Research Advances

3D Geological Modeling of the Xiangshan Uraniferous Volcanic , Jiangxi Province

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Objective

Three-dimensional (3D) subsurface geological models have been gaining considerable attention wordwide. 3D geological surveys and modelling in the Xiangshan uraniferous volcanic basin, Le'an county, Jiangxi Province is a pilot project of the China Geological Survey. The Xiangshan volcanic basin is the third largest volcanic-type uranium ore field worldwide. This basin is composed of Lower Cretaceous rhyodacite and porphyritic lava with shattered phenocrysts, as well as small amounts of high-level intrusive acidic rocks, overlying a basement of metamorphic rocks. More than 60 years of exploration and mining activities have revealed the most important geological characteristics and factors controlling the uranium mineralization, which can be summarized as the "three blinds" (blind faults, blind rock bodies, and blind ore shoots), and "three interfaces" (faults cutting through the basement, interface between the Ehuling Formation and Daguding Formation, and interface between high-level intrusive bodies and wall rocks). It is important to construct 3D geological models considering these ore-controlling geological factors to demonstrate the spatial distribution of these interfaces and faults.

Methods

3D geological modeling was conducted using the GOCAD software. The materials used to build the models mainly included (1) one fully covered 1:25000 remote sensing map and related geological interpretation, which provided topography data and macroscopic volcanic structural characteristics; (2) one 1:50000 surface geological map with precise lithological data; (3) 1459 borehole logs and 447 exploration line profiles and interrupted profiles; and (4) 19 magnetotelluric sounding (MT) lines with 1220 points, and 14 controllable source magnetotelluric sounding (CSAMT) lines with 1198 points. The MT lines were equally distributed over the entire volcanic basin with a 2-km line spacing and a 250-m point spacing; the CSAMT was conducted at locations considered to be favorable for mineralization. The inversion and comprehensive interpretation of the MT and CSAMT data were performed under the constraints of the geological map, drilling, and rock physical data: 1629 rock specimens for physical measurement, among which 1386 and 243 specimens were from drill cores and the surface, respectively. These geophysical data were used to help identify the subsurface faults and rock bodies.

In this project, a multi-source data modeling technique was used, merging processes that included three progressive steps: integration of data sources, integration of geometric space, and merging of geological cognition, followed by the data merging technique at each step.

Results

This study systematically describes a series of constraint-interpolation techniques for the first time, such as point-to-line constraint, point (line)-to-surface constraint, constraint on border, constraint border extremity on border, and control thickness constraint.

Four levels of 3D geological models were built according to precisions, depths, and area, namely, the Tuoshang map-sheet, deposits, Zoujiashan-Julong'an, and Xiangshan volcanic basin, all constructed by combining multi-source data. The primary modeling results demonstrate the following geological characteristics: (1) the unconformity interface between the Xiangshan volcanic bodies and the underlying metamorphic rocks is clearly demonstrated by near-continuous low-resistance anomalies. The volcanic rocks from the Daguding Formation, which are spatially associated with the main uranium deposits, exhibit successively low resistance and medium density, and are thicker in the western part of the basin than in the eastern part, demonstrating an E–W zonal distribution. In contrast, the volcanic rocks of the Ehuling Formaion exhibit high resistance and low density and are relatively thick in the central region of the basin. Tubular low resistance anomalies in the NW Xiangshan peak correspond to a channel of erupted porphyritic lava with shattered phenocrysts of the Ehuling Formation. This volcanic channel generally has a steep tubular shape and dips to the SE, with a surface radius of approximately 2 km (Fig. 1); (2) the Lower Cretaceous coarse granitic porphyry is generally annularly distributed. The metamorphic basement displays a NE dipping complex

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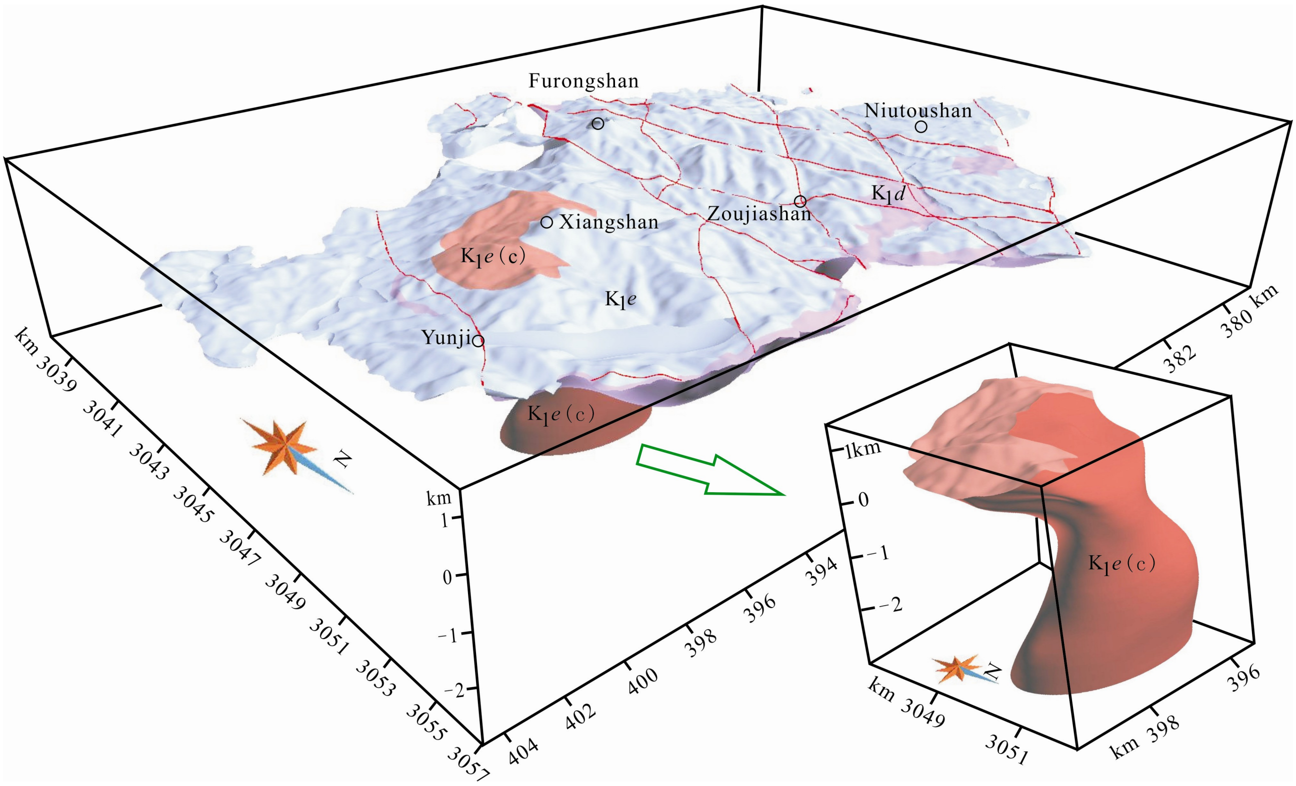

Fig. 1. 3D geological model of the Lower Cretaceous volcanic rocks in the Xiangshan volcanic basin.

K_1d, K_1e, and K_1e (c) represent the Daguding Formation, Ehuling Formation, and the volcanic neck of the Ehuling Formation, respectively. The red lines represent faults. The pink color and deep red color represent the surface outcrop and underground part of the Ehuling Formation, respectively.

anticline, and the Xiangshan volcanic basin is developed above its core. A Caledonian granitic intrusion dipping to the NE is developed in the basement of the southern part of the basin. The identification of a double basement of metamorphic rocks and granite in the western part of the basin provides a new opportunity for the study of uranium mineralization in this area; (3) the framework faults are mainly NE striking, with a small number of NW striking ones. A new NE insidious fault under the Cretaceous red beds and an arc-like volcanic collapse structure in the northern basin were found. These structures are sizable and coincide with low impedance anomalies in space. The Xiangshan volcanic basin is structurally intercalated by two faults, and resembles a graben with various uplifts and sags.

Conclusions

The method of "digital geological mapping modeling" was proposed and firstly used in this study, and the method of "geological profile modeling" was improved. The "digital geological mapping modeling" method can be applied to various fields of geoscience, as it can directly process digital geological mapping data and comprehensively apply geophysical exploration and local mine data. Additionally, it can be used as a new method for surface geological mapping and as a transitional model for deeper 3D geological surveys.

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