Development of Browsing System for Two- and Three-Dimensional Geological Data

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ABSTRACT

Geological data play an important role in disaster assessment, environmental preservation, and underground utilization. In particular, stratigraphic columns are quite useful to understand subsurface conditions. The purpose of this study is to make stratigraphic columns in an urban area accessible to the public on the Web. For the purposes of this study, we developed a browsing system for two- and three-dimensional geological data: stratigraphic columns, a two-dimensional geological map, and a three-dimensional geological model. The stratigraphic columns include borehole data and outcrop data in the northern part of the Boso Peninsula, Japan. The two-dimensional geological map and three-dimensional geological model have been constructed based on the stratigraphic columns. The browsing system consists of free and open source software programs. In conclusion, the developed system will contribute to better environments for promoting utilization of geological data. Future works are to collect more stratigraphic columns and to construct a reliable three-dimensional geological model.

1. INTRODUCTION

Geological data are essential for understanding subsurface geological conditions. In Japan, many studies have been made on stratigraphy in urban areas by the national government, research institutes, and local governments. In general, in the stratigraphic research, many stratigraphic columns such as borehole data and outcrop data are obtained by drilling survey and field survey. However, most of these data have been archived not as digital data but as paper-based data. In addition, some outcrop data do not have numerical information of geospatial coordinates. This becomes a big obstacle not only to accurate correlation of stratigraphic columns between multiple areas but also to application of archived data to other analyses based on computer processing.

The purpose of this study is to create an environment suitable for promoting utilization of geological data. For this purpose, we need to archive the geological data as a form suitable for easy use and to make them accessible to the public on the Web. In this study, as the first step to achieve our purpose, we have collected stratigraphic columns in the Boso area, Japan. Further, we have developed a browsing system for two-dimensional (2D) and three-dimensional (3D) geological data using Free and Open Source Software for Geoinformatics / Geospatial (FOSS4G). This paper reports the developed browsing system focusing on currently accessible data.

2. THE STUDY AREA

The study area is the northern part of the Boso Peninsula, Japan (Figure 1). The area covers a range of lat. 35°19′48.8′′ to 35°54′04.7′′ and long. 139°47′20.5′′ to 140°43′10.4′′. These coordinates are based on the International Terrestrial Reference Frame (ITRF). This area has about 5,300 sq. km (84km × 63km) with altitudes of -3m - 184m, and is underlain by the Middle to Upper Pleistocene and the Holocene, coastal to fluvial sediments.

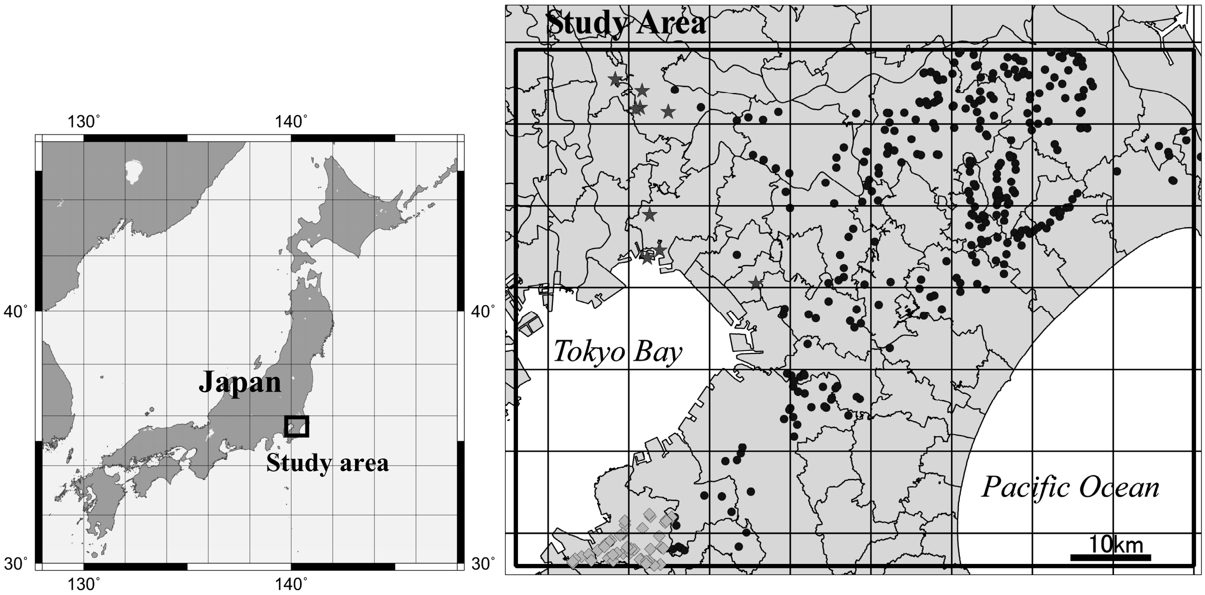

Figure 1. The study area. In right figure, star symbols show locations of borehole data. Circle and diamond symbols show locations of outcrop data.

3. ACCESSIBLE DATA

3.1 Stratigraphic columns

Two kinds of stratigraphic columns are accessible. One is borehole data obtained by drilling survey. Another is outcrop data published as paper-based reports (Nakazato, 1993; Sato, 1993; Komatsubara *et al.*, 2004). We have used nine borehole data and 351 outcrop data for constructing 3D model. Figure 1 (right) shows locations of borehole data and outcrop data.

3.2 Geological model

In this study, we have constructed a 3D geological model of study area and made these data accessible on the Web. The 3D geological model is an integrated model of a terrain classification map and a subsurface geological model. The terrain classification map consists of 19 categories such as beach ridge, natural levee, and terrace, etc. It has been generated based on several kinds of geospatial data: Digital Elevation Models (DEMs), topographic maps, land condition maps, aerial photos, and geological maps. The subsurface model consists of eight geological units. It has been constructed based on collected stratigraphic columns: borehole data and outcrop data. Here we applied an algorithm proposed in Shiono *et al.* (1998) to construct the subsurface geological model. Figure 2 shows a data flow diagram of constructing the 3D geological model.

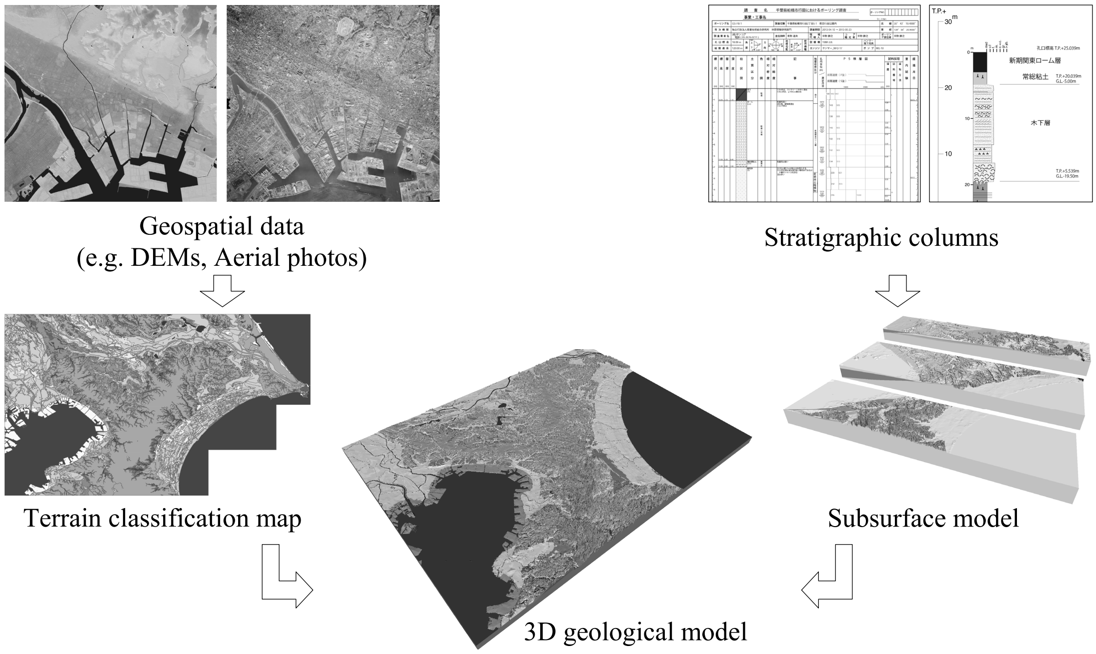

Figure 2. Data flow diagram of constructing 3D geological model.

4. BROWSING SYSTEM FOR 2D and 3D GEOLOGICAL DATA

4.1 System configuration

The browsing system works on LINUX OS environment. It has been implemented by integrating Web server, Web mapping client, and relational database management system. Table 1 shows software configuration of the browsing system. All of the software can be downloaded via the Internet.

Table 1. Software configuration.

Software		Download Site
Operating System	CentOS	http://www.centos.org/
Web Sever	Apache	http://apache.org/
Mapping Client	OpenLayers	http://openlayers.org/
Data Base	PostgreSQL	http://postgresql.org/
Spatial DB Extension	PostGIS	http://www.postgis.org/
Tool / Library	GDAL / OGR	http://gdal.org/
Other Software	PHP	http://php.net/
	Python	https://www.python.org/

4.2 Functions of the system

The developed system provides functions that enable us to browse stratigraphic columns, to search for borehole data, to browse a 3D geological model, and to generate geological cross sections. All operations can be done through the Web browser such as Internet Explorer or Mozilla Fire Fox. The detail of the functions is described below.

(1) Browse of stratigraphic columns

Users can display locations of borehole data and outcrop data on a background map by selecting a layer name from the list of overlay layers. Attribute information of each data is accessible by clicking a marker of the data on the map. Attribute information contains URLs for digital files of stratigraphic columns. Borehole data are provided in XML format and PDF format. The former includes both numerical information and text information of borehole data. The latter includes a column image. These files are compliant with the specifications of borehole data by Japan Construction Information Center (JACIC). Outcrop data provided in PDF format include a column image and geophysical data such as P and S wave velocity and density. Figure 3 shows an example of browsing stratigraphic columns.

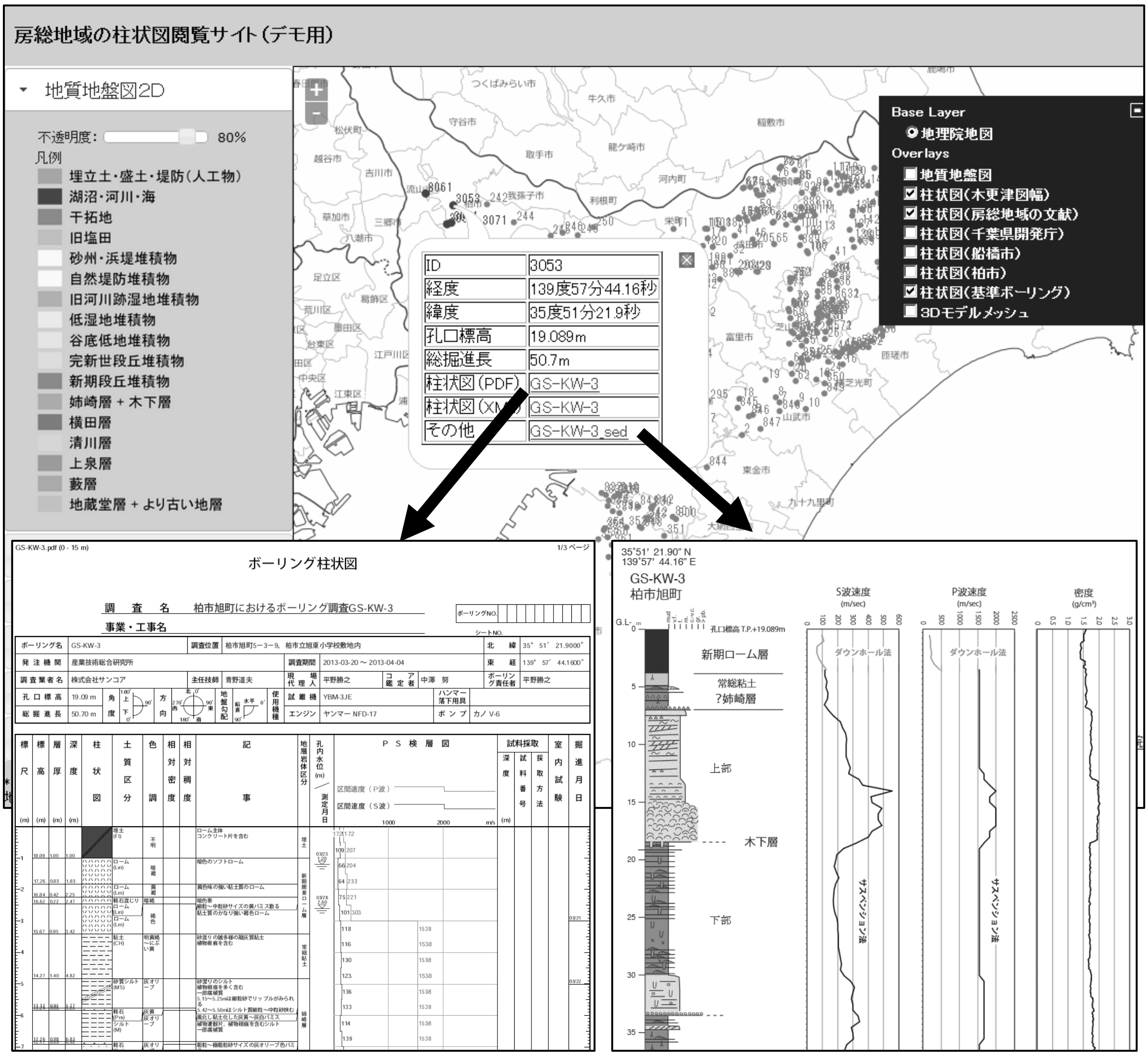

Figure 3. Example of browsing stratigraphic columns.

提供元	経度	緯度	孔口標高	総掘進長	リンク
(独)産業技術総合研究所	140度07分02.9660秒	35度38分35.4800秒	27.37	120	XML PDF1 PDF2
(独)産業技術総合研究所	139度58分20.9000秒	35度43分10.4000秒	18.09	124.15	XML PDF1 PDF2
(独)産業技術総合研究所	139度57分14.0000秒	35度50分8.9000秒	25.38	120	XML PDF1 PDF2
(独)産業技術総合研究所	139度57分44.1600秒	35度51分21.9000秒	19.09	50.7	XML PDF1 PDF2
(独)産業技術総合研究所	139度55分31.8100秒	35度52分8.0500秒	16.86	60.9	XML PDF1 PDF2
(独)産業技術総合研究所	139度59分53.2100秒	35度49分57.5600秒	21.69	60	XML PDF1 PDF2

Figure 4. Example of searching database for borehole data by keywords.

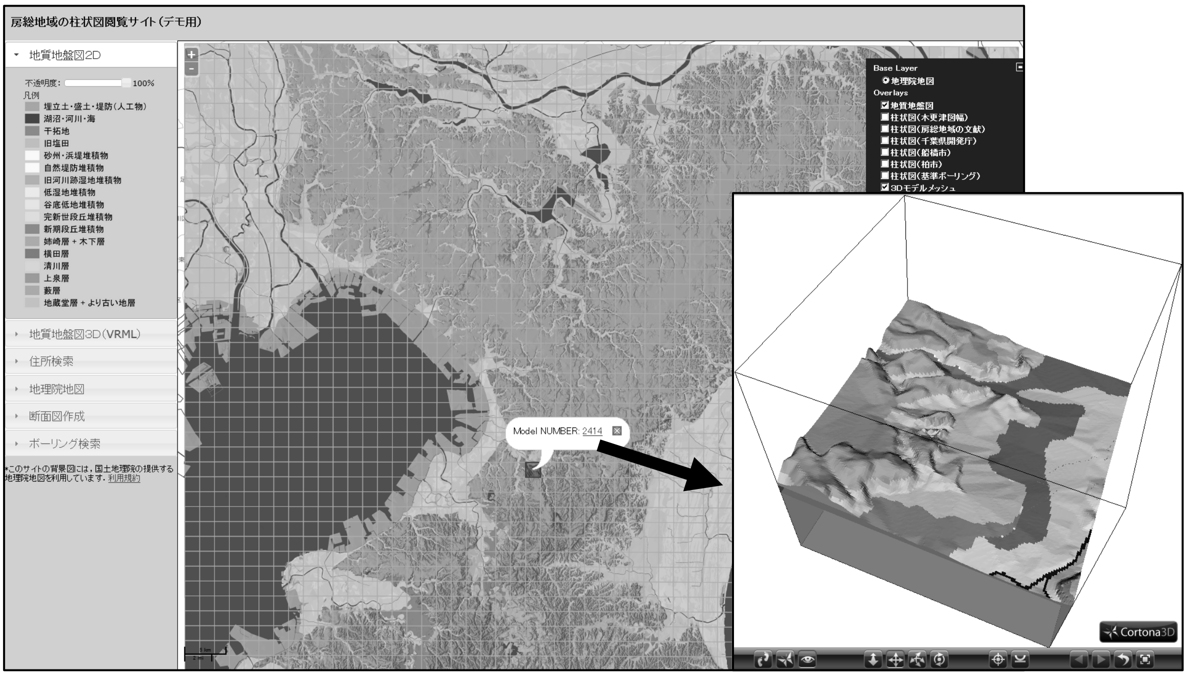

Figure 5. Example of browsing 3D geological model in 2D and 3D.

(2) Search for borehole data

Users can search the PostgreSQL / PostGIS database for borehole data by keywords. At this moment, available keywords are geospatial coordinates (search range), an elevation level, and a total drilled depth. A search range can be specified by dragging the mouse over the map screen. Figure 4 shows an example of searching the database for borehole data by keywords.

(3) Browse of the 3D geological model

The 3D geological model is provided as 2D and 3D views. In the case of a 2D view, the geological model is provided as a geological map. Users can display a geological map by selecting a layer name in the same manner as stratigraphic columns. In the case of a 3D view, the geological model is provided as a set of Virtual Reality Modeling Language (VRML) models. The constructed 3D geological model is evenly divided into 56 × 42 parts. Each part has a range of 1.5 km square by 100m deep. Users can display each VRML model by selecting a grid cell displayed on the map screen. For browsing 3D models, users need to install VRML browser or plug-in tool on their PC. Figure 5 shows an example of browsing the 3D geological model.

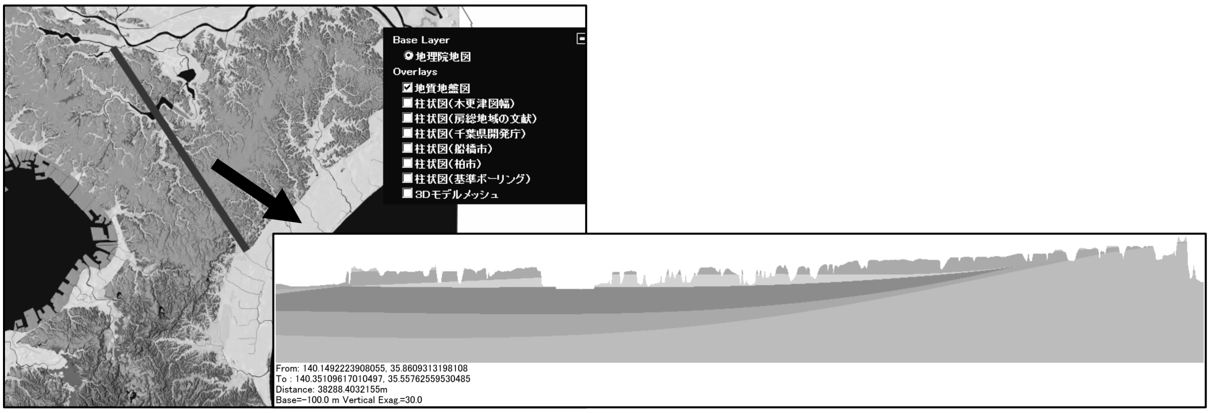

Figure 6. Example of generating a geological cross section.

(4) Generation of geological cross sections

Users can generate a geological cross section of the 3D geological model by specifying a starting point, an ending point, a base height, and an exaggeration rate with respect to height. The starting / ending points can be specified by clicking the points on the map screen. Figure 6 shows an example of generating a geological cross section.

5. CONCLUSIONS

In this study, we developed a browsing system for 2D and 3D geological data. This will contribute to a better environment for promoting utilization of stratigraphic columns. Future works of this study are to increase quantity of stratigraphic columns and to enhance the quality of the 3D geological model. In addition, we should expand the types of accessible geological data.

6. ACKNOWLEDGEMENT

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