A STUDY ON EXPRESSION METHOD FOR RELIABILITY OF THREE DIMENSIONAL GEOLOGIC MODEL

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ABSTRACT

A three dimensional geologic model affects the result of subsurface analysis for environmental pollution and natural disaster in urban area. It is necessary to define and express the reliability of the three dimensional geologic model. In this study, we examined two expression methods for the reliability of the three dimensional geologic model based on the density of the borehole data. And, we applied these methods to the three dimensional geologic model of the Western Osaka Plain.

1. INTRODUCTION

For the solution of urban area problems such as environmental pollution and natural disaster prevention, it is necessary to provide the high resolution three dimensional (3D) geologic model. Generally, the surface modeling method has been used to create these subsurface geologic models. In this method, the geologic model may be defined by the logical model of geologic structure and the geological boundary surfaces. The logical model shows the hierarchical relationship between these boundary surfaces and geologic units. The geological boundary surfaces can be calculated from the borehole data by using surface estimation program based on spline function algorithm (Nonogaki *et al*., 2008). The 3D models have large effects on the result of analysis for solving above problems. Therefore, the reliability of the model is required for the providing the geologic information. However, the reliability of the model constructed by the surface modeling method using spline surface estimation algorithm is not generally expressed.

In this paper, the expression methods for the reliability of the 3D geologic model based on the borehole data density are discussed. And, the several visualization results applied to the 3D geologic model of the Western Osaka Plain (Masumoto *et al*., 2011) are shown.

2. EVALUATION AND EXPRESSION OF RELIABILITY

In this study, the following methods to construct and visualization of the 3D geologic model were chosen as the object of the reliability expression.

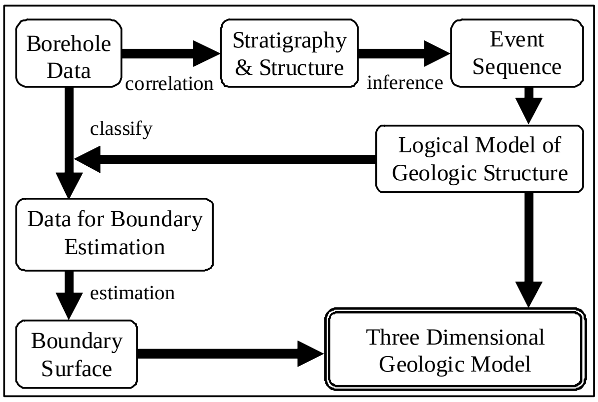

Figure 1. Data flow of the 3D geologic modeling based on borehole data.

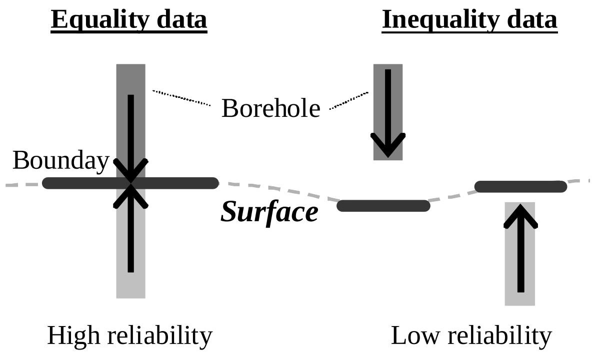

Figure 2. Equality data and inequality data for surface estimation.

(1) The surface modeling method based on the logical model of geologic structure (Shiono *et al*., 1998),
(2) The spline surface estimation method based on smoothing algorithm with bi-cubic B-spline function (Nonogaki *et al*., 2008),
(3) The visualization method of 3D geologic model using Nviz of GRASS-GIS (Masumoto *et al*., 2004).

The data flow of this 3D geologic modeling method is shown in Figure 1. For the evaluation of the reliability, various discussions are necessary (e.g. Koike and Shoji, 2008). But, there is not enough of the necessary basic theory for the reliability of this surface estimation method. Then, the density distribution of the borehole data is simply used to evaluate the reliability. The following two expression methods have been developed and tested.

Expression method by geologic boundary surface (Surface Method)

The reliability is expressed by the data density of grid points on the geologic boundary surface of model. The density of the each grid point is calculated by the number of the elevation data used for surface estimation in the reference circle area. There are two types of elevation data. One is equality elevation data and the other is inequality elevation data (Figure 2). For the density calculation, the inequality data are assigned a half weight of the equality data.

Expression method by three dimensional model space (Grid Method)

The reliability is expressed by the data density on the 3D grid points of model space. This 3D grid is composed by a row of two dimensional horizontal grids that are equally spaced in a vertical position (Figure 3). These horizontal grid conditions such as grid spacing are set to the same condition of the geologic boundary surfaces of the 3D geologic model. The density of the each horizontal grid point is calculated by the number of data points. There are two types of data point. One is the cross point where borehole data line intersects the horizontal grid surface and the other is the close point where borehole data line does not intersect but near distance to horizontal grid surface. For the density calculation, the close point data is assigned a low weight of the cross data according to the distance between end of borehole and horizontal grid surface (Figure 4).

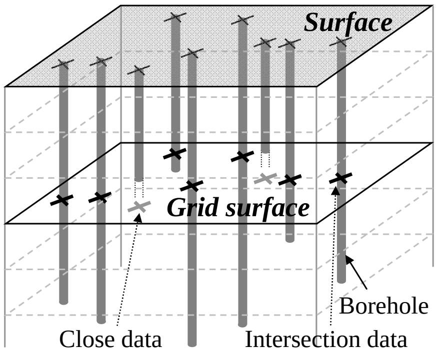

Figure 3. 3D grid and borehole data.

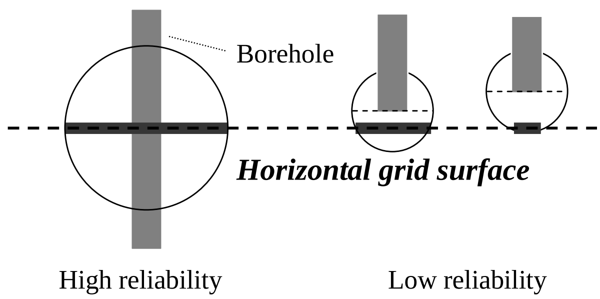

Figure 4. Intersection data and close data.

3. EXAMPLES

As an example of the expression method of the reliability, the subsurface model of the Western Osaka Plain was used. The outline of this model is shown in Figure 5. Figure 5(a) shows the stratigraphy of this study area including the relationships between geologic units and geologic boundary surfaces of this model. Figure 5(d) shows the visualizing example of this model using Nviz of GRASS GIS. The area of this model is 5 × 5 km, the horizontal grid resolution is 5 × 5 m, and the vertical resolution is 1m that ranged from +20m to −30m in height. The number of borehole data is 3100 derived from the Borehole Database of Osaka City and the Kansai Geo-informatics Database (Kansai Geoinformatics Agency).

Surface Method

For an example of the surface method, the results of S_{19} geologic boundary surface are shown in Figure 6. Figure 6(a) shows the data points of S_{19} for surface estimation. Figure 6(b) shows the reliability contours based on the data density. Figure 6(c) shows the surface shape in 3D. Figure 6(d) shows the expression example of the reliability by transparency. This transparency is in inverse proportion to the reliability based on the data density. The original surfaces and the reliability expressions of S_8, S_{12}, and S_{19} are shown in Figure 7. From these images, it is easy to understand that the lower side surfaces of the model show the lower reliability.

Grid Method

For an example of the grid method, the contour surfaces of the reliability in the model space are shown in Figure 8 using VRML viewer and Griview3D software (Inui *et al.*, 2009). Figure 9 shows the reliability of the model space by the vertical sections using VRML viewer. Figure 10 shows the reliability of horizontal sections at 10m depth intervals. Figure 10(f) shows these sections in 3D using Nviz. From these images, it is also easy understand that the lower side of model space shows the lower reliability. Using this reliability distribution, the expression examples of the geologic vertical section X-Y in Figure 5(d) are shown in Figure 11. Figure 11(a) shows the original geologic section, and Figure 11(b) shows the reliability at the same section. Figure 11(c) and (d) shows the reliability of the geologic section by the brightness and the transparency, respectively. Figure 12 shows the expression examples of the geologic horizontal section at −20m depth in the same order of Figure 11. The expression examples of the geologic model by the transparency are shown in Figure 13. The difference of Figure 13(a) and (b) is only in background color. For the expression of the reliability, it is clear that the white color background image is easy to understand.

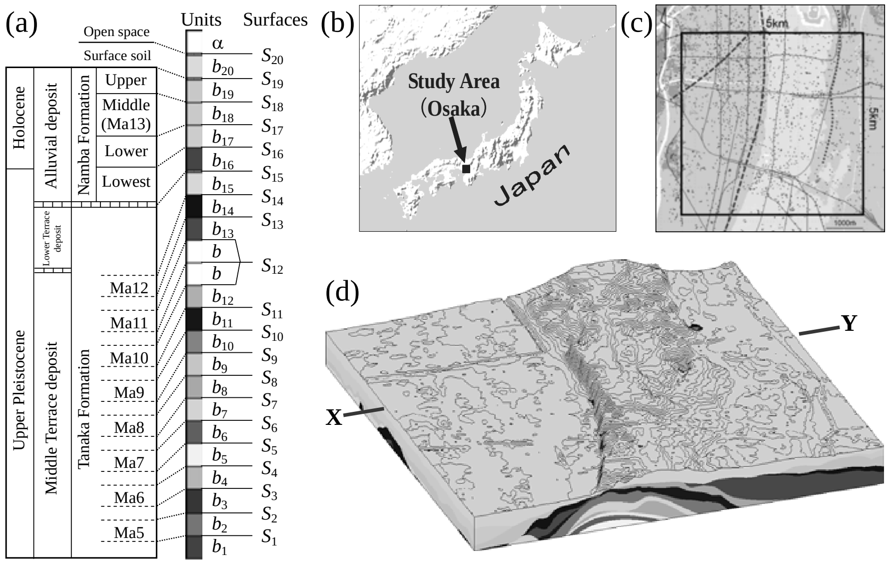

Figure 5. Outline of the 3D geologic model of the Western Osaka Plain.

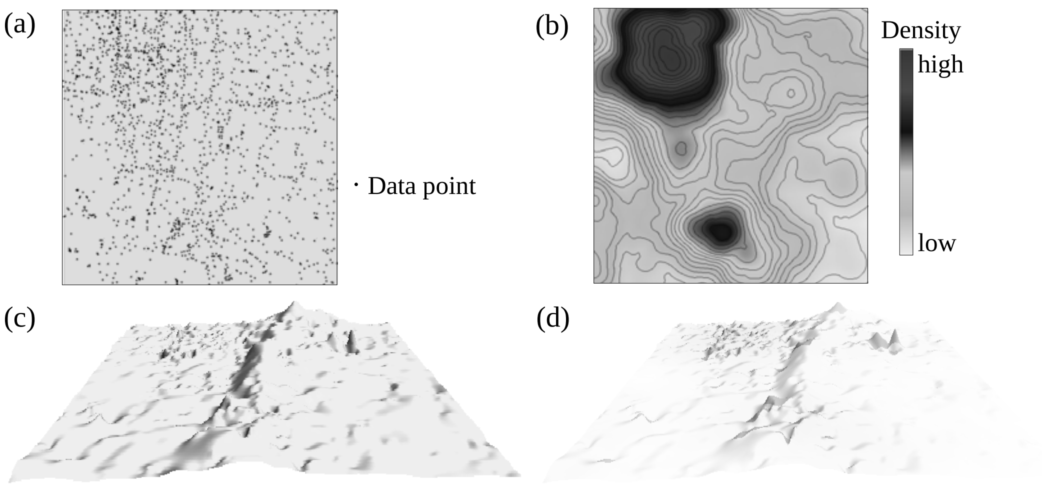

Figure 6. Example of surface method for geologic boundary surface S_{19}.

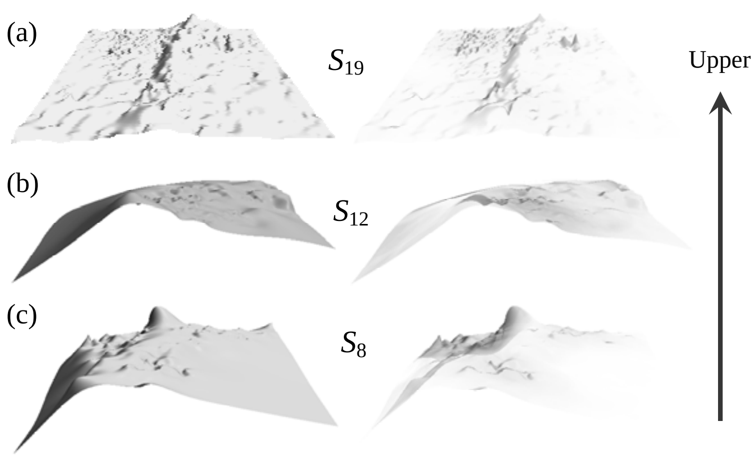

Figure 7. Original surfaces and the reliability expressions.

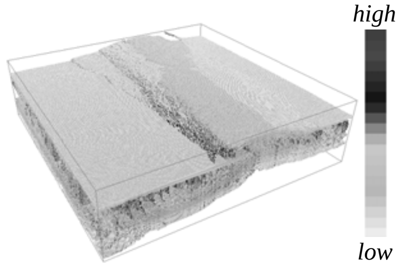

Figure 8. Contour surfaces of the reliability.

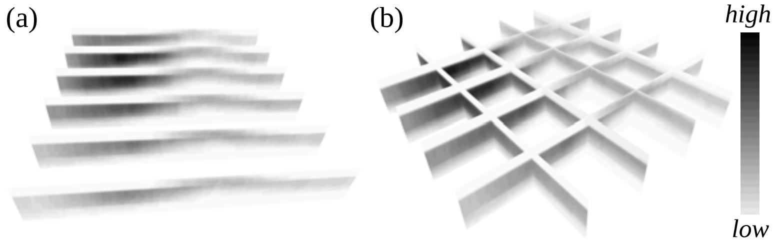

Figure 9. Reliability of the model space by vertical sections.

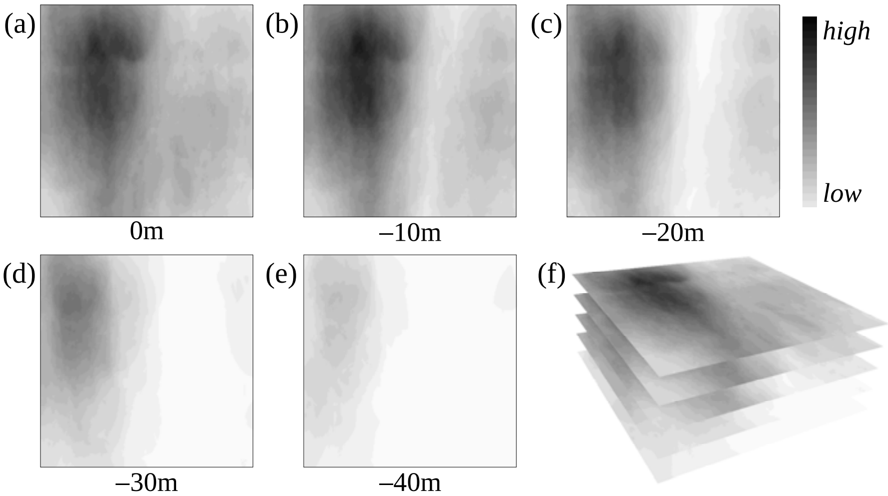

Figure 10. Reliability of horizontal sections at 10m depth intervals.

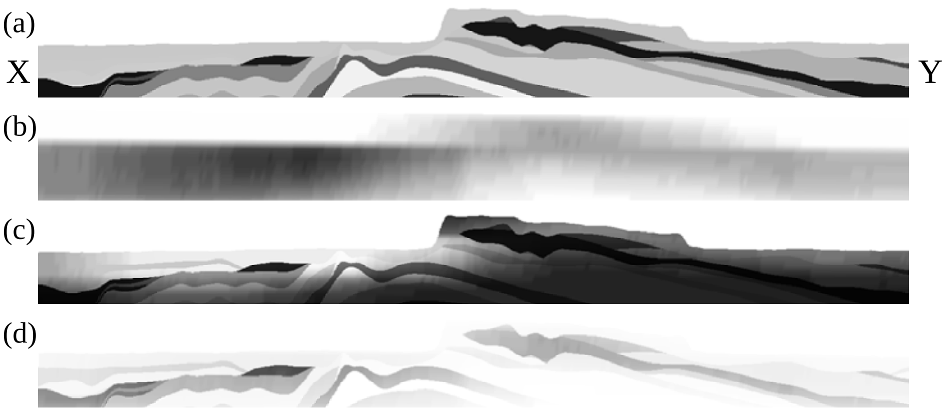

Figure 11. Expression examples of the geologic vertical section.

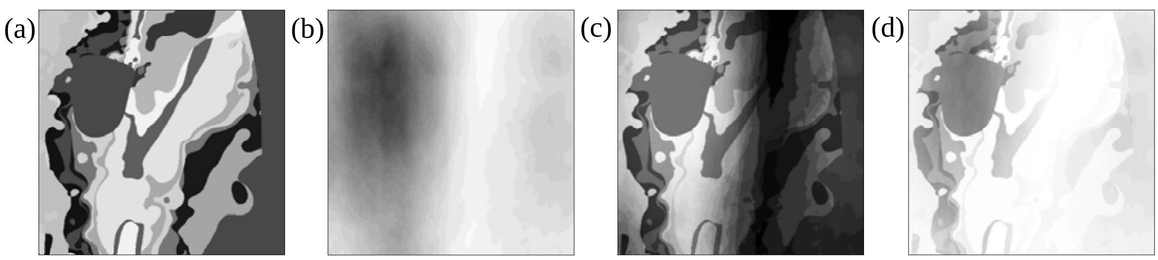

Figure 12. expression examples of the geologic horizontal section at –20m depth.

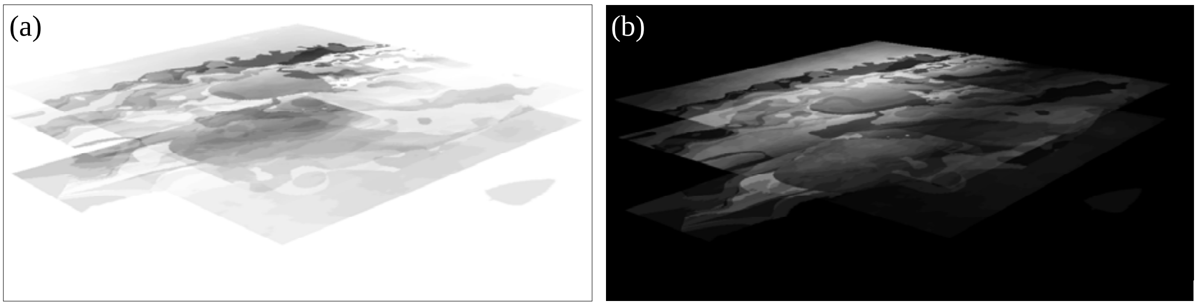

Figure 13. Expression examples of the geologic model by the transparency.

4. CONCLUSIONS

Two expression methods for the reliability of the 3D geologic model based on the borehole data density have been discussed. There is not enough of the necessary basic discussion about the evaluation of the data reliability. In the future, it is necessary to investigate a new theory, algorithm and method for the reliability expression of the 3D geologic model.

5. ACKNOWLEDGEMENT

This study was supported by KAKENHI (22500094, 24251004; Grant-in-Aid for Scientific Research by Japan Society for Promotion of Science).

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