

Research on Automatic Mapping Method of Geologic Column

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Abstract

The realization of the digital reservoir can greatly improve the information level of the petroleum corporation in hydrocarbon exploration and development, reduce risk and improve efficiency. Wells are the core object of digital reservoir management. Geologic column of drilling is the main carrier of multi-source information. Automatic mapping method and multi-source information fusion of geologic column have become a research hotspot of digital reservoir construction. This paper describes current situation of the domestic reservoir management and practical problem of geological maps digitizing. The thought and process of geologic column automatic mapping, which are based on spatial information technology, are submitted. The partition of information bar is settled on. The three-tier system architecture of automatic mapping system is established. With the support of XML technology, XSD is used to make the parameter template of geologic column automatic mapping and realize corresponding configuration wizard. UML is used to design the automatic mapping system. The lithological plate and geological symbols is coded to realize automatic mapping of corresponding drawing elements. The drawing methods of logging and petrophysical data are improved and the visualization of curve and numerical stick figure is achieved. The integration method of casting photos, core images and geologic column is submitted. For the secondary development technology of ArcGIS Engine, object-oriented program is adopted to realize automatic mapping of geologic ArcGIS Engine column. This paper provides a new way for the geologic column mapping during the process of digital reservoir construction.

Keywords: digital reservoir; geologic column; information bar; automatic mapping

1. Introduction

After Gore, the former vice president of United States, presented the "Digital Earth", the information construction now is sweeping across the globe [1]. Oil industry, as the economic lifeline of the country, raises the prospects for construction of Smart Fields, Digital Oil Field, Field of the Future, e-field, Intelligent Energy [2-6]. Exploration and development are the main business of the petroleum corporation and closely associated with "digital reservoir" construction which has become the focus of digital oilfield. Problems which digital reservoir has to solve are the integrated management of multidisciplinary data and results, synthetic display, analysis evaluation, etc. The emergence of spatial information technologies provides solutions for these problems. Through spatial information technology, all kinds of information can be integrated and

shown with maps and analyzed comprehensively [7-11]. Digital reservoir has become an effective way of modern reservoir management [6].

In most domestic oil fields, the paper media storage and manual management are still the important means of geological maps storage, and sometimes even the only single storage way of geological maps. This greatly affects the reservoir data management efficiency and even results in the loss of important data due to damage of paper maps [12]. Meanwhile, in the exploration and development process of hydrocarbon reservoirs the researchers need to gather and organize a lot of data to draw a large amount of geology maps with the assistance of vector graphics software such as COREDRAW, AOTUCAD, MapInfo Professional and ArcGIS Desktop. The manual drawing way is often used with poor precision and long drawing cycle. The development of fast mapping and integrated management of geological maps has become the focus of research in the digital reservoir construction process [9].

In the long-term exploration and development, the oil field has accumulated a large amount of original data of seismic, drilling, well logging, well testing and other aspects. Much of these data is associated with hydrocarbon wells. The geologic column is a major carrier of comprehensive display of hydrocarbon wells multi-source information, and also the evaluation map of reservoir information display and analysis. Through oilfield enterprises research, the demand of geologic column automatic mapping is confirmed. Then with the use of spatial information technology and ArcGIS Engine secondary development platform, rapid automatic mapping methods aiming at geologic column are studied. The Figure 1 shows DFD of geologic column automatic mapping and visualization.

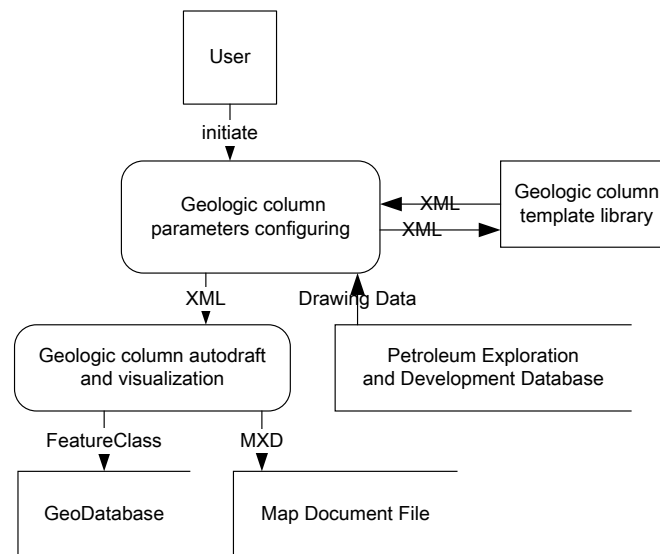


Figure 1. DFD of Geologic Column Automatic Mapping and Visualization

2. Workflow

The geologic column is divided with Information bar (information column) referring to hydrocarbon geological map specification and drawings standard [14]. On this basis, geologic column is divided into layers according to the characteristics of the ArcGIS Geodatabase. Then the Microsoft data access technology OLEDB is used to perform research on oilfield static database,

develop database and various data files, and write corresponding data access components, and realize the automatic extraction of geological histogram mapping data including lithology, logging, measured physical property, core image, formation, deposition and note data.

After that, the methods of creating columnar drawing element are studied, and encapsulated corresponding objects through using ArcGIS Engine Developer kit. Finally, C# Program Design Language (PDL) is used to write UI and realize the geologic column fast mapping system. It is show in Figure 2.

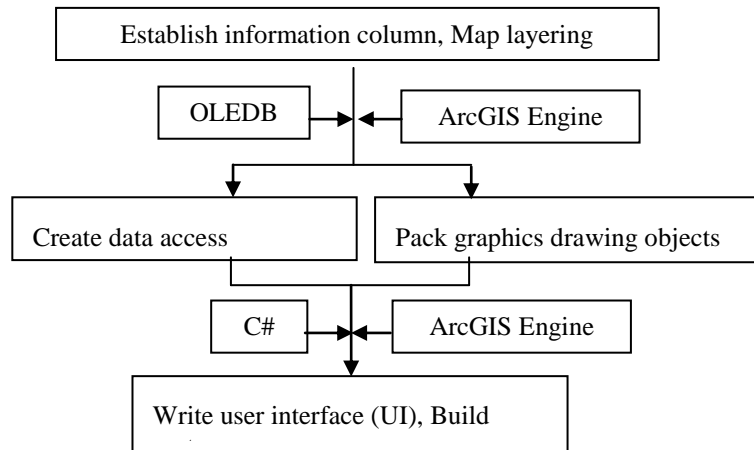


Figure 2. Geological Column Drawing Process

3. Dividing Scheme of Information Bar

The geologic column is one of the base maps of oilfield exploration and development, and can present the changes in stratigraphic profile with depth. These changes include stratigraphy, tectonics, lithology, color, hydrocarbon show, sedimentary facies, core, logging, and so on. The information and research results in the wellbore with depth can be reflected in geologic column to achieve integration and visualization of all various information.

On the basis of geologic column mapping standards and research of oilfield enterprises, the paper uses information column to divide the geologic column into the following information bars:

- (1) General Information bar --Storing basic information of column title, frame, depth gauge, etc.
- (2) Text annotation information bar -- The information carrier of text annotation to visualize the information, stratigraphic division, sedimentary facies, core description, notes, etc.
- (3) Logging and physical property information bar -- Realizing visualization of various logging data and physical properties by curve or numerical robust graph.
- (4) Lithologic Information bar—Realizing visualization of lithologic data by lithologic chart spot and drawing lithologic section.
- (5) Symbol information bar –Realizingvisualization of sedimentary structure, results Interpretation, hydrocarbon show and various logging data by symbol map.

- (6) Image information bar – Realizing the visualization of core pictures, cast photo and analysis char and the integration of geological column information.

4. System Architecture

According to the customer demand of functionality to edit client vector data, the server load and the network load, C / S model is applied to design automatic mapping system of geologic column. Figure 3 shows the architecture of geologic column automatic mapping and visualization system.

4.1. Data Layer (DAL)

Including petroleum exploration and development database, GeoDatabase spatial database. With the related database access components, automatic mapping-based data can be extracted and the space feature set of the geologic column can be operated.

4.2. Logic Layer (BLL)

Including WellCreator (the core class of geologic column automatic mapping), the FeatureClassOperator (the accessory class operating the featureclass in Geodatabase), the LithSymbol (the creating class of lithologic chart spot), and the Geosymbol. WellCreator realizes the mapping of the generic information bar, the logging information bar, the physical property explaining bar and image information.

4.3. Presentation Layer (USL)

FrmMain is the system's primary interface, which can realize the interaction with the users through the menu, shortcut keys and function controls. FrmMap can visualize the geological column. FrmWellConfig is used wizard pattern to realize the configuration of geologic column automatic mapping parameters.

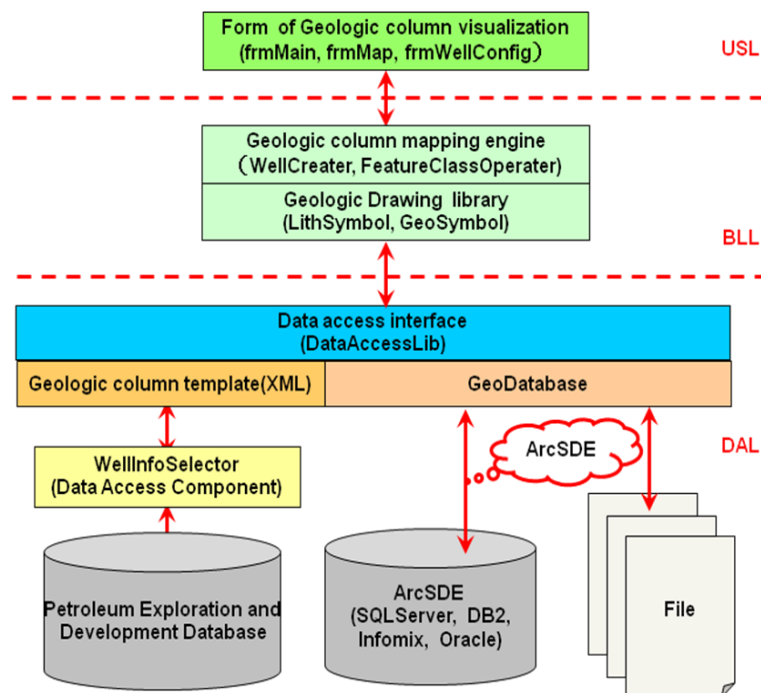


Figure 3. The Architecture of Geologic Column Automatic Mapping System

5. Realization of Automatic Mapping

5.1. Parameters Template Customization

The key problem that the automatic mapping of geologic column needs to resolve is to make complex parameter template to order. The geologic column is the combination of many kinds of information bars. Each information bar contains its own complex mapping parameters. Simple information bar can hardly customize the template and storage parameters. ADO.net, the Microsoft data access technology, provides a set of dataset objects which are the collection of the data table and capable of expressing the relationship between various data tables. In particular, ADO.net supports XML technologies, which makes the dataset support XML document output and input and also solves the problem of mapping parameter template storage. With the XSD in XML technology, the parameter template of automatic mapping is customized. The parameter template is set with C# programming language. Figure 4 shows the parameter template, and the corresponding wizard interface of configuring parameter is shown in Figure 5.

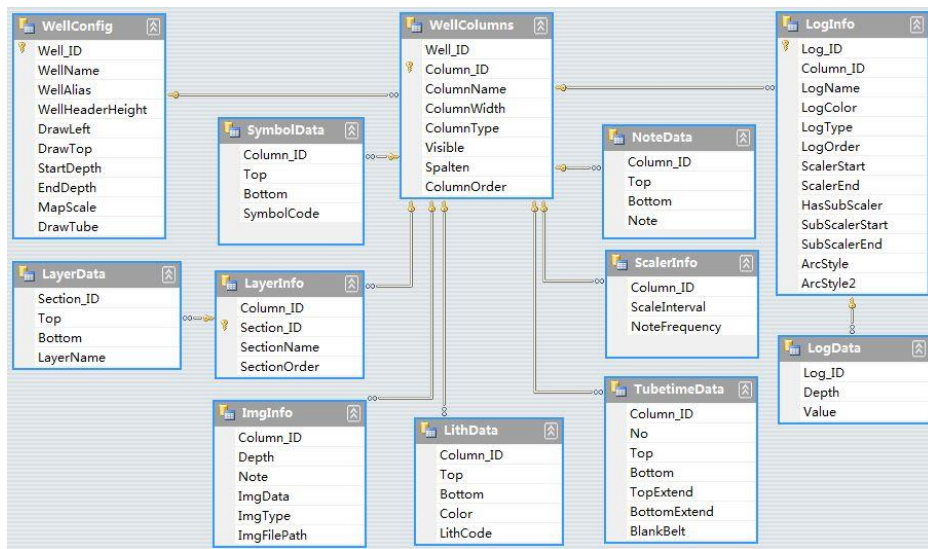


Figure 4. Configuration Parameters of Geologic Column (XSD)

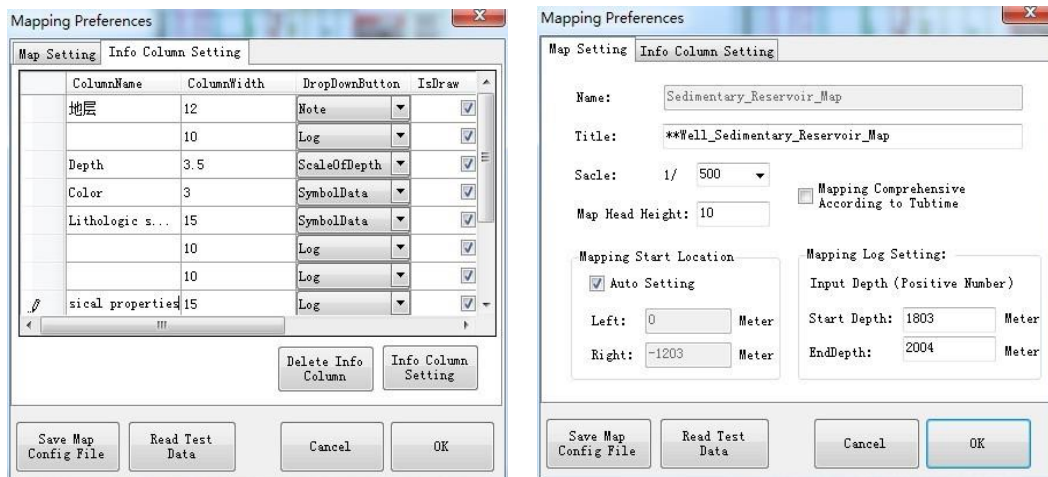


Figure 5. Wizard Interface of Parameter Configuration
 (A.General Setting B.Column Setting)

5.2. Design and Implementation of the Core Classes

According to the information bars of geologic column, the paper designs static structure diagrams of geological column automatic mapping. Various classes and their mutual relations involved in geologic column mapping are shown in Figure 6. Among these classes, WellCreator is the core class. Under the assist of FeatureClassOperator class, FeatureClass which corresponds to the geological column is created with ArcGIS Engine. The relationship between the WellColum class and WellCreator class is a paradigmatic relation. The WellCreator class contains the properties of WellColumns which is a collection of various WellColum. WellCreator class creates information bars of various geological columns through contained WellColum. GeneralColumn, ImageColumn, SymbolColumn, LithColumn, NoteColumn, LogColumn are derived from WellColum to create information bars.

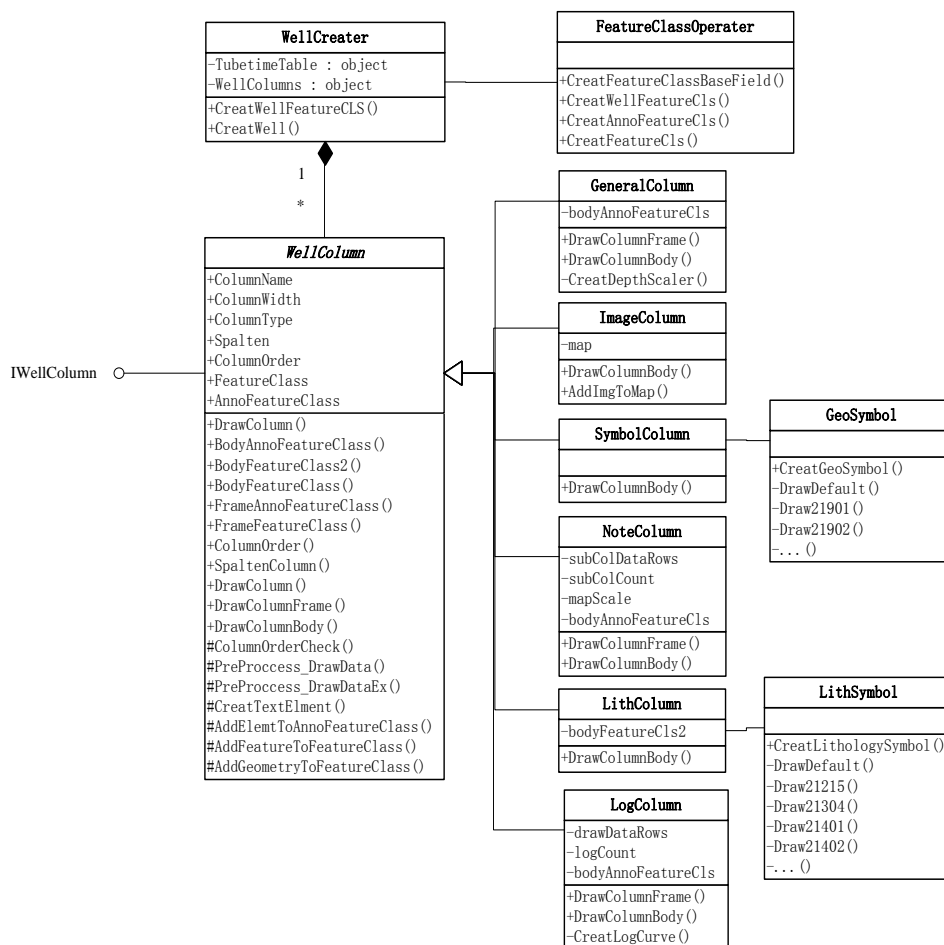


Figure 6. Class Structure Diagram of Geologic Column Automatic Mapping

5.2.1. Implementation of LithSymbol Class and GeoSymbol Class

LithSymbol class implements the creation of various lithologic chart spot and assists LithColumn information bar to create of the lithologic section. GeoSymbol class is used to create the symbols corresponding to sedimentary structures, hydrocarbon shows, log interpretation and conclusion, and can also assist SymbolColumn class to create the symbol bar.

Based on the experience of reservoir description and in reference to symbol coding rules of geological mapping software, the paper encodes lithologic pattern spots and geological symbols involved in automatic mapping process of geological columns. Table 1 shows the detailed encoding rules.

Then lithologic chart spots and geological symbols are created with elements such as points, lines and surfaces in ArcGIS Engine.

Table 1. Geologic Symbols Encoding

Signature	Drawing elements	Signature	Drawing elements
2	Lithology	43	Logging information
21	Sedimentary rock	44	Interpretation result
212	Conglomerate	4401	Reservoir
213	Sandstone	4402	Poor reservoir
21301	Gravelly sandstone	4404	Oil-water layer
21305	Fine sandstone	44011	Wwater layer
22	Magmatic rock	5	Well symbols
23	Metamorphic rock	51	Exploratory well
31	Contact relationship	52	Drilling
32	Regional structure	53	Development wells

5.2.2. Achievement of Logcolumn and Petrophysical Bar: The key problem in mapping logColumn and petrophysical bar is to set the vertical and horizontal scale.

In general, the vertical axis shows depth in meters (m) and the horizontal axis shows a logging or physical property value, such as SP, RT, AC, POR, PERM, etc. The way is to set coordinate system in unit of meter, and the ration in Y direction is 1:1. The X coordinate and Y coordinate of target element spots can be calculated by the following equations.

$$X = FrameX + \frac{Columnwidth \times (Value - ScalerStart)}{ScalerEnd - ScalerStart} \quad (1)$$

$$Y = FrameY - (Depth - StartDepth) \quad (2)$$

Where: FrameX-initial coordinate in X axis; FrameY-initial coordinate in Y axis; Columnwidth-the width of information bar; Depth-the measured depth of target element; Value-the measured parameter value of target element; StartDepth-the start depth of target element; ScaleStart-the start scale of horizontal scale; ScaleEnd-the end scale of vertical scale.

5.3. Automatic Mapping Process

With the UML technology, the timing diagram corresponding to the automatic mapping process of geologic column is designed. The collaborative relationships between various classes in drawing geologic columns are shown in Figure 7.

FrmMain is the form class corresponding to the main interface of system. FrmWellConfig sets parameter template of automatic mapping. WellInfoSelector extracts basic data from the oilfield static database, development database and other various data files. WellCreator creates the geologic column. FrmMap is a child form and assists to visualize the geologic column.

According to the timing diagram, the automatic mapping of geologic columns is realized through coding with the C # programming language.

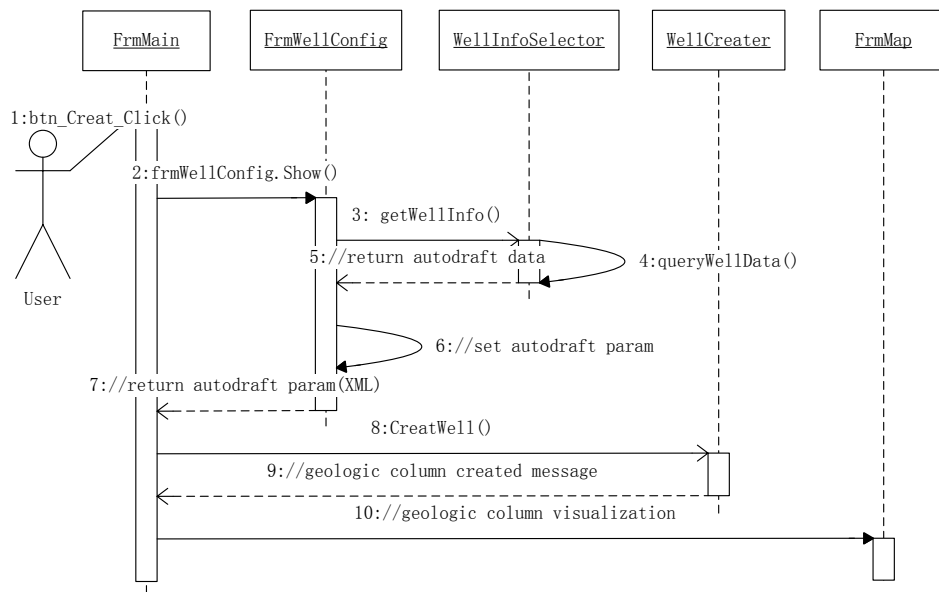


Figure 7. The Timing Diagram of Automatic Mapping System

6. Application

Through collecting strata data, lithology data, logging data, measured physical properties, core description data and core scanning photos from a drilling well in some oil field, the automatic mapping system is used to customize template and rapidly draw comprehensive geologic columns of core descriptions, gamma location and reservoir sedimentary. The comprehensive geologic column of core description is shown in Figure 8.

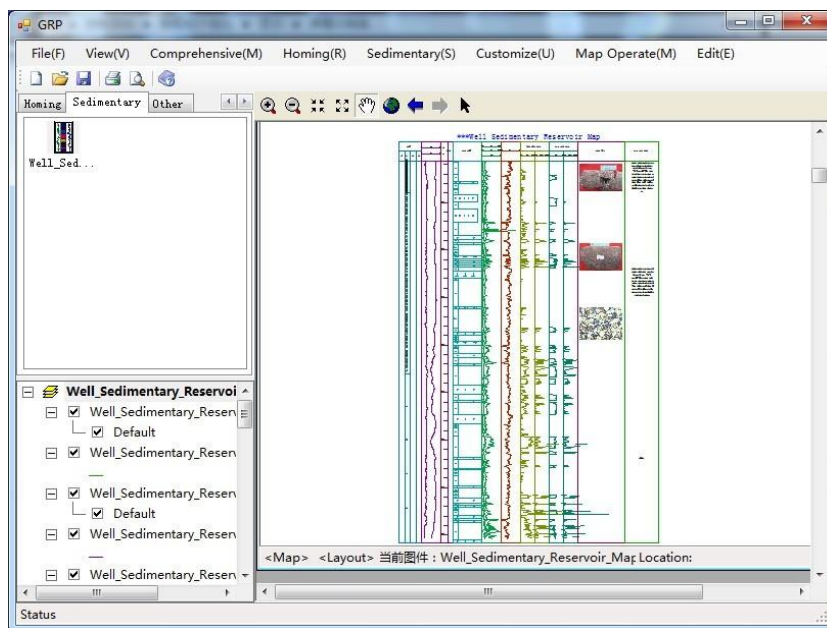


Figure 8. Application of Automatic Mapping System

The management of the geologic column and information sharing within the enterprise network (Intranet). For the adopted C / S structure, it is difficult for the method to share maps on the internet, and the application scope of the automatic mapping system is constrained to some extent. This automatic mapping method can be applied to fast mapping of various geologic columns during digital reservoir construction, and also application shows that the drawing time of geologic column of core description reduces to 5 minutes from 1.5 days. The ArcGIS Engine based automatic mapping method can greatly improve mapping efficiency of geologic column. With the aid of spatial data management solutions of the ArcGIS GeoDatabase, the method can also implement integrative can be applied to vector mapping in daily geological study.

7. Conclusions

As the main carrier of multi- source information from wells, the geologic column is the important object of the modern reservoir management. During the process of digital reservoir construction, researchers must draw a great number of geological columns. This automatic mapping system meets the requirement of digital reservoir construction and provides new way for geological column mapping.

The major study conclusions are summarized as follows.

- 1) The automatic mapping thought of logical column is built on spatial information technology.
- 2) The dividing scheme of geologic column information bar is put forward.
- 3) The mapping parameter template based on XML technology is customized.
- 4) The C#, one object- oriented programming language, is used to realize the automatic mapping system of logical column.

The paper establishes a certain theoretical foundation for digital reservoir construction and has some reference value.

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