Multi-scale 3D modeling of the structure and geometry of the Echassières/Beauvoir region, French Massif Central

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Résumé

Rare-metal granites (RMG) and pegmatites are a significant source of hard-rock lithium, representing an extreme expression of continental crust magmatism. The processes governing their melt ascent and final emplacement remain a subject of scientific debate, with a key focus on the role of tectonic structures in providing magma migration pathways.
This study defines the structural framework of the Beauvoir RMG deposit in the northern French Massif Central (Echassières – La Sioule area) by integrating diverse geological, structural, and geophysical data into multi-scale 3D models. The Variscan orogeny created fundamental deep crustal structures that provided the framework for the late magmas, and in particular RMG's emplacement. However, the final geometry of these structures was significantly influenced by later tectonism and specifically the Oligocene extensional event which created new brittle faults and reactivated older ones. An accurate 3D model must therefore account for the combined effects of these tectonic events.

The methodology combines traditional structural fieldwork with an automated GIS-based approach for regional fault network mapping. On the other hand, internal ductile fabric of the host metamorphic units is integrated based on measured and compiled foliation orientation measurements digitized from exiting rather ancient maps. Then, multi-scale 3D geological models are constructed using Geomodeller's implicit modeling, a technique well-suited for complex geometries. The models are computed using various data inputs, including

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field structural measurements, geological boundary traces, and information from drill cores. Besides, available geophysical datasets (heliborne electromagnetic and magnetic survey and ground gravimetric data) are used to constrain the deeper geometry by imaging the interface between the granites and their host rocks around the Beauvoir pluton. This integrated approach provides a robust understanding of how the geological and structural framework influence the migration and final location of these critical RMG magma bodies.
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