DEVELOPMENT OF 3D GEOLOGICAL MODELING SYSTEM FOR HANOI CITY USING BOREHOLE DATA

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ABSTRACT

In Hanoi city, the capital of Vietnam, environmental problems have been increasing in recent years. The main reason is rapid urbanization. The urbanization of Hanoi city has a relationship with the geological urban transformation as a landfill historically. Therefore it is important to consider the geography and subsurface structure of Hanoi city. 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 as the 3D geological modeling.

1. INTRODUCTION

In Hanoi, the capital of Vietnam, 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. In the rainy season, flooding occurs by heavy rain. Because the discharging water system is very old. Sometimes, buildings are sinking under the ground slowly because of the subsidence. The reason is excessive pumping of groundwater. Hanoi city is depend on the groundwater for the daily life water. These problems is related to the geography and subsurface structure of Hanoi city.

In this study, we collected the elevation data and borehole data through Hanoi University of Mining and Geology. Firstly, we need to 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 well construction of Hanoi city. We input it the developed borehole database for share with Vietnamese researcher. Finally, we constructed the 3D geological model of Hanoi city and visualized it using GRASS GIS.

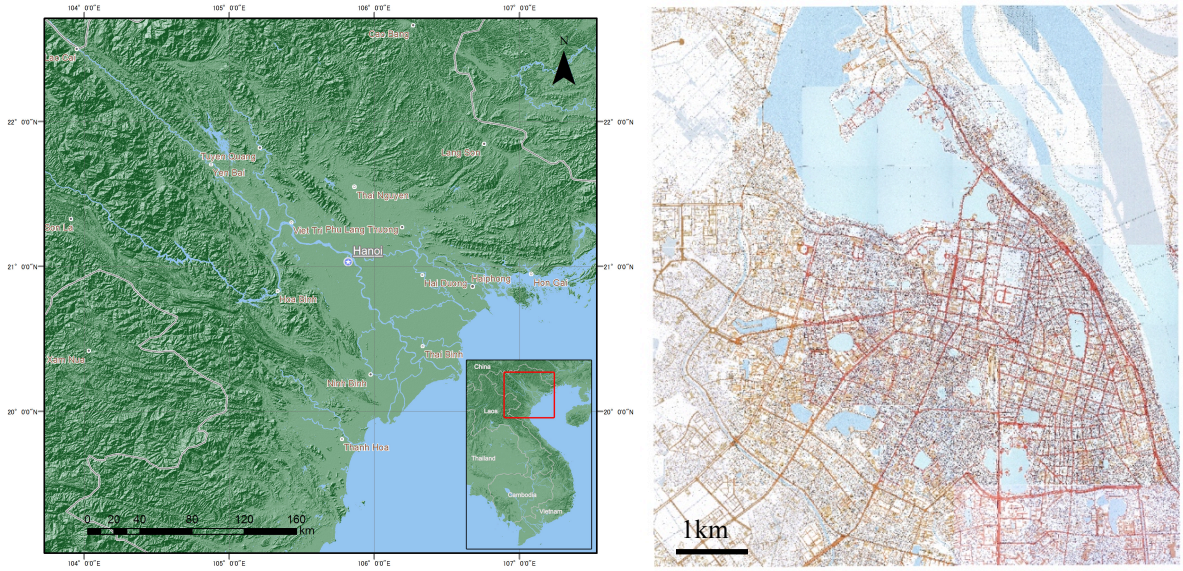


Figure 1. Research area of Hani city, Vietnam.

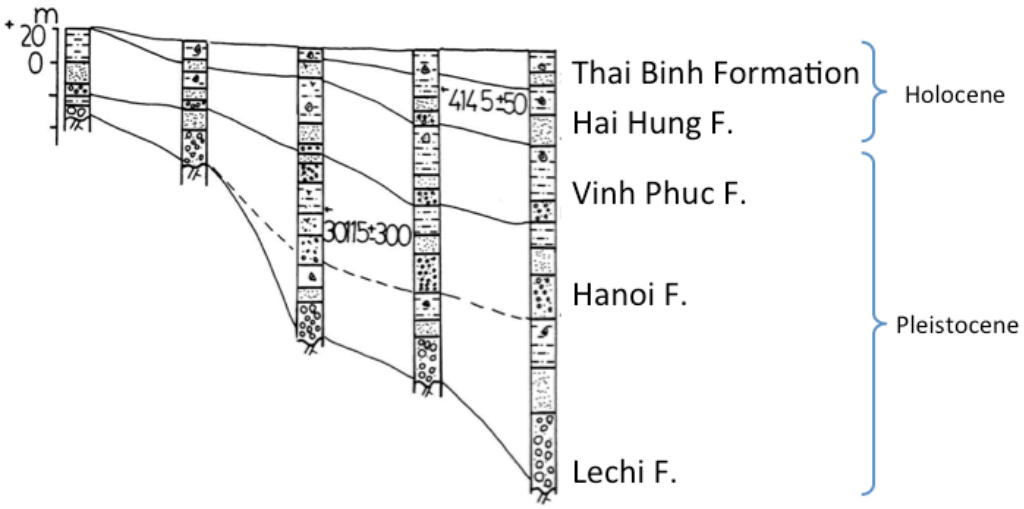


Figure 2. The outline profile section of Red River Delta.

2. THE RESEARCH AREA

Research area is the center part of Hanoi city, Vietnam (Figure 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″ . The coordinate system is VN2000. Hanoi is located on Red River Delta. The geology of Red River Delta is shown by Tran *et al*. (1991). Figure 2 shows the outline profile section of Red River Delta. This area is underlain by the Pleistocene and the Holocene sedimentary rocks. The Pleistocene rocks are divided into the Lechi Formation, Hanoi Formation and Vinh Phuc Formation. The Holocene rocks are divided into the Hai Hung Formation and Thai Binh Formation.

(a) (b)

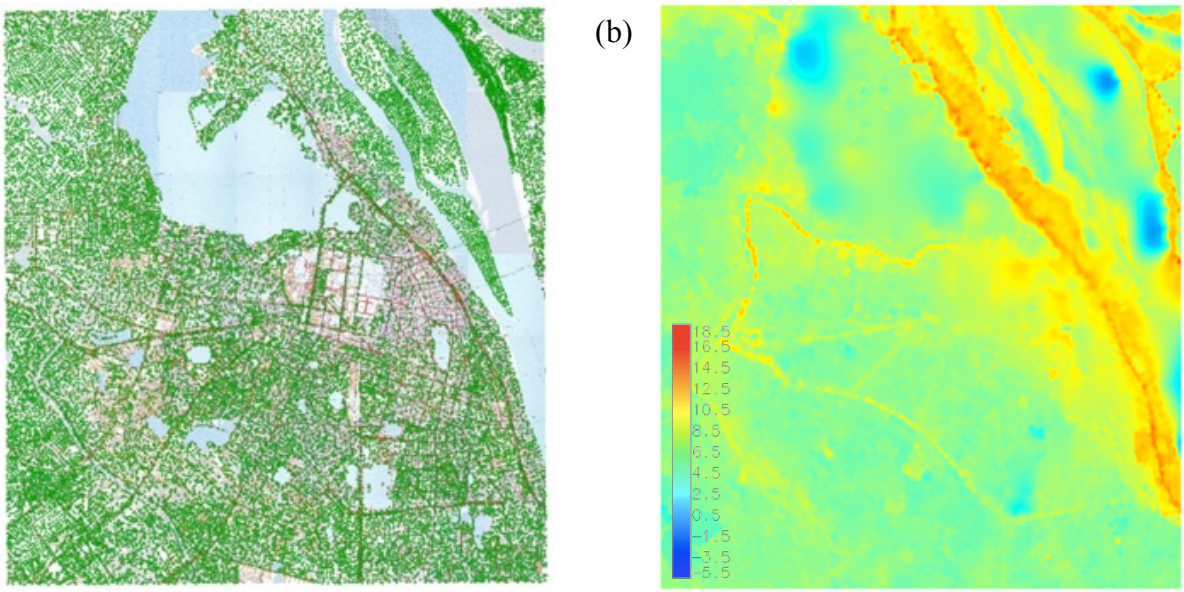


Figure 3. The elevation survey points and generated DEM .

3. GENERATION OF TOPOGRAPHIC DEM

Forty-nine maps of an elevation survey points were collected through Hanoi University of Mining and Geology. The scale is 1:2,000. Figure 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 (Figure 3(a)). We generated a DEM based on the surface estimation method, we call it BS-Horizon (Nonogaki *et al*., 2008). Figure 3(b) shows a DEM of the research area. The very subtle elevation gaps are significantly recognizable on it.

4. BOREHOLE DATA

One hundred-sixty borehole data of Hanoi city was collected through Hanoi University of Mining and Geology. The distribution map of collected borehole data is shown in Figure 4. Code mean the name of the town, number means drilling point. Each borehole data is a non-core drill data for the well construction. Figure 5 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 Figure 5. 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 Figure 5. However, the description of lithofacies were not standardized. Therefore we unificated the geological description by Japanese standard, JASIC (Japan Construction Information Center Foundation) description. We classified 30 types of descriptions (Table 1).

5. DEVELOPMENT OF BOREHOLE DATABASE

3D geological modeling system using Web-GIS is constructed by Masumoto *et al*. (2010). This system has been established by the subsurface modeling of Western Osaka Plain in Japan using the real borehole database. All the geologic description of the borehole

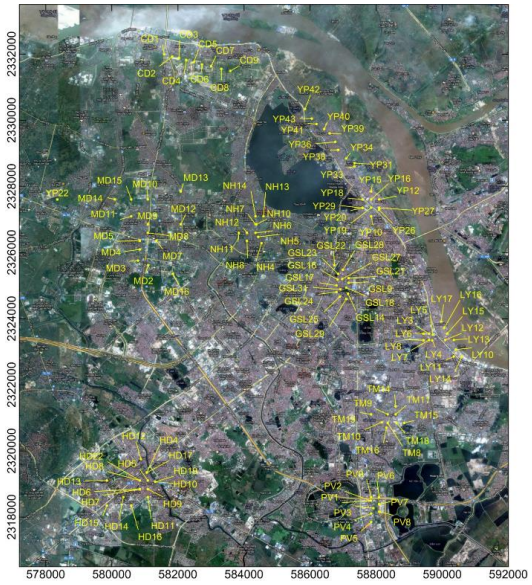
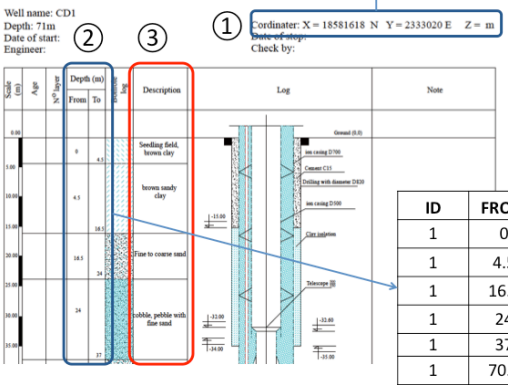


Figure 4. The distribution map of collected borehole data .

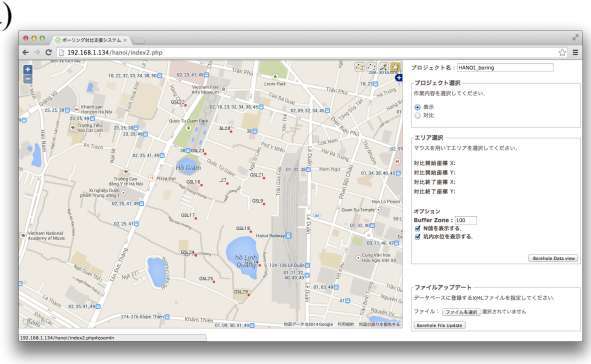
ID	Area	EPSG28418_EW	EPSG28418_NS
1	CD1	18581618	2333020



ID	FROM	TO
1	0	4.5
1	4.5	16.5
1	16.5	24
1	24	37
1	37	70.5
1	70.5	71

Figure 5. An example of borehole data.

(a)



(b)

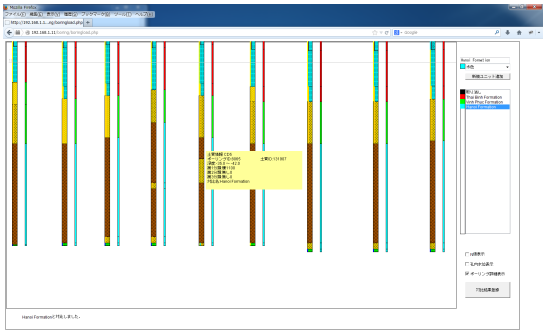


Figure 6. The borehole database.

Table 1. Unification of description.

Type	Description （Japanese / 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
...	...	...
30	礫 / Gravel	01100

database can be displayed and used for stratigraphic correlation. The 3D geological model and geological profiles along the straight line can be expressed using VRML. We are improving and developing this system to integrate the Vietnamese borehole database.

We developed the borehole database for the Vietnamese borehole data. Figure 6(a) shows the borehole database. This database can not only show the distribution of borehole data but also classify the stratigraphy based on the geological formation of Hanoi city (Figure 6 (b)).

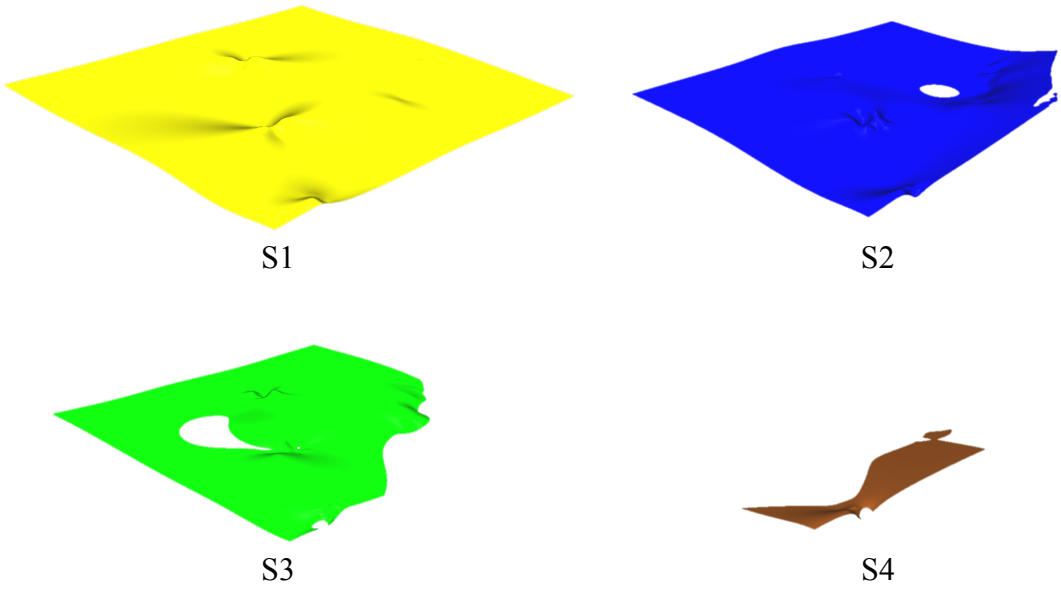


Figure 7. The geological boundary surfaces DEMs.

Table 2. The logical model of this area.

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

6. 3D GEOLOGICAL MODELING

We outputted each geological boundary surface data from the borehole database based on Figure 2 and estimated DEMs of the geological boundary surfaces for 3D geological modeling using the same method of the topographic DEM. The geological boundary surfaces DEM S1, S2, S3 and S4 are shown in Figure 7.

The spatial distribution and the relation of geological units are expressed in the logical model based on the fundamental field data and the knowledge. The 3D geological model is composed the DEMs of the geological boundary surfaces and the logical model. The logical model of this area based on the stratigraphic sequence 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. The example of visualization of 3D geological model using GRASS GIS is shown in Figure 8.

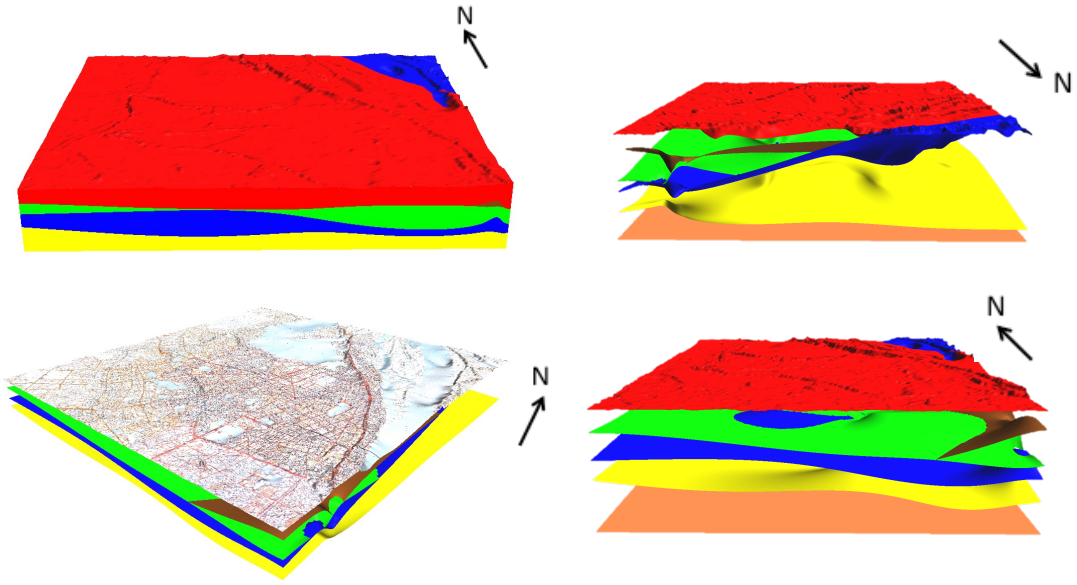


Figure 8. The example of visualization of 3D geological model.

7. CONCLUSIONS

In this study, we constructed the 3D geological model using the borehole data of Hanoi city. This 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 develop the accessible 3D geological modeling system using Web-GIS.

8. REFERENCES

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

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