Available online at *gisws.media.osaka-cu.ac.jp/gisideas16/*

GIS-IDEAS 2016

International Conference on GeoInformatics for Spatial-Infrastructure Development in Earth & Allied Sciences (GIS-IDEAS)

Utilization of Elevation and Borehole Data of Hanoi City, Vietnam -Construction of 3D Geological Model-

Go YONEZAWA[a,*], Susumu NONOGAKI[b], Muneki MITAMURA[a], Kenichi SAKURAI[c], Luan Xuan TRUONG[d], Shinji MASUMOTO[a], Tatsuya NEMOTO[a] and Venkatesh RAGHAVAN[a]

[a]*Osaka City University,*
3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, JAPAN
[b] *National Institute of Advanced Industrial Science and Technology (AIST)*
Central 7, 1-1-1 Higashi, Tsukuba, Ibaraki 305-8567, JAPAN
[c]*Osaka Information and Computer Science College,*
6-8-4 Uehonmachi Tennouji-ku Osaka 543-0001, JAPAN
[d]*Hanoi University of Mining and Geology,*
Dong Ngac, Tu Liem, Hanoi, VIETNAM

Abstract

In Hanoi city, the capital of Vietnam, the environmental problems (land subsidence, flood, groundwater pollution and so on) have been increasing in recent years. The main reason is rapid urbanization and water control. The urbanization of Hanoi city has a relationship with the geological urban transformation as a landfill historically. In this study, we collected the elevation data and borehole data through Hanoi University of Mining and Geology. We can show the efficient utilization of such data using 3D Geological Model.

Keywords: DEM; Borehole Data; 3D Geological Model

1. Introduction

In Southeast Asian area, the environmental problems such as land subsidence, flooding occurs by heavy rain, traffic problem and groundwater pollution have been increasing in recent years. This main reason is rapid urbanization and population increase. Regarding the mitigation and prevention of the environmental issues of urban area, it is important to prepare and analyze with the geological information. For the solution of these issues, it is necessary to provide the geological information accurately and effectively. The 3D (three-dimensional) geological model is an important geological information generated as a result of geological analysis based on the fundamental field survey data and the knowledge of the geologist. The method of 3D geological modeling based on the logical model of geologic structure has been developed by Masumoto et al.

* Corresponding author. Tel.: +81-6-6605-3392.
E-mail address: yonezawa@media.osaka-cu.ac.jp.

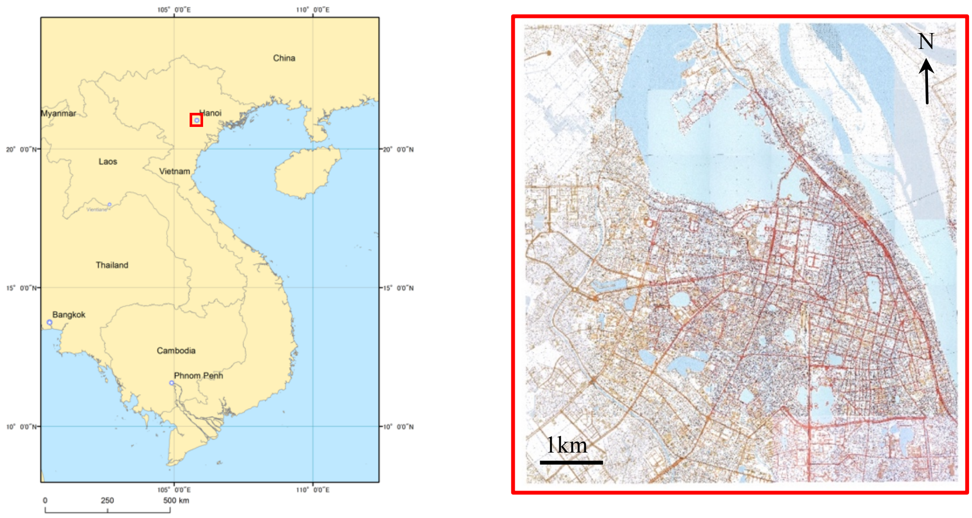

Fig. 1. Research area of Hanoi city, Vietnam.

(1997) and Shiono et al. (1998), and its actual visualization 3D geological modeling has been proposed by Masumoto et al. (2004) using GRASS GIS and Yonezawa et al. (2004) using Visual Basic program Geomodel2000.

In this study, we collected the elevation data and borehole data with Hanoi University of Mining and Geology. Firstly, we generate the DEM (Digital Elevation Model) using the elevation data. DEM is a digital representation of ground surface topography and the most important element of topographic analysis. Secondly, we analyzed the borehole data for the well construction of Hanoi city. Finally, we constructed the 3D geological model of Hanoi city and visualized it using GRASS GIS.

2. Research Area and Geology

In Hanoi city, the capital of Vietnam, the environmental problems (land subsidence, flood, groundwater pollution and so on) have been increasing in recent years. The main reason is rapid urbanization and water control. The urbanization of Hanoi city has a relationship with the geological urban transformation as a landfill historically. Research area is the center part of Hanoi city, Vietnam (Fig.1). The area covers a range of lat. 21° 00′ 00″ to 21° 04′ 22.5″ and long. 105° 47′ 30″ to 105° 51′ 52.5″ . These coordinates are based on the VN2000. Hanoi City included in this area is located on Red River Delta. The geology of Red River Delta is shown by Tran et al. (1991) and Haruyama (2004). This area is underlain by the Holocene, the Pleistocene and the Pliocene sedimentary rocks. The Holocene rocks are divided into the Thai Binh Formation and the Hai Hung Formation. The Pleistocene rocks are divided into the Vinh Phuc Formation, the Hanoi Formation and the Lechi Formation. The Pliocene rocks is the Vinh Bao Formation.

3. Elevation and Borehole data of Hanoi city

Forty-nine maps of an elevation survey points were collected through Hanoi University of Mining and Geology. The scale is 1:2,000. Right image of Fig.1 shows the whole area, being a composite of the 49 maps. The research area is 7km x 7km, and the number of survey points is 16,745. We generated a DEM based on the elevation of survey (Yonezawa, 2009). The surface estimation method, we call it BS-Horizon is developed by Nonogaki et al. (2008). The very subtle elevation gaps are significantly recognizable on it.

One hundred-sixty borehole data of Hanoi city was collected and each borehole data is a non-core drill data for the well construction. The distribution map of collected borehole data is shown in Fig.2 (a). Red line is our collected data area with 500 m interval mesh. Fig.2 (b) shows an example of borehole data. We picked up some information from the borehole data. The well name and drilling point can be found from ① of Fig.2 (b). The drilling point was described as the EPSG Geodetic Parameter Dataset (28418, Datum; Pulkovo 1942, Projection; Gauss-Kruger zone 18). Each thickness and lithofacies can be found from ② and ③ of Fig.2 (b). However, the description of lithofacies were not standardized. The description of lithofacies of Vietnamese borehole data were not standardized as shown in Fig.2 (b). Therefore we unified the geological description by Japanese standard, JASIC (Japan Construction Information Center Foundation) description. The collected 160 borehole data was classified 30 types of descriptions as shown in Table 1. The classified data is inputted using the data acquisition module. We can compare the geological model of the Red river delta showed by Tran et al. (1991) and

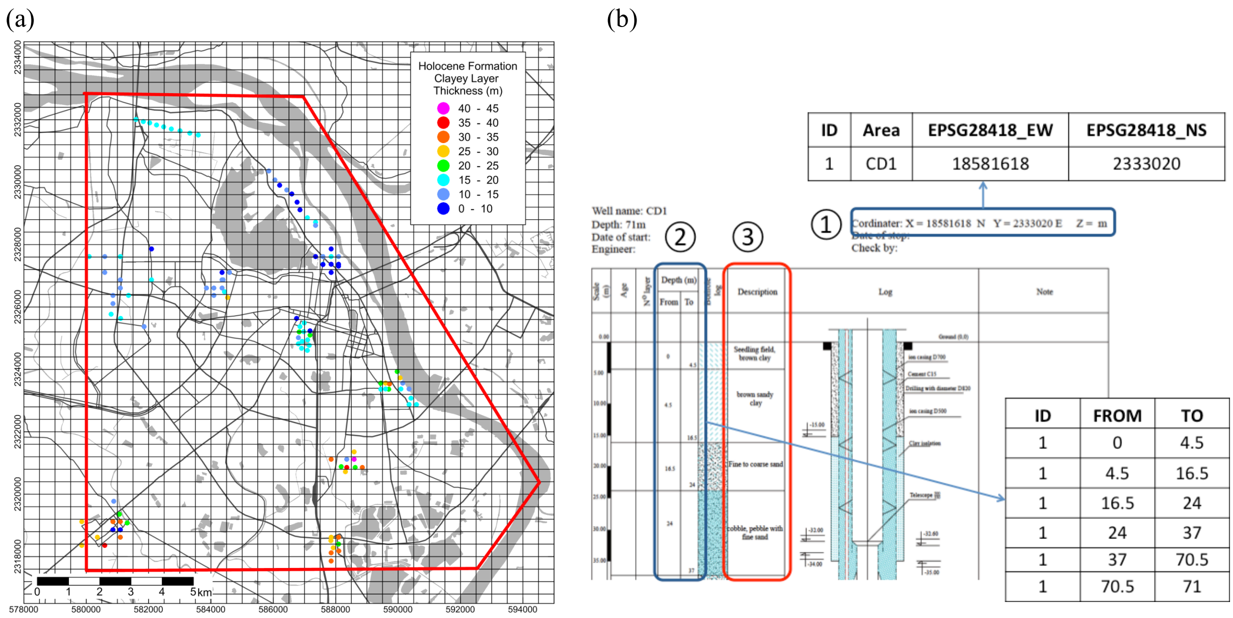

Fig. 2. Borehole data of Hanoi city.

(a) The distribution map of collected borehole data. (b) An example of borehole data.

Table 1. Unification of description.

Type	Description (Japanese)	Description (English)	JACIC
1	礫混り泥岩	Mudstone with gravel	20042
2	泥岩	Mudstone	20040
3	砂岩	Sandstone	20020
4	有機質土混りシルト質粘土	Silty clay with organic soil	03236
5	砂混りシルト質粘土	Silty clay with sand	03233
6	シルト質粘土	Silty clay	03230
7	礫混り砂質粘土	Sandy clay with gravel	03222
8	砂質粘土	Sandy clay	03220
9	有機質土混り粘土	Clay with organic soil	03206
10	シルト混り粘土	Clay with silt	03204
11	礫混り粘土	Gravelly clay	03202
12	粘土	Clay	03200
13	有機質土混り砂質シルト	Sandy silt with organic soil	03126
14	礫混り砂質シルト	Sandy silt with gravel	03122
15	砂質シルト	Sandy silt	03120
16	砂混りシルト	Silt with sand	03103
17	礫混りシルト	Silt with gravel	03102
18	シルト質細砂	Silty fine sand	02430
19	有機質土混り細砂	Fine sand with organic soil	02406
20	粘土混り細砂	Fine sand with clay	02405
21	シルト混り細砂	Fine sand with silt	02404
22	礫混り細砂	Fine sand with gravel	02402
23	細砂	Fine sand	02400
24	シルト混り粗砂	Coarse sand with silt	02204
25	礫混り粗砂	Coarse sand with gravel	02202
26	粗砂	Coarse sand	02200
27	粘土混り礫	Gravel with clay	01105
28	シルト混り礫	Gravel with silt	01104
29	砂混り礫	Gravel with sand	01103
30	礫	Gravel	01100
31	No data	No data	

Table 2. The logical model of Hanoi city.

	S1	S2	S3	S4	S5
Lechi F.	–				–
Hanoi F.	+	–			–
Vinh Phuc F.	+	+	–		–
Hai Hung F.	+	+	+	–	–
Thai Binh F.	+	+	+	+	–
Ground(Air)					+

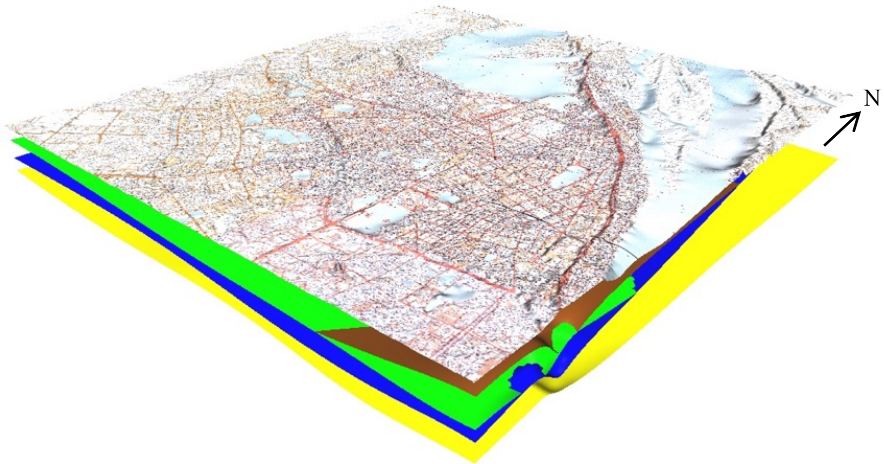

Fig. 3. The example of visualization of 3D geological model.

Haruyama (2004) and supports a stratigraphic correlation using the stratigraphic correlation module. In this case, we divided into the five geological units.

4. Construction and Utilization of 3D Geological Model

The 3D geological model is composed the DEMs of the geological boundary surfaces and the logical model. The spatial distribution and the relation of geological units are expressed in the logical model based on the fundamental field data and the knowledge. Thus the logical model of geological structure and the boundary surface are calculated for the visualization of 3D geological model. The outline of constructing of 3D geological model is as follows.

We can verify the logical consistency from the stratigraphic correlation and generate the geological event using the classify and arrange module (Shiono et al., 1998; Iwamura et al. 2008). We can define the event of geological structure of Hanoi city as V5=（v1, c*, c*, c*, c*）. It is calculated from the recursive definition proposed in Yonezawa et al. (2005). The logical model of geological structure is constructed by this event using the logical modeling module. The constructed logical mode based on the stratigraphic correlation is shown in Table 2. + mean the geological unit lies above the corresponding boundary surface. – mean the geological unit lies below the corresponding boundary surface. Blank mean no specific relation with the surface.

Each geological boundary surface DEM (S1, S2, S3 and S4) is estimated using the same method of Chapter 3. S5 is a topographic surface, it is generated in Chapter 3. In geologic function module, 3D geological model is constructed virtually using the logical model and DEMs. In this study, the data of logical model and each DEM of geological boundary are outputted from GRASS GIS of FOSS4G, the 3D geological model can be expressed using the visualization tool NVIZ of GRASS GIS. The screenshots of the 3D geological model are shown in Fig. 3.

The 3D geologic model is provided as 2D and 3D visualization. We displayed a geological cross section of the 3D geological model. Fig. 4 is an example of geological cross section. Future work is needed to identify the actual geologic structure of Hanoi city to compare the 3D geological model.

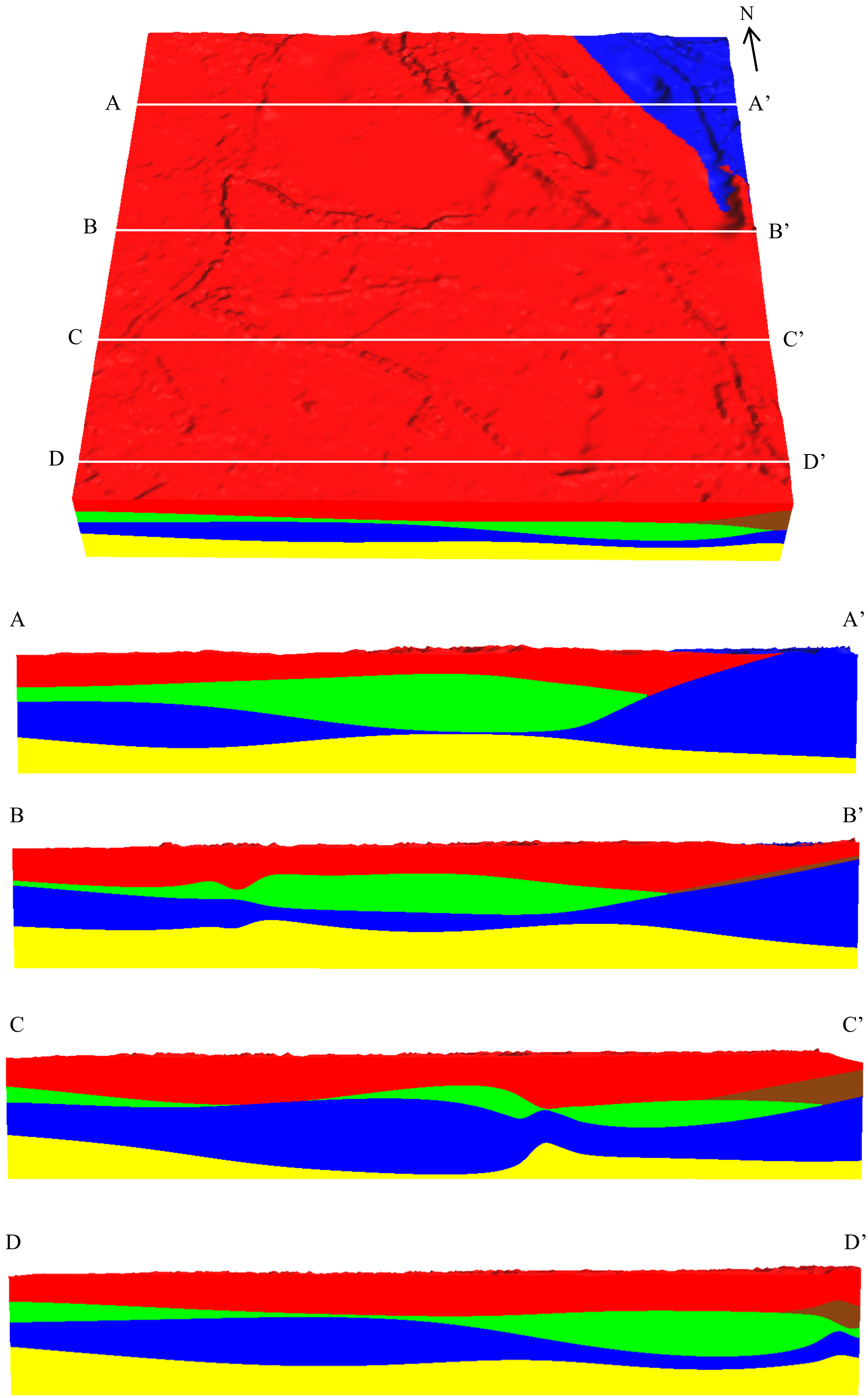

Fig.4 The example of geological cross section.

5. Conclusion

In this research, we visualized the 3D geological model using the elevation and borehole data of Hanoi city, Vietnam. The basic elements are very important for the effective utilization of the geological information, and can provide better understanding and high reliability. The 3D geological model is useful not only for the elucidation of geological structure of Hanoi city but also for the provision of the basis data to various fields. It is important to consider the urban sustainability of Hanoi city as in improvement of urban infrastructure and disaster prevention. Future works of this study are to enhance the accessible 3D geological modeling system for Vietnamese researcher.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 24251004.

References

Haruyama, S., 2004, Natural Environmental Study Applied for Agriculture in the Northern Vietnam: Natural Hazard and their Diffence Policy against Disaster, the Red River Delta, KOKONSHOIN, 131.

Iwamura, S., Masumoto, S., and Shiono, K., 2008. GeoSEQ: A program to generate constraints of geologic surface from survey data based on logical model of geologic structure. Geoinformatics, 19(2), 84-87.

Masumoto, S., Shiono, K., Raghavan, V., Sakamoto, M., and Wadatsumi, K., 1997. Geologic information on GIS -Special characteristics of geologic map information-. Geoinformatics, 8(2), 99-106.

Masumoto, S., Raghavan, V., Yonezawa, G., Nemoto, T. and Shiono, K., 2004. Construction and visualization of a three dimensional geologic model using GRASS GIS. Transactions in GIS, 8(2), 211-223.

Nonogaki, S., Masumoto, S. and Shiono, K., 2008. Optimal determination of geologic boundary surface using cubic B-spline. Geoinformatics, 19(2), 61-77.

Shiono, K., Masumoto, S., and Sakamoto, M., 1998. Characterization of 3D distribution of sedimentary layers and geomapping algorithm -Logical model of geologic structure-. Geoinformatics, 9(3), 121-134.

Tran M., Ngo Q.T., Do T. V. T., Nguyen D. M., and Nguyen V. V., 1991. Quaternary Sedimentation of the principal deltas of Vietnam. Journal of Southeast Asian Earth Science, 6(1), 103-110.

Yonezawa, G., Masumoto, S., Nemoto, T., Sakamoto, M. and Shiono, K., 2004. Visualization of Geologic Boundaries Based on Generalized Geologic Function. Geoinformatics, 15(4), 193-208.

Yonezawa, G., Kajiyama, A., Masumoto, S. and Shiono, K., 2005. Formulation of Faulted Geologic Structures. Geoinformatics, 16(3), 177-189.

Yonezawa G., 2009. 3-D Topographical Analysis in Hanoi, Vietnam. Southeast Asian Studies, 46(4), 519-531.