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Combined forward and inverse modelling reveals the source of the Permian volcanism in the Oslo Graben

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The volcanic Oslo Graben forms the northern part of the Oslo Rift and is associated with high-amplitude positive magnetic anomalies and a gravity high. A recent compilation of potential field and petrophysical data from the Oslo region enables a detailed interpretation of the crustal architecture and the location of the magmatic sources in the Oslo Graben area.

The Bouguer gravity high of the Oslo Graben has a steep, westward-facing gradient partly located to the west of the rift, and a much gentler eastern gradient. The asymmetry of the local gravity high, points to the over-thrusted high-grade and high-density Kongsberg Complex being the main source of the anomaly. The 3D density model of the Oslo Rift explains the shape of the Bouguer gravity high as a combined effect of crustal thinning and the presence of a transcrustal ramp related to a mid-crustal layer that reaches the surface in the Kongsberg and Bamble Sectors.

The magnetic anomaly of the Oslo Graben is separated into a northern and southern part: The Nordmarka Igneous Complex and the Vestfold Igneous Region. The magnetic field data of the Nordmarka Igneous Complex are unique since two surveys recorded at different flight altitudes (50 m above ground and 3400 m above sea level) exist. The magnetic anomaly reaches values up to 1500 nT over an elongated area of 75 by 30 km. At the surface the Nordmarka Igneous Complex is heterogeneous, and features a variety of igneous rocks (e.g. syenite, granite, basalt), and local structures, such as calderas, ring fracture zones and their associated circular-shaped magnetic anomalies. Analysis of the depth-to-bottom of the magnetic source indicates the presence of a more than 15 km thick intrusion with a lateral extension slightly larger than the surface expression of the Nordmarka Igneous Complex.

Forward modelling of the magnetic field constrained by petrophysical data supports our results. Petrophysical data from surface rocks indicate an average susceptibility of 0.015 SI with a Q-factor of 0.3 and a density of 2600 kg/m**3. Our preferred 3D model includes a granitic layer with a maximum thickness of 4.5 km. This body explains the local gravity anomaly, but magnetic data reveals that the granite can only represent the upper layer of a deep-seated igneous body. The depth extent of an underlying more magnetic part of the body reaches 15 km depth; susceptibility, Q-ratio and density increase with depth.

The petrophysical parameters applied at the base of the structure in the model are typical for gabbro. The intrusion is interpreted to indicate a differentiation series from base (gabbro) to top (granite). This petrological variation with depth is not detectable in the gravity anomaly because the density contrast to the surrounding crust is very small. Based on our modelling, the igneous intrusion is mushroom-shaped with a broad stem. The granitoid part of the structure represents the cap of the mushroom while the intermediate and mafic differentiation series in the lower part make up the stem. The broad intrusion in the upper to middle crust can replace the concept of magmatic underplating below the crust, which for quite some time has been regarded as the source of the magmatism.