3D MODELING AND VISUALIZATION OF GEOLOGY VOLUME BASED ON GEOPHYSICAL FIELD DATA

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ABSTRACT

3D modeling and visualization of geology volume is very important to interpret accurately and locate subsurface geology volume for mining exploration and deep prospecting. However, it faces a lack of information because the target area is usually unexplored and lacks geological data. This paper presents our experience in applying a 3D model of geology volume based on geophysics. This work has researched and developed a 3D visualization system. It is based on an OO (orientated object) approach and modular programming, uses the C^{++} language and Microsoft .NET platform. This system has built first a high resistivity method and MT database. The system uses irregular tetrahedrons to construct its model and then finally has built the 3D geological model itself.

Keywords: Geology volume, 3D visualization, Modeling method, Tetrahedron

1 INTRODUCTION

Traditional geological modeling is built upon known information, such as ichnography, section planes, and drill histograms. Especially for unexplored fields and the deep part of old diggings, drilling exploration is expensive, requires a long period of time and much skill. Consequently, in the exploration stage, one must use the correct geophysical method to get good geological information. How to transform a large amount of geophysical data into a geological 3D model that geologists can see and feel is a problem to be addressed.

In recent years, many researchers have done much work on 3D modeling and visualization, moving from 2D and 2.5D to real 3D. However, real 3D visualization in geology has not been perfected. Geoscience researchers must do much more study and exploration (Xu & Niu, 2006).

Internationally, there are many well-known organizations and software in this field, such as ESRI and ArcView 3D Analyst; GEONOVA and DILAS; Lynx and LYNX; SSI (Surpac Software International Pty Ltd), Surpac Vision; GEO Visual System Limited and GEOCard; Nancy University, and GOCAD; DGI (Dynamic Graphics Inc) and Earth Vision Modeling System. In China, there are ShiPu and IMAGIS; JiAo Corporation and CCGIS; LingTu Corporation and VRMap; ZhongDi Corporation and MapGIS (MAPGIS-TDE); DongFangTaiTan Corporation and TITAN.

2 THE DATA SOURCE

There is a large amount of geology data resources. The data types and formats are also different and can be classified into three kinds.
First, already existing geology data. This kind of data mainly includes ichnography, section planes, trench

exploration maps, and regional geology maps. These maps are in 2D and are on paper. The traditional geology models mainly depend on this kind of data.

The construction of a geology model, however, depends greatly on existing data, which are generated from a high degree of exploration. So the significance of the knowledge from mine development from these data is limited. The data volume is small and the time to acquire the data is long, so to increase the amount of data takes a great deal of manpower and material resources. Further, it is very difficult to add to this geological information and dig for more information.

Second, real drill data. For areas with good amounts of drill data, it is a good choice to construct 3D geology modeling using these drill data. At present, most international mining corporations use this kind of data to construct 3D geology models. In China, the China University of Mining and Technology uses drill data in studying data models, such as Pro. Wu LiXin has used the GTP model to construct a coalmine model based on drill data.

Models constructed by using drill data are accurate because underlying data are reliable. However, constructing such a databank consumes a lot of time. Otherwise, this method is suitable for regular strata and much drill data.

Third, geophysical field data. Geophysical methods are many, and the data type is different. In the field, the measure lines are random. Otherwise, the data are very abundant and can be easily adapted to construct complicated 3D geology models.

With the development of geophysical exploration technology and deep geology prospecting, it is critical for prospecting using geophysical methods to have information about physical properties and parameters of geology volume, especially for large areas of blind zones and deep old mines. Because drill exploration is very costly and requires long periods of time in exploration, it needs to use an adapted geophysical method to explore. So the trend is to use a 3D geology model. For abundance in geophysical data, it is vital to choose the modeling method.

3 3D MODELING METHOD

Researchers have been studying the 3D data model for many years. New data models are continually emerging. At present, 3D data models can be classified facial models, volumetric models, and mixed models.

Facial models are the most widely used models at present time. The character of this method is that all the object boundaries are composed of a face, such as in the GRID model, the TIN model, and the contour line model. The TIN (Triangulated Irregular Network) is a widely used model, and the algorithm is becoming mature. Study about it is always of interest. The TIN method uses an irregular triangle to construct a geology volume, and it demands that all the scattered data points be connected to some mode, continually but not overlapping. In 2001, Cao, et al. researched 3D modeling and used the TIN method to express the interface of a geological model, but not the inner details of the geology volume.

The volumetric model is also a widely used model, and it has a great future (Wang, 2004). The thought is that 3D geology volume is dispersed as volume elements. The idea behind the model is that a geology volume can be cut into one or more base element volumes. Further, the element volume expresses not only the shape but also attributes, such as volume, quality, and so on. Volumetric models include CSG, OCTREE, TEN, etc. In 1992, Guo discussed using OCTREE to construct 3D models. In 2002, Wu put forward the GTP model and did research on topological arithmetic.

The mixed model is a compromise method that takes advantage of two or more data models. The usual model combinations are TIN+RASTER, TIN+OCTREE, and so on. In 1998, Gong put forward the vector and raster integration model. In 1998, Li put forward three models: TIN+CSG, OCTREE+TEN, and a raster and vector integration model.

In the past decades, more than 30 modeling methods have been put forward. They include face models, volumetric models, and mixed models. The TEN model appears to be the best method to express and reconstruct geology volume (Sun, Xue, Ma, & Mao, 2002）.

Table 1. 3D modeling method (Wu, 2003)

Face model	**Volume model**		**Mixture model**
	Irregular volume element model	Irregular volume element model	
TIN	CSG	TEN	TIN－CSG
Grid	Voxel	Pyramid	TIN－Octree
B-Rep	Octree	TP	Wireframe－Block
Wireframe	Needle	Cell	Octree－TEN
Series Section	Regular Block	Irregular Block	
Series-Section-TIN		Solid	
DEM		3D Voroni	
		GTP	

4 AN EXAMPLE OF 3D MODELING AND VISUALIZATION

We use the high-density electricity technique data from ShanXin province and MT data from HeiLongJiang province to model and visualize a 3D model of geology based on the TEN method. Based former work, we have researched and developed a 3D visualization system, based on OO (orientated object) idea and modular programming, using the C^{++} language and the Microsoft.NET platform. This system first has used the high resistivity method and an MT database. Data files use Access Excel and SQL servers. The system uses an irregular tetrahedron to construct the 3D geological model.

It is shown that this visualization system has accurately reflected the real geological space character and provides visualization data for further geological work (Qi, 2006）. [4]

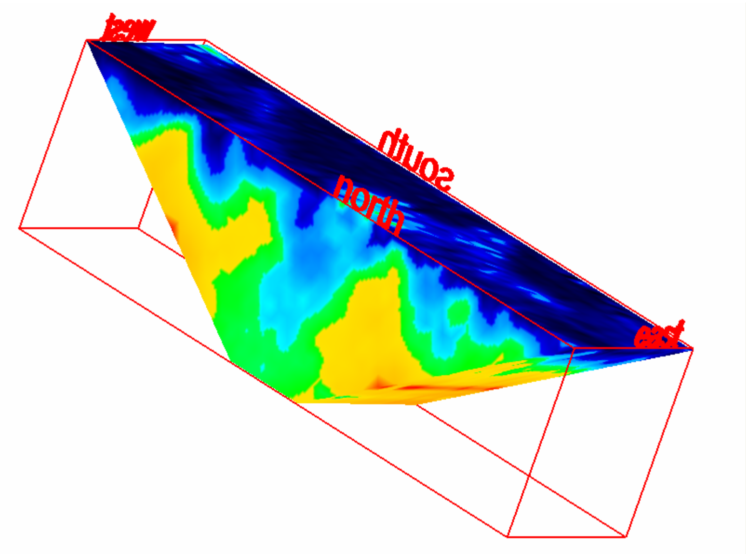

Figure 1. Geology model of a complicated cavity based on RC data

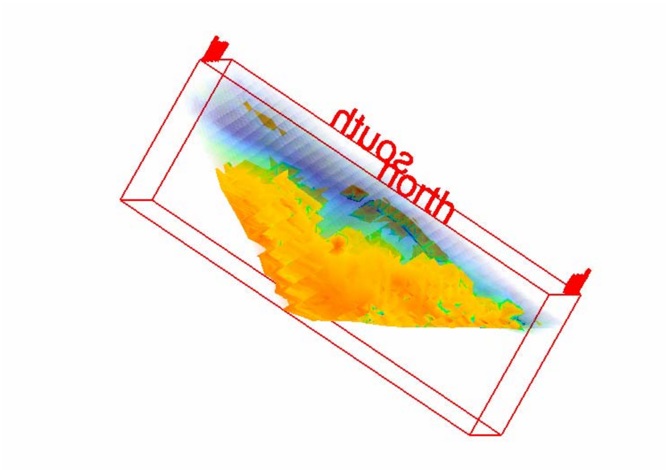

Figure 2. Transparent model of a complicated cavity based on data

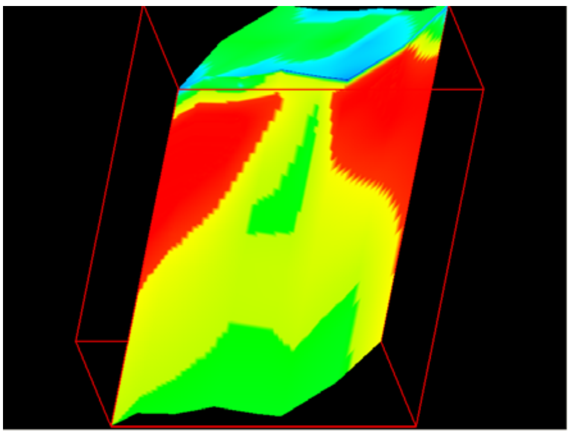

Figure 3. 3D geology model based on MT data

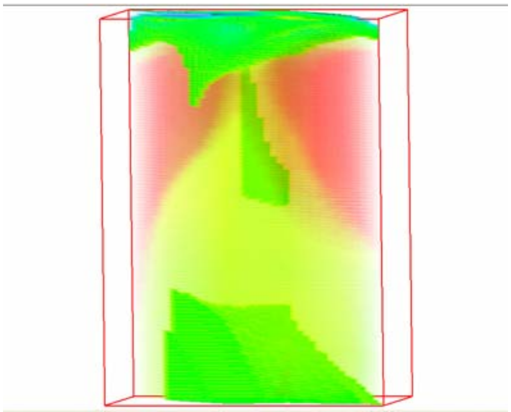

Figure 4. 3D transparent geology model based on MT data

5 CONCLUSION

Geophysics is the study of the Earth using physical theory and methods (Liu, 2003). There are gravity, magnetic and electric method, seismology, radioactivity, geothermal and other facets to study. Each geophysical method is one physical aspect of the of geology volume. This is only one type of geology volume, as geology has many different geophysical characteristics (Liu & Zhu, 2003). Real 3D geological models require more than one type of physical data, however.

With the development of modern mining and measurement techniques, many kinds of geophysical data are now available. How to use the large volume of data to construct accurate 3D models and display them rapidly is a new question. Another important question is how to manage such large data banks and promote 3D GMS.

The TEN model is a new method of volume modeling. Although at present this kind of software is not fully developed, TEN has the least number of faces in volume models and can express the attribute of complicated geology volume. This method still must deal with large amounts of data, complex arithmetic, and difficult space imaging. However, these problems will be solved with the development of new computer techniques. This article provides an example of such a solution (Qi, 2006).

Finally, in 3D geology modeling, the modeling method is related to the data model. If the data model is proper, it will promote efficient modeling. Moreover, it should use standards as much Qi, M. (2006) as possible.

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