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Near Field and Tunnel Effects Study of Controlled Source Magnetotellurics on the Hallandsåsen Horst; Sweden

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In nearly all studies conducted in Sweden using the EnviroMT controlled source technique, near field effects can be seen at frequencies below 15 kHz. In this study a profile parallel to the Hallandsåsen railway tunnel in southern Sweden crossing the 2D Hallandsåsen horst, the electromagnetic response is further influenced by the conductive armed concrete coating the tunnel walls at a depth of 150 m below the surface. Thus the problem of simulating the electromagnetic response from the 3D structure using a controlled source becomes complicated and inversion results based upon 2D models must be interpreted with care.
A synthetic 3D model consisting of two conductive zones crossing the profile and one tunnel parallel to the profile was set up and the responses were calculated using the 3D forward program X3D (Avdeev, 2006) to study both the near field effect and the tunnel effect. The geometry of transmitters and receivers was the same as for the field measurements conducted earlier.
Apparent resistivity and phase responses are quite similar to those of the real data in both current modes (parallel and orthogonal to the tunnel). A transitional zone between the near field and far field was seen in the synthetic response with dropping apparent resistivity compared with the plane wave response. This effect is more obvious in parallel mode with the electric current perpendicular to the conductive zones and parallel to the tunnel. When comparing this response to the model response without the tunnel, the differences between the apparent resistivity in the parallel mode show that the conductive tunnel reduces the near field effect. In the perpendicular mode, there is only a small near field effect. The difference between the responses with and without tunnel in the perpendicular mode is very small, indicating that the apparent resistivity is not much influenced by the conductor. The phase in the parallel mode only drops at the stations close to the source, but without tunnel there are big differences between plane wave and controlled source response, indicating a strong tunnel effect in the phase of parallel mode. In the perpendicular mode, the near field effect and tunnel effect are generally small.
The real part of the vertical magnetic transfer functions with and without the tunnel are represented as induction arrows. The induction arrows are enhanced by the tunnel and the direction and magnitude of the arrows is influenced by the source and tunnel.
2D inversion including the parallel mode (TM) and tippers should be done with care because of the transitional effect in the parallel mode and the hidden near field effect in tippers and impedance, whereas the perpendicular mode (TE) can be more safely modeled .