On the Possibility of a Seamless World Geological Map Based on the Global Map and Operated in GIS

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1. INTRODUCTION

To contribute to the Earth Summit Agenda 21 in 1992, a program on global maps was proposed for the group of global geographic data sets of known and verified quality with consistent specifications. The Global Map Group is a common asset of mankind to distribute maps world-wide at marginal cost with scientific quality under an international collaborative initiative. National Mapping Organizations of 84 countries and regions participated in Global Mapping Project as of May 2001. The initial outcome of the Global Map has released on November 2000 for five countries from the web site http://www.iscgm.org/ and some other countries followed in addition.

Figure 1. Current participating countries in Global Mapping Program (Akiyama, 2001)

2. THREE PHASES OF SEAMLESS GEOLOGICAL MAPS

Seamless digital maps give you several advantages, such as allowing you to browse geological data over countries to know where you have to prepare detailed investigations and allowing you to identify target areas for detailed assessments.

There should be some classes or categorical ranks of the meaning of a seamless geological map. Perfect seamless maps are well compiled with well standardized and correlated geological units and boundaries as well as all symbols like faults and folds—we can not really expect to meet this standard at this time though we have tried in various ways to do so (Sato, et al., 2000, for instance).

In practice, what we can call seamless maps might be maps with some seamless attributes of map factors like the scale, the resolution and the borders at the edge. We have to make the scale matched among maps. Geological Surveys and related organizations are publishing various scale of maps, most of which have been printed on paper sheets. You can scan them to store in digital form and to open through the internet by any Geological Survey or organization. The problem is to adjust real scales and resolutions of image maps by scanning in order to fit to the appropriate scale and size of data under the appropriate projection of maps. You have to modify not only the scale and size but also methods of projection. Usually colors, symbols, and boundary lines of polygonal geological distributions in various units and groups can not be concordant to create the perfect seamless geology among different source of maps from different countries.

We have three phases to create seamless maps. We define the first phase as the PRIMARY SEAMLESS that sets the scale, the resolution, and the area fitting of borders of maps under the same projection method. Locations in maps can be correlated together so that you can integrate any thematic and other categorized maps in the same scale, resolution, and projection. If you modify the projection orthogonal (longitude and latitude), this provides a better way to pass the maps of the same scale and resolution to any other projection. Scanned raster images are necessary to integrate the primary seamless maps. Every difference between images can be omitted except for the projection, the scale, and the resolution which are needed to provide seamless locations in maps. This phase can be partly operated in GIS within a quadrangle map based on the compiled seamless map in smaller scale. We consider this phase useful to visualize all maps stored in the different countries in libraries or in hidden map cases as well as to have the maps in digital form to prevent the natural loss of paper maps.

Next, we convert the primary seamless maps to the ADVANCED SEAMLESS phase that we define as products of adjusting other essential factors such as geological colors, lines or border lines, polygonal patterns, and categorical symbols at points, lines and polygons. Vectorized map data are necessary to provide the seamless adjustments of units by unit concordance. The COMPILED SEAMLESS phase can be defined as the standardization of all the factors of map information as well as the associated database within a seamless map. These phases of seamless maps can be operated in a GIS.

The three phases can be summarized as follows.

Phase 1: Primary seamless geological maps
- seamless among map boundaries
- identical scale, resolution, and projection methods
- in raster-base

Phase 2: Advanced seamless geological maps
- can be overlapped on the primary seamless maps
- seamless among geological boundaries
- identical colors, lines, polygons, and symbols
- in vector-base

Phase 3: Compiled seamless geological maps
- seamless for all geological categories
- identical factors of whole maps

3. EXAMPLES OF SEAMLESS GEOLOGICAL MAPS OPERATED IN GIS

In the Geological Survey of Japan, we are testing the operation of seamless geological maps in the vectorized advanced seamless phase at a million and at a two hundred thousand scale together with the primary seamless phase at two hundred thousand and fifty thousand scales. Two hundred thousand scale geological maps cover most of the Japanese land area, so that the first index page shows the area at this scale(Fig.2).

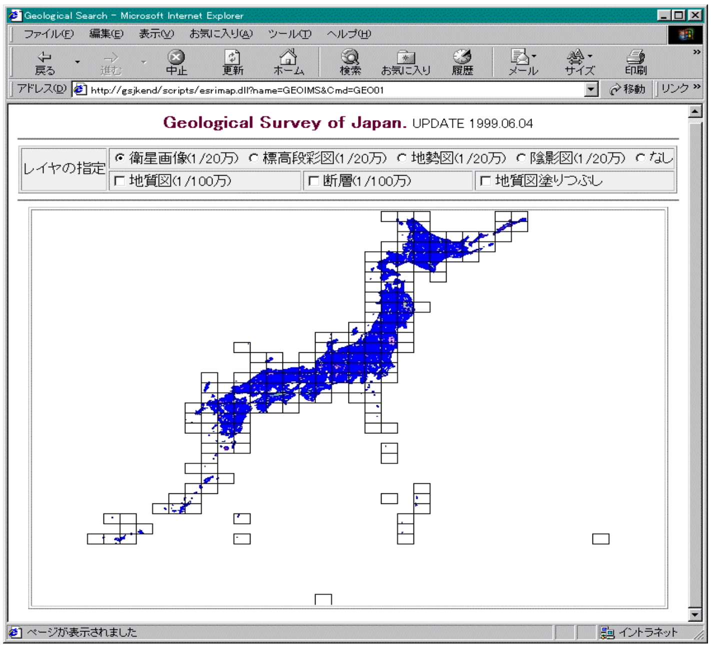

Figure 2 The first page of map server database. Users can choose the area of quadrangle map at two hundred thousand scale.

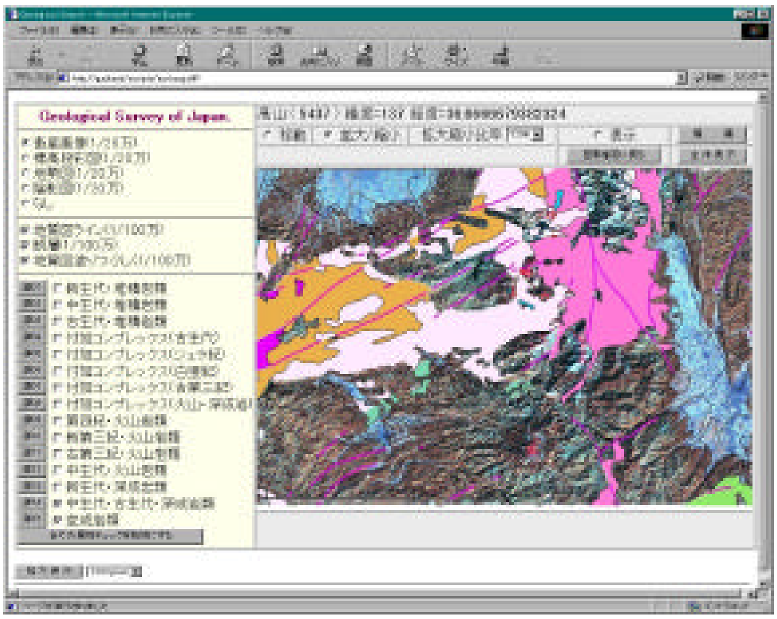

Figure 3 An example to show the selected geological map on infrared satellite image in an intranet system. Users can choose geological categories in the GIS map server.

The database in the intranet holds a compiled seamless geological map of Japan at a million scale and in vector format, seamless digital elevation data of all Japanese land area in a 50 meter mesh, and seamless infrared images from satellite sensors of LANDSAT-TM, JERS, MOS, ADEOS-1, and EOS(TERRA)-ASTER in mosaic and in 25 and 50 meter ground resolution(Kouda and Murakami, 2001). All these can be expressed in the form of advanced seamless or in compiled seamless maps. The intranet database system also covers geological maps at two hundred thousand scale in raster and vector formats for the primary seamless step - we have not yet finished adjusting geological categories as well as boundaries of each geological unit at this scale over Japan (Fig.3).

The Geological Survey of Japan together with CCOP countries is working to provide the compiled seamless geological maps with various information operated in GIS in East and Southeast Asia at two million scale(Sato, et al., 2000).

The region of the western Pacific rim countries is covered by 6 sheets of compiled seamless geological maps (Fig.4). At this small scale of two million we can avoid some local differences by ignoring details or integrating categories, so that leading geologists can decide geological factors such as symbols and colors through the compilation process (Fig.5). Users can treat and add any data of their own such as resources, for instance, to the sheets in GIS in Lambert Azimuthal Equal-area Projection Method.

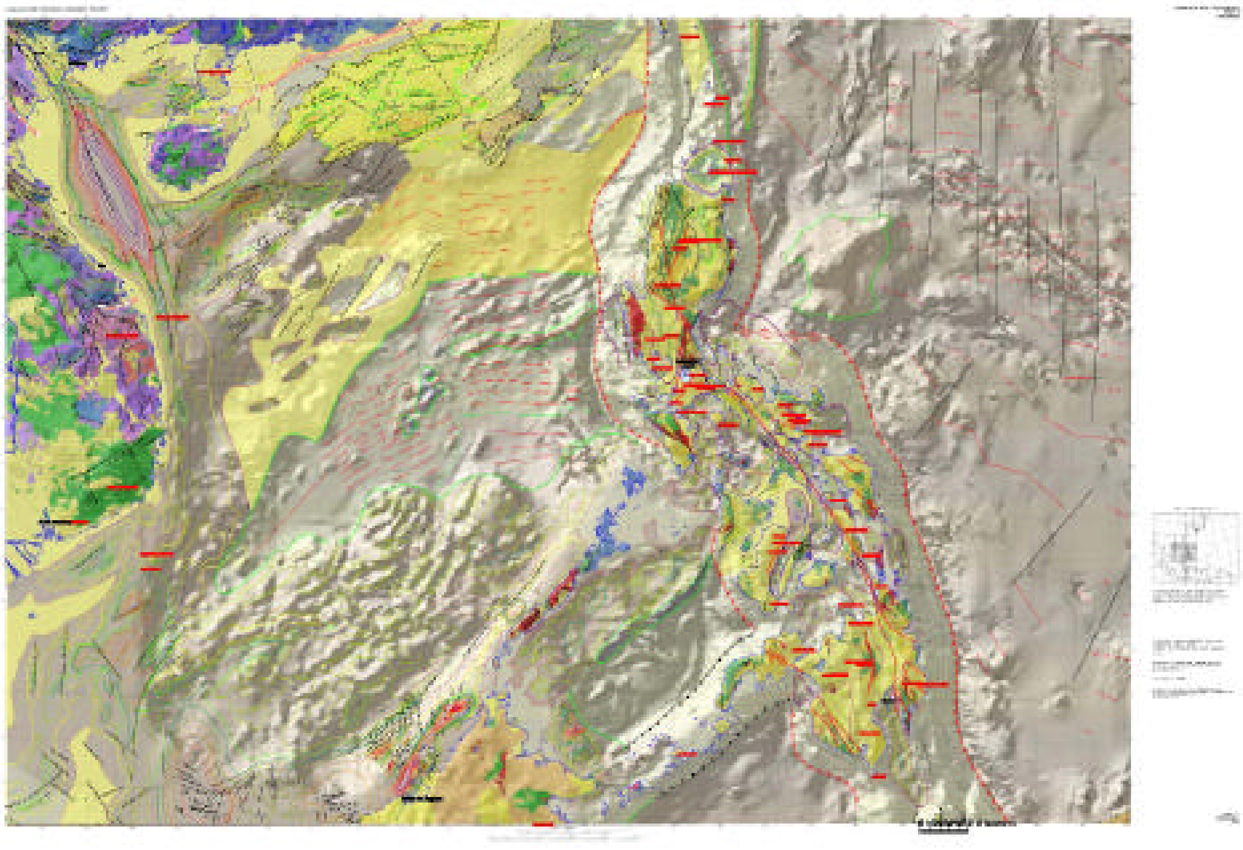

Figure 4 Compiled Map Sheet 4 including China, Philippine, Vietnam, Malaysia, and Indonesia at two million scale geological map in general overview. Volcanoes are expressed by names in red. (Sato, et al., 2000)

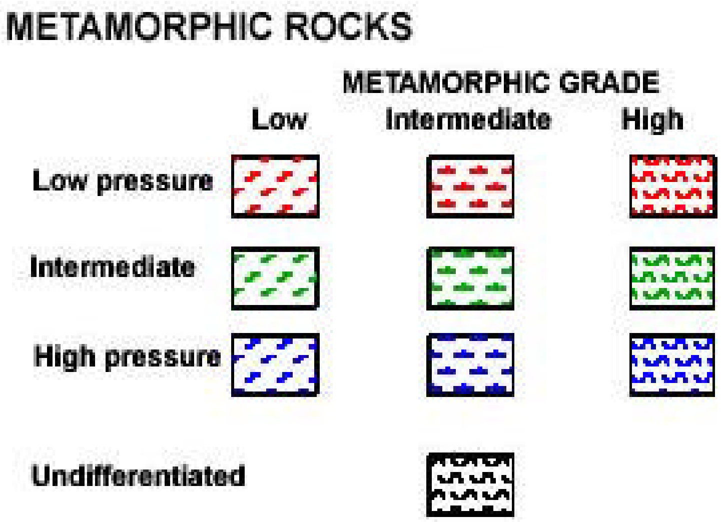

Figure 5 An example of rock legend with symbols and colors(Sato, et al., 2000).

The problem will occur when you expand the scale from two million to larger. There are many published geological maps at larger scale in this region, but they provided the data at different scales with different projections using various standards of symbols that are discordant with each together. Topographic and geographic maps have not yet been completely produced in this region. A possible way to introduce seamless geological maps at a larger scale in this region is to scan known maps from each organization and exchange these with modified but identical methods of projection, scale, and resolution in a raster basis. This indicates the necessity to install an international framework to exchange raster data of geological maps in this region.

4. ON THE POSSIBILITY OF A SEAMLESS WORLD GEOLOGICAL MAPS

In order to acquire the same framework for the world geological maps at a scale of larger than a million, it is necessary to install a similar scheme of international collaborations and steps or phases. Prior to geological maps, the data sets of Global Map have been released at a million scale adapted to the newer system of world coordinates such as ITRF(97). If we adopt the Global Map products to overlie geological maps in a raster basis with appropriately transformed coordinates, we will take hold of the first step of world seamless geological maps in raster basis with identical scale, resolution, and projection, but without other categories of maps. More detailed local maps can be obtained by making vectorized data with well-correlated standardization of colors, boundary and other lines, polygons, and symbols. Compiled geological maps at a smaller scale may assist the standardization of map factors.

REFRENCES

Akiyama, M.: Promotion of Global Mapping project. 7th United Nations Reginal Cartographic Conference for the Americas, Jan.22-26, 2001.

Kouda, R. and Murakami, Y: Precisely projected infrared satellite data over all Japanese Islands. Geological Survey of Japan Interim report IF/01/1, 2001.

Sato, T. , Okumura, K., and WG for Compilation Geotectonic Map: Geotectonic Map of East and Southeast Asia: Sheets 4,5, and 6-First Product of th CCOP-CPCEMR Geotectonic Map Project-. Corordinating Committee for Coastal and Offshore Geoscience Programmes i Eas and Southeast Asia(CCOP), CCOP Technical Bulletin Volume 27, published by Geological Survey of Japan, 2000.