

## **Interactive Presentation of Geological Hazard Maps Using Geohazardview**

Joel BANDIBAS, Koji WAKITA and Hirokazu KATO

Institute of Geoscience, National Institute of Advanced Industrial Science and Technology

(Received for 2 Apr. 2003 and in revised form 23 Jan. 2004)

### **ABSTRACT**

An interactive method for showing geological hazard maps and related information using GIS software was developed at the Geological Survey of Japan. The main purpose of this software is to readily provide information about geological hazards to a wide range of users. The region of interest is East Asia. The software provides a good alternative to viewing geological hazard maps and related information in paper format. It incorporates spatial and a-spatial data that interactively present the time, locations, and the areas affected by the occurrence of geological hazards as well as related information. Queries on particular hazard information such as the number of casualties, magnitude and location of earthquake epicenters, and names and locations of volcanoes that erupted in a particular year can be easily made. Simulations of such particular geological events as the spread of volcanic ash during major volcanic eruptions also can be easily shown. This new software is named GeoHazardView.

### **1. INTRODUCTION**

Increased vulnerability to natural disasters of developing countries is a major reason for concern (Kato and EANHMP, 2002). The potential loss of human lives and property due to natural hazards is very high in the urban areas of these countries (Munich Re., 2002). The study of geological hazards is very useful for mitigating such losses. Geological hazard maps generally are used to provide information about the occurrence of past geological hazards and future potential occurrences. They are used by planners and policy makers in establishing national and regional development plans in order to minimize potential waste of resources committed for development and loss of human life due to geological hazard events.

Information obtained from conventional geological hazard maps does not always provide sufficient data for users' needs. The difficulty in presenting more relevant information on geological hazard maps in conventional paper format is due to the limited available physical space of that format. Printing more information on such paper maps tends to confuse rather than provide more needed information to users. Furthermore, these kinds of maps provide little opportunity for users to ask for additional information, to determine the relationships between different kinds of information and important quantitative analyses. Furthermore, geological hazards have important temporal attributes. Presenting these attributes on the map; e.g. the sequence of volcanic eruptions in a region or the frequency of earthquakes in a particular area during a particular period of time is very difficult. To present these kinds of information very clearly requires the printing of a series of maps.

Conversion of such maps to digital format and the linking of the maps' information to related data in a GIS have many advan-

tages. Information given in digital map form is easily accessible to policy makers or users for decision making and such applications as education, research and exploration (Champati, 2000). Accessing information via mainstream GIS software, however, requires sufficient familiarity with the software and a good grasp of the spatial information and digital database structure concept. Most users would find it very difficult to use the system and retrieve the information needed. We offer a system for presenting geological hazard maps of East Asia in an easy and interactive way by means of new GIS software that was developed at the Geological Survey of Japan. Its main use is to present geological hazard information interactively and to manage and maintain a geological hazard database. Important information can be easily obtained using this software and simulations of important geological hazard phenomena shown on-screen. This software is called GeoHazardView.

### **2. GEOLOGICAL HAZARD DATABASE**

The geological hazard information used for the interactive geological hazard map was obtained from data generated from the Eastern Asia Natural Hazards Mapping Project (EANHMP) which was endorsed by the Coordinating Committee for Coastal and the Offshore Geoscience Program (CCOP) and implemented in 1994 by the Geological Survey of Japan, AIST. That project produced a Geological Hazard Map of Eastern Asia in 2002 (Kato and EANHMP, 2002). Other available sources of geological hazard information are the published works of Kato et al. (1994) and Kato and Shimazaki (1997). The database covers all of East and Southeast Asia and includes a geological map of those regions.

The volcanic hazard portion of the database includes all major volcanic eruptions from 0002 to 1997 AD. The volcanic database

consists of 260 records, representing the 260 major volcanoes in the region. Each record contains the volcano's name, its geographic location (latitude and longitude), height above sea level (m), eruption characteristics, as well as the presence or absence of craters or a snow cap, and a topographic caldera depression. The record also includes the name of the country or region, nearest town or city, dates of major eruptions, number of casualties in each eruption, and a picture and satellite image of the volcano. Future versions of the database will include maps of areas affected by volcanic eruptions, volcanic hazard risk level maps, and volcanic eruption video clips.

The earthquake hazard portion of the database includes major earthquakes that occurred in the region from 780 BC to 1999 AD. It is made up of 1,125 records, each of which contains the location name (starting with the country or region name), geographic location (latitude and longitude), dates of earthquake occurrences, numbers of casualties, focal depth (km), magnitude at the epicenter, and whether the phenomena were associated with tsunamis. Future versions of the database will include some pictures and video clips.

For the tsunami and landslide database, more information regarding these geological hazard types has still to be gathered. The database in the current CD-ROM version contains only vector data showing areas prone to tsunami and landslides in East and Southeast Asia.

The geological hazard database will undergo continuous updating. GeoHazardView software can be used for such updating, but the update feature of this software will not be activated in

the CD-ROM to be distributed. Renewal and updating of the database will take place at the Geological Survey of Japan in order to synchronize the changes to the database in the CD-ROM. Later CD-ROM versions will include the updated version of the database. Data compilers from all countries in the region will submit new geological hazard information to the Geological Survey of Japan for inclusion in the geological hazard database. The CD-ROM will be made available to interested individuals or organizations at minimal cost (mainly cost of shipment).

### 3. GEOHAZARDVIEW SOFTWARE

This software was written with Microsoft Visual C++ programming language at the Geological Survey of Japan. Its main purpose is to inform users about geological hazards. It is designed to be very user friendly and is operated in a straightforward "point and click" operation. Even those who do not have technical knowledge of geology can easily use this software. It also can be used to manage and maintain the GIS-based geological hazard information database.

The types of geological hazard handled by the software are volcanic, earthquake, tsunami, and landslide hazards. Fig. 1 gives the general flowchart for the GeoHazardView software. It shows the major components of the software and the different decision nodes and possible software courses of actions depending on the decision path chosen by the user. The software has unique database formats for its spatial and a-spatial information. These can be converted to other formats compatible with the mainstream GIS

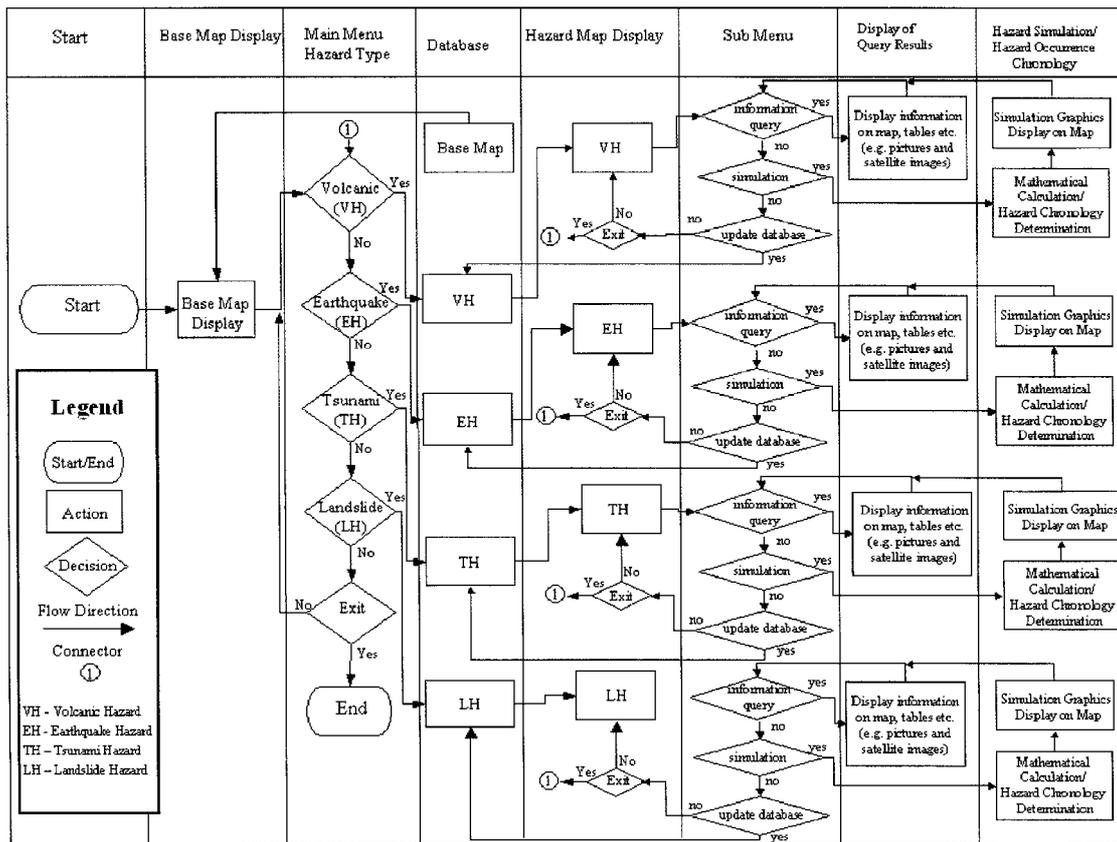


Fig. 1 Flowchart for GeoHazardView software.

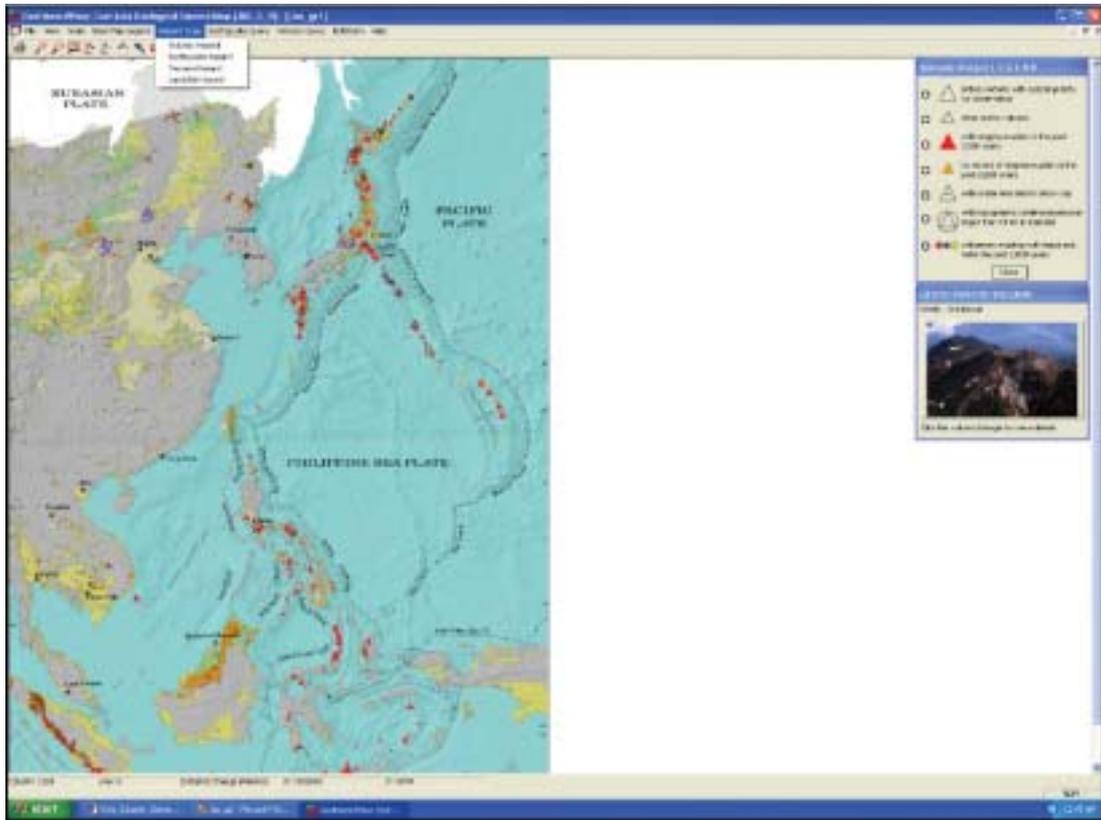


Fig. 2 GeoHazardView in volcanic hazard mode.

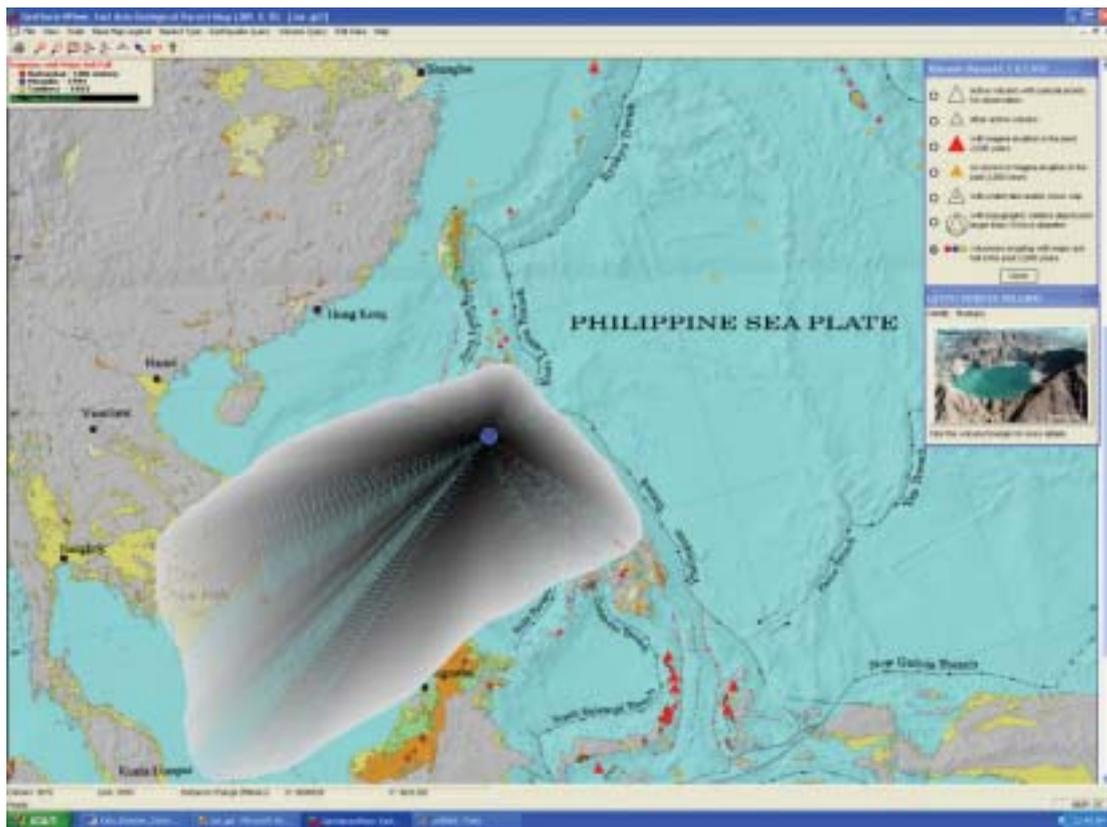


Fig. 3 Simulation of ash distribution from the 1991 Mount Pinatubo eruption.



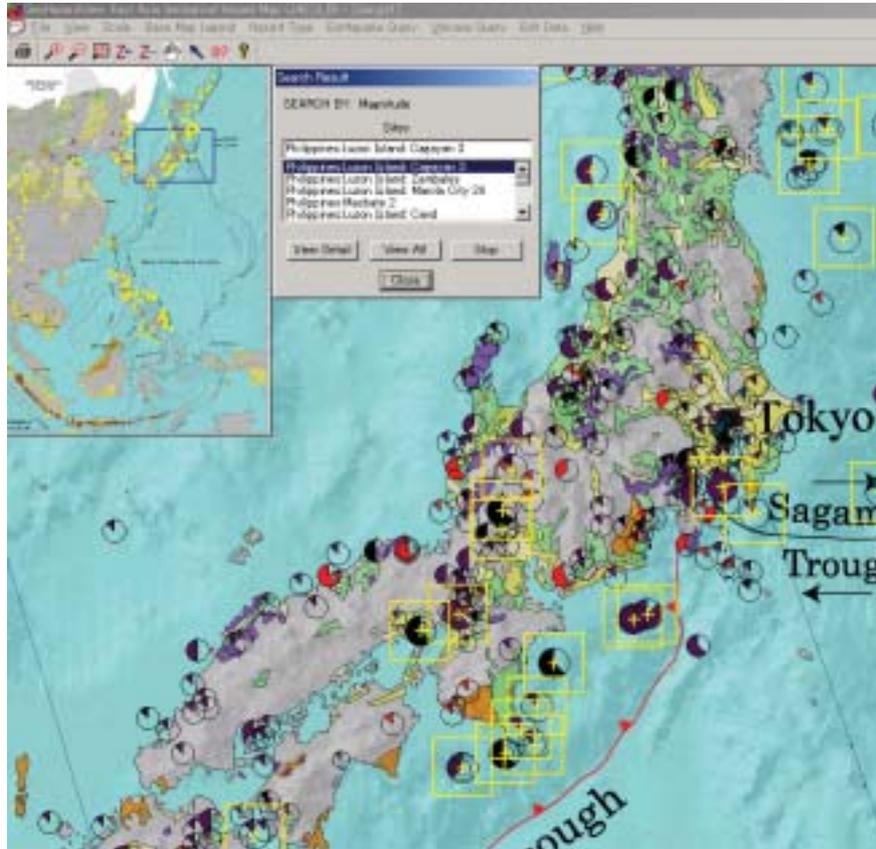


Fig. 6 Query results about earthquakes of magnitudes greater than 7.

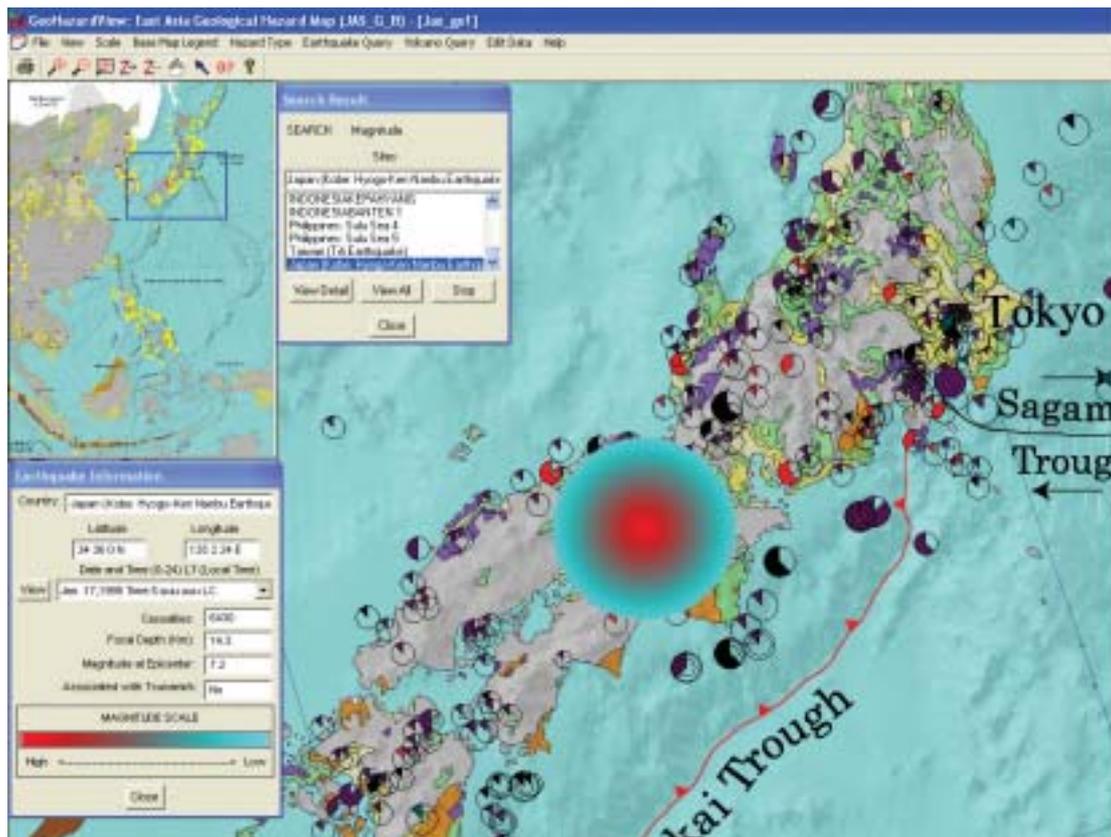


Fig. 7 Query results about the Kobe earthquake of Jan. 17, 1995.

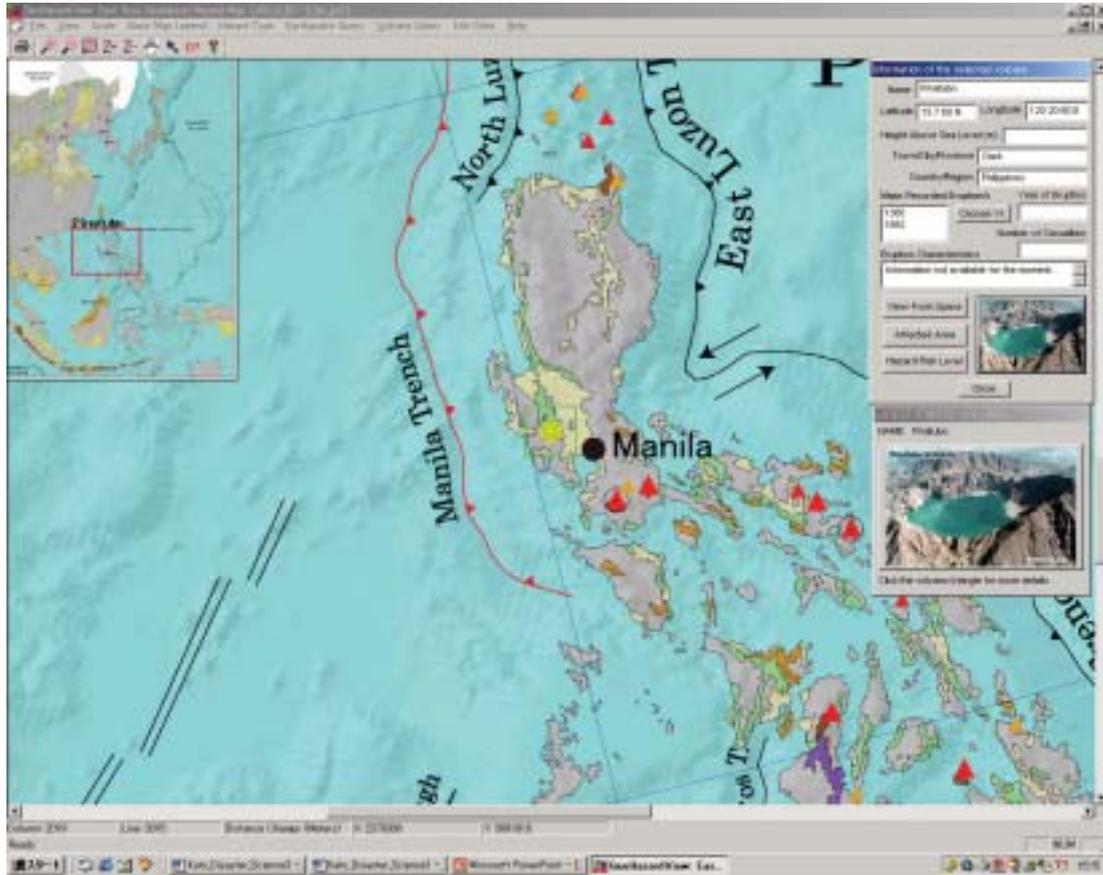


Fig. 8 Query results about information on Mount Pinatubo volcano.

from the source is assumed to be directly related to the farthest point at which ash fall in a particular direction was observed. The quantity of ash in the air also is assumed to decrease with distance from the source. The simulation uses an expanding polygon, the color of which ranges from black, at the volcano site, to light gray at the most distant deposition from the volcano. The simulation shows the relative speed of ash movement from its volcanic origin to the surrounding areas and the relative amount of ash, starting from high (black) at the volcano site to low (light gray) with distance as the ash cloud moves away from the origin. The picture of a volcano also can be displayed by pointing the mouse at the volcano's location on the map. Double clicking the location results in the display of information about the volcano including an enlarge picture and a satellite image. Fig. 4 shows the earthquake hazard map and its interactive legend. Clicking one of the radio buttons on the legend highlights the earthquake epicenters represented by the symbols seen in the legend. More detailed information about an earthquake also can be obtained by directly double clicking the earthquake symbol shown on the map.

### 3.2 Information Queries

Queries about particular hazard information such as the number of casualties, earthquake magnitude, the location of earthquake epicenters, and names and locations of volcanoes that erupted in a particular year can easily be made. Different search methods choices can be found on the menu bar. Search parameters can be defined by using the search dialog boxes to extract the information

needed from the database. Fig. 5 shows examples of search dialog boxes. Fig. 5a shows the search for earthquake epicenters of magnitudes greater than 7.00. Fig. 5b shows the search for a volcano through the use of volcano name search dialog box. Results of the query in Fig. 5a are displayed on the map and tables, as shown in Fig. 6. Selecting an item on the table will show further detailed information about a particular geological event such as the one shown in Fig. 7. That figure shows the epicenter of the Kobe earthquake of January 17, 1995. Information about the earthquake, including the magnitude scale, is shown in the dialog box. The scale shown by the software gives magnitudes from high at the epicenter to low as distance from the epicenter increases. It is a graphical display that highlights the location of the earthquake on the map.

Additional information also can be obtained by directly double clicking on the symbol given on the map or in the map's legend. Fig. 8 shows the results of double clicking the Mount Pinatubo volcano site on the map. Information about the volcano is displayed in the dialog box on the right of the screen. Clicking the "View From Space" button on the dialog box displays the satellite image of the volcano (Fig. 9). Queries using the date the hazard occurred also can be made using the software. The locations of the hazards that occurred for a chosen date will be highlighted.

### 3.3 Hazard Occurrence Chronology Show

One of the most important features of the GeoHazardView

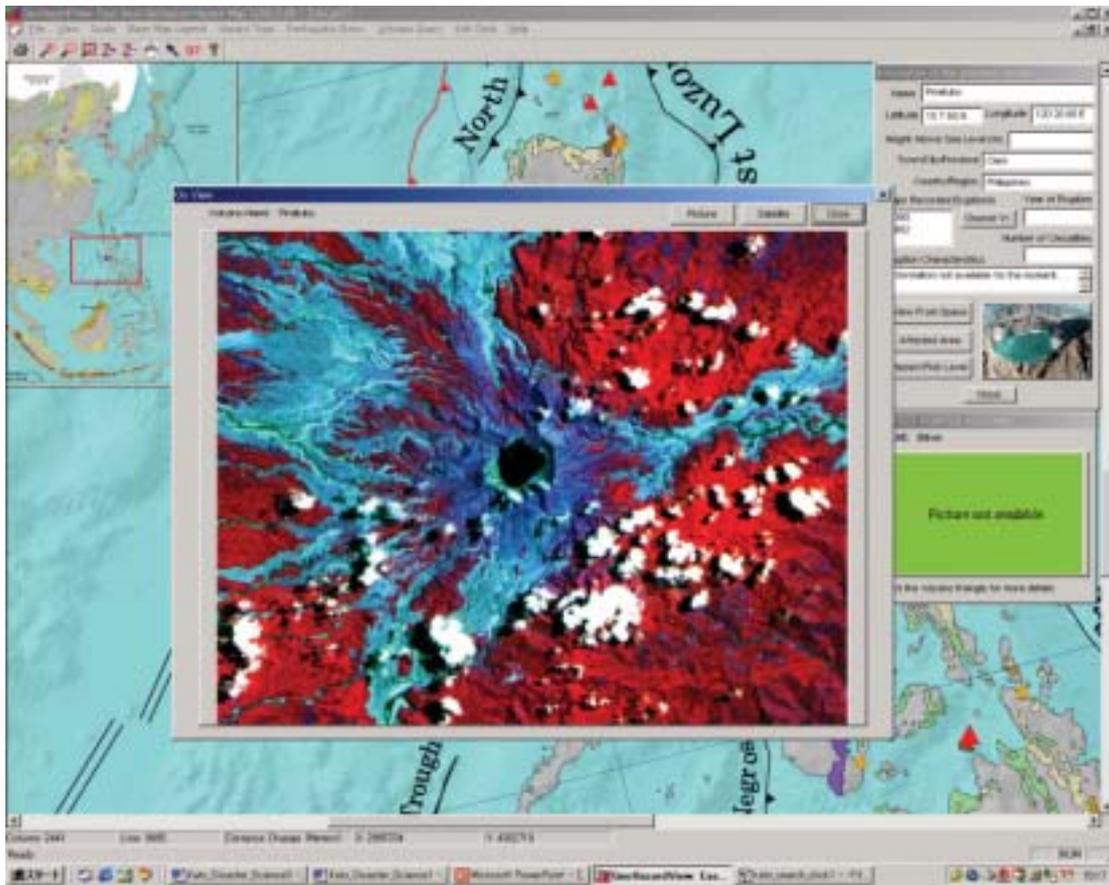


Fig. 9 Query results about the satellite image of Mount Pinatubo volcano.

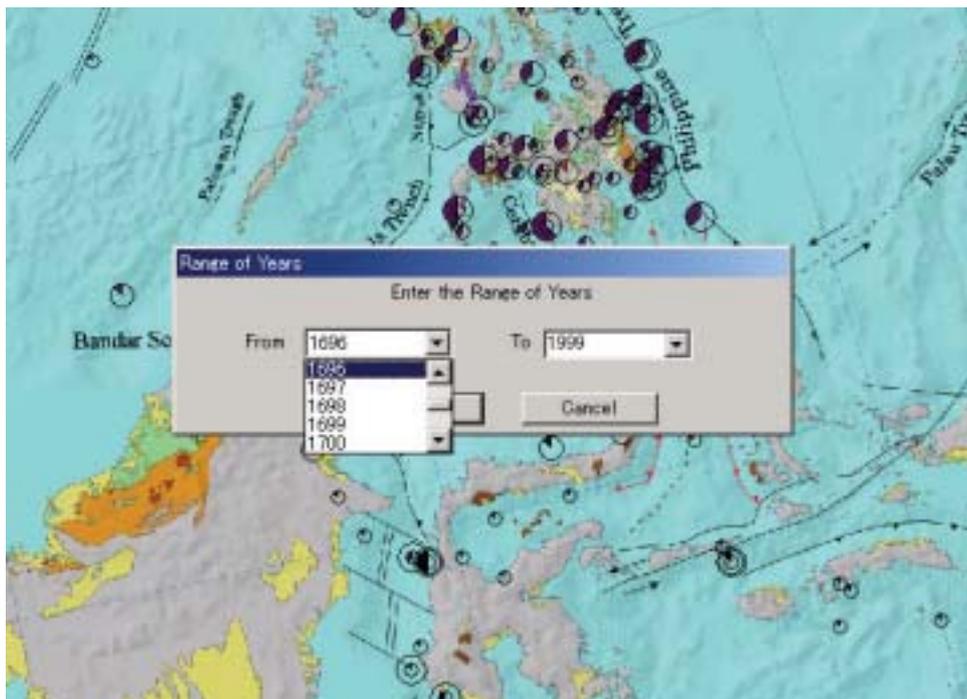
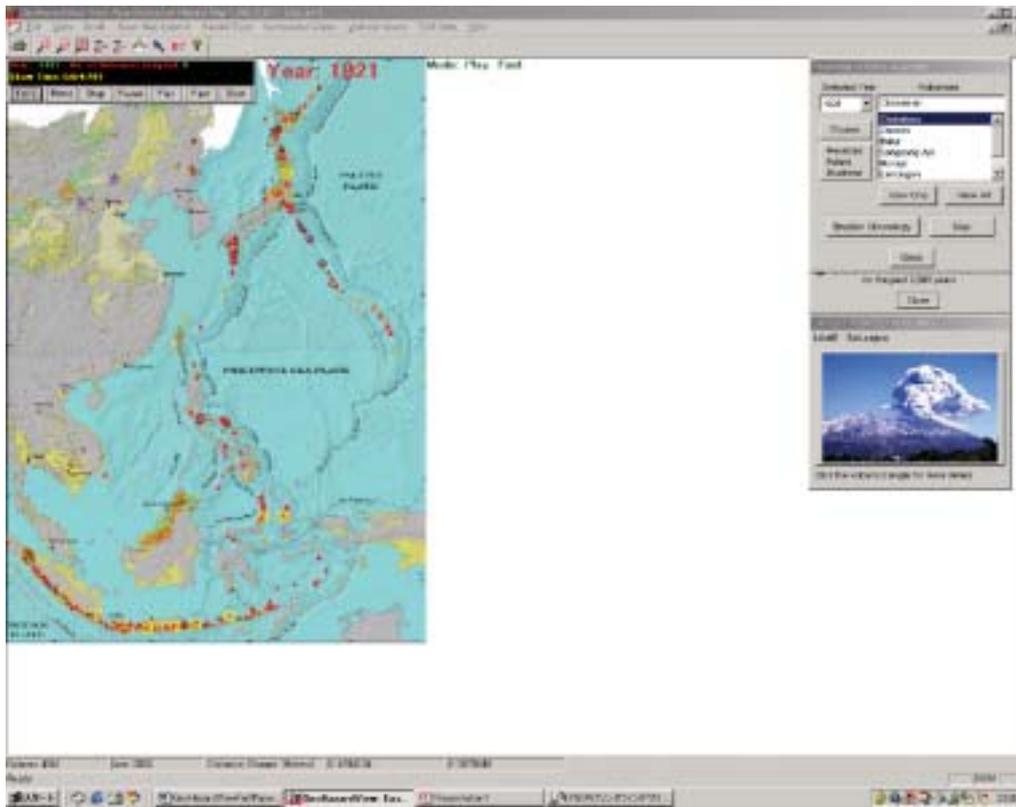
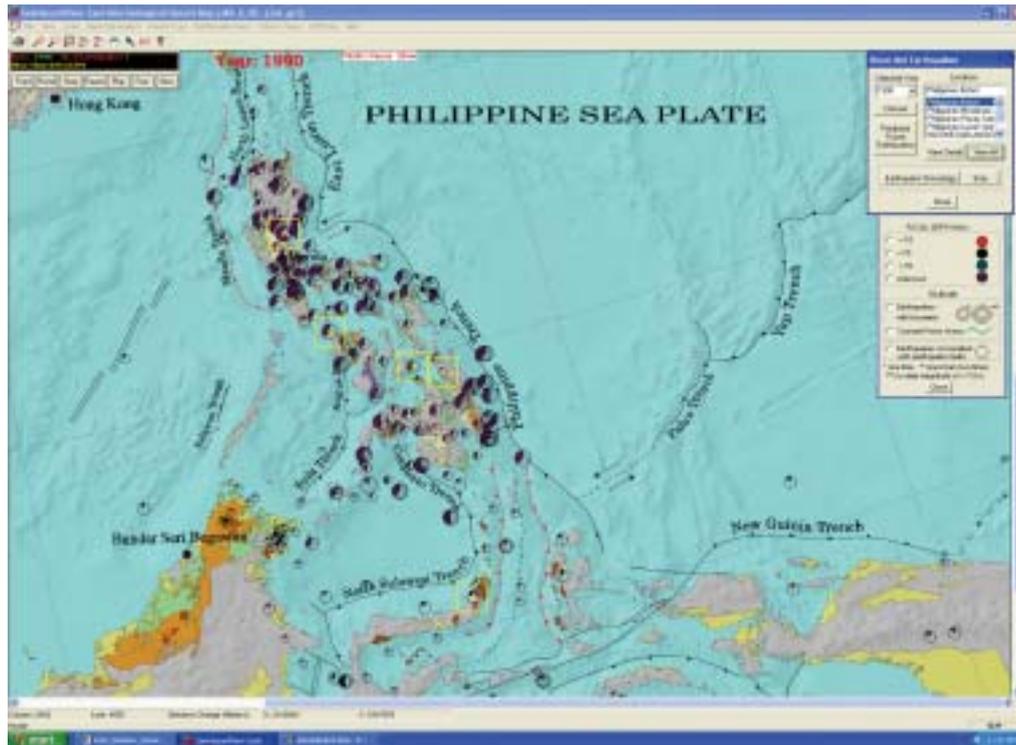


Fig. 10 Setting the range of years for the geological hazard chronology show.



a)



b)

Fig. 11 Geological hazard occurrence chronology highlighting the locations of volcanoes that erupted in 1821 (a) and those of earthquake epicenters in 1990 (b).

software is its ability to show geological hazard occurrence chronology in a spatial context. The show displays locations of past hazard occurrences for a chosen range of years. It involves the continuous increment of years from the earliest to the latest. The change in year also will show changes in information displayed on the map that correspond to new hazard events that occurred during that year. The speed of the year increment during the show can be adjusted. Fig. 10 shows the dialog box for choosing a range of years for the show. Fig. 11 shows the examples of the show. Fig. 11a displays highlighted locations of volcanoes that erupted in the year 1821. The list box on the right of the screen gives the names of the volcanoes highlighted on the map. Detailed information about a particular volcano on the list can be viewed readily by choosing the volcano's name in the list box. Fig. 11b shows the highlighted locations of earthquake epicenters in the year 1990. The list of highlighted epicenter locations is shown in the list box on the right of the screen. Detailed information about any earthquake in the list can be viewed by choosing its location name in the list box.

#### 4. SUMMARY

Interactive presentation of the geological hazard map for Eastern Asia using GeoHazardView software provides a good alternative to viewing geological hazard maps and related information in paper form. The ease with which geological hazard infor-

mation is obtained and the ability of the system to present information in spatial context makes this software very useful to a wide range of users. It provides an important source of information for land use planners and policy makers, as well as good teaching material for use in elementary and high school science classes. The software will be continuously improved by adding important features to future versions.

#### 5. REFERENCES

- Champati, R.P.K., 2000. GIS in Geoscience. GIS Development. *Online resource: <http://www.gisdevelopment.net/magazine/gisdev/2000/may/gisg.shtml>*.
- Kato, H. and Eastern Asia Natural Hazard Mapping Project, 2002. Explanatory Note of East Asia Geological Hazards Map, Geological Survey of Japan, AIST.
- Kato, H., Y. Kinugasa, E. Tsukuda and K. Wakita, 1994. Natural Hazards Mapping – International Forum. Report No. 281, Geological Survey of Japan, AIST, 176pp.
- Kato, H. and Y. Shimazaki, 1997. An Approach to Natural Hazards Mapping in Eastern Asia, Eastern Asia Geological Hazard Mapping Project and Geological Survey of Japan, AIST, 76pp.
- Munich Reinsurance Company, 2000. Topics 2000. Natural Catastrophes: The Current Position. Special Millennium Issue, Munich Re Group, Munich, 126pp.