# Web Sharing of Three-Dimensional Geological Data using Open Source Software

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## ABSTRACT

*Geological data play an important role in understanding subsurface conditions which are related to natural disasters. Recently, a web sharing of geological data has received increasing attention. However, few studies have been made on web sharing techniques of three-dimensional geological data. In this study, we have developed a web sharing system of four types of geological data: borehole logs, geological map, geological cross-section, and surface-based three-dimensional geological model.*

## 1. INTRODUCTION

Recently, prevention and mitigation of natural disasters are growing concern among the general public in Japan. For the prevention and mitigation of natural disasters, we need not only to accumulate geological information useful for understanding subsurface conditions but also to improve an environment for Web sharing of geological information.

As for Web sharing of geological information, in Japan, two-dimensional (2D) digital geological maps with various scales are downloadable on the Web for free. Some of these maps are conformed with the Open Geospatial Consortium (OGC) standards like Web Map Service (WMS) and Web Map Tile Service (WMTS). In urban areas which are often underlain by the Quaternary costal and fluvial deposits, borehole logs created for public construction works and/or stratigraphic studies have been accumulated by national institutes and local governments, and some logs are open to the general public on the Web. In addition, some geological cross-sections in Metropolitan areas are also open to the public. However, there are few Web sharing services of three-dimensional (3D) geological data like 3D geological model which gives easy-to-understand visualization of geological structure.

In order to improve geological literary of the general public, which is quite important in prevention and mitigation of natural disasters, it is necessary to create an environment capable to share many types of geological data. Nonogaki et al. (2014) developed a Web sharing system of geological data including borehole logs, 2D geological map, geological cross-section, and 3D geological map. However, this system still has many technical problems. In this study, we enhanced some functions of this system, in particular, ones for plotting locations of borehole logs, for generating geological cross-section, and for visualizing 3D geological model. In this paper, we describe a summary of the new system, focusing on the enhanced functions.

## 2. AVAILABLE DATA

Geological data available in the new system are (1) borehole logs, (2) 3D geological model, (3) 2D geological map, and (4) geological cross-section. In this chapter, summary of each data is described.

### 2.1 Borehole logs

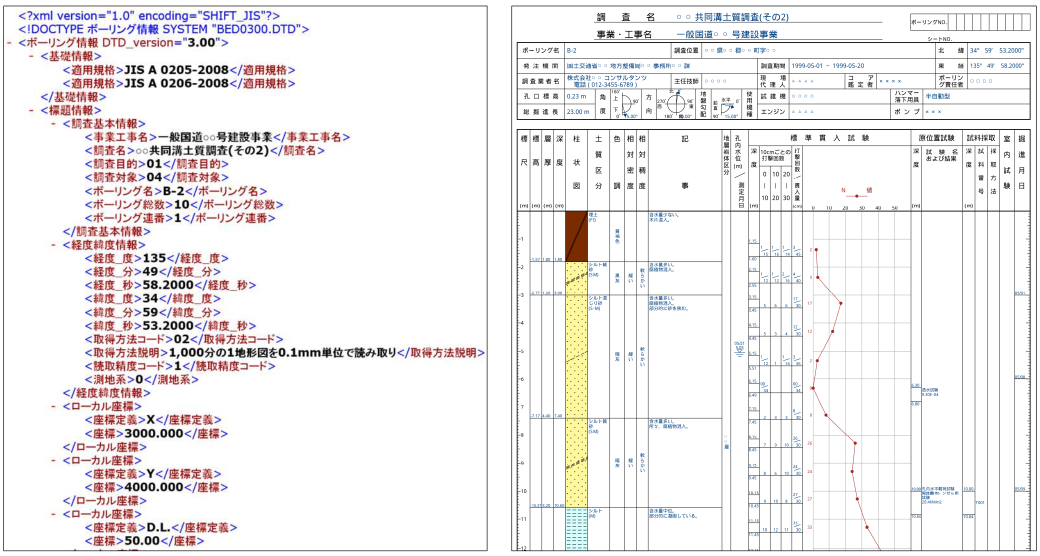
Borehole logs used in our study are the ones created for public construction works and/or stratigraphic studies. These logs are stored in XML and PDF format according to the specifications of the Japan Construction Information Center. This XML format can contain many kinds of geological information such as lithofacies, color, density, water content, PS velocity, standard penetration test result. Figure 1 shows an example of XML and PDF.

### 2.2 3D geological model

3D geological model is a surface-based one which consists of two elements: the logical model of geological structure (Shiono et al., 1998) and the Digital Elevation Models (DEMs) of geological boundary surfaces and geomorphic surface. The DEMs of geological boundary surfaces are generated on the basis of the results of stratigraphic correlation of borehole logs by using spline fitting technique (Nonogaki et al., 2012).

### 2.3 2D geological map

2D geological map is generated from 3D geological model by using GRASS GIS (Masumoto et al., 2004). Though the original 2D geological map is a single file which has same spatial resolution as 3D geological model, for web mapping, the map is divided into some small PNG images (tile images).



Data source: https://www.cals-ed.go.jp/

**Figure 1 Example of borehole log: (Left) XML, (right) PDF.**

### 2.4 Geological cross-section

2D geological cross section is generated from 3D geological model. Its spatial resolution depends on that of 3D geological model.

## 3. WEB SHARING SYSTEM

The Web sharing system in this study is implemented based on the one by Nonogaki et al. (2014). Therefore, in this chapter, we just describe software configuration of the new system and enhanced functions.

### 3.1 Software configuration

The new system is constituted of Free and Open Source Software for Geoinformatics / Geospatial (Table 1), and has almost same functions as those of the previous one. The biggest difference from the previous system is adoption of Leaflet as a mapping client. All functions are available through common Web browsers such as Internet Explorer or Mozilla Fire Fox.

### 3.2 Enhanced functions

#### *3.2.1 Function for plotting locations of borehole logs*

In the previous system, a simple GeoJSON was used for plotting locations of borehole logs. However, a plotting process with GeoJSON cannot secure high rendering speed when there is a huge number of borehole logs. To solve this problem, we adopted the binary vector tile technique using Leaflet.MapboxVectorTile which is a plugin for Leaflet, and realized much higher rendering speed than previous. Figure 2 shows an example of plotting about 10,000 locations using the binary vector tile on Web map with zoom level 13 and 15. In the figure, Open Street Map is used for background map.

#### *3.2.2 Function for generating geological cross-section*

A geological cross-section generated from the previous system was a simple PNG image without a scale for elevation and distance. Thus, users cannot easily understand the scale of geological structure drawn in the output image. In our study, we adopted PDF for file format of output image. In this case, we can easily add textual and graphical information such as meta

**Table 1. Software list.**

| Software | | Download Website |
|---|---|---|
| Operating System | CentOS | http://www.centos.org/ |
| Mapping Client | Leaflet | http://apache.org/ |
| Database | PostgreSQL | http://www.postgresql.jp/ |
| Tool/Library | GDAL/OGR | http://gdal.org/ |

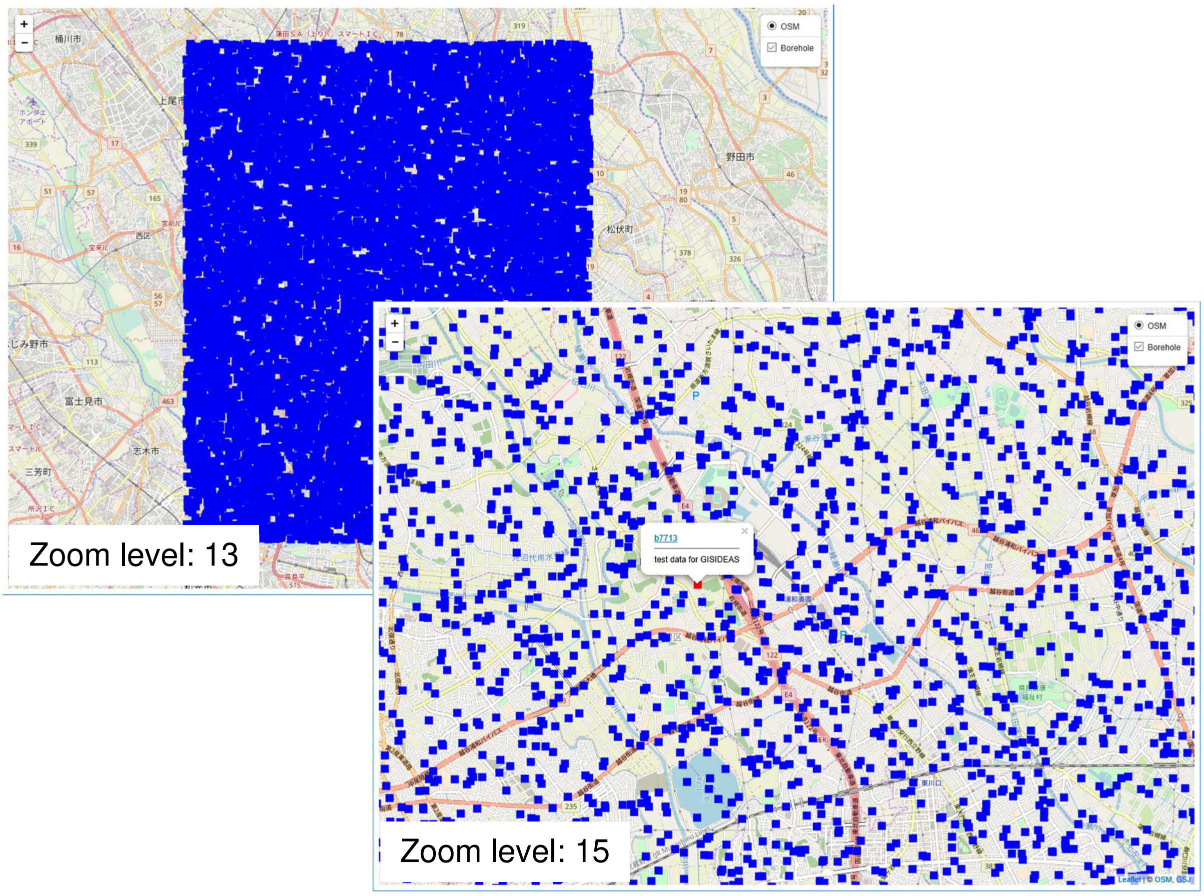



**Figure2. Example of plotting locations of borehole logs.**

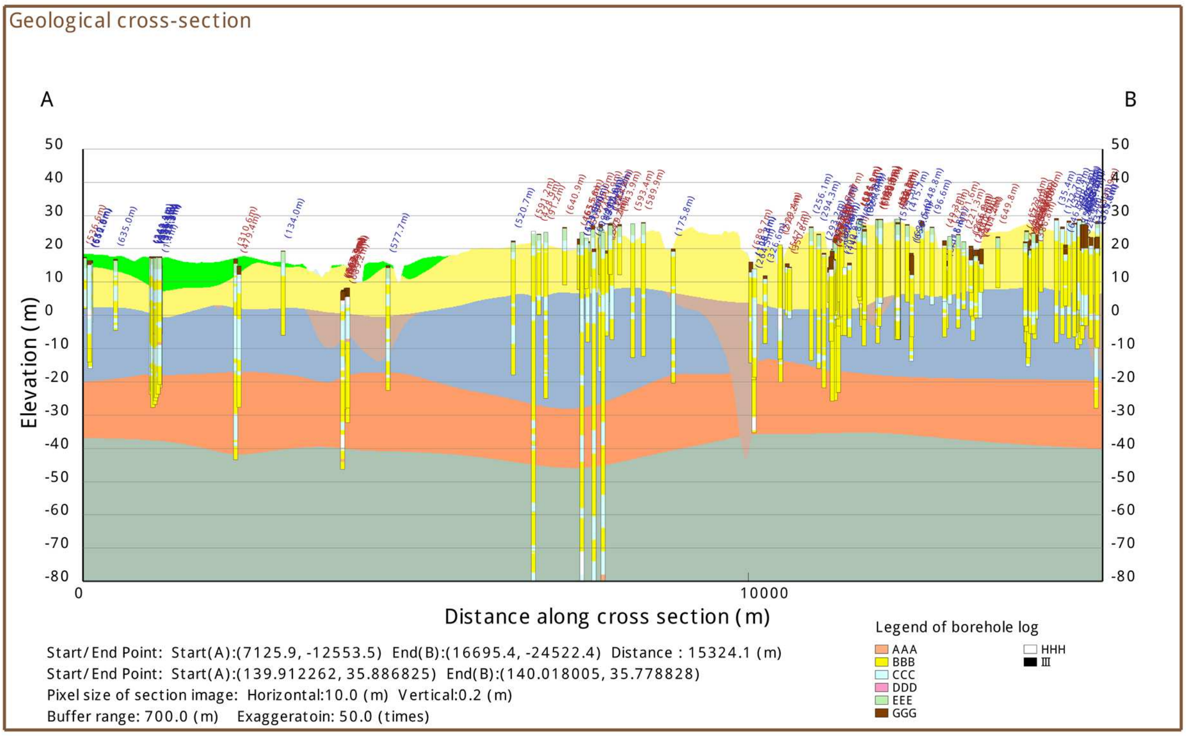



**Figure 3. Example of generation of geological cross-section.**

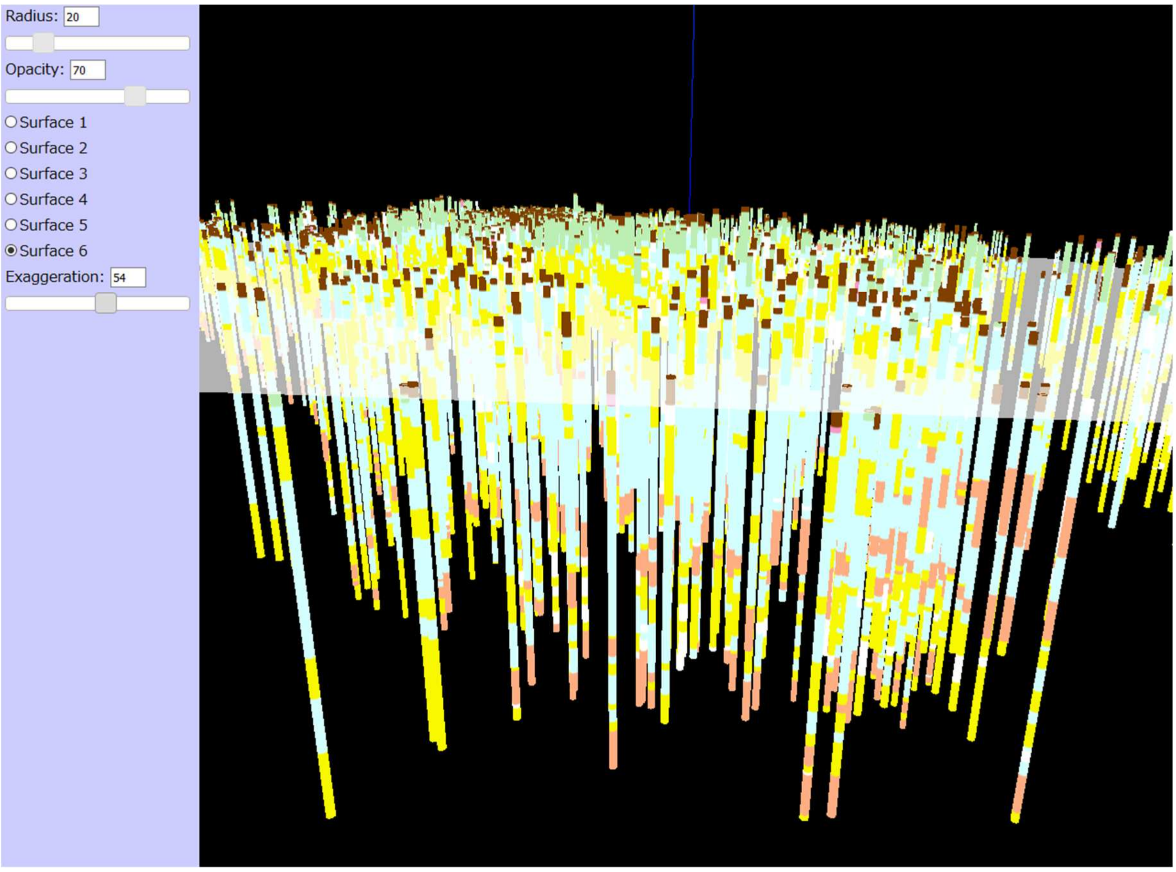



**Figure 4. Example of visualizing 3D geological model with WebGL.**

information of the cross-section and a scale of geological structure. In addition, we can draw other geological objects on the cross-section like borehole logs existing in the geographical neighborhood of user-specified line. Figure 3 shows an example of generating a geological cross-section.

### *3.2.3 Function for visualizing 3D geological model*

A 3D geological model was stored in Virtual Reality Model Language (VRML) in the previous system. However, to display 3D graphics in the VRML on Web browser, users need to install a plugin to their computer. In addition, usage of most plugins for VRML is too difficult for a beginner. To improve this situation, we adopt WebGL technique into visualizing 3D geological model. Figure 4 shows an example of visualizing 3D geological model with WebGL. This implementation dramatically improves an operability of browsing 3D model.

## 4. CONCLUSIONS

In this study, we enhanced some functions of Web sharing system of geological data, in particular, ones for plotting locations of borehole logs, for generating geological cross-section, and for visualizing 3D geological model. These implementations must contribute to utilization of geological data, to improvement of geological literacy among the general public, and to better prevention/mitigation of natural disaster.

For practical use of this system, there are many challenges to overcome. For example, we have to increase available types of geological data, to improve a processing speed for generating a geological cross-section and for rendering 3D geological model, and to develop functions which can support smartphones and tablet devices.

## ACKNOLEDGEMENTS

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