Electrical conductivity structure suggests no plume beneath the Tristan da Cunha hotspot in the southern Atlantic Ocean

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Tristan da Cunha Island is one of the classical hot spots in the Atlantic Ocean, situated at the western end of the aseismic Walvis Ridge which forms a connection to the Cretaceous Etendeka flood basalt province in northwestern Namibia. The discussion about its source (in shallow asthenosphere or deeper mantle) have not reached consensus yet because of lack of the geophysical observations in the area. A marine magnetotelluric (MT) experiment was conducted together with seismological observations in the area in 2012–2013 through a German-Japanese collaboration with the goal to constrain the physical state of the mantle beneath the area. A total of 26 MT seafloor stations were deployed around the Tristan da Cunha Islands and available data were retrieved and processed from 24 stations. We applied iterative topographic effect correction and one-dimensional (1-D) conductivity structure inversion to the data. Then, we conducted three-dimensional (3-D) inversion analysis incorporating the topographic effect, using the 1-D model as the initial model. The local small-scale topography and the far continental coast effects are incorporated as the distortion term in the 3-D inversion. The preliminary result of our analysis shows no evidence of a significant conductive anomaly arising from the mantle transition zone, suggesting that the current magmatic source (major place of melting) of the hotspot activity is in the shallow upper mantle. This is in contrast to results from geochemical analysis, in which samples along the Tristan track exhibit an ocean-island-basalt-type incompatible element pattern pointing to a deep mantle source of the melt. Our findings therefore might indicate that the deep mantle up-welling underneath Tristan da Cunha Islands may be almost dead. A conductive anomaly at about 100 km depth in our derived conductivity model to the southwest of Tristan da Cunha Islands may be as the result of an interaction between the mid-ocean ridge and/or up-welling further south, e.g., beneath the Gough Island, which is the other termination of the Walvis Ridge and shows clearer geochemical evidence for a plume source. This conductor bulges upward beneath a fracture zone just south of the Tristan da Cunha islands. It may suggest that the fracture zone can be a path that melt can transport from the asthenosphere to the seafloor (maybe the islands nearby) although the anomaly was not clearly imaged in upper 20 km depths.

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