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Research Advances

Where are the Volcanic Calderas in the Xiangshan Volcanic Basin of Jiangxi? Implications from Anisotropy of Magnetic Susceptibility

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Objective

As the world's third largest volcanic type uranium ore field, the Xiangshan volcanic basin has attracted much attention for its large industrial value. The ore hosting rocks are mainly the early Cretaceous rhyodacite and porphyroclastic lava, as well as small amounts of high level intrusive acidic rocks and metamorphic rocks. The vertical alteration of polymetallic mineralization-related uranium reaches 1000 m. The uranium mineralization in the Xiangshan basin is closely related to the volcano structure, and the flow structure is not obvious for the high degree of crystallization of the lava. In addition, volcanic topography is not clear due to the later erosional effect. Therefore, there are different understandings about the volcanic caldera or magma channel. The rhyodacite and the main body of porphyroclastic lava are from different lava channels, or they are genetic inherited? Is porphyroclastic lava a product of a large caldera, or is it from multiple volcanic-magmatic channels? This work tried to recover the direction of the ancient magmatic flow through the study of anisotropy of magnetic susceptibility (AMS) of the rhyodacite and porphyroclastic lava, and further determined the location of the ancient volcanic calderas combined with remote sensing, geological, geophysical and drilling data. This project aims to discover the uranium-bearing ancient volcanic calderas using AMS, which is firstly conducted in China.

Methods

Few researches have concentrated on the volcanic channels from the Xiangshan volcanic basin, which mainly referred to remote sensing, geomorphology and gravity. This work used the direction of magma flow to understand the position of the ancient volcanic channels. The main purpose of AMS measurement is to analyze the flow direction of magma, which can be verified with the field magmatic flow elements. Orientational samples, such as elongated debris and phenocryst, were collected and analyzed in lab, aiming to make comparison with AMS data. A total of 920 orientational cores were sampled from 16 sampling lines and 93 sampling points in the Xiangshan basin, and eight to ten cores were collected at each drilling site, including 435 rhyodacite and 485 porphyroclastic lava cores, respectively. These measurements were performed on AGICO Kappabridges MFK1 and MicroMag3900.

Results

Hysteresis loops and *k-T* diagram of rhyolite and porphyroclastic lava show magnetic properties of ferromagnetic minerals, which may be maghemite or pyrrhotite and magnetite. Most samples have a relatively low Hc and Mrs/Ms ratio (0.07–0.3), indicating that the magnetite in the rock samples is pseudo-domain to multi-domain. From the data of AMS of rhyodacite and porphyroclastic lava, it is found that both the rhyodacite and porphyroclastic lava have high magnetic susceptibility (K_m), mostly concentrating in the range of (1000–3000) $\times 10^{-6}$ SI; most of the samples exhibited a flat magnetic susceptibility magnitude ellipsoid (T>0). The anisotropy degree (P_j) is less than 1.1, and there is no obvious increasing trend with the increase of magnetic susceptibility, which indicates that the rocks were not subjected to strong deformation.

The obtained AMS data show obvious regularity, which can indicate the lava flow direction and location of the main calderas (Fig. 1). (1) The magnetic foliation of the large-scale porphyroclastic lava from the Xiangshan Peak to the Huxi Town presents NWW–SEE in strike, and the magnetite lineation of Youfang–Xiangshi is near NE–SW. It suggests that the Xiangshan Peak was an ancient volcanic caldera. The interpretation of magnetotelluric sounding shows that the low-resistivity anomaly, 1 km northwest of the Xiangshan peak, is interpreted as the volcanic neck of the eruption center of the porphyroclastic lava. The volcanic neck in general was steeply tubular, dipping to the southeast, with surface radius of about 2 km.

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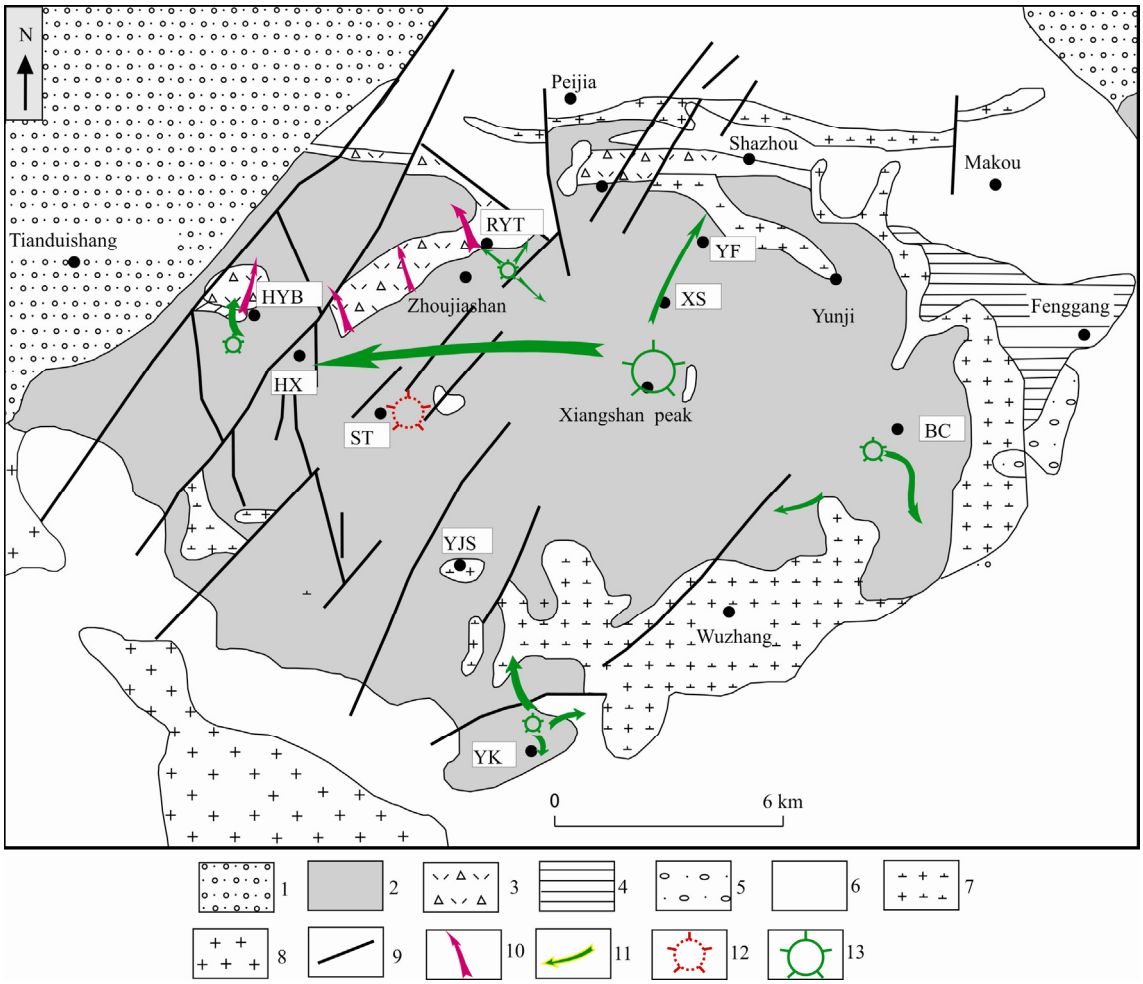

Fig. 1. AMS survey results in Xiangshan volcanic basin.
1, Upper Cretaceous red beds; 2, Porphyroclastic lava and volcanic clastic rocks from Ehuling Formation; 3, Volcanic clastic rocks and rhyodacite from the Daguding Formation; 4, Sandstone (gravel) from the Upper Triassic Jijiachong Formation; 5, Sandstone (gravel) from Middle-Devonian Yunshan Formation; 6, Metamorphic rock of Qingbaikouian; 7, Coarse-grained granitic porphyry, porphyritic granite from Shazhou unit; 8, Granite from early Devonian Lean unit; 9, Fracture; 10, Inferred flow direction of rhyodacite; 11, Inferred flow direction of porphyroclastic lava; 12, Inferred rhyodacite crater; 13, Inferred porphyroclastic lava crater. HX, Huxi Town; ST, Shutang; YF, Youfang; XS, Xiangshi; RYT, Ruyiting; HYB, Heyuanbei; BC, Baichang; YK, Yankeng; YJS, Yangjiashan.

(2) 500–1500 m south of Ruyiting, 13 sampling locations display circular magnetic lineation. It also indicates the existence of caldera. (3) Because of vegetation cover, the drilling sites in the Baichang and Yankeng areas in the east and south of Xiangshan Peak are sparse, but they are nearly ring-shaped, and the calderas are also inferred in the two places. (4) Combined with borehole data from industry companies, the ancient volcanic channels of the rhyodacite may be located in the vicinity of Shutang and be covered by porphyroclastic lava.

Conclusions

The main volcanic caldera of rhyodacite in the Daguding Formation may be the Xiangshan Peak or near Shutang, and the secondary magmatic channel is located in Heyuanbei. For the porphyroclastic lava in the Ehuling Formation, its main volcanic caldera was located at the Xiangshan peak, and the secondary channel dispersedly located in the Heyuanbei, Yangjiashan (Furongshan), Yankeng, and Baichang. Magma channels for the rhyodacite and porphyroclastic lava have inheritance. In previous work, the volcanic caldera distribution was preliminarily analyzed by remote sensing (annular, radial fracture), volcanic agglomerate distribution and field orientational element observation, which are in accordance with the above AMS data mostly.

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