Investigating Mantle Dynamics in the Newer Volcanics Province: Insights from Magnetotelluric Data

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SUMMARY

The Newer Volcanics Province (NVP) in southeast Australia, characterized by over 400 volcanic centers formed in the last 4.5 million years, poses significant natural hazards to the region. While mantle plumes have been traditionally cited as the origin of intraplate volcanism, the NVP's formation is increasingly attributed to edge-driven convection (EDC) and shear-driven upwelling (SDU). This study presents new magnetotelluric (MT) data to support these geodynamic processes.

We conducted three-dimensional inversions of MT data from 49 new broadband sites, supplemented by 143 previously collected sites. Our results reveal a 20-40 km deep, moderately low resistivity zone (~10–300 Ω m) beneath the Mt Gambier subprovince, termed the Gambier Conductor. This conductor aligns with a significant lithosphere-asthenosphere boundary step, suggesting fluid-catalyzed alteration of the crust due to magmatic volatiles. A notable low-resistivity zone (<10 Ω m) at ~25 km depth is interpreted as 1.2–3.6% partial melt.

These findings are crucial given the region's history of eruptions, such as the recent 5,000-year-old eruption at Mt Schank. Understanding the distribution of partial melt and magmatic volatiles is essential for assessing future volcanic risks, especially for densely populated areas like Geelong, Ballarat, and western Melbourne.

Our data supports the hypothesis that the NVP's volcanism results from EDC and SDU processes. The detected resistivity anomalies correlate with regional seismic features and suggest that mantle dynamics are influenced by the lithospheric structure and plate motions. These insights contribute to a more comprehensive understanding of intraplate volcanic provinces, highlighting the importance of continuous monitoring and detailed geophysical studies to mitigate volcanic hazards in populated regions.

Keywords: Newer Volcanic Province, Edge-Driven Convection, Shear-Driven Upwelling, Intracontinental volcanism