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Magnetotelluric investigation of the Alnö alkaline and carbonatite ring complex, central Sweden

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Alnö complex, 553-590 Ma, located in central Sweden, is one of the largest of few known alkaline and carbonatite ring intrusions in the world. The complex primarily consists of alkaline silicate rocks (ijolite, nepheline-syenite and pyroxenite) and a wide range of carbonatite dykes with different compositions (e.g., sövite). To better understand the intrusion mechanism(s) and the deeper structure of the intrusion, three high-resolution reflection seismic, gravity and magnetic profiles, crossing the main intrusion, were acquired in winter 2010. Together with these, petrophysical measurements on various rock samples have also been carried out. These data not only successfully showed the lateral extension of the intrusion at depth but also suggested a solidified saucer-shaped magma chamber at about 3 km depth that is associated with caldera-related ring-type fault systems. To further elucidate these interpretations, magnetotelluric (MT) data were acquired in summer 2013.

The MT data were measured at 34 stations across the intrusion and designed so that a 3D conductivity model can be obtained. Most of the sites are located along the seismic profiles, while the rest is distributed over the intrusion area, to provide lateral and off-profile information. The time series were recorded with four broadband MT instruments simultaneously. The used sampling rates were 1000 Hz (two hours after midnight) and 20 Hz (a full day). The collected MT data are highly influenced by noise from cultural sources. Luckily, higher frequencies are less influenced providing a good coverage of the interest depth of about 5 km. Therefore, the data processing and analysis focused solely on the high frequency data. To decrease the effect of noise, the best quality site in one day was chosen for remote referencing the other three. Even if the sites were only 500 to 1000 m apart, better results were obtained, indicating very localized noise sources in the area.

The strike analysis of the obtained transfer functions show a wide range of strike directions with a main direction of about 70° azimuth. The dimensionality analysis show that 2D inversion conditions are met. 2D inversions of the determinant of the transfer functions were carried out along the three seismic profiles. A 3D resistivity model of the area was also obtained by inverting the full impedance tensor. The resistivity models suggest a conductor under the ring complex that extends to about 3 km depth, correlating well with the results from the reflection seismic profiles.

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