High-resolution Resistivity structure of the Datong volcanic field and its deep origin: Evidence from a dense Magnetotelluric array study

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SUMMARY

The Datong volcanic field (DVF) is a typical Cenozoic rift system intraplate volcanic region in the North China Craton. The research of intraplate volcanoes has always been a hotspot because their genesis and evolution remain difficult to analyze relative to traditional volcanoes at the plate boundaries. Previous research shows that the DVF is subject to extensional tectonics and experiences surface uplift, subsidence, and significant seismic activity. However, reliable geophysical information on the magma system of the DVF is limited. The Magnetotelluric(MT) method is highly sensitive to detecting magma melts. We collected 264 broadband MT stations covering the junction of the Trans-North China Orogen and the Inner Mongolian Suture Zone (112.5°-115.5°E, 38.8°-41.3°N), which completely encompasses the DVF. We present a high-resolution three-dimensional resistivity model of the crust and upper mantle beneath the DVF, derived from the above MT data by using the ModEM code. The study investigates the relationship of shallow magma chambers, surface responses, and deep heat and material supply sources. The model separately shows three spatial consistent high conductive zones at a depth of 5~15, 18~50, and 25~120 km beneath the DVF. The high-conductivity structures in the DVF pass through the Moho, extend to the upper mantle, and are connected from top to bottom. The high-conductivity anomalies in the upper crust correspond well with surface faults and volcanic cones, suggesting they may be residual pathways for magma ascent. Meanwhile, the high-conductivity anomaly in the middle to lower crust is connected to the high-conductivity anomaly in the crust-mantle transition zone to the west, potentially indicating the response of a potential magma chamber for the DVF. Gradually shallowing high-conductivity anomaly in the upper mantle from west to east may represent partial melting materials, providing sustained supply to the overlying magma chamber. Geochemical data similarly indicate that magma systems may originate from the upper mantle, stored in the middle to lower crust before eruption. The model suggests that the asthenosphere may experience upwelling in the DVF, potentially resulting in thermal erosion of the overlying continental lithosphere. The DVF is situated within an NNE-directed shear-extensional tectonic setting. Under the far-field compression in the Tibetan Plateau from the northeast during the Cenozoic, asthenospheric material continuously upwells along structurally weak zones, providing a sustained heat source to magma chambers. Mantle material undergoes decompression, melting within the crust, rapidly ascending and erupting.

Keywords: Datong volcanic field, Magnetotelluric, Magma system, Partial melt