification of seismic source zones for seismic hazard maps.

During the late 1980's, USGS volcanologists worked with counterparts in Indonesia to prepare a draft map at a scale of 1:2,000,000 on the Volcano Hazards of the Indonesian region, including location (name and IAVCEI number), danger index, year of latest activity, observational status, ash fall areas, air routes, and population centers; other parameters are being added and map should be completed at a scale of 1:2,500,000 in the near future.

Keywords: Hazards mapping, CPMP, USGS, Natural Hazards, East Asia

Geological Survey of Japan Report, No.281, 1995 p.11-12

Natural hazards mapping and GIS development in the Australian region

R. Wally Johnson

Australian Geological Survey Organization, Australia

ABSTRACT

Natural Hazards Map Working Group are preparing to compile 1:10 million-scale map entitled Natural Hazards Potential of the Southwest Quadrant. Twelve hazards were selected for representation as follows:
Group 1: earthquakes, tsunamis, landslides, cyclones, and volcanoes; Group 2: severe storms, floods, droughts and bushfires; Group 3: wave height, pack ice, and icebergs, and superstructure ice.

NATURAL HAZARDS MAPPING

An Australia-based Natural Hazards Map Working Group (NHMWG) is close to completing preparation of a 1:10 million-scale map entitled Natural Hazards Potential of the Southwest Quadrant. The map is a contribution to the International Decade for Natural Disaster Reduction (IDNDR). It represents also one of the series of earth-science maps that have been produced by the Circum-Pacific Map Project (CPMP). More particularly, the map is one of the set of standard 1: 10 million sheets that-encompasses the region from Thailand in the northwest, to the central Pacific in the northeast, to Antarctica in the south. The lessons learned during the three years spent in preparing this regional-scale hazards map may be of significance to those of us who will be involved in developing the Natural Hazards Mapping of Eastern Asia Project during the course of this International Forum.

The NHMWG decided at the outset to attempt mapping both geological and meteorological hazards. Mapping geological hazards alone was considered to be inadequate, as the Southwest Quadrant is affected severely by weather hazards, especially cyclones, flooding, and severe storms (as well as droughts and bushfires in Australia). Also, some geological and meteorological hazards are closely related: volcanic mudflows (lahars) may be initiated by heavy rain during and after explosive eruptive activity, landslides may form as a result of the passage of cyclones, and so on. However, the NHMWG decided against including what may be termed 'biological' natural hazards (disease,epidemiology), even though biological processes underpin an understanding of 'meteorological' hazards such as bushfires and drought.

The NHMWG also decided to take a somewhat different approach in mapping natural hazards. We were aware of previous small-scale hazards maps that were basically records of past events, but we decided in the case of our map to attempt rather the representation of hazard *potential.* There is, of course, a great deal of overlap in these two approaches: identifying the hazard potential of an area depends heavily on an understanding of what hazardous events have (or have not) taken place there in the past. Nevertheless, the map-design strategy we adopted involves an attempt to portray areas likely to be affected by future events. For example, we give emphasis to those Holocene volcanoes that have *not* been active in recent centuries, as these - rather than historically, frequently active volcanoes - are the most likely to produce large-scale eruptions that will have regional consequences.

The fixed 1:10 million scale of the map clearly was a limitation in the preparatory stage as some hazards are poorly represented at such a small scale - particularly landslides and volcanic eruptions. However, we

Keywords: Hazards mapping,GIS,Natural hazards,Australia,NHMWG

were not deterred by this limitation as the scale is quite effective for portraying such important regional hazards as cyclones and earthquakes. Furthermore, small-scale maps of regions criss-crossed by political national boundaries provide emphasis to the view that natural hazards themselves are non-political and that international cooperation is essential in tackling problems of hazard-data analysis and mapping. Thus, the main purpose of our map is to enhance an awareness of the range of natural hazards throughout the region. The map is being designed with decision-makers and the general public (rather than scientific hazard specialists) in mind. A major challenge for us in this regard is map design: being able to portray a range of different hazard types in a way that is understood readily by non-specialists and yet is based on the best available scientific information. We value highly the expertise and advice of our map designers.

Data availability also was a major problem. There are good regional databases for earthquakes, cyclones, and volcanic eruptions, and these are available in digitized format. However,the regional information base for events such as floods, droughts, bushfires, and severe storms is disappointingly diffuse, difficult to access, and generally non-digitized. An outcome of this limitation was that we were obliged to take a somewhat pragmatic approach in compiling data in order to have the map published within a reasonable timeframe. Twelve hazards finally were selected for representation. These fall into three groups:

Group 1: earthquakes, tsunamis, landslides, cyclones, and volcanoes. These are hazards that can be represented most easily throughout the Southwest Quadrant on the basis of existing information.

Group 2: severe storms, floods, droughts and bushfires. This group includes hazards that affect Australia particularly, but information on them is less easily accessible for the remainder of the region.

Group 3: wave heights, pack ice and icebergs, and superstructure ice. These maritime hazards affect mainly the Southern Ocean and Antarctic region in the lower part of the sheet area. They are shown easily as they have minimal overlap with the other hazards elsewhere on the sheet. They have been taken without change from the 1:17 million-scale CPMP map of natural hazards.

The most important outcome of preparing the 1 :10 million-scale hazards map has been recognition of the inadequate way in which fundamental hazards information is managed in the region. There is no integrated approach to hazards-data management. Furthermore, few data are digitized that would permit the computer-based collection, storage, retrieval, and analysis of hazards information. The recent explosion in the development of Geographic Information systems (GIS) is an encouragement for hazards data to be treated in this way.

An Australian Natural Hazards GIS Working Group has been established in order to explore ways of setting up a national GIS network for natural-hazards data management. The Working Group is made up largely of Australian Government scientists and managers from the Australian Bureau of Meteorology, the Australian Geological Survey Organization, and the National Resource Information Center (NRIC, a government agency with extensive expertise and experience in GIS technology and data management). The GIS Working Group also is working in close consultation with members of the Australian Urban and Regional Information Systems Association (AURISA) whose interests include the application of GIS methodology in public-safety issues (human-induced hazards, such as chemical spills and gas leaks, as well as natural ones). The GIS Working Group and AURISA are collaborating in the running of a Hazard Information Forum to be held in Australia in August.

A vision for the future for both groups is that an Australian GIS network may serve as a basis for a *regional* approach to natural-hazard data management. Countries of the Southwest Pacific and -Southeast Asian region would collaborate in establishing their individual hazards-information database requirements as part of a regional network in which data standards are unified and information is exchanged, compared, and analyzed. We visualize an effective linkage of computer-based information 'nodes' in different countries so that mitigating the effects of natural hazards is tackled on a regional and cooperative basis. Hazard maps of different scales would be only one set of a range of products to emerge.

Geological Survey of Japan Report, No.281, 1995 p.13-17

Progress in the International Decade for Natural Disaster Reduction

Ken Sudo

IDNDR Secretariat, The United Nations Geneva Office, Switzerland

ABSTRACT

This report is a brief introduction on the global activity of IDNDR. The objectives of IDNDR are to reduce through concerted international action, especially in developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters. The IDNDR provides an opportunity and a framework for international operation on disaster reduction.

Background

Natural hazards - including earthquakes, tsunamis, volcanic eruptions, landslides, avalanches, tropical cyclones and other windstorms, floods, wildfire, drought, and locust infestations - occur throughout much of the world. Disasters stemming from these hazards kill more than 1 million people each decade, leave countless other destitute, and cause huge economic losses. Among the myriad of disastrous events in the last few years, each of the largest - a typhoon in Bangladesh and an earthquake in China - has claimed hundreds of thousands of lives. The toll from disasters is particularly severe and tragic in developing countries. In recent years, they have suffered 90 per cent of the deaths and have often had their development goals set back year and even decades. With population growth and urbanization and with disaster vulnerable development, the risk of still greater tragedies is increasing. Now is the time to confront this issue head-on.

These are the introductory words in a report presented by the Secretary-General of the United Nations as a background document, when the U.N. General Assembly decided to designate the 1990's as the International Decade for Natural Disaster Reduction (IDNDR).

The Munich Re-insurance estimated that economic losses due to natural disasters have increased three fold from the 1960's to the 1990, and in the first few years of the 1990's are running at about $50 billion per year. The majority of these enormous economic losses are incurred in industrially developed parts of the world, but the relative impact is much greater on countries with lower per capital incomes. For countries with lowest GNP, disaster mortalities are several times higher than for middle income countries. In the book titled as "The Environment as Hazard", the authors, Burton, Kates and White describe how deaths and suffering due to natural disasters are closely related to poverty. "Ninety-five per cent of disaster-related death occur among 2/3 of the world's population that occupy developing countries."

Two fundamental observations formed the impetus to the IDNDR. First, the extent of loss of lives, physical damage and economic costs caused by disasters; their overall impact has often become an unbearable burden both on the stricken locations and on the socioeconomic development process of vulnerable countries. Second, the availability in today's world of a wealth of other sectors, that could be transferred and applied to the reduction of the overall impact of disaster on society. As a key result of the preparatory work for the Decade, these essential considerations found broad recognition and were endorsed by the United nations in the decision to launch the IDNDR.

Keywords:IDNDR,International Cooperation,Switzerland,UNCED,UNDHA,Natural Hazards,Mitigation

Objectives and Goals for IDNDR

When the U. N. General Assembly adopted resolution 44/236 in 1989 and formally decided on the IDNDR, the following objectives and goals were established:

1. The objectives of the Decade is to reduce through concerted international action, especially in developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters, such as earthquakes, windstorms, tsunamis, floods, landslides, volcanic eruptions, wildfire, grasshopper and locust infestations, drought and decertification and other calamities of natural origin.

2. The goals of the Decade are:

(a) To improve the capacity of each country to mitigate the effects of natural disasters expeditiously and effectively, paying special attention to assisting developing countries in the assessment of disaster damage potential and in the establishment of early warning systems and disaster-resistant structures when and where needed;

(b) To devise appropriate guidelines and strategies for applying existing scientific and technical knowledge, taking into account the cultural and economic diversity among nations;

(c) To foster scientific and engineering endeavors aimed at closing critical gaps in knowledge in order to reduce loss of life and property;

(d) To disseminate existing and new technical information related to measures for the assessment, prediction and mitigation of natural disasters;

(e) To develop measures for the assessment, prediction, prevention and mitigation of natural disasters through programmes of technical assistance and technology transfer, demonstration projects, and education and training, tailored to specific disasters and locations, and to evaluate the effectiveness of those programmes.

The Assembly underlines the fundamental responsibility of the vulnerable countries themselves; in order to initiate coherent disaster-mitigation activities, countries were requested to create multi-sectoral national committees or focal points for IDNDR, which would stimulate and coordinate local initiatives aiming at the objectives of the Decade. The Assembly furthermore called specifically on scientific and technological institutions, as well as industrial cooperation, to participate in disaster-reduction activities, recognizing very clearly the extent of the benefits, the capabilities and resources of these groups could bring about.

Such a country-centered approach is indeed geared to obtaining maximum advantage from country level expertise and should be embodied in disaster-reduction policies and actions right from the outset. To date, over 100 national Committee or Focal Points have been established in response to the call by the General Assembly and to promotional activities that focused on the identification of local expertise and knowledge that could be mobilized in a country-level disaster mitigation effort. An important concern is that these national groups include all relevant local expertise in disaster management and prevention, as well as in scientific and technical knowledge; all these components are essential for the successful application of advanced technologies to disaster reduction.

Organizational Arrangements during the IDNDR

Overall advice with respect to the Decade is provided by a Special High-Level Council and a Scientific and Technical Committee (STC), on the IDNDR has been established. The role of the Committee is to develop overall programmes to be taken into account in bilateral and multilateral cooperation for the Decade, paying attention to priorities and gaps in technical knowledge identified at the national level, in particular by national committees; to assess and evaluate the activities carried out in the course of the Decade; and to make recommendations on the overall programmes in an annual report to the Secretary-General.

A secretariat responsible for the day-today coordination of the Decade has been established and is located in Geneva, Switzerland. Originally, the Secretariat worked in close association with the then UNDRO; since the establishment of the Department of Humanitarian Affairs (DHA), the Secretariat reports to DHA. The organization of the UN system have participated in the IDNDR from the early phases of programme development through an Inter Agency Steering Committee and a Working Group. These have provided a forum for inter-agency coordination and information exchange.

Activities and Progress

The first years of IDNDR have been characterized by the formulation of targets and the initiation of projects. The STC has met on four occasions, the last one being in New Delhi in February 1993. "Three Targets of the Decade" to be completed by all countries by the year 2000 have been adopted, namely:

(a) Comprehensive national assessments of risks from natural hazards, with these assessments taken into account in development plans;

(b) Mitigation plans at national and/or local levels, involving long-term prevention and preparedness and community awareness; and

(c) Ready access to global, regional, national and local warning systems and broad dissemination of warnings.

Criteria for various types of IDNDR projects at national, regional and international level have been established as well, with the following classification:

(a) International IDNDR Demonstration Projects: those projects intended to provide clear examples of activities which fall within the framework programme of the Decade as already endorsed by the Committee. In addition, these projects need a very good operational organization and recognized implementing bodies.

(b) International and Regional IDNDR Projects: which fall within the framework programme of the Decade and contribute towards achieving one or more of the targets.

(c) National IDNDR Projects: which fall within the framework programme of the Decade and contribute to achieving one or more of the targets, some of which may carry a particular value.

(d) national IDNDR Demonstration Projects: National Committee and Focal Points may wish to designate a limited number of projects in this category, with criteria similar to (a) above, and notify the Secretariat.

A note of special concern made at the last STC session is that the latest available statistics indicate that in 1991, 162,000 people lost their lives and that US$44 billion in economic damage occurred because of 434 major disasters. In 1992 Hurricane Andrew caused economic losses in the United States of over US$ 20 billion, while thanks to effective advance warnings, loss of life was limited.

Projects

At present about 25 projects have been endorsed as International IDNDR Demonstration Projects and there are many more national and regional projects classified as IDNDR projects. A major problem is of course securing financial support for these projects. National and Regional projects are normally funded by a Government (National Committees) of the area(s) in which they would be implemented.

It was reported at the fourth STC that:

"While funding for most projects has already been provided, as for example by the European Community Development Fund (EDF), the Netherlands and Germany, UN agencies and nongovernmental international organization, other initiatives, including some demonstration projects, are however facing problems in obtaining financial support. The STC therefore recommended that information about individual projects should be disseminated through a variety of channels, including STOP Disasters, and that the STC should play a more active part in promoting such projects, including contacts with donors."

Guidance on project development to the Secretariat and advice to the STC is provided for by a subcommittee. The terms of reference for the subcommittee specify that it will:

(a) encourage the formulation of IDNDR projects in all four categories, especially at national and regional

levels;
(b) review proposed projects and, if needed, suggest modifications;
(c) periodically review and recommend projects to be designated as International Demonstration Projects, taking into account the need the major programme areas of the Decade and the above criteria;
(d) advise on possible avenues for funding or otherwise requested, other Decade projects;
(e) provide guideline to the Secretariat as required on categorization of projects in line with the above criteria, and
(f) keep under review the above guidelines and criteria and recommend changes to the STC as necessary.

Information Strategy

Eleven issues of STOP Disasters, the IDNDR newsletter, have been issued to date. The press run has been gradually increased from 8000 to 10000 (as of December 1992) and plans are presently under consideration to reach a target circulation of 30000 in line with the recommendation of the Second STC meeting. The newsletter is currently distributed in 178 countries to national IDNDR committees, national agencies involved in disaster management, institute, financial and banking institutes, insurance companies, etc. which have an interest in the Decade programme. The newsletter is published by the Osservatorio Vesviano in cooperation with the IDNDR Secretariat.

The 1992 International day for natural Disaster Reduction was observed under the theme "Natural Disaster Reduction for Sustainable Development". The 1993 International Day (13 October 1993) will be observed under the theme "Stop Disasters: Focus on School and Hospitals".

An implementation plan of the IDNDR Information Strategy was approved by the fourth STC session. The plan aims to contribute, through the Decade Programme and a participatory approach, it the establishment of a long term communicative relationship between generators, transmitters and users of information, an essential prerequisite for motivating people to adopt or promote disaster reduction measures.

Follow-up on UNCED and Agenda 21

The STC at its fourth session reviewed the outcome of the UNCED in Rio in June 1992 and identified four major follow-up activities that could potentially help reduce disaster losses:
(1) The formation of a Commission for Sustainable Development to monitor progress on Agenda 21;
(2) The Framework Convention on Climate Change;
(3) Negotiation of a new convention on Desertification and Drought, and
(4) The Conference on Sustainable Development of Small Island States (Barbados, April 1994).

Of special interest to participants at this meeting may be the reference to chapter 7 of Agenda 21. This chapter deals with "Promoting Sustainable Human Settlement Development" and contains direct reference to "promoting human settlement planning and management in disaster-prone areas."

1994 World Conference on Natural Disaster Reduction

A World Conference on Natural Disaster Reduction, organizes in coordination with the UNDHA/IDNDR and the Government of Japan will be held in Yokohama from 23-27 May 1994. The aims of the Conference are to:
(a) review IDNDR accomplishments at national, regional and international levels;
(b) chart an action programme for the future;
(c) exchange information on the implementation of IDNDR programmes and policies;
(d) increase awareness of the importance of the progress of disaster reduction policies.

Participation in the conference is to include government ministers and high-level officials who will be preparing and presenting national reports on their IDNDR-related activities. Additionally, participants are expected from regional and international organization, concerned with natural disasters, governmental and non-governmental representatives, and other interested persons. Furthermore, an invitation is extended to all who are involved in Decade activities, including those from the field of planning, finance, foreign affairs, health, science, engineering, civil defense, private sectors, including the insurance industry, the media and emergency preparedness.There will be a series of Topical Sessions on:

Cost Benefits of hazard Mitigation, Drought Management, Inter-relationships between Technological and natural hazards, Building Hazard-Resistant Structures, Warning Systems and Preparedness for Disaster Reduction, and Vulnerable Groups and Communities.

The Conference is designed to be neither exclusively technical nor political, but rather to provide an opportunity for policy makers to exchange ideas and hazard reduction strategies in unique forum.

The results of the Conference will contribute to the mid-term review of the Decade in 1994 by the Unite nations Economic and Social Council, as required by the General Assembly.

Concluding remarks

The objective, goals and targets for the IDNDR are straight forward, and I do not believe anyone question them. However, natural disasters occur in many different shapes and cause a wide spectrum of impacts. The consequences of a natural disaster depends on many factors, including socioeconomic factors, and it has been suggested that anthropogenic influences are the main cause for the growing disaster potential. In particular, unplanned, often informal settlements in disaster prone and rapid urbanization expose man to dangers directly or indirectly related to natural disasters. However there is still hope and I would like to conclude with a quote from a recent speech by Mr. Jim Bruce, Chairman of the IDNDR Scientific and Technical Committee: "Through the decade of the 90's, we are determined to reach a higher plateau of global awareness of the suffering and damages due to natural disasters and to put in place the actions, both possible and necessary, to reduce these human and economic losses. But it will take a major effort on the part of all disaster-prone countries - that is all of our countries - to bring this about. The IDNDR provides an opportunity and a framework for international operation. For the sake of the people of the world, let us work together to make it happen."

Geological Survey of Japan Report, No.281, 1995 p.19-24

Hazard Map and International Cooperation

Michio Hashizume* and R. Missotten

*Nows at UNESCO Regional Office for Science and Technology for Southeast Asia, Jakarta

UNESCO, France

ABSTRACT

First, several basic problems to be considered in the hazard map project will be discussed on the basis of criteria given in "Natural Disasters and Vulnerability Analysis" published by UNDRO in 1979. Secondly, international cooperation which might be developed to solve these problems will be discussed in view of the United Nations. Thirdly, brief introduction will be made for possible contribution and cooperation of UNESCO with the mandate to promote the study of disaster reduction.

Subject to be considered in hazard map

The Office of the United Nations Disaster Relief Co-ordinator (UNDRO, presently Department of Humanitarian Affairs) defined the following basic terminology in its report "Natural Disasters and Vulnerability Analysis" (UNDRO, 1979):

Natural Hazard: Probability of occurrence, within a specific period of time in a given area, of a potentially damaging natural phenomenon;

Vulnerability: Degree of loss to given element at risk or set of such elements resulting from the occurrence of the natural phenomenon of a given magnitude and expressed on a scale from 0 to 1;

Elements at Risk: Population, buildings and civil engineering works, economic activities, public services, utilities and infrastructure, etc. at risk in a given area;

Specific Risk: Expected degree of loss due to a particular natural phenomenon and as a function of both natural hazard and vulnerability;

Risk: Expected number of lives lost, persons injured, damage to property and disruption of economic activity due to a particular natural phenomenon, and consequently the product of specific risk and element at risk.

Each thematic map on hazards may have different feature according to the purpose and users. A sheet of map which illustrates the aspects as defined above will be:

Map on Hazards will be a base for any further analysis. It will be for the interest primarily of scientists and science education. Numbers of maps illustrating seismicity, volcanoes, typhoon (hurricane, cyclone) trajectories which are the analytical expression of natural phenomena are in this category.

Keywords: UNESCO, France, Natural hazards, International Cooperation

Map on Vulnerability will be of major concern of engineer and architect.

Maps illustrating micro-zoning of area susceptible to liquefaction at earthquake is an example. Socio-cultural background such as construction practice and codes, training, anthropology and human behavior, etc. is also important constituent of vulnerability. How it could be illustrated in a sheet or in other form may require special consideration.

Map on Element at Risk should be completed by administrative authorities. Maps illustrating human settlement, industrial facility, infrastructure, life lines, communication network, etc. represent human activities at risks. Cultural monuments should be also considered as an element at risk.

Map on Specific Risk will be of special concern to landuse planning, urban development, insurance industry, etc.. Risk zoning maps for particular facility at volcanic eruption, avalanche at mountain slope, etc. are the examples.

Map on Risk is of major concern of population and industries at risk, administrative and relief personnel, and policy maker. Seismic risk assessment map of large cities in seismic active area is of tremendous importance for safety and economy of the county.

Map of historical disaster is also important tool to illustrate the disaster. However, since the disaster is the direct and indirect effects to human life and the associated socio-economic activities caused by natural phenomena, record of disasters in the past may not necessarily be the appropriate material to analyze the risk assessment in the future. Particularly, it is true when development of human activities changes rapidly the vulnerability and element at risk.

Ideally a thematic hazards map should contain all of the above components and it should facilitate interlinking among these components through visual inspection with final objective to sensitize risk assessment of particular type of natural phenomena at particular place.

Designing of map

Designing of map should be made in particular care. These maps should itself visually sensitize mathematical operation;

*RISK = SPECIFIC RISK * ELEMENTS AT RISK*

SPECIFIC RISK = f(NATURAL HAZARD, VULNERABILITY)

If a map shows such as earthquake epicenters on a geographic map, it may be considered as a hazard map. A good example of comprehensive hazards map is World Map of Natural Hazards, Munchener Ruck. However, when various GIS databases such as of elements at risk and analytical database for vulnerability should be illustrated on a topographic map by overlaying technique, it will necessarily require introduction of computer technology. Now-a-day high resolution video is affordable in very low cost. Storage media containing point, vector, raster, and text data, as well as database together with appropriate model presentation and perhaps audio information will need CD-ROM which is rapidly becoming standard device for PC. Development of user friendly software should be another important component. The technique may not only be limited to facilitate conventional overlay, zoom up or standard technology available at such as remote sensing analysis, it should also be a dedicated software to illustrate mathematical operation given above. For user side, costs for device is no longer the problem. It is most desirable if the map can be utilized by various purposes and by various audiences, from community level to local and governmental authorities, professional, and educational personnel. Most comprehensive manual should be edited in plain language.

Careful attention should be made in hazards and risk assessment using records of disasters in the past. Some of the disasters are quite singular or rare phenomena although they might have caused significant damage to the population. An example is an event at the Lake Nyos, August 1986, in Cameroon, which suddenly erupted carbon dioxide gas dissolved in the lake causing death toll of 1746. However, once the cause is known and appropriate preventive measure should be taken, the phenomenon can no longer be a hazard agent. In many cases, a relatively low magnitude earthquake but rare phenomena at a particular area tends to cause severe damage.

Earthquakes which hit Cairo in 1992 and near Hyderabad September 1993 may be regarded as such cases. The vulnerability is generally not very high against such events if appropriate construction technique should have been applied. The casualties were due to lack of preparedness of the population to such relatively rare phenomena. However, it is unlikely that the same event will happen in the near future at the same place in a similar manner as simple application of mathematical formula of likelihood may indicate.

Complex disasters, such as combination of meteorological and hydrological disasters, or combination of volcanic event and hydro-geological condition (lahar) will be illustrated most comprehensively when overlay technique should be used with appropriate GIS. Most complicated events are those of complex combination of human/natural agents. The earthquake of Magnitude 8.1 which hit Mexico City in September 1985 may be among this category. In normal case at the epicentral distance as far as 300 km, such extraordinary damage is not expected.

The casualty was attributed to rather singular process in earthquake generation mechanism, high vulnerability of foundation at the sinistered area, construction practice, socio-economical problems, and preparedness. Such are the recent tendency of major disasters occurred in the world.Although it may not be the immediate purpose of this mapping project to consider all of these problems, the map should be the base to provide information to assess such complex phenomena.A special consideration should be made for regional and global disasters. For example, desertification at a particular site could be most comprehensively observed by zoom up of particular site from a large scale map containing relevant geographical, geological and geophysical information. The work can most effectively be done by computer aided data processing. Compatibility of data type to facilitate export and import of files of various type would be very important for such analysis.

Designing of software and databases for easy correction and version-up is important to catch up rapid development of technology as well as needs of human society.

International cooperation

Standardization of database and assessment method beyond political boundaries is an important task in thematic map editing. The hazard assessment methods for earthquake and volcano are among the relatively well defined. Some efforts are being made to quantify landslide information (UNESCO Working Party on World Landslide Inventory, 1993). Cooperation with relevant scientific organizations and appropriate training of local scientists will improve the quality of map.On the other hand, hazard assessment of desertification is still at the state-of-the-art. Progress of sciences is awaited for such problems.

Some local communities may not be willing to disclose risks they are exposed because of their concern to the devaluation of land price. More complicated problems are the fact that the criteria of standardization is

very much dependent on socio-cultural background. For farmers in certain areas, flood is considered as a seasonal event to fertilize the lands. But for urban dwellers, it is no more than a natural disaster.
Therefore, there is a wide range of concept in preventive measure. It is most desirable that the map could be seen and understood from all parties with different socio-cultural background. In order to make a map uniform, however, some standard should be applied rendering further interpretation to the readers. In this respect efforts are being made to express damages in terms of economy units (Berz, 1988).

The standardization needs wide range of cooperation, including international, regional, national and community level. In order to support such cooperation, participation from various experts are anticipated such as those of cartography, geodesy, geophysics, geology, space technology, informatics including GIS, architect, civil engineer, physical planner, social science, governmental and local administration, and cultural preservation. Participation of and possibly coordination by International organization like UNESCO would facilitate such cooperation and may promote associated transfer of technology.

Data acquisition and collection

There are numbers of international organization which are specialized for or have a program of collecting information that are relevant to the present project. On the other hand, a large number of information belongs to the prerogative to the government authority. For example information on element at risk is the primarily concern of the administration of the nation at risk. Territorial problem or nomenclature of site sometimes comes out uneasy problem in mapping. Assistance from the United Nations would help such consolidation.

Learning from previous works of the similar nature is extremely fruitful. Cooperation with on-going national and international programs which has similar or complementary nature will also be of great value. An example is the UNESCO- ITC Project on Geo-information for Environmentally Sound Management of Natural Resources which has already accomplished a few experimental work for application of Remote Sensing data into hazard mapping (ITC, 1993) and it has a plan to deploy such experimental work in South East Asia.

Technology transfer and training

Importance of technology transfer and training particularly at community level could not be too much emphasized. For this end translation of publication into local languages should be given high priority. Appropriate pricing and distribution through proper channel may need international cooperation.

UNESCO's Possible Contribution to the Project is follow:

The mandate

The origin of the Natural Hazards Program in UNESCO may be traced back to 1960 when the United Nations Economic and Social Council (ECOSOC) asked that UNESCO begin a comprehensive study of ways and means to reduce earthquake damage. This mandate was gradually broadened to include the scientific study of other natural hazards. It was in 1980 that the study of natural hazards was fully integrated into a programs within the Science Sector with a responsibility to promote research on the cause and effects of hazards.

On the other hand, greater concerns are growing on the inter-relation between environmental degradation and disasters. The launching of the IDNDR served to refocus attention on these UNESCO programs, and on their importance for reducing the vulnerability of society to natural hazards. More recently, a long program cooperation between UNESCO and ITC, is developing to the establishment of a center to integrate environmental and developmental aspects in disaster reduction.

Institutional framework

The pertinent institutional framework for the program activities consists of the following elements:

1. Specialized Agency within the United Nations System
2. Regional Office for Science and Technology for Southeast Asia (ROSTSEA)
   Regional Office for Science and Technology for South and Central Asia (ROSTCA)
3. National Commission for UNESCO
4. UNESCO Center for Integration of Environmental and Developmental Aspects in Disaster Reduction at ITC
5. International Council of Scientific Unions (Statutes A for UNESCO)
6. International Seismological Center (Statutes B for UNESCO)
7. Memorandum of Understanding between USGS and UNESCO for Cooperation in IDNDR

Program activities

The related program activities are:

1. International Geological Correlation Program (IGCP)
   International Hydrological Program (IHP)
   Intergovernmental Oceanographic Commission (IOC)
2. Geological Application of Remote Sensing (UNESCO/IUGS)
3. Post-Earthquake Evaluation Program (UNESCO/USGS/Council of Europe)
4. Tsunami Warning System in the Pacific
5. International Mobile Early Warning System for Volcanic Eruptions
6. UNESUCO Working Party on World Landslide Inventory
7. Seismological network projects in Asia
8. Urban geology and waste disposal
9. Project: Training Materials for Disaster Reduction
10. Publications of scientific maps
11. Publications of scientific books

References

MAPS

1. Significant Earthquakes 1900-1979, NOAA/WDC-A/OFDA
2. Natural Hazards Map of the Circum-Pacific Region (Pacific Basin Sheet), CPEMR, 1990
3. Circum-Pacific Seismic Potential 1989-1999, USGS/OFDA, 1989
4. Tsunami in the Pacific Basin 1990-1983, NOAA/WDC- A/OFDA/CPEMR
5. This Dynamic Planet: World Map of Volcanoes, Earthquakes, and Planet Tectonics, USGS/Smithsonian Inst., 1989
6. World Seismicity 1789-1988, NEIC, 1989
7. Seismicity of the world: 1960-1980, US Navy, 1981
8. World Map of Natural Hazards, Munchener Ruch, 1988
9. Soil Map of the World, FAO-Unesco, 1971
10. World Map of the Status of Human-Induced Soil Degradation, UNEP, 1990

DATABASES

1. The Natural Hazards Data Resources Directory, NOAA, 1990
2. World catalogue of very large floods, UNESCO, 1976
3. Disaster History: significant Data on Major Disasters Worldwide, 1900-present, OFDA

4. International Disaster Assistance Terms, OFDA, 1984
5. Directory of the World Landslide Inventory, USGS, 1992
6. Glossary: Disaster Management, DHA, 1992 Worldwide Tsunami Database (computer readable), National Geophysical Data Center
7. Volcanoes of the World, Smithsonian Institute, 1981
8. Global Hypocenter Database (CD-ROM), NEIC

INSTITUTIONS

1. Directory of National Officials Responsible for the Management of Disasters, Emergency Plans and Disaster Registrations, UNDRO
2. Directory of Training Institutions for Disaster Management, UNDRO
3. Directory of National and International Schools, Institutions and Agencies Providing Training in Disaster Management, UNDRO
4. Commission for the Geological Map of the World

for the others see Earthquake Disaster Reduction Handbook 1992, IISEE, pp213-241.

Bertz, G., 1988, List of Major Disasters 1960-1987, Natural Hazards, 1, 97-99.

ITC, 1993, GISSIS.

UNDRO, 1979, Natural Disasters and Vulnerability Analysis.

UNESCO Working Party on World Landslide Inventory, 1993, A Suggested Method for Describing the Activity of a Landslide, Bull. IAEG, 47, 53-57.

Geological Survey of Japan Report, No.281, 1995 p.25-35

A Framework for Regional and Global Seismic Hazard Assessment

Domenico Giardini

Instituto Nazionale di Geofisica, Italy

ABSTRACT

This paper outlines the concept of assessment and application of seismic hazard at regional and global scales and details the strategies and structure of the GSHAP; more details can be found in *Giardini and Basham* (1993).

INTRODUCTION

Earthquakes adversely affect large parts of the Earth, and vulnerability to disaster is increasing as urbanization and developments occupy more areas that are prone to the effects of significant earthquakes. In order to minimize the loss of life, property damage and social and economic disruption caused by earthquakes, it is essential that reliable estimates of seismic hazard be available to national decision makers and engineers for land use planning and improved building design and construction.

The United Nations, recognizing natural disasters as a major threat to human life and development, designed the 1990-2000 period as the International Decade for Natural Disaster Reduction (UN/IDNDR; UN Res. 42/169/1987); the Decade goals are to increase worldwide awareness, foster the prevention and reduce the risks of natural disasters, through the widespread application of modern science and technology. As the first, necessary measure toward the implementation of risk reduction strategies, the Scientific and Technical Committee (STC) of the UN/IDNDR has endorsed international demonstration projects designed to improve the assessment of natural hazards (earthquakes, volcanoes, tropical hurricanes, floods, ...). Among the spearhead programs endorsed in the UN/IDNDR context is the proposal of the International Lithosphere Program (ILP) for a Global Seismic Hazard Assessment Program (GSHAP), with the sponsorship of the International Council of Scientific Unions (ICSU).

THE GLOBAL SEISMIC HAZARD

Earthquakes are the expression of the continuing evolution of the Earth planet and its surface. Earthquakes are the most deadly of the natural disasters affecting the human environment; indeed catastrophic earthquakes have marked the whole human history, accounting for 60% of worldwide casualties associated with natural disasters (Figure 1); a relatively small country like Italy averaged more than 100,000 casualties for each of the last three centuries.

Earthquakes occur worldwide; while gigantic events (M>8.5) happen only rarely and in restricted areas of the globe, large and moderate earthquakes (6.5<M<8.5) may take place in all continental areas, if with very different frequency (Figure 2). Seismic events of moderate and small dimensions (5<M<6.5) may occur virtually everywhere, as tragically shown by the 1993 event in central India. The average global seismicity records every year 1 very large event (M>8), 10 large events (M>7), 100 moderate events (M>6) and more than 1,000 smaller earthquakes (M>5). The economic damage inflicted by natural disasters and by

Keywords: Seismic hazard assessment, GSHAP, Earthquake, Disaster

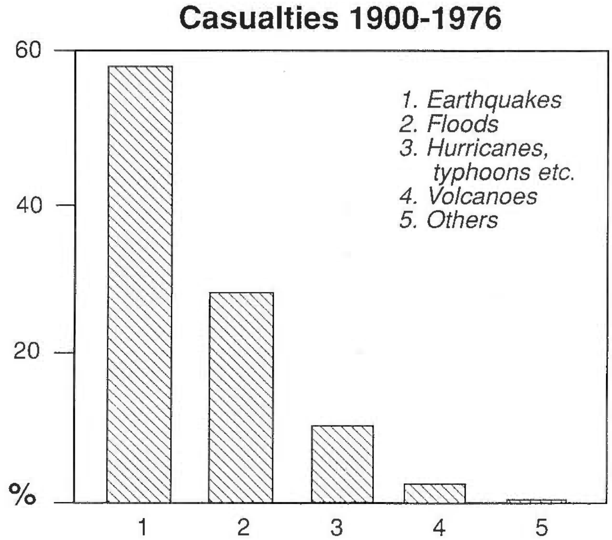

Fig. 1. Percentages of losses from different types of natural disasters in the 1900-1976 period (percentage data from the IDNDR Office).

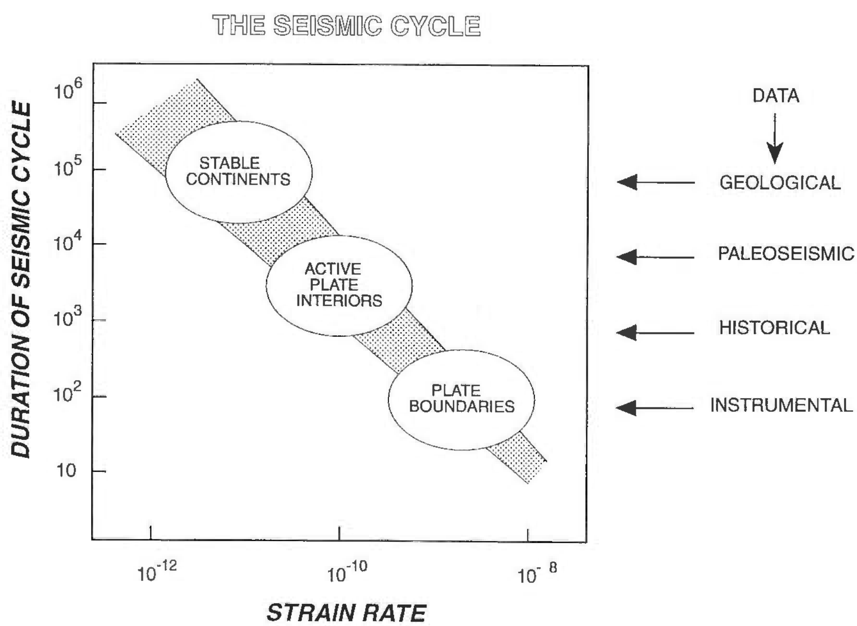

Fig. 2. Different types of seismotectonic provinces are displayed as function of strain rate and duration of the characteristic seismic cycle (modified after *Burton, personale comunication, 1993*).
To the right are indicated the input data required to control earthquake recurrence at different time scales.

earthquakes is increasing with time. The long-term effects of a catastrophic earthquake (the disruption of the economic chain, the human resettlement, the reconstruction to modern standards) may last decades and absorb a considerable part of a national budget; the reconstruction of the Irpinia region (Central Italy) after the 1980 event (M=7) has exceeded 50,000 M$ to date, and the predicted damage which would be inflicted today by the repetition of the great 1923 Tokyo earthquake (M=8.3; 100,000 casualties) would total up to

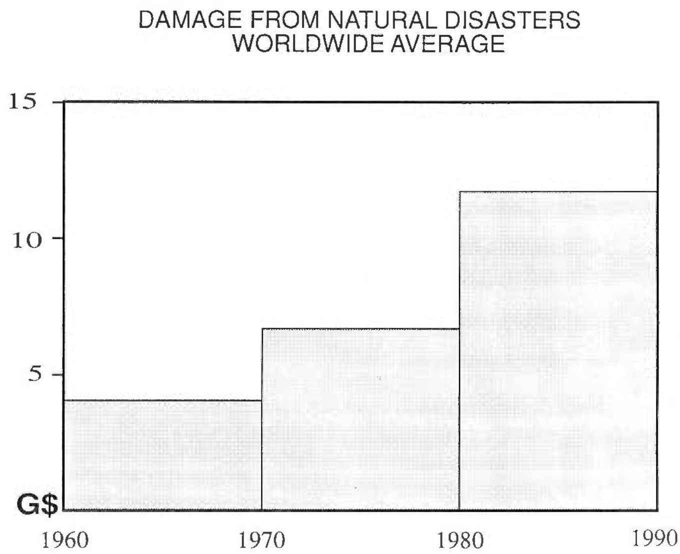

Fig. 3. Yearly average of worldwide damage from natural disasters in the last three decades (data from Munich Re.).

one fourth of the GNP of Japan.

Global seismic hazard and vulnerability to earthquakes are increasing steadily (Figure 3) as urbanization and development occupy more areas that are prone to the effects of significant earthquakes; the uncontrolled growth of megacities in highly seismic areas around the world is often associated with the construction of seismically unsafe buildings and infrastructures, and undertaken with an insufficient knowledge of the existing seismic hazard. Moderate and even small earthquakes may turn catastrophic in earthquake prone areas with poor building construction practice, as shown by the 1960 event in Morocco (M=5.8; 12,000 casualties) and the 1972 event in Nicaragua (M=6.2; 5,000 casualties; damages for 40% of GNP).

THE ASSESSMENT OF SEISMIC HAZARD

The seismic hazard is a measure of the ground shaking associated to the recurrence of earthquakes and is defined at any location as the probability of occurrence of seismic ground shaking in a specified time interval. A map of seismic hazard contours areas of equal seismic hazard expressed in terms of ground shaking parameters such as intensity, peak ground acceleration or velocity.

Seismic hazard assumes a different meaning to different users. For example, the 30-years probability of acceleration exceeding 10% of gravity characterizes the geographical extent of moderate shaking at high degrees of likelihood (ex. 50-50), of high interest for the design and protection against highly probable shaking damage; on the other hand, the maximum acceleration expected at a 6% probability in 30 years measures the expected highest levels of shaking, even with a very low probability of occurrence (ex. 1 in 20), and is used in designing engineered structures to withstand a once-in-a lifetime level of shaking, typically for critical facilities.

The basic elements of modern seismic hazard assessment can be grouped into four main categories:

- **Earthquake Catalogues and Data Bases**: the compilation of a uniform data-base and catalogue of seismicity for the historical (pre-1900), early-instrumental (1900-1964) and instrumental periods (1964-

today).

- **Seismotectonics and Earthquake Source Zones**: the creation of a master seismic source model to explain the spatial-temporal distribution of the seismicity, using evidence from seismotectonics, paleo-seismology, geomorphology, mapping of active faults, geodetic estimates of crustal deformation, remote sensing and geodynamic models to constrain the earthquake cyclicity in different tectonic provinces (Figure 2).

- **Strong Seismic Ground Motion**: the evaluation of ground shaking as function of earthquake size and distance, taking into account propagation effects in different tectonic and structural environments and using direct measures of the damage caused by the earthquake (the seismic intensity) and instrumental values of ground acceleration.

- **Computation of Seismic Hazard**: the computation of the probability of occurrence of ground shaking in a given time period, to produce maps of seismic hazard and related uncertainties at appropriate scales.

The quality and availability of the basic data needed for seismic hazard assessment varies greatly around the world (see, for example, in Figure 4, the geographical distribution of completeness level for historical earthquake catalogues).

In addition, the methodologies for the assessment of seismic hazard have evolved through five generations of models:

1. **Historical Determinism** maps the maximum intensity of earthquake effects recorded in known historical times, to represent, with appropriate corrections, the highest intensity to be expected in the future.

2. **Historical Probabilism** builds a statistical model of seismogenic sources to reproduce the historical record

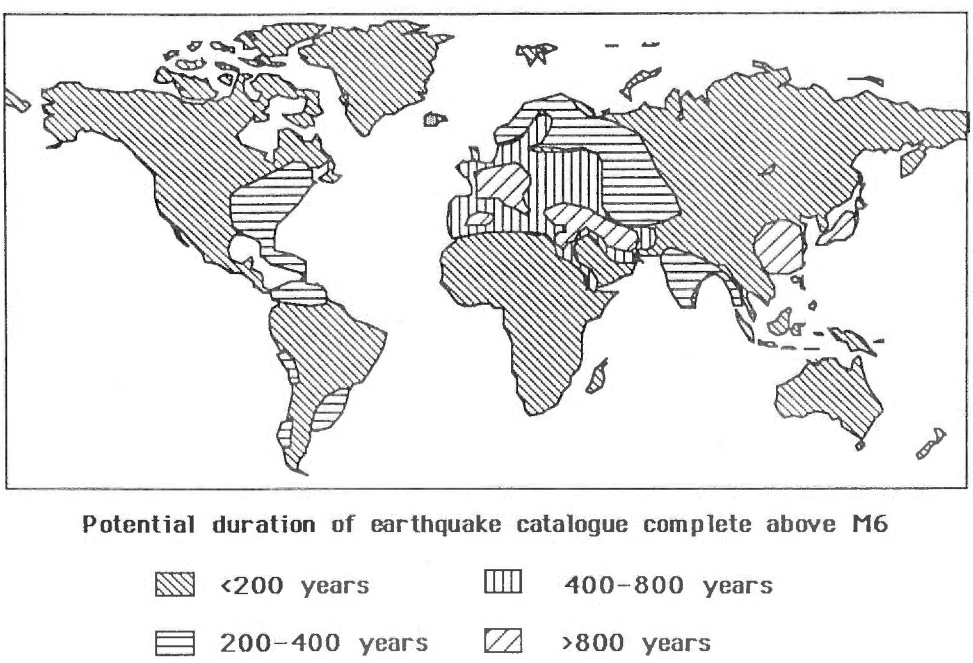

Fig. 4. Geographical distribution of completeness level for historical earthquake catalogues (*Muir-Wood, 1993*).

of seismicity (location in space and time, frequency-size distribution).

3. **Seismotectonic Probabilism** incorporates geological evidence (prehistoric record of paleoseismic activity, geomorphology, rates of crustal deformation from land and space geodesy, neotectonic and geodynamic modelling) to supplement the historical record of seismicity in building a seismic source model covering earthquake cycles up to a few thousands years.

4. **Time-Dependent Seismotectonic Probabilism**: the use of non-Poissonian statistics allows to take into account not only the periodicity of earthquake recurrence but also the time elapsed since the last significant earthquake, as a most significant parameter in assessing the future seismic activity.

5. **Earthquake Prediction**: where sufficient knowledge of the earthquake genesis is collected, the spatial-temporal-size characteristics of future significant earthquakes can be predicted.

The adoption of these different methodologies may lead to largely different expectations of seismic hazard for the same location (Figure 5). Seismic hazard is assessed by most nations as the preliminary step toward the adoption of building construction codes; different regions of the world exist in different generations of hazard. Some national assessments are still in the first or second generation, while some areas are experimenting with fourth-generation mapping. A goal of a global program should be to bring all regions up to a third generation hazard culture and produce seismotectonic probabilitic assessments of seismic hazard.

FROM SEISMIC HAZARD TO RISK MITIGATION

The assessment of seismic hazard is the first step in the evaluation of the seismic risk, obtained by convolving the seismic hazard with local site amplification effects tied to soil conditions and with the

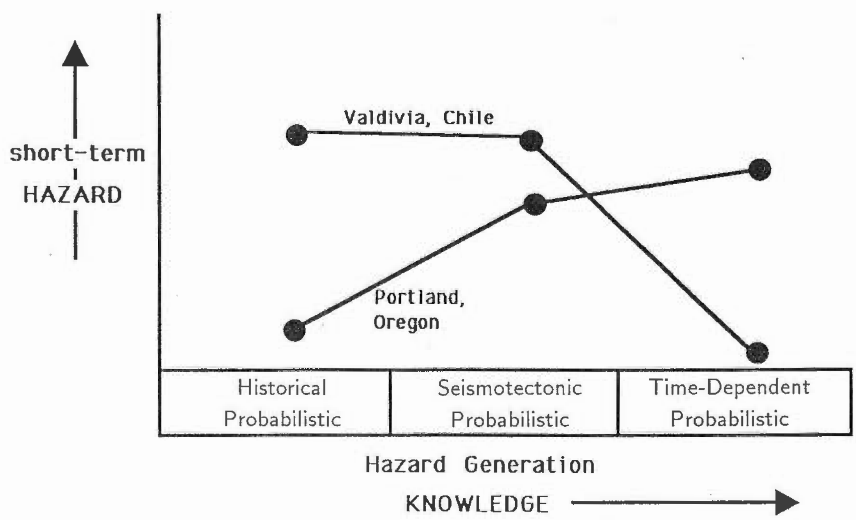

Fig. 5. Estimates of short-term seismic hazard obtained with different assessment methodologies (see text for details) for two cities characterized by similar seismo-tectonic setting but a rather different seismic history; Valdivia is affected by large earthquakes about once every century, the last one occurring only a few years ago, while Portland has not experienced a large earthquake in the last two centuries (modified after *Muir- Wood, 1993*).

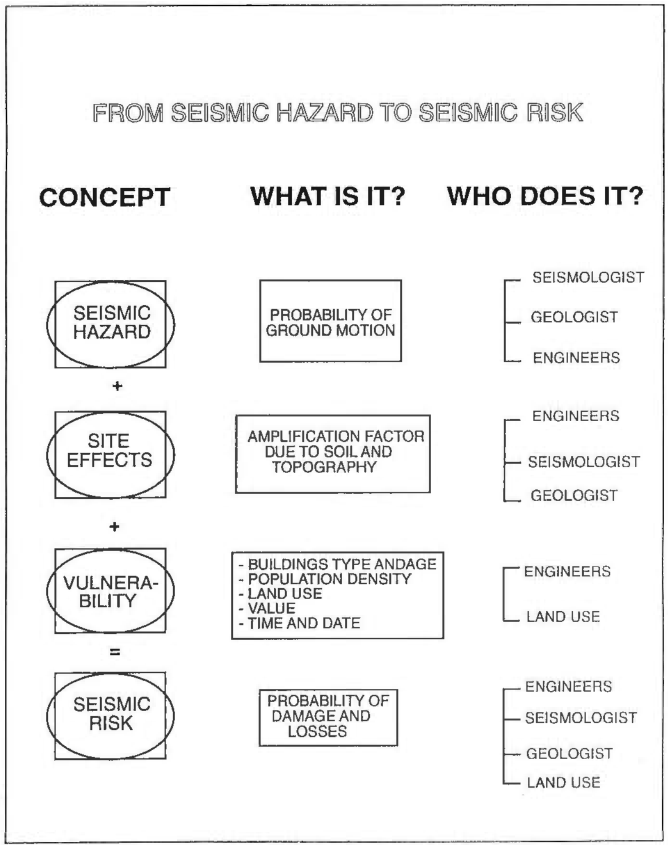

Fig. 6. A schematic display of the concepts, elements and required expertise behind the assessment of seismic hazard and risk.

intrinsic value and vulnerability of the existing buildings and infrastructures. Frequently, large events in remote areas result in high seismic hazard but pose no risk; on the contrary, moderate events in densely populated areas entail small hazard but high risk. The assessment of seismic hazard and risk should be conducted in coordinated fashion by seismologists, geologists, engineers and land-use planners (Figure 6).

While short- and mid-term earthquake prediction may one day be able to reduce significantly the death toll of earthquakes, the environmental effects (collapse of buildings and infrastructures, disruption of the productive chain, human resettlement) can be reduced only through a long-term prevention policy in earthquake-prone areas based on the assessment of seismic hazard and risk, the implementation of safe building construction codes, the increased public awareness on natural disasters, a strategy of land-use planning taking into account the seismic hazard and the occurrence of other natural disasters.

The assessment of seismic hazard is only the first link of the prevention chain (Figure 7); concrete measures for seismic risk mitigation include:

- **Seismic Zoning**: the prime measure for the reduction of the earthquake risk is the definition the seismic zonation of the territory, with established safety coefficients used in the design and construction of private and public buildings.

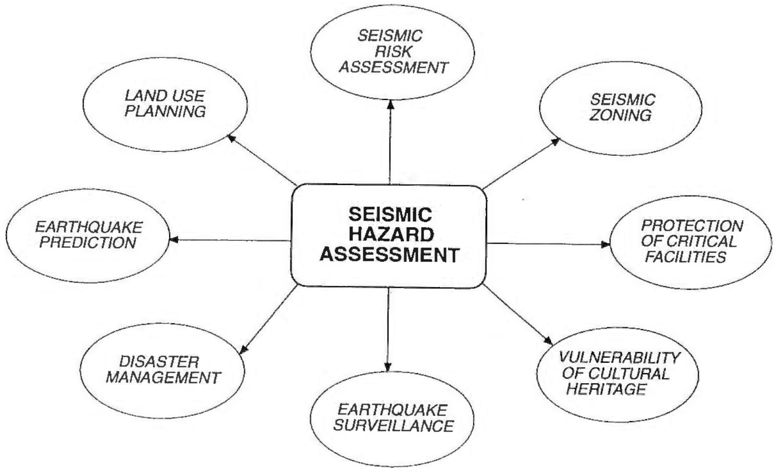

Fig. 7. Concrete measures for seismic risk mitigation which require the assessment of seismic hazard as basic input.

- **Vulnerability of Cultural Heritage**: the strategy for the defense of the historic cultural heritage should be the prevention of earthquake damage, rather than intervention following the disaster, and it can only be implemented if we understand where the hazard lies.

- **Protection of Critical Facilities**: to protect the large-scale addition of man to the territory (industrial and chemical complexes, nuclear and conventional power plants, technological concentrations, large dams, major communication systems, harbours ...) the complete understanding of the Earth dynamics is required to: optimize the design, construction and management, assess the safety and environmental interaction and protect the human habitat.

- **Land Use Planning**: the long-term effects of a catastrophic earthquake - the disruption of the economic chain, the human resettlement, the reconstruction to modern standards - may last decades and absorb a considerable part of a national budget; the long-term strategy for land-use planning needs to take into account the recurrence of earthquakes and other natural disasters.

- **Earthquake Prediction**: the identification of earthquake-prone areas and the assessment of time-dependent hazard are the first step toward the prediction of the earthquake recurrence and allows to implement prediction test areas.

- **Disaster Management**: in areas of high hazard, emergency plans can be prepared well in advance of the earthquake, to increase public awareness, optimize disaster management and relief intervention, and reduce damage and losses.

- **Earthquake Surveillance**: a better understanding of the location and interaction of seismogenic structures allows to target in a more proficient way the routine activities of seismic monitoring.

THE GLOBAL SEISMIC HAZARD ASSESSMENT PROGRAM

The Global Seismic Hazard Assessment Program proposed by ILP has been endorsed as a demonstration project by the UN/IDNDR (III UN/IDNDR/STC; Geneva, March 1992) with the support of the international

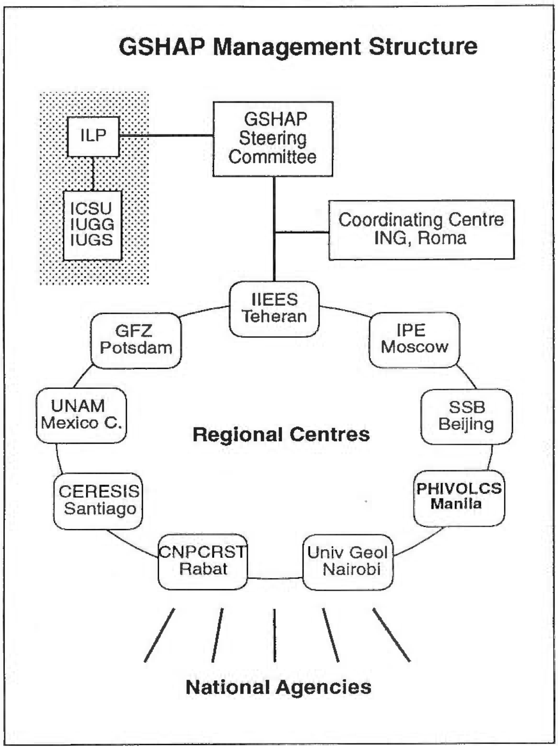

Fig. 8. The management structure of the Global Seismic Hazard Assessment Program at institutional, global, regional and local level.

scientific agencies (ICSU, IUGG, IUGS, IASPEI) and of UNESCO. The primary goal of GSHAP is to ensure that national agency be able to assess seismic hazard in a regionally coordinated fashion and with the most advanced methods.

A regional approach

The program is coordinated at global level and implemented at regional and local scale (Figure 8), with a regionalized approach based on the establishment of Regional Centres to assist national efforts, compile homogeneous regional data bases, ensure the needed coordination in across-boundaries hazard assessment, and provide a framework for data exchange and the implementation of unified assessment procedures. While the Regional Centres represent the backbone of the program, much of the work is done at the national level to ensure that all of the appropriate data bases on historical and instrumental seismicity, strong motion and macroseismic data and knowledge of earthquake characteristics are assembled.

GSHAP Regional Centres are hosted by main geophysical institutions in all continents (Figure 9): North and Central America (UNAM, Mexico City), South America (CERESIS, Santiago), Northern Europe (GFZ, Potsdam), the Mediterranean basin (CNPCRST, Rabat), Continental Africa (University of Nairobi), the Middle East (IIEES, Teheran), Northern Eurasia (JIPE, Moscow), Central-Southern Asia (SSB, Beijing) and East Asia-Oceania (PHIVOLCS, Manila).

Each Regional Centre is headed by a Regional Coordinator, a respected scientist with recognized leadership in regional seismotectonics and hazard assessment and assisted by a panel of experts drawn from

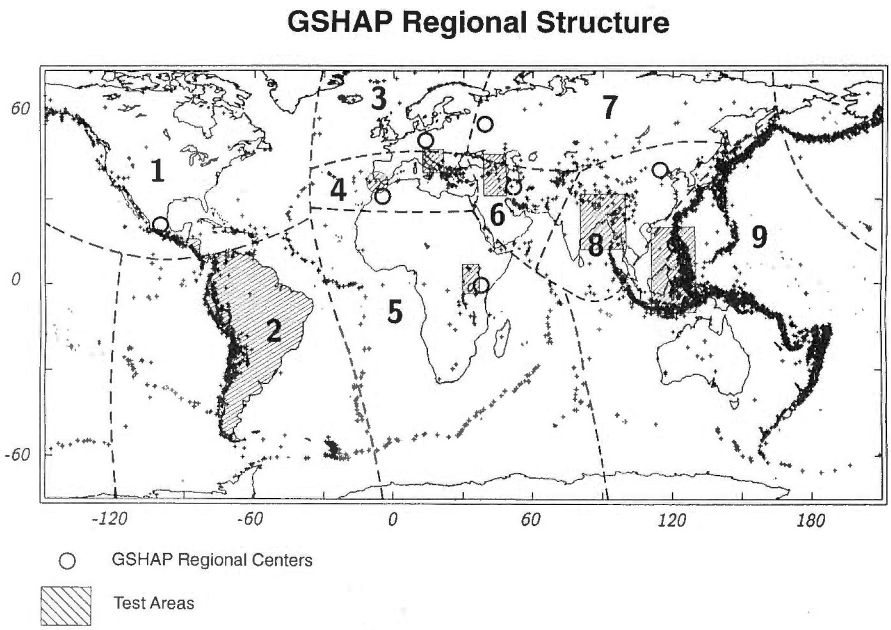

Fig. 9. The regional structure of the Global Seismic Hazard Assessment Program; regions, regional centers and test areas are identified.

the region. The activities conducted under the responsibility of the Regional Coordinator include to establish the Regional Centre (physical location, equipment, personal), identify and activate an operative network of national correspondents in all nations in each region, organize meetings of national representatives to review existing efforts and schedule regional activities, prepare funding requests to secure support and resources, identify test areas for the implementation of the GSHAP multinational approach and assemble joint regional geophysical datasets, coordinate the compilation and analysis of regional data bases and catalogues and the assessment of regional seismic hazard and organize an efficient training and educational program.

In addition, GSHAP designed test areas in all continents, characterized by different tectonic environments and varying levels of seismic hazard, for the initial implementation of the program's goals and methodologies (Figure 9): South America, the Guatemala-Panama portion of Central America, Spain-Maghreb, the Adriatic plate (Mediterranean), the Central Rift system in Eastern Africa, Eastern Turkey-Iran, North India-Tibet-Burma, Indonesia-Philippines.

Targets

The principal targets for GSHAP are the developing countries located in active earthquake belts, that do not have adequate national programs for seismic hazard evaluation. Countries with moderate seismic hazards, which they may not normally estimate and take into account, will also benefit from GSHAP; this is especially true for regions with rare, but potentially very damaging earthquakes, where the hazard estimation can be based on knowledge from similar regions worldwide. Countries that have both high- seismic hazards and advanced national assessment programs are also important targets for the program; their active participation is the key to ensuring regional coordination, high technical and scientific standards, and ultimately the success of the program. Finally, international funding and relief agencies will be provided with a reference framework of global seismic hazards which, coupled with vulnerability studies, can guide their efforts in the latter part of the Decade.

Time plan

The first year of GSHAP implementation has been launched with a Technical Planning Meeting, held in Roma in June 1992, and with concentrated efforts in establishing a regional subdivision of the world and selecting Regional Centres in all continents, devising homogeneous procedures for assembling databases and assessing seismic hazard, initiating activities in test areas with high seismic hazard, obtaining support and resources for the program, nominating the Steering Committee and determining the management structure of the program. Following this preparatory phase (1992-1993), GSHAP will consist of two phases; the first two-year phase (1993-1994) will target specific areas where the multi-national approach will be applied and comparative tests will be conducted to evaluate the performance of selected methodologies in different seismo-tectonic environments; the second two-year phase will expand the regional coverage of GSHAP and transfer the technology of the hazard computational capability from the Regional Centres to participating countries.

Products

The most important seismic hazard product that will become available in each of the Regional Centres by mid Decade will be a computer-based model of earthquake potential and ground shaking potential that can be utilized to produce seismic hazard maps at any required regional and national scale. To this purpose GSHAP has established homogeneous guidelines to deal with the four main components of seismic hazard assessment (earthquake catalogues, seismotectonics and earthquake source zones, strong seismic ground motion and seismic hazard computation) and to select a suite of approaches to deal in homogeneous fashion with different seismotectonic environments, produce hazard estimates at appropriate national scales, depict various ground motion parameters meeting different engineering or national requirements.

GSHAP seeks to foster the widespread application of advanced knowledge and methodologies in hazard assessment and its use in seismic risk reduction. A training and educational program will be conducted at the Regional Centres, focussing on the compilation of geophysical data bases, the assessment of seismic hazard, the use of hazard evaluation in the reduction of seismic risk, the technology transfer of the data bases, hazard model and computational programs to participating national agencies.

Coordination

GSHAP provides a framework for enhanced cooperation in multi-national seismic hazard assessment by building on existing capabilities and assessment efforts at national and regional scales. GSHAP sponsors the compilation of national and regional data bases to common standards and supports the implementation of hazard and risk assessment at national scale; special emphasis is therefore placed on obtaining close working relationships with the appropriate national seismological agencies and institutes. In addition, GSHAP will maintain close coordination with the ILP structure and programs and with the international hazards projects conducted in various regions of the globe; it will incorporate the results of three ILP projects: the World Stress Map, the World Map of Active Faults, and Paleoseismicity of the Late Holocene, initiated to improve understanding of the earthquake process and to provide a firmer basis for the assessment of seismic hazards.

GSHAP has been endorsed by the International Association of Seismology and Physics of the Earth's Interior (IASPEI) as one of the main contributions of the seismological-geophysical community to the Decade.

Finally, to ensure that the program's seismic hazard products are appropriate to the needs of low-cost, earthquake resistant design and construction, a particular necessity exists to coordinate GSHAP purpose and activities with the international earthquake engineering community (WFEO/UATI, IAEE).

CONCLUSION

The UN/IDNDR provides an important chance to improve the global seismic hazard assessment by coordinating national efforts in multi-national, regional projects, reaching a consensus on the scientific methodologies for the seismic hazard evaluation and ensuring that the most advanced methodologies be available worldwide through technology transfer and educational programs.

The ILP's Global Seismic Hazard Assessment Program embodies many of the strategies and priorities of the IDNDR, filling a critical gap cited by many countries in attempting to assess properly the seismic hazard of their territory for the implementation of risk mitigation strategies. The program promotes a regionally coordinated, homogeneous approach to seismic hazard evaluation; the ultimate benefits will be national assessments of seismic hazards, available before the end of the Decade.

The implementation of sound seismic hazard estimations into policies for seismic risk reduction will allow a focus on the prevention of earthquake effects rather than intervention following the disasters. A framework for regional and global seismic hazard assessment, *Proceedings*, International Forum on Natural Hazards Mapping.

Acknowledgements

This report was presented at the International Forum on Natural Hazards Mapping held in Tsukuba, Japan, in July 1993. I am grateful to Y. Kinugasa and to the Geological Survey of Japan for inviting me to the Forum and to ERSDAC for supporting my travel.

References

Giardini, D. and P.W. Basham, The ILP 's Global Seismic Hazard Assessment Program for the UN/IDNDR, Special Issue, Annali di Geofisica, 36, n.3-4, 257 pg., 1993.

Muir-Wood, R., From global seismotectonics to global seismic hazard, Annali di Geofisica, 36, n.3-4, 153-168, 1993.

Geological Survey of Japan Report, No.281, 1995 p.37-43

ESCAP'S Position vis-a-vis Natural Hazards Mapping in Asia and the Pacific Region

Huub Van Wees

United Nations Economic and Social Commission for Asia and the Pacific(ESCAP), United Nations, Thailand

INTRODUCTION

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), with its headquarters in Bangkok, Thailand, has seen its membership rise dramatically in recent years, and it now stands at 48 members and 10 associate member states. Together these countries make up the largest UN Regional Commission, representing almost two thirds of the world's population, and occupying the largest combined territory, both continental and marine.

It will hardly be necessary to dwell once again on the concentration and frequency of natural disasters in the Asia-Pacific region. After all, a significant portion of the world's hazard belts is situated within the ESCAP region, which is plagued by earthquakes, cyclones, floods, droughts, volcanic eruptions, landslides and tsunamis. The fact that most of the countries affected are still in a developing stage aggravates the situation, as their ability to achieve development objectives are often seriously jeopardized by the recurrent impact of natural disasters.

As we all know, the United Nations General Assembly, recognizing the importance of reducing the impact of natural disasters on all humans and particularly those in developing countries, proclaimed the 1990's as the International Decade for Natural Disaster Reduction. During this decade, the international community is to pay special attention to the development of frameworks of international cooperation in the field of natural disaster reduction. The stated aim is to reduce, especially in developing countries, the loss of life and property, and to diminish social and economic disruption caused by such disasters.

Although prior to the Decade, ESCAP had already been involved in efforts to mitigate the effects of natural disasters, particularly when water-related, IDNDR has provided new impetus for attempts to achieve international cooperation in natural disaster reduction. An interdisciplinary task force for IDNDR was subsequently established within the ESCAP Secretariat to undertake multi-sectoral activities aimed at natural disaster reduction in the region.

Early in 1991, in cooperation with UNDRO and the IDNDR Secretariat, and supported by the Government of Japan, ESCAP organized the Regional Symposium for the International Decade for Natural Disaster Reduction in Asia and the Pacific. This was held at ESCAP headquarters in Bangkok, Thailand. Twenty two member and associate member countries, as well as international and regional organizations took an active part in this Symposium, which resulted in some explicit recommendations, quoted in Volume I of the Proceedings, containing a selection of technical background papers and country reports on national efforts to reduce the impact of natural, particularly water-related disasters. After some delay, Volume II is currently being prepared for publication and deals more specifically with geology-related disasters, notably seismic

Keywords: Natural hazards mapping, ESCAP, Asia,Pacific, International Cooperation

and volcanic disasters, and to a lesser degree with landslides and tsunamis.

For historical reasons, ESCAP's activities in the area of natural disaster reduction have favored water-related disasters, as its previous Bureau of Flood Control (now the Water Resources Section), was involved in this long before the Decade started. The Secretariat's approach in dealing with geology-related disasters reflects ESCAP's long-term view, embodied in its "Geology for Planning" programme. This programme advocates the full incorporation of geological data in the planning of land use and urban development, with the explicit aim to avoid future geology-related disasters, be they 'man-made' or 'natural'. In the next chapter, the rationale behind this approach is expanded upon.

NATURAL HAZARD MAPS - HOW AND WHY

As the aim of the International Decade for Natural Disaster Reduction is to halve the loss of life and property caused by natural disasters, the question to ask is how. The simple answer of course is to avoid natural disasters from occurring, or if that proves too difficult, to at least mitigate the effects of such disasters on life and property.

Many individuals or even whole societies have come to accept natural disasters as normal facts of life, as unavoidable and "natural" as their name implies. But is this fatalistic view really valid? Before arguing this point it is worth dwelling - perhaps superfluously - on the concept of what actually constitutes a natural "hazard", as distinct from "risk" or "disaster". The following definitions are generally followed:

A **hazard** is the probability that a given area will be affected by potentially destructive natural processes or products within a given period of time. **A risk** is the possibility of a loss, such as life, property and/or productive capacity within an area subject to hazards. Risk assessment involves the consideration of the following relation:

RISK = VALUE X VULNERABILITY X PROBABILITY,

where VALUE may include the number of lives, property, civil works and/or productive capacity threatened, and VULNERABILITY is a measure of the proportion of the value likely to be lost in a given hazardous event. Finally, a **disaster** is the tragic result if such a hazardous event does indeed lead to the loss of life, property and productive capacity that happens to be at risk within a given hazardous area.

The message seems clear: natural disasters do not take place if the value (life, property, productive capacity, etc.) is not put at risk by locating them in hazardous areas (hazard zones). Consequently, if we are able to avoid "hazardous events " from becoming " natural disasters", even if only in some cases, we would fulfill the objectives of IDNDR.

Singling out geology-related hazards in Asia and the Pacific, the task before us is more clearly defined, i.e., we have to consider how to avoid *earthquakes* and/or *volcanic eruptions* from becoming natural disasters (similarly, related "events" such as *landslides* and *tsunamis*, do not necessarily have to result in disasters either).

The obvious goals here are 1) to avoid future disasters altogether (or to make the chance of their occurrence very small) in areas that have yet to be developed or are in an early stage of development, and 2) to minimize the scale and impact of future disasters on life, property and productive capacity that are evidently already at risk and are impossible or unlikely to be moved to safer areas, for whatever reason, historical or otherwise. Here we have come across the major issues in the field of geology-related disasters:

1) **land use planning** and 2) **disaster management.**

Taking the long-term view, proper land use planning, by incorporating all geology-related data available, would identify and allocate hazard-free areas for industrial and urban development and thus be by far the most effective way of dealing with seismic or volcanic disasters: high gains at relatively low costs.

However, as we obviously do not live in a pristine world, but instead have inherited less-than ideal living conditions in often unsuitable locations, we are in such cases morally obliged to take the short-term view as well. Large concentrations of people, particularly in cities and coastal areas that happen to be within hazardous zones, if they cannot or will not be moved to safer areas, deserve to have at least a fighting chance of survival in the event of a natural disaster. Authorities in charge of disaster management will therefore have to have at their disposal reliable estimates of the type and severity of the damage likely to occur to people and property, and even more important: where. When acted upon, such information will translate in contingency plans and efficient relief operations that will save lives and, through enforcement of building codes, safeguard or limit damage to property. (In this context: making it a legal requirement to have property insurance against damage inflicted by natural, particularly seismic events may well be the most efficient way to ensure that 1) building codes are indeed followed and that 2) codes are properly allocated according to realistic criteria based on actual geological conditions).

What both approaches have in common is their reliance on geological data on which to base crucial planning and management decisions. A related aspect not to be overlooked is that such geodata need not only be reliable, the information must also be readily understandable to the planners and decision-makers who are likely to be educated laymen as far as geoscience is concerned.

User-friendly maps

Geological sciences are map-oriented. Hence the most user-friendly format for such data is the thematic map. To produce such maps requires from geologists, seismologists, volcanologists and other geoscientists that they become more client-oriented and produce maps uncluttered with data, irrelevant to the 'theme' at hand. It is precisely this aspect that has hitherto been the focus of ESCAP's "Geology for Planning" programme, which has worked for and still promotes the active and efficient interchange of relevant information between the geoscience and planning communities of member countries. ESCAP activities should follow a three-pronged approach:

1) Creating awareness of the crucial nature of geological information, in order to avoid natural as well as man-made geology-related disasters.
2) Training geoscientists in the production of user-friendly presentations of relevant data (thematic maps, e.g. depicting hazard-zoning, risk-zoning, past disasters, etc.).
3) Promoting the establishment of a framework of communication between the geoscience and planning communities: essentially an organizational issue.

Apart from organizing seminars, workshops and training courses, the Secretariat has published numerous case studies, mainly of urban centres in the ESCAP region, that have suffered from the disastrous effects of ignoring geology in their planning and development stages. Such studies create an awareness of the crucial nature of geology in the avoidance of natural geology-related disasters in the future. Later issues of the ESCAP Atlas of Urban Geology have focused more and more on the thematic map as a communications and planning tool. Current preparatory work to publish a series of urban and environmental geological maps of the city of Ningbo, in China, must be viewed in this light. This series of 15 maps is among the first attempts in the region to produce a comprehensive set of thematic maps, ranging from groundwater vulnerability through bearing strength to ground stability, etc. and culminating in land use recommendations aimed at avoiding undue disasters, either natural or man-induced, but all geology-related. When published, the maps are expected to attract interest as an Asian "first" and as prototypes worth emulating even if fine-tuning may prove to be necessary.

This ESCAP activity, albeit less than spectacular, may turn out to be significant indeed if it will foster a new breed of geologists and other geoscientists, who are able and willing to transform their cherished scientific data into practical, ready-to-use maps that will save lives and limit damage to property and production capacities.

Needless to say, that the Secretariat, alongside many other activities in the field of geoscience, must continue on its chosen path, viz. promoting the incorporation of geological data in both long- and short-term planning aimed at avoiding or reducing the impact of natural disasters. This will have to be done on a country-specific basis, as some developing countries will still need to build or strengthen institutional capabilities to collect relevant geodata, while others may want to concentrate more on staff training to improve interpretational and/or presentational skills; yet others may have to focus more on organizational or managerial issues. All these aspects are taken into account in a new project proposal currently under donor review and which will hopefully become operational this year.

A POTENTIAL ROLE FOR REMOTE SENSING

As part of the international effort to achieve the IDNDR objectives to significantly reduce the impact of natural hazards on populations, assets and national economies, with emphasis on developing countries, it is only natural that next to traditional methods of research and observation, the latest in technological advances are mobilized for this purpose.

In this regard, let us consider the role remote sensing could and does play in reducing the effect of the main geology-related hazards: earthquakes and volcanic eruptions (the all important role that satellites already play in early-warning and monitoring of weather-related disasters is known to us all). Like the traditional ground and airborne observation methods that will remain indispensable, satellite-borne remote sensing has a dual role to play, since it has mapping as well as monitoring capabilities, with a promising forecasting potential.

Mapping

In the collection of input data for the production of thematic maps, satellites could assist in assessing and mapping the extent of damage, as well as surface expressions like faults or shear zones associated with earthquakes that would help both in building up a historic record and in interpretation of causative processes. The effects of volcanic eruptions are easier to map, as lava flows, ash falls and lahars are all rather obvious phenomena. Landslide areas also are easily mappable after-the-fact.

Monitoring

Floods and typhoons are both more common and easier to monitor, which explains the predominant use of remote sensing in these fields. To a lesser extent, but still significantly so, volcanism can be monitored after, during and often also before eruption, due to what amounts to 'inflationary behavior' of the volcano. In the case of earthquakes, however, the situation is more complex and precursory phenomena are harder to detect. Yet, here may lie a task particularly well suited for remote sensing by satellite.

In September 1992, when Mr. Kouzo Watanabe, as Minister for International Trade and Industry of the

Government of Japan, proposed a programme of international scientific cooperation to cope a.o. with natural hazards, the launching of the first Japanese Earth Resources Satellite was imminent. Naturally, JERS-1 was indeed expected to play a contributive role in the proposed disaster reduction programme, in addition to using its resource assessment and environmental monitoring capabilities.

Forecasting

No doubt a host of mapping and monitoring activities are already foreseen for JERS-1. Even so, it may be worth dwelling on the additional role satellites of this kind could play in prediction. Volcanic eruptions as well as earthquakes are preceded by a multitude of associated phenomena that, if properly studied and understood, could well develop into a forecasting capability.

Thermal precursors

Dr. Qiang Zuji, at the ESCAP-UNDRO Workshop on the Application of Space Techniques to Combat Disasters held September 1991 in Beijing, put it as follows: "Compared to existing earthquake prediction technology and methods of seismic monitoring and prediction, remote sensing technology is of a unique technical superiority [e.g.] because of its ability to monitor the dynamic evolution of thermal anomalies on the Earth's surface macroscopically, which could lead to an improved ability for earthquake prediction". His words were based on observations of changes in ground temperature prior to earthquakes of magnitudes higher than 5 that struck China in 1989. It was found that among 15 such events, 11 experienced increases in ground temperature immediately (2 to 7 days) before the main tremor. Despite shortcomings due to the instruments* inability to penetrate cloud cover (although Qiang *et al.* (1991) suggest some ways to get around the problem), this precursory behavior may be worth studying further and could well lead to higher quality predictions of both time and place of major earthquakes.

Ground swell

Another phenomenon worth considering in this context is the precursory vertical ground movement associated with volcanic eruptions (well known) and with earthquakes (less well studied). Of course in several locations, this phenomenon has been and is being used in monitoring known earthquake faults as well as volcanoes. Such work can be very effective as an early-warning system, and should of course continue. The drawbacks however, especially concerning earthquakes, are that 1) the area expected to fail has to be known in detail beforehand, i.e., it has to be preceded by earlier stages of prediction, and 2) the instruments are tied down, so the observations have very limited bearing outside the immediate vicinity. One possible remedy would be a proliferation of instruments and measuring stations, an option that only the most affluent society could begin to contemplate, if at all.

Here again, satellite technology could step in as a welcome solution. The current easing of international tensions has led to more liberal policies with regard to making available on a commercial basis, certain advanced capabilities and data that were previously inaccessible or of lesser quality. Field geologists already benefit from highly accurate global positioning systems. Within the context of the present Forum, it is worth noting the extreme precision with which vertical shifts in ground elevation can now be detected by synthetic aperture radar (reportedly down to 1 mm) although horizontal resolution is much less. Prof. Amos Nur (pers. comm., 1992) of Stanford University, California agreed that research using this capability to detect acute stress- (and therefore strain-) buildup associated with earthquakes holds promise of better prediction in the

**) The instruments considered are an Advanced Very High Resolution Radiometer (AVHRR) and a Visible Light Thermal Infrared Spin Scan Radiometer (VISSR).*

future. Studying 'current' earthquakes and their strain phenomena immediately before these seismic events could produce clues as to which behavior is most indicative of imminent earthquakes.

In this way, an extensive database on precursory behavior would be accumulated, that could greatly enhance seismology's diagnostic skills. As mentioned, the satellite's independence of a specific site guarantees that more relevant data will be collected in a shorter time span. Moreover, any ground movement associated with an impending earthquake is likely to be detected, even in areas where earthquakes are not expected. 'New' earthquake faults or shear zones away from 'classical' earthquake lines may thus be discovered or confirmed. Examples of such new seismic lines have been observed in California by Nur *et al.* (1992, in manuscript) and no doubt elsewhere.

The two examples mentioned above of seismic precursors potentially detectable by satellite are likely to be joined by others as soon as this line of research is pursued in earnest and on an international level. With current SAR-equipped satellites, their orbital cycles of around 11/2 months are a major impediment in the development of an effective early-warning system, whereas geostationary orbits will not provide the resolution required. Hence, close international cooperation is clearly what is needed here. Nevertheless, a single-satellite approach would yield at least some answers with regard to technical feasibilities on which to base collaborative programmes that are sure to come.

Coordination and collaboration

Returning to the topic of small-scale natural hazards maps of Asia and the Pacific region, there are a number of points to consider. Many initiatives have been developed with similar or related 'themes', both worldwide and regional. In the Asia-Pacific region alone, ten small scale maps are available with relevance to seismic hazards. The main sources of these maps are the People's Republic of China, The Circum-Pacific Council's CPMP, Japan, the USGS and Munich Reinsurance.

Seen in this light, the present Japanese initiative is understood to be a most welcome effort to arrive at a truly international data compilation that merits the name of Natural Hazards Map of Eastern Asia or, to more closely match the recommendations of the member states that make up the ESCAP Commission, among which Japan: Seismic (and Volcanic) Hazards Map(s) of Asia and the Pacific. ESCAP is particularly supportive of the proposed programme as it clearly identifies the various small-scale maps that will provide an overview as the first stage in a series of activities leading up to large-scale thematic zoning maps that are suitable for practitioners.

RECAPITULATION

Natural Hazards mapping in Asia and the Pacific should be seen as a significant contribution to natural disaster reduction in the region, as it may be expected to produce a hierarchical series of maps, culminating in truly client-oriented, user-friendly thematic (hazard- and risk-zoning) maps that will be used in practice, i.e., both in land-use planning (in an effort to avoid natural disasters) as well as in disaster management (preparedness, relief operations, etc.) and - not least important - in insurance (facilitating the enforcement of building codes). In addition, part of the effort should continue to go into research aimed at generating an effective early-warning system, hopefully by including the latest in remote sensing techniques.

ESCAP expects this comprehensive approach to be effective in achieving the objectives of IDNDR, with both short- and long-term effects that will continue to reap benefits for the populations of the region, way beyond the Decade.

RELEVANT DOCUMENTATION

ESCAP (1988): "Urban Geology in Asia and the Pacific- Bangladesh, Fiji, Indonesia, Malaysia, Nepal, Pakistan, Republic of Korea, Sri Lanka, Thailand and Viet Nam"; Atlas of Urban Geology, Volume 2.

______, (1990): "Geology for Land-Use Planning in Asia - China, Indonesia, Malaysia, the Philippines and Thailand"; Atlas of Urban Geology, Volume 4.

______, (1991): "Natural Disaster Reduction in Asia and the Pacific: Launching the International Decade for Natural Disaster Reduction, Volume 1, Proceedings, Water-related Disasters, 11-15 February 1991, Bangkok.

______, (1992): "Environmental and Urban Geology for Sustainable Development of New Economic Zones" - Project Document, Natural Resources Division.

NUR, Amos, Hagai Ron, Greg Beroza and Laura Alfonsi (1992): "The Mechanical Origin of the Mojave Desert, Earthquake Line" - Department of Geophysics, Stanford University (in manuscript form).

QIANG Zuji, Xu Xiudeng and Dian Changgong (1991): "Monitoring and Predicting Impending Earthquakes using Satellite Remote Sensing Techniques". In: "Remote Sensing to Combat Natural Disasters" - Report of the United Nations ESCAP/UNDRO Workshop on the Application of Space Techniques to Combat Natural Disasters, 23-28 September 1991, Beijing. pp. 102-108.

RYNN, John M.W. (1992): "Earthquake Prognostics for Australia: Earthquake Zonation of Urbanized Areas in Australia - Implementation of International Lessons with those from the 1989 Newcastle and Other Australian Earthquakes" - paper presented at the 7th International Seminar on Earthquake Prognostics, 22-26 September 1992, Bangkok.

RYNN, Jack (1992): "Brief Report on the Concept of a Natural Hazards Map for Australia and the Western Pacific Eastern Asia Region, Based on Australian IDNDR Project 2/91" - Centre for Earthquake Research in Australia.

Geological Survey of Japan Report, No.281, 1995 p.45-49

Hazard Map Project and Related Activities of Natural Disaster Science in Japan

Shinjiro Mizutani

Nagoya University, Japan

ABSTRACT

This report describes a brief review of history of the natural disaster science in Japan in relation to studies of hazards maps before and after World War II. One of the epock-making matters is the establishment of Japan Society for Natural Disaster Science in 1981. In the course of the study on disasters, although, some hazard maps were published in Japan, we should develop the new methods and techniques for compiling the hazard map.

INTRODUCTION

The Japanese Islands are located in East Asia, that is, in the eastern part of the Eurasia continent and in the western part of the Pacific ocean. The natural environment of these islands is essentially controlled by movement of the earth crust and the meteorological factors between the greatest ocean and the greatest landmass. Basically they are of two origins, endogenetic and exogenetic. The former is represented by movement of two lithospheric plates or subduction of the Pacific and Philippine plates underneath the Amur plate; surface expression of this structure appears as tremors of ground and burning mountains. In the atmosphere and hydrosphere of this region, there is a Pacific equivalent of the hurricane of the Western hemisphere, which is frequently born in the tropical zone of Southeast Asia near the Philippines and used to hit Japan. Japanese people have suffered from these three types of natural disasters, i.e., earthquakes, volcanic eruptions and typhoons.

Since the Japanese islands are densely populated and provided with intelligent facilities of high-technologies, damages by natural disasters become more serious problems in modem cities or metropolitan areas. We are always discussing the disasters from the scientific or technological viewpoint, and nowadays from the social or economical viewpoint. We had "The International Forum for Natural Hazard Mapping" in Tsukuba on June 22-24, 1993; right after the meeting, we have experienced a big earthquake named "Heisei 5 (1993) Hokkaido-Nanseioki Earthquake" on July 12 which accompanied Tsunami at Okushiri Island. We frequently feel that we live on the dynamic earth.

Undoubtedly, the reduction or mitigation of the natural disaster damages is, and will be, part of important tasks of the earth scientists. Although it is really difficult to predict a disaster or to prevent the natural phenomena related to the disaster, we can do some works for public awareness and preparedness in order to reduce the loss of lives and properties. Natural hazard mapping is one of such works we can do. In this report, I will describe a brief review of history of the natural disaster science in Japan in relation to studies of hazard maps.

EARLY PERIOD OF STUDIES OF NATURAL DISASTERS

An earthquake occurred on October 28, 1891 in central Japan. It is called "Nobi Earthquake" and is probably so far the most well-known earthquake in the world, because scientists first recognized a direct

Keywords: Natural hazards, Hazard mapping, Japan,Natural disasters, IDNDR

relationship between earth's trembling and faulting. The fault extends 80 km with vertical gap of 6 m and horizontal displacement of 4 m. Sir Archibald Geikie, who was a president of Geological Society of London, cited in his text-book a sketch of the fault described by Prof. B.Koto (geologist) as evidence of earthquake which makes a fault, but the cause-and-effect of earthquake and faulting was not yet fully understood at that time.

After abolition of feudalism in the first decade of the Meiji Period (1868-1912), westernization of daily life took place in every part of the Japanese society; the period saw Japan's transformation from an old polity into a modern industrial country along with its emergence from isolation into the ranks of major powerful nation. Academic organizations and educational systems of European style were also introduced and established. The Japanese government invited Western lecturers, sent student abroad, and had them teach specialized course when they returned to Japan. The Japan Academy was thus established in 1879 and the University of Tokyo in 1886, renamed as the Imperial University of Tokyo in 1897.

Prof. B. Koto was one of such scientists who returned from Europe and taught students in University of Tokyo. The earthquake (Nobi Earthquake of 1891) and the resultant fault (Midori Fault) was investigated by him together with the members of research group of "The Committee for Earthquake Disaster Prevention". In 1923, we experienced the Great Kanto Earthquake (or Great Tokyo Earthquake) on September 1, the most destructive earthquake in the modern period of Japan. The government and the public had paid attention to the earthquake; and the Committee for Earthquake Disaster Prevention was reorganized in 1925 as an institute named the Earthquake Research Institute of University of Tokyo, and it became a center of seismology in Japan.

Before World War II in Japan, research works regarding the natural disasters has been carried out in the Earthquake Research Institute, where studies on the earthquakes and volcanic eruptions have been done chiefly from the scientific viewpoint. In the early half of this century, Japan was still in a stage of so-called developing country, because the economic progress has been rather low in rate. Daily lives of the Japanese people were also at low levels when compared with those of the European families. Science of the disaster prevention or prediction has been treated as part of the basic science in every academic institution. During the war time of the 1940's, academic environments were miserable for all the students in universities and colleges. In addition, information concerning natural disasters was usually controlled on the military basis; in fact, nothing has been informed to the public as to the big damages by the Tounankai Earthquake (Dec. 7, 1944) and the Mikawa Earthquake (Jan. 13, 1945).

NATURAL DISASTER SCIENCE AFTER WORLD WAR II

Some of seismologists and geophysicists were, however, aware of these two earthquakes having occurred just before the end of the war. Discussing the damages, they pointed out the importance of the study of earthquake, when the Nankai Earthquake (Dec. 21, 1946) occurred. In newspapers also reported were the damages by two typhoons (Sept. 17-18, 1945; Sept. 14-15, 1947) and by heavy rain and flood. Prof. K.Sassa (geophysicist) and other professors of Kyoto University established a juridical foundation named Institute for Disaster Prevention in Kyoto. In 1948, we had another damage by earthquake of the inland type (Fukui Earthquake of June 28, 1948). Probably, this was one of the factors to promote the study of natural disasters in Japan, and in 1951 the Disaster Prevention Research Institute was established at Kyoto University. It began with three sections, i.e., the scientific section to carry out a basic study on natural disasters, the hydrological section to study floods and related disasters, and the engineering section to do an applied research on counter-measures. Now, in 1993, it consists of 16 sections, 7 observatories and one administration office.

The Earthquake Research Institute of University of Tokyo and the Disaster Prevention Research Institute of Kyoto University were two academic research centers in Japan - for natural disasters mainly of earthquakes and volcanic eruptions in the former, and for those of earthquakes, volcanic eruptions, typhoons, windstorms, floods, coastal damages and landslides in the latter.

After the Isewan Typhoon of Sept. 26-27, 1959, however, a new trend of activities to promote the research work of the natural disasters appeared. Right after the rescue reconstruction of the damages by the Isewan Typhoon, Prof. M.Hasegawa (geophysicist), President of Fukui University, asked an officer of the administrative committee of the Association of Japanese National Universities to send a letter to all the presidents of the national universities in order to investigate the actual circumstances of academic environment for research works on the natural disasters in the universities. He worked diligently together with Prof. Z. Tsukano (geologist) of Fukui University, organized a research group and got the research fund exclusively for the study of natural disasters. At the outset, the group was composed of only 13 members funded by the Grant-in-Aid for the Scientific Research given by the Ministry of Education of the Japanese Government amounting ¥800,000, headed by Prof. M.Hasegawa. This marked the birth of the Japanese Group of Natural Disaster Science, now composed of more than 1,500 members in all.

This group of researchers including geophysicists, geologists, geochemists, hydrologists, civil engineers, meteorologists and others, is established as an inter-university organization, having eleven discipline-oriented subgroups on one hand and six local subgroups on the other. A researcher always belongs to a subgroup of his specialty and at the same time to his local subgroup, thus the group being composed of scientists of various specialties and of local university professors closely interwoven with each other. The group has been managed by a standing committee and several steering committees which consist of a chairman of each subgroup of specialities and of each local subgroup. In this decade, some of the members of this research group have been working not only in Japan but also abroad.

No doubt, studies of the disaster prevention or mitigation are undertaken in the academic organization, while projects or plans against the disasters should be implemented through the national and/or local governments. We have, therefore, many research institutions of the governments; the Geological Survey of Japan (belonging to "Agency of Industrial Science and Technology" of the Ministry of International Trade and Industry) or the National Research Institute for Earth Science and Disaster Prevention (belonging to Science and Technology Agency) are by far the most well-known and active institutions. Land-development projects, urbanization with transportation facilities or environmental conservation plans are being implemented under the governmental policies, and they are usually administratively guided by the following offices of the Japanese Government: Disaster Prevention Bureau of National Land Agency / Meteorological Agency of Ministry of Transport / Public Works Research Institute, Building Research Institute and Geographical Survey Institute (all these three belong to Ministry of Construction) / Fire-Defense Agency of Ministry of Home Affair.

JAPAN SOCIETY FOR NATURAL DISASTER SCIENCE

During the 1970's, researchers of natural disasters in universities and in institutions were increasing, and they began to exchange information and their study-results. They discussed that disciplines concerning natural disasters essentially consist of science and technology, but they extended their tasks much wider into the social science involving psychology and sometimes economy. In fact, many case-studies of disasters have been undertaken from socio-technological or socio-psychological viewpoint.

The Japanese Group for Natural Disaster Science was originally supported financially by the Grant-in-Aid for Scientific Research given to us by the Ministry of Education of the Japanese government. This group is essentially of an academic type, and it had been argued that it had better for us to manage this group by membership-fee of all the research-members as an academic society like other nonprofit organization of science. Prof. I. Matsuzawa (geologist) of Nagoya University was one of the leaders who exerted himself to establish the society. He presented his idea and organized professors, and in 1981, he established the society named "Japan Society for Natural Disaster Science'' and was elected as the first president of the society. The first volume of the publication named "Journal of Japan Society for Natural Disaster Science" was published in March 1982.

Studies of the disasters are slowly changing to a wider and more interdisciplinary field of investigation.

For example, the importance of public awareness of the natural disasters is recognized again, and as a result, some of the university teachers even in an engineering department have much interests in "education on natural disasters" rather than mechanism of disastrous phenomena. On this kind of studies, we need much help of the specialists in the social science. The study of "panic" is another example of such new field of investigation, where many psychologists have been working together with the natural scientists. We should pay much attention to the panic state of mass movement of persons in a restricted narrow space and/or time, when considering emergency evacuations at the time of disaster. Awareness and preparedness before disaster, voluntarism and rescue at the time of disaster, rehabilitation and reconstruction after the disaster these items have not been traditionally treated in the field of natural disaster science - become part of major works to be discussed. The principal task of the natural disaster science is to predict and prevent the disaster; but, if it is difficult to do, we should work for the public in order to mitigate the damage. Along with extending our field of investigation, "hazard map" became as one of the main projects in our science.

HAZARD MAP PROJECT

For public awareness and preparedness, "map" furnishes very fruitful information to understand the social and natural environments in our daily lives. If we can depict characteristic features on a map before and after a disaster, the difference represents the resultant effect by that disaster and it will be utilized for evacuation, housing, land-development and other purposes. Possibly, it can be used for insurance. There may be various kinds of "hazard map" in type of dimension, in scale and in expression of items treated. In the 1970's in Japan, however, we could not discuss openly the hazard map, because if it were published, it would directly affect the ground-price of the mapped area. If it is published in scale of 1:1,000,000, the map is exclusively for academic use. But it is published in scale of 1:10,000, the hazard map will be very valuable and used for various purposes, sometimes for a different purpose.

We had, however, several kinds of maps, like a map showing a possible liquefaction area; they were demonstrated solely for the research work in an academic meeting in the early 1980's. We had no severe problem on this kind of map, because possible hazardous areas are distributed mostly in a coastal or fluvial part - not in a residential part - of a region. On the contrary, when a map includes the residential part, a serious discussion might be aroused. This kind of discussion has been stirred up many times in a local society.

In the late 1980's, however, local societies or public became cooperative for the publication of this kind of map, because people are aware of the importance of the hazard map for their own safety and preparedness. In an academic group, discussion on the hazard map is extended much broader than before. Prof. S.Aramaki (volcanologist) of University of Tokyo discussed a conception of the map of volcanic hazard by presenting an example of damage at Armero of Colombia in 1985, while Prof. Y.Katsui (volcanologist) of Hokkaido University, compiled a map of volcanic disasters in Hokkaido. Similarly, a group of researchers on landslide in governmental sector as well as academic one has been working to compile a map showing landslide areas in Japan in various scale. In most cases, the data is stored and is utilized for public service as a computer-aided database.

It has been pointed out so far that one case-study on a disaster of a particular type will be always helpful to understand the other of the same type in a different place. In a course of making a hazard map, we will research all the records of past disasters, and we will have a comprehensive understanding as to the disasters at that place. What's more important is that during the works and publication of a hazard map public awareness and preparedness will increasingly grow up, which will be most powerful at the time of next occurrence of disaster. Scientists know what the map is and what its potential could be.

As a noticeable work, I can show "Guidelines for Preparing Volcanic Hazard Maps: published in 1992 by National Land Agency, Government of Japan (in English, 58 pp.)". This booklet describes Sakurajima Volcano of Kagoshima Prefecture, Southwest Japan, as an example. Hazard maps (and map for disaster prevention) were published, under the guidance of Prof. H.Kawakami (civil engineer) of Shinshu University, in 1988 and 1989 in Nagano City, Central Japan, where many landslides are now in progress. These examples drew attentions of all people, local as well as national, in Japan.

IDNDR AND HAZARD MAP PROJECTS

There is no particular boundary in nature, although discussions are frequently made on the political basis along national boundaries on a map. Hazard maps have nothing to do with such boundaries, and they should be treated not only interdisiplinarily but also internationally. Except for topographical analysis, we will treat every part of the earth surface equally. Because of this essential nature of the hazard map, a hazard map project is a good example for recognition of the natural environment and for understanding the disaster management in a global scale. I believe that the hazard map project is one of the best among the proposals presented in International Decade for Natural Disaster Reduction (IDNDR).

Hazard map projects include (1) description of the natural environment, (2) collection of records of the past disasters, (3) prediction of possible disasters both in type and quantity, (4) evacuation process, (5) possible damage map, both physical and economical, including maintenance and reconstruction of lifelines, (6) map for land-development planning, and (7) summary map exclusively used for public awareness. Difficulties are found in expression of different disasters, because the size of area concerned is always different depending on the type of disaster. Rock-fall disasters are frequently small in size when treated as a natural phenomenon, but if a falling block hits a person, the result will be a fatal one. Similar discussion will be inevitable in the modern cities where every part is densely populated. Nowadays much more important is the safety of lifelines or communication cables in so-called intelligent buildings. It is said that for the disaster management in a modern city, we need hazard maps of a quite different type. We should develop the methods and techniques for getting data to compile the hazard map, which also make progress of the natural disaster science.

I should close my discussion on the hazard map project by describing the results which will be obtained and expected during this decade. They are as follows: (1) Needless to say, the direct result will be to use the map for the preparedness and disaster management in the mapped area. (2) During the work, it is also expected that international cooperative research teams will be fostered in various branches of natural disaster science. (3) During or after a work, we will be able to collect a large amount of data as to the disasters of particular area. They will be invaluable, and, therefore, we should keep them in a data-center for general use. Enthusiastic efforts will be needed for establishing such center.

This year, 1993, was a special year for us, because Dr. Frank Press (geophysicist), the proposer of IDNDR, came to Tokyo in April as a laureate of Japan Prize. Some Japanese scientists celebrated the prize by realizing his contributions to the natural disaster science. We had an international meeting in Tsukuba for "Natural Hazard Mapping" on June 22-24, and in Nagoya we had another international meeting for "Disaster Management in Metropolitan Areas for the 21st Century" on November 1-4. This year was also remembered as a year when many disasters happened in the world as well as in Japan. The Japanese people have much more interests in natural disasters than before, and they will understand the project of Natural Hazard Mapping, which forms a major part of the natural disaster science.

Geological Survey of Japan Report, No.281, 1995 p.51-53

Eastern Asia Natural Hazards Mapping Project - a contribution to the IDNDR and GSHAP

Yoshihiro Kinugasa

Geological Survey of Japan, Japan

ABSTRACT

Geological Survey of Japan (GSJ) proposed the Eastern Asia Natural Hazards Mapping Project (EANHMP) in 1992 through international collaboration. As the first phase, this project focuses on geological hazards in the given area. GSJ held the International Forum "Hazards Mapping" at Tsukuba in June, 1993. The goal of this project is to compile a small scale geological hazards map of eastern Asia with relevant activities such as development data bases and Geographic Information System, and publication of maps and documents in digital form as well as conventional forms. All countries in the region are invited to participate in the project. Participation from outside the region is also welcome.

OBJECTIVES

a) To enhance awareness of geological hazards among decision makers and the general public in the region.
b) To promote scientific study of geological hazards in this region.
c) To transfer technology to developing countries through collaborative activities.
d) To contribute to the IDNDR and GSHAP.

ACTIVITIES

a) Development of data bases on geological hazards incorporating locally available data which would supplement existing data files.
b) Compilation of a small scale map to present regional characteristics of geological hazards.
c) Publication of the output from the project in both hard copy and digital form which enhance the usefulness of the compiled data.

SCHEDULE

1993: International Forum on Natural Hazards Mapping to define scope of work of East Asia Natural Hazards Map.
1994: First Working Group Meeting.
1995: Second Working Group Meeting.
1996: Special Symposium on Geological Hazards at the 30th International Geologic Congress in Beijing, China. Third Working Group Meeting.
1997: Fourth Working Group Meeting.
1998: Publication of map sheets, reports, and concluding symposium.

Keywords: Natural hazards mapping, Japan, GSJ, GSHAP, IDNDR, Asia

PARTICIPATION

All countries in the region are invited to participate in the project. Participation from outside the region is also welcome.

ORGANIZATION

a) Each participating country would establish its own National Committee responsible for collecting and organizing information for their part of the region.
b) An overall Steering Committee would meet annually to review national contribution, oversea the central compilation of the Natural Hazard Map and data base, and select an International Advisory Board.
c) Subcommittees for each hazard would also be established such as earthquake, volcano, mass-movement, database/GIS and remote sensing.

AGENDA FOR MAP LEGENDS

1. Earthquake

1.1 Major Destructive Earthquakes
Source: "Catalog of Significant Earthquakes", NOAA
Agenda: Criteria for map symbols, e. g. casualties, damage, magnitude.
Determine lower threshold.

1.2 Background Seismicity
Source: ISC or NEIC
Agenda: Determine threshold of magnitude, depth and age to be plotted.

1.3 Active Faults
Source: ILP Task Group 11-2 (Trifonov Project)
Agenda: Data availability.

2. Volcanoes

2.1 Major Destructive Eruptions
Source: "Volcanoes of the World", Smithsonian Institute
Agenda: Possible criteria for categorizing volcanic hazards other than the
Volcanic Explosively Index (VEI)

2.2 Distribution of Volcanoes
Source: "Volcanoes of the World", Smithsonian Institute
Agenda: Possible other source and other categorization criteria besides
rock types (Basalt, Andesite, Dacite) by color.

3. Landslides

3.1 Distribution of Landslides
Source: USGS
Agenda: Criteria for map symbols, size threshold and source availability.

4. Ground Subsidence, Liquefaction and Flood

4.1 Thick Alluvial deposit, vulnerable to subsidence and liquefaction
Source: geologic maps?
Agenda: Data availability

4.2 Lowland, vulnerable to flood
Source: topo map?

Agenda: Categorization criteria.

5. Tsunami

Source: Pacific Tsunami Warning Center?

Agenda: Data availability and categorization criteria

6. Other Elements

Soil erosion, Sink hole collapse, Desertification

7. Climatic Hazards

Glacial phenomena

8. Back Ground Information

Geology, Tectonics, Population, Infrastructure

Ⅱ. Database and GIS for Natural Hazards

Geological Survey of Japan Report, No.281, 1995 p.57-84

Natural Hazards Data and Information in the United States

Paula K. Dunbar* ,Sylvia C. Dane **and Paul Kilho Park***

**National Geophysical Data Center, NOAA,*
***Natural Hazards Research and Applications Information Center, Institute of Behavioral Science, University of Colorado,*
****NOAA, Office of the Chief Scientist.*

ABSTRACT

The United States suffers loss of human life and tremendous property damage from natural hazards each year. We need to understand the physical nature of natural hazards and society's response to disasters to reduce these fatalities and economic losses. This understanding comes from collecting information, conducting research, and disseminating the results. Mitigation can only occur if these data exist and are easily accessible. In this paper we describe organizations in the U.S. that maintain databases on natural hazards, collect information on mitigating the impacts of natural hazards, or are involved in natural hazards research. The name of the organization, contact information, descriptions of the databases and information available from each organization are also included. The paper is organized by sections covering earthquakes, volcanoes, landslides, hurricanes, severe storms, wildfires, drought, and floods. In addition to providing database and research information, watch and warning procedures are discussed where applicable. Also included are sections covering disaster epidemiology and the international electronic availability of natural hazards data and database information. The most comprehensive clearinghouse for disaster information, operated by the University of Colorado at its Natural Hazards Research and Applications Information Center, is also described.

INTRODUCTION

The United States suffers loss of human life and tremendous property damage from natural hazards each year. Listed below are recent examples of some of the worst natural disasters in recorded history in the United States:

- The Loma Prieta earthquake, $6 billion in damages and 62 deaths (1989);
- Tornadoes in the Chicago area, $165 million in damages and 27 deaths (1990);
- Oakland/Berkeley Hills wildfire, $1.5 billion in damages and 25 deaths (1991);
- Hurricane Andrew[1], $30 billion in damages and 50 deaths (1992);
- "The Blizzard of the Century" in the eastern U.S., $6 billion in damages and 270 deaths (1993).

These events may eventually be overshadowed by the Mississippi flooding that occurred during the summer of 1993. As a result of the flood, disasters were declared in nine states, and over a thousand levees were damaged. Current damage estimates are at $12.5 billion, and the total number of deaths is now at 47. Even while this natural disaster is unfolding, scientists, emergency managers, and the general public are asking questions such as:

- Could this disaster have been prevented?
- Is this event related to global climate change?
- Should we rebuild in the same places using the same designs?

Keywords: Natural Hazards, USA, Database, Earthquake, Volcanic hazards, Landslide

[1] Hurricane is the word for "cyclone" in the U.S.

· How do we help communities deal with and recover from this flood?

The Mississippi flood, like many disasters that occur in the U.S., has caused greater economic loss than loss of lives. This is due, in part, to the building codes and land use planning programs used in the U.S. These codes and programs result from knowledge gained from natural hazards research and data collection. Despite the progress that has been made in natural disaster reduction, the U.S. is not immune to the risks involved in natural disasters. Professionals involved in disaster mitigation ask questions such as:

· What would be the impact of a hurricane that struck a major city such as Miami, Florida?
· What would be the impact of a magnitude 8.0 or greater earthquake in a major city such as Los Angeles, California?
· What would be the impact of a large earthquake in the New Madrid, Missouri region, which could potentially cause damage and deaths in eight states?

These statistics and related questions clearly illustrate why the U.S. devotes numerous resources to reducing the impacts of natural disasters. The purpose of this report is not to answer these questions, but to present a summary of some of the organizations involved in providing the answers. We have emphasized organizations that are involved in data collection and information archiving and synthesis related to natural disasters.

Most disaster mitigation in the U.S. is approached as a cooperative effort between local, state, and federal government agencies, volunteer organizations, and the private sector. These groups often work effectively together because of the exchange of pertinent data and practical applications of that data. For example, land-use planners often work with seismologists when planning a city, and emergency managers work with the National Weather Service and the U.S. Army Corps of Engineers when preparing response plans, including evacuation for severe thunderstorms, hurricanes, and floods. This sharing of information and expertise is an ongoing process of communication and education among different levels of government, academia, and non-profit and private institutions.

The following sections describe organizations in the U.S. that maintain databases on natural hazards, collect information on mitigating the impacts of natural hazards, or are involved in natural hazards research. The hazards include earthquakes, volcanoes, landslides, hurricanes, severe storms, wildfires, drought, and floods. A section is also included describing the national Centers for Disease Control and Prevention (CDC), which are dedicated to preventing disease and mitigating injury resulting from natural disasters. The CDC has a unique program to collect information on disaster-affected communities. In addition to the disaster-specific sections, a description is also included of the electronic availability of natural hazards data.

The list of agencies provides an introduction to currently available natural hazards databases. In most cases, the organization listed can provide additional information sources related to their particular natural hazard specialization. If the natural hazard data or information required is not available from the organizations listed, or if they are unable to provide a referral, the authors suggest contacting the Natural Hazards Research and Applications Information Center, located at the University of Colorado. The philosophy of the center, as well as the services they provide, are described below.

NATURAL HAZARDS RESEARCH AND APPLICATIONS INFORMATION CENTER

The Natural Hazards Center was founded in 1975 following a national study that examined the status of hazards research in the U.S. It was discovered during that study that a substantial amount of knowledge was not being transferred to those that implement mitigation. As a result, the Natural Hazards Center was created as a clearinghouse for information on the economic loss, human suffering, and social disruption caused by earthquakes, floods, hurricanes, tornadoes, and other natural disasters. The center's main goal is to link producers and users of hazards research, working to apply the knowledge gained in one area to problems in another. It concentrates on answering queries and provides information about natural hazards in a variety of formats. In this way, the center helps practitioners learn about and use the latest research to improve policy at the local, state, and national level.

Natural Hazards Observer and other Publications

To inform individuals about activities of others, the center publishes a bimonthly newsletter, the ***Natural Hazards Observer***, that provides current information on natural hazards to over 12,000 subscribers in the U.S. and abroad. The ***Observer*** includes articles on issues regarding all aspects of natural hazards; new research; important legislation; upcoming conferences; and new publications, slides, and videos. (Subscriptions within the U.S. are free; subscriptions sent beyond the U.S. cost $15.00 a year.) In addition, the center publishes working papers, monographs, special publications, and bibliographies that are all available for purchase. Recent center publications addressed: the short-term impacts of the Loma Prieta earthquake, earthquake insurance, earthquake mitigation, floodplain management, coastal erosion and land use practices, community organizational partnerships for responding to natural disasters, biological hazard preparedness, the response to Hurricane Hugo, preparedness for earthquakes and hurricanes in Puerto Rico, and the economic measurement of impacts from natural disasters. The center also funds Quick Response Grants for researchers to travel to the site of a disaster in the immediate aftermath to gather information that would otherwise be lost; reports from these researchers are also available for purchase.

Natural Hazards Center Library

The Natural Hazards Center's library has one of the most extensive collections of hazards literature in the U.S. This nonlending library is an important resource for scholars and practitioners who need information on the different aspects of hazards. The collection includes approximately 12,000 reports, articles, brochures, books, and statutes, as well as a diverse assortment of periodicals, professional journals, bibliographies, and government publications. In addition, the library is the national repository of the Floodplain Management Resource Center, a collection of information specifically related to local, state, and national programs, policies, and procedures regarding floodplain management.

Workshop on Hazards Research and Applications

Every summer, the center sponsors the invitational Workshop on Hazards Research and Applications to encourage communication within the natural hazards community. Representatives from local, state, and federal governments, private industry, public interest groups, and research institutions come to Boulder, Colorado, to discuss a wide range of hazard and disaster issues. The workshop tries to ensure the application of research to real world problems and aims to identify new and developing needs each year so that both research and policy will address these issues. International participants are encouraged to join in the workshop to share both information and knowledge on coping with natural disasters.

Electronic Newsletter/Bulletin Board

Finally, the center operates an electronic newsletter/bulletin board. ***Disaster Research*** is a forum for researchers and practitioners to communicate and discuss issues regarding hazards. The newsletter is distributed via several computer networks, including that of the United Nations. (**Contact** the Natural Hazards Research and Applications Information Center, Institute of Behavioral Science #6, Campus Box 482, University of Colorado, Boulder, CO 80309-0482, U.S.A.; phone: (303) 492-6818; fax: (303) 492-2151; E-mail Internet: hazards@vaxf.Colorado.EDU).

INTERNET

The Internet is the world's largest computer network. It began about 20 years ago as a U.S. Defense Department network called the ARPAnet. It was part of a research project tasked with designing a network that could withstand partial outages and still function. The requirements of the design were that communication occurred between a source and a destination computer and that the network itself was assumed to be unreliable; any portion of the network could disappear at any time. This was achieved by giving the communicating computers responsibility for ensuring that communication was accomplished (Krol, 1992).

Access to Internet was initially limited to computer science researchers, government employees, and government contractors; but it now includes universities, businesses, and libraries and is accessible to over 40 countries. Table 1 shows the current computer network availability in several countries (Krol, 1992). Figure 1 shows the current NASA Science Internet network that links the U.S., Canada, Chile, the former Soviet Union, several European countries, Japan, China, Australia, New Zealand, and Antarctica.

Internet offers a wide range of services such as electronic mail, bulletin boards, file transfer, remote login, and index programs. To use basic Internet services, users need to know the following tools:

telnet: used for logging into other computers on the Internet.

ftp: used to retrieve files from public archives on the Internet.

Electronic mail (E-mail): used to send messages.

Basic terms used in the Internet are described below:

Host: The name of the computer to which you are sending mail.

Internet: The collection of networks, including MILNT, NSN, and NSFnet, that use TCP/IP protocol and function as a single, cooperative virtual network.

Table 1. International Network Connectivity

COUNTRY	BITNET	INTERNET	UUCP	FIDONET	OSI/ISO
Australia		Operational	Widespread	Widespread	
China			Minimal		Widespread
Fiji			Minimal		
French Polynesia			Minimal		
Hong Kong	Widespread	Operational		Widespread	
India	Minimal	Operational	Widespread		
Indonesia			Minimal		
Japan	Widespread	Operational	Widespread	Widespread	
South Korea	Widespread	Operational	Widespread	Widespread	
Malaysia	Minimal		Minimal		
New Caledonia			Minimal		
New Zealand		Operational	Minimal	Widespread	
Pakistan			Minimal		
Papua New Guinea			Minimal		
Philippines			Minimal	Widespread	
Singapore	Minimal	Operational	Minimal	Widespread	
Sri Lanka			Minimal		
Taiwan	Widespread	Operational	Minimal	Widespread	
Thailand				Widespread	
United States	Widespread	Operational	Widespread	Widespread	Widespread
Vanuatu			Minimal		

NASA Science Internet

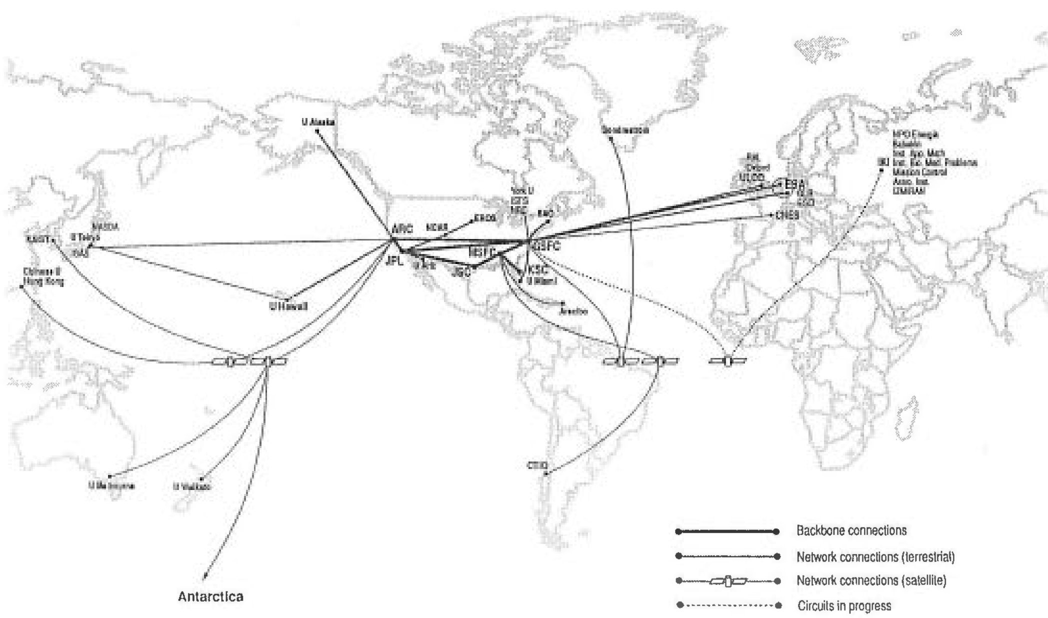

Fig. 1. NASA Science Internet network.

Mail Gateway: A machine that connects two or more electronic mail systems (especially dissimilar mail systems on two different networks) and transfers mail messages among them.
Username: The account name of the recipient of the electronic mail.

United Nations International Emergency Network

The United Nations International Emergency Network (UNIENET) is a part of the Internet. The UNIENET offers information from several agencies: the Natural Hazards Research and Applications Center (NHRAIC), the United Nation's Department of Humanitarian Affairs (DHA), High Commissioner for Refugees (UNHCR), Food and Agriculture Organization (FAO), World Health Organization (WHO), the International Federation of Red Cross Societies (IFRC), International Civil Defence Organization (ICDO), Organization of American States/Department of Regional Development (OAS/DRD), Pan American Health Organization (PAHO), Disaster Management Training Programme (DMTP), Asian Disaster Preparedness Center (ADPC), and the International Decade for Natural Disaster Reduction (IDNDR) U.N. Secretariat.

Beyond exploring the resources and information available from these organizations, UNIENET users can also read the latest DHA situation reports, scan DHA's international list of emergency contacts, survey several other on-line databases, access other U.N. networks, and look at various indexes of UNIENET users—possibly in order to use the network's electronic mail facility to contact those individuals. (**Contact** UNIENET Network Manager, Department of Humanitarian Affairs, United Nations, Palais des Nations, CH-1211 Geneva 10, Switzerland; phone (41-22) 917-2661; fax (41-22) 917-0023; E-mail Internet: UNX002@cgnet.com).

GOPHERS on the Internet

There are now approximately 50,000 databases available over Internet. To facilitate locating the information desired, researchers have developed software tools to navigate the Internet. Examples of these aids are Gophers, Wide-Area Information Servers, World-Wide Web, etc. Gopher is the most popular of these tools. If a computer is running gopher, the software provides a menu and structure that organize the information and resources available on that computer. It also enables users to look for information residing on any of the hundreds of other gopher machines around the world. These tools will eventually lead to the creation of "electronic communities"—collections of researchers who are linked electronically and share information, instruments, software, and computing capability. To access gopher servers, a person must be using a computer that has gopher client (user) software (available free from a number of Internet sites). Users should check with their computer center, system operator, or network consultant regarding the availability of this service.

EERC/NISEE Gopher

An earthquake information gopher server has been developed by the National Information Service for Earthquake Engineering (NISEE) at the Earthquake Engineering Research Center (EERC), to facilitate communication among organizations and individuals in the fields of earthquake engineering, hazard mitigation, disaster response, and related disciplines. The NISEE's role is to identify organizations that should be listed on this server and invite them to participate. When one logs onto the EERC/NISEE gopher, one receives the menu shown in Figure 2.

When a particular option is selected, text describing that option or additional menus appear. For an organization, the mission of the organization, publications lists, and other relevant information is provided. The system also links into gophers and computers providing additional information at other locations. For example, from the NISEE gopher, one can peruse information on the EPIX gopher at Simon Fraser University, Vancouver, Canada (see below); the Earthquake Engineering Abstracts database at the University of California, Berkeley; the National Center for Earthquake Engineering Research (NCEER) anonymous ftp (file transfer protocol) site in Buffalo, New York; and the National Earthquake Information Center's Quick Epicenter Determination (QED) system in Golden, Colorado. Gopher users can reach EERC/NISEE by typing " gopher nisee.ce.berkeley.edu". (**Contact** Katherine Frohmberg, National Information Service for Earthquake Engineering, Earthquake Engineering Research Center, University of California, 1301 South 46th Street, Richmond, California 94804-4698, U.S.A.; phone: (510) 231-9401; fax: (510) 231-9471; E-mail Internet: katie@eerc.berkeley.edu).

1. About the Earthquake Information Gopher Server
2. Applied Technology Council (ATC).
3. California, OES, Earthquake Information Project/
4. Caltech, Earthquake Engineering Laboratory (CALTECH)/
5. Earthquake Engineering Research Center (EERC)/
6. Earthquake Engineering Research Institute (EERI)/
7. National Center for Earthquake Engineering Research (NCEER)/
8. National Information Service for Earthquake Engineering (NISEE)/
9. Natural Hazards Research & Applications Information Center (NHRAIC)/
10. Other Information Sources/
11. Calendars for Related Events/

Fig. 2. First menu displayed on the EERC/NISEE gopher

EPIX Gopher

Another new gopher, entitled the "Emergency Preparedness Information Exchange'' (EPIX), is now on-line via the Internet from Simon Fraser University's Centre for Policy Research on Science and Technology in Vancouver, British Columbia, Canada. The purpose of EPIX is to promote and facilitate the exchange of ideas and information among Canadian and international public and private organizations dealing with natural and technological disasters. EPIX is an example of international cooperative networking, since its features include not only locally based information and applications, but also links to services provided by others worldwide via the Internet. Initially, the creators of the EPIX gopher are focusing on consolidating existing Internet services regarding emergency and disaster management, as well as on building a base of Canadian information. Current services include: information about emergency and disaster management organizations; topics (such as emergency communications, training programs, research programs and information services, natural and socio-technological hazards); on-line discussion groups, libraries, and databases (including weather and recent seismic reports); and connections to other networks. Gopher users can reach EPIX by typing "gopher disaster.cprost.sfu.ca 5555''. (**Contact** Peter Anderson, Department of Communication, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6; phone (604) 291-3687; fax (604) 291-4024; E-mail anderson@sfu.ca).

International Directory Network

The International Directory Network (IDN) is another source of information on natural hazards databases available worldwide. The IDN is a database of directory information managed by three coordinating nodes worldwide; information is exchanged through a common Directory Interchange Format (DIF). The three nodes, located in the U.S., Japan, and Italy, have identical databases. There are 13 additional cooperating nodes that gather and contribute directory information to the network every two weeks (Figure 3). The directory provides descriptions of datasets and information on how to obtain available data from the earth and

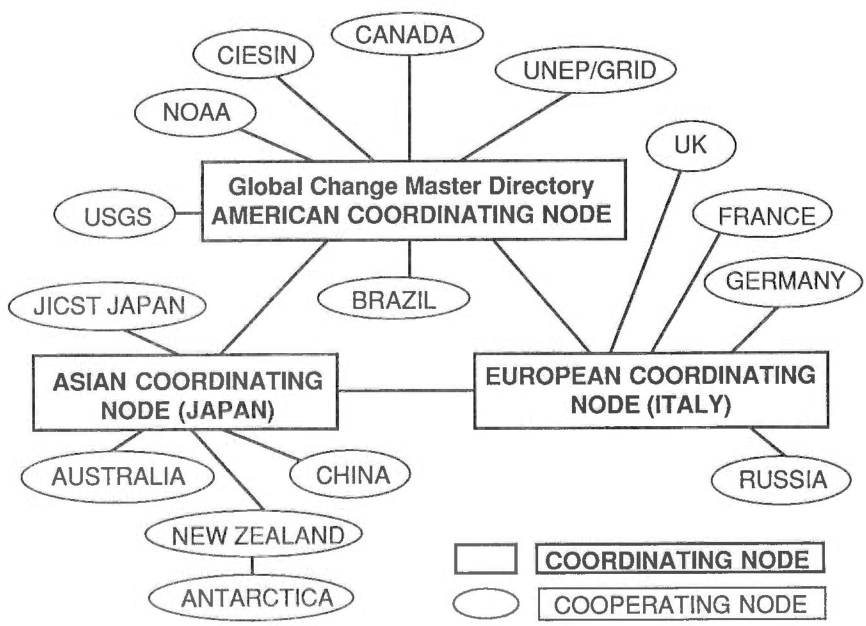

Fig. 3. Coordinating and cooperating nodes of the International Directory Network.

space sciences. This means that scientists in China, for example, have immediate access to descriptions of data sets available in China as well as Japan, the U.S., Italy, Canada, Brazil, the U.K., France, Germany, Russia, and Australia. (Contact Shinichi Sobue, Earth Observation Center, National Space Development Agency, 1401 Numanoue, Ohashi, Hatoyama-machi, Hiki-gun, Saitama-ken, 350-03, Japan; phone: 81-492-96-1611; fax: 81-492-98-1001).

FLOODS

Floods are the most common natural disaster in the U.S. and are one of the most critical threats faced by state and local emergency coordinators. Floods comprise 90% of all presidential declarations of emergency or disaster, and more than 75% of all presidentially declared disasters involve flash flooding. Flash flooding has annually caused between 145 and 200 deaths and driven over 200,000 Americans from their homes. The federal government has spent more than $26 billion for flood protection, and annual national flood damages range from $2 to $4 billion, with half of all losses occurring in agricultural production (Figure 4, Federal Interagency Floodplain Management Task Force, 1992).

The U.S. government administers the National Flood Insurance Program (NFIP), which offers flood insurance to homeowners based on mapping of floodplains and incentives for effective land-use and construction practices. Floodplains are mapped according to where floods are likely to occur with 1% probability a year, commonly known as the "100-year floodplain." However, of the $2.6 billion in flood insurance claims paid by the NFIP from 1978 to 1987, more than 31% were for flooding in areas *outside* the mapped 100-year floodplain. This is due in large part to rapid urbanization, which often exceeds the capacity of governments to remap and change regulations. The value of developing and adhering to floodplain regulations can be seen in Figure 5 (Federal Interagency Floodplain Management Task Force, 1992).

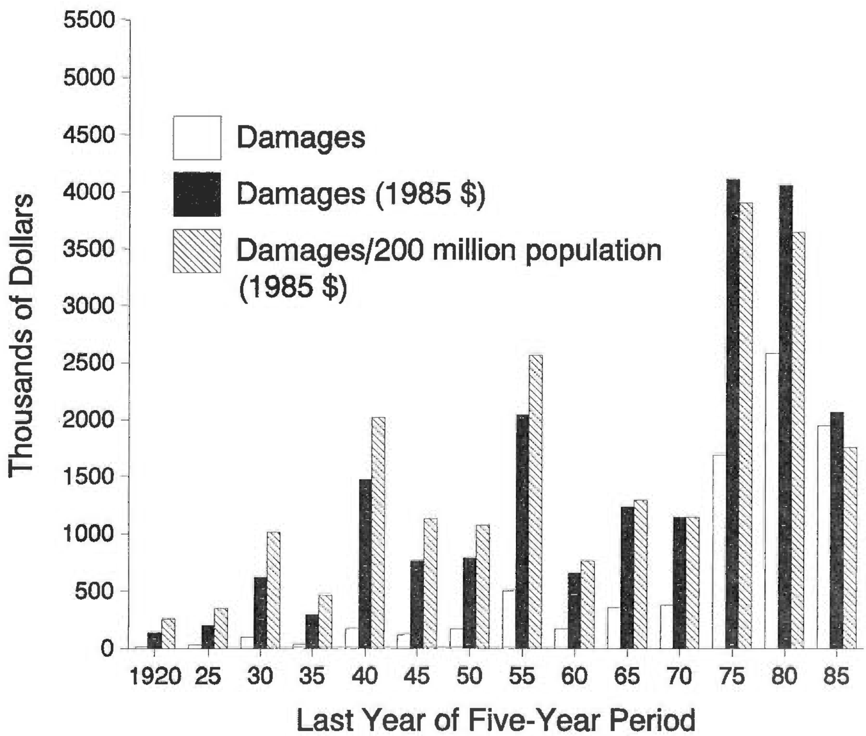

Fig. 4. Average annual flood damages for five-year periods in the United States, 1916-1985

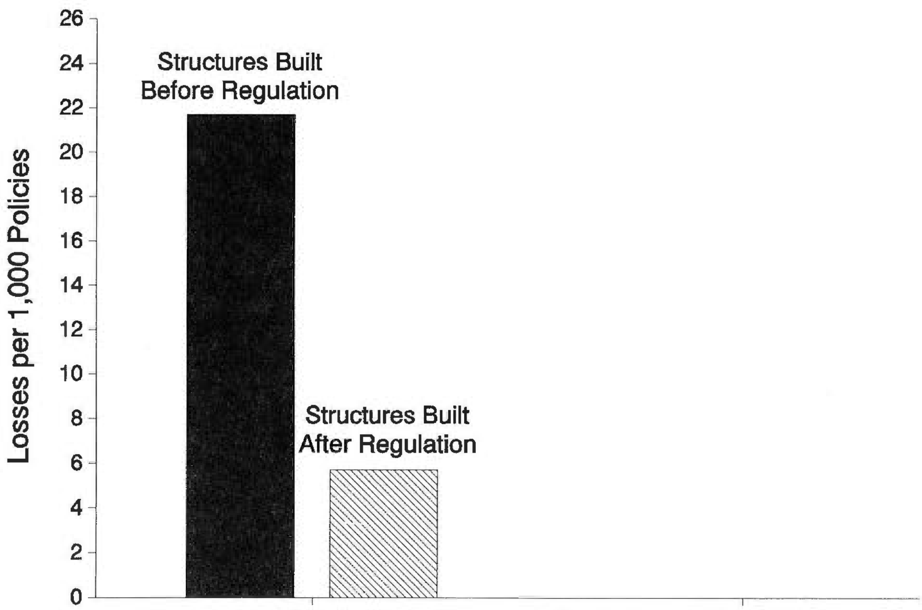

Fig. 5. Average losses per 1,000 flood insurance polices on unregulated versus regulated structures, 1978-1988

Effective floodplain management requires sound understanding of the physical, biological, geological, and chemical processes that impact flood hazards. Equally important is understanding the social processes involved in human interaction with the floodplain. In addition, it is necessary to measure the extent and quality of important floodplain resources and the occurrence and impacts of flood events. This knowledge base has been carried out through the combined efforts of governmental units at all levels, academic institutions, and the private sector, primarily with funding from federal agencies. Typically, data are collected at the state and local levels, while the federal government, academic institutions, or other organizations assemble these data into useful formats.

FEMA Floodplain mapping

Federal Emergency Management Agency (FEMA) mapping of floodplains for Flood Insurance Rate Maps (FIRMs) for the NFIP began in 1968 when the Federal Insurance Administration (FIA) began identifying flood-prone communities. As of 1990, more than 12,000 flood risk studies had been initiated. The FIA spends about $36 million annually to update published flood risk information and to provide detailed flood risk information where none existed before. In addition, the FIA receives support in mapping floodplains from the U.S. Army Corps of Engineers, the Soil Conservation Service, the Tennessee Valley Authority, the U.S. Geological Survey (USGS), and state and local governments. FEMA has initiated pilot projects to develop FIRMs on a GIS (geographic information system) and is developing a standard for digital FIRMs in public domain use. FEMA has also committed to a program to digitize FIRMs for at least 340 counties in the Consolidated Metropolitan Statistical Areas with the greatest amount of property at risk to flooding. (**Contact** the National Flood Insurance Program, ATTN: Public Affairs Coordinator, P.O. Box 99, Lanham, Maryland 20703, U.S.A.; phone: (800) 638-6620; or **Contact** Gary Oran, Systems Analyst, Federal Emergency Management Agency, Federal Insurance Administration, National Flood Insurance Program, 500 C Street S.W., Washington, D.C. 20472, U.S.A.; phone: (301) 731-5300, ext. 2130; fax: (301) 731-9121).

USGS Topographic mapping

Topographic information is one of the basic requirements for floodplain management and the development of floodplain maps. The USGS has mapped most of the continental U.S. with contour intervals of 1.5 to 3.0 meters. These maps formed the basis for early flood-prone area maps and are still used to delineate approximate limits of floodplain areas where detailed maps have not yet been prepared. Local governments often prepare more detailed topographic maps. The USGS is now converting existing topographic map information to a digital database. (**Contact** the Information Specialist, U.S. Geological Survey, Earth Sciences Information Center, National Center, Reston, Virginia 22092, U.S.A.; phone: (703) 648-6892; fax: (703) 648-5548).

NWS Flood forecasting, warning, and response

Historically, most flood warning efforts in the U.S. were the responsibility of the National Weather Service (NWS). The NWS developed, through its River Forecast Centers, hydrologic models for large river systems. However, on hundreds of smaller streams, the NWS has developed a system called the Automated Local Evaluation in Real Time (ALERT), which does not rely on volunteer observers but rather a completely automated system of gages, transmitters, microcomputers, and specially designed software to process the data. Another type of automated flood warning system was developed for parts of the Appalachian region, known as the Integrated Flood Observing and Warning System (IFLOWS). This system is more regional than ALERT, more dependent on NWS warnings, and provides less opportunity for issuing warnings. (**Contact** Kevin Stewart, Urban Drainage and Flood Control District, Floodplain Management Program, 2480 West 26th Avenue, #156-B, Denver, Colorado 80211, U.S.A.; phone: (303) 455-6277; fax: (303) 455-7880).

USGS Streamflow data

The vast majority of stream gages in the U.S. are operated by the USGS. These gages are usually a cooperative effort between the USGS and a local or state agency. Almost all of the gages are located on larger watersheds. Water data have been published by the USGS annually since 1890. These data are stored on a computerized database known as the National Water Data Storage and Retrieval System (WATSTORE). (Contact the U.S. Geological Survey, National Water Data Exchange (NAWDEX), MS 421, National Center, Reston, Virginia 22092, U.S.A.).

WILDFIRES

Wildfires are a frequent threat faced by state and local emergency coordinators in the U.S. According to U.S. Forest Services figures for the years 1986-1988, the average number of wildfires nationally was 140,341. The State of Georgia had the highest average of 12,478. Although annual death and economic damage rates have not been determined, the worst single event in terms of deaths was the 1871 wildfire in Wisconsin where 1,182 people died. The worst single wildfire season in 60 years occurred in 1988 when the federal government spent $538 million to combat fires in widespread areas of the West, where 6,000 soldiers and marines and nearly 4,000 temporary workers assisted the 20,000 professional firefighters on the line (FEMA, 1991).

International Association of Wildland Fires

To mitigate against forest fires, the International Association of Wildland Fires (IAWF) was formed in Fairfield, Washington. The IAWF serves as a clearinghouse for wildland fire technical and professional information and maintains a library and databases. The databases include the ***International Bibliography Bulletin of Wildland Fire***, a bibliographic listing of over 35,000 magazine and journal articles, and the ***International Directory of Wildland Fire***, a list of over 30,000 researchers, managers, consultants, libraries, and agencies, involved in forest fire mitigation. The association publishes a quarterly magazine, ***Hotsheet***, which includes technical articles on wildfires, news of the association, member profiles, general news pertaining to wildfire hazard management, and announcements of upcoming events. In addition, the association publishes the ***International Journal of Wildland Fire***, and the ***International Bibliographic***

***Bulletin of Wildland Fire*.** (**Contact** Jason M. Greenlee, International Association of Wildland Fire, P.O. Box 328, Fairfield, Washington 99012-0328, U.S.A.; phone: (509) 283-2397; fax: (509) 283-2264; E-mail Internet: jgreenlee@igc.apc.org).

SEVERE STORMS

Severe weather in the U.S. includes severe thunderstorms, hailstorms, flash floods, winter storms, and high winds. The entire U.S., except Hawaii, is at risk from winter storms. The annual average snow-related deaths for 1936-1969 was 88. Then for the years 1986 through 1989, the National Weather Service (NWS) data indicate that winter weather conditions were responsible for 415 deaths. The worst event in the U.S. occurred in the "1888 East Coast Blizzard" when 400 deaths were recorded (FEMA, 1991). The most costly storm occurred in the 1993 "Blizzard of the Century" in the eastern U.S., which caused $6 billion in damages and 270 deaths.

The U.S. averages 748 tornadoes a year, which is approximately half of the world's tornadoes (Grazulis, 1991). Tornadoes are a risk in all states, but are more frequent in the Midwest, Southeast, and Southwest. The annual rate of deaths (averaged over the years 1959 to 1988) stands at 83. The annual rate of economic damage for the years 1965-1972 ranged from $50 to $500 million and over $500 million for 1973 to 1975 (FEMA, 1991). The worst event in this century occurred on 18 March 1925, when eight tornadoes in Missouri, Illinois, Indiana, Kentucky, Tennessee, and Alabama caused 689 deaths. The worst November on record was in 1988 when 121 tornadoes, mainly concentrated in four major outbreaks, struck 15 south-central states. A total of 14 lives were lost and damages were in excess of $108 million (FEMA, 1991). (**Contact** Tom Grazulis, The Tornado Project, P.O. Box 302, St. Johnsbury, Vermont 05819, U.S.A.; phone (802) 748-2505).

National Severe Storms Forecast Center

The National Severe Storms Forecast Center (NSSFC) of the National Weather Service (NWS) is responsible for forecasting tornadoes and severe thunderstorms throughout the contiguous U.S. The responsibilities of the NSSFC are carried out by the Severe Local Storms Unit, the National Aviation Weather Advisory Unit, and the Techniques Development Unit. The NSSFC also maintains a severe weather database that contains information on hailstorms, flash floods, winter storms, and high winds in the U.S. from 1950-1993. (**Contact** John Halmstad or Hugh Crowther, National Severe Storms Forecast Center, National Weather Service, NOAA, Room 1728, Federal Building, 601 East 12th Street, Kansas City, Missouri 64106-2877, U.S.A.; phone: (816) 426-3367; fax: (816) 426-3453).

NSSFC Severe Local Storms Unit

The Severe Local Storms Unit has responsibility for three national programs. The *Tornado and Severe Thunderstorm Forecast Program* is responsible for issuing tornado and severe thunderstorm watches for the 48 contiguous states (Alaska and Hawaii are not included). Severe weather watches are issued for areas where thunderstorms are forecast to produce one or more of the following during the next two to six hours: 1) hailstones of 2 cm or greater diameter, 2) surface wind gusts of 93 km an hour or greater, or 3) tornadoes. The *Satellite Data Interpretation Program* involves the receipt, processing, and interpretation of satellite data provided by the Geostationary Operational Environmental Satellites (GOES). From the interpretation, a Synoptic Interpretation Message (SIM) is prepared and transmitted four times daily with information on the location, movement, and changes in intensity of all significant weather systems as depicted by the satellite sensors. This information is used by forecasters throughout the U.S. as input to their weather forecast programs. The *National Weather Summary Program* issues the National Weather Summary twice daily. This product contains information on significant weather that has occurred in the U.S. and is disseminated nationally for use by radio, television, newspapers, and other media interests.

NSSFC National Aviation Weather Advisory Unit

The National Aviation Weather Advisory Unit (NAWAU) issues bulletins to aviation interests for in-flight hazardous weather phenomena associated with thunderstorms and aviation advisories and forecasts for potentially hazardous flying weather for the 48 contiguous states. In addition, area forecasts are issued three times daily that serve as a primary pilot weather briefing tool for the Federal Aviation Administration (FAA) flight service station briefers.

NSSFC Techniques Development Unit

The Techniques Development Unit conducts research and development to improve the forecasting ability of the NSSFC operational forecasters. The unit's activities include scientific studies on weather conditions leading to severe storms, development and implementation of modern interactive computer technology in the forecast environment, development of diagnostic techniques for severe storm and aviation related forecast problems, development of techniques which will improve the efficiency and effectiveness of the forecasters, evaluation of new data sources, and verification of NSSFC forecasts and national watch and warning forecasts.

National Climatic Data Center

The National Climatic Data Center (NCDC) collects all U.S. weather records and is the largest climatic center in the world. Data are obtained from the National Severe Storms Laboratory, the National Weather Service, the weather services of the U.S. Air Force and Navy, the Federal Aviation Administration, and the U.S. Coast Guard. Also included are cloud photography and other data obtained from environmental satellites. The NCDC also administers World Data Center-A, Meteorology, which provides for international data exchange. The NCDC offers a variety of products and services on severe weather in the U.S., available in digital and hard copy form. Over 200 of these data sets are described in the NCDC publication, ***Selective Guide to Climatic Data Sources***. A few examples of products and data sets distributed by the NCDC are listed below:

Storm Data, a monthly bulletin with data on all severe storms or unusual weather phenomena in the U.S. and annual summaries of tornadoes, lightning, and hurricanes.

Local Climatological Data, a monthly bulletin, with annual summaries, containing daily and monthly temperatures, dew point temperatures, heating and cooling-degree days, weather, precipitation, snowfall, pressure, wind, sunshine, and sky cover for 290 U.S. NWS stations.

Monthly Climatic Data for the World, monthly mean values of surface and upper air measurements from a large number of selected stations throughout the world.

World Weather Records, a six-volume set containing monthly and annual tables of mean temperature, mean pressure, and total precipitation for most stations throughout the world.

Climates of the World, average temperature and precipitation data for approximately 800 stations throughout the world.

Catalog of Publications of the World Meteorological Organization (Geneva, Switzerland: WMO, 1983).

In addition, the NCDC offers several datasets on CD-ROM, including:

National Climate Information, monthly sequential temperature, precipitation, and drought data for the 344 climate divisions in the contiguous U.S. for 1895-1989.

International Station Meteorological Climate Summary, climatological summaries for about 980 locations worldwide.

Summary of Meteorological Observations-Surface, monthly and annual summaries of weather conditions, precipitation, surface winds, temperature and relative humidity, and pressure for approximately 650 worldwide locations for 1973-1989.

(**Contact** Tom Ross, National Climatic Data Center, NOAA, Research Customer Service Group, Room 121, Federal Building, 37 Battery Park Avenue, Asheville, North Carolina 28801-2696, U.S.A.; phone: (704) 271-4994; fax: (704) 271-4876; E-mail Internet: tross@ncdc.noaa.gov).

DROUGHT

Although the frequency of droughts is difficult to measure, the entire U.S. is at risk from drought. In 1987-1989, the U.S. suffered $39 billion in losses due to drought, including crop losses, river transportation disruption, economic impacts, water supply problems, and wildfires.

International Drought Information Center

The International Drought Information Center (IDIC) was established in 1988 to improve understanding and awareness of the problems associated with drought management and planning. The objectives of the center are to collect, analyze, package, and disseminate information on current episodes of drought. The center also reports on response, mitigation, and planning activities of governments and international organizations and provides information on new technologies relating to drought management and planning. Information on drought conditions and planning and response is disseminated three times a year through the newsletter, ***Drought Network News***. The IDIC also publishes the ***IDIC Technical Report Series***, which contains information on the center's research and outreach activities. The center also maintains a database containing contact information for over 1,200 managers and technical specialists involved in drought preparedness.

The IDIC conducts training seminars on drought management and preparedness in developing regions of the world. Seminars were held in Botswana and Brazil in 1989. In 1991, representatives from 15 Asian and Pacific countries participated in a training seminar held in Thailand. These seminars have been co-sponsored by the United Nations Environment Programme, World Meteorological Organization, and the National Oceanic and Atmospheric Administration. (**Contact** Donald A. Wilhite, International Drought Information Center, Department of Agricultural Meteorology, 241 L. W. Chase Hall, University of Nebraska, Lincoln, Nebraska 68583-0728, U.S.A.; phone: (402) 472-6707; fax: (402) 472-6614).

National Climatic Data Center

The National Climatic Data Center (NCDC) provides several products useful in drought analysis including:

Atlas of Monthly Palmer Hydrological Drought Indices for the Contiguous U.S.
Atlas of Monthly Palmer Moisture Anomaly Indices
Atlas of Monthly Palmer Drought Severity Indices
Atlas of Monthly and Seasonal Precipitation Departures from Normal for the Contiguous U.S.
Probabilities and Precipitation Required to End/Ameliorate Droughts

(**Contact** Tom Ross, National Climatic Data Center, NOAA, Research Customer Service Group, Room 121, Federal Building, 37 Battery Park Avenue, Asheville, North Carolina 28801-2696, U.S.A.; phone: (704) 271-4994; fax: (704) 271-4876; E-mail Internet: tross@ncdc.noaa.gov).

HURRICANES

Hurricane Andrew in 1992, with $30 billion in damages and 50 deaths, was the costliest disaster in U.S. history. Areas vulnerable to hurricanes in the U.S. include the territories in the Caribbean, the entire east coast from Texas to Maine (Figure 6, Federal Interagency Floodplain Management Task Force, 1992), and the tropical areas of the western Pacific Ocean, including Hawaii. Florida has experienced the largest number of hurricanes of any state, with 57 between 1871 and 1989. The annual rate of deaths from hurricanes is 33 (FEMA, 1991).

The first hurricane-warning display system in America was established in 1847 by the Royal Engineers of England, based upon barometric readings. In 1890, responsibility for hurricane warnings was transferred to the Weather Bureau under the Department of Agriculture. In the following years, warnings were issued from locations not sensitive to the risks involved with hurricanes. This resulted in warnings being issued with

Fig. 6. Number of major hurricanes directly affecting the East and Gulf coasts of the United States, 1899-1989

inadequate response time and in some instances, warnings not being issued at all. A tragic example of this occurred when a major hurricane struck Galveston, Texas, on 8-9 September 1900, killing more than 6,000 people. There is no record of any formal hurricane warning reaching Galveston (Sheets, 1990). This and other incidents led to the establishment of hurricane forecast centers at Jacksonville, Florida; New Orleans, Louisiana; San Juan, Puerto Rico; and Boston, Massachusetts. In 1943, the hurricane forecast office at Jacksonville was moved to Miami and was officially designated as the National Hurricane Center in 1955.

National Hurricane Center

Today, NOAA's National Hurricane Center (NHC) is responsible for monitoring tropical disturbances and hurricanes in the North Atlantic, eastern North Pacific, Caribbean Sea, and Gulf of Mexico. Using data from NOAA's GOES satellite, ship observations, reconnaissance aircraft, buoy, and radar data; the center issues advisories and forecasts on hurricanes. The NHC warning process involves three major groups: 1) NWS meteorologists, responsible for determining the meteorological and hydrological conditions expected and associated warnings required for protection of life and property; 2) local and state officials who determine what response is needed, and 3) the media who communicate the warnings to the general public. For optimum response from warnings, there must be sufficient lead time and overwarning must be kept to a minimum to avoid complacency. The center maintains a historic database of hurricane records, containing position and strength estimates at 6-hour intervals used in hurricane analysis and modelling. (**Contact** Miles Lawrence, National Hurricane Center, National Weather Service, NOAA, 1320 South Dixie Highway, Room 631, Coral Gables, Florida 33146, U.S.A.; phone: (305) 536-5547; fax: (305) 536-6881).

NCDC Hurricane Databases

The National Hurricane Center, foreign meteorological services, and the Joint Typhoon Warning Center in Guam provide data to NOAA's National Climatic Data Center (NCDC). Products provided by the NCDC containing plots, searches, and analyses of hurricanes and tropical cyclones, include:

Tropical Cyclones of the N. Atlantic Ocean, 1871-1986, storm track maps updated through 1989.

North Atlantic Tropical Cyclones, 1950-1980, extracts from National Summary Annuals.

Mariners Worldwide Climatic Guide to Tropical Storms at Sea, narrative information and charts showing storm tracks, frequency maps, and tropical cyclone roses.

In addition, the NCDC offers the ***Global Tropical and Extra-Tropical Cyclone Climatic Atlas*** CD-ROM. (**Contact** Tom Ross, National Climatic Data Center, NOAA, Research Customer Service Group, Room 121, Federal Building, 37 Battery Park Avenue, Asheville, North Carolina 28801-2696, U.S.A.; phone: (704) 271-4994; fax: (704) 271-4876; E-mail Internet: tross@ncdc.noaa.gov).

EARTHQUAKES

There are literally thousands of earthquakes in the U.S. each year. Most of these are of such small magnitude that they are not felt, but tens of potentially damaging earthquakes of magnitude 5.0 or greater on the Richter Scale occur annually in the U.S. Earthquakes occur most frequently in the states west of the Rocky Mountains, but all 50 states have experienced earthquakes in the last century. Historically, large and destructive earthquakes have occurred in the New Madrid, Missouri, region.

The greatest loss of life from an earthquake in the U.S. occurred in the 1906 San Francisco quake when 700 lives were lost. The greatest economic damage from an earthquake was the more than $6 billion loss caused by the 1989 Loma Prieta earthquake. Resulting from past events and the future threat from earthquakes, there are several organizations in the U.S. involved in data collection and earthquake hazard reduction. The U.S. Geological Survey of the Department of the Interior and the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce are two of the primary government agencies that administer programs related to earthquake hazard reduction. In addition to the USGS and NOAA, the National Center for Earthquake Engineering Research (NCEER) and the National Information Service for Earthquake Engineering (NISEE) serve as clearinghouses of literature pertinent to the fields of earthquake engineering and earthquake hazards reduction. In addition, professional societies such as the Earthquake Engineering Research Institute (EERI) are involved in earthquake engineering research.

National Earthquake Information Center

The National Earthquake Information Center (NEIC) of the U.S. Geological Survey is responsible for the rapid collection and dissemination of information on earthquakes in the U.S. and worldwide. The NEIC was established in Rockville, Maryland, in 1966 as part of the U.S. Coast and Geodetic Survey, which had

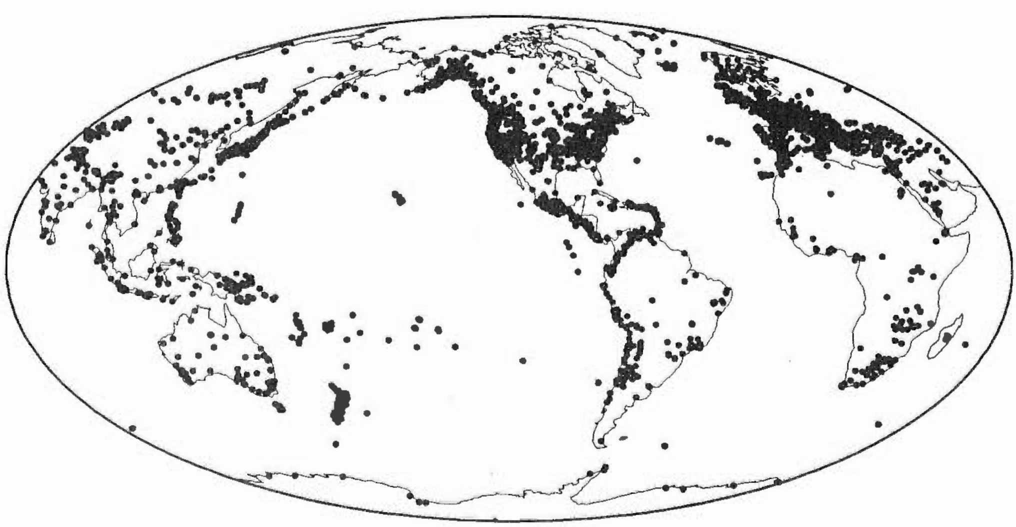

Fig. 7. Seismograph stations reporting data to the National Earthquake Information Service.

assumed responsibility for the collection of seismological data in the U.S. from the Weather Bureau in 1925.

The NEIC operates a 24-hour-a-day service that rapidly determines the location and magnitude of earthquakes worldwide. The agency receives data from over 3,000 seismic reporting stations (Figure 7). The NEIC then compiles reports on earthquake occurrences and earthquake effects and communicates this information to interested groups. The reports are issued for earthquakes throughout the world that are magnitude 6.5 or greater or have caused damage or casualties. Reports are also issued for earthquakes that have been felt in the U.S. The information is given to federal and state government agencies who are responsible for emergency responses, government public information channels, national and international news media, scientific groups including groups planning aftershock studies, and private citizens who request information. If a damaging earthquake occurs in a foreign country, the information is passed to the staffs of the American embassies and consulates in the affected countries and to the United Nations Department of Humanitarian Affairs (UNDHA).

NEIC Publications

The NEIC publishes several lists of earthquake data, including:

Quick Epicenter Determinations (QED), a preliminary list of earthquakes that is computed daily and available by telephone and computer. It includes about 250 events each month.

Preliminary Determination of Epicenters (PDE), a list of about 150 events that is published and distributed weekly to those contributing data to the NEIC.

Preliminary Determination of Epicenters Monthly Listing, a list of over 1,200 events that is available by subscription from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Earthquake Data Report (EDR), a report of additional information on the events listed in the ***PDE Monthly Listing***, issued at the same time as the ***PDE Monthly Listing***. The EDR is available to seismologists on a data-exchange basis and is also available on floppy diskette through the USGS Books and Open File Services, Denver Federal Center, Box 25286, Denver, Colorado 80225. (**Contact** Bruce Presgrave, National Earthquake Information Center, U.S. Geological Survey, P.O. Box 25046, MS 967, Denver Federal Center, Denver, Colorado 80225-0046, U.S.A.; phone: (800) 525-7848; phone: (303) 273-8500; fax: (303) 273-8450; Dial-a-Quake phone: (303) 273-8516).

NEIC Data on CD-ROM

The NEIC also provides earthquake data on CD-ROM including:

Global Hypocenter Data Base CD-ROM, an extract of selected catalogs from the Earthquake Data Base System located at the NEIC. The combined earthquake catalogs (seven worldwide and 12 regional) span a time period from 2100 B.C. through 1988. The Epic software allows the user to search, retrieve, output earthquake information in user selectable formats, and display seismicity on the user's monitor.

NEIC Earthquake Digital Data CD-ROM, a collection of 10 discs that contain digital waveform data from the Global Digital Seismograph Network and from other global networks around the world. The data in Volume 1 starts in January 1980 and Volume 10 ends with data in June 1987. Software is available for IBM-compatible personal computers only (Bridgett, 1991). (Contact Madeline Zirbes, National Earthquake Information Center, U.S. Geological Survey, P.O. Box 25046, MS 967, Denver Federal Center, Denver, Colorado 80225-0046, U.S.A.; phone: (303) 273-8418; fax: (303) 273-8450).

NEIC Bulletin Board System

The NEIC operates an Electronic Bulletin Board System (BBS) which provides information on seismology and geomagnetism. It is accessible 24 hours a day, 365 days a year. The BBS telephone number is (303) 273-8508; modem speeds from 300 to 2400 baud rate are accepted automatically; communications program setup is eight data bits, no parity, and one stop bit. Users may log in as GUEST without a password or may become registered by entering NEW. (**Contact** Roger Hunter, National Earthquake Information

Center, U.S. Geological Survey, P.O. Box 25046, MS 967, Denver Federal Center, Denver, Colorado 80225-0046, U.S.A.; phone (303) 273-8472; fax: (303) 273-8450).

NEIC Earthquake Intensity Data

The NEIC also collects intensity information on earthquakes in the U.S. These data are published in the annual, ***United States Earthquakes***; and in the USGS Professional Paper #1527, ***Seismicity of the United States, 1568-1989 (Revised).*** (**Contact** James Dewey, National Earthquake Information Center, U.S. Geological Survey, P.O. Box 25046, MS 967, Denver Federal Center, Denver, Colorado 80225-0046, U.S.A.; phone: (303) 273-8419; fax: (303) 273-8450).

USGS National Strong Motion Program

The first seismic engineering program in the U.S. began in 1931 and was administered by the Seismological Field Survey (SFS) of the U.S. Coast and Geodetic Survey. This program remained the responsibility of the SFS until 1973, when the USGS assimilated the program into its Earthquake Hazards Reduction Program. The current federal seismic engineering program operates the National Cooperative Strong Motion Network (NCSMN) with nearly 1,000 stations in 40 states and Puerto Rico. This network is administered by the USGS in cooperation with both private industry and numerous federal, state, and local agencies and organizations. Primary objectives of the program are to record strong ground motions and the response of representative engineered structures during moderate to large earthquakes, and to disseminate the resulting data and information about the records, sites, and structures to the earthquake engineering research and design community. All the accelerograms are archived, and copies can be obtained from the USGS. (**Contact** Gerald Brady, Branch of Earthquake and Geomagnetic Information, U.S. Geological Survey, 345 Middlefield Road, MS 977, Menlo Park, California 94025, U.S.A.; phone: (415) 329-5664; fax: (415) 329-5163).

National Geophysical Data Center

The National Geophysical Data Center (NGDC) of the National Oceanic and Atmospheric Administration (NOAA) provides many products and services related to earthquakes and earthquake engineering. The NGDC was created in 1965 under the Environmental Science Services Administration (ESSA) with seismogram management as one of its responsibilities. The NGDC became a part of NOAA in 1970 and was moved to Boulder, Colorado, in 1972. Today, the NGDC maintains several earthquake databases, including one with more than 1.75 million worldwide earthquakes and earth disturbances, another of significant earthquakes, and one of earthquake intensities.

NGDC Data on CD-ROM

Earthquakes with magnitudes greater than 2.5 for North America from 1534-1985 are available on the NGDC CD-ROM, Geophysics of North America. The CD-ROM also includes topography, gravity, magnetics, imagery, stress, and thermal data for North America. Access software and a tutorial on the access software are provided. (**Contact** Allen M. Hittelman, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6591; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Earthquake Database

The NGDC Earthquake Database holds information on more than 1.75 million earthquakes and other earth disturbances recorded worldwide for the period 2150 B.C. to the present. The database includes (where available) date and origin time of the event, location, depth, magnitude, maximum intensity, and related earthquake phenomena (including faulting, tsunami, volcanism, and resulting casualties and property damage). Data are available in digital and analog form; users can request data retrievals based on geographic area, time period, magnitude range, or maximum intensity. An example of an earthquake search is shown in

Figure 8. (**Contact** Lowell Whiteside, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6477; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Significant Earthquake Database

The Significant Earthquake Database is a global digital database containing information on more than 5,000 destructive earthquakes from 2150 B.C. to the present. The database is also available in printed form in the ***Catalog of Significant Earthquakes 2150 B.C. - 1991 A.D.*** The events in the file must meet at least one of the following criteria: moderate damage (approximately $1 million or more), 10 or more deaths, magnitude 7.5 or greater, or Modified Mercalli intensity X or greater (for events lacking magnitude). The following seismological parameters are included for each event: date, time, epicenter, depth, magnitude, intensity, deaths, damage, tsunami, geographic location, and references. The map, ***World Map of Significant Earthquakes, 1900-1979***, was also created from an earlier version of this database. (**Contact** Paula K. Dunbar, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6084; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Earthquake Intensity File

The Earthquake Intensity File is a collection of damage and felt reports for over 22,000 U.S. earthquakes. The digital database contains information regarding epicentral coordinates, magnitudes, focal depths, names and coordinates of reporting cities, reported intensities, and the cities' distances from the epicenter. Users can request retrievals of the database and maps that plot recorded intensities can be generated. Earthquakes listed in the file date from 1638 to 1985; the file is updated as new information becomes available. (**Contact** Paula K. Dunbar, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6084; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Geologic Hazards Photographs

The NGDC maintains an extensive photograph file depicting worldwide natural hazards. The photographs have been thematically assembled into slide sets depicting earthquake damage, volcanic effects, tsunamis, and landslides. A photograph from the collection is shown in Figure 9. (**Contact** Dennis Smith, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6277; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Seismograph Station Bulletins

The Seismograph Station Bulletins Database contains more than 500,000 microfiche pages from seismograph station bulletins for the years 1900 to 1965. The bulletins provide information on the characteristics of the recording instruments and whether certain events were recorded at particular stations. (**Contact** Paula K. Dunbar, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6084; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

NGDC Worldwide Strong Motion Data Archive

In 1970, the NGDC assumed responsibility for archiving and disseminating strong motion data. The worldwide strong motion data archive is the largest in the world, with more than 17,000 digitized and processed accelerograph records dating from 1933 to the present. To simplify locating all the strong motion data applicable to a particular study, a PC-based catalog system known as **SMCAT** (**S**trong **M**otion Data **CAT**alog) was created. The present catalog contains 25 fields of information that document the triggering event, station characteristics, and peak recorded ground motion values. The catalog is disseminated on floppy discs along with a user-oriented, menu-drive program for quick and convenient catalog searches. (**Contact** Paula K. Dunbar, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado

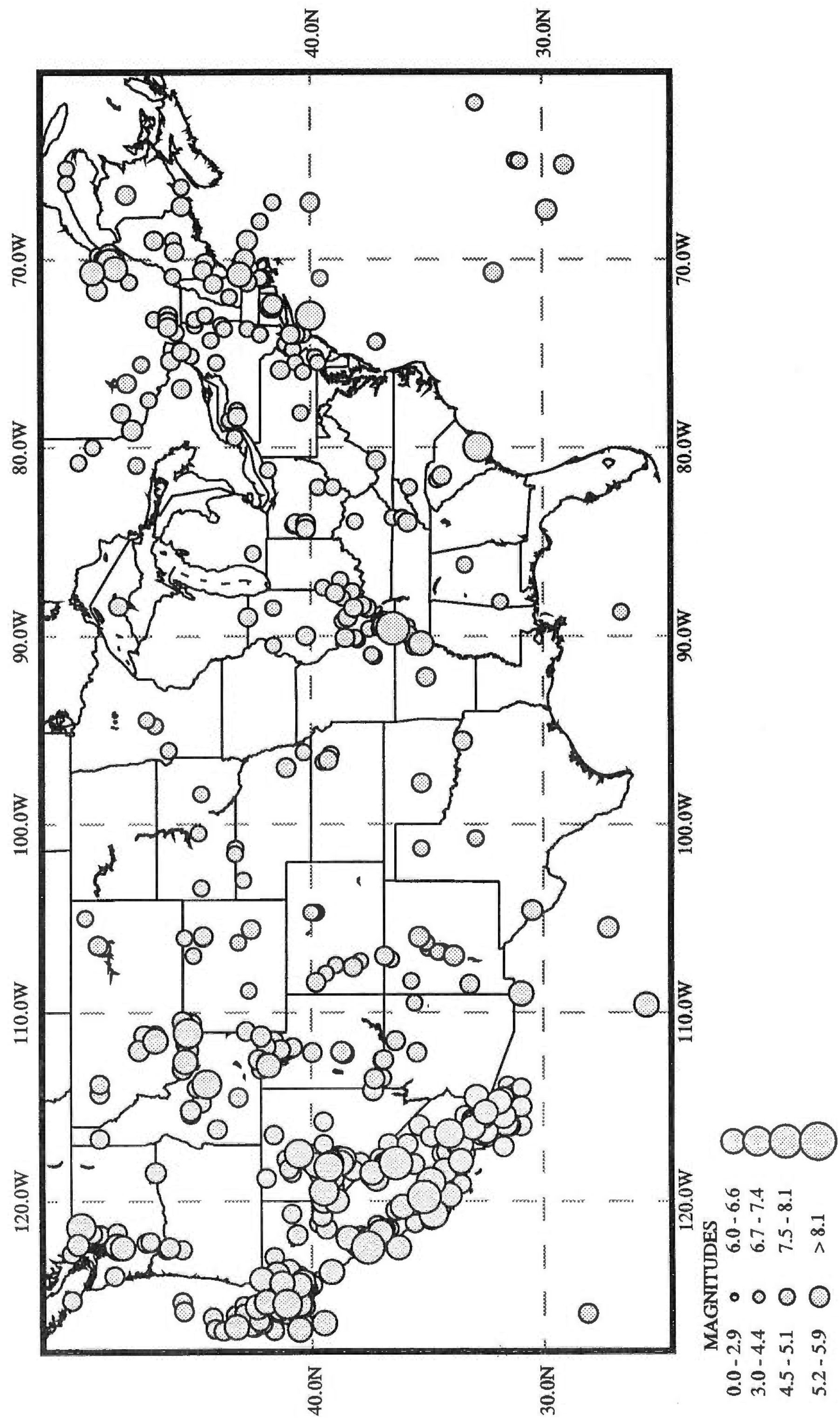

Fig. 8. Seismicity of the United States from 1500 to 1993

Fig. 9. Photograph from the NGDC slide set collection depicting damage from the Loma Prieta earthquake of October, 1989

80303-3328, U.S.A.; phone: (303) 497-6084; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

Southern California Earthquake Center

The Southern California Earthquake Center (SCEC), located at the California Institute of Technology in Pasadena, was established in 1991 to coordinate the efforts of various California universities and the USGS in a comprehensive, integrated approach to understanding earthquakes. The principal task of the SCEC is to develop a master model of seismic hazards in southern California. Part of this process includes the collection of seismological data at the SCEC–Data Center (SCEC–DC). Data currently stored by the SCEC–DC include Southern California Seismic Network (SCSN) catalog listings (1932 to the present); digital seismograms for local, regional, and teleseismic events recorded by the SCSN (July 1981 to January 1983 and July 1983 to the present); ASCII data files containing event information associated with each digital seismogram; triggered terrascope data for teleseisms (May 1990 to the present); local southern California events (September 1990 to the present); and GPS Rinex data (July 1 to July 25, 1992). Digital waveforms recorded by portable instruments deployed by the SCEC and other institutions as well as strong motion and geodetic data are expected to be on-line in the near future. The database can be accessed via Internet. (**Contact** Katrin Douglass, Southern California Earthquake Center, California Institute of Technology, Seismological Laboratory, Mail Code 252-21, Pasadena, California 91125, U.S.A.; phone (818) 395-2106; fax (818) 564-0715; E-mail Internet: katrin@seismo.gps.caltech.edu).

Earthquake Engineering Research Institute

The Earthquake Engineering Research Institute (EERI) is a national, nonprofit, technical society of engineers, geoscientists, architects, planners, and social scientists. EERI was founded in 1949 as an outgrowth of the Advisory Committee on Engineering Seismology of the U.S. Coast and Geodetic Survey to encourage research in the field of earthquake engineering. The institute is best known for its field investigations and reconnaissance reports detailing the effects of destructive earthquakes. Members receive quarterly issues of ***Earthquake Spectra: The Professional Journal of the Earthquake Engineering Research Institute***, that publishes papers by researchers and practitioners in the professions dedicated to earthquake hazards reduction, and the monthly ***EERI Newsletter***, that offers information of current interest, notes on recent earthquakes, announcements of publications, and a calendar of upcoming professional meetings, seminars, and conferences. Members also receive special reconnaissance reports following all major earthquakes, new EERI publications, and the annual ***Membership Roster***. Other publications, slide sets, videos, and conference registrations are available to members at special reduced rates. (**Contact** Susan K. Tubbesing, Earthquake Engineering Research Institute, 499 14th Street, Suite 320, Oakland, California, 94612-1902, U.S.A., phone (510) 451-0905; fax: (510) 451-5411).

National Center for Earthquake Engineering Research

The National Center for Earthquake Engineering Research (NCEER) was established in 1986 to address earthquake engineering from a national perspective. NCEER's mission is to improve earthquake hazard mitigation by involving over 50 institutions in 20 states. NCEER's four major research areas are: the *Building Project*, the *Nonstructural Components Project*, the *Lifelines Project*, and the *Bridge Project*. In addition to NCEER's research programs, knowledge transfer is an integral part of NCEER's **Research and Implementation Plan**. *Knowledge Transfer* at NCEER is accomplished through workshops, conferences, the publication of a technical report series, and a quarterly newsletter the ***NCEER Bulletin***, as well as the promotion of an active Information Service.

NCEER Information Service

The NCEER Information Service is a comprehensive source of information on earthquake engineering, earthquake hazard mitigation, disaster preparedness, and related topics such as human response to disaster, earthquake education, and reconstruction after earthquakes. The mission of the Information Service is to disseminate earthquake information by: 1) providing reference and research assistance to investigators, practitioners, and the general public; 2) acquiring and maintaining an extensive collection of books, journals, and audiovisual materials in earthquake engineering and hazard mitigation; 3) developing and maintaining the online bibliographic database **QUAKELINE**; and 4) producing a monthly newsletter, ***Information Service News***. The **QUAKELINE** database is available for searching worldwide through the Bibliographic Retrieval System (BRS) network and also at no charge through the "LIBS INTERNET ACCESS SOFTWARE." (**Contact** Patricia Coty or Dorothy Tao, NCEER Information Service, c/o Science and Engineering Library, State University of New York at Buffalo, 304 Capen Hall, Buffalo, New York 14260-2200, U.S.A.; phone: (716) 645-3377, fax: (716) 645-3379; E-mail Bitnet: NERNCEER@UBVMS.BITNET or **Contact** the Japanese offices of BRS Information Technologies (03) 3502-6471).

Earthquake Engineering Research Center

The Earthquake Engineering Research Center (EERC), located at the University of California, Berkeley, and at the California Institute of Technology, Pasadena, is dedicated to research, education, and dissemination of technical information in earthquake hazard mitigation. EERC publishes papers by researchers in earthquake hazards reduction, and provides current information on earthquake engineering research in the newsletter ***EERC News***. The EERC library contains more than 30,000 books, research reports, monographs, maps, and audiovisual materials on earthquake hazards and their mitigation.

EERC National Information Service for Earthquake Engineering

The goal of the National Information Service for Earthquake Engineering (NISEE) at EERC is to collect, enhance, and disseminate earthquake engineering information. NISEE maintains a bibliographic database of literature in earthquake engineering and earthquake hazards mitigation. In addition, NISEE has developed an earthquake information gopher (see EERC/NISEE Gopher). (**Contact** Katherine Frohmberg, National Information Service for Earthquake Engineering, Earthquake Engineering Research Center, University of California, 1301 South 46th Street, Richmond, California 94804-4698, U.S.A.; phone: (510) 231-9401; fax: (510) 231-9471; E-mail Internet: katie@eerc.berkeley.edu).

TSUNAMIS

The primary threat from the effects of tsunamis in the U.S. lies in the coastal areas of Hawaii, Alaska, Washington, Oregon, and California. While these events are somewhat rare, tsunamis have been responsible for at least 470 fatalities and several hundred million dollars in property damage in the U.S. (Lander, 1989). Hawaii and Alaska are the highest risk areas and experience damaging tsunamis approximately every seven years (FEMA, 1991). Damaging tsunamis occur less frequently on the U.S. west coast and rarely occur on the U.S. east coast. Guam and other U.S. possessions in the Pacific record a tsunami approximately every 3 years, but are at low risk because the waves cause almost no damage. The Virgin Islands and Puerto Rico have experienced damaging tsunamis in the past, but they occur infrequently.

The worst tsunami in the U.S. occurred on 1 April 1946 when a magnitude 7.3 earthquake in the Aleutian Islands generated a tsunami with wave heights of 16.8 m above sea level, killing 159 people and causing $26 million property damage in Hawaii. The 1964 Prince William Sound earthquake (magnitude 8.4), one of the largest shocks ever recorded on the North American continent, generated a tsunami that caused $96 million in damage and 122 deaths in Alaska and on the west coast of the U.S. (Lander, 1989).

Following the Aleutian tsunami in 1946, the U.S. Coast and Geodetic Survey was asked to provide a tsunami warning system for the Hawaiian Islands. A warning system had to be developed with the capability to: 1) rapidly detect and locate each earthquake; 2) determine the actual existence of a tsunami; and 3) calculate the expected time of arrival of the tsunami in the islands. In 1948, the Seismic Sea Wave Warning System (SSWWS) was put into operation at the Seismological Observatory at Ewa Beach near Honolulu. The SSWWS furnished tsunami warning information to the civil and military authorities of the Hawaiian islands. In 1953, the information began to be disseminated to the U.S. west coast. After the devastating earthquake off the coast of central Chile in 1960, many countries and territories joined the SSWWS for warnings of future tsunamis.

International Tsunami Information Center

The facilities of the SSWWS were strengthened in 1966 with the establishment of the International Tsunami Information Center (ITIC) and the International Coordination Group for the Tsunami Warning System (ICG/ITSU). Twenty-six nations are now members of ITSU in the Pacific. The System makes use of 69 seismic stations, 65 tide stations, and 101 dissemination points scattered throughout the Pacific Basin. Jointly run by the Intergovernmental Oceanographic Commission of UNESCO and the National Weather Service (NWS), the ITIC maintains an extensive library of tsunami publications including bibliographies, maps, photograph files, newspaper articles, and early warning system technology materials. The ITIC also publishes the biannual ***Tsunami Newsletter***. (**Contact** Director, International Tsunami Information Center, P.O. Box 50027, Honolulu, Hawaii, 96850-4993, U.S.A.; phone (808) 541-1658; fax: (808) 541-1678).

Pacific Tsunami Warning Center

The Pacific Tsunami Warning Center (PTWC), operated by the NWS, monitors seismological and tidal instruments in Hawaii and around the Pacific Ocean and prepares and distributes Watches and Warnings of tsunamis that may threaten lives and property. The PTWC also functions as the National Tsunami Warning Center responsible for providing tsunami warning services for all coastal states and other U.S. interests throughout the Pacific. The PTWC is most effective in warning against tsunamis that affect the entire Pacific Basin. Warnings for local and regional tsunamis occurring within 45 minutes to one hour of an earthquake event cannot be effectively disseminated by the PTWC in the same way as they are for remote source tsunamis. As a result, local and regional warning centers have been established for Hawaii, Alaska, and the U.S. west coast. The PTWC provides regional warning services for Hawaii; the Alaska Tsunami Warning Center (ATWC) provides regional warning services for Alaska, British Columbia, Washington, Oregon, and California. (**Contact** Michael Blackford, Pacific Tsunami Warning Center, 91-270 Fort Weaver Road, Ewa Beach, Hawaii, 96706, U.S.A.; phone (808) 689-8207; fax (808) 689-4543; E-mail Internet: ptwc@nalu.tsunami.soest.hawaii.edu).

NGDC Tsunami Databases

The National Geophysical Data Center (NGDC) has a major role in post-event data collection (including the compilation and cataloging of tsunami data) and provides a variety of products regarding tsunamis. The Pacific Tsunami Data Base includes approximately 2,000 events and 6,000 locations where tsunamis were observed. Tsunami mareograms containing tide gage records are also available on microfilm. In addition, the NGDC has several publications containing descriptive data about reported tsunami events and their effects, including:

United States Tsunamis (including United States possessions) 1690-1988
Tsunamis in the Pacific Basin (map)
Tsunamis in Peru-Chile
Tsunamis on the West Coast of the U.S.
2nd UJNR Tsunami Workshop, Honolulu, Hawaii, 5-6 November 1990, Proceedings

(**Contact** Patricia A. Lockridge, National Geophysical Data Center, NOAA, E/GC1, 325 Broadway, Boulder, Colorado 80303-3328, U.S.A.; phone: (303) 497-6446; fax: (303) 497-6513; E-mail Internet: info@mail.ngdc.noaa.gov).

VOLCANOES

The 1980 eruption of Mt. St. Helens in southwestern Washington caused the largest landslide by volume in recorded history. It also resulted in 60 deaths and approximately $1.5 billion in damage (FEMA, 1991). The U.S. has over 65 active or potentially active volcanoes, which is more than all other countries except Indonesia and Japan (Wright, 1992). The primary areas at risk from volcanic eruptions are the Pacific Rim states of Hawaii, Alaska, Washington, Oregon, and California. In addition, areas of potentially active volcanoes are found in Arizona, New Mexico, Idaho, Montana, and Wyoming. In the U.S., the USGS and the Smithsonian Institution administer programs on volcano hazards reduction.

USGS Volcanic Hazards Assessment Program

The Volcanic Hazards Assessment Program at the USGS was formed with the goals of preventing loss of life and property resulting from volcanic eruptions and volcano-related hydrologic events and minimizing economic hardship and social disruption that commonly occur when volcanoes threaten to erupt (Wright, 1992). To accomplish these goals, the USGS monitors currently active volcanoes and conducts research on active and prehistoric volcanic processes. Monitoring operations are carried out at the Hawaiian Volcano Observatory, founded in 1912; the Cascades Volcano Observatory, formed after the 1980 eruption of Mt. St. Helens; and the Alaska Volcano Observatory, added in 1988. An additional monitoring program of the Long Valley Caldera in eastern California is operated from the USGS center in Menlo Park, California. From information collected at these observatories and data telemetered via Global Positioning Satellites (GPS), eruption prediction is becoming a reality. Virtually every eruption has measurable precursors, such as precursory earthquakes and ground deformation. The recognition and interpretation of these precursors is improving yearly. Reduction of volcano hazards is only possible if information is effectively communicated to government officials and the general public. To communicate the results of volcano monitoring and research, the USGS publishes hazard assessments, including hazard-zone maps and general-interest publications on volcanic phenomena, and conducts media briefings and meetings with public officials.

In addition to the work being done in the U.S., the USGS contributes to the International Volcano Early Warning and Disaster Assistance Program (VDAP) through its Volcano Crisis Assistance Team (VCAT). The program is funded by the U.S. Agency for International Development's Office of Foreign Disaster Assistance (USAID/OFDA) and the USGS. The VDAP began as a rapid-response team, but has evolved to include a substantial component of work toward pre-eruption preparedness. For example, VDAP helped to establish the Observatorio Vulcanologico de Colombia and upgraded capabilities of the Guatemalan Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia, and the Ecuadorian Instituto Geofisico, Escuela Politecnica Nacional. Another example of international cooperation was the successful forecast of the eruptive events and effects of the 1991 eruption of Mount Pinatubo by the USGS and the Philippine Institute of Volcanology and Seismology. Table 2 is an example of alert levels issued prior to an eruption (Wolfe, 1992). (**Contact** William E. Scott, Cascades Volcano Observatory, U.S. Geological Survey, 5400 MacArthur Blvd., Vancouver, Washington 98661, U.S.A.; phone: (206) 696-7909; fax: (206) 696-7866; E-mail Internet: wescott@pwavan.wr.usgs.gov).

Table 2. Hazard-alert levels established for volcano-hazard communication at Mount Pinatubo

ALERT LEVEL	CRITERIA	INTERPRETATION
0	Background, quiet	No eruption in foreseeable future
1	Low-level seismic, fumarolic, other unrest	Magmatic, tectonic, or hydrothermal disturbance; no eruption imminent
2	Moderate level of seismic, other unrest, with positive evidence for involvement of magma	Probable magmatic intrusion; could eventually lead to an eruption
3	Relatively high and increasing unrest including numerous b-type earthquakes; accelerating ground deformation; increased vigor of fumaroles, gas emission	If trend increasing unrest continues, eruption possible within two weeks
4	Intense unrest, including harmonic tremor and/or many "long period" ("low frequency") earthquakes	Eruption possible within 24 hr
5	Eruption in progress	Eruption in progress
	STAND-DOWN PROCEDURES: In order to protect against "lull before the storm" phenomena, alert levels will be maintained for the following periods. AFTER activity decreases to the next lower level: From level 4 to level 3: Wait a week From level 3 to level 2: Wait 72 hr	

Smithsonian Global Volcanism Program

The Smithsonian Center for Short-Lived Phenomena was founded in 1968 for reporting of volcanic and other natural events. In 1975, the Smithsonian Institution stopped supporting the Center for Short-Lived Phenomena and transferred essential employees to the newly formed Scientific Event Alert Network (SEAN). In 1990, SEAN was renamed the Global Volcanism Network, which became responsible for maintaining descriptive reports on current worldwide volcanic activity. This global network consists of more than 1,000 correspondents, including professional volcanologists, scientists in other specialties, travelers, and other observers. The Smithsonian publishes the reports from this network in the monthly ***Bulletin of the Global Volcanism Network***. (Subscriptions within the U.S. are $18.00, subscriptions sent beyond the U.S. cost $28.00 a year, available from the American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009; phone (202) 462-6900.) The first decade of reports from SEAN are compiled and indexed in the publication ***Global Volcanism 1975-1985*** (McClelland, 1989).

The Smithsonian also maintains a database of geographic, volcanologic, and eruption information on volcanoes active in recent, or Holocene, time. Much of this information was published in ***Volcanoes of the World*** (Simkin, 1982), and a revised version will be available in the near future. (**Contact** Tom Simkin, Global Volcanism Program, National Museum of Natural History, MRC 119, Washington, DC 20560, U.S.A.; phone: (202) 357-2786; fax: (202) 357-2476; E-mail Internet: mnhms017@SIVM.SI.EDU; Bitnet: mnhms017@SIVM; Omnet: smithsonian.volcano; and PINET: volcano).

NOAA-FAA Volcano Hazards Alert Program

When a volcanic eruption occurs, ash columns can rise faster than 1 km/second and spread out for thousands of kilometers. The abrasiveness, melting point, and electrical properties of volcanic ash are extremely hazardous to modern commercial jet aircraft. Ash can cause serious engine damage (resulting in a compressor stall or a "lame out''), can scratch the forward windscreen to make viewing impossible, and can cause electrical discharges which can interfere with communications and navigation systems. To reduce these aviation hazards, NOAA and the Federal Aviation Administration (FAA) have developed a program to track ash clouds and provide warnings to commercial aircraft; considerable interaction occurs between the USGS and Smithsonian programs.

The National Weather Service (NWS) has the responsibility to issue SIGMETS for volcanic ash in the airspace designated as U.S. Flight Information Regions (FIRs), which includes much of North America, the North Pacific, and the North Atlantic. Warnings are issued from the National Aviation Weather Advisory Unit in Kansas City for the contiguous U.S. and portions of the oceanic areas north of 30°N. between 30° E. and 160°E. Other SIGMET responsibilities reside with the Meteorological Watch Offices (MWO) at: Anchorage, Alaska; Guam; Honolulu, Hawaii; and Miami, Florida. Satellite analysis of volcanic ash plumes outside of the U.S. FIRs are provided to the FAA by the NOAA/NESDIS Synoptic Analysis Branch. (**Contact** James S. Lynch, Synoptic Analysis Branch, Satellite Services Division, NOAA-NESDIS, E/SP23, WWB 401, 5200 Auth Road, Camp Springs, Maryland, 20233, U.S.A.; phone: (301) 763-8444; fax: (301) 763-8131).

LANDSLIDES

Although precise data regarding landslides are not available, a landslide disaster occurs somewhere in the world almost every day. Some disasters, such as earthquakes or tornadoes, occur suddenly and with little or no warning. On the other hand, prolonged drought or ground subsidence may occur over a much longer period with equally damaging effects. Landslides encompass both extremes: sudden and catastrophic, and slow and insidious (Fleming, 1980). Landslides are often "secondary effects'' and occur after an earthquake, a volcanic eruption, or strong wave action on a shoreline. The alteration of sloping land by humans can also result in landslides.

The annual death rate in the United States from landslides is 25 to 50, with annual economic losses estimated at $1 to $2 billion (FEMA, 1991). The 1985 report on "Reducing Losses from Landsliding in the United States,'' by the Committee on Ground Failure Hazards of the National Research Council states that "The loss of life from landsliding is comparable to the total loss of life from floods, earthquakes and hurricanes'' (Krohn and Slosson, 1976).

As mentioned previously in the Volcanoes section, the world's largest landslide in terms of volume occurred when the northern part of the cone of the Mt. St. Helens volcano collapsed just before the 18 May 1980 eruption. Even though this was the largest landslide in history, because of effective evacuation and preparedness measures, less than 10 people were killed by the landslide (FEMA, 1991). The landslides caused by Mt. St. Helens, which were a secondary effect of the volcanic eruption, created another potential secondary effect. The landslides created three "natural'' dams which, in the opinion of the USGS, are extremely unstable and likely to collapse and release millions of liters of water from the lakes that have formed behind the dams. In an effort to confront the landslide problem, the USGS supports several programs involved in the research of landslides (FEMA, 1991).

National Landslide Information Center

The USGS established the National Landslide Information Center (NLIC) in 1990 to collect, analyze, and distribute information on all aspects of landslides worldwide. The NLIC began as a repository for landslide reports, maps, and photographs originally intended to serve researchers in the Landslide Hazard Research Program of the USGS. It has evolved into a library of landslide information for anyone wishing to search a standard system of computerized bibliographic keywords, authors, and related information. Current active databases include more than 9,000 landslide maps and reports; contact information and interests of landslide researchers and related professionals; uncataloged photographic materials; worldwide newspaper reports that describe landslide damage, fatalities, and conditions surrounding landslide disasters; and press releases, copies of legislation, and other documents on landslide-hazards mitigation. The center also maintains a global database on landslide dams and a World Landslide Inventory, which reports significant events and maintains communication between about 300 overseas contacts. (**Contact** William M. Brown III, National Landslide Information Center, U.S. Geological Survey, P.O. Box 25046, MS 966, Denver Federal Center, Denver, Colorado 80225-0046, U.S.A.; phone: (800) 654-4966; phone: (303) 273-8587; fax: (303) 273-8600; E-mail Internet: wbrown@gldrtv.cr.usgs.gov).

Branch of Western Regional Geology

The Branch of Western Regional Geology of the USGS has digital files relating to landslide hazards in western states. For example, a database of landslides in New Mexico has been completed, and regional landslide hazard maps of the state are being prepared. Prototype databases for San Mateo County give landslide susceptibility; slope; debris flow potential; earthquake liquefaction potential; expected earthquake damage to tilt-up concrete, wood-frame, and concrete and steel buildings; and expected felt intensity for a repeat of the 1906 San Francisco earthquake. Branch members also help produce the ***International Landslide Research Group (ILRG) Newsletter***, which monitors and provides information on landslides and landslide research worldwide. Cooperative programs with the Italian National Research Council in Perugia, the Caribbean Landslide Working Group (Jamaica), the Andalusian Group of Natural Hazards and Environment (Spain), and the Geography Department at Heidelberg University (Germany) provide opportunities for students to receive instruction and guidance on regional landslide hazard analysis using Geographic Information System (GIS) techniques. (**Contact** Earl E. Brabb, U.S. Geological Survey, 345 Middlefield Road, MS 975, Menlo Park, California 94025, U.S.A.; phone: (415) 329-5140; fax: (415) 329-4936; E-mail Internet: ebrabb@isdmnl.wr.usgs.gov).

DISASTER EPIDEMIOLOGY

Epidemiology is the study of causes and determinants of disease in populations. Disaster epidemiology is extended to include the causes of fatalities and injuries as well as disease. Several institutions in the U.S. are involved in studying the relationship between casualties and injuries resulting from natural disasters and issues such as building performance, occupant actions, and search and rescue in collapsed buildings. The Centers for Disease Control and Prevention (CDC) based in Atlanta, Georgia, have major responsibilities for coordinating and managing the health response in the event of major emergencies and disasters. In addition to this responsibility, CDC and the American Red Cross (ARC) maintain a database of epidemiological information on all major natural disasters that have occurred in the U.S. and associated territories since 1987.

Centers for Disease Control and Prevention and American Red Cross

In 1987, ARC and CDC developed a natural disaster morbidity and mortality surveillance system. The ARC Disaster Health Services staff collect two types of data: 1) information on the circumstances of deaths and injuries for disaster-affected populations, and 2) information on injuries and illnesses sustained by ARC disaster field staff. The CDC epidemiologists then code and enter the data into a computer for processing and statistical analysis. The database includes statistics on deaths, injuries, and illnesses associated with all major natural disasters that occurred in the U.S. and associated territories from 1987 to 1993. Analysis of this data provides information for developing citizen protection guidelines to reduce or prevent future natural-disaster-related disease and injury. (**Contact** Eric K. Noji, M.D., Centers for Disease Control and Prevention, Disaster Assessment and Epidemiology Section, Health Studies Branch, Division of Environmental Hazards and Health Effects, MS F46, 4770 Buford Highway, N.E., Atlanta, Georgia, 30341-3724, U.S.A.; phone: (404) 488-7350; fax: (404) 488-7335).

DISCUSSION AND CONCLUSION

We have attempted to summarize the most readily accessible natural hazards data available in the U.S. and organizations currently involved in natural hazards research. As previously stated, if the information required is not available from the organizations described above, we suggest contacting the Natural Hazards Research and Applications Information Center. Many professionals contact the Hazards Center first when looking for information or beginning a research project so that they may be directed to the appropriate program, researcher, or government official to assist them, share their experiences, or offer guidance. In the past, for example, center staff have provided information and suggestions regarding the proposed national all-hazards insurance program; possible activities for the U.S. in the International Decade for Natural Disaster Reduction (IDNDR), January 1990-December 1999; floodplain management programs; predictions of possible earthquakes; the upcoming national assessment of the status of natural hazards research in the U.S.; and the impact of natural disasters on technological hazards. In addition, the center staff responded to requests regarding recovery from Hurricane Andrew and the flooding in the U.S. Midwest in the summer of 1993, and provided sources of information on structural damage caused by snow, ice, earthquake, and wind.

In the future, it is important that data collection and research continues to further reduce the impact of natural disasters. Research into the physical nature of natural hazards is important for improving engineering and management systems. Social science research is also necessary to improve understanding of human behavior and reactions to natural hazards and disasters. Most importantly, this information must be available to those who make the decisions about programs and policies that are intended to reduce the impacts of natural hazards. This information should be used to plan each phase of natural disaster reduction including: mitigation, preparedness, response, and recovery. As knowledge is gained, the information must be effectively communicated to all groups involved. Therefore, it is essential that resources be devoted to increasing communication among researchers, practitioners, government officials, the media, the general public, as well as the international community.

REFERENCES

Bridgett, I.S., and Miller, T.R. (1991) ***USGS Library/SIGCAT CD-ROM Compendium***, U.S. Geological Survey Open-file Report 91-40, p. 71, 91.

Federal Emergency Management Agency, Office of Civil Defense (1991) Principal Threats Facing ***Communities and Local Emergency Management Coordinators***, p. 17, 20, 25, 28-29, 40-41, 46-48.

Federal Interagency Floodplain Management Task Force (1992) ***Floodplain Management in the United States: An Assessment Report***, vol. 1, Summary Report, prepared for the Federal Interagency Floodplain Management Task Force by the Natural Hazards Research and Applications Center, p. 14, 17, 31.

Fleming, R.W. and Taylor, F.A. (1980) ***Estimating the Costs of Landslide Damage in the United States***, U.S. Geological Survey Circular 832, p. 1-2, 5, 20.

Grazulis, T.P. (1991) ***Significant Tornadoes 1880-1989, Volume I, Discussion and Analysis***, p. 128.

Khrohn, J.P. and Slosson, J.E. (1976) "Landslide potential in the United States," ***California Geology***, v. 29, no. 10, p. 224-231.

Krol, E. (1992) ***The Whole INTERNET***, p. 1-9, 350-352.

Lander, J.F. and Lockridge, P.A. (1989) ***United States Tsunamis (including United States possessions) 1 690-1988***, p. 1, 5-7, 38-39, 119, 166-167.

McClelland, L., Simkin, T., Summers, M., Nielsen, E., Stein, T.C. (1989) ***Global Volcanism 1975-1985***, p.2-7.

Sheets, R.C. (1990) "The National Hurricane Center—Past, Present, and Future," ***Weather and Forecasting***, vol. 5, no. 2, p. 185-232.

Simkin, T., Siebert, L., McClelland, L., Bridge, D., Newhall, C., and Latter, J.H. (1982) ***Volcanoes of the World***, p. 1-2.

Wolfe, E.W. (1992) "The 1991 Eruptions of Mount Pinatubo, Philippines," ***Earthquakes and Volcanoes***, vol. 23, number 1, p. 5-35.

Wright, T.L., and Pierson, T.C. (1992) ***Living with Volcanoes, The U.S. Geological Survey's Volcano Hazards Program***, p. 1.

Geological Survey of Japan Report, No.281, 1995 p.85-99

Applications of Satellite Remote Sensing and GIS, to the Inventory and Analysis of Geological Hazards: A Review of the Results of an UNESCO Sponsored Project of International Cooperation

Niek Rengers and Robert Soeters

International Institute for Aerospace Survey and Earth Sciences(ITC), The Netherlands

ABSTRACT

The organizational background, the objectives and the main phases of execution of an international research project on mountain hazard mapping using GIS are described.

Airborne and satellite remote sensing techniques, such as photography, imaging radar and multispectral scanning provide spatially distributed electromagnetic reflection data from the earth's surface. In a process of digital image processing, these data can be geo-referenced and be made ready for the production of imagery for visual interpretation and for introduction into a Geographical Information System.

A GIS makes it possible to combine data about the geology, terrain form and a number of other terrain characteristics, as derived from maps, field surveys and from remote sensing in an analysis to determine the influence of these various terrain factors on the likelihood of occurrence of a number of different slope instability processes.

The authors discuss the possibilities and limitations of scale and resolution of remote sensing imagery, when it is used for slope instability hazard analysis. Key factors are the size of the slope instability phenomena and the various scales at which hazard maps should be prepared for regional, local and site planning purposes.

Conclusions are presented about the applicability of available types of airborne and satellite remote sensing imagery and desirable developments for the future are indicated.

INTRODUCTION

Since two decades non-photographic Remote Sensing has undergone an enormous development andhas found widespread application. However, in many cases strong overselling of the potentials ofRemote Sensing has created disappointment for its users.

Another recent development is the application of Geo Information Systems (GIS) in the Earth Sciences.

Although it is clear that the integration of Remote Sensing with GIS offers very interesting perspectives (Ehlers *et al.*, 1989), the present authors have critically reviewed possibilities and limitations of this integration, specially when applied to mountain hazard mapping. The authors are involved in a research program sponsored by UNESCO, EEC and Netherlands government. This research program in the framework of the Decade of Disaster Reduction aims at the development of Mountain Hazard Mapping methodologies using PC-based GIS and the transfer of these methodologies to hazard mapping specialists in the Andean countries Bolivia, Colombia, Ecuador, Peru, and Venezuela. In the developed methodology the use of remote sensing imagery plays a large role.

Keywords: International cooperation, Remote sensing, Geological hazards, GIS, UNESCO

REMOTE SENSING (RS) AND GEO INFORMATION SYSTEMS (GIS)

Both digital RS and raster-based GIS are assigning numerical values to well defined areas (sceneelements) of the earth's surface to produce a numerical image of the earth's surface. Through a process of image correction and resampling the geocoded RS data can be matched with the raster cells of the GIS. This opens wide possibilities of correlation studies between basic RS data and thematic information derived from the introduction of digitized maps in the GIS.

In order to determine which limitations are set to these correlations it is important to define which type of data with which resolution are available from digital remote sensing and how these fit to the thematic information introduced into the GIS from other sources. Figure 1 shows in general terms the relationship between GIS and RS. Remote Sensing is shown as one of a number of possible inputs of data/information into a GIS.

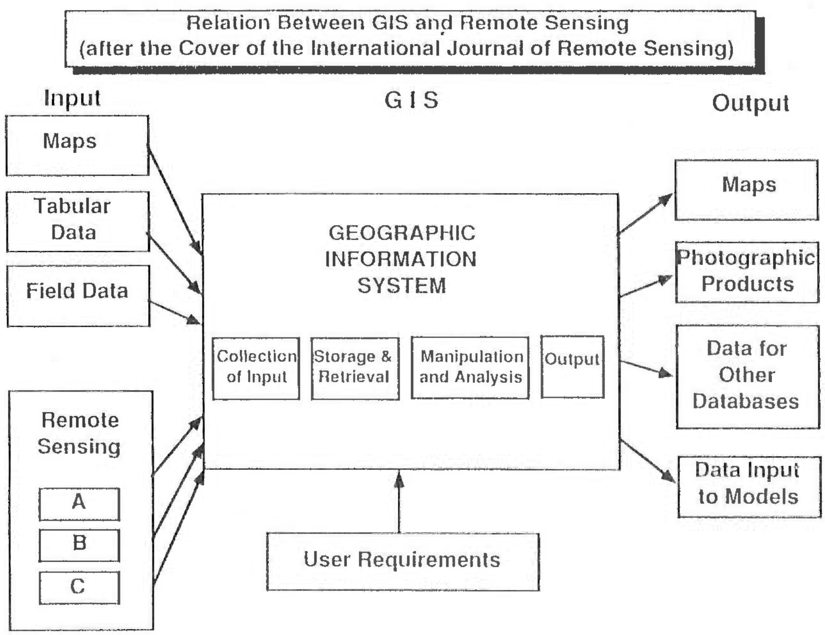

Fig. 1. Relationships between Geographic Information Systems and Remote Sensing

Figure 2 shows in more detail which possibilities exist for the input of RS data or information derived from RS data into the GIS:

1)Direct inputting of raw RS data into the database of a GIS

2)Digital Image Processing (DIP) of raw RS data; this may include geometric correction, image enhancement and resampling procedures, and subsequent input of calibrated and/or geocoded data into the GIS

3)Digital Image Processing of the raw RS data; preparation of a picture; visual interpretation of the picture; input of the thematic interpretation into the GIS by digitization of the thematic interpretation map.

The interrupted line in figure 2 encloses a GIS in which DIP capabilities are integrated. An example of such a GIS is the PC based ILWIS system which has been developed at ITC (Valenzuela, 1988) and which was used in a hazard assessment analysis (Soeters *et al.* 1991). A schematic representation of ILWIS is given in figure 3.

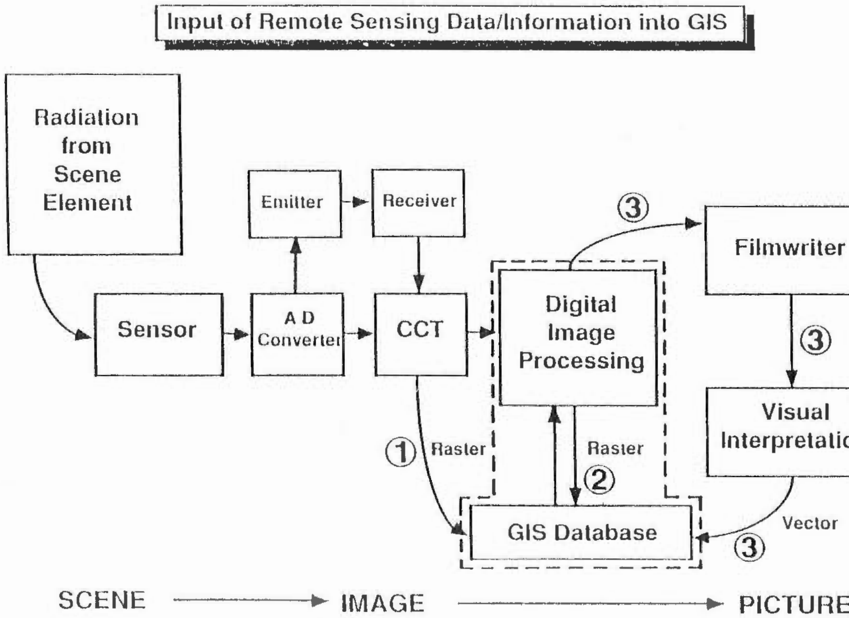

Fig. 2. Input of R S Data/Information into a GIS. The interrupted line encloses a GIS in which Digital Image Processing has been integrated. For explanation of numbers see text.

The introduction of digital image processing capabilities in the GIS results in important advantages. The ILWIS software for instance will allow for:

- display of geometrically corrected images (ortho-photography and TM-, SPOT imagery) and overlaying with thematic information from other sources
- screen digitizing over displayed raster imagery
- display of individual bands or colour composites using tools as linear stretching, histogram equalization, filtering, etc.
- supervised classification in the imagery

MOUNTAIN HAZARD MAPPING AT VARIOUS SCALES

Natural hazard mapping is not restricted to the delineation of occurrences of phenomena of mass movement, flooding, earthquakes, volcanism in the past but is focussed on making predictions about occurrence of such phenomena in the future (Varnes, 1984). Hazard maps outline zones which are defined in terms of the probability of occurrence of potentially damaging phenomena within a certain span of time.

During the process of the preparation of such maps the influence of a number of factors on the likelihood of occurrence must be assessed. The more detailed the resulting map should be, the more factors will have to be studied. The methodology which has to be followed depends on the scale of the map to be prepared, on the purpose for what it is made and on the amount of information which is available about the area concerned.

The following gives an overview of the various scales of mass movement hazard maps which are prepared in the framework of the Mountain Hazard Mapping research project described by Soeters *et al.* (1991), with a short description of the purpose for which they are used, the methodology which is applied, the input information necessary, and the type of remote sensing imagery which can be used.

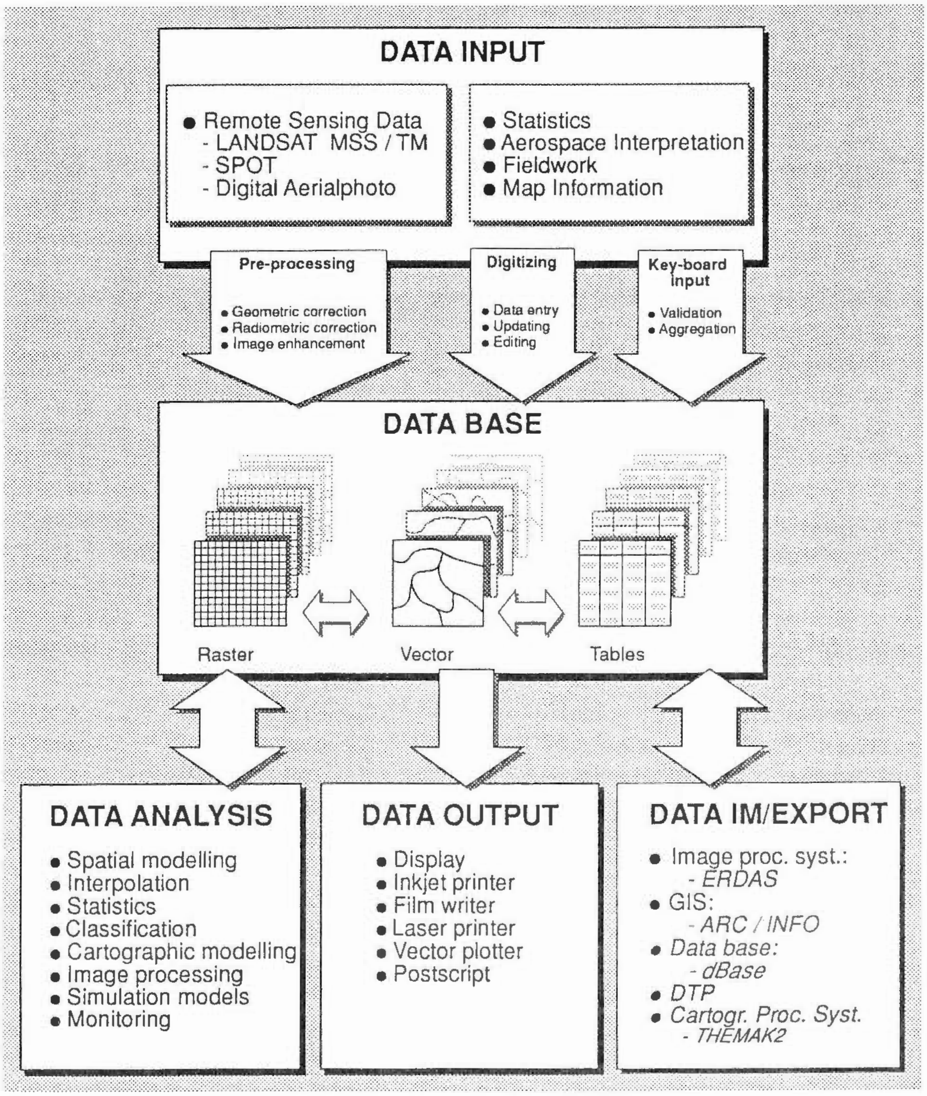

Fig. 3. Schematic representation of ILWIS

REGIONAL SCALE HAZARD MAPPING (1:100,000 to 1:250,000)

Application:

Early planning stages of regional (infrastructural) development

Methodology used:

Qualitative and semi-quantitative approach, map overlaying, simple statistics and experience based assessments.

Information required:

Thematic maps on the geology, geomorphology, landuse and topography and drainage network of the area at a regional (small) scale. If such an information is not available, the approach of Terrain Mapping Units

(TMU's; Meijerink, 1988) can be followed. TMU's are terrain classes discernible on small scale stereoscopic images (Stereo SPOT or aerial photographs) which can be considered as homogeneous in terms genesis, lithology and distribution of soils. Mapping of individual mass movement phenomena is not possible at this scale and the correlation of TMU's and slope instability processes should rely on inventory maps.

The knowledge on the distribution of mass movements can be obtained by the study of available records and data bases on landslide occurrences or the study of sample areas on large scale photographs and by walk-over surveys.

Remote sensing imagery required:

As the terrain zoning at this stage is based primarily on morphological characteristics of the terrain, use can be made of stereo imagery at small scale (1:50,000 to 1:150,000), which is either black and white panchromatic or multispectral and combined to a colour composite picture. Radar imagery may be useful at this stage in the differentiation of the terrain units. Limited use is made of large scale photographs for the characterization of the attributes belonging to the TMU's and for process mapping.

MEDIUM SCALE HAZARD MAPPING (1:25,000 to 1:50,000)

Application:

To determine hazard zones with an accuracy which can serve for the location of engineering structures, for road location and in urban extension planning.

Methodology used:

Variety of analytical methods, statistical methods such as multivariate and discriminant analysis in determining weight of contributing factors, map crossings and hazard indexing.

Input information required:

Detailed topographic information in the form of a Digital Elevation Model (DEM), reliable slope instability inventory map, geomorphological map, engineering geological map emphasizing on lithology, rock mass properties and spatial orientation and intensity of discontinuities and land use map. For the establishment of the activity of slope instability sequential data are required. Available data bases and historic files may enable a correlation of the processes with climatological conditions (precipitation, snow melt).

Remote sensing imagery required:

Large scale aerial photography (1:15,000 to 1:25,000), panchromatic, colour or false colour infrared.

Spatial resolution must allow for the identification and analysis of individual slope failures. Medium and/or small scale photography (1:30,000 to 1:50,000) may serve for the mapping of the contributing parameters (factor maps).

LARGE SCALE HAZARD MAPPING (1:5,000 to 1.15,000)

Application:

In the early stages of a site investigation for civil engineering works, to determine quantitatively the hazard of particular damaging phenomena.

Methodology used:

Detailed observations according to the methodology described under Medium Scale Hazard Mapping, coupled with quantitative analytical methods such as deterministic and probabilistic stability analysis supported by a limited amount of geotechnical (laboratory) testing.

Input information required:

Detailed topographic information (corresponding to large scale topo maps of 1:5,000 to 1:10,000). Detailed data on engineering soil conditions, relationships with underlying lithological units, structural geological conditions, hydrogeological conditions and expected variations in function of precipitation and geotechnical characterization of the geological units.

Remote sensing imagery required:

Large scale (1:5,000 to 1:10,000) aerial photographs panchromatic black and white, colour or false colour infrared, are of limited use in the slope stability assessment but may serve very well for the monitoring of the mass movement.

As a conclusion it can be stated that for all scales of hazard mapping stereo imagery is of utmost importance as the zones into which the terrain is divided are distinguished primarily on the basis of morphology, rocks and soils. For those scales of hazard mapping which are more detailed than the regional scale, the resolution of the imagery is becoming of great importance as the occurrence of individual mass movements is an important input information in the analytical methods which are used for hazard assessment at those scales. In the following chapter the aspects of ground resolution and the relation to the size of objects which can be recognized and identified will be discussed.

THE ROLE OF REMOTE SENSING IMAGERY

The interpretability of slope instability features on remote sensed images is based on the recognition and identification of elements associated with slope movements, the study of these imaged features and the deduction of their significance for a particular type of slope instability.

This definition implies that slope instability phenomena are seldomly identified as such, but ***interpreted*** by the analysis of a certain number of elements pertaining to the slope failure and characterising its nature. From the definition is becomes clear that the interpretability of slope instability phenomena depends in the first place on the spatial resolution of the images and the size of the features which can be recognized or identified and which are characterizing the slope movement. This statement is also based on the consideration that spectral information by itself seldomly allows for the interpretation of slope movements, it only influences the contrast of the features which are usually interpreted on the basis of their land form and pattern.

1.Spatial Resolution

The meaning of the word resolution is giving cause to confusion as it is used with different meanings in photography and in non-photographic remote sensing.

In aerial photography "ground resolution" is usually defined (see figure 4) as the minimum number of meters per line pair on the ground which is still visible as two distinct lines of different colour or grey tone in the picture.

In non-photographic remote sensing the expression "ground resolution" is mostly used to indicate the size of the area on the ground ("scene element" or "instantaneous field of view, (IFOV)") of which the radiation is integrated to give one radiation value in the image. When the image is presented as a picture without data reduction, then the ground resolution area will form the basic element (pixel) of the picture.

In order to prevent confusion the authors prefer to use the expression "**ground resolution cell**", which is equal to the scene element in non-photographic remote sensing and where the Resolution in terms of meters per ground resolution cell (Rm/grc) is related to photographic resolution in terms of meters per line-pair (Rm/lp) in the following way (after Naithani, 1990):

For simplicity reasons in the following text and tables the size of a ground resolution cell in

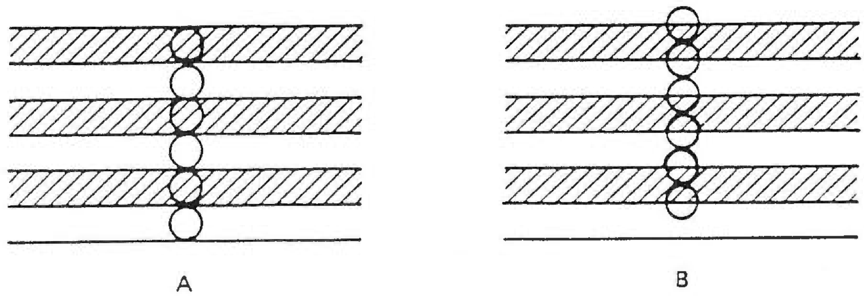

Fig. 4. Line pairs and ground resolution cells (GRC) to define resolution in aerial photography (after Naithani, 1990)
A: six GRC resolve three line pairs
B: more than six GRC are needed to resolve three line-pairs

aerialphotography will be rounded off to 1/2.5 x the value for the resolution in meters per line pair as presented by Naithani (1990).

Figure 4 shows that line-pairs on the ground must be more than 3 ground resolution cells wide in order to be detectable on the image or picture as line-pairs with contrasting greytones or colours. Objects which are not lines but which are irregular in form need a size of at least 3x2 ground resolution cells (see also table of figure 5) to be detectable on the basis of their known spectral characteristics against a contrasting background.

Detection in this context means that it is possible to decide if an object of known spectral characteristics is present or absent at a defined geographical location.
Recognition means that it is possible to decide if an object of known form and spectral characteristics is present anywhere in the picture.
Identification means that it is possible to identify objects of variable form and spectral characteristics on the basis of their form characteristics and context within the background.

	Detection	Recog-nition	Identi-fication
EXTREME CONTRAST white or black object in variable grey tone background	5 - 8 (2 x 3)	10-15 (3 x 4)	20 - 30 (5 x 6)
HIGH CONTRAST dark or light object in grey tone background	10 - 15 (3 x 4)	30-40 (5 x 7)	80 - 100 (8 x 10)
LOW CONTRAST grey tone feature in grey tone background	200 - 250 (10 x 20)	400x600 (20x30)	1000 - 1500 (30 x 40)

Fig. 5. Number of ground resolution cells (GRC) needed to detect, recognize or identify objects against backgrounds of various contrast to the object. In parentheses an indication is given of the minimum dimensions of non-elongated objects counted in numbers of GRC.

On the basis of their experience with visual interpretation of remote sensing imagery the authors have concluded that for various greytone contrast relationships between object and background the numbers of ground resolution cells needed to detect, recognize and identify objects in a picture are as listed in the figure 5. Behind the number of cells is given in parentheses an indication of the size (expressed in number of ground resolution cells) for objects of non elongated shape as is usually the case for mass movement phenomena. The largest dimension of the objects is used in the table of figure 8 to indicate which size mass movement features should have in order to be detectable, recognizable or identifiable in photographic or other type of remote sensing imagery.

Extreme contrast exists when a completely white or black object is present against a variable greytone background.
High contrast indicates a dark or light object against a greytone background.

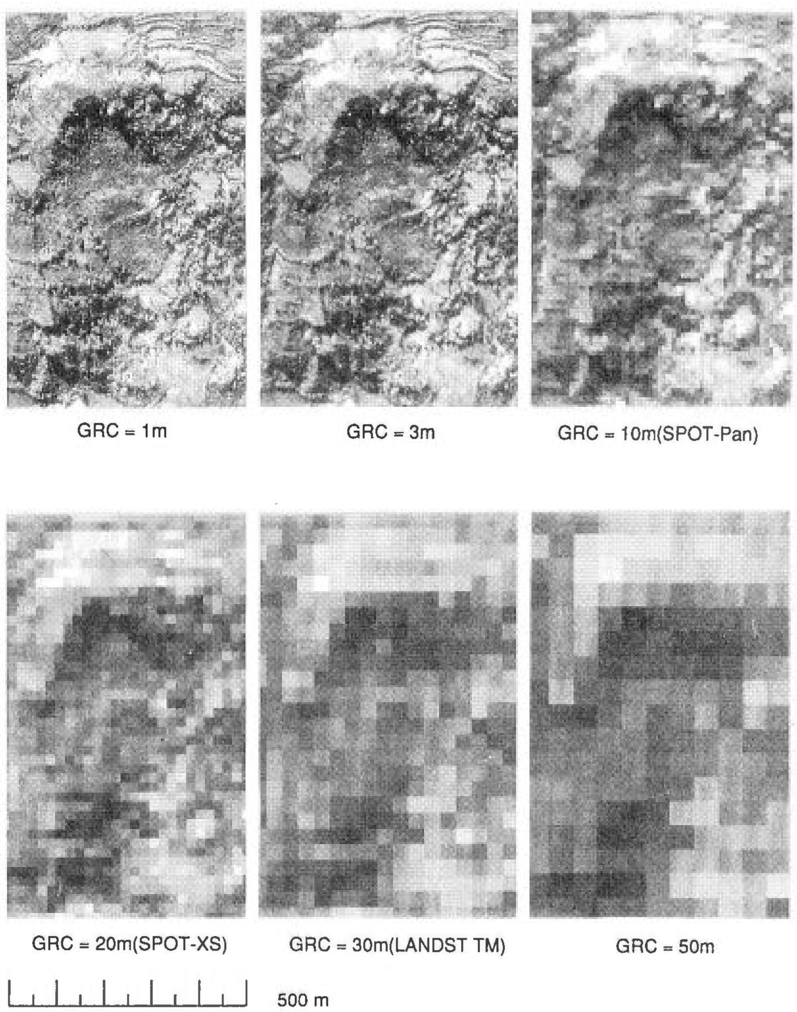

Fig. 6. Pictures of an area in the Central Spanish Pyrenees showing a landslide scar with shadow (***high contrast***) in the central upper part of the picture and a deposition area of landslide debris (***low contrast***) in the lower middle part of the picture. The pictures were derived from a scanned large scale aerial photograph and have artificially aggregated pixel sizes as if the ground resolution cell (GRC) size of the pictures would have had values of 1m, 3m, 10m, 20m, 30m, and 50m.

Low contrast indicates that the spectral characteristics of the object do not differ significantly from the background and that objects can only be identified or recognized on the basis of their form characteristics.

This is illustrated by the figures 6 and 7 which were derived from a large scale aerial photograph, which was digitized with a raster size as if the original ground resolution cell had been 0.3 meter. The individual pictures were then printed with artificially aggregated pixels as if the ground resolution cell size had been 1 m, 3 m, 10 m, 20 m, 30 m, and 50 m.

Figure 6 shows the various ground resolution cell size pictures of an area in the Central Spanish Pyrenees (Sissakian *et al.* 1983) which shows a landslide scar with shadow (giving ***high contrast***) in the upper middle part and a deposition area of landslide debris in the central to lower part. The deposition area is recognizable by a characteristic surface texture (***low contrast***) and by a surrounding line of higher vegetation in the pictures with small ground resolution cell sizes.

Figure 7 shows the same photograph, but now with an artificially enhanced landslide scar in complete white to show the effect of ***extreme contrast*** on the detectability.

The table of figure 8 shows the sizes of objects which can just be detected, recognized and identified in photography of various scales and in various types of non-photographic remote sensing imagery. The sizes were determined by multiplying the ground resolution cell size for the type of imagery with the largest of the two dimensions of the object in the table of figure 5. The ground resolution cell size for aerial photography was determined by dividing with a factor of 2.5 the values for resolution in meters per line-pair as given by Naithani (1990).

The values given in the table are only giving an indication of the order of magnitude of the size of objects, taking into consideration the contrast as this will influence the relationship between ground resolution cell size and interpretability of the object.

When the applicability of Remote Sensing is defined by the spatial resolution alone, as is done in the table, one should look as well at the medium size of slope failures. Although sizes of landslides vary enormously, also for different types of slope failure, it may be concluded from other studies (Cleaves, 1961; Crozier, 1973; Carrara, 1982) that the average size of landslides of engineering importance is in the order of many tens of metres to a few hundreds of metres. This implies that the larger of these slope failures may be recognized on SPOT Panchromatic imagery if there is a high contrast, but satellite imagery will normally be unsuitable for a proper analysis of smaller slope instability phenomena.

The authors have shown earlier (Sissakian *et al.* 1983) the limited applicability of small scale aerial photography although its ground resolution cell size is ten times as large as in SPOT Pan. Based on such experience obtained in several areas under different terrain conditions, it is concluded that the best type of imagery allowing for the inventory of slope instability phenomena is aerial photography at scales from 1:15,000 to 1.25,000.

2. Geometrial correction of Aerial Photography

The traditional strict boundary between photographic and digital imagery can be overcome by the scanning of photography which produces "digital photography". Such photoscanning produces a digital file in which the photographic image is resolved in lines and columns of image elements of which the coordinates are the photo coordinates and of which the greytone is the average of the image element-area on the photograph, the size of which is chosen for the scanning procedure. This element size can be chosen to be so small (< 0.03 mm) that visual interpretation does not show any difference between the original photograph and the image produced from the digital file by a film writer. By aggregation procedures picture elements or "pixels" can be produced of larger sizes in which the greytone of the composing image elements is averaged. The figures 6 and 7 have been produced in this way so as to produce simulated images from various satellite

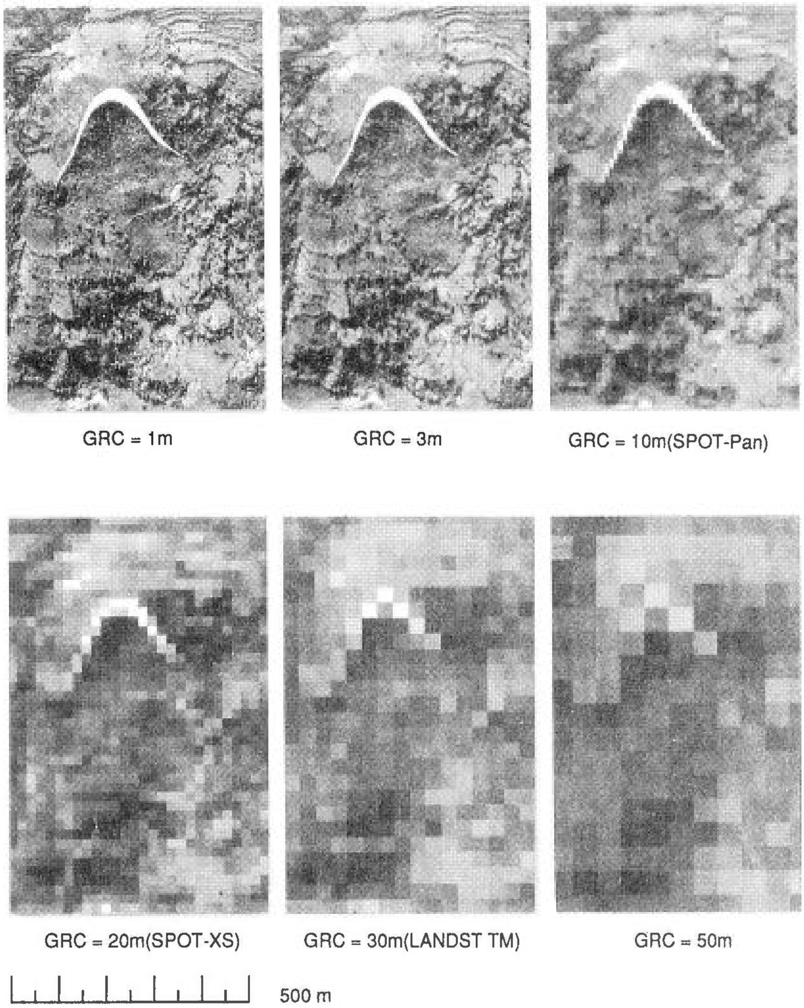

Fig. 7. Pictures of the same area and with the same ground resolution cell sizes an the pictures in figure 6, but now with an enhanced slide scar in complete white to show the influence of ***extreme*** contrast on the resolution characteristices of the pictures with various ground resolution cell sizes. Such extreme contrast conditions are rarely encountered in imagery of the non-snow-covered parts of the continental earth.

remote sensing systems from digitized photography.

As soon as the photographic image is available in the form of a digital file, all image processing techniques can be used to enhance or geometrically transform the image. Bargagli (1991) has shown how photographic images can be transformed into an ortho photo projection of the required scale which can be used within the GIS environment of the ILWIS system. Verweij and Budde (1991) used this technique for the monitoring of fire events visible on aerial photography coverage at widely differing scales taken in 10 different years from an area in Colombia.

Although the accuracy of the geometrical correction procedure depends to a high degree on the accuracy of the available control points which are recognizable in the image, the first impression is that the procedure leads to results which are better than the results of conventional techniques for the transfer of photo data to a topographic base map.

3. Spectral and temporal information

Additional to the synoptic spatial information, satellite imagery is also offering spectral information as the reflection intensity data are obtained in different wavelength bands. Black and white images obtained in various wavelength bands may be combined into colour composites of which the false colour composite, comparable to the false colour infrared photography, is the most common.

Infrared photography, specially sensitive for registering differences in vegetational conditions and variations in soil humidity, has been used successfully in slope instability studies and for this reason beneficial results could be expected from spectral remote sensing data obtained in the infrared wavelength bands.

However, the size of areas with anomalous drainage conditions or disturbed vegetational conditions, responsible for anomalous spectral responses, is generally too small to enable an interpretation of individual instability features on the basis of spectral criteria.

Practical applications of spectral information from satellite imagery are possible when a direct relationship is known between slope instability and vegetational conditions as described by McKean (McKean *et al.*, 1991). Spectral vegetation indices map spatial patterns of grass senescence which are found to be related with soil thickness and slope instability, while slope failures in forested areas expose understory vegetation and soils and also alter the site spectral characteristics.

A similar approach, but now on large scale, is demonstrated by Bison *et al.* (1990), who correlates thermal data with the soil humidity and the pore water pressure to monitor slopes for slope instability.

Satellite systems, orbiting around the earth, also make it possible to obtain regularly data from the same area allowing to follow processes in time. As far as this temporal information of satellite data is concerned, it can be observed that satellite imagery may serve in slope instability hazard impact assessment. Data obtained shortly after a period of slope instability will show a high contrast between the zones affected by slope instability and the stable surroundings, which results in detectable spectral anomalies.

Pictures of an area in the Central Spanish Pyrenees showing a landslide scar with shadow (***high contrast***)

		Landsat MSS	Landsat TM	Spot XS	Spot Pan	A.P.*) 1:100.000	A.P.*) 1:50.000	A.P.*) 1:25.000	A.P.*) 1:10.000
GROUND RESOLUTION CELL SIZE		80m	30m	20m	10m	1m	0.5m	0.25m	0.1m
HIGH CONTRAST feature-background	Detection	320m	120m	80m	40m	4m	2m	1 m	0.4m
	Recognition	560m	210m	140m	70m	7m	3.5m	1.8m	0.7m
	Identification	800m	300m	200m	100m	10m	5m	2.5m	1 m
LOW CONTRAST feature-background	Detection	1600m	600m	400m	200m	20m	10m	5m	2m
	Recognition	2400m	900m	600m	300m	30m	15m	7.5m	3m
	Identification	3200m	1200m	800m	400m	40m	20m	10 m	4m

*) Without Forward Movement Correction

Fig. 8.Table with the minimum sizes of objects to be detected, recognized and identified for various conditions of contrast with their background in various types of imagery. Values should only be used as an indication of the order of magnitude. For a detailed explanation on the determination of the size values see the text.

in the central upper part of the picture and a deposition area of landslide debris (***low contrast***) in the lower middle part of the picture. The pictures were derived from a scanned large scale aerial photograph and have artificially aggregated pixel sizes as if the ground resolution cell (GRC) size of the pictures would have had values of 1 m, 3 m, 10 m, 20 m, 30 m, and 50 m.

Pictures of the same area and with the same ground resolution cell sizes as the pictures in figure 6, but now with an enhanced slide scar in complete white to show the influence of ***extreme contrast*** on the resolution characteristics of the pictures with various ground resolution cell sizes. Such extreme contrast conditions are rarely encountered in imagery of the non-snow-covered parts of the continental earth.

CONCLUSIONS ON POSSIBILITIES FOR TODAY

Satellite remote sensing can be a useful source of input data for GIS used for landslide hazardassessment if the GIS is incorporating digital image processing facilities.

The application of presently available satellite remote sensing is limited as far as it refers to the direct mapping of slope instability features. The spatial resolution does not allow for the identification of landslides features smaller than 100 m in conditions of favorable strong contrast between the feature and the background. If contrast conditions are less favorable then identification is even limited to features larger than 400 metres.

The need for stereo imagery, which is necessary for the interpretation of the characteristic and diagnostic morphological features of slope failures, further limits the applicability of an important part of the presently available remote sensing imagery.

The above mentioned limitations lead to the conclusion that SPOT imagery can be used for the regional scale landslide hazard mapping to outline terrain mapping units. Thematic Mapper images could be used as well if stereomates for stereoscopic vision are prepared with help of a detailed digital elevation model of the terrain.

For larger scale hazard mapping at the medium and large scale it is necessary to make inventories of existing landslide phenomena, for which aerial photography with its good spatial resolution characteristics is needed.

The most evident applicability of satellite data is in the indirect mapping methods, when landslide

Platform	Year	Spectral Bands	Spectral Range	Stereo	Ground Resolution Cell Size	Country
Shuttle	1983	1	Radar	No	17-58 m	U.S.
		2	VIS/NIR	No	20 m	W.-GERMANY
Landsat-4/-5	1982/84	4	VIS/NIR	No *	80 m	U.S.
		7	VIS/NIR	No *	30 m	
			MIR/TIR	No	(TIR:120 m)	
SPOT	1986	1	Pan(VIS)	Yes	10 m	FRANCE
		3	VIS/NIR	Yes	20 m	
MOS	1987	4	VIS/NIR	No	50 m	JAPAN
IRS-1A	1988	4	VIS/NIR	No	36.5 m	INDIA

VIS = visible ; NIR = Near Infrared ;
MIR = Middle Infrared ; TIR = Thermal Infrared

* Stereo can be produced using a good quality Digital Elevation Model

Fig. 9. Current high resolution satellite remote sensing missions suitable for GIS applications (Ehlers *et al.*, 1989).

controlling factors, such as a particular geomorphological setting, a lithology or a specific landuse, are identified and outlined on the satellite imagery and entered into a GIS. In practice it implies a combined use of satellite imagery and large scale aerial photography. For the inventory mapping and the analytical part of the slope instability assessment large scale aerial photography is used for representative sample areas, while the extrapolation of the findings is executed on smaller scale imagery. In this procedure where local (large scale) information is combined with regional (small scale) data the value of stereo SPOT cannot be overestimated (Scanvic, 1989).

The potentials of the use of radar imagery for landslide hazard mapping still need further investigation. Results of work on terrain roughness classification (Slaney and Singhroy, 1991) seem encouraging, but problems are still associated with the production of calibrated and geometrically corrected radar imagery. Such corrected imagery is absolutely indispensable before the data can be introduced in the GIS for correlation with other thematic information on the terrain characteristics.

ERS 1 and probably also JERS data will be used by the authors in the near future in their research project on mountain hazard mapping (Soeters *et al.*, 1991), to evaluate the application potential of rader imagery for terrain roughness classification.

Especially interesting for application of radar imagery in tropical mountainous areas is the independence from weather conditions for the collection of data.

WISHES FOR THE FUTURE

A number of wishes from the authors of this paper have emerged from their work in hazard mapping and as users of remote sensing data in a GIS environment for this purpose. Although space will not allow a full treatment of the backgrounds of these wishes, it is thought useful to express them here as suggestions to those who are involved in the development of GIS and in the planning for future remote sensing missions.

1. ***Long term availability*** of remote sensing imagery of the types which are now widely used such as TM and SPOT is essential for long term monitoring of changes of the earth's surface.

Platform	Year	Spectral Bands	Spectral Range	Ground Resolution Cell Size	Country
Landsat 6	1991	8	Pan	15 m	U.S.A.
			VIS/NIR	30 m	U.S.A.
			MIR/TIR	120 m	U.S.A.
MOS 2	1991	4	VIS/NIR	50 m	JAPAN
ERS 1	1991	1	Radar	30 m	ESA
Shuttle	1992	2	Radar (SIR-C)	25 m	U.S.A.
		1	Radar (X-SAR)	25 m	GERMANY
JERS 1	1992	1	Radar (SAR)	20 m	JAPAN
SROSS-1	1992	1	Pan	52x80m	INDIA, GERMANY
SPOT-3	1993	1	Pan	10 m	FRANCE
		3	VIS/NIR	20 m	FRANCE
Radarsat	1994	1	Radar (SAR)	30 m	CANADA
EOS	1997	196	VIS/NIR	30 m	U.S.A.
		64	VIS/NIR	800 m	ESA, JAPAN
		1	Radar (SAR)	30 m	ESA, JAPAN

Fig. 10. Planned satellite remote sensing missions suitable for GIS applications (Ehlers et al. 1989).

2. For ***radar imagery*** there is a need for high quality geometrical correction procedures which can lead to standard geocoded radar imagery, usable for input into GIS. Improvements on resolution may lead to wider applications of radar imagery in landslide hazard mapping, if the imagery yields suitable information on terrain roughness characteristics.

3. For ***optical remote sensing*** improvements would be welcome in ground resolution. Ground resolution cell sizes in the order of 0.5 to 1 m would be necessary to be able to use satellite remote sensing for the inventory of landslide phenomena. Zooming in to areas of particular interest would be an interesting approach.

4. For an optimal ***integration of remote sensing with GIS*** it would be profitable to achieve a standardization in remote sensing of ground resolution cell sizes and geocoding systems. This will improve the possibilities to compare and integrate data sets of different sources and scales and can reduce the volume of data sets with a quadtree approach.

5. To improve their application possibilities in the applied earth sciences the following ***improvements of geo information systems*** will be indispensable.
   - the development of better models and decision rules of general applicability to describe geological and hazard causing processes
   - the development of 3-dimensional and 4-dimensional (including the time factor) GIS systems for the more detailed analysis of landslide hazards at a large scale
   - the improvement of the user friendliness of GIS systems to the general public.

6. There is a strong need for ***education of earth scientists for the application of remote sensing and geo information systems***. Not only should training in these fields be included in all University curricula, but also provisions should be made that experienced earth scientists are offered application courses to be able to benefit in their work from the possibilities offered by the application of remote sensing and GIS. There is presently in this respect not only a gap between earth scientists of the developed and the third world, but also between those in the developed world who have and those who have not had an opportunity to work with remote sensing and GIS.

REFERENCES

BARGAGLI, A. - 1991, "Screen Digitizing, Geometric Corrections & Monoplotting for SPOT, Landsat and Normal Aerial Photographs on the ILWIS Environment", ITC Internal Report, Enschede, 1991, 29 pp.

BISON, P., E. GRINZATO, A. PASUTO AND S. SILVANO - 1990, "Thermal infra-red remote sensing in landslide survey", Proc. 6th Int. Congr. IAEG, Vol. 2, pp. 873-878, Amsterdam.

CARRARA, A. M. SORRISO-VALVO AND C. REALI - 1982, "Analysis of landslide form and incidence by statistical techniques, Southern Italy", Z. Geomorf. N.F. Vol. 9, pp. 35-62.

CLEAVES, A.G. - 1961, "Landslide investigations: A field handbook for use in highway location and design". U.S. Bur. of Publ. Roads, 67 pp.

CROZIER, M.J. - 1973, "Techniques for the morphometric analysis of landslips", Z. Geomorph. N.F. 17.1, pp. 78-101.

EHLERS, M., G. EDWARDS AND Y. BEDARD - "Integration of Remote Sensing with Geographic Information Systems: A Necessary Evolution". Photogrammetric Engineering and Remote Sensing, Vol. 55, No. 11, November 1989, pp. 1619-1627.

McKEAN, D.F. H.W. CALKINS AND D.J. PEUGUET - 1991, "Remote Sensing and landslide hazard assessment", Photogr. Eng. and RS Vol. 57, No. 9, pp. 1185-1193.

MEIJERINK, A.M.J. - "Data Acquisition and Data Capture Through Mapping Units", ITC Journal 1988-1, pp. 23-44.

NAITHANI, K.K. - "Can Satellite Images Replace Aerial Photographs? A Photogrammetrist's View", ITC Journal 1990-1, pp. 29-31.

SCANVIC, J.Y. AND F. GIRAULT - 1989, "Imagerie SPOT-1 et inventaire des mouvements de terrain: l'exemple de La Paz (Bolivie)", Photo-Interpretation 1989-2, 12 pp. Ed. Technip, Paris.

SISSAKIAN, V. R. SOETERS AND N. RENGERS - "Engineering Geological Mapping from Aerial Photographs: The Influence of Photo Scale on Map Quality and the Use of Stero-orthophotographs", ITC Journal 1983-2, pp. 109-118, 1983.

SLANEY, R. AND V. SINGHROY - "SAR for Non-Renewable Resources Applications", Proceedings IUGS Meeting on Remote Sensing in Global Geoscience Processes, Boulder, Colorado, May 1991.

SOETERS, R., N. RENGERS AND C.J. VAN WESTEN - "Remote Sensing and Geographical Information Systems as Applied to Mountain Hazard Analysis and Environmental Monitoring", Eighth Thematic Conference on Geologic Remote Sensing, Denver, Colorado, U.S.A., 1991, pp. 1389-1403.

VALENZUELA, C.R. - "ILWIS Overview", ITC Journal 1988-1, pp. 3-14.

VARNES, D.J. - "Landslide Hazard Zonation: A Review of Principles and Practices". International Association of Engineering Geology Commission on Landslides and Other Mass Movements on Slopes. UNESCO series on Natural Hazards, Nr. 3, 1984, pp. 61.

VERWEIJ, P. AND P.E. BUDDE - "Monitoring Fire Events in a GIS by MEANS of Ortho Photo Projections", ITC Internal Report, Enschede, March 1991, 10 pp.

Geological Survey of Japan Report, No.281, 1995 p.101-108

Methodology for Regional Mapping of Natural Hazards using Remote Sensing and Geographical Information Systems. The experience of the GARS programme in Colombia

Eric LEROI*, Robert MISSOTTEN**, Olivier ROUZEAU*,
Jean-Yves SCANVIC*, German VARGAS***, Christian WEBER*

** BRGM, France, ** Unesco, France, *** Ingeominas, Colombia*

ABSTRACT

The Geological Application of Remote Sensing project in the Chimocacha Valley of Colombia illustrates the use of remote sensing in the mapping of zones susceptible to landslides. It follows an initial project, launched in 1984, on the integration of multisensor data for geological mapping in tropical environments.

The basic information for surface lithology, tectonics, land use and biomass in the Colombian Andes is readily acquired from the interpretation of SPOT and TM stereoscopic images, which also enable calculation of a DEM for quantifying geomorphology. A raster-mode Geographical Information System makes it possible to determine the critical criteria of slope instability, calculate their values, propose a probabilistic model and finally prepare landslide hazard maps at scales ranging from 1:25,000 to 1:50,000. A methodology of this type can be used for mapping a variety of natural hazards of geological origin.

INTRODUCTION: THE GARS PROGRAMME

The Geological Applications on Remote Sensing (GARS) Programme was launched in 1983 by the International Union of Geological Sciences (IUGS) and Unesco. The aims of the programme were :

1) to demonstrate the use of advanced remote sensing techniques for the resolution of key geological questions;
2) to ensure the transfer of information and technology through cooperative research in the field in combination with educational programmes;
3) to ensure wide dissemination of the results.

The first GARS project began in Africa in 1984 with the objective of developing new methods for the integration of multisensor data in order to improve structural and lithological mapping in tropical environments. Field research and ground-truth observations were made in test areas in western Tanzania and in Burundi. The project was carried out by an international team of experts in computer-aided cartography from Germany, geoscientists from Belgium, Burundi and Tanzania and remote sensing specialists from France. The participating organizations to a large extent financed the execution of the project; Unesco and IUGS provided seed funding. The research results were published in the international literature with acknowledgments to GARS. Reviews were published in 1988 and 1990 in Series No. 8, Geological Sciences, of the Royal Museum for Central Africa, Belgium, and in the ISPRS journal "Photogrammetry and Remote Sensing".

Keywords: GARS, Remote sensing, GIS, Hazard mapping, Colombia

The project was continued at the request of six Unesco member states: Belgium, Burundi Tanzania, Rwanda, Uganda and Zambia. Follow-up was entirely devoted to technology transfer.

The second GARS project was launched in 1986 after several meetings with Latin American remote sensing and geological organizations. It was decided to place the emphasis on a project of landslide hazard mapping using remote sensing and Geographical Information System (GIS) technology. A test site was chosen in Colombia and geoscientists and remote sensing experts from Latin America, Canada, France and the Netherlands set the project in motion in 1987. The UNESCO-IUGS contribution to this project is similar to that for the first GARS project. ESA and NASDA are donating radar data. The French Centre National d'Etudes Spatiales (CNES) supported GARS in the framework of its International Space Year (ISY) activities and SPOT Aval funding. BRGM has been also funding the project through its scientific research endowment. The European Community contributed to the organization of regional training and an expert workshop in Latin America.

Amongst natural hazards, landslides represent a major danger for most of the Latin American countries, especially in the Andean area, where they are exacerbated by human settlement. They are the subject of methodological research to improve techniques for mapping terrain vulnerability, the current approach being based on geological and structural studies, geomorphology and modelling.

Until now, because of their excellent spatial resolution and stereoscopic capability, aerial photographs have been regarded as an extremely important tool for compiling landslide inventories as a complement to field surveys. However, they are often old, and, for economic or administrative reasons, new acquisitions are not always feasible. While they constitute a valuable statement of pre-existing conditions they tend to be somewhat ineffective owing to their analogic character, which limits access to the large variety of triggering factors for identifying and mapping sensitive areas on a regional scale.

A new approach, using the range of available satellite products, was therefore used. The methodology, based on the use of digital images supplied by the SPOT satellite HRV instrument, has been set up by BRGM in the La Paz area, in Bolivia, which had been surveyed in great detail in 1976.

SPOT data, characterized by excellent spatial resolution (10-20 m) and access to stereoscopy, have been considered *a priori* as compatible with the average size of landslides and calculation of a digital elevation model (DEM). The basic information on slope, drainage pattern and exposure has been readily acquired by specifically developed software on a GIS, opening new possibilities in quantitative geomorphology. Finally, the approach to the study has placed emphasis on the fact that spatial remote sensing can be advantageously substituted for aerial photographs for the preparation of geocoded thematic files for computation into a GIS and provide a vulnerability map for decision-makers at scales ranging from 1:25,000 to 1:50,000 (Scanvic *et al.*, 1989; Masure *et al.*, 1990).

GARS PROJECT ON LANDSLIDE SUSCEPTIBILITY IN COLOMBIA: PRINCIPAL RESULTS

The GARS project in Colombia concerns landslide-susceptibility mapping in the upper Chicamocha Valley (see colour plate). The area includes a considerable number of large landslides, particularly debris flows, certain of which are currently active and threaten the town of Paz del Rio and the railway line essential for the transportation of coal and iron from the mines to the iron and steel plants. These landslides are related to a specific geological context:

1) The area is affected by the complex tectonics related to the active subduction taking place between the

Nazca plate, on the Pacific ocean side to the west and the South American plate to the east. The main stratigraphic units are bounded by north-south thrusts and faults.

2) The lithology is characterized by clay and argillaceous sequences interbedded with sandstones.

3) Coal and iron are mined along the steep valley sides.

Landslide-susceptibility mapping has been done using a geographic information system operating a specific raster-mode software, Synergis, developed by BRGM. This makes it possible, through image interpretation, classification and DEM geomorphological information, to determine which criteria are fundamental for mapping slope instability in a given area. The procedure enabling assessment and mapping of potentially hazardous zones comprises several phases:

1) Acquisition of remote sensing data. Because of cloud cover only one image of the SPOT stereo-pair has been acquired; a Landsat TM vertical image, of 30 m ground resolution, has therefore been substituted for the second one.

2) Data processing and colour composite restitution at 1:50,000 scale.

3) Visual interpretation. Lithology, image discontinuities, landslides and head scarps of debris flows are extracted from the landscape restituted by stereoscopy. The Chicamocha Valley is characterized by north-south striking sedimentary rocks, generally well-exposed, so that it was possible to make a map, of better quality than those produced previously on the basis of field observations (Cardenas *et al.*, 1989; Vargas, 1989), from remotely sensed data. This has also shown that the fault pattern is more complex than expected, particularly with respect to the east-west fractures which are a normal consequence of convergence between the Nazca and South American plates, the frequency of which has hitherto been underestimated. Lastly, particular attention has been paid to the head scarps of debris flows which have been considered as indicators of ground instability and used in determining, by statistical methods, the critical conditions of the various permanent hazard factors.

4) Digitization. All these observations are digitized and geocoded and, if necessary, vector mode files are transformed to raster mode.

5) Supervised land-use classification. This has been performed from the SPOT image, and has resulted in the distinction of seven classes, four for vegetation-covered areas and three for bare ground and human settlements.

6) Computation, using 3 D software applied to the SPOT/Landsat DEM, of the files providing the basic quantitative geomorphologic information, i.e. slope, exposure and drainage, the last being transformed into raster-mode drainage-density files.

7) Creation of panoramic views by combining DEM and the corresponding panchromatic or colour imagery.

8) Statistical analysis. The five raster-mode files corresponding to the permanent hazard factors (lithology, slope, drainage, tectonics and land-use) are loaded into the database and multivariate analysis is then performed.

Debris-flow head-scarps are used to pilot a statistical method and determine the critical conditions of

Table 1: Susceptibility according to geological formation

	Geological formation according to G. Vargas 1989	Total surface area of formation (no. of pixels)	Length of head-scarp (no. of pixels)	Susceptibility
	Unmapped	34191	0	0
	QUATERNARY			
Qa1Qs	Alluvial fan and residual soil	66	0	0
Qdz1	Old unstable colluvial fan	3415	181	5,30
Qdz2	Recent unstable colluvial fan	1969	46	2,34
Qc	Valley colluvial fan	3506	74	2,11
Qd	Slope colluvial fan	7999	233	2,91
QcQd	Indifferentiated colluvial fan	12365	177	1,43
Qfl	Fluvio-lacustrine sediment	1937	0	0
Qt3	Fluvio-lacustrine terrace	274	0	0
Qt2	Recent alluvial terrace	1528	10	0,64
Qt1	Old alluvial terrace	1063	0	0
QsQd	Colluvial fan and residual soil	3790	41	1,08
Qfg	Fluvio-glacial terrace	6073	77	1,27
QcQfg	Fluvio-glacial colluvial fan	1162	0	0
Qm	Moraine terrace	791	0	0
	TERTIARY			
TQc	Teneria Conglomerate	5954	67	1,12
Teco	Concentracion Formation (clay + iron)	32316	678	2,10
Tpp	Picacho Formation (clay, sandstone)	13790	277	2,01
Tpss	Upper Socha Formation (clay)	14363	347	2,41
Tpsi	Lower Socha Formation (sandstone, clay)	9848	285	2,89
	CRETACEOUS			
Ktg	Guadas Formation (clay + coal)	19150	491	2,56
Ksga	Upper Guadaloupe Formation (silt)	2642	45	1,70
Ksgp	Lower Guadaloupe Formation (clay)	2121	37	1,74
Ksl	La Luna Formation (marl, chert)	2774	68	2,45
Ksc	Chipaque Formation (clay)	2997	122	4,07
Kiu	Une Formation (siltstone)	4574	63	1,38
Kits	Upper Tibasosa Formation (limestone)	3785	66	1,74
Kiti	Lower Tibasosa Formation (siltstone)	5737	61	1,06
	JURASSIC			
Jg	Giron Formation (conglomerate)	6827	59	0,86
	PALEOZOIC			
pDs	Silgara Formation (metasediment)	3106	13	0,42
	TOTAL	210113		

relative landslides susceptibility separately for the five permanent factors. The results are improved if head-scarps are divided into classes, for instance according to the relative ages of the associated landslides - old, intermediate, recent (see colour plate).For each permanent factor, values are compiled in separate tables, histograms and displays of relative landslide susceptibility (see Table 1).

The most effective parameters in the Chicamocha Valley are lithology, slope and land-use. The main observations on the results are the following:

· *Geological formations.* The highest susceptibility is for colluvial fans, which are in many instances composed of the debris from ancient landslides, and for black clays and interbedded siltstones with subordinate thin-bedded fractured limestone. Classification of head scarps into three classes (active, intermediate, ancient), partly based on field reconnaissance, improves the method, showing for instance that the coal measures are highly sensitive to the action of active landslides, illustrating a statistical relation with mining.

· *Slope.* For slopes less than 20°, susceptibility is low and independent of slope. Between 20° and 50° susceptibility increases gradually as a function of slope; the risk then remains constant up to 70°. Decreasing susceptibility above 70° is probably due to the lack of soil and weathered rock on steep slopes, but is also a consequence of geomorphology, as rock types upon which landslides are generated in this region do not generally give rise to rugged landscapes, although exceptions do occur.

· *Land-use and vegetation cover.* Although these are generally considered as potentially relevant factors in the case of shallow sliding, concrete evidence for specific relationships is difficult to find in the literature.

· *Image-discontinuities.* These have been interpreted on the SPOT-Landsat stereoscopic images, according to standard photointerpretation criteria. This has shown a NE-SW and NW-SE system of fractures the importance of which was underestimated in previous geological mapping based on landscape analysis using aerial photographs. This new observation is clear evidence of eastward-directed tectonic stress related to the subduction of the Nazca plate and should have an effect on ground landslide susceptibility;

· *Drainage.* This has been extracted from the DEM, using software developed by the Istar Co., and transformed into a raster-mode drainage-density map.

· *Landslide susceptibility mapping.* Each image pixel is characterized by the values of relative landslide susceptibility for the five permanent factors. The sum of these values then makes possible calculation and mapping of the landslide susceptibility using SynergGIS.

For instance, if, for a given pixel P:

P1.3 colluvial fan
P2.4 cultivated soil (crops)
P3.8 slope between 71 and 800
P4.2 image discontinuities, 1-50 density
P5.5 drainage density, 31-400

the corresponding susceptibilities are:

S1.3 = 5.30
S2.4 = 1.46
S3.8 = 1.76
S4.2 = 1.92
S5.5 = 2.06

Landslide susceptibility is simply obtained by addition and for the above example is 12.50.

This method also makes it possible easily to combine the different factors in a GIS and directly to compare each factor two by two. For instance all factors can be classified as a function of their susceptibility independently of the family to which they belong, a geological unit susceptibility can thus be compared to the susceptibility of a certain slope class, and the relative influence on the landslide dynamic calculated. This method has been systematically applied by pixel and a landslide susceptibility map drawn up. This map is calibrated on landslides, susceptibility being defined according to head scarp criteria, and its major interest is to be predictive. Postulating the same phenomena leads to the same consequences; the landslide susceptibility map delineates as yet undisturbed but potentially unstable zones. The final document can be particularly useful in terms of risk planning.

Recent assessments on the Chicamocha test site have shown the validity of this type of mapping in Andean conditions.

CONCLUSIONS

Although improvement is still possible in the methods of evaluating the weight of certain factors such as faults and drainage, the project on the Chicamocha Valley test site has shown that, provided that stereoscopy is obtained, the processing and interpretation of remotely sensed data makes it possible, with limited field control, using GIS technology and a statistical approach based on the recognition of debris-flow head-scarps in the landscape, to map landslide hazards at the 1:50,000 scale. The work on the two projects in the Andes has led to the development and fine-tuning of a methodology.

The resulting document has been assessed by comparison with the published map and by field control in selected areas, which have shown the validity of this type of mapping in Andean conditions.

The assessment of the capacity of radar to improve landslide identification and mapping is programmed for 1993-1994 using ERS-1 and JERS-1 in Colombia.

On the basis of the above results a similar mapping methodology is being applied in northwest Taiwan using airborne radar data. More generally, it is feasible to extend this approach to various natural hazards of geological origin. The next GARS project could be designed to support the Natural Hazards Map Project of East Asia on specific sites.

REFERENCES

CARDENAS L.A., VARGAS J. (1989). - Estudio de estabilidad en El Alto Chicamocha, sector Tasco, Paz del Rio, Socha. Universidad de Colombia, Sogamozo, Trabajo de grado.

GUILLANDE R., CARO L., CHOROWICZ J. (1991). - A first approach to digital mapping of landslides hazards in the Andes of Colombia using remote sensing technics (GARS project) in Episodes (USA). Vol. 14 No. 4 - 1991.

LEROY E., ROUZEAU O., SCANVIC J.Y., WEBER C., VARGAS G. (1993). - Remote sensing in landslide hazard mapping using GIS technology in the Colombian Andes. Episodes (USA). Vol. 15- No. 1.9.

MASURE Ph., SCANVIC J.Y. (1990). - Risques naturels en milieu urbain : cartographie par tldtection de la sensibilit des sols aux mouvements de terrain. L'exemple de La Paz, Bolivie. Spot, outil de dveloppement, juin 1990, Cepaduis Ed., Toulouse.

POLIDORI L. (1991). - Validation de modles numriques de terrain, application la cartographie des risques gologiques. Thse Doctorat 3e cycle, Universit Paris VII. UFR Physique Paris, France.

SCANVIC J.Y. (1990). - Mapping the vulnerability of ground to landslides: Potential use of Spot stereoscopic data for da Paz (Bolivie) International Symposium on Remote Sensing of Environment 23rd Bangkoh Thailand 1990. Proceedings p. 703-708.

______, CHOROWICZ J., GUILLANDE J., WEBER C., ROUZEAU O. (1991). - Stereoscopic space remote sensing as a tool for mapping zones liable to landslides. The GARS project in Colombia. Symposium for geological hazard, Pekin, october 1991.

______, GIRAULT F. (1989). - Imagerie Spot 1 et inventaire des mouvements de terrain : l'exemple de La Paz (Bolivie). Revue photo-interprtation 1989-2, fasc. 1, Ed. Technip, Paris.

______, LEROY E., ROUZEAU O., VARGAS G., CHOROWICZ J. (1992). - Spot digital elevation model and landslides risk mapping in Colombia. A GARS Unesco cooperation project. European International Space Year Conference, Munich, April 1992.

______, ______, ______, WEBER C. - Stereoscopic space remote sensing as a tool for mapping zones liable to landslides examples in Bolivia, Colombia and Taiwan. International geological congress, Kyoto, Japan, August, 1992.

______, VARGAS G. (1992). - Remote sensing landslide hazard mapping in Colombia: training aspects. European Space Year Conference. Munich, April 1992.

______, WEBER C., ROUZEAU O. (1991). - Landslide susceptibility mapping in the Andes using GIS technology. Remote sensing in Global Geosciences Workshop, May 3-4, 1991. ERIM University of Colorado, Boulder USA.

VARGAS G. (1989) .- Estudio geologico - geomorphologico y evaluacion de amenazas de la Cuenca alta del rio Chicamocha entre Socha y Balencito. Departamento de Boyaca, Colombia. Informe technico Ingeominas.

______ (1991). - Mthodologie pour l'tablissement des cartes de sensibilit aux mouvements de terrain fonde sur l'utilisation d'un couple strographique Spot TM. Applications la rgion de Paz del Rio, Colombie. Mmoire de DESS, Universit Pierre et Marie Curie, Paris VI (France), juillet 1991.

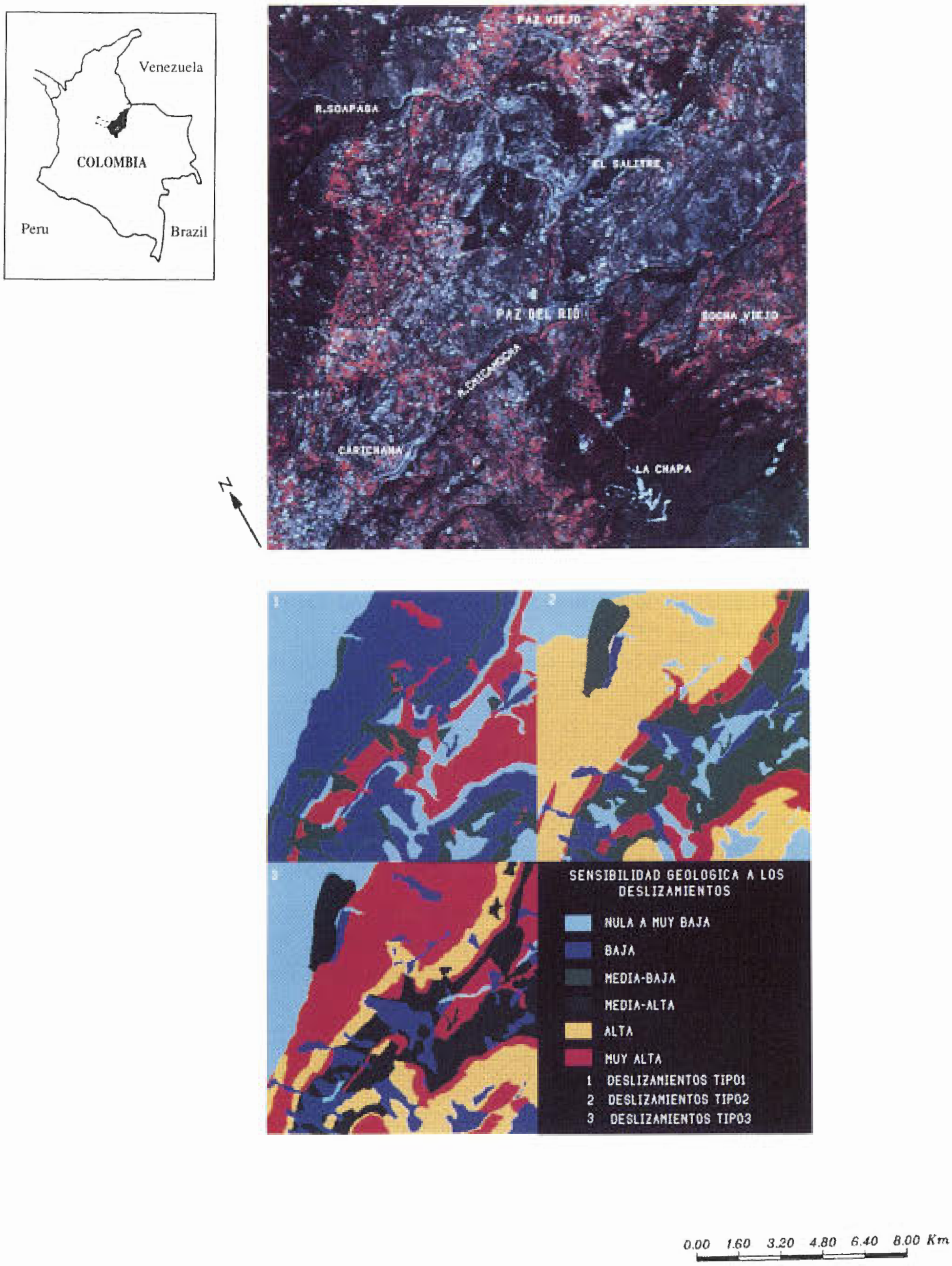

Fig. 1. *Above*: Spot image, colour composite, Paz del Rio area (BRGM processing).
Below: Landslide susceptibility, Paz del Rio area: light blue - zero to very low; dark blue - low; green - medium low; dark green - medium high; yellow - high; red - very high.

1 landslides, type 1 (old).
2 landslides, type 2 (intermediate).
3 landslides, type 3 (recent).

Geological Survey of Japan Report, No.281, 1995 p.109-112

The International Directory Network and Connected Data Information Systems for Research in the Earth and Space Sciences

James R. Thieman

National Space Science Data Center, NASA, U.S.A.

ABSTRACT

Many researchers are becoming aware of the International Directory Network (IDN), an interconnected federation of international directories to Earth and space science data. Are you aware, however, of the many Earth-science-relevant information systems which can be accessed automatically from the directions? After determining potentially useful data sets in various disciplines through directories such as the Global Change Master Directory, it is becoming increasingly possible to get detailed information about the correlative possibilities of these data sets through the connected guide/catalog and inventory systems. Such capabilities as data set browse, subsetting, analysis, etc. are avaliable now and will be imploving in the future.

INTERNATIONAL DIRECTORY NETWORK

In the attempt to bring the research community closer together, the International Directory Network(IDN) was created. The IDN is composed of a federation of directory databases on widely-scattered computers which are interconnected through networks. Several of the directories are intended as a service to the entire world community and are made freely accessible to the community through computer network connections and dial-in lines. The user does not need to establish as account to use the directories and no passwords are required. No training is necessary to use the system to get information on Earth and space science data sets as well as information on selected data information systems, spacecraft, sensors, and data gathering projects or campaigns.

Two types of nodes make up the IDN. The coordinating nodes have completely identical databases at each location(U.S., Italy and Japan). They are open to use by the general community and are particularly intended for access by users in the continental vicinity in which they are located (i.e., America, Europe and Asia). Access information for these nodes is supplied at the end of this article. The other nodes are cooperating nodes which share information with the coordinating nodes but have databases which may be a subset of that of the coordinating nodes. Cooperating nodes contribute information to the overall network, but may only be used by a small group for local data management and information purposes. Many of these types of nodes exist now and more are being contemplated in the near future.

The glue which holds the entire IDN together is a standard of describing dataset information called the Directory Interchange Format (DIF). All dataset information passed among the nodes is exchanged in this form. Contributions of information on datasets by the general community are encouraged. Creation of a DIF file describing a dataset is a relatively simple process and once this file is created it can be automatically loaded into the directory databases and shared with the directory nodes. Thus, the information is quickly spread throughout the world. Contact the author for further information about DIF if you have datasets you wish to advertise.

Keyword: Directory, Network, Space science, Earth science, Information system

CONNECTED INFORMATION SYSTEMS

The IDN provides more than just dataset information, however. When the user accesses a patricular dataset description there is sometimes an indication that an automatic connection is available to another information system which has more detailed information about this dataset. Whereas directories just have brief, overview information about datasets, the other information systems may offer more complete information about the whole dataset such as calibration, information, sensor characteristics, detailed usage information, etc. These types of information systems are classified as guide systems. Still others contain details about the parts of the datasets such as whether the data are available for a particular location and/or time period. Systems which have dataset granule information are classified as inventories. Some information systems have combinations of directory, guide, and/or inventory capabilities. They mau also allow the user to browse and manipulate the data..

From the directories a user can be automatically connected to the guides and inventories and use the capabilities there to ultimatelly determine exactly what data are needed and then order the data. This can be done in a matter of minutes ot hours rather than the weeks to months that were required through mail and telephone interactions. Note that these systems are available not only in the Earth science area but also in several other space science disciplines. Increasingly, it is becoming possible to get subjects of the data themselves directly through the network, so the entire data acquisition process can be completed in a very short time. Once the users find out about the other information systems they can also learn how to access them directly rather than through IDN. Then they can go directly to these systems in the future. More of these types of automated connections are being added all the time. If you are aware of a system which may be useful in this context, please contact the author.

DIRECTORY ACCESS

To use the coordinating nodes of the IDN one can follow the procedures listed below according to what type of access(network connection or dial-in line) is available.

AMERICAN IDN NODE ACCESS

>From NSI/DEC net (SPAN):

$ SET HOST NSSDCA
USERNAME: NSSDC

>From INTERNET:

TELNET 128.183.36.23
USERNAME: NSSDC

>From OMNET:

GOTO NSSDC

By DIAL-IN LINES:

Set to 8 bits, no parity, 1 stop bit
Dial 301-286-9000
COONECT 1200 (or 2400 or 300)
Enter several carriage returns
ENTER NUMBRER
MD
CALLING 55201 (or 55202)

CALLING COMPLETE
Enter several carriage returns
USERNAME: NSSDC

JAPANESE IDN NODE ACCESS
>From NSI/DECnet (SPAN):
$ SET HOST 41950
USERNAME: NASDADIR
>From INTERNET:
TELNET 133.56.72.1
USERNAME: NASDADIR
By DIAL-IN LINES:
Set to 8 bits, no parity, 1 stop bit
XON/OFF
Dial 81-492-94-6400 (0492-96-6400 in Japan)
1200-9600 bps.(DEC Kanji)
USERNAME: NASDADIR
>From PACKET EXCHANGE NETWORK:
(DDP-P, Venus-P
DTE Number 44014437216(4437216 in Japan)
USERNAME: NASDADIR

EUROPEAN IDN NODE ACCESS
>From NSI/DECnet (SPAN)
$ SET HOST 29628
USERNAME: ESAPID
> From INTERNET 192.106.252.160
USERNAME: ESAPID
Via DIRECT DIAL
Set to 8 bits, no parity, 1 stop bit
Dial (+39) 6 9417335
DIAL-IN LINES - File 21 of ESA Quest System
(no LINKS possible within Quest
help available at (+39) 6 94180300)
Austria DATEX-P (+232) 2618180 61
Belgium DCS (+206) 2210443 61
Canada DATAPAC (+3020) 85801458 61
Denmark DATAPAK (+238) 238301063841 61
Finland DATAPAK (+244) 204076 61
France TRANSPAC (+2080) 175000394 61
note: when using the prefix, the leading 1 should be dropped
Germany DATEX-P (+262) 45050369 061
Ireland EIRPAC (+2724) 36059222 61
Italy ITAPAC (+222) 26410174 61
DDN 111005306009
ESAPAC 299020030001
NL DN-1 (+204) 1290176 61
Norway DATAPAK (+2422) 110627
Spain IBERPAC (+2145) 214062321 61

Sweden DATAPAK (+2403) 710416 61
UK PSS (+234) 219201156 61

CONCLUSION

In connection, the IDN and interconnected information systems are services available to you now. Of course many people, especially those in developing countries do not now have connections to computer networks or modems for computer access through telephone system. If you do not have network or dial-in connection capability there will be PC-based stand-alone versions of the directory available soon. Contact the author if you are interested in this apporach.

For those who can access the directories as they are now available on-line, please try them and let the author know how their utility can be improved for your purpose.

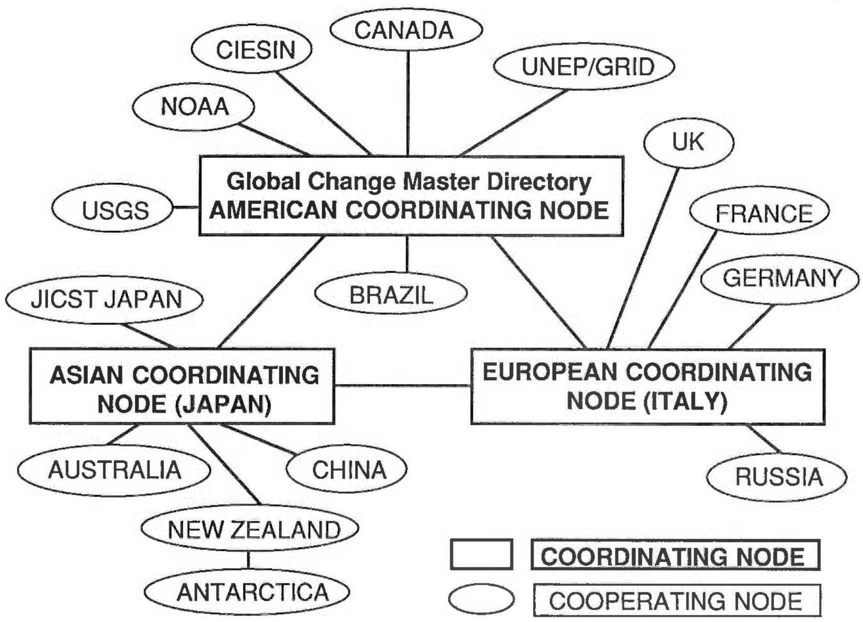

Fig. 1. INTERNATIONAL DIRECTORY NETWORK (IDN)

Ⅲ. Natural Hazards in Eastern Asia

Geological Survey of Japan Report, No.281, 1995 p.115-117

Institutional Program at Asian Institute of Technology and Asian Disaster Preparedness Center

Satyendra P. Gupta

Asian Disaster Preparedness Center
Asian Institute of Technology , Thailand

ABSTRACT

This report describes a summary of Asian Institute of Techonology and Asian Disaster Preparedness Center, and thier activities.AIT states that it will take a leadership role in the promotion of technological change and its management for sustainable development in the Asia-Pacific region under the international cooperation.

AIT, ADPC AND THEIR ACTIVITIES

My presentation will be focussed on Asian Institute of Technology and Asian Disaster Preparedness Center. I shall be brief on Asian Institute of Technology as I have a VDO which will provide a good view of AIT.

The SEATO Graduate School of Engineering Project was approved in 1957 and the school was established in 1959 at Chulalongkorn University Campus at Bangkok. The first group of students numbering 18 only started with studies of Hydraulic Engineering. The basic purpose of establishing this graduate school was to stop the brain drain from Southeast Asian countries to the west and to provide a base for master's degree studies as there were no facilities at that time in this part for this. During 1967 the Asian Institute of Technology was established as an independent, autonomous, international institution of higher learning. During 1973 the present campus of AIT was opened.

Today AIT has about 1000 master's and doctoral students studying Agriculture and Food Engineering, Computer Science, Energy Technology, Environmental, Geotechnical, Structural Engineering, Construction, Human Settlement, Management, Water Resources and Telecommunication with a faculty of about 175. There are several outreach centers like Asian Disaster Preparedness Center, Continuing Education Center etc.

The mission statement of AIT states that it will take a leadership role in the promotion of technological change and its management for sustainable development in the Asia-Pacific region, through high level education, research and outreach activities which integrates technology, planning and management.

AIT has graduated about 6000 students from 43 countries mainly from Asia-Pacific region but some from North America, Europe and Africa too. New programs like AIT Center in Vietnam, Bio-process technology, industrial park etc. are in the process of establishment. AIT is also working to establish training center in Laos and Cambodia.

The Asian Disaster Preparedness Center (ADPC) was established in January 1986 at the Asian Institute of Technology in response to requests from countries of the region for international assistance in strengthening their disaster management systems. The aims of the ADPC are to assist countries of the Asia-Pacific region in formulating their policies and developing their capabilities in all aspects of disaster management.

Further to provide regional training facilities in the field of disaster management, provide focal point of a regional disaster information network, encourage and support disaster research throughout the region,

Keywords: AIT,ADPC, Thailand, Disaster reduction, International cooperation, Training

undertake planning services, technical programs and consultancies as may be requested, produce disaster training and public information material for use in the region.

The original concept with which we got established was reasonably sound but progress over the last seven years has not been made evenly on all areas as mentioned.

With the initial support received mainly from USAID-OFDA and UNDP it was possible to develop disaster management training course. It is held two times a year and provides an overview to all types of disasters. This course can be best described as a generalist's course and participants from organisations like Ministry of Relief and Rehabilitation, Fire Services, Red Cross, Ministry of Social Welfare, National Disaster Offices, Police Department, Civil Defense, Church Welfare Organisations and Nongovernment Organisations mostly attend. Occasionally we have participants from technical organisations but very few.

With special funding from sponsors ADPC has also conducted course like Improving Cyclone Warning, Response and Mitigation eight times in last three years in the Asia-Pacific region. It was held three times in Bangkok and once in Bangladesh, Philippines, Vietnam and two times in South Pacific in Fiji and Western Samoa. All courses were conducted on a regional basis. In this program a country sends a group of meteorologist, response official and an engineer to participate in a multi-disciplinary program. ADPC will also be conducting Disaster Management Training Program (DMTP) of the UN in six Asian countries.

On the technical front two international courses on Aseismic Design and Construction of structure exclusively for engineers have been held. In this course the emphasis was to understand earthquake behaviour on structures, damages caused and design as well as construction techniques. The funding for one of the above program came from USAID-OFDA and UNESCO and the second from ASEAN-Canada Fund and UNESCO. We also had an international training course funded by ASEAN-Canada Fund on Flood Loss Prevention, Mitigation and Management for South East Asian engineers.

Last year with the sponsorship of Government of Japan through JICA, and Department of Humanitarian-Affairs-Geneva, United Nations, ADPC has established a five years program on disaster prevention and mitigation for technical personnel. Participants will come from Asia-Pacific region and this year in February we conducted the first program on Seismic Hazards Mitigation in this series.

International Earthquake Prognostics Seminar and Seismic Risk Management Workshop under WSSI was also organised by ADPC. Other notable works has been damage, evaluations and recommendations after Nepal Earthquake (1988), Typhoon Sisang in the Philippines (1987) and Cyclone Val in Western Samoa (1992).

The recommendations provided for Nepal led to UN sponsored Seismic Hazards Reduction Project. The work in the Philippines which started after Typhoon Sisang in which ADPC had a significant contributions in all its phases of development and implementation earned World Habitat Awards and now provides safe typhoon resistant shelters to thousands of people in the Philippines.

The recommendations provided to Government of Western Samoa has led to UNCHS Project which is in development stage. At the request of Asian Development Bank, ADPC conducted a regional study on disaster mitigation in the Asia-Pacific and produced two books on its findings. These books are available through ADB. Apart from these achievements several other consultancies and missions have been provided. ADPC is a new and young organization and has not been able to fulfill all its aims as outlined in the beginning but efforts are continuing within limitations. Recently with internal changes ADPC has decided to basically concentrate on four areas training, mitigation, information and consultancy. We are putting our house in order, defining our programs and hope sooner we will have our directions.

With regards to our association and contributions to this project, please allow me to explain our position. The division of Integrated Natural Resources Development and Management (INRDM) at AIT is engaged in teaching and research work. They have the capability and capacity to deal with mapping work. At this time they are mostly involved in land cover and natural resources mapping work.

Further United Nations Environmental Program (UNEP) has established a program activity center at AIT known as Global Resource Information Database or (GRID). GRID is an important element of Earthwatch and is also involved in environmental assessment activity. GRID has also a very good facility of data storage and map production. ADPC has good collaborations with these centers. ADPC, GRID and INRDM had inhouse discussions for possible participation in this project. We express our interest in the program and would very much like to participate in it but before we can discuss further, we would like to know more about the project first and the kind of involvement desired. In the meantime looking to our facilities and available resources at our end we would like to make modest contributions to the project in the following way.

This digital version of the base map for East Asia including coastline, political boundary, river and some elevation information can be supplied to serve as reference map at 1: 1,000,000 scale. We can also assist the project through its inhouse expertise on information, database design and data input for the development of a geographic information system and remote sensing. Through its network, ADPC and GRID has the capability to coordinate the collection, analysis and dissemination of relevant information to potential users within the region. We can also serve as a data base repository. If desired GRID can also provide the technical resource for application of modern information systems. We can also assist in defining as to what kind of hazard maps are needed by potential users and propagate its usefulness through our training programs. In the absence of enough information on this project it is difficult to make more suggestions but I must say that we are interested in this project and would provide cooperation to the best of our ability.

Geological Survey of Japan Report, No.281, 1995 p.119-124

Seismic Hazards and Mapping of China

Ding Guoyu

State Seismological Bureau , China

ABSTRACT

As China is a country of high seismicity characterized by wide distribution; large magnitude and shallow focal depth, and plus poor anti-seismic capability of structures, earthquake hazard constitute major natural catastrophes to the people, and cause serious economic losses to the country. So, among the different kinds of natural hazards, the reduction of seismic hazards has been specifically concern of the government and scientists. In recent years, different kinds of maps concerned seismic hazards have been compiled. In this paper a brief introduction on the status of seismic hazards mapping in China has been given. But the study of seismic hazard mapping is just beginning and many monographic studies should be further conducted on the mapping principles, methodology and technique of digitalization.

NATURAL HAZARD MAPPING IN CHINA

As a information carrier, map is a effective measure to directly reflect the regional features. In recent years, natural hazard map of different forms and content have been compiled in China. There are comprehensive and thematic maps in content , and map sheets and atlas etc. in form. For example:

1. Natural Hazard Atlas of China

It is a large comprehensive atlas, compiled by Chinese People's Insurance Company and Beijing Nomal University, and published by the Science Press in 1992. It is composed of 5 parts:

(1) Hazardgenic environments and hazard-bearing bodies. It includes maps of geology, topography, traffic, cities, and population.

(2) Hazardgenic factors of different kind (i.e. hazards of different kind). They are divided into 33 kinds, such as meteorogical hazards, inundation, biological hazards, desertization and desertification, enviromental polution, endemia etc.

(3) Hazard condition.

(4) Natural hazard monitoring and warning system.

(5) Policy of hazard reduction .

There are more than 100 kinds of maps of scale 1:12,000,000 to 1:36,000,000.

2. Geological Hazard Prevention And Construction Atlas Of China

It is a large thematic atlas, compiled by Ministry of Geology and Mineral Resources, Committee of Science and Technology and Committee of Planning of China, published by the Geology Press in 1991. The background , origin, feature, harm and prevention and construction measurement of 31 geological hazards of China were introduced. Maps, photos and different materials were included.

3. Environmental Geologic Map Series of China. The map series are compiled by China Institute of Hydrogeology and Engineering Geology Exploration and composed of 18 maps. Eleven of them are published and being published, including 8 maps of the geologic hazard group.

Keywords: seismic hazards, China, hazards mapping, natural hazards, earthquake, SSB

China is an earthquake-prone country, with very intense seismicities, therefore, among the different kinds of natural hazards the reduction of seismic hazards has long been a specifically concern of the Chinese government and scientists.

SEISMIC HAZARD IN CHINA

Seismic activity in China is characterized by high frequency, large magnitude and extensive distribution (Shi Zhenliang, 1974). Of the 30 Chinese administrative provinces, Autonomous Regions and Municipalities, 21 have suffered from earthquakes of M over 6. There is an area of 3,120,000km2, up to 32.5% of the gross Chinese land area, 136 cities, nearly 45% of the Chinese cities , are located in regions of seismic intensity of 7 or 8. Among them are 30 cities with a population of 500,000 amounting to 58%, and 20 with population of one million or more, amounting to 70%.

Earthquakes in Mainland China are typically intraplate events with complex crust structure backgrounds. Most of these earthquakes have occurred within the middle crust, about 10-25km in depth. Because of the shallow focal depth, all the large earthquakes that have occurred in heavily populated regions have caused severe disasters.

In more than 3,000 years, according to historical records, there have been nearly 10,000 earthquakes including some 6,000 destructive ones in China. Documentation from 1200 to 1990A.D. recorded 147 earthquakes of magnitude 7 and 19 extremely violent ones of magnitude 8 or more(Gu Gongxu, 1983a,b).

In 1556 the Huaxian earthquake near Xian killed as many as 830,000 lives. Haiyuan earthquake in Ningxia Autonomous Region (1920) claimed more than 200,000. There have been 290 earthquakes with M>6 in the continent of China since 1900, 7 of them are of M 8, 44 of M=7-7.9 and 240 of M=6-6.9. The average interval is about 13 years for strong earthquake with M 8, 2-3 years for M=7-7.9, and in each year there are 2-3 earthquakes with M=6-6.9. Since 1966, more than 20 strong earthquake have occurred. The tragic Tangshan earthquake (1976, M=7.8) not only slaughtered some 240,000 people, but also destroyed the industrial city in a moment, a rare case ever recorded in the world history of earthquake. Table 1 shows the casualities and losses caused by disastrous earthquakes occurred in China since this century.

According to the roughly account, within the 90 years, there were more than 715 earthquake events on the Chinese mainland which resulted in the death of about 614,680 people, and injury to 929,505, only the Tangshan earthquake caused direct economic losses towering to RMB(Chinese yuan) 9.6 billion. Seismic hazards have brought about grave losses and tremendous threats to the Chinese people.

SEISMIC HAZARDS MAPPING

In recent years, different kinds of map concerned seismic hazards have been compiled in China in order to meet the need of study, prevention and reduction of seismic hazards. All these maps are divided into three groups:

1. Geological maps concerned seismic hazards. It includes : map of surface faults, active fault map, active tectonic map and seismotectonic map (Ding Guoyu, 1989).

2. Seismic activity map. it includes epicenter distribution map, distribution map of historical earthquakes, earthquake focal depth map, map of earthquake focal mechanism solution . Seismic intensity zoning map and seismic risk zoning map are of this group.

3. Seismic hazards map. It includes seismic hazards type map, seismic hazards zoning map, distribution map of seismic hazards events, and seismic hazards losses estimating map.

The geological and seismic maps can provide a background framework for further research on seismic hazards of different types and serve as a scientific basis for extrapolating those geological and seismic activity into the past and future, which will aid in mitigating seismic hazards and protection of environment.

The maps bellow have been compiled and published in China (Ma Xingyuan, 1987, 1989; Ding Guoyu, 1991):

Table 1 The list of M ≥ 7 earthquakes with heavy damages in China since 1900

Date (M-D-Y)	Locality	M	I_0 *	Casualties and damages
08-22-1902	Atushi, Xinjiang	$8\frac{1}{4}$	>X	500 injured or killed, all adobe and wooden housing collapsed
12-23-1906	The southwestern Manas, Xinjiang	8	X	280 deaths, more than 2,000 housing collapsed
02-13-1918	Nan'ac, Guandong	$7\frac{1}{4}$	X	80% people injured or killed, housing throughout Nan'ao country razed
06-05-1920	Sea off Hualian, Taiwan	8		Dozens of people injured or killed
12-16-1920	Haiyuan, Ningxia	$8\frac{1}{2}$	XII	More than 200,000 people killed, town entirely destroyed
09-02-1922	Southeastern sea to Yilan, Taiwan	$7\frac{1}{2}$		Several people killed, 14 houses collapsed
09-15-1922	The southeastern Yilan, Taiwan	$7\frac{1}{4}$		Several people injured, 24 houses collapsed
03-24-1923	Lubuo and Daofu, Sichuan	$7\frac{1}{4}$	X	More than 3,000 people killed, all housing in afflicted Sichuan area collapsed
03-16-1925	Dali, Yunnan	7	IX	3,600 killed in Dali county, conflagration after quake, more than 70,000 houses destroyed
05-23-1927	Gulang, Gansu	8	XI	More than 4,000 killed, 90% houses collapsed
08-11-1931	Fuyun, Xinjiang	8	XI	About 10,000 killed, many houses collapsed, ground fissuring up to 300km
12-25-1932	Changma, Gansu	$7\frac{1}{2}$	X	270 killed, 80-90% houses collapsed
08-25-1933	Diexi, Sichuan	$7\frac{1}{4}$	X	6,800 killed, 2,500 killed by the associated water disaster, houses in 60 odd towns destroyed completely
04-21-1935	Xinzhu and Taizhong Taiwan	7		3,200 killed, 10,000 odd injured, all houses collapsed
08-01-1937	Heze, Shandong	7	IX	390 killed, 30,000 odd houses collapsed
05-16-1941	Gengma, Yunnan	7	IX	Doens killed or injured
12-16-1941	Jiayi, Taiwan	7	IX-X	300 odd killed, 1700 odd houses collapsed
05-25-1948	The southern Litang, Sichuan	$7\frac{1}{4}$	X	800 killed, 90% houses collapsed
02-24-1949	The northeastern Kuche, Xinjang	$7\frac{1}{4}$	IX	10 odd killed, about 4,000 houses coollapsed Kuche, Xinjiang
08-15-1950	Chayu, Tibet	$8\frac{1}{2}$	≥X	Great casualty, 90% adobe houses collapsed
02-11-1954	The northeastern Shandan, Gansu	$7\frac{1}{4}$	IX	47 killed, 20-30% houses collapsed
04-14-1955	The south of Kangding, Sichuan	$7\frac{1}{2}$	IX	90% adobe houses collapsed
03-22-1966	Ningjin-Dongwang Xingtai, Hebei	7.2	X	Almost all houses in the county razed
07-18-1969	Bohai Sea	7.4	≥VII	About 1,000 houses at various places in Shandong collapsed or destroyed
01-05-1970	Tonghai, Yunnan	7.7	X	90% houses razed
02-06-1973	Luhuo, Sichuan	7.6	X	All houses but wooden ones collapsed
02-04-1975	Haicheng, Liaoning	7.3	IX	50% rural houses collapsed
05-29-1976	Longling, Yunaaan	7.5	IX	About 50% houses collapsed by two quakes
07-28-1976	Tangshan, Hebei	7.8	XI	240,000 killed, the city almost razed
11-16-1988	Lancang and Gengma, Yunnan	7.6	IX	731 killed, 4,640 injured

* I_0 is the epice hest intensity

1. Neotectonic map
2. Seismotectonic map
3. Active tectonic map
4. Map of active faults
5. Earthquake fault map
6. Recent crustal vertical deformation map
7. Recent crustal stress field map
8. Distribution map of strong earthquake epicenters
9. Map of historical earthquakes
10. Earthquake focal depth map
11. Map of earthquake focal solution
12. Comprehensive isoseismoline map
13. Seismic intensity zoning map
14. Seismic hazards distribution map
15. Seismic hazards zoning map
16. Seismic hazards losses estimating map

It is impossible to give an overall review of all these maps, so only a few major maps will be briefly introduced below.

1. Map of active faults

The active fault studies is of considerable significance in the seismic hazards research, both in the theory and in practice. Nowadays the active fault study is one of the hot study subjects in many regions in the world. It has provided an important access to understanding the nature of the origin of the seismic hazards. Therefore, a comprehensive study and systematic mapping of active faults are needed. In China several nation-wide active fault maps were compiled (scale 1:12,000,000 and 1:6,000,000). Now the mapping with scale 1:50,000 along some main active faults (about 20 faults) is going on, which is a key project of the State Seismological Bureau of China (Deng Qidong *et al*, 1990).

2. Seismic intensity zoning map

Two nation-wide seismic intensity zoning maps were compiled in 1957 and 1977 respectively (Deng Qidong, 1980; State Seismological Bureau, 1981; Liu Huixian, 987). During the last decade we began to make a new seismic intensity zoning map (1:4,000,000), and the map was published at the end of 1990.

The new seismic zoning map employed the popular analysis method of earthquake risk probability, incorporated the inhomogeneity of the seismic activity in Chinese Mainland and the recent research achievements in earthquake prediction, important improvement in analyzing models and methods (State Seismological Bureau, 1991a,b).

3. Seismic hazards map

Earthquake-made catastrophes with two categories : direct and secondary. The former are defined as direct damage of buildings, while secondary catastrophes mean surface destruction such as ground cracking, sand-soil liquefaction, rockfall, landslide and mud flow as well as tsunami.

The seismic hazards map of China shows the following two aspects:

(1) The intensity distribution of historical earthquakes. 3 categories of intensity region were summarized and plotted on the map (7 , 7 - 6 , 6 regions).

(2) The major types of surface damage caused by earthquakes are the following 4 types: a) the motion of water bodies (tsunami, watergushing etc.), b) damage of soil bodies (sand liquefaction, silt softing, subsidence, cracking, collapsing, landslides etc.), c) damages of rock bodies (rock rupturing, collapsing, rockslides, and caving etc.), d) the direct earthquake damages (earthquake fault) .

4. Seismic hazards zoning map

The earthquake-induced hazards show regionalized distribution rather than being evenly distributed in all parts of China. A throughout consideration of such a feature will be greatly help in planning seismic hazards prevention, earthquake countermeasures as well as hazard reduction work in China. 6 sub-zones might be classified:

(1) areas with few or small earthquakes, which produce insignificant seismic hazards (North-eastern China, South-eastern China).

(2) areas with numerous earthquake and frequent seismic hazards (Northern China, South-east coast).

(3) areas distributed with small and moderate earthquakes which produce intermediate hazards (the middle and lower reaches of the Yangtze river).

(4) areas with frequent occurrences of strong and moderate earthquakes which produce severe earthquake hazards (North-South zone).

(5) areas with scattered epicenters of historical earthquakes, showing insignificant hazards (Tarim, Qaidam Basins, Northern part of the Tibet. sparsely populated).

(6) areas with intensively developed strong earthquakes and insignificant hazards (the southern Tibetan Valleys, sparsely populated).

PROSPECT

1. It can be concluded that seismic hazards mapping is just beginning in China. Although a few maps concerned seismic hazards have been compiled, most of them are of small scale, and a comprehensive seismic hazards map of bigger scale which includes different kinds of data is needed .

2. Maps of bigger scale is needed to reflect the content of the specific seismic hazards, but the scale of comprehensive seismic hazard map of big area is relatively smaller. How to solve the problem is worth studying.

3. The works below are being done in seismic hazard mapping in China :

(1) Mapping of some (about 20) major active faults of 1:50,000 is being done.

(2) New principle and method of seismic zoning map is being studying.

(3) Data base of seismic hazards is being established and new technique of digitalizational mapping is being applied.

4. As an information carrier, map is an effective measure to directly reflect the regional features. Natural hazard map of abundant scientific contents is one of the scientific bases which can help us in understanding natural hazards and making response to them. The more complete the data is, the more reasonable the bases of hazard reduction will be. It is very important to establish information system, data base, advanced data analyzing system and mapping technology. On the other hand, natural hazard reduction is a world-wide problem, so international co-operation is needed. The project of the Natural Hazard Mapping of Eastern Asia will make important contribution to it .

REFERENCES

Deng Qidong *et al*, (1980) The principles and methods for compiling the Seismic Zoning Map of China, Acta Seismologica Sinica. Vol.2, No.1, P.90- 110.

______, *et al*, (1990) The Haiyuan Active Fault zone. Seismological Press. P.286.

Ding Gouyu (Chief Editor), (1989) Atlas of Active Faults in China, seismological Press, P.121.

______, (Chief Editor), (1991) Lithospheric Dynamics of China. Explanatory Notes for the Atlas of Lithospheric Dynamics of China. Seismological Press, P.600.

Gu Gongxu, (1983a) Earthquake Catalogue of China (1970-1979), Seismological Press, P.334.

______ (1983b) Earthquake Catalogue of China (1831.B.C.-1969.A.D), Scientific Press, P.894.

Liu Huixian, (1987) On the Seismic Zoning Map of China, Proceedings of International Seminar on Seismic zonation, Seismological Press, P.35-42.

Ma Xingyuan, (1987) Explanatory Notes for the Lithospheric Dynamics Map of China and Adjacent seas. (scale 1:4,000,000) Geological Publishing House, P.53.

______, (chief editor), (1989) Lithosperic Dynamics Atlas of China, China Cartographic Publishing

House, P.68.

Shi Zhenliang *et al.*, (1974) Certain characteristics of seismic activity in China. Acta Geophysica Sinica, Vol.17, No.1, P1-12.

State Seismological Bureau of China, (1981) The Report on ational Seismic Zonation of China. Seismological Press, P.382.

______, (1991a) Explanation of Seismic Intensity Zoning Map of China, Seismological Press, P.21.

______, (1991b) Earthquake Mechanisms in China and its Adjacent Areas, Seismological Press, P.20.

Geological Survey of Japan Report, No.281, 1995 p.125-128

Geologic Hazards in China and Their Prevention

Xie Zhangzhong, Zhang Guoxiang, Que Lieding, Duan Yonghou

China Institute of Hydrogeology and Engineering Geology Exploraica, China

ABSTRACT

China is a vast country that has a long history, abundant natural resources and a largest population. With its complex geographic, geologic and climatic conditions, various geologic hazards happen frequently and make China one of the most severely affected countries in the world. According the "Investigation of Geologic Hazards in China" done in 1992, there are totally 29 types of geology-concerned hazards in the country, including earthquake, landslide, rockfall, debris flow, land subsidence, ground collapse, ground crack, soil erosion, land desertization, land salinization, freezing-thaw deformation, coastal hazard, (sea level rise, sea water intrusion, coastal erosion, storm tide), mine disasters (water eruption, coal auto-combustion, gas explosion), disasters in special soils (loess collapse, expansive soil, silty soft earth), endemic diseases, groundwater pollution, river-lake concerned disasters (silting, bank collapse, seepage and induced earthquakes), cold-water farmland etc. Drastic losses in human lives and economy are reported caused by these hazards each year.

Regional Geologic Hazards

Owing to difference in geology, geography and economy in various parts of China, the geologic hazards show rather diverse types, combinations, occurrences and intensities. A distinct regional characteristics and zonation are found in the development of the hazards. From west to east, the country is divisible into 3 parts by the Helan-Liupan-Longmen-Ailao mountains and the Great Hinggan-Taihang-Wuling-Xuefeng mountains (roughly coordinate with the 3 mega-stages of the landform). The western part is prominently hilly plateau featured by high elevation, deep dissection, vigorous crust deformation, complicated structural deformation and strata, dry climate, heavy weather and fractured rocks. Accordingly the geologic hazards occurred there are mainly earthquake, debris flow, freezing-thawing deformation and desertization. The central part is the transitional zone from mountainous to plain regions. It is also characterized by precipitous topography, heavy weather, deep dissection and active faulting. The hazards developed there are earthquake, landslide, debris flow, soil erosion desertization, ground deformation, loess collapse and mine disasters. The eastern part is made up of plain, coast and continental shelf, with small relief, humid climate and heavy rainfall. The hazards commonly seen there are earthquake, ground deformation, landslide, debris flow, river-lake disasters, coastal disasters, land salinization, cold-water farmland, etc.

From north to south, giant mountain ranges, such as the Yinshan - Tianshan, the Qinling and the Nanling, lie across the continental China, and severe landslide, soil erosion are developing along them. In the large river valleys between them there occur land desertization, salinization, soil erosion, ground deformation and landslide-debris flow. Climatically, China strides frigid zone, temperate zone and tropical zone, demonstrating a sophisticated climate condition. The regions south of the Qinling Ranges have a precipitation of 800 - 1200mm, and the regions north of it have rainfall of 400 - 600mm, while in the northwestern China gets only less than 250mm of rain annually. Such differences no doubt affect the development and types of geologic hazards.

Keywords: China, Geologic hazards, Prevention, Earthquake, Landslide, Rockfall, Ground deformation,soil erosion

Major Hazard Types and Their Harm

(1) Earthquake

Lying in the circum-Pacific earthquake belt in the east and in the Eurasian earthquake belt on the west, China is the top earthquake-suffering countries in the world. Within this century, there were recorded 9 earthquakes greater than M 8 degree ; 80 earthquakes ranging M 7-8 degree, with 52 or them occurred during 1949-1990 in the territory of China.

The earthquakes occurred in China are mostly structural earthquakes. All the provinces but for Zhejiang and Guizhou have records of earthquakes larger than M 6. Volcanic quakes are recorded only in Jilin, with the maximum magnitude no more than 2.5 degree. Since 1960's, there have been reported earthquakes in at least 15 reservoirs. They are clearly related to water storage and are exclusively micro-quakes with maximum ranging M 1.0-6.1 degree, with the highest intensities reaching 8 degree. The earthquakes in continental China (excluding the Taiwan Province and the adjacent seas) show a trend of strong and numerous earthquakes in the western part and weak and sparse in the east, with the western provinces such as Xinjiang, Tibet, Inner Mongolia, Gansu, Qinghai Yunnan and Sichuan suffering greatly from them. However, owing to the difference in economy and population density between the western and eastern parts, the earthquake damages are usually much severer in the eastern China.

Since earthquakes are abrupt and sometimes unpredictable, they are apt to cause drastic death toll and economic losses. Within this century, China has seen 4 seismic phases, claiming the minimum death toll of 25000 and the largest of 270000. The earthquake hazard is in China both frequent and intensive, and has a serious threat to cities. About 70% of the large cities having over 1 million people are located inside the area with earthquake intensity risk larger than 7 degree.

(2) Rockfall, landslide and debris flow

These hazards severely threaten people's life and production of the following provinces: Sichuan, Yunnan, Shaanxi, Ningxia, Gansu, Guizhou, Hubei, Liaoning, Beijing, Hebei, Jiangxi and Fujian. Statistics show there are totally several hundred thousand occurrences of rockfall,landslide and debris flows and economic losses amount to several billion yuan.

In terms of scale, landslide is the largest type of the three, next is debris flow. One landslide are generally over 10000 m^3 in volume and the huge ones can be 1 billion m^3; mudflows usually range form hundred thousands to several million m^3 ; while rock are not more than 1 million m^3 in bulk.

These hazards usually cause death and injury of local residences, destroy construction, traffic and industrial facilities. According to statistics, there are more than 400 cities and towns seriously threatened by these hazards. Over 60 towns and cities suffer frequently from landslides and rockfalls, and 50 odds towns have trouble with mudflows. The annual death toll rate caused by landslide, mudflow and rockfall spans 1 : 10^7-1 : 1-10^6, correspondent to the world average.

(3) Ground deformation

Ground deformation in China includes land subsidence, ground collapse and ground crack.Land subsidence is reported in several dozens of cities and districts, and the subsiding area totals more than 10000 km^2. Ground collapse (karst collapse, mining collapse) numbers several thousands and collapse holes total over 30000 and collapsing area more than 1000 km^2. Ground cracks amount to 1000 odds and several hundred km in total length. All the three cause a direct economic losses as much as several hundreds million yuan per year.

Land subsidence mainly happens in the following regions: a. Lower Yangtze River plain; b. Hebei plain; c. Circum Bohai Sea region; d. southeastern China coastal area; e. River valleys and intermountain basin. Regional subsidence is occurring in Hebei, circum-Bohai zone and Lower Yangtze plain, with subsiding area ranging from hundreds to ten thousand km^2. The large ones are related to structural movement.

Karst collapse is distributed in limestone region, concentrated in Guangdong, Guangxi, Hunan, Sichuan, Guizhou, Yunnan, Liaoning, Hebei and Jiangxi provinces where karst is well developed.

Mining collapse is widespread in mine-rich provinces, such as Shanxi, Shandong, Anhui, Heilongjiang and Jiangsu. Ground crack is developed in the Quaternary depressions spreading in many parts of the country.

Ground deformation hazard is closely related with artificial economic activities. Large amounts of pumping and discharging groundwater is the major inducing factor for ground deformation. Irrational exhausting mining is the major cause of mining collapse.

The damages caused by land subsidence include: a. The loss in ground elevation resulted in deterioration of flood-resisting and storm-tide preventing abilities; b. Destroying foundation of structures; and c. Lowering voyage ability under bridge. Shanghai, as the first subsiding metropolis found in China, suffered badly from the above damages. At present the severest case is the Tianjin City, where storm-tide became a serious threat to its economy.

Ground crack can tear off buildings, break ground facilities and make farmland leaking. For example, the ground cracks in the Xian City creep across factories, schools, traffic facilities, 329 villages, 132 buildings and 1057 cabins.

Ground collapse can suddenly destroy on-lying houses, farmland, structures and roads. The abrupt occurrence often cause injury and death of people. Mining collapse in the whole country totals over 1000 km^2 and karst collapse makes up several hundred km^2.

(4) Soil erosion, land desertization and salinization

a. Soil erosion

On the east of the Great Hinggan Range-Yinshan-Helan Mountains-eastern margin of Qinghai-Tibet Plateau, soil erosion plays a major role as geologic hazard, especially in the loess plateau and hilly lands in South China. Soil erosion area on the Loess Plateau amounts to 40000 km^2 and the erosion modular is 8000 t/km a. The soil erosion is stronger in the north and the west and weaker in the east and south. As a major geologic hazard in China, soil erosion covers an area of 1.82 million km^2 19% of the territory and 4.683 billion ton of soil were lost.

b. Land desertization

Deserts and desertized land are spreaded in the middle-west and northwestern China. According to statistics, there are 334000 km^2 of desertizing land, 37000 km^2 of sand-blowing land and 1.16 million km^2 of deserts and gobi, totalling 15.3 million km^2, (15.9% of the territory), which has exceeded the total area of cultivated land. The government has paid great efforts to control the sand hazard and significant achievements have been obtained. However, the invasion of sand has not yet been stopped.

Apart from unfavorable natural conditions (arid climate and loose soil), irrational cultivation and deforestation contribute greatly to the hazard.

c. Land salinization

Salinized lands is distributed in the semi-humid coastal region and semi-arid, arid regions on the north of the Huaihe River-Qinling Mts. - Bayan Har Mts. - Tanggula Mts. line. They take up 818000 km^2 in 16 provinces. There are also about 173000 km^2 of potential salinized land in the country. All efforts have been make to control the hazard and the salinized land is decreasing gradually.

(5) other geologic hazards

Endemic diseases Most of provinces in China have troubles with endemic diseases which are related to geologic factors. Totally 3348 cases of various diseases have been reported in 15 provinces.

Sea water intrusion When groundwater is excessively pumped in coastal regions, sea water will intrude into fresh aquifer to deteriorate water sources. This occurs in the Shandong, eastern Liaoning and Hebei provinces. The total intruding area amounts to nearly 1000 km^2.

Groundwater pollution Water pollution are widespread in China, especially in urban areas. Several tens of cities have been regarded as seriously polluted ones.

Freezing-thawing deformation Frozen earth is found in the northmost parts of China. Thawing deformation can break up structures and traffic facilities. In terms of area, perennial frozen earth covers over 1/5 of the territory, and seasonal frozen earth is even wider.

Silting In the northeast China, silting mainly occurs in reservoirs; in central China it is developed in river beds, and in the east China, in lakes. The source of silt comes from soil erosion.

Other hazards, such as tunnel water burst, gas explosion, coal autocombustion, bank failure, cold-water farm field, reservoir seepage, and soil liquification have also caused various damages and losses.

Prevention and Treatment of Hazards

As a country suffered frequently from natural hazards, China has made great efforts to prevent and treat these disasters. Study and controlling have been done since 1950's those seriously affected ecologic environment and turned out to be disastrous. However, large scale and comprehensive work had not been conducted until the 1980's. At present the research work is focused on abrupt disasters, and till now at least 37 severe hazard spots have been controlled and many more are being investigated and monitored. In 1992, a national survey to geologic hazards was conducted on scale of (1:500000-1:5500000). Provincial investigation (1:500000) is still going on. In the previous years a large number of environmental-geologic explorations and assessment were done to large rivers, traffic lines, mines cities and key hazard areas. In the meantime, Geologic Hazard Map Series of China (1:500000) was compiled.

Since geologic hazards are caused by both geologic process and human activities, the prevention and control work should include both protection of natural environment and control of irrational artificial engineering activities.

Investigation should be done before economic planning and exploitation of natural resources. The investigation usually cover the impact the project will have on environment and the interaction between the environment and the project. A long term comprehensive program should be established to demonstrate the interrelationship of economic development, social change and natural environment, and environmental administration should be done under the guarantee of law and administrative regulation. Environmental factors should be included in governmental budget to avoid environmental deterioration and geologic hazards. The followings are the work we are doing in China.

1. Conduct further investigation on regional geologic hazard distribution and, complete prevention regionalization to defiminate risk zones.
2. To reinforce hazard mitigation projects Apart from the present control works, more hazard spots affecting cities and towns, major traffic lines, large rivers, and critical hazard types are to be explored and treated.
3. To set up and improve geologic hazard monitoring and predicting system and hazard data base. They will high light landslide, debris flow, rock, fall, land subsidence and the threatened cities, traffic lines and mines.
4. To promote the study of hazard prevention theory and techniques.
5. To strengthen international communication and cooperation on theory and equipments.

Geological Survey of Japan Report, No.281, 1995 p.129-133

Volcanic Hazards Mapping in Indonesia

R. Sukhyar

Volcanological Survey of Indonesia, Indonesia

ABSTRACT

In Indonesia, there are 129 active volcanoes and older volcanoes and at least forty of them have erupted at various scale and various types of eruption since 1980. They damaged severely Indonesian society. Volcanic hazard maps are hoped to be used for such hazard mitigation and land-management

1. Ninety seven active volcanoes have their base maps of volcanic hazard zonations. Though they are qualitatively designed but they are very practicable.
2. Indonesian scientists, also the rests in the world are faced challenges in providing scientifically based volcanic hazards. Scientists at present stage have not succeeded supplying civilian a quantitative volcanic hazard map.
3. At present stage VSI priorities only hazards derived from flowage deposits,while that of air-falls remains unresolved.
4. Problem arises in assessing volcanic hazards of volcanoes that have no historic eruptions and no age data. The assessment is taken by analogy to similar type of volcano but having historic eruptions.
5. VSI priorities a short-term hazards instead of the long term ones because of time and budget shortage.

INTRODUCTION

The need of hazards assessment is an urgency for Indonesia, where three million people shelter in hazardous volcanic areas. The number of 129 active volcanoes and older volcanoes have significantly contributed to people a fertile land and in this place they seek hopes for life and eventually being reluctant to leave their homes even though dangers may attack them at any time. Particularly the situation in populous regions like Java worsen due to a hard competition to get a space. Therefore people tend to cultivate to higher elevations on volcanoes' slopes.

Since 1980 at least forty volcanic eruptions have occurred at various scale and various types of eruption. The eruptions have led to a number of forty eight victims. Of them thirty five were caused by roof collapses due to heavy burden of pyroclastic falls. A good example of this poor condition is experienced from the Kelut 1990 eruption, where thirty two people lost live.

The Volcanological Survey of Indonesia is the only government institution which is assigned to conduct volcanic hazard assessment, volcano monitoring and guide and counsel to people about volcanic hazards. By VSI issues of any status of volcanic activity is stated and to civil authority recommendation of action needed is sent to them for securing civilian. In fields VSI is practically under an implementation unit or a task group which is headed by a chief of regency. One volcano may cover more than one regency, and thus the task in disseminating volcanic hazard information is uneasy. In the country where a large number of people uneducated hazard maps designed have to be. as practicable and simple as possible.

Keywords: Volcanic Hazard, Hazards Mapping, Indonesia, Hazards Zonation, Volcano

NATURE OF INDONESIAN VOLCANOES

Indonesian volcanoes are typically andesitic as many others in arc tectonic setting. They grow to reach a certain high about 3000 - 3300 m above see level. Seventy nine volcanoes have their historic eruption records, therefore their "short-term" hazard assessment is relatively simple to establish. The term of short and long- term hazards are adopted from Crandel *et al* (1980). The rest of active volcanoes are identified by presence of volcanic manifestation such as solfatara. For the latter where heavy cultivation and thick soil covering them have caused more difficult in revealing their stratigraphy.

Types of volcanic products are commonly lava, pyroclastic flow, fall and surge and lahar. The type of pyroclastic flow are usually bomb and ash of St. Vincent pyroclcastic flows or block and ash Merapi type pyroclastic flows. Extent of hazards is enhanced for volcanoes possess a crater lake such as Kelut. it is clearly seen in history that the number of victims is increasing with volume of the water of the Kelut crater lake.

Three types of volcano and their associated hazards are recognized:

1. Polygenetic, this type constitutes the largest number of volcano. Their hazards are pyroclastic 1 flows (bomb and pyroclastic flows), fall,lava or lava domes and associated block and ash pyroclastic flows and lahar. Types of eruption are strombolian, vulcanian and Plinian. In many cases the type of eruption of a volcano may not change drastically. For instance Kelut in the last three hundred years remain in its St. Vincent eruption type. After a paroxysmal destruction forming a caldera for tens and hundreds years activity is represented by strombolian and mild vulcanian such as demonstrated by Anak Krakatau, Batur and Raung in Java. For volcanoes appearing on sea tsunami may be generated.

2. Monogenetic. This type is very rare, the best example is the "eccentric cone" on the foot of the Lamongan polygenetic volcano, as cinder cone and maar. Products are pyroclastic fall,surges and minor lava. Type of eruptions are strombolian and phreatomagmatic and phreatic eruptions as result of basaltic magma and water interaction. The Lamongan main cone includes products of strombolian and vulcanian resulting in pyroclastic air-falls. Although there is no evidence historically of this type of monogenetic volcano but from morphological cardinal of the youngest cinder cone it is interpreted that the youngest cone might appear some hundreds of years ago.

3. Volcanic Complex (geothermal field) such as Dieng
   In this volcano effect of volcanic gas is the main hazard. A small phreatic explosions may occur and usually lead to the formation of explosion pits and trigger escaping of underground trapped volcanic gas or steam. The most difficulty is to identify gas emission sites and to portray their hazards onto a map because their emergences are widely distributed.

PROCEDURES OF VOLCANIC HAZARD MAPPING

Scientifically mapping of volcanic hazards is done by investigation of volcanic deposits, their types, extends and ages of previous eruptions. Hazards assessment can be up-dated because of new date found. The further step is to present these components on a map called volcanic hazard map that is hoped to be used as a consideration in land-use management.

Short-Term Hazard

Experiences of the VSI until now have emphasized that a good hazard zonation map are is easily established on volcanoes with a good historic eruption records. Because their eruption products are mostly well preserved and thus are easily recognized. For many volcanoes their type of eruptions almost remain unchanged or only slightly varied therefore the assessment is more simply done and the map can be applicable and fit the reality. In identifying extent of hazard the following steps are done:

1. to characterize types of volcanic deposits and their extends. The extent can be well identified in the field because of their young ages and usually being preserved.
2. to trace as much as possible the extensive effect of any type of eruption (pyroclastic flows, fall,lava and lahar) laterally. Historic eruptions are commonly witnessed therefore their extends of effect can be obtained from villages and then easily traced on maps.

For volcanoes that has no eruption records or poorly reported then the study is based on the youngest stratigraphic sequence. In practice many VSI's scientists are more concerns in flowage deposits such as pyroclastic flows and lahar. This is because the study of air falls require longer time and therefore tend to consume more fund. Indeed the study is important in assessing effects of air falls on roof of building.

Long-Term Hazard

This is aimed to anticipate a possible an infrequent larger degree of eruption than ever happened in history or reported. VSI, at present, has not focused attentively in the such study for a certain reason. That is a need of age dating, where there is no facility for this and the study spends a longer time, meaning need of more budget.

MAP PRESENTATION

For practical purposes in portraying hazard components the farthest extent of any deposits of historic eruptive products become an important aspect to be considered. Therefore justification in drawing a boundary of certain hazard is regarded for those events that have created the largest effect and extent. The hazard components are plotted in a topographic map of scale 1: 50.000.

Hazard Zonation Classification

VSI classifies hazard zonation adopted from Kusumadinata's idea (1979). Volcanoes that certainly have showed historic eruptions are divided into :

1. Forbidden zone, that is area frequently or often affected by pyroclastic flows, falls or lava (or dome). Therefore this zone is recommended to be emptied from any human activity. Practically this term is subjected to the volcanoes are showing continuous magmatic activity such as Merapi and Semeru. Forbidden zone is also used for hazardous volcanic gases, as manifested in Dieng, central Java.

2. Danger Zone I is an area that is most likely affected by pyroclastics (flow and fall and lava flows) when an eruption occurs. This zone has to be evacuated when precursory signs for an eruption is obvious. No permanent building is allowed.

3. Danger Zone II is a zone that is most likely subjected by lahar. This zone is also evacuated during an eruption. By consensus commonly is taken an area with a radius 8 km from the vent.

For volcanoes with no historic eruption records two zones are used, namely:

1. Danger Zone, that is a zone most likely subjected by pyroclastic flows and lava from future eruptions and it has to be evacuated when precursory trends for an eruption is certain. Hazards are assessed by regarding

the upper stratigraphic successions.
However, this is very uneasy because of heavy vegetation and deep soil eliminating information.
Therefore their hazards assessment is hardly justified.
Commonly the boundary of the zone is taken with an analogy to similar type of volcanos that pose historic eruptions.

2. Alert zone is the extension of the danger zone in a case of increased scale of eruption effect. A consensus is taken to cover an area of radius 8 km from the vent.

Conditions of application of both types of hazard zonation map are:

1. Future eruptions will originate from summit or main vent. In practice actually the eruption seems to be magmatic. In many cases revisions are possible. This is because of lack of data. For instance monitoring result predicts no big eruption because of no support from deformation. The danger area may be effective in the crater only not as large as in the map. VSI has experienced a few times for Tangkubanparahu volcano in West Java where only phreatic activities occurred.

2. Future options will be vertical in eruptive column and consequently the effect on the ground is radial.

3. The eruption is not an explosive one that leads to a collapse or the formation of caldera. It means that field data of large eruptive event (caldera formation) at this stage is ignored. Thus, the map prepared is at most used for a short-term volcanic hazard volcanic hazards.

4. The morphology of the volcano will not change appreciably between the established time of hazard zonation map and when an eruption occurs.

During an eruption volcanic hazard map may be modified particularly in supplying other agencies or civilian about scale and course of impending hazards such as lahars and floods. This information is commonly directed to public works that deals with construction and rehabilitation activities.

THE PROGRESS

Ninety seven active volcanoes have been investigated for their potential hazards. But only two have been published, those are Kelut and Merapi volcanoes. The rests are available their base maps and ready for use whenever required. The base map of every volcano is also enclosed in its guide book published by VSI and have been disseminated to local authorities. Besides 35 volcanoes have been geologically studied and of them 15 volcanoes have been published.

Unfortunately geologic data has not optimally used for hazard assessment. This is due to lack of absolute age information and consensus among scientists have not been reached to formalize basic consideration of age for assessment purposes. One wishes to consider deposits with age less than 10.000 years while the others regard the younger ages. The study of geology is currently restricted on grouping deposits in one rock unit without much to see detailed stratigraphy. This because lack of time of investigation particularly in tracing the extent of pyroclastic falls.

Most hazard maps have been tested in the field at least by eruptions of different volcanoes, at least 40 eruptions in the last thirteen years. None of the eruption products (flowage deposits) ever passed over the danger zone of any particular volcanoes. The only problem, in some cases is that courses of flowage deposits may differ from previous ones though still be in the danger zone.

FUTURE TASK

A design or model of hazard assessment from pyroclastic airfalls has not been resolved. By the facts most victims in the scene of volcanic eruptions were caused by roof collapses due to heavy load of fall deposits. This model may combine information of behavior of volcano in term of eruption types, prevailing wind and its speed and the height of eruptive column. At least a model can contribute public authorities information about the scale of effect or damage at a certain distance. Likewise this can also be useful in providing a suggestion about a possible construction requirement of building has to be met in volcanic areas.

References

1. Crandel, D.R *et.al*(1981). Sourcebook for volcanic-Hazards Zonation.

2. Kusumadinata, K (1979). Catalogue of Indonesian volcanoes. Volcanological Survey of Indonesia.

Geological Survey of Japan Report, No.281, 1995 p.135-138

Geological Hazard in Indonesia

Irwan Bahar

Geological Research and Development Centre,
Ministry of Mines and Energy, Indonesia

ABSTRACT

This report introduces Indonesian Natural Hazards Mitigation Programme such as Seismic/ Earthquake Hazard Mitigation Programme and Landslide Hazards Mitigation Programmes.BAKORNAS P. B (The National Coordinating Board for People Welfare), a non-structural government board formulates politics, issues directives and guidelines on disaster mitigation.

GEOLOGICAL HAZARDS IN INDONESIA

Indonesian region is the focus of convergence of three tectonic plates, the Pacific, Indo-Australia and Eurasia plates. Because of this location of the triple junction, Indonesia is exposed to geologic hazards. Volcanic eruptions, earthquakes and landslides are among the critical hazards that threaten the area and over the years have claimed thousand of human lives.

The Indonesian seismic belt lies in a terrain of volcanic arc and extends over 6,000 km from Sumatra through Java, Sulawesi and Banda Arc to Halmahera. The seismicity along this archipelago is very high, accounting for about 10 % of total seismicity in the world. On an average about 400 earthquakes occur annually, and ten of these are high magnitude earthquake. In tectonically active areas, especially along the active faults and fault zones, earthquake induced landslide are a fragment occurrence.

Some 129 active volcanoes are situated along the Indonesian island arc. Their lava is andesitic in composition which means that the volcanoes are of the explosive type. Landslides, generally controlled by lithology, slope stability and climate, are in Indonesia in many cases closely related or caused by earthquakes and volcanic activity. About 300 major landslides occur in Indonesia every year.

The Geological Hazard Mitigation Programme in Indonesia monitors earthquakes, landslides and volcanic activity. The Seismic Hazard Mitigation Programme involves the preparation of seismic zoning maps, defining and enforcement of building codes, seismic network and monitoring, seismotectonic studies, earthquake resistance building research, provides training and organizes seminars; it has also set up, and controls, the Indonesia Disaster Management Center which deals with various types of natural disasters in Indonesia.

Institution -RELATED

Civil Defence for Natural Hazard Mitigation Programme i.e. "BAKORNAS P.B" "(The National Coordinating Board for People Welfare)".

BAKORNAS P.B. is a non-structural government board which formulates policies, issues directives and guidelines on disaster prevention, on providing relief, rehabilitation, and reconstruction, both at the national and local level. Its legal framework stems from a Presidential Decision Issued in 1979, and modified later by

Keywords: Geologic hazards, Indonesia, Hazard Mitigation, Earthquake, Landslide, BAKORNAS P.B.

a Presidential Decree in 1990. The board is directly accountable to the President through its chairman, the Minister for Coordination of People's Welfare. The main activities of BAKORNAS P.B. are supported by an array of institutions which perform individual functions in disaster management. These institution become operational as and when needed, and act in accordance with the needs and priorities identified by BAKORNAS P.B. other board members of BAKORNAS P.B. are the Minister of Social Welfare, Home Affairs and Health, and the Commander of the Armed Forces. When disaster strikes, the governor of the affected province also becomes a member of BAKORNAS P.B. In addition, officials of the Defence and Security Department, Mining and Energy Department and nongovernmental organization may be mobilized to become part of BAKORNAS P.B's inter-institutional support.

The institutional related with the Geological Hazard Investigation and Mitigation Programme such as ;

- Geological Research and Development Centre (GRDC), for the earthquake risk analysis and mitigation.

- Meteorological and Geophysical Agency (MGA), are dealing with seismic recording and data processing for the routine earthquake monitoring.

- Directorate of Environmental Geology (DEG), for landslide mitigation and environmental problems.

- Volcanological Survey of Indonesia (VSI), for volcanic hazard monitoring and forecasting.

THE SEISMIC TELEMETRY NETWORK IN INDONESIA

The Seismic Telemetry Network Telecommunications and Data Processing Center is a high technology facility owned by the Meteorological and Geophysical Agency (MGA). It was established through the seismology communication project known as SISCOM, with support of the French Government.
The Seismic Network has 27 remote stations grouped into five sub-networks each sub-network with a radius of about 200 km. The sub-networks are :

- Sub-network I, near Medan in North Sumatra has 8 remote stations. The Regional Seismic Center (RSC) is provided with seismic data processing facilities.
- Sub-network II, near Jakarta in West Java has 6 remote stations. The RSC is provided with seismic data processing facilities.
- Sub-network III, near Denpasar, Bali, has 8 remote stations. The RSC is provided with seismic data processing facilities.
- Sub-network IV, near Ujung Pandang, South Sulawesi, it has 3 remote stations.
- Sub-network V, near Jayapura, Irian Jaya, has 2 remote stations.

In addition to the RSC, the SISCOM project also installed the National Seismic Center (NSC) at the MGA headquarters in Jakarta. The seismic data recorded at this NSC comes from the five RSC's through the telecommunication line in real time. The NSC is also provided with seismic data processing facilities.

GEOLOGICAL HAZARD MITIGATION PROGRAMME

1. Seismic/Earthquake Hazard Mitigation Programme :

   a. Preparation of a Seismic Zoning Map

   A seismic hazard zoning map was prepared based on the geological conditions and the baseline data of the recorder earthquake occurrence. The map is used for regional development planning.

   b. Preparation and Enforcement of Building Code

A building code is already in existence; however, the enforcement of the code has to be stepped up.

c. Seismic Network and Monitoring
The seismic stations covering the whole country are operated by the Bureau of Meteorological and Geophysics. The network is part of the worldwide seismic network.

d. Seismotectonic Study
Detailed geological investigation is carried out in earthquake prone areas. Microtremor study is aimed at understanding the focal mechanism and also at analyzing the potential accumulation of energy in the fault segment, leading to the forecasting of the probable occurrence of earthquakes in the fault zone.

e. Earthquake - Resistance Building Research

The Earthquake-Resistance Building Research is undertaken by the Public Works Department. Pilot projects for public housing have been initiated in some of the earthquake-prone areas.
Strong motion seismographs (accelographs) are required to be installed in high-rise building in order to study the dominant seismic period of the area.

2. Landslide Hazards Mitigation Programme :

a. Landslide Susceptibility Map is a map showing of areas susceptible to landsliding. The map has been constructed using a geological map; inventory of landslides; a slope map; and soil and rock properties. The map is presented in scale 1:100,000, and it design for public as simple, easily understood statement on the susceptibility of specific areas to landsliding.
The mapping programme has been conducted since 1984, and 5 sheets or 8 sheets that were completed were published.
The map of susceptibility to landslide is very important for supporting National and Regional Spatial Planning Programme.

b. Landslide Investigations have been carried out on landslide prone areas in order to investigate and to evaluate the cause and mechanism of the landslide, to assess the sites for resettlement and rehabilitation of the landslide area.

c. Landslide Studies are detailed investigations that have been done using monitoring stations to understand the mechanism and the factors triggered off the landslide thus counter measures and early warning of future landslide can be developed.

d. Public Awareness Programme has been done by giving warning to local government every beginning of rainy seasons; dissemination of information about landslides; education programme; etc.

e. Landslide Data Base has been developed using geographic information system recently.

Attachment : Chart of "BAKORNAS PB" (The National Coordinating Board for People Welfare).

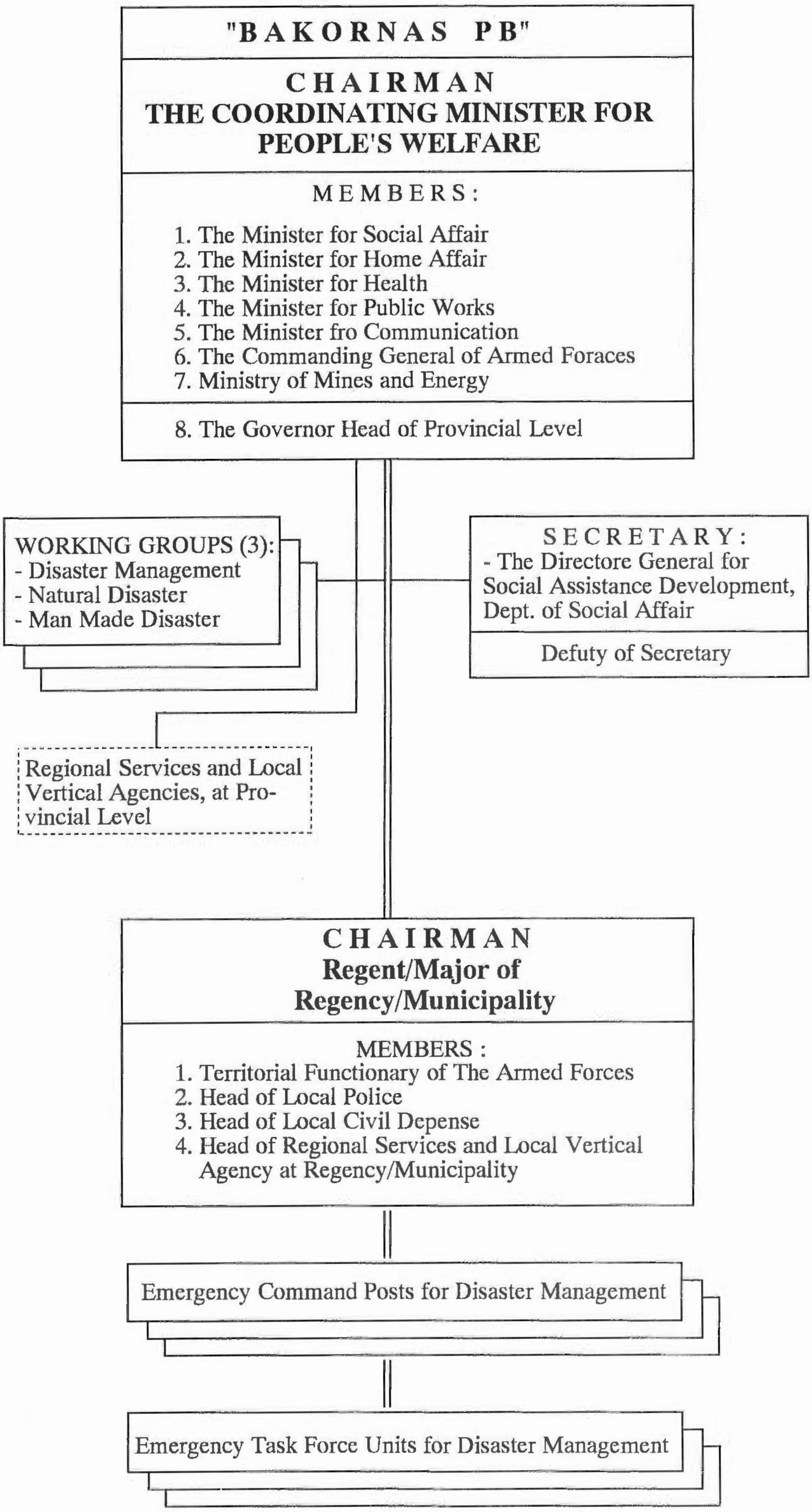

Fig.1 Disaster Management in Indonesia

Geological Survey of Japan Report, No.281, 1995 p.139-144

Geohazard in Peninsular Malaysia

Zakaria Mohamad

Geological Survey of Malaysia, Malaysia

ABSTRACT

In recent years, due to the rapid pace of industrialization and development in Malaysia, there has been a steady flow of population from the rural to the urban areas. One of the most important population centres in Malaysia is the city of Kuala Lumpur which is situated in the tin-rich Klang Valley.

A large part of Kuala Lumpur is underlain by limestone and it is inevitable that sinkholes are formed occasionally. There had been accessions where roads had partially collapsed into sinkholes. The Sg. Besi-Serdang road suffered a similar fate where a section of the road collapsed into a sinkhole. Formation of sinkholes have always inevitable led to general subsidence of the ground above and as a result, cracks appeared on road.

In the outskirts of Kuala Lumpur, numerous housing estates are site on low hills. Where terraces have not been properly designed, landslips are known to have occurred. In other part of Peninsular Malaysia, subaerial landslides along highways constructed through mountainous terrain are common during long monsoon seasons.

Rockfalls do occur in Peninsula Malaysia. Most of them related to limestone hills and other rock overhangs along road cut. Rockfall of a limestone hill near Changkat Jering-Ipoh Highway shows that apart geological factors, a number of secondary caused could also hastened the rockfall. They are incessant rain which can loosen the rock mass, and man-made vibration caused by blasting in the quarry nearby.

The rapid development of the Kuala Lumpur area has led to rapid 'deforestation' of the area resulting in a substantial increase of surface runoff as well as siltation of the rivers. Hence during rainstorm, most low-lying areas are flood-prone.

Earth tremors generated from earthquakes in Sumatra can be felt occasionally in Kuala Lumpur. Minor damages like cracking of wall plaster, window breakage, loosening of ceiling slabs do result from such earth tremors.

To overcome such problems, the Geological Survey of Malaysia has set up an Environmental and Urban Geology Unit to investigate potential geological hazards and to produce urban geological maps useful to town planners, engineers and architects.

INTRODUCTION

Malaysia comprises the Malay Peninsula, Sabah and Sarawak with a total land area of around 330,433 km^2. Sabah and Sarawak are separated from the Peninsula by about 530 km of the South China Sea. Geohazard like rockfalls, landslips, sinkholes and land subsidences do occasionally occur in Peninsular Malaysia. Some examples of such events experienced are briefly described as below.

LAND SUBSIDENCE AND SINKHOLE

It has been estimated that perhaps one-fourth of the earth's surface area is underlain by rocks which are susceptible to solution activities leading to surface depressions or sinkhole formation. Thus foundation problems related to such natural phenomena are common through out the world.

Like most natural phenomena, it is difficult to predict where and when sinkholes may occur as the

Keywords: Malaysia, Geohazards, Landslide, Sinkhole, Flooding, Seismicity, Rockfall

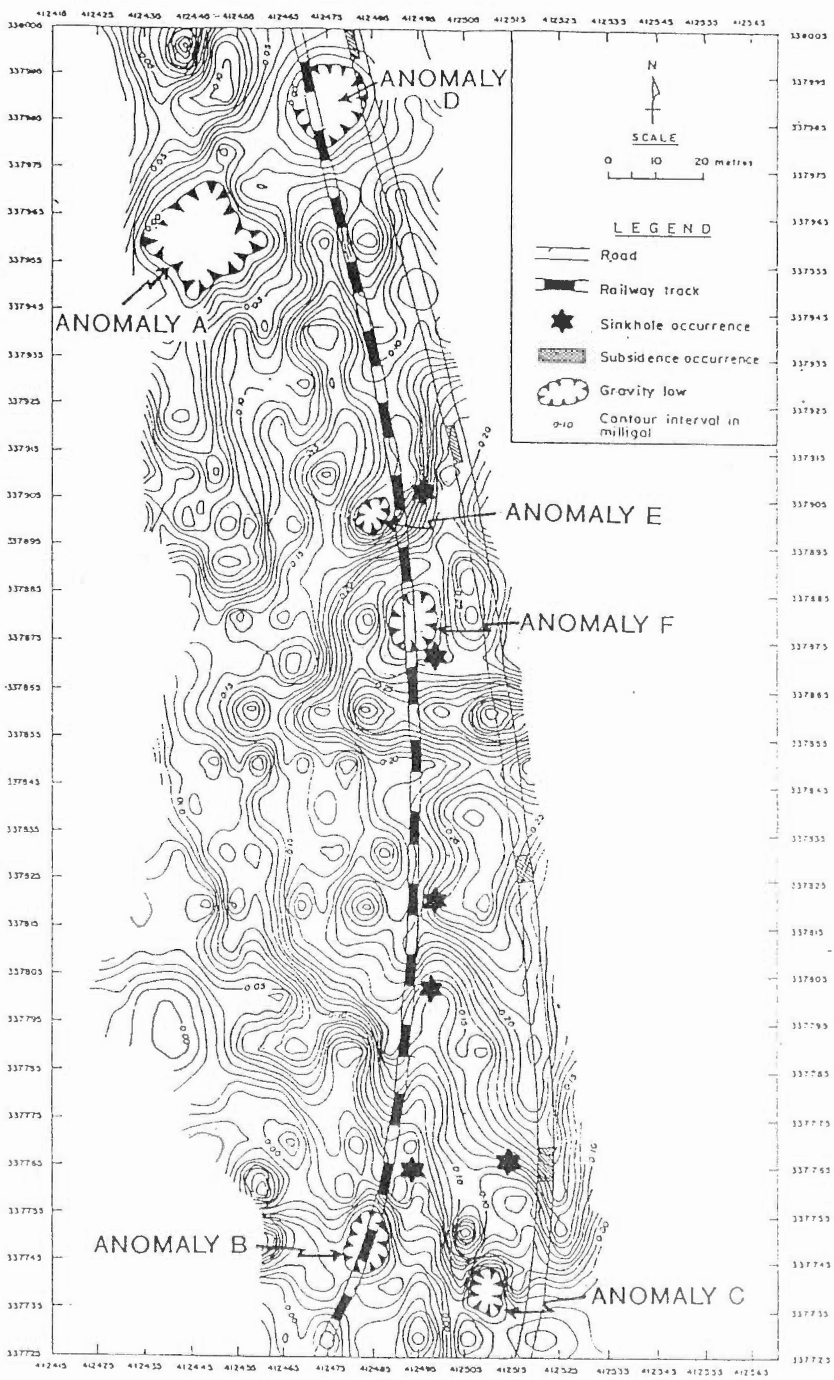

Fig.1 Residual Bouguer Anomaly Map at Sungai Besi-Serdang Road

dissolution of carbonate rocks is a slow process by human scale. As such it can be only be ascertained that land subsidence over such a geological formation is inevitable over a long period of time. The rate of subsidence is often magnified by an accelerated lowering of the ground water table which can be naturally induced or man created. In such cases the ground should appear to stabilize after a period of time. However, due to the nature of the bedrock, such areas cannot avoid recurring ground subsidence even if the subsurface regime reverts back to its original conditions.

In Kuala Lumpur, limestone is present as bedrock underlying alluvium or mined-out alluvial ground over 50 % of the cities area. Limestone bedrock is found in the Kepong area in northwestern portion of Kuala Lumpur, extending in the southeasterly direction to Setapak and Sentul in central Kuala Lumpur and Sungai Besi in the central southern portion of Kuala Lumpur.

Sinkholes in and adjacent to Sg. Besi-Serdang road in southern of Kuala Lumpur, pose costly construction and potential maintenance and safety problem. As a result occurrences of road subsidence and sinkhole along the road, geophysical survey involving microgravity method was conducted. The objective of survey are to delineate other potentially unstable areas which may be prone to subsidence and sinkhole formation. The survey detected a spatial relationship between the sinkhole and subsidence occurrences and microgravity anomalies (Figure 1), apparently, the report of the occurrences are observed in the vicinities of the microgravity anomalies. More than 10 sinkholes, depressions, and related features have been formed in or near the road. The development of sinkholes is restricted to the area underlain by Kuala Lumpur Limestone , and in the immediate vicinity of limestone-granite contact. A general lowering of the water table resulting from large withdrawal of ground water from mining ponds nearby makes the area prone to the development of sinkholes. Sinkholes occur where cavities develop in residual or alluvial deposits overlying opening in limestone. The downward migration of the deposits into openings in the underlying limestone and the formation and collapse of the cavities are caused or accelerated by a decline in the water table.

Limestone bedrock, due to solutioning by the seeping surface water as well as groundwater often forms highly irregular karstic features such as pinnacles, cliffs and overhangs, with solution channels, cavities and collapsed cavities with floats. Such features can cause considerable difficulties in piling operation. One recent example is a sinkhole formation in a proposed site for a multi-story building located in central of Kuala Lumpur. The sinkhole measuring 20 meters in diameter and 5 meters depth formed while piling work is in progress. Therefore, it is important to have an adequate number of drillholes drilled to sufficient depths into solid bedrock before a reasonably clear picture of the subsurface profile can be envisaged.

LANDSLIDES

There are approximately 32,000 kilometers of road and highways throughout Malaysia . Construction and maintenance costs for roads and highways traversing mountainous terrain in Malaysia are relatively high because they are often located in logistically difficult areas and they are located in a tropical climate where prolonged and intense rainfall is common during long monsoon seasons. Subaerial landslides are common along highways constructed through mountainous terrain in Malaysia. Their consequences are serious in terms of loss of property and utility.

In developed area, regolith failure are commonly found along most of the newly excavated road cuttings such as in Charas and Ampang areas. Regolith failures involves landsliding at shallow depth (usually less than 1 to 2 meters) over a less pervious surface such bedrock and are characteristically triggered by either prolonged or heavy rainstorm. In areas where granite forms the underlying bedrock, the interface between the residual soil layer and underlying weathered rock is quite sharp and this interface often forms the failure sliding plan. These slides, however, are often minor, causing minimal damage and inconvenience to the public. Deep-seated slides usually occur in colluvium and usually during periods of heavy rainfall. The failure planes of most slides are semi-circular. Quite a number of these slides are known to have occurred in the Damansara. Charas and Ampang areas where some of the hill slopes are quite high, with heights of up to 50 meters. The slide occurred as a result of an increase in the pore-pressure due to periods of intense rainfall.

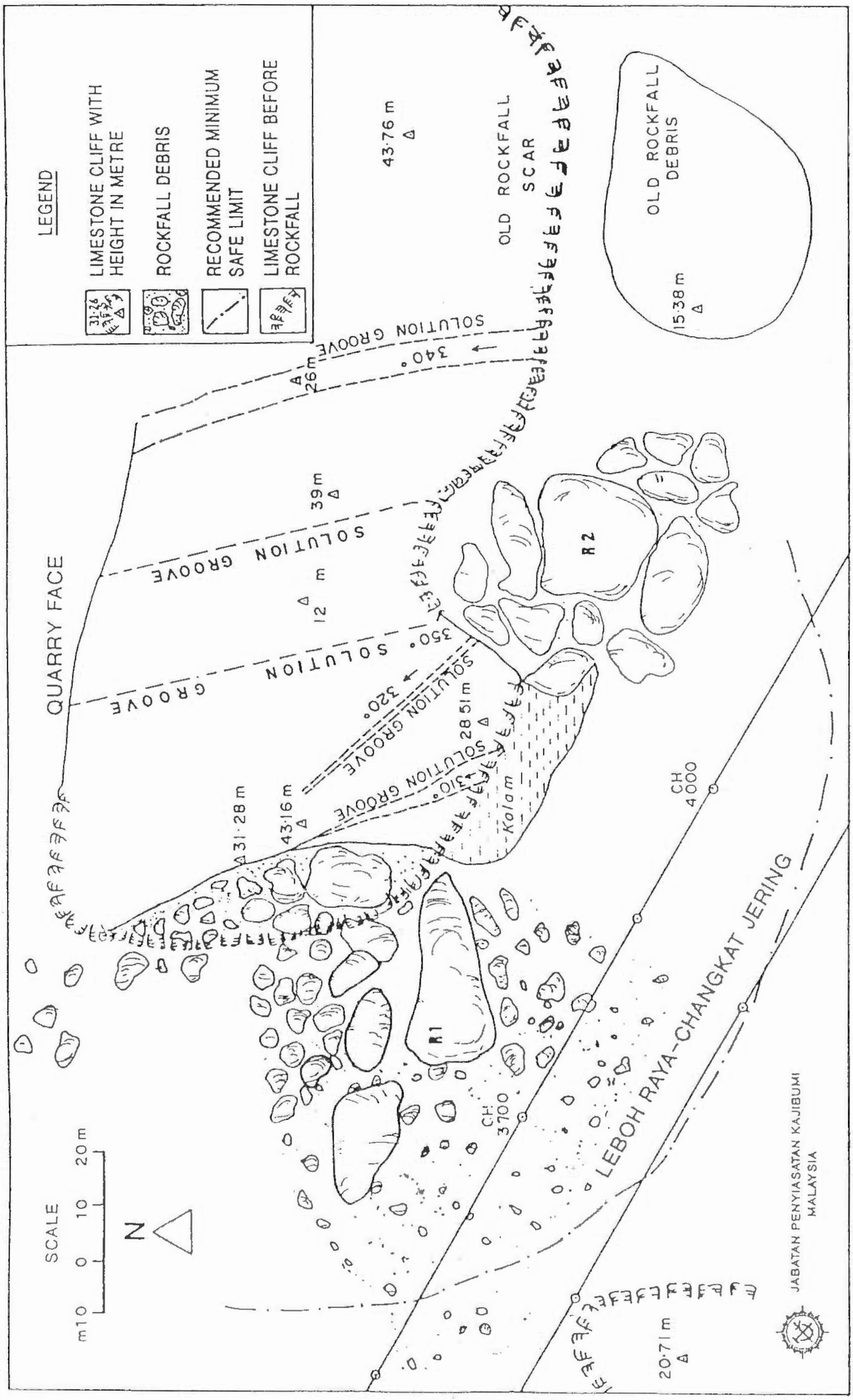

Fig.2 Rockfall at Changkat Jering-Ipoh Highway

ROCKFALLS

Rockfalls do occur in Peninsula Malaysia. Most of them related to limestone hills and other rock overhangs along road cut. One example of rockfall is a limestone hill located near Changkat Jering-Ipoh Highway (Figure 2). First rockfall occurred in western portion of the limestone hill(R1) and few months later another rockfall took place at southern portion of the hill (R2). The heights of the vertical cliff about 43 meters and the rock debris spread out less than twice of the heights of the cliff. Therefore safety limit was drawn at distance two and half of the heights of the overhang cliff. The biggest loose block was about 32 meters by 15 meters and estimated weights about 10,000 tones. No causalities was reported in this incident. It seems the block detects from main body along subvertical joint sets and solution grooves. Due to the chemical composition of limestone, weathering along planes of weakness such shears, joints, faults, is a natural long-term process of denudation on the limestone hills. The cohesive strength across such planes of weakness is reduced and subsequently fails to support the rock slabs or blocks, thus giving rise to a rockfall. Apart from the geological factors mentioned above, a number of secondary causes could also have hastened the rockfall and they are incessant rain which can loosen the rock mass, and vibration caused by blasting in the quarry nearby.

FLOODING

Flooding involves the inundation of the land, usually lowlying , by water in excess of the capacity of the local drainage system. It most commonly results from rainstorms that effect both the coastal and valley-floor areas, but the flooding hazard may also be increased by urbanization.

Rapid development of the urban centres has led to rapid 'deforestation' of the areas resulting in a substantial increase of surface runoff as well as siltation of the rivers. Hence most lowlying areas in the urban centres are flood prone .

The flood-prone areas in Kuala Lumpur are the lowlying areas in the vicinity of the Sungai Gombak-Sungai Setapak and Kampong Baharu areas.

The Drainage and Irrigation Department has taken some remedial steps to combat the flooding hazard. Most significant of all is the construction of a flood mitigation dam at the Sungai Batu-Sungai Tua confluence, located about 10 km north of Kuala Lumpur to control the flooding hazards.

SEISMICITY

Peninsular Malaysia is essentially seismically inactive. However, earth tremors resulting from earthquakes in and off Sumatra, Indonesia, can be felt occasionally in Kuala Lumpur.

The most recent tremor recorded in the Kuala Lumpur area was on the 27th August 1984. Vibrations were felt in some floor of a high-rise buildings. The tremor was assessed to be 'Three' on the Modified Mercalli Scale. The highest tremor experienced in Peninsular Malaysia was in Kuala Lumpur, measuring 'Five' on the M. M. Scale and that tremor took place way back in 1936.

It is unlikely that any building which is structurally sound will collapse as a result of tremors about 200 kilometres away. However, there may be some minor damage like cracking of plaster, cracks on walls and window more easily effected as they act as sensors.

CONCLUSION

In recognizing the importance of engineering geology in urban development and landaus planning, an Environmental and Urban Geology Unit was established in the Geological Survey of Malaysia to investigate on potential hazards, and to produce urban geological maps useful to town planners, engineers and architects.

The scope of work carried out by the Unit includes surface and subsurface geological and engineering geological mapping on a scale of 1:10.000 and geophysical surveys. However, most of the information on subsurface geology is obtained from bore-logs of drillings for soil investigations and mineral exploration purposes. The bore-logs analyzed in detail, with information on the thickness of residual soil, alluvium and type of bedrock are marked on maps.

A geological hazards map is also being prepared on a scale of 1:10,000 where areas with dangerous rock slopes and soil slope, sinkholes etc. are demarcated. Future work includes the preparation of regional geohazard maps for landaus planning and urban development (Figure 3). Hopefully, with the engineering geological data input, urban development can be carried out systematically and cost-effectively in all stages.

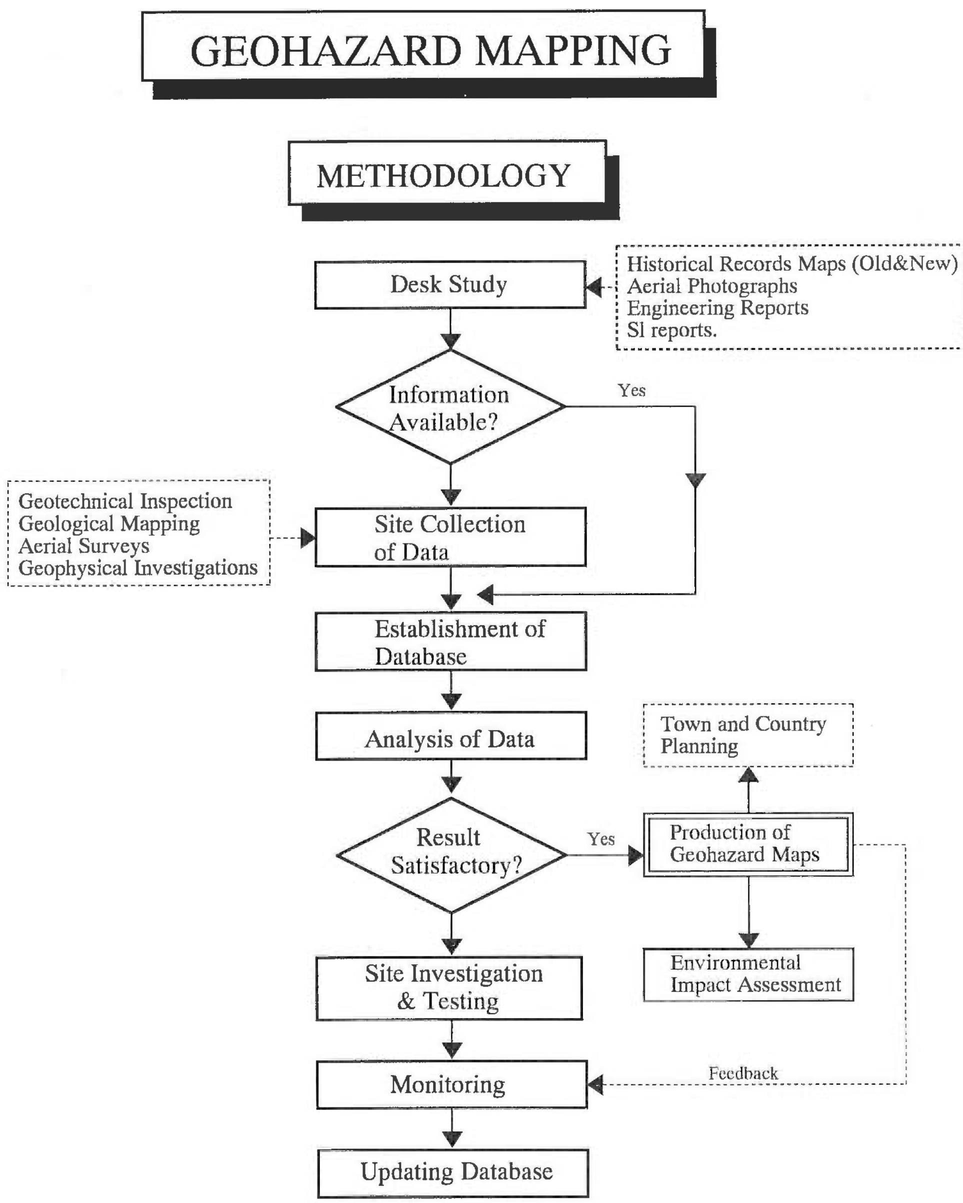

Fig.3 Flow chart showing the methodology involved in the production of Geohazard Map

Geological Survey of Japan Report, No.281, 1995 p.145-148

Natural Hazards in Korea

Su-gon Lee

Korea Institute of Geology, Mining & Materials (KIGAM), Korea

ABSTRACT

The objectives of this brief report are to categorize the natural hazards, to identify the extent of damage and to consider the research being undertaken in Korea.Fortunately,in Korea, the risk from natural hazards is not great excluding landslides, which result in an average annual loss of 60 lives and property valued at 10-30 million U.S. dollars.

INTRODUCTION

Koreans have been encountered with various types of natural hazards. Its government, however, puts the subject aside for a long time because it had to concentrate its efforts on the subject of higher priority which is economic growth and industrialization of the country. Naturally, no particular attention was paid to natural hazards unless they were resulted in serious loss of life or property.

With the improvement of its standard of living and booming of construction industry, Koreans began to conduct systematic studies on the various aspects of natural hazards in Korea. Since the late 1980's a few studies have been implemented to classify and identify the causes of natural hazards. These studies are still in their early stage and therefore sufficiently detailed natural hazard mapping is rarely conducted in Korea until now.

Natural hazards can be classified in descending order of importance as follows:

1. Landslides
2. Changes in water level
3. Subsidences
4. Earthquakes
5. Storm surges and tsunamis
6. Volcanoes

As far as Korea is concerned, the risk from natural hazards is not great with the exception of landslides which will be elaborated later.

It is needless to say that natural hazards are considerably influenced by geological and climatic conditions, and for this reason it is most necessary to consider the regional characteristics of the Korean peninsula.

GENERAL INTRODUCTION TO KOREA

PHYSIOGRAPHY: Korea is a peninsula located in the middle part of eastern Asia and situated between China and Japan, covering an area of 221,000 km^2. In general, the peninsula is mountainous (about 70% of the total area), rarely exceeding 1,200m in altitude, with northeast-southwest trending physiographic features. An average rate of submergence of the west coast was reported as 0.4mm per year over the last 4,000 years. Many terrace landscapes can be recognized all over South Korea. They indicate that the

Keywords: Natural hazards, Korea,Landslide, Storm surge, Tsunami, Earthquake, Volcano

Korean peninsula has suffered many cycles of weathering and erosion arising from uplift and tilting probably during Cenozoic times.

CLIMATE AND VEGETATION: The climate of South Korea is governed by its latitude and is classified as temperate. It has four distinct seasons. The mean annual temperature is 10°C with a maximum of 30°C in summer and a minimum of -15°C in winter. The average annual rainfall is about 1,200 mm, 60% of which falls during the summer period from June to August. Various species of vegetation cover about 70% of the total area of Korea. Approximately 60% of the total woodland is covered with needle-leaved trees, 20% with broad-leaved trees and the remainder with mixed or bamboo forests.

GEOLOGY: Geology of Korean peninsula consists of various strata aged from Precambrian to Cenozoic era. The most predominant rock types are gneiss, schist and granite, which cover two thirds of the total land. Gneiss and schist complex of Archeozoic to Middle Proterozoic age form the basement of the entire Korean peninsula, and granite was emplaced during Mesozoic era throughout the Peninsula. Other geological elements (37%) consist of basalt, porphyrite, tuff, shale, sandstone and limestone of Cenozoic era. There are numerous major faults trending NNE-SSW and showing predominantly strike-slip movement.

WEATHERING AND EROSION: Regardless of soil types, the depth of residual soils on hillsides is limited to a few meters as a maximum, although the weathering depth in Korean granites may exceed 10-30m on the lower slopes. The depth of Korean granitic terrains is relatively shallow compared with other granitic areas such as Hong Kong(60-100m), Malaysia (30-300m) and Australia(60-90m). In general the intensity of weathering in korean granites decreases gradually from the ground surface downwards with a relatively sharp transition from weathered soil to rock being observed at depth without the distinct formation of corestones. The fairly shallow depth of weathering which greatly affects the mode of slope failure, is due to the moderate climate and to erosion. The rate of erosion, which occurs mainly during seasonal heavy rainfall, ranges from 1.5 to 4cm per year at 200 to 300 inclination of hillside.

LANDSLIDES

Landslides are one of the major geological hazards encountered in Korea, resulting in an average annual loss of 60 lives and property valued at 10-30 million U.S dollars.

Landslides can occur in any area of hilly or mountainous topography and are not restricted to specific locations. Most landslides in Korea are triggered by rainstorms during the three month period from July to September. Landslides of various magnitude frequently occur on the Korean terrain and the most dominant types are these listed as follows:

1) On shallow to deeply weathered profiles of the mid-mountain slopes and slope-bottoms, debris flows and debris avalanches usually occur in saprolite and along the boundary between saprolite and weathered bed rock respectively, on locally steep ground surfaces of between 350-440 and with a height of less than 20m.
   It is known that landslides in Korea occur frequently, but on a relatively small scale (less than a few meters in depth), and that their general patterns are shallow and straight.
2) At deeply-weathered sites at the base of mountain slopes, occasionally debris slides occur along relic joints of completely weathered to highly weathered rocks on steep ground surfaces.
3) On the shallow-weathered areas near mountain tops and upper slopes, rock slides occur along joints.
4) In addition to natural causes, landslides can often be induced by construction works creating unstable slopes. Civil engineers in Korea often fail to take into account the effect of geological conditions on cut slopes, resulting in numerous unstable rock cuttings on express-ways and national roads, and in major cities.

Several case studies of instability on cut slopes of less weathered rocks have been intermittently carried out by KIGAM since the middle of the 1980's. However systematic studies on its types, characters and prevention methods have yet to be fully investigated on a regional basis.

CHANGES IN WATER LEVEL

With its industrialization, water usage became heavier in urban cities of Korea. Increasing use of water, both for household and industrial purposes combined with major civil engineering ground works, have resulted in a lowering of the ground water level.

Some hydrogeologists believe that this will ultimately load to different settlement in building and infrastructures. At present however, there is no evidence to substantiate this belief, and any regional records are available now.

SUBSIDENCES

Although the Korean mining industry has been in existence for several decades, mainly for coal, no practical research was implemented to study the associated surface instability phenomena until late in the 1980's.

The reason for such a long delay can be explained generally by two points. Firstly, most of the Korean collieries were located in mountainous region and mining activity did not cause any apparent surface damage. Secondly the Korean government was heavily involved in the procurement of alternative energy sources during the two periods of oil crisis, and were more concerned in giving priority to coal production than the prevention of mining damage.

Nowadays however, surface mining resources are depleted and mining areas are densely populated. Under the circumstances, mining activity in the vicinity of sprawling mining towns has caused considerable damage, which gave an impetus to establishing a special research programma on mining subsidence. Mining damage encountered in Korea can be classified under two categories, namely the damage to the mines and the damage to nearby villages, whereas the former stands for the inflow of surface water into underground gangways through open cracks or cave-in pits, and the latter includes the destruction of houses, the drain of surface water resources and the leakage of the water irrigated. Of these two categories, the first is the more common, and serious concern has been expressed due to the great increase in pumping costs and the frequent occurrence of mine inundation accidents.

Thus KIGAM launched into site investigation in the vicinity of some coal fields in the year 1988 and has been installing subsidence monuments at the collieries of geologic interest for periodic measurement of surface deformation. However systematical regional hazard mapping on surface subsidence due to mining openings has not been produced in Korea until now.

Recently, in May 1993, there was a large subsidence (40m wide * 40m long * 15m deep) in an abandoned mining area which had been recently developed into an industrialized zone, resulting in the loss of 100 tombs.

EARTHQUAKES

The major earthquake activity in Asia take place in a seismotectonic zone beyond the Korean peninsula, so earthquakes in and around the peninsula tend to be small in size (generally earthquake magnitude (m) is less than scale 4), with infrequent occurrence and rather diffuse geographic distribution. No detailed seismological information is yet available in the region.

In 1992, a seismic station has been installed in the south-east coast of Korea in order to support the Japanese research in global seismology in the western Pacific region, (namely POSEIDON: Pacific Orient Seismic Digital Observation Network).

However, since 1971, Korean seismologists have investigated old documents, re-estimated the intensities, and classified the activities on the basis of grade, occurring place and time, in order to assess possible risk of nuclear power plant sites. Korea has several tens of historic records of earthquakes with damages on human beings and properties. In addition the historical earthquake map was published by KIER (1981). The seismicity in Korea is believed to be related to tectonic structure.

Though earthquakes are not so frequent in Korea, Korean engineers must use the Korean Building code on seismic analysis for structures, in the design of construction such as nuclear power plants, harbors and multistory buildings, etc. as a legal procedure since 1987.

Based on geologic evidence to date, there are no known active faults within the Korean peninsula. However, even though the specific relationship has now been intensively studied, some Korean geologists have stated that most of the seismicity of the Korean peninsula can probably be related to known faults and faults along tectonic boundaries.

STORM SURGES AND TSUNAMIS

Storm surges often occur during the Typhoon season in summer, however tsunamis (seismic sea waves) occur rarely in Korea in comparison with Japan. Korea has recorded four distinct tsunami events from the Japanese coasts (1741, 1940, 1964 and 1983). In general, human casualties and damage to property resulting from tsunamis in Korea are minimal.

VOLCANOES

Quaternary volcanic eruptions took place in islands to the south and east. At present there is no volcanic activity on the Korean peninsula and volcanic eruptions are thought to have been completed by the Pleistocene epoch.

*** To provide basic data for hazard mapping, the following informative documentation is available in Korea.**

(1) Geological maps : of entire county at 1:50,000 scale and of selected area at 1:25,000 scale. (KIGAM)
(2) Engineering geological maps : of 8 areas at 1:25,000 scale. (KIGAM)
(3) Slope instability map : compiled by assembling data of areas reported as barren land (over 10ha = 100,000m^2 in size) by the Korean National Forest Bureau. Due to this inadequate compiling method, this map should not be considered as a landslide map showing actual landslide areas in Korea.
(4) Hydrogeological maps: of 7 areas at 1:25,000 scale.(KIGAM)
(5) Geomorphological maps: of entire country at 1:50,000 and 1:25,000 scale and of some urban areas at 1:5,000 scale.
(6) Remote sensing data : such as aerial photographs (of entire country at 1:20,000 scale and of some urban areas at 1:1,200 to 1:10,000 scale); and satellite data (at 1:100,000 scale).
(7) Recently the digitizing mapping programma with the aid of GIS has been undertaken (since 1990) by various research organizations including KICAM.

*** Korean research organization dedicated to natural hazards are as follows**

(1) Landslides: KIGAM, Korean National Forest Bureau, Korea Institute of Construction Technology
(2) Changes in water level:
(3) Subsidences: KIGAM
(4) Earthquakes: KIGAM
(5) Storm surges and tsunamis : Korea Meteorological Administration, Office of Hydrographic Affairs, Korean Ocean Research Development Institute.
(6) Volcanoes : KIGAM

Geological Survey of Japan Report, No.281, 1995 p.149-151

Seismoactive Faults in relation to Earthquakes of Mongolia

D. Dorjnamjaa, G. Badarch, and L. Ganbaatar

Institute of Geology of the Mongolian Academy of Sciences

ABSTRACT

This paper considers deals with character of arrangement and development of the seismoactive ruptures associated with the earthquake on territory of Mongolia. Mongolia, as one of the high-seismic regions in Central Asian seismic belt, is subjected to frequent and strong earthquakes. Particularly, the western part of her territory is active. In the XX century, from 1903, more than 60 earthquakes of M>6.5 (of magnitude from 7 to 11-12) have taken place here. Among them 10 strongest earthquakes called the big dislocation of surface, and that seismic catastrophes, marked in 1905, 1931, 1957 and 1967, which is accompanied by seismotectonic deformations of length until hundreds km. Therefore, especially last years Mongolian geoscientists have contributed a, great effort to the study of geological hazards in order to provide a scientific basis for taking.

SEISMOTECTONIC FAULTS AND GEOLOGICAL HAZARDS

Geological hazards can be considered as those recent geological processes which may effect the human activities and may be induced or triggered by human activities. The occurrence and distribution of geological processes are dictated by the behaviour of geodynamic system of lithosphere. The geodynamic effect can directly cause the endogenetic geologic process, such as earthquakes, fault activity, while the exogenetic geological hazards, such as landfall, debris flow, ash flow and hot-mud flow. According to recent study of continental crust of the Earth of Mongolia, in the geological history since Paleozoic period there were several events of plate collisions putting the Siberia plate, the North Mongolian microplate, Mongolian Altay and Central Mongolian terrains and the Indo-Sinian plate together. Probably,these collision events formed the geotectonic pattern of lithosphere of Mongolian continent. However, the geodynamic system determining the active tectonics and recent relief in Mongolia is controlled by collision of the Indo-Sinian plate on the Euro-Asian plate. According to Patriat *et al.* (1982) subduction of the Indian plate under Eurasia began 110 Ma ago, corresponding to the time of India-Asia collision in the Aptian. This event caused the uplift of western and central high-mountain parts of Mongolia and eastern Mongolian continental plateau in particular. Most of depressions were formed in an extension environments. Uplift is predominant in west and north of Mongolia and depression is in southern and western Mongolia. The terrains between them is of transitional characteristics. The above-mentioned geodynamic condition is one of principal important factors influencing the distribution of geological and natural hazards in Mongolia. In the west and central parts of territory Arhich is characterized by an uplift, the active permafrost, glacial hazards, ground and rock avalanche and snow swamping are predominant. In the south and southeast parts of Mongolia due to dry climatic condition the most prominent geological hazards are sandy desertization and drought.

Earthquakes are one of endogenetic geologic hazards which are essentially dependent upon geodynamic behaviour of lithosphere. It can be seen that the seismicity of Mongolian territory is consistent with boundary loading conditions. The density of epicenters of historical records of earthquake can reflect the actual stress conditions. It is recognized that the seismicity in the north and west parts of Mongolia is higher than in east Mongolia. Four earthquakes with magnitudes(M) > 8 have occurred just within the west of Mongolia. The

Keywords: Seisomoactive fault, Earthquake, Mongolia, Geological hazards, Seismotectonics

dominant style of seismic faulting for each was strike-slip: left-lateral on easterly trending planes in the 1905 Bulnay and Tsetserleg earthquakes and in the 1957 Gobi Altay earthquake. The ruptures associated with these earthquakes. Most of the relief and active structures apparently formed in the end of the Cenozoic Era (e.g., Devyatkin, 1975). Most large seismic faults and epicenters are located within the Mongolian Altay, Gobi Altay, Khsngayn Nuruu and northern Mongolia. According to I. Baljinnyam and others, main style of faulting in the Mongolian Altay appears to be right-lateral strike-slip on planes trending north (northwest) - south (southeast). The Gobi Altay might be seen as the southeastward geographic continuation of the Mongolian Altay. The Gobi Altay earthquake of 1957 December 4 (M= 8.3) was catastrophic event. Three main zones of surface faults comprise most of the faulting. Very large components of reverse and left-lateral strike-slip faulting characterize a zone roughly 250 km long and more than 30 km wide. The main surface rupture, along the Bogd fault,trends roughly east southeast for 250 km along the northern flank of the mountain Ih Bogd and its continuations east and west. A second rupture, the Toromhon overthrust, trends roughly north-south for 32 km (Solonenko and others, 1960) and approaches the Bogd fault from the south in the eastern third of the rupture. The third break lies along the southern flank of Ih Bogd and trends roughly west-northwest for a total length of about 70 km. N. A. Florensov and V.P.Solonenko (1963) reported horizontal components as large as 7-8 m and vertical components of 2-3 m. According to facts and data of Molnar and Tapponnier we assume that the faults in the Mongolian Altay are parallel and use the product of the average slip and the length of a rupture as a surrogate for the seismic moment. The relevant products are given by: 2.5 m along 36 km (Sagsay rupture), and 4.5 m along 215 km (Ar Hotol rupture). The sum of the products of these ruptures and lengths is 2,000 km. The Khangay Huruu is a broad upland within the western part of central Mongolia. It is bounded and cut by active faults of different orientations and senses of movement. The eastern limit of prominent active faulting; in the Khangay might be the rupture zone of the Mogod earthquakes of 1967. Mogod earthquakes of 1967 January 5 and 20 (M=7.8 and M=6.7) are one of greatest in central Mongolia and occurred between Orkhon and Tuul rivers; near the Burget nuruu. Khil'ko and others (1985) associated these with a right lateral fault zone that trends north-south and a southeast trending zone of reverse faulting emanating from the south end of the main rupture. It should be pointed out that deformation is complicated and diffuse at the southern end of this rupture. The Bulnay earthquake of 1905 July 23, M=8.2 (Khil'ko and others, 1985) make it one of the largest known historic earthquakes in continental regions. This fault is a major strike-slip fault, clearly visible on the Landsat imagery (Tapponnier and Molnar, 1979). This fault marks the northern edge of the Khangayn Nuruu. Most of the seismic moment can be associated with slip along a segment, about 375 km in length, of this east-west trending, left-lateral strike-slip fault.

Within the north Mongolia are known the three grabens, trend roughly north from the eastern end of the Eulnay and Tsetserleg strike-slip faults. The lake, Hovsgol Nuur, fills the eastern most of these grabens, but all three grabens are clear on the Landsat imagery (Tapponnier and Molnar, 1979). Devyatkin (1975) reported that these grabens probably formed since Plio-Pleistocene time, with the central Darkhad graven the earliest, the western Busiyn Gol next, and finally the Hovsgol graven. All these faults are characterized by normal faulting.

CONCLUSION

1. A new seismotectonic map (Khil'ko and others, 1985) is the further development on a new geological-geophysical base of the first scheme of seismologic and neotectonic structures of the Mongolian territory. The distinguished big seismologic zones determine the general background of seismic activity in different regions of Mongolia, some structural elements have the different level of seismicity, and the force of earthquakes may change essentially a short way off, depending on local geological conditions.

2. The determination of seismologic zones and their differentiation on magnitude of expected greatest earthquakes is related to number of more important problems of seismotectonic analysis. Certainly,the approach to decision of this problem must realize compositely with an application of all existing seismic,

geological and geophysical data.

3. The dominant type of active seismic faulting in western and central Mongolia is strike-slip: right-lateral on northerly to northwesterly trending planes and left-lateral on easterly or east-southeasterly trending faults. Large components of strike-slip faulting characterize essentially all of the major earthquakes that occurred in this century. Mongolia apparently has undergone intense tectonic activity for only a small fraction of the time since India collided with Eurasia in early Cenozoic time.

Acknowledgments. The manuscript of this paper has been improved by reviewing of Academician R.Barsbold. We wish to express my sincere to him.

REFERENCES

Devyatkin, E.V.1975. Neotectonic structures of western Mongolia (in Russian), in Mesozoic and Cenozoic Tectonics and Magmatism of Mongolia, Nauka, Moscow, p.264-282.

Florensov, N.A., and V.P.Solonenko (eds.).1963. The Gobi Altai Earthquake (in Russian), Akad.Nauk USSR, Moscow. (English translation, U.S.Dept.Commerce, Washington; D.C.1965).

Khil's ko, S. D., R. A. Kurushin, V. M. Kochetkov, I. Balzhinnyam, and D. Monkoo. 1985. Strong earthquakes, paleoseismogeological and macroseismic data, Chapter 3 of Earthquakes and the Bases for Seismic Zoning of Mongolia. Transactions 41, The Joint Soviet-Mongolian Scientific Geological Research Expedition, p. 19-83.

National Atlas of the Mongolian People's Republic. Ulaanbaatar, Moscow. 1990. p. 40.

Tapponnier, P., P. Molnar. 1979. Active faulting and Cenozoic tectonics of the Tien Shan, Nongolia and Baykal Regions, Journal of Geophysical Research, v. 84, p. 3425-3459.

Geological Survey of Japan Report, No.281, 1995 p.153-154

Overview of Geological Hazards in Vietnam

Tran Van Tri

Geological Survey of Vietnam, Vietnam

ABSTRACT

This paper presents only some main features of geological hazards such as seismic hazards, volcanic hazards and landslides in Vietnam. Neotectonic features cause such geological hazards are resulted from the collision of India with Eurasia, and the extrusions,strike-slip motions of Indochina together with the geodynamic evolution of surrounding sea regions.

GEOLOGIC SETTINGS AND GEOLOGIC HAZARDS OF VIETNAM

Situated in the central part of Southeast Asia, Vietnam is essentially a tropical country with a hot and humid climate and integral orographic structure. It is a junction of the West Pacific and Mediterranean tectonic belts which have been reactivated during the recent geologic times [12] . It is due to this unique position that natural hazards are widely developed in Vietnam, causing serious disasters and damages.

Neotectonic features in Vietnam and adjacent areas are characterized by vertical, lateral and rotational movements with strong differentiation, resulted from the collision of India with Eurasia, and the subsequent extrusions, strike-slip motions of Indochina together with the geodynamic evolution of East Vietnam Sea, South China Sea and Sundaland. These features are endogenic causes of active faulting, land cracking, earthquakes, volcanism and geothermal activities.

The main orientation of Cenozoic active faults is NW-SE. Besides, NE-SW and sub-meridional orientations are also common [15]. Seismic activities are recorded in many locations along these fault systems, most frequently in North Vietnam; while volcanic eruptions are wide spread in the South, both on shore and off shore.

Earthquakes of maximum intensity of 8-9 degrees in MSK-64 scale or Mmax = 6.6 - 7 occur along Songma, Sonla, Dienbien-Laichau faults; the areas originating earthquakes of Mmax = 6.1-6.5 are commonly distributed in Songhong, Songchay, Songca and Central Offshore fault belts; those with Mmax = 5.6 - 6 occur along Bacgiang, Samnua, Siengkhuang fault belts; those with Mmax = 5.1 - 5.5 along Caobang-Langson, Tuyenquang, Songda, Raonay, Sahuynh Camranh, Conson fault belts, etc. [6, 10, 13, 14].

The highland area of South Vietnam is largely covered by a Cenozoic basalt sheet which extends westward into the neighboring Laos, Cambodia and Thailand as well as eastward into East Vietnam Sea where several volcanic sea mounts have been identified together with high energy heat flows and tsunamis [9,11,2].

Exogenous phenomena such as landslide, rock fall, slope failure, etc. occur in many places of mountain areas in the North and Central Vietnam. Erosion is widespread in mountain areas and along the coast line [1. 8]. Ground cracking and faulting occur in the Central Highland, Hanoi depression. Besides, other phenomena such as salt water intrusion, land subsidence, groundwater pollution, swamping, etc., have been observed in urban areas of Hanoi, Hochiminh City, Red river and Mekong deltas, coastal areas [3. 8].

Natural hazards in Vietnam are investigated by the Geological Survey of Vietnam, General Department of Meteorology and Hydrology, National Center of Natural Science and Technology, Ministry of Water Resources, as well as some related universities. However, the studies have just been started recently and have

Keywords: Geological hazards, Vietnam, Earthquake, Landslide, Land subsidence, Monitoring

been carried not systematically and only within a limited extent. Some seismic, geodynamic, groundwater level, land subsidence monitoring networks have been established. Extensive Quaternary geological and neotectonic studies are being carried out which include geological hazard investigations: inventory and mapping of earthquakes, landslides, faulting, fracturing, slope and costal erosion, land subsidence, groundwater pollution, etc. However, due to the lack of methodology and equipment, our country is in need of international cooperation and support, in order that we could carry out proper investigation and have appropriate measures for preventing and controlling the geological hazards.

REFERENCES

1. Nguyen Duc Dai, 1992. The environment, natural resources and erosion status along the coastal zone of Vietnam. Regional Seminar on Environmental Geology. Proceedings, Hanoi, Vietnam.
2. Gorskov A.P 1981. Investigation of under-sea volcano in 10th trip. Sci. res. "Volcanology" . J. Volcanology and Seismology No 6, USSR (in Russian).
3. Tran Van Hoang, 1992. Geoenvironment, disasters and development in Southeast Asia. Reg. Sem. on Environmental Geology. Proceedings, Hanoi, Vietnam.
4. Nguyen Chu Hoi, 1992. Environmental degradation and natural resources along Vietnam coast line. J. Scientific activities" No 2.
5. John L. Rau *et al*, 1991. The problems of land subsidence in the world and in Vietnam. CGI, 2nd. Proceedings, vol. 2, Hanoi, Vietnam.
6. Nguyen Kim Lap, 1987. The seismicity of the Indochina peninsula. J. Earth Sciences. To. 9 (1).
7. Nguyen Quang My, 1992. Initial research of present geoenvironment in Vietnam. Reg. Sem. on Environmental Geology. Proceedings, Hanoi.
8. Vo Con Nghiep, 1993. Some issues from geology and environmental geology in the urbanization of Vietnam. J. Scientific activities. No. 5.
9. Patte E., 1924. Etude de l'ile des cendres, volcano apparu au large de la cote d'Annam. Bull. Serv. Geol. Indoch, vol. XII, fasc. 2.
10. Bui Cong Que *et al.*, 1991. Seismogenetic zone in the Indochina Peninsula. CGI. 2nd. Proceedings, vol. 2, Hanoi, Vietnam.
11. Saurin E. 1967. Neotectonique de l'Inndochine . Rev. Geogr. phys. Geol. dyn., vol. IX, fasc 2, Paris.
12. Tran Van Tri *et al.*, 1985. The main tectonic feature of Vietnam. Proc. 1st CGI, vol. I. Hochiminh, Vietnam.
13. Pham Van Thuc *et al.*, 1985. Seismic zoning in the territory Gf Vietnam. Acta Geophysica Polonica, vol. XXXIII, No 2.
14. Nguyen Dinh Xuyen, 1991. Seismic zoning of the territory of Vietnam. CGI. 2nd. Proceedings, vol. 2, Hanoi, Vietnam.
15. Nguyen Trong Yem *et al.*, 1991. Appearance characters, distribution rules of recent dislocation in Red river trough and neighboring regions. CGI 2nd. Proc. vol 1, Hanoi, Vietnam.

Geological Survey of Japan Report, No.281, 1995 p.155-157

Natural Hazards in Cambodia : Flood Disaster

Thach Xovalsay

Department of Geology and Mines, Cambodia

ABSTRACT

The main hazard of Cambodia is flood disaster resulted from its climate,tropical monsoon. This report introduces an example of flood disasters, which occurred in September 1991. The initial flood damages are that 132,200 families require good assistance and that 50,000 families need suvival kits, and severe damages on houses, rice field etc.

BRIEF GEOGRAPHIC

Cambodia is a small country in that part of southeast Asia commonly called "Indochina." It lies between ten and fifteen degrees north latitude and 102 and 108 degrees longitude. The country has an area of 181.035 square kilometres (km^2) sharing its 2,438 kilometres land border with Thailand, Laos and Vietnam. The north and northwestern boundaries correspond with watershed and streams, while the eastern and southern boundaries shared with Vietnam have been delineated artificially. To the south Cambodia's 425 miles of coastline are warched by the waters of the Gulf of Siam.

The Country' central plain, which comprise 3/4 of the total land area, is 10-30 metres above sea level. The plains area is drained by the Mekong, Tonle Sap, and Bassac Rivers through the Mekong Delta in Southern Vietnam.

Cambodia's climate is tropical monsoon with two distinct seasons. The rainy season from June - October and a dry season from November - May. The rainfall period is frequently interrupted by a so-caled"small dry season", a period of normally one to two weeks of relatively less or even no rainfall furing the period June/July, or sometimes even in August. The intensive rainfall period in September and October coincides with the peak of the high water levels of the Mekong River, which can lead to severe flooding in riped areas. In November, rainfall drops to the level of the period May - August, and during December to February there is little or no rainfall.

Rainfall varies in different part of the country as well as from year to year. Rainfall in Cambodia is uneven and irregular, resulting in periodic droughts or floods, sometimes concurrently in different part of the country. The Cardamom and Elephant ranges block the flow of the southwesterly monsoon, with the result that central Cambodia is drier and clearer than other lands at the same latitude. The central basin and Mekong plains area receives a yearly average of between 1,000 and 1,500 millimetres of rainfall. The country's heaviest rainfall occurs on the coast between the mountains and the Gulf of Siam (5,000 millimetres in Bokor, and 3,800 millimetres in Kompong Som).

FLOOD DISASTER SEPTEMBER 1991

At monsoon 1991, Cambodia was marked by a significant flood, that it has not happened the same before.

Kompong Speu province was one of the most severely affected areas in Cambodia by August - September floods in 1991. The damaged areas were located along the Prek Thnot and extended to parts of both Kandal and Takeo provinces.

Keywords: Flood, Cambodia, Disaster, Relief, Damages

Typical damage can be seen at 150 m breach of Road N0 3 (RN 3) at the original Prek Thnot course South of the Toek Thla and Kompong Tuol diversions (constructed during 1975-1978). The breach at the same place happened twice in 1980s, although with lesser width than that of 1991.

A heavy rainfall in mid August 1991 lasted to September the monthly or daily rainfalls this year not extremely high, (170 mm/ 10 days) probably the occurrence of this summer rainfails was about once every three years. On the other hand, the Mekong water levels, as well as the Bassac, rose very high in August. The peak in Vientiane was recorded on 10 August and in Phnom Penh in early September, and more or less the high water levels continued till mid October.

The Prek Thnot used to receive a reversed flow from the Bassac during June - August. Such back water affected period this year lasted longer. This matter contributed to prolong the flooded period and increased damage.

From 20 to 22 August 1991, typhoon (fred) caused heavy rainfall in North and Northeast Thailand, Laos, Vietnam, and Cambodia, resulting in flooding of large area and considerable damage with some loss of life. Continued heavy rain throughout the remainder of August and the first half of September 1991 resulted in further flooding and damage to crops and infrastructure.

In Cambodia, Kompong Speu province was the first affected as waste amounts of rain water run off from nearby mountains caused the collapse of two dams on 21 and 22 August 1991 resulting in strong current flows, in some cases reported to be as high as two meters. These enormous water flows proceeded to the nearby provinces of Kandal. Takeo, Kampot, and to areas in the vicinity of Phnom Penh.

A few days after this initial swift and unexpected flooding large areas along the Mekong River in Kompong Cham. Prey Veng, Kratie and Stung Treng were inundated with the rain water flowing south from Laos and Thailand. Other major rivers further south such as the Tonle Bassac and Tonle Sap also overflowed their banks. With the strong currents and flooding ali along the rivers, serious concern arose with regard to the protection of Phnom Penh especially in light of the identification of several weak points in surrounding dykes.

DESCRIBED DATA OF FLOOD DISASTER

A team dealing with the re-appraisal of the Prek Thnot project, irrigation, observed the August 1991 flood, its extent, depth and duration. Their report (EUROCONSULT October 1991) includes description of data collected in the field and an evaluation on a preliminary basis:

The total area flooded amounts to 14,000 ha in Kompong Speu and 32,000 ha in Kandal province (between airport and lake Tonle Bati);

-Water depths reached 2.5 m around Kompong Speu, 1 m around Kompong Tram and 1 m in Kandal stung area;

-Duration of flooding varied between 2-3 days in Kompong Speu to 8-10 days in the lower areas, between Prek Thnot river and Lake Tonle Bati, just west of road N0 2;

-The flood caused overtopping of road N0 3 over a section of 12 km at a level of + 14.50 or there abouts. Road N0 2 was overtopped to depth between 0.40 and 0.70 m over a length of 12-13 km.

-Just south of the Kampong Tuol regulator road N0 3 was breached over more than 100 m.

-The flood raged through the Kandal Stung area, direction lake Tonle Bati after the bank along the Prek Thnot and road N0 3 gave away.

SUMMARY OF EMERGENCY PHASE RELIEF REQUIREMENT

The National Flood Relief Committee reported the initial flood damages sustained from mid - August until mid - September as follows:

- 10 provinces affected in total
- 132,000 families or 650,000 persons require good assistance.

- 50,000 families in need of survival kits consisting of temporary shelter and household items.
- 3,000 houses totally destroyed
- 234,000 of most productive rice fields (or 1.5 percent of total planted area) flooded
- 143,000 ha of rice paddy crop destroyed.
- Massive losses of livestock with risk of epidemic diseases among survivors.
- Significant infrastructural damage to roads/bridges and critical irrigation structure.

This report was made available to the international and local donor community and served as validation for subsequent appeals for assistance.

Reprot referring :

- Hydrology Department
- Roads and Bridges Department
- UNDP.

Geological Survey of Japan Report, No.281, 1995 p.159-167

Natural Hazards Mapping in India

P. L. Narula

Geological Survey of India

ABSTRACT

Geological Survey of India has made significant contributions to mitigate natural hazards.In the hazards mapping, GSI,for example, has initiated a programme of landslide hazard potential maps of the Himalayan Region. Another top- rank disasters in India are flood hazard and seismic hazard. GSI also carries on many mitigation programmes on those hazards. Recent volcanic activity are restricted only in the two volcanic islands,therefore that damage is not so severe as the former disasters.

INTRODUCTION

Throughout the human history natural phenomena like earthquakes, landslides, avalanches, floods, cyclones, droughts and volcanic eruptions have intermittently caused widespread devastation at one time or the other in different parts of the World. The processes continue to pose serious challenge to human settlements and civilization. The magnitude of such devastation can be gauged from the fact that the natural calamities during the past two decades have claimed more than 2.8 million lives, adversely affecting 820 million people and a financial loss of the order of 25-100 billion dollars. Although estimates range widely it is believed that natural hazards account for up to 4% of the total annual deaths of which nearly 75% result directly from river floods, tropical cyclones and associated sea surges. These casualities, however, are not evenly distributed throughout the world. The natural hazards induced catastrophes most frequently and more severely affect the developing countries. The effects of natural disasters is much more acute in the developing countries with higher population densities through the financial losses may be of lesser magnitude when compared to those of the developed nations. The miseries caused to the population and the casualities suffered in developing countries are much more than for the developed countries.

India, is a country of diverse physiographic and climatological conditions, has to contend with the effects of the natural hazards and the scene of the devastation by natural hazards in India is no different from those of the other countries. The vast coast line and the proneness of the area to some of the vast devastating cyclones of the world, particularly the east and west coast, have thus been repeatedly flooded and flood plains of major rivers like the Ganga and Bharahmputra have to face the brunt of the floods almost annually. The Himalayan region, which is a part of the Alpide-Himalayan seismic belt, is a domain which has witnesses the devastating effects of 4 of world's largest magnitude earthquakes in the last one century and the rising trends of the Himalaya and their fragile and complex geological environment has resulted in innumerable landslides causing loss of life and property.

On a regional scale, like many other countries of the world, we in India have been able to demarcate domains which are prone to damages by earthquakes, landslides, floods and cyclones but what needs to be done is to initiate larger scale evaluation studies to generate a reliable multidisciplinary data base on the parameters contributing to the mechanism of various natural disasters, from which concerted researches could be launched for better understanding of these phenomenon. From these would stem evolution of rational and economic means for policy formulations necessary for mitigating the effects of natural hazards.

Keywords: India, Natural hazards, Hazards Mapping, Tropical cyclone, Volcanic hazards

The Geological Survey of India has made significant contributions in the geoseismological studies as well as major wastage processes. A wealth of data has been generated in these fields which has been utilized for identification of broad seismotectonic domains, preparation of seismic zoning maps as well as codes of practice for a major civil engineering structures and guiding researches for progressive improvements and modifications, keeping abreast with the state of Art in this field. Another field in which the survey has taken lead is the parameteric analysis of landslides for identifications and analysis of the varied mechanisms of mass wastage processes for preparations of landslide hazard zonation maps. These maps would serve as a guide for planning and execution of developmental projects as well as mitigation efforts to reduce the miseries of people who are frequently effected by these landslides and avalanches.

The evaluation of flood hazard ,mainly depends on understanding and forecasting of precipitation patterns and duration as well as patterns of runoff and sediment transport and deposition in the trunk as well as tributary stream systems. A lot of research is being carried out by various agencies in our country and the necessary input on the siltation patterns, greatly dependant on the geomorphological, geological and erosive characteristics of the catchment yielding the silt need specialist treatment and thus is to be provided by the Geological Survey. This input whereever, necessary is being provided by us to other National Organisations responsible for flood forecasting and mitigation effects.

Detailed meteorological studies for tracking the path and anticipated velocities of the cyclones shall provide time for advance warning and mobilisation of mitigation efforts in the cyclonic storm/sea surge areas of the coast.

LANDSLIDE HAZARDS MAPPING

Landslides constitute a major natural hazards which account for considerable loss of life and damage to communication routes, human settlements, agricultural and forest land, particularly in the Himalayan terrain. While elaborate assessment methodologies, forecasting and warming measures are being systematically evolved and adopted for other types of calamities few such arrangements exist for landslides, even in the areas where landslide hazard is quite high. The management of this hazard is generally confined to post-disaster assessment of the mechanism, remedial measures along with temporary relief and rehabilitation of the people, if this disasters affects agricultural land, houses and human life. The Geological Survey of India have been involved in the site specific investigations of a number of landslides particularly those related to communication routes, urban settlements and River Valley Projects. The pioneering investigation related to the stability of slopes date back to 1896 when the Geological Survey of India was called upon to study the stability of slopes around Nainital, an important hill resort. Prior to this a classical documentation carried out by Sir T.H. Holland of the Survey in 1893, of the catastrophic rock slide in Birhiganga valley, leading to creation of a huge reservoir. These studies were instrumental in obviating loss of life by flooding due to its partial breach, predicted with uncanny accuracy. The detailed evaluation of the mechanism of failure in varying geoenvironments, identification of responsible parameters including the evaluation of the characteristics of the slope forming materials, geohydrological conditions and geomechanical evaluation of discontinuity surfaces for kinematic assessment of stability of natural as well as cut slopes have been practised by the Engineering Geologists of the Survey and the innovations made in the remedial measures have proved successful. The data generated by large scale geological mapping of the hazardous locales (site specific) has been of immense value for deterministic and probablistic evaluation of the factors of safety. These types of investigations, though essential for designing safe cut slopes or for evolving treatment measures for failing slopes, would be of marginal use for purposes of regional landslide hazard evaluation.

In order to provide synoptic maps for regional planning, the Geological Survey of India has initiated a programme of landslide hazard potential maps of the Himalayan Region as well as the Nilgiri Hills and Forest Coast of Peninsula taking into consideration the physical characteristics of the slope forming materials, general physiography, rainfall patterns, seismicity, the domains of crustal instability and the landslide incidences. This study has lead to the categorisation of the terrain in these basic classes of instability with two subdivisions in each as depicted.

These basic maps have been utilized to narrow down the targets for further detailed landslide hazard potential mapping utilizing more comprehensive parametric analysis of the hazard contributing factors to generate maps of 1:50,000 scale, for areas of specific objective as well as prioritised regional coverage. It should be appreciated that depending on the scale of maps the quality and utility of these maps would also change. By progressive increase in the scale of mapping, the zonation would approach realistic susceptibility conditions and parametric analysis would become more rigorous, almost reaching the probablistic to determininstic site specific levels.

To assess the post Uttarkashi earthquake scenario of the coseismic landslide events and to validate the landslide hazard potential ratings a landslide hazard map has been prepared on 1:50,000 scale covering the meisoseismal and surrounding area. This study has indicated a very good fit with the incidences and has given a high level of confidence in the extrapolation of high risk areas. For comparative evaluation of the Pre and Post earthquake scenario IRS LISS II imageries have been utilized for this purpose .

STATUS OF EARTHQUAKE HAZARD STUDIES IN INDIA

It is estimated that about 50% of the Indian sub-continent is subjected to varying degrees of earthquake hazard which is amply demonstrated by the fact that more than 650 earthquakes in excess of magnitude 5 have been recorded in this domain during the last one century majority of which were located in the Himalayan frontal area, seismically one of the most active intracontinental regions in the world . Four great earthquakes i.e. the 1899 Shillong earthquake, the 1905 Kangra earthquake, the 1934 Bihar Nepal earthquake and 1950 Assam earthquake of magnitude in excess of 8 occurred in this belt in a short priod of about 53 years. The Himalayan mountain ranges have risen to the gigantic heights as a result of continent to continent collision of the Indian plate with the Eurasian plate nearly 40 rnillion years ago. The continued northward movement since then has caused deformation of the rockmasses, piling them one upon the other to form the high Himalaya and this movement is believed to be still continuing. The strain build up caused by this movement is the reason for the vulnerability of this region to the earthquake activity.

The Peninsular part of Indian sub-continent has also been visited by a number of damaging earthquakes albeit with larger recurrence intervals and of lesser magnitude than those of the Himalayan area. The basis of Kutch earthquake of 1819 which provided the earliest well documented record of earthquake faulting and resultant 25 km long and 3 m high 'Allah Bandh' and the more recent December 1967 Koyna earthquake (M = 6.3) amply demonstrated that certain parts of the Peninsular India are also vulnerable to earthquake hazard. The Koyna earthquake which took place after the impoundment of reservoir is world's best known example for reservoir induced seismicity.

From the earthquake scenario given above, it is evident that the Indian sub-continent is a locale where there were ample opportunities of carrying out the researches on the domains of differing deformation styles including areas of active subduction in the Arakan Yoma belt (Indian plate subducting the Burmese plate, a locale for Intermediate to deep focus earthquakes), the continent to continent collision zone of Himalayan arc and the interacontinental extension tectonic regimes of Peninsular India.

Prior to the development of instrumental seismology in India, in the beginning of the present century, the scientific study of earthquakes was being undertaken by the Geological Survey of India through the macroseismic field surveys, preparation of isoseismal maps and interpretations on the mechanism and source faults for these earthquakes.

After the occurrence of Great Assam earthquake of June, 1897, necessity of installing some seismographs was felt and three observatories one each at Alipore (Calcutta) Colaba (Bombay) and Madras were established in 1898-99. Subsequently an instrument designed by Prof. Omori of Japanwas loaned to Meteorological Department after 1905 Kangra earthquake and was installed at Simla. After independance a plan was prepared for systematic coverage of the country by establishing observatory network. Presently there are about 120 seismological observatories set up by IMD and other Organisations, out of these 67 stations are located in high seismicity areas, primarily in the Himalayan Region and the Shillong Massif. The organizations engaged in the instrumental recording are the IMD, NGRI, BARC, Roorkee University and various State Governments. In addition to these observatories there are about 100 portable seismographs with various organizations which have been employed from time to time for monitoring of tectonic lineaments to establish contemporary deformational activity, monitoring of after shocks of main events and also for geothermal field surveys. With the establishment of these networks and local telemetered arrays for microseismic monitoring considerable researches have been made for understanding the earthquake mechanism, crustal structure modelling and improvement in the state of art in the earthquake parameters. The Geological Survey of India, being the premier organisation, entrusted with the assessment of this natural hazard, has contributed its might for understanding the physics, tectonic correlation and the damage patterns caused by major events as well as assessment of the earthquake hazard potentials of various tectonic domains.

MACROSEISMIC SURVEYS FOR MAJOR EARTHQUAKES

The first scientific study of an Indian earthquake was carried out by Dr. T. Oldham of Geological Survey of India of the Great Cachar earthquake of 1869. This was followed by the classical work of Dr. R.D. Oldham who made a very thorough study of the Great Assam Earthquake of June, 12, 1897 and published his observations in the form of a memoir. This monumental work laid foundations of modern seismology not only in India but the whole world. It was in this study that existence of longitudinal (P), Transverse (S) and Surface (L) waves was identified on the records of seismographs. Since this pioneering effort the officers of Geological Survey of India have investigated most of the damaging earthquakes recorded in the Indian sub-continent and the records of the same have been published from time-to-time. The field surveys for the earthquakes which occurred between 1970 till date have also been investigated and the results published in different journals, primarily of the Geological Survey of India. Isoseismal maps of some of the important events are incorporated. Most recent in the chain of devastating earthquakes in the Himalayan region was the Uttarkashi earthquakes (M = 6.6) of 20th October, 1991 which took a toll of 768 lives, thousands were injured and caused severe to partial damage to about 0.1 million houses besides initiation of numerous coseismic landslides, collapse of bridges and resultant disruption of the communication routes making relief operations a stupendous task. There were conspicuous changes in the chemistry of thermal waters of some of the springs because of dilution by the regional groundwater as well as mixing of thermal waters with new reservoir sources which got connected to the earlier thermal reservoirs. These changes were conspicuous in the mesoseismal area of this event. The Geological Survey of India have carried out comprehensive damage surveys, analysed the data to arrive at isoseismic patterns, the possible source mechanism. All this data has been incorporated in a special Pub. No. 30 of the Geological Survey of India (Aug. 1992). The most interesting findings of these surveys were: Huge landslide occurrence in the isoseist VIII and above; drastic changes in the chemistry of hot springs which cannot be explained only by dilution, no damage to a 39 m. high concrete dam located in the mesoseismal area which was designed for 0.15 g. though the peak ground acceleration recorded in the vicinity was more than twice this design value; very good match of the isoseismals with the strong motion records and matching of the attenuation patterns of the isoseismals with the tectonic frame work of the area;convensional type of constructions, walls with timber bracings and lighter tin roofs, being more earthquake resistant than poorly designed cement mortar and thick slab roofings which have come up in the recent years.

EARTHQUAKE HAZARD EVALUTION

From the ensuing discussions it is evident that Indian subcontinent is prone to earthquake hazard of varing degrees, the Himalayan region being most severly affected. It is not possible to prevent the occurrence of this natural phenomenon but the disastrous effects could be mitigated by thorough understanding of their mechanism, frequency, magnitude and the capability of existing structures to withstand the dynamic effects of these events by improving the state of art in designing earthquake resistant structures.

Considering wide variation in the seismic hazard in terms of intensity of ground motion and frequency of occurrence an attempt was first made in the year 1962 for seismic zonation of the country so that the margin of safety against earthquake forces for all similar constructions is evenly distributed. This effort was based primarily on the epicentral map and the isoseismals maps of various damaging earthquakes published by the Geological Survey of India. The intensities of major earthquakes were plotted to divide whole country into zones which have experienced a particular intensity during historical earthquakes. It is evident that in this exercise it was assumed that the regions that have experienced earthquakes in the past, will also do so in the future during the expected life span of man made constructions. Unfortunately the historical record of earthquakes in India is limited and can only be extended to past 200 years. Thus statistical evaluation of the periodicity of different magnitude earthquakes in different domains is not properly constrained. The evidence of which was given by Koyna earthquake of 1967 which occurred in the zone where it was least expected with reference of seismic zoning map of 1962 or 1966 and the thinking had to be revised about the earthquake potentialities of different tectonic domains of the country. This necessitated the third revision of the seismic zoning map in the year 1970, where in the influence of tectonic domains, the recency of movement along certain tectonic surfaces and the seismicity patterns were the necessary inputs. Even in the code revised in 1984 utilizing the seismic zoning map of 1970 it was stipulated that for the civil structures of high hazard potential, more rigorous inputs on the earthquake potentials and resultant motion characteristics should be made taking into consideration the local geotectonic environment. It is well known that the preparation of seismic zoning map is a dynamic process and revisions have to be made along with the advances in the state of Art.

The basic concept that the areas which have experienced large earthquakes would do so with in life span of future constructions does not find favour with many researchers as the recurrence interval for large magnitude earthquakes could be much longer than the stipulated life of the structure as the time required for accumulation of strain to the levels of large magnitude earthquakes would be a period of some centuries. Moreover, large earthquakes may occur where only small earthquakes have been recorded. These anomalies indicate the limitation of restricted data base used for regression analysis.

In view of the limited seismological and historical records and long recurrence intervals between potentially damaging earthquakes, need for geological methods as a suppliment to the seismological records has been felt right from the time when the seismic zoning maps and codes were first conceived. In the last twenty five years a lot of research has gone into this geological route and a number of empirical relations have come in vogue for assessing the maximum generating capabilities of seismogenic faults. Recognition of seismogenic faults is the first requisite which has been realised through recognition of neotectonic adjustments along tectonic lineaments. For engineering purposes these faults are the ones which have developed or rejuvinated during the Holocene and late Pleistocene times. The most widely accepted definitionof active faults for normal engineering practice are those along which adjustments have taken place during the last 10,000 years but for more hazardous structures like Atomic Power Plants, the adjustments which have taken place during the last 35,000 years are also included in the category of active faults. These neotectonic features have further to be constrained with respect tothe locales of strain build up as many of the active faults could be a manifestation of an seismic creep and not related to seismogenatic source. Even if, the neotectonic faults are established to be aeismogenic the recurrence intervals of earthquakes, which could potentially be generated by these faults would not be an easy proposition to establish and recourse may have to taken to carry out paleoseismicity studies along with geochronological inputs. Such studies are being planned in our country.

In view of the above constraints it is amply justified that there is a need for developing seismotectonic models, synthesising various data sets to assess the total seismic potential of different seismogenic sources, evolve and update the attenuation relationships of motion characteristics so that the seismic zoning maps become more meaningful as an input for aseismic design of structures.

SEISMOTECTONICS APPROACH FOR ESTABLISHING DESIGN BASE EARTHQUAKES

The inadequate seismological and historical records for statistical treatment of the data base, particularly for higher magnitude earthquakes which have long recurrence intervals, has created a need for developing and utilising geological methods to further extend backwards in time the seismological data base. Some empirical relationships have been suggested by various researches to relate the fault lengths or displacements with the earthquake generating capabilities. The application of these relationships, however, needs a careful identification of the source faults as any wrong identification would lead to either overestimated seismic hazard and thus costly designs or underestimation which could lead to unsafe structures. The first step in this direction is to establish the relative or absolute age of the faults which can be achieved either by geological, seismological or historical data bases. Identification of neotectonic activity along any tectonic surface by geological reasoning need not necessarily be indicative of its seismogenic capability. Such neotectonic faults need monitoring and detailed evaluation for assigning them the status of generating faults.

In fact, for such features to be seismogenic one must have unequivocal evidences of strain build along them up and should not be confused with aseismic creep. More often than not the seismogenic faults are blind features and are located below the cover of upper crustal material and thus delineation of these faults is a difficult proposition. Therefore, multidisciplinary inputs and rationalised conceptualised interpretation for identifying such seismogenic faults, considering the geotectonic model and contemporary deformation styles is a necessity. The various important inputs needed are listed below:-

A Tectonic framework identifying the tectonic surfaces with the chronological order of their developmentpreserved in the geological history on the basis of global plate tectonic concepts.
B Neotectonic status of various surfaces and chronological codification of displacements.
C Spatial distribution of the earthquakes with reression analysis for arriving at maximum probable earthquake. In order to bridge the information gap of the historical data base palaeoseismicity studies are necessary to correlate horizons of deformational structures in late quaternary sediments with major past earthquake events.
D Focal mechanism studies to arrive at deformational styles and evolve correlation with the prevalent tectonic set up. As well as preparation of tectonic flux maps and correlate with geological structures.
E Use of geophysical approaches for constraining the crustal structure.
F Heat flow characteristics and their relationship with contemporary tectonics.

Utilising approaches enumerated above Narula (1991) has prepared various thematic maps depicting deformational styles, seismicity, tectonic flux etc. to arrive at an integrated seismotectonic map of the NW Himalaya, wherein domains having similar contemporary deformational styles have been identified. The domains have been further subdivided into discrete crustal blocks for evaluating their EQ generating capabilities. This basic approach is being adopted for covering the entire subcontinent with progressive refinements.

It is well known that the seismic risk of an area is represented by the danger of earthquake damage that structures and human population is prone to suffer and the total loss of property and human life a particular earthquake can cause. The preceding discussions were primarily aimed at the inputs which are planned to be taken up for economic and safe designs of major constructions. Even for this purpose researches are necessary for the space time variations in the seismicity and the attenuation energy depending upon the local geological conditions including characteristics and density contrasts with depth. It has been the data base about the accelerations observed with respect to the source area is limited, particularly for earthquakes of magnitude more than 6 and the regression relationships suggested by various researches do not satisfy the local geological conditions. The macroseismic surveys conducted for a number of earthquakes have indicated that the intensity patterns for the earthquakes in the Himalaya are not in consonance with any of these relationships. Thus, there is a need for refinement of these relationships with reference to Himalayan region and researches are being planned to achieve the same.

MICROZONATION

Seismic microzonation is a process for identifying relevant geological, hydrological, seismological and geotechnical conditions of a specific region and thus is similar in basic procedure to that of macrozonation discussed above, only difference being in the detailing of the inputs particularly the conditions which could change locally the energy attenuation patterns as well as secondary effects like the initiation of landslides, subsidences, liquefaction etc. The detailed inputs required for the purpose of microzonation in addition to the ones identified for macrozonation are -

i) Spatial and geometric distribution of macro level geological structure and their response to dynamic loading induced by earthqukes.
ii) Identification of contrasting lithologies, having considerable aerial extent which may provide different responses to wave propagation.
iii) To bring out marked geomorphic contrasts which could modify the ground response.
iv) Demarcate areas of soft unconsolidated sediments, their ground water condition as well as physical characteristics for assessing their potential for accentuation of motions as well as proneness to liquefaction and
v) Identify slopes having critical stability equilibrium where ground shaking could induce landslides.

In our country all these informations are generally collected, synthesised and analysed before the aseismic design of major structures. Projects have also been identified for carrying out microzonation in high density population congregations like Delhi to assess in detail the seismic hazard and the risk involved.

FLOOD HAZARD IN INDIA

As in the case with worldwide flood hazard scenario, floods in India rank at the top of natural disasters in terms of loss of life, damage to property and misery to people, Eighteen out of 62 major rivers of the country are flood prone and the area vulnerable to flood hazards is estimated to be of the order of 40 million ha. Out of which about 45% could be provided reasonable degree of protection by structural and nonstructural measures. Such protection measures have been provided in area of about 13.57 million ha. at the cost of Rs. 2115.40 crores (1986-87). It may, however, be pointed out that the annual damage cost shows an increasing trend which may reflect on encroachment on the flood plains, modification in the landuse patterns resulting in the increased flood runoff and also because of the improvement in the data collection systems. Thus the input gone in the protection measures is more than off set from the ground truth.

The bulk of flood damage in India tables place in the Ganga basin in the states of U.P., Bihar and West Bengal; the Brahmputra valley in Assam, Indravati valley in Andhra Pradesh and Mahanadi Basin in Orissa. The average annual damages by floods (Avg. of data between 1955-88) are of the order of 885.90 crores, avg. area effected 8.11 million ha. and lives lost were 1,495. The decade wise averages are given in the following table.

Block period	**Area affected in million ha. Max.**	**Avg.**	Population affected in million	Lives lost	Damages in mill. Rs.
1953-60	11.17	6.95	31.95	889	11870
1961-70	9.54	5.94	32.24	3496	2868
1971-80	18.61	11.49	70.45	11316	14547.5
1981-88	23.95	10.58	61.03	3442	50095.4

The evaluation of the flood hazard mainly depends on understanding and forecasting of precipitation patterns and duration as well as patterns of runoff and sediment transport and deposition in the trunk as well as tributary stream systems. The major inputs in these evaluations are related to hydrological studies, monitoring and forecasting which is primarily being looked after by Water Resources departments at the Centre as well as State levels. Flood plain zoning identifying areas liable to floods of different frequencies have been attempted for some of the basins. As the geological inputs are marginal in nature details of these hazards assessments are not being dealtwith. Researches are being carried out by various agencies- Flood hazard evaluation and the geomorphological and geological characteristics responsible for effecting changes in the sedimentation patterns and thus changing the flood proneness are the fields in which Officers of the Geological Survey of India are engaged.

TROPICAL CYCLONE HAZARD

Tropical cyclones are the deadliest natural hazard which is faced by the Indian coastline, particularly the east coast. In the last two and a half centures, 12 out of 15 deadliest cyclones which have occurred round the globe took place over the coastal areas in the North Bay of Bengal. From the records it is evident that special attention has to be paid for mitigation of this natural phenomenon particularly in the fields of cyclone warning systems as well identification and preventive measures in the areas which are most affected by this phenomenon. In the last two decades most severe cyclones in our sub-continent have been the 1970 cyclone which endundated 75% of Bangladesh and claimed around 300,000 lives followed by 1971, 1973 and 1977 cyclone which claimed 10,000, 5000 and 10,000 lives respectively on the east coast provinces of India. In the 1977 cyclone 400 sq. miles of furtile land was submerged and 50,000 cattle perished. The most devastating effect of such a disaster is the loss of shelter, fertile land, crop and contimination of ground water. Efforts are being made to carry out the zonation work in the coastal regions to catagorise areas depending on the frequency and intensity of cyclone effects so that effective mitigation and protective measures are possible.

In our country on an average 13 cyclones of various intensities hit the Bay of Bengal coast while this number is only two in the Arabian Sea. The highest cyclone hazard is faced by East Godavari, Krishna, Nellore and Shrikakulam districts of Andhra Pradesh, Balosore, Cuttack, Ganjam and Puri districts of Orissa, Chingalput and Tanjavur districts of Tamil Nadu and Midnapur and 24 Parganas districts of West Bengal. Moderate Hazard is faced by Guntur and Vishakhapatnam districts of AP, (East coast); South Arcot, Ramanathapuram and Trinilveli districts of Tamil Nadu; Bhavnagar, Bulsar, Broach, Jamnagar, Junagad and Kutch districts of Gujarat; South Kanara district of Karnataka; Calicut, Cannanore, Ernakulam, Trivandrum and Malapuram districts of Kerala.

VOLCANIC HAZARD

In the Indian subcontinent recent volcanic activity is known only in the Barren and Narcondum Islands of

Andaman Sea. These two volcanic islands lie in the middle of an arcuate zone of late to post Tertiary subduction related arc volcanism with the great Sunda chain of volcanoes running through the volcanic ranges of Sumatra and Java in the south and extending north into Burma. It is related with the spreading domain of Andaman sea.

Hobday, Mallet and Ball were the pioneering geologists who had visited these islands in the nineteenth century and described their topography and geology (Mallet, 1885, 1895; Ball, 1888, 1893). Subsequently Washington (1924) published a short petrography with six bulk rock analyses, four of the Barren and two of the Narcondum rocks, identifying the former as basalt and augite andesite and the latter as hornblende dacite. Geological investigations were carried out by Geological Survey of India (GSI) during 1959-61 in these two volcanoes for locating native sulpher deposits (Raina, 1961 and 1987; Pawde and Raina, 1962). Marine Wing of GSI carried out bathymetric survey around this island and have suggested the presence of three under sea volcanic ridges, one along the extension of the island in NNE-SSW trend and the other two south and east of Barren island rising about 450 to 700 m above the surrounding sea floor (av. depth 1600 m) (Banerjee *et.al.* 1988). Ocean bottom magneto-meters (OBM's) were deployed in the Andaman Sea on either side of the Narcondum and Barren islands to study the variations of the magnetic field around the dormant volcano of Barren island and extinct volcano of Narcondum Island. Magnetic profile across Barren Island suggests the presence of a heated mass at depth (Banerjee, 1990). Recently Halder *et.al.* (1990-91) initiated in detail the petrography, mineralogy and chemistry of different lava flows in selected sectors in order to work out an appropriate model of magma generation in geotectonically active environment.

The volcano in Barren Island located at about 125 km. north east of Port Blair, headquaters of Indian Union Terriroty of Andaman and Nicobar Islands, has recently become active after remaining more or less dor~mant for nearly two centuries. The last eruption of this volcano took place in 1803.

A team of scientists from Geological Survey of India visited Barren Island area on the 11th May, 1991 and conducted preliminary appraisal of the activity and collected samples of recently erupted ash and dust from boats and vessels plying close to the Islands. On the spot examination has revealed that the parasitic vent located on the north-eastern face of the central volcanic cone is the source from where there is a continuous pouring of red hot lava and effusion of smoke in short intervals of few seconds. While the column of the smoke gushing out of the vent could be observed even from a distance of 30 km or so, the volcanic fall our in form of ash and fine cinters is hoted only very close to the Island. The dust particles are dark and magnetic in nature containing small fragments of glass impregnated with ironoxides/and mineral fragments of plagioclase and olivine. The red hot volcanic bombs ejecting out with heavy rumbling and hissing sound are thrown to the heights of about 50 metres depending on size. The maximum size of the ejected material was of 50 to 60 cm. However, boulders upto the size of 4 m length were also noted which were apparently ejected during the initial phase of the present eruption. The hot lava rolling down the slope of the cone was getting deposited in the northern valley from where it has started flowing westward following the course of earlier lava flow of 1803. An area of about 800m x 200m in dimension has been till date covered by the youngest lava material with an average thickness of about 5 to 6 metres. The youngest lava is gradually covering the previously erupted lava pile particularly in the northern and western part of the valley and is advancing towards west and south-west of the Island, being only about 250 metres from the edge of the sea water at the landing site. A bulging effect is also visible on the north-eastern face of the existing cone possibly due to accumulation of the liquid lave melt coming out from the mouth of eruption. This is likely to change the existing morphology of the main volcanic cone.

Trees in the valley and along the cauldron walls have mostly got burnt or charred. No perceptible seismic tremors were felt in the Island during the visit of the party.

Appendix

Geological Survey of Japan Report, No.281, 1995 p.171-176

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Thailand ADPC /AIT 1	Prof. Satyendra P. Gupta Senior Consultant	Asian Disaster Preparedness Center Asian Institute of Technology	ADPC, AIT, GPO Box 2754 Bangkok 10501 Thailand	Tel 66-2-524-5356 Fax 66-2-524-5360
Thailand CCOP 2	Mr. He Qixiang Chief	Technical Service Unit CCOP Technical Secretariat	2nd Floor, Offshore Mining Organization Building 110/2 Sathorn Nua Road Bangkok 10500 Thailand	Tel 66-2-234-3578 Fax 66-2-237-1221
Thailand UN ESCAP 3	Dr. Huub Van Wees Scientific Affairs Officer	Natural Resources Division United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)	United Nations Building Rajadamnern Avenue Bangkok 10200 Thailand	Tel 66-2-282-9161 ext.1526 Fax 66-2-243-0786
India 4	Mr. P. L. Narula Director	Seismo Tectonic and Landslide Division Geological Survey of India	GSI, Lucknow India 226020	Tel 29-6941 Fax 91-33-2496956
Indonesia 5	Dr. R. Sukhyar Division Chief	Directorate General of Geology and Mineral Resources Volcanological Survey of Indonesia	VS1, JL. Diponegoro 57 Bandung Indonesia	Tel 62-22-72606 Fax 62-22-702761
Indonesia 6	Dr. Irwan Bahar Director	Directorate General of Geology and Mineral Resources Geological Research and Developement Centre	Jl. Diponegoro 57 Bandung Indonesia	Tel 62-22-72601 Fax 62-22-702669
Cambodia 7	Mr. Thach Xovalsay Vice-Director	Department of Geology and Mines Ministry of Industry	45Bd Tou Samuth Phnom Penh Cambodia	Tel 855-23-2-3077 Fax 855-23-2-6011
Philippines 8	Dr. Raymundo S. Punongbayan Director	Philippine Institute of Volcanology and Seismology Dept. of Science and Technology	6th Floor, Hizon Building 29 Quezon Avenue, Quezon City Philippines	Tel 63-2-712-4669 Fax 63-2-711-3077
Vietnam 9	Dr. Tran Van Tri Deputy Director General	Geological Survey of Vietnam	Cuc Dia Chat VN 6 Pham Ngu Lao Str. Hanoi Vietnam	Tel 84-42-54734 Fax 84-42-54734
Malaysia 10	Mr. Zakaria Mohamad	Environmental andUrban Geology Section Geological Survey of Malaysia	19-21 Floor, Tabong Haji Building Jalan Tun Razak P. O. Box 11110, 50736 Kuala Lumpur, Malaysia	Tel 60-3-2611033, 2611034, 2611035 Fax 60-3-2611036

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Mongolia 11	Dr. Dorj Dorjnamjaa Vice-Director	Institute of Geology Academy of Science, Mongolia	P.O. Letter-Box 863 Ulaanbaatar 210613 Mongolia	Tel 9-76-1-51135 Fax 9-76-1-51935 9-76-1-310014
Korea 12	Dr. Lee Su-gon Senior Engineering Geologist	Environmental Geology Group Korea Institute of Geology, Mining & Materials	30 Kajung-Dong, Yusung-ku Taejon Korea 305-350	Tel 82-42-868-3054, 862-1107(HOME) Fax 82-42-861-9720 or 9727
China 13	Dr. Wu Jing Yang President, Senior Researcher	China Institute of Hydrogeology & Engineering Geology Exploration	20 Dahuisi, Haidian District, Beijijg China 100081	Tel 86-1-8311627 Fax 86-1-8311639
China 14	Prof. Duan Yonghou Chief Engineer	China Institute of Hydrogeology & Engineering Geology Exploration	20, Dahuisi, Haidian District Beijing China	Tel 86-1-8311556 Fax 86-1-8311639
China 15	Dr. Wang Xichuan Geologist	China Institute of Hydrogeology & Engineering Geology Exploration	20, Dahuisi, Haidian District Beijing China	Tel 86-1-8311556 Fax 86-1-8311639
China 16	Mr. Zhang Dun Hydrologist	International Co-operation Department of MGMRC	64, Funei Street, XiSi, Beijing China	Tel 86-1-6032122 Fax 86-1-6024523
China 17	Prof. Ding Guoyu	Satate Seismological Bureau	63, Fuxing Avenue Beijing 100036 China	Tel 821-5522-2309 Fax 86-1-8210995
China 18	Dr. Liu Yarong	Chinese Institute of Geology and Mineral Resources Information	No. 277 Fuwai Street Beijing 100037 China	Tel 86-1-835-2833 Fax
China Taipei 19	Dr. Chien-Shui Huang	Central Geological Survey	2 Lane 109, Hua-Hsin Street Chung-ho, Taipei Taiwan	Tel 886-2-9429140 Fax 886-2-9429291
Italy 20	Prof. Domenico Giardini	Istituto Nazionale di Geofisica Global Seismic Hazard Assessment Program	Via di Vigna Murata 605 00143 Roma Italy	Tel 39-6-51-860-487 Fax 39-6-50-411-81 e-mail: giardini@in8800.cine

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Australia 21	Dr. R. Wally Johnson Chief Research Scientist	Australian Geological Survey Organization	GPO BOX 378 Canberra, ACT 2601 Australia	Tel 61-6-249-9377 Fax 61-6-249-9983
Swiss IDNDR 22	Dr. Ken Sudo Expert for Earthquake Engineering	IDNDR Secretariat Office des NATIONS UNIES Palais des Nations	CH-1211 Geneve 10 Suisse	Tel 41-22-798-58-50 ext. 365 Fax 41-22-733-86-95
USA 23	Dr. Maurice J. Terman Scientist Emeritus	Office of International Geology U. S. Geological Survey	MS 917, Reston VA 22092 USA	Tel 1-703-648-6070 Fax 1-703-648-4227
USA 24	Dr. Paul Kilho Park Special Assistant to Chairman	Subcommittee on National Disaster Reduction, CEES, U.S. Government	1825 Connecticut Avenue N.W. (Room 625) Washington, DC 20235-0001 USA	Tel 1-202-606-4360 Fax 1-202-606-4355
The Netherlands 25	Dr. Niek Rengers Vice-Rector	International Institute for Aerospace Survey and Earth Sciences	350 Boulevard 1945 P. O. Box 6 7500 AA Enschede The Netherlands	Tel 31-53-874-213 Fax 31-53-874-200
France UNESCO 26	Dr. Michio Hashizume Programme Specialist	Division of Earth Sciences Science Sector, UNESCO	7, place de Fontenoy 75352 Paris 07 SP France	Tel 33-1-45-68-41-22 Fax 33-1-43-06-11-22
France CGMW 27	Dr. Philippe Bouysse Secretary General	Commission for the Geological Map of the World	77, rue Claude-Bernard 75005 Paris France	Tel 33-1-47-07-22-84 Fax 33-1-43-36-76-55
France GARS 28	Dr. Christian C. Weber Chairman	BRGM - French Geological Survey	B.P. 6009-45060 Orléans, Cedex 2 France	Tel 33-38.64.34.24 Fax 33-38.64.39.90
Japan 29	Prof. Shigeo Aramaki	Department of Geology and Mineralogy Hokkaido University	N10, W8, Kitaku, Sapporo 060 Japan	Tel 81-11-716-2111 ext. 2723 Fax 81-11-746-0396
Japan 30	Dr. Katuhiko Ishibashi	IISEE Building Research Institute	1, Tatehara, Tsukuba 305 Japan	Tel 81-298-64-2151 ext. 464 Fax 81-298-64-2989

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Japan 31	Dr. Norio Oyagi	Fukada Geological Institute	2-13-12, Honkogagome, Bunkyoku, Tokyo 113 Japan	Tel 81-3-3944-8010 Fax 81-3-3944-5404
Japan 32	Prof. Yoshiaki Kawata	Disaster Prevention Research Institute, Kyoto University	Goka-syo, Uji Kyoto 611 Japan	Tel 81-774-32-3111 Fax 81-774-31-8294
Japan 33	Dr. Jiro Komai	Earth Resources Satelite Data Analysis Center	3-12-1, Kachidoki, Chuoku, Tokyo 104 Japan	Tel 81-3-3533-9380 Fax 81-3-3533-9383
Japan 34	Prof. Shinjiro Mizutani	Department of Earth and Planetary Sciences, Nagoya University	Chikusaku, Nagoya 464-01 Japan	Tel 81-52-781-5111 Fax 81-52-782-7091
Japan 35	Dr. Yoshihiko Shimazaki	Nikko Exploration & Development Co., Ltd.	2-7-10 Tranomon, Minato-ku Tokyo 105 Japan	Tel 81-3-3503-7781 Fax 81-3-3508-9785
Japan 36	Dr. Takeo Sato Dupty Director-General	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3501 Fax 81-298-56-4989
Japan 37	Dr. Hirokazu Hase Director	International Geology Office Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3575 Fax 81-298-56-4989
Japan 38	Dr. Yoshihiro Kinugasa	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3688 Fax 81-298-52-3461
Japan 39	Dr. Hirokazu Kato	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-56-7783 Fax 81-298-56-4989
Japan 40	Dr. Ichiyo Isobe	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3686 Fax 81-298-56-4989

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Japan 41	Dr. Yasuo Kanazawa	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3576 Fax 81-298-56-4989
Japan 42	Dr. Shigeru Suto	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3659 Fax 81-298-56-8725
Japan 43	Dr. Harufumi Noro	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3643 Fax 81-298-56-4989
Japan 44	Dr. Haruo Yamazaki	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3696 Fax 81-298-52-3461
Japan 45	Dr. Eikichi Tsukuda	Geological Survey of Japan	Govt. Bldg No.2 4-1-67, Otemae, Chyo-ku Osaka 540 Japan	Tel 81-6-941-5377 Fax 81-6-941-5378
Japan 46	Dr. Koji Wakita	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-58-2472 Fax 81-298-56-4989
Japan 47	Dr. Yasushi Yamaguchi	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-58-2472 Fax 81-298-56-4989
Japan 48	Dr. Toshitaka Kamai	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3685 Fax 81-298-56-4989
Japan 49	Dr. Norio Matsumoto	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-54-3643 Fax 81-298-56-4989
Japan 50	Dr. Satoshi Tsuchida	Geological Survey of Japan	1-1-3, Higashi, Tsukuba 305 Japan	Tel 81-298-58-2472 Fax 81-298-56-4989

Tsukuba, Japan 93.06.24

Country	Name Position	Affiliation	Address	Tel Fax
Japan 51	Dr. Masanori Ozaki	AIST	3-1-1, Kasumigaseki Chiyoda-ku Tokyo 100 Japan	Tel 81-3-3501-6011 Fax 81-3-3580-8025

平成７年３月17日

平成７年３月24日

通商産業省工業技術院　地　質　調　査　所

〒305　茨城県つくば市東１丁目１－３

印刷者　溝手堅治

印刷所　アサヒビジネス株式会社

茨城県つくば市竹園２－11－６

地　調　報　告
Rept. Geol. Surv. Japan
No.281, 1994